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Nelia Maritz
Environmental Officer
Native Vegetation Regulation
Department of Water and Environmental Regulation
Prime House, 8 Davidson Terrace
Joondalup, Perth, WA, 6027

Dear Nelia,

Response to Request for Further Information for the Shire of Broome's Clearing Permit Application (CPS9542-1)

1 Introduction

On 23 December 2021, the Shire of Broome (the Shire) submitted a Clearing Permit Application (CPS 9542-1) to the Department of Water and Environmental Regulation (DWER), to clear 69.02 hectares of native vegetation within Lot 550 on Plan 421448. The purpose of this Clearing Permit was to establish the Shire's proposed Community Recycling Centre (and associated infrastructure) at the Shire's new Regional Resource Recovery Park (RRRP).

On 3 February 2022, the Shire received confirmation from the DWER that the Shire's Clearing Permit Application was valid in accordance with sections 51E (1) and (2) of the *Environmental Protection Act 1986* (EP Act) and was accepted for assessment. During the assessment process, the DWER sent a Request for Information (RFI) on 4 August 2022 to the Shire. On behalf of the Shire, Talis Consultants Pty Ltd (Talis) was engaged to prepare this response to items identified within the RFI, under Schedule 1.

2 Project Background

The Shire owns and operates a landfill and resource recovery site in Broome and provides kerbside waste collection and recycling services (through a contractor) to residents and businesses. The Shire's current active landfill at the Buckleys Road Waste Management Facility (Buckleys Road WMF) is a Class II landfill. The landfill at Buckleys Road WMF is fast approaching the end of its operational life, with the latest survey data suggesting 4-5 years of landfill airspace remaining. This forecast is based upon current waste generation rates within the Shire and compaction rates achieved at the landfill. In addition, the remaining landfill estimates include the expansion of landfilling activities into the existing Community Recycling Centre (CRC) area of Buckley's Road WMF, which would require the Shire to provide access to an alternative CRC to ensure these services for the Broome community continue. Therefore, the most pressing challenge for the Shire is in managing the impacts of the limited landfill void space and the time needed to design and construct a new CRC and landfill.

To complement the waste management services being offered, the Shire will also establish a Liquid Waste Facility (LWF) to service the Broome community and wider Kimberley Region through the

acceptance of sullage and industrial liquid wastes. While there are other LWFs in the wider Kimberley region, their ability to accept and treat additional volumes of liquid wastes are limited. In some instances, some Shires and commercial waste generators are having to transport their material over 1,800km for appropriate disposal i.e., from Kununurra to Karratha.

The Shire has developed a Waste Strategy (Broome Waste Strategy) to guide the direction and resourcing of waste management in the Shire for the next ten years. The Broome Waste Strategy was produced in line with Western Australia's Waste Avoidance and Resource Recovery Strategy 2030, the Kimberley Integrated Waste Management Plan 2018-2023, the DWER Waste Plan Resource Kit and relevant Shire strategic documents. The purpose of the Broome Waste Strategy is to provide a framework for effective, efficient, and sustainable waste management within the Shire from 2021-2031.

From the initial scoping phases, the Shire identified the opportunity to advance the recycling and resource recovery initiatives for both the Shire and the wider Kimberley area through the development of the RRRP. The RRRP will consist of an integrated CRC, LWF and new Class III Landfill. The Shire is proposing to stage the developments of the two key elements as follows:

- Phase 1: CRC, LWF and associated supporting infrastructure; and
- Phase 2: Landfill Cells 1 and 2, Leachate Pond and associated supporting infrastructure.

The CRC will provide the full range of community and light commercial waste acceptance services including recyclable, household hazardous waste, bulky waste (i.e., greenwaste, scrap metal, used tyres, and construction and demolition waste) as well as refuse requiring appropriate disposal. The Shire proposes to construct Phase 1 and continue landfilling operations at Buckleys Road WMF until such time that all useable landfill void space has been consumed. The Shire will construct Phase 2 prior to final capping and closure activities at Buckleys Road WMF to ensure that appropriate disposal services continue and that a smooth transition of waste disposal can occur at the RRRP.

At present, there are no waste management facilities located within the Kimberley region with the capacity to provide reuse, recycling, materials processing, and best practice disposal services. Therefore, the RRRP will provide a range of sustainable initiatives that fills a vital gap in recycling, liquid waste and landfill disposal infrastructure for the Shire and the wider Kimberley region. Aligning with the Waste Management Hierarchy, the RRRP will deliver important community services to reuse, recycle, and recover materials, and improve on the current disposal services through construction of a Class III Landfill. This infrastructure will be designed and constructed to best practice standards and will be the future for the provision of modern sustainable waste management services for the Broome community and the Kimberley region.

3 CRC Works Approval Application Background and Status

The siting of waste management facilities, particularly landfills, is a complex process with the requirement for the assessment of a variety of factors including environmental, social and financial aspects. The Shire has completed substantial works in relation to this critical aspect of the RRRP project. In 2014 the Site Selection Study commenced by conducting desktop analyses of the study area to identify areas within which Sites of Interest were likely to be found. This commenced with the setting of Site Selection Criteria covering the key aspects including environmental, social, heritage and surrounding infrastructure. Extensive consultation with key stakeholders was undertaken during this process and the adopted Site Selection Criteria provided the framework for all future site selection works for the RRRP.

In order to identify a Preferred Site(s), the Sites of Interest underwent evaluation to assess their strengths and weakness. The principal evaluation tool used was a Multi Criteria Analysis (MCA) which was based on the Site Selection Criteria. Following a sensitivity analysis of the MCA, the Site Selection Study was released for stakeholder and community feedback.

Following consideration of the detailed investigations, in February 2018 Council resolved that an area of 125 hectares (ha) located on Lot 270 Great Northern Highway (referred to as Site G1) would be the Preferred Site for the Broome RRRP. Since the identification of the Preferred Site for the RRRP, there were significant delays in obtaining approval to access Site G1 and as a result, the Shire commenced assessing several alternative sites that warranted further detailed investigations. Talis was engaged to undertake desktop reviews of potential sites, which resulted in the Shire proposing a new site covering 119 ha over the northern section of Lot 990 on DP 414194 Broome-Cape Leveque Road and the northern section of Lot 593 on DP 71791 Broome-Cape Leveque Road (referred to as Site D2).

In late October 2019, the Shire was granted access to Site G1 to undertake the intrusive investigations required to determine the suitability of a landfill for the site. With the Shire officially being granted access to Site G1 in late October 2019, the Shire chose to move forward with the on-site investigations for both Sites G1 and D2 and to collate site specific information to assist the Shire make an informed decision on a Preferred Site for the Broome RRRP landfill and commissioned Talis to further progress the RRRP towards an approvals process through the consideration of both locations.

Based on the two sites and requirement to develop the CRC at Site D2, two Development Options (Integrated and / or Network) were presented through the Community Engagement process (see Figure 1).



Figure 1: Project Development Options

Sites D2 and G1 were assessed to determine their compliance with relevant criteria as determined by the relevant government agencies and complimented by some key factors relevant to the Shire. This allowed for a comparison of both sites across a range of set criterion to highlight the technical strengths and weaknesses as well as points of difference between each other. Site D2 was identified as being the most preferred site for the following key reasons:

- Greater separation to ground water which would ensure compliance with the 3m separation distance from groundwater;
- Provided greater volume of soils (on average 14m) below the landfill for natural attenuation to reduce the risk to groundwater;

- The site can satisfy the Shire's desires to achieve a material balance and excavate surplus pindan soils for engineering purposes;
- The site is in a smaller surface water catchment area, resulting in:
 - Less risk of flooding; and
 - Will requiring less engineering and maintenance requirements to mitigate flooding risks.
- Meets all recommended separation distances to sensitive receptors; and
- A vegetation buffer can be maintained to maintain visual amenity.

Following extensive community consultation, the Shire of Broome Council voted on the preferred location and approved Option 1 for an integrated Site D2 and further studies were progressed on this basis.

On 24 June 2021, the Shire submitted a Works Approval Application (W6606/2021/1) to the DWER for the construction of a new CRC at the Shire's RRRP. During the assessment process, the DWER sent a Request for Information (RFI) to the Shire, on 19 January 2022. Talis on behalf of the Shire submitted a response to this RFI to the DWER on 20 May 2022, which included additional information of the construction of a new Liquid Waste Facility (LWF), a tyre monocoil, and the initial stages of the RRRP's proposed Surface Water Management System (SWMS), which are to be constructed in conjunction with the CRC.

The DWER undertook a preliminary review of the information submitted and determined that due to the addition of multiple items of critical containment infrastructure, and the addition of multiple new categories to the assessment, the scope of the DWER's assessment substantially changed beyond the scope of what was originally advertised. Given the new scope of the Works Approval Application, it was recommended that the application package be withdrawn and resubmitted. Therefore, on 8 June 2022, Talis on behalf of the Shire submitted to the DWER a withdrawal notice, which was accepted by the DWER on 9 June 2022.

Between June and September 2022, Talis on behalf of the Shire progressed with the detailed design of the CRC (and associated infrastructure) and prepared several additional documents (See APPENDIX C) to support the CRC Works Approval Resubmission Application, including:

- Bushfire Management Plan;
- Bushfire Risk – Assessment & Management Plan;
- Draft Surface Water Management Plan;
- Groundwater Management Plan;
- Feral Animal and Vermin Control Management Plan;
- Weed Management Plan;
- Asbestos Management Plan;
- Construction & Demolition Management Plan;
- Odour Impact Assessment; and
- Noise Impact Assessment.

In addition, the Shire undertook additional engagement with key stakeholders, including, the Department of Biodiversity, Conservation and Attractions (DBCA) and Nyamba Buru Yawuru (Yawuru) representatives to ensure that the revised CRC Works Approval Resubmission addressed their

concerns. The Shire provided a Letter Response to the DBCA's concerns on the 4 August 2022 and considered feedback from the DBCA in the preparation of the Feral Animal and Vermin Control Management Plan and the Weed Management Plan documents. In most instances, feedback received by the DBCA was incorporated into these finalised documents.

On the 13 September 2022, Talis on behalf of the Shire resubmitted the CRC Works Approval Application (the Application) to the DWER. On 13 October 2022, the DWER issued the Application Invoice for payment (Invoice Number W-W6738/2022/1) to the Shire and confirmed that the Validation for the Application step had been completed. DWER's correspondence also noted that there were some outstanding matters within the Application and further information on these items is required to ensure that DWER can complete their assessment. Talis on behalf of the Shire are currently preparing a response to this information and it will be submitted before the end of November 2022.

4 Response to DWER RFI

In consultation with the Shire and Spectrum Ecology & Spatial (Spectrum), Talis has prepared responses to the DWER's Schedule 1. Details can be found in the tables provided in this letter, which are as follows:

- DWER Information Requirement 1 – Evidence of efforts taken to avoid and / or mitigate significant environmental impacts resulting from the proposed clearing;
- DWER Information Requirement 2 – A priority ecological community assessment is required for the area proposed to be cleared, to confirm the presence / absence of the *Corymbia paractia* dominated community on dunes Priority Ecological Community (PEC);
- DWER Information Requirement 3 – Mitigation of impacts to environmental values of the adjacent Yawuru Birragun Conservation Park resulting from the proposed clearing; and
- DWER Information Requirement 4 – Works Approval;

5 Revision of Clearing Permit Boundary

Historically, the extent of the RRRP incorporated parts of three (3) Lots, which had a combine area of 1,191,393m². As the RRRP Project progressed, the Shire undertook a Lot amalgamation and alteration, resulting in one Lot that is 1,205,179m² and covers the entire Site. This new Lot is designated as Lot 550 on DP421448. For zoning purposes, the Shire also created Reserve R53878, which is completely identical in shape and extent to Lot 550 on DP421448, to allow the Shire to carry out waste management activities within one Lot boundary.

During a review of the RRRP's surface water management system, it was noted that there was a discrepancy between the proposed clearing permit boundary and the Lot 550/Reserve R53878 boundary. The clearing permit boundary does not align to the full extent of the proposed Lot/Reserve boundary and therefore does not align to the full extent of required clearing works.

As a result, when Spectrum drafted the subsequent Detailed Flora & Vegetation Report (2020), a small portion of the southern boundary (approximately 18m wide by 675m long) was excluded. This has been discussed with Spectrum in detail and it was confirmed that this minor extension equates to an additional 18m extension on a site that has a length of 1.7km, or 13,786m² additional on a site of 1,205,179m² (or 0.01% increase). Spectrum confirmed that this minor extension would not have changed their approach to the assessment or their field survey methodology. Therefore, Spectrum

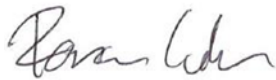
has reviewed and updated the Detailed Flora & Vegetation Report and relevant mapping accordingly (See APPENDIX B) to cover the full extent of the Reserve.

The revised clearing area for consideration by the DWER, is illustrated in Drawing C-005 provided in APPENDIX A.

6 Closing

Talis appreciates the DWER's consideration of this additional information and if you have any queries please do not hesitate to contact Talis' Project Manager, Megan Mather on 0413 703 673 or megan.mather@talisconsultants.com.au. Alternatively, you can contact the undersigned.

Yours sincerely,



Ronan Cullen
Director - Waste Management Section Leader

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DWER Information Requirement 1 – Evidence of efforts taken to avoid and / or mitigate significant environmental impacts

Item No.	DWER Information Required	Shire's Response
1	<p>Evidence of efforts taken to avoid and / or mitigate significant environmental impacts resulting from the proposed clearing.</p> <p>Rational</p> <p>The preliminary assessment has identified that the area proposed to be cleared comprises significant habitat for:</p> <ul style="list-style-type: none"> • Priority flora species: <i>Corymbia paractia</i> (P1), <i>Jacquemontia</i> sp. <i>Broome</i> (P1) and <i>Terminalia kumpaja</i> (P3) • Priority ecological community '<i>Corymbia paractia</i> 	<p><u>Consideration of Alternative Sites</u></p> <p><i>Site Selection Background</i></p> <p>The siting of waste management facilities, particularly landfills, can be a complex process with the requirement for the assessment of a variety of factors including environmental, social and financial aspects as well as seasonality changes to values. The Shire has been working for over a decade to identify a suitable site for the RRRP. This commenced with the Shire consulting with a range of stakeholders, including the Broome community, Yawuru and various Government departments.</p> <p>The Shire, supported by Talis conducted an initial desktop site analysis of potentially suitable sites located within a 60km radius of Broome. From this process, the Shire assessed well over 20 potential sites across the 60km radius. Arising from these works, multiple Sites of Interest were identified that required onsite investigations. The Shire had undertaken onsite investigations of over 5 sites. including topographical, flora and fauna, heritage, hydrological, geotechnical and hydrogeological to confirm their suitability for development of the Project.</p> <p>The outcome of these investigations was to help the Shire make an informed decision sites that warranted further consideration for the development of the Project. Of the five sites that investigations were undertaken on, only two were deemed suitable for further detailed consideration. In 2019 these investigations led the Shire to undertake a detailed assessment of the technical and financial implications of two key options based around the two Sites of Interest:</p> <ul style="list-style-type: none"> • Site D2: located 12km northeast of Broome's town centre along Cape Leveque Road. Site D2 is 5.5km northeast of the Buckleys Road WMF (this is the selected location for the Project); and • Site G1: located 38 km northeast of Broome's town centre along Great northern Highway. Site G1 is 31km east of the Buckleys Road WMF. <p>To assess and compare the suitability of the sites for landfilling activities, the environmental and social aspects of each site were assessed against a variety of criteria devised from the Shire's requirements as well as the following guidance from various government bodies:</p>

	<p>dominated community on dunes'</p> <ul style="list-style-type: none"> The Greater Bilby listed as Vulnerable under the EP Act and EPBC Act <p>In addition, the preliminary assessment has identified potential impact that may cause land degradation in the form of risk of surface water run-off and impact neighbouring conservation reserve through spread and introduction of weeds and edge effects.</p> <p>It is noted that the Shire wish to clear all vegetation within the Development Footprint (69 ha) to allow for flexibility within this area in which to establish infrastructure for RRRP. It is also noted that the exact</p>	<ul style="list-style-type: none"> Environment Protection Authority Victoria 2015 Best Practice Environmental Management - Siting, Design, Operation and Rehabilitation of Landfills (BPEM Guideline); Environmental Protection Authority WA Draft Guidance Statement: Separation Distances (2015) (Draft Guidance Statement); and Industry standards from the Waste Management Branch of the DWER. <p>Although the BPEM Guideline is a Victorian EPA document, the guideline contains the most stringent landfill standards available within Australia. Its use for assessing metropolitan and major regional centre landfills throughout WA is accepted by the DWER. The BPEM Guideline aims to provide existing and future operators of landfills, planning authorities and regulating bodies with:</p> <ul style="list-style-type: none"> Information on the potential impact of landfills on the environment and how this is to be assessed; A clear statement of environmental performance objectives of each segment of the environment; and Information on how to avoid or minimise environmental impacts, including suggested Best Practice Landfill Guidelines' measures, to assist them to meet the objectives. <p>The EPA Draft Guideline Statement on Separation Distances was released for stakeholder and public comments in October 2015. Although still in draft format, the Guidance Statement was adopted for the study as it contained the most stringent requirements for separation distances for landfills and associated waste infrastructure within WA. Sensitive land uses are those which are sensitive to emissions from industrial and similar activities, and include residential developments, hospitals, schools, shopping centres and some public buildings (EPA, 2015b). Separation distance between sensitive receptors and sites used for waste management purposes varies according to the type of waste received and the activities occurring.</p> <p>The DWER's Waste Industry Licensing Branch administrates the approvals for waste facilities across the State. The DWER has adopted requirements for future landfills and cells to achieve a separation distance of 3m from the lowest point of the basal cell and the highest groundwater level ever recorded. This exceeds the BPEM Guidelines which is specified as 2m groundwater separation distance.</p> <p>Other key factors associated with the assessment of the suitability of each site was its ability to deliver upon the Shire's Landfill Design Requirements. A key component of this was for the site to facilitate 6m excavations, while maintaining the DWER 3m groundwater separation distance, to secure valuable fill material to support the site development but also other Shire works project. The recommendations from these various sources have been adopted for assessing each site across the following key environmental and social aspects:</p>
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<p>location of the infrastructure will be determined at the detailed design stage and through further community consultation.</p> <p>However, given the significant environmental impacts list above, implementation of the mitigation hierarchy is required which includes consideration of alternatives and justification on why alternative locations are not suitable, and avoidance of clearing of native vegetation. If impacts can't be avoided, then mitigation measures and strategies to reduce impacts are required.</p>	<ul style="list-style-type: none"> • Buffer and separation distances; • Topography; • Soils; • Flora and Fauna; • Surface water; and • Groundwater. <p>Site D2 and G1 were assessed to determine their compliance with relevant criteria as determined by the relevant government agencies and complemented by some key factors relevant to the Shire. This allowed for a comparison of both sites across a range of set criterion to highlight the technical strengths and weaknesses as well as points of difference between each other. Site D2 was identified as being the most preferred site for the following key reasons:</p> <ul style="list-style-type: none"> • Greater separation to ground water which would ensure compliance with the 3m separation distance from groundwater; • Provided greater volume of soils (on average 14m) below the landfill for natural attenuation to reduce the risk to groundwater; • The site can satisfy the Shire desires to achieve a material balance and excavate surplus pindan soils for engineering purposes; • The site is in a smaller surface water catchment area, resulting in: <ul style="list-style-type: none"> o Less risk of flooding; and o Will requiring less engineering and maintenance requirements to mitigate flooding risks. • Meets all recommended separation distances to sensitive receptors; and • A vegetation buffer can be maintained to maintain visual amenity. <p>From the 1 of February 2021 to the 17 March 2021 Talis supported the Shire through extensive Community Consultation events, which are summarised below:</p> <ul style="list-style-type: none"> • Face-Face Engagement: Nyamba Buru Yawuru Meeting, Environs Kimberley Meeting, Coconut Well Meeting, Pop-up Information Sessions and Questionnaires and Community Information Sessions;
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	<ul style="list-style-type: none"> Printed Electronic Media: Factsheets, Information Packs at Meetings and Sessions, and Engagement Summary Pamphlet & Report; and Electronic Media: Online Surveys and creation of Project Website. <p>The webpage remains live and interactive and will continue to do so throughout the life of the Project (www.rrrp.com.au).</p> <p>Following extensive community consultation, the Shire's Council voted on the preferred location, Site D2 in April 2021 and has since been working towards seeking appropriate approvals.</p> <p>The RRRP Project is not just about landfill activities, it also includes a holistic and sustainable approach to long-term delivery of recycling, resource recovery and waste management services. It offers a best-practice integrated facility that supports the community to reuse, recycle and recover waste materials. This creates a reduced reliance on landfill and allows the Shire to reduce the quantity of waste going into the landfill. From the onset of the RRRP Project, the Shire identified the opportunity for the Project to advance the recycling and resource recovery initiatives as well as the standard of waste treatment services for the Shire and the wider Kimberley region.</p> <p>As noted in Section 3, the CRC Works Approval Application was resubmitted on the 13 September 2022 and is in the process of being reviewed by the DWER. There was a significant amount of additional work undertaken to prepare the resubmission, including preparation of additional environmental assessments and management plans. This information and supporting documents can be viewed within the revised Environmental Assessment Management Plan (EAMP).</p> <p>It is expected that any resulting approval will contain a range of binding conditions also addressing the potential for environmental impacts.</p> <p><u>Consideration of Alternative Layouts</u></p> <p><i>Design and Facility Footprint</i></p> <p>Following the Shire's resolution on the preferred Site location for the establishment of the RRRP, Talis proceeded with the development of the Site Master Plan layout and progressing the design of the RRRP. During the initial design phase, Talis considered multiple aspects of the facility's design that could have an influence on several environmental aspects, including surface water management and flora and fauna.</p> <p>To ensure that external surface waters are managed appropriately, a Site levee system will need to be constructed. The purpose of this levee system is to exclude all external surface water flows from a 0.2% Annual Exceedance</p>
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	<p>Probability storm event, or a 1-in-500-year storm event from entering the Site. The levee will direct external surface water flows in a south-westerly direction, mimicking the natural flows within the area. In addition, the flood modelling undertaken for the internal design of the Site describes that the maximum velocity in the levee drain is only 1.5m/s in a 1-in-100-year storm event, which is considered to be a relatively low velocity.</p> <p>The Detailed Flora & Vegetation Assessment undertaken by Spectrum noted reference of the required buffer zone of the Sersalisia sericea PEC (See Drawing TW19113-02 in APPENDIX A), which was identified in the north-west corner of the Site. As a result, Talis modified the design and footprint extent of the RRRP area proposed to be cleared away from the north-western corner and focused towards the middle and southern portion of the Site. Drawing C-003 has been provided in APPENDIX A which shows the buffer zone in comparison to the proposed development footprint.</p> <p><u>Avoidance of Clearing Measures</u></p> <p>The Shire is committed to reducing clearing requirements where possible. As discussed under item 4, the purpose of the RRRP is to maximise diversion of recyclable and resource recovery materials to reduce volumes of waste disposed to Landfill through the construction of the CRC, including supporting infrastructure like the Reuse Shop / Education Centre and implementation of waste education campaigns by the Shire. In addition, implementation of future waste management reduction activities like Food Organic and Garden Organic Collection systems and Waste to Energy will further support the Shire's ambitions of reducing waste to landfill and may reduce the need to clear additional landfill cells.</p> <p>All required clearing will be undertaken progressively across the proposed Phase 1 and Phase 2 development stages.</p> <p>A revised clearing area for Phase 1 is now reduced to a minimum that will still allow for the construction of Phase 1 infrastructure and provide the operational flexibility for the Site. This includes the area for the construction of all infrastructure, necessary bushfire buffers, a stockpile area for surplus excavated soil material from Phase 1 development. The surplus excavated material is required to be stored on-site until it is required for: the capping of Buckley's Road Waste Management Landfill Facility, construction of Phase 2 Development and capping of the future landfill.</p> <p>The stockpile area was determined based on the volume of excavated material surplus of approximately 145,000m³, which would be require a stockpile area of 200m by 200m, slopes of 1:2.5 and an assumed maximum stockpile height of 4m for safe storage.</p> <p>Further details are provided under Item 4. The revised clearing area for consideration by the DWER is illustrated in Drawing C-005 provided in APPENDIX A.</p>
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		<p><u>Mitigation Measures</u></p> <p><i>Management of Potential Degradation of Vegetation</i></p> <p>Further information to address this item is provided in DWER Information Requirement 3 table.</p> <p><i>Consideration of the Greater Bilby</i></p> <p>To support the Site Selection process and the Clearing Permit Application for the preliminary site investigations, Talis, on behalf of the Shire, engaged Spectrum to undertake a Reconnaissance Flora and Level 1 Fauna Assessment (Spectrum Report) at the RRRP site.</p> <p>During the field surveys, the presence of the Greater Bilby was not confirmed; however, approximately 160 previous records have also been recorded from within 40km of the Study Areas, and several recent surveys on the Dampier Peninsula have identified signs of Greater Bilby presence. The apparent lack of any burrows or significant foraging activity can only indicate that Greater Bilby were not present at the time of the field survey; however, individuals could utilise habitats in either of the Study Areas in the future as home ranges are usually temporary and may suddenly shift when food availability changes (Burbidge and Johnson, 2008).</p> <p>The executive summary of the Spectrum report noted the following:</p> <ul style="list-style-type: none"> • <i>“the Greater Bilby (Macrotis lagotis) is considered to have a high likelihood of occurrence within the study areas”; and</i> • <i>“Clearing of either study area is not expected to significantly impact on any terrestrial vertebrate fauna species identified during this study. Preclearing searches for evidence of active Greater Bilby burrows should be completed immediately prior to any clearing activities. With the exception of the Northern Brushtail Possum, any individuals present within the clearance area are expected to flee the area immediately prior to clearing due to the high noise and vibrations associated with clearing activities. Clearing activity conducted in either study area is not expected to have a significant impact on any Short Range Endemic invertebrate taxa due to the widely distribute habitats present within the study area.”</i> <p>The Shire will adopt recommendations provided in the Spectrum Report as well as adopting operational and environmental management measures to mitigate any direct and indirect impacts to the surrounding flora and fauna, including implementation of the following:</p>
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		<ul style="list-style-type: none"> • Immediately prior to clearing, a suitably qualified person will walk along the clearing path to ensure no new active Greater Bilby burrows have been constructed post fauna survey; • Implementation of the completed Weed Management Plan; • Implementation of the completed Feral Animal and Vermin Management Plan; • Implementation of operational and environmental controls to mitigate impacts of odour, dust and noise generation; and • Progressive clearing. <p><u>Rehabilitation</u></p> <p>There are several areas across the Site where clearing is unavoidable but can be rehabilitated following conclusion of operations (e.g., landfill). The rehabilitation works will be carried out progressively when possible and the landfill rehabilitation works will be undertaken as per the RRRP's Landfill Closure Plan, which will be drafted and submitted to the DWER six months prior to the closure of the first landfill cell as typically required by the DWER.</p> <p>There are several types of rehabilitation that are available to the Shire, including but limited to the following:</p> <ul style="list-style-type: none"> • A hydromulch dressing applied on top of the landfill restoration soils in order to stabilise the soil surface, retain soil / prevent dust, suppress weed growth, accelerate the establishment of vegetation and protect vegetation from surface water run-off; • A seed mix will be based on species native to the Broome region; and • Supplementary tube stock species could be planted if needed. <p>The Shire is continuing to investigate the most appropriate rehabilitation strategy for the RRRP.</p> <p><u>Conclusion</u></p> <p>The siting and design of waste management facilities, particularly landfills, can be a complex process and there are limited locations where these facilities can be established. The Shire has undertaken extensive site investigations to determine the most viable location for its new RRRP facility for over a decade which includes detailed investigations:</p> <ul style="list-style-type: none"> • Geotechnical Investigation;
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	<ul style="list-style-type: none">• Hydrology Assessment;• Hydrogeological Modelling;• Flora, Fauna and vegetation Assessments; and• Heritage Investigations. <p>This culminated in the selection of the D2 Site as the preferred location for this essential community infrastructure project. In the placement of various proposed waste infrastructure elements, the Shire has followed the mitigation hierarchy. The development footprint seeks to first eliminate impacts to flora and fauna, where possible. The development footprint was optimised from the initial Master Plan, through Concept Design and into Detailed Design to eliminate unnecessary clearing, such as the relocation of the northern levee (see Figure 2).</p> <p>Where impacts are unavoidable, the Shire adopts mitigation measures and strategies to reduce impacts as outlined in the series of management plans that have been developed to date (See APPENDIX C).</p> <p>Finally, the Site will be progressively rehabilitated with native vegetation as those areas of the Site have completed their uses.</p>
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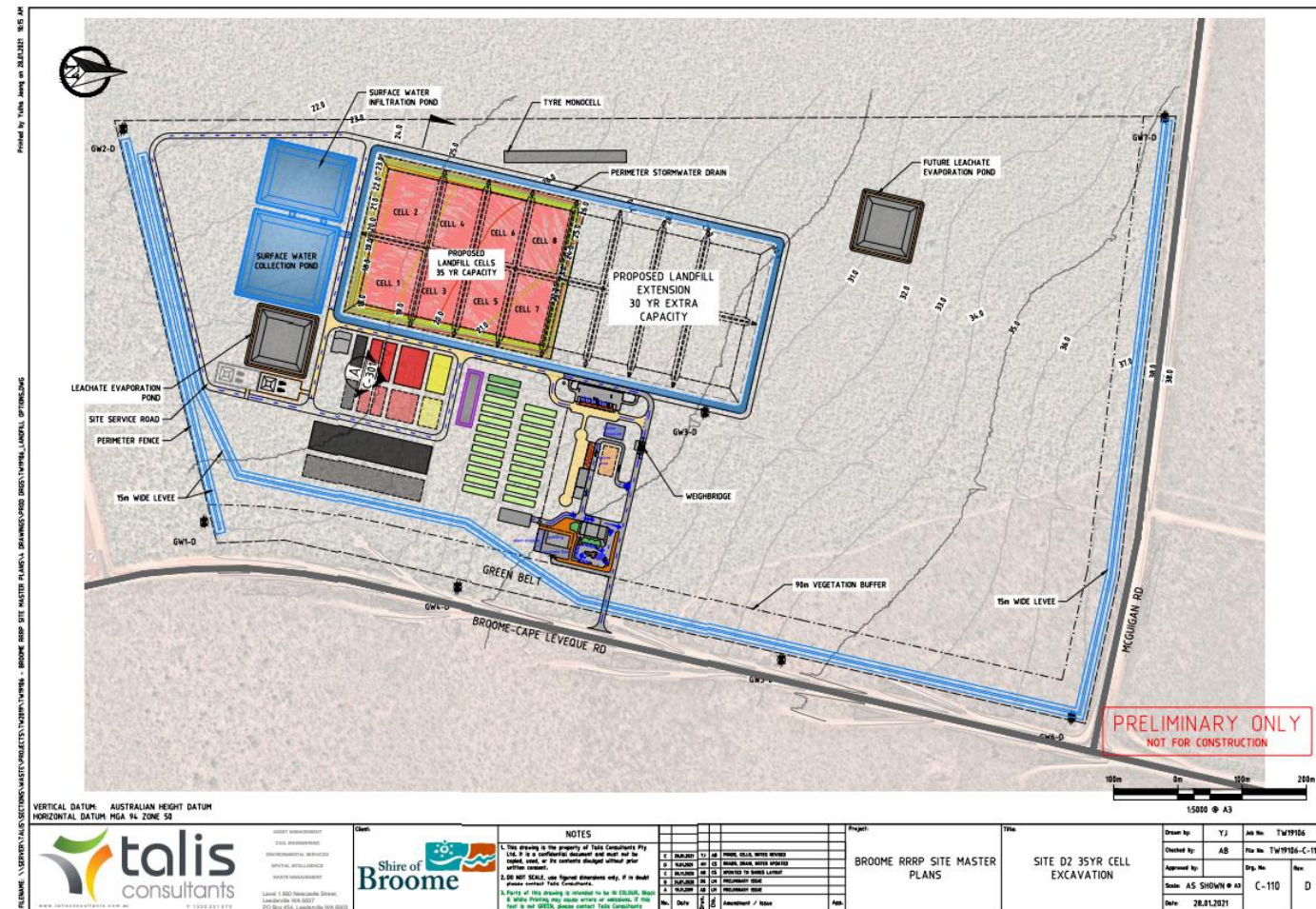


Figure 2: Initial Master Plan

Through discussions with the Shire, consideration of stakeholder feedback and information delivered through the Site detailed investigations, Talis amended the Master Plan (Figure 3). The revised Master Plan relocated the northern levee

southwards and aimed to reduce vegetation clearing and impacts on the PEC buffer zone where possible, while also providing operational flexibility and considering all of the waste management activities that the Shire wants to make available to its community (now and into the future).

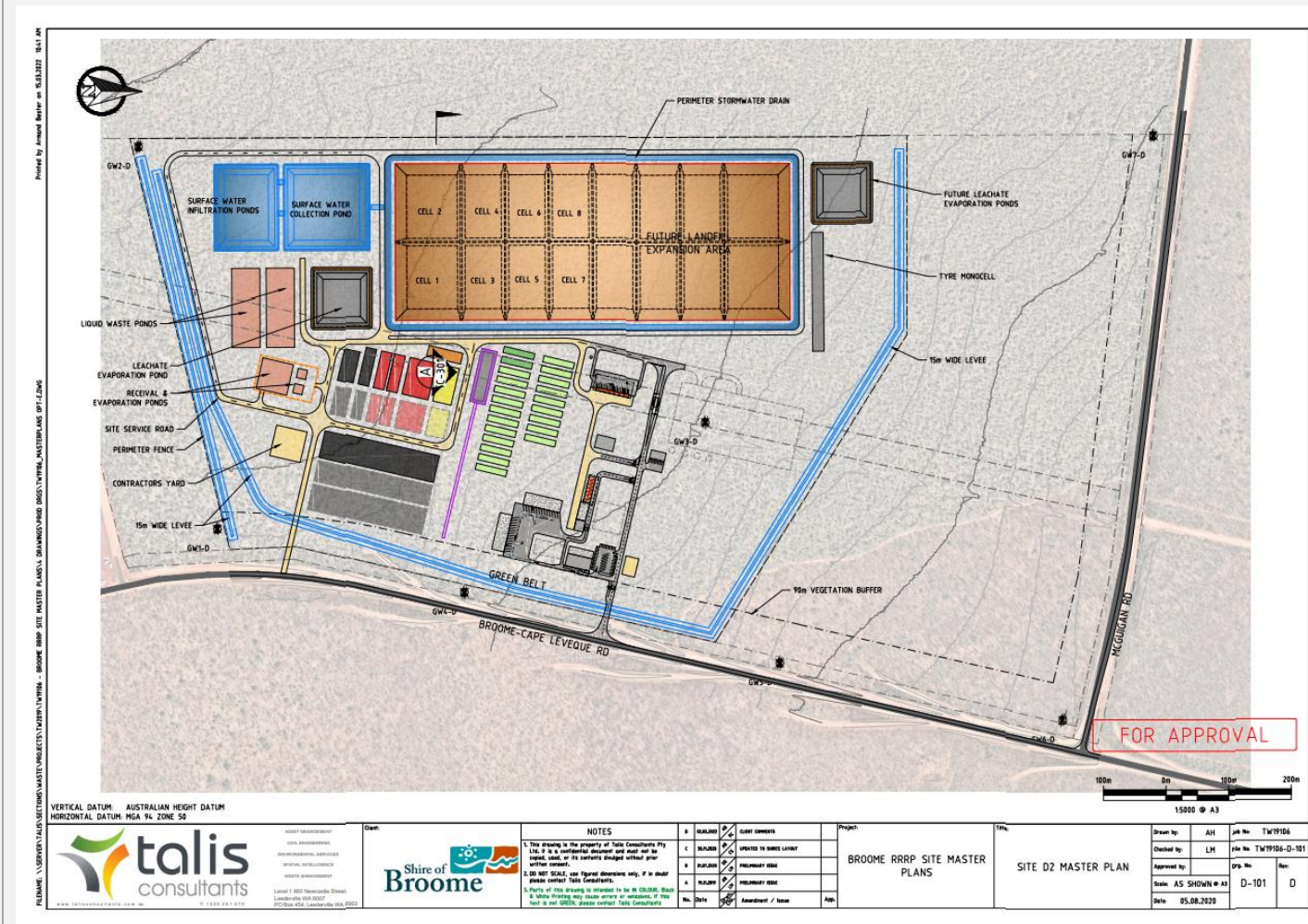


Figure 3: Approved Master Plan.

DWER Information Requirement 2 – Response to Priority Ecological Community Assessment for *Corymbia paractia* dominated community on dunes PEC

Item No.	DWER Information Required	Shire's Response
2	<p>A priority ecological community assessment is required for the area proposed to be cleared, to confirm the presence/absence of the <i>Corymbia paractia</i> dominated community on dunes Priority Ecological Community (PEC).</p> <p>Please note that should a PEC be identified, additional surveys of surrounding areas will also be required to determine the PEC's size and distribution. A protective buffer would also need to be created around the PEC's boundaries, which may impact on the application area.</p> <p>Rationale</p> <p>The flora and vegetation survey provided with the application indicates that the species listed as occurring within the application area/parts of the application area are indicative of the <i>Corymbia paractia</i> dominated community on dunes PEC. However, the extent of this PEC within the application area has not been provided. This information is required so that the impact of the proposed clearing on the occurrence of this PEC, can be determined.</p> <p>If the PEC is present, a map must be provided delineating the patch of the PEC identified on site. Information on its extent (in hectares) and condition is also required.</p>	<p>Talis has received guidance from Ecological consultants, Spectrum on this item. As a result, Spectrum has prepared a Memorandum and updated the Detailed Flora & Vegetation (See APPENDIX B).</p>

DWER Information Requirement 3 – Mitigation impacts to environmental values of the Yawuru Conservation Park

Item No.	DWER Information Required	Shire's Response
3	<p>Mitigation of impacts to the environmental values of the adjacent Yawuru Birragun Conservation Park resulting from the proposed clearing.</p> <p>Rational</p> <p>The preliminary assessment and expert advice received from the DBCA identified significant direct and indirect impacts to environmental values of the adjacent Yawuru Birragun Conservation Park (the Conservation Park).</p> <p>Direct impacts for site specific environmental values include introduction of weeds, risk of surface water run-off, and other edge</p>	<p>The Shire notes that cumulative impacts of dust, weeds, litter, altered surface water run-off, edge effects and fire could potentially result in degradation of vegetation to the adjacent Conservation Park.</p> <p>The Shire is committed to ensuring that operational and environmental management at the RRRP is conducted effectively and to best practice standards. The Shire has included additional information through the development of additional management plans on these mitigation measures. These management plans aim to mitigate potential impacts and provide guidance on proposed control methods to ensure cumulative impacts are appropriately managed or reduced.</p> <p>Surface Water Management</p> <p>The Shire engaged Talis to prepare a Surface Water Management Plan (SWMP). The draft SWMP is provided in APPENDIX C and will be updated following the completion of the detailed design of the Site landfill. The finalised SWMP will be submitted to the DWER as part of the Landfill Works Approval Application. The SWMP outlines the operational surface water management strategy for the Site that achieves two key objectives: minimising leachate generation and proactively managing surface water that ensures discharge offsite in a controlled manner from only designated points.</p> <p>To ensure that surface water is appropriately managed to both avoid surface water flow into the Site and minimise impacts from rainwater within the Site, the following measures will be adopted at a minimum and further details are provided in the SWMP:</p> <ul style="list-style-type: none"> • Levee bund system with the following specifications (subject to final detailed design): <ul style="list-style-type: none"> ○ 1.3m height; ○ 15m base width; ○ 2m top width; ○ 2,242m long for the primary levee bund and 650, long for the secondary levee bund; ○ Associated 20m drain between the primary and secondary levee bunds along the Site's southern boundary; and

<p>effects such as dust and rubbish spread.</p> <p>Further information is required as to how the above land degradation risks resulting from the proposed clearing are proposed to be minimised or managed.</p> <p>It is recommended that a 30 metre buffer is provided, along with the development of a weed management plan to reduce the risk of the spread of weeds.</p>	<ul style="list-style-type: none"> ○ Ensures discharge of offsite floodwaters directly south of the Site boundary to mitigate direct discharge into the Conservation Park. • A permanent canopy will prevent rainfall entering hook lift bins and mixing with waste in the light vehicles drop off, on-ground recyclables and reuse drive through areas; • Hazardous Household Waste will be stored in a fully enclosed building thereby avoiding interaction with stormwater; • Uncontaminated stormwater will be diverted away from the waste storage areas and released in a controlled manner through a separate drainage system to ensure that it does not come into contact with the leachate collection systems; • All stormwater engineering features will be inspected regularly and maintenance works scheduled appropriately; • The road surfaces of the CRC will be delineated with kerbs and will utilise suitable slope gradients to guide the flow of surface water to the CRC retention pond; • The hardstand services of the Greenwaste Stockpile Area and CRC Service Area will utilise suitable slope gradients to guide the flow of surface water to the greenwaste retention pond; • A surface water pond system which will be constructed as per the concept design discussed in Section 6.3 of the EAMP that has the capacity to manage a 1-in-20 year, 24 hour duration storm event across the whole Site in line with best practice standards, in particular for sedimentation control purposes; • A surface water pond system that ensures that any discharge offsite will be in a controlled manner directly south of the Site boundary to mitigate direct discharge into the Conservation Park; • A surface water management system that ensures a clear separation between clean surface water, potentially contaminated surface water, leachate and liquid waste; • Any offsite surface water discharge point will 'daylight' to the existing topography levels at the Site boundary to mitigate erosion issues; • All ponds proposed for the LWF will be raised above existing ground levels with a small perimeter bund to prevent stormwater ingress; • A Surface Water Management Plan will be prepared at the Licence Application stage to manage the risks associated with surface water; and • Weather will be monitored on a daily basis.
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	<p>It is anticipated that the implementation of the management measures listed above will be sufficient to manage onsite and offsite surface water impacts at the Site, in particular mitigate most surface water impacts to the Conservation Park where possible.</p> <p>Litter Management</p> <p>To ensure that the generation of litter that could potentially impact the adjacent Conservation Park is minimised and appropriately managed at the CRC, the following management measures will be implemented:</p> <ul style="list-style-type: none"> • Unloaded waste and recyclable materials will be confined to the designated drop-off areas; • Source separated commodities will be stored in a designated area; • Temporary bin covers will be applied to waste containers during periods of inclement weather; • Waste loads entering and leaving the Site will be covered to prevent uncontrolled release of litter; • A perimeter fence will be installed to minimise any litter escaping; • The perimeter fence will be inspected regularly and any maintenance works scheduled accordingly; • Any litter generated around and immediately outside the Site will be collected on a regular basis; • Installation of signage; • The capping and revegetation of the completed landfill cells; • Restrict Site access around the Site via restricting access to tracks; and • Installation of CCTV for security and site monitoring purposes. <p>The Shire believes these management measures will mitigate incidences of accidental littering, illegal dumping, and subsequent impacts to the Conservation Park. In addition, the Shire's Rangers can impose fines for illegal dumping of rubbish, which includes rubbish being blown off the back of uncovered loads.</p> <p>Dust Management</p> <p>The CRC, LWF, Tyre Monocell and Surface Water Management System has the potential to generate dust during construction. Although these are anticipated to be significantly less than for construction, there is also potential for dust generation during operational activities of the CRC and Tyre Monocell, including:</p> <ul style="list-style-type: none"> • Temporary impacts of dust associated with construction and development of the Site;
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		<ul style="list-style-type: none"> • Material handling (loading and unloading, etc.) across various recycling and waste streams; and • The periodical processing of greenwaste (approximately every 6 months) and Construction & Demolition (C&D) waste. The C&D waste processing is anticipated to occur on an ad-hoc basis when sufficient volumes make this viable, i.e. approximately every 2-3 years). <p>To manage the generation of dust onsite, the Shire will implement the following management measures:</p> <ul style="list-style-type: none"> • Appropriate dust management measures will be implemented during the construction works and as necessary during operation (i.e. use of water cart); • Vehicles will be restricted to a maximum speed of 10km/hour, which will be signposted at appropriate locations including the entrance; • All waste loads are to be covered during transport to and from the Site; • Roads are to be sealed where viable and maintained; • Waste stockpiles/loads may be wet down prior to handling and/or avoided in windy conditions; and • An Asbestos Management Plan and C&D Sampling Plan will be prepared at the Licence Application stage to manage the risks associated with dust generated from the processing of C&D waste. <p>It is anticipated that the implementation of the management measures listed above will be sufficient to limit dust at the Site and reduce any impacts on the neighbouring Conservation Park.</p> <p>Weed Management</p> <p><u>Shire Wide Weed Management Strategy</u></p> <p>The designation of weeds in the Broome Shire locality is provided by Appendix 2 of the Weed Management Strategy, available from the Shire's website (https://www.broome.wa.gov.au/files/sharedassets/public/weed-strategy-final.pdf) which also includes management methods. Weed identification and designation is also informed by:</p> <ul style="list-style-type: none"> • "Kimberley Weeds" index cards; • Roebuck Bay Working Group's "Coastal Gardens: A planting guide for Broome on the Dampier Peninsula" booklet; • Department of Primary Industry and Regional Development website and "Weeds to Watch" poster; • Department of Biodiversity, Conservation and Attractions "Weed" page.
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	<p>Ongoing training is essential for the continued development of staff knowledge and expertise. The Shire supports further learning through the Shire’s induction process. Training in weed identification from germination to seeding, understanding of weed lifecycles and appropriate control methods for target species and hygiene protocols for use of machinery and equipment is considered vital for all staff working in the Broome habitat.</p> <p>On the 31 March 2022, the Shire adopted the Broome Weed Management Strategy, which provides a framework for best practice weed management within the Shire. The Weed Management Strategy aims to protect the environment, economy, community, and industry from adverse impacts of weeds. The Shire prepared the Weed Management Strategy with consideration from the Shire’s State of the Environment Report (2015) and in consultation with numerous stakeholders. The Weed Management Strategy identifies weed priorities and sets out an integrated Weed Management Approach.</p> <p><u>RRRP Design Considerations</u></p> <p>As a best practice site and noting the sensitive nature of surrounding lands, in particular the Yawuru Birragun Conservation Park, the placement of key infrastructure elements was carefully considered during the initial stages of the RRRP Project. The Site is designed so as to passively mitigate impact as much as possible, before relying on active management methods. In particular, the placement of the greenwaste drop-off and processing areas was carefully considered.</p> <p>Green waste operational activities have the highest potential to spread weeds due to its inherent nature. These activities include receipt, storage, mulching, and distribution of plant material that often includes weeds. For this reason, it was considered essential for the greenwaste disposal, storage and processing operations to be centrally located within the Site. The central location ensures that no matter which way the wind is blowing any weed material must travel the maximum distance obtainable to the Site boundary. As a heavily controlled and monitored site any weeds attempting to spread from the greenwaste area will be monitored and effectively controlled.</p> <p>Weed Management Plan</p> <p>Passive design solutions are not able to prevent all spread of weeds, so the Shire engaged Talis to prepare a Weed Management Plan. This was prepared with reference to the Shire’s Weed Management Strategy and in consultation with the DBCA, the Conservation Park land managers. The draft Weed Management Plan was provided to the DBCA on 28 July 2022 and incorporated the majority of their feedback. Notably this will be a living document and commits to annual reviews so that it can be updated to deal with evolving weed management issues. Some of the initial management measures proposed include:</p>
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		<ul style="list-style-type: none"> • Staff training and awareness; • Equipment inspection and washdown of weed-bearing material; • Weed mapping (Requested by DBCA); and • Weed control regimes. <p>It is anticipated that the implementation of the passive design measures and the Weed Management Plan, which includes the management measures listed above amongst others, will be sufficient to manage weeds on Site and restrict the spread of weeds to neighbouring properties. Additionally, as the facility progresses into operation, the Shire is committed to continuing to work with neighbouring landowners to assess the level of impact and adjust management measures as required.</p> <p>Feral Animal and Vermin Management Plan</p> <p>Specialist consultants, Terrestrial Ecosystems, were engaged to prepare a draft Feral Animal and Vermin Management Plan. This was provided to the DBCA for their input on 23 June 2022. Their comments and suggestions were carefully reviewed with the majority incorporated into the finalised plan.</p> <p>The Feral Animal and Vermin Management Plan identifies how the Shire will mitigate, minimise, and control the attraction of vermin and feral animals at the Site. Some of the key management measures involve:</p> <ul style="list-style-type: none"> • Installation of a 1.8m high perimeter fence that will be monitored and maintained on a regular basis; • All waste loads are to be covered during transport; • Ensuring that wildlife and feral or vermin species have limited opportunities to access food and water at the RRRP; • Daily operations will include monitoring for feral cats, foxes and wild dogs; • Any suspected and/or known shelters or breeding grounds for vermin on the Site will be eliminated; • Should any feral animal or vermin issues be experienced, professional services will be utilised to implement appropriate control/eradication methods; • General refuse waste from the Mixed Waste Drop Off Facility will be regularly disposed to landfill and compacted and covered to best practice standards at the end of each day; and • Regular litter collections onsite and immediate surrounds as required.
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	<p>Through implementing these management plans and control measures, the Shire will ensure the operation of the Site will have minimal to negligible effects on neighbouring properties. These measures are to go above and beyond its operation in accordance with relevant approvals and / or licence conditions.</p> <p>There are also incidents that may be outside the Shire's control, i.e., bushfire events. However, the Shire's subconsultants have prepared a Bushfire Management Plan and Bushfire Risk – Assessment and Management Report, which provides guidance on bushfire management measures, including asset protection zones, identification of high-risk hazards and separation distance to be adopted by the Shire to implement and maintain during the operation of the RRRP.</p> <p>Buffer Zone</p> <p>Talis note that the DWER have recommended that a 30m buffer zone be provided to mitigate any potential direct and indirect impacts to neighbouring land. Talis can confirm that the 30m buffer zone from the Site boundary is achieved.</p> <p>Talis and the Shire have considered all necessary buffer zones as outlined in the relevant guidance documentation listed in Table 1 of this letter. For example, the design of the RRRP's landfill will align with the DWER's Draft Guidance Statement, and no waste deposition will take place within 35m of the Site boundary.</p> <p>As shown in Drawing C-003 provided in APPENDIX A, there is no proposed waste infrastructure within 30m of the Site boundary, only low-risk associated infrastructure, i.e. security fencing, bushfire breaks, internal access tracks, and surface water management levee system and swales.</p>
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DWER Information Requirement 4 – Works Approval

Item No.	DWER Information Required	Shire's Response																				
4	<p>Works Approval</p> <p>Rational</p> <p>At present the works approval for the project has been withdrawn and requires resubmission. If the works approval for the identified purpose is not granted, it would be unnecessarily harmful to the environment for DWER to authorise native vegetation clearing when such clearing may not be required.</p> <p>It is noted that you wish to clear the entire development footprint, including the areas proposed for stage 1 and stage 2 of the project. However only a works</p>	<p>CRC Works Approval Application</p> <p>The proposed timelines for the completion of the CRC Works Approval Application were nominated in Section 6.1.10 of the EAMP and are as follows:</p> <table><tr><th>Task</th><th>Duration</th><th>Start</th><th>End</th></tr><tr><td>Works Approval Assessment</td><td>3 months</td><td>September 2022</td><td>November 2022</td></tr><tr><td>Detailed Design</td><td>3 months</td><td>August 2022</td><td>October 2022</td></tr><tr><td>Shire Procurement (Advertisement, Evaluation, Award and Contractor Mobilisation)</td><td>5 months</td><td>October 2022</td><td>March 2023</td></tr><tr><td>CRC Construction</td><td>8 months</td><td>March 2023</td><td>November 2023</td></tr></table> <p>As noted in Section 3, the CRC Works Approval Application was resubmitted to the DWER on the 13 September 2022. Conversations held between Talis's Project Manager, Megan Mather, and the DWER's Assessment Officer (Tanya Johnson) on 6 October 2022, noted that the DWER would endeavour to undertake their assessment within the 60 day assessment period, which would be around end of November 2022. However, they could not guarantee that a determination could be made before the end of November 2022, as there were still some outstanding actions required to be undertaken, including the DWER issuing the Invoice for the Works Approval Application and consultation with key stakeholders for seeking comment and feedback.</p> <p>On 13 October 2022, the DWER issued the Application Invoice for payment (Invoice Number W-W6738/2022/1) to the Shire and confirmed that the Validation for the Application step had been completed. The Shire issued a purchase Order to DWER's Accounts Receivable Division for this invoice on the 18 October 2022. DWER's correspondence also noted that there were some outstanding matters within the Application and further information on these items is</p>	Task	Duration	Start	End	Works Approval Assessment	3 months	September 2022	November 2022	Detailed Design	3 months	August 2022	October 2022	Shire Procurement (Advertisement, Evaluation, Award and Contractor Mobilisation)	5 months	October 2022	March 2023	CRC Construction	8 months	March 2023	November 2023
Task	Duration	Start	End																			
Works Approval Assessment	3 months	September 2022	November 2022																			
Detailed Design	3 months	August 2022	October 2022																			
Shire Procurement (Advertisement, Evaluation, Award and Contractor Mobilisation)	5 months	October 2022	March 2023																			
CRC Construction	8 months	March 2023	November 2023																			

	<p>approval for stage 1 was applied for.</p> <p>Given that the stage 2 of the project is not planned to be initiated for many years and that works approval for stage 1 (11.67 hectares of proposed clearing) is only being considered by the department at this stage, it is recommend that the application area is amended to only reflect the clearing necessary for the works approval being applied for and not future stages that would require additional approvals.</p>	<p>required to ensure that DWER can complete their assessment. Talis on behalf of the Shire are currently preparing a response to this information and it will be submitted in November 2022.</p> <p>Clearing Permit Area</p> <p>The clearing permit was submitted to clear the entire development footprint, including the areas proposed for Stage 1 and Stage 2 developments of the Project. The Clearing Permit submission noted that clearing within the future expansion areas would only be undertaken once the other relevant approvals had been granted (i.e. Works Approval to construct the CRC (and supporting infrastructure) and / or Landfill Works Approval) and / or where required to support operational activities and compliance with prepared management plans (i.e. the Bushfire Management Plan).</p> <p>The CRC Works Approval Application was submitted for Stage 1 development only and Talis is preparing a separate Landfill Works Approval Application for the Stage 2 development (i.e., Cells 1 & 2 of the Class III landfill), which is anticipated to be submitted in early 2023. As part of the Landfill Works Approval Application process, the Application will include descriptions of the clearing requirements for the future expansion areas across the remainder of the Site. And depending on the outcome of that assessment process, will depend on approval requirements for future clearing works for expansion areas.</p> <p>Talis recognises that the DWER does not want to grant clearing permission for both Stage 1 and Stage 2 developments concurrently. However, clearing approval for just Stage 1 development footprint does not provide the operational flexibility and certainty that the Shire requires, including their ability to clear for the purposes of providing essential community infrastructure (i.e. Stage 2, development of the Class III Landfill). In addition, significant earthworks will be undertaken during the construction of the Stage 1 development. The stockpiling of excavated materials for future use outside of the Stage 1 operational area (i.e. within Stage 2 Landfill Footprint) is required to ensure that all planned activities within this area can still be undertaken. The Shire intends to use the stockpiled material for future waste management activities, including but not limited to the permanent capping of the landfill at Buckleys Road.</p> <p>The purpose of the RRRP is to maximise diversion of recyclable and resource recovery materials to reduce volumes of waste disposed to Landfill through the construction of the CRC, including supporting infrastructure like the Reuse Shop / Education Centre and implementation of waste education campaigns by the Shire. In addition, implementation of future waste management reduction activities like Food Organic and Garden Organic Collection systems and Waste to Energy will further support the Shire's ambitions of reducing waste to landfill and may reduce the need to clear additional landfill cells.</p> <p>Therefore, Talis has proposed a revised clearing area for consideration by the DWER, illustrated in Drawing C-005 provided in APPENDIX A.</p>
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APPENDIX A

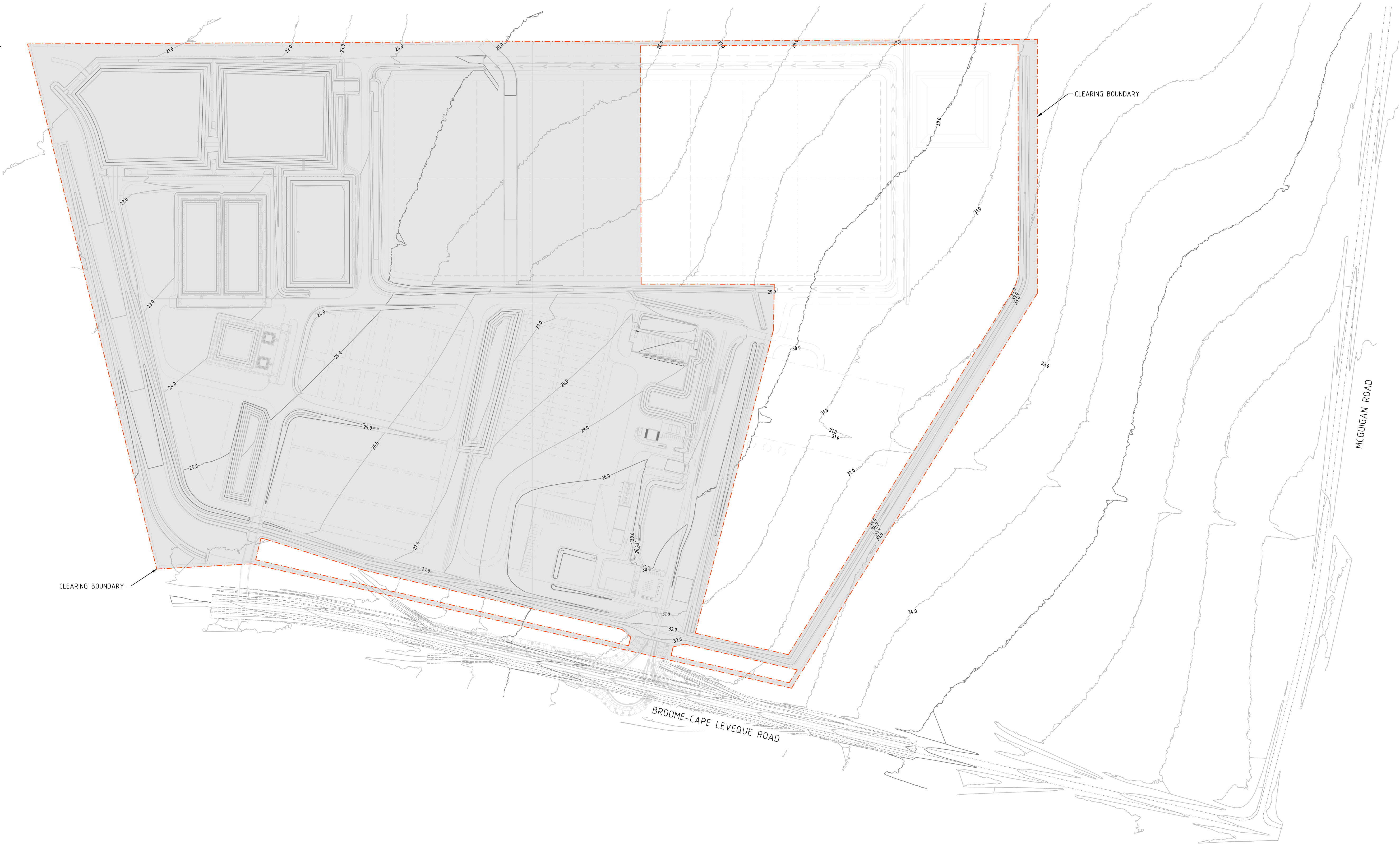
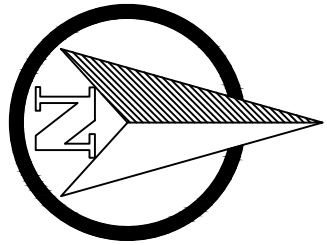
Drawings

TC21049 – SET-C-005_RevC – Clearing Boundary Layout

TW19113_02_Site_Development_and_Significant_Flora_RevD

TC21049 – SET-C-003_RevD_Buffer – General Arrangement

FILENAME: \\SERVER\TALIS\SECTIONS\CIVIL\PROJECTS\TC2021\TC1049 - BROOME RRRP DETAILED DESIGN\DRAWINGS\1. DRAWINGS\TC1049 - SET.DWG
Printed by Amanda Beebe on 25.10.2022 09:23 PM



LEGEND:
--- CLEARING FOOTPRINT

PRELIMINARY ONLY
NOT FOR CONSTRUCTION



VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 94 ZONE 51



ASSET
ENGINEERING
ENVIRONMENT
NOISE
SPATIAL
WASTE

PERTH
604 Newcastle Street Leederville WA6007
PO Box 454 Leederville WA 6903



Client:

NOTES

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C	26.10.2022	AB	SH	CLEARING BOUNDARY REVISED	SH
B	25.10.2022	YJ	AB	SOUTHERN LEVEE UPDATED	SH
A	30.09.2022	YJ	AB	DETAILED DESIGN ISSUE	SH
No.	Date	By	Check	Amendment / Issue	App.

Project:

**BROOME RRRP SITE
CONSTRUCTION**

Title:

**CLEARING BOUNDARY
LAYOUT**

Scale: 1:2500 @ A1 Date: 30.09.2022

Drawn: YJ Checked: AB Approved: SH

Job No: TC21049 Drg. No: C-005 Rev: C

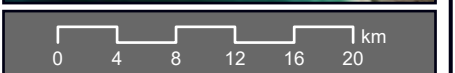
Filename: TC21049 - SET.DWG

- - - - Security Fence
 - - - - 90m Vegetation Buffer
 [Red Box] Site Boundary
 [Purple Hatched Box] Priority Ecological Communities (PEC)
 [Blue Box] Levee
 [Light Green Box] CRC Development
 [Orange Box] Future Development
 [Light Orange Box] Development Footprint

Significant Flora

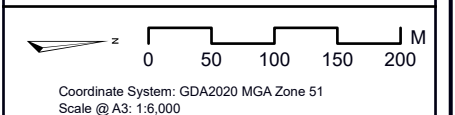
- Sersalisia sericea (PEC Indicator Species)
- Corymbia paractia (P1)
- Jacquemontia sp. Broome (A.A. Mitchell 3028) (P1)
- Terminalia kumpaja (P3)

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LOT No.550
Cape Leveque Road

Clearing Permit Application Shire of Broome

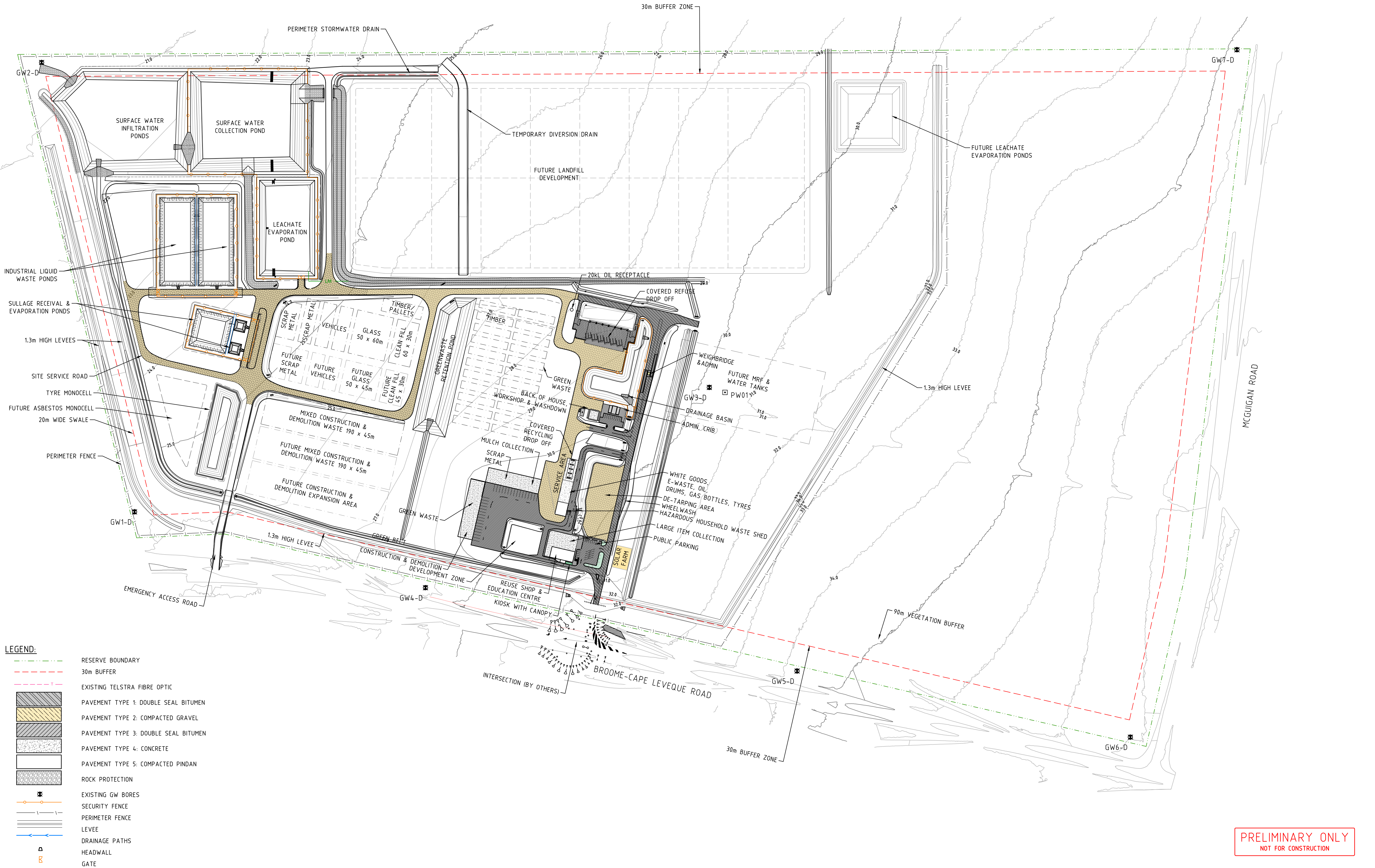
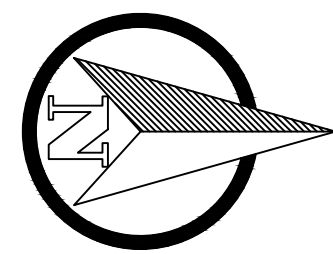


Prepared: T Baskerville	Date: 28/10/2022
Reviewed: M Mather	Revision: D
Project: TW19113	



Figure 02

Data source: Roads - Landgate, 2022. Flora - Spectrum Ecology, 2020. Imagery: Nearmap, 2022.



VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 94 ZONE 51



ASSET
ENGINEERING
ENVIRONMENT
NOISE
SPATIAL
WASTE

PERTH
604 Newcastle Street Leederville WA6007
PO Box 454 Leederville WA 6903

Client:



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No.	Date	By	App.	Amendment / Issue
D	25.10.2022	YJ	AB	SOUTHERN LEVEE UPDATED
C	30.09.2022	YJ	AB	DETAILED DESIGN ISSUE WITH CLIENT COMMENTS
B	02.09.2022	AB	SH	DETAILED DESIGN
A	25.05.2022	YJ	AB	CONCEPT DESIGN ISSUE

Project:

BROOME RRRP SITE
CONSTRUCTION

Title:

GENERAL ARRANGEMENT

Scale: As Shown @ A1 Date: 25.05.2022

Drawn: YJ Checked: AB Approved: SH

Job No: TC21049 Drg. No: C-003 Rev:

Filename: TC21049 - SET.DWG

APPENDIX B

Spectrum Memorandum and Updated Detailed Flora & Vegetation Report

MEMO LETTER

**BROOME REGIONAL RESOURCE
RECOVERY PARK**

**UPDATE TO THE DETAILED FLORA
& VEGETATION REPORT**

PREPARED FOR: TALIS CONSULTANTS | SHIRE OF BROOME





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Email: info@spectrumecology.com.au



Project ID: 2245		Broome Regional Resource Recovery Park Update to the Detailed Flora & Vegetation Report	
Prepared for:		Talis Consultants Shire of Broome	
Date of issue:		12 Oct 2022	
Prepared by:		Astrid Heidrich	
Spectrum Review:		Melissa Hay	

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1. PROJECT BACKGROUND

In 2020, Spectrum Ecology & Spatial (Spectrum) completed a detailed flora and vegetation assessment at the Regional Resource Recovery Park in Broome. During the assessment, one Priority Ecological Community (PEC) which is listed as Priority 1 was recorded during the desktop assessment: *Corymbia paractia* PEC. Based on the presence of scattered *Corymbia paractia* trees on site (13 specimens at 10 locations), the PEC was assessed as likely to occur at the D2 Study Area.

During the Clearing Permit application process, the Department of Water and Environmental Regulation (DWER) requested further information regarding the PEC. Item 2 of the request form states: "A priority ecological community assessment is required for the area proposed to be cleared, to confirm the presence/absence of the *Corymbia paractia* dominated community on dunes Priority Ecological Community (PEC). Please note that should a PEC be identified, additional surveys of surrounding areas will also be required to determine the PEC's size and distribution. A protective buffer would also need to be created around the PEC's boundaries, which may impact on the application area."

In response to this, Spectrum has reviewed the existing detailed flora and vegetation assessment report (Spectrum Ecology, 2020) to provide additional information on the likelihood of *Corymbia paractia* PEC to occur on site.

This memo letter outlines these changes made in the detailed flora and vegetation assessment report (Spectrum Ecology, 2020).

2. METHODS

The *Corymbia paractia* PEC is described as "*Corymbia paractia* dominated community on dunes" (DBCA 2020), and is restricted to a narrow coastal zone in the Broome area, where beach dunes transition into pindan soils (Kenneally et al., 1996). As such, Spectrum completed a desktop assessment based on the identification of the transition zone between Holocene coastal dunes (where the *C. paractia* PEC is typically found) and red pindan soils. The analysis was based on the use of current high resolution satellite imagery (WorldView imagery from 12 April 2021 with a 0.5 m resolution) and an overlay of polygons where *C. paractia* has been identified as the dominant species. Using these inputs, a transition zone line vector was generated through digitisation over the satellite imagery. A conservative approach was applied (with the transition zone line being digitised further inland) in case of doubt and/or of unclear visible boundaries (which were mostly clearly observed through a change in soil colour from white sands to red soil).

A Euclidean distance raster (with a 10 m resolution) was created from the digitised transition zone line, covering an area that included the currently known extent of *C. paractia* PEC as well as site D2. This dataset was used to extract the mean distance to the transition zone for all polygons identified as *C. paractia* PEC, as well as site D2.

3. RESULTS

The distribution of mean distances from *Corymbia paractia* PEC areas (provided by DBCA) to the transition zone line is presented in Figure 3.1. The mean, median, and maximum values of that distribution are 278 m, 225 m and 1,199 m, respectively. The mean distance from site D2 to the transition zone is 3,076 m, and the minimum distance from site D2 to the transition zone is 2,303 m, which is far greater than the maximum distance between known *C. paractia* PECs and the transition zone (1,199 m). The location of the *C. paractia* PEC areas and site D2 in relation to the transition zone line is displayed in Figure 3.2.

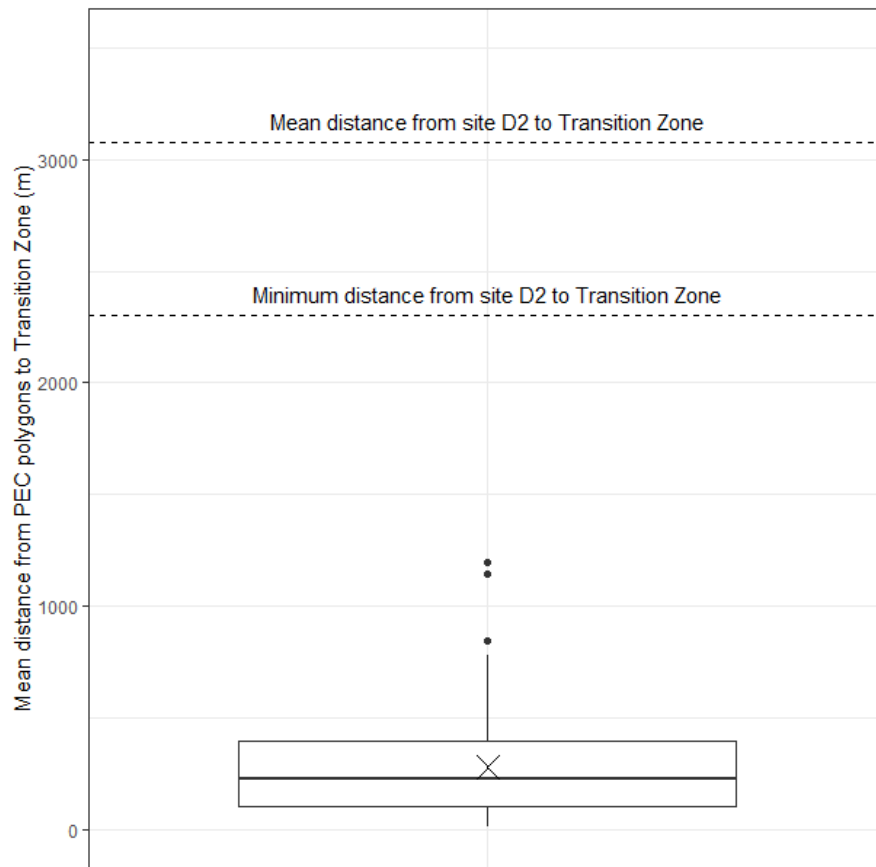


Figure 3.1: Mean Distance Distribution from Known *C. paractia* PECs to the Newly Defined Transition Zone

Note: The top limit of the box represents the 1st quartile, and the bottom limit represents the 3rd quartile. The width of the box represents the interquartile range (IQR). The line in the middle of the box represents the median (or 2nd quartile), and the "x" represents the mean value. The whisker lines show the location of the minimum and maximum values on each side of the box. Outlier points on top of boxplot show polygons with a mean distance to the transition zone beyond $1.5 \times \text{IQR}$ from the top end of the box.

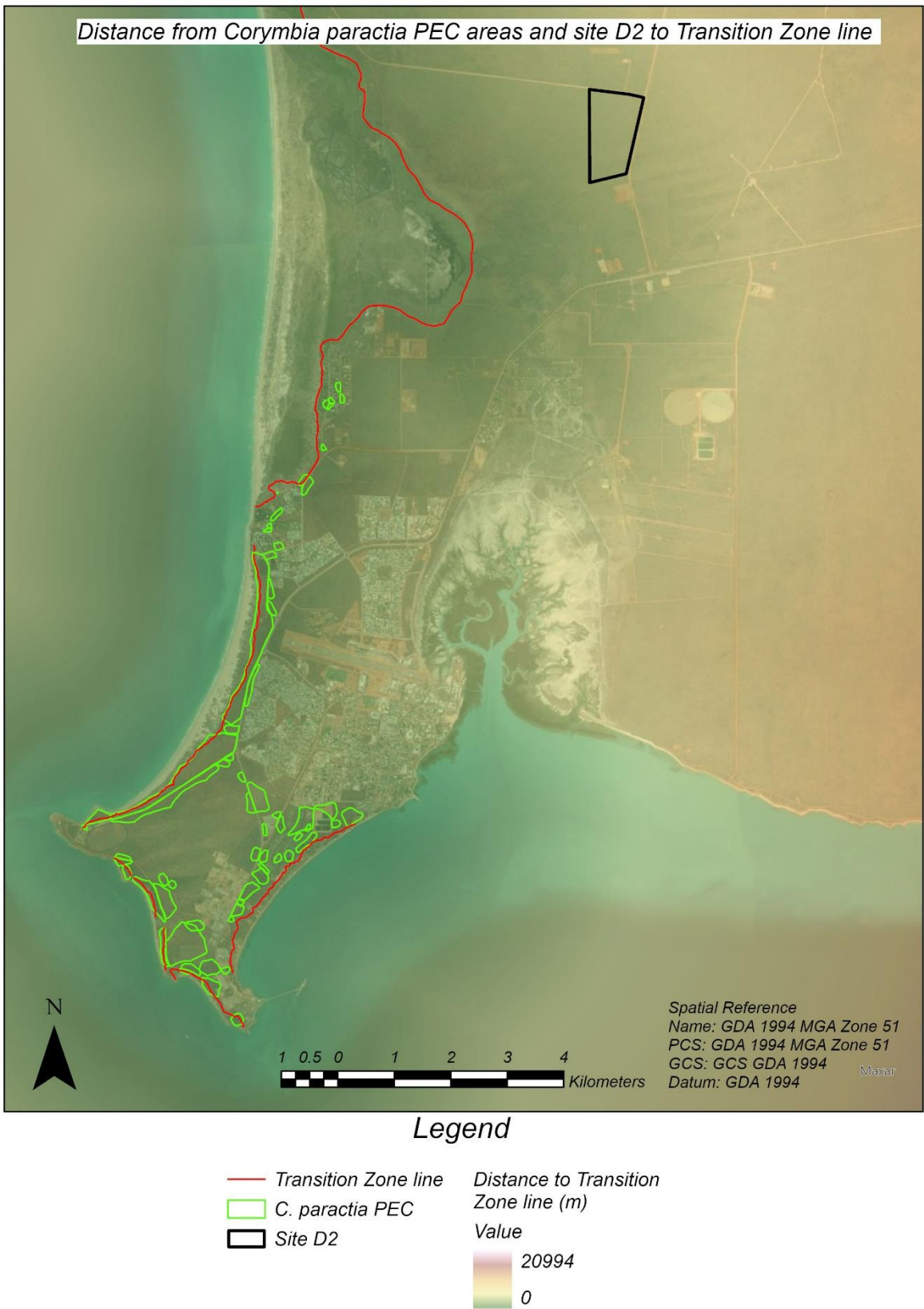


Figure 3.2: Distance from *C. paractia* PEC Areas and Site D2 to Transition Zone Line

4. CONCLUSION

In response to DWER's comment "A priority ecological community assessment is required for the area proposed to be cleared, to confirm the presence/absence of the *Corymbia paractia* dominated community on dunes Priority Ecological Community (PEC)", Spectrum completed the distance mapping and concluded that the *Corymbia paractia* PEC is unlikely to occur at the D2 Study Area.

Based on this, Spectrum believes that no additional surveys are required regarding the *Corymbia paractia* PEC on site.

BROOME REGIONAL RESOURCE RECOVERY PARK DETAILED FLORA & VEGETATION ASSESSMENT

PREPARED FOR: TALIS CONSULTANTS |
SHIRE OF BROOME



**Spectrum
ECOLOGY**



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EXECUTIVE SUMMARY

The Shire of Broome is investigating two sites ('D2' and 'G1' – the Study Areas) for the placement of a new community recycling centre and/or landfill. The D2 Study Area is 122 ha and located approximately 10 km north of Broome. The G1 Study Area is 98 ha and located approximately 33 km north-east of Broome. As part of the site investigations, a range of hydrogeological and geotechnical works are required which will involve the removal of native vegetation (approximately 2.5 ha for D2 and 3.0 ha for G1).

Talis Consultants, on behalf of the Broome Shire, commissioned Spectrum Ecology (Spectrum) to undertake a detailed flora and vegetation assessment for the Broome Regional Resource Recovery Park (RRRP) Project.

A total of 127 confirmed vascular plant taxa were recorded during the survey, of which four were introduced taxa. No Threatened Flora taxa were recorded in the survey. Three Priority Flora taxa have been recorded within D2 Study Area: *Corymbia paractia* (Priority 1), *Jacquemontia* sp. Broome (A.A. Mitchell 3028) (Priority 1), and *Terminalia kumpaja* (Priority 3). No Priority species were recorded from G1 Study Area. All Priority Flora taxa recorded in the Study Areas were assessed to have low local and regional significance. None of the introduced flora are listed as Declared Pests in Western Australia.

No floristic Threatened Ecological Communities were recorded within the Study Areas. The desktop assessment found the Mangarr (Minyjuru) (P1) Priority Ecological Community (PEC) was present in north-west corner of the D2 Study Area. Scattered *Sersalisia sericea* (Minyjuru) trees were recorded in the D2 Study Area outside the current PEC; however, it is unlikely that these individuals indicate the presence of the Mangarr PEC. The *Corymbia paractia* (P1) PEC has a low likelihood to be present at the D2 Study Area. *C. paractia* was recorded from 10 locations on site but the Study Area lies outside the maximum distance of known *C. paractia* PECs to the transition zone (2,303 m vs 1,199 m). TEC or PECs are not likely to occur within the G1 Study Area.

One vegetation type was recorded within the two Study Areas and is described as: *Corymbia greeniana* low open woodland with *Acacia eriopoda* and *Bauhinia cunninghamii* tall open shrubland, over *Triodia schinzii* and *Triodia caelestialis* low sparse hummock grassland and *Chrysopogon pallidus* and *Sorghum plumosum* low sparse tussock grassland. The vegetation unit (V001) was considered to have low regional and local significance as the distribution was not restricted within the bioregion and did not provide habitat for restricted significant flora.

1. INTRODUCTION

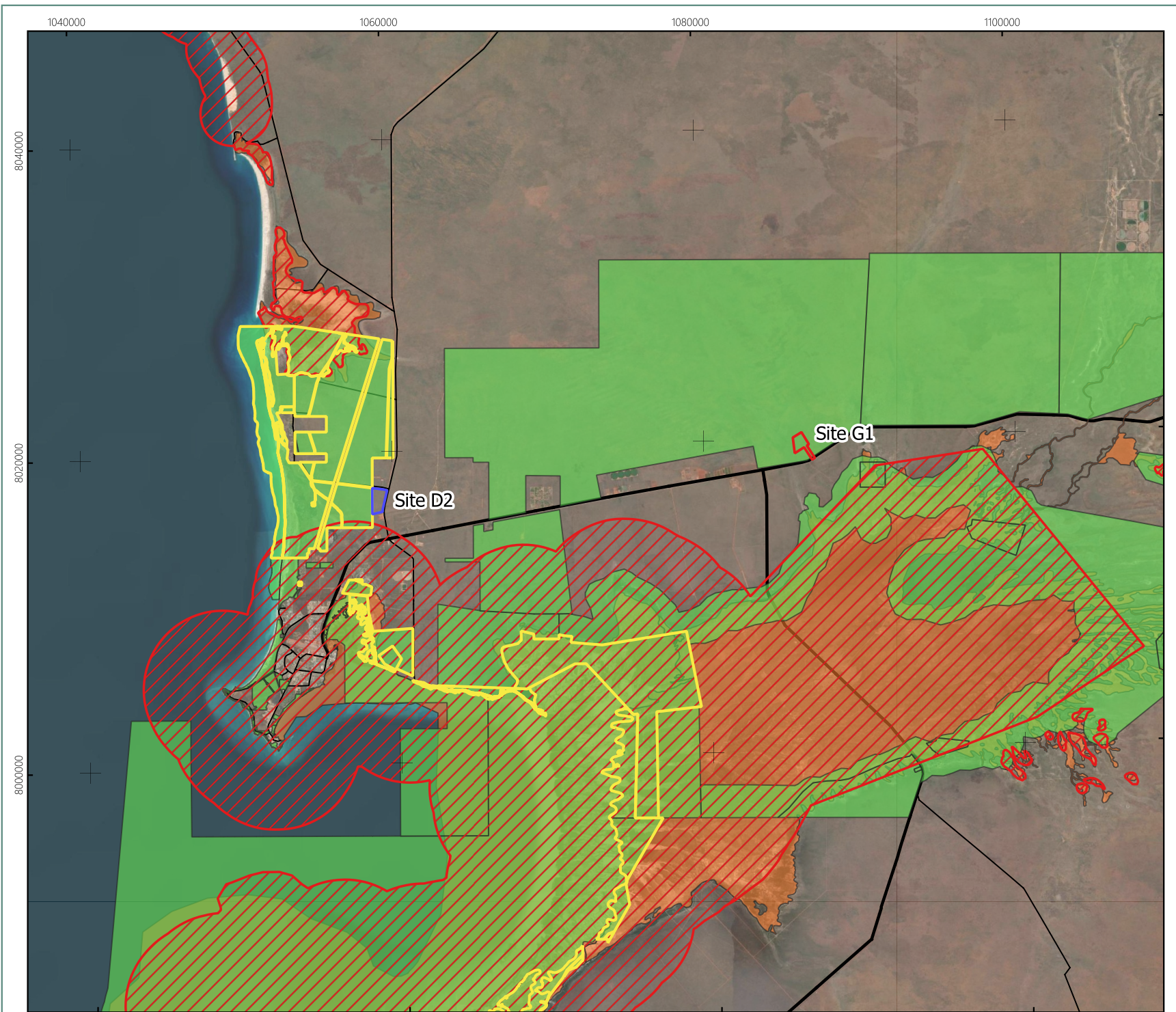
1.1. Project Background

The Shire of Broome is investigating two sites ('D2' and 'G1') for the placement of a new community recycling centre and landfill. The D2 Study Area is 122 ha and located approximately 10 km north of Broome. The G1 Study Area is 98 ha and located approximately 33 km north-east of Broome. As part of the site investigations, a range of hydrogeological and geotechnical works are required which will involve the removal of native vegetation (approximately 2.5 ha for D2 and 3.0 ha for G1). The disturbance to vegetation will include access tracks, boreholes, and trial pits. To allow such works to occur, a Native Vegetation Clearing Permit (NVCP) will be necessary and, as such, flora and fauna surveys are required to be undertaken in support of the NVCP application. Flora and Fauna surveys have previously been conducted at the G1 prior to the movement of the site boundary to its current location.

1.2. Objectives

Talis Consultants, on behalf of the Broome Shire, commissioned Spectrum Ecology (Spectrum) to undertake a detailed flora and vegetation assessment for the Broome RRRP Project. Spectrum Ecology previously conducted a reconnaissance flora and Level 1 fauna survey at the D2 and G1 Study Areas in December 2019 to determine the environmental values present at the sites (Map 1.1) and provide support to relevant applications to undertake initial hydrogeological and geotechnical investigations for the development of the RRRP project.

The following is a brief technical report and survey data that satisfies the relevant regulatory guidance statements and documents the results, findings, and limitations of the survey.

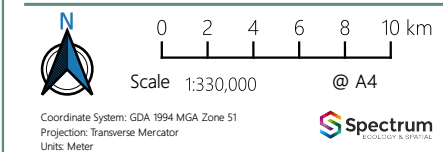


Legend

- Stie D2
- Site G1
- CAPAD Protected Areas
- Environmentally Sensitive Areas (ESA)
- Yawuru Indigenous Protected Area
- Directory of Important Wetlands

Roads

- Principal Road
- Minor Road



Author: CS

Date: 04-10-2022

Location of Study Area & Significant Lands

Broome Regional Resource
Recovery Park

Prepared for
Talis | Broome Shire

Map
1.1

1.3. Bioregion & Climate

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies Australia into regions based on dominant landscape, climate, lithology, geology, landform, and vegetation (Thackway & Cresswell, 1995).

The Study Area is located in the Pindanland (DAL02) IBRA subregion within the larger Dampierland (DAL) region (Figure 1.1). The Pindanland subregion comprises the western half of Dampierland, including the sandplains of the Dampier Peninsula, extending south along the hinterland of Eighty Mile Beach and north to include the paleodelta of the Fitzroy River (Graham, 2002). It is further described as having a fine-textured sand-sheet with low dunes covered by pindan vegetation, being the coastal, semi-arid, north-western margin of the Canning Basin (Graham, 2002). Inland vegetation typically consists of *Triodia* spp. (spinifex) or *Chrysopogon* spp. (ribbon grass) grasslands under *Acacia* spp. open shrub with low open woodlands of *Eucalyptus* species.

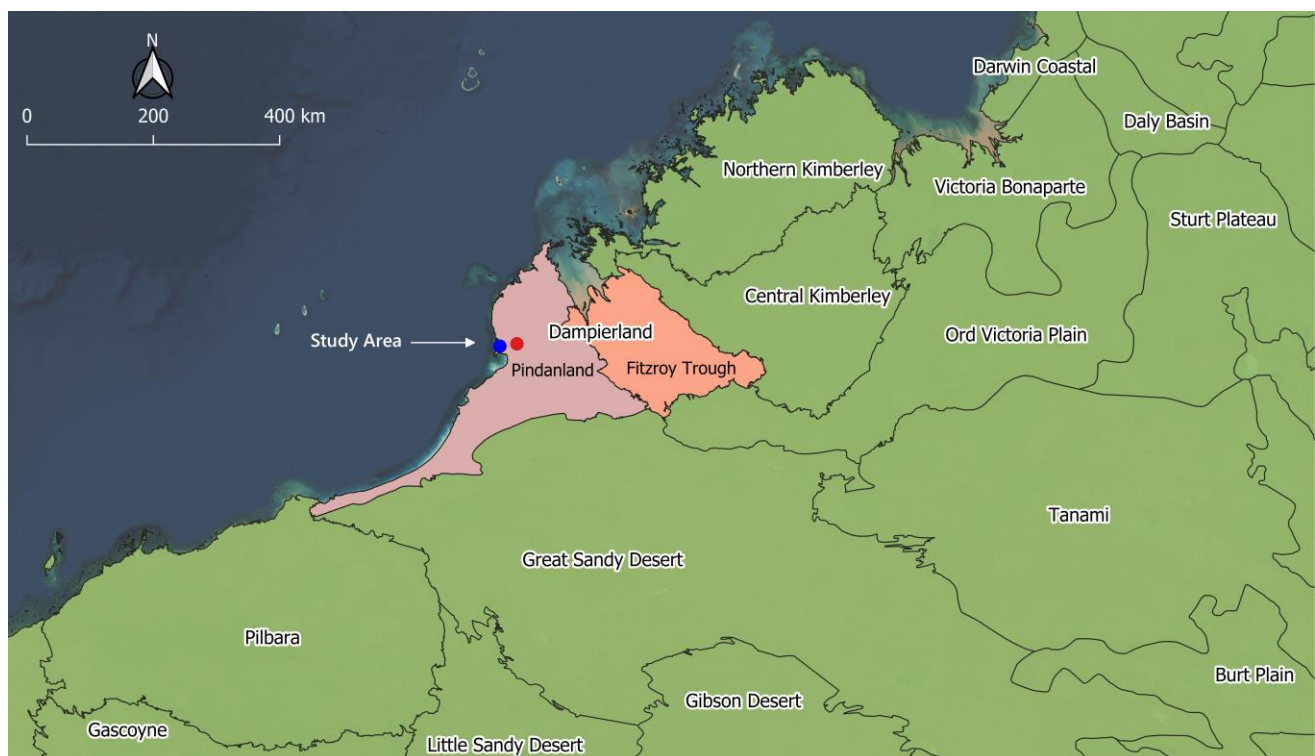


Figure 1.1: IBRA Classification of the Study Areas

The climate near Broome is dry, hot, and tropical and divided into a dry and wet season. The dry season runs from April to November, with very little rain and daily temperatures around 30°C. During the wet season, from December to March, average temperatures are several degrees higher along with erratic, often heavy rainfall, high humidity, and the possibility of tropical cyclones. The median annual rainfall is 561 mm, however the range of recorded annual rainfall is highly variable, from 132 mm to 1599 mm (Bureau of Meteorology, 2019).

1.4. Disturbance History

The dominant land uses for the Pindanland subregion include grazing on native pastures, unallocated crown land, and crown reserves. At the time of survey, the most recent fire within the Study Area and surrounds occurred in 2019.

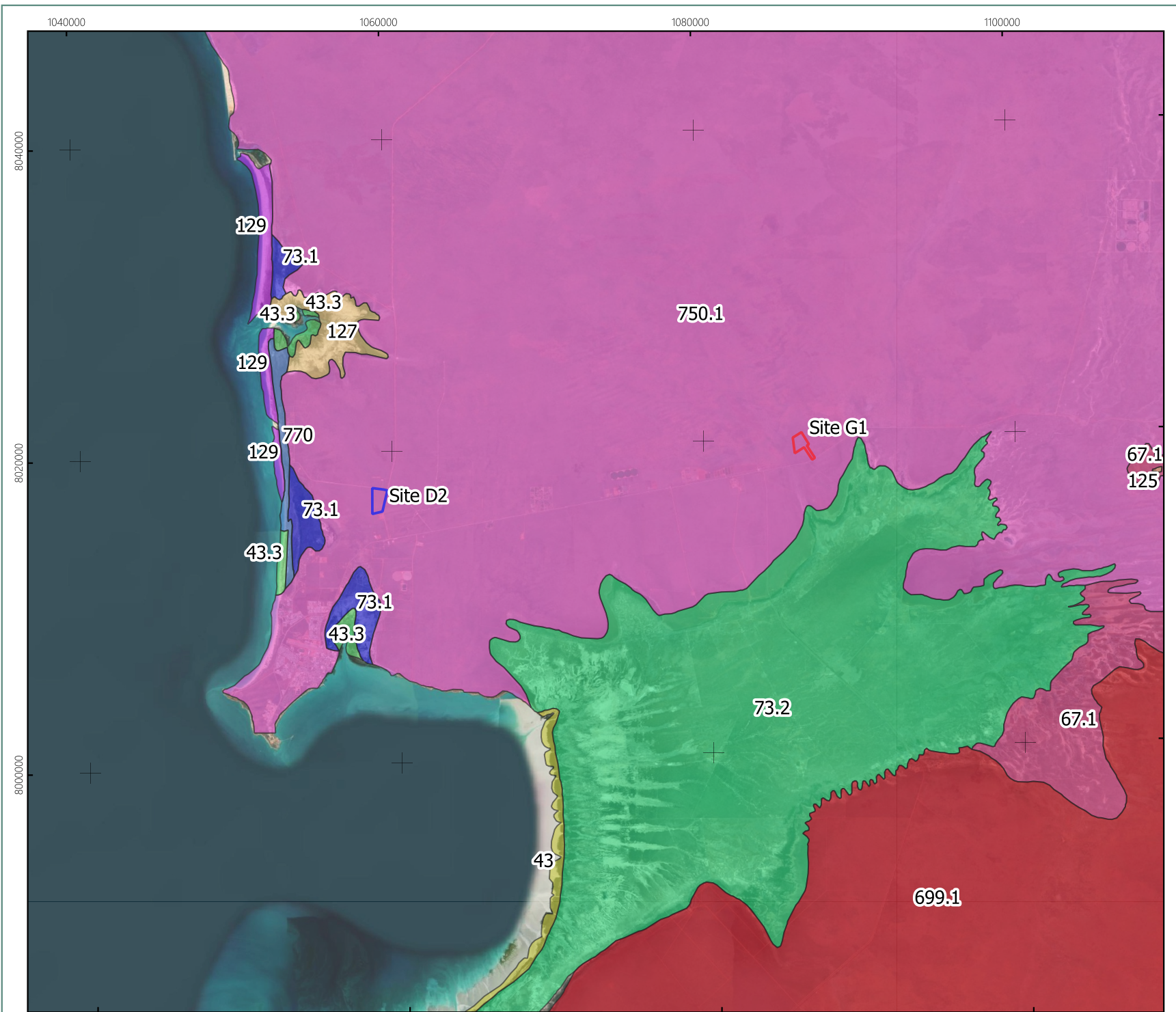
1.5. Beard Vegetation

Pre-European vegetation mapping was originally undertaken by J. S. Beard at various scales across the state and has since been updated to be consistent with the National Vegetation Information System (NVIS) descriptions at a scale of 1:250,000 (DPIRD 2020). State-wide vegetation statistics are available for these units, listing pre-European extent, current extent, and area in DBCA managed lands, are a useful tool to determine if a vegetation unit is rare or otherwise significant (WAGov, 2019). The unit mapped at the Study Areas has more than 99.7% of its pre-European extent remaining.

Both Study Areas occur entirely within one vegetation sub-association (750.1). This sub-association is restricted to the Dampierland IBRA region but is the second largest sub-association within the region and widespread. The vegetation classification is listed in Table 1.1 and presented in Map 1.2.

Table 1.1: Beard Vegetation

Sub-association	NVIS Level VI Vegetation Description	Area in Study (ha)	% of Study Area	Pre-European Whole State (ha)	Current Extent State (ha)	% Remaining	% of Current Extent in DBCA Land
750.1	<i>Corymbia polycarpa</i> , <i>Corymbia papuana</i> and <i>Corymbia setosa</i> woodland, over <i>Acacia eriopoda</i> , <i>Acacia holosericea</i> and <i>Dolichandrone occidentalis</i> tall shrubland, over <i>Chrysopogon</i> sp. open tussock grassland	D2 – 121 G1 – 98	D2 – 100% G1 – 100%	1,221,911.2	1,218,020.5	99.7	2.7



Legend

 D2 Study Area

 G1 Study Area

Beard Vegetation Units

43.0

43.3

67.1

73.1

73.2

125.0

127.0

129.0

699.1

750.1

770.0



0 2 4 6 8 10 km

Scale 1:330,000

@ A4

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Units: Meter

Spectrum
ECOLOGICAL & SPATIAL

Author: CS

Date: 04-10-2022

Beard Vegetation

Broome Regional Resource
Recovery Park

Map

1.2

Prepared for
Talis | Broome Shire

1.6. Geology

The geology of Western Australia (WA) has been mapped at a scale of 1:50,000, 1:100,000, 1:250,000, and 1:500,000. The township of Broome has been mapped to the finer scale 1:50,000 (Map 1.3), the surrounding region limited to a 1:250,000 and 1:500,000 scales.

Both study areas are located over the Broome, Mowla and Melligo Sandstones (K-bm-st) 1:500,000 geological unit, the total extent of this geological unit is 2,260,980 ha in WA and 1,980,210 ha in the Dampierland IBRA. The K-bm-st geological unit mapped at the Study Areas is widespread across WA and the Dampierland IBRA. The unit has less than 0.001% of its total occurrence within the Study Areas.

The D2 Study Area occurs within the Sm10 (1:50k) and Qz (1:250k) geological units. Both units are described as homogenous fine-grained red sands. The G1 Study Area is located over the Qs (1:250k) geological unit which is comprised of sand and silt and occurs extensively in the surrounding region. Extrapolating from the 1:50,000 geological units, the G1 site likely falls within the Sm10 (1:50k) geological unit (Table 1.2; Map 1.3). The geological units are listed in Table 1.2 and mapped at 1:50,000 in Map 1.3.

Table 1.2: Geological Units

Scale	Code	Description	Area in Study Area (ha)	% of Study Area
D2 Study Area				
1:50k	Sm10	Silky sand: red, fine-grained, sub-rounded quartz, variable silt content, homogeneous	121	100%
1:250k	Qz	Red sand, fine to medium; minor silt; aeolian	121	100%
1:500k	K-bm-st	Fine- to coarse-grained sandstone; minor mudstone and conglomerate	121	100%
G1 Study Area				
1:50k*	Sm10	Silty sand: red, fine-grained, sub-rounded quartz, variable silt content, homogeneous	98	100%
1:250k	Qs	Sand, silt; minor gravel: mixed alluvial and aeolian	98	100%
1:500k	K-bm-st	Fine- to coarse-grained sandstone; minor mudstone and conglomerate	98	100%

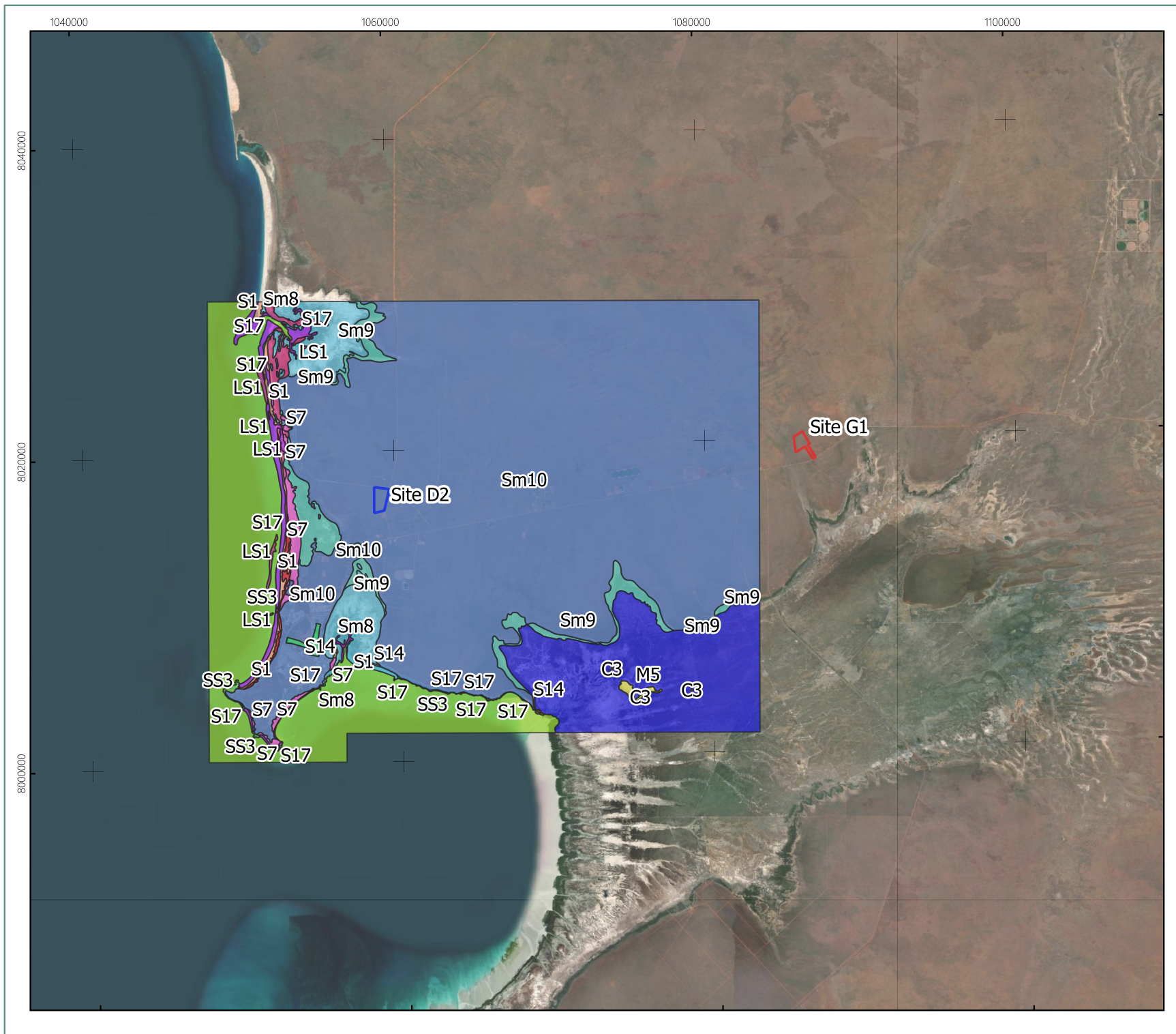
*Estimate based on 1:50,000 and 1:250,000 geological units.

1.7. Land Systems

Study Areas are on the boundary between Yeeda and Wanganut land systems (Schoknecht & Payne, 2011). The Yeeda land system is dominated by red sandplains supporting pindan vegetation with dense *Acacia* shrubs, scattered bloodwood and grey box trees and curly spinifex and ribbon grass. The Wanganut land system is dominated by low-lying sandplain and dunefields with through-going drainage (Schoknecht & Payne, 2011). The land systems associated with the Study Areas are presented in Table 1.3 and Map 1.4.

Table 1.3: Land Systems

Land System	Description	Area in Project (ha)	Total Extent (ha)	Location & Description of Occurrence
Yeeda	Sandplain, deep red and yellow sands, pindan and tall woodlands.	D2 – 24 G1 – 95	2,130,800	Widespread across the Dampierland IBRA region. Predominantly found on the Pindanland IBRA subregion.
Wanganut	Low-lying sandplain and dunefields with through-going drainage, pindan.	D2 – 97 G1 – 3	697,300	Located in the northern half of the Dampierland IBRA region. Found evenly across both the Pindanland and Fitzroy Trough IBRA subregions.



Legend

 D2 Study Area

 G1 Study Area

Geological Units 1:50,000

C3

Gsb1

LS1

M5

Made grd

S1

S14

S17

S2

S7

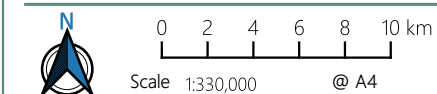
Sm10

Sm8

Sm9

SS3

Ocean



Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Units: Meter

Spectrum
ECOLOGICAL & SPATIAL

Author: CS

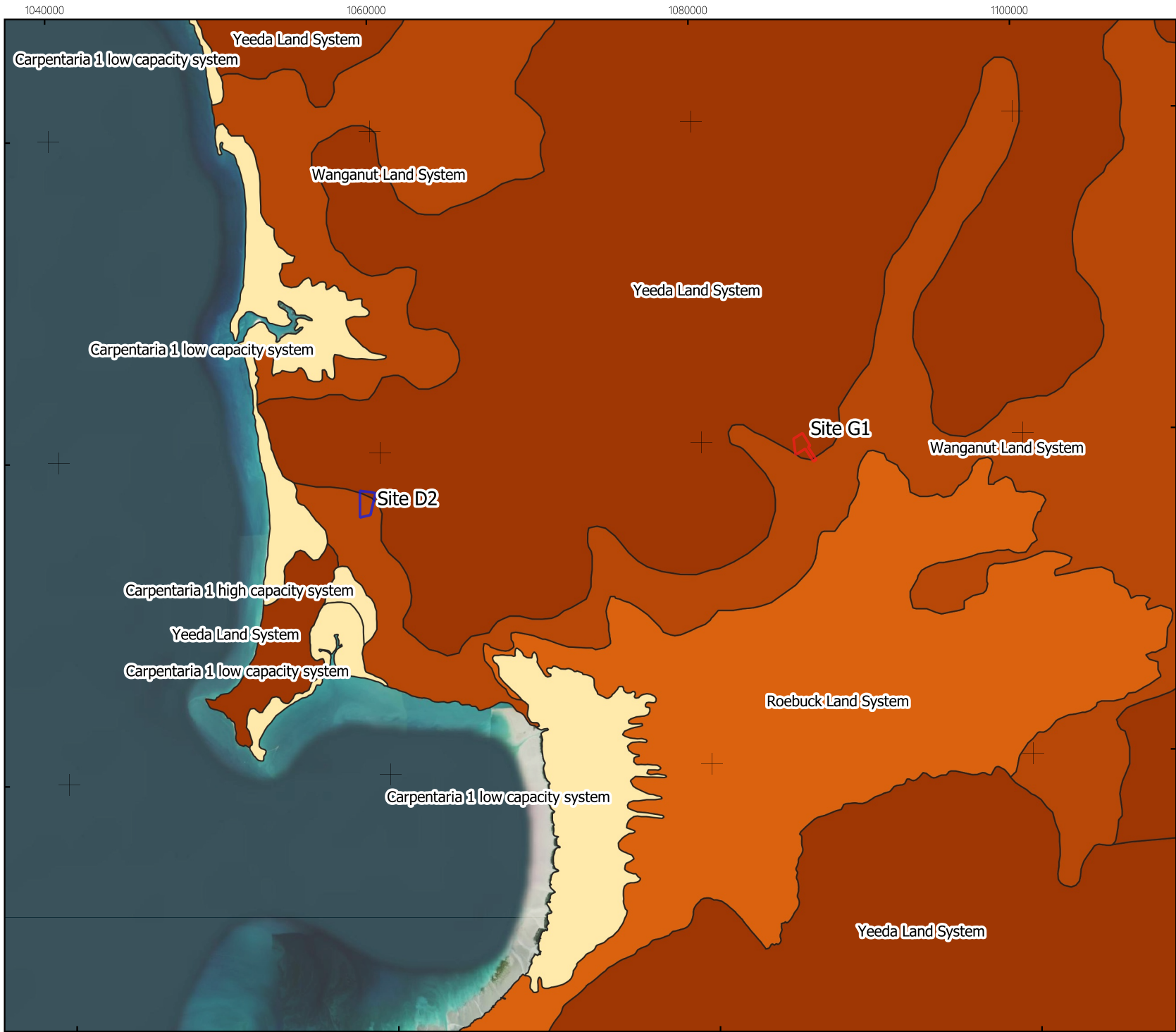
Date: 04-10-2022

Geology (1:50,000)

Broome Regional Resource
Recovery Park

Prepared for
Talis | Broome Shire

Map
1.3



Legend

- D2 Study Area
- G1 Study Area

Land Systems

- Carpentaria 1 high capacity system
- Carpentaria 1 low capacity system
- Roebuck Land System
- Wanganut Land System
- Yeeda Land System



0 2 4 6 8 10 km

Scale 1:330,000 @ A4

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Units: Meter



Author: CS

Date: 04-10-2022

Land Systems

Broome Regional Resource
Recovery Park

Map

1.4

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Talis | Broome Shire

1.8. Significant Lands

1.8.1. Environmentally Sensitive Lands

Environmentally Sensitive Areas (ESA) that are associated with flora and vegetation are areas that are defined by the Department of Water and Environmental Regulation (2019) as:

- A defined wetland and the area within 50 m of a wetland;
- The area covered by vegetation within 50 m of Threatened Flora, to the extent to which the vegetation is continuous with the vegetation in which the Threatened Flora is located;
- The area covered by a TEC;
- A Bush Forever site;
- Areas covered by the Gngangara Mound Crown Land Policy and Western Swamp Tortoise Policy; and
- Areas covered by lakes, wetlands and fringing vegetation of the Swan Coastal Plain Lakes Policy, including South West Agricultural Zone Wetlands Policy and Swan and Canning Rivers Policy.

No ESAs were mapped within the Project. Both Study Areas are located to the north of a large ESA that comprises the Roebuck Bay and associated Roebuck Plain areas (Map 1.1).

1.8.2. Australian Wetlands Database

The Australian Wetlands Database includes nationally significant wetlands (as listed in the directory of important wetlands), wetlands listed under the Ramsar convention, wetlands that are representative, rare or unique, or wetlands that are considered of international importance (DoEE, 2019).

No nationally significant wetlands, including Ramsar wetlands, were mapped within the Project (Map 1.1).

1.8.3. Conservation Estate

A search of the Collaborative Australian Protected Area Database (CAPAD), identified several protected areas located within 50 km of the Study Areas. These protected areas and their approximate distance from the Study Areas are listed in Table 1.4.

The G1 Study Area is located within the Yawuru Indigenous Protected Area (IPA). The combined area of the 5(1)(h) Reserves listed in Table 1.4 make up a small portion of the greater Yawuru IPA. The D2 Study Area is not located within any protected areas though is immediately east of the Yawuru Birragun Conservation Reserve. Conservation Estate, ESAs, nationally significant wetlands, and the extent of the Yawuru IPA are displayed on Map 1.1.

Table 1.4: Significant Lands Within 50 km of the Study Areas

Reserve Name (Protected Area ID)	Relevant to the Study Area		Jurisdiction/ Size
	Distance	Direction	
5(1)(h) Reserves			
Broome Bird Observatory (WA_41066)	D2 – 13.8 km G1 –23.9 km	Southeast Southwest	Western Australia, 2.7 ha
Broome Wildlife Centre (WA_47964)	D2 – 6.5 km G1 – 32.3 km	Southwest West southwest	Western Australia, 5.0 ha
Unnamed (WA_51105)	D2 – 11.9 km G1 –26.6 km	South Southwest	Western Australia, 317.0 ha
Yawuru Conservation Estate (WA_51162)	D2 – 5.5 km G1 – 30.5 km	West West	Western Australia, 2,515.6 ha
Unnamed (WA_51497)	D2 – 4.6 km G1 – 28 km	South Southwest	Western Australia, 716.5 ha

Reserve Name (Protected Area ID)	Relevant to the Study Area		Jurisdiction/ Size
	Distance	Direction	
Unnamed (WA_51583)	D2 – 11.9 km G1 – 13.3 km	Southeast Southwest	Western Australia, 4,896.0 ha
Unnamed (WA_51617)	D2 – 13.6 km G1 – 24.9 km	Southeast Southwest	Western Australia, 5.7 ha
Unnamed (WA_51932)	D2 – 19.4 km G1 – 20.8 km	Southeast Southwest	Western Australia, 5,778.5 ha
Yawuru Birragun Conservation Park (WA_52354)	D2 – Directly adjacent G1 – 25km	West West	Western Australia, 7,223.8 ha
Indigenous Protected Areas			
Yawuru (CWTB_IPA75)	D2 – Directly adjacent G1 – Located within IPA	West Within	Commonwealth of Australia, 210,763.7 ha

2. METHODOLOGY

2.1. Project Team & Licenses

Spectrum Ecology staff involved with this assessment are listed in Table 2.1, along with their role, years of experience and relevant licenses.

Table 2.1: Project Team & Licences

Staff	Role	Experience	Licences
Melissa Hay (Principal Botanist)	Reporting, QA	12 years	-
Chris Parker (Senior Botanist/Ecologist)	Field Assessment, reporting, data analysis	10 years	Flora: FB62000009-2
Dr Jaume Rusalleda Alvarez	Spatial analysis, mapping	11 years	-
Chris Shaw (Botanist)	Field Assessment, reporting, data analysis	3 years	Flora: FB62000241
Dr Tim Hammer (Taxonomist/Botanist)	Plant IDs, reporting	5 years	-

2.2. Field Survey Timing

Climate data and conditions leading up to the detailed flora survey recorded at Broome Airport (Bureau of Meteorology station #003003) are presented in Figure 2.1 and Table 2.2. The D2 and G1 Study Areas are located approximately 10 km north-north-east and 33 km east-north-east of the Broome Airport weather station, respectively.

The reconnaissance flora survey was undertaken after a period of below annual rainfall. Broome Airport recorded 265 mm under the median total annual rainfall (Table 2.2).

Total rainfall for the 12-month period prior to the detailed flora survey (April 2019–March 2020) was 512 mm, 49 mm higher than the median total annual rainfall recorded at Broome Airport (561 mm). Total rainfall for the three-month period prior to the field survey (January–March) was 433 mm, 3 mm above the long term median for the same period of time (430 mm) (Table 2.2). Seasonal conditions were above median for the timing of the detailed field survey, as recommended by the technical guidance (EPA, 2016b).

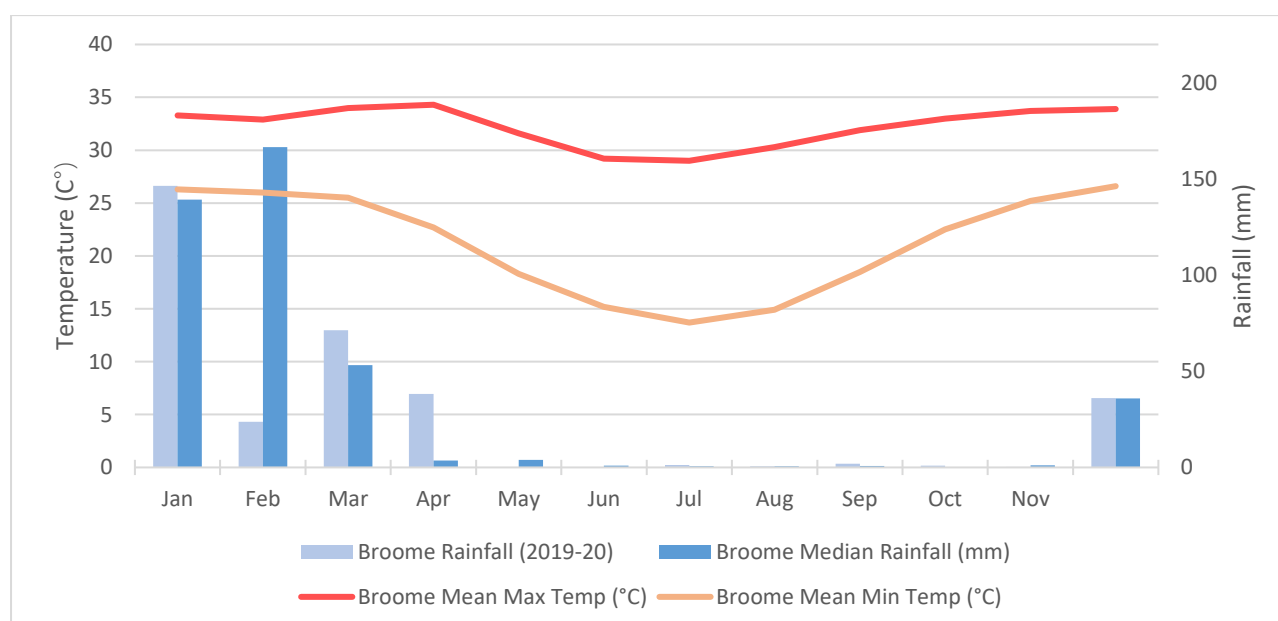


Figure 2.1: Climate Data (1940-2020) for Broome Airport (#003003)

Table 2.2: Field Survey Timing & Rainfall

Field Survey	Date	Person Days	BOM Station	Rainfall (mm)					
				3 Months Prior	3 Month Median	+/-	12 Months Prior	Annual Median	+/-
Reconnaissance flora survey	26 Nov 2019	1	Broome Airport	4	5	-2	296	561	-265
Detailed flora survey	19 – 23 April 2020	10	Broome Airport	433	430	3	512	561	49

2.3. Legislation & Guidelines

Flora and fauna in Western Australia are protected by various legislation, including:

- The State *Biodiversity Conservation Act 2016* (BC Act);
- The National *Environmental Protection Act 1986* (EP Act); and
- The National *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

This detailed assessment is compliant with the appropriate flora guidelines as outlined in:

- EPA Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016b).

2.4. Significant Flora & Vegetation Definitions

Flora and vegetation can be considered significant for a range of reasons.

Significant flora can include (EPA, 2016a):

- Being identified as Threatened: Critically Endangered, Endangered or Vulnerable (state listed BC Act and/or nationally listed EPBC Act);
- Being identified as Priority species: Priority 1 to 4 (DBCA, 2019);
- Locally endemic or association with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems);
- New species or anomalous features that indicate a potential new species;
- Representative of the range of a species (particularly, at the extremes of range recently discovered range extensions, or isolated outliers of the main range);
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids; and
- Relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

Significant vegetation can include (EPA, 2016a):

- Threatened Ecological Community (TEC): Critically Endangered, Endangered or Vulnerable (state listed BC Act and/or nationally listed EPBC Act);
- Priority Ecological Community (PEC): Priority 1 to 5 (DBCA, 2020);
- Restricted distribution;
- Degree of historical impact from threatening processes;
- A role as a refuge; or
- Providing an important function required to maintain ecological integrity of a significant ecosystem.

2.5. Introduced Flora & Declared Plant Categories

Introduced flora can pose a threat to native vegetation and biodiversity. The Department of Primary Industries and Regional Development (DPIRD) keeps a database of organisms that are declared pests in Western Australia. This database is regulated under the Biosecurity and Agricultural Management Act (WA Gov, 2007). The legal status and control requirements for these environmentally significant weeds are provided in Appendix A.

2.6. Nomenclature

Flora nomenclature used in this report is consistent with the DBCA Census of Western Australian Plants database, provided through FloraBase (Western Australian Herbarium, 2020) and is current at the time of report preparation.

2.7. Desktop Assessment

A desktop review of all relevant and available flora and vegetation data sources was undertaken prior to the field survey to determine the species and communities that are likely to occur in the Study Area. This review included searches of relevant databases and a review of relevant literature from the surrounding region.

2.7.1. Database Searches

The database searches completed for this project are listed in Table 2.3.

Table 2.3: Details of Database Searches

Data Source	Custodian	Details
Threatened & Priority Flora database (WAH/TPFL)	Department of Biodiversity, Conservation and Attractions (DBCA)	Date: 26/11/2020 Buffer: 50 km around a central point Reference: 27-1119FL
TEC & PEC database		Date: 17/12/2019 Buffer 50 km around a central point Reference: 15-0219EC
Commonwealth Protected Matters Search Tool (PMST)	Department of the Environment and Energy (DoEE)	Date: 13/11/19 Buffer: 40 km
NatureMap	Department of Parks and Wildlife (DPAW) / Western Australian Museum	Date: 13/11/19 Centre point: 17°54'10"S, 122°20'17"E Buffer: 40 km
Index of Biodiversity Surveys of Assessments (IBSA) database.	Department of Water and Environmental Regulation (DWER)	Date: 10/01/2020

2.7.2. Previously Conducted Flora Assessments

A desktop review of all relevant and available literature was undertaken prior to the field assessment. The following previous survey reports were searched to determine species of conservation significance likely to occur in the Study Area. The Index of Biodiversity Surveys and Assessments (IBSA) was also utilised to access available previous assessment reports from the surrounding region. Details of each report are summarised in Table 2.4 and mapped in Map 2.1.

Table 2.4: Previously Conducted Flora Assessments

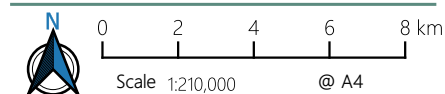
Report Title	Level of Assessment	Field Survey Timing
Mamabulanjin Orchard Flora and Fauna Survey (GHD, 2019).	Detailed and targeted flora & vegetation. Level 1 and targeted fauna.	1–2 May 2019 (flora & vegetation).
Distribution, ecology and cultural importance of Gunurru or Cable Beach Ghost Gum <i>Corymbia paractia</i> in the Broome area, Western Australia (Environs Kimberley, 2018).	Targeted survey and distribution mapping of Cable Beach Ghost Gum <i>Corymbia paractia</i> .	November – December 2016 (flowering period).
Broome Road Industrial Area Targeted Survey (GHD, 2018).	Targeted flora survey (<i>Polymeria</i> sp. Broome and <i>Jacquemontia</i> sp. Broome).	24–27 April 2017, 10–12 May 2017.
Flora, Vegetation and Fauna Assessment – Broome Asparagus Farm (AECOM, 2017).	Detailed (single phase) flora & vegetation, Level 1 fauna.	8–12 May 2017 (Flora).
Broome Landfill Flora, Vegetation and Fauna Survey (Astron, 2017).	Level 2 flora & vegetation, Level 1 fauna.	2–3 November 2016 (Flora & Fauna). 3–5 April 2017 (Flora).
Broome Motorplex Environmental Site Investigation (GHD, 2016).	Level 2 (single phase) flora & vegetation.	18–24 March 2016 (flora & vegetation).
Priority Ecological Community (PEC) Mapping and condition assessment: "Relict dune system dominated by extensive stands of Mangarr (Minyjuru) <i>Sersalisia</i> (formerly <i>Pouteria</i>) <i>sericea</i> " (Willing & Beames, 2015)^	Targeted survey and condition assessment of the Minyjuru (<i>Sersalisia sericea</i>) dominated relict dune system PEC.	November 2013 – March 2014.
Broome North – Northern Portion (Area B). Preliminary Environmental Impact Assessment and Biological Survey (GHD, 2009).	Level 1 flora & vegetation.	Field: 3–6 June 2008.

^ Exact location not known



Legend

- D2 Study Area
- G1 Study Area
- Broome Motorplex Sites (GHD 2016)
- Mamabalanjin Orchard (GHD 2019)
- Targeted Corymbia (Environs Kimb 2018)
- Cable Beach Rd East (GHD 2016)
- Broome Industrial Targeted (GHD 2018)
- Broome Asparagus Farm (AECOM 2017)
- Broome Landfill G1 RevA (Astron 2017)
- Broome North Area B (GHD 2009)
- Principal Road
- Minor Road



Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Units: Meter

Spectrum
ECOLOGICAL & SPATIAL

Author: CS

Date: 04-10-2022

Previously Conducted Flora Assessments

Broome Regional Resource
Recovery Park

Prepared for
Talis | Broome Shire

Map
2.1

2.7.3. Number of Plants

The significant flora records from the database searches and literature review vary considerably in the amount of detail, regarding abundance, that is available. Ranging from accurate counts, foliage cover, and general descriptions to no detail at all. Where no value was provided for abundance, the numbers were inferred according to Table 2.5. The assumption of value is likely to be an underestimate and hence final estimates are likely to be conservative. Where a range of potential abundance is provided, the lower middle value of the range was used. Exact duplicates were removed and where abundance values differ, the larger number was used.

Table 2.5: Number of Plants Assumed

Description or Cover Provided	Cover (%)	# Plants Assumed
No value	-	1
Rare, few, scattered, some, isolated plants, isolated clumps, very sparse, uncommon	<2%	3
Several, small group, scarce, sparse, scattered, small population, dozens	2-10%	10
Infrequent, uncommon, many, medium sized patch	10-30%	20
Occasional, moderately common, localised, large patch	30-70%	30
Common, Locally common, locally frequent, locally scattered, locally abundant, mid-dense, healthy population	>70%	50
Frequent, very common, plentiful, abundant, dominant, extensive, dense	>70%	100

2.7.4. Likelihood of Occurrence Assessment

The following information was collated for each significant flora taxon or vegetation community identified during the desktop assessment:

- Conservation status (EPBC Act, WC Act, DBCA listing);
- Description of species and flowering period (flora only);
- Description of habitat requirements and presence within the Project;
- Source of record (DBCA, previous report etc.); and
- Distance of record to the Project.

A likelihood of occurrence assessment was then conducted using the criteria listed in Table 2.6. This included assessing the distance of the record from the Study Areas (historical database records considered not accurate were excluded if required), and presence of appropriate habitats within the Study Areas (using land systems, geology, vegetation mapping, and/or aerial imagery).

Table 2.6: Likelihood of Occurrence Assessment Criteria

Likelihood	Flora & Vegetation
Recorded	Species or vegetation community accurately recorded within the Study Area during the literature review (includes TEC/PEC buffers that intersect).
High	Species or vegetation community recorded in close proximity of the Study Area, and suitable habitat does, or is likely to occur.
Medium	Species or vegetation community recorded outside the Study Area but within 20 km and suitable habitat may occur.
Low	Species or vegetation community rarely or not recorded within 20 km of the Study Area and suitable habitat does not likely occur within the Study Area.

2.7.5. Data for the Index of Biodiversity Survey's for Assessment (IBSA)

The Environmental Protection Authority has given instruction that all biological surveys collecting data on biodiversity submit the report and associated raw data to IBSA as an IBSA data package.

All survey data collected will be provided electronically to comply with IBSA data standards.

2.8. Detailed Flora & Vegetation Assessment

2.8.1. Field Methodology & Sampling Effort

A reconnaissance level flora and vegetation assessment was previously conducted at the Study Areas in November 2019. This was considered appropriate as it is the preliminary investigation into environmental values of the Study Areas. The detailed flora survey was conducted in the months following the wet season (February – April).

During the reconnaissance survey, five relevés were sampled within the Study Areas; including two relevés at D2 Study Area, three relevés in G1 Study Area. The detailed flora survey across both Study Areas was comprised of:

- Five 50 × 50 m quadrats (one located outside the Study Area);
- Five relevés (three located outside the Study Area); and
- 45 km of traverses with 100m spacing.


A combination of quadrats, relevés, traverses, and opportunistic sampling is appropriate for a detailed level survey as stipulated in the guidance statement (EPA, 2016b). These survey techniques are described in Table 2.7. Sites and traverses surveyed at the Study Areas are mapped in Map 2.2 and Map 2.3, respectively.

Table 2.7: Detailed Flora & Vegetation Assessment Survey Technique


Technique	Description
Quadrat	<p>Quadrats are a comprehensive survey technique for gathering information for detailed flora and vegetation surveys. Each vegetation unit must be represented by a minimum of three quadrat sites over two seasons and have at least one corner (NW) permanently marked.</p> <p>Information collected at each quadrat includes:</p> <ul style="list-style-type: none"> • Site code, date, location, botanist; • Four photographs, one from each corner of the site; • Vegetation condition and disturbances (including fire); • Landform, including slope, soil, rock type, aspect; • Flora and vegetation information; dominant cover, structure and species count where necessary; and • Comprehensive recording of every species within the quadrat boundary (50 × 50 m).
Relevés	<p>Relevés used in a detailed survey are employed to support the vegetation mapping and survey effort. They are a lower intensity survey technique or sampled where quadrats are too dangerous to set up. Information collected at each relevé is the same as that of a quadrat site, excluding the comprehensive collection of every species within the quadrat boundary, and the requirement to permanently mark the site's corners.</p>
Traverses	<p>A traverse is an unmarked route along which data is collected. Traverses are useful for identifying the boundaries and characteristics of vegetation types, selecting sites for detailed survey, and targeting significant flora or vegetation.</p> <p>Information recorded along a traverse is as for the relevé, with the addition of noting vegetation changes and relationships between vegetation and substrate.</p>

Technique	Description
Opportunistic Sampling	Flora and vegetation not recorded through other sampling methods was opportunistically sampled as encountered in the study area. Opportunistic sampling also included recording locations of significant, introduced (weed) and unknown species.
Targeted Sampling	<p>Areas likely to support significant flora or vegetation were targeted during the survey, including areas with existing records of significant flora.</p> <p>Areas were selected based on existing records from database searches, geology, vegetation mapping and known Environmentally Sensitive Areas. Where possible, unusual, and restricted geological features within the study area were sampled.</p> <p>When potentially significant flora were encountered during the survey, sufficient information was recorded to complete a Threatened and Priority Flora Report Form (TPRF).</p>

Legend

 D2 Study Area

Detailed Flora Survey

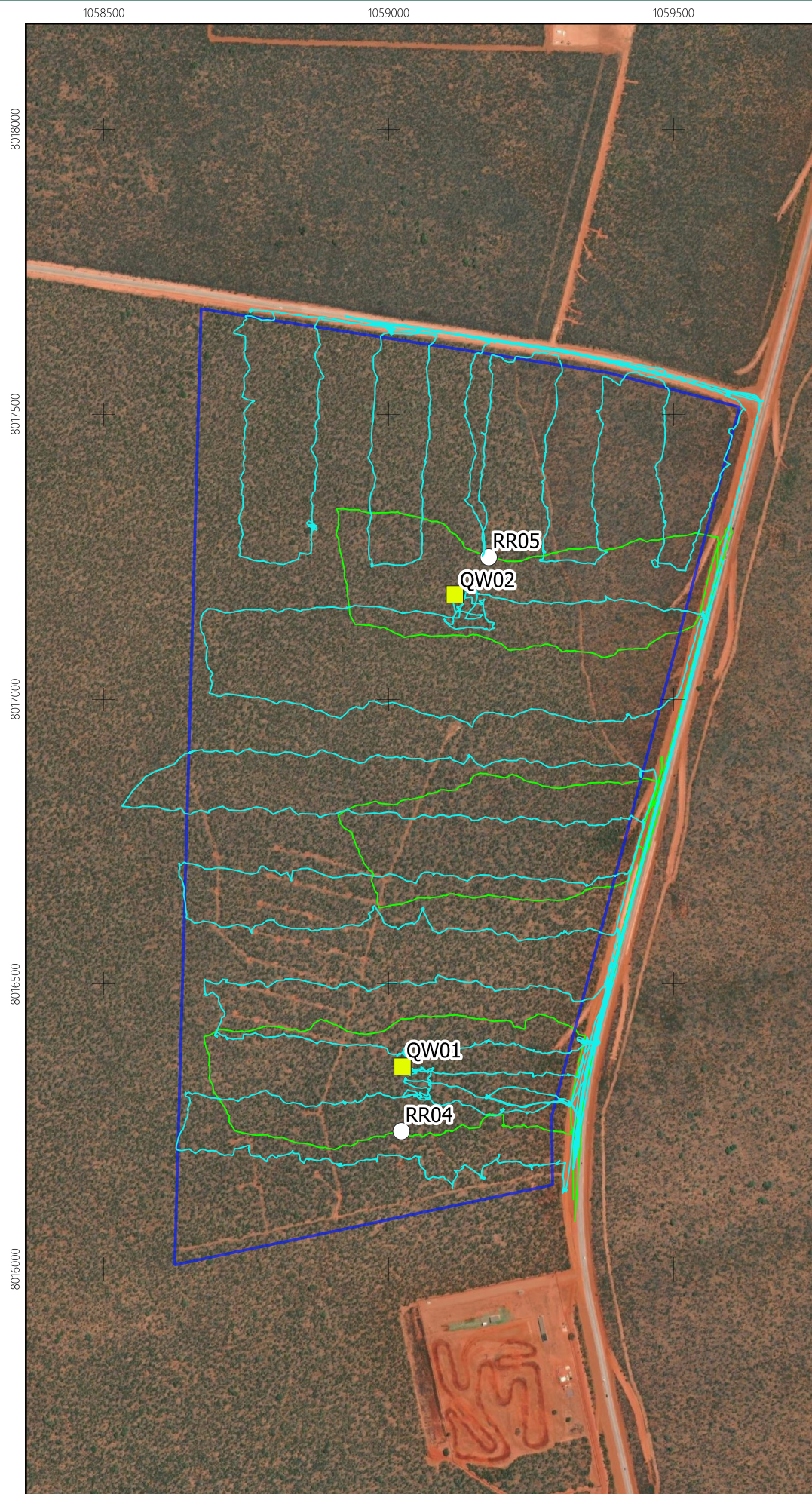
 Quadrat

 Site Traverse

Reconnaissance Flora Survey

 Releve

 Site Traverse



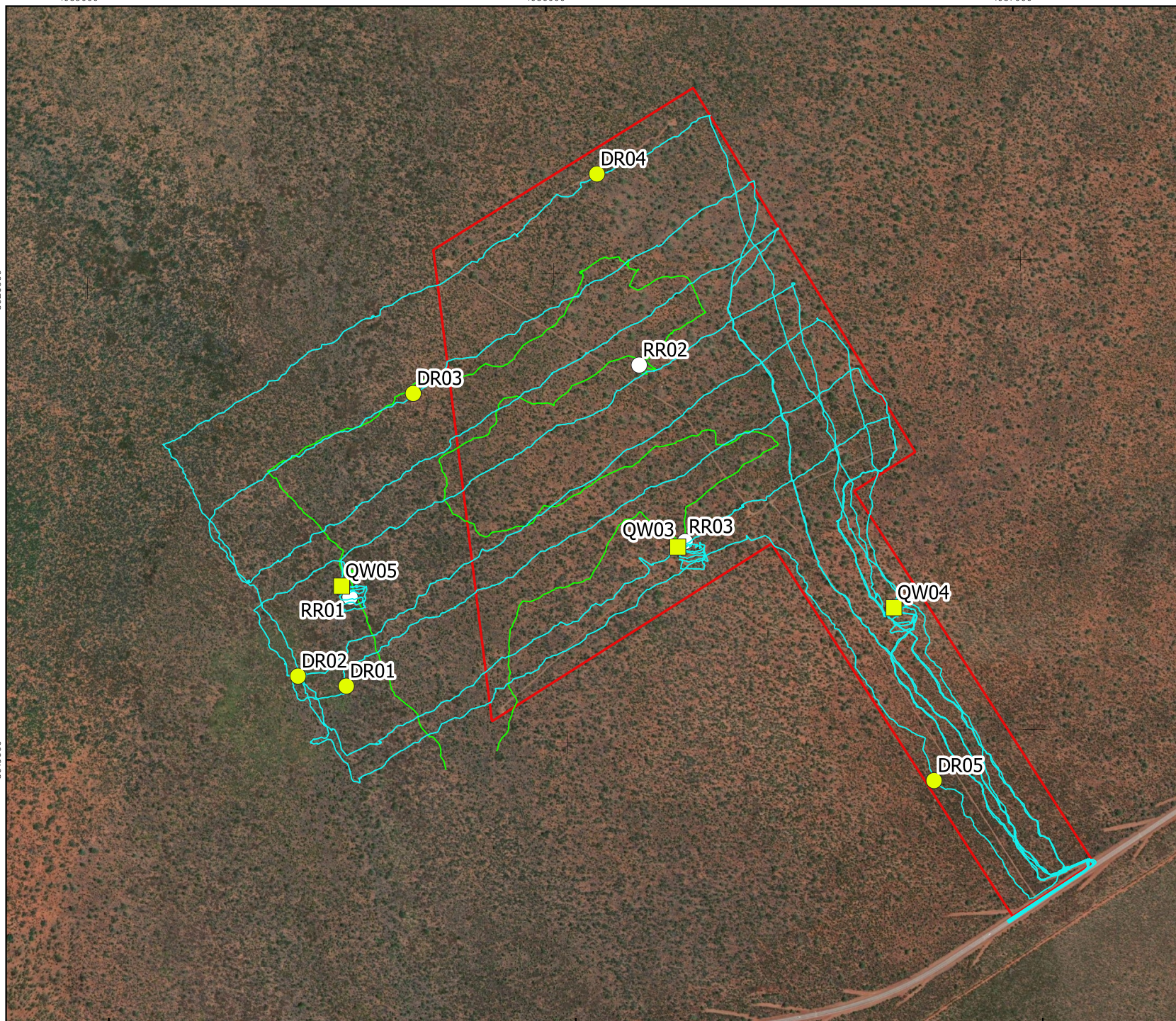
1085000

1086000

1087000

8020000

8019000



Legend

G1 Study Area

Detailed flora Survey

Quadrat

Releve

Site Traverse

Reconnaissance Flora Survey

Releve

Site Traverse



0 0.2 0.4 km
Scale 1:12,000 @ A4

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Units: Meter

Spectrum
ECOLOGICAL & SPATIAL

Author: CS

Date: 05-10-2022

G1 Study Area Flora Survey Effort

Broome Regional Resource
Recovery Park

Map

2.3

Prepared for
Talis | Broome Shire

2.8.2. Vegetation & Condition Mapping

The data collected from relevés, traverses, as well as general field notes, observations and aerial photography were used to map the vegetation across the Study Areas. Vegetation was classified structurally based on the dominant species. The vegetation classification is consistent with NVIS Level V – association vegetation descriptions (referred to as a ‘vegetation unit’ for the local scale in this report). This level of description provides information on the dominant growth form, height and cover for up to three species for each of the upper, mid and ground strata (ESCAVI, 2003).

Vegetation condition was recorded at relevés and where areas of different vegetation condition were observed from both ground truthing and aerial imagery. The vegetation condition was mapped across the study area at the same scale as the vegetation mapping. Vegetation condition ratings follow the scale recommended for the Northern Botanical Province (EPA, 2016), summarised in Table 2.8.

Table 2.8: Vegetation Condition Scale & Criteria – Northern Province

Vegetation Condition	Disturbance Criteria
Excellent	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
Very Good	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
Good	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
Degraded	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
Completely Degraded	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or ‘parkland cleared’ with their flora comprising weed or crop species with isolated native trees or shrubs.

2.8.3. Specimen Identification & Lodgement

Flora specimens were collected of any suspected or known significant flora and to confirm species recorded during the relevés for vegetation mapping. Specimens were identified by plant Taxonomist Dr Timothy Hammer using the appropriate taxonomic keys and, where required, relevant taxonomic experts at the Western Australian Herbarium were consulted.

Specimens are vouchered with the Western Australian Herbarium as per guidance; when they represent new populations of Threatened or Priority Flora, new occurrences of TECs or PECs, individuals that have atypical characteristics, or bioregional range extensions.

2.8.4. Transition Zone Definition

A desktop assessment was completed based on the identification of the transition zone between Holocene coastal dunes (where the *Corymbia paractia* is typically found) and red Pindan soils. The analysis was based on the use of current high-resolution imagery (WorldView imagery from 12/4/2021 with a 0.5 m resolution) and an overlay of polygons where *C. paractia* has been identified as the dominant species. Using these

inputs, a transition zone line vector was generated through digitization over the satellite imagery. A conservative approach was applied (with the transition zone line being digitized further inland) in case of doubt and/or of unclear visible boundaries (which were mostly clearly observed through a change in soil colour from white sands to red soil).

An Euclidean distance raster (with a 10 m resolution) was created from the digitized transition zone line, covering an area that included the currently known extent of *C. paractia* PEC as well as site D2. This dataset was used to extract the mean distance to the transition zone for all polygons identified as *C. paractia* PEC as well as site D2.

2.8.5. Limitations & Constraints

Survey specific limitations and constraints for the flora and vegetation assessment of the Study Areas are discussed in Table 2.9.

Table 2.9: Limitations & Constraints

Limitation	Constraint	Comment
Availability of contextual information at a regional and local scale.	No	There were several surveys identified in the Literature Review and available from the IBSA database in close proximity (20 km) to the study areas (see Table 2.4). These surveys gave excellent local and regional contextual information, particularly for conservation significance. For historical context, Beard mapping has been used, however this mapping is conducted at a coarse scale (1:250,000) and can only provide an approximate comparison.
Competency/experience of the team carrying out the survey, including experience in the bioregion surveyed.	No	Botanist Chris Parker has ten years' experience in conducting botanical surveys throughout Western Australia, including experience within the Dampier Peninsula and Kimberly bioregion. Botanist Chris Shaw has 3 years' experience.
Restrictions to, or functionality of survey equipment and tools to complete the flora and vegetation assessment.	No	There were no restrictions to or compromised functionality of survey equipment or tools that would adversely affect the flora and vegetation equipment during the current survey.
Proportion of flora recorded and/or collected, any identification issues.	No/ Somewhat	Proportion of flora collected was consistent with expectations for this type of survey and survey timing in the context of other surveys of a similar level and seasonality. There was adequate floristic material available for the majority of the Priority Flora species listed with a high to low Likelihood of occurring within the Study Areas. The survey was conducted when these plants were expected to be flowering. The only exception was <i>Corymbia paractia</i> (P1) which was not flowering at the time of the survey and fruit was rarely present on trees. Without adequate floristic material <i>Corymbia paractia</i> is difficult to distinguish between other species, such as <i>Corymbia flavesces</i> which has a similar distribution. However, some fruit material was collected which aided in the identification. Plants were identified by taxonomist Tim Hammer who has botanical and taxonomic experience throughout Western Australia. Where there were complexities specialist taxonomists at the Western Australian herbarium were consulted. Thirteen specimens were unable to be confirmed or left with a query on their species confirmation due to poor quality material. This may also be contributed to the seasonal conditions for several specimens.
Survey effort and extent.	No	Prior to the field survey, quadrat sites were selected to represent the diversity of vegetation and geology present at the study area. This was sufficient to map and classify the vegetation of the study area for the Reconnaissance assessment. All the vegetation types identified are common for this area. The Study Area was adequately assessed in accordance with the Guidance Statement Guidelines

Limitation	Constraint	Comment
Access restrictions within the survey area.	No	There were no access limitations in the flora and vegetation survey.
Survey timing, rainfall, season of survey.	No	<p>The field survey timing was considered appropriate season for a flora and vegetation survey conducted in the Kimberley Botanical Province.</p> <p>Despite surveying the sites in April when <i>Corymbia paractia</i> is not typically flowering (December) there was some fruit material collected for the identification of some of the trees.</p>
Disturbance that may have affected the results of survey such as fire, flood or clearing.	No/ Somewhat	Large areas of the G1 Study Area were recorded as recently burnt. However; two quadrats were placed in unburnt areas that allowed adequate interpretation of flora and vegetation composition.

3. RESULTS

3.1. Flora

3.1.1. Desktop Assessment

Twenty significant flora taxa were recovered during the flora desktop assessment. One Threatened species, *Seringia exastia*, was assigned a Medium likelihood of occurring at the Site D2 due to its proximity (<10 km) and the possibility of suitable habitat occurring. *Seringia exastia* was given a Low probability of occurring at Site G1.

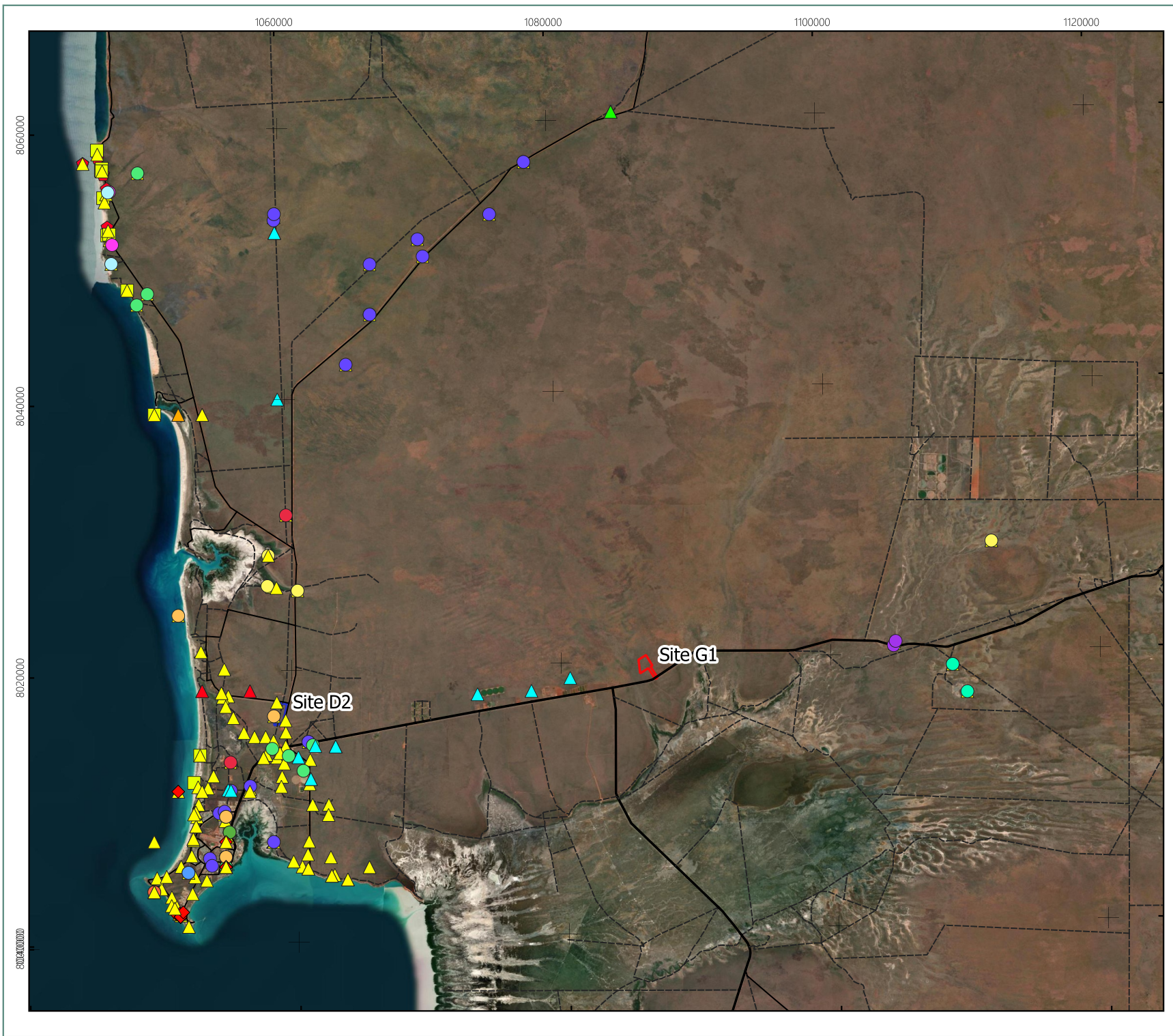
Corymbia paractia (Priority 1) was identified as Recorded within Site D2, with multiple individuals having been recorded along McGuigan Rd and Broome-Cape Leveque Rd by previous surveys. Five taxa have been assigned a High likelihood of occurrence at Site D2 due to the proximity of previous records and the occurrence of suitable habitat:

- *Jacquemontia* sp. Broome (A.A. Mitchell 3028) (Priority 1);
- *Aphyllodium glossocarpum* (Priority 3);
- *Glycine pindanica* (Priority 3);
- *Polymeria* sp. Broome (K.F. Kenneally 9759) (Priority 3); and
- *Terminalia kumpaja* (Priority 3).

Jacquemontia sp. Broome (A.A. Mitchell 3028) was given a Medium likelihood of occurrence at Site G1 due proximity of previous records and suitable habitat occurring within. No significant taxa were assigned High likelihood of occurrence at Site G1. The likelihood of occurrence for all significant flora recorded during the desktop are listed in Table 3.1 and detailed in Appendix B. Records are mapped in Map 3.1

Table 3.1: Significant Flora – Desktop Assessment

Likelihood	Status	Species
Site D2		
Recorded	Priority 1	<i>Corymbia paractia</i>
High	Priority 1	<i>Jacquemontia</i> sp. Broome (A.A. Mitchell 3028)
	Priority 3	<i>Aphyllodium glossocarpum</i> , <i>Glycine pindanica</i> , <i>Polymeria</i> sp. Broome (K.F. Kenneally 9759), <i>Terminalia kumpaja</i>
Medium	Threatened	<i>Seringia exastia</i>
	Priority 3	<i>Seringia katatona</i> , <i>Stylidium pindanicum</i>
Low	Priority 1	<i>Aphyllodium parvifolium</i> , <i>Ipomoea tolmerana</i> subsp. <i>occidentalis</i> , <i>Thespidium basiflorum</i>
	Priority 2	<i>Gomphrena pusilla</i>
	Priority 3	<i>Acacia monticola</i> x <i>tumida</i> var. <i>kulparn</i> , <i>Bonamia oblongifolia</i> , <i>Fuirena incrassata</i> , <i>Goodenia byrnesii</i> , <i>Lophostemon grandiflorus</i> subsp. <i>grandiflorus</i> , <i>Nymphoides beaglensis</i>
	Priority 4	<i>Pittosporum moluccanum</i>
Site G1		
Medium	Priority 1	<i>Jacquemontia</i> sp. Broome (A.A. Mitchell 3028)
Low	Threatened	<i>Seringia exastia</i>
	Priority 1	<i>Aphyllodium parvifolium</i> , <i>Corymbia paractia</i> , <i>Ipomoea tolmerana</i> subsp. <i>occidentalis</i> , <i>Thespidium basiflorum</i>
	Priority 2	<i>Gomphrena pusilla</i>
	Priority 3	<i>Acacia monticola</i> x <i>tumida</i> var. <i>kulparn</i> , <i>Aphyllodium glossocarpum</i> , <i>Bonamia oblongifolia</i> , <i>Fuirena incrassata</i> , <i>Glycine pindanica</i> , <i>Goodenia byrnesii</i> , <i>Lophostemon grandiflorus</i> subsp. <i>grandiflorus</i> , <i>Nymphoides beaglensis</i> , <i>Polymeria</i> sp. Broome (K.F. Kenneally 9759), <i>Seringia katatona</i> , <i>Stylidium pindanicum</i> , <i>Terminalia kumpaja</i>
	Priority 4	<i>Pittosporum moluccanum</i>



Legend

□ D2 Study Area

□ G1 Study Area

Roads

— Principal Road

— Minor Road

-- Track

Threatened flora

◆ *Seringia exastia*

Priority 1 Flora

▲ *Aphyllodium parvifolium*

▲ *Corymbia paractia*

▲ *Ipomoea tolmerana* subsp. *occidentalis*

▲ *Jacquemontia* sp. *Broome* (A.A. Mitchell 3028)

▲ *Thespidium basiflorum*

Priority 2 Flora

■ *Gomphrena pusilla*

Priority 3 Flora

● *Acacia monticola* x *tumida* var. *kulparn*

● *Aphyllodium glossocarpum*

● *Bonamia oblongifolia*

● *Fuirena incrassata*

● *Glycine pindanica*

● *Goodenia byrnesii*

● *Lophostemon grandiflorus* subsp. *grandiflorus*

● *Nymphoides beaglensis*

● *Polymeria* sp. *Broome* (K.F. Kenneally 9759)

● *Seringia katatona*

● *Stylidium pindanicum*

● *Terminalia kumpaja*

Priority 4 Flora

◆ *Pittosporum moluccanum*



0 5 10 km
Scale 1:400,000 @ A4

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Units: Meter



Author: TH

Date: 05-10-2022

Desktop Assessment Significant Flora Records

Broome Regional Resource
Recovery Park

Prepared for
Talis | Broome Shire

Map
3.1

3.1.2. Current Survey

A total of 127 taxa from 39 families and 93 genera were recorded during the survey. The most species rich family was Fabaceae, with 26 species from 14 genera recorded, followed by Poaceae with 16 species from 11 genera. The most species rich genus was *Acacia* with five species recorded. Of the 125 taxa recorded, three were significant flora and four were introduced species. The complete species list is presented in Appendix C.

3.1.2.1. Species Accumulation Curve

The species accumulation curve (SAC) is presented in Figure 3.1. The Chao 2 non-parametric species richness estimator indicated that 89.8% of flora species were recorded in the quadrats. The SAC was plotted using the *specaccum* function in the *vegan* package in R v.4. Appendix D lists the site by species matrix.

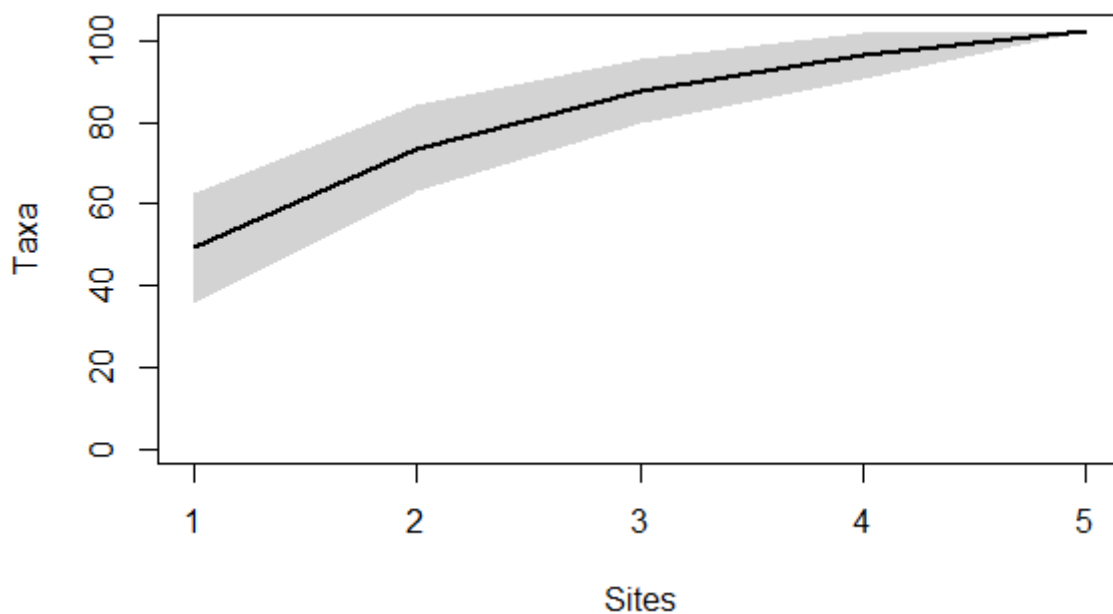


Figure 3.1: Species Accumulation Curve

3.1.2.2. Significant Flora

No Threatened Flora taxa were recorded within the Study Areas.

Three Priority Flora taxa were recorded within Site D2:

- *Corymbia paractia* (Priority 1);
- *Jacquemontia* sp. Broome (A.A. Mitchell 3028) (Priority 1); and
- *Terminalia kumpaja* (Priority 3).

No Priority species were recorded from Site G1. *Sersalisia sericea*, a PEC indicator species, was recorded within both Study Areas. The Priority species recorded are outlined in Table 3.2 and mapped in Map 3.2 and Map 3.3.

Table 3.2: Significant Flora

Taxon		Description	Study Area	# of Individuals		Photograph
P1	<i>Corymbia paractia</i>	Tree (often several-stemmed), 4-6(-12) m high, bark smooth, white, shedding in thin scales.	D2	14		
P1	<i>Jacquemontia</i> sp. Broome (A.A. Mitchell 3028)	Perennial herb or subshrub with creeping habit. Flowers pink.	D2	715		
P3	<i>Terminalia kumpaja</i>	Small tree to 6 m, bark deeply fissured and corky.	D2	80		

Map images used with permission of the Western Australian Herbarium, Department of Biodiversity, Conservation and Attractions (<https://florabase.dpaw.wa.gov.au/help/copyright>). Accessed on 15/06/2020.

Legend

Detailed Flora Survey

■ Quadrat

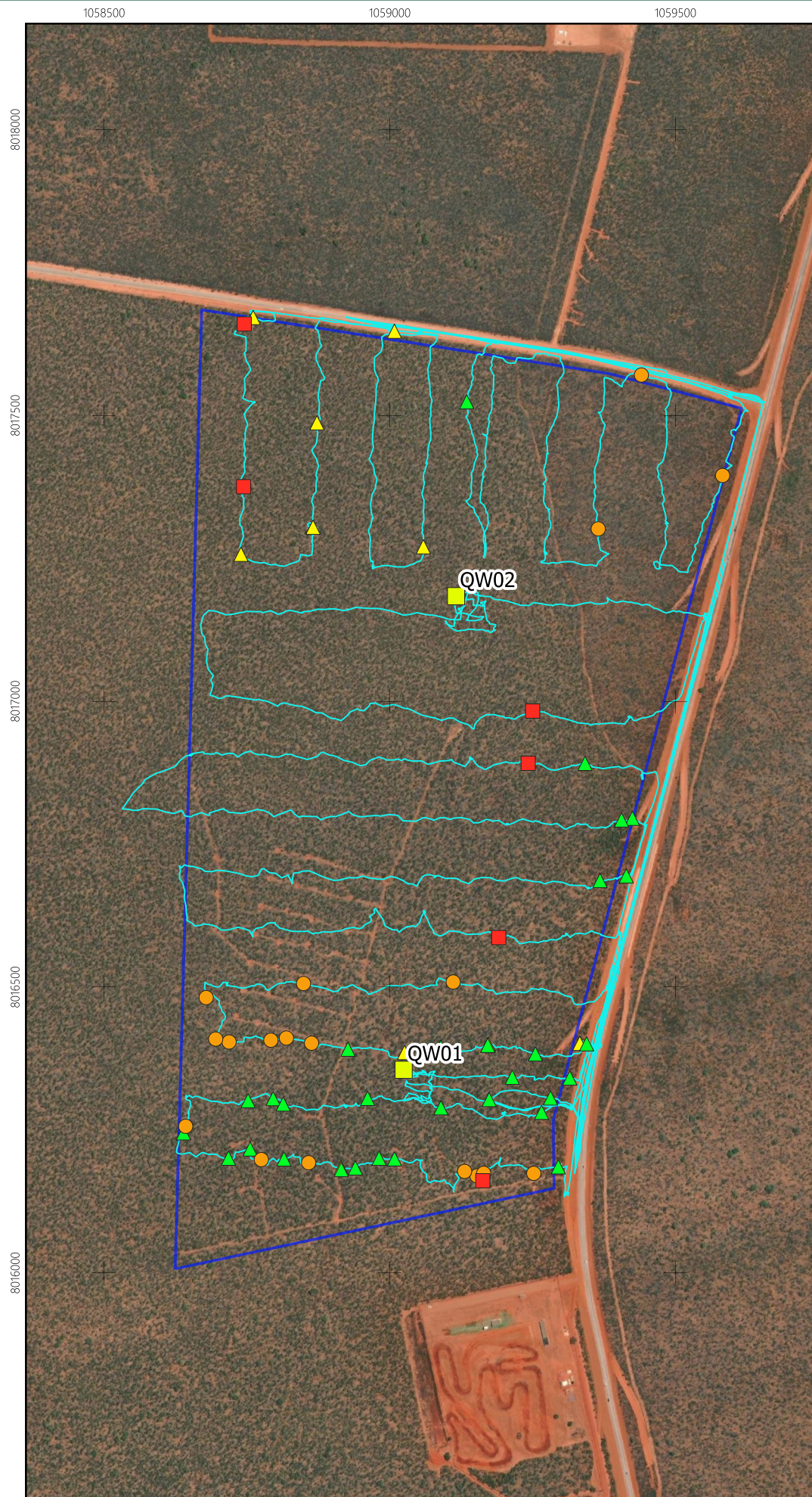
— Site Traverse

Significant Flora

▲ *Corymbia paractia* (P1)

▲ *Jacquemontia* sp. Broome (P1)

● *Terminalia kumpaja* (P3)



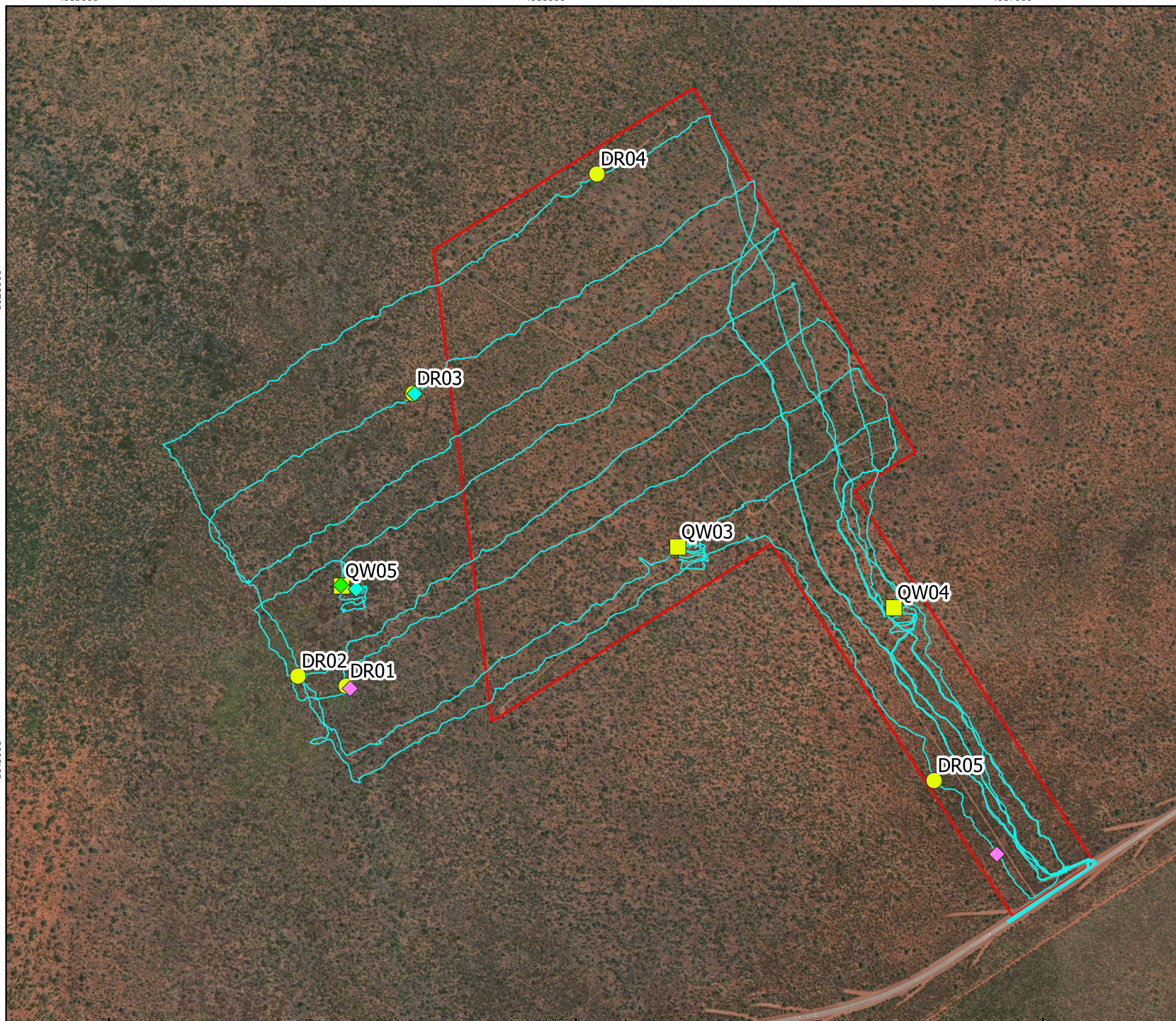
1085000

1086000

1087000

8020000

8019000



Legend

Detailed Flora Survey

- Quadrat
- Releve
- Site Traverse

Introduced Flora

- ◆ ?**Lolium perenne*
- ◆ **Conyza bonariensis*
- ◆ **Stylosanthes hamata*



0 0.2 0.4 km
Scale 1:12,000 @ A4

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum
ECOLOGICAL & SPATIAL

Author: TH

Date: 05-10-2022

G1 Study Area Significant and Introduced Flora Records

Broome Regional Resource
Recovery Park

Map

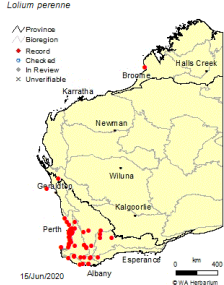
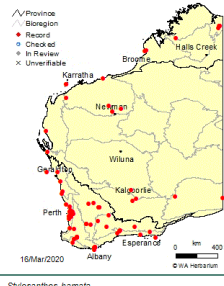
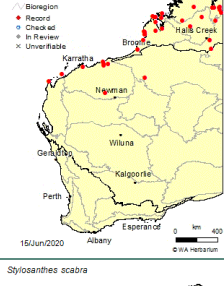
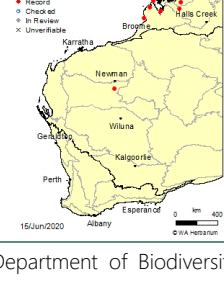
3.3

Prepared for
Talis | Broome Shire

3.1.2.3. Introduced Flora

Four introduced flora species were recorded from one quadrat and two relevé sites (Table 3.3). *Stylosanthes hamata* was the most common and was recorded at one relevé in G1 and seven opportunist collections in D2 and G1, especially near the roads. None of these species are Declared Pests in Western Australia. The records are mapped in Map 3.4.

Table 3.3: Introduced Flora Recorded at the Study Area

Family	Species	# of Individuals	Distribution	Environmental Significance
Poaceae	*? <i>Lolium perenne</i>	# of records: 2 # of plants: 4		Permitted – s11
Asteraceae	* <i>Conyza bonariensis</i>	# of records: 1 # of plants: 1		Permitted – s11
Fabaceae	* <i>Stylosanthes hamata</i>	# of records: 8 # of plants: 339		Permitted – s11
Fabaceae	* <i>Stylosanthes scabra</i>	# of records: 1 # of plants: 3		Permitted – s11

Map images used with permission of the Western Australian Herbarium, Department of Biodiversity, Conservation and Attractions (<https://florabase.dpaw.wa.gov.au/help/copyright>). Accessed on 15/06/2020.

1060000 1070000 1080000 1090000

8030000

8020000

8010000



Legend

Introduced Flora

- ▲ ?**Lolium perenne*
- ▲ **Conyza bonariensis*
- ▲ **Stylosanthes hamata*
- ▲ **Stylosanthes scabra*



0 2.5 5 km

Scale 1:170,000 @ A4

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Units: Meter

Spectrum
ECOLOGICAL & SPATIAL

Author: TH

Date: 05-10-2022

Introduced Flora

Broome Regional Resource
Recovery Park

Map

3.4

Prepared for
Talis | Broome Shire

3.2. Vegetation

3.2.1. TEC & PEC Communities

Twelve ecosystems of conservation significance, consisting of 118 records, were identified from the database search and are listed in Table 3.4 and mapped in Map 3.5.

Two floristic Threatened Ecological Communities (TECs) occur within 50 km of the Study Areas (Table 3.4). The Monsoon Thickets TEC and the Roebuck Bay Mudflats TEC are listed as Vulnerable and restricted to coastal sand dunes. The Study Areas have a low likelihood of containing the two TECs as they are not located at Roebuck Bay and they are mapped on different geological and vegetation units to the TECs.

Four Priority 1 Priority Ecological Communities (PECs) were recorded within 50 km of the Study Areas (Table 3.4). The Mangarr (Minyjuru) P1 PEC was recorded within the north-west corner of the D2 Study Area (Map 3.5). The Dwarf Pindan Heath P1 PEC and Vegetation Association 770 P1 PEC were classified as low likelihood of occurring within the Study Areas due to their location and vegetation description. The *Corymbia paractia* PEC is defined as “*C. paractia* dominated community on dunes” (DBCA, 2020). Despite the close proximity of the D2 Study Area to the known PEC (Map 3.5), the Study Area is located outside the transition zone (Map 3.6). Distribution of the mean distances between known *Corymbia paractia* PEC areas and the transition zone has been assessed and results are shown in Figure 3.2. Mean, median, and maximum values for distribution are 278 m, 225 m, and 1,199 m, respectively. The mean distance between site D2 and the transition zone is 3,076 m, with a minimum distance of 2,303 m, which is significantly larger than the distribution values. For this reason, the *C. paractia* PEC has been assigned a low likelihood of occurrence at the Study Areas.

Five Priority 3 and one Priority 4 PECs occurred within 50 km of the Study Areas (Table 3.4). The Vegetation Association 73 P3 PEC was classified as a medium likelihood of occurring within both Study Areas due to their close proximity to the PEC buffer (Map 3.5).

Table 3.4: TEC & PEC Desktop Assessment

Likelihood D2	G1	Status	PEC	Description	Distance from Project
Low	Low	Vulnerable / Endangered TEC	Monsoon Thickets	Monsoon (vine) thickets on coastal sand dunes of Dampier Peninsula.	D2 – 5.9 km SE G1 – 32.7 km SE
Low	Low	Vulnerable TEC	Roebuck Bay Mudflats	Species-rich faunal community of the intertidal mudflats of Roebuck Bay.	D2 – 0.6 km S G1 – 8.6 km SE
Low	Low	PEC P1	<i>Corymbia paractia</i>	<i>Corymbia paractia</i> dominated community on dunes.	D2 – 5.2 km SE G1 – 31.8 km E
Low	Low		Dwarf Pindan Heath	Dwarf pindan heath community of Broome coast.	D2 – 14.0 km SE G1 – 38.0 km SE
Recorded	Low		Mangarr (Minyjuru)	Relict dune system dominated by extensive stands of Minyjuru (Mangarr - <i>Sersalisia sericea</i>).	D2 – Within buffer G1 – 24.1 km E
Low	Low		Vegetation Association 770	Shrublands; Wattle thicket near Broome.	D2 – 4.9 km E G1 – 31.8 km E
Low	Low	PEC P3	Eighty Mile Land System	Beach foredunes, longitudinal coastal dunes and sandy plains with tussock grasslands and spinifex grasslands.	D2 – 41.7 km S G1 – 57.2 km SE
Low	Low		Roebuck Land System	Paleo-tidal coastal plains and tidal flats with saline soil supporting salt-water couch grasslands, samphire low shrublands, melaleuca thickets and mangroves.	D2 – 10.1 km SW G1 – 2.1 km SW
Low	Low		Vegetation Association 37	Shrublands; teatree thicket.	D2 – 31 km SW G1 – 35 km SE

Likelihood D2	G1	Status	PEC	Description	Distance from Project
Low	Low		Vegetation Association 67	Grasslands, tall bunch grass savanna, sparse low tree; ribbon grass & paperbarks.	D2 – 39.9 km SE G1 – 19.6 km E
Medium	Medium		Vegetation Association 73	Grasslands, short bunch grass savanna, grass; salt water grassland (<i>Sporobolus virginicus</i>).	D2 – 3.1 km W G1 – 1.7 km SE
Low	Low	PEC P4	Nimalarica Claypan	Nimalaica claypan is a unique, almost permanent, freshwater lake inland from Willie Creek, Broome.	D2 – 7.9 km N G1 – 26.9 km NE

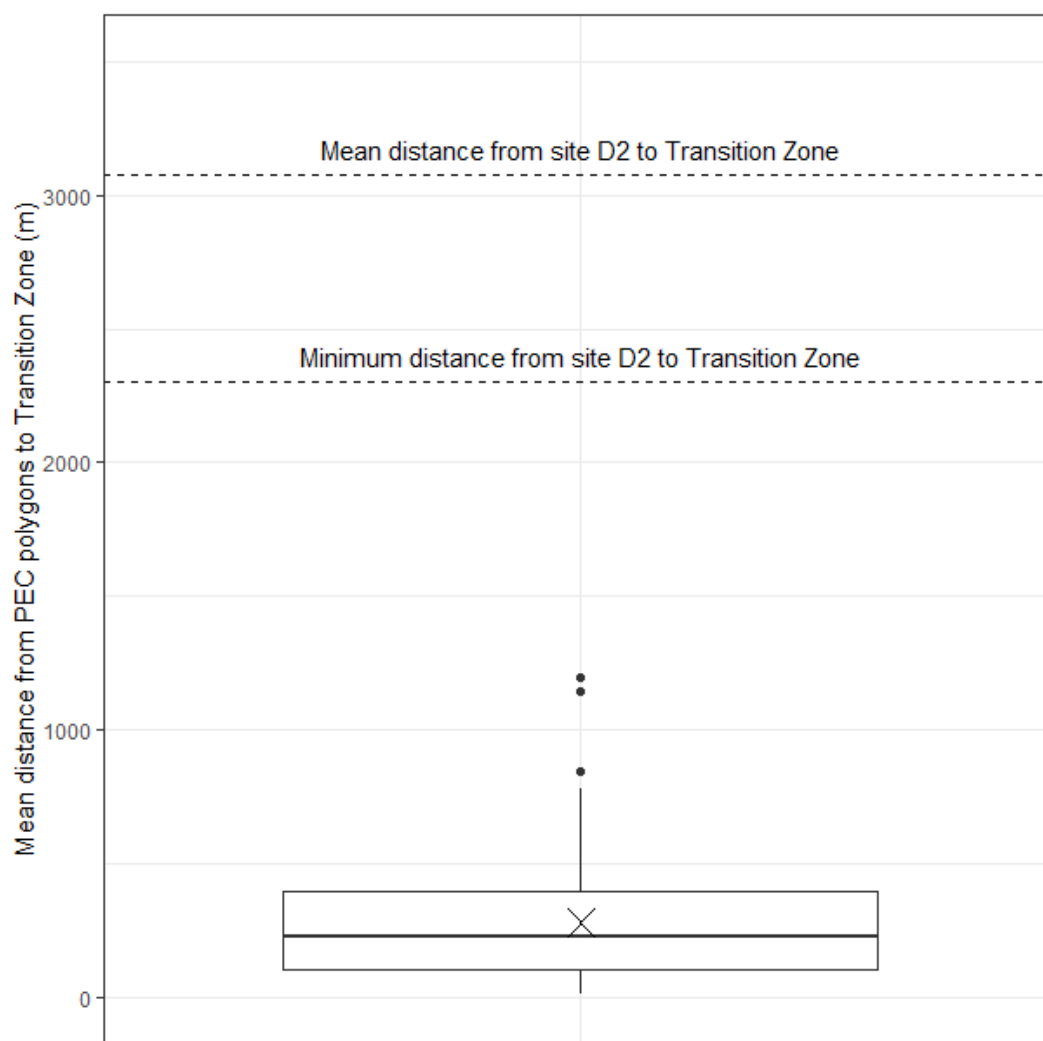
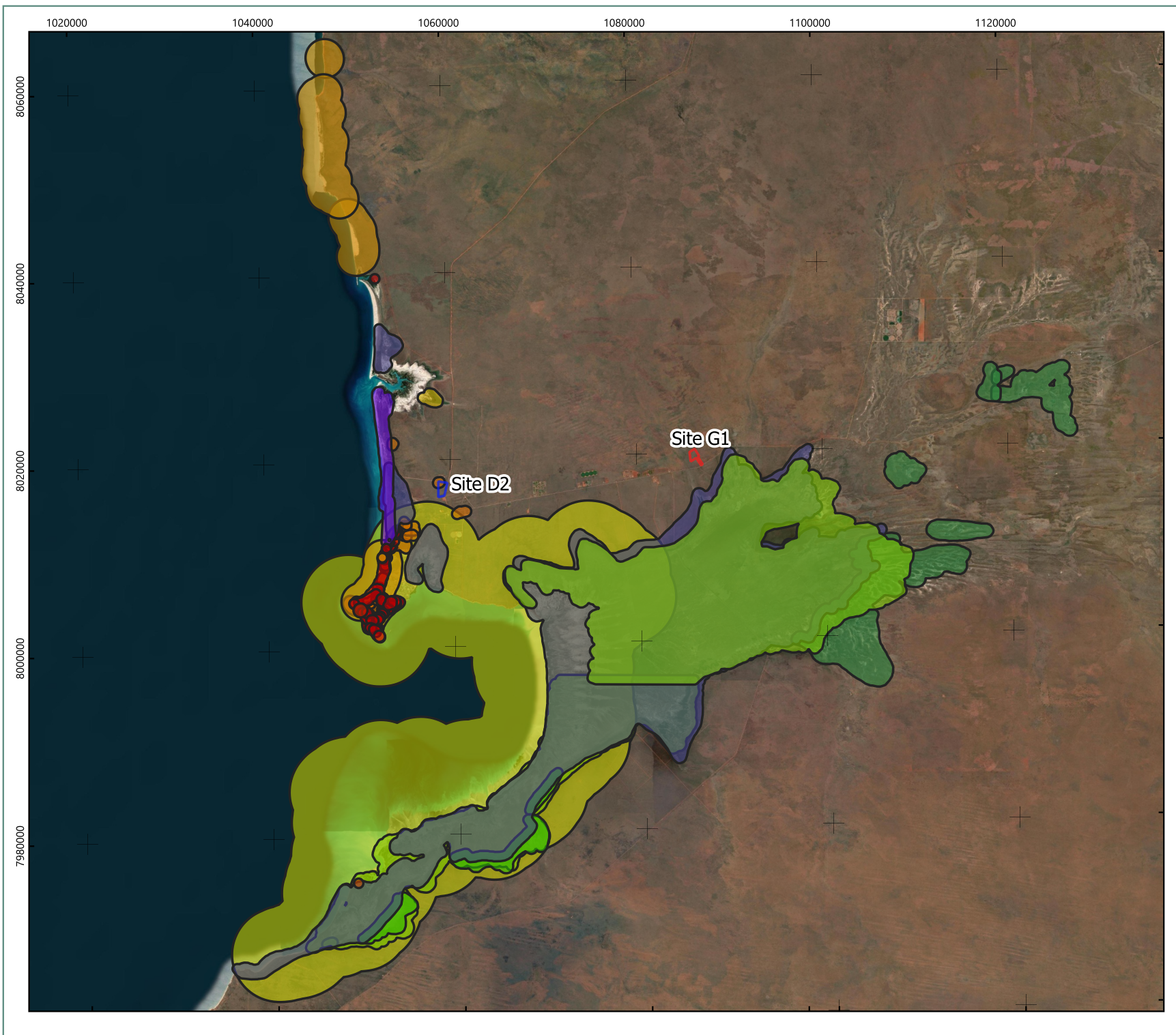


Figure 3.2: Mean Distance Distribution Between Known *C. paractia* PECs and the Newly Defined Transition Zone

The top limit of the box represents the 1st quartile, and the bottom limit represents the 3rd quartile. The width of the box represents the interquartile range (IQR). The line in the middle of the box represents the median (or 2nd quartile), and the "x" represents the mean value. The whisker lines show the location of the minimum and maximum values on each side of the box. Outlier points on top of boxplot show polygons with a mean distance to the transition zone beyond 1.5*IQR from the top end of the box.



Legend

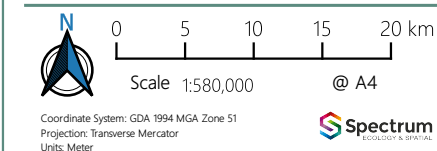
- D2 Study Area
- G1 Study Area

TEC-PEC

- Corymbia paractia
- Dwarf pindan heath
- Eighty Mile Land System
- Mangarr (Minyjuru)
- Monsoon thickets
- Nimalarica Claypan
- Roebuck Bay mudflats
- Roebuck Land System
- Vegetation Association 37
- Vegetation Association 67
- Vegetation Association 73
- Vegetation Association 770

Roads

- Principal Road
- Minor Road



Author: CS

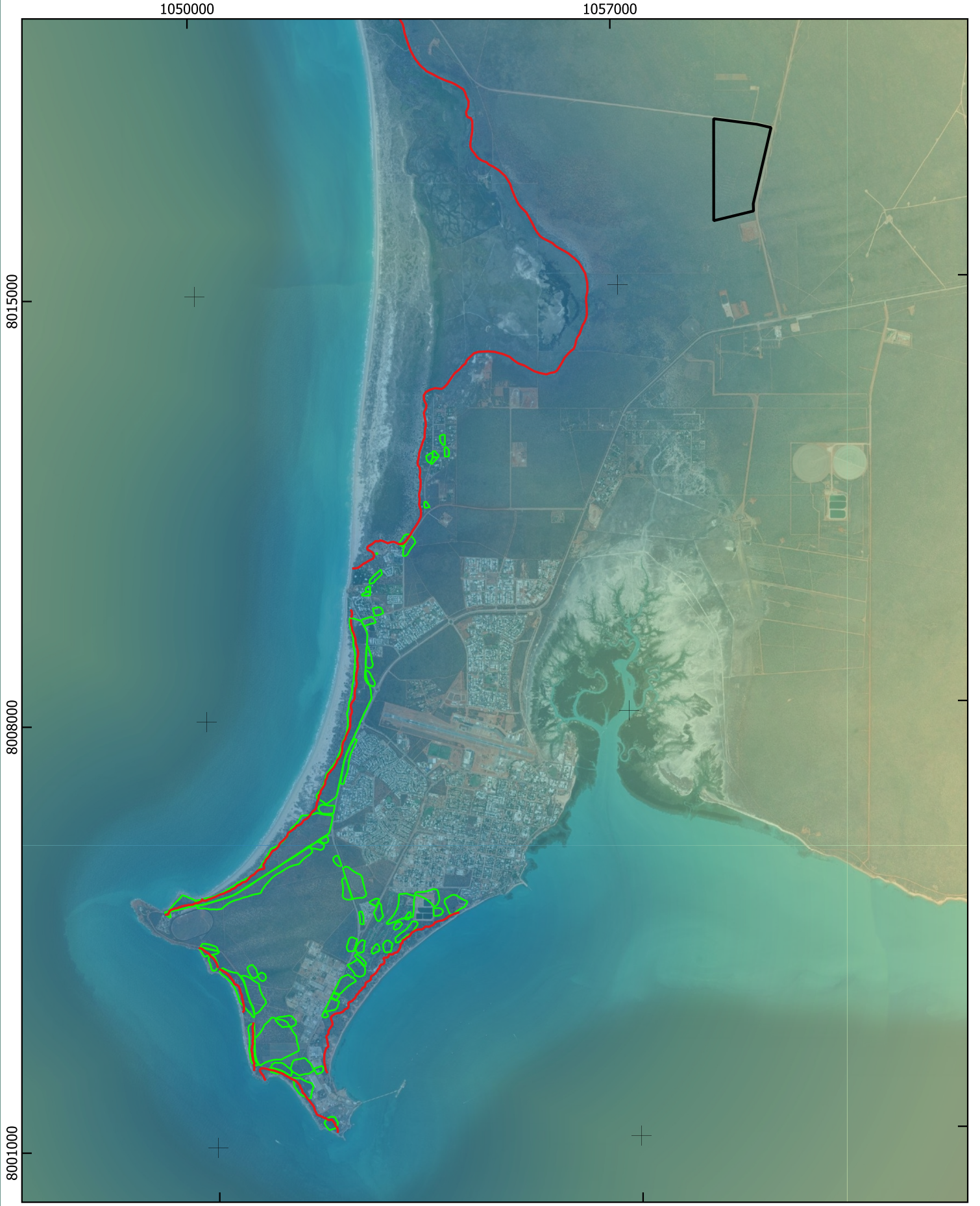
Date: 05-10-2022

TEC & PEC Search Results

Broome Regional Resource
Recovery Park

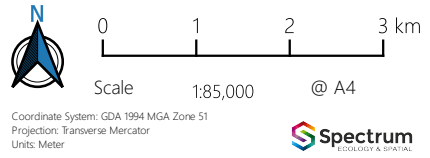
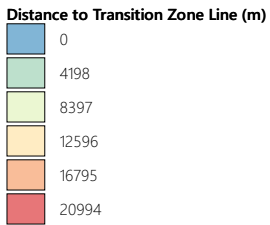
Prepared for
Talis | Broome Shire

Map
3.5



Legend

- D2 Study Area
- Corymbia paractia* PEC Areas
- Transition Line



Author: MH Approved: AH Date: 11-10-2022



Transition Zone
Mapping
Broome Regional Resource
Recovery Park
MAP
3.6

Prepared for
Talis | Broome Shire

3.2.2. Vegetation Types

Two vegetation types were recorded; however, only one vegetation type was recorded within the Study Areas. The two vegetation types are described in Table 3.5. The vegetation types at the D2 and G1 Study Areas are presented in Map 3.7 and Map 3.8, respectively. The dendrogram is presented in Figure 3.3. Two clusters containing QW01 and QW03 and QW02 and QW04 were identified in the dendrogram but were not given separate vegetation units due to the short distance or low dissimilarity (dissimilarity = 0.49) between clusters (Figure 3.3). Furthermore, the similarity in the vegetation between the two clusters was confirmed by comparing the dominant species. Site descriptions are presented in Appendix E.

Table 3.5: Vegetation Types

Unit	Description	Associated Species (Priority Species in Bold)	Quadrats	Area (ha)	Representative Photo
V001	<i>Corymbia greeniana</i> low open woodland with <i>Acacia eriopoda</i> and <i>Bauhinia cunninghamii</i> tall open shrubland, over <i>Triodia schinzii</i> and <i>Triodia caelestialis</i> low sparse hummock grassland and <i>Chrysopogon pallidus</i> and <i>Sorghum plumosum</i> low sparse tussock grassland.	<i>Acacia colei</i> var. <i>colei</i> <i>Aristida hygrometrica</i> <i>Corymbia zygophylla</i> <i>Grewia pindanica</i> <i>Corymbia paractia</i> <i>Jacquemontia</i> sp. Broome (A.A. Mitchell 3028) <i>Terminalia kumpaja</i>	QW01 QW02 QW03 QW04	220	
V002	<i>Brachychiton diversifolius</i> subsp. <i>diversifolius</i> low open woodland over, <i>Atalaya hemiglauc</i> , <i>Codonocarpus cotinifolius</i> , and <i>Grewia pindanica</i> mid sparse shrubland, over <i>Aristida holathera</i> var. <i>latifolia</i> sparse tussock grassland.	<i>Acacia platycarpa</i> <i>Bauhinia cunninghamii</i> <i>Triodia schinzii</i>	QW05	0	

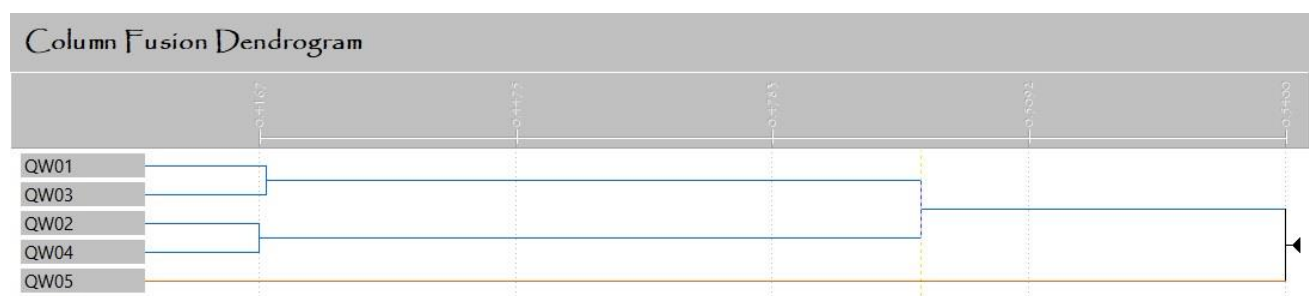



Figure 3.3: Dendrogram of Floristic Analysis

3.2.3. Vegetation Condition

The two Study Areas were mapped as having Excellent (100%) vegetation condition. Weeds were rarely recorded in the Study Areas Map 3.4.

Legend

 D2 Study Area

Detailed Flora Survey

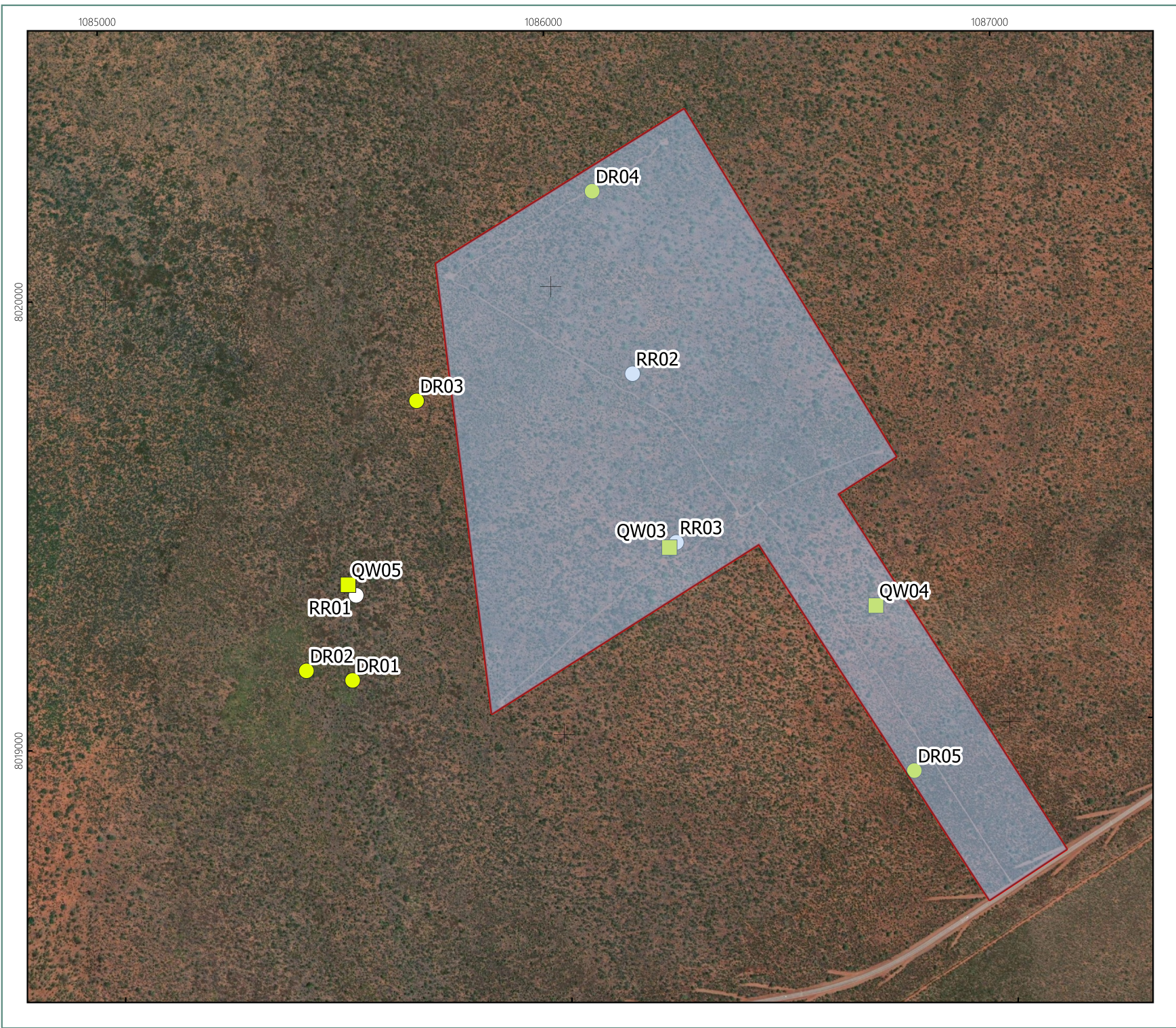
 Quadrat

 Releve

Vegetation Units

 V001





Legend

G1 Study Area

Detailed Flora Survey

Quadrat

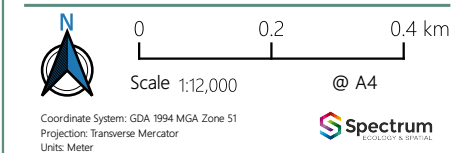
Releve

Reconnaissance Flora Survey

Releve

Vegetation Units

V001



Author: CS

Date: 11-10-2022

G1 Study Area Vegetation Mapping

Broome Regional Resource
Recovery Park

Prepared for
Talis | Broome Shire

Map
3.8

4. DISCUSSION

4.1. Threatened Flora

No Threatened Flora taxa were recorded in the current survey or considered likely to occur.

One Threatened Flora taxon was recorded during the desktop assessment, *Seringia exastia*, located 9 km south-west of Site D2 and 33 km south-west of Site G1.

4.1.1. Local & Regional Significance

There were three significant flora taxa recorded from Site D2, *Corymbia paractia* (Priority 1), *Terminalia kumpaja*, and *Jacquemontia* sp. Broome (A.A. Mitchell 3028). Other significant flora taxa assessed in the desktop were thoroughly searched for but were not found.

Corymbia paractia (Priority 1) was confirmed to occur in Site D2, where it was Recorded in the desktop assessment. Site D2 is within the modelled distribution of the species that was performed by Environs Kimberley (2018). A previous record of *Terminalia kumpaja* (Priority 3) was within 40 m of the Site D2, and it was recorded as occurring from Site D2 at 18 new locations. Thirty-one new locations of *Jacquemontia* sp. Broome (A.A. Mitchell 3028) were recorded from Site D2.

The three Priority taxa recorded from Site D2 were assigned a Low local and regional significance. This is in addition to *Glycine pindanica* (Priority 3) that was given a High likelihood of occurring in Site D2 during the desktop assessment, but which was not recorded during the survey. These taxa are locally common around the Broome area, as well as being known from additional records in the region that were outside of the 50 km database search radius.

Aphyllodium glossocarpum (Priority 3) was also assigned a High likelihood of occurring at Site D2 in the desktop assessment. This species was ranked as having a High local significance if it were to be found at the Study Area, as it is known from only two previous records around Broome, which was it was reported as the sole individual when collected. Given the effort of the current survey, it is unlikely that this species occurs within either Study Area. While maybe rare or under-collected in the Broome area, the species is known from records north to Dampier Peninsula and in the Shire of Wyndham-East Kimberley, and for this reason is considered to have a Low regional significance.

Table 4.1: Priority Flora of Local & Regional Significance

Taxa	Recorded in Survey	Desktop Likelihood	Local Significance	Regional Significance		
Priority 1						
<i>Corymbia paractia</i>	Yes	Recorded (D2)	Locally common in the near-coastal areas around Broome.	Low	Recorded from the Dampierland IBRA region, from Broome townsite to Coulomb Point Nature Reserve. An outlying record exists north of Camballin.	Low
		Low (G1)				
<i>Jacquemontia</i> sp. Broome (A.A. Mitchell 3028)	Yes	High (D2)	Known from several previous locations in the vicinity of Broome.	Low	Recorded from the Dampierland IBRA region, with most records around Broome townsite.	Low
		Medium (G1)				
Priority 3						
<i>Aphyllodium glossocarpum</i>	No	High (D2)	Known from two records in the local area, where it was recorded as rare.	High	Known from records from Broome townsite to Shire of Wyndham-East Kimberley.	Low
		Low (G1)				
<i>Glycine pindanica</i>	No	High (D2)	Many records in the local area. Recorded on a widespread landform type that is not restricted.	Low	Recorded from the Dampierland IBRA region from Broome townsite to the Dampier Peninsula.	Low
		Low (G1)				
<i>Terminalia kumpaja</i>	Yes	High (D2)	Known from several previous locations in the vicinity of Broome.	Low	Recorded from the Dampierland and Great Sandy Desert IBRA regions. More common and widespread in the vicinity of Eighty Mile Beach.	Low
		Low (G1)				

4.2. Vegetation

4.2.1. Vegetation Resembling TEC/PEC

Two TECs and ten PECs were recorded within 50 km of the Study Areas and of these the Mangarr (Minyjuru) PEC was recorded within the D2 Study Area in the desktop assessment (Map 3.5). and the *Corymbia paractia* PEC was assigned a high likelihood of occurrence within the D2 Study Area.

The Mangarr PEC “contains frequent mature (100 years +) *Sersalisia sericea* or otherwise known as Minyjuru” and occurs on parallel dunes in the area south east of Gantheaume Point (DBCA, 2020). Stands of *Sersalisia sericea* (Minyjuru) occur in association with the Monsoon vine thicket TEC (DBCA, 2020). Woodland and desert/aridlands plant species associated with Mangarr PEC and records of these plant species during the detailed flora survey are presented in Table 4.2.

Table 4.2: Mangarr (Minyjuru) PEC *Sersalisia sericea* & Associated Plant Species

Associated Taxa	D2 Records			G1 Records		
	QW01 Cover %	QW02 Cover %	Opportunistic Count #	QW03 Cover %	QW04 Cover %	Opportunistic Count #
<i>Sersalisia sericea</i>	-	-	10	-	-	1
<i>Corymbia zygophylla</i>	1.0	-	1	-	0.2	-
<i>Corynotheca micrantha</i>	-	-	-	-	-	-
<i>Erythrophleum chlorostachys</i>	-	-	-	-	-	-
<i>Goodenia sepalosa</i>	0.01	0.01	-	0.01	-	-
<i>Gyrostemon tepperi</i>	0.1	-	-	-	-	-
<i>Hakea macrocarpa</i>	-	-	-	-	0.01	-
<i>Scaevola parvifolia</i>	-	-	-	-	-	1
<i>Senna costata</i>	-	0.01	-	0.25	-	-
<i>Solanum cunninghamii</i>	-	-	-	-	-	-
<i>Triodia</i> species	25	17	-	3	5	-

Ten *Sersalisia sericea* trees were identified at six locations within the D2 Study Area (Table 4.2; Map 3.2). Four *Sersalisia sericea* trees occurred within the existing PEC at D2 and were likely recorded by Willing & Beames (2015) during the mapping and condition assessment of the Mangarr PEC. Six *Sersalisia sericea* trees were located 200–250 m from the D2 Study Area’s eastern boundary (Map 3.2). Three of these *Sersalisia sericea* trees were located outside the PEC but within the D2 Study Area and were recorded by Willing & Beames (2015). Willing & Beames (2015) did not classify this small cluster of trees as a Mangarr PEC as they exist outside defined patches due to historical clearing and the degradation of vegetation. It is unlikely the *Sersalisia sericea* trees recorded outside the existing Mangarr PEC but within the D2 Study Area represent the PEC based on previous mapping of its distribution by Willing & Beames (2015). Willing & Beames (2015) suggested the outlier *Sersalisia sericea* trees be protected from clearing.

A single *Sersalisia sericea* tree was recorded at the G1 Study Area (Table 4.2). The individual *Sersalisia sericea* tree recorded at the G1 Study Area does not represent the Mangarr PEC as there were no frequent mature individuals recorded in the detailed flora survey (Table 4.2).

The *Corymbia paractia* PEC is described as “*Corymbia paractia* dominated community on dunes” (DBCA, 2020). The current *Corymbia paractia* PEC occurs in the Broome township area, and the PEC may occur in the transition zone between coastal vine thickets and Pindan vegetation (DBCA, 2020). Distribution

modelling of *Corymbia paractia* indicates the species is common in vegetation surrounding Broome and the species was previously recorded at the D2 Study Area (Environs Kimberley, 2018). During the current survey, *Corymbia paractia* was recorded 10 times (13 individuals) within the D2 Study Area (Map 3.1; Map 3.2). However, spatial definition of the distribution of mean distances from the *C. paractia* PEC to the transition zone indicates that the D2 Study Area is located outside possible distribution of the PEC (Map 3.6). Based on this, the *Corymbia paractia* PEC is therefore unlikely to occur at the D2 Study Area.

4.2.2. Local & Regional Significance

Regional significance was determined by comparing the vegetation units of the Project with the pre-European vegetation association mapping undertaken by Beard (DPIRD, 2019; see Section 1.5) to determine potential regional extent. Local significance was determined using the other definitions for significant vegetation (Section 2.4); whether it plays a role as refuge, has a degree of historical impact from threatening processes or maintains integrity of a significant ecosystem.

The Beard vegetation unit associated with the two Study Areas has a wide distribution throughout the Dampierland IBRA region. The Study Areas represent a small fraction of the Yeeda and Wanganut Land Systems which are widespread across the Dampierland IBRA region and Western Australia. The V001 vegetation type mapped at both Study Areas have a low regional significance.

The V001 vegetation unit mapped at both Study Areas is considered to have a low significance. The D2 Study Area overlaps with a Mangarr PEC; however, this PECs is not locally restricted. The V001 vegetation unit provides refuge to three significant flora, these three species recorded at the D2 Study Area are locally and regionally widespread. *Corymbia paractia* is locally abundant, despite being significant and regionally restricted to vegetation surrounding the township of Broome. It was recorded from ten locations within the D2 Study Area, which lies just outside the modelled historical extent of the species (Environs Kimberley, 2018).

4.3. Principles for Clearing Native Vegetation

An assessment on how the proposed vegetation clearing applies to the native vegetation clearing principles is present below in Table 4.3

Table 4.3: 10 Native Vegetation Clearing Principles

Principle Number	Principle	Assessment	Outcome
(a)	It comprises a high level of biological diversity.	<p>There was one vegetation type identified from the Study Areas derived from flat Pindan Plains. There were 127 taxa from 39 families and 93 genera were recorded during the survey. The proportion of flora collected was consistent with expectations for this type of survey and survey timing in the context of other surveys of a similar level and seasonality. Both Study Areas fall in the 750.1 Pre-European Vegetation mapping classification. This vegetation unit covers more than 1.2 million hectares, of which, approximately 99% is undisturbed.</p> <p>There were 31 and 38 vertebrate fauna species found within the D2 and G1 Study Areas, respectively.</p> <p>Given the species count, vegetation types, literature review and the Pre-European vegetation units, the vegetation at the Study Areas is not considered to have a high level of biological diversity.</p>	The Proposal at the Study Areas is not likely to be at variance to this Principle.
(b)	It comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.	The Pindan shrubland habitat that occurs in the Study Areas is homogenous and the microhabitats present are not thought likely to support short range endemic invertebrate species. Overall, the Pindan Shrubland habitat recorded from within the Study Areas occurs across a large continuous extend across the Dampier Peninsula, which indicates that there is a low likelihood that the habitat within the Study Areas supports any taxa with a distribution restricted to either Study Area.	The Proposal at the Study Areas is not likely to be at variance to this Principle.

Principle Number	Principle	Assessment	Outcome
(c)	It includes, or is necessary for the continued existence of, rare flora.	<p>No Threatened Flora were recorded in the reconnaissance or detailed survey at the D2 and G1 Study Areas. One Threatened Flora species <i>Seringia exastia</i> was identified in the database searches. This species was considered to have a medium likelihood of occurrence at D2 and a low likelihood of occurrence at G1. <i>Seringia exastia</i> was not recorded during the exhaustive detailed and targeted assessment.</p> <p>Three Priority Flora, <i>Corymbia paractia</i> (P1), <i>Jacquemontia</i> sp. Broome (P1), and <i>Terminalia kumpaja</i> (P3) were recorded within the D2 Study Area. Nineteen Priority Flora were recorded in the desktop assessment, <i>Aphyllodium glossocarpum</i> (P3), <i>Glycine pindanica</i> (P3), and <i>Polymeria</i> sp. Broome (P3) were considered to have a high likelihood of occurrence in the D2 Study Area.</p> <p>Although the D2 Study Area includes conservation significant flora and has appropriate habitat for conservation significant flora, clearing of the D2 Study Area is unlikely to threaten the continued existence of the recorded Priority Flora and other Priority Flora with High Likelihood of occurrence. Vegetation at the D2 Study Area is not necessary for the continued existence of this conservation significant flora. The disturbance footprint within the D2 Study Area can be located in an area that avoids recorded conservation significant flora.</p> <p>No Priority Flora were recorded at the G1 Study Area.</p> <p>Although the G1 Study Area has appropriate habitat for conservation significant flora, clearing of the G1 Study Area is unlikely to threaten the continued existence of these Priority Flora.</p>	<p>The Proposal at the D2 Study Area is not likely to be at variance to this Principle.</p> <p>The Proposal at the G1 Study Area is not likely to be at variance to this Principle.</p>

Principle Number	Principle	Assessment	Outcome
(d)	It comprises the whole or a part of, or is necessary for the maintenance of a threatened ecological community.	<p>No Threatened Ecological Communities were recorded within the D2 and G1 Study Areas. One federally listed TEC (State listed Vulnerable) was identified from the database searches, Monsoon vine thicket. An additional State listed, Vulnerable Ecological Community, Roebuck Bay mudflats was identified from the database searches. These ecological communities are associated with riparian vegetation and do not resemble any vegetation communities of the Study Areas.</p> <p>The buffers of two P1 Priority Ecological Communities (PEC) were recorded in the D2 Study Area during the database searches. The Mangarr (Minyjuru) PEC is described as "relict dune system dominated by extensive stands of Minyjuru (Mangarr - <i>Sersalisia sericea</i>)". The Mangarr PEC was previously recorded in the north-west corner of the D2 Study Area. During the survey, <i>Sersalisia sericea</i> trees were targeted during the 100 m spaced traverses and six trees were recorded outside the current PEC boundary in the north-west corner; however, it is unlikely these trees represent the Mangarr PEC based on previous surveys of the Study Area.</p> <p>The <i>Corymbia paractia</i> PEC is described as "<i>Corymbia paractia</i> dominated community on dunes". Distribution modelling completed for mean distances between <i>C. paractia</i> PEC to the transition zone indicates that the D2 Study Area lies outside the potential distribution of the PEC, and that it is likely that the <i>Corymbia paractia</i> PEC occurs at site D2.</p> <p>No PECs or TECs were recorded from the G1 Study Area. Three PECs are within 10 km to the south of the G1 Study Area. Each of these PECs are associated with riparian communities and do not occur at the G1 Study Area.</p> <p>Native vegetation at the G1 Study Area does not comprise the whole or part of, or is necessary for the maintenance of a TEC.</p>	<p>The Proposal at the D2 Study Area is somewhat at variance to this Principle.</p> <p>The Proposal at the G1 Study Area is not likely to be at variance to this Principle.</p>
(e)	It is significant as a remnant of native vegetation in an area that has been extensively cleared.	<p>The Study Areas are 100% comprised of the 750.1 Beard vegetation unit. The vegetation unit is widespread and 99.7% of its pre-European extent remains. The Study Areas represent a small fraction of the vegetation unit. The vegetation at the Study Areas is not significant as the vegetation unit has not been extensively cleared.</p>	<p>The Proposal at the Study Areas is not likely to be at variance to this Principle.</p>

Principle Number	Principle	Assessment	Outcome
(f)	It is growing in, or in association with, an environment associated with a watercourse or wetland.	No nationally significant wetlands, including Ramsar wetlands or watercourses were located within the Study Areas. The D2 Study Area occurs 1 km north of the buffer surrounding the Roebuck bay Mudflats; Species-rich faunal community of the intertidal mudflats of Roebuck Bay.	The Proposal at the Study Areas is not likely to be at variance to this Principle.
(g)	The clearing of the vegetation is likely to cause appreciable land degradation.	The total area to be cleared at the D2 Study Area is 2.5 ha. The Total area to be cleared at the G1 Study Area is 3.0 ha. Considering the small area proposed to be cleared, the history of minimal land clearing in the area and existing vegetation condition of the Study Area, it is unlikely that the proposed clearing will cause appreciable land degradation.	The Proposal at the Study Areas is not likely to be at variance to this Principle.
(h)	The clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.	One conservation area, Yawuru Birragun Conservation Park (WA_52354) is adjacent and directly west of the D2 Study Area. Clearing of approximately 2.5 ha to establish temporary tracks, bore holes and trial pits at the D2 Study Area is unlikely to impact the environmental values of this area. No conservation areas are within the vicinity of the G1 Study Area as defined by the Land Management Act (1984) as National Parks, Nature Reserves, Conservation Reserve or other areas managed for biodiversity conservation. The clearing of vegetation (3.0 ha) in the G1 Study Area is not considered to impact on the environmental values of any adjacent or nearby conservation area.	The Proposal at the Study Areas is not likely to be at variance to this Principle.
(i)	The clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.	The proposed clearing of native vegetation at D2 (2.5 ha) and G1 (3.0 ha) to establish temporary tracks, bore holes and trial pits at the Study Areas is not expected to cause deterioration in the quality of surface or underground water. Further site investigation works including hydrological surveys will provide more information as the project matures.	The Proposal at the Study Areas is not likely to be at variance to this Principle.

Principle Number	Principle	Assessment	Outcome
(j)	The clearing of the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.	The remnant vegetation proposed to be cleared at the D2 and G1 Study Areas is 2.5 ha and 3.0 ha, respectively. These areas are small and are not expected to cause or exacerbate the instance of flooding.	The Proposal at the Study Areas is not likely to be at variance to this Principle.

5. CONCLUSION

5.1. Threatened Flora

No Threatened Flora have previously been recorded within the Study Areas. One Threatened Flora taxon was assigned a medium likelihood of occurrence, *Seringia exastia*, but was not found in the current survey.

5.2. Significant Flora

A total of three Priority Flora taxa have been recorded within the Study Areas:

- *Corymbia paractia* (Priority 1);
- *Jacquemontia* sp. Broome (A.A. Mitchell 3028) (Priority 1); and
- *Terminalia kumpaja* (Priority 3).

All Priority Flora taxa recorded in the Study Areas were assessed to have Low local and regional significance.

5.3. Vegetation

Twelve ecosystems of conservation significance were recorded in the vicinity of the Study Areas.

The Desktop Assessment found the Mangarr (Minyjuru) (P1) Priority Ecological Community was present in north-west corner of the D2 Study Area. Scattered *Sersalisia sericea* (Minyjuru) trees were recorded in the D2 Study Area but were unlikely to indicate the presence of the Mangarr PEC based on previous surveys.

The *Corymbia paractia* P1 PEC is unlikely to occur within the Study Areas based on the distance of the sites to the transition zone (>2,303 m). TEC or PECs are not likely to occur within the G1 Study Areas.

One vegetation unit (V001) was mapped at the two Study Areas. The vegetation unit is not likely to have local and regional significance.

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Appendix A: Conservation Codes



Appendix A1: Definitions of Conservation Categories under the EPBC Act

Category	Definition
Extinct	A native species is eligible to be included in the extinct category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
Extinct in the Wild	A native species is eligible to be included in the extinct in the wild category at a particular time if, at that time: (a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered	A native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered	A native species is eligible to be included in the endangered category at a particular time if, at that time: (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable	A native species is eligible to be included in the vulnerable category at a particular time if, at that time: (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.
Conservation Dependent	A native species is eligible to be included in the conservation dependent category at a particular time if, at that time: (a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory; (iv) cessation of the plan of management would adversely affect the conservation status of the species.

Appendix A2: Definitions of Conservation Categories under the BC Act (DBCA 2019)

Threatened Species: Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as Threatened species under section 26(2) of the Biodiversity Conservation Act 2016 (BC Act).

Threatened fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for Threatened Fauna.

Threatened Flora is that subset of 'Rare Flora' listed under schedules 1 to 3 of the Wildlife Conservation (Rare Flora) Notice 2018 for Threatened Flora.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.

Category	Definition
CR	<p>Critically endangered species</p> <p>Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines".</p> <p>Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for critically endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for critically endangered flora.</p>
EN	<p>Endangered species</p> <p>Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines".</p> <p>Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for endangered flora.</p>
VU	<p>Vulnerable species</p> <p>Threatened species considered to be "facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines".</p> <p>Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for vulnerable fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for vulnerable flora.</p>

Extinct species: Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild.

Category	Definition
EX	<p>Extinct species</p> <p>Species where "there is no reasonable doubt that the last member of the species has died", and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act).</p> <p>Published as presumed extinct under schedule 4 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for extinct fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for extinct flora.</p>
EW	<p>Extinct in the wild species</p> <p>Species that "is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere</p>

	<p>in its past range, despite surveys over a time frame appropriate to its life cycle and form”, and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act).</p> <p>Currently there are no Threatened fauna or Threatened Flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.</p>
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Specially protected species: Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection.

Species that are listed as Threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.

MI	<p>Migratory species</p> <p>Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act).</p> <p>Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals, that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species.</p> <p>Published as migratory birds protected under an international agreement under schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.</p>
CD	<p>Species of special conservation interest (Conservation dependant fauna)</p> <p>Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as Threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act).</p> <p>Published as conservation dependent fauna under schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.</p>
OS	<p>Other specially protected species</p> <p>Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act).</p> <p>Published as other specially protected fauna under schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.</p>

¹ The definition of flora includes algae, fungi and lichens.

² Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).

Appendix A3: Definitions of Priority Species Classification (DBCA 2019)

Priority species: Possibly Threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of Priority for survey and evaluation of conservation status so that consideration can be given to their declaration as Threatened fauna or flora.

Species that are adequately known, are rare but not Threatened, or meet criteria for near Threatened, or that have been recently removed from the Threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

Category	Definition
P1	<p>Priority 1: Poorly-known species</p> <p>Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.</p>
P2	<p>Priority 2: Poorly-known species</p> <p>Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.</p>
P3	<p>Priority 3: Poorly-known species</p> <p>Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.</p>
P4	<p>Priority 4: Rare, Near Threatened and other species in need of monitoring</p> <p>(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently Threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands.</p> <p>(b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent.</p> <p>(c) Species that have been removed from the list of Threatened species during the past five years for reasons other than taxonomy</p>

Appendix A4: Legal Status Definition of Listed Plants in Western Australia

Legal Status	Definition
Declared Pest, Prohibited – s12	Prohibited organisms are declared pests by virtue of section 22(1) and may only be imported and kept subject to permits.
Declared Pest – s22(2)	Declared pests must satisfy any applicable import requirements when imported and may be subject to control keeping requirements.
Permitted – s11	Permitted organisms must satisfy applicable import requirements and import permits (where required).
Permitted, Requires Permit – r73	Regulation 73 permitted organisms may be subject to restriction under legislation other than the BAM Act (2007).
Unlisted	Unlisted organisms are prohibited in WA.
Control Categories	Definition
C1 Exclusion	Organisms should be excluded from parts or all of WA.
C2 Eradication	Organisms should be eradicated from all or parts of WA.
C3 Management	Organisms should have some form of management applied that will alleviate the harmful impact of the organism, reduce the numbers or distribution of the organism or prevent or contain the spread of the organism.
Unassigned	Declared pest that are recognised as having a harmful impact under certain circumstances where their subsequent control requirements are determined by a plan or other legislative arrangements under the Act.
Keeping Categories	Definition
Prohibited keeping	Can only be kept under a permit for public display, education or scientific purposes.
Restricted keeping	Kept under a permit by private individuals due to a low risk of becoming a problem for the environment.
Exempt keeping	No permit or conditions are required for keeping. Organism may be subject to restrictions under the Wildlife Conservation Act (WCA, 1950).

Appendix B: Flora Desktop Assessment



Status	Family	Taxon	Description	Habitat	Closest Record to D2 (km)	Closest Record to G1 (km)	Likelihood (D2)	Likelihood (G1)
P3	Fabaceae	<i>Acacia monticola</i> x <i>tumida</i> var. <i>kulparn</i>	Low shrub. Hybrid of <i>Acacia monticola</i> and <i>A. tumida</i> var. <i>kulparn</i> .	Coastal cliffs.	10	33	Low	Low
P3	Fabaceae	<i>Aphyllodium glossocarpum</i>	Spreading or erect shrub, to 1.2 m high. Flowers pink-purple.	Sand. Pindan.	4	28	High	Low
P1	Fabaceae	<i>Aphyllodium parvifolium</i>	Trailing shrub, to 0.3 m high. Flowers purple-pink.	Sand. Sandhills.	22	38	Low	Low
P3	Convolvulaceae	<i>Bonamia oblongifolia</i>	Perennial herb or shrub. Flowers blue.	Sandy or gravelly soils.	36	50	Low	Low
P1	Myrtaceae	<i>Corymbia paractia</i>	Tree 4-6(-12) m high, bark smooth, white, shedding in thin scales. Flowers white.	Skeletal soils. In transition zone between coastal beach dunes & red pindan soils.	0	24	Recorded	Low
P3	Cyperaceae	<i>Fuirena incrassata</i>	Annual sedge 0.1-0.3 m high, perianth of 3 bristles and 3 clawed scales; scales 3-veined in basal part and thickened distally.	Sand, sandy clay. Swamps, creek beds, claypans, semi-saline lakes.	45	18	Low	Low
P3	Fabaceae	<i>Glycine pindanica</i>	Prostrate or scrambling perennial, herb or climber. Flowers pink/blue-purple.	Pindan soils.	2	25	High	Low
P2	Amaranthaceae	<i>Gomphrena pusilla</i>	Slender branching annual herb, to 0.2 m high. Flowers white.	Fine beach sand. Behind foredune, on limestone.	6	33	Low	Low
P3	Goodeniaceae	<i>Goodenia byrnesii</i>	Prostrate to decumbent herb, stems to 30 cm. Flowers yellow.	Sand. Edge of creek.	13	36	Low	Low
P1	Convolvulaceae	<i>Ipomoea tolmerana</i> subsp. <i>occidentalis</i>	Perennial vine with mid mauve flowers, growing up to 1 m tall.	Red pindan plain.	49	39	Low	Low
P1	Convolvulaceae	<i>Jacquemontia</i> sp. Broome (A.A. Mitchell 3028)	Perennial herb or subshrub. Flowers pink.	Red pindan plain.	1	5	High	Medium
P3	Myrtaceae	<i>Lophostemon grandiflorus</i> subsp. <i>grandiflorus</i>	Tree 4-8 m high. Flowers cream-white.	Damp habitats (swamps, seepages).	34	49	Low	Low
P3	Menyanthaceae	<i>Nymphoides beaglensis</i>	Aquatic annual herb. Flowers white/white-pink-purple.	Edges of permanent waterholes or in seasonally inundated claypans & depressions.	22	49	Low	Low

Status	Family	Taxon	Description	Habitat	Closest Record to D2 (km)	Closest Record to G1 (km)	Likelihood (D2)	Likelihood (G1)
P4	Pittosporaceae	<i>Pittosporum moluccanum</i>	Tree 2-6 m high. Flower white.	White sand. Sand dunes.	37	50	Low	Low
P3	Convolvulaceae	<i>Polymeria</i> sp. Broome (K.F. Kenneally 9759)	Perennial herb or subshrub. Flowers pink.	Red pindan plain.	2	23	High	Low
T	Malvaceae	<i>Seringia exastia</i>	Erect compact multi-stemmed shrub to 0.9 m high. Flowers purple.	Red pindan plain.	9	33	Medium	Low
P3	Malvaceae	<i>Seringia katatona</i>	Shrub. Flowers mauve.	Red sand.	8	33	Medium	Low
P3	Stylidiaceae	<i>Stylidium pindanicum</i>	Annual herb to 20 cm. Flowers pink.	Clay soil. Open woodland over grassland.	8	26	Medium	Low
P3	Combretaceae	<i>Terminalia kumpaja</i>	Small tree to 6 m tall. Bark deeply furrowed and corky.	Red pindan plain.	0.04	27	High	Low
P1	Asteraceae	<i>Thespidium basiflorum</i>	Densely tufted perennial herb to 0.2 m high. Flowers green.	Sandy soils. Creeks.	2	29	Low	Low

Appendix C: Species List



Family	Taxon	Comment & Significance
Aizoaceae	<i>Trianthema pilosum</i>	-
Amaranthaceae	<i>Ptilotus exaltatus</i>	-
	<i>Ptilotus lanatus</i>	-
	<i>Ptilotus polystachyus</i>	-
Apocynaceae	<i>Carissa lanceolata</i>	-
	<i>Marsdenia viridiflora</i> subsp. <i>tropica</i>	-
Araliaceae	<i>Trachymene oleracea</i>	-
Asteraceae	<i>Conyza bonariensis</i>	Weed
	<i>Pterocaulon intermedium</i>	-
	<i>Pterocaulon serrulatum</i> var. <i>velutinum</i>	-
Bignoniaceae	<i>Dolichandrone occidentalis</i>	-
	<i>Ehretia saligna</i> var. <i>saligna</i>	-
Boraginaceae	<i>Heliotropium leptaleum</i>	-
	<i>Heliotropium ovalifolium</i>	-
	<i>Trichodesma zeylanicum</i>	-
Byblidaceae	<i>Byblis filifolia</i>	-
Caryophyllaceae	<i>Polycarpha longiflora</i>	-
Celastraceae	<i>Stackhousia intermedia</i>	-
Cleomaceae	<i>Cleome tetrandra</i> var. <i>tetrandra</i>	-
Combretaceae	<i>Terminalia ferdinandiana</i>	-
	<i>Terminalia hadleyana</i>	-
	<i>Terminalia kumpaja</i>	Priority 3
Commelinaceae	<i>Murdannia graminea</i>	-
Convolvulaceae	<i>Bonamia ?media</i>	Sterile
	<i>Evolvulus alsinoides</i> var. <i>decumbens</i>	-
	<i>Ipomoea</i> sp.	Sterile
	<i>Jacquemontia</i> sp. Broome (A.A. Mitchell 3028)	Priority 1
	<i>Operculina aequisejala</i>	-
Cucurbitaceae	<i>Cucumis variabilis</i>	-
Cyperaceae	<i>Bulbostylis barbata</i>	-
	<i>Cyperus conicus</i>	-
	<i>Fimbristylis oxystachya</i>	-
	<i>Scleria brownii</i>	-
Euphorbiaceae	<i>Euphorbia coghlanii</i>	-
	Euphorbiaceae sp.	Sterile
Fabaceae	<i>Acacia adoxa</i> var. <i>subglabra</i>	-
	<i>Acacia colei</i> var. <i>colei</i>	-
	<i>Acacia eriopoda</i>	-
	<i>Acacia platycarpa</i>	-
	<i>Acacia tumida</i> var. <i>tumida</i>	-
	<i>Bauhinia cunninghamii</i>	-
	<i>Cajanus marmoratus</i>	-
	<i>Chamaecrista moorei</i>	-
	<i>Crotalaria cunninghamii</i>	-
	<i>Crotalaria medicaginea</i> var. <i>neglecta</i>	-
	<i>Crotalaria ramosissima</i>	-
	<i>Cullen corallum</i>	-
	Fabaceae sp.	Sterile
	<i>Glycine tomentella</i>	-
	<i>Indigofera colutea</i>	-
	<i>Indigofera linifolia</i>	-
	<i>Jacksonia aculeata</i>	-
	<i>Rhynchosia minima</i>	-
	<i>Senna costata</i>	-
	<i>Senna notabilis</i>	-
	<i>Stylosanthes hamata</i>	Weed
	<i>Stylosanthes scabra</i>	Weed

Family	Taxon	Comment & Significance
	<i>Tephrosia leptoclada</i>	-
	<i>Tephrosia remotiflora</i>	-
	<i>Tephrosia rosea</i> var. <i>rosea</i>	-
	<i>Tephrosia</i> sp.	Sterile
	<i>Zornia chaetophora</i>	-
Goodeniaceae	<i>Goodenia scaevolina</i>	-
	<i>Goodenia sepalosa</i> var. <i>sepalosa</i>	-
	<i>Scaevola parvifolia</i> subsp. <i>parvifolia</i>	-
	<i>Velleia panduriformis</i>	-
Gyrostemonaceae	<i>Codonocarpus cotinifolius</i>	-
	<i>Gyrostemon tepperi</i>	-
Malvaceae	<i>Abutilon australiense</i>	-
	<i>Abutilon otocarpum</i>	-
	<i>Brachychiton diversifolius</i> subsp. <i>diversifolius</i>	-
	<i>Corchorus sidoides</i> subsp. <i>sidoides</i>	-
	<i>Corchorus sidoides</i> subsp. <i>vermicularis</i>	-
	<i>Gossypium australe</i>	-
	<i>Grewia breviflora</i>	-
	<i>Grewia pindanica</i>	-
	<i>Melhanian oblongifolia</i>	-
	<i>Sida rohlenae</i> subsp. <i>occidentalis</i>	-
	<i>Sida</i> sp. Pindan (B.G. Thomson 3398)	-
	<i>Waltheria indica</i>	-
Menispermaceae	<i>Tinospora smilacina</i>	-
Montiaceae	<i>Calandrinia strophilata</i>	-
Moraceae	? <i>Ficus aculeata</i>	Sterile
	<i>Ficus aculeata</i> var. <i>indecora</i>	-
Myrtaceae	<i>Corymbia ?flavescens</i>	Sterile
	<i>Corymbia flavescens</i>	-
	<i>Corymbia greeniana</i>	-
	<i>Corymbia paractia</i>	Priority 1
	<i>Corymbia zygophylla</i>	-
	<i>Eucalyptus tectifera</i>	-
	<i>Melaleuca nervosa</i>	-
Nyctaginaceae	<i>Boerhavia gardneri</i>	-
Oleaceae	<i>Jasminum didymum</i> var. <i>lineare</i>	-
Orobanchaceae	<i>Buchnera asperata</i>	-
	<i>Buchnera ramosissima</i>	-
Phyllanthaceae	<i>Flueggea virosa</i> subsp. <i>melanthesoides</i>	-
	<i>Phyllanthus maderaspatensis</i>	-
	<i>Synostemon rhytidospemus</i>	-
Poaceae	? <i>Lolium perenne</i>	Weed; Insufficient material
	<i>Aristida holathera</i> var. <i>latifolia</i>	-
	<i>Aristida hygrometrica</i>	-
	<i>Chrysopogon pallidus</i>	-
	<i>Digitaria bicornis</i>	-
	<i>Enneapogon pallidus</i>	-
	<i>Eragrostis eriopoda</i>	-
	<i>Eriachne melicacea</i>	-
	<i>Eriachne obtusa</i>	-
	<i>Eriachne pindanica</i>	-
	<i>Schizachyrium fragile</i>	-
	<i>Sorghum plumosum</i>	-
	<i>Sorghum timorensis</i>	-
	<i>Triodia caelestialis</i>	-
	<i>Triodia schinzii</i>	-
	<i>Yakirra australiensis</i> var. <i>australiensis</i>	-

Family	Taxon	Comment & Significance
Proteaceae	<i>Grevillea pyramidalis</i> subsp. <i>pyramidalis</i>	-
	<i>Hakea macrocarpa</i>	-
	<i>Persoonia falcata</i>	-
Rhamnaceae	<i>Ventilago viminalis</i>	-
Rubiaceae	<i>Dentella misera</i>	-
	<i>Gardenia pyriformis</i> subsp. <i>keartlandii</i>	-
	<i>Oldenlandia mitrasacmoides</i> subsp. <i>mitrasacmoides</i>	-
	<i>Spermacoce occidentalis</i>	-
Santalaceae	<i>Santalum lanceolatum</i>	-
Sapindaceae	<i>Atalaya hemiglauc</i>	-
	<i>Dodonaea hispidula</i> var. <i>arida</i>	-
Sapotaceae	<i>Sersalisia sericea</i>	PEC Indicator Species
Solanaceae	<i>Solanum dioicum</i>	-
Violaceae	<i>Hybanthus aurantiacus</i>	-
Zygophyllaceae	<i>Tribulopsis angustifolia</i>	-

Appendix D: Site by Species Matrix



Taxa	DR01	DR02	DR03	DR04	DR05	QW01	QW02	QW03	QW04	QW05
? <i>Ficus aculeata</i>	-	-	-	-	-	-	-	-	-	-
? <i>Lolium perenne</i>	-	-	2	-	-	-	-	-	-	0.01
<i>Abutilon australiense</i>	-	-	-	-	-	0.01	-	-	-	-
<i>Abutilon otocarpum</i>	-	-	-	-	-	0.01	0.01	0.02	-	0.01
<i>Acacia adoxa</i> var. <i>subglabra</i>	-	-	-	-	-	1	-	-	-	-
<i>Acacia colei</i> var. <i>colei</i>	-	-	-	-	-	0.5	1	0.25	-	-
<i>Acacia eriopoda</i>	-	0.5	1.5	2	2	20.01	21	5	20	0.2
<i>Acacia platycarpa</i>	15	-	0.1	-	-	-	-	-	-	2
<i>Acacia tumida</i> var. <i>tumida</i>	-	-	-	-	-	-	-	-	-	-
<i>Aristida holathera</i> var. <i>latifolia</i>	-	-	-	-	-	0.3	0.1	0.5	1.5	0.2
<i>Aristida hygrometrica</i>	6.5	0.5	-	0.3	-	-	0.2	0.2	3	6
<i>Atalaya hemiglauc</i>	2	-	0.1	-	-	-	-	0.1	0.02	1
<i>Bauhinia cunninghamii</i>	3	-	3	6	-	0.2	2	6	-	3
<i>Boerhavia gardneri</i>	-	-	-	-	-	-	0.01	-	-	0.01
<i>Bonamia</i> ? <i>media</i>	-	-	-	-	-	-	-	0.1	-	-
<i>Brachychiton diversifolius</i> subsp. <i>diversifolius</i>	-	0.2	-	0.1	1	0.01	-	0.4	1.5	0.2
<i>Buchnera asperata</i>	-	-	-	-	-	-	-	0.01	-	-
<i>Buchnera ramosissima</i>	-	-	-	-	-	-	-	-	-	-
<i>Bulbostylis barbata</i>	-	-	-	-	-	-	-	0.01	0.01	0.01
<i>Byblis filifolia</i>	-	-	-	-	-	-	-	-	-	-
<i>Cajanus marmoratus</i>	0.5	0.1	-	-	-	-	-	0.01	-	-
<i>Calandrinia strophilata</i>	-	-	-	-	-	-	0.01	0.01	0.01	-
<i>Carissa lanceolata</i>	-	-	0.5	-	-	-	-	1	-	0.2
<i>Chamaecrista moorei</i>	-	-	-	-	-	0.01	0.01	-	-	-
<i>Chrysopogon pallidus</i>	17	3	8	0.5	3	15	5	15	2	4
<i>Cleome tetrandra</i> var. <i>tetrandra</i>	-	-	-	-	-	0.01	0.01	0.01	-	-
<i>Codonocarpus cotinifolius</i>	-	-	0.1	-	-	-	0.1	-	0.1	-
<i>Conyza bonariensis</i>	-	-	-	-	-	-	-	-	-	0.01
<i>Corchorus sidoides</i> subsp. <i>sidoides</i>	-	-	-	-	-	0.11	-	0.2	-	-
<i>Corchorus sidoides</i> subsp. <i>vermicularis</i>	-	0.1	0.1	-	-	-	0.01	-	0.1	0.1
<i>Corymbia</i> ? <i>flavescens</i>	-	-	-	5	-	-	-	3	-	-
<i>Corymbia flavescens</i>	-	-	-	-	-	-	-	-	-	-
<i>Corymbia greeniana</i>	-	-	-	5	1	2	0.5	1	10	-
<i>Corymbia paractia</i>	-	-	-	-	-	-	-	-	-	-
<i>Corymbia zygophylla</i>	-	-	-	-	5	1	-	-	0.2	-
<i>Crotalaria cunninghamii</i>	2	-	-	-	-	-	-	-	-	0.1
<i>Crotalaria medicaginea</i> var. <i>neglecta</i>	0.2	-	-	-	-	-	0.01	-	0.01	0.1
<i>Crotalaria ramosissima</i>	-	-	-	-	-	0.01	0.01	0.01	-	-


Taxa	DR01	DR02	DR03	DR04	DR05	QW01	QW02	QW03	QW04	QW05
<i>Cucumis variabilis</i>	-	-	-	-	-	0.01	-	0.01	0.01	0.01
<i>Cullen corallum</i>	-	-	-	-	-	-	-	-	-	-
<i>Cyperus conicus</i>	-	-	-	-	-	-	-	-	-	-
<i>Dentella misera</i>	-	0.01	-	-	-	-	-	-	-	0.01
<i>Digitaria bicornis</i>	-	-	-	-	-	-	-	-	-	-
<i>Dodonaea hispidula</i> var. <i>arida</i>	-	-	-	-	-	1	-	-	-	-
<i>Dolichandrone occidentalis</i>	-	-	-	-	-	-	0.5	0.3	0.1	-
<i>Ehretia saligna</i> var. <i>saligna</i>	-	0.1	0.1	-	-	0.1	0.2	0.2	-	0.01
<i>Enneapogon pallidus</i>	-	-	-	-	-	-	-	-	-	0.01
<i>Eragrostis eriopoda</i>	-	2	-	-	-	-	0.01	-	0.01	0.01
<i>Eriachne melicacea</i>	-	-	-	-	0.5	-	0.1	0.05	3	-
<i>Eriachne obtusa</i>	-	-	-	-	-	1	-	-	-	-
<i>Eriachne pindanica</i>	-	-	-	-	-	0.01	-	0.1	-	0.01
<i>Eucalyptus tectifica</i>	-	-	-	5	-	-	-	-	-	-
<i>Euphorbia coghlani</i>	-	-	-	-	-	0.01	0.01	0.01	0.01	-
<i>Euphorbiaceae</i> sp.	-	-	-	-	-	-	-	-	-	-
<i>Evolvulus alsinoides</i> var. <i>decumbens</i>	-	-	-	-	-	0.2	0.01	0.01	0.01	0.01
<i>Fabaceae</i> sp.	-	-	-	-	-	-	-	0.1	-	-
<i>Ficus aculeata</i> var. <i>indecora</i>	-	-	-	-	-	3	0.5	-	0.01	-
<i>Fimbristylis oxystachya</i>	-	-	-	-	-	0.01	0.01	-	-	-
<i>Flueggea virosa</i> subsp. <i>melanthesoides</i>	-	0.1	-	-	-	-	-	-	0.1	0.5
<i>Gardenia pyrifolia</i> subsp. <i>keartlandii</i>	-	-	-	-	-	-	0.2	1	-	-
<i>Glycine tomentella</i>	-	-	-	-	-	0.02	0.1	0.02	-	-
<i>Goodenia scaevolina</i>	-	-	-	-	-	-	-	-	-	-
<i>Goodenia sepalosa</i> var. <i>sepalosa</i>	-	-	-	-	-	0.01	0.01	0.01	-	-
<i>Gossypium australe</i>	-	-	-	-	-	-	-	-	-	-
<i>Grevillea pyramidalis</i> subsp. <i>pyramidalis</i>	-	-	0.1	-	-	-	-	1	-	0.2
<i>Grewia breviflora</i>	1	-	0.2	-	-	-	-	0.1	-	2.01
<i>Grewia pindanica</i>	-	-	0.1	-	-	-	0.1	2	-	0.1
<i>Gyrostemon tepperi</i>	-	-	-	-	-	0.1	-	-	-	-
<i>Hakea macrocarpa</i>	-	-	0.2	2	-	-	-	-	0.01	0.01
<i>Heliotropium leptaleum</i>	-	-	-	-	-	0.01	0.01	-	-	-
<i>Heliotropium ovalifolium</i>	-	-	-	-	-	-	0.01	-	-	-
<i>Hybanthus aurantiacus</i>	-	-	-	-	-	0.01	0.01	-	0.01	-
<i>Indigofera colutea</i>	-	-	-	-	-	-	-	0.01	-	-
<i>Indigofera linifolia</i>	-	-	-	-	-	-	0.01	0.01	-	0.01
<i>Ipomoea</i> sp.	-	-	-	-	-	-	0.1	0.01	-	-
<i>Jacksonia aculeata</i>	-	-	-	-	-	-	0.01	-	-	-


Taxa	DR01	DR02	DR03	DR04	DR05	QW01	QW02	QW03	QW04	QW05
<i>Jacquemontia</i> sp. Broome (A.A. Mitchell 3028)	-	-	-	-	-	2	-	-	-	-
<i>Jasminum didymum</i> var. <i>lineare</i>	-	-	-	-	-	-	-	-	-	0.01
<i>Marsdenia viridiflora</i> subsp. <i>tropica</i>	-	-	-	-	-	0.02	-	0.01	0.01	-
<i>Melaleuca nervosa</i>	5	40	-	-	-	-	-	-	-	-
<i>Melhania oblongifolia</i>	-	-	-	-	-	0.1	-	0.1	-	0.1
<i>Murdannia graminea</i>	-	-	-	-	-	-	0.01	0.01	0.01	0.01
<i>Oldenlandia mitrasacmoides</i> subsp. <i>mitrasacmoides</i>	-	-	-	-	-	0.01	0.01	-	-	-
<i>Operculina aequisejala</i>	-	-	-	-	-	-	-	-	-	-
<i>Persoonia falcata</i>	-	-	-	-	-	-	0.1	0.01	-	0.01
<i>Phyllanthus maderaspatensis</i>	-	-	-	-	-	-	0.01	-	0.01	-
<i>Polycarpaea longiflora</i>	-	-	-	-	-	-	-	0.01	-	-
<i>Pterocaulon intermedium</i>	-	-	-	-	-	-	-	-	-	-
<i>Pterocaulon serrulatum</i> var. <i>velutinum</i>	0.5	0.1	-	-	-	-	-	-	-	0.51
<i>Ptilotus exaltatus</i>	-	-	-	-	-	-	0.01	-	-	-
<i>Ptilotus lanatus</i>	-	-	-	-	-	-	-	0.1	-	0.01
<i>Ptilotus polystachyus</i>	-	-	-	-	-	-	-	0.01	0.01	-
<i>Rhynchosia minima</i>	-	-	-	-	-	0.01	0.01	-	-	-
<i>Santalum lanceolatum</i>	-	-	2.5	-	-	-	-	-	-	-
<i>Scaevola parvifolia</i> subsp. <i>parvifolia</i>	-	0.01	-	-	-	-	-	-	-	-
<i>Schizachyrium fragile</i>	-	-	-	-	-	-	0.01	-	0.01	-
<i>Scleria brownii</i>	-	-	-	-	-	0.1	0.01	0.1	-	-
<i>Senna costata</i>	-	-	-	-	-	-	0.01	0.25	-	-
<i>Senna notabilis</i>	-	-	-	-	-	-	-	-	-	-
<i>Sersalisia sericea</i>	-	-	-	-	-	-	-	-	-	-
<i>Sida rohlenae</i> subsp. <i>occidentalis</i>	-	-	-	-	-	-	0.01	-	-	-
<i>Sida</i> sp. Pindan (B.G. Thomson 3398)	-	-	-	-	-	-	0.02	-	-	-
<i>Solanum dioicum</i>	-	-	-	-	-	0.1	0.01	-	0.01	0.01
<i>Sorghum plumosum</i>	-	-	-	4	30	3	0.2	3.05	0.5	0.01
<i>Sorghum timorense</i>	-	-	-	-	0.5	-	-	-	-	-
<i>Spermocoe occidentalis</i>	-	0.01	-	-	-	0.01	0.1	0.01	-	0.01
<i>Stackhousia intermedia</i>	-	-	-	-	-	-	0.01	-	0.01	-
<i>Stylosanthes hamata</i>	0.01	-	-	-	-	-	-	-	-	-
<i>Stylosanthes scabra</i>	-	-	-	-	-	-	-	-	-	-
<i>Synostemon rhytidospermus</i>	-	-	-	-	-	-	-	0.01	-	-
<i>Tephrosia leptoclada</i>	-	-	-	-	-	0.01	0.01	-	-	-
<i>Tephrosia remotiflora</i>	-	-	-	-	-	0.01	-	0.01	-	-
<i>Tephrosia rosea</i> var. <i>rosea</i>	-	-	-	-	-	-	-	-	-	-
<i>Tephrosia</i> sp.	-	-	-	-	-	-	-	-	-	-


Taxa	DR01	DR02	DR03	DR04	DR05	QW01	QW02	QW03	QW04	QW05
<i>Terminalia ferdinandiana</i>	-	-	-	-	1	-	-	-	0.1	-
<i>Terminalia hadleyana</i>	-	-	-	-	1	-	0.1	-	0.5	-
<i>Terminalia kumpaja</i>	-	-	-	-	-	-	-	0.01	-	-
<i>Tinospora smilacina</i>	-	-	-	-	-	0.01	0.01	0.01	0.01	0.01
<i>Trachymene oleracea</i>	-	-	-	-	-	-	-	-	-	-
<i>Trianthema pilosum</i>	-	0.01	1	-	-	0.01	0.01	0.02	0.01	-
<i>Tribulopsis angustifolia</i>	-	-	-	-	-	-	-	-	0.01	0.01
<i>Trichodesma zeylanicum</i>	-	-	-	-	-	0.2	0.01	0.1	0.05	0.1
<i>Triodia caelestialis</i>	0.1	-	-	-	-	-	17	-	5	0.1
<i>Triodia schinzii</i>	-	4	-	0.1	-	25	-	3	-	-
<i>Velleia panduriformis</i>	-	-	-	-	-	-	-	-	-	-
<i>Ventilago viminalis</i>	-	-	-	-	-	0.01	-	-	-	0.2
<i>Waltheria indica</i>	-	-	-	-	-	0.2	-	0.01	0.01	0.01
<i>Yakirra australiensis</i> var. <i>australiensis</i>	-	-	-	-	-	0.02	0.01	0.1	0.01	-
<i>Zornia chaetophora</i>	-	-	-	-	-	-	-	0.01	-	0.01


Appendix E: Sites Sheets





Site: QW01		Type: Quadrat		Size: 50 x 50		Date: 20/04/2020		Botanist: CS	
Landform:	Flat, Plain								
Slope, aspect:	<1° - Level								
Soil:	Clayey sand, Red								
Rocks:	No Rocks								
Abundance:	-								
Size:	-								
Fire:	2-5 years								
Condition:	Excellent								
Notes:	-								
Veg Unit:	V001								
Location (NW):	51 422737 8024105								
Species			Height	Cover	Species		Height	Cover	
<i>Abutilon australiense</i>			0.4	0.01	<i>Glycine tomentella</i>		0.1	0.01	
<i>Abutilon otocarpum</i>			0.2	0.01	<i>Glycine tomentella</i>		0.2	0.01	
<i>Acacia adoxa</i> var. <i>subglabra</i>			0.4	1	<i>Goodenia sepalosa</i> var. <i>sepalosa</i>		0.1	0.01	
<i>Acacia colei</i> var. <i>colei</i>			2	0.5	<i>Gyrostemon tepperi</i>		1	0.1	
<i>Acacia eriopoda</i>			4	20	<i>Heliotropium leptaleum</i>		0.3	0.01	
<i>Aristida holathera</i> var. <i>latifolia</i>			0.3	0.3	<i>Hybanthus aurantiacus</i>		0.4	0.01	
<i>Bauhinia cunninghamii</i>			2	0.2	<i>Jacquemontia</i> sp. Broome (A.A. Mitchell 3028)		0.4	2	
<i>Brachychiton diversifolius</i> subsp. <i>diversifolius</i>			1.5	0.01	<i>Marsdenia viridiflora</i> subsp. <i>tropica</i>		0.2	0.01	
<i>Chamaecrista moorei</i>			0.3	0.01	<i>Melhania oblongifolia</i>		0.4	0.1	
<i>Chrysopogon pallidus</i>			0.4	15	<i>Oldenlandia mitrasacmoides</i> subsp. <i>mitrasacmoides</i>		0.3	0.01	
<i>Cleome tetrandra</i> var. <i>tetrandra</i>			0.2	0.01	<i>Rhynchosia minima</i>		0.1	0.01	
<i>Corchorus sidoides</i> subsp. <i>sidoides</i>			0.3	0.1	<i>Scleria brownii</i>		0.4	0.1	
<i>Corymbia greeniana</i>			3	2	<i>Solanum dioicum</i>		0.3	0.1	
<i>Corymbia zygophylla</i>			3	1	<i>Sorghum plumosum</i>		0.4	3	
<i>Crotalaria ramosissima</i>			0.2	0.01	<i>Spermacoce occidentalis</i>		0.1	0.01	
<i>Cucumis variabilis</i>			0.2	0.01	<i>Tephrosia leptoclada</i>		0.2	0.01	
<i>Dodonaea hispidula</i> var. <i>arida</i>			0.5	1	<i>Tephrosia remotiflora</i>		0.1	0.01	
<i>Ehretia saligna</i> var. <i>saligna</i>			2	0.1	<i>Tinospora smilacina</i>		0.1	0.01	
<i>Eriachne obtusa</i>			0.4	1	<i>Trianthema pilosum</i>		0.1	0.01	
<i>Eriachne pindanica</i>			0.2	0.01	<i>Trichodesma zeylanicum</i>		0.2	0.2	
<i>Euphorbia coghlanii</i>			0.2	0.01	<i>Triodia schinzii</i>		0.4	25	
<i>Evolvulus alsinoides</i> var. <i>decumbens</i>			0.3	0.2	<i>Ventilago viminalis</i>		1	0.01	
<i>Ficus aculeata</i> var. <i>indecora</i>			2.5	3	<i>Waltheria indica</i>		0.3	0.2	
<i>Fimbristylis oxystachya</i>			0.1	0.01	<i>Yakirra australiensis</i> var. <i>australiensis</i>		0.2	0.01	


Site: QW02		Type: Quadrat		Size: 50 x 50		Date: 18/04/2020		Botanist: CP	
Landform:	Flat, Plain								
Slope, aspect:	1° - Very Gentle, S								
Soil:	Clayey sand, Orange								
Rocks:	No Rocks								
Abundance:	-								
Size:	-								
Fire:	>5 years								
Condition:	Excellent								
Notes:	-								
Veg Unit:	V001								
Location (NW):	51 422797 8024943								
Species			Height	Cover	Species			Height	Cover
<i>Abutilon otocarpum</i>			0.15	0.01	<i>Heliotropium leptaleum</i>			0.3	0.01
<i>Acacia colei</i> var. <i>colei</i>			2.5	1	<i>Heliotropium ovalifolium</i>			0.15	0.01
<i>Acacia eriopoda</i>			3	21	<i>Hybanthus aurantiacus</i>			0.35	0.01
<i>Aristida holathera</i> var. <i>latifolia</i>			0.4	0.1	<i>Indigofera linifolia</i>			0.2	0.01
<i>Aristida hygrometrica</i>			0.4	0.2	<i>Ipomoea</i> sp.			0.01	0.1
<i>Bauhinia cunninghamii</i>			2.6	2	<i>Jacksonia aculeata</i>			0.35	0.01
<i>Boerhavia gardneri</i>			0.2	0.01	<i>Murdannia graminea</i>			0.4	0.01
<i>Calandrinia strophiolata</i>			0.15	0.01	<i>Oldenlandia mitrasacmoides</i> subsp. <i>mitrasacmoides</i>			0.35	0.01
<i>Chamaecrista moorei</i>			0.3	0.01	<i>Persoonia falcata</i>			1.7	0.1
<i>Chrysopogon pallidus</i>			0.5	5	<i>Phyllanthus maderaspatensis</i>			0.25	0.01
<i>Cleome tetrandra</i> var. <i>tetrandra</i>			0.2	0.01	<i>Ptilotus exaltatus</i>			0.1	0.01
<i>Codonocarpus cotinifolius</i>			0.5	0.1	<i>Rhynchosia minima</i>			0.3	0.01
<i>Corchorus sidoides</i> subsp. <i>vermicularis</i>			0.3	0.01	<i>Schizachyrium fragile</i>			0.3	0.01
<i>Corymbia greeniana</i>			3	0.5	<i>Scleria brownii</i>			0.3	0.01
<i>Crotalaria medicaginea</i> var. <i>neglecta</i>			0.2	0.01	<i>Senna costata</i>			0.9	0.01
<i>Crotalaria ramosissima</i>			0.2	0.01	<i>Sida rohlenae</i> subsp. <i>occidentalis</i>			0.4	0.01
<i>Dolichandrone occidentalis</i>			1.8	0.5	<i>Sida</i> sp. <i>Pindan</i> (B.G. Thomson 3398)			0.3	0.01
<i>Ehretia saligna</i> var. <i>saligna</i>			1.8	0.2	<i>Solanum dioicum</i>			0.4	0.01
<i>Eragrostis eriopoda</i>			0.35	0.01	<i>Sorghum plumosum</i>			0.01	0.2
<i>Eriachne melicacea</i>			0.4	0.1	<i>Spermacoce occidentalis</i>			0.2	0.1
<i>Euphorbia coghlanii</i>			0.2	0.01	<i>Stackhousia intermedia</i>			0.3	0.01
<i>Evolvulus alsinoides</i> var. <i>decumbens</i>			0.2	0.01	<i>Tephrosia leptoclada</i>			0.25	0.01
<i>Ficus aculeata</i> var. <i>indecora</i>			2.4	0.5	<i>Terminalia hadleyana</i>			2.2	0.1
<i>Fimbristylis oxystachya</i>			0.3	0.01	<i>Tinospora smilacina</i>			0.2	0.01
<i>Gardenia pyriformis</i> subsp. <i>keartlandii</i>			2.4	0.2	<i>Trianthema pilosum</i>			0.1	0.01
<i>Glycine tomentella</i>			0.2	0.1	<i>Trichodesma zeylanicum</i>			0.2	0.01
<i>Goodenia sepalosa</i> var. <i>sepalosa</i>			0.2	0.01	<i>Triodia caelestialis</i>			0.4	17
<i>Grewia pindanica</i>			3.5	0.1	<i>Yakirra australiensis</i> var. <i>australiensis</i>			0.15	0.01


Site: QW03		Type: Quadrat		Size: 50 x 50		Date: 20/04/2020		Botanist: CS	
Landform:	Flat, Plain								
Slope, aspect:	<1° - Level								
Soil:	Clayey sand, Red								
Rocks:	No Rocks								
Abundance:	-								
Size:	-								
Fire:	2-5 years								
Condition:	Excellent								
Notes:	-								
Veg Unit:	V001								
Location (NW):	51 449797 8028067								
Species			Height	Cover	Species			Height	Cover
Abutilon otocarpum			0.1	0.01	Glycine tomentella			0.1	0.01
Acacia colei var. colei			3	0.25	Goodenia sepalosa var. sepalosa			0.1	0.01
Acacia eriopoda			3	5	Grevillea pyramidalis subsp. pyramidalis			1.5	1
Aristida holathera var. latifolia			0.3	0.5	Grewia breviflora			1.2	0.1
Aristida hygrometrica			0.3	0.2	Grewia pindanica			1.5	2
Atalaya hemiglauc			0.5	0.1	Indigofera colutea			0.15	0.01
Bauhinia cunninghamii			3.5	6	Indigofera linifolia			0.25	0.01
Bonamia ?media			0.1	0.1	Ipomoea sp.			0.1	0.01
Brachychiton diversifolius subsp. diversifolius			4	0.2	Marsdenia viridiflora subsp. tropica			0.6	0.01
Buchnera asperata			0.4	0.01	Melhania oblongifolia			0.4	0.1
Bulbostylis barbata			0.1	0.01	Murdannia graminea			0.2	0.01
Cajanus marmoratus			0.3	0.01	Persoonia falcata			0.3	0.01
Calandrinia strophilata			0.2	0.01	Polycarpaea longiflora			0.2	0.01
Carissa lanceolata			1.75	1	Ptilotus lanatus			0.5	0.1
Chrysopogon pallidus			0.4	15	Ptilotus polystachyus			0.5	0.01
Cleome tetrandra var. tetrandra			0.1	0.01	Scleria brownii			0.2	0.1
Corchorus sidoides subsp. sidoides			0.2	0.1	Senna costata			2	0.25
Corymbia ?flavescens			8	3	Sorghum plumosum			0.4	3
Corymbia greeniana			4.5	1	Spermacoce occidentalis			0.1	0.01
Crotalaria ramosissima			0.1	0.01	Synostemon rhytidospermus			0.5	0.01
Cucumis variabilis			0.2	0.01	Tephrosia remotiflora			0.5	0.01
Dolichandrone occidentalis			4	0.3	Terminalia kumpaja			0.5	0.01
Ehretia saligna var. saligna			2	0.2	Tinospora smilacina			0.2	0.01
Eriachne melicacea			0.3	0.05	Trianthema pilosum			0.1	0.01
Eriachne pindanica			0.2	0.1	Trichodesma zeylanicum			0.3	0.1
Euphorbia coghlanii			0.1	0.01	Triodia schinzii			0.4	3
Evolvulus alsinoides var. decumbens			0.2	0.01	Waltheria indica			1.2	0.01
Fabaceae sp.			1.2	0.1	Yakirra australiensis var. australiensis			0.2	0.1
Gardenia pyriformis subsp. keartlandii			2.5	1	Zornia chaetophora			0.25	0.01


Site: QW04		Type: Quadrat	Size: 50 x 50	Date: 20/04/2020	Botanist: CP
Landform:	Flat, Plain				
Slope, aspect:	1° - Very Gentle				
Soil:	Clayey sand; Red, Orange				
Rocks:	No Rocks				
Abundance:	-				
Size:	-				
Fire:	2-5 years				
Condition:	Excellent				
Notes:	-				
Veg Unit:	V001				
Location (NW):	51 450199 8027895				
Species			Height	Cover	
<i>Acacia eriopoda</i>			3.2	20	
<i>Aristida holathera</i> var. <i>latifolia</i>			0.4	1.0	
<i>Aristida hygrometrica</i>			0.45	3	
<i>Atalaya hemiglauc</i>			1.2	0.01	
<i>Brachychiton diversifolius</i> subsp. <i>diversifolius</i>			4.5	1.5	
<i>Bulbostylis barbata</i>			0.15	0.01	
<i>Calandrinia strophilata</i>			0.1	0.01	
<i>Chrysopogon pallidus</i>			0.4	2	
<i>Codonocarpus cotinifolius</i>			0.9	0.1	
<i>Corchorus sidioides</i> subsp. <i>vermicularis</i>			0.3	0.1	
<i>Corymbia greeniana</i>			6.5	10	
<i>Corymbia zygophylla</i>			3.5	0.2	
<i>Crotalaria medicaginea</i> var. <i>neglecta</i>			0.25	0.01	
<i>Cucumis variabilis</i>			0.3	0.01	
<i>Dolichandrone occidentalis</i>			3	0.1	
<i>Eragrostis eriopoda</i>			0.3	0.01	
<i>Eriachne melicacea</i>			0.4	3	
<i>Euphorbia coghlanii</i>			0.15	0.01	
<i>Evolvulus alsinoides</i> var. <i>decumbens</i>			0.2	0.01	
<i>Ficus aculeata</i> var. <i>indecora</i>			0.5	0.01	
Species			Height	Cover	
<i>Flueggea virosa</i> subsp. <i>melanthesoides</i>			1.5	0.1	
<i>Hakea macrocarpa</i>			2.1	0.01	
<i>Hybanthus aurantiacus</i>			0.3	0.01	
<i>Marsdenia viridiflora</i> subsp. <i>tropica</i>			0.3	0.01	
<i>Murdannia graminea</i>			0.4	0.01	
<i>Phyllanthus maderaspatensis</i>			0.3	0.01	
<i>Ptilotus polystachyus</i>			0.4	0.01	
<i>Schizachyrium fragile</i>			0.15	0.01	
<i>Solanum dioicum</i>			0.35	0.01	
<i>Sorghum plumosum</i>			1.1	0.5	
<i>Stackhousia intermedia</i>			0.3	0.01	
<i>Terminalia ferdinandiana</i>			2.2	0.1	
<i>Terminalia hadleyana</i>			4.5	0.5	
<i>Tinospora smilacina</i>			0.9	0.01	
<i>Trianthema pilosum</i>			0.1	0.01	
<i>Tribulopsis angustifolia</i>			0.15	0.01	
<i>Trichodesma zeylanicum</i>			0.5	0.04	
<i>Triodia caelestialis</i>			0.4	5	
<i>Waltheria indica</i>			0.4	0.01	
<i>Yakirra australiensis</i> var. <i>australiensis</i>			0.15	0.01	


Site: QW05		Type: Quadrat		Size: 50 x 50		Date: 20/04/2020		Botanist: CP	
Landform:	Drainage, Drainage line on flat								
Slope, aspect:	Gentle - 3°, S								
Soil:	Sandy clay, Light orange								
Rocks:	No rocks								
Abundance:									
Size:									
Fire:	2-5 years								
Condition:	Excellent								
Notes:	-								
Veg Unit:	V002								
Location (NW):	51 449030 8027941								
Species			Height	Cover	Species		Height	Cover	
<i>?Lolium perenne</i>			0.7	0.01	<i>Flueggea virosa</i> subsp. <i>melanthesoides</i>		1.5	0.5	
<i>Abutilon otocarpum</i>			0.4	0.01	<i>Grevillea pyramidalis</i> subsp. <i>pyramidalis</i>		1.9	0.2	
<i>Acacia eriopoda</i>			2.5	0.2	<i>Grewia breviflora</i>		0.5	0.01	
<i>Acacia platycarpa</i>			2.2	2	<i>Grewia breviflora</i>		3.2	2	
<i>Aristida holathera</i> var. <i>latifolia</i>			0.3	0.2	<i>Grewia pindanica</i>		0.8	0.1	
<i>Aristida hygrometrica</i>			0.5	6	<i>Hakea macrocarpa</i>		1.8	0.01	
<i>Atalaya hemiglauca</i>			0.9	0.5	<i>Indigofera linifolia</i>		0.2	0.01	
<i>Bauhinia cunninghamii</i>			3	3	<i>Jasminum didymum</i> var. <i>lineare</i>		0.9	0.01	
<i>Boerhavia gardneri</i>			0.2	0.01	<i>Melhania oblongifolia</i>		0.4	0.1	
<i>Brachychiton diversifolius</i> subsp. <i>diversifolius</i>			2.8	0.2	<i>Murdannia graminea</i>		0.4	0.01	
<i>Bulbostylis barbata</i>			0.15	0.01	<i>Persoonia falcata</i>		2.4	0.01	
<i>Carissa lanceolata</i>			1.6	0.2	<i>Pterocaulon serrulatum</i> var. <i>velutinum</i>		0.4	0.3	
<i>Chrysopogon pallidus</i>			0.4	4	<i>Ptilotus lanatus</i>		0.3	0.01	
<i>Conyza bonariensis</i>			0.3	0.01	<i>Solanum dioicum</i>		0.4	0.01	
<i>Corchorus sidoides</i> subsp. <i>vermicularis</i>			0.3	0.1	<i>Sorghum plumosum</i>		1	0.01	
<i>Crotalaria cunninghamii</i>			1.5	0.1	<i>Spermacoce occidentalis</i>		0.15	0.01	
<i>Crotalaria medicaginea</i> var. <i>neglecta</i>			0.6	0.1	<i>Tinospora smilacina</i>		1.5	0.01	
<i>Cucumis variabilis</i>			0.6	0.01	<i>Tribulopsis angustifolia</i>		0.2	0.01	
<i>Dentella misera</i>			0.05	0.01	<i>Trichodesma zeylanicum</i>		0.8	0.1	
<i>Ehretia saligna</i> var. <i>saligna</i>			2.5	0.01	<i>Triodia caelestialis</i>		0.3	0.1	
<i>Enneapogon pallidus</i>			0.5	0.01	<i>Ventilago viminalis</i>		4.5	0.2	
<i>Eragrostis eriopoda</i>			0.3	0.01	<i>Waltheria indica</i>		0.4	0.01	
<i>Eriachne pindanica</i>			0.2	0.01	<i>Zornia chaetophora</i>		0.3	0.01	
<i>Evolvulus alsinoides</i> var. <i>decumbens</i>			0.2	0.01					

Site: DR01		Type: Relevé	Size: NA	Date: 20/04/2020	Botanist: CP
Landform:	Drainage, Drainage line on flat				
Slope, aspect:	Very gentle - 1°, S				
Soil:	Sandy clay, Light orange				
Rocks:	No rocks				
Abundance:					
Size:					
Fire:	<1 year				
Condition:	Excellent				
Notes:	-				
Veg Unit:	-				
Location (NW):	51 449030 8027941				
Species	Height	Cover	Species	Height	Cover
<i>Acacia platycarpa</i>	2.2	15	<i>Crotalaria medicaginea</i> var. <i>neglecta</i>	0.5	0.2
<i>Aristida hygrometrica</i>	0.5	5	<i>Grewia breviflora</i>	1.2	1
<i>Atalaya hemiglaucula</i>	1.5	1	<i>Melaleuca nervosa</i>	1.8	5
<i>Bauhinia cunninghamii</i>	4	3	<i>Pterocaulon serrulatum</i> var. <i>velutinum</i>	0.4	0.5
<i>Cajanus marmoratus</i>	0.25	0.5	<i>Stylosanthes hamata</i>	0.4	0.01
<i>Chrysopogon pallidus</i>	0.4	15	<i>Triodia caelestialis</i>	0.3	0.1
<i>Crotalaria cunninghamii</i>	1.2	2			

Site: DR02	Type: Releve	Size: NA	Date: 20/04/2020	Botanist: CS	
Landform:	Flat, Plain				
Slope, aspect:	Very gentle - 1°, S				
Soil:	Sandy clay, orange				
Rocks:	No rocks				
Abundance:					
Size:					
Fire:	<1 year				
Condition:	Excellent				
Notes:	-				
Veg Unit:	-				
Location (NW):	51 448928 8027745				
Species	Height	Cover	Species	Height	Cover
<i>Acacia eriopoda</i>	0.9	0.5	<i>Eragrostis eriopoda</i>	0.4	2
<i>Aristida hygrometrica</i>	0.3	0.5	<i>Flueggea virosa</i> subsp. <i>melanthesoides</i>	0.8	0.1
<i>Brachychiton diversifolius</i> subsp. <i>diversifolius</i>	2.8	0.2	<i>Melaleuca nervosa</i>	0.4	40
<i>Cajanus marmoratus</i>	0.15	0.1	<i>Pterocaulon serrulatum</i> var. <i>velutinum</i>	0.4	0.1
<i>Chrysopogon pallidus</i>	0.3	3	<i>Scaevola parvifolia</i> subsp. <i>parvifolia</i>	0.2	0.01
<i>Corchorus sidoides</i> subsp. <i>vermicularis</i>	0.3	0.1	<i>Spermacoce occidentalis</i>	0.1	0.01
<i>Dentella misera</i>	0.05	0.01	<i>Trianthema pilosum</i>	0.1	0.01
<i>Ehretia saligna</i> var. <i>saligna</i>	0.5	0.1	<i>Triodia schinzii</i>	0.3	4

Site: DR03		Type: Releve		Size: NA		Date: 21/04/2020		Botanist: CP	
Landform:	Flat, Plain								
Slope, aspect:	Level - 1°								
Soil:	Sandy clay, light orange								
Rocks:	No rocks								
Abundance:									
Size:									
Fire:	<1 year								
Condition:	Excellent								
Notes:	Similar to QW05, just recently burnt								
Veg Unit:	-								
Location (NW):	51 449175 8028350								
Species			Height	Cover	Species			Height	Cover
<i>?Lolium perenne</i>			0.4	2	<i>Corchorus sidoides</i> subsp. <i>vermicularis</i>			0.3	0.1
<i>Acacia eriopoda</i>			0.7	1.5	<i>Ehretia saligna</i> var. <i>saligna</i>			0.9	0.1
<i>Acacia platycarpa</i>			0.4	0.1	<i>Grevillea pyramidalis</i> subsp. <i>pyramidalis</i>			1.6	0.1
<i>Atalaya hemiglauca</i>			2.2	0.1	<i>Grewia breviflora</i>			1.5	0.2
<i>Bauhinia cunninghamii</i>			3	3	<i>Grewia pindanica</i>			0.5	0.1
<i>Carissa lanceolata</i>			0.5	0.5	<i>Hakea macrocarpa</i>			2.2	0.2
<i>Chrysopogon pallidus</i>			0.6	8	<i>Santalum lanceolatum</i>			0.6	2.5
<i>Codonocarpus cotinifolius</i>			1.7	0.1	<i>Trianthema pilosum</i>			0.05	1

Site: DR04		Type: Releve		Size: NA		Date: 21/04/2020		Botanist: CS	
Landform:	Flat, Plain								
Slope, aspect:	Level - 1°								
Soil:	Sandy clay, orange								
Rocks:	No rocks								
Abundance:									
Size:									
Fire:	<1 year								
Condition:	Excellent								
Notes:	Burnt recently								
Veg Unit:	-								
Location (NW):	51 449563 8028812								
Species				Height	Cover	Species		Height	Cover
<i>Acacia eriopoda</i>				1.5	2	<i>Corymbia greeniana</i>		0.3	0.1
<i>Aristida hygrometrica</i>				0.4	0.3	<i>Eucalyptus tectifica</i>		0.9	0.1
<i>Bauhinia cunninghamii</i>				4	6	<i>Hakea macrocarpa</i>		2.2	0.2
<i>Brachychiton diversifolius</i> subsp. <i>diversifolius</i>				2.5	0.1	<i>Santalum lanceolatum</i>		0.6	2.5
<i>Corymbia ?flavescens</i>				10	5	<i>Sorghum plumosum</i>		1.5	0.2
<i>Chrysopogon pallidus</i>				0.6	8	<i>Trianthema pilosum</i>		0.05	1
<i>Codonocarpus cotinifolius</i>				1.7	0.1	<i>Triodia schinzii</i>		0.5	0.1

Site: DR05		Type: Releve		Size: NA		Date: 21/04/2020		Botanist: CP	
Landform:	Flat, Plain								
Slope, aspect:	Very Gentle - 1°								
Soil:	Clayey sand, red orange								
Rocks:	No rocks								
Abundance:									
Size:									
Fire:	<1 year								
Condition:	Excellent								
Notes:	-								
Veg Unit:	-								
Location (NW):	51 450292 8027532								
Species			Height	Cover	Species		Height	Cover	
<i>Acacia eriopoda</i>			0.6	2	<i>Sorghum plumosum</i>		2	30	
<i>Aristida hygrometrica</i>			0.45	1	<i>Sorghum timorense</i>		0.4	0.5	
<i>Brachychiton diversifolius</i> subsp. <i>diversifolius</i>			4	1	<i>Terminalia ferdinandiana</i>		4.5	1	
<i>Corymbia greeniana</i>			5	1	<i>Terminalia hadleyana</i>		5	1	
<i>Corymbia zygophylla</i>			5	5	<i>Hakea macrocarpa</i>		2.2	0.2	
<i>Chrysopogon pallidus</i>			0.6	8	<i>Santalum lanceolatum</i>		0.6	2.5	
<i>Codonocarpus cotinifolius</i>			1.7	0.1	<i>Trianthema pilosum</i>		0.05	1	
<i>Eriachne melicacea</i>			0.4	0.5					



APPENDIX C

Additional Site Management Plans

Bushfire management plan/Statement addressing the Bushfire Protection Criteria coversheet

Site address: Lot 550 Cape Leveque Road, BROOME

Site visit: Yes ☒ No ☐

Date of site visit (if applicable): Day 17 Month March Year 2022

Report author or reviewer: Kathy Nastov

WA BPAD accreditation level (please circle):

Not accredited ☐ Level 1 BAL assessor ☐ Level 2 practitioner ☐ Level 3 practitioner ☒

If accredited please provide the following.

BPAD accreditation number: 27794 Accreditation expiry: Month August Year 2022

Bushfire management plan version number: #220075 (v1.1)

Bushfire management plan date: Day 13 Month May Year 2022

Client/business name: Talis Consultants

	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?		<input checked="" type="checkbox"/>
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the bushfire protection criteria elements)?	<input checked="" type="checkbox"/>	

Is the proposal any of the following (see [SPP 3.7 for definitions](#))?

	Yes	No
Unavoidable development (in BAL-40 or BAL-FZ)		
Strategic planning proposal (including rezoning applications)		
High risk land-use	<input checked="" type="checkbox"/>	
Vulnerable land-use		

None of the above ☐

Note: Only if one (or more) of the above answers in the tables is yes should the decision maker (e.g. local government or the WAPC) refer the proposal to DFES for comment.

Why has it been given one of the above listed classifications (E.g. Considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

Regional Recycling Resource Recovery Facility which will store and process waste products and land fill operations which are considered a high risk land use.

The information provided within this bushfire management plan to the best of my knowledge is true and correct:

Signature of report author or reviewer



Date 13 / 05 / 2022



Bushfire Management Plan

Broome Regional Resource Recovery Centre

Lot 550 Cape Leveque Road

Shire of Broome

Planning Stage:	Development Application
------------------------	-------------------------

Bushfire Policy – Specific Development or Use Type:	High Risk Land Use
--	--------------------

Job Number:	220075
--------------------	--------

Assessment Date:	17 March 2022
-------------------------	---------------

Report Date:	13 May 2022
---------------------	-------------

BPP Group Pty Ltd t/a Bushfire Prone Planning
ACN: 39 166 551 784 | ABN: 39 166 551 784

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DOCUMENT CONTROL


PREPARATION				
Author:	Greg Dunstan (BPAD No. 16382)			
Co-Author:	Mike Scott (BPAD Level 3 - No. 27795)			
VERSION HISTORY				
Version	Version Details	Date		
1.0	Original Document Issue	29 April 2022		
1.1	Updated to include Staff Crib and Amenities Building	13 May 2022		
BMP (Standard DA-Non-Tourism) Template v8.5				
DISTRIBUTION				
Destination	Version	No. Copies	Hard Copy	Electronic Copy
Person/Business: Talis Consultants – Megan Mather Email: megan.mather@talisconsultants.com.au	1.1	1	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Person/Business: Talis Consultants – Stewart Hyde Email: stewart.hyde@talisconsultants.com.au	1.1	1	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<p>Limitation of Liability: The measures contained in this Bushfire Management Plan, are considered to be minimum requirements and they do not guarantee that a building will not be damaged in a bushfire, persons injured, or fatalities occur either on the subject site or off the site while evacuating. This is substantially due to the unpredictable nature and behaviour of fire and fire weather conditions. Additionally, the correct implementation of the required bushfire protection measures will depend upon, among other things, the ongoing actions of the landowners and/or operators over which Bushfire Prone Planning has no control.</p> <p>All surveys, forecasts, projections and recommendations made in this report associated with the proposed development are made in good faith based on information available to Bushfire Prone Planning at the time. All maps included herein are indicative in nature and are not to be used for accurate calculations.</p> <p>Notwithstanding anything contained therein, Bushfire Prone Planning will not, except as the law may require, be liable for any loss or other consequences whether or not due to the negligence of their consultants, their servants or agents, arising out of the services provided by their consultants.</p> <p>Copyright ©2022 BPP Group Pty Ltd: All intellectual property rights, including copyright, in format and proprietary content contained in documents created by Bushfire Prone Planning, remain the property of BPP Group Pty Ltd. Any use made of such format or content without the prior written approval of Bushfire Prone Planning, will constitute an infringement on the rights of the Company which reserves all legal rights and remedies in respect of any such infringement.</p>				

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EXECUTIVE SUMMARY

The proposed Regional Resource Recovery Centre operation at Lot 550 Cape Leveque Road, Broome, in the Shire of Broome will facilitate the storage of landfill and waste processing operations which are considered a High-Risk Land Use under State Planning Policy 3.7 Planning in Bushfire Prone Areas and the associated Guidelines for Planning in Bushfire Prone Areas (WAPC v1.4 December 2021). This Bushfire Management Plan (BMP) has been prepared to support a development application for an establishment of the Regional Resource Recovery Centre to be constructed in stages as operational cells reach capacity.

All buildings onsite are able to establish a BAL-29 dimensioned APZ wholly within the lot boundary. Figure 3.2: The BAL Contour Map Post Development, displays locations where this is achievable within the lot boundary. Landfill cells are a high-risk hazard and require separation from bushfire prone vegetation and specific requirements may be imposed on the facility, or any processes undertaken (e.g. storage, processing, transportation), by the relevant regulatory authority, such as local council, planning departments, environmental regulators or workplace health and safety regulators. Site specific factors such as buffers from surrounding vegetation and stockpiled waste need to be taken into account when considering pile dimensions for waste types and bulk green waste storage areas. Hazardous materials should not be stored within asset protection zones around the buildings on the site.

The site is accessed from Broome Cape Leveque Road, which is the main arterial route to the north and wider Dampier Peninsula area. The remote location of the facility and current road network does not enable the site to achieve technical compliance with road access and egress requirements for two directions of continuous travel to a lower threat destination, as the Lot is approximately 1.8km from the intersection with Broome Road. A High Risk Land Use Bushfire Risk Assessment Report is provided as a separate document to address the high risk nature of the proposal including the ability to achieve a safe road access and egress to and from the site.

The internal road network of the site is also sufficient for the standards of public roads and the site will incorporate ample firefighting water supply considerations for the high risk landuse, associated flammable and combustible liquids and materials, and special hazards that may present a problem for fire-fighting.

Neighbouring the site to the south is the Broome Motocross club and Reserve land surrounds the proposed facility which contains extensive scrub vegetation which would support a landscape fire run. The bushfire risk to the site is considered to be acceptable where Asset Protection Zones are implemented and maintained, and the onsite bushfire procedures are effectively actioned.

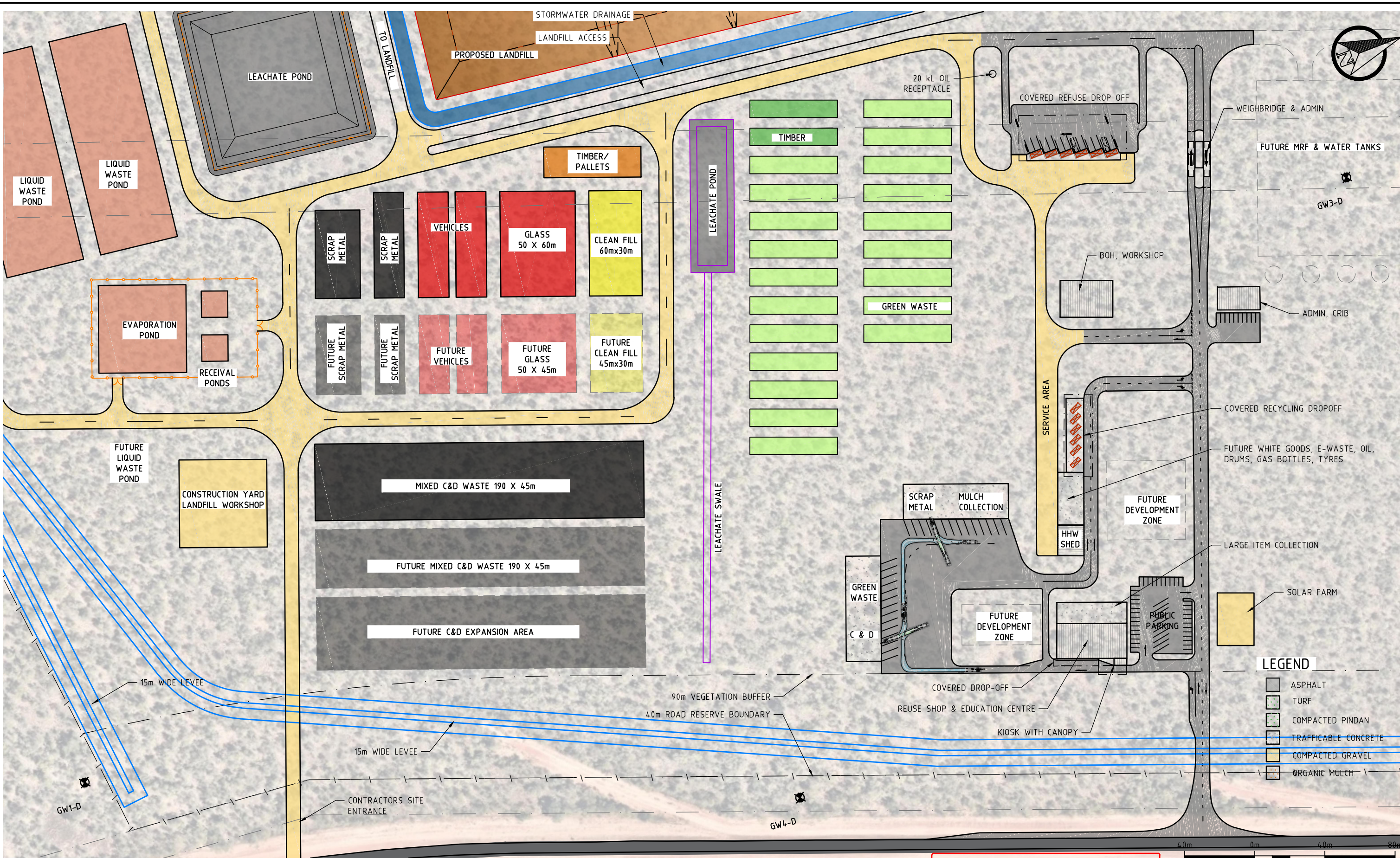
The subsequent bushfire high risk landuse and emergency documentation will provide detail on a safer onsite location to shelter, as a last resort, in the event of a bushfire. The reuse shop and education centre building is nominated as the onsite shelter as it can accommodate all persons onsite, has first aid and water supplies, will have a 10kW/m² Asset Protection Zone, is easily accessible by foot or vehicle and is close to the site access/egress points.

Application of the requirements of this Bushfire Management Plan and the High Risk Land Use – Bushfire Risk Assessment Report documentation, will reduce the residual risk from bushfire to persons and assets on the development site.

1 PROPOSAL DETAILS

1.1 Description and Associated Plans and Maps

Landowner / Proponent:	Shire of Broome
Bushfire Prone Planning Commissioned to Produce the Bushfire Management Plan (BMP) By:	Talis Consultants
For Submission To:	Shire of Broome
Purpose of the BMP:	To satisfy a condition of planning approval
'Development' Site Total Area:	121.0 hectares
No. of Existing/Proposed Lots:	1 existing lot
Staged Development and Management of Potential Bushfire Hazard Issues	
The staging of construction of the facility means that the bushfire mitigation measures will be triggered at the subsequent development stages and updates to the bushfire management planning may be required to address site specific changes on the site.	



VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 94 ZONE 50

FOR APPROVAL

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ASSET MANAGEMENT
CIVIL ENGINEERING
ENVIRONMENTAL SERVICES
SPATIAL INTELLIGENCE
WASTE MANAGEMENT

Client:

NOTES

- This drawing is the property of Talis Consultants Pty Ltd. It is a confidential document and must not be copied, used, or its contents divulged without prior written consent.
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No.	Date	Drawn	Checked	Amendment / Issue	App.
G	02.03.2022	YJ	AB	CLIENT UPDATES	
F	18.02.2022	YJ	AB	STAFF CRIB & AMENITIES MOVED	
E	15.02.2022	YJ	AB	FOR APPROVAL	

Project: BROOME RRRP SITE MASTER PLANS

Title: COMMUNITY RECYCLING CENTRE MASTER PLAN

Drawn by:	YJ	Job No:	TW19106
Checked by:	AB	File No:	TW19106-D-102
Approved by:		Dr. No:	
Scale:	AS SHOWN @ A3	D-102	G
Date:	02.03.2022		



Figure 1.2
Location Plan

Lot 550 on Plan 421448, Area : 121.0000 ha
Cape Leveque Road
WATERBANK
SHIRE OF BROOME

----- **LEGEND** -----

- Subject Site
- Bush Fire Brigade
- State Emergency Service Unit
- Volunteer Fire & Rescue Service
- Proposed Building Envelope

Reserves

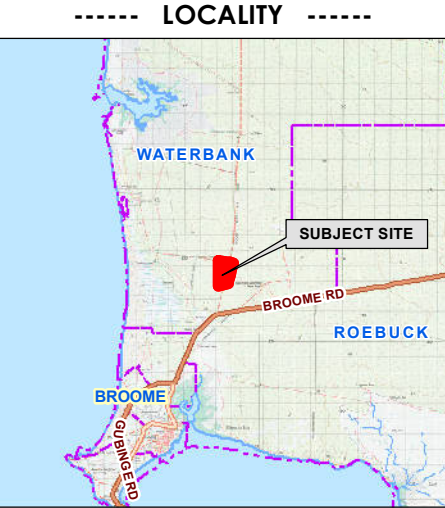
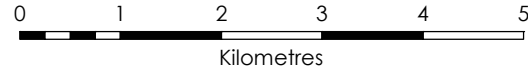
- Reserves

Legislated Lands and Waters

- Marine Park
- Section 5(1)(g) Reserve
- Section 5(1)(h) Reserve

DBCA Lands of Interest

- UCL - Dept Interest






Aerial Imagery : Landgate/SLIP
Image Date : Apr 2021

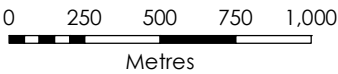
Coordinate System: GDA 1994 MGA Zone 51
Projection: Universal Transverse Mercator Units: Metre
Map compiled by: Ian Ross 25/03/2022
Map updated by: Ian Ross 25/03/2022
A3 Scale 1:75,000



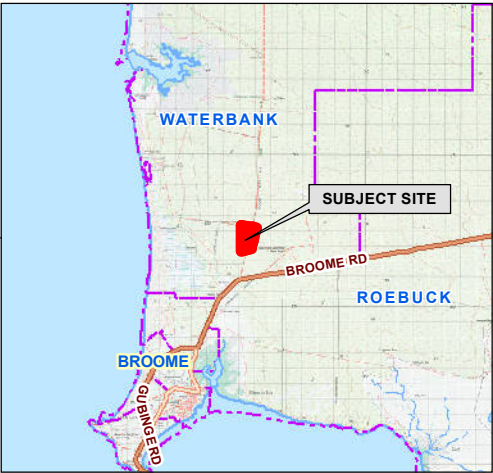
Figure 1.3
Bushfire Prone Area

Lot 550 on Plan 421448, Area : 121.0000 ha
Cape Leveque Road
WATERBANK
SHIRE OF BROOME

- **LEGEND** -----
-  Subject Site
 -  Other Lots
 -  Bushfire Prone Areas (2019)



----- **LOCALITY** -----



Aerial Imagery : Landgate/SLIP
Image Date : Apr 2021

Coordinate System: GDA 1994 MGA Zone 51
Projection: Universal Transverse Mercator Units: Metre
Map compiled by: Ian Ross 25/03/2022
Map updated by: Ian Ross 25/03/2022
A3 Scale 1:25,000

1.2 The Specific 'Land Use' and the Bushfire Planning Requirements

SPP 3.7, the associated Guidelines and Position Statements, define certain land uses that require additional and/or alternative bushfire related assessment and additional information to be provided. This is necessary to facilitate planning application assessment and for subsequent operational use.

When such a proposal is unable to fully achieve the implementation of all required bushfire protection measures - as established by the 'acceptable solutions' contained in the Guidelines and Position Statements – further assessments and the development of additional protection measures are required.

The land use classification that applies to the proposal is identified in Table 1.1, along with the required additional assessments and information and the form and location in which this is provided.

Table 1.1: The determined land use and assessment/information requirements.

THE PROPOSED LAND USE CLASSIFICATION AND BUSHFIRE PLANNING REQUIREMENTS		
Assessment / Information / Documents Detail		
The proposed land use classification is determined to be:		High Risk
Category, type and/or operations of the land use that have determined the classification:		Combustible (flammable) materials (including hazardous materials) stored onsite AND business operations that are a potential source of ignition for onsite or offsite flammable/combustible materials
The Policies, Guidelines and Position Statements against which the proposed land use will be assessed, and which guide the information to be provided. ¹	SPP 3.7	<input checked="" type="checkbox"/>
	Guidelines including the BPC	<input checked="" type="checkbox"/>
	Guidelines excluding the BPC	n/a
	Position Statement - BPC Element 1 and 2	<input checked="" type="checkbox"/>
	Position Statement - Tourism	n/a
The documents and the information developed and the format and location in which they are provided.	Bushfire Management Plan (BMP)	<input checked="" type="checkbox"/> This Document
	Bushfire Risk Assessment Report (RMP)	<input checked="" type="checkbox"/> Separate Document
	Risk Assessment and Treatment Plan	n/a
	Bushfire Emergency Plan (BEP)	<input type="checkbox"/> Separate Document
	BEP Supporting Information	<input type="checkbox"/> Separate Document
	Additional bushfire protection measures	<input checked="" type="checkbox"/> In BMP s5.4.1
	Owner/operator additional responsibilities associated with the land use.	<input checked="" type="checkbox"/> In BMP s5.4.2
Note 1: State Planning Policy 3.7 Planning in Bushfire Prone Areas; Guidelines for Planning in Bushfire Prone Areas WAPC 2021 v1.4; Bushfire Protection Criteria (BPC) established in the Guidelines; Position Statement: Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design WAPC November 2019; Position Statement: Tourism land uses in bushfire prone areas WAPC October 2019.		

1.3 Existing Documentation Relevant to the Construction of this Plan

This section acknowledges any known reports or plans that have been prepared for previous planning stages, that refer to the subject area and that may or will impact upon the assessment of bushfire risk and/or the implementation of bushfire protection measures and will be referenced in this Bushfire Management Plan.

Table 1.2: Existing relevant documentation.

RELEVANT EXISTING DOCUMENTS		
Existing Document	Copy Provided by Client	Title
Structure Plan	N/A	
Environmental Report	No	
Landscaping Plan	No	
Emergency Management Plan	N/A	
Bushfire Risk Assessments	N/A	

A Bushfire Risk Assessment Report (High-Risk Land Use) has been prepared alongside this Bushfire Management Plan.

2 ENVIRONMENTAL CONSIDERATIONS

2.1 Native Vegetation – Restrictions to Modification and/or Clearing

Many bushfire prone areas also have high biodiversity values. SPP 3.7 policy objective 5.4 recognises the need to consider bushfire risk management measures alongside environmental, biodiversity and conservation values (Guidelines s2.3).

There is a requirement to identify any need for onsite modification and/or clearing of native vegetation and whether this may trigger potential environmental impact/referral requirements under State and Federal environmental legislation. Confirmation that any proposed native vegetation modification and/or clearing is acceptable, should be received from the relevant agencies by the proponent and provided to the bushfire consultant for inclusion in the Bushfire Management Plan if it will influence the required bushfire planning assessments and outcomes. The following table details any potential environmental restrictions of which the author of this report is aware.

Table 2.1: Native vegetation and potential environmental considerations and restrictions.

NATIVE VEGETATION MODIFICATION / CLEARING - POTENTIAL ENVIRONMENTAL RESTRICTIONS IDENTIFIED				
Environmental Considerations / Features	Potential Mapping Data Source (SLIP / Local Planning)	Relevant to Proposed Development	Data Applied	Action Required
Onsite clearing of native vegetation is required.		Yes		
Environmental impact/referral requirements under State and Federal environmental legislation may be triggered.		Yes		
National Park / Nature Reserve	DBCA-011	No-Confirmed by Bushfire Consultant	Relevant Database Reviewed by Bushfire Consultant	None
Conservation Covenant	DPIRD-023	Not Known	Data Not Readily Available to Bushfire Consultant	Proponent to Seek Advice
Bush Forever Site	DPLH-019	Not Known	Data Not Readily Available to Bushfire Consultant	Proponent to Seek Advice
RAMSAR Wetland	DBCA-010	No-Confirmed by Bushfire Consultant	Relevant Database Reviewed by Bushfire Consultant	None
Geomorphic and Other Wetland	DBCA-011-019, 040, 043, 044	No-Confirmed by Bushfire Consultant	Relevant Database Reviewed by Bushfire Consultant	None
Threatened and Priority Ecological Communities (TECs or PECs)	DBCA-038	Unlikely	Relevant Database Reviewed by Bushfire Consultant	Proponent to Seek Advice
Threatened and Priority Flora including Declared Rare Flora (DRFs)	DBCA-036	Not Known	Data Not Readily Available to Bushfire Consultant	Proponent to Seek Advice
Land Identified as significant through a Local Biodiversity Strategy	LG - Intramaps	Not Known	Data Not Readily Available to Bushfire Consultant	Proponent to Seek Advice

Statement of how the identified environmental feature(s) is dealt with in this Bushfire Management Plan (and the location of relevant information):

The assessments and bushfire protection measures detailed the BMP, assume that environmental approval will be achieved or clearing permit exemptions will apply.

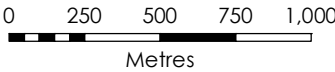
It is advised that the proponent seek further advice from an Environmental Consultant or the WA Department of Biodiversity Conservation and Attractions for further information on the condition and species contained within the proposed development area and the requirement for referral of the proposal.



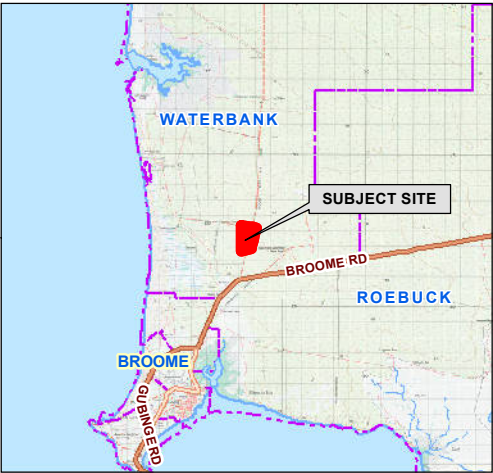
Figure 2.1
Environmental Considerations

Lot 550 on Plan 421448, Area : 121.0000 ha
Cape Leveque Road
WATERBANK
SHIRE OF BROOME

- **LEGEND** -----
- Subject Site
 - Other Lots
 - Reserves**
 - Reserves
 - Legislated Lands and Waters**
 - Section 5(1)(h) Reserve
 - Clearing Regulations**
 - Clearing Regulations



----- **LOCALITY** -----



Aerial Imagery : Landgate/SLIP
Image Date : Apr 2021

Coordinate System: GDA 1994 MGA Zone 51
Projection: Universal Transverse Mercator Units: Metre
Map compiled by: Ian Ross 25/03/2022
Map updated by: Ian Ross 25/03/2022
A3 Scale 1:25,000



Development Design Considerations

Establishing development in bushfire prone areas can adversely affect the retention of native vegetation through clearing associated with the creation of lots and/or asset protection zones. Where loss of vegetation is not acceptable or causes conflict with landscape or environmental objectives, it will be necessary to consider available design options to minimise the removal of native vegetation.

Table 2.2: Development design.

MINIMISE THE REMOVAL OF NATIVE VEGETATION	
Design Option	Assessment / Action
Reduction of lot yield	N/A
Cluster development	N/A
Construct building to a standard corresponding to a higher BAL as per BCA (AS 3959:2018 and/or NASH Standard)	N/A
Modify the development location	N/A
Clearing of native vegetation is an intended consequence of and requirement for facility operation. Most of the site comprises native vegetation, with limited to no cleared areas. The lot area has been designated for landfill, waste storage and recycling operations.	
IMPACT ON ADJOINING LAND	
Is this planning proposal able to implement the required bushfire protection measures within the boundaries of the land being developed so as not to impact on the bushfire and environmental management of neighbouring reserves, properties or conservation covenants?	Yes
All bushfire protection measures can be applied wholly within the boundaries of the lot. Additional bushfire protection measures applicable to the site (operating procedures) are intended to reduce the risk of bushfire ignition in adjoining land.	

2.2 Retained Vegetation / Re-vegetation / Landscape Plans (including POS)

Riparian zones, wetland/foreshore buffers, road verges and public open space may have plans to re-vegetate or retain vegetation as part of the proposed development. Vegetation corridors may be created between offsite and onsite vegetation and provide a route for fire to enter a development area.

All retained/planned vegetation and its management will be considered in the development of this Bushfire Management Plan.

Is re-vegetation of riparian zones and/or wetland or foreshore buffers and/or public open space a part of this Proposal?	No
Is the requirement for ongoing maintenance of existing vegetation in riparian zones and/or wetland or foreshore buffers and/or public open space a part of this Proposal?	No
Has a landscape plan been developed for the proposed development?	Unknown
Areas within the Lot that are outside of the proposed development construction and operational area are to remain as native vegetation unless proposed as a low threat buffer or asset protection zone.	
The bushfire management plan does not include the revegetation of operation cells with the facility and is therefore consistent with bushfire mitigation measures.	

3 POTENTIAL BUSHFIRE IMPACT ASSESSMENT

3.1 Assessment Input

3.1.1 Fire Danger Index (FDI) Applied

AS 3959:2018 Table 2.1 specifies the fire danger index values to apply for different regions. The values used in the model calculations are for the Forest Fire Danger Index (FFDI) and for which equivalent representative values of the Grassland Fire Danger Index (GFDI) are applied as per Appendix B. The values can be modified if appropriately justified.

Table 3.1: Applied FDI Value

FDI VALUE			
Vegetation Areas	As per AS 3959:2018 Table 2.1	As per DFES for the Location	Value Applied
All	80	N/A	80

3.1.2 Vegetation Classification and Effective Slope

Classification: Bushfire prone vegetation identification and classification has been conducted in accordance with AS 3959:2018 s2.2.3 and the Visual Guide for Bushfire Risk Assessment in WA (DoP February 2016).

When more than one vegetation type is present, each type is identified separately, and the applied classification considers the potential bushfire intensity and behaviour from the vegetation types present and ensures the worst case scenario is accounted for – this may not be from the predominant vegetation type.

The vegetation structure has been assessed as it will be in its mature state (rather than what might be observed on the day). Areas of modified vegetation are assessed as they will be in their natural unmodified state (unless maintained in a permanently low threat, minimal fuel condition, satisfying AS 3959:2018 s2.2.3.2(f) and asset protection zone standards). Vegetation destroyed or damaged by a bushfire or other natural disaster has been assessed on its revegetated mature state.

Effective Slope: Refers to the ground slope under each area of classified vegetation and is described in the direction relative to the view from the building or proposed development site. Effective slope is not the same as 'average slope', rather it is the slope which most significantly influences fire behaviour. This slope has a direct and significant influence on a bushfire's rate of spread and intensity.

Where there is a significant change in effective slope under an area of classified vegetation, that will cause a change in fire behaviour, separate vegetation areas will be identified to enable the correct assessment.

When the effective slope, under a given area of bushfire prone vegetation, will be different relative to multiple proposed development sites, then the effective slopes corresponding to the different locations, are separately identified.

Planned Re-vegetation/Landscaping Considerations

Vegetation that is to remain within the operational area of the site will be required to meet asset protection zone standards where it falls within asset protection zones around buildings or the required buffer separation from on-site hazardous materials. The vegetation on-site is to be strictly controlled by site operations.

Where landscape planting is to occur, Bushfire Prone Planning recommends the use of species with a low capacity for ignition source and ember generation for on-site landscaping during the operational life of the facility.







Excluded Bushfire Prone Vegetation







All vegetation within the assessment area has been classified following AS3959 – 2018 in a worst case scenario mature vegetation state. On-site areas within the levee area have been excluded for post development mapping relevant to the planned construction of the facility.



Table 3.2: Vegetation classification and effective slope.





ALL VEGETATION WITHIN 150 METRES OF THE PROPOSED DEVELOPMENT				
Vegetation Area	Identified Vegetation Types ¹ or Description if 'Excluded'	Applied Vegetation Classification ¹	Effective Slope (degrees) ² (AS 3959:2018 Method 1)	
			Assessed	Applied Range
1	Closed scrub D-13; Open scrub D-14	Class D Scrub	0	Flat
2	Closed scrub D-13; Open scrub D-14	Class D Scrub	0	Flat
3	Closed scrub D-13; Open scrub D-14	Class D Scrub	0	Flat
Representative photos of each vegetation area, descriptions and classification justification, are presented on the following pages. The areas of classified vegetation are defined, and the photo locations identified on Figure 3.1, the vegetation and topography map.				
Note ¹ : Described and classified as per AS 3959:2018 Table 2.3 and Figures 2.3 and 2.4 (A)-(H)				
Note ² : Effective slope measured as per AS 3959:2018 Section 2.2.5 and Appendix B Part B4				



VEGETATION AREA 1 & 3	
AS 3959:2018 Vegetation Classification Applied:	Class D Scrub
Vegetation Types Present:	Closed scrub D-13; Open scrub D-14
Description/Justification:	Predominantly areas of Closed Scrub 2.6m to 4m in height with >30% foliage cover with pockets of Open scrub. Grass understorey. Scattered low trees to 4m in height within the scrub areas.
<div>  <p>Site Assessment Photo -17°51'26", 122°16'2", 55.3m, 7° 17/03/2022 08:17:00</p> </div> <div>  <p>Site Assessment Photo -17°51'26", 122°16'2", 61.7m, 192° 17/03/2022 08:19:06</p> </div>	
Photo ID: 1	Photo ID: 2
<div>  <p>Site Assessment Photo -17°51'26", 122°16'2", 55.3m, 185° 17/03/2022 08:19:53</p> </div>	
Photo ID: 3	



VEGETATION AREA 1 & 3	
AS 3959:2018 Vegetation Classification Applied:	Class D Scrub
Vegetation Types Present:	Closed scrub D-13; Open scrub D-14
Description/Justification:	Predominantly areas of Closed Scrub 2.6m to 4m in height with >30% foliage cover with pockets of Open scrub. Grass understorey. Scattered low trees to 4m in height within the scrub areas.
<div>  <p>Site Assessment Photo -17°51'28", 122°16'22", 55.9m, 57° 17/03/2022 08:24:33</p> </div> <div>  <p>Site Assessment Photo -17°51'29", 122°16'22", 55.2m, 182° 17/03/2022 08:25:07</p> </div>	
Photo ID: 4	Photo ID: 5
<div>  <p>Site Assessment Photo -17°51'31", 122°16'33", 57.6m, 196° 17/03/2022 08:29:10</p> </div> <div>  <p>Site Assessment Photo -17°51'31", 122°16'33", 60.2m, 233° 17/03/2022 08:31:13</p> </div>	
Photo ID: 6	Photo ID: 7
<div>  <p>Site Assessment Photo -17°51'32", 122°16'33", 56.8m, 52° 17/03/2022 08:32:13</p> </div> <div>  <p>Site Assessment Photo -17°51'32", 122°16'33", 56.7m, 221° 17/03/2022 08:32:47</p> </div>	
Photo ID: 8	Photo ID: 9

VEGETATION AREA 1, 2 & 3	
AS 3959:2018 Vegetation Classification Applied:	Class D Scrub
Vegetation Types Present:	Closed scrub D-13; Open scrub D-14
Description/Justification:	Predominantly areas of Closed Scrub 2.6m to 4m in height with >30% foliage cover with pockets of Open scrub. Grass understorey. Scattered low trees to 4m in height within the scrub areas.
<div>   </div>	
Photo ID: 10	Photo ID: 11
<div>   </div>	
Photo ID: 12	Photo ID: 13
<div>   </div>	
Photo ID: 14	Photo ID: 15

VEGETATION AREA 2 & 3	
AS 3959:2018 Vegetation Classification Applied:	Class D Scrub
Vegetation Types Present:	Closed scrub D-13; Open scrub D-14
Description/Justification:	Predominantly areas of Closed Scrub 2.6m to 4m in height with >30% foliage cover with pockets of Open scrub. Grass understorey. Scattered low trees to 4m in height within the scrub areas.
<div>   </div>	
Photo ID: 16	Photo ID: 17
<div>   </div>	
Photo ID: 18	Photo ID: 19
<div>   </div>	
Photo ID: 20	Photo ID: 21

VEGETATION AREA 1	
AS 3959:2018 Vegetation Classification Applied:	Class D Scrub
Vegetation Types Present:	Closed scrub D-13; Open scrub D-14
Description/Justification:	Predominantly areas of Closed Scrub 2.6m to 4m in height with >30% foliage cover with pockets of Open scrub. Grass understorey. Scattered low trees to 4m in height within the scrub areas.
<div>  <p>Site Assessment Photo -17°52'16", 122°16'20", 49.1m, 310° 17/03/2022 09:58:44</p> </div> <div>  <p>Site Assessment Photo -17°52'20", 122°16'1", 49.0m, 263° 17/03/2022 09:10:05</p> </div>	
Photo ID: 22	Photo ID: 23
<div>  <p>Site Assessment Photo -17°52'20", 122°16'1", 42.2m, 205° 17/03/2022 09:10:35</p> </div> <div>  <p>Site Assessment Photo -17°52'20", 122°16'1", 41.4m, 274° 17/03/2022 09:10:52</p> </div>	
Photo ID: 24	Photo ID: 25
<div>  <p>Site Assessment Photo -17°52'18", 122°16'23", 235.9m, 301° 17/03/2022 15:13:20</p> </div>	
Photo ID: 28	

EXCLUDED AREA	
AS 3959:2018 Vegetation Classification Applied:	Excluded as per Section 2.2.3.2 (e)
Vegetation Types Present:	Non-vegetated Areas
Description/Justification:	Cleared motocross track, driveways and facilities.
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Site Assessment Photo -17°54'27", 122°13'54", 266° 17/03/2022 15:10:31</p> </div> <div style="text-align: center;">  <p>Site Assessment Photo -17°52'21", 122°16'24", 53.1m, 232° 17/03/2022 15:10:37</p> </div> </div>	
Photo ID: 26	Photo ID: 27

EXCLUDED AREA	
AS 3959:2018 Vegetation Classification Applied:	Excluded as per Section 2.2.3.2 (e)
Vegetation Types Present:	Non-vegetated Areas
Description/Justification:	Roads and cleared road reserve verges. Road reserves vary from ~24m to ~30m in width (McGuigan Road) and ~34m to ~40m in width (Broome Cape Leveque Road).
<div>   </div>	
Photo ID: 29	Photo ID: 30
<div>   </div>	
Photo ID: 31	Photo ID: 32

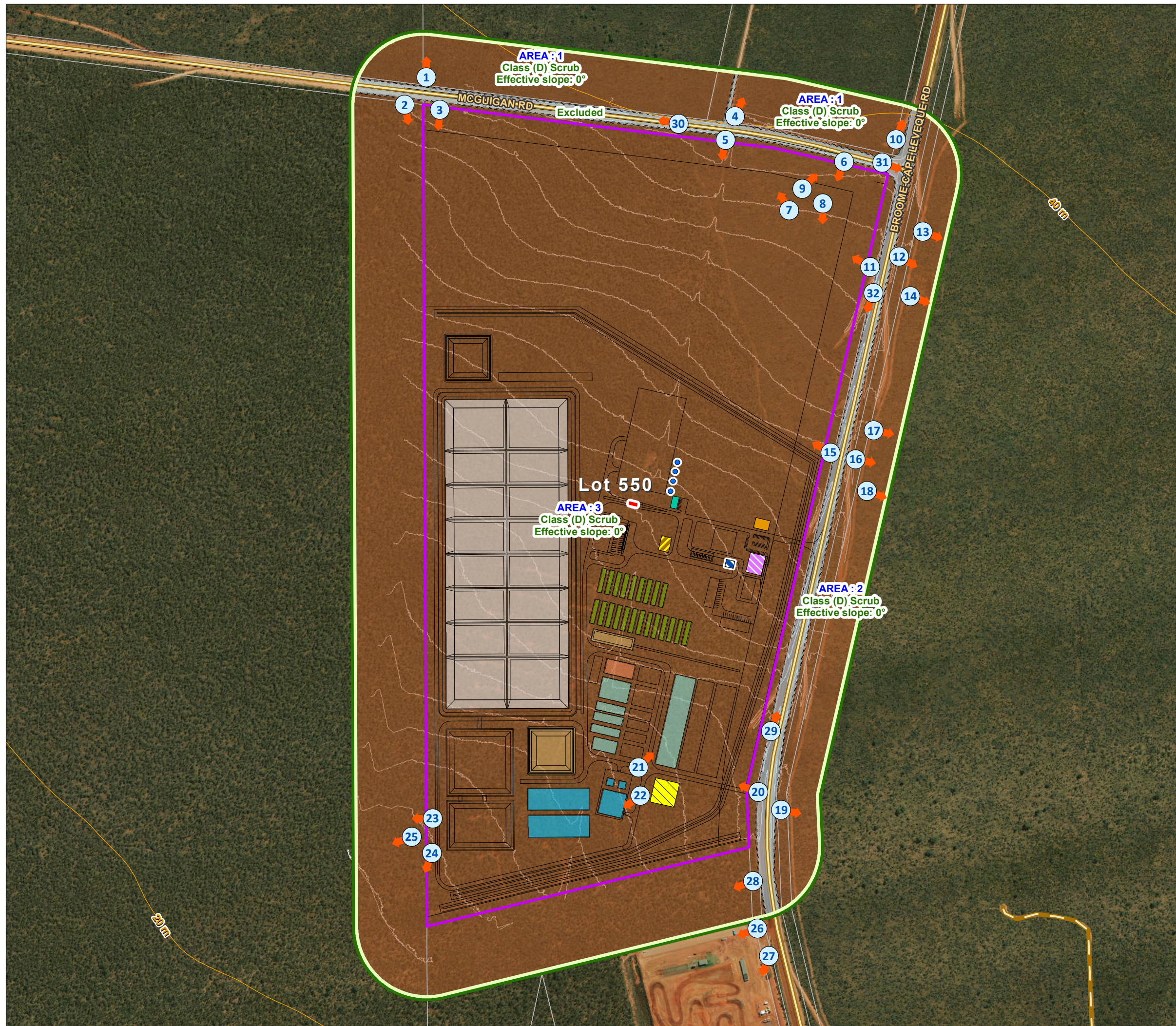
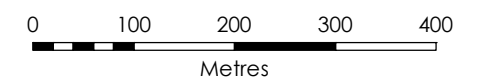
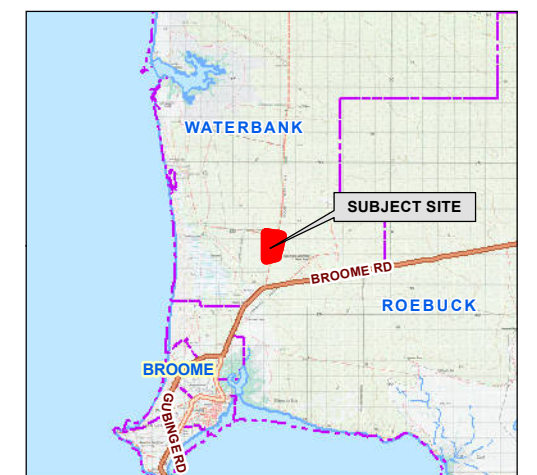


Figure 3.1
Topography & Classified Vegetation (Existing)
 Lot 550 on Plan 421448, Area : 121.0000 ha
 Cape Leveque Road
 WATERBANK
 SHIRE OF BROOME

- **LEGEND** -----
- Subject Site
 - Other Lots
 - ← Photo & Direction
 - Proposed Structures**
 - Weighbridge Admin Building
 - Admin and Crib
 - Solar Farm
 - HHW Shed
 - Water Tank
 - Reuse Shop and Education Centre
 - Construction Yard Landfill Workshop
 - BOH, Workshop
 - Development Layout**
 - Clean Fill
 - Evaporation Ponds & Liquid Waste
 - Timber & Green Waste
 - Various Waste Areas
 - Landfill
 - Leachate Pond
 - 150m Vegetation Assessment Area**
 - 150m from Subject Site
 - Classified Vegetation**
 - Class (D) Scrub
 - Exclusion 2.2.3.2



----- **LOCALITY** -----



Aerial Imagery : Landgate/SLIP
 Image Date : Apr 2021



Coordinate System: GDA 1994 MGA Zone 51
 Projection: Universal Transverse Mercator Units: Metre
 Map compiled by: Ian Ross 16/05/2022
 Map updated by: Ian Ross 16/05/2022
 A3 Scale 1:7,500



Figure 3.1.1
Topography & Classified Vegetation (Post Development)
Lot 550 on Plan 421448, Area : 121.0000 ha
Cape Leveque Road
WATERBANK
SHIRE OF BROOME

----- **LEGEND** -----

Subject Site

- Subject Site
- Other Lots

Proposed Structures

- Weighbridge Admin Building
- Admin and Crib
- Solar Farm
- HHW Shed
- Water Tank
- Reuse Shop and Education Centre
- Construction Yard Landfill Workshop
- BOH, Workshop

Proposed Structures Asset Protection

- 13m 29kw APZ
- 44.1m 10kw APZ
- 100m Buffer Zone

Development Layout

- Clean Fill
- Evaporation Ponds & Liquid Waste
- Timber & Green Waste
- Various Waste Areas
- Landfill
- Leachate Pond

150m Vegetation Assessment Area

- 150m from Subject Site

Classified Vegetation

- Class (D) Scrub
- Exclusion 2.2.3.2

0 100 200 300 400
Metres

----- **LOCALITY** -----

Aerial Imagery : Landgate/SLIP
Image Date : Apr 2021

Coordinate System: GDA 1994 MGA Zone 51
Projection: Universal Transverse Mercator Units: Metre
Map compiled by: Ian Ross 16/05/2022
Map updated by: Ian Ross 16/05/2022
A3 Scale 1:7,500

3.1.3 Vegetation Separation Distance

The vegetation separation distance is the horizontal distance measured from the relevant parts of an existing building or a future building's planned location (within a lot) to the determined edge of an area of classified vegetation.

This separation distance applied to determining a Bushfire Attack Level (BAL) can be either:

- The measured distance – for which the location of the building relative to the edge of classified vegetation must be known. This will result in single determined BAL that will apply to a building. (The measured distance is a required calculation input); or
- A calculated minimum and maximum distance (range) that will correspond to each individual BAL. The calculated distances provide an indicative (or achievable) BAL for which the determined BAL will be dependent on the known location of the building relative to the edge of classified vegetation.

The calculated range of distances corresponding to each BAL can be presented in different formats (tables or a BAL contour map), dependent on the form of information that is most appropriate for the proposed development/use. These distance ranges corresponding to BAL(s) will be presented in Section 3.2: 'Assessment Output'.

For the proposed land use, the applicable vegetation separation distances will be presented within the Bushfire Management Plan in this location:

In Section 3.2 'Assessment Output' as a table containing the calculated ranges of distance corresponding to each BAL and illustrated as a BAL Contour Map.

3.2 Assessment Output

UNDERSTANDING THE RESULTS OF THE BUSHFIRE IMPACT ASSESSMENT

Bushfire Attack Levels (BALs) – Their Application in the Building Environment is Different to the Planning Environment

In the building environment, a **determined BAL** is required for the proposed construction at the building application stage. This is to inform approval considerations and establish the bushfire construction standards that are to apply. An indicative BAL is not acceptable for a building application.

In the planning environment, through the application of SPP 3.7 and associated Guidelines, the deemed to satisfy requirement for a proposed 'development site' or sites (defined by the LPS Amendment Regulations 2015 as "that part of a lot on which a building that is the subject of development stands or is to be constructed"), is that a BAL-29 or lower rating can be achieved once all works associated with the proposal are completed. For planning approval purposes, an **indicative BAL** can provide the required information.

Determined Bushfire Attack Level

A determined BAL is to apply to an existing building or the 'development site' on which the building is to be constructed and not to a lot or building envelope. Its purpose is to state the potential radiant heat flux to which the building will be exposed, thereby determining the construction standard to be applied.

A determined BAL cannot be given for a future building whose design and position on the lot are unknown or the vegetation separation distance has not been established. It is not until these variables have been fixed that a determined BAL can be stated, and a BAL Certificate can be issued.

The one exception is when a building **of any dimension** can be **positioned anywhere** on a proposed lot (within R-Code building setbacks) or within a defined building envelope, and always remain subject to the same BAL, regardless of the retention of any existing classified vegetation either onsite or offsite.

Indicative Bushfire Attack Level

If a BAL is not able to achieve 'determined' status it will be an indicative BAL. It indicates the BAL that can be achieved by the proposed development/use. However, it is conditional upon an assessment variable(s) being confirmed at a later stage (e.g. the building location is established/changed, or vegetation is modified/removed to establish the vegetation separation distance).

A BAL certificate cannot be issued for an indicative BAL – unless that BAL cannot vary (refer to 'Determined BAL' above).

In table form, a single or a range of indicative BAL(s) may be presented. If a single indicative BAL is stated for a defined area (i.e. the lot or building envelope), this will be the highest indicative BAL impacting the defined area.

In BAL contour map form (refer to Section 3.2.2), the illustrated BAL contours visually identify areas of land for which if any part of an existing or proposed building is located on that land and within the BAL contours, then the highest BAL affecting that building (or part of the land on which the building will be constructed), will be the indicative BAL that is to apply.

The BAL can only become a determined BAL once the actual location of that building on the land is known and/or the required minimum vegetation separation distance corresponding to the relevant BAL contour is established (refer to Table 3.x).

3.2.1 Bushfire Attack Level Results - BAL Contour Map Format

INTERPRETATION OF THE BUSHFIRE ATTACK LEVEL (BAL) CONTOUR MAP

The contour map will present different coloured contour intervals extending from the areas of classified bushfire prone vegetation. These represent the different bushfire attack levels that will exist at varying distances away from the classified vegetation in the event of a bushfire in that vegetation.

The areas of classified vegetation to be considered in developing the BAL contours, are those that will remain as the intended end state of the subject development once earthworks, clearing and/or landscaping and re-vegetation have been completed (or each stage completed).

Each bushfire attack level corresponds to a set range of radiant heat flux that is generated by a bushfire. That range is defined by the AS 3959:2018 BAL determination methodology.

The width of each shaded BAL contour is a diagrammatic representation of the separation distances from the classified vegetation that correspond to each BAL for each separately identified area of classified vegetation. They have been calculated by the application of the unique site variables including vegetation types and structure, ground slope and applied fire weather.

(Refer to Section 3.2 'Understanding the Results of the Bushfire Impact Assessment' for the explanation of how BAL(s) for buildings will be assessed from the BAL Contour Map).

Construction of the BAL Contours

VEGETATION AREAS APPLIED TO THE DEVELOPMENT OF THE BAL CONTOUR MAP

All identified areas of classified vegetation have been applied with the following exceptions:

1. All vegetation within Asset Protection Zones around buildings and within the levee area are excluded as it is a requirement of this BMP that these areas will be managed to a low bushfire threat state.
2. Portions of road reserve along the sealed road that are devoid of vegetation and where it can reasonably be expected to be maintained clear through road maintenance programs.

VEGETATION SEPARATION DISTANCES APPLIED

The distances that have been applied to illustrating the width of each BAL contour shown in Figure 3.2 are stated in Table 3.3. These correspond to each Bushfire Attack Level and are specific to the proposed development site.

Table 3.3: Vegetation separation distances applied to construct the BAL contours.

BAL CONTOUR MAP – APPLIED VEGETATION SEPARATION DISTANCES								
Derived from the Application of Method 1 BAL Determination Methodology (AS 3959:2018 Section 2, Table 2.5) ¹								
Vegetation Area	Vegetation Classification	Effective Slope (degree range)	BAL and Corresponding Separation Distance (m)					
			BAL-FZ	BAL-40	BAL-29	BAL-19	BAL12.5	BAL-LOW
1	Class D Scrub	upslope or flat	<10	10-<13	13-<19	19-<27	27-<100	>100
2	Class D Scrub	upslope or flat	<10	10-<13	13-<19	19-<27	27-<100	>100
3	Class D Scrub	upslope or flat	<10	10-<13	13-<19	19-<27	27-<100	>100
Note ¹ All the assessment inputs applied are presented in Section 2.1.								



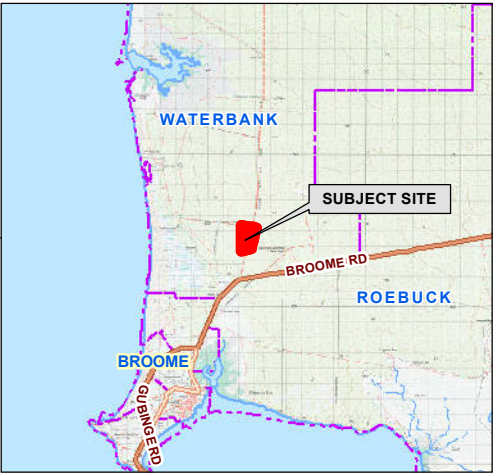
Figure 3.2
**BAL Contour Map
(Post Development)**
Lot 550 on Plan 421448, Area : 121.0000 ha
Cape Leveque Road
WATERBANK
SHIRE OF BROOME

----- **LEGEND** -----

- Subject Site
- Proposed Structures**
 - Weighbridge Admin Building
 - Admin and Crib
 - Solar Farm
 - HHW Shed
 - Water Tank
 - Reuse Shop and Education Centre
 - Construction Yard Landfill Workshop
 - BOH, Workshop
- Proposed Structures Asset Protection**
 - 13m 29kw APZ
 - 44.1m 10kw APZ
 - 100m Buffer Zone
- Development Layout**
 - Clean Fill
 - Evaporation Ponds & Liquid Waste
 - Timber & Green Waste
 - Various Waste Areas
 - Landfill
 - Leachate Pond
- 100m Vegetation Assessment Area**
 - 100m from Subject Site
 - Classified Vegetation Boundary
- Indicative Bushfire Attack Levels**
 - BAL FZ
 - BAL 40
 - BAL 29
 - BAL 19
 - BAL 12.5
 - BAL LOW

0 100 200 300 400
Metres

----- **LOCALITY** -----



Aerial Imagery : Landgate/SLIP
Image Date : Apr 2021

Coordinate System: GDA 1994 MGA Zone 51
Projection: Universal Transverse Mercator Units: Metre
Map compiled by: Ian Ross 16/05/2022
Map updated by: Ian Ross 16/05/2022
A3 Scale 1:7,500

3.2.2 Bushfire Attack Level Results - Derived from The BAL Contour Map

Table 3.4: Indicative and determined BAL(s) for proposed building works.

BUSHFIRE ATTACK LEVEL FOR BUILDINGS/STRUCTURE		
BAL Determination Methodology Applied ¹	Method 1 as per AS 3959:2018 s2.2.6 and Table 2.5.	
Building/Structure Description	Indicative BAL (refer to start of s2.2)	Determined BAL (refer to start of s2.2)
Reuse Shop & Education Centre	BAL-12.5	-
Staff Crib & Amenities building	BAL-LOW	-
HHW Shed	BAL-LOW	-
BOH, Workshop	BAL-LOW	-
Weighbridge Admin	BAL-LOW	-
Solar Farm	BAL-12.5	-
Construction yard landfill workshop	BAL-12.5	-
<i>Note¹ Assessment inputs applied are presented in Section 3.1.</i>		

The indicative bushfire attack level (BAL) ratings in the table above are derived on the assumption that scrub vegetation within the site area bounded by the levee, can and will be removed or modified to low threat standards.

The proposed buildings/sheds/structures listed above can meet the planning requirement of being located in an area within the site where a BAL rating of BAL-29 can be achieved through implementation of asset protection zones. A minimum BAL-29 (29kW/m²) asset protection zone around relevant buildings/structures is indicated on Figure 3.2 BAL Contour Map (Post Development).

A minimum 10kW/m² asset protection zone buffer is indicated around the Reuse shop and Education Centre building to enable a safer onsite location to shelter, as a last resort, in the event of a bushfire.

3.2.3 Determined Separation Distances Corresponding to 10kW/m² of Radiant Heat Flux

Acceptable solutions with regard to radiant heat exposure during a bushfire emergency event can apply to certain 'vulnerable' land uses. These solutions establish the requirements for safer onsite shelter locations to be subject to radiant heat flux no greater than 10 kW/m² for a building or 2 kW/m² for an open area.

The subject site is not considered a vulnerable land use, however it is a requirement of the 'Existing Vehicular Access/Egress Route Risk Assessment' identified in the 'High Risk Land Use – Bushfire Risk Assessment Report' for this site, that a nominated safer onsite building be identified.

The reuse shop and education centre building is nominated as the safer onsite location, as part of the bushfire evacuation planning for the site, and is to be used as a last resort in the event of a local bushfire event. A 10kW/m² Asset Protection Zone is to be established around the building, and the required vegetation separation distances are tabulated below.

Table 3.5: Specific vegetation separation distances for 'vulnerable land use' application (applied for shelter-in-place procedures).

SEPARATION DISTANCES CORRESPONDING TO 10 kW/m ² OF RADIANT HEAT FLUX		
BAL Determination Methodology Applied ¹		Method 1 as per AS 3959:2018 s2.2.6 and Table 2.5.
Vegetation Area	Vegetation Classification	Separation Distance Corresponding to 10 kW/m ² (metres)
1	Class D Scrub	44.1
<i>Note¹ Assessment inputs applied are presented in Section 3.1. AS 3959:2018 method 2 calculation input/output summary data is presented for reference in Appendix 4</i>		

The maximum radiant heat exposure from Vegetation Areas that will affect the nominated building, after the 10kW/m² APZ is established, are shown in the Table below.

Table 3.6: Determined exposure to radiant heat flux for stated building or open area.

MAXIMUM RADIANT HEAT FLUX EXPOSURE			
BAL Determination Methodology Applied ¹		Method 1 as per AS 3959:2018 s2.2.6 and Table 2.5.	
Building Description	Vegetation Area	Vegetation Classification	Maximum Radiant Heat Flux Exposure (kW/m ²)
Reuse shop and education centre	1	Class D Scrub	10
<i>Note¹ Assessment inputs applied are presented in Section 3.1. AS 3959:2018 method 2 calculation input/output summary data is presented for reference in Appendix 4</i>			

4 IDENTIFICATION OF BUSHFIRE HAZARD ISSUES

In response to the Bushfire Management Plan requirements established by Appendix 5 of the Guidelines for Planning in Bushfire Prone Areas (WAPC 2021 v1.4), the following statements are made to assist in the understanding of whether the proposal is likely to be able to comply with the bushfire protection criteria now or in subsequent planning stages.

Spatial Context - Broader Landscape Considerations	
Wider road network and access constraints	Due to the remoteness and sparse population of the Kimberley there is a limited road network available for public use over the broader landscape that service the site. At a more local level the site has access to Broome Road via Cape Leveque Road. Broome Road is a main arterial road for the region and provides access to further destinations.
Proximity of settlements and emergency services	The Shire of Broome Administration is approximately 12 kilometres from the subject site. The Broome Regional Bushfire Brigade is located 6.6 kilometres and 5 minutes from the site on Wattle Drive and the Broome Volunteer Fire and Rescue Service located 13.1 kilometres and 12 minutes from the site on Frederick Street.
Bushfire prone vegetation types and extent (including conserved vegetation)	Significant extents of bushfire prone vegetation exist across the broader landscape as retained native vegetation (scrub).
Topography and fire behaviour interactions.	The topography is generally flat or gently sloping and will not greatly affect the rate of spread or intensity of a bushfire. Bushfire behaviour will be influenced by prevailing wind direction and wind speed.
Potential for extreme fire behaviour and pyro convective events.	Possible due to the large areas of bushfire prone vegetation, high temperatures experienced in the locality during the dry season conducive to bushfires.
Environmental Considerations	
Constraints to implementing required and/or additional bushfire protection measures	The environment considerations have not identified any issues affecting the bushfire protection measures.
Provision of Access Within the Subject Site	
Potential constraints	Good access/egress and construction standard of internal roads/driveways will be available throughout the site.
Potential Bushfire Impacts	
Flame and radiant heat and ability to establish an APZ	All onsite buildings will be subject to a BAL rating of BAL-12.5 or lower, will not be subject to flame contact and will be subject to a relatively low radiant heat level during a bushfire event. (Post Development)
Embers/firebrands, smoke and fire-driven wind	These will be the major impacts to the subject site. The appropriate protection measure of strict management of the asset protection zones and low fuel areas will mitigate the risk.

5 ASSESSMENT AGAINST THE BUSHFIRE PROTECTION CRITERIA ESTABLISHED BY THE GUIDELINES

For a development application that is not a 'Tourism Land Use' to be considered compliant with SPP 3.7, it must satisfy (achieve) the intent of each of the four elements of the bushfire protection criteria. These criteria are established by the *Guidelines for Planning in Bushfire Prone Areas WAPC 2021 v1.4*). Compliance can be achieved by either:

- Meeting all applicable acceptable solutions corresponding to each element (i.e. the minimum bushfire protection measures that are deemed to satisfy planning requirements); or
- Where an acceptable solution cannot be met, by developing a performance solution that satisfies the established requirements.

5.1 Local Government Variations to Apply

Local governments may add to or modify the acceptable solutions of the Bushfire Protection Criteria (BPC) and/or apply technical requirements that vary from those specified in the *Guidelines for Planning in Bushfire Prone Areas (WAPC)*. In such instances, this Proposal will be assessed against these variations and/or any specific local government technical requirements for emergency access and water. Refer to Appendices 2 and 3 for relevant technical requirements.

Will local or regional variations (endorsed by WAPC / DFES) to the applicable acceptable solutions established by the <i>Guidelines</i> or the <i>Position Statement: Tourism land uses in bushfire prone areas WAPC October 2019</i> , apply to this Proposal?	N/A
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5.2 Summary of Assessment Against the Bushfire Protection Criteria

SUMMARISED OUTCOME OF THE ASSESSMENT AGAINST THE BUSHFIRE PROTECTION CRITERIA					
Element of the Bushfire Protection Criteria	Basis for the Proposal Achieving Full Compliance with SPP 3.7			The Proposal Cannot Achieve Full Compliance with SPP 3.7	
	Acceptable Solutions Met		Achieves the Intent of the Element		
	All applicable solutions are fully met	All applicable solutions are not fully met. A merit based assessment and/or a bushfire performance comparison of the proposals residual risk with that of the residual risk of the acceptable solution is conducted (refer Note 4)	A performance principle-based solution is applied	Bushfire planning development type that may not require full compliance is applied	An improvement in bushfire performance compared to the existing development is detailed (refer Note 4)
1. Location	✓			N/A	
2. Siting and Design of Development	✓				
3. Vehicular Access		✓			
4. Water	✓				
5. Vulnerable Tourism & Land Uses	N/A				

Note: The development proposal has been assessed:

- Against the requirements established in Appendix 4 of the *Guidelines for Planning in Bushfire Prone Areas*, WAPC 2021 v1.4 (*Guidelines*). The Guidelines are found at <https://www.planning.wa.gov.au/8194.aspx>; and
- Applying the interpretation guidance provided in *Position Statement: Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design* (WAPC Nov 2019).
- Applying any endorsed variations to the Guideline's acceptable solutions and associated technical requirements that have been established by the local government. If known and applicable these have been stated in Section 5.1 with the detail included as an appendix if required by the local government.
- When non-compliant with SPP 3.7 and when appropriate, by utilising additional compliance pathways that include the application of merit based assessment and comparative bushfire performance. The validity of this approach is derived from relevant decisions made by the responsible authorities (refer Appendix 2).

5.3 Assessment Detail

Element 1: Location	
Intent: To ensure that strategic planning proposals, subdivision and development applications are located in areas with the least possible risk of bushfire to facilitate the protection of people, property and infrastructure.	
Compliance: How the proposed development achieves the intent of Element 1:	By fully meeting all applicable acceptable solutions established by the bushfire protection criteria (Guidelines v1.4 WAPC 2021)
ASSESSMENT (COMPLIANCE) STATEMENTS For each applicable acceptable solution, the following statements present the results of the assessment of the proposed development/use against the requirements established by the <i>Guidelines</i> (WAPC 2021 v1.4) and apply the interpretation guidance established by the <i>Position Statement: Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design</i> (WAPC Nov 2019).	
Acceptable Solution: A1.1: Development Location	
ASSESSMENT AGAINST THE REQUIREMENTS ESTABLISHED BY THE GUIDELINES The site will enable an area of land within the Lot that can be considered suitable for development by being able to obtain a BAL-29 or lower rating. Identified on the BAL Contour Map (Figure 3.2) areas of the development site are subject to radiant heat levels corresponding to BAL-40 and BAL-FZ ratings, this is addressed by development design through minimum setbacks from unmanaged vegetation. This meets the requirements established by Acceptable Solution A1.1 and its associated explanatory note.	
ASSESSMENT AGAINST THE REQUIREMENTS ESTABLISHED BY THE POSITION STATEMENT	
The position statement establishes that: <ul style="list-style-type: none"> • The source of risk (the hazard) to be considered in Element 1 is the "level of bushfire exposure" from the type and extent of bushfire prone vegetation and the topography of the land on which it exists; and • "Consideration should be given to the site context" which includes the land both "within and adjoining the subject site". The "hazards remaining within the site should not be considered in isolation of the hazards adjoining the site, as the potential impact of a bushfire will be dependent on the wider risk context." The position statement also recognises: <ul style="list-style-type: none"> • That the proposed development site and its surrounding land may be part of an area "identified for development or intensification of land use prior to the release of SPP 3.7"; consequently • Consideration by decision-makers "should also be given to improving bushfire management of the site and surrounding area, thereby reducing the vulnerability of people property and infrastructure to bushfire"; and • The application of mitigation measures to lessen the risk to the broader area would include improvements to the local road network (including emergency access ways), improvements/additions to firefighting water supply and increasing separation distance from the hazard. 	
The Hazard Within the Subject Site An area of native scrub vegetation will remain onsite to the north of the development site between the facility levee and McGuigan Road and to the south alongside the levee and perimeter fence line.	

Element 1: Location

The ability to establish the required APZs around buildings/structures in conjunction with cleared hardstand and storage areas within the site, increase separation from hazards and provide protection to buildings from greater levels of radiant heat.

The primary bushfire threat from bushfire prone vegetation remaining within the proposed lot will be embers. This threat will be mitigated by the application of appropriate building design, bushfire construction standards where applicable and ongoing maintenance of the APZ's to ensure the buildings will not be impacted by consequential fire within combustible materials used, stored or accumulated within the APZ.

The impact of the slopes under the vegetation will be dependent on a bushfire's direction of travel, but the subject site is relatively flat and therefore bushfire will not be influenced by the site slope, but rather wind driven. In its current state, significantly intense bushfire behaviour is possible, particularly if onsite vegetation is ignited by a bushfire burning in the adjoining land and they are involved together.

The Hazard Adjoining the Subject Site

The subject site is surrounded by large areas of bushfire prone vegetation. The potential exists for intense bushfire behaviour to occur within these areas of bushfire prone vegetation. The potential bushfire impact on persons and property within the subject site will primarily be ember attack.

The ember threat will be mitigated by the ongoing maintenance of the Asset Protection Zones, to ensure the buildings will not be impacted by consequential fire within combustible materials used, stored or accumulated within the APZ. The radiant heat level is mitigated by maintaining good separation distances between buildings and vegetation external to the site.

The impact of slope will be negligible as the surrounding topography is generally flat or gently sloping.

Bushfire prone vegetation within the surrounding locality exists as native vegetation classified as Class D Scrub.

The impact of the slope under the vegetation will be dependent on a bushfire's direction of travel, but slopes in the range of zero to five degrees downslope from the proposed development do exist. Bushfire travelling upslope will have increased intensity and rate of spread. However, the adjoining land cannot be considered as rugged (which would present the potential for more extreme and variable fire behaviour).

Element 2: Siting and Design of Development

Intent: To ensure that the siting and design of development (note: not building/construction design) minimises the level of bushfire impact.

Compliance: How the proposed development achieves the intent of Element 2:

By fully meeting all applicable acceptable solutions established by the bushfire protection criteria (Guidelines v1.4 WAPC 2021)

ASSESSMENT (COMPLIANCE) STATEMENTS

For each applicable acceptable solution, the following statements present the results of the assessment of the proposed development/use against the requirements established by the *Guidelines (WAPC 2021 v1.4)* and apply the interpretation guidance established by the *Position Statement: Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design (WAPC Nov 2019)*.

Acceptable Solution: A2.1: Asset Protection Zone

THE APZ - DEVELOPMENT SITING AND DESIGN PLANNING REQUIREMENTS

The necessary outcome of bushfire planning for development siting and design, is to ensure that a building can be located within the developable portion of any lot (i.e. outside those parts of the lot that form the required R-Code building setbacks, or any other excluded area), and be subject to potential radiant heat from a bushfire not exceeding 29 kW/m² (i.e. a maximum BAL of BAL-29).

This will be achieved when the size of the "low fuel area immediately surrounding a building", the asset protection zone (APZ), is large enough. This requires a certain separation distance to exist between the building and areas of classified vegetation. These are the BAL-29 APZ dimensions and they will vary dependent on site specific parameters.

The APZ should be contained solely within the boundaries of the lot, except in instances where the neighbouring lot(s) or adjacent public land will be managed in a low-fuel state on an ongoing basis, in perpetuity.

Where possible, planning for siting and design should incorporate elements that include non-vegetated areas (e.g. roads/parking/drainage) and/or formally managed areas of vegetation (public open space/recreation areas/services installed in a common section of land), as either part of the required APZ dimensions or to additionally increase separation distances to provide greater protection. These elements create robust and easier managed asset protection zones.

THE ASSESSMENT

Future buildings on the development site can be surrounded by an APZ that will ensure the potential radiant heat impact of a bushfire does not exceed 29 kW/m² (BAL-29). The required APZ specifications of width, location and management can be achieved.

APZ Width: The required APZ dimensions to ensure buildings are subject to a maximum BAL of BAL-29 (measured from any external wall or supporting post or column to the edge of the classified vegetation), has been determined in Section 3.2 of this BMP and are:

BAL-29 APZ Dimensions		
Buildings, sheds, structures	Building to Vegetation Area 1	Minimum 13 metres
	Building to Vegetation Area 2	Minimum 13 metres
	Building to Vegetation Area 3	Minimum 13 metres

APZ Location: The APZs are able to be contained solely within the boundaries of the Lot (development site area).

- Road verge with a commitment from the local government to manage.

Onsite vegetation will be required to be modified/removed, the authority for which will need to be received from the local government.

Element 2: Siting and Design of Development

APZ Management: All vegetation that will require modification/removal and future management is onsite and therefore under the control of the landowner.

Retained vegetation will be managed in accordance with the technical requirements established by the Schedule 1: 'Standards for Asset Protection Zones (Guidelines)'. The APZ specifications are also detailed in Appendix 1 and the Shire of Broome may have additional requirements established by their Firebreak Notice.

THE APZ – REQUIRED DIMENSIONS TO SATISFY FUTURE BUILDING (AND ONGOING MANAGEMENT)

It is important for the landowner to be aware that the APZ dimensions that will be required to be physically established and maintained on each lot surrounding relevant future buildings, may be different to those stated above for the BAL-29 APZ - which is the minimum dimension a planning proposal needs to show can be established to comply with SPP 3.7.

The actual APZ dimensions to be physically established and maintained, will be based on which of the following establishes the larger APZ dimension:

- The dimensions corresponding to the determined BAL of a building (refer to Section 3.2 for explanation of the 'planning' versus 'building' requirements and 'indicative' versus 'determined' BAL); or where practicable
- The APZ dimensions established by the local government's Firebreak Notice.

If the dimensions of the APZ that are to be established are known at this time, they will be stated below.

The potential to reduce future construction BAL's for future buildings below BAL-29 is possible (See Figure 3.2), assuming the removal of native vegetation within the area bounded by the levee occurs.

For this proposal all buildings, sheds and structures will require a 20 metre Asset Protection Zone as per the requirements of the Shire of Broome Fire Break & Fuel Hazard Reduction Notice.

As an additional bushfire protection measure the Reuse shop and Education Centre is nominated as a shelter in place building (or place of last resort) in the event of a bushfire, when it is too late to evacuate. The building is required to be subject to a maximum potential radiant heat flux level of 10kW/m². The APZ for this building is calculated to be 44.1 metres (See Appendix 4).

Element 3: Vehicular Access

Intent: To ensure that the vehicular access serving a subdivision/development is available and safe during a bushfire event.

Compliance: How the proposed development achieves the intent of Element 3:

By fully meeting all applicable acceptable solutions established by the bushfire protection criteria (Guidelines v1.4 WAPC 2021)

ASSESSMENT (COMPLIANCE) STATEMENTS

For each applicable acceptable solution, the following statements present the results of the assessment of the proposed development/use against the requirements established by the *Guidelines (WAPC 2021 v1.4)*.

Acceptable Solution: A3.1: Public Roads

The existing external and future internal road network within the site will provide public and emergency vehicles a suitable trafficable transport route and will be available at all times under all weather conditions. The construction technical requirements established by the Guidelines and/or the local government can and will be complied with. The subject portion of Cape Leveque Road that provides access to the facility exceeds the minimum requirements of Table 6 Column 1.

Acceptable Solution: A3.2a: Multiple Access Routes

Two way access is available at Broome Road, a distance of 1.8 kilometres from the subject site. Broome Road provides access west to the Broome townsite or east to Great Northern Highway where access is available north to Derby or south to Port Hedland.

Acceptable Solution: A3.2b: Emergency Access Way

- Not Applicable -

Acceptable Solution: A3.3: Through Roads

Cape Leveque Road is an existing 'dead end road' that extends over 200 kilometres and provide access to the wider Dampier Peninsula area. Informal roads connect with Cape Leveque Road through various land tenure. However, the subject site is located approximately 1.8 kilometres metres from the intersection with Broome Road. This is 1.6 kilometres greater than the nominal/allowable access distance of 200 metres.

The subject site is therefore technically non-compliant with this acceptable solution and a risk based assessment is provided as a separate document.

Acceptable Solution: A3.4a: Perimeter Roads

- Not Applicable -

Acceptable Solution: A3.4b: Fire Service Access Routes

- Not Applicable -

Acceptable Solution: A3.5: Battle-axe Access Legs

- Not Applicable -

Acceptable Solution: A3.6: Private Driveways

Site internal driveways will provide access and egress for large commercial and private vehicles and suitable turnaround areas, including carparks, are available throughout the site. The driveways provide easy access throughout the site in the form of a looped driveway/road system. Driveways will be a high construction standard to accommodate the landuse including both asphalt for main traffic and public use areas and compacted gravel for site operations.

Element 4: Water

Intent: To ensure water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire.

Compliance: How the proposed development achieves the intent of Element 4:

By fully meeting all applicable acceptable solutions established by the bushfire protection criteria (Guidelines v1.4 WAPC 2021)

ASSESSMENT (COMPLIANCE) STATEMENTS

For each applicable acceptable solution, the following statements present the results of the assessment of the proposed development/use against the requirements established by the *Guidelines (WAPC 2021 v1.4)*.

Acceptable Solution: A4.1: Identification of Future Water Supply

A reticulated water supply is not currently available to the site. The closest reticulated hydrant is located 2.3 kilometres of the subject site within the Broome Road Industrial Park (Hydrants located on Katsuyama Road and on Warrgamburu Drive, within the Industrial Park).

Required hydrant separation distances – 100 m commercial, 200 m residential, 400 m rural residential >1ha

Acceptable Solution: A4.2: Provision of Water for Fire Fighting Purposes

The proposed development has an ample firefighting water supply as required for the waste management and landfill use, including water tanks and water carts. The exact volume of available firefighting water supply is unknown but will have a capacity far exceeding 50,000L.

Water tanks and/or standpipes are required to be fitted with couplings in accordance with Appendix 3.

The construction technical requirements established by the Guidelines and/or the local government can and will be complied with.

5.4 Addressing Non-Compliance with Applicable Acceptable Solutions

Where the proposed development/use is unable to fully comply with all required planning elements, for which a corresponding set of acceptable solutions has been established, there are several methodology options that potentially can be applied to progress the proposal for consideration by the decision makers.

These are established by SPP 3.7 (and the associated Guidelines) as risk and merit based assessments, specific DPLH Position Statements or through precedence set by previous planning application cases progressing through relevant State reviewing bodies.

THE ACCEPTABLE SOLUTION(S) UNABLE TO BE COMPLIED WITH	
Acceptable Solution	Brief Description of Non-Compliance
A3.3 Through roads	The subject site is greater than 200 metres down a 'dead end road'.

THE METHODOLOGY APPLIED TO PROGRESS THE ASSESSMENT OF THE PROPOSED DEVELOPMENT /USE		
Methodology Options	Applied	Information location
Prepare a Bushfire Risk Assessment	<input checked="" type="checkbox"/>	Provided as separate document

5.5 Additional Bushfire Protection Measures

The following bushfire protection measures are to be implemented and maintained. They are additional to those established by the relevant acceptable solutions applied to the proposed subdivision, development or use.

The relevant acceptable solutions are those against which this planning proposal has been assessed in Section 5.2 of this Bushfire Management Plan.

5.5.1 Additional Measures Established by the Bushfire Risk Assessment Report ('High Risk' Land Use)

SUMMARY OF ADDITIONAL BUSHFIRE PROTECTION MEASURES (TREATMENTS) TO BE APPLIED by the BUSHFIRE RISK ASSESSMENT REPORT ('High Risk' Land Use) (Detail Contained in the Bushfire Risk Assessment Report (High Risk Land Use))		
Bushfire Protection Measure	Relevant Site Specific Details	Application
Emergency response (Evacuation and shelter-in-place)	Increased size of APZ for shelter in place building to distances corresponding to a radiant heat flux not exceeding 10kW/m ² .	To be applied
Emergency response (Evacuation and shelter-in-place)	Proposed shelter in place building (Reuse Shop and Education Centre) is required to be constructed to AS 3959-2018 standards for BAL-29.	To be applied
Building resilience	Staff Crib and Amenities building is required to be constructed to AS 3959-2018 standards for BAL-12.5.	To be applied
Building resilience	Inspect proposed design of the shelter in place building (Reuse Shop and Education Centre) for design vulnerabilities.	Recommended to be applied
Procedures for storage of all flammable onsite material	<ul style="list-style-type: none"> Flammable materials that will potentially be consequential fires, for example wooden pallets, to be stored a minimum 20 metres from any building and not within the APZ. Onsite waste disposal bins to be located: <ul style="list-style-type: none"> a) with a lid, at a minimum of 6 metres from buildings and within a maintained APZ, or; b) without lid, at a minimum of 20 metres from buildings and within a maintained APZ. 	To be applied
Minimise level of bushfire impact	Install a minimum BAL-29 dimensioned APZ around all stored combustible materials onsite, including diesel storage, landfill cells and stored waste. Note this is currently achieved in the proposed site layout, see Figure 3.2: the BAL Contour Map.	To be applied
Firefighting water supply	Finalise layout and availability of firefighting resources. Note that staff or emergency services are not intended to suppress a bushfire, but to defend assets and prevent consequential fire in combustible waste or other material. Therefore, appropriate resources to prevent or suppress onsite fires are likely also appropriate to bushfire response.	To be applied
Procedures for staff and contractors	Preparation and implementation of an appropriate operating procedures document. This must consider: <ul style="list-style-type: none"> Spontaneous combustion, particularly within green waste windrows; HAZMAT responses to multiple fuel types; Surface and subsurface landfill fires, including identification and response; Site responses to prevent onsite fires igniting a bushfire; Machinery and plant maintenance and cleaning; Mechanical and structural fires; Installation and maintenance of Asset Protection Zones (APZs). 	To be applied

Procedures for staff and contractors	Procedures to include reference to the Bushfire Emergency Plan (BEP)	To be applied
Develop a Bushfire Emergency Plan (BEP)	To inform the landowners (and operators as applicable) of the preparation, response, recovery and review procedures (and associated actions) that will apply to the subject property and its operation. To be supplied as a separate document.	To be applied
Implementation of BEP.	Responsible persons will remain onsite, when operational, and be trained in the implementation of the required Bushfire Emergency Plan.	To be applied
Procedures for staff and contractors	Update Emergency Management Plan to include bushfire evacuation procedures.	To be applied
Training and education	A training program for initial response to the bushfire response (refer to Bushfire Emergency Plan (BEP))	To be applied
Training and education	Bushfire awareness training to be provided to staff.	To be applied
Emergency Services response	Invite the Broome Regional Bushfire Brigade and the Broome Volunteer Fire and Rescue Service to inspect and familiarise with the site.	Recommended to be applied

6 RESPONSIBILITIES FOR IMPLEMENTATION AND MANAGEMENT OF THE BUSHFIRE PROTECTION MEASURES

Table 6.1: BMP Implementation responsibilities prior to occupancy or building.

Landowner (Developer) – Implementation Responsibilities	
No.	Implementation Actions
1	<p>The local government may condition a development application approval with a requirement for the landowner/proponent to register a notification onto the certificate of title and deposited plan.</p> <p>This will be done pursuant to Section 70A <i>Transfer of Land Act 1893</i> as amended ('Factors affecting use and enjoyment of land, notification on title'). This is to give notice of the bushfire hazard and any restrictions and/or protective measures required to be maintained at the owner's cost.</p> <p>This condition ensures that:</p> <ol style="list-style-type: none"> 1. Landowners/proponents are aware their lot is in a designated bushfire prone area and of their obligations to apply the stated bushfire risk management measures; and 2. Potential purchasers are alerted to the Bushfire Management Plan so that future landowners/proponents can continue to apply the bushfire risk management measures that have been established in the Plan.
2	<p>Post planning approval, the entity responsible for having the BMP prepared should ensure that anyone listed as having responsibility under the Plan has endorsed it and is provided with a copy for their information and informed that it contains their responsibilities. This includes the landowners/proponents (including future landowners where the Plan was prepared as part of a development approval), local government and any other authorities or referral agencies ('Guidelines' s4.6.3).</p>
3	<p>Establish the Asset Protection Zone (APZ) surrounding all buildings and structures to the dimensions stated in this BMP.</p> <p>Establish the APZ to the above dimensions and to the standards established by the Guidelines (refer to Appendix 1) or as varied by the local government through their Firebreak Notice This is the responsibility of the landowner.</p>
4	<p>The subject lot is to be compliant with the Shire of Broome Fire Break & Fuel Hazard Reduction Notice issued under s33 of the Bushfires Act 1954.</p> <p>This may include specifications for asset protection zones that differ from the Guideline's APZ Standards, with the intent to better satisfy local conditions. When these are more stringent than those created by the Guidelines, or less stringent and endorsed by the WAPC and DFES, they must be complied with. Refer to Appendix 1.</p>
5	<p>To implement the additional risk treatments contained in Section 5.5 of this Bushfire Management Plan, in addition to the measures that are established by the acceptable solutions.</p>
6	<p>There is an outstanding obligation, created by this Bushfire Management Plan, for a Bushfire Emergency Plan for proposed occupants to be developed and approved prior to occupancy. The Bushfire Emergency Plan establishes the required actions corresponding to a set of relevant procedures that are to be followed in preparation for a bushfire emergency event and in response to and recovery from, a bushfire emergency event.</p>
7	<p>A copy of the Bushfire Emergency Plan must be provided to the landowner/occupier and they are to be informed that it contains responsibilities that must be actioned.</p> <p>This Plan must be read, and the instructions contained in the Plan that require certain information to be displayed and available to all occupants, must be complied with.</p>

8	All actions contained within the Pre-Season Procedure established by the Bushfire Emergency Plan, must be completed.
9	There is an outstanding obligation, created by this Bushfire Management Plan, for a Bushfire Risk Assessment Report to be developed and approved for the 'high risk' land use (refer to Section 1.2).
10	All proposed risk treatments that have been identified within the Bushfire Risk Assessment Report for this site, must be implemented prior to storage of waste materials at the facility/premises. These are contained in Section 5.5 of this Bushfire Management Plan.
11	<p>Prior to any future building work, inform the builder of the existence of this Bushfire Management Plan and the responsibilities it contains, regarding the required construction standards. This will be:</p> <ul style="list-style-type: none"> • The standard corresponding to the determined BAL, as per the bushfire provisions of the Building Code of Australia (BCA); and/or • A higher standard because the BMP establishes that the construction standard is to correspond to a higher BAL as an additional bushfire protection measure.

Table 6.2: Ongoing management responsibilities for the Landowner/Occupier.

Landowner/Occupier - Ongoing	
No.	Ongoing Management Actions
1	Maintain the Asset Protection Zone (APZ) surrounding all buildings and structures to the dimensions stated in this BMP. Maintain the APZ to the above dimensions and to the standards established by the Guidelines (refer to Appendix 1) or as varied by the local government through their Firebreak Notice (refer to the following responsibility).
2	Comply with the Shire of Broome Fire Break & Fuel Hazard Reduction Notice issued under s33 of the Bush Fires Act 1954. This may include specifications for asset protection zones that differ from the Guideline's APZ Standards, with the intent to better satisfy local conditions. When these are more stringent than those created by the Guidelines, or less stringent and endorsed by the WAPC and DFES, they must be complied with. Refer to Appendix 1.
3	Maintain vehicular access routes within the development to the required surface condition and clearances as stated in the BMP (Appendix 2).
4	Maintain the emergency water supply tanks and their associated fittings and vehicular access in good working condition.
5	Maintain the additional bushfire protection measures established by the Bushfire Risk Assessment Report, contained in Section 5.5 of this Bushfire Management Plan, in addition to the measures that are established by the acceptable solutions.
6	Ensure that any builders (of future structures on the lot) are aware of the existence of this Bushfire Management Plan and the responsibilities it contains regarding the application of construction standards corresponding to a determined BAL.
7	Ensure all future buildings the landowner has responsibility for, are designed and constructed in full compliance with: <ul style="list-style-type: none"> 1. the requirements of the WA Building Act 2011 and the bushfire provisions of the Building Code of Australia (BCA); and 2. with any identified additional requirements established by this BMP or the local government.
8	Annually review the Bushfire Emergency Plan and conduct the pre-season preparation procedure.
9	The Bushfire Risk Assessment Report containing bushfire risk management measures for flammable onsite hazards and operations with the potential to ignite a bushfire, must be reviewed each year and relevant information updated. All required measures must continue to be complied with.

Table 6.3: Ongoing management responsibilities for the Local Government.

Local Government - Ongoing	
No.	Ongoing Management Actions
1	Monitor landowner compliance with the Bushfire Management Plan and the annual Fire Break & Fuel Hazard Reduction Notice.

APPENDIX 1: TECHNICAL REQUIREMENTS FOR ONSITE VEGETATION MANAGEMENT

A1.1 Requirements Established by Element 2, A2.1, E2 and Schedule 1 (Guidelines v1.4)

The APZ:

This is an area surrounding a habitable building containing either no fire fuels and/or low threat fire fuels that are maintained in a minimal fuel condition. The primary objectives include:

- To ensure the building is sufficiently separated from the bushfire hazard to limit the impact of its direct attack mechanisms i.e. reduce the potential for direct flame contact on the building, reduce the level of radiant heat to which the building is exposed, prevent surface fire spreading to the building and (dependent on the vegetation types) some reduction on the level of ember attack. *Schedule 1: Standards for Asset Protection Zones* (reproduced in Appendix 1) and the explanatory notes in the Guidelines (DPLH as amended) provide guidance for achieving this objective. The relevant local government may have further guidance tailored to local conditions in their annual firebreak notice (reproduced in Appendix 1 when applicable);
- To ensure other combustible materials that can result in consequential fire (typically ignited by embers) within both the APZ and parts of the building - are eliminated, minimised and/or appropriately located or protected. The explanatory notes in the Guidelines (DPLH as amended) provide some guidance for achieving this objective (and other sources are available); and
- Provide a defensible space for firefighting activities.

Bushfire Planning Requirements:

For planning purposes (as opposed to building purposes – see additional notes in Section 5.4 of this BMP - 'What sized APZ must be established') - the necessary outcome for siting and design of development, is to demonstrate that a building can be located within the developable portion of any lot (i.e. outside those parts of the lot that form the required R-Code building setbacks, or any other excluded area), and be subject to potential radiant heat from a bushfire in the adjacent vegetation not exceeding 29 kW/m² (i.e. a maximum BAL rating of BAL-29).

This will be achieved when the dimensions of the APZ are large enough. These are the BAL-29 APZ dimensions, and they will vary dependent on the type of vegetation present and the slope of the ground under that vegetation. The required dimensions are determined in this BMP. Other requirements include:

- The APZ should be contained solely within the boundaries of each lot, except in instances where the neighbouring lot(s) or adjacent public land will be maintained to a low-fuel state in perpetuity, and this can be justified (or are non-vegetated).
- Where possible, planning for siting and design of development should incorporate elements that include non-vegetated areas (e.g. roads / parking / drainage / water body) and/or formally managed areas of vegetation (public open space / recreation areas / services installed in a common section of land), as either part of the required APZ dimensions for each lot or to additionally increase separation distances to provide greater protection.

Explanatory Notes – Guidelines E2

These notes address:

- Managing an Asset Protection Zone (APZ) to a low threat state;
- Landscaping and design of an asset protection zone; and
- Plant flammability

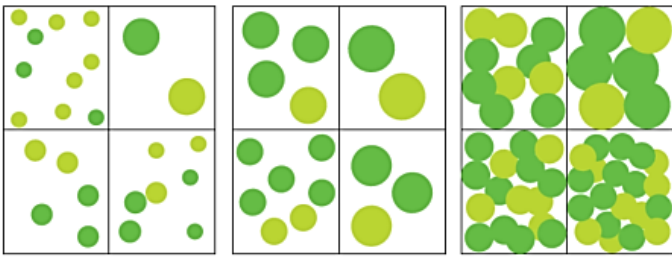
Schedule 1: Standards for Asset Protection Zones

Refer to the following extract from the Guidelines.



ELEMENT 2: SITING AND DESIGN OF DEVELOPMENT

SCHEDULE 1: STANDARDS FOR ASSET PROTECTION ZONES

OBJECT	REQUIREMENT
Fences within the APZ	<ul style="list-style-type: none"> Should be constructed from non-combustible materials (for example, iron, brick, limestone, metal post and wire, or bushfire-resisting timber referenced in Appendix F of AS 3959).
Fine fuel load (Combustible, dead vegetation matter <6 millimetres in thickness)	<ul style="list-style-type: none"> Should be managed and removed on a regular basis to maintain a low threat state. Should be maintained at <2 tonnes per hectare (on average). Mulches should be non-combustible such as stone, gravel or crushed mineral earth or wood mulch >6 millimetres in thickness.
Trees* (>6 metres in height)	<ul style="list-style-type: none"> Trunks at maturity should be a minimum distance of six metres from all elevations of the building. Branches at maturity should not touch or overhang a building or powerline. Lower branches and loose bark should be removed to a height of two metres above the ground and/or surface vegetation. Canopy cover within the APZ should be <15 per cent of the total APZ area. Tree canopies at maturity should be at least five metres apart to avoid forming a continuous canopy. Stands of existing mature trees with interlocking canopies may be treated as an individual canopy provided that the total canopy cover within the APZ will not exceed 15 per cent and are not connected to the tree canopy outside the APZ. <p>Figure 19: Tree canopy cover – ranging from 15 to 70 per cent at maturity</p>  <p>15% 30% 70%</p>
Shrub* and scrub* (0.5 metres to six metres in height). Shrub and scrub >6 metres in height are to be treated as trees.	<ul style="list-style-type: none"> Should not be located under trees or within three metres of buildings. Should not be planted in clumps >5 square metres in area. Clumps should be separated from each other and any exposed window or door by at least 10 metres.
Ground covers* (<0.5 metres in height. Ground covers >0.5 metres in height are to be treated as shrubs)	<ul style="list-style-type: none"> Can be planted under trees but must be maintained to remove dead plant material, as prescribed in 'Fine fuel load' above. Can be located within two metres of a structure, but three metres from windows or doors if >100 millimetres in height.

OBJECT	REQUIREMENT
Grass	<ul style="list-style-type: none"> Grass should be maintained at a height of 100 millimetres or less, at all times. Wherever possible, perennial grasses should be used and well-hydrated with regular application of wetting agents and efficient irrigation.
Defendable space	<ul style="list-style-type: none"> Within three metres of each wall or supporting post of a habitable building, the area is kept free from vegetation, but can include ground covers, grass and non-combustible mulches as prescribed above.
LP Gas Cylinders	<ul style="list-style-type: none"> Should be located on the side of a building furthest from the likely direction of a bushfire or on the side of a building where surrounding classified vegetation is upslope, at least one metre from vulnerable parts of a building. The pressure relief valve should point away from the house. No flammable material within six metres from the front of the valve. Must sit on a firm, level and non-combustible base and be secured to a solid structure.

* Plant flammability, landscaping design and maintenance should be considered – refer to explanatory notes

A1.2 Established by AS 3959:2018 – Low Threat and Non-Vegetated Areas

AS 3959 establishes the methodology for determining a bushfire attack level (BAL) along with the corresponding construction requirements. The methodology includes the classification of the subject site's vegetation according to their 'type' and the application of the corresponding bushfire behaviour parameters in determining the applicable BAL(s). Certain vegetation can be considered as low threat and excluded from classification. Where this has occurred in the assessing of the subject site, the extract below establishes the state that area of land must be maintained to.

15

AS 3959:2018

2.2.3.2 Exclusions—Low threat vegetation and non-vegetated areas

The following vegetation shall be excluded from a BAL assessment:

- Vegetation of any type that is more than 100 m from the site.
- Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified vegetation.
- Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other or of other areas of vegetation being classified vegetation.
- Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified vegetation.
- Non-vegetated areas, that is, areas permanently cleared of vegetation, including waterways, exposed beaches, roads, footpaths, buildings and rocky outcrops.
- Vegetation regarded as low threat due to factors such as flammability, moisture content or fuel load. This includes grassland managed in a minimal fuel condition, mangroves and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, orchards, banana plantations, market gardens (and other non-curing crops), cultivated gardens, commercial nurseries, nature strips and windbreaks.

NOTES:

- Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognizable as short-cropped grass for example, to a nominal height of 100 mm).
- A windbreak is considered a single row of trees used as a screen or to reduce the effect of wind on the leeward side of the trees.

A1.3 Established by the Local Government – the Firebreak Notice

The relevant local government's current Firebreak Notice is available on their website, at their offices and is distributed as ratepayer's information. It must be complied with.

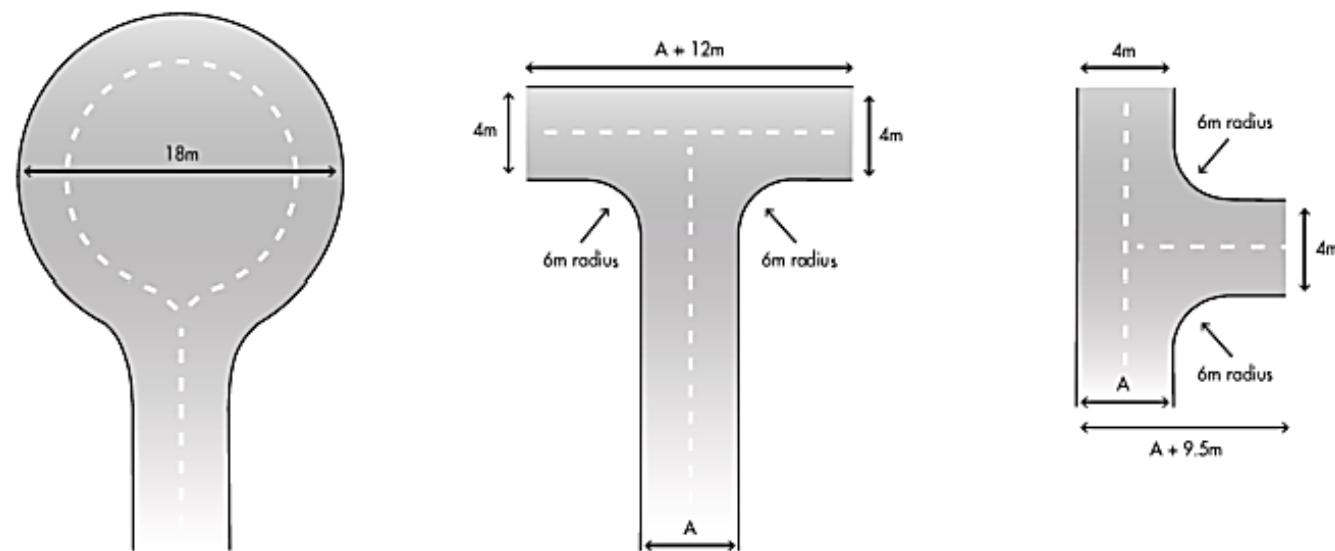
These requirements are established by the relevant local government's Firebreak Notice created under s33 of the Bushfires Act 1954 and issued annually (potentially with revisions). The Firebreak Notice may include additional components directed at managing fuel loads, accessibility and general property management with respect to limiting potential bushfire impact.

If Asset Protection Zone (APZ) specifications are defined in the Firebreak Notice, these may differ from the Standards established by the Guideline's, with the intent to better satisfy local conditions. When these are more stringent than those created by the Guidelines, or less stringent and endorsed by the WAPC and DFES, they must be complied with.

APPENDIX 2: TECHNICAL REQUIREMENTS FOR VEHICULAR ACCESS

The design/layout requirements for access are established by the acceptable solutions of the Guidelines (DPLH, 2021 v1.4) Element 3 and vary dependent on the access component, the land use and the presence of 'vulnerable' persons. Consequently, the best reference source are the Guidelines. The technical requirements that are fixed for all components and uses are presented in this appendix.

GUIDELINES TABLE 6, EXPLANATORY NOTES E3.3 & E3.6 AND RELEVANT ACCEPTABLE SOLUTIONS

Technical Component	Vehicular Access Types / Components			
	Public Roads	Emergency Access Way ¹	Fire Service Access Route ¹	Battle-axe and Private Driveways ²
Minimum trafficable surface (m)	In accordance with A3.1	6	6	4
Minimum Horizontal clearance (m)	N/A	6	6	6
Minimum Vertical clearance (m)	4.5			
Minimum weight capacity (t)	15			
Maximum Grade Unsealed Road ³	As outlined in the IPWEA Subdivision Guidelines	1:10 (10%)		
Maximum Grade Sealed Road ³		1:7 (14.3%)		
Maximum Average Grade Sealed Road		1:10 (10%)		
Minimum Inner Radius of Road Curves (m)		8.5		
Turnaround Area Dimensions for No-through road, Battle-axe Legs and Private Driveways ⁴				
<div></div>				
Passing Bay Requirements for Battle-axe leg and Private Driveway				
When the access component length is greater than the stated maximum, passing bays are required every 200m with a minimum length of 20m and a minimum additional trafficable width of 2m (i.e. the combined trafficable width of the passing bay and constructed private driveway to be a minimum 6m).				
Emergency Access Way – Additional Requirements				
Provide a through connection to a public road, be no more than 500m in length, must be signposted and if gated, gates must be open the whole trafficable width and remain unlocked.				
<div>¹ To have crossfalls between 3 and 6%. ² Where driveways and battle-axe legs are not required to comply with the widths in A3.5 or A3.6, they are to comply with the Residential Design Codes and Development Control Policy 2.2 Residential Subdivision. ³ Dips must have no more than a 1 in 8 (12.5% or 7.1 degree) entry and exit angle. ⁴ The turnaround area should be within 30m of the main habitable building.</div>				

APPENDIX 3: TECHNICAL REQUIREMENTS FOR FIREFIGHTING WATER SUPPLY

RETICULATED AREAS – HYDRANT SUPPLY

The Guidelines state "where a reticulated water supply is existing or proposed, hydrant connection(s) should be provided in accordance with the specifications of the relevant water supply authority."

The main scheme water suppliers / authorities in WA are The Water Corporation, AqWest – Bunbury Water Corporation and Busselton Water Corporation. Various local authority exists in other non-scheme and regional areas. However, most existing fire hydrants are connected to Water Corporation water mains.

Consequently, the hydrant location specifications from The Water Corporation's 'No 63 Water Reticulation Standard' (Ver 3 Rev 15) are provided in the extract below with the key distances relevant to bushfire planning assessments being highlighted. This Standard is deemed to be the baseline criteria for developments and should be applied unless different local water supply authority conditions apply. Other applicable specification will be found in the Standard.

Note: The maximum distance from a hydrant to the rear of a lot/building is generally interpreted as not applicable to large lot sizes where the maximum distance becomes an impractical limitation i.e. typically rural residential areas.

Design Standard DS 63
Water Reticulation Standard



2.2.1.5 Appurtenances

c. Hydrants

Hydrants shall be screw-down hydrant with built-in isolation valve and installed only on DN100 or larger pipes. Hydrants shall be located:

- so that the maximum distance between a hydrant and the rear of a building envelope, (or in the absence of a building envelope the rear of the lot) shall be 120m;
- so that spacing (as measured by hose-run) between hydrants in non-residential or mixed use areas shall be maximized and no greater than 100m;
- so that spacing (as measured by hose-run) between hydrants in residential areas with lots per dwelling <10,000m² shall be maximized and no greater than 200m;
- so that spacing between hydrants (as measured by hose-run) in rural residential areas where minimum lots per dwelling is >10,000 m² (1ha) shall be maximized and no greater than 400m;
- centrally along the frontage of a lot to avoid being under driveways, unless the lot features a frontage 6m or less, in which case it shall be placed to the side opposite the driveway;
- at lots that have the widest frontage in the local area;
- where appropriate at the truncation of road junctions or intersections so that they can serve more than one street and can be readily located;
- on both sides of the major roads at staggered intervals where there are mains on both sides of the road;
- at major intersections on dual multi-lane roads, where two hydrants are to be sited on diagonally opposite corners;
- hydrants should be located at least 20m from traffic calming devices i.e., median slow points or chokers, chicanes, mini traffic circles, and intersection 'pop-outs' to ensure traffic is not impeded;
- in a position not less than 10m from any high voltage main electrical distribution equipment such as transformers and distribution boards, liquefied petroleum gas or other combustible storage;
- directly on top of the main using a tee unless proved to be impractical.

NON-RETICULATED AREAS – STATIC SUPPLY

For specified requirements, refer to the Guidelines Element 4: Water – Acceptable Solution A4.2, Explanatory Notes E4 (that provide water supply establishment detail under the headings of water supply; independent water and power supply; strategic water supplies, alternative water sources and location of water tanks) and the technical requirements established by Schedule 2 (reproduced below).

SCHEDULE 2: WATER SUPPLY DEDICATED FOR BUSHFIRE FIREFIGHTING PURPOSES

2.1 Water supply requirements

Water dedicated for firefighting should be provided in accordance with Table 7 below, and be in addition to water required for drinking purposes.

Table 7: Water supply dedicated for bushfire firefighting purposes

PLANNING APPLICATION	NON-RETICULATED AREAS
Development application	10,000L per habitable building
Structure Plan / Subdivision: Creation of 1 additional lot	10,000L per lot
Structure Plan / Subdivision: Creation of 3 to 24 lots	10,000L tank per lot or 50,000L strategic water tank
Structure Plan / Subdivision: Creation of 25 lots or more	50,000L per 25 lots or part thereof Provided as a strategic water tank(s) or 10,000L tank per lot

2.2 Technical requirements

2.2.1 Construction and design

An above-ground tank and associated stand should be constructed of non-combustible material. The tank may need to comply with AS/NZS 3500.1:2018.

Below ground tanks should have a 200mm diameter access hole to allow tankers or emergency service vehicles to refill direct from the tank, with the outlet location clearly marked at the surface. The tank may need to comply with AS/NZS 3500.1:2018. An inspection opening may double as the access hole provided that the inspection opening meets the requirements of AS/NZS 3500.1:2018. If the tank is required under the BCA as part of fire hydrant installation, then the tank will also need to comply with AS 2419.

Where an outlet for an emergency service vehicle is provided, then an unobstructed, hardened ground surface is to be supplied within four metres of any water supply.

2.2.2 Pipes and fittings

All above-ground, exposed water supply pipes and fittings should be metal. Fittings should be located away from the source of bushfire attack and be in accordance with the applicable section below, unless otherwise specified by the local government.

2.2.2.1 Fittings for above-ground water tanks:

- Commercial land uses: 125mm Storz fitting; or
- Strategic water tanks: 50mm or 100mm (where applicable and adapters are available) male camlock coupling with full flow valve; or
- Standalone water tanks: 50mm male camlock coupling with full flow valve; or
- Combined water tanks: 50mm male camlock coupling with full flow valve or a domestic fitting, being a standard household tap that enables an occupant to access the water supply with domestic hoses or buckets for extinguishing minor fires.

2.2.2.2 Remote outlets

In certain circumstances, it may be beneficial to have the outlet located away from the water supply. In such instances in which a remote outlet is to be used, the applicant should consult the local government and DFES on their proposal.

EXAMPLE CONSTRUCTION AND FITTINGS



Strategic 47,000 Litre Concrete Tank & Protected Fittings



10,000 Litre Concrete Tank



Storz and Camlock Couplings



Full Flow 50mm Ball Valve



Full Flow 50mm Gate Valve and Male Camlock

APPENDIX 4: AS 3959:2018 METHOD 2 INPUT/OUTPUT CALCULATION SUMMARIES

DETERMINING 10 KW/M² SEPARATION DISTANCES

Vegetation Area 1



Calculated March 31, 2022, 1:45 pm (MDc v.4.9)

Recycling Resource Centre Cape Leveque Road, Broome

Minimum Distance Calculator - AS3959-2018 (Method 2)			
Inputs		Outputs	
Fire Danger Index	80	Rate of spread	4.16 km/h
Vegetation classification	Scrub	Flame length	11.62 m
Understorey fuel load	25 t/ha	Flame angle	65 °, 71 °, 76 °, 79 °, 80 ° & 84 °
Total fuel load	25 t/ha	Elevation of receiver	5.26 m, 5.49 m, 5.64 m, 5.7 m, 5.72 m & 5.78 m
Vegetation height	m	Fire intensity	53,815 kW/m
Effective slope	0 °	Transmissivity	0.865, 0.848, 0.824, 0.8, 0.788 & 0.732
Site slope	0 °	Viewfactor	0.413, 0.3045, 0.2058, 0.1396, 0.1134 & 0.0304
Flame width	100 m	Minimum distance to < 40 kW/m ²	13.9 m
Windspeed	45 km/h	Minimum distance to < 29 kW/m ²	18.7 m
Heat of combustion	18,600 kJ/kg	Minimum distance to < 19 kW/m ²	27 m
Flame temperature	1,200 K	Minimum distance to < 12.5 kW/m ²	37.5 m
		Minimum distance to < 10 kW/m ²	44.1 m

Rate of Spread - Catchpole et al. 1998

Flame length - Byram, 1959

Elevation of receiver - Douglas & Tan, 2005

Flame angle - Douglas & Tan, 2005

Radiant heat flux - Drysdale, 1999, Sullivan et al., 2003, Douglas & Tan, 2005



Broome Regional Resource
Recovery Centre

Bushfire Risk - Assessment & Management Report



Produced to meet the relevant requirements of STATE PLANNING POLICY 3.7 Planning in Bushfire Prone Areas & Guidelines

Lot 550 Broome-Cape Leveque Road

Shire of Broome

14 April 2022

Job Reference No: 210716

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<p>Limitations: The protection measures contained in this Bushfire Risk – Assessment and Management Report, are considered to be minimum requirements and they do not guarantee that buildings or infrastructure will not be damaged in a bushfire, persons injured, or fatalities occur either on the subject site or off the site while evacuating. This is substantially due to the unpredictable nature and behaviour of fire and fire weather conditions. Additionally, the correct implementation of the recommended protection measures will depend upon, among other things, the ongoing actions of the landowners and/or operators over which Bushfire Prone Planning has no control.</p> <p>All surveys, forecasts, projections and recommendations made in this report associated with the proposed development are made in good faith based on information available to Bushfire Prone Planning at the time. All maps included herein are indicative in nature and are not to be used for accurate calculations.</p> <p>Notwithstanding anything contained therein, Bushfire Prone Planning will not, except as the law may require, be liable for any loss or other consequences whether or not due to the negligence of their consultants, their servants or agents, arising out of the services provided by their consultants.</p> <p>Copyright © 2022 BPP Group Pty Ltd: All intellectual property rights, including copyright, in format and proprietary content contained in documents created by Bushfire Prone Planning, remain the property of BPP Group Pty Ltd. Any use made of such format or content without the prior written approval of Bushfire Prone Planning, will constitute an infringement on the rights of the Company which reserves all legal rights and remedies in respect of any such infringement.</p>					

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1 CONSULTANT STATEMENT - KEY OBSERVATIONS

The statement provides a subjective overall opinion to the persons tasked with reading this report and making decisions

The intent is to further assist or clarify the reported outcome. Importantly, the statement draws on the relevant qualifications and practical experience associated with bushfire and bushfire events and their management, of the bushfire practitioner compiling or approving this report.

In the absence of the required set of risk factor criteria, risk level matrix and risk tolerability scale being established by the regulatory authorities to enable the derivation of a 'determined' risk level - this statement will necessarily be framed around the applied assessment process that derives an 'indicative risk' level (refer to section 2.3.4 and Appendix 2).

The following statement is based on:

1. My opinions as an accredited bushfire practitioner with relevant experience and qualification; and
2. Supporting information derived from the assessments detailed in this report.

Summary Statement

The proposed development type must necessarily be remote from established settlements, and therefore exposed to bushfire prone vegetation. The site, immediate surrounds, and greater landscape is generally consistent, having a flat topography and vegetation meeting Class D Scrub classification. Waste processing facilities pose a dual risk, as onsite fires can ignite bushfires and vice versa. Onsite fires can be a HAZMAT incident and result in toxic plume exposure to persons onsite and offsite. The operational area of the site will be cleared of vegetation. Much of the site including green and timber waste, clean fill, vehicles, solar farm and collection zones will be subject to <10kW/m² of radiant heat flux from a bushfire.

The preparation and implementation of appropriate operating procedures is critical in prevention of and responses to onsite ignition of stored material and bushfire, particularly ember attack. This future document (referred to here as Standard Operating Procedures) must consider a range of hazards including:

- Spontaneous combustion, particularly within green waste windrows;
- HAZMAT responses to multiple fuel types;
- Surface and subsurface landfill fires, including identification and response;
- Site responses to prevent onsite fires igniting a bushfire;
- Machinery and plant maintenance and cleaning;
- Mechanical and structural fires.

Effective access and egress from the site is available via Broome-Cape Leveque Road, however it is bounded by the bushfire hazard for its entire route to the Broome town centre. Broome-Cape Leveque Road is an existing dead-end road with the proposed facility having 'official' two-way access available after 1.8km of travel at Broome Highway. Provision of two-way access is constrained by the existing road layout and is unlikely to be rectified with the remote location. Where a bushfire threatens the evacuation route, the Reuse Shop and Education Centre has been identified as an appropriate shelter in place location. This structure is required to establish an APZ to limit radiant heat flux to <10kW/m² and be constructed to the standards for BAL-29 under AS3959.

Broome-Cape Leveque Road is over 200km in length with multiple informal secondary access options through land of various tenures, which realistically can be used in an emergency scenario. Additionally suitable destinations do exist north on Broome-Cape Leveque Road and west on McGuigan Road where a beach is considered 'suitable.' The shoreline is a minimum fuel area which can and has been utilised in a bushfire emergency.

The persons onsite will be of low vulnerability, being either site staff, contractors, or local residents familiar with the region. All persons will necessarily have access to their own motorised, closed-cabin transportation. All staff are recommended to receive bushfire awareness training and a Standard Operating Procedures and/or Bushfire

Emergency Plan will nominate an Emergency Response Team and outline responsibilities and procedures in a bushfire event.

The bushfire prone vegetation impacting the site is consistent across the local region, being Class D Scrub with a generally flat topography. This vegetation extends for hundreds of square kilometres bounded only by the shoreline and limited developed areas including the Broome Townsite. The vegetation will support a campaign fire run due to the extreme extent, however the vegetation type will not generate significant embers/firebrands due to the primarily fine fuels and lack of appropriate bark. Stored waste materials are susceptible to ember attack and thus the lower exposure to ember attack limits the risk relative to similar developments in proximity to forest fuel types.

The scrub will not produce significant fire-generated winds, and the native vegetation and proposed landscaping to not include larger trees which could cause potential obstructions. The remaining impacts of radiant heat and flame contact will be limited where the Asset Protection Zone requirements are strictly maintained and staff onsite take appropriate responses to bushfires to minimise the likelihood and severity of consequential fires.

Key Factors Contributing to the Opinion

- The bushfire hazard, associated threat levels and the ability to apply protection measures
- The exposure of elements at risk and the ability to apply protection measures
- The vulnerability of elements at risk and the ability to apply protection measures

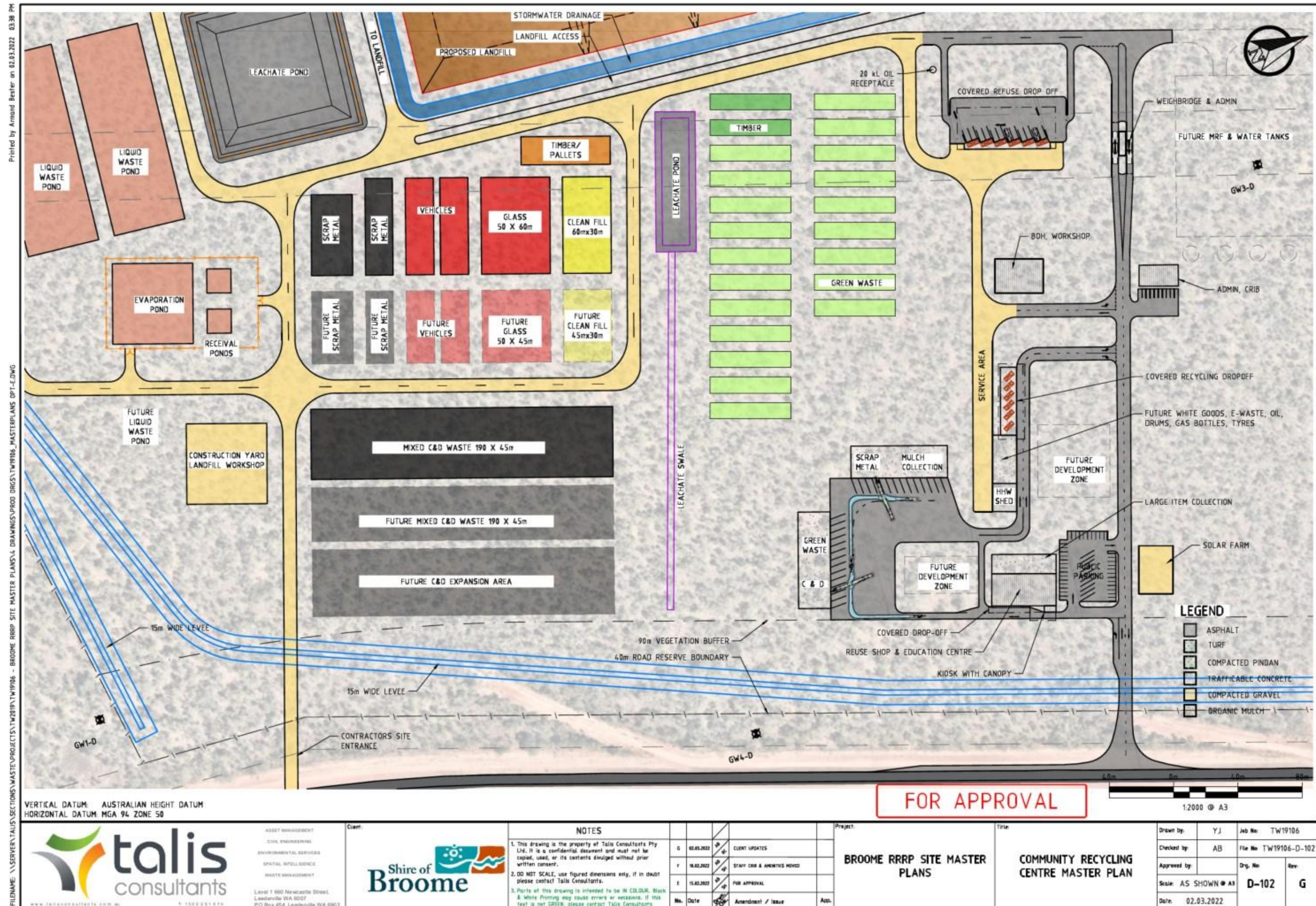
2 INTRODUCTION

2.1 THE PROPOSED DEVELOPMENT/USE

The proposed Broome Regional Resource Recovery Centre includes waste transfer/processing operations, storage, composting and landfill. These land uses are considered a High-Risk Land Use under State Planning Policy 3.7 Planning in Bushfire Prone Areas and the associated Guidelines for Planning in Bushfire Prone Areas (WAPC v1.4 December 2021).

This Bushfire Risk Assessment has been prepared alongside and in support of the associated Bushfire Management Plan.

Figure 2.1: Site Diagram/Plan



2.2 THE RISK ASSESSMENT OBJECTIVES

The Table 2.1 identifies the primary objectives of conducting the risk assessment process for the subject development/use. These will direct the way the process is conducted, and the type of information reported. Relevant objectives are typically determined by two key factors:

1. The type of development/use. Development can include subdivision of land, construction or modification of buildings, structures and infrastructure assets. Land uses can include those defined as residential, commercial, 'high risk' and 'vulnerable' (including tourism and events).
2. The stage of planning for the development/use. The two key stages are:
 - a) At the earlier planning stage of new development/use (when final details of the proposed development/use are not fully known) or when investigating the potential for the improvement of an existing development/use.

For these scenarios the requirement is to inform the relevant persons (planners / designers / operators / owners) regarding the application of bushfire protection measures to the greatest extent reasonably practicable. The intent being to achieve the required degree of bushfire resilience and an acceptable level of risk to persons and property; or

- b) At the submission for planning approval or 'decision to proceed' stage. All relevant details of the proposed development/use are known. The exposed elements are known, and the extent of exposure and vulnerability can be determined after assessment of the contribution to risk mitigation of all existing, planned and recommended bushfire protection measures.

The requirement at this planning stage is to inform decision makers by providing either an indication of the residual bushfire risk or a determined residual bushfire risk level (note there are limitations to the ability to provide determined risk levels - refer to section 2.3.4 for explanation).

Table 2.1: Identifying the risk assessment objectives for the subject development/use.

INFORMATION TO BE DERIVED FROM THE RISK ASSESSMENT		
Potential Objectives	Applicable	Comments
<p>New development/use:</p> <p>Inform relevant persons, at the appropriate planning stage, of available bushfire protection measures to be incorporated into siting, design, construction, education and management, to optimise bushfire performance.</p> <p>Identify from the established universe of potential bushfire protection measure principles, the site specific measures that have the potential to be applied as a package of protection measures to:</p> <ul style="list-style-type: none"> Ensure buildings, structures and other physical assets are resilient against bushfire hazard threats, to the greatest extent practicable. Ensure persons have their exposure and vulnerability to bushfire hazard threats reduced, to the greatest extent practicable. <p>Provide implementation advice as necessary.</p>	✓	<p>The facility layout is known and the assessments within this report and the associated Bushfire Management Plan are based on the assumption that no further modifications can/will be made. The site is currently vegetated, however the vegetation within the operational area will be cleared.</p>

<p>Existing development/use:</p> <p>Inform the owner / management of the existing operation (buildings and use) regarding the current level of bushfire resilience performance and person safety.</p> <p>Identify protection measures that can be implemented to improve that performance.</p> <p>Assess the standard of current application of any protection measures and provide recommendations to improve as necessary.</p> <p>Identify from the established universe of potential bushfire protection measure principles, additional site specific measures that have the potential to be applied as a package of protection measures to:</p> <ul style="list-style-type: none"> • Improve the bushfire resilience of buildings, structures and other physical assets to the greatest extent practicable; and • Reduce persons exposure and vulnerability to bushfire hazard threats reduced to the greatest extent practicable. <p>Provide implementation advice as necessary.</p>	<input type="checkbox"/>	
<p>Identify: The existence and types of bushfire prone vegetation onsite and offsite.</p> <p>Initially this may be limited to a desktop assessment with ground truthing to follow at a later date.</p>	<input checked="" type="checkbox"/>	<p>Bushfire prone vegetation currently exists both onsite and offsite. After preparation of the site for construction/operations, the operational areas will be clear of vegetation.</p>
<p>Assess: The relative levels each bushfire hazard threat (attack mechanism) presents.</p> <p>Identify if the broader physical landscape surrounding the subject development/use has the potential to increase or decrease the levels of those threats.</p>	<input checked="" type="checkbox"/>	<p>The local and broader landscape is largely consistent. Ember attack poses the greatest hazard poses the greatest threat in most scenarios.</p>
<p>Identify: All at risk physical elements that are exposed to the potential threats of the bushfire hazard.</p>	<input checked="" type="checkbox"/>	<p>This is the primary purpose of this assessment. Note that these elements, when compromised, are a hazard themselves.</p>
<p>Identify: All at risk human elements that are exposed to the potential threats of the bushfire hazard.</p>	<input checked="" type="checkbox"/>	<p>Human elements are considered in terms of vulnerability to bushfire and onsite (potential HAZMAT) fires.</p>
<p>Identify: All at risk commercial / private large livestock elements that are exposed to the potential threats of the bushfire hazard and whose care represents a potential exposure and vulnerability setting for person elements.</p>	<input type="checkbox"/>	
<p>Identify: Bushfire protection measures that have or can be applied to reduce the bushfire hazard threat levels to the greatest extent allowable and practicable.</p>	<input type="checkbox"/>	
<p>Identify: Bushfire protection measures that have or can be applied to reduce the exposure and vulnerability of</p>	<input checked="" type="checkbox"/>	<p>Onsite preparation and responses are vital to reducing vulnerability.</p>

buildings/structures, infrastructure and other physical assets thereby increasing asset resilience against bushfire hazard threats to the greatest extent practicable.		
Identify: Bushfire protection measures that have or can be applied to reduce the exposure and vulnerability of persons to bushfire hazard threats to the greatest extent practicable.	✓	Training and preparation will reduce both exposure and vulnerability.
Identify: Assets that owners/operators are prepared to lose from consequential fire resulting from a bushfire event rather than apply sufficient protection measures i.e., the asset loss risk is to be retained. This may be due to cost or practicability. Consideration of consequent risk and risk mitigation measures available to persons from asset abandonment.	✓	The loss of waste material due to fire is tolerable. The concerns are spread of uncontrolled onsite fire, ignition of offsite bushfire, and HAZMAT exposure to persons.
Assess: The <u>indicative</u> residual risk levels to inform planners / designers / operators / owners and/or relevant decision makers. This is to be achieved through the use of relative threat, exposure and vulnerability levels, the indicative risk matrix and risk tolerance scale established by the bushfire consultant. (Refer to Section 2.3.4, Appendix 2 and the glossary for additional information).	✓	The results of the assessment are discussed in Section 3.
Assess: The <u>determined</u> residual risk levels to inform planners / designers / operators / owners and/or relevant decision makers. This is to be achieved through the application of threat, exposure and vulnerability level criteria, a determined risk level matrix and a risk tolerance scale that have been established by the relevant authorities. (Refer to Section 2.3.4, Appendix 2 and the glossary for additional information).	<input type="checkbox"/>	The required risk factor criteria have not been developed by the relevant authority (refer to section 2.3.3).

2.3 THE APPLIED RISK ASSESSMENT PROCESS

2.3.1 THE DEFINITION OF RISK

For the applied risk assessment process, the relevant risks are the potential for loss of life, injury, or destroyed or damaged assets which results in personal loss and economic loss due to disruption of services and/or repair or replacement of buildings and infrastructure. The source of the risk is the is bushfire as a natural hazard.

2.3.2 THE ASSESSMENT PROCESS (FRAMEWORK)

To conduct and report the risk assessment process, Bushfire Prone Planning has adapted the understanding of disaster risk as described by the United Nations Office for Disaster Risk Reduction (UNDRR) and shown in Figure 2.2.

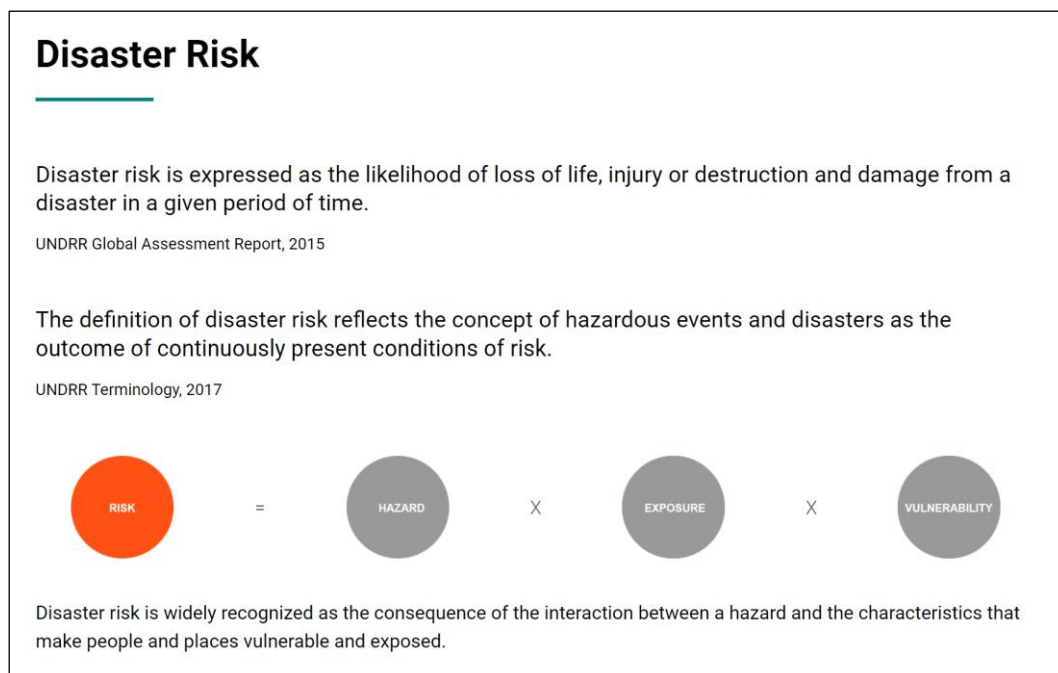


Figure 2.2: Understanding disaster risk (Source: United Nations Office for Disaster Risk Reduction [46]).

Although the UNDRR approach is designed to addresses disaster risk at large scale strategic levels, it can justifiably be applied to all scales of planning because it is focused on natural hazards and establishes a concept that can be readily adapted. The rationale for adopting this approach, rather than the methodology established by the National Emergency Risk Assessment Guidelines (AIDR 2020, NERAG), is provided in Appendix 1.

Also utilised within this assessment approach are relevant principles and measures to be applied in the development of bushfire risk mitigation strategies that are detailed in the Bushfire Verification Method Handbook [14].

PROCESS OVERVIEW

The risk presented by a natural hazard (such as a bushfire) is a consequence of the interaction between the potential threats associated with the hazard and the exposure and vulnerability of any elements at risk from those threats (the 'exposed elements').

The application of available protection measures will lower the risk by:

1. Reducing the number and/or level of the hazard threats; and/or
2. Reducing the level of exposure and/or vulnerability of the elements at risk.

Figure 2.3 illustrates the framework of the adapted risk assessment process (refer to the glossary for terminology information and Appendix 2 provides greater detail of the risk analysis component of the assessment process).

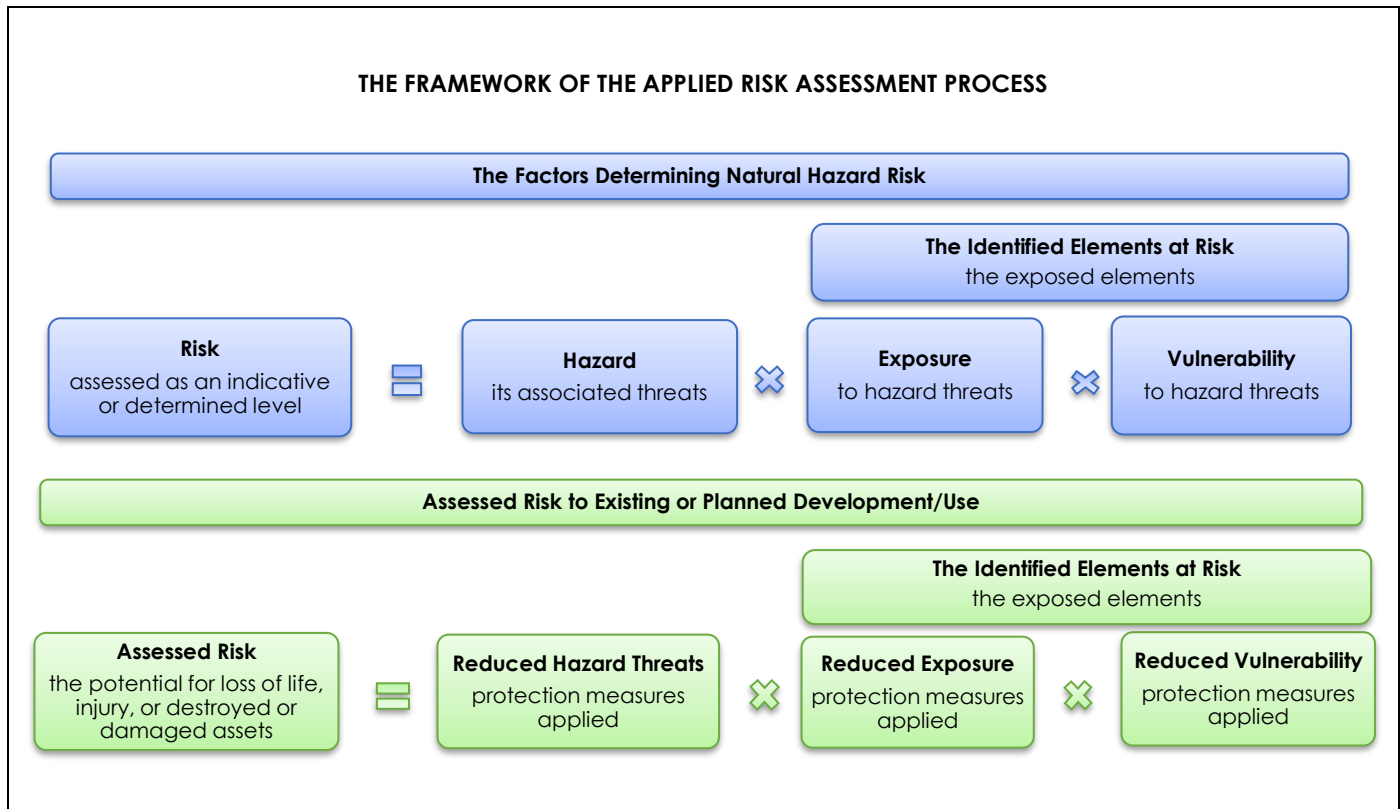


Figure 2.3: Framework of the applied risk assessment process.

2.3.3 RISK LEVEL ANALYSIS

(Refer to Appendix 2 and 3 and the Glossary for additional information.)

When the derivation of risk levels is a stated assessment objective, the risk analysis will derive a risk level as a summary outcome. The required risk level analysis can be conducted for either each exposed element separately and/or the proposed or existing development/use overall.

The risk level can be reported as either indicative or determined:

- **Indicative Risk Level:** This is derived based on a comparison of the numbers of protection measures able to be applied with the number of possible measures in the protection measure 'universe'. Appropriate weighting is given to the level of effectiveness of each of the measures. The intent is to provide a qualitative understanding of the level of risk that exists, to assist with making the required decisions.
- **Determined Risk Level:** This is derived using defined sets of risk factor criteria that correspond to each hazard threat level, exposure level and vulnerability level, for the elements at risk. Subsequently, how these defined levels are then applied to establish a determined risk level and its tolerability, is defined by an accepted risk level matrix and risk tolerance scale.

The risk factor criteria must reflect societies preparedness to tolerate risk and should be determined by regulatory authorities exercising their responsibilities. The criteria will vary dependent on development/use type and scale.

Consequently, the risk factor criteria (and potentially the risk level matrix and risk tolerance scale) need to be defined by the regulatory authorities before they can be applied in assessing a determined risk level.

Dependent on the stage of development/use, or to meet differing assessment objectives, the risk level can also be reported as:

- **Inherent Risk:** As the current risk when the assessment has only accounted for the bushfire protection measures that are either already in place (for existing development/use), or are planned to be incorporated into the proposed development/use; or
- **Residual Risk:** As the remaining risk when the assessment has also accounted for the application of any additional protection measures recommended by this report. If there are none, the residual risk is the same as the inherent risk.

2.3.4 USING THE ASSESSMENT PROCESS TO MEET THE STATED OBJECTIVES

The reporting objectives (established in Section 2.2) will vary for different types and stages of proposed (or existing) development/use. However, the same base framework is able to be utilised and the process can be adapted to achieve the required outcomes.

Figure 2.4 provides further detail of the adopted assessment process, based on the framework shown in Figure 2.3.

2.3.5 BUSHFIRE PROTECTION MEASURE EFFECTIVENESS RATINGS

The following effectiveness ratings are applied to the applicable bushfire protection measures, as part of the risk assessment process, and as a factor applied in deriving 'relative' threat, exposure and vulnerability levels.

The more effective a bushfire protection measure is, the greater its value in increasing bushfire resilience (buildings/structures), and/or increasing the safety of persons and in decreasing the level of risk associated with bushfire.

The effectiveness ratings incorporate the qualities of:

1. **Independence:** As a qualitative assessment, the extent to which the protection measure has the capacity to reduce threat, exposure and vulnerability levels as either independent of other protection measures (i.e., standalone) or requiring the cumulative capacity of a package of interdependent measures; and
2. **Passiveness:** The capacity of the protection measure to function without the active involvement of persons.

The greater the independence and passiveness of a protection measure, the greater its effectiveness.

Table 2.2: Bushfire protection measure effectiveness ratings.

THE APPLIED BUSHFIRE PROTECTION MEASURE EFFECTIVENESS RATINGS	
Rating / Descriptor	Protective Characteristics and Capability
Very High (Independent and Passive)	Very significant risk reduction as an independent (standalone) measure. Impact on risk reduction is immediate and persistent in all scenarios. Operates passively with no or minimal requirement for ongoing implementation, management and maintenance. A priority measure to be implemented wherever possible.
High (Independent and Passive)	Material risk reduction as an independent (standalone) measure; Operates passively with none or minimal requirement for ongoing implementation, management and maintenance.
Effective (Independent and Active)	Material risk reduction as an independent (standalone) measure; Effectiveness relies on active implementation, management, maintenance and/or response.
Moderate (Combined and Passive or Active)	Alone the measure will have limited impact on risk reduction. It has additive value when combined with other protection measures to create a 'package' of bushfire protection measures. Effectiveness is achieved both passively and/or with active implementation, management, maintenance and/or response.
Not Relevant	The measure is not relevant to the type of development/use. (Note: this is different to not being able to be applied – it is just not relevant to any configuration of the subject development/use.

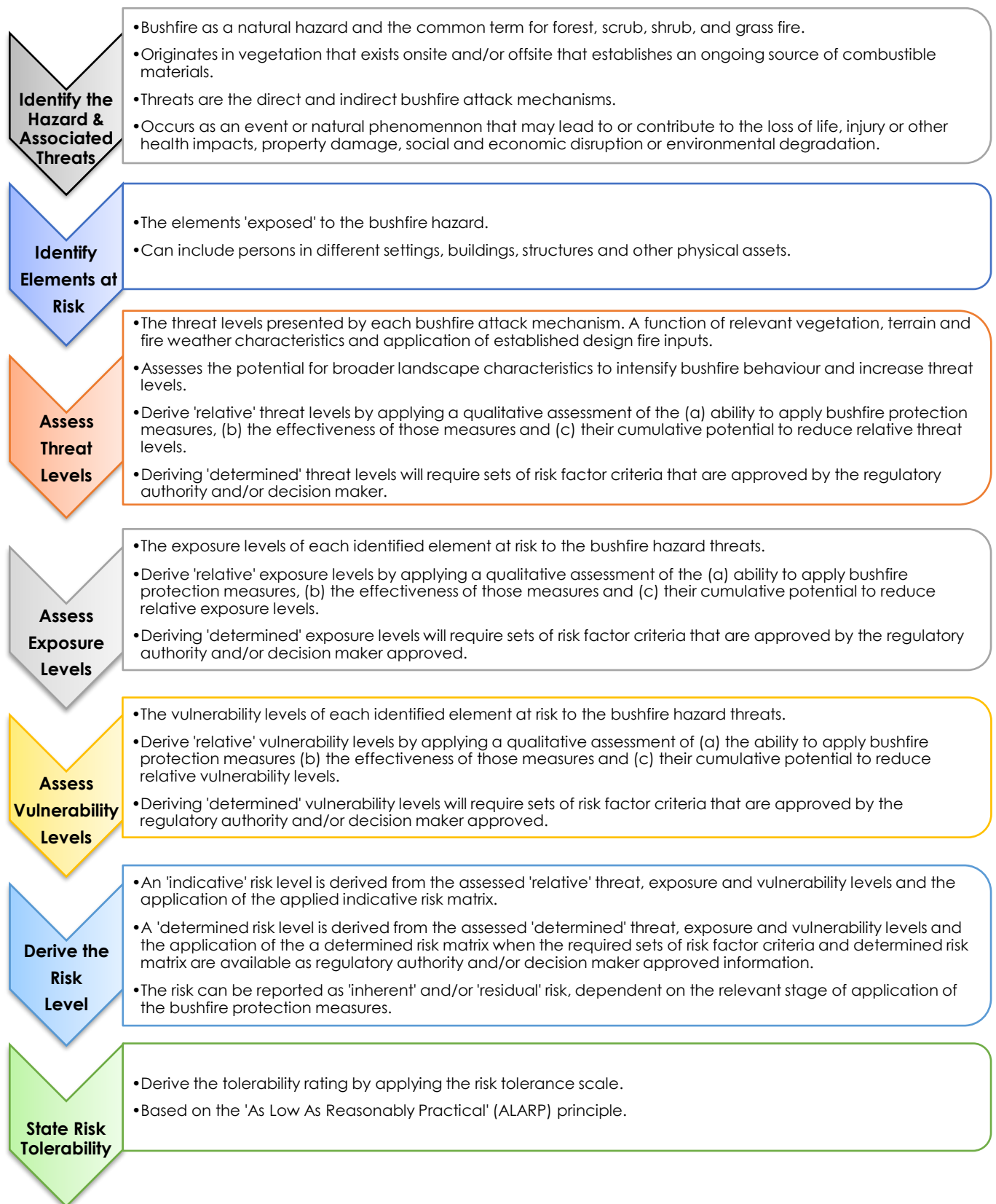


Figure 2.4: Outline of the adapted risk assessment process applied in this report.

2.4 THE BUSHFIRE HAZARD - BEHAVIOUR AND ATTACK MECHANISMS

Information regarding bushfire attack mechanisms and the potential influence of the broader landscape on the intensification of fire behaviour, is provided in Appendix 4 and 5. The content of these appendices is outlined below. Providing this information is intended to:

1. Assist those tasked with making design, construction, planning and management decisions (based on the information and assessments presented in this report), to have a better understanding of bushfire hazards where this may not be within their general field of expertise. This knowledge may also benefit development of innovative protection measures to increase the bushfire resilience of buildings/structures and/or improve persons safety and/or reduce bushfire threat levels; and
2. Assist readers understand why the assessment of the bushfire hazard threats and the presentation of the identified protection measures is organised the way it is in this report. It can also assist with guiding the search for additional information when necessary.

CONTENT OF APPENDIX 4

1. Factors Influencing Bushfire Behaviour
 - Vegetation and other fuels - key characteristics
 - Weather
 - Topography
2. Bushfire Direct Attack Mechanisms
 - Ember attack
 - Radiant heat attack
 - Bushfire flame attack
 - Surface fire attack
3. Bushfire Indirect Attack Mechanisms
 - Debris accumulation
 - Consequential fire
 - Fire driven wind
 - Tree strike and/or obstruction

CONTENT OF APPENDIX 5

1. Recent bushfire research
2. Dynamic Fire Behaviours
 - Spotting
 - Fire whirl/tornado
 - Junction fire
 - Crown fire
 - Eruptive fire
 - Fire channelling (vorticity-driven lateral spread)
 - Conflagrations
 - Downbursts
 - Pyroconvective events.
3. Drivers of deep flaming
4. Extreme bushfire events
5. Physical requirements of terrain, fuel load (and windspeed) for deep flaming.

3 ASSESSMENT SUMMARY

The assessment summary is presented in three parts. Section 3.1 states the derived bushfire threat levels, and the exposure and vulnerability levels of each element at risk – as the factors from which the risk levels are derived.

Section 3.2 two shows the type of risk level that is to be reported, states the derived risk levels and the tolerability of that risk - for each exposed element and each identified area of bushfire prone vegetation.

Section 3.3 in which the bushfire protection measures that can be applied are summarised and in which operational document they will need to be incorporated.

3.1 THE ASSESSED THREAT, EXPOSURE AND VULNERABILITY LEVELS ESTABLISHING THE RISK LEVEL

Table 3.1: The assessed threat levels of the bushfire hazard.

ASSESSED HAZARD THREAT LEVELS ¹		
Bushfire Prone Vegetation All vegetation in the locality is comparable	Relative Threat Level ²	
	Inherent	Residual
Within the assessment area and within the broader locality. Refer to Figure 4.1	Moderate	Low
Route from facility to Broome Town Centre (Approximately 8.8km)	Moderate	Moderate
¹ Refer to Section 6 for detailed assessment information. ² Refer to Appendix 2 for explanatory information.		

Table 3.2: The assessed exposure and vulnerability levels for each exposed element to the stated area of bushfire prone vegetation.

ASSESSED EXPOSURE AND VULNERABILITY LEVELS OF IDENTIFIED ELEMENTS AT RISK ¹					
Vegetation Area / Location		Within the assessment area and within the broader locality. Refer to Figure 4.1			
Elements At Risk ²		Relative Exposure Level ³		Relative Vulnerability Level ³	
Category Numbers	Description	Inherent	Residual	Inherent	Residual
1	Persons located onsite and temporarily offsite	Moderate	Low	Moderate	Low
2	Persons on access/egress routes in vehicles	Moderate	Moderate	Moderate	Moderate
5, 6, 8	Buildings/Structures - NCC Classes 1-10	Moderate	Low	Moderate	Low
12	Fixed (hard) infrastructure assets	Low	Very Low	Moderate	Low
¹ Refer to Sections 7 and 8 for detailed assessment information. ² Refer to their identification in Section 5. ³ Refer to Appendix 2 for explanatory information.					

3.2 THE ASSESSED BUSHFIRE RISK LEVEL AND ITS TOLERABILITY

Table 3.3: Identifying the 'type' of risk level being assessed and reported in this report.

THE TYPE OF RISK LEVEL DERIVED FROM THE ASSESSMENT ¹

Indicative Risk		Determined Risk	
Inherent	Residual	Inherent	Residual
✓	✓	□	□
¹ Refer to Section 2, Appendix 2 and the glossary for explanatory information (inherent/residual corresponds to the level that available protection measures have been considered in the assessment with 'residual' including recommended measures).			

Table 3.4: The tolerability of the assessed risk levels for each exposed element and corresponding to the identified areas of bushfire prone vegetation.

THE ASSESSED BUSHFIRE RISK LEVEL AND TOLERABILITY ²					
Vegetation Area / Location		Within the assessment area and within the broader locality. Refer to Figure 4.1			
Elements At Risk ¹		Indicative Risk Level ²		Residual Risk Tolerability (ALARP) ³	Adjusted Residual Risk Tolerability (ALARP) ⁴
Category Numbers	Description	Inherent	Residual		
1	Persons located onsite and temporarily offsite	Moderate	Low	Acceptable	N/A
2	Persons on access/egress routes in vehicles	Moderate	Moderate	Tolerable / Acceptable	N/A
5, 6, 8	Buildings/Structures - NCC Classes 1-10	Moderate	Low	Acceptable	N/A
12	Fixed (hard) infrastructure assets	Low	Very Low	Acceptable	N/A
¹ Refer to their identification in Section 5. ² Refer to Section 2, Appendix 2 and the glossary for explanatory information (inherent/residual corresponds to the level that available protection measures have been considered in the assessment with 'residual' including recommended measures). ³ Refer to Appendix 3 for information supporting the application of the tolerance scale. ⁴ Refer to Section 3.2.1 for adjustment justification when applicable.					

3.2.1 ADJUSTMENT OF RESIDUAL RISK TOLERABILITY

Development/use scenarios can exist where - for certain elements at risk - high and extreme levels of residual risk might be considered to be a tolerable or acceptable level of risk.
Such a situation may exist when the exposed element is not persons and the economic cost due to the loss or damage of assets and/or disruption of services, is a risk that is retained by the owners as an informed decision.
The knock-on risk implications to persons who might be associated with these elements will need to be part of the tolerability adjustment assessment.

Table 3.5: Identification of relevant exposed elements and justification for adjustment of risk tolerability.

ELEMENTS AT RISK SUBJECT TO ADJUSTMENT OF RISK TOLERANCE		
Elements At Risk ¹		Justification For Risk Tolerance Adjustment
Category Numbers	Description	

12	Fixed (Hard) Infrastructure Assets: telecommunications / power generation / transport / water supply / waste management	<p>Stored waste onsite including landfill, green waste, timber, and recyclables hold relatively low inherent value.</p> <p>Loss of these assets is tolerable and their defence is largely to prevent generation of toxic plume and consequential fire spread.</p> <p>These materials have not been considered as an Element at Risk for the purposes of this assessment. They are instead considered a Consequential Fire Hazard.</p>
¹ Refer to their identification in Section 5.		

3.3 BUSHFIRE PROTECTION MEASURE APPLICATION & IMPLEMENTATION SUMMARY

Ensuring the Identified Protection Measures are Applied

The assessed 'base' hazard threat level and the ability to apply bushfire protection measures, are the key determinants of the risk to persons and property associated with the subject development/use.

Existing, planned and recommended protection measures have been accounted for in the derivation of the inherent and residual risk levels for each identified element at risk.

Consequently, it is crucial that these applied protection measures are incorporated into the relevant operational documents to ensure their actual implementation - if proceeding with the development/use is approved.

The required operational documents can be one or more of the following:

- **The Bushfire Management Plan (BMP)** – in which a limited number of bushfire protection measures are being addressed as the bushfire protection criteria to be met. The BMP also has scope to recommend additional protection measures as required and justifiable;
- **The Bushfire Emergency Plan (BEP)** - which addresses a particular set of bushfire protection measures associated with the preparation for, response to, recovery from and the review of a bushfire emergency event, including the movement of persons to safer locations;
- **A Site Emergency Plan** – which typically is prepared for uses associated with higher risk operations that involve flammable/hazardous materials or may present a source of ignition for bushfire prone vegetation. For these uses, there is a regulatory requirement for an appropriate site emergency plan to establish how a range of relevant emergency events is to be prepared for and responded to. A bushfire event is an additional emergency that must be incorporated into that plan; or
- **Project Design Documents** – which are in the development phase and require specific information about the protection measures that can be incorporated to mitigate risk associated with a bushfire event.
- **A Bushfire Resilience Works Program** – for an existing or planned development/use (operation) the works program document will detail additional works and procedures (i.e. protection measures) that need to be conducted to improve the bushfire resilience of persons and property – as a once off or annually. It also identifies the priority level for individual works so that potentially limited funds can be allocated in the most effective way.

The relevant information is derived from the results of this Bushfire Risk – Assessment and Management Report which essentially is utilised as a bushfire threat and resilience audit for the existing operation.

The check to ensure the incorporation of bushfire protection measures into the relevant operational document is established within the tables below. It is aligned with each individual bushfire protection measure that is presented as a summary description grouped by element at risk and the protection principle being employed.

The detailed protection measure information is contained within Sections 6, 7 and 8 of this report.

3.3.1 THREAT (BUSHFIRE HAZARD) REDUCING PROTECTION MEASURES

Table 3.6: Summarised application of threat reducing protection measures (refer to section 6.1 for details).

Threat Reducing Protection Measure			Application Status		Protection Measure Incorporation Checklist				
Protection principle	Ref. No.	Brief Description	Exists or Planned (fully/partly)	Additionally Recommended	Bushfire Management Plan	Bushfire Emergency Plan	Site Emergency Plan	Project Design	Works Program
Prevent fire ignition and/or severity by controlling the fuel	1.1	Remove offsite bushfire fuel	Cannot be applied						
	1.2	Reduce offsite bushfire fuel - hazard reduction burning	✓	□	□	□	□	□	✓
	1.3	Reduce offsite bushfire fuel- mechanical	Cannot be applied						
	1.4	Remove onsite bushfire fuel	✓	□	✓	□	□	✓	□
	1.5	Reduce onsite bushfire fuel - hazard reduction burning	□	✓	□	□	□	□	✓
	1.6	Reduce onsite bushfire fuel - mechanical	Not relevant to the development						
	1.7	Reduce onsite consequential fire fine fuels	✓	□	✓	□	□	□	□
	1.8	Reduce road verge fuel	✓	□	□	□	□	□	✓
	1.9	Greater enforcement applied to compliance with the local government's fire break and fuel load notice	Cannot be applied						
Prevent fire ignition by controlling heat energy sources	1.10	Operational procedures – fire safe site procedures	✓	✓	□	□	✓	□	□
	1.11	Operational procedures – hazard reduction burning	□	✓	□	□	✓	□	□
	1.12	Equipment design – limit potential for spark production	□	✓	□	□	□	✓	□
	1.13	Legal enforcement – of total fire bans	Cannot be applied						
	1.14	Legal enforcement – methods to reduce arson	Cannot be applied						
	1.15	Education of persons	□	✓	□	✓	□	□	□
Prevent fire ignition by controlling heat energy source and fuel interactions	1.16	Shielding of ignition sources from bushfire fuels	□	□	□	□	□	✓	□
	1.17	Separation of ignition sources from bushfire fuels	✓	✓	□	□	□	✓	□
	1.18	Equipment design – control energy transfer to fuels	□	✓	□	□	✓	□	□

3.3.2 EXPOSURE REDUCING PROTECTION MEASURES - PERSONS

Table 3.7: Summarised application of exposure reducing protection measures for persons (refer to sections 7.1.1 & 7.2.1 for details).

Exposure Reducing Protection Measure - Persons			Application Status Subject Development/Use		Operational Documents Protection Measure Incorporation Checklist				
Protection Principle	Ref. No.	Brief Description	Exists or Planned (fully/partly)	Additionally Recommended	Bushfire Management Plan	Bushfire Emergency Plan	Site Emergency Plan	Project Design	Works Program
Separation from All Bushfire Threats	Persons Located Onsite and Temporarily Offsite								
	2.1	Stay away from the subject site	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	2.2	Stay within the subject site – remote offsite hazard	Cannot be applied						
	2.3	Relocate away from remote hazard - safer offsite location available	Not relevant to the development						
	2.4	Evacuate from the subject site - safer offsite location(s) available	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	2.5	Relocate within the subject site - safer onsite area	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	2.6	Relocate within the subject site – pathway to safer onsite building	Cannot be applied						
	2.7	Pre-emptively relocate away from the subject site	Cannot be applied						
	Persons on Access / Egress Routes in Vehicles								
	3.1	Locating route away from adjacent hazards	Cannot be applied						
	3.2	Egress routes located to ensure driving away from hazard	Cannot be applied						
	3.3	Greater road width	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	3.4	Reduce and maintain road verge fuel to low threat state	Not relevant to the development						
Shielding from All Bushfire Threats	Persons Located Onsite and Temporarily Offsite								
	2.8	On-site shelter building – community bushfire refuge standard	Not relevant to the development						
	2.9	On-site shelter building – accommodation not part of site use	Not relevant to the development						
	2.10	On-site shelter building – appropriate threat resilience	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	2.11	On-site shelter structure – Class 10c	Not relevant to the development						
	2.12	Constructed barrier – shield persons in the open	Not relevant to the development						
	2.13	Natural barrier - shield persons in the open	Not relevant to the development						
	2.14	Constructed/natural barrier – shielding for persons on pathways to safer onsite area/building:	Cannot be applied						
	Persons on Access / Egress Routes in Vehicles								
	3.5	Vehicle type – protection level	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3.3.3 VULNERABILITY REDUCING PROTECTION MEASURES - PERSONS

Table 3.8: Summarised application of vulnerability reducing protection measures for persons (refer to sections 8.1.1 & 8.2.1 for details).

Vulnerability Reducing Protection Measure - Persons			Application Status		Operational Documents				
Protection Principle	Ref. No.	Brief Description	Exists or Planned (fully/partly)	Additionally Recommended	Bushfire Management Plan	Bushfire Emergency Plan	Site Emergency Plan	Project Design	Works Program
Transport and Multiple Evacuation Destinations and Routes Available	Persons Located Onsite and Temporarily Offsite								
	7.1	Sufficient evacuation transport available	✓	□	□	□	□	□	□
	7.2	Multiple safer offsite locations available	Cannot be applied						
Provision of Bushfire Emergency Information and Education	7.3	Bushfire emergency plan	□	✓	□	✓	✓	□	□
	7.4	Bushfire emergency poster	□	✓	□	✓	□	□	□
	7.5	Bushfire protection measures to be implemented are published in the relevant operational documents	□	✓	✓	✓	✓	□	□
	7.6	Prominent display of information stating safe early evacuation is the primary procedure	□	✓	□	✓	□	□	□
	7.7	Egress pathway signage	Not relevant to the development						
	7.8	Trained personnel onsite	□	✓	□	✓	□	□	□
	7.9	Build community resilience through education	□	□	□	□	□	□	□
	7.10	Encourage 'property bushfire resilience assessments'	Not relevant to the development						
A Bushfire Emergency Firefighting Capability Exists (Response)	7.11	Personnel onsite can manage bushfire emergency procedures	✓	✓	□	✓	✓	□	□
	7.12	Personnel onsite can operate firefighting equipment	✓	✓	□	✓	✓	□	□
	7.13	Locations of vulnerable persons are registered	Not relevant to the development						
	7.14	External emergency services available	✓	✓	□	□	✓	□	□
Apply Best (Safer) Road Design and Construction (Materials)	Persons on Access / Egress Routes in Vehicles								
	8.1	Road width	✓	□	□	□	□	□	□
	8.2	Road gradient	✓	□	□	□	□	□	□
	8.3	Road Clearance	✓	□	□	□	□	□	□
	8.4	Road Surface Materials	✓	□	□	□	□	□	□
	8.5	Driver road ahead visibility and signage	✓	□	□	□	□	□	□

	8.6	Road length	Cannot be applied						
	8.7	Interconnected roads	Cannot be applied						
Evacuees Self-Sufficient (Local Awareness and Transport)	8.8	Persons onsite have local awareness	✓	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	8.9	Persons onsite have own transport	✓	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3.3.4 EXPOSURE REDUCING PROTECTION MEASURES – BUILDINGS / OTHER STRUCTURES/ INFRASTRUCTURE

Table 3.9: Summarised application of exposure reducing protection measures for buildings / other structures / infrastructure (refer to sections 7.3.1 & 7.5.1 for details).

Exposure Reducing Protection Measure - Buildings / Other Structures/ Infrastructure			Application Status Subject Development/Use		Operational Documents Protection Measure Incorporation Checklist				
Protection Principle	Ref. No.	Brief Description	Exists or Planned (fully/partly)	Additionally Recommended	Bushfire Management Plan	Bushfire Emergency Plan	Site Emergency Plan	Project Design	Works Program
Separation from All Bushfire Threats	4.1, 6.1	Asset protection zone (APZ)	✓	✓	✓	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	4.2, 6.2	Siting of buildings/structures - wind	Cannot be applied						
	4.3, 6.3	Use of non-vegetated areas and/or public open space	Cannot be applied						
	4.4, 6.4	Landscaping - tree location	✓	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	✓	<input type="checkbox"/>
	4.5, 6.5	Separation of stored flammable products - gas in cylinders	✓	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	✓	<input type="checkbox"/>
	4.6, 6.6	Separation from stored flammable products – fuels / other hazardous materials	✓	✓	<input type="checkbox"/>	<input type="checkbox"/>	✓	✓	<input type="checkbox"/>
	4.7, 6.7	Separation from stored and constructed combustible items	✓	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	✓	✓	<input type="checkbox"/>
Shielding from All Bushfire Threats	4.8, 6.8	Constructed Barrier – bushfire fuels	Cannot be applied						
	4.9, 6.9	Constructed Barrier – consequential fire fuels	Cannot be applied						
	4.10, 6.10	Natural Barrier - landforms	Cannot be applied						
	4.11, 6.11	Planted Barrier - vegetation	Cannot be applied						
	4.12, 6.12	Shield non-structural essential elements	Cannot be applied						

3.3.5 VULNERABILITY REDUCING PROTECTION MEASURES – BUILDINGS / OTHER STRUCTURES / INFRASTRUCTURE

Table 3.10: Summarised application of vulnerability reducing protection measures for buildings / other structures / infrastructure (refer to sections 8.3.1 & 8.5.1 for detail).

Vulnerability Reducing Protection Measure - Buildings / Other Structures/ Infrastructure			Application Status		Operational Documents				
Protection Principle	Ref. No.	Brief Description	Exists or Planned (fully/partly)	Additionally Recommended	Bushfire Management Plan	Bushfire Emergency Plan	Site Emergency Plan	Project Design	Works Program
Design and Construction Materials	9.1, 11.1	Construction to a standard - AS 3959:2018	✓	✓	✓	□	□	□	□
	9.2, 11.2	Construction to a standard – NASH Standard	Not relevant to the development						
	9.3, 11.3	Construction materials – external and internal cavity building elements	✓	✓	□	□	□	□	□
	9.4, 11.4	Construction materials – consequential fire fuels	✓	✓	□	□	□	✓	□
	9.5, 11.5	Construction – resistant to high wind	Not relevant to the development						
	9.6, 11.6	Construction – gas supply	✓	□	□	□	□	✓	□
	9.7, 11.7	Construction - electricity supply or Construction non-structural essential elements	Not relevant to the development						
	9.8, 11.8	Minimise debris and ember accumulation – re-entrant detail	✓	✓	□	□	□	✓	□
	9.9, 11.9	Minimise debris and ember accumulation – trapping surfaces	✓	✓	□	□	□	✓	□
	9.10, 11.10	Minimise debris and ember accumulation – roof plumbing	✓	✓	□	□	□	✓	□
	9.11, 11.11	Minimise debris and ember accumulation – construction cavities	✓	✓	□	□	□	✓	□
	9.12, 11.12	Minimise flame/radiant heat/ember/debris entry - external openings	✓	✓	□	□	□	✓	□
	9.13, 11.13	Screening and sealing - gaps and penetrations	✓	✓	□	□	□	✓	□
	9.14, 11.14	Screening - external doors and windows	✓	✓	□	□	□	✓	□
	9.15, 11.15	Shutters - external doors and windows	✓	✓	□	□	□	✓	□
	9.16, 11.16	Landscaping construction - fences and walls	Not relevant to the development						

Firefighting Capability	9.17, 11.17	Firefighting water supply	✓	✓	✓	□	✓	□	□
	9.18, 11.18	Firefighting equipment – active operation	✓	✓	□	✓	✓	□	□
	9.19, 11.19	Firefighting equipment – passive operation	✓	□	✓	□	□	□	□
	9.20, 11.20	Firefighting equipment – maintain operability	□	✓	□	□	□	□	□
	9.22, 11.21	Firebreaks for access	Not relevant to the development						
Management And Maintaining Effectiveness Of Applied Protection Measures	9.22, 11.22	Formal management / maintenance plan – actions and responsibilities	✓	□	✓	□	□	□	□

4 IDENTIFICATION OF THE BUSHFIRE HAZARD

SEPARATE IDENTIFICATION OF ONSITE AND OFFSITE VEGETATION




The approach adopted in this report is to separately identify onsite and offsite bushfire prone vegetation when the distinction exists, and it is necessary. There are two reasons for this:

1. The required assessment of the broader landscape's influence on bushfire hazard threat levels will most likely be considering vegetation and terrain that is external to the subject development/use site and therefore needs to be separately identified; and
2. Owners and operators of a site will be more likely to have the authority to make and maintain any required changes to the extent and the composition of bushfire prone vegetation onsite. The only constraint will be any environmental conditions established by relevant authorities.

This contrasts with the situation that exists for offsite vegetation. In these cases, the owner/operator does not normally have any authority to modify or manage offsite vegetation to reduce threats and maintain that reduction in perpetuity. Rather, the authority for management of offsite vegetation resides with a third party such as another landowner or a government authority.

Consequently, management of offsite vegetation requires the establishment of enforceable vegetation management agreements if any reduction in threat level is to be achieved and accounted for in the threat level assessment. These can be problematic to establish.

4.1 ONSITE AND OFFSITE BUSHFIRE PRONE VEGETATION

Location		Within the assessment area and within the broader locality. Refer to Figure 4.1	
Classification or Exclusion Clause		Class D Scrub	Effective Slope (deg) Flat 0
Types Identified	Closed scrub D-13	Open scrub D-14	
Description & Classification Justification	Predominantly areas of Closed Scrub 2.6m to 4m in height with >30% foliage cover with pockets of Open scrub. Grass understorey. Scattered low trees to 4m in height within the scrub areas. The vegetation is consistent within both the assessment area and the greater region and has generally flat topography. For the purposes of Risk Assessment there is no value in assessing onsite or offsite vegetation, or vegetation bounding access routes, separately. The vegetation structure contains high fine fuel loads; however the bark types are either coarse and tight or smooth. Embers will generally be limited to short distance spotting. Fast-moving, wind driven fire behaviour is likely.		
Post Development Assumptions:	The vegetation within the development footprint of the facility will be removed. Otherwise, vegetation is expected to remain in its current state.		
<div><div></div><div></div></div>			
Photo ID: 1		Photo ID: 2	
<div><div></div><div></div></div>			
Photo ID: 3		Photo ID: 4	

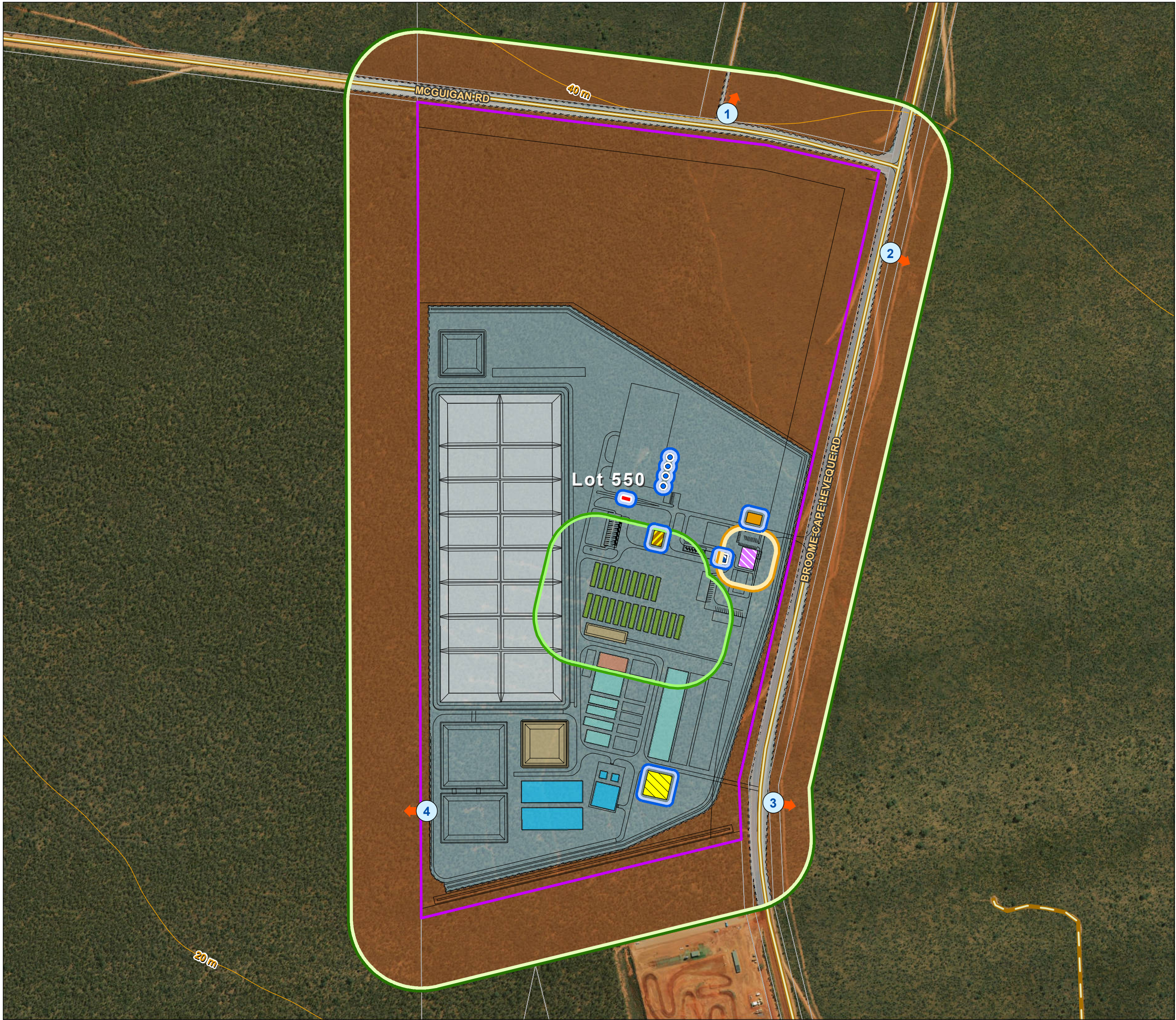


Figure 4.1
Bushfire Prone Vegetation

Lot 550 on Plan 421448, Area : 121.0000 ha
Cape Leveque Road
WATERBANK
SHIRE OF BROOME

----- **LEGEND** -----

Subject Site
 Other Lots
 Photo & Direction

Proposed Structures

- Weighbridge Admin Building
- Solar Farm
- HHW Shed
- Water Tank
- Reuse Shop and Education Centre
- Construction Yard Landfill Workshop
- BOH, Workshop

Proposed Structures Asset Protection

- 13m 29kw APZ
- 44.1m 10kw APZ
- 100m Buffer Zone

Development Layout

- Clean Fill
- Evaporation Ponds & Liquid Waste
- Timber & Green Waste
- Various Waste Areas
- Landfill
- Leachate Pond

150m Vegetation Assessment Area

- 150m from Subject Site

Classified Vegetation

- Class (D) Scrub
- Exclusion 2.2.3.2

0 100 200 300 400
Metres

----- **LOCALITY** -----

Aerial Imagery : Landgate/SLIP
Image Date : Apr 2021

Coordinate System: GDA 1994 MGA Zone 51
Projection: Universal Transverse Mercator Units: Metre
Map compiled by: Ian Ross 28/04/2022
Map updated by: Ian Ross 28/04/2022
A3 Scale 1:7,500

4.2 THE BROADER LANDSCAPE/ENVIRONMENT AND ITS POTENTIAL TO INTENSIFY FIRE BEHAVIOUR

More recent research into bushfire propagation has highlighted the role of environmental factors that are responsible for dynamic bushfire propagation and subsequent extreme fire development. Dynamic fire propagation arises from complex interactions between the terrain, the atmosphere and the fire. The intensified fire behaviour of an extreme bushfire event will significantly increase the threat levels generated by the bushfire attack mechanisms. Refer to Appendix 5 for an explanation of dynamic fire behaviours (DFBs) and their involvement in extreme bushfire events.

Consequently, in assessing the bushfire hazard threat levels to which the at risk elements of a proposed development/use could be exposed, the potential for dynamic bushfire propagation and subsequent development of extreme bushfire events within the broader landscape surrounding a subject site, must be assessed. The results of this assessment are incorporated into the assessed bushfire hazard threat levels for each attack mechanism in Section 4.5.

Table 4.2: Broader landscape assessment – the potential for extreme fire events to increase threat levels.

ASSESSING THE POTENTIAL FOR AN EXTREME BUSHFIRE EVENT TO DEVELOP AND INCREASE THE LEVEL OF THREATS IMPACTING THE SUBJECT SITE			
Relevant Physical Factors ¹	Factor Existence in Surrounding Landscape	Potential to Increase Bushfire Threat Levels	Assessment Comments
Physical factors more typically associated with conflagrations that are more likely to exist as large surface based bushfire events			
Large continuous areas of bushfire prone vegetation	Substantially Exists	Low	Few developed areas outside of the Broome townsite exist. The Class D Scrub which is typical of the region, extends for hundreds of square kilometres.
Heavier fuel loads	Does Not Exist		The vegetation is dominated by tall grasses and short trees. While heavier fuel loads are available in woody trees, they are not susceptible to continuous burning after the passage of the fire front.
Fuel types (bark) that produce significant quantities of embers / firebrands (spotting);	Does Not Exist		The bark types are either coarse and tight or smooth. Embers will generally be limited to moderate, short distance spotting.
Sufficient area of land and vegetation to support multiple fires of scale	Substantially Exists		The vegetation is regional in scale. However, few developed areas exist requiring response, thus more remote fires can be given a lower priority.
Terrain that can facilitate development of topographically modified winds (e.g. scarp or foehn-like)	Does Not Exist		The landscape within the locality is generally flat. The topography will have a negligible impact on bushfire behaviour.
Strong synoptic winds (i.e., not fire driven)	Does Not Exist		For most of the year, Broome receives westerly wind between 15 and 20km/hr. Gusts occasionally exceed 25km/hr. The wind cannot be considered strong, and the flat relief, consistent vegetation height, and consistent direction makes the influence of wind generally predictable.

ASSESSING THE POTENTIAL FOR AN EXTREME BUSHFIRE EVENT TO DEVELOP AND INCREASE THE LEVEL OF THREATS IMPACTING THE SUBJECT SITE			
Relevant Physical Factors ¹	Factor Existence in Surrounding Landscape	Potential to Increase Bushfire Threat Levels	Assessment Comments
Physical factors with identified links to deep flaming and the development of pyroconvective, coupled atmosphere, bushfire events			
Terrain slopes of approximately 24° or greater - or some degrees lower with greater wind speeds (associated with eruptive fire)	Does Not Exist	Low	The regional topography is generally flat.
Rugged terrain with local relief in the order of at least 300m (associated with eruptive fire)	Does Not Exist		
Terrain with leeward slopes >20-25 degrees (associated with vorticity-driven lateral spread)	Does Not Exist		
Wind direction within 30-40° of topographic aspect (associated with vorticity-driven lateral spread)	Does Not Exist		
Wind speed in excess of approximately 20 km/hr (associated with vorticity-driven lateral spread)	Possible to Occur		For most of the year, Broome receives westerly wind between 15 and 20km/hr. Gusts occasionally exceed 25km/hr.
Heavy forest fuel types with loads in excess of 15-20 t/ha (associated with vorticity-driven lateral spread)	Does Not Exist		The region does not host forest fuel types.
Fuel moisture content around 5% or less (associated with vorticity-driven lateral spread)	Insignificant / Unlikely to Occur		Moisture content varies on annual and recent rainfall patterns. In Broome's tropical climate, fuel will have relatively high moisture during the hotter periods.
Sufficiently sized areas (scale) of bushfire prone vegetation to potentially support deep flaming and supply the required quasi-instantaneous energy release.	Substantially Exists		Few developed areas outside of the Broome townsite exist. The Class D Scrub which is typical of the region, extends for hundreds of square kilometres.
Atmospheric instability to create opportunity for atmospheric coupling and violent pyroconvection.	Possible to Occur		It will be assumed, as a minimum, that at most locations, the potential for vertical movement of air without any resistance to that movement (e.g. temperature inversions) can always exist. That is, it is not sufficiently risk averse to assume that atmospheric instability will never exist – different temperature air masses can always interact as a consequence of the passage of different weather systems at any location.
¹ These are physical terrain / environment factors that are either required for certain dynamic fire behaviours or will enhance the potential for and the development of an extreme bushfire event.			

4.3 ASSESSMENT OF VEGETATION CHARACTERISTICS DRIVING BUSHFIRE ATTACK MECHANISM THREAT LEVELS

This qualitative assessment derives the **base threat levels** of identified areas of bushfire prone vegetation by accounting for:

1. Fuel types, arrangement and quantities; and
2. The existence of relevant characteristics within the broader landscape that have the potential to intensify bushfire behaviour and increase threat levels.

Note: This assessment does not account for the existence or potential application of threat reducing protection measures or the level of exposure and vulnerability of elements at risk. These are accounted for in subsequent steps of the risk assessment process that results in the derivation of inherent and/or residual risk levels.

Table 4.3: The assessed potential for bushfire attack mechanisms originating from the relevant vegetation to adversely impact exposed elements.

CHARACTERISTICS ASSESSMENT OF THE BUSHFIRE PRONE VEGETATION AND ITS POTENTIAL TO IMPACT ¹ ELEMENTS AT RISK – THE BASE THREAT LEVEL		
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1	
Identified Characteristics that will Contribute to the Severity of the Attack Mechanism and Consequent Base Threat Level to All Elements at Risk		Base Threat Level (the relative potential for adverse impact on exposed elements)
Direct Bushfire Attack Mechanisms		
Ember Attack: This threat level is strongly correlated with the existence of bark fuels. The varied typical rates of spread and residence time for flame fronts in different vegetation types is also incorporated into the threat level assessment (these impact on time available to make decisions and time exposed to threats).	The grassy understory of the vegetation has a high (>80%) foliage cover allowing for a continuous spread. The residence time will be less than 5 seconds, with potential coarser and residual fuels burning for longer. These coarse fuels are unlikely to produce embers after the passage of the fire front. The fine fuels will generally be consumed in the headfire. The bark types are either coarse and tight or smooth. Embers will generally be limited to medium intensity, short distance spotting (<200m). It is possible for embers to be carried >1km but the frequency/intensity would be very low.	Low

CHARACTERISTICS ASSESSMENT OF THE BUSHFIRE PRONE VEGETATION AND ITS POTENTIAL TO IMPACT ¹ ELEMENTS AT RISK – THE BASE THREAT LEVEL

Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1	
<p>Radiant Heat Attack: This threat level is a function of fuel characteristics (size, shape, quantity, type, arrangement and moisture content) and the landscape and weather factors that can intensify fire behaviour.</p> <p>Larger flame sizes and higher temperatures produce higher levels of heat.</p> <p>The varied typical rates of spread and residence time for flame fronts in different vegetation types is also incorporated into the threat level assessment (these impact on time available to make decisions and time exposed to threats).</p>	<p>The rate of spread for the vegetation type may reach 30km/hr during extreme fire weather conditions. The residence time within the vegetation will be short (<5 seconds) as fine fuels will be quickly consumed. The residual heat after the passage of the fire front will be low.</p> <p>The radiant heat impact on the development will be short and relatively low, both due to setbacks from the vegetation and the residence time.</p>	Low
<p>Bushfire Flame Attack: This threat level is a function of potential flame lengths which are significantly influenced by fine fuel loads and the slope of the land on which the fire is burning.</p> <p>The varied typical rates of spread and residence time for flame fronts in different vegetation types is also incorporated into the threat level assessment (these impact on time available to make decisions and time exposed to threats).</p>	<p>The flame length for the scrub vegetation may extend to 12m in extreme scenarios, with up to 6m more likely from the grassy understory.</p> <p>The topography is flat and will not influence flame length. The setbacks of the assets within the proposed developments prevent flame attack.</p> <p>However, Category 3: Persons on access/egress routes in vehicles, can potentially be exposed.</p>	Moderate
<p>Surface Fire Attack: This threat level is a function of the existence of intermittent surface fuels surrounding and leading up to exposed elements.</p>	<p>The facility will be constructed on a clear hardstand. Minimal surface fuels will be available as few trees will exist to generate leaf litter and gardens (with associated plants and mulch) are not proposed.</p>	Very Low
Indirect Bushfire Attack Mechanisms		
<p>Debris Accumulation – threat level is a function of having a source of vegetative debris, its extent and proximity to exposed elements.</p>	<p>Minimal vegetative debris is expected to remain onsite.</p>	Very Low

CHARACTERISTICS ASSESSMENT OF THE BUSHFIRE PRONE VEGETATION AND ITS POTENTIAL TO IMPACT ¹ ELEMENTS AT RISK – THE BASE THREAT LEVEL

Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1	
Consequential Fire – threat level is a function of the existence of accumulated debris (fine fuels) and stored or constructed combustible / flammable items that exist either as part of the site use or operations or are adjoining/adjacent buildings/structures (heavy fuels).	<p>The green waste windrows will not be aerated and thus will not support long flame lengths. The timber will necessarily be aerated, having coarser fuel types. This storage area is separated from other processing and storage areas.</p> <p>Other combustible waste storage onsite is separated from the hazard but exposed to ember attack. These materials may ignite and spread to other stockpiles. Some materials (glass and scrap metal) are non-combustible.</p> <p>The landfill cells pose an extreme risk of consequential fire when exposed, and a fire within a cell causes a HAZMAT concern and can have ongoing issues of continuing subsurface fires and subsurface cavities.</p>	Extreme
Fire Driven Wind – threat level is correlated with the potential for development of extreme bushfire events (refer to Appendix 5).	Potential fire behaviour will be wind driven, grassland fire behaviour, and the greatest risk for increased fire behaviour and rate of spread will be if there are 2 or more ignition points and the fire fronts or flanking fires merge. This is known as a junction zone and will experience greater fire intensity for a short period of time (1-2 minutes) however can generate whirls or tornadoes that usually carry and spread fire.	Moderate
Tree Strike and Obstruction – threat level is a function of the existence of trees and their proximity to exposed elements.	The proposed facility will not contain tall trees, and within the surrounding vegetation reach a height of 4m. No trees will be close enough to identified Elements to pose a hazard.	Very Low

¹ Refer to glossary.

4.4 BUSHFIRE ATTACK LEVELS (BAL) AND CORRESPONDING SEPARATION DISTANCES

In assessing risk, knowing the separation distances away from each identified area of classified vegetation that correspond to a BAL rating, assists with evaluating threat levels from that bushfire hazard and the exposure levels of elements at risk. BAL ratings indicate the level of radiant heat that an exposed element will be subject to. They also indicate the potential for flame contact (refer to Appendix 7 for additional information).

Table 4.4: Vegetation separation distances corresponding to radiant heat levels (and illustrated as BAL contours in Figure 3.2 of the associated Bushfire Management Plan).

THE CALCULATED VEGETATION SEPARATION DISTANCES CORRESPONDING TO THE STATED LEVEL OF RADIANT HEAT ¹										
Vegetation Classification ¹		Effective Slope [degree range]	Separation Distances (m) Corresponding to Stated Level of Radiant Heat							
			Bushfire Attack Level						Radiant Heat kW/m ²	
Area /Location	Class		BAL-FZ	BAL-40	BAL-29	BAL-19	BAL12.5	BAL-LOW	10	2
1	(D) Scrub	upslope or flat	<10	10-<13	13-<19	19-<27	27-<100	>100	>44.1	N/A
2	(D) Scrub	upslope or flat	<10	10-<13	13-<19	19-<27	27-<100	>100	>44.1	N/A
3	(D) Scrub	upslope or flat	<10	10-<13	13-<19	19-<27	27-<100	>100	>44.1	N/A

¹ Derived from the application of method 1 BAL determination methodology (AS 3959:2018 Section 2, Table 2.5). All modelling input and output values in including method 2 Radiant Heat calculations are provided in Section 3 of the associated BMP.

5 IDENTIFICATION OF ELEMENTS AT RISK

Elements at risk are those exposed to the bushfire hazard threats identified in Section 4. This section establishes the generic list of possible elements at risk and identifies the exposed elements of the subject development/use.

Table 5.1: Identification of the exposed elements of the subject development/use.

ELEMENTS AT RISK (THE EXPOSED ELEMENTS)		
Category Number	Description	Relevant to the Subject Development/Use Risk Assessment
1	Persons located onsite: as part of site operations or visitors) and Persons temporarily offsite as part of site operations: (e.g. tourism day trips)	✓
2	Persons on Access/Egress Routes (in Vehicles): i.e., roads, driveways, access ways	✓
3	Buildings - NCC Class 1 & 2: residential - of a domestic nature	
4	Buildings - NCC Class 3: residential – of long term or transient nature, for unrelated people	
5	Buildings – NCC Class 5: offices for professional or commercial purposes	✓
6	Buildings – NCC Class 6: shops selling retail goods or services to the public	✓
7	Buildings – NCC Class 7: warehouses & carparks - storage – wholesale goods / vehicles	
8	Buildings – NCC Class 8: factory / workshop / laboratory - in which a process is carried out	✓
9	Buildings – NCC Class 9: health care / residential care / assembly	
10	Buildings or Structures – NCC Class 10: non-habitable – shed / carport / garage / fence / retaining wall etc.	
11	Non-Building Accommodation: caravans / camper trailers / tents etc	
12	Fixed (Hard) Infrastructure Assets: telecommunications / power generation / transport / water supply / waste management	✓
13	Livestock/Animals: as part of commercial or private operations (saleyards / events / wildlife sanctuaries).	

Table 5.2: Description of the identified exposed elements for the subject development/use.

ELEMENT AT RISK DETAIL FOR THE SUBJECT DEVELOPMENT/USE		
Category Number(s)	Exposed Element	Description
1	Persons located onsite and temporarily offsite	Staff and visitors (general public).
2	Persons on access/egress routes in vehicles	The route servicing the site exposes persons to potential bushfire impacts.
5, 6, 8	Buildings/Structures - NCC Classes 1-10	Various building classes exist onsite, none of which are required to comply with AS3959 construction standards. The Reuse Shop and Education Centre building is required to establish an APZ to a maximum <10kW/m ² of radiant heat flux and be constructed to the requirements of BAL-29. This will provide a suitable shelter in place location.
12	Fixed (hard) infrastructure assets	The solar farm is a fixed asset.

		Landfill, green waste, timber, and recyclables are a fixed asset. These are a tolerable loss, however they pose a major potential fire and HAZMAT risk.
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6 ASSESSING BUSHFIRE HAZARD THREAT LEVELS

Summary of the qualitative assessment process for deriving the relative threat levels presented by each identified area of bushfire prone vegetation;

1. Identify all protection measures (grouped by protection principle) that are available to reduce relative threat levels and rate their relative effectiveness;
2. Identify the application status of each protection measure and produce a numerical summary of their availability versus their ability to be applied. Differentiation by measure effectiveness is applied;
3. Assess the potential threat reducing impact of the package of protection measures that is able to be applied. The effectiveness rating weights the potential impact of an individual measure; and
4. Derive the relative threat level, for each identified area of bushfire prone vegetation, by accounting for:
 - The relevant characteristics of the vegetation as they influence the bushfire attack mechanisms and establish the base threat level;
 - The potential threat increasing influence of the broader landscape; and
 - The impact of the applied package of protection measures in reducing threat levels (refer to Section 2.3.3 and Appendix 2 for additional risk assessment process information).

6.1 PROTECTION MEASURES TO REDUCE BUSHFIRE THREAT LEVELS – IDENTIFICATION AND APPLICATION

Table 6.1: For the stated area of vegetation, all available bushfire protection measures for preventing or reducing the potential for fire ignition and eliminating or reducing its threat levels.

PROTECTION MEASURES TO REDUCE BUSHFIRE THREAT LEVELS		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1					
PROTECTION PRINCIPLE - PREVENT FIRE IGNITION AND/OR SEVERITY BY CONTROLLING THE FUEL: Eliminate or reduce vegetation fuel loads, modify their properties (vegetation types and the arrangement of the fuels). Maintain the measures over time to eliminate bushfire or lower the severity of fire behaviours and the consequent threat levels. The measures may conflict with desired / regulated environmental conservation outcomes and this remains a potential limitation.						
1.1	Remove Offsite Bushfire Fuel: Remove fuel permanently by clearing bushfire prone vegetation when an authority exists.	Very High	No	No	No	No
Informative and/or Site Specific Comment/Assessment: Offsite vegetation cannot be removed/cleared due to environmental values.						

PROTECTION MEASURES TO REDUCE BUSHFIRE THREAT LEVELS		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
Vegetation Area / Location		Within the assessment area and within the broader locality. Refer to Figure 4.1				
1.2	Reduce Offsite Bushfire Fuel: Programmed hazard reduction burning when an authority exists to conduct and maintain (refer to Appendix 6 for additional information).	Effective	Partly	Partly	No	No
Informative and/or Site Specific Comment/Assessment: Intermittent hazard reduction burning is currently undertaken. Increased frequency of hazard reduction burns are unlikely to reduce the hazard in the vegetation type.						
1.3	Reduce Offsite Bushfire Fuel: Mechanical fuel reduction to modify composition of vegetation types and/or the arrangement of fuels and maintain the modification over time e.g. reduce canopy, limit higher threat bark types, minimise 'ladder' fuels' - when an authority exists to conduct and maintain.	Effective	Partly	No	No	No
Informative and/or Site Specific Comment/Assessment: The measure would cause environmental disturbance and is impractical considering the extent of vegetation.						
1.4	Remove Onsite Bushfire Fuel: Remove fuel permanently by clearing bushfire prone vegetation when approved.	Very High	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment: The lot is currently vegetated. All bushfire prone vegetation overlapping the development footprint will be cleared. Clearing outside this footprint will not significantly reduce the hazard posed, as the proposed asset locations are mostly >100m from the development boundary.						
1.5	Reduce Onsite Bushfire Fuel: Programmed hazard reduction burning (refer to Appendix 6 for additional information).	Effective	Yes	No	No	Yes
Informative and/or Site Specific Comment/Assessment: Offsite hazard reduction burning is planned and occasionally undertaken. Providing permission to the relevant authority for these burning programs to include vegetation within the lot boundary is advised.						
1.6	Reduce Onsite Bushfire Fuel: Mechanical fuel reduction to modify composition of vegetation types and/or the arrangement of fuels and maintain the modification over time e.g. reduce canopy, limit higher threat bark types, minimise 'ladder' fuels' - when approved.	Effective	Partly	Partly	No	No
Informative and/or Site Specific Comment/Assessment: The measure would cause environmental disturbance and is impractical considering the extent of vegetation.						
1.7	Reduce Onsite Consequential Fire Fine Fuels: Apply the specifications for an Asset Protection Zone (APZ) surrounding the exposed element(s) to ensure this area contains minimal consequential fire fuels and is maintained in a low threat state. The specifications are established in the Guidelines [22] within the Explanatory Notes for Element 2 of the Bushfire Protection Criteria and Schedule 1: Standards for Asset Protection Zones.	Effective	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment: APZ to be established and maintained in accordance with the associated BMP.						

PROTECTION MEASURES TO REDUCE BUSHFIRE THREAT LEVELS		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Vegetation Area / Location		Within the assessment area and within the broader locality. Refer to Figure 4.1				
1.8	Reduce Road Verge Fuel: Road verges of designated evacuation routes are subject to fuel load reduction, tree management and ongoing maintenance when an authority exists to conduct and maintain.	Effective	Partly	Yes	No	No
Informative and/or Site Specific Comment/Assessment: Broome Highway and Broome-Cape Leveque Road have cleared or reduced fuel shoulders extending a minimum of 4m from either verge. Additional clearance is unlikely to be agreed and/or maintained.						
1.9	Greater Enforcement Applied to Compliance with the Local Government's Fire Break and Fuel Load Notice: Inform the relevant landowners of the high level of enforcement that will be applied under the authority conferred through Section 33 of the Bush Fires Act 1954.	Effective	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: The APZ requirements outlined in the associated BMP exceed those of the Shire of Broome's Firebreak Notice.						
PROTECTION PRINCIPLE – PREVENT FIRE IGNITION BY CONTROLLING HEAT ENERGY SOURCES: Fire prevention focussed on potential ignition sources from human actions and/or faulty or poorly designed equipment. Natural causes of ignition (lightning) cannot be controlled and are a limitation.						
1.10	Operational Procedures: Apply fire safe principles to site operation procedures including: <ul style="list-style-type: none">Eliminating or reducing the potential for open air creation of fire, embers or sparks; andClosing identified high risk operations when a bushfire event exists. Ensure safe practices are carried out via appropriate guidelines, protocols, signage and education.	Very High	Yes	No	Yes	Yes
Informative and/or Site Specific Comment/Assessment: Operating procedures for any waste management facility are critical for prevention and management of onsite fires, including consequential fires.						
1.11	Operational Procedures: Ensure proper management of hazard reduction burning as an unintended ignition source.	Moderate	Yes	Partly	No	Yes
Informative and/or Site Specific Comment/Assessment: Burn Prescriptions will be developed each year prior to burning. This management can include preventative measures onsite during burns.						
1.12	Equipment Design: Apply fire safe design principles to equipment, vehicles, and energy transmission etc. Design to control rate of energy release and eliminate/reduce potential for open air creation of fire, embers or sparks.	Moderate	Yes	No	No	Yes
Informative and/or Site Specific Comment/Assessment: To be included in equipment design stage or purchase stage.						
1.13	Legal Enforcement: Impose restrictions on source of ignition operations by enforcing total fire bans.	Effective	Yes	No	No	No

PROTECTION MEASURES TO REDUCE BUSHFIRE THREAT LEVELS		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1					
Informative and/or Site Specific Comment/Assessment: This is unnecessary for the facility. Onsite activity capable of igniting a fire will be strictly controlled by the Standard Operating Procedures.						
1.14	Legal Enforcement: Reduce arson events by monitoring / enforcement / penalties.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: Unlikely to have any impact given the scale and population density of the region.						
1.15	Education: Educate persons to reduce the occurrence of accidental ignitions in vegetation by persons and/or vehicles, particularly with regard to road reserves.	Moderate	Yes	No	No	Yes
Informative and/or Site Specific Comment/Assessment: Bushfire awareness training will be provided to all staff.						
PROTECTION PRINCIPLE - PREVENT FIRE IGNITION BY CONTROLLING HEAT ENERGY SOURCE AND FUEL INTERACTIONS: Fire prevention focussed on limiting potential ignition sources by preventing a source and a fuel being able to interact.						
1.16	Shielding of Ignition Sources: Utilise physical barriers (shielding) between bushfire fuels and heat energy sources such as electricity generation / transmission, fuel supplies, stored flammable products etc. Examples include appropriate walls, enclosures, and underground transmission of electricity or liquid/gas fuels.	Moderate	No	No	Yes	No
Informative and/or Site Specific Comment/Assessment: The design of landfill cells creates bunds between the active face and surrounds. This creates a shield against radiant heat for persons and materials. The site will be compliant with relevant legislation (Dangerous Goods Safety (Storage and Handling of Non-Explosives) Regulations 2007 (the Regulations), Dangerous Goods Safety Act 2004 etc).						
1.17	Separation of Ignition Sources: Establish sufficient separation distance between bushfire fuels and heat energy sources such as electricity generation / transmission, fuel supplies, stored flammable products etc.	Moderate	Yes	No	Partly	Yes
Informative and/or Site Specific Comment/Assessment: Flammable materials stored onsite are separated within the proposed site layout. These separations are to be formalised in the Standard Operating Procedures.						
1.18	Equipment Design: Through design and materials, control heat energy transfer via conduction, convection and radiation of heat energy.	Moderate	Yes	No	Partly	Yes
Informative and/or Site Specific Comment/Assessment: Situations such as litter being trapped against the undercarriage of site heavy vehicles operating in the active landfill face. Preventative measures are to be formalised in the Standard Operating Procedures.						

PROTECTION MEASURES TO REDUCE BUSHFIRE THREAT LEVELS		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1					
¹ Refer to section 2.3.4 for effectiveness rating explanation.						
² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.						

6.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 6.2: For the stated area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

BUSHFIRE THREAT REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1					
The Protection Principle	Effectiveness Rating ¹	Numbers of Protection Measures				
		Total Available	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Prevent Fire Ignition and/or Severity by Controlling the Fuel	Very High	2	1	-	1	-
	High	-	-	-	-	-
	Effective	7	7	3	2	1
	Moderate	-	-	-	-	-
	Not Relevant	-	-	-	-	-
Prevent Fire Ignition by Controlling Heat Energy (Ignition) Sources	Very High	1	1	-	1	1
	High	-	-	-	-	-
	Effective	1	1	-	-	-
	Moderate	4	4	1	-	3
	Not Relevant	-	-	-	-	-
Prevent Fire Ignition by Controlling Heat Energy Source and Fuel Interactions	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	-	-	-	-	-
	Moderate	3	2	-	3	2
	Not Relevant	-	-	-	-	-
Total Numbers	Very High	3	2	-	2	1
	High	-	-	-	-	-
	Effective	8	8	3	2	1
	Moderate	7	6	1	3	5
	Not Relevant	-	-	-	-	-
	Totals	18	16	4	7	7
¹ Refer to section 2.3.4 for effectiveness rating explanation. ² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measure can and should be implemented.						

6.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (THREAT REDUCTION)

Table 6.3: The potential impact of the applied protection measures in reducing threat levels in the stated area of bushfire prone vegetation.

THE ASSESSED IMPACT OF APPLIED PROTECTION MEASURES ON REDUCING THREAT LEVELS								
Vegetation Area / Location		Within the assessment area and within the broader locality. Refer to Figure 4.1						
Protection Measures Applied to Assessment ¹	The Bushfire Hazard Threats ²							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Medium	Medium	Medium	None	Minimal	Very Significant	Minimal	None
	Medium				Significant			
Existing, Planned and Recommended (applied to residual risk)	Minimal	Minimal	Medium	None	Minimal	Medium	Minimal	None
	Minimal				Medium			
¹ Corresponds to the stage at which the risk level is to be reported i.e. inherent or residual (refer to Section 2.3.3)								
² Refer to Appendix 4 for explanatory information.								

Assessment Comments:

Site plans and supporting documentation, and information provided to developers through the associated Bushfire Management Plan (including designation of the shelter-in-place building), are considered Planned.

Recommendations within this Risk Assessment include works and documentation which either do not currently exist, or who's status is unknown.

Consequential fires in stored material onsite pose the greatest hazard to persons and structures.

6.4 ASSESSED HAZARD THREAT LEVELS

Assessed as a function of the base threat levels of the bushfire hazard (refer to Section 4.5) and the number and effectiveness of protection measures that will be applied and their ability to reduce the levels of threat from the identified areas of bushfire prone vegetation. The assessed exposure and vulnerability levels are not a part of the function.

Table 6.4: The assessed threat levels corresponding to the stated area of bushfire prone vegetation.

THE ASSESSED IMPACT OF APPLIED PROTECTION MEASURES ON REDUCING THREAT LEVELS								
Vegetation Area / Location		Route from facility to Broome Town Centre (Approximately 8.8km)						
Protection Measures Applied to Assessment ¹	The Bushfire Hazard Threats ²							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Minimal	Significant	Significant	Minimal	Minimal	Minimal	Minimal	Minimal
	Medium				Minimal			
Existing, Planned and Recommended (applied to residual risk)	Minimal	Significant	Significant	Minimal	Minimal	Minimal	Minimal	Minimal
	Medium				Minimal			
¹ Corresponds to the stage at which the risk level is to be reported i.e. inherent or residual (refer to Section 2.3.3).								
² Refer to Appendix 2 for explanatory information.								

Assessment Comments: No recommendations are applicable. The inherent and residual risk are the same.

7 ASSESSING THE EXPOSURE LEVELS OF ELEMENTS AT RISK

Summary of the qualitative assessment process for deriving the relative exposure levels (to the bushfire hazard threats) for each identified element at risk:

1. Identify all protection measures (grouped by protection principle) that are available to reduce relative exposure levels and rate their relative effectiveness;
2. Identify the application status of each protection measure and produce a numerical summary of their availability versus their ability to be applied. Differentiation by measure effectiveness is applied;
3. Assess the potential exposure reducing impact of the package of protection measures that is able to be applied. The effectiveness rating weights the potential impact of an individual measure; and
4. Derive the relative exposure level of the identified element at risk, to each identified area of bushfire prone vegetation (refer to Section 2.3.3 and Appendix 2 for additional risk assessment process information).

7.1 PERSONS ONSITE OR TEMPORARILY OFFSITE (ELEMENT AT RISK CATEGORY 1)

7.1.1 PROTECTION MEASURES AVAILABLE TO REDUCE EXPOSURE LEVELS AND THEIR APPLICATION STATUS

Table 7.1.1: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
PROTECTION PRINCIPLE – SEPARATION FROM THE HAZARD: To ensure that the persons are located or re-located at a sufficient distance from the bushfire hazard to ensure the level of exposure to the threats, and the associated risk of persons death or injury, is contained within acceptable parameters.						
2.1	Stay Away from the Subject Site: In response to a pre-determined fire danger rating and/or total fire ban or set months of the year (bushfire season), prevent access to, occupancy or operation of the subject site (i.e. closure of use). The relevant conditions and the requirement to stay away will be established through a Bushfire Emergency Plan.	Very High	Yes	No	No	Partly
Informative and/or Site Specific Comment/Assessment: Complete closure of the facility is impractical. It is recommended that certain site works be halted in accordance with a Total Fire Ban or Heavy Vehicle Movement Ban, including landfill cell unloading and compaction, during days of a Fire Danger Rating (FDR) of Catastrophic.						
2.2	Stay Within the Subject Site – Remote Hazard: For offsite tourism operations, all associated persons (staff, guests, visitors), in response to a pre-determined fire danger rating and/or total fire ban, will remain on-site as better communication and	Not Relevant	N/A	N/A	N/A	N/A

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
	sheltering options exist on-site. The relevant conditions and the requirement to stay will be established through a Bushfire Emergency Plan.					
Informative and/or Site Specific Comment/Assessment: The development is not a tourism use.						
2.3	Relocate Away from Remote Hazard - Safer Offsite Location Available: For offsite tourism operations (where persons are to be moved offsite as part of operations e.g., tourism day trips), a suitable offsite alternative safer location(s) is identified as a destination should the subject site and/or the route back to the subject site, be impacted by a bushfire event. That is, two safer locations will exist.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: The development is not a tourism use.						
2.4	Evacuate from the Subject Site: Safer Offsite Location(s) Available: A building/area is accessible from the subject site as an evacuation destination. The offsite location exists at a sufficient distance away ensuring that the destination and the subject site are very unlikely to be simultaneously impacted by a bushfire event.	Moderate	Yes	Yes	Yes	No
Informative and/or Site Specific Comment/Assessment: The Broome town centre is an appropriate evacuation destination. However, the route is bounded by bushfire prone vegetation for approximately 8.7km before reaching a low threat area.						
2.5	Relocate Within the Subject Site - Safer Onsite Area: Provide an accessible area located in the open (i.e. not in an enclosed building), within the subject site and on which persons can assemble and that will not be subject to radiant heat flux in excess of 2 kW/m ² (determined using a flame temperature of 1200 K). Consideration must also be given to potential exposure to embers, adverse weather, availability of water / facilities and the relative importance of these to the specific use proposal.	Moderate	Yes	No	Yes	Yes
Informative and/or Site Specific Comment/Assessment: No location onsite is subject to <2kW/m ² of radiant heat flux.						
2.6	Relocate Within the Subject Site – Pathway to Safer Onsite Area/Building: To facilitate the lower risk movement, on foot, of persons and firefighters on the site, heavy fuels are excluded from areas adjacent to pathways used to access designated safer locations onsite. The required minimum separation distances are [13] [31]: <ul style="list-style-type: none">At least 4m from stored heavy fuels (refer to Appendix 4).At least 6m from stored and constructed large heavy fuels (refer to Appendix 4).At least 12m from constructed large heavy fuels that are buildings/structures other than the one being evacuated.	Effective	No	No	No	No

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
	Additionally: <ul style="list-style-type: none">The pathway/route is constructed of non-combustible materials;No gas bottles are venting towards the pathway/route; andShrubs are separated from the pathway/route corresponding to a distance to minimise the threats to persons on foot with consideration of their flammability and height.					
Informative and/or Site Specific Comment/Assessment: The route will remain clear. The site use necessarily stores heavy fuels throughout the area, thus the measure is impractical.						
2.7	Pre-Emptively Relocate Away from the Subject Site: In response to a pre-determined fire danger rating and/or total fire ban or other established conditions, all persons onsite will pre-emptively relocate offsite for the duration of the existence of the conditions. The relevant conditions and the requirement to pre-emptively relocate will be established through a Bushfire Emergency Plan.	Effective	Partly	No	No	No
Informative and/or Site Specific Comment/Assessment: Complete closure of the facility to visitors/staff is impractical.						
PROTECTION PRINCIPLE – SHIELDING FROM THE HAZARD: To utilise constructed or natural shielding to reduce the exposure of persons to the flame, radiant heat, and ember attack from bushfire and consequential fire.						
2.8	On-site Shelter Building – Community Refuge: For a ‘vulnerable land use’ (defined by SPP 3.7 [43]), provide a building which is constructed in accordance with the NCC and the ABCB Design and Construction of Community Bushfire Refuges – Information Handbook [20]. Note: preferred floor area per person is an increase from 0.75 m² to 1.0 m² (Guidelines v1.4) [22].	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: The site is not a ‘vulnerable land use.’						
2.9	On-site Shelter Building – No Accommodation in the Site Use: For a ‘vulnerable land use’ (defined by SPP 3.7 [43]), and for which accommodation is not part of the site use, provide a building that will not be subject to radiant heat flux in excess of 10 kW/m² (determined using AS 3959 BAL determination methodology [4] and applying a flame temperature of 1200 K) and constructed to the bushfire standard corresponding to the BAL-29 rating (to provide greater resistance to consequential fire).	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: The site is not a ‘vulnerable land use.’						
2.10	On-site Shelter Building – Appropriate Threat Resilience: For other than a ‘vulnerable land use’ (defined by SPP 3.7 [43]), provide a building that incorporates sufficient design and construction protection measures to reduce the building	Effective	Yes	No	Yes	Yes

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
	<p>vulnerability to bushfire and consequential fire threats to an appropriate level (refer to the section of this report that identifies bushfire protection measures to reduce the vulnerability of buildings/structures).</p> <p>Alternatively, provide a building that will not be subject to radiant heat flux in excess of 10 kW/m² (determined using AS 3959 BAL determination methodology [4] and applying a flame temperature of 1200 K) and constructed to the bushfire standard corresponding to the BAL-29 rating (to provide greater resistance to consequential fire).</p>					
<p><i>Informative and/or Site Specific Comment/Assessment: The Reuse Shop and Education Centre has been designated as the onsite shelter, as it can accommodate all persons onsite and provide adequate amenities, is close to access/egress routes, and can establish a sufficient APZ to limit radiant heat flux to <10kW/m².</i></p> <p><i>The above APZ is required to be installed and the building is required to be constructed to AS3959 standards for BAL-29.</i></p>						
2.11	<p>On-site Shelter Structure – Class 10c: Provide a private bushfire shelter (Class 10c building) constructed in accordance with the NCC and the Performance Standard – <i>The design and construction of private bushfire shelter (ABCB 2014)</i>.</p> <p>This is not a standalone measure but an additional measure as a last resort.</p>	Moderate	No	No	No	No
<p><i>Informative and/or Site Specific Comment/Assessment: The bushfire exposure of the site is insufficient to warrant the measure.</i></p>						
2.12	<p>Constructed Barrier – Shield Persons in the Open: Construct walls / fences / landforms as shielding structures that are not buildings, applying appropriate fire resistant / non-combustible construction materials (e.g. masonry, steel, earthworks). These are to withstand the impact of direct bushfire attack mechanisms for the required period of time and provide the required reduction in threat levels to persons in the open.</p> <p>Construction requirements will correspond, as a minimum, to the BAL-FZ requirements for walls as established by AS 3959:2018 [4] and/or the NASH Standard [33] and additionally informed by the research report 'Research and Investigation into the Performance of Residential Boundary Fencing Systems in Bushfires' [29].</p>	Moderate	No	No	No	No
<p><i>Informative and/or Site Specific Comment/Assessment: The bushfire exposure of the site is insufficient to warrant the measure.</i></p>						
2.13	<p>Natural Barrier – Shield Persons in the Open: Utilise natural landforms that have the potential to shield persons from the bushfire and consequential fire threats.</p>	Moderate	No	No	No	No
<p><i>Informative and/or Site Specific Comment/Assessment: The local area is effectively flat. There are no appropriate landforms.</i></p>						
2.14	<p>Constructed/Natural Barrier – Shielding for Persons on Pathways to Safer Onsite Area/Building: Where possible, alongside pathways to an on-site shelter building/area, utilise walls / fences / landforms as shielding structures constructed using fire resistant / non-combustible construction materials (e.g. masonry, steel, earthworks).</p>	Moderate	No	No	No	No

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
	<p>These are to withstand the impact of direct bushfire attack mechanisms for the required period of time and provide the required reduction in threat levels to persons (including firefighters) traversing the pathway.</p> <p>Construction can be informed by the BAL-FZ requirements for walls as established by AS 3959:2018 [4] and/or the NASH Standard [33] and additionally informed by the research report 'Research and Investigation into the Performance of Residential Boundary Fencing Systems in Bushfires' [29].</p>					
Informative and/or Site Specific Comment/Assessment: The bushfire exposure of the site is insufficient to warrant the measure.						
¹ Refer to section 2.3.4 for effectiveness rating explanation.						
² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.						

7.1.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 7.1.2: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

EXPOSURE REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Element at Risk	Persons located onsite and temporarily offsite (Category 1)					
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1					
The Protection Principle	Effectiveness Rating ¹	Numbers of Protection Measures				
		Total Available	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Separation from the Hazard	Very High	1	1	-	-	1
	High	-	-	-	-	-
	Effective	2	-	-	-	-
	Moderate	2	1	1	1	-
	Not Relevant	2	-	-	-	-
Shielding from the Hazard	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	1	1	-	1	1
	Moderate	4	-	-	-	-
	Not Relevant	2	-	-	-	-
Total Numbers	Very High	1	1	-	-	1
	High	-	-	-	-	-
	Effective	3	1	-	1	1
	Moderate	6	1	1	1	-
	Not Relevant	4	-	-	-	-
Totals		14	2	1	2	2

¹ Refer to section 2.3.4 for effectiveness rating explanation.

² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.

7.1.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (EXPOSURE REDUCTION)

Table 7.1.3: For the stated element at risk, the potential impact of the applied protection measures in reducing exposure levels to the stated area of bushfire prone vegetation.

THE ASSESSED IMPACT OF APPLIED MEASURES ON REDUCING EXPOSURE								
Element at Risk		Persons located onsite and temporarily offsite (Category 1)						
Vegetation Area / Location		Within the assessment area and within the broader locality. Refer to Figure 4.1						
Protection Measures Applied to Assessment ¹	The Bushfire Hazard Threats ²							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accum.	Conseq. Fire	Fire Driven Wind	Tree Strike / Obstruct
Existing and Planned (applied to inherent risk)	Medium	Medium	Minimal	Minimal	None	Very Significant	Medium	None
	Medium				Significant			
Existing, Planned and Recommended (applied to residual risk)	Minimal	Minimal	Minimal	Minimal	None	Medium	Minimal	None
	Minimal				Minimal			
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3								
² Refer to Appendix 4 for explanatory information.								

Assessment Comments: Inherent risk includes planned measures. The site has few existing measures as no works have been undertaken. The inherent risk of indirect mechanisms is significant. The inherent risk of direct and indirect attack mechanisms is minimal once recommended measures are applied.

7.1.4 ASSESSED EXPOSURE LEVEL

Assessed as a function of the number and effectiveness of protection measures that will be applied and their ability to reduce the exposure of the identified element at risk. The assessed threat and vulnerability levels are not a part of the function.

Table 7.1.4: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED EXPOSURE LEVEL	
Element at Risk	Persons located onsite and temporarily offsite (Category 1)
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1
Protection Measures Applied to Assessment ¹	Relative Exposure Level ²
Existing and Planned	Moderate
Existing, Planned and Recommended	Low
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3	
² Refer to Appendix 2 for explanatory information.	

Assessment Comments: The current risk after accounting for existing and any 'planned' protection measures but before the application of any additional protection measures that have been identified and recommended, the exposure level is moderate.

The existing, planned and recommended protection measures are tabled above, this includes additional protection measures recommended within this document and its associated Bushfire Management Plan.

7.2 PERSONS ON ACCESS/EGRESS ROUTES IN VEHICLES (ELEMENT AT RISK CATEGORY 2)

7.2.1 PROTECTION MEASURES AVAILABLE TO REDUCE EXPOSURE LEVELS AND THEIR APPLICATION STATUS

Table 7.2.1: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS ON ACCESS/EGRESS ROUTES IN VEHICLES (CATEGORY 2)						
Access/Egress Route ID:		Route from facility to Broome Town Centre (Approximately 8.8km)				
PROTECTION PRINCIPLE - SEPARATION FROM ALL BUSHFIRE THREATS: To utilise distance away from all relevant bushfire hazard threats (direct and indirect attack mechanisms) while traversing an access/egress route in a vehicle to lower the exposure of persons to the threats for the expected time on the route.						
3.1	Locating Routes Away from Adjacent Hazards: Existing or to be installed vehicular access/egress route components (roads, access ways, and driveways) are positioned to maximise the distance away from any adjacent bushfire prone vegetation where possible.	High	No	No	No	No
Informative and/or Site Specific Comment/Assessment: The measure is not under the control of the proponent and is not possible in the local landscape.						
3.2	Egress Routes Located to Ensure Driving Away from Hazard: Existing or to be installed vehicular access/egress route components (roads, access ways, and driveways) are positioned so that the direction of egress is away from the hazard into lower threat areas.	Very High	No	No	No	No
Informative and/or Site Specific Comment/Assessment: Low threat areas are reached at the Broome Townsite. The route is entirely bounded by Class D Scrub vegetation.						
3.3	Greater Road Width: Wider roads will allow for a greater separation distance between traversing vehicles and the bushfire hazard. The incorporation of non-vegetated and trafficable road verges/shoulders and adjacent footpaths can also safely increase effective separation for slower moving vehicles.	High	No	Yes	No	No
Informative and/or Site Specific Comment/Assessment: Broome Highway and Broome-Cape Leveque Road have cleared or reduced fuel shoulders extending a minimum of 4m from either verge. Additional clearance is unlikely to be agreed and/or maintained.						
3.4	Reduce and Maintain Road Verge Fuel to Low Threat State: Road verges, or part off, have vegetation removed or reduced to a minimal fuel, low threat state annually to increase the separation distance from the bushfire hazard. This is	Effective	No	No	No	No

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS ON ACCESS/EGRESS ROUTES IN VEHICLES (CATEGORY 2)						
Access/Egress Route ID:		Route from facility to Broome Town Centre (Approximately 8.8km)				
	practical when an authority exists to conduct the management and will have greater impact as a protection measure if there is certainty it will be carried out.					
Informative and/or Site Specific Comment/Assessment: The road verges are not vegetated (see 3.3).						
PROTECTION PRINCIPLE - SHIELDING FROM ALL BUSHFIRE THREATS: To utilise constructed or natural shielding to reduce the exposure of persons traversing the access/egress routes to the direct attack mechanisms of bushfire. To assist with ensuring the level of exposure to the threats is survivable for the expected time on the route while travelling in a vehicle.						
3.5	<p>Vehicle Type – Protection Level: People can only tolerate low levels of radiant heat without some protection. Vehicles provide some protection from low intensity fires (if they stay on cleared area and remain in the vehicle) but they will not protect people in moderate to intense grass fires or in any location where scrub or forest adjoin the road.</p> <p>Protection provided by vehicles with predominantly metal bodies (including roof) and able to be enclosed (glass window), while limited is also still significant. It is particularly significant when compared to other potentially available modes of transport on roads (e.g. open top/backed vehicles, motorbikes, bicycles and being on foot).</p> <p>The availability such vehicles of required capacity can contribute to reduced exposure to the bushfire threats for persons on access/egress routes.</p>	Moderate	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: Visitors and contractors accessing the site will be transporting waste material and will therefore have an enclosed vehicle. The site is 8.8km from the Broome Townsite so any persons onsite will necessarily have a mode of transportation.						
¹ Refer to section 2.3.4 for effectiveness rating explanation.						
² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.						

7.2.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 7.2.2: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

EXPOSURE REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Element at Risk	Persons on access/egress routes in vehicles (Category 2)					
Access/Egress Route ID	Route from facility to Broome Town Centre (Approximately 8.8km)					
The Protection Principle	Effectiveness Rating ¹	Numbers of Protection Measures				
		Total Available	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Separation from the Bushfire Hazard	Very High	1	-	-	-	-
	High	2	1	1	-	-
	Effective	1	-	-	-	-
	Moderate	-	-	-	-	-
	Not Relevant	-	-	-	-	-
Shielding from the Bushfire Hazard	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	-	-	-	-	-
	Moderate	1	1	1	-	-
	Not Relevant	-	-	-	-	-
Total Numbers	Very High	1	-	-	-	-
	High	2	1	1	-	-
	Effective	1	-	-	-	-
	Moderate	1	1	1	-	-
	Not Relevant	-	-	-	-	-
	Totals	5	2	2	-	-

¹ Refer to section 2.3.4 for effectiveness rating explanation.

² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.

7.2.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (EXPOSURE REDUCTION)

Table 7.2.3: For the stated element at risk, the potential impact of the applied protection measures in reducing exposure levels to the stated area of bushfire prone vegetation.

THE ASSESSED IMPACT OF APPLIED MEASURES ON REDUCING EXPOSURE								
Element at Risk		Persons on access/egress routes in vehicles (Category 2)						
Access/Egress Route ID		Route from facility to Broome Town Centre (Approximately 8.8km)						
Protection Measures Applied to Assessment ¹	The Bushfire Hazard Threats ²							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Minimal	Significant	Significant	Minimal	Minimal	Minimal	Minimal	Minimal
	Medium				Minimal			
Existing, Planned and Recommended (applied to residual risk)	Minimal	Significant	Significant	Minimal	Minimal	Minimal	Minimal	Minimal
	Medium				Minimal			
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3								
² Refer to Appendix 4 for explanatory information.								

Assessment Comments: No recommendations are applicable. The inherent and residual risk are the same.

7.2.4 ASSESSED EXPOSURE LEVEL

Assessed as a function of the number and effectiveness of protection measures that will be applied and their ability to reduce the exposure of the identified element at risk. The assessed threat and vulnerability levels are not a part of the function.

Table 7.2.4: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED EXPOSURE LEVEL – A FUNCTION OF PROTECTION MEASURE APPLICATION, EFFECTIVENESS & IMPACT	
Element at Risk	Persons on access/egress routes in vehicles (Category 2)
Access/Egress Route ID	Route from facility to Broome Town Centre (Approximately 8.8km)
Protection Measures Applied to Assessment ¹	Relative Exposure Level ²
Existing and Planned (applied to inherent risk)	Moderate
Existing, Planned and Recommended (applied to residual risk)	Moderate
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3	
² Refer to Appendix 2 for explanatory information.	

Assessment Comments: No recommendations are applicable. The inherent and residual risk are the same.

7.3 BUILDINGS AND STRUCTURES NCC CLASSES 1-10 (ELEMENT AT RISK CATEGORIES 3-10)

7.3.1 PROTECTION MEASURES AVAILABLE TO REDUCE EXPOSURE LEVELS AND THEIR APPLICATION STATUS

Table 7.3.1: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
PROTECTION PRINCIPLE – SEPARATION FROM ALL BUSHFIRE THREATS (SITING): To locate (site) the buildings and attached/adjacent structures at distances away from the direct and indirect attack mechanisms of bushfire (the hazard threats) to reduce their exposure. The required distances will be dependent on the relative threat levels and the degree of bushfire resilience that is or is planned to be incorporated into the exposed elements through design and construction.						
4.1	<p>Asset Protection Zone (APZ): Ensure an APZ can be established surrounding the exposed element(s) to create the required separation distance from the bushfire hazard and its threats (the direct and indirect attack mechanisms). This is to be an area containing minimal fire fuels and maintained in a low threat state. The <i>Explanatory Notes for Element 2 of the Bushfire Protection Criteria and Schedule 1: Standards for Asset Protection Zones</i> established in the Guidelines [22] provides the key requirements for establishing and maintaining an APZ.</p> <p>Additional requirements may exist within a relevant local governments firebreak notice, or the responsibilities established by an applicable Bushfire Management Plan (BMP).</p> <p>The required dimensions of the APZ will correspond to the maximum level of radiant heat the exposed element is to be exposed to – or a greater distance if it is stipulated by a different authority (e.g. firebreak notice of BMP). As a minimum avoid dimensions (separation distances) that correspond to BAL-FZ and BAL-40 ratings for any given site/vegetation combination of relevant the parameters (Note: this will also apply to BAL-29 separation distances if flame length modelling indicates potential contact due to specific site and effective slope configurations).</p> <p>The APZ should be contained solely within the boundaries of each lot, except in instances where the neighbouring lot(s) or adjacent public land will be managed in a low-fuel state on an ongoing basis, in perpetuity.</p> <p>Note that the APZ does not provide separation from the consequential fire attack mechanism. Separation from consequential fire fuels requires additional assessment and management.</p>	Effective	Yes	No	Yes	Yes
Informative and/or Site Specific Comment/Assessment: All relevant structures, storage areas and waste disposal cells are required to install a minimum BAL-29 APZ within the associated Bushfire Management Plan.						
4.2	<p>Siting of Buildings/Structures - Wind: Site the buildings and attached/adjacent structures in locations that have lower wind exposure. Avoid the top and sides of ridges which are especially vulnerable to fire driven winds as well as topographically</p>	Moderate	No	No	No	No

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
	influenced winds. Winds can directly or indirectly (carrying materials/debris) cause damage to the external building envelope potentially allowing flame, radiant heat and ember entry.					
Informative and/or Site Specific Comment/Assessment: The topography of the local area is almost entirely flat and offsite vegetation has a consistent height of 3-4m. Structures/assets will have comparable wind exposure regardless of siting.						
4.3	Use of Non-Vegetated Areas and/or Public Open Space: Reduce exposure by increasing separation from APZ landscaping vegetation and/or the bushfire hazard by incorporating these lowest threat areas adjacent to buildings/structures and/or adjacent to the bushfire hazard. These lowest threat components of the APZ include non-vegetated areas (e.g. footpaths, paved areas, roads, parking, drainage, swimming pools), formally managed areas of vegetation (public open space and other recreation areas) and services installed in a common section of non-vegetated land. These elements create robust and easier managed asset protection zones.	Moderate	No	No	No	No
Informative and/or Site Specific Comment/Assessment: The local area is entirely vegetated, excepting the roads and verges, and the Broome Motocross Club to the south.						
4.4	Landscaping - Tree Location: Use separation to minimise the potential for debris accumulation and tree strike damage to the building envelop potentially allowing flame, radiant heat and ember entry to internal spaces. <ul style="list-style-type: none">The buildings/structures are separated from trees (or trees from buildings) by a distance of at least 1.5 times the height of the tallest tree.Trees that produce significant quantities of debris (fine fuels) during the bushfire season should be located a sufficient distance away from vulnerable exposed elements to ensure debris cannot Drop and accumulate within at least 4m of buildings/structures or be likely to be relocated by wind to closer than 4m to buildings / structures.If the minimum distance cannot be achieved with an existing tree either remove the tree or at least ensure tree branches are sufficiently separated from buildings and attached/adjacent structures (at a minimum to not overhang) to ensure branches cannot fall onto or be blown onto the buildings/structures.	Moderate	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment: The APZ will be entirely non-vegetated hardstand.						
4.5	Separation of Stored Flammable Products - Gas in Cylinders: To reduce the potential for gas flaring or explosion (consequential fire), installation of LPG cylinders is to apply as a minimum, the principles and requirements established in AS 1596 and LP Gas cylinder safety in bushfire prone areas (Energy Safety – Govt. of WA).	Moderate	Yes	No	Yes	No

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
	Otherwise, the required separation distance is 6m from any combustible materials. Heat from bushfire or consequential fire can be sufficient to cause cylinder pressure to reach critical levels and the pressure relief valve release large quantities of gas (flare). If the cylinder falls over the pressure relief valve may not function correctly, and the cylinder may rupture (explosion).					
Informative and/or Site Specific Comment/Assessment: LPG cylinders will be installed following the stated requirements.						
4.6	Separation from Stored Flammable Products – Fuels / Other Hazardous Materials: Establish sufficient separation distance between the consequential fire fuels and buildings/structures. The required separation distance will be dependent on the fuel and storage type.	Moderate	Yes	No	Yes	
Informative and/or Site Specific Comment/Assessment: Combustible materials are stored onsite as part of the primary site operations, and the proposed layout sites these stockpiles appropriately. The Reuse Shop and Education Centre is immediately alongside a large item collection area for sale and/or repurposing. Items stored in this area may be combustible and require separation from the structure. At a minimum, combustible items should me moved >6m from the building in a bushfire event.						
4.7	Separation from Stored and Constructed Combustible Items: These consequential fire fuels include: <ul style="list-style-type: none">Stored Combustible Items - Heavy Fuels e.g. building materials, packaging materials, firewood, sporting/playground equipment, outdoor furniture, rubbish bins etc:Stored Combustible Items – Large Heavy Fuels e.g. vehicles, caravans, boats and large quantities of dead vegetation materials stored as part of site use.Constructed Combustible Items – Heavy Fuels e.g. landscaping structures including fences, screens, walls, plastic water tanks.Constructed Combustible Items – Large Heavy Fuels e.g. adjacent buildings/structures including houses, sheds, garages, carports. (Note: If the adjacent structure is constructed to BAL-29 requirements or greater and can implement a significant number of additional bushfire protection measures associated with reducing exposure and vulnerability, these minimum separation distances could be reduced by 30%) [31]. Apply the rule of thumb [13] “assume flames produced from a consequential fire source will be twice as high as the object itself ... where the consequential fire source is a structure, then the maximum eave height is a reasonable measure of maximum height”.	Moderate	Yes	No	Yes	

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
	<p>Apply the following separation distances from the subject building/structure as a multiple of the height of the consequential fire source and dependent on the construction standard applied to the building/structure [13 and 31]:</p> <ul style="list-style-type: none">At least six times the height when the building/structure construction incorporates design and materials that is only intended to resist low levels of radiant heat up to 12.5 kW/m²) and no flame contact;Between 4 and 6 six times the height when the building/structure construction incorporates design and materials intended to resist radiant heat up to 29 kW/m² and no flame contact.Between 2 and 4 times the height when the building/structure construction incorporates design and materials intended to resist up to 40kW/m² and potential flame contact.Less than 2 times the height when the building/structure construction incorporates design and materials intended to resist extreme levels of radiant heat and flame contact.Zero separation distance is required if the building/structure is separated by a non-combustible FRL 60/60/60 rated wall or the potential consequential fire source is fully enclosed by the building/structure.					
Informative and/or Site Specific Comment/Assessment: This component includes green waste and timber stockpiles, vehicles, and all structures onsite. Structures have >40m separation distance from heavy fuels and other structures.						
PROTECTION PRINCIPLE – SHIELDING FROM ALL BUSHFIRE THREATS: To shield buildings and attached/adjacent structures (or other consequential fire fuels) from the direct bushfire attack mechanisms of flame, radiant heat, surface fire and surface migration of embers. To also reduce exposure to the indirect attack mechanism of debris accumulation against buildings/structures and other consequential fire fuels and wind attack.						
4.8	<p>Constructed Barrier – Bushfire Fuels: Walls, fences and/or landforms to shield the subject building/structure from direct and indirect bushfire attack mechanisms and reduce the potential impact of these threats to vulnerable exposed elements.</p> <p>Must be constructed using appropriate fire resistant / non-combustible construction materials (e.g. masonry, steel, earthworks). These are to withstand the impact of direct bushfire attack mechanisms for the required period of time.</p> <p>Apply the bushfire construction standards for external walls subject to the assessed level of radiant heat or flame contact to which the barrier will be exposed (or otherwise to BAL-FZ requirements). These are established by AS 3959:2018 [4] and/or the NASH Standard [33] and additionally informed by the research report ‘Research and Investigation into the Performance of Residential Boundary Fencing Systems in Bushfires.’ [29]</p>	High	No	No	No	
Informative and/or Site Specific Comment/Assessment: Barriers against bushfire impacts are not proposed to be installed. They are not a practical measure to reduce exposure.						

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
4.9	Constructed Barrier – Consequential Fire Fuels: Applicable to all consequential fire fuel sources. Install a non-combustible barrier (including complete enclosure when appropriate), of required robustness, that can perform the following as relevant: <ul style="list-style-type: none">Reduce the exposure of the subject building/structure to the threats of consequential fire; and/orReduce the exposure of the consequential fire fuels to the bushfire hazard.	Moderate	Partly	No	Partly	No
Informative and/or Site Specific Comment/Assessment: The bunds on the flanks of the landfill cells will create a shield of earthworks against bushfire impacts for the waste within the landfill cell and stored material immediately behind, which in the current proposed layout will include the timber and green waste windrows. The effect of the shielding is likely to be minimal and reduce the radiant heat experienced only.						
4.10	Natural Barrier - Landforms: Use existing natural landforms to reduce buildings/structures exposure to radiant heat, and lower wind speeds (prevailing synoptic and/or fire driven).	High	No	No	No	No
Informative and/or Site Specific Comment/Assessment: The local area is effectively flat. There are no appropriate landforms.						
4.11	Planted Barrier - Vegetation Barrier: Use appropriate hedges and trees strategically to reduce (to varying extents) buildings/structures exposure to radiant heat, to filter/trap embers and firebrands, and to lower wind speeds (prevailing synoptic and/or fire driven).	Moderate	No	No	No	No
Informative and/or Site Specific Comment/Assessment: The operational area of the facility will be entirely non-vegetated.						
4.12	Shield Non-Structural Essential Elements: These are elements essential to the continued operation of the building/structure which are potentially exposed to fire attack mechanisms of both bushfire and consequential fire. They include cabling and plumbing associated with power / data transmission and water / fuel transport. When the use of fire rated materials to the degree necessary is not possible or practical, the application of non-combustible shielding can be applied to reduce exposure to the bushfire threats. Shielding includes underground installation.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: These components have a low exposure and vulnerability to bushfire impacts relative to structures and stored material. This is an unnecessary measure.						
¹ Refer to section 2.3.4 for effectiveness rating explanation.						
² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.						

7.3.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 7.3.2: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

EXPOSURE REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Element at Risk	Buildings/Structures - NCC Classes 1-10 (Categories 5, 6, 8)					
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1					
The Protection Principle	Effectiveness Rating ¹	Numbers of Protection Measures				
		Total Available	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Separation from the Hazard	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	1	1	-	1	1
	Moderate	6	4	-	4	1
	Not Relevant	-	-	-	-	-
Shielding from the Hazard	Very High	-	-	-	-	-
	High	2	-	-	-	-
	Effective	-	-	-	-	-
	Moderate	3	2	-	1	-
	Not Relevant	-	-	-	-	-
Total Numbers	Very High	-	-	-	-	-
	High	2	-	-	-	-
	Effective	1	1	-	1	1
	Moderate	9	6	-	5	1
	Not Relevant	-	-	-	-	-
Totals		12	7	-	5	2

¹ Refer to section 2.3.4 for effectiveness rating explanation.

² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.

7.3.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (EXPOSURE REDUCTION)

Table 7.3.3: For the stated element at risk, the potential impact of the applied protection measures in reducing exposure levels to the stated area of bushfire prone vegetation.

THE ASSESSED IMPACT OF APPLIED MEASURES ON REDUCING EXPOSURE								
Element at Risk	Buildings/Structures - NCC Classes 1-10 (Categories 5, 6, 8)							
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1							
Protection Measures Applied to Assessment ¹	The Bushfire Hazard Threats ²							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accum.	Conseq. Fire	Fire Driven Wind	Tree Strike / Obstruct
Existing and Planned (applied to inherent risk)	Medium	Minimal	None	Minimal	Medium	Significant	Minimal	None
	Minimal				Medium			
Existing, Planned and Recommended (applied to residual risk)	Minimal	Minimal	None	Minimal	Minimal	Medium	Minimal	None
	Minimal				Minimal			
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3								
² Refer to Appendix 4 for explanatory information.								

Assessment Comments: Proposed structures onsite are primarily exposed to consequential fire hazards within the operational area of the facility.

7.3.4 ASSESSED EXPOSURE LEVEL

Assessed as a function of the number and effectiveness of protection measures that will be applied and their ability to reduce the exposure of the identified element at risk. The assessed threat and vulnerability levels are not a part of the function.

Table 7.3.4: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED EXPOSURE LEVEL	
Element at Risk	Buildings/Structures - NCC Classes 1-10 (Categories 5, 6, 8)
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1
Protection Measures Applied to Assessment ¹	Relative Exposure Level ²
Existing and Planned (applied to inherent risk)	Moderate
Existing, Planned and Recommended (applied to residual risk)	Low
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3	
² Refer to Appendix 2 for explanatory information.	

Assessment Comments: Reducing the likelihood and proximity of consequential fires reduces exposure of structures.

7.4 NON-BUILDING ACCOMMODATION (ELEMENT AT RISK CATEGORY 11)

No Category 11 Elements are proposed as part of the facility.

7.5 FIXED (HARD) INFRASTRUCTURE ASSETS (ELEMENT AT RISK CATEGORY 12)

7.5.1 PROTECTION MEASURES AVAILABLE TO REDUCE EXPOSURE LEVELS AND THEIR APPLICATION STATUS

Table 7.5.1: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: FIXED (HARD) INFRASTRUCTURE ASSETS (CATEGORY 12)						
PROTECTION PRINCIPLE – SEPARATION FROM ALL BUSHFIRE THREATS (SITING): To locate (site) the buildings and attached/adjacent structures at distances away from the direct and indirect attack mechanisms of bushfire (the hazard threats) to reduce their exposure. The required distances will be dependent on the relative threat levels and the degree of bushfire resilience that is or is planned to be incorporated into the exposed elements through design and construction.						
6.1	<p>Asset Protection Zone (APZ): Ensure an APZ can be established surrounding the exposed element(s) to create the required separation distance from the bushfire hazard and its threats (the direct and indirect attack mechanisms). This is to be an area containing minimal fire fuels and maintained in a low threat state. The <i>Explanatory Notes for Element 2 of the Bushfire Protection Criteria and Schedule 1: Standards for Asset Protection Zones</i> established in the Guidelines [22] provides the key requirements for establishing and maintaining an APZ.</p> <p>Additional requirements may exist within a relevant local governments firebreak notice, or the responsibilities established by an applicable Bushfire Management Plan (BMP).</p> <p>The required dimensions of the APZ will correspond to the maximum level of radiant heat the exposed element is to be exposed to – or a greater distance if it is stipulated by a different authority (e.g. firebreak notice or BMP). As a minimum avoid dimensions (separation distances) that correspond to BAL-FZ and BAL-40 ratings for any given site/vegetation combination of the relevant parameters. Note that this will also apply to BAL-29 separation distances if flame length modelling indicates potential contact due to specific site and effective slope configurations.</p> <p>The APZ should be contained solely within the boundaries of each lot, except in instances where the neighbouring lot(s) or adjacent public land will be managed in a low-fuel state on an ongoing basis, in perpetuity.</p> <p>Note that the APZ does not provide separation from the consequential fire attack mechanism. Separation from consequential fire fuels requires additional assessment and management.</p>	Effective	Yes	No	Yes	Yes
Informative and/or Site Specific Comment/Assessment: The Solar Farm is required to install a minimum BAL-29 APZ within the associated Bushfire Management Plan. This APZ exceeds the 44.1m setback for <10kW/m ² radiant heat flux exposure. See BMP Appendix 4 for Method 2 output summary.						
6.2	<p>Siting of Buildings/Structures - Wind: Site the buildings/structures/infrastructure in locations that have lower wind exposure. Avoid the top and sides of ridges which are especially vulnerable to fire driven winds as well as topographically</p>	Moderate	No	No	No	No

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: FIXED (HARD) INFRASTRUCTURE ASSETS (CATEGORY 12)						
	influenced winds. Winds can directly or indirectly (carrying materials/debris) cause damage to the external building envelope potentially allowing flame, radiant heat and ember entry.					
Informative and/or Site Specific Comment/Assessment: The topography of the local area is almost entirely flat and offsite vegetation has a consistent height of 3-4m. Structures/assets will have comparable wind exposure regardless of siting.						
6.3	Use of Non-Vegetated Areas and/or Public Open Space: Reduce exposure by increasing separation from APZ landscaping vegetation and/or the bushfire hazard by incorporating these lowest threat areas adjacent to buildings/structures and/or adjacent to the bushfire hazard. These lowest threat components of the APZ include non-vegetated areas (e.g. footpaths, paved areas, roads, parking, drainage, swimming pools), formally managed areas of vegetation (public open space and other recreation areas) and services installed in a common section of non-vegetated land. These elements create robust and easier managed asset protection zones.	Moderate	No	No	No	No
Informative and/or Site Specific Comment/Assessment: The local area is entirely vegetated, excepting the roads and verges, and the Broome Motocross Club to the south.						
6.4	Landscaping - Tree Location: Use separation to minimise the potential for debris accumulation and tree strike damage to the building envelop potentially allowing flame, radiant heat and ember entry to internal spaces. <ul style="list-style-type: none">The buildings/structures are separated from trees (or trees from buildings) by a distance of at least 1.5 times the height of the tallest tree.Trees that produce significant quantities of debris (fine fuels) during the bushfire season should be located a sufficient distance away from vulnerable exposed elements to ensure debris cannot drop and accumulate within at least 4m of buildings/structures or be likely to be relocated by wind to closer than 4m to buildings / structures.If the minimum distances cannot be achieved with an existing tree either remove the tree or at least ensure tree branches are sufficiently separated from buildings and attached/adjacent structures (at a minimum to not overhang) to ensure branches cannot fall onto or be blown onto the buildings/structures.	Moderate	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment: The APZ will be entirely non-vegetated hardstand.						
6.5	Separation from Stored Flammable Products - Gas in Cylinders: To reduce the potential for gas flaring or explosion (consequential fire), installation of LPG cylinders is to apply as a minimum, the principles and requirements established in AS 1596 and LP Gas cylinder safety in bushfire prone areas (Energy Safety – Govt. of WA).	Moderate	No	No	No	No

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: FIXED (HARD) INFRASTRUCTURE ASSETS (CATEGORY 12)						
	Otherwise, the required separation distance is 6m from any combustible materials. Heat from bushfire or consequential fire can be sufficient to cause cylinder pressure to reach critical levels and the pressure relief valve release large quantities of gas (flare). If the cylinder falls over the pressure relief valve may not function correctly, and the cylinder may rupture (explosion).					
Informative and/or Site Specific Comment/Assessment: LPG cylinders are not part of the Solar Farm.						
6.6	Separation from Stored Flammable Products – Fuels / Other Hazardous Materials: Establish sufficient separation distance between the consequential fire fuels and buildings/structures. The required separation distance will be dependent on the fuel and storage type.	Moderate	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment: The location of the proposed Solar Farm is isolated from flammable material storage.						
6.7	Separation from Stored and Constructed Combustible Items: These consequential fire fuels include: <ul style="list-style-type: none">• Stored Combustible Items - Heavy Fuels e.g. building materials, packaging materials, rubbish bins etc:• Stored Combustible Items – Large Heavy Fuels e.g. vehicles, caravans and large quantities of dead vegetation materials stored as part of site use.• Constructed Combustible Items – Heavy Fuels e.g. landscaping structures including fences, screens, walls, plastic water tanks.• Constructed Combustible Items – Large Heavy Fuels e.g. adjacent buildings/structures including houses, sheds, garages, carports. (Note: If the adjacent structure is constructed to BAL-29 requirements or greater and can implement a significant number of additional bushfire protection measures associated with reducing exposure and vulnerability, these minimum separation distances could be reduced by 30%) [31]. <i>Apply the rule of thumb [13] “assume flames produced from a consequential fire source will be twice as high as the object itself ... where the consequential fire source is a structure, then the maximum eave height is a reasonable measure of maximum height”.</i> Apply the following separation distances from the subject building/structure as a multiple of the height of the consequential fire source and dependent on the construction standard applied to the building/structure [13 and 31]: <ul style="list-style-type: none">• At least six times the height when the building/structure construction incorporates design and materials that is only intended to resist low levels of radiant heat up to 12.5 kW/m²) and no flame contact;	Moderate	Yes	No	Yes	No

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: FIXED (HARD) INFRASTRUCTURE ASSETS (CATEGORY 12)						
	<ul style="list-style-type: none">Between 4 and 6 six times the height when the building/structure construction incorporates design and materials intended to resist radiant heat up to 29 kW/m² and no flame contact.Between 2 and 4 times the height when the building/structure construction incorporates design and materials intended to resist up to 40kW/m² and potential flame contact.Less than 2 times the height when the building/structure construction incorporates design and materials intended to resist extreme levels of radiant heat and flame contact.Zero separation distance is required if the building/structure is separated by a non-combustible FRL 60/60/60 rated wall or the potential consequential fire source is fully enclosed by the building/structure.					
Informative and/or Site Specific Comment/Assessment: The location of the proposed Solar Farm is isolated from heavy fuels and structures.						
PROTECTION PRINCIPLE – SHIELDING FROM ALL BUSHFIRE THREATS: To shield buildings and attached/adjacent structures (or other consequential fire fuels) from the direct bushfire attack mechanisms of flame, radiant heat, surface fire and surface migration of embers. To also reduce exposure to the indirect attack mechanism of debris accumulation against buildings/structures and other consequential fire fuels and wind attack.						
6.8	<p>Constructed Barrier – Bushfire Fuels: Walls, fences and/or landforms to shield the subject building/structure from direct and indirect bushfire attack mechanisms and reduce the potential impact of these threats to vulnerable exposed elements.</p> <p>Must be constructed using appropriate fire resistant / non-combustible construction materials (e.g. masonry, steel, earthworks). These are to withstand the impact of direct bushfire attack mechanisms for the required period of time.</p> <p>Apply the bushfire construction standards for external walls subject to the assessed level of radiant heat or flame contact to which the barrier will be exposed (or otherwise to BAL-FZ requirements). These are established by AS 3959:2018 [4] and/or the NASH Standard [33] and additionally informed by the research report 'Research and Investigation into the Performance of Residential Boundary Fencing Systems in Bushfires.' [29]</p>	High	No	No	No	No
Informative and/or Site Specific Comment/Assessment: Barriers against bushfire impacts are not proposed to be installed. They are not a practical measure to reduce exposure.						
6.9	<p>Constructed Barrier (shielding from consequential fire): Applicable to all consequential fire fuel sources. Install a non-combustible barrier (including complete enclosure when appropriate), of required robustness, that can perform the following as relevant:</p> <ul style="list-style-type: none">Reduce the exposure of the subject building/structure to the threats of consequential fire; and/orReduce the exposure of the consequential fire fuels to the bushfire hazard.	Moderate	No	No	No	No

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: FIXED (HARD) INFRASTRUCTURE ASSETS (CATEGORY 12)						
Informative and/or Site Specific Comment/Assessment: No consequential fire fuel sources are located around the Solar Farm.						
6.10	Natural Barrier - Landforms: Use existing natural landforms to reduce buildings/structures exposure to radiant heat, and lower wind speeds (prevailing synoptic and/or fire driven).	High	No	No	No	No
Informative and/or Site Specific Comment/Assessment: The local area is effectively flat. There are no appropriate landforms.						
6.11	Natural Barrier – Vegetation: Use appropriate hedges and trees strategically to reduce (to varying extents) buildings/structures exposure to radiant heat, to filter/trap embers and firebrands, and to lower wind speeds (prevailing synoptic and/or fire driven).	Moderate	No	No	No	No
Informative and/or Site Specific Comment/Assessment: The operational area of the facility will be entirely non-vegetated.						
6.12	Shield Non-Structural Essential Elements: These are elements essential to the continued operation of the built asset which are potentially exposed to fire attack mechanisms of both bushfire and consequential fire. They include cabling and plumbing associated with power / data transmission and water / fuel transport. When the use of fire rated materials to the degree necessary is not possible or practical, the application of non-combustible shielding can be applied to reduce exposure to the threats. Shielding includes underground installation.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: These components have a low exposure and vulnerability to bushfire impacts relative to structures and stored material. This is an unnecessary measure.						
¹ Refer to section 2.3.4 for effectiveness rating explanation.						
² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.						

7.5.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 7.5.2: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

EXPOSURE REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Element at Risk	Fixed (hard) infrastructure assets (Category 12)					
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1					
The Protection Principle	Effectiveness Rating ¹	Numbers of Protection Measures				
		Total Available	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Separation from the Hazard	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	1	1	-	1	1
	Moderate	6	3	-	3	-
	Not Relevant	-	-	-	-	-
Shielding from the Hazard	Very High	-	-	-	-	-
	High	2	-	-	-	-
	Effective	-	-	-	-	-
	Moderate	3	1	-	-	-
	Not Relevant	-	-	-	-	-
Total Numbers	Very High	-	-	-	-	-
	High	2	-	-	-	-
	Effective	1	1	-	1	1
	Moderate	9	4	-	3	-
	Not Relevant	-	-	-	-	-
Totals		12	5	-	4	1

¹ Refer to section 2.3.4 for effectiveness rating explanation.

² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.

7.5.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (EXPOSURE REDUCTION)

Table 7.5.3: For the stated element at risk, the potential impact of the applied protection measures in reducing exposure levels to the stated area of bushfire prone vegetation.

THE ASSESSED IMPACT OF APPLIED MEASURES ON REDUCING EXPOSURE								
Element at Risk	Fixed (hard) infrastructure assets (Category 12)							
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1							
Protection Measures Applied to Assessment ¹	The Bushfire Hazard Threats ²							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Minimal	Minimal	None	Minimal	Minimal	Medium	Minimal	None
	Minimal				Medium			
Existing, Planned and Recommended (applied to residual risk)	Minimal	Minimal	None	Minimal	Minimal	Minimal	Minimal	None
	Minimal				Minimal			
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3								
² Refer to Appendix 4 for explanatory information.								

Assessment Comments: The proposed Solar Farm is not exposed to significant bushfire impacts.

7.5.4 ASSESSED EXPOSURE LEVEL

Assessed as a function of the number and effectiveness of protection measures that will be applied and their ability to reduce the exposure of the identified element at risk. The assessed threat and vulnerability levels are not a part of the function.

Table 7.5.4: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED EXPOSURE LEVEL	
Element at Risk	Fixed (hard) infrastructure assets (Category 12)
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1
Protection Measures Applied to Assessment ¹	Relative Exposure Level ²
Existing and Planned (applied to inherent risk)	Low
Existing, Planned and Recommended (applied to residual risk)	Very Low
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3	
² Refer to Appendix 2 for explanatory information.	

Assessment Comments: Strict Asset Protection Zone requirements to eliminate consequential fuel sources will result in a very low relative exposure level.

8 ASSESSING THE VULNERABILITY LEVELS OF ELEMENTS AT RISK

Summary of the qualitative assessment process for deriving the relative vulnerability levels (to the bushfire hazard threats) for each identified element at risk:

1. Identify all protection measures (grouped by protection principle) that are available to reduce relative vulnerability levels and rate their relative effectiveness;
2. Identify the application status of each protection measure and produce a numerical summary of their availability versus their ability to be applied. Differentiation by measure effectiveness is applied;
3. Assess the potential vulnerability reducing impact of the package of protection measures that is able to be applied. The effectiveness rating weights the potential impact of an individual measure; and
4. Derive the relative vulnerability level of the identified element at risk to each identified area of bushfire prone vegetation (refer to Section 2.3.3 and Appendix 2 for additional risk assessment process information).

8.1 PERSONS ONSITE OR TEMPORARILY OFFSITE (ELEMENT AT RISK CATEGORY 1)

8.1.1 PROTECTION MEASURES AVAILABLE TO REDUCE VULNERABILITY LEVELS AND THEIR APPLICATION STATUS

Table 8.1.1: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
PROTECTION PRINCIPLE – TRANSPORT AND MULTIPLE EVACUATION DESTINATIONS AND ROUTES AVAILABLE						
7.1	Sufficient Evacuation Transport Available: Ensure that all persons likely to be on site have access to transport. This can be through own vehicles, facility vehicles, a formal arrangement with an external provider or a combination of these.	Effective	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: All staff and visitors will have their own transportation.						
7.2	Multiple Safer Offsite Locations Available: Increasing the route and destination options decreases vulnerability of persons as the exposed element. Multiple buildings/areas are accessible from the subject site as evacuation destinations. The offsite locations exist at a sufficient distance from the subject site ensuring that the destination and the subject site are very unlikely to be simultaneously impacted by a bushfire event.	Very High	Yes	Partly	No	No

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
	For the most robust scenario: <ul style="list-style-type: none">Multiple access/egress route are available to the safer locations from the subject site;The entirety of at least two routes is unlikely to be simultaneously impacted by a bushfire event; andThe availability of water and amenities corresponding to person numbers increases the effectiveness of the measure.					
<i>Informative and/or Site Specific Comment/Assessment: Broome-Cape Leveque Road is over 200km in length with multiple informal secondary access options through land of various tenures, which realistically can be used in an emergency scenario. Additionally suitable destinations do exist north on Broome-Cape Leveque Road and west on McGuigan Road where a beach is considered 'suitable.' The shoreline is a minimum fuel area which can and has been utilised in a bushfire emergency. Realistically, the Broome Townsite is a suitable destination and if this route is compromised, shelter-in-place is likely the safer option.</i>						
PROTECTION PRINCIPLE – PROVISION OF BUSHFIRE EMERGENCY INFORMATION AND EDUCATION						
7.3	Bushfire Emergency Plan: Is produced and appropriately located within the site of the subject development/use. It is an operational document that details site specific preparation, response, recovery and review procedures. It is produced for use by the site owners, managers, operators and occupants (as relevant).	Effective	Yes	No	No	Yes
<i>Informative and/or Site Specific Comment/Assessment: Bushfire Emergency Plan and Supporting Information document is to be developed. A future Standard Operating Procedures or general Evacuation Plan document for the site may fulfill this obligation.</i>						
7.4	Bushfire Emergency Poster: A poster is prominently displayed, for the attention of all persons onsite. It presents the key emergency contacts, information sources and response procedures in the event of a bushfire event. It has increased value attached to its display when there are no bushfire emergency trained persons onsite or no persons that are familiar with the site and local area.	Moderate	Yes	No	No	Yes
<i>Informative and/or Site Specific Comment/Assessment: A Bushfire Emergency Poster is to be developed with the Bushfire Emergency Plan.</i>						
7.5	Bushfire Protection Measures to be Implemented are Published in the Relevant Operational Documents: The relevant documents can include the Bushfire Management Plan (BMP), the Bushfire Emergency Plan (BEP), the Site Emergency Plan (as required to be developed by the operators of 'high risk' land uses), and any relevant documents associated with a projects design phase.	Effective	Yes	No	No	Yes

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
	The purpose of this measure is to ensure the application of relevant protection measures, that have been identified in this Bushfire Risk Assessment and Management Report, will be acted upon through responsibilities created by the operational documents.					
Informative and/or Site Specific Comment/Assessment: The BMP has been developed alongside this Risk Assessment. A future Standard Operating Procedures document must contain bushfire protection measures.						
7.6	Prominent Display of Information Stating Safe Early Evacuation is the Primary Procedure: For the subject development/use evacuation in the event of a bushfire within the locality has or is likely to be determined as the primary response procedure and that it must be conducted early. This option is available. The emphasis on early rather than a late evacuation is important. Analysis of past events identify that most people who die in bushfires are caught in the open, either in vehicles or on foot, because they have left their property too late. For evacuation to provide the safest response for occupants, it must be conducted early. Being on roads when a bushfire is close is a high risk action. Otherwise, sheltering-in-place is likely to provide greater protection to persons – particularly when a suitable onsite shelter place is identified.	Moderate	Yes	No	No	Yes
Informative and/or Site Specific Comment/Assessment: This can be combined with the required Bushfire Emergency Poster.						
7.7	Egress Pathway Signage: Where pathways exist onsite for occupants to relocate to an identified safer onsite location, appropriate signage to guide unfamiliar persons can reduce their vulnerability.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: The shelter-in-place building is at the public exit to the site. Specific signage is not necessary where exit signage is available. Contractors have a private entry but are expected to know the location of the Reuse Shop and Education Centre (the shelter-in-place building).						
7.8	Trained Personnel Onsite: Operational persons (staff) are provided with bushfire emergency management training, aligned with the subject site's prepared Bushfire Emergency Plan (BEP). The intent also includes identifying the specific roles and persons to fill any required responsibilities that have determined through the BEP construction process.	Moderate	Yes	No	No	Yes
Informative and/or Site Specific Comment/Assessment: Bushfire Awareness training to be provided.						
7.9	Build Community Resilience Through Education: When relevant to the type and scale of proposed development/use, the delivery of effective education programs can result in lowering the vulnerability of the community to a bushfire event, once the information has been acted upon and packages of protection measures put in place.	Effective	Yes	Partly	No	No

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
	<p>Local government develops an ongoing program of innovative and leading edge community and landowner education that builds on the information presented within this Bushfire Risk Assessment and Management Report.</p> <p>Subsequent implementation of recommended/required protection measures can be encouraged through legislation, education, audits, enforcement and penalties as appropriate.</p> <p>Examples of such community education programs exist in various jurisdictions. The CSIRO (2020) Climate and Disaster Resilience Overview Report in 'Recommendation No. 5' [18] encourages collaboration with research agencies on the issue of building community resilience.</p>					
Informative and/or Site Specific Comment/Assessment: The local government provides some bushfire risk reduction information. The proposed development is independent of the community as a whole.						
7.10	<p>Encourage 'Property Bushfire Resilience Assessments': Local government to promote (and potentially incentivise) the conducting of these assessments and the implementation of any recommendations. These assessments address bushfire hazard threat levels and the level of exposure and vulnerability of buildings and persons. It identifies appropriate protection measures to increase bushfire resilience.</p>	Effective	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: The local government does not have the resources for the measure regarding the proposed development.						
PROTECTION PRINCIPLE – A BUSHFIRE EMERGENCY FIREFIGHTING CAPABILITY EXISTS (RESPONSE)						
7.11	<p>Personnel Onsite Can Manage Bushfire Emergency Procedures: Different categories of persons can perform this role in different scenarios, with potentially varying levels of expertise and effectiveness. These include:</p> <ul style="list-style-type: none">Appropriately trained person(s) will be onsite at all times, or able to be onsite at short notice. They are trained in bushfire emergency procedures in general and have specific knowledge of site preparation, response and recovery procedures from the required Bushfire Emergency Plan), and the environment in which the development/use exists. This person(s) may have the official title of fire warden.An untrained person familiar with the local area will be onsite at all times. They have knowledge and instruction gained from the required Bushfire Emergency Plan for the subject development/use and will ensure the preparation, response and recovery procedures established by the required Bushfire Emergency Plan are conducted appropriately and provide emergency event guidance to any other persons onsite.	Effective	Yes	No	Yes	Yes
Informative and/or Site Specific Comment/Assessment: An Emergency Response Team will be designated and trained to carry out various emergency procedures. This will be outlined in the Standard Operating Procedures document.						

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
7.12	Personnel Onsite Can Operate Firefighting Equipment: Such person(s) is suitably capable of maintaining and operating any installed firefighting water supply and associated pumps, hoses/nozzles and sprinklers.	Moderate	Yes	No	Yes	Yes
Informative and/or Site Specific Comment/Assessment: This will be a requirement of training all site staff.						
7.13	Locations of Vulnerable Persons are Registered: Relevant department of local government and their emergency services maintains a register of the location of land uses that are likely to result in a number of 'vulnerable' persons residing onsite, so that their needs can be addressed as a priority in a bushfire emergency. The subject development/use would exist on that register.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: Vulnerable persons are unlikely to attend the site.						
7.14	External Emergency Services Available: An emergency service with a bushfire response capability is located within a realistic operational distance of the subject development/use. Bushfire services include volunteer bushfire brigades, volunteer fire and emergency services, DFES career fire and Rescue Service or Parks and Wildlife. Even if an emergency service response capability exists, effectiveness will be limited by number of resources and their availability likelihood at the crucial time. <i>Bushfire Verification Method – Handbook s6.6 [14] states “During significant bushfires, there will be conflicting demands on fire brigade resources and reliance should not be placed on fire brigade intervention to protect a specific property. Prior to the 2009 Black Saturday fires, an early evacuation or stay and defend policy was in place and data from major fires indicated that the presence of occupants significantly increased the probability of house survival (refer Table 7.1). However, in response to the subsequent Royal Commission findings there is now a greater emphasis on early evacuation. Whilst this is expected to reduce fatalities by reducing the numbers of people at risk, a negative consequence will be an increase in property losses for buildings constructed to similar standards. It should therefore be assumed that there will be no fire brigade or occupant intervention with respect to protecting a specific property.”</i>	Effective	Yes	Yes	No	Yes
Informative and/or Site Specific Comment/Assessment: It is recommended that the Broome Regional Bushfire Brigade and the Broome Volunteer Fire and Rescue Service be invited to inspect and familiarise with the site.						
¹ Refer to section 2.3.4 for effectiveness rating explanation. ² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.						

8.1.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 8.1.2: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

VULNERABILITY REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Element at Risk	Persons located onsite and temporarily offsite (Category 1)					
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1					
The Protection Principle	Effectiveness Rating ¹	Numbers of Protection Measures				
		Total Available	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Transport and Multiple evacuation destinations and routes available	Very High	1	1	1	-	-
	High	-	-	-	-	-
	Effective	1	1	1	-	-
	Moderate	-	-	-	-	-
	Not Relevant	-	-	-	-	-
Provision of bushfire emergency information and education	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	4	4	1	-	2
	Moderate	4	4	-	-	3
	Not Relevant	-	-	-	-	-
A bushfire emergency firefighting capability exists (response)	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	2	2	1	1	2
	Moderate	1	1	-	1	1
	Not Relevant	1	-	-	-	-
Total Numbers	Very High	1	1	1	-	-
	High	-	-	-	-	-
	Effective	7	7	3	1	4
	Moderate	5	5	-	1	4
	Not Relevant	1	-	-	-	-
	Totals	14	13	4	2	8

¹ Refer to section 2.3.4 for effectiveness rating explanation.

² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.

8.1.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (VULNERABILITY REDUCTION)

Table 8.1.3: For the stated element at risk, the potential impact of the applied protection measures in reducing vulnerability levels to the stated area of bushfire prone vegetation.

THE ASSESSED IMPACT OF APPLIED MEASURES ON REDUCING VULNERABILITY								
Element at Risk	Persons located onsite and temporarily offsite (Category 1)							
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1							
Protection Measures Applied to Assessment ¹	The Bushfire Hazard Threats ²							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Minimal	Medium	Medium	Minimal	None	Significant	Minimal	None
	Medium				Medium			
Existing, Planned and Recommended (applied to residual risk)	Minimal	Minimal	Minimal	Minimal	None	Medium	Minimal	None
	Minimal				Minimal			
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3								
² Refer to Appendix 4 for explanatory information.								

Assessment Comments: Consequential fires in stored material onsite pose the greatest hazard to persons.

8.1.4 ASSESSED VULNERABILITY LEVEL

Assessed as a function of the number and effectiveness of protection measures that will be applied and their ability to reduce the vulnerability of the identified element at risk. The assessed threat and exposure levels are not a part of the function.

Table 8.1.4: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED VULNERABILITY LEVEL	
Element at Risk	Persons located onsite and temporarily offsite (Category 1)
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1
Protection Measures Applied to Assessment ¹	Relative Vulnerability Level ²
Existing and Planned (applied to inherent risk)	Moderate
Existing, Planned and Recommended (applied to residual risk)	Low
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3	
² Refer to Appendix 2 for explanatory information.	

Assessment Comments: Appropriate training and response, evacuation, and shelter in place options reduce the vulnerability of persons to bushfire impacts.

8.2 PERSONS ON ACCESS/EGRESS ROUTES (IN VEHICLES) OR PATHWAYS (ELEMENT AT RISK CATEGORY 2)

8.2.1 PROTECTION MEASURES AVAILABLE TO REDUCE VULNERABILITY LEVELS AND THEIR APPLICATION STATUS

Table 8.2.1: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS ON ACCESS/EGRESS ROUTES IN VEHICLES (CATEGORY 2)						
Access/Egress Route ID:		Route from facility to Broome Town Centre (Approximately 8.8km)				
PROTECTION PRINCIPLE – APPLY BEST (SAFER) ROAD DESIGN AND CONSTRUCTION (MATERIALS): The application of as many of the following protection measures as possible ensures a greater level of safety for users and lowers the associated risk when roads need to be used to evacuate to a safer offsite location in potentially high stress situations within a threatening environment.						
Safety for persons using the route is increased through reducing the likelihood of vehicle/terrain or vehicle/vehicle accidents and the ability to maintain travelling speed.						
8.1	Road Width: Ensure appropriate width roads are installed. Wider roads allow safer passing of the anticipated traffic that can be travelling in both directions (e.g. emergency services travelling towards the emergency event). The effectiveness of road width to reduce vulnerability is also a function of the required carriage capacity - which may be increased by the proposed development/use when it will increase traffic intensity. The incorporation of non-vegetated and trafficable road verges/shoulders and adjacent footpaths can also be considered to increase effective width for slower moving vehicles (providing additional separation from the hazard and passing opportunities).	High	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: Broome Highway and Broome-Cape Leveque Road are two-lane and approximately 8m wide with cleared or reduced fuel shoulders extending a minimum of 4m from either verge. The site has low staff occupancy and visitation, likely below 20 persons at any one time. Both roads are remote and access low population density areas, aside from the Broome Townsite. Road widths and traffic are unlikely to be a contributing factor.						
8.2	Road Gradient: Ensure appropriate road gradients are available. Lower gradients ensure traction and speed can be maintained and can also be associated with driver visibility. Appropriate gradients will depend on the constructed surface materials and the weights and tractive capability of expected vehicle types.	High	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: The locality is almost entirely flat.						
8.3	Road Clearance: Ensure appropriate clearance can exist and is established. Sufficient horizontal and vertical clearances from obstructions ensure unhindered movement of all possible vehicle types;	High	Yes	Yes	No	No

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS ON ACCESS/EGRESS ROUTES IN VEHICLES (CATEGORY 2)						
Access/Egress Route ID:		Route from facility to Broome Town Centre (Approximately 8.8km)				
Informative and/or Site Specific Comment/Assessment: Broome Highway and Broome-Cape Leveque Road have cleared or reduced fuel shoulders extending a minimum of 4m from either verge. No overhanging trees or any vertical obstructions exist.						
8.4	Road Surface Materials: Ensure that roads are constructed of materials that will provide the necessary traction (also a function of gradient), can support the weight of all expected vehicle types and remain operational in all weather. The required supportive capacity also applies to associated structures such as bridges.	High	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: Roads are sealed bitumen.						
8.5	Driver Visibility and Road Ahead Signage: Ensure that road design provides high levels of visibility ahead (at least in the absence of smoke and embers) and informative signage indicating relevant 'up ahead' route information (includes information stating distance to turnaround area for narrow roads in more remote locations). Good visibility is associated with the avoidance 'blind' corners and crests to the greatest extent possible.	High	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: The roads are largely straight or with gentle curves. The wide shoulders allow clear lines of view.						
8.6	Road / Pathway Length: Shorter distances to safer locations reduce the length of time persons remain vulnerable to bushfire threats.	Very High	No	No	No	No
Informative and/or Site Specific Comment/Assessment: The site use type is necessarily remote from residential built-out areas. It is not appropriate to reduce the distance to low threat areas.						
8.7	Interconnected Roads: Ensuring that the design of the road network provides through roads and avoids dead-end roads, provides the choice of alternative routes for drivers to minimise close contact with a bushfire event. Otherwise vehicles and persons can be trapped.	High	No	No	No	No
Informative and/or Site Specific Comment/Assessment: Broome-Cape Leveque Road and McGuigan Road are functionally dead-end roads. Broome-Cape Leveque Road is >200km in length. Multiple informal secondary access options through land of various tenures exist, which realistically can be used in an emergency scenario.						
PROTECTION PRINCIPLE – EVACUEES SELF-SUFFICIENT (LOCAL AWARENESS AND TRANSPORT): The 'type' of persons that will be present on the site of the proposed development/use influences their degree of vulnerability to both bushfire threats and to risk associated with vehicular accidents in a stressful environment. Persons that have local knowledge, are self-supportive, have their own transport and are physically and mentally capable present the lowest degree of vulnerability for this factor.						

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS ON ACCESS/EGRESS ROUTES IN VEHICLES (CATEGORY 2)						
Access/Egress Route ID:		Route from facility to Broome Town Centre (Approximately 8.8km)				
This contrasts with persons who meet the SPP 3.7 definition of 'vulnerable' where the most vulnerable are likely to be less effective at making the required decisions and carrying out the required actions in the timeframe required. They are likely to be dependent on others for both information and transport and will not have any local knowledge.						
8.8	Self Sufficient Persons with Local Awareness: These are the type of persons that will be present on the site of the proposed development/use.	Effective	Yes	Yes	No	No
8.9	Persons Onsite Have Own Transport: There is no need to have arrangements in place for external provision of evacuation vehicles.	Effective	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: Staff and visitors will necessarily be residents of the local area, familiar with the layout, and have their own transport.						
¹ Refer to section 2.3.4 for effectiveness rating explanation.						
² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.						

8.2.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 8.2.2: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

VULNERABILITY REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Element at Risk	Persons on access/egress routes in vehicles (Category 2)					
Access/Egress Route ID	Route from facility to Broome Town Centre (Approximately 8.8km)					
The Protection Principle	Effectiveness Rating ¹	Numbers of Protection Measures				
		Total Available	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Road Design and Construction (Materials)	Very High	1	-	-	-	-
	High	6	5	5	-	-
	Effective	-	-	-	-	-
	Moderate	-	-	-	-	-
	Not Relevant	-	-	-	-	-
Evacuees Self-Sufficient in Transport and Local Knowledge	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	2	2	2	-	-
	Moderate	-	-	-	-	-
	Not Relevant	-	-	-	-	-
Total Numbers	Very High	1	-	-	-	-
	High	6	5	5	-	-
	Effective	2	2	2	-	-
	Moderate	-	-	-	-	-
	Not Relevant	-	-	-	-	-
	Totals	9	7	7		-

¹ Refer to section 2.3.4 for effectiveness rating explanation.

² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.

8.2.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (VULNERABILITY REDUCTION)

Table 8.2.3: For the stated element at risk, the assessed impact of the applied protection measures corresponding to the stated area of bushfire prone vegetation.

THE ASSESSED IMPACT OF APPLIED MEASURES ON REDUCING VULNERABILITY								
Element at Risk		Persons on access/egress routes in vehicles (Category 2)						
Access/Egress Route ID		Route from facility to Broome Town Centre (Approximately 8.8km)						
Protection Measures Applied to Assessment ¹	The Bushfire Hazard Threats ²							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Minimal	Significant	Significant	Minimal	Minimal	Minimal	Minimal	Minimal
	Medium				Minimal			
Existing, Planned and Recommended (applied to residual risk)	Minimal	Significant	Significant	Minimal	Minimal	Minimal	Minimal	Minimal
	Medium				Minimal			
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3								
² Refer to Appendix 4 for explanatory information.								

Assessment Comments: No recommendations are applicable. The inherent and residual risk are the same.

8.2.4 ASSESSED VULNERABILITY LEVEL

Assessed as a function of the number and effectiveness of protection measures that will be applied and their ability to reduce the vulnerability of the identified element at risk. The assessed threat and exposure levels are not a part of the function.

Table 8.2.4: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED VULNERABILITY LEVEL	
Element at Risk	Persons on access/egress routes in vehicles (Category 2)
Access/Egress Route ID	Route from facility to Broome Town Centre (Approximately 8.8km)
Protection Measures Applied to Assessment ¹	Relative Vulnerability Level ²
Existing and Planned (applied to inherent risk)	Moderate
Existing, Planned and Recommended (applied to residual risk)	Moderate
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3	
² Refer to Appendix 2 for explanatory information.	

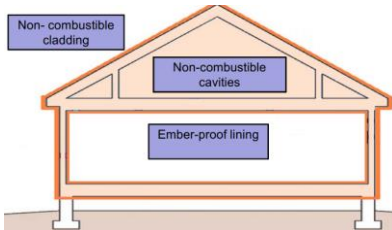
Assessment Comments: No recommendations are applicable. The inherent and residual risk are the same.

8.3 BUILDINGS AND STRUCTURES NCC CLASSES 1-10 (ELEMENT AT RISK CATEGORIES 3-10)

8.3.1 PROTECTION MEASURES AVAILABLE TO REDUCE VULNERABILITY LEVELS AND THEIR APPLICATION STATUS

Table 8.3.1: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
<p>PROTECTION PRINCIPLE – DESIGN AND CONSTRUCTION (MATERIALS): Increase bushfire resilience through the application of beneficial design and construction, including using non-combustible materials and minimising the use of vulnerable materials, to the greatest extent possible. Practicality and cost will be key considerations in determining the viability of applying protection measures in differing scenarios, but this should be determined with due consideration of threat levels and the importance of the elements at risk.</p> <p>The constructed systems should utilise the following properties to the greatest extent possible: reliability (which requires their durability over time, low maintenance and being unlikely to change over time), robustness (which limits damage spread from minor sources, continue to protect when thermally loaded and protects vulnerable elements), resilience (which enables their return to a functional state following an overload) and redundancy (which ensures the fate of the subject building/structure is not reliant on the effective performance of a single element). Refer to the glossary for additional explanation.</p> <p>The principle is also applicable to constructed consequential fire fuels.</p>						
9.1	<p>Construction to a Standard - AS 3959:2018 [4]: Apply the specified requirements to construction. These are intended to reduce the risk of building ignition from bushfire direct attack mechanisms. Note that the indirect attack mechanisms and the threats presented by consequential fire fuels are not specifically considered.</p> <p><i>“The standard is primarily concerned with improving the ability of buildings ... to better withstand attack from bushfire thus giving a measure of protection to the building occupants (until the fire front passes), as well as to the building itself”.</i></p> <p>The AS 3959 approach adopts a strategy that relies on the integrity of the building's exterior envelope (i.e., the cladding of roof/wall/eaves, floor supporting structures/flooring and all penetrations) to resist all bushfire exposure conditions and environmental actions thereby protecting all structural construction elements behind it, including allowable combustible materials. It provides protection by:</p> <ul style="list-style-type: none">• Using specified materials that provide ignition resistance (tolerance of radiant heat and flames). Higher BAL ratings impose increased construction requirements for these exterior envelope materials;• Specifying precise gap control (applicable to all bushfire attack levels) for the exterior envelope of the building to prevent ember entry); and• Attached and adjacent structures (within 6m) must also comply with the Standard.	High	Yes	No	Yes	Yes

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
Informative and/or Site Specific Comment/Assessment: Various building classes exist onsite, none of which are required to comply with AS3959 construction standards. The Reuse Shop and Education Centre building is required to establish an APZ to limit radiant heat flux to <10kW/m² and is required to be constructed to the requirements of BAL-29. This will provide a suitable shelter in place location.						
9.2	<p>Construction to a Standard – NASH Standard [33]: Apply the specified requirements to construction. The Standard:</p> <p><i>“Sets out acceptable construction requirements for residential and low-rise buildings in bushfire prone areas to reduce the risk of ignition from bushfire attack involving embers, radiant heat and direct flame impingement using non-combustible materials. Buildings constructed in accordance with this Standard are intended to provide a sheltering envelope during the passage of a bushfire flame front. They do not constitute ‘last resort’ private bushfire shelters as defined in the NCC. The Standard is based on achieving ignition resistance through non-combustible construction using conventional building materials and a level of redundancy to provide a high level of performance in extreme bushfire events and an increased probability that unattended buildings will survive such events.”</i></p> <p>Key attributes of the Standard include:</p> <ul style="list-style-type: none">Materials used anywhere on the building envelope (see shaded part of diagram below), must be non-combustible except for a small amount allowed externally that includes flooring, window frames, doors and external decorative trim. The building envelope is comprised of a framed roof/ceiling system, an external wall system and a floor system; <div></div> <ul style="list-style-type: none">The same construction requirements apply for all BAL ratings up to BAL-40 (except for external doors and windows which apply AS 3959 requirements). An additional benefit of this is the built in resistance to the direct attack mechanisms of consequential fire when lower BAL ratings apply.It does not rely on eliminating ember entry to the roof space, wall cavities and floor system as these are non-combustible construction. Embers only need to be kept from entering the internal living/operating spaces.It is ember tolerant without unrealistic workmanship, supervision and maintenance requirements;	Very High	Yes	No	No	No

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
	<ul style="list-style-type: none">The combination of a non-combustible cladding and cavities is a robust solution that enables the building to be configured so that failure or damage to one element does not lead to the inevitable failure of the building or a breach of the habitable envelope; andAttached and adjacent structures (within 6m) must also comply with the Standard.					
Informative and/or Site Specific Comment/Assessment: The measure is not cost-effective for the relevant structures.						
9.3	Construction Materials – External And Internal Cavity Building Elements: Excluding internal living or operation spaces, to the degree necessary, utilise materials resistant to fire attack mechanisms of flame and radiant heat (preferably non-combustible) for all relevant building elements, including wall, roof, floor, supporting structures and framing systems.	Very High	Yes	No	Partly	Yes
Informative and/or Site Specific Comment/Assessment: Recommended but not a requirement.						
9.4	Construction Materials – Consequential Fire Fuels: For constructed large consequential fire fuels, construct using non-combustible materials to the fullest extent possible. These include: <ul style="list-style-type: none">Surrounding landscaping items - fences/screens, retaining walls, gazebos, plastic water tanks etc;Attached structures - decks, verandahs, stairs, carports, garages, pergolas, patios, etc;Adjacent structures - houses, sheds, garages, carports, etc. Structure to structure fire is a common cause of overall building loss in post bushfire event assessments [9].	Very High	Yes	No	Partly	Yes
Informative and/or Site Specific Comment/Assessment: Recommend structures be non-combustible. This may apply to large item storage beside the Reuse Shop and Education Centre.						
9.5	Construction – Resistant To High Wind: Apply construction measures to prevent the type of building damage from wind that will open or create gaps (from the wind itself or carried projectiles) and allow the entry of embers, radiant heat and flames. This type of damage is typically superficial damage. Building codes relating to wind (e.g., cyclones) do not necessarily address this superficial type of impact. Additional fixings for building envelope claddings and protection of the most vulnerable elements, such as glazing, from debris impact, are key considerations. Consider applying the principles of the NASH Standard [33] design solution to construction. "Potential wind effects directly associated with bushfire events have been considered in this Standard. Wind actions may affect houses subject to a bushfire attack in various ways including:	High	Yes	No	Partly	No

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
	<ul style="list-style-type: none">The intensity of flame front activity may produce locally high wind pressures on parts of the building;In the post fire phase, some weakened components on the building envelope may be vulnerable to normal design pressures; andWind can drive embers into the building envelope." <p>Most applicable when the physical requirements exist for the development of an extreme bushfire event within the surrounding broader landscape.</p>					
Informative and/or Site Specific Comment/Assessment: The bushfire behaviour impacting the site will not produce significant fire generated winds.						
9.6	<p>Construction – Gas Supply: All gas cylinders are installed and maintained in accordance with AS 1596. This standard includes requirements for small portable cylinders and larger cylinders used for domestic house supply. These include:</p> <ul style="list-style-type: none">Safety release valve shall be directed away from the building and persons access/egress routes;Metal piping and fittings shall be used on all piping inside the building's cavities and enclosable occupied spaces and the high pressure side of any gas regulators; andTethers securing cylinders are to be non-combustible. <p>The objective is to reduce the risk of local fire against a building and reduce the risk of death or injury, from gas flaring or explosion. The rationale is gas cylinders which have either flared or ruptured are commonly found in post bushfire surveys [9]. The heat from the bushfire or consequential local fire has been sufficient to cause their pressure to reach critical levels beyond which their pressure release valve releases large quantities of LP gas. If these gas cylinders fall over, this pressure release valve may no longer function correctly, meaning that the gas cylinder may continue to increase in pressure with continued heating until the cylinder ruptures. The resulting explosion includes a pressure wave and large ball of flame which can threaten nearby life and buildings.</p>	Moderate	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment: LPG cylinders will be installed following the stated requirements.						
9.7	<p>Construction - Electricity Supply: Cabling to be shielded (includes installing underground within subject property boundary) from applicable bushfire attack mechanisms.</p> <p>The objective is to assist with continuity of supply for essential site operations and/or electrically driven firefighting pumps. It also reduces the risk of electrocution to any persons onsite and reduces potentially additional sources of fire ignition. It is common in bushfires for power infrastructure to burn and collapse or be impacted by falling trees or branches while power lines are still live. Removing this risk may be appropriate for some sites.</p>	Moderate	Yes	No	No	No

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
Informative and/or Site Specific Comment/Assessment: These components have a low exposure and vulnerability to bushfire impacts relative to structures and stored material. This is an unnecessary measure.						
9.8	Minimise Debris and Ember Accumulation – Re-Entrant Detail: Avoid or minimise the accumulation of unburnt debris and embers by avoiding re-entrant details and/or adopting aerodynamic forms that will self-shed windblown debris and embers. For example: <ul style="list-style-type: none">Simple building/structure footprints that avoid re-entrant corners in access ways, at wall/floor, wall/ground, roof/wall junctions and around doors, vents, windows; andSimple roof layouts that avoid valleys and minimise the number of ridges that need protection details (e.g. skillion roofs).	High	Yes	No	Yes	Yes
9.9	Minimise Debris and Ember Accumulation – Trapping Surfaces: Avoid or minimise the use of exposed combustible surfaces that can trap and accumulate embers. These can include: <ul style="list-style-type: none">Horizontal, or shallow angle surfaces e.g. exposed wall/roof framework, roofs, decking, verandahs, steps, windowsills; andVertical surfaces with rough textured cladding (e.g. sawn timber).	Moderate	Yes	No	Partly	Yes
9.10	Minimise Debris and Ember Accumulation – Roof Plumbing: All roof plumbing (gutters, valleys) is protected from the accumulation of debris and embers that can result in direct fire attack mechanisms immediately adjacent to any combustible elements within the roof cavity.	Moderate	Yes	No	Partly	Yes
9.11	Minimise Debris and Ember Accumulation – Construction Cavities: Apply designs that lower the potential for accumulation of embers and debris within cavity spaces of buildings/structures. Examples include concrete floor slab on the ground and solid masonry walls.	Moderate	Yes	No	Yes	Yes
9.12	Minimise Flame/Radiant Heat/Ember/Debris Entry - External Openings: Limit potential sites for entry through the external envelope to internal spaces and combustible materials within (as consequential fire fuels).	High	Yes	No	Yes	Yes
9.13	Screening and Sealing - Gaps and Penetrations: Apply fire rated sealants and/or install metal screening (corrosion resistant steel, bronze, aluminium <2mm aperture). All external construction and penetration gaps with apertures greater than 2mm will allow ember entry (and potentially debris) to internal cavities and combustible materials within (as consequential fire fuels).	Moderate	Yes	No	Yes	Yes

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
	This includes gaps in roofs, walls, doors, windows and their surrounding trims – including those associated with penetrations, vents, weepholes, poor workmanship and material deterioration and movement over time (maintenance). Internal fire is difficult to see and extinguish.					
9.14	Screening - External Doors and Windows: Metal screens (corrosion resistant steel, bronze, aluminium <2mm aperture) installed over non-openable and/or openable parts of windows and doors to prevent ember entry to internal spaces containing combustible materials (consequential fire fuels) and reduce radiant heat load on vulnerable surfaces.	Moderate	Yes	No	Yes	Yes
9.15	Shutters - External Doors and Windows: Fire rated shutters Installed to significantly increase bushfire resistance of the vulnerable building elements. Any requirement for onsite manual activation is a potential limitation to effectiveness.	Moderate	Yes	No	Yes	Yes
Informative and/or Site Specific Comment/Assessment: Structure design is unknown at this stage, but likely to be relatively simple and meet the requirements for their assessed BAL, excepting the Reuse Shop and Education Centre which is required to be constructed to BAL-29. Designs should be checked for the above recommendations.						
9.16	Landscaping Construction - Fences and Walls: Non-combustible materials are used for fences, walls (including retaining walls), screens, garden edging, play equipment and other built structures - as potential consequential fire fuels. Where relevant, the capacity to resist high winds, to minimise potential for impact damage to subject building/structure, should also be incorporated.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: These components will not be part of site landscaping.						
PROTECTION PRINCIPLE – FIREFIGHTING CAPABILITY: Provide sufficient, reliable and bushfire resilient water supply and delivery capability as is necessary for active and/or passive systems.						
9.17	Firefighting Water Supply: Have a dedicated static supply of firefighting water for the protection of buildings/structures before and after the passage of a bushfire front. Adequate water supply is critical for any firefighting operation, particularly where property protection is the intent. This is necessary when: <ul style="list-style-type: none">A water supply additional to a reticulated water supply is required to counter the loss of firefighting water as a protection measure, should the reticulated supply be interrupted;It is the only source of firefighting water. All tanks shall be non-combustible. Aside from losing water, failure of combustible tank can provide an additional heat or load to a vulnerable building element. Metal piping and fittings shall be used for any above ground components. The limitation to the effectiveness of the measure is the requirement for persons to be present and have the minimum required operational knowledge and/or access to appropriate information.	Effective	Yes	No	Yes	Yes

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
Informative and/or Site Specific Comment/Assessment: The facility will have an ample firefighting water supply, as large-scale water supply is required for site operations. Multiple water tanks with pumps are located strategically around the site. These water supplies are required to be fitted with appropriate couplings, as per the associated BMP Appendix 3.						
9.18	Firefighting Equipment – Active Operation: In addition to a dedicated water supply, appropriate firefighting equipment is installed (pumps, hoses, sprinklers etc). These will be resilient to bushfire impact, to the extent necessary, through the application of appropriate equipment materials and protection (shielding or separation from the hazard). The limitation to the effectiveness of the measure is the requirement for persons to be present and have the minimum required operational knowledge and/or access to appropriate information.	Effective	Yes	No	Yes	Yes
Informative and/or Site Specific Comment/Assessment: It is recommended that each structure be fitted with a compliant hose reel to service that structure. Fire in stored materials will require the response of onsite tankers.						
9.19	Firefighting Equipment – Passive Operation: In addition to a dedicated water supply, appropriate water dispensing apparatus are installed (e.g. pumps, plumbing and sprinklers) that are automatically activated. These will be resilient to bushfire impact, to the extent necessary, through the application of appropriate equipment materials and protection (shielding or separation from the hazard).	High	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment: APZ requirements are applied to these assets as part of the BMP.						
9.20	Firefighting Equipment – Maintain Operability: Where water pumps, shutters or other active/passive protection measures rely on the continued supply of electricity, establish barriers (shielding) or separation from potential damaging factors (e.g. falling trees/branches, fire, or other impact sources). For example, bury transmission systems to the greatest extent possible.	Moderate	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment: These components have a low exposure and vulnerability to bushfire impacts relative to structures and stored material. This is an unnecessary measure.						
9.21	Firebreaks For Access: Installation and maintenance of firebreaks to remove vegetation, limit surface fire progression and facilitate firefighting access / backburning.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: The entire facility will be cleared to a trafficable hardstand. A firebreak would not increase the available access.						
PROTECTION PRINCIPLE – MANAGEMENT AND MAINTAINING EFFECTIVENESS OF APPLIED PROTECTION MEASURES: To ensure the retention of the level of bushfire resilience that has been established through the implementation of appropriate bushfire protection measures, formal and enforceable responsibilities are created.						

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORIES 5, 6, 8)						
9.22	<p>Formal Management/Maintenance Plan – Actions and Responsibilities: Through a bushfire management plan, site operations emergency plan, bushfire emergency plan, operational annual works plan and/or a ‘firebreak’ notice, a mechanism is put in place to ensure that:</p> <ul style="list-style-type: none">• The required management and maintenance of applied bushfire protection measures is conducted on a regular basis – with the interval dependent on the necessary frequency that will maintain full effectiveness; and• The relevant protection measures are known and understood; and• Responsibilities are created <p>The different documents will be able to satisfactorily perform this function to differing extents.</p>	Effective	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: The measure is established in the associated BMP.						
¹ Refer to section 2.3.4 for effectiveness rating explanation.						
² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.						

8.3.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 8.3.2: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

VULNERABILITY REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Element at Risk	Buildings/Structures - NCC Classes 1-10 (Categories 5, 6, 8)					
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1					
The Protection Principle	Effectiveness Rating ¹	Numbers of Protection Measures				
		Total Available	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Design and Construction (Materials)	Very High	3	3	-	2	2
	High	4	4	-	4	3
	Effective	-	-	-	-	-
	Moderate	9	9	-	7	6
	Not Relevant	-	-	-	-	-
Firefighting Capability	Very High	-	-	-	-	-
	High	1	1	-	1	-
	Effective	2	2	-	2	2
	Moderate	2	2	-	1	-
	Not Relevant	-	-	-	-	-
Management and Maintaining Effectiveness of Applied Protection Measures	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	1	1	1	-	-
	Moderate	-	-	-	-	-
	Not Relevant	-	-	-	-	-
Total Numbers	Very High	3	3	-	2	2
	High	5	5	-	5	3
	Effective	3	3	1	2	2
	Moderate	11	11	-	8	6
	Not Relevant	-	-	-	-	-
	Totals	22	22	1	17	13

¹ Refer to section 2.3.4 for effectiveness rating explanation.

² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.

8.3.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (VULNERABILITY REDUCTION)

Table 8.3.3: For the stated element at risk, The potential impact of the applied protection measures in reducing vulnerability levels to the stated area of bushfire prone vegetation.

THE ASSESSED IMPACT OF APPLIED MEASURES ON REDUCING VULNERABILITY								
Element at Risk	Buildings/Structures - NCC Classes 1-10 (Categories 5, 6, 8)							
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1							
Protection Measures Applied to Assessment ¹	The Bushfire Hazard Threats ²							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Medium	Minimal	Medium	Medium	Minimal	Significant	Minimal	None
	Medium				Medium			
Existing, Planned and Recommended (applied to residual risk)	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	None
	Minimal				Minimal			
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3								
² Refer to Appendix 4 for explanatory information.								

Assessment Comments: Ember attack is the primary threat, indirectly causing consequential fires.

8.3.4 ASSESSED VULNERABILITY LEVEL

Assessed as a function of the number and effectiveness of protection measures that will be applied and their ability to reduce the vulnerability of the identified element at risk. The assessed threat and exposure levels are not a part of the function.

Table 8.3.4: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED VULNERABILITY LEVEL	
Element at Risk	Buildings/Structures - NCC Classes 1-10 (Categories 5, 6, 8)
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1
Protection Measures Applied to Assessment ¹	Relative Vulnerability Level ²
Existing and Planned (applied to inherent risk)	Moderate
Existing, Planned and Recommended (applied to residual risk)	Low
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3	
² Refer to Appendix 2 for explanatory information.	

Assessment Comments: Consideration of design vulnerabilities and improved firefighting reduces vulnerability to ember attack and consequential fires.

8.4 NON-BUILDING ACCOMMODATION (ELEMENT AT RISK CATEGORY 11)

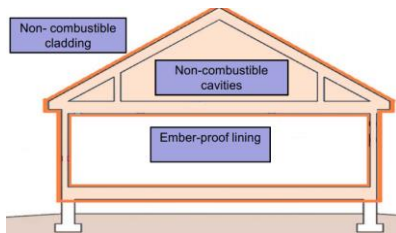
No Category 11 Elements are proposed as part of the facility.

8.5 FIXED (HARD) INFRASTRUCTURE ASSETS (ELEMENT AT RISK CATEGORY 12)

8.5.1 PROTECTION MEASURES AVAILABLE TO REDUCE VULNERABILITY LEVELS AND THEIR APPLICATION STATUS

Table 8.5.1: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: FIXED (HARD) INFRASTRUCTURE ASSETS (CATEGORY 12)						
<p>PROTECTION PRINCIPLE – DESIGN AND CONSTRUCTION (MATERIALS): Increase bushfire resilience through the application of beneficial design and construction, including using non-combustible materials and minimising the use of vulnerable materials, to the greatest extent possible. Practicality and cost will be key considerations in determining the viability of applying protection measures in differing scenarios, but this should be determined with due consideration of threat levels and the importance of the elements at risk.</p> <p>The constructed systems should utilise the following properties to the greatest extent possible: <u>reliability</u> (which requires their durability over time, low maintenance and being unlikely to change over time), <u>robustness</u> (which limits damage spread from minor sources, continue to protect when thermally loaded and protects vulnerable elements), <u>resilience</u> (which enables their return to a functional state following an overload) and <u>redundancy</u> (which ensures the fate of the subject building/structure is not reliant on the effective performance of a single element). Refer to the glossary for additional explanation.</p> <p>The principle is also applicable to constructed consequential fire fuels.</p>						
11.1	<p>Construction to a Standard - AS 3959:2018 [4]: Use the principles and requirements established in the Standard, for buildings in general, and apply to the infrastructure assets where they have merit.</p> <p>These are intended to reduce the risk of building ignition from bushfire direct attack mechanisms. Note that the indirect attack mechanisms and the threats presented by consequential fire fuels are not specifically considered. Key attributes of the Standard that may have relevance to other built assets include:</p> <ul style="list-style-type: none">• The AS 3959 strategy that relies on the integrity of the building's exterior envelope (i.e., the cladding of roof/wall/eaves, floor supporting structures/flooring and all penetrations) to resist all bushfire exposure conditions and environmental actions thereby protecting all structural construction elements behind it, including allowable combustible materials.• Using specified materials that provide ignition resistance (tolerance of radiant heat and flames). Higher BAL ratings impose increased construction requirements for these exterior envelope materials;• Specifying precise gap control (applicable to all bushfire attack levels) for the exterior envelope of the building to prevent ember entry); and• Attached and adjacent structures (within 6m) must also comply with the Standard.	High	No	No	No	No
11.2	<p>Construction to a Standard – NASH Standard [33]: Use the principles and requirements established in the Standard, for residential and low-rise buildings, and apply to the infrastructure assets where they have merit.</p>	Very High	No	No	No	No

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: FIXED (HARD) INFRASTRUCTURE ASSETS (CATEGORY 12)						
	<p>Key attributes of the Standard that may have relevance to other built assets include:</p> <ul style="list-style-type: none">Materials used anywhere on the building envelope (see shaded part of diagram below), must be non-combustible (except for a small number of smaller building elements). The building envelope is comprised of a framed roof/ceiling system, an external wall system and a floor system; <div></div> <ul style="list-style-type: none">The same construction requirements apply for all BAL ratings up to BAL-40 (except for external doors and windows which apply AS 3959 requirements). An additional benefit of this is the built in resistance to the direct attack mechanisms of consequential fire when lower BAL ratings apply.It does not rely on eliminating ember entry to the roof space, wall cavities and floor system as these are non-combustible construction. Embers only need to be kept from entering the internal living/operating spaces.It is ember tolerant without unrealistic workmanship, supervision and maintenance requirements;The combination of a non-combustible cladding and cavities is a robust solution that enables the building to be configured so that failure or damage to one element does not lead to the inevitable failure of the building or a breach of the habitable envelope; andAttached and adjacent structures (within 6m) must also comply with the Standard.					
Informative and/or Site Specific Comment/Assessment: The Solar Farm is not a structure which can comply with AS3959 or NASH.						
11.3	Construction Materials – External and Internal Cavity Building Elements: Excluding internal living or operation spaces, to the degree necessary, utilise materials resistant to fire attack mechanisms of flame and radiant heat (preferably non-combustible) for all relevant building elements, including wall, roof, floor, supporting structures and framing systems.	Very High	No	No	No	No
11.4	Construction Materials – Consequential Fire Fuels: For constructed large consequential fire fuels, construct using non-combustible materials to the fullest extent possible. These can include attached structures, adjacent structures and surrounding landscaping items.	Very High	No	No	No	No

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: FIXED (HARD) INFRASTRUCTURE ASSETS (CATEGORY 12)						
11.5	<p>Construction – Resistant To High Wind: Apply construction measures to prevent the type of building damage from wind that will open or create gaps (from the wind itself or carried projectiles) and allow the entry of embers, radiant heat and flames.</p> <p>This type of damage is typically superficial damage. Building codes relating to wind (e.g., cyclones) do not necessarily address this superficial type of impact.</p> <p>Additional fixings for building envelope claddings and protection of the most vulnerable elements, such as glazing, from debris impact, are key considerations.</p> <p>Consider applying the principles of the NASH Standard [33] design solution to construction.</p> <p>“Potential wind effects directly associated with bushfire events have been considered in this Standard. Wind actions may affect buildings subject to a bushfire attack in various ways including:</p> <ul style="list-style-type: none">• The intensity of flame front activity may produce locally high wind pressures on parts of the building;• In the post fire phase, some weakened components on the building envelope may be vulnerable to normal design pressures; and• Wind can drive embers into the building envelope.” <p>Most applicable when the physical requirements exist for the development of an extreme bushfire event within the surrounding broader landscape.</p>	High	No	No	No	No
11.6	<p>Construction – Gas Supply: All gas cylinders are installed and maintained in accordance with AS 1596 (for domestic house supply) as a guide. The requirement of the standard includes:</p> <ul style="list-style-type: none">• Safety release valve shall be directed away from the building and persons access/egress routes;• Metal piping and fittings shall be used on all piping inside the building's cavities and enclosable occupied spaces and the high pressure side of any gas regulators; and• Tethers securing cylinders are to be non-combustible. <p>The objective is to reduce the risk of local fire against a building and reduce the risk of death or injury, from gas flaring or explosion. The rationale is gas cylinders which have either flared or ruptured are commonly found in post bushfire surveys [9]. The heat from the bushfire or consequential local fire has been sufficient to cause their pressure to reach critical levels beyond which their pressure release valve releases large quantities of LP gas. If these gas cylinders fall over, this pressure release valve may no longer function correctly, meaning that the gas cylinder may continue to increase in pressure with continued heating until the cylinder ruptures. The resulting explosion includes a pressure wave and large ball of flame which can threaten nearby life and buildings.</p>	Not Relevant	N/A	N/A	N/A	N/A

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: FIXED (HARD) INFRASTRUCTURE ASSETS (CATEGORY 12)						
11.7	Construction Materials – Non-Structural Essential Elements: Utilise fire/radiant heat rated products (rated to the level determined as necessary), for the construction of non-structural elements that are essential to the continued operation of the built asset and are exposed to a bushfire hazard. These include cabling and plumbing associated with power / data transmission and water / fuel transport.	High	No	No	No	No
11.8	Minimise Debris and Ember Accumulation – Re-Entrant Detail: Avoid or minimise the accumulation of unburnt debris and embers by avoiding re-entrant details and/or adopting aerodynamic forms that will self-shed windblown debris and embers. For example: <ul style="list-style-type: none">Simple building/structure footprints that avoid re-entrant corners in access ways, at wall/floor, wall/ground, roof/wall junctions and around doors, vents, windows; andSimple roof layouts that avoid valleys and minimise the number of ridges that need protection details (e.g. skillion roofs).	High	No	No	No	No
11.9	Minimise Debris and Ember Accumulation – Trapping Surfaces: Avoid or minimise the use of exposed combustible surfaces that can trap and accumulate embers. These can include: <ul style="list-style-type: none">Horizontal, or shallow angle surfaces e.g. exposed wall/roof framework, roofs, decking, verandahs, steps, windowsills; andVertical surfaces with rough textured cladding (e.g. sawn timber).	Moderate	No	No	No	No
11.10	Minimise Debris and Ember Accumulation – Roof Plumbing: All roof plumbing (gutters, valleys) is protected from the accumulation of debris and embers that can result in direct fire attack mechanisms immediately adjacent to any combustible elements within the roof cavity.	Moderate	No	No	No	No
11.11	Minimise Debris and Ember Accumulation – Construction Cavities: Apply designs that lower the potential for accumulation of embers and debris within cavity spaces of buildings/structures. Examples include concrete floor slab on the ground and solid masonry walls.	Moderate	No	No	No	No
11.12	Minimise Flame/Radiant Heat/Ember/Debris Entry - External Openings: Limit potential sites for entry to internal spaces through the external envelope and combustible materials within (as consequential fire fuels).	Not Relevant	N/A	N/A	N/A	N/A
11.13	Screening and Sealing - Gaps And Penetrations: Apply fire rated sealants and/or install metal screening (corrosion resistant steel, bronze, aluminium <2mm aperture).	Not Relevant	N/A	N/A	N/A	N/A

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommended
ELEMENT AT RISK: FIXED (HARD) INFRASTRUCTURE ASSETS (CATEGORY 12)						
	All external construction and penetration gaps with apertures greater than 2mm will allow ember entry (and potentially debris) to internal cavities and combustible materials within (as consequential fire fuels). This includes gaps in roofs, walls, doors, windows and their surrounding trims – including those associated with penetrations, vents, weepholes, poor workmanship and material deterioration and movement over time (maintenance). Internal fire is difficult to see and extinguish.					
11.14	Screening - External Doors and Windows: Metal screens (corrosion resistant steel, bronze, aluminium <2mm aperture) installed over non-openable and/or openable parts of windows and doors to prevent ember entry to internal spaces containing combustible materials (consequential fire fuels) and reduce radiant heat load on vulnerable surfaces.	Not Relevant	N/A	N/A	N/A	N/A
11.15	Shutters - External Doors and Windows: Fire rated shutters Installed to significantly increase bushfire resistance of the vulnerable building elements. Any requirement for onsite manual activation is a potential limitation to effectiveness.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: The Solar Farm has a set design which either cannot be modified or does not have the designated component (such as doors).						
11.16	Landscaping Construction - Fences and Walls: Non-combustible materials are used for fences, walls (including retaining walls), screens and other built structures - as potential consequential fire fuels. Where relevant, the capacity to resist high winds, to minimise potential for impact damage to subject building/structure, should also be incorporated.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: These components will not be part of site landscaping.						
PROTECTION PRINCIPLE – FIREFIGHTING CAPABILITY: Provide sufficient, reliable and bushfire resilient water supply and delivery capability as is necessary for active and/or passive systems.						
11.17	Firefighting Water Supply: Have a dedicated static supply of firefighting water for the protection of buildings/structures before and after the passage of a bushfire front. Adequate water supply is critical for any firefighting operation, particularly where property protection is the intent. This is necessary when: <ul style="list-style-type: none">A water supply additional to a reticulated water supply is required to counter the loss of firefighting water as a protection measure, should the reticulated supply be interrupted;It is the only source of firefighting water. All tanks shall be non-combustible. Aside from losing water, failure of combustible tank can provide an additional heat or load to a vulnerable building element. Metal piping and fittings shall be used for any above ground components.	Effective	Yes	No	Yes	Yes

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: FIXED (HARD) INFRASTRUCTURE ASSETS (CATEGORY 12)						
	The limitation to the effectiveness of the measure is the requirement for persons to be present and have the minimum required operational knowledge and/or access to appropriate information.					
Informative and/or Site Specific Comment/Assessment: The facility will have an ample firefighting water supply, as large-scale water supply is required for site operations. Multiple water tanks with pumps are located strategically around the site. These water supplies are required to be fitted with appropriate couplings, as per the associated BMP Appendix 3.						
11.18	Firefighting Equipment – Active Operation: In addition to a dedicated water supply, appropriate firefighting equipment is installed (pumps, hoses, sprinklers etc). These will be resilient to bushfire impact, to the extent necessary, through the application of appropriate equipment materials and protection (shielding or separation from the hazard). The limitation to the effectiveness of the measure is the requirement for persons to be present and have the minimum required operational knowledge and/or access to appropriate information.	Effective	Yes	No	Yes	Yes
Informative and/or Site Specific Comment/Assessment: It is recommended that compliant hose reel(s) are able to reach all sections of the Solar Farm.						
11.19	Fire Fighting Equipment – Passive Operation: In addition to a dedicated water supply, appropriate water dispensing apparatus are installed (e.g. pumps, plumbing and sprinklers) that are automatically activated. These will be resilient to bushfire impact, to the extent necessary, through the application of appropriate equipment materials and protection (shielding or separation from the hazard).	High	No	No	No	No
Informative and/or Site Specific Comment/Assessment: The measure is not applicable to the Solar Farm.						
11.20	Fire Fighting Equipment – Maintain Operability: Where water pumps, shutters or other active/passive protection measures rely on the continued supply of electricity, establish barriers (shielding) or separation from potential damaging factors (e.g. falling trees/branches, fire, or other impact sources). For example, bury transmission systems to the greatest extent possible.	Moderate	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment: These components have a low exposure and vulnerability to bushfire impacts relative to structures and stored material. This is an unnecessary measure.						
11.21	Firebreaks: Installation and maintenance of firebreaks to remove vegetation, limit surface fire progression and facilitate firefighting access / backburning.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: The entire facility will be cleared to a trafficable hardstand. A firebreak would not increase the available access.						

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating ¹	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: FIXED (HARD) INFRASTRUCTURE ASSETS (CATEGORY 12)						
PROTECTION PRINCIPLE – MANAGEMENT AND MAINTAINING EFFECTIVENESS OF APPLIED PROTECTION MEASURES: To ensure the retention of the level of bushfire resilience that has been established through the implementation of appropriate bushfire protection measures, formal and enforceable responsibilities are created.						
11.22	<p>Formal Management/Maintenance Plan – Actions and Responsibilities: Through a bushfire management plan, site operations emergency plan, bushfire emergency plan, operational annual works plan and/or a 'firebreak' notice, a mechanism is put in place to ensure that:</p> <ul style="list-style-type: none">• The required management and maintenance of applied bushfire protection measures is conducted on a regular basis – with the interval dependent on the necessary frequency that will maintain full effectiveness; and• The relevant protection measures are known and understood; and• Responsibilities are created <p>The different documents will be able to satisfactorily perform this function to differing extents.</p>	Effective	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: The measure is established in the associated BMP.						
¹ Refer to section 2.3.4 for effectiveness rating explanation.						
² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.						

8.5.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 8.5.2: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

VULNERABILITY REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Element at Risk	Fixed (hard) infrastructure assets (Category 12)					
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1					
The Protection Principle	Effectiveness Rating ¹	Numbers of Protection Measures				
		Total Available	Application Status ²			
			Possible	Exists	Planned	Additionally Recommend
Design and Construction (Materials)	Very High	3	-	-	-	-
	High	4	-	-	-	-
	Effective	-	-	-	-	-
	Moderate	4	1	-	-	-
	Not Relevant	5	-	-	-	-
Firefighting Capability	Very High	-	-	-	-	-
	High	1	-	-	-	-
	Effective	2	2	-	2	2
	Moderate	2	2	-	1	-
	Not Relevant	-	-	-	-	-
Management and Maintaining Effectiveness of Applied Protection Measures	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	1	1	-	1	-
	Moderate	-	-	-	-	-
	Not Relevant	-	-	-	-	-
Total Numbers	Very High	3	-	-	-	-
	High	5	-	-	-	-
	Effective	3	3	-	3	2
	Moderate	11	3	-	1	-
	Not Relevant	-	-	-	-	-
	Totals	22	6	-	4	2

¹ Refer to section 2.3.4 for effectiveness rating explanation.

² Possible = measure could potentially be applied to subject development/use/site; Exists = measure already implemented; Planned = measure is proposed in BMP or development plans; Additionally Recommend = it is the opinion of the bushfire consultant that the additional measures can and should be implemented.

8.5.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (VULNERABILITY REDUCTION)

Table 8.5.3: For the stated element at risk, the potential impact of the applied protection measures in reducing vulnerability levels to the stated area of bushfire prone vegetation.

THE ASSESSED IMPACT OF APPLIED MEASURES ON REDUCING VULNERABILITY								
Element at Risk	Fixed (hard) infrastructure assets (Category 12)							
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1							
Protection Measures Applied to Assessment ¹	The Bushfire Hazard Threats ²							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Medium	Minimal	Medium	Medium	Minimal	Significant	Minimal	None
	Medium				Medium			
Existing, Planned and Recommended (applied to residual risk)	Minimal	Minimal	Minimal	Minimal	Minimal	Medium	Minimal	None
	Minimal				Minimal			
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3								
² Refer to Appendix 4 for explanatory information.								

Assessment Comments: The design of the Solar Farm cannot likely be made more resistant to bushfire impacts.

8.5.4 ASSESSED VULNERABILITY LEVEL

Assessed as a function of the number and effectiveness of protection measures that will be applied and their ability to reduce the vulnerability of the identified element at risk. The assessed threat and exposure levels are not a part of the function.

Table 8.5.4: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED VULNERABILITY LEVEL	
Element at Risk	Fixed (hard) infrastructure assets (Category 12)
Vegetation Area / Location	Within the assessment area and within the broader locality. Refer to Figure 4.1
Protection Measures Applied to Assessment ¹	Relative Vulnerability Level ²
Existing and Planned (applied to inherent risk)	Moderate
Existing, Planned and Recommended (applied to residual risk)	Low
¹ Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3	
² Refer to Appendix 2 for explanatory information.	

Assessment Comments: The relative vulnerability of the Solar Farm can be improved by effective firefighting capability and response.

APPENDIX 1: RATIONALE FOR THE SELECTION OF THE APPLIED RISK ASSESSMENT PROCESS

The following information regarding the selection and adaptation of the risk assessment process applied in this report is presented to help inform persons (as necessary) tasked with understanding this report.

KEY DRIVERS

Bushfire Prone Planning has taken into account the following key drivers in determining the most appropriate risk assessment process to apply:

1. The relevant hazard types.

Bushfire hazards are a natural hazard rather than a human-induced hazard (refer to glossary and see limitations of ISO 31000 in the next section). Natural processes and phenomena present particular types of threats.

Consequently, the assessment process needs to be able to specifically deal with the unique characteristics of bushfire hazards in a way that derives meaningful risk-based information that can be readily interpreted and applied.

A logical framework is needed around which the development of bushfire protection measures (risk treatments) can be constructed, assessed and understood by those tasked with making decisions based on the provided information.

2. The relevant risks to be addressed.

These are the potential loss of life, injury, or destroyed or damaged assets as the risk exists in relation to the threats generated by natural bushfire hazards, rather than the range of additional or different risks that can originate from predominantly human activity and choices.

3. The complexity and/or scale of proposed development/use.

For different development/use proposals, there are significant differences in the types of information required for the hazard assessments and the derivation of operationally useful information that is to be applied to mitigating the associated risks.

For example, higher level, strategic planning proposals (e.g., LGA, State or National) or complex development, will require a completely different level of assessment and protection measure development compared to a single small development proposal.

Also, different uses may be able to tolerate different levels of risk. For example the Guidelines v1.4 cl 5.5.2 establish that "different tourism land uses ... may require different levels of risk management".

Consequently, the applied risk management process will need to be able to accommodate these differences and remain both logical, useable and efficient to compile. It will need to be capable of being relatively easy to scaled up or down to provide a relevant and useful report.

LIMITATIONS OF ISO 31000:2018 AND NERAG

The approach adopted by Bushfire Prone Planning (BPP) contrasts with the typical approach historically used in various Australian jurisdictions. This historical approach conducts the risk management process by applying the *National Emergency Risk Assessment Guidelines (AIDR 2020, NERAG)*.

However, the considered view of BPP is that NERAG is unable to effectively provide the required outcomes for assessing risk associated with a natural hazard or evaluate the impact of specific bushfire protection measures at the finer grained level required (i.e. satisfy the key drivers discussed above).

It is not practical to fully justify the above statement here, but the following is noted:

The determination of pre and post treatment risk levels is a key objective of NERAG, and this is determined as the product of consequence and likelihood ratings. These ratings have the following inherent weaknesses in meeting the risk assessment requirements for a natural hazard:

1. Consequence levels are derived from a set of established qualitative and quantitative criteria - which are very broad based and have less relevance at smaller scales of development/use. No direct link between the application of a risk treatment(s) and how that can justifiably alter a consequence level is established; and

2. Likelihood levels (of both the emergency event and the consequences – which is difficult to separate) are derived from a set of established quantitative (probability) criteria. Varying the levels of this factor has limited applicability when the pragmatic requirement is to assume an emergency event will occur.

Also relevant is that the *NERAG* state they are “primarily focussed on assessing emergency risks” and that they are “structured to align broadly with relevant sections of *ISO 31000:2018 – Risk Management Guidelines*”. *ISO 31000:2018* states that its intended use is “... to provide guidelines on managing risk faced by organisations”.

The key point is that organisational risk is derived from a ‘human-induced hazard’ rather than a natural hazard (refer to the glossary) – but it is a natural hazard (bushfire) that is to be the source of risk addressed by the risk assessment requirement established by SPP 3.7 and the associated Guidelines.

Consequently, it is BPP’s considered opinion that applying *ISO 31000:2018* and *NERAG* to assessing risk associated with a bushfire hazard has significant assessment, application and relevance limitations.

THE APPLIED ADAPTED RISK ASSESSMENT APPROACH

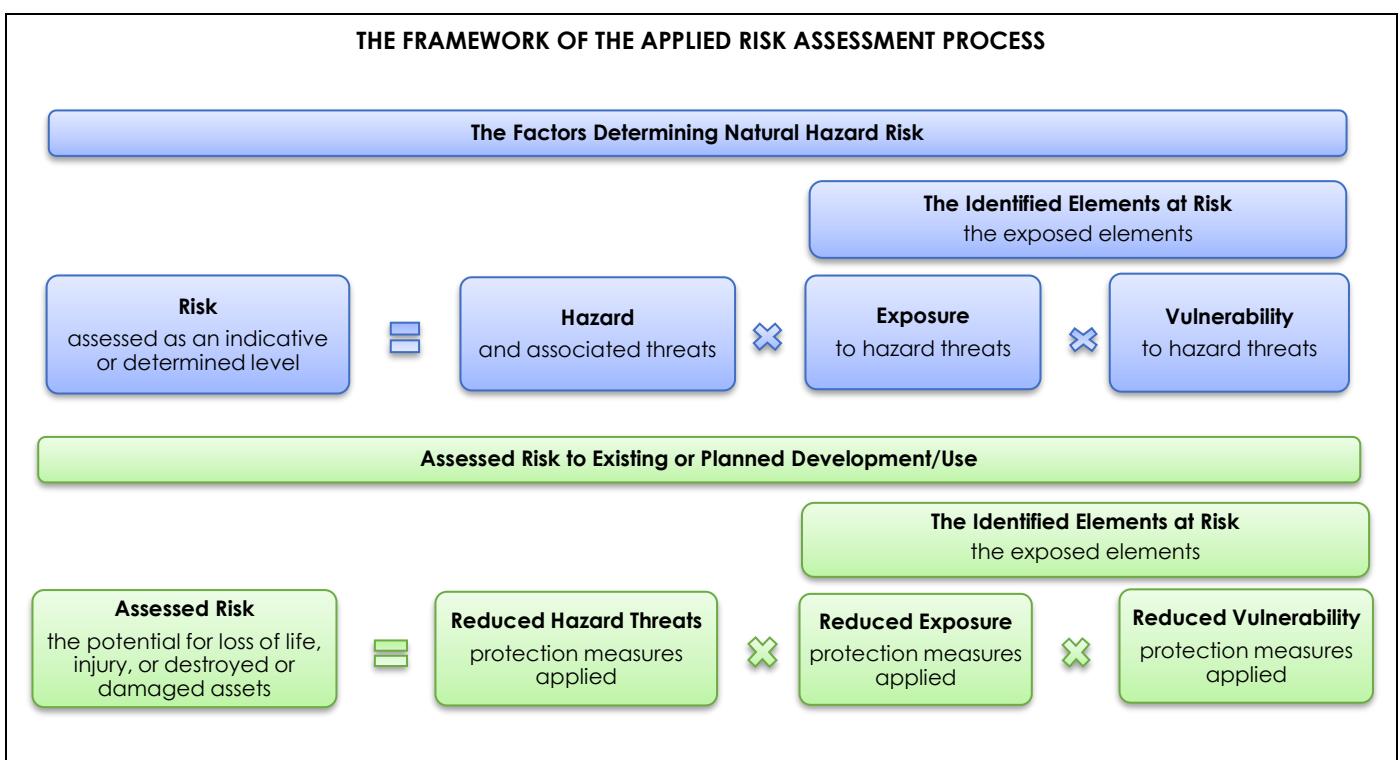
In acknowledging the key drivers, and the limitations of the risk management process developed by *ISO 31000* and adapted by *NERAG*, Bushfire Prone Planning has adapted the understanding of disaster risk that is used by the United Nations Office for Disaster Risk Reduction (*UNDRR*).

Although the *UNDRR* approach is designed to addresses disaster risk at large scale strategic levels, it can justifiably be applied to all scales of planning because it is focused on natural hazards and establishes a concept that can be readily adapted.

The risk assessment report that is developed applying this process presents relevant, logical, comprehensive and practical facts, to appropriately inform those persons tasked with either:

- Planning the siting, design, construction and management of development/use to ensure an appropriate level of bushfire resilience is achieved and limiting associated risks to tolerable levels; or
- With making pragmatic planning approval decisions.

Figure 2.3 is reproduced below and illustrates the framework of the adapted risk assessment process.



Copy of Figure 2.3: Illustrated framework of the applied risk assessment process.

APPENDIX 2: RISK LEVEL ANALYSIS – ADDITIONAL EXPLANATION

INDICATIVE RISK LEVELS

Justification for reporting indicative risk levels is based on the following factors:

1. There is a finite 'universe' of bushfire protection measure principles that can be applied to reducing hazard threats and the exposure and vulnerability of at risk elements;
2. There will be a range of development/use specific protection measures associated with each protection measure principle. The number of available protection measures will vary dependent on the type and scale of development/use, but effectively there will also be a practical limit; and
3. Bushfire protection measures will vary in their standalone effectiveness at mitigating risk (refer to section 2.3.4);

Consequently, an indication of the level of risk – for a given development/use - can be gained by:

1. Assessing 'relative' threat levels.
2. Deriving 'relative' exposure and vulnerability levels by:
 - a) Assessing how many protection measure principles and associated measures are applicable and can be applied;
 - b) Assessing the relative effectiveness of each protection measure; and
 - c) Comparing the numbers of applied protection measures with the number of possible measures in the protection measure 'universe'.
3. Making a qualitative assessment of the potential impact of the applied protection measures (including appropriate weighting given to their individual effectiveness) that can reduce the relative threat, exposure and vulnerability levels.
4. Derive the indicative risk level by applying the risk matrix shown as Table A2.1 and establish the tolerability of the risk by applying the risk tolerance scale of Table A3.2, Appendix 3.

Providing an indicative risk level establishes a qualitative understanding of the level of risk that potentially exists and is intended to inform and assist with making various planning decisions.

Deriving indicative risk levels is essentially a compilation and assessment of physical facts rather than determinations of what is to constitute different levels of threat, exposure and vulnerability and subsequently intolerable, tolerable and acceptable levels of risk for every development/use scenario.

An indicative risk level can be derived from an assessment of the site, the planned development/use and the knowledge and experience of the bushfire practitioner – such that an opinion can be provided regarding risk levels.

DETERMINED RISK LEVELS

Reporting determined risk levels will require reference information being available to the assessor so that 'determined' levels of threat, exposure and vulnerability can be established (this contrasts with the 'relative' levels required in deriving an indicative risk level).

The required reference information are the risk factor criteria, the risk level matrix and the risk tolerability scale.

Risk Factor Criteria

The required risk factor criteria will establish:

- What factors are to define the different 'determined' levels of hazard threats;
- What factors are to define the different 'determined' levels of exposure of elements at risk; and
- What factors are to define the different 'determined' levels of vulnerability of elements at risk.

Risk Level Matrix

The matrix will establish how the 'determined' levels of threat, exposure and vulnerability are to be applied in deriving the 'determined' risk level. Different sets of matrices to account for different development types, uses and scales will be required. The rationale for this statement includes:

- Different development types, uses and scales are potentially capable of tolerating different levels of risk and still be considered by the relevant authority (who are reflecting the understood society/community position), to remain acceptable;
- Recognition that different levels of risk can be tolerated by different development, use and scale is indicated in the Guidelines v1.4 where cl 5.5.2 establishes that "different tourism land uses ... may require different levels of risk management"; and
- To account for the variation, one risk level matrix could establish a moderate determined risk level for a given development type/use/scale and combination of threat, exposure and vulnerability levels.

For the same combination of threat, exposure and vulnerability levels but for a different development type/use/scale, a different risk level matrix could establish an extreme determined risk level; and

Risk Tolerance Scale

After the 'determined' risk level has been derived from the risk assessment process, a methodology is required to classify the risk level as either unacceptable, tolerable or acceptable. Currently Bushfire Prone Planning is applying the ALARP principle and associated risk tolerance scale (refer to Appendix 3).

The Current Limitations to Deriving a Determined Risk Level

The required reference information (i.e. the risk factor criteria, sets of risk matrices and the risk tolerance scale) is necessarily required to be provided by the relevant regulatory authorities /decision makers. The rationale for this statement is:

1. The information must reflect the expectations and understanding and accepting of risk as held by society and communities, and directed through its governing bodies;
2. The information must be standardised to the greatest extent possible so that it provides an acceptable and trusted basis on which the determined risk level can be derived and be relied upon in making decisions.
3. Properly establishing the reference information cannot be justifiably relegated to individual assessors with varied expertise, qualification and without any approved responsibility to provide such information. Their expertise might more appropriately be utilised in assisting the responsible authorities to establish the information.

Where the required reference information has not been established and provided by the responsible authorities, determined risk levels cannot be the final outcome when using this risk assessment process. Currently, this reference information does not exist.

HOW THE LIKELIHOOD OF A BUSHFIRE EVENT OCCURRING HAS BEEN DEALT WITH

The approach taken with the applied risk assessment process is to apply the pragmatic assumption that a bushfire will occur. It is assumed it can occur within any timeframe and could result in loss or life or injury, or unacceptable damage to property and or unacceptable disruption to services. This approach accepts that the requirements for fire of fuel, ignition source and oxygen will always exist. That is:

- The fire fuels being considered will always be there unless physically removed permanently;
- A potential ignition source will always exist through lightning and/or human activities; and
- The potential for adverse fire weather conditions to exist at some point within each year will always be present.

This contrasts with applying a quantitative approach based on the historical record of past bushfire event and determining the mathematical probability of a future event. This approach is problematic to achieving increased bushfire resilience at all stages of existing or proposed development/use for these reasons:

- Historical data may not be available or have enough data sets to be accurate. It cannot account for future changes in climate that may result in a different occurrence period. Consequently, further assumptions need to be made;
- Siting, design and construction of development to resist bushfire threats is much easier, more practical (and likely economical), to incorporate at initial planning stages rather than the retro-establishment of protection measures when circumstances change or tolerance of risk decreases;

- Time spent conducting historical research, performing statistical calculations and modifying risk levels, apart from being costly, is likely better spent assessing potential threat, exposure and vulnerability levels and developing appropriate protection measures; and
- The likelihood of occurrence cannot modify the levels of hazard threats, exposure or vulnerability. It can only be applied to reduce the overall risk level. That is, it would be applied as a modifying factor via the established risk level matrix and not the established risk factor criteria. The validity of incorporating such a factor may be indicated when, despite the existence of vegetation that can burn, there are other mitigating physical conditions that exist at the specific site that make the likelihood of ignition and severity of bushfire behaviour very low. How this is applied would need to be established by the authority establishing the relevant risk level matrix.

Table A2.1: Risk matrix for deriving indicative risk levels from the assessed relative levels of threat, exposure and vulnerability.

INDICATIVE RISK LEVEL MATRIX						
Relative Threat Level (a)	Relative Exposure Level (b)	Relative Vulnerability Level (c)				
		Very Low (1)	Low (2)	Moderate (3)	High (4)	Extreme (5)
Very Low (1)	Very Low (1)	VL1	VL2	VL3	L4	L5
	Low (2)	VL2	VL3	L4	L5	L6
	Moderate (3)	VL3	L4	L5	L6	M7
	High (4)	L4	L5	L6	M7	M8
	Extreme (5)	L5	L6	M7	M8	H9
Low (2)	Very Low (1)	VL2	VL3	L4	L5	L6
	Low (2)	VL3	L4	L5	L6	M7
	Moderate (3)	L4	L5	L6	M7	M8
	High (4)	L5	L6	M7	M8	H9
	Extreme (5)	L6	M7	M8	H9	H10
Moderate (3)	Very Low (1)	VL3	L4	L5	L6	M7
	Low (2)	L4	L5	L6	M7	M8
	Moderate (3)	L5	L6	M7	M8	H9
	High (4)	L6	M7	M8	H9	H10
	Extreme (5)	M7	M8	H9	H10	H11
High (4)	Very Low (1)	L4	L5	L6	M7	M8
	Low (2)	L5	L6	M7	M8	H9
	Moderate (3)	L6	M7	M8	H9	H10
	High (4)	M7	M8	H9	H10	H11
	Extreme (5)	M8	H9	H10	H11	E12
Extreme (5)	Very Low (1)	L5	L6	M7	M8	H9
	Low (2)	L6	M7	M8	H9	H10
	Moderate (3)	M7	M8	H9	H10	H11
	High (4)	M8	H9	H10	H11	E12
	Extreme (5)	H9	H10	H11	E12	E13

Indicative risk level key: VL = very low, L = low, M = moderate, H = high, E = extreme.

The qualitative relative levels are assigned a numerical value.

The indicative risk value is calculated as = (a + b + c) – 2 and range from 1 (lowest) to 13 (greatest).

The indicative risk levels are derived from an assigned a numerical range: very low = 1-3, low = 4-6, moderate = 7-8, high = 9-11, extreme = 12-13.

APPENDIX 3: THE ALARP PRINCIPLE AND THE RISK TOLERANCE SCALE APPLIED

The following information is intended to provide an understanding of the ALARP principle and provide justification for its application in this risk assessment report.

THE ALARP PRINCIPLE

The As Low as Reasonably Practicable (ALARP) principle is based on the belief it is not possible to completely eliminate all risk involved, there will always be a certain level of risk remaining known as residual risk. The term is used to express the expected level of residual risk within a system, activity or, relevant to this document, within a proposed development/use, when good practice, judgement and duty of care are applied to decisions and operations.

The origins of the ALARP (As Low as Reasonably Practicable) principle are from United Kingdom case law and their regulatory framework. It is applied by their Health and Safety Executive (HSE) and is used by regulators and companies around the world as it provides a logical basis for managing risks – including its adaption for use in the following Australian guidelines:

- Australian Institute for Disaster Resilience, 2020; Land use Planning for Disaster Resilient Communities;
- WA Department of Mines, Industry Regulation and Safety, 2020; Petroleum safety and major hazard facility – guide. ALARP demonstration;
- NOPSEMA (Australia's offshore energy regulator), 2020; ALARP and risk assessment guidance notes;
- Department of Planning Lands and Heritage (DPLH), 2019; Coastal hazard risk management and adaptation planning guidelines;
- Planning Institute of Australia, 2015; National Land Use Planning Guidelines for Disaster Resilient Communities; and
- NERAG 2010, an earlier version of NERAG 2020, applied the ALARP Principle.

The ALARP principle has been defined by the United Kingdom Health and Safety Executive (HSE-UK, 2001) to depict the concept that efforts to reduce risk should be continued until the incremental cost in doing so is grossly disproportionate to the value of the incremental risk reduction achieved (see figure). Incremental cost is defined in terms of time, effort, finance or other expenditure of resources – including loss of natural resources. Usually, each incremental reduction in risk will require a greater expenditure of resources.

This concept is depicted in Figure A3.1 where the triangle represents the decreasing risk and the diminishing proportional benefit as risk is reduced. There are also three regions shown in the figure into which general levels of residual risk can fall. The residual risk should fall either in the broadly acceptable region, or near the bottom of the tolerable region. This approach allows higher levels of safety to be provided where it is feasible.

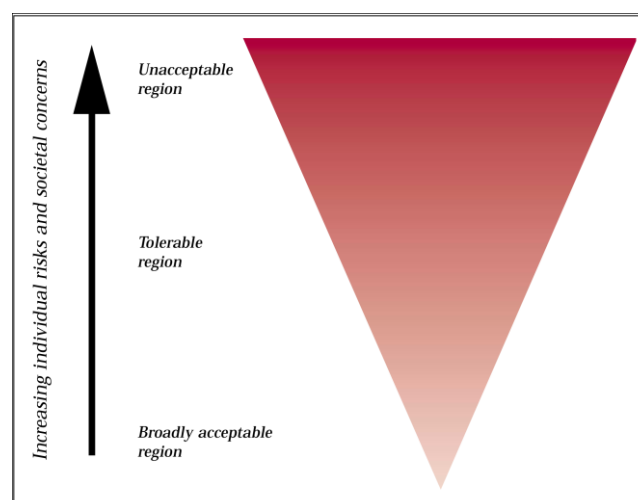


Figure A3.1: HSE framework for the tolerability of risk (source: HSE-UK, 2001)

Moving up the triangle from the region considered broadly acceptable, through a tolerable region (for which a greater range of risk can be considered), to an unacceptable region, represents increasing levels of 'risk' for a particular hazard or hazardous activity (determined through relevant risk analysis). Table A3.1 describes the risks that define each region.

Table A3.1: The risks associated with the risk tolerance regions (adapted from HSE-UK, 2001)

THE ALARP PRINCIPLE – DEFINING THE REGIONS OF RISK TOLERANCE	
Unacceptable Region	<p>For practical purposes, a particular risk falling into this region is regarded as unacceptable whatever the level of benefits associated with the activity.</p> <p>Any activity, practice or use of land giving rise to risks falling in this region would, as a matter of principle, be not approved unless the activity or practice can be modified to reduce the degree of risk so that it falls in one of the regions below, or there are exceptional reasons for the activity, practice or use to be retained.</p>
Tolerable Region	<p>Risks in this region are typical of the risks from activities that people are prepared to tolerate in order to secure benefits, in the expectation that:</p> <ul style="list-style-type: none"> • The nature and level of the risks are properly assessed, and the results used properly to determine control measures. The assessment of the risks needs to be based on the best available scientific evidence and, where evidence is lacking, on the best available scientific advice; • The residual risks are not unduly high and kept as low as reasonably practicable. This is the region to which the ALARP principle applies; and • The risks are periodically reviewed to ensure that they still meet the ALARP criteria, for example, by ascertaining whether further or new control measures need to be introduced to take into account changes over time, such as new knowledge about the risk or the availability of new techniques for reducing or eliminating risks. • In practice and where possible, the intent should be that residual risk continues to be driven down the tolerable range so that it falls either in the broadly acceptable region or is near the bottom of the tolerable region, in keeping with the duty to ensure health, safety and welfare so far as is reasonably practicable as per the ALARP principal.
Broadly Acceptable Region	<p>Risks falling into this region are generally regarded as insignificant and adequately controlled. Regulators would not usually require further action to reduce risks unless reasonably practicable measures are available.</p> <p>The levels of risk characterising this region are comparable to those that people regard as insignificant or trivial in their daily lives. They are typical of the risk from activities that are inherently not very hazardous or from hazardous activities that can be, and are, readily controlled to produce very low risks.</p>
<p>Note: The risk tolerability framework is a conceptual model. The factors and processes that ultimately decide whether a risk is unacceptable, tolerable or broadly acceptable are dynamic in nature and are sometimes governed by the particular circumstances, time and environment in which the activity, practice or use occurs or is proposed. Standards change and public expectations vary between societies and change with time.</p>	

RISK TOLERANCE SCALE

The application of a risk tolerance scale is necessary to:

1. Identify which exposed elements must be given priority for the development and application of bushfire protection measures; and
2. Where planning approval is being sought, identify if the determined residual risk levels can be considered as tolerable or acceptable and therefore capable of being approved for this factor, or not.

The risk tolerance scale to be applied within the risk assessment report, when the required risk factor criteria and risk level matrix are available, is established in Table A3.2.

Table A3.2: The applied risk tolerance scale

APPLIED RISK TOLERANCE SCALE - INCORPORATING THE ALARP PRINCIPLE			
Determined Residual Risk Level	Tolerability Description and Action Required		Risk Tolerance Level ¹
Extreme	The risks are unacceptable and require immediate implementation of risk management measures to eliminate or reduce risk to tolerable or acceptable levels. Proposed development giving rise to risks in this region would not be approved unless there are exceptional reasons for the development to proceed.		Unacceptable
High	The risks are the most severe that can be tolerated but not unduly high. They require monitoring in the short term as risk management measures are likely to be needed in the short term given the intent should be to drive residual risk lower down the tolerable range where possible.	Tolerance Regions Subject to ALARP Principle	Tolerable - if ALARP -
Medium	The risk is approaching an acceptable level. It can be tolerated and requires monitoring in the short to medium term. Need to consider potential changes over time in the risk and/or techniques for reducing/eliminating risk. Risk management measures may be needed to reduce risk to more acceptable levels where possible – or accept the risk.		Tolerable / Acceptable - if ALARP -
Low	The risk is accepted as it is generally regarded as insignificant or adequately controlled by existing measures. No additional risk management measures will be required in the short to medium term other than monitoring.		Acceptable
Very Low			

¹ Refer to the glossary for definitions of the tolerance levels.

APPLICATION JUSTIFICATION

The following is taken from the 'National Land Use Planning Guidelines for Disaster Resilient Communities' (Planning Institute of Australia, 2015) and is also referred to in the document 'Land use Planning for Disaster Resilient Communities' (Australian Institute for Disaster Resilience, 2020).

Of relevance to planners in the NERAG is the ALARP principle and how it is used in evaluating risks. According to NERAG, the ALARP principle is applied to define boundaries between risks that are generally intolerable, tolerable or broadly acceptable. The ALARP principle will help to prioritise a risk hierarchy and determine which risks require action and which do not. Those that are broadly acceptable naturally require little, if any, action while risks that are at an intolerable level require attention to bring them to a tolerable level.

According to NERAG, it is entirely appropriate and accepted practice that risks may be tolerated, provided that the risks are known and managed.

The ALARP principle is particularly relevant to planners and other built environment professionals as it provides the means to categorise risks according to their severity, and to assign risk treatment options accordingly.

It is important to note that the effect each hazard has on a community and its settlement is different, and therefore land use planning and building responses may not always be appropriate to treat the risk borne by a particular hazard. Equally, the effectiveness or strength of response provided by land use planning or building may not be sufficient to fully address the risk.

In addition, it is likely that through a normal natural hazard management process a range of treatment measures will be proposed, tested and implemented to provide a comprehensive approach to risk treatment that may involve other measures working in concert with land use planning or building responses.

The manner in which land use planning and building responses are deployed to treat specific instances of natural hazard risk will vary depending on location, information availability, community views, broader development intent for the settlement under analysis and the effect of complementary risk treatment measures.

However, the ALARP principle provides a good reference for demonstrating the land use responses for the various ALARP risk categories. Generally speaking, in areas of intolerable risk the strongest land use planning and building responses should apply. Conversely, in areas of acceptable risk only minimal controls should apply, if at all.

The most complex risk category for which to prescribe treatment from a land use and building perspective is those areas of tolerable risk. Such risks in existing settlements may not be sufficiently concerning to warrant severe use restrictions or relocation, however they will need treatment over time to ensure the risk does not increase. Treatment options in this instance may include limiting vulnerable uses in this area, restricting significant intensification of development, and promoting resilient urban design. Such areas of tolerable risk are also best avoided from a greenfield perspective to limit increases in future risk and costs associated with infrastructure failure in these locations that could otherwise been avoided.

APPENDIX 4: THE BUSHFIRE HAZARD – BEHAVIOUR AND ATTACK MECHANISMS

FACTORS INFLUENCING BUSHFIRE BEHAVIOUR

There are three primary factors that influence the intensity, speed and spread of a bushfire. Any increase in these behaviours will result in greater threat levels, to exposed elements, from the bushfire attack mechanisms.

1. **VEGETATION AND OTHER FUELS:** Key characteristics that will influence fire behaviour include:

- **Fuel size and shape** – anything less than 6mm diameter/thickness is considered a fine fuel and will ignite and burn quickly. Larger/heavier fuels take longer to ignite but burn for longer, so the threat exists for longer;
- **Fuel load** – the quantity of available fuel (t/ha) will influence the size of the fire. In particular it is the fine fuel load that determines the intensity of the bushfire and the flame sizes. Vegetation type and period over which it can accumulate will determine fuel loads;
- **Vegetation type** – this influences the size, shape and quantity of available fuels. For bushfire purposes vegetation types include the classifications of forest, woodland, scrub, shrubland and grassland (with total fuel loads typically decreasing in that order);
- **Fuel arrangement** – will influence two factors of fire behaviour (1) the speed and intensity of burning and (2) how much of the total fuels are likely to be involved in the fire simultaneously. The first factor is a function of how densely packed or aerated the fuels are with the more available arrangement burning with greater intensity. The second factor is a function of the availability of 'ladder' fuels (i.e. near surface, elevated and bark fuels) to carry fire up the vegetation profile, and the continuity of fuels to carry the fire across the land; and
- **Fuel moisture content** – drier fuels will ignite easily and burn quickly. The inherent moisture content of the vegetative fuels is a function of the vegetation type and arrangement and/or the positioning of the vegetation complex near readily available sources of moisture.

Greater quantities of finer, dryer, aerated and connected fuels will result in more severe behaviours and elevated bushfire threat levels. Large extents of vegetation (broader landscape scale) can have additional implications for the development of extreme bushfire events and the consequent increase in bushfire threat levels (refer to Appendix 5 for additional information).

2. **WEATHER:** Adverse fire weather that results in more severe behaviours and elevated threat levels includes strong winds, high temperatures, low relative humidity and extended periods of these factors.

Weather events at the broader landscape scale can have implications for the development of extreme bushfire events and consequent increase in bushfire threat levels (refer to Appendix 5 for additional information).

3. **TOPOGRAPHY:** The physical terrain can influence the severity of fire behaviour. At a local scale, it is the influence of ground slope on the rate a fire spreads, that is most relevant. Fire travels faster up slopes (rule of thumb is a doubling of speed for every 10 degrees increase in slope). Greater rates of spread increase fire intensity and the resultant threat levels.

At the broader landscape scale, the impact of topography can be significant and includes establishing the potential for development of certain dynamic fire behaviours that can lead to extreme bushfire events and elevated threat levels (refer to Appendix 5 for additional information).

BUSHFIRE DIRECT ATTACK MECHANISMS

EMBER ATTACK: Ember attack is the most common way for structures to ignite in a bushfire. Scientific research indicates that at least 80% of building losses from past Australian bushfires can be attributed to ember/firebrand attack (mostly in isolation but also in combination with radiant heat), and the resultant consequential fires. (Leonard J.E. et.al; 2004 – Bianchi R. et.al. 2005 - Bianchi R. et.al. 2006).

Embers are the primary ignition source for consequential fire:

- They accumulate around and on vulnerable parts of structures (roofs, gutters, doors, windows, re-entrant corners)
- They enter gaps in structures envelopes to vulnerable internal cavities and spaces.
- They ignite surface materials such as walls and decks and any accumulated vegetative debris.

Embers can attack structures for a significant length of time before and after the passage of the fire front, as well as during. This potential length of exposure is an important factor in the consideration of the level of threat embers present.

An ember is a small particle of burning material that is transported in the winds that accompany a bushfire (larger particles can exist as firebrands from certain vegetation types). Typically these consist of plant materials such as bark, leaves and twigs that exist as part of the standing vegetation or has collected or been placed on the ground.

Of the plant materials, bark is the predominant source of embers but built timber elements will also produce embers.

Bark is the primary source of embers and spotting in Australian eucalypt forests due to the key attributes of ease of ignition, extended burnout time and the favourable size to weight ratio and aerodynamic properties. Differences in these attributes strongly influence the spotting potential from different forest types – and therefore the potential hazard rating of the bark.

The type of tree bark will determine the size, shape and number of embers/firebrands which, along with the prevailing fire behaviour and weather conditions will dictate the spotting distances and density of ignitions.

Fine fibrous barks - including stringybarks (e.g. jarrah), have loosely attached fibrous flakes and can produce massive quantities of embers (prolific spotting) for shorter (up to 0.75 km) and medium distances (up to 5 km).

Short distance spotting (including ember showers) are generally the result of embers and firebrands blown directly ahead of the fire with little or no lofting. Density tends to decrease with distance from the fire front.

Medium distance spotting results from embers and firebrands that are lofted briefly in a convection column or blown from an elevated position (e.g., from tree tops on ridges). With sufficient density and coalescing spot fires, this can rapidly increase the size of a fire (deep flaming) leading to dynamic fire behaviours and extreme fire events.

Ribbon/candle type barks - have longer burnout time, extended flight paths and are more likely to be responsible for longer distance spotting > 5 km (with up to 30 km having been authenticated). This results from significant lofting of large firebrands (e.g. curled hollow tubes of bark that can burn for 40 minutes) in well-developed convection columns. These develop as separate, independent fires. Very long distance spotting requires Intense fire, maintenance of a strong convection column (to lift firebrands aloft) and strong winds aloft (to transport the firebrands).

Other bark types - that include coarsely fibrous (e.g. marri) / slab or smooth / platy and papery barks - produce lower quantities of embers and shorter distance spotting. Their highest bark hazard ratings that are lower than fine fibrous or ribbon barks.

(Sources: CSIRO Climate and Disaster Resilience Report 2020 and Overall Fuel Hazard Assessment Guide 4th edition July 2010, Victoria DSE and Cruz, MG (2021) The Vesta Mk 2 rate of fire spread model: a user's guide. CSIRO).

The importance of establishing protection measures to mitigate the potential impact of consequential fire ignited by the ember attack mechanism, cannot be overstated.

RADIANT HEAT ATTACK: This heat radiates in all directions from a bushfire and can potentially be felt hundreds of meters away. The amount of heat that a flame can transfer to other objects is influenced by the flame size and its temperature. These are a function of the characteristics of the fuels being burnt including fuel size, dryness, structure, arrangement and quantity. The bushfire is additionally influenced by the weather and topography factors that can intensify fire behaviour (described at end of this section).

Radiant heat:

- Can damage or destroy elements that are vulnerable to higher levels of heat;
- Can dry and heat vegetation and other fuels (combustible materials such as timber) to a temperature at which they ignite or are more easily ignited by existing flames or embers; and
- Is an extremely significant threat to people when they are not physically shielded. Protective clothing can provide only limited protection.

BUSHFIRE FLAME ATTACK: When flames make contact with structures they can flow over, under and around – impacting surfaces not directly facing the bushfire.

Flames will be longer when fine fuel loads are higher and will move faster up slopes and generally, slower down slopes.

Flame temperatures are highest in the lower parts of the flame and decrease towards the tip. The flame has two distinct regions - the lower solid body flame and the upper part that is a transitory flame (intermittently present). Both flame regions can damage structures.

Note: AS 3959:2018 *Construction of buildings in bushfire prone areas*, establishes both the construction requirements corresponding to each Bushfire Attack Level (BAL) and the methodology for determining a BAL. For a bushfire modelled using this methodology, the derived flame length only provides an estimate of the solid body flame length.

SURFACE FIRE ATTACK: These are low intensity fires (less than 0.5m high) burning along the ground consuming mostly intermittent fine fuels such as vegetation debris, litter, and mulches. They are typically patchy and erratic in their direction and short lived (<40 seconds) when burning in the absence of heavier fuels.

Typically these fires will be on the land immediately surrounding buildings and associated structures and other heavy fuels. Their importance as a threat is the bringing of direct flame contact, higher radiant heat and embers closer to these exposed elements.

BUSHFIRE INDIRECT ATTACK MECHANISMS

DEBRIS ACCUMULATION: The relevant debris are combustible fine fuels that can accumulate (by falling or being windblown) in close proximity to subject structures and their surrounding structures and other heavy fuels. This makes the burning of these structures/fuels much easier and more likely through the ignition of the accumulated debris by ember attack.

This debris can accumulate over long time periods (years) in locations such as:

- On horizontal or close to horizontal surfaces and rough timber surfaces;
- Within re-entrant corners and roof gutters/valleys;
- Against vertical surfaces; and
- Within internal spaces /cavities and under sub-floors when gaps are present.

The potential threat level will be determined by:

- The presence of vegetation types that produce quantities of debris with those that produce in the driest and hottest part of the year presenting a greater threat;
- The extent of this vegetation; and
- The proximity of this vegetation to the exposed and vulnerable structures.

CONSEQUENTIAL FIRE:

Consequential fire is the burning of vulnerable (combustible/flammable) materials, items and structures that exist within the area surrounding the subject building or structure – the surrounding vulnerable elements.

The burning of these surrounding vulnerable elements can result in the subject building/ structure being exposed to the direct fire attack mechanisms (threats) of flame, radiant heat, embers and surface fire from a close distance.

These are threats that are separate from and additional to the threats generated by the bushfire front itself - which can be and often is, a considerable distance away.

The importance of establishing protection measures to mitigate the potential impact of consequential fire cannot be overstated.

Consequential fire fuels consist of both fine and heavy fuels.

Fine fuels:

- Dead plant material such as leaves grass, bark and twigs thinner than 6mm (or live material less than 3mm thick that can be consumed in a fire involving dead material); and
- Originate from the indirect bushfire attack mechanism of 'debris accumulation' and potentially from other areas of landscaped vegetation.

Heavy and Large Heavy Fuels:

- **Stored combustible / flammable items:**
 - Building materials, packaging materials, firewood, sporting/playground equipment, outdoor furniture, matting, rubbish bins etc;
 - Large quantities of dead vegetation materials stored as part of site use;

- Liquids and gases; and
- Vehicles, caravans and boats, etc.
- **Constructed combustible items:**
 - Surrounding landscaping items - fences/screens, retaining walls, gazebos, plastic water tanks etc;
 - Attached structures - decks, verandahs, stairs, carports, garages, pergolas, patios, etc;
 - Adjacent structures - houses, sheds, garages, carports, etc. Structure to structure fire is a common cause of overall building loss in post bushfire event assessments [9].

FIRE DRIVEN WIND: Severe bushfires are commonly accompanied by high winds due to the prevailing weather conditions. Localised high winds can be induced by the bushfire. When the required factors exist, the bushfire can couple with the atmosphere (pyro-convective) resulting in extreme bushfire events and gusty, severe windspeeds.

These winds can directly damage the external envelope of a building or structure by pressure (low and high) or the carriage of varying types of solid debris. This provides openings for other bushfire attack mechanisms to enter and ignite internal cavities.

TREE STRIKE/OBSTRUCTION: Branches or trees, subject to strong winds and/or tree burnout, can:

- Damage the envelope of a structure creating openings for direct attack mechanisms of bushfire (or consequential fire) to ignite internal cavities or living space:
- Fall and obstruct access to or egress from, a structure or site being impacted by bushfire.

APPENDIX 5: THE BROADER LANDSCAPE AND EXTREME BUSHFIRE EVENTS

The content of this appendix is an overview of information that supports the assessment approach of section 4.4 of this report. It considers the risk implications arising from what is being learnt from the latest research work within the bushfire science of dynamic fire propagation and extreme fire development.

Any potential for extreme fire events to develop in the broader landscape surrounding the subject site, will result in increased in bushfire hazard threat levels to exposed elements and must be accounted for in the risk assessment.

The selected compilation of information is taken from various sources including peer reviewed research papers [references 1-3, 12, 15, 21, 27, 28, 41, 42].

RECENT BUSHFIRE RESEARCH

Traditionally, bushfire modelling conducted to determine rates of spread, intensity, flame lengths, radiant heat etc and provide measurements of threat levels, has been based on the quasi-steady fire state (i.e. a fire propagating under constant and uniform fuel, weather and topography – after it has finished its growth phase).

More recent research has provided important insights into the dynamic nature of fire spread in the landscape and identified local drivers of bushfire risk and highlighted the role of environmental factors that are significant for large and extreme fire development.

These environmental factors include aspects of the vertical structure of the atmosphere, meso-scale fire weather processes (e.g., sea breezes, cold fronts, squall lines, convective complexes), interactions between the fire and the atmosphere, and the modification of fire weather and fire behaviour due to the local topography.

From this work, a number of processes that can contribute significantly to the level of risk posed by a bushfire have been identified. These include:

- Extreme fire weather processes;
- Dynamic fire propagation; and
- Violent pyroconvection and pyrogenic winds.

Of particular relevance to this risk assessment are the topographic aspects of the broader landscape surrounding the subject site and the potential it might present for dynamic fire propagation, development of extreme fire events and therefore increased bushfire hazard threat levels and consequent risk.

DYNAMIC FIRE BEHAVIOURS

Dynamic fire behaviours (DFBs) result from interactions between the physical factors of fuel, terrain, fire weather conditions, atmosphere and different parts of the bushfire itself. They are physical phenomenon that involve rapid changes of fire behaviour and occur under specific conditions.

Certain DFBs occur at various scales and time frames (e.g. spotting), others only at large scales (e.g., conflagrations and pyroconvective events) and others at small scales and short time spans (e.g. junction fires, fire whirls). The following fire behaviours are considered DFBs:

Spotting

The production of embers/firebrands, carried by the wind/convective currents that ignite spot fires ahead of the bushfire front. Under extreme conditions, with the necessary fuels, mass spotting events can occur. Dependent on fuel types, winds and convective currents, embers can be consumed by the fire front itself or travel tens of kilometres. Spot fire occurrence can be so prevalent that spotting becomes the dominant propagation mechanism – with the fire spreading as a cascade of spot fires forming a 'pseudo' front.

Fire Whirl / Tornado

Various sized (<1m - >150m) spinning vortices of ascending hot air and gases that carry smoke, debris, and flame. The intensity of larger whirls compares to tornados. Can induce fire spread contrary to prevailing wind and ignite spot fires away from the fire front.

Junction Fire

Is associated with merging fire fronts that produces very high rates of spread and have the potential to generate fire whirls / tornadoes.

Crown Fire

Types of tree crown fires have been categorised according to their degree of dependence on the surface fire phase - passive, active, independent - with the last two being considered dynamic fire behaviour.

Active crown fire is "a fire in which a solid flame develops in the crowns of trees, but the surface and crown phases advance as a linked unit dependent on each other."

Independent crown fires "advance in the tree crowns alone, not requiring any energy from the surface fire to sustain combustion or movement."

For a crown fire to start, a surface fire of sufficient intensity is first necessary. The distance between the heat source at the ground surface and the canopy-fuel layer will determine how much of the surface fire's energy is dissipated before reaching the fuels at the base of the canopy. The higher the canopy base, the lower the chance of crowning.

The existence of trees themselves, separated from surface fuels, can offer a degree of protection by absorbing radiant heat, trapping embers and shielding from winds. Necessary considerations include:

- Eliminating understorey fuels;
- Species Issue: Understanding the extent to which the trees will contribute to fuels (leaves/bark/twigs etc) that accumulate on the ground and when moved (wind) become involved in consequential fire away from the tree during the fire season. This needs to be considered against the maintenance capability (regular removal of material) of the responsible entity; and
- Species / Positioning Issue: Requirements include not being highly flammable, no loose stringy bark, less able to trap embers, not being prone to branches breaking in high winds potentially causing structural damage to buildings (allowing ember entry) and keeping crowns separated as an additional measure of safety and allow wind to permeate rather than be totally blocked.

Eruptive Fire

Behaviour where the head fire accelerates rapidly on sufficiently steep terrain with sufficiently strong wind – as a result of fire plume attachment to the surface, bathing it in flames ahead of the front (pre-heating).

Fire Channelling / VLS (vorticity-driven lateral spread)

Behaviour where rapid lateral fire spread, in generated vortices, occurs across a sufficiently steep leeward slope in a direction approximately transverse to the prevailing winds. This results in the rapid increase in width of the fire front. VLS are highly effective at producing mass spotting events.

Conflagrations

These are large, intense, destructive fires. They have a moving front as distinguished from a fire storm (blow up / pyroconvective fire). With sufficient vegetation extent, fuel loads and the development of dynamic fire behaviours, the large amounts of heat and moisture released can cause its plume to rise into the atmosphere and develop large cumulus or cumulonimbus flammagenitus cloud (pyrocumulus or pyrocumulonimbus). Where the extent of vertical development is limited (e.g. a stable atmosphere, or insufficient flaming zone), the fire is likely to remain a surface based event.

Downbursts

These are strong wind downdrafts associated with convective columns of heated air (and associated cloud forms). The consequent falling columns of cooled air induce an outburst of strong winds on or near the ground that radially spread causing fire spread in directions contrary to the prevailing wind.

Pyroconvective Event

A pyro-convective event is an extreme manifestation of a conflagration that develops in an unstable atmosphere and can transition into a towering pyrocumulus or a pyrocumulonimbus (pyroCb's) that can extend to the upper troposphere or lower stratosphere. With the fire/atmosphere coupling, it has evolved beyond a purely surface based fire into dynamic fire propagation rather than quasi-steady propagation. In the violent pyroconvective system:

- As a fire's plume reaches higher into the atmosphere, larger scale mixing can cause drier and higher-momentum upper air to be transferred back to the surface, thereby further exacerbating the potential for more intense fire behaviour, including fire spread contrary to the prevailing wind direction;
- Pyrogenic winds can cause considerable damage to structures, directly or indirectly, increasing their vulnerability to bushfire attack mechanisms; and

- The pyroCb's carry dense ember loads, fire and other burning debris and generate lightning, all with very little rain or hail that would typically occur with an ordinary thunderstorm.

DRIVERS OF DEEP FLAMING

Deep flaming is the fire condition when the active flaming zone is unusually large and flame-front intensity is simultaneously great, resulting in large quasi-instantaneous energy release.

Deep flaming can be produced by numbers of mechanisms on varying terrain (flat, undulating or rugged) when a large enough area of sufficiently heavy fuels is present. These mechanisms include:

- Very strong winds – so the head fire advances more rapidly than the back of the flaming zone;
- Change in wind direction – so the long flank of a fire is transformed into a fast running head fire;
- Eruptive fire behaviour – where steep slopes can cause a fire to accelerate rapidly;
- Vorticity-driven lateral spread (wind channelling) – where strong winds and steep terrain interact to rapidly drive a fire laterally, accompanied by downwind mass spotting and consequent coalescing of spot fires forming large areas of flame (can include the DFB of 'junction fire').

Research has identified strong links between:

- Eruptive fire behaviour, VLS and the occurrence of deep flaming; and
- The development of deep flaming and extreme bushfire events.

EXTREME BUSHFIRE EVENTS

Extreme bushfire events create disproportionate risks to human and environmental. Their development is affected by dynamic feedback processes that result in unpredictable behaviour, and the worsening of rates of spread and intensities - even when environmental conditions are consistent.

The term 'extreme bushfire' is applied in the recent bushfire science literature in two ways:

1. Where it refers to large, intense bushfires in which one or more DFBs are simultaneously involved; and
2. Where it more specifically refers to a fire that exhibits deep or widespread flaming in an atmospheric environment conducive to the development of violent pyroconvection, often manifesting as towering pyrocumulus (pyroCu) or pyrocumulonimbus (pyroCb) storm(s) – also referred to as blow-up fire event(s).

A distinguishing feature of these types of fires is that they involve a coupling of the fire with an unstable atmosphere to a much greater vertical extent, well above the mixed layer, which modifies or maintains the fire's propagation (e.g. through mass spotting, blustering winds and lightning);

Relevance to Risk Assessment: Given that this risk assessment is concerned with identifying the potential for the broader landscape surrounding the subject site to increase bushfire risk, the following common aspects of the two above descriptions are relevant:

- An extreme fire is a large intense fire, so it requires a sufficient area and sufficient fuels in which to develop; and
- An extreme fire of scale requires the formation of deep flaming to develop.

Consequently, the risk assessment is primarily focused on the extent and fuel types/loads of bushfire prone vegetation and the existence of terrain (topography) properties necessary for the relevant dynamic fire behaviours - rather than the potential for adverse fire weather / atmospheric conditions - whose likely occurrence can be assumed as possible.

Note also that the second description requires an unstable atmosphere - to enable deep/violent pyroconvection and subsequent significant cloud formation and latent heat release. This is not essential for the first. Consequently, this identifies a potential difference between the two defined extreme bushfire events to be considered when assessing risk:

- Large, intense bushfires can occur without deep convective column development. These fires remain as surface fires (essentially wind-driven fires), with a greater predictability of behaviour; and
- Large, intense bushfire that couple with an unstable atmosphere are no longer surface based. They are associated with a higher level of energy, chaos, and nonlinearity due to the enhanced (fire-induced)

interaction between the boundary layer and the free troposphere, which may introduce factors that act to maintain or enhance widespread flaming. The fire behaviour is much more unpredictable.

PHYSICAL REQUIREMENTS OF TERRAIN, FUEL LOAD (AND WINDSPEED) FOR DEEP FLAMING

The dynamic fire behaviours of eruptive fire and VLS and associated mass spotting, along with potential for topographically modified winds to develop, are strongly linked with the development of deep flaming, which is a prerequisite for extreme bushfire events.

There are certain environmental thresholds that are required to be met for these dynamic fire behaviours to occur. These are described below and form part of the assessment of the bushfire hazard in Section 4.5.

Eruptive Fire Behaviour

Eruptive fires are characterised by a rapid acceleration of the head fire rate of spread (exponential increases in rate of spread have been observed). It results in a rapid deepening of the flaming zone (larger area of active flame), from which heat is released into the atmosphere.

Eruptive fire results from the interaction between the slope of the terrain and the fire's plume. In the absence of wind, plume attachment can be expected on terrain that is inclined at roughly 24° or more and the effects of wind could cause plume attachment on slopes inclined at angles of 24° or lower. Consequently, the primary topographic requirement for eruptive fire is sufficiently steep terrain and sufficiently strong wind.

"This mode of fire propagation is completely contrary to that expected under the quasi- steady fire spread paradigm ... eruptive fire behaviour poses a serious threat to the successful containment of a bushfire and provides a mechanism that can substantially elevate the risk posed by a bushfire in areas that are prone to its occurrence".

Rugged terrain (areas with local topographic relief >300m), is particularly prone to eruptive fire (and dynamic fire behaviours in general).

Fire Channelling (Vorticity-Driven Lateral Spread)

Fire channelling (VLS) exists when a fire exhibits rapid spread in a direction transverse to the synoptic winds as well as in the usual downwind direction. It is characterised by intense lateral and downwind spotting and production of extensive flaming zones.

VLS is highly effective at producing mass spotting events. A link between deep flaming events caused by VLS and the formation of pyroCb has been demonstrated. Under extreme conditions, spot fire occurrence can be so prevalent that spotting becomes the dominant propagation mechanism.

VLS can only be expected to occur on parts of the landscape, and under certain fire weather conditions. VLS occurrence depends critically on the following:

- Leeward slopes greater than 20-25° are required;
- Wind direction must be within 30-40° of the topographic aspect;
- Wind speed in excess of about 20 km h⁻¹ are required;
- Generally VLS is only observed in heavy forest fuel types with load in excess of 15-20 t ha; and
- Fuel moisture content – dense spotting and downwind extension of the flaming zone are far more likely when fuel moisture contents are around 5% or less.

Topographically Modified Surface Winds - Downslope Winds

In WA the scarp winds are the well-known local occurrence of downslope winds. Similar meteorological phenomena (typically as foehn winds) occur in the lee of mountain ranges in many parts of the world, particularly on ranges with gentle windward and steep leeward slopes.

Scarp winds are nocturnal, strong and gusty winds that develop near the base of the scarp through summer months. The local mechanism is for a synoptic easterly flow, causing air to rise to the top of the scarp from further inland, at which point it is cooler and denser than the surrounding airmass. This produces an unstable situation and consequently the air flows down the scarp as a turbulent density current.

There are implications for enhanced fire activity for a fire located in a region of downslope winds, as they provide a clear mechanism for rapid, irregular direction of fire spread as well as turbulent transport of firebrands and plume development. If a 'hydraulic jump' is also present, the strong vertical motion in the jump region is a mechanism for lofting and dispersal of firebrands further ahead of the bushfire front.

APPENDIX 6: HAZARD REDUCTION BURNING – ADDITIONAL INFORMATION

The following information provides supporting guidance to the relevant bushfire protection measures that reduce bushfire hazard threat levels by reducing fuel levels.

1. SIGNIFICANT AREAS (LARGER) AREAS OF BUSHFIRE PRONE VEGETATION

Annually

Prior to the bushfire season ensure the following management of the identified areas of vegetation is conducted:

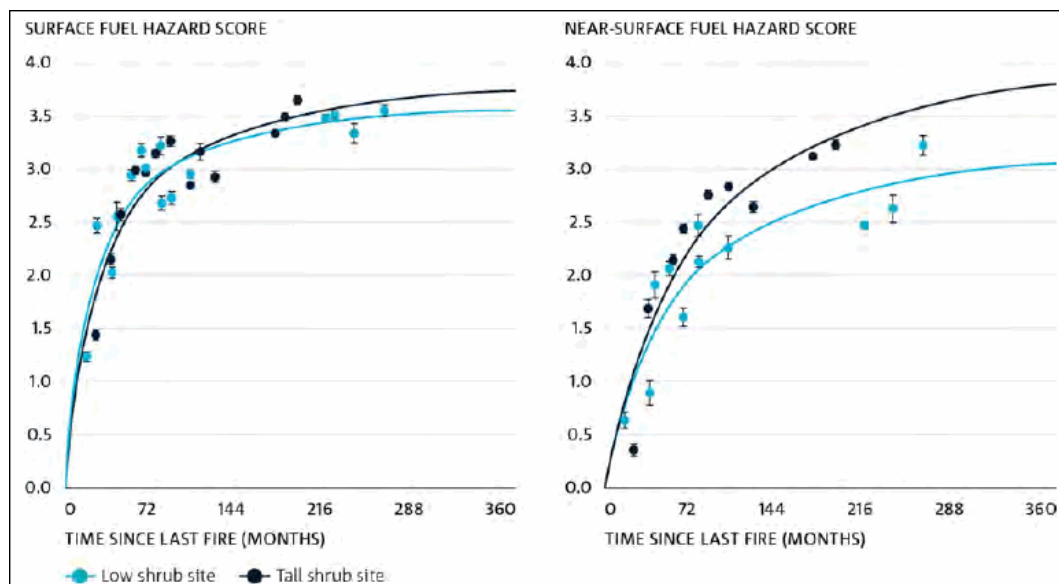
- Maintain the pruning of all trees and tall shrubs to a height of at least 2m from the ground and remove the material; and
- Remove any dead trees (that are not habitat trees), fallen branches and dead shrubs.

Burn Interval

Conduct hazard reduction burns at intervals that will ensure surface and near surface fuel loads (i.e. fine fuels – accumulated leaf litter, combustible plant materials and twigs up to 6mm diameter) remain less than 8 t/ha at all times.

It is likely the burning interval will need to be shorter than that which is typically currently conducted. The following statement and data from the Climate and Disaster Technical Report, CSIRO, 2020 [17] indicates the requirement for increased frequency of hazard reduction due to the rapid increase in surface and near surface fuel loads after hazard reduction burning.

“The only study published on the dynamics and structure of fine fuel in dry eucalypt forest following prescribed fire is that of Gould et al. (2011) utilising data to drive an exponential fuel accumulation relation for the key fuel attributes of surface fuel hazard and near-surface fuel hazard. In this study of time since fire in jarrah forest (Eucalyptus marginata), it was found that, over the 20-year period of the study (1979-1999) while surface fuel loads continued to increase indefinitely (up to and beyond 20 years), attributes such as percent cover and hazard score essentially plateaued after 6-9 years. Similarly, near-surface fuel loads were found to stop increasing significantly after 15-18 years whereas near-surface height and hazard score stopped increasing significantly after 9-12 years and 12-15 years, respectively (Figure 14). Bark hazard was found to be affected by hazard reduction burning for up to 12 years after hazard reduction burning”



*“Figure 14 Recovery of surface (left) and near-surface fuel hazard (right) in Jarrah Forest following hazard reduction burning. Under these conditions these fuel attributes returned to equivalent long unburnt state after approximately 12-15 years but the response in the first few years following burning is extremely rapid, **achieving 75% of fuel hazard within 4 years (surface) and 5-7 years (near-surface) depending on presence of shrub layer** (Redrawn from Gould et al. 2011)”*

2. THE BROADER LANDSCAPE

The following information has merit for consideration and is taken from the peer reviewed paper 'A framework for prioritising prescribed burning on public land in Western Australia'; Howard T. et al, DBCA and DFES; International Journal of Wildland Fire 2020, 29, 314-325.

To develop and apply this protection measure it is likely interested entities, such as local government will need to engage and work with the relevant state government agency responsible for the identified areas of vegetation.

The collaboration will be necessary to establish the required indicators of acceptable risk - as they are determined through the application of the following published framework - and to establish a responsibility to conduct the ongoing management of these areas of vegetation to maintain compliance with the established indicators.

KEY RELEVANT POINTS FROM THE FRAMEWORK (QUOTED)

Introduction to the framework:

- The framework provides principles and a rationale for programming fuel management with indicators to demonstrate that bushfire risk has been reduced to an acceptable level.
- Each bushfire risk management zone is divided into fire management areas, based on the management intent. These are areas where fuels will be managed primarily to minimise the likelihood of fire causing adverse impacts on human settlements or critical infrastructure, to reduce the risk of bushfire at the landscape scale or to achieve other land management outcomes. Indicators of acceptable bushfire risk are defined for each fire management area and are modified according to the distribution of assets and potential fire behaviour in the landscape.
- The framework establishes principles and a rationale for programming fuel management and, critically, provides indicators that demonstrate that bushfire risk has been reduced to an acceptable level. The acceptable level of bushfire risk is determined through a risk assessment and prioritisation process.

Principles for managing bushfire risk applied in the framework:

- **Consistent with international standard:** The regional risk framework commits to applying risk management in a manner that is consistent with AS ISO 31000: 2018 Risk management guidelines (Standards Australia 2018). This involves adherence to the principles of risk management, and applying the risk management process to the identification, assessment and treatment of risk.
- **Fuels are managed to reduce the harm:** Managing the fuel available to burn is critical to managing the threat posed by bushfire. The available fuel, and its structure, affect the speed and intensity of a bushfire, which, in turn, determine both its potential to cause damage and suppression difficulty. Done at appropriate temporal and spatial scales, managing the quantity, structure and distribution of fuel available has been demonstrated to be an effective and efficient way to reduce the severity and extent of damage by bushfires.
- **Fuel management does not eliminate risk:** Fuel management aims to reduce the negative consequences of bushfires rather than prevent their occurrence. Given the importance of fire to maintaining ecosystem health and resilience, it is neither desirable nor feasible to eliminate bushfire from natural landscapes and it is recognised that both planned and unplanned fire can have benefits. Fuel management aims to reduce risk to an acceptable level by greatly enhancing and supporting the effectiveness of other measures, including bushfire law, fire suppression, urban planning, building codes for fire-prone areas and community preparedness.
- Fuel management is planned and integrated. Bushfire management puts people first, risk is managed at an appropriate scale and ecological requirements are considered when managing fuel.

Framework for managing bushfire risk by prescribed burning:

- The framework identifies bushfire risk management zones (BRMZ), recognises different fuel types (and associated fuel accumulation and fire behaviour models), classifies public lands within each zone into fire management areas (FMA) - with the Settlement-Hazard Separation classification being the relevant fire management area for the Mundaring town centre - and develops indicators of acceptable risk.
- **Bushfire Risk Management Zones:** The framework identifies eight bushfire risk management zones (BRMZ) characterised by broad consistency of land use, asset distribution, fire environment (vegetation, fuels and climate) and fire management practices that combine to create a characteristic risk profile (Fig. 2). The Southwest zone includes the majority of the state's population, urban development and infrastructure.
- **Fuel Types:** The framework recognises 13 broad types across Western Australia. Fuel types are based primarily on structural attributes of the vegetation that influence fire behaviour. For each fuel type, best available information

has been assembled regarding post-fire patterns of fuel accumulation, fire ecology, including the requirements of fire sensitive species and communities, harmful fire regimes and fire regimes compatible with ecosystem health. Where possible, the framework assigns each fuel type appropriate fuel accumulation and fire behaviour models and identifies the key weather attributes required to model fire behaviour. These models are used when setting indicators of acceptable bushfire risk, which are defined for different fuels according to the rates of fuel accumulation and the fire behaviour they may support.

- **Fire Management Areas:** Public lands within each BRMZ are further classified into four fire management areas (FMAs) characterised as Settlement-Hazard Separation, Critical Infrastructure Buffer, Landscape Risk Reduction and Remote Area Management. These FMAs are defined by the primary intent of fuel management, which is a function of potential fire behaviour and the type and distribution of assets characteristic of the area. The framework recognises six classes of assets that may be affected by bushfire: settlements, dispersed populations, critical infrastructure, protected species and communities, economic assets and other assets (non-critical infrastructure, ecological, cultural).
- The Settlement-Hazard Separation FMA provides an area proximal to settlements where fuels are managed relatively intensively to minimise the likelihood of a bushfire being sustained, damaging properties or endangering people. Here, fuel management to protect settlements takes precedence over other land management objectives, though other land management outcomes can be pursued to the extent that they do not conflict with the primary management intent.
- The extent of the area described by each FMA varies according to the fuel type and the BRMZ in which it occurs ... The breadth of the Settlement-Hazard Separation FMA is calculated to be sufficient to significantly reduce the likelihood of damage to assets from direct flame contact, radiant heat and ember attack and to provide adequate opportunity for fire suppression. This calculation is based on a combination of data derived from fire behaviour models and expert practitioner judgement. The Settlement-Hazard Separation FMAs are the largest in forest fuels that are prone to long-range spotting, severe ember storms and crown fire behaviour.
- **Indicators of Acceptable Bushfire Risk:** Are set for bushfire-prone fuel types in each FMA ... Indicators are expressed in terms of the proportion of the landscape that is managed such that the treated fuels will not support a head fire of an intensity that precludes effective suppression action under weather conditions corresponding to the 95th percentile fire danger index ... Weather conditions (air temperature, relative humidity, wind speed) corresponding to the 95th percentile FFDI are identified and used as inputs to fire behaviour models for calculating forward rate of spread and fire intensity (Table 1).
- The intent of fuel management is to reduce the quantity and alter the arrangement of fuels such that a bushfire is likely to spread more slowly, burn with lower intensity, be easier to suppress and cause less damage.
- **The indicators of acceptable risk for the Settlement-Hazard Separation FMA for open eucalypt forest and tall/open eucalypt forest is a target of 60% of fuel less than threshold intensity for a distance of 5km surrounding settlements.**

As an open eucalypt forest example at the Perth rural urban interface, the fuel age and load to achieve threshold fire intensity under weather conditions representing 95th percentile values of the FFDI for the Bickley location are stated as 5 years and 8 t/ha.

APPENDIX 7: BUSHFIRE ATTACK LEVELS AND BAL CONTOUR MAPS EXPLAINED

Bushfire attack levels are determined using the methodology established by AS 3959:2018 Construction of buildings in bushfire prone areas. The Standard defines a bushfire attack level (BAL) as a "means of measuring the severity of a building's exposure to ember attack, radiant heat and direct flame contact, using increments of radiant heat expressed in kW/m²."

Each BAL rating represents a set range of radiant heat flux (see table below). The amount of radiant heat and flame lengths generated by a bushfire is dependent on many factors that are modelled using the Standard's fire behaviour and flame length models. Key factors include vegetation type, terrain and a range of fire weather factors.

The variation that can exist in these factors results in different separation distances, away from bushfire prone vegetation, corresponding to a given BAL rating.

In assessing risk, knowing the separation distances away from each identified area of classified vegetation that correspond to a BAL rating, assists with evaluating threat levels from that bushfire hazard and the exposure levels of elements at risk.

Bushfire Attack Level	Explanation [Source AS3959:2018]
BAL – LOW	There is insufficient risk to warrant specific construction requirements but there is still some risk. <i>Important Note: For AS3959:2018 purposes, BAL-LOW will exist at 100m from classified vegetation (50m for Grassland).</i> <i>However, embers/firebrands from certain vegetation types can ignite spot fires ahead of the fire front for significant distances – short range spotting up to 740m, medium range spotting up to 5km and long range spotting has been authenticated up to 30km.</i>
BAL – 12.5	There is a risk of ember attack. Construction elements are expected to be exposed to heat flux not greater than 12.5 kW/m ²
BAL – 19	There is a risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to radiant heat. The construction elements are expected to be exposed to a heat flux not greater than 19 kW/m ² .
BAL – 29	There is an increased risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to an increased level radiant heat. The construction elements are expected to be exposed to a heat flux not greater than 29 kW/m ² .
BAL – 40	There is a much increased risk of ember attack and burning debris ignited by windborne embers, a likelihood of exposure to a high level of radiant heat and some likelihood of direct exposure to flames from the fire front. The construction elements are expected to be exposed to a heat flux not greater than 40kW/m ² .
BAL – FZ (Flame Zone)	There is an extremely high risk of ember attack and burning debris ignited by windborne embers, and a likelihood of exposure to an extreme level of radiant heat and direct exposure to flames from the fire front. The construction elements are expected to be exposed to a heat flux greater than 40 kW/m ² .

THE BAL CONTOUR MAP - ILLUSTRATING THE CALCULATED SEPARATION DISTANCES CORRESPONDING TO BAL RATINGS

The BAL contour map illustrates different coloured contour intervals extending out from each different area of classified bushfire prone vegetation. The minimum and maximum distances of each contour, from each area of vegetation, is a diagrammatic representation of the calculated separation distances that correspond to each BAL rating. These take into account the specific site conditions.

Each coloured contour represents a different bushfire attack level and anything within that contour will be subject to that BAL rating and its corresponding level of radiant heat.

GLOSSARY

APPLIED TERMINOLOGY	
Consequence	<p>The outcome of an event or situation expressed qualitatively or quantitatively, being a loss, injury, disadvantage or gain. In the emergency risk management context, consequences are generally described as the effects on persons, society, the environment and the economy. <i>(Source: DPLH 2019)</i></p> <p>An impact on the natural, economic, built or social environments as a result of the hazard. The consequences are influenced by the vulnerability of elements at risk, by the exposure of elements at risk to the hazard, and by the characteristics of the hazard. <i>(Source: PIA, 2015).</i></p> <p>The outcome of an event that affects objectives. Can be a range of consequences; can be certain or uncertain; can have positive or negative effects; can be expressed qualitatively or quantitatively; can escalate through knock-on effects. <i>(Source: ISO Guide 73:2009)</i></p>
Controls	<p>A measure that maintains and/or modifies risk. Controls include, but are not limited to, any process, policy, device, practice, or other conditions and/or actions which maintain and/or modify risk. <i>(Source: AIDR Knowledge Hub; Glossary)</i></p> <p>A control is any measure or action that modifies or regulates risk. Controls include any policy, procedure, practice, process, technology, technique, method, or device that modifies or regulates risk. Risk treatments become controls, or modify existing controls, once they are implemented. <i>(Source: Praxiom)</i></p> <p><i>Note: 'Protection Measures' and 'Risk Treatments' will be alternative terms used in this risk assessment report.</i></p>
Decision Maker	<p>The Minister for Planning, State Administrative Tribunal, Western Australian Planning Commission, Development Assessment Panel, any other State decision-making authorities, and/or the relevant local government and their delegates that make decisions regarding the application of this Policy. <i>(Source: SPP 3.7)</i></p> <p>For proposed development or use that is not subject to planning approval, the relevant decision makers are those tasked with the development and management of a development or use. Typically this might be an existing development/use for which an improved bushfire performance is being sought.</p>
Elements At Risk	<p>The population, buildings and civil engineering works economic activities, public services and infrastructure, etc. exposed to hazards. <i>(Australian Institute for Disaster Resilience, 2019)</i></p>
Exposure	<p>Refers to the people and things in the path of potential hazards. <i>(Source: AIDR LUPDRC, 2020)</i></p> <p>The elements within a given area that have been, or could be, subject to the impact of a particular hazard. Bushfire exposure can refer to property that may be endangered by a fire burning in another structure or by a bushfire. <i>(Source: AIDR Knowledge Hub; Glossary)</i></p> <p>The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard prone areas. Measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability and capacity of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest. <i>(Source: UNDRR, 2017)</i></p>

Hazard	<p>A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.</p> <p>Hazards may be natural, anthropogenic or socionatural in origin.</p> <ul style="list-style-type: none"> • Natural hazards are predominantly associated with natural processes and phenomena (note: disasters often follow natural hazards, but there is no such thing a natural disaster); • Anthropogenic hazards are human-induced – being induced entirely or predominantly by human activities and choices; • Socionatural hazards are associated with a combination of natural and anthropogenic factors, including environmental degradation and climate change. <p>Hazards may be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity or magnitude, frequency and probability.</p> <p><i>(Source: UNDRR Terminology 2017)</i></p> <p>A source of potential harm or a situation with a potential to cause loss. A potential or existing condition that may cause harm to people, or damage to property or the environment. A source of risk. <i>(Source: AIDR Knowledge Hub; Glossary)</i></p>
Hazardous Event	<p>The manifestation of a hazard in a particular place during a particular period of time.</p> <p>[Severe hazardous events can lead to a disaster as a result of the combination of hazard occurrence and other risk factors.]</p> <p><i>(Source: United Nations Office for Disaster Risk Reduction, 2017)</i></p>
Hazard Identification	<p>The process of recognising that a hazard exists and defining its characteristics. <i>(Australian Institute for Disaster Resilience, 2019)</i></p>
Hazard - Bushfire	<p>A fuel complex, defined by amount, type condition, arrangement, and location, that determines the degree of hazard. <i>(Source: AIDR Knowledge Hub; Glossary)</i></p> <p>The term 'bushfire hazard' in this assessment report is intended to refer to both bushfire prone vegetation and the associated potential bushfire event itself. The term 'bushfire' is being applied as the common term for forest, scrub, shrub, and grass fire events.</p>
Hazard - Urban Fire	<p>1. Susceptibility of a material to burn. 2. The presence of combustible materials. 3. A process or activity posing a fire risk if not adequately controlled. <i>(Source: AIDR Knowledge Hub; Glossary)</i></p>
Hazardous Material	<p>A substance or material which has been determined by an appropriate authority to be capable of posing an unreasonable risk to health, safety and property. <i>(Source: AIDR Knowledge Hub; Glossary)</i></p>
Impact	<p>Describes as a quantitative or qualitative measure, the relative potential ability of a threat to adversely affect an exposed element or of a protection measure to reduce threat, exposure or vulnerability levels and consequently, risk levels.</p>
Likelihood	<p>Chance of something happening. The likelihood level reflects the probability of both the emergency event and the estimated consequences occurring as a result of the event. <i>(Source: AIDR NERAG, 2020)</i></p> <p>In risk management terminology, the word 'likelihood' is used to refer to the chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically - such as a probability or a frequency over a given time period. <i>(Source: ISO Guide 73:2009)</i></p>

	<p>The chance of an event occurring. Likelihood may be represented as a statistical probability (such as Annual Exceedance Probability), or where this is not possible, it can be represented qualitatively using such measures as 'likely', 'possible', and 'rare'. (Source: PIA, 2015).</p>
Mitigation	<p>The lessening or minimizing of the adverse impacts of a hazardous event. The adverse impacts of hazards, in particular natural hazards, often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures include engineering techniques and hazard-resistant construction as well as improved environmental and social policies and public awareness. (Source: UNDRR, 2017)</p>
Reliability	<p>Refers to the expected reliability of a designed solution (protection measure). Over time it will be a function of:</p> <ul style="list-style-type: none"> • Its Initial likely reliability; • Its durability which may or may not be a function of maintenance; • The level of maintenance required; • The likelihood of solution being modified over time; and • The influence of other adjoining/adjacent structures or stored materials that may be installed after the initial construction. <p>(Adapted from Kelly M. et al; <i>Structural Design Options for Residential Buildings in Bushfire Areas</i>, Australasian Structural Engineering Conference November 2016)</p>
Resilience	<p>The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management. (United Nations Office for Disaster Risk Reduction, 2017)</p> <p>Is that property of a building, system, or community that facilitates its return to a functional state following an overload. In the context of bushfire damage, resilience will be maximised when:</p> <ul style="list-style-type: none"> • There is a high probability of an attacked building remaining fit for purpose; and • There is a low time and cost to make badly damaged buildings fit for purpose. <p>(Adapted from Kelly M. et al; <i>Structural Design Options for Residential Buildings in Bushfire Areas</i>, Australasian Structural Engineering Conference November 2016)</p>
Robustness	<p>Refers to that property of structural systems that seeks to achieve proportionality of damage to the severity of an overloading event. It will be maximised when bushfire design solutions:</p> <ul style="list-style-type: none"> • Have few 'weak links' that allow progressive spread of damage from minor sources; • Consist of materials and assemblies that retain physical properties when thermally loaded beyond their design capacity; and • Include protection of inherently vulnerable and brittle elements. Such as openings to internal parts of structures (including doors and windows) and essential services that maintain required functioning (e.g. cabling and plumbing). <p>(Adapted from Kelly M. et al; <i>Structural Design Options for Residential Buildings in Bushfire Areas</i>, Australasian Structural Engineering Conference November 2016)</p> <p>As a design principle it means that the design and materials are not easily damaged or compromised, and do not require manual operation or intervention to work (Source: State Government of Queensland, CSIRO, 2020)</p>

Redundancy	<p>Refers to design that ensures the fate of the subject building/structure is not reliant on the effective performance of a single element. (State Government of Queensland, CSIRO, 2020)</p> <p>An example is a roof system that does not rely solely on the roof cladding to resist bushfire threats. It has additional layers of resistance including non-combustible roof/ceiling framing, insulation and ceiling lining, and the sealing/screening of gaps into internal operating spaces.</p>
Risk	<p>Disaster risk is the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. (Source: UNDRR, 2017)</p> <p>Disaster risk is a product of a hazard (a sudden event or shock), exposure (the people and things in the path of potential hazards), vulnerability (the potential for those people and things to be adversely impacted by a hazard) and the capacity (the ability for those people and assets and systems to survive and adapt). (Source: ADR LUPDRC, 2020)</p> <p>Risk is the chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood. In <u>emergency management</u> it is a concept used to describe the likelihood of harmful consequences arising from the interaction of hazards, communities and the environment. (Source: PIA, 2015)</p>
Risk Management	<p>Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses. (Source: UNDRR, 2017)</p> <p>Coordinated activities of an organisation or a government to direct and control risk. The risk management process includes the activities of:</p> <ul style="list-style-type: none"> • Communication and consultation; • Establishing the context; • Risk Assessment (risk identification, risk analysis, risk evaluation); • Risk Treatment; and • Monitoring and Review. (Source: ADR NERAG, 2020)
Risk Identification	<p>Process of finding, recognising and describing sources of risks, their causes and their potential consequences. (Source: ISO Guide 73:2009)</p> <p>Is a process used to find, recognise, and describe the risks that could affect the achievement of objectives. (Source: Praxiom)</p>
Risk Source	<p>An element which, alone or in combination, has the intrinsic potential to give rise to risk. (Source: ISO Guide 73:2009)</p>
Risk Assessment	<p>Disaster risk assessment is a qualitative or quantitative approach to determine the nature and extent of disaster risk by analysing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people property, services and livelihoods and the environment on which they depend. Assessments include the identification of hazards; a review of the technical characteristics of hazards such as their location, intensity, frequency, and probability; the analysis of exposure and vulnerability, including the physical, social, health, environmental and economic dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities with respect to likely risk scenarios. (Source: UNDRR, 2017)</p> <p>The overall process of risk identification, risk analysis and risk evaluation. (Source: ISO Guide 73:2009)</p>

Risk Analysis	<p>The process to comprehend the nature of risk and determine the level of risk. Provides the basis for risk evaluation and decisions about risk treatment. (Source: ISO Guide 73:2009)</p> <p>Is a process that is used to understand the nature, sources, and causes of the risks that you have identified and to estimate the level of risk. It is also used to study impacts and consequences and to examine the controls that currently exist. How detailed your risk analysis ought to be will depend upon the risk, the purpose of the analysis, the information you have, and the resources available. (Source: Praxiom)</p> <p>In this risk assessment report, risk analysis is the part of the risk assessment process that assesses the hazard threat levels, identifies the protection measures (and their effectiveness) that can be applied and derives the levels of exposure and vulnerability of the identified elements at risk, based on the ability to apply protection measures.</p> <p>From this information indicative risk levels can be derived. Where relevant sets of risk factor criteria and a risk level matrix have been established by the relevant authorities, a determined risk level can be derived.</p> <p>The required risk level analysis can be conducted for either each exposed element separately and/or the proposed or existing development/use overall.</p>
Risk Evaluation	<p>The process used to determine risk management priorities by evaluating and comparing the level of risk against predetermined standards, target risk levels or other criteria. (Source: PIA, 2015)</p> <p>In this risk assessment report, it is the process of classifying the acceptability of the levels of risk, derived from the risk analysis, by reference to an established risk tolerance scale. The relevant tolerance scale will be that derived from the application of the 'as low as reasonably practicable' principle – 'ALARP' (refer to Appendix 3 for further information).</p> <p>This process can only be conducted when <u>determined</u> risk levels have been derived.</p>
Risk Factor Criteria	<p>In this risk assessment report, the risk factor criteria establish the parameters that will define the different hazard threat levels, the different levels of exposure of elements at risk and the different levels of vulnerability of elements at risk. Different sets of risk factor criteria can exist corresponding to different development types, uses and scale. They are applied as part of the risk analysis.</p> <p>These criteria are established by the relevant authorities as they must reflect societies preparedness to tolerate risk and be determined by those authorities exercising their responsibilities.</p>
Risk Level Matrix	<p>In this risk assessment report, the risk level matrix establishes how the assessed levels of hazard threats, exposure and vulnerability are to be analysed in deriving a determined risk level. It is applied as part of the risk analysis.</p> <p>The matrix is established by the relevant authorities as they must reflect societies preparedness to tolerate risk and be determined by those authorities exercising their responsibilities.</p>
Risk Tolerance Scale	<p>In this risk assessment report the applied risk tolerance scale defines the acceptability of determined risk levels based on the 'as low as reasonably practical' principle (ALARP).</p> <p>The risk tolerance scale can be applied within the risk assessment report when the required risk factor criteria and risk level matrix are available.</p>
Risk - Inherent	<p>In this risk assessment report, inherent risk is considered to be current risk after accounting for existing and any planned/proposed controls but before the application of any additional controls (risk treatments / protection measures) that have been identified subsequent to the initial risk analysis and recommended by the bushfire consultant.</p> <p>This approach is supported by the information provided by the following two references.</p>

	<p>(Source: Wikipedia)</p> <p>Inherent risk, in risk management is:</p> <ul style="list-style-type: none"> an assessed level of raw or untreated risk; that is, the natural level of risk inherent in a process or activity without doing anything to reduce the likelihood or mitigate the severity of a mishap, or the amount of risk before the application of the risk reduction effects of controls; or Another definition is that inherent risk is the current risk level given the existing set of controls, which may be incomplete or less than ideal, rather than an absence of any controls. <p>(Source: www.fairinstitute.org)</p> <p>"Confusion exists between Inherent Risk and Residual Risk ... Here are the standard definitions of the two concepts:</p> <ul style="list-style-type: none"> Inherent risk represents the amount of risk that exists in the absence of controls. Residual risk is the amount of risk that remains after controls are accounted for. <p>Sounds straightforward. But these two terms seem to fall apart when put into practice. Applying the above definitions to the clients' scenario uncovered the fact that the 'inherent' risk being described was not a 'no controls' environment, but rather, one that only excluded some controls.</p> <p>The flaw with inherent risk is that in most cases, when used in practice, it does not explicitly consider which controls are being included or excluded. A truly inherent risk state, in our example, would assume no employee background checks or interviews are conducted and that no locks exist on any doors. This could lead to almost any risk scenario being evaluated as inherently high. Treating inherent risk therefore can be quite arbitrary. According to Jack Jones, author of <i>Measuring and Managing Information Risk: A FAIR Approach</i> and creator of the FAIR model, much more realistic and useful definitions would be:</p> <ul style="list-style-type: none"> Inherent risk is current risk level given the existing set of controls rather than the hypothetical notion of an absence of any controls; and Residual risk would then be whatever risk level remain after additional controls are applied."
Risk - Residual	<p>Is the risk left over after you've implemented a risk treatment option. It's the risk remaining after you've reduced the risk, removed the source of the risk, modified the consequences, changed the probabilities, transferred the risk, or retained the risk. (Source: Praxiom)</p> <p>The risk remaining after any risk treatment has been applied to reduce its potential likelihood and/or its potential consequences. Residual risk can also be any risk that is chosen to be retained rather than treated (Source: AIDR LUPDRC, 2020)</p> <p>Residual risk can contain unidentified risk. Residual risk can also be known as retained risk. (Source: ISO Guide 73:2009)</p> <p>The disaster risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained. The presence of residual risk implies a continuing need to develop and support effective capacities for emergency services, preparedness, response and recovery, together with socioeconomic policies such as safety nets and risk transfer mechanisms, as part of a holistic approach. (Source: UNDRR, 2017)</p>
Risk Level - Determined	<p>Magnitude of a risk or a combination of risks. In this risk assessment report, as an outcome of the risk analysis, a determined risk level is derived from:</p>

	<ol style="list-style-type: none"> 1. The determination of threat, exposure and vulnerability levels by reference to an established set of risk factor criteria that corresponds to each risk level (for each factor); and 2. The determination of the risk level by reference to an established risk level matrix that incorporates threat, exposure and vulnerability levels.
Risk Level - Indicative	<p>Magnitude of a risk or a combination of risks. In this risk assessment report, as an outcome of the risk analysis, an indicative risk level is derived from analysis of the number of bushfire protection measures able to be implemented compared to the number of measures available, and the relative effectiveness of each at reducing threat, exposure and/or vulnerability levels.</p> <p>Overall, more applicable and applied measures is better and the measures with a higher effectiveness rating have greater weighting in the analysis.</p>
Risk - Acceptable	<p>Risks that do not need further treatment. The expression acceptable level of risk refers to the level at which it is decided that further restricting or otherwise altering the activity is not worthwhile e.g. additional effort will not result in significant reductions in risk levels. (Source: DPLH, 2019)</p> <p>That level of risk that is sufficiently low that society is comfortable with it. Society does not generally consider expenditure in further reducing such risks justifiable. (Source: AIDR Knowledge Hub)</p> <p>Acceptable risk or tolerable risk is an important sub-term (of disaster risk). The extent to which a disaster risk is deemed acceptable or tolerable depends on existing social, economic, political, cultural, technical and environmental conditions. (Source: UNDRR, 2017)</p> <p>Note: <i>It is generally accepted that nothing can be absolutely free of risk, everything under some circumstance can cause harm. There are differing levels of risk and consequently levels of safety. In practice, attaining zero risk is not possible. Nevertheless, after risk avoidance, reduction/mitigation, transfer or acceptance - the residual risk may be determined as acceptable, as judged by the participants in an activity and decision makers (who apply societies expectations). For certain land uses, the residual risk may exist at higher levels but still be judged by to be acceptable (or tolerable) on this basis.</i></p>
Risk - Tolerable	<p>The willingness to live with a risk to secure benefits and achieve objectives, on the understanding that it is being properly controlled. 'Tolerability' does not mean 'acceptability'. Tolerating a risk does not mean that it is regarded as negligible, or something we may ignore, but rather as something that needs to be kept under review and reduced further, if deemed necessary. (Source: DPLH, 2019)</p> <p>Certain levels of risk may be tolerated, provided that the risks are known and managed. (Source: AIDR LUPDRC, 2020)</p> <p>Risk tolerance is defined as the organisations or stakeholder's readiness to bear the risk, after risk treatment, in order to achieve its objectives. Risk tolerance can be influenced by legal or regulatory requirements. (Source: ISO Guide 73:2009)</p> <p>A level of risk that defines the ALARP region, as risks that should be driven to the broadly acceptable region. (Source: PIA, 2015)</p>
Risk - Intolerable	<p>A level of risk that is so high that require risk treatment measures whatever their cost, or the elimination of the risk. (Source: PIA, 2015)</p> <p>Risk that is unacceptable in any circumstances or at any level. (Source: DPLH, 2019)</p>
Risk Treatment	<p>Risk treatment options available as part of the risk management process are generally categorised as follows:</p>

	<ul style="list-style-type: none"> • Risk Avoidance: Measures taken to avoid risks from natural hazards. Can include avoiding development in hazardous areas, relocating people or assets away from hazardous areas, or developing buffer zones to the hazard; • Risk reduction/mitigation: Measures undertaken to reduce the risks from natural hazards. Includes building control and development controls; • Risk Transfer: Measures taken to transfer the risk from natural hazards from one party to another; and • Risk Acceptance: The acceptance of risk from a natural hazard. Any realised losses will be borne by those parties exposed to the hazard. This is not specifically a treatment option as no action is taken, but it is an option for addressing risk. <p>(Source: AIDR LUPDRC, 2020)</p>
Retrofitting	<p>Reinforcement or upgrading of existing structures to become more resistant and resilient to the damaging effects of hazards.</p> <p>Retrofitting requires consideration of the design and function of the structure, the stresses that the structure may be subject to from particular hazards or hazard scenarios and the practicality and costs of different retrofitting options. (Source: UNDRR, 2017)</p>
Structural and Non-Structural Measures	<p>Structural measures are any physical construction to reduce or avoid possible impacts of hazards, or the application of engineering techniques or technology to achieve hazard resistance and resilience in structures or systems.</p> <p>Non-structural measures are measures not involving physical construction which use knowledge, practice or agreement to reduce disaster risks and impacts, in particular through policies and laws, public awareness raising, training and education.</p> <p>Common non-structural measures include building codes, land-use planning laws and their enforcement, research and assessment, information resources and public awareness programmes. (Source: UNDRR, 2017)</p>
Threats	<p>The mechanisms by which hazards can impact exposed elements.</p>
Vulnerability	<p>The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards. (United Nations Office for Disaster Risk Reduction, 2017)</p> <p>The characteristic or property of a community, system or object that makes it susceptible to the damaging effects of a specific hazard.</p> <p>Can be defined according to the responses of people, houses and assets in mitigating the impacts of a hazard. Specifically, it refers to the extent to which a community, building, services or location is likely to be damaged or disrupted by the impacts of a hazard, such as a bushfire.</p> <p>Building vulnerability refers to weak points in a building caused by its design, construction, use of materials and management (including maintenance). These weak points are identified in the context that they are not able to withstand the level of hazard they are exposed to.</p> <p>Climate and weather may directly influence the buildings vulnerability through several processes including (i) moisture content of combustible elements around and within buildings (ii) gaps between materials that may shrink and expand due to changes in moisture content and temperature (iii) wind action causing damage or dislocation of elements. (Source: State Government of Queensland, CSIRO, 2020; Bushfire Resilient Building Guidance for Queensland Homes)</p>

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Surface Water Management Plan

Regional Resource Recovery Park



Prepared for Shire of Broome


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Name	Position	File Reference
Colleen Panizza	Senior Waste Engineer	TW21177-04 - Broome Surface Water Management Plan_2.0
Signature		

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Drawings

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1 Introduction

Talis Consultants Pty Ltd (Talis) was commissioned by the Shire of Broome (the Shire) to prepare a Surface Water Management Plan for the Regional Resource Recovery Park (the Site) that summarises the assessments and strategy for managing surface water during the fully operational and post-closure phases of the waste management activities at the Site.

1.1 Background

The Shire's current landfill at the Buckley's Road Waste Management Facility is approaching the end of its operational life. The Shire identified the opportunity for a new facility that would have the capacity to advance the recycling and resource recovery initiatives as well as the standard of waste treatment services for the Shire and the wider Kimberley area. In November 2019, the Shire commissioned Talis to undertake a site selection study for the Regional Resource Recovery Park. The development option that the Shire chose was for a fully integrated site including a Class III landfill, community recycling centre (CRC), and liquid waste facility (LWF).

In December 2021, Talis was commissioned to undertake the detailed design of the new facility, designated as the Regional Resource Recovery Park, to be located approximately 12km northeast from the town centre along Broome-Cape Leveque Road. As part of the detailed design phase of the Project, a surface water management system has been designed to process the surface water from the Site. To ensure that the surface water can be adequately managed throughout the operational and post-closure phases of the Site, a Surface Water Management Plan has been developed.

1.2 Scope of Report

The Surface Water Management Plan summarises the design and staged development of a better practice and operationally flexible surface water management system for the Site's waste management activities. Therefore, the Surface Water Management Plan contains the following elements:

- Site Information;
- Local Climate Data;
- Surface Water Management Strategy;
 - Surface water management requirements;
 - Surface water generation modelling;
 - Surface water infrastructure requirements;
 - Construction timeline;
 - Operational management and monitoring strategy; and
- Local Flood Risk Assessment.

1.3 Legislative Context

The following policies and guidelines have been adopted or considered when developing the framework for this Surface Water Management Plan:

- *Best Practice Environmental Management: Siting, design, operation and rehabilitation of landfills*, Environment Protection Authority, Victoria, 2015 (Best Practice Landfill Guidelines); and
- *IR-F27 Application Form Annex: Category Checklist (solid waste landfill sites)*, Department of Water and Environmental Regulation, Western Australia, Version 1, January 2022 (DWER Landfill Application Form Checklist).

Table 1-1 outlines the specific information requirements within the DWER Landfill Application Form Checklist with regard to surface water management.

Table 1-1: DWER Landfill Application Form Checklist – Surface Water Management

Part	Requirements
2F	Surface water management <ul style="list-style-type: none"> • The premises must be designed and constructed to ensure that stormwater is diverted away from the landfill cell, leachate pond and other waste handling areas. This may be achieved through the use of surface grade changes, bunding, interceptor drains, piping and other drainage systems. • Stormwater which has come into contact with waste materials must be collected and managed as leachate in the leachate management system.
2.18	<p><u>Surface water management</u>²⁹</p> <p>Provide details on the proposed stormwater management strategies and controls for the landfill premises including, but not limited to:</p> <ul style="list-style-type: none"> • diversion of stormwater away from areas containing waste using drainage features, bunds, interceptor drains or other drainage systems • details on clean stormwater holding ponds to be constructed (if required); design specifications and an overview of construction works should also be provided • details of any proposed controlled releases of clean stormwater into the environment and/or proposed reuse options on-site • erosion and sediment control along drainage lines and discharge points, including stormwater flow control, vegetation, detention ponds, minimising land disturbance, and other temporary and permanent erosion protection measures. <p>Note 29: Guidance on stormwater management can be found in DWER's Stormwater Management Manual for Western Australia.</p>
2.19	Design drawings and layout figure(s) of the proposed surface water management infrastructure.
2G	Monitoring Requirements <p>A comprehensive monitoring program should be developed to support the ongoing operation of a landfill facility. Aspects that should be included in the program (as a minimum) include leachate, landfill gas, surface water and groundwater. Odour monitoring should also be considered, depending on the environmental siting.</p>
2.20	<p><u>Groundwater and surface water monitoring</u></p> <p>Provide details on the proposed groundwater and surface water monitoring program, including, but not limited to:</p> <ul style="list-style-type: none"> • sampling locations

Part	Requirements
	<ul style="list-style-type: none"> • well construction specifications • sampling methodology • analysis suite • sampling frequency • reporting requirements. <p>The monitoring program should as a minimum seek to establish:</p> <ul style="list-style-type: none"> • the background groundwater quality and levels (in mAHD and mBGL) • the background surface water quality and levels/flow rates and flow direction • the local aquifers, and groundwater flow direction and rates of each aquifer • a monitoring network that acts as an early indicator of leachate contamination in groundwater or surface water prior to offsite migration. <p>For a new facility, the operator should seek to demonstrate baseline groundwater and/or surface water conditions prior to construction works and to feed the results of this monitoring into the initial CSM development.</p> <p>A sampling and analysis quality plan (SAQP) should be prepared to ensure that the data collected is representative and sufficient to address critical gaps and uncertainties identified in the CSM so that the information obtained provides a reliable basis for continually reviewing site operations and meeting compliance requirements of the operating licence.</p> <p>Further guidance on developing a groundwater and surface monitoring program, including the development of a SAQP, can be sourced from DWER's Assessment and management of contaminated sites guideline and from Schedule B2 of the <i>National Environment Protection (Assessment of Site Contamination) Measure 1999</i>.</p>

2 Site Information

The following sections provides general information of the Site, including current layout, licencing, and environmental attributes.

2.1 Site Layout

The proposed Site layout can be seen in Drawing C-100 provided in Appendix A. Access to the Site is via Broome-Cape Leveque Road on the eastern boundary of the Site. The main entrance road heads west towards the landfill with future expansion area to the north and the CRC and material stockpile areas to the south. The landfill occupies the west portion of the Site with the proposed surface water collection and infiltration ponds, the landfill leachate evaporation pond and the LWF to its south in the lowest topographical point of the Site. A levee bund system will be constructed along the Site's north, east and south boundaries to redirect offsite flood waters around the Site.

2.2 Environmental Attributes

2.2.1 Topography

The Site is relatively flat, with an average slope of approximately 1% from 38.5 metres (m) Australian Height Datum (AHD) at the north-east corner to 21.0mAHD at the south-western corner. The proposed surface water ponds that will manage the majority of the Site's surface water runoff will be in the south-west corner of the Site, which provides a generally flat area between 23.5-21.5mAHD for any proposed surface water management infrastructure. The Site's topography is shown in Drawing C-002 (Appendix A).

2.2.2 Geology

As part of the Site Selection works an intrusive investigation was undertaken by Talis in November 2020 which included drilling fourteen (14) boreholes at seven (7) locations across the Site and construction of 50 test pits. The generalised soil profile recorded across the Site was consistent with the regional geology and comprised of:

- Silty clayey SAND – pale red sand, fine to medium grained, subangular with trace gravel probably of aeolian origin to between 10-15 mbgl (Pindan Plain Soil); overlying
- SANDSTONE – pale yellow to white, very fine to medium grained, variably cemented, bedded to weakly bedded sandstone probably of shallow marine or tidal origin (Broome Sandstone).

2.2.3 Groundwater

A hydrogeological investigation for the Site Selection works for the Site was undertaken to assess both the groundwater regime beneath the Site and the risk to environmental values and adjacent properties in relation to the proposed development at the Site. A total of seven (7) deep wells and 7 shallow wells have been established within the Site to obtain baseline groundwater data. The locations of these monitoring bores are shown in Drawing C-002 (Appendix A).

Groundwater data recorded from December 2020 to March 2021 indicates that the groundwater depth ranges from approximately 16m to 32m below ground level (bgl) as shown in Table 2-1. The general inferred direction of groundwater flow is in a south to southwest direction across the Site towards the Indian Ocean.

The minimum groundwater depth from these monitoring bores indicates an adequate separation of the groundwater within the leachate management area that will be compliant with Best Practice Landfill Guidelines.

Table 2-1: Depth to Groundwater Characteristics

Well ID	Ground Level Elevation (mAHD)	Minimum Static Water Level (mbgl)	Minimum Static Water Level (mAHD)
GW1-D	25.6	20.7	4.9
GW2-D	20.6	16.0	4.6
GW3-D	30.2	25.2	5.0
GW4-D	28.8	23.6	5.2
GW5-D	34.2	28.9	5.3
GW6-D	37.9	32.4	5.5
GW7-D	35.2	30.1	5.1

2.2.4 Surface Water

The Site is located in relatively flat terrain which experiences surface water flow in a south westerly direction during rain events. Any surface water runoff passes onto the neighbouring properties to the west, the Yawuru Birragun Conservation Park, and the motocross to the south.

There are no permanent surface water bodies on the Site. The nearest surface water bodies are Buckley's Plain (land subject to inundation) approximately 3km to the west south-west and Dampier Creek, approximately 5.5km to the south. Further to the west is the Indian Ocean, which is approximately 5.5km from the Site.

As part of the surface water management design, it is important to mitigate onsite flooding, to provide sediment control, and to ensure controlled release of any surface water runoff into the environment.

3 Local Climate Data

The local and regional climate data sources utilised in designing the surface water management system at the Site include the following:

- Rainfall;
- Temperature;
- Pan Evaporation;
- Relative Humidity;
- Solar Exposure; and
- Wind Speed.

Historic weather data is typically sourced from the Bureau of Meteorology (BOM) website. The Bureau of Meteorology's (BOM) closest weather station with long-term data is Broome Airport (Station 003003). The prevailing wind speed and direction, temperature, solar exposure, and humidity data has been sourced from this weather station.

However, there is limited quality controlled BOM rainfall data available for the Site. Therefore, the rainfall and pan evaporation data were sourced from SILO. SILO is a database of Australian climate data from 1889 to the present 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: -17.85, Longitude: 122.25) encompasses the Site in its entirety.

A 50-year data period was selected to gain a large range of rainfall scenarios whilst maintaining the quality of the data, as the SILO model indicates there are significant limitations on data pre-1957.

3.1 Temperature

The highest mean temperature is 34.3°C, occurring in April, whilst the lowest mean temperature is 13.7°C occurring in July. Table 3-1 shows the average maximum and minimum temperatures at the Broome Airport weather station (Station number: 003003) for years 1939 to 2021.

Table 3-1: Maximum and Minimum Temperatures from Broome Airport Station (1939-2021)

Aspect	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Max. Temp. (°C)	33	33	34	34	32	29	29	30	32	33	34	34
Mean Min. Temp. (°C)	26	26	26	23	18	15	14	15	19	23	25	27

3.2 Rainfall

The climate is considered to be semi-arid as per the Köppen classification system used by BOM. The local climate is defined by distinct wet and dry seasons. Rainfall is distinctly erratic with the majority of rain occurring within the wet season (November to April). The monthly rainfall rates for the Site from 1970 to 2021 for various scenarios are provided in Table 3-2.

Table 3-2: Rainfall Overview in Millimetres for the Site (1970-2021)

Aspect	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	230	194	105	24.2	20.8	14.4	6.4	2.5	1.3	1.9	10.7	86.4	698
50th Percentile	26.9	202	247	66.5	4.6	0.0	0.0	0.7	0.0	10.9	0.5	110	668
90th Percentile	737	268	146	0.0	10.5	0.4	0.0	0.4	1.5	0.4	21.4	11.3	1,196
Highest	945	619	20.6	2.2	0.7	0.0	0.4	1.1	0.5	0.1	5.9	14.5	1,610

The mean annual rainfall for the Site is calculated as 698 millimetres (mm) with the highest recorded annual rainfall at 1,610mm, which occurred in 2018. The 50th and 90th percentile rainfall years recorded a rainfall of 668mm (in 1996) and 1,196mm (in 1982), respectively.

3.2.1 Short Duration Design Rainfall

Rainfall Intensity Frequency Duration (IFD) data for the Site was obtained using the BOM Computerised Design IFD Rainfall System (CDIRS) and the Australian Rainfall and Runoff 2016 database (ARR2016). CDIRS produces a complete set of IFD curves and associated weather data based on user-defined coordinates (<http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016>).

Table 3-3 summarises the Annual Exceedance Probability (AEP) of storms with 1 to 72-hour (hr) durations. AEPs are required to estimate precipitation rates for a range of events.

Table 3-3: Summary of Annual Exceedance Probabilities for Broome, WA (ARR2016)

Storm Duration	1 in 10	1 in 20	1 in 50	1 in 100
	10%	5%	2%	1%
	Rainfall Depth (mm)			
1 hour	74.1	84.1	96.5	105
2 hour	95	109	127	140
3 hour	109	127	149	166
6 hour	137	163	198	225
12 hour	175	213	265	308
24 hour	226	280	354	416
48 hour	288	359	455	534
72 hour	326	406	508	592

When undertaking the surface water modelling, rainfall intensity is calculated using the time of concentration and the AEP Polynomial Coefficients. The coefficients used to model rainfall intensity are presented in Table 3-4.

Table 3-4: AEP Polynomial Coefficients

Coefficient	Storm Event						
	1:1	1:2	1:5	1:10	1:20	1:50	1:100
	63.2%	50%	20%	10%	5%	2%	1%
C ₀	0.941	1.07	1.37	1.52	1.64	1.78	1.86
C ₁	0.576	0.618	0.670	0.670	0.656	0.621	0.578
C ₂	0.321	0.276	0.226	0.232	0.253	0.302	0.358
C ₃	-0.136	-0.120	-0.105	-0.110	-0.122	-0.147	-0.174
C ₄	0.020	0.018	0.016	0.018	0.021	0.026	0.032
C ₅	-0.0012	-0.0011	-0.0010	-0.0012	-0.0015	-0.002	-0.003
C ₆	2.44E-05	2.05E-05	2.21E-05	2.95E-05	3.92E-05	6.00E-05	8.06E-05

3.3 Pan Evaporation

The approximate average daily pan evaporation rates for the Site are based on the calculated monthly rates from SILO. Table 3-5 outlines the average pan evaporation data, from 1970 to 2021.

Table 3-5: Pan Evaporation Average Data for the Site in Millimetres (1970-2021)

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Monthly	257	212	232	225	210	184	198	225	248	285	291	288	2,856
Daily	8.3	7.6	7.5	7.5	6.8	6.1	6.4	7.3	8.3	9.2	9.7	9.3	

The daily average pan evaporation ranges from 6.1mm to 9.7mm and monthly from 184mm to 291mm. The total annual pan evaporation for the Site is calculated as 2,856mm. This is a significant potential evaporation rate that is more than double the 90th percentile rainfall year experienced at Site.

3.4 Regional Flood Trends

In February 2021, a Flood Modelling Study was undertaken of the Site. The study concluded that the Site has a relatively small contributing catchment area with no concentrated flow channels discernible in the available terrain mapping. To mitigate sheet flow entering the Site, it is collected around the perimeter and conveyed through a 20m wide drain via a levee bund system with a maximum height of 1.3m. The primary levee bund is 2,242m long and the secondary levee bund located only along the Site's southern boundary is 650m long. The recommended top width for the levee is 2 metres, with side slopes not to exceed 3H:1V. Armour rock is recommended along the northern batter of the 20m wide swale at the channel bend within the southeast corner of the Site. The location and design of the levee is presented in Drawing C-200, available in Appendix A.

This study has assessed both the 1% AEP and 0.2% AEP flood events; all design recommendations are based on the 0.2% event with a minimum 300mm freeboard. A range of levee locations and drain configurations was applied in the hydraulic modelling, indicating that further adjustments to the site infrastructure locations of up to 200 metres are unlikely to reduce the offsite water surface elevation impacts by more than 2cm in the 0.2% AEP flood event.

4 Surface Water Management Strategy

Environmental risks associated with landfill leachate and surface water within the overall Site boundary will be managed through the Site's Surface Water Management System (SWMS). To appropriately manage these risks, the SWMS needs to achieve two key objectives including minimising landfill leachate generation and proactively managing surface water. These objectives, and the design features incorporated to achieve these, are shown in Table 4-1.

Table 4-1: Objectives and Associated Design Features of the Surface Water Management Plan

Objective	Design Feature
Minimise Leachate Generation	Implement a best practice capping and surface water management system over the landfill.
	Phase the construction of the capping and surface water management systems.
	Develop a drainage system along the toe of the landfill that: <ul style="list-style-type: none"> • 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 surface water management system is appropriately sized to manage a 1-in-20 year Average Recurrence Interval (ARI) storm event and will not result in catastrophic failures during a 1-in-100 year ARI storm event.
	Establish controlled discharge points for surface water.

4.1 Key Infrastructure

To address the objectives outlined in Table 4-1, the infrastructure for the surface water management system will include collection/infiltration ponds, retention ponds, a levee bund system and drainage channels around the Site. The following subsections further outline the proposed future key infrastructure that will form the Site's SWMS.

4.1.1 Drainage Channels

Drainage channels in the form of trapezoidal open swales will be utilised to effectively transport surface water runoff within the Site to collection points for attenuation or diversion offsite. Two types of drains will be used in the final design as discussed in the following subsections.

4.1.1.1 Perimeter Drains

Perimeter drains will run around the boundary of the landfill and other proposed Site infrastructure. The landfill perimeter drains will mainly collect surface water that sheds from the landfill's restoration profile following permanent capping works. All perimeter drains will connect to the series of proposed

surface water ponds around the Site, which are discussed further in Section 4.1.2. These drains will be clean earth channels, with some sections lined with rock armouring as detailed in Section 4.3.1.1.

4.1.1.2 Cut-off Drains

Cut-off drains will be installed around the Site to effectively maintain separation between clean surface water and surface water that has come into contact with the Site's waste management activities. Cut-off drains, featuring a trapezoidal channel shape, will be used to divert clean upslope water away from the landfill and other Site infrastructure towards the regional drainage system. These drains will assist in reducing the surface water entering the Site's main SWMS, particularly from the Site's northern portion and within the landfill development footprint. Many of these cut-off drains will be temporary and relocated as operations expand.

4.1.1.3 CRC Internal Drain Network

The Community Recycling Centre (CRC) will contain a network of internal surface water drains that will collect the majority of all runoff into its retention pond before it is released into the Site's overall perimeter drain system. Grated pits and footpath crossings will also be constructed in conjunction with the drain network, but these elements will not be addressed within this SWMP and instead will be detailed within the Detailed Design drawing set for the Project.

4.1.2 Surface Water Ponds

A number of ponds will be constructed around the Site to effectively manage surface water through either attenuation, evaporation, or discharge offsite in a controlled manner. The details of the Site's proposed surface water pond system are as followed:

- A surface water collection pond (Pond 1), which will be lined with a HDPE geomembrane;
- A surface water infiltration pond (Pond 2), which will be unlined with an uncompacted base to promote infiltration;
- A greenwaste retention pond (Pond 3), which will consist of a 300mm compacted subgrade layer and overflow into the surface water collection pond during extreme rainfall events; and
- A Community Recycling Centre (CRC) retention pond (Pond 4), which will consist of a 300mm compacted subgrade layer and overflow into the surface water collection pond during extreme rainfall events.

The surface water collection and infiltration ponds will be located south of the landfill. All perimeter drains will transfer surface water runoff into the collection pond. The collection pond will overflow into the infiltration pond, which will be constructed from in-situ soil material with a naturally moderate hydraulic conductivity to allow the water to infiltrate back into the ground. The infiltration pond will also feature a passive emergency spillway to the southernmost point of the Site where surface water runoff will discharge offsite in a controlled manner during extreme rainfall events. This discharge point is positioned immediately south of the Site to mitigate direct discharge into the Yawuru Birragun Conservation Park.

The greenwaste retention pond will be located south of the Greenwaste Hardstand Area and manage all run-off from this area up to a 1-in-20, 24hr storm event. The pond will then overflow into the collection pond if required, via a series of open drainage channels prior to the surface water being transferred offsite overflowing into the infiltration pond.

The Community Recycling Centre (CRC) retention pond will be located within the CRC development footprint and will manage surface water runoff from the service and operational areas of the CRC. As with the greenwaste retention pond, the CRC retention pond will then overflow into the collection pond if required, via a series of open drainage channels prior to the surface water being transferred offsite overflowing into the infiltration pond.

The retention ponds are intended to evaporate the surface water run-off from small rainfall events, and delay surface water run-off from extreme rainfall events from being transferred into the collection pond.

4.1.3 Levee System

To understand the infrastructure and engineering requirements to manage potential impacts from offsite flooding, hydrology modelling was completed for flood events up to the 0.2% Annual Exceedance Probability (AEP) event, or the 500-year Average Recurrence Interval (ARI) flood. Using regional topographic data, the catchment area was identified to be 5km² (inclusive of the Site). This is a relatively small contributing catchment area with no concentrated flow channels discernible in the available terrain mapping. The hydrology modelling indicates that surface water can be adequately managed by establishing a primary levee bund along the northern, eastern and southern Site boundary with a secondary levee bund only along the Site's southern boundary. A 20m wide drain will be constructed between the two levee bunds and be used in conjugation with the levee bund system to direct offsite sheet flow/floodwaters around the Site into the area south of the facility. This levee bund system will effectively direct these offsite waters around the southern end of the Site and ultimately "daylight" south in the Site's south-western corner, mitigating any direct discharge into the Yawuru Birragun Conservation Park.

4.2 Surface Water Modelling

According to Best Practice Landfill Guidelines, the SWMS should be designed to contain and control surface water runoff from a 1-in-20 year AEP storm event, at a minimum, for putrescible landfills. However, storm events up to 1-in-100 year recurrence intervals should also be considered to ensure that they do not result in any catastrophic failures such as flooding of the landfill. Therefore, the design of the surface water management infrastructure at the Site will consider 1-in-20 year storm events with contingencies for 1-in-100 year storm events.

To determine the appropriate design for the proposed surface water management infrastructure, modelling was undertaken utilising a Microsoft Excel surface water pond and drainage swale sizing algorithm based on local climate data including rainfall depth and intensity.

4.2.1 Catchment Areas

To assist modelling, the Site was split into sub-catchment areas, with the Site divided into seventeen sub-catchments based on topographical data, the design of the landfill and other supporting infrastructure. Drawing C-200, available in Appendix A, displays the main catchments for the Site. In order to design the CRC internal drain network, the catchment for the CRC Area was further split into sub-catchments.

The following sections discussing the design criteria for the catchments.

4.2.1.1 Runoff Coefficient

As discussed in Section 2.2.2, the Site geology consists of silty clayey sand classified as pindan plain soil overlaying Broome sandstone.

The topsoils of the landfill slopes will be constructed with Site-won soils with a maximum grade of approximately 5%. According to the School of Agricultural and Biological Engineering at the University of Illinois Urbana-Champaign¹, the runoff coefficient for graded clayey soil at a gradient of 5-10% is 0.5, and this value was used for modelling purposes. The landfill slopes will be modelled as having no plant cover as a conservative measure, but the slopes will be progressively revegetated during closure with fast-growing plants that will significantly lower the runoff coefficient within the first year following revegetation works.

Non-landfill catchments were assumed to be vegetated clayey soils at slopes of less than 5%, with a modelled runoff coefficient of 0.35 to 0.5. The catchment areas that encompass the Green Waste Hardstand and C&D laydown area, is predominantly hardstand surface, and a corresponding runoff coefficient of 0.65 was used for these catchments. The catchment area that encompasses the Community Recycling Centre is mainly bitumen and a corresponding runoff coefficient of 0.7 has been used.

4.2.1.2 Kerby's Roughness Factor

Kerby's roughness factor considers the effect of friction on the velocity of the surface water runoff as it moves across a particular surface. The Site's catchment areas' surfaces and corresponding roughness factors are as follows:

- Landfill and laydown areas are considered to have smooth bare soil, with a roughness factor of 0.10 as a conservative measure that essentially means that surface water flow across the catchment area to the swale is not slowed down by the roughness of the surface;
- Upslope and internal clean water areas are considered to be grass pasture, with a corresponding roughness factor of 0.40; and
- The Community Recycling Centre is a paved surface, with a corresponding roughness factor of 0.02.

4.2.1.3 Catchment Design Summary

Table 4-2 summarises the design details of the overall catchment areas considered for the SWMS, while Table 4-3 outlines the details of the CRC area (Catchment J) which is used for the design of the CRC internal drain network.

Table 4-2: Summary of Catchment Areas for the Site

Catchment	Description	Area (ha)	Runoff Coefficient	Kerby's Roughness Factor
A	Landfill	1.67	0.5	0.10
B	Landfill	6.42	0.5	0.10
C	Landfill	1.45	0.5	0.10
D	Landfill	1.87	0.5	0.10
E	Landfill	2.25	0.5	0.10

¹ <http://abe-research.illinois.edu/courses/tsm352/lectures/runoffcoeffs.html>

Catchment	Description	Area (ha)	Runoff Coefficient	Kerby's Roughness Factor
F	Landfill	0.85	0.5	0.10
G	Landfill	1.68	0.5	0.10
H	Area directly north of landfill; to be diverted directly offsite	5.05	0.35	0.40
I	North-western corner of Site	9.59	0.5	0.10
J	CRC Area; overflow directed to storage pond	5.79	0.7	0.02
K	Greenwaste hardstand & CRC service area; overflow directed to storage pond	5.82	0.65	0.10
L	C&D laydown area	3.45	0.5	0.10
M	Bulky items laydown area	2.67	0.5	0.10
N	Area around the leachate pond	0.51	0.5	0.10
O	Area between storage pond & landfill	0.46	0.5	0.10
P	Runoff from levee	0.36	0.5	0.10
Q	Southern section of Site	4.35	0.5	0.10
R*	Temporary drain within landfill footprint; to be diverted directly offsite	14.4	0.5	0.10

*Catchment R is a temporary catchment that will reduce as landfill operations progress, and it is considered to ensure that landfill operations are not impacted by surface water run-off from within the large landfill development area.

Table 4-3: Summary of Catchment Areas for the CRC (Catchment J)*

Catchment	Area (ha)	Runoff Coefficient	Kerby's Roughness Factor
J1	0.31	0.7	0.02
J2	0.74		
J3	1.14		
J4	0.11		
J5	0.02		
J6	0.19		
J7	1.60		
J8	0.42		

*Note: These sub-catchments exclude the CRC Retention Pond and other areas within Catchment J that do not feed into the proposed CRC internal drain network.

The catchment areas identified in Table 4-2 are utilised to calculate the required capacity of the surface water ponds and the necessary geometry of swale system across the Site to transfer surface water runoff to these ponds.

The catchment areas identified in Table 4-3 are used for the design of the CRC internal drain network to transfer surface water runoff into the Site's main swale system.

4.2.2 Swale System

The Microsoft Excel spreadsheet algorithm uses the Kerby-Kirpich Method to determine the flow rate of the surface water through the swale system during a specified rainfall event. In order to use this

method, the movement of the surface water through the swale system has been conceptualised with the key components of the swale system outlined in the following subsections.

4.2.2.1 Surface Water Movements

Surface water runoff from catchments is conveyed through a series of open drainage channels and culverts to sedimentation or attenuation ponds across the Site. Table 4-4 shows a summary of surface water movements from each catchment and the corresponding drainage swales that surface water flows. For example, surface water runoff from Catchment A will first flow through Swale 1, then through Swale 2 and Swale 8, into Pond 1. The surface water can then overflow into Pond 2 via the passive emergency spillway.

Table 4-4: Summary of Surface Water Movements for the Site

Catchment	1 st Swale	2 nd Swale	3 rd Swale	4 th Swale	5 th Swale	6 th Swale	1 st Pond	2 nd Pond*	3 rd Pond*
A	1	2	8				1	2	
B	2	8					1	2	
C	3	4	5	6	7	8	1	2	
D	4	5	6	7	8		1	2	
E	5	6	7	8			1	2	
F	6	7	8				1	2	
G	7	8					1	2	
H	9						N/A**		
I	10	4	5	6	7	8	1	2	
J	11	5	6	7	8		4	1	2
K	12	6	7	8			3	1	2
L	13	14	15				1	2	
M	14	15					1	2	
N	15						1	2	
O	16						1	2	
P	17	18					2		
Q	18						2		
R	19						N/A**		

*Only excess surface water not contained in preceding ponds will overflow into subsequent ponds

**The clean surface water run-off from Catchment H and Catchment R do not enter into the Site's surface water pond system

As discussed in Section 4.2.1.3, the CRC Area (Catchment J) has been split into sub-catchments to design the CRC internal drain network. Table 4-4 shows a summary of surface water movements through this one catchment and the corresponding drainage swales that surface water flows.

Table 4-5: Summary of Surface Water Movements for the CRC Area

Catchment	1 st Swale	2 nd Swale	3 rd Swale	4 th Swale	5 th Swale	6 th Swale	1 st Pond	2 nd Pond*	3 rd Pond*
J1	C1	C2	C3	C4	C5	C6	4	1	2
J2	C2	C3	C4	C5	C6		4	1	2
J3	C3	C4	C5	C6			4	1	2
J4	C4	C5	C6				4	1	2
J5	C5	C6					4	1	2
J6	C6						4	1	2
J7	C7						4	1	2
J8	C8	11					1	2	

*Only excess surface water not contained in preceding ponds will overflow into subsequent ponds

4.2.2.2 Manning's Coefficient

Manning's coefficient describes the roughness of the swale surface, which is determined by the material used to construct the swale. The following Manning's coefficients (n) have been considered for the swale system:

- Unlined earth channel: 0.022
- Gravelly earth channel: 0.025
- Concrete (Cement) finished: 0.012

4.2.2.3 Kerby-Kirpich Method

The swale system was designed using a Microsoft Excel algorithm modelled after the Kerby-Kirpich method to estimate the watershed time of concentration (t_c) for a rainfall event. The method requires adding the overland flow time (Kerby, t_{ov}) to the channel flow time (Kirpich, t_{ch}) in order to obtain the time of concentration. The following equations were utilised to determine the time of concentration:

$$t_c = t_{ov} + t_{ch} \quad \text{Eq. 1}$$

$$t_{ov} = 1.44 \times (L \times N)^{0.467} \times S^{-0.235} \quad \text{Eq. 2}$$

where

L = Length of overland flow

N = Kerby's roughness coefficient, 0.10

S = Slope gradient of the overland flow

$$t_{ch} = 0.0195 \times L^{0.770} \times S^{-0.385} \quad \text{Eq. 3}$$

where

L = Length of swale flow

S = Slope gradient of the swale flow

Where multiple catchments drain into a single swale, the minimum overland flow time was used as a conservative measure when modelling, increasing the effective rainfall intensity across all catchments that feed into that swale.

Once the time of concentration has been determined, then the theoretical peak flow rate through each swale can be calculated and compared to the maximum allowable flow rate through the swale as determined by its design geometry. If the maximum allowable flow rate is greater than the theoretical peak flow rate, then the design of swale has passed. The following equations were utilised to perform this design check:

$$Q_t = C \times I \times A \quad \text{Eq. 4}$$

where

Q_t = Theoretical peak flow rate, m³/hr

C = Runoff coefficient

I = Rainfall intensity at time of concentration, m/hr

A = Catchment surface area, m²

$$V = 1/n \times R_h^{2/3} \times S_s^{1/2} \quad \text{Eq. 5}$$

where

V = Velocity of surface water through the swale

n = Manning's coefficient

R_h = Hydraulic radius

S_s = Slope of swale

$$Q_a = V \times A_s \quad \text{Eq. 6}$$

where

Q_a = Maximum allowable flow rate, m³/hr

V = Velocity of surface water through the swale, m/hr

A_s = Cross-sectional area of the swale, m²

4.2.2.4 Swale System Design Summary

A summary of the swale system's design considerations is provided in Table 4-6. The lining system of each swale, which determines the Manning's coefficient, is discussed further in Section 4.3.1.1.

Table 4-6: Key Swale Design Considerations

Swale No.	Lining	Manning's Coefficient	Average Gradient
1	Earth channel - clean	0.022	0.006
2	Earth channel - clean	0.022	0.009
3	Earth channel - clean	0.022	0.012
4	Earth channel - gravelly	0.025	0.009
5	Earth channel - gravelly	0.025	0.009
6	Earth channel - gravelly	0.025	0.013
7	Earth channel - gravelly	0.025	0.005
8	Earth channel - gravelly	0.025	0.004
9	Earth channel - clean	0.022	0.007

Swale No.	Lining	Manning's Coefficient	Average Gradient
10	Earth channel - clean	0.022	0.006
11	Earth channel - clean	0.022	0.011
12	Earth channel - clean	0.022	0.005
13	Earth channel - clean	0.022	0.010
14	Earth channel - clean	0.022	0.005
15	Earth channel - gravelly	0.025	0.006
16	Earth channel - clean	0.022	0.007
17	Earth channel - clean	0.022	0.012
18	Earth channel - clean	0.022	0.007
19*	Earth channel - clean	0.022	0.006
C1	Earth channel - clean	0.022	0.007
C2	Earth channel - clean	0.022	0.004
C3	Earth channel - clean	0.022	0.006
C4	Earth channel - clean	0.022	0.006
C5	Earth channel - clean	0.022	0.020
C6	Earth channel - clean	0.022	0.003
C7	Earth channel - clean	0.022	0.008
C8	Earth channel - clean	0.022	0.015

**Swale 19 is an interim swale that will be decommissioned and reconstructed within the landfill development footprint as landfill operations progress until the surface water management system as shown in Drawing C-200 has been fully constructed and Swale 19 is no longer required.*

4.3 Surface Water Infrastructure Design

The following sections describe the modelling results and the finalised design characteristics of the key infrastructure proposed for the Site's surface water management strategy.

4.3.1 Swale System

Swales at the Site will have the general trapezoidal design shown in Figure 4-1.

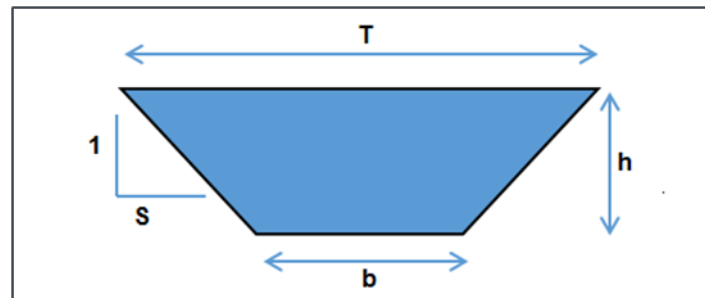


Figure 4-1: Swale Geometry

The designs of the swale system are presented in Table 4-7, with the dimensions corresponding to the swale shown in Figure 4-1. Drawing C-204, C-205 and C-206, attached in Appendix A, show illustrations of these swales.

Table 4-7: Swale Designs

Swale Design	Side Slope [S]	Bottom Width [b] (m)	Top Width [T] (m)	Height [h] (m)
1	3	1	5.2	0.7
2	3	1	7	1
3	3	2	6.2	0.7
4	3	3	10.2	1.2
5	3	3	11.4	1.4
6	3	6	15	1.5
7	3	6	16.2	1.7
8	3	10.5	22.5	2
9	3	3.5	6.5	0.5*
10	3	2	8	1
11	3	2	6.8	0.8
12	3	1	7	1
13	3	1	7	1
14	3	1	7.6	1.1
15	3	1	9.4	1.4
16	3	1	5.2	0.7
17	3	1	4.6	0.6
18	3	5	9.2	0.7
19**	3	11	14	0.5*
C1	4	0.3	6.22	0.74
C2	4	0.3	7.5	0.9
C3	4	0.3	9.1	1.1

Swale Design	Side Slope [S]	Bottom Width [b] (m)	Top Width [T] (m)	Height [h] (m)
C4	4	0.3	9.1	1.1
C5	4	0.3	6.46	0.77
C6	4	0.3	8.62	1.04
C7	4	0.3	8.02	0.965
C8	15 (Upslope) 4 (Downslope)	0.3	20	1.08

*Swale 9 and Swale 19 are interim swales that will divert clean surface water from Site's vegetated areas directly offsite. Due to the low environmental risk, a freeboard of 0.3m has been assumed for these swales to ensure that each swale is able to "daylight" into the existing ground levels offsite.

**Swale 19 is an interim swale that will be decommissioned and reconstructed within the landfill development footprint as landfill operations progress. The swale design will change with each reconstruction as Catchment R surface area decreases until Swale 19 is no longer required.

Using the swale designs in Table 4-7, each swale was assessed using the Kerby-Kirpich method outlined in Section 4.2.1.2. The results of this modelling and assessment are presented in Table 4-8. Appendix B displays the full spreadsheet used for the surface water modelling works.

Table 4-8: Swale Modelling Results

Swale	Q_t (m ³ /hr)	V (m/s)	Q_a (m ³ /hr)	Check $Q_t < Q_a$	Factor of Safety
1	486	0.94	1,085	PASS	2.2
2	3,318	1.92	8,656	PASS	2.6
3	348	1.44	2,697	PASS	7.8
4	8,787	2.30	29,507	PASS	3.4
5	19,171	2.73	50,326	PASS	2.6
6	32,628	3.72	120,678	PASS	3.7
7	45,310	2.65	109,775	PASS	2.4
8	62,348	2.77	224,003	PASS	3.6
9	1,716	1.15	3,405	PASS	2.0
10	3,919	1.75	11,029	PASS	2.8
11	2,151	1.72	5,399	PASS	2.5
12	2,663	1.46	6,551	PASS	2.5
13	1,252	1.997	8,988	PASS	7.2
14	3,463	1.65	9,972	PASS	2.9
15	5,971	2.01	24,108	PASS	4.0
16	124	1.00	1,149	PASS	9.2
17	92	0.91	425	PASS	4.6
18	1,820	1.19	4,782	PASS	2.6
19	4,488	1.13	9,426	PASS	2.1

Swale	Q_t (m ³ /hr)	V (m/s)	Q_a (m ³ /hr)	Check $Q_t < Q_a$	Factor of Safety
C1	65	0.58	135	PASS	2.1
C2	342	0.73	737	PASS	2.2
C3	990	1.09	1,982	PASS	2.0
C4	1,211	1.15	2,464	PASS	2.0
C5	541	1.50	1,189	PASS	2.2
C6	1,749	0.98	3,599	PASS	2.1
C7	543	1.04	1,096	PASS	2.0
C8	59	0.66	161	PASS	2.7

Note: Q_t is the theoretical peak flow rate that the swale would need to manage
 V is the maximum velocity of the water through the swale
 Q_a is the maximum allowable flow rate the swale can manage, excluding the freeboard

All swale designs are deemed to have passed. As a conservative measure, a factor of safety of 2.0 as a minimum was applied in addition to a freeboard of 0.5m for the main Site swale system (with the exception of Swale 9 and Swale 19 which have a freeboard of 0.3m due to the low environmental risk) and a minimum freeboard of 0.6m for the CRC internal drain network.

The swales are designed to accommodate flows generated during a 1-in-100-year storm event, with all swale designs determined as acceptable for managing surface water as it passes through the system.

4.3.1.1 Rock Armouring

To mitigate scouring and maintain the integrity of the swale system, rock armouring will be installed in strategic points across the system, specifically at high-throughput swales (greater than 2.0m/s velocity), in steeper swale sections, and at bends, junctions and intersection points. The methodology for determining the minimum stone diameter used in the rock armouring and thickness of the armouring itself is outlined in Austroads Guide to Road Design Part 5B: Drainage – Open Channels, Culverts and Floodways. The maximum velocity in each swale section has already been calculated using the Microsoft Excel algorithm described in Section 4.2.1.3. Table 4-9 outlines the proposed rock armouring details for the swale system, and the calculations are provided in Appendix B.

Table 4-9: Rock Armouring Details for Swale System

Location	Maximum Velocity (m/s)	Bed Velocity (m/s)	Minimum Stone Diameter (mm)	Design Stone Diameter (mm)	Layer Thickness (mm)
Swale 4	2.30	1.61	110	150	225
Swale 5	2.73	1.91	150	150	225
Swale 6	3.72	2.61	270	300	450
Swale 7	2.65	1.85	140	150	225
Swale 8	2.77	1.94	150	150	225

Location	Maximum Velocity (m/s)	Bed Velocity (m/s)	Minimum Stone Diameter (mm)	Design Stone Diameter (mm)	Layer Thickness (mm)
Swale 15	2.01	1.41	80	150	225

Notes:

The Maximum Velocity is the maximum velocity of the surface water through any part of the swale for the specified swale.

The Bed Velocity is 0.70 times the Velocity through the swale.

The Minimum Thickness of the rock armouring is 1.5 times the largest stone diameter.

It is proposed that rock armouring for all swales that require protection, with the exception of Swale 6, will be a well-graded material with a majority of the material having a diameter of 150mm. This layer should be 1.5 times the largest diameter of stone, which is expected to be approximately 225mm. The rock armouring for Swale 6 should be approximately 450mm thick and comprised of a well-graded material with 300mm diameter stones.

Beneath each rock-lined layer, a 150mm filter layer and geotextile layer should also be installed. The filter layer should consist of an intermediary material with a diameter between that of the rock armour and the underlying soil. Typically, smaller gravel or crushed aggregate is suitable for use in the filter layer, however sands, sandy gravels and gravelly sands may also be suitable. If the material does not feature any fine-grained particles, such as sands, the geotextile layer may not be required. Drawing C-204 and Drawing C-205 show the layout of the rock and filter layers for these swales.

4.3.1.2 Culverts

Sixteen (No. 16) reinforced-concrete box culverts are currently proposed as part of the surface water management scheme to allow for the transfer of surface water under the Site's road network. All culverts are shown in Drawing C-200, provided in Appendix A. Preliminary conceptual calculations have been undertaken for the sizing of the culverts for the Site's main perimeter swale system, which are provided in Appendix B.

Due to the intricate surface water management system aspects within the CRC area, a software program called Drains by Watercom was utilised for all culverts required within the CRC (Culverts 1-8, & 16). Drains is stormwater drainage system design and analysis software commonly used in civil/roadwork applications across Australia. An Initial Loss – Continuing Loss (IL-CL) hydrological model was used with input data sourced from the Australian Rainfall and Runoff (ARR) Datahub (pervious area initial loss of 20.4mm and pervious area continuing loss of 4.3mm/hr). Stormwater pits in sag locations have been assumed to be 50% blocked during a storm event. A climate change rainfall multiplier of 1.203 was applied, which effectively increases the rainfall intensities by 20.3%. A one-dimensional unsteady hydraulic model has been used in the flow calculations.

All other culverts outside of the CRC area (Culverts 9-15) were designed utilising Austroads Guide to Road Design - Part 5B: Drainage - Open Channels, Culverts and Floodways Design Manual. The methodology presented in Section 3 of this design manual, in conjunction with the box culvert nomographs contained in Appendix B, was applied since it supports the operation and management of a larger scale road network with higher potential flow volumes.

Each culvert, regardless of design methodology, has been designed with a factor of safety of a 1.2 as a minimum to account for partial blockages and silt build-ups, prior to maintenance/clearing. Each culvert is deemed fit-for-purpose for up to a 1-in-100 year storm event without any overflow/overtopping. The culvert schedule is provided in Drawing C-500, in Appendix A.

4.3.2 Surface Water Ponds

The surface water management pond system will consist of one collection pond (Pond 1), one infiltration pond (Pond 2) and two retentions ponds: CRC retention pond (Pond 3) and Greenwaste retention pond (Pond 4). Table 4-10 outlines the key design criteria for each pond.

Table 4-10: Summary of Surface Water Pond Design Criteria

Pond	Approx. Dimensions [LxWxh] (m)	Side Slopes (V:H)	Operational Depth [d] (m)	Operational Capacity (m ³)	24hr Infiltration Rate Capability (m ³)	Required Capacity for 1:20yr, 24hr (m ³)
Pond 1	136 x 155 x 5.9	1:3	3.8	55,201	0	59,516*
Pond 2	136 x 156 x 4.5	1:4	2.0	23,392	2,237	15,950**
Pond 3	45 x 186 x 4.4	1:3 / 1:4	3.6	12,973	0	12,939
Pond 4	50 x 92 x 1.8	1:3 / 1:4	1.3	5,220	0	N/A

*Minor overflow into Pond 2

**Inclusive of the overflow volume from Pond 1

Ponds 1, 2 and 3 have been designed to handle a 1-in-20-year, 24-hour storm event as part of an integrated surface water management system. Ponds 3 and 4 have been designed to overflow into Pond 1 during extreme rainfall events. Pond 1 has been designed to overflow into Pond 2 in larger storm events. The outlet from Pond 2 is the primary off-site discharge point for the Site.

Pond 1 will be lined with an HDPE geomembrane, and to mitigate wind uplift, permanent surcharge will be installed along the perimeter toe of the pond. Cargo netting /roped egress points will be installed on the interior face of Pond 1 and will be enclosed by a 1.8m high chain-link fence as a health and safety measure.

Pond 2 is an infiltration pond that will be unlined and uncompacted to promote infiltration rates. While the pond batters will not be subject to overland flow, the slope gradient will be at a reduced 1:4 due to the volume and potential velocity of the surface water runoff that will enter into the pond. The pond will be constructed with in-situ soil materials that have a moderate hydraulic conductivity.

Ponds 1 and 2 have been designed to hold a 1-in-20-year, 24hr storm event within its operational capacity (maintaining +1m freeboard) as one system. Any greater storm event will result in a controlled release into the environment via Pond 2's drive through spillway.

Ponds 3 and 4 will be earth lined with a compacted 300mm subgrade layer. The retention ponds are intended to evaporate the surface water run-off from small rainfall events, and delay surface water run-off from extreme rainfall events from being transferred into the collection pond (Pond 1). To mitigate erosion issues, any batters that will be subject to overland flow will have a reduced slope gradient of 1:4 (V:H). All other pond batters will have a 1:3 (V:H) slope gradient. To mitigate any environmental risk from the runoff within the Greenwaste Hardstand Area, Pond 3 has been designed to hold a 1-in-20-year, 24hr storm event within its operational capacity (maintaining a +500mm freeboard). Due to the low risk from runoff within the CRC area, there is no required capacity for Pond 4. Large storm events within the catchments for Ponds 3 and 4 will result in a controlled release into the Site's main perimeter swale system via a box culvert system.

4.4 Construction Timeline

The Regional Resource Recovery Park development will be constructed in phases and the SWMS will be constructed progressively as required. During Phase 1 development, the proposed surface water pond system and all surface water swales and culverts needed for the infrastructure built during Phase 1 will be constructed. The surface water swales will be extended along with any corresponding culverts as additional construction phases are undertaken until all of the SWMS is complete as per Drawing C-200.

4.5 Operational Management and Monitoring Strategy

To ensure environmental impacts are mitigated and the facility meets licence requirements, appropriate operational management, especially for surface water, must be undertaken. Regular site maintenance and repairs of drains and other associated surface water management infrastructure will be undertaken. Site staff will particularly inspect the system for evidence of contamination, excessive sedimentation and structural integrity of the system on a regular basis. Table 4-11 shows the recommended monitoring and maintenance schedule to preserve the integrity of the SWMS. Further details of the operational management strategy are provided in the Site's Operational and Environmental Management Plan (OEMP).

Table 4-11: Monitoring and Maintenance Schedule for the SWMS

Activity	Frequency
Integrity of each surface water pond	Weekly
Integrity of all surface water drains, bunding and channels	Weekly or following heavy rainfall events
Integrity of all rock armouring	Monthly or following heavy rainfall events
Integrity of all overflow points and outlets	Monthly or daily during heavy rainfall events

In addition to the infrastructure of the SWMS, water within the system should also be monitored to ensure compliance with the Site licence and to identify any environmental issues that may impact surface waters. Surface water monitoring will be defined within the Site licence, and monitoring points and regimes for proposed infrastructure will be developed as it is constructed. It is anticipated that the inlets and outlets for the surface water collection and infiltration ponds (Ponds 1 and 2) will be designated as sampling points for monitoring and testing for potential contaminants.

5 Local Flood Risk Assessment

5.1 Offsite Impacts

The Flood Modelling Study undertaken in February 2021 concluded that the Site could be potentially affected by flooding in the surrounding areas. To protect the Site from such events, it is proposed that a levee bund system will be constructed along the northern, eastern and southern boundary of the Site, which will feed into a 20m wide swale. This proposed system is intended to divert these offsite floodwaters around the Site.

The levee will be constructed from compacted soil excavated from the Site, and be compacted to a minimum of 95% Maximum Modified Dry Density (MMDD). Table 5-1 provides a summary of the key design characteristics of the proposed levee bund system.

Table 5-1: Key Design Characteristics of the Levee Bund System

Side Slope (V:H)	Maximum Bottom Width (m)	Top Width (m)	Length (m)	Height (m)
1:4	12.5	2	2,242 (Primary) 650 (Secondary)	1.3

Where the internal edge of the 20m wide swale is likely to be affected by flooding, rock armouring will be installed to protect the batter from erosion and scouring caused by the regional flooding events. Rock armouring will be utilised on the outside edge of the primary levee bund for scour prevention and erosion resistance from regional flooding events.

According to the Flood Study, the 20m wide swale would experience a typical flow velocity of less than 2m/s at less than 1.5m depths even during significant weather events. The methodology for determining the minimum stone diameter used in the rock armouring and thickness of the armouring itself is outlined in Austroads Guide to Road Design Part 5B: Drainage – Open Channels, Culverts and Floodways, specifically Figure 2.22. Using the study's flow velocity, Table 5-2 provides a summary of the minimum rock armouring requirements for the 20m wide swale.

Table 5-2: Minimum Rock Armouring Details for Levee Bund System

Bed Velocity (m/s)	D ₅₀ Stone Diameter (mm)	Minimum Thickness (mm)
0.50	75	112.5

The minimum thickness of the rock armouring for the levee bund system is 112.5mm, using a minimum stone size of 75mm in diameter.

In order to protect the integrity of the 20m wide swale and allow for regional flood events above the modelled scenario, a Factor of Safety of 1.25 has been applied to the flow velocity. It is therefore proposed that rock armouring installed along the southern end of the 20m wide swale will consist of a separation geotextile, 150mm granular filter layer and 225mm minimum thickness of well graded riprap (125mm maximum stone diameter), placed to a height of up to 1.3m. Typical levee bund system construction details are shown on Drawing C-207.

5.2 Onsite Impacts – Design Review

The finalised surface water management system (SWMS) design will be assessed using the regional flood model to confirm that there are no onsite flooding impacts on the Site's proposed infrastructure

and to check that the surface water management system can successfully mitigate any flooding within the Site during a nominated flood event.

The proposed SWMS design will be assessed against a number of flood events, including 1-in-100 year and 1-in-500 year for durations of 24 hours. The results and reporting will be provided when available.

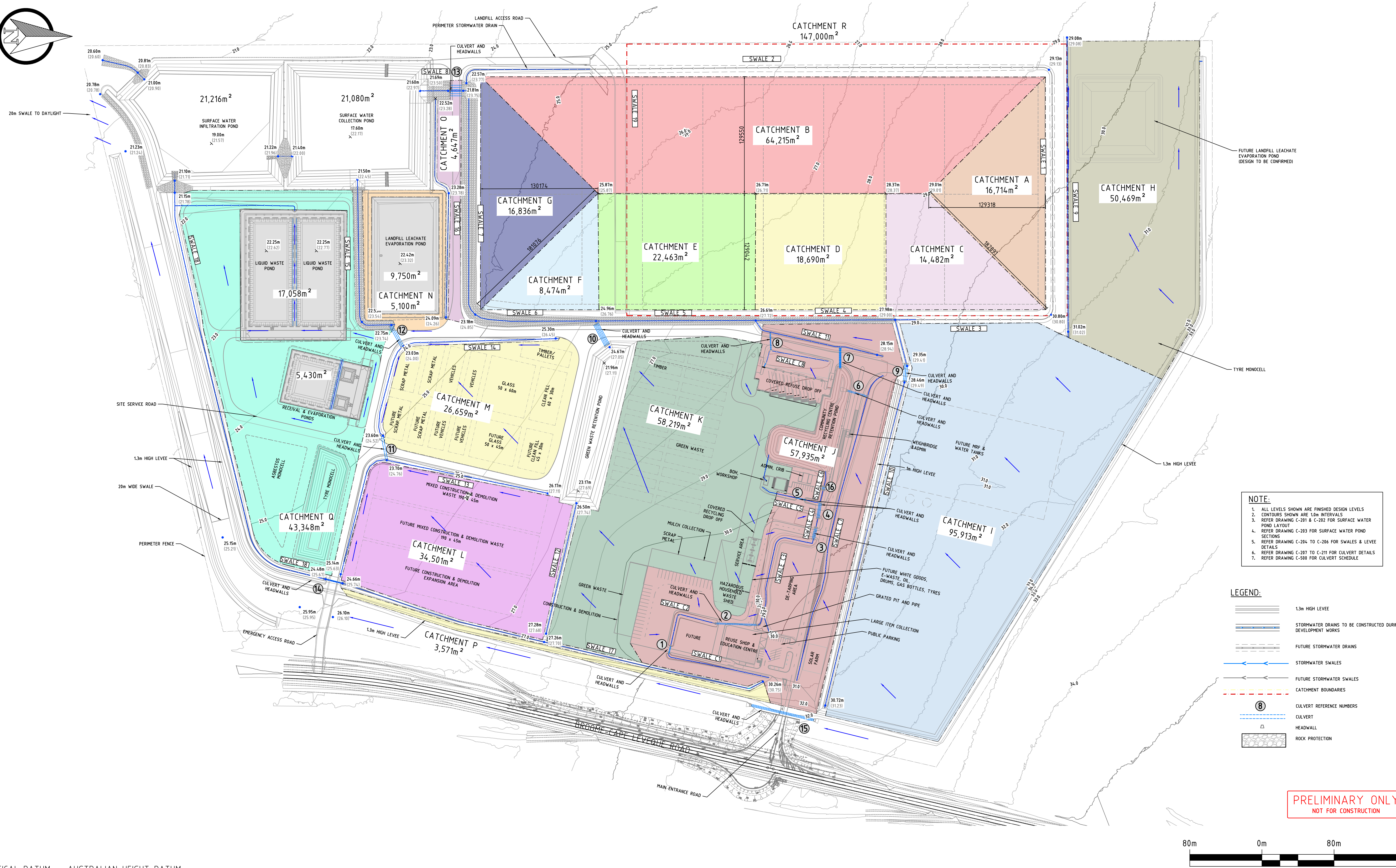
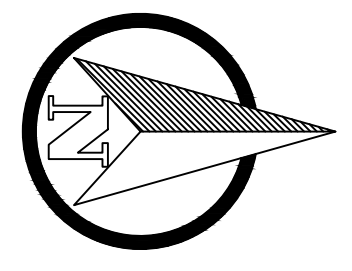
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APPENDIX A

Drawings

Drawing C-200: Surface Water Management System Layout Plan
Drawing C-201: Surface Water Collection & Infiltration Ponds Layout
Drawing C-202: Greenwaste & Community Recycling Centre Ponds Layout
Drawing C-203: Surface Water Pond System Sections
Drawing C-204: Typical Swale Sections Sheet 1 of 3
Drawing C-205: Typical Swale Sections Sheet 2 of 3
Drawing C-206: Typical Swale Sections Sheet 3 of 3
Drawing C-207: Typical Levee Sections
Drawing C-208: Culvert Details Sheet 1 of 2
Drawing C-209: Culvert Details Sheet 2 of 2
Drawing C-210: Typical Drive Through Swale Details
Drawing C-213: Surface Water & Retention Ponds Long Sections
Drawing C-500: Culvert Schedule

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FILENAME: \\SERVER\TALIS\SECTIONS\CIVIL\PROJECTS\TC201049 - BROOME RRRP DETAILED DESIGN\DRAWINGS\1. DRAWINGS\TC201049 - SW_SET.DWG



NOTE:
1. ALL LEVELS SHOWN ARE FINISHED DESIGN LEVELS
2. CONTOURS SHOWN ARE 1.0m INTERVALS
3. REFER DRAWING C-201 & C-202 FOR SURFACE WATER POND LAYOUT
4. REFER DRAWING C-203 FOR SURFACE WATER POND SECTIONS
5. REFER DRAWING C-204 TO C-206 FOR SWALES & LEVEE DETAILS
6. REFER DRAWING C-207 TO C-211 FOR CULVERT DETAILS
7. REFER DRAWING C-500 FOR CULVERT SCHEDULE

- LEGEND:**
- 1.3m HIGH LEVEE
 - STORMWATER DRAINS TO BE CONSTRUCTED DURING INITIAL DEVELOPMENT WORKS
 - FUTURE STORMWATER DRAINS
 - STORMWATER SWALES
 - FUTURE STORMWATER SWALES
 - CATCHMENT BOUNDARIES
 - CULVERT REFERENCE NUMBERS
 - CULVERT
 - HEADWALL
 - ROCK PROTECTION

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B	02.09.2022	AB	SH	DETAIL DESIGN	SH
A	25.05.2022	YJ	AB	CONCEPT DESIGN ISSUE	SH

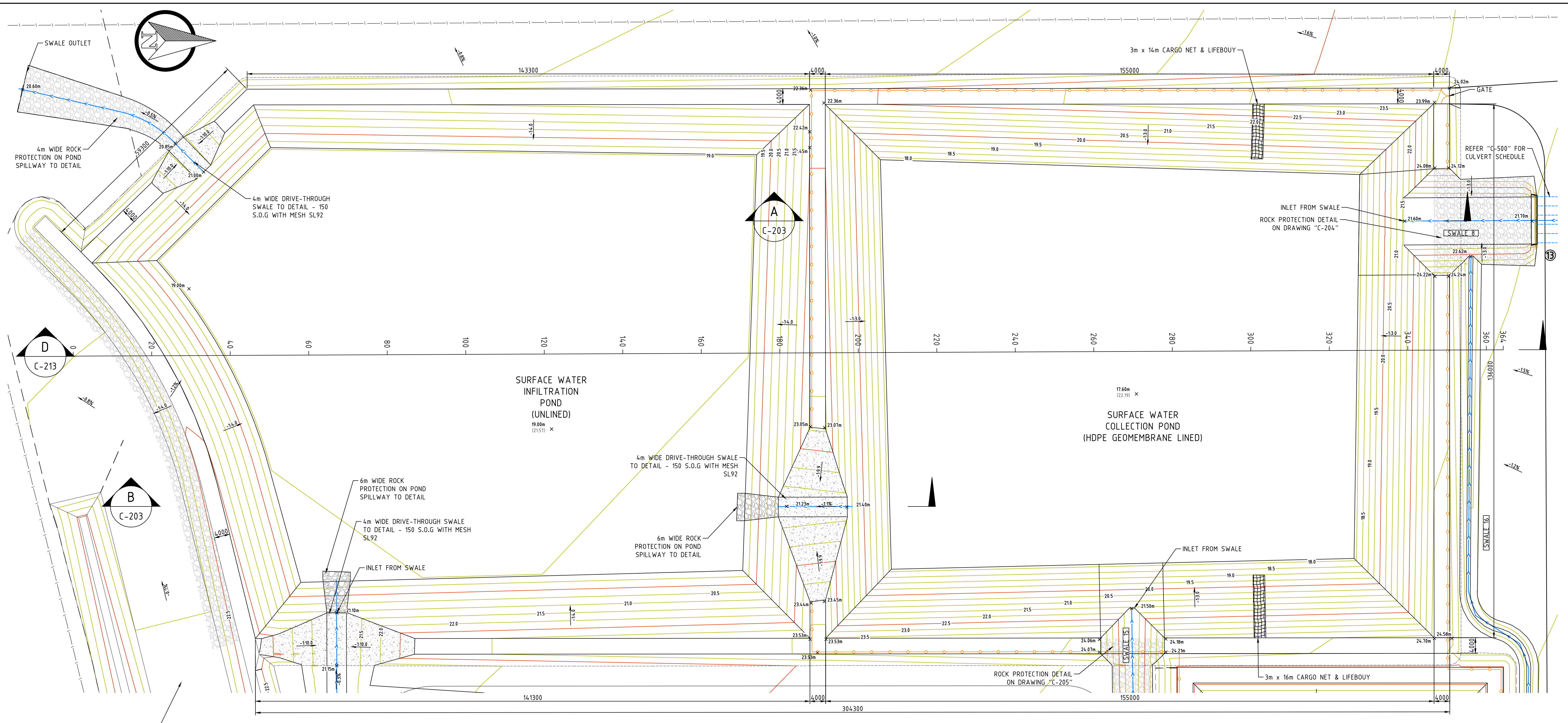
Project: **BROOME RRRP SITE CONSTRUCTION**

Title: **SURFACE WATER MANAGEMENT SYSTEM LAYOUT PLAN**

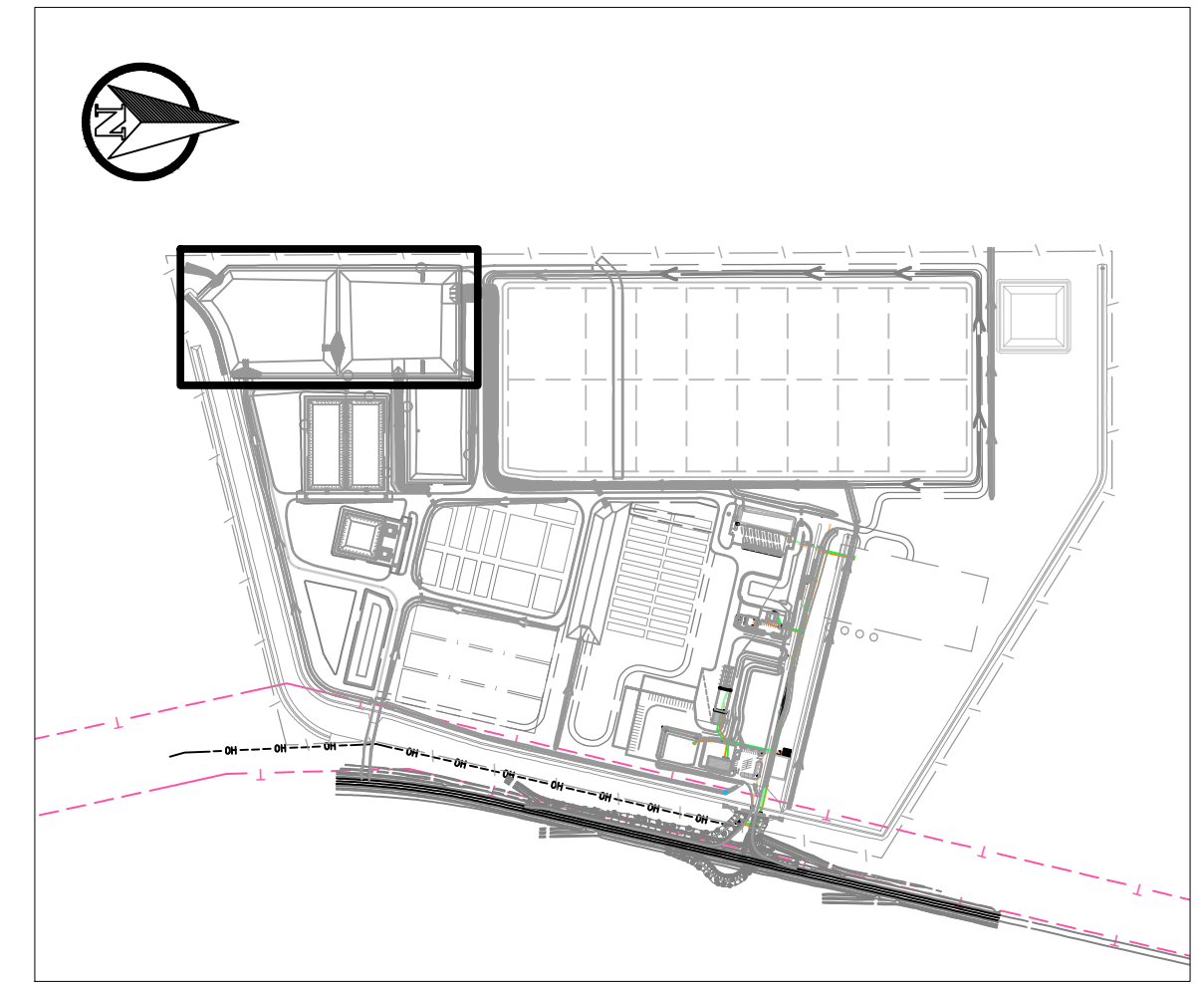
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Filename: TC21049 - SW_SET.DWG			

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PLAN - SURFACE WATER POND LAYOUT
SCALE: 1:500



KEYPLAN
SCALE: 1:10000

- LEGEND:
- DESIGN CONTOURS
 - PAVEMENT TYPE 4: CONCRETE
 - PAVEMENT TYPE 5: COMPACTED PINDAN
 - ROCK PROTECTION
 - SECURITY FENCE
 - PERIMETER FENCE
 - DRAINAGE PATHS
 - CULVERT REFERENCE NUMBER
 - CARGO NET
 - GATE
 - CULVERT
 - HEADWALL

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C	30.09.2022	YJ	AB	DETAILED DESIGN ISSUE WITH CLIENT COMMENTS	SH
B	02.09.2022	AB	SH	DETAIL DESIGN	SH
A	25.05.2022	YJ	AB	CONCEPT DESIGN ISSUE	SH

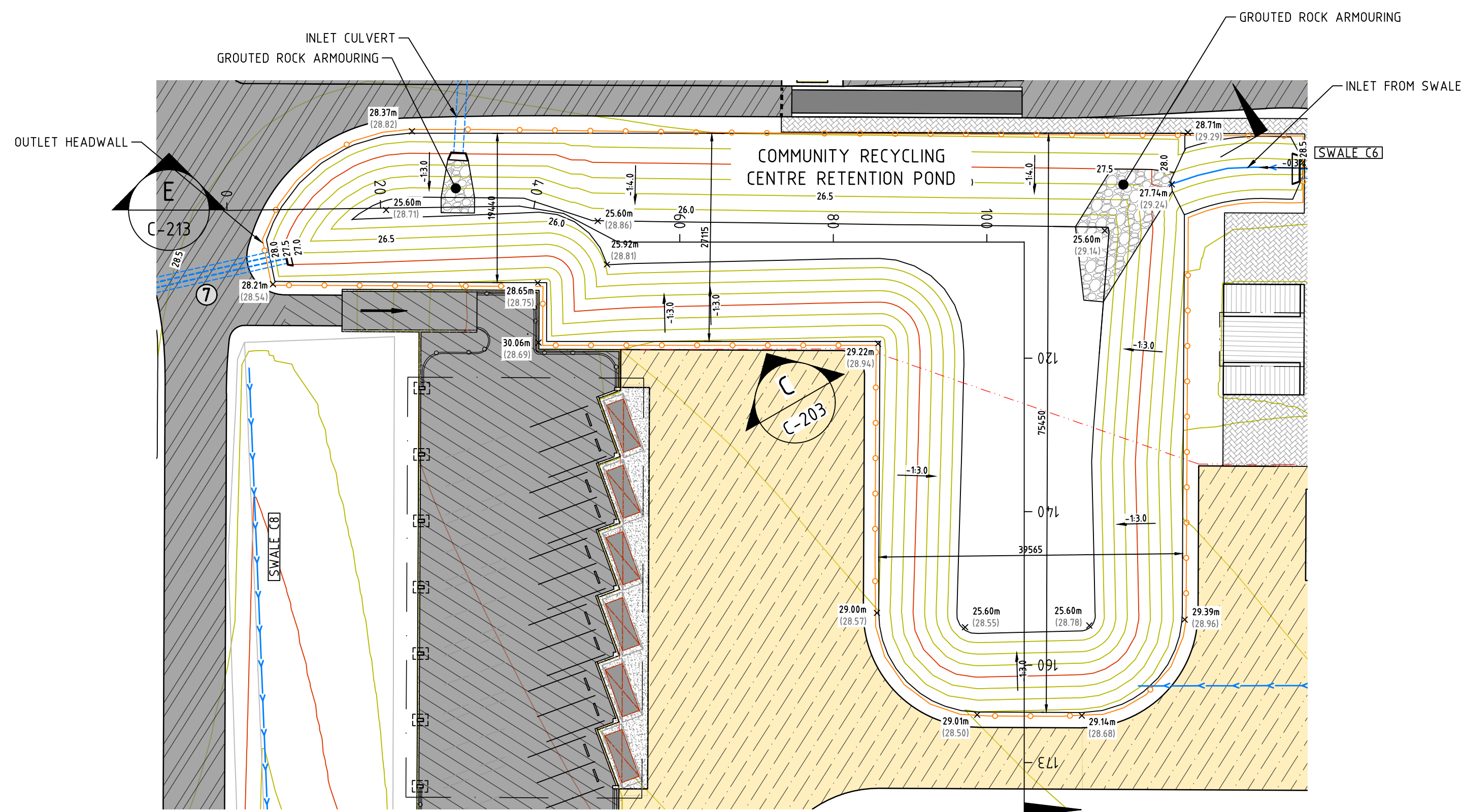
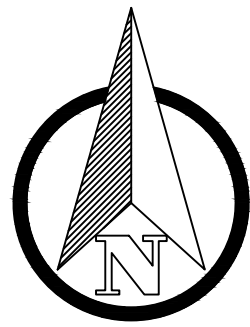
Project:

**BROOME RRRP SITE
CONSTRUCTION**

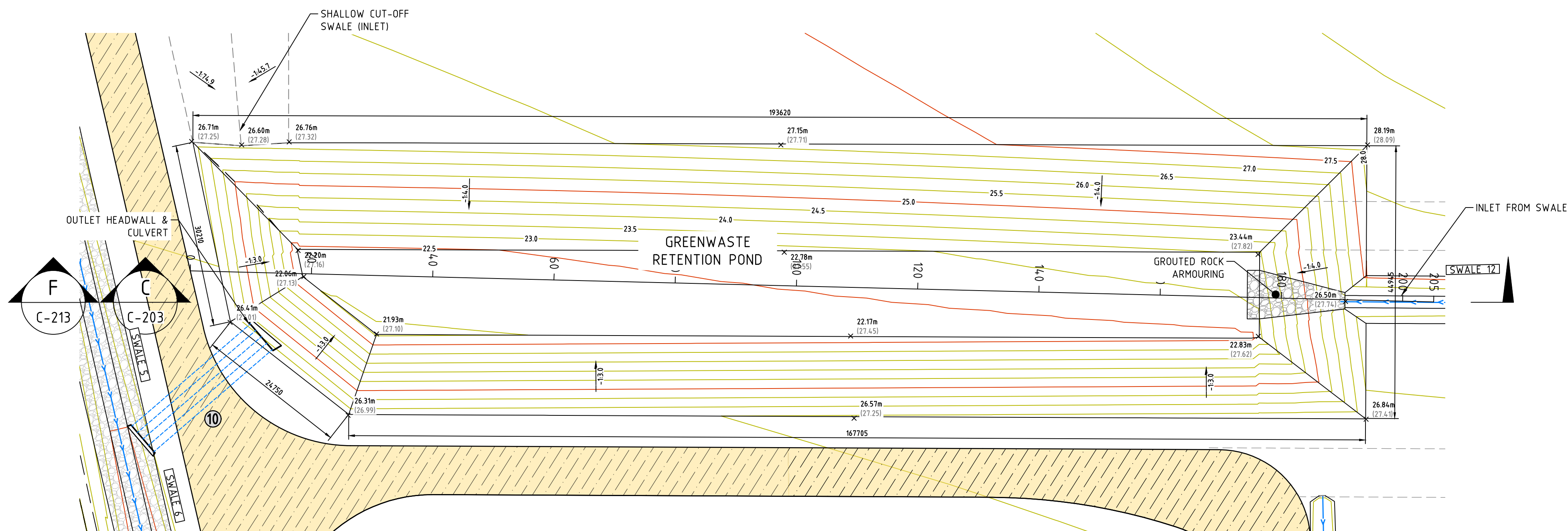
Title:

**SURFACE WATER COLLECTION
& INFILTRATION PONDS
LAYOUT**

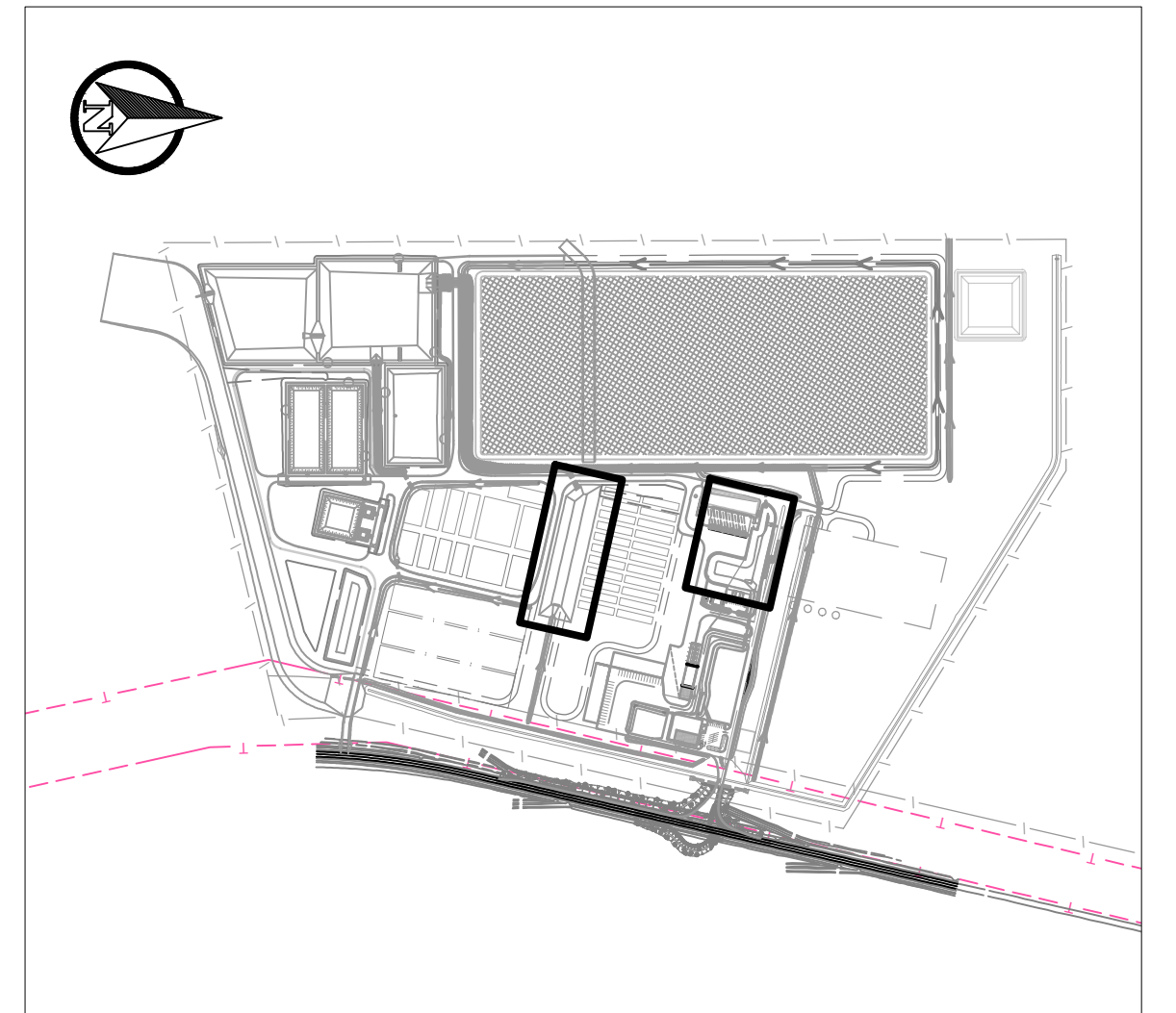
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		Approved: SH	
Job No: TC21049		Drg. No: C-201	
		Rev: <div><div></div>D</div>	
Filename: TC21049 - SW_SET.DWG			



PLAN - COMMUNITY RECYCLING CENTRE RETENTION POND
SCALE: 1:500



PLAN - GREENWASTE RETENTION POND
SCALE: 1:500

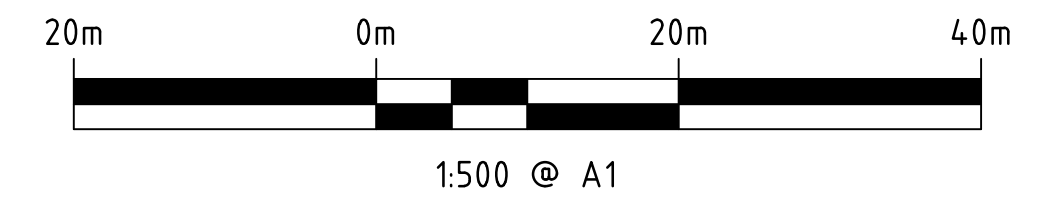


KEYPLAN
SCALE: 1:10000

LEGEND:

- DESIGN CONTOURS
- PAVEMENT TYPE 1: ASPHALT
- PAVEMENT TYPE 2: COMPACTED GRAVEL
- PAVEMENT TYPE 3: ASPHALT
- ROCK PROTECTION
- BRICK PAVING
- HAND RAIL
- BARRIER
- DRAINAGE PATHS
- CULVERT REFERENCE NUMBER
- CANOPY OVER
- HEADWALL
- CULVERT

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No.	Date	By	Check	Amendment / Issue	App.

Project:

**BROOME RRRP SITE
CONSTRUCTION**

Title:

**GREEN WASTE & COMMUNITY
RECYCLING CENTRE
RETENTION PONDS LAYOUT**

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		Approved: SH	
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TC21049		C-202	
		Rev: 	
Filename: TC21049 - SW_SET.DWG			

APPENDIX B

Surface Water Modelling Results

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Table 1.1: Site Details

Site Location:	Broome Landfill
Latitude:	-17.8375
Longitude:	122.2625

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%	0.5%	0.2%	0.1%	0.05%
Hours	BoM	1:1	1:2	1:5	1:10	1:20	1:50	1:100	1:200	1:500	1:1000	1:2000
0.02	1 min	2.56	2.91	3.94	4.58	5.17	5.9	6.42	7.41	8.93	10.2	11.6
0.03	2 min	4.28	4.92	6.77	7.88	8.87	10	10.8	12.5	15	17	19.2
0.05	3 min	6.1	7	9.6	11.2	12.6	14.3	15.5	17.8	21.4	24.4	27.6
0.07	4 min	7.87	9	12.3	14.3	16.1	18.4	19.9	23	27.6	31.5	35.7
0.08	5 min	9.54	10.9	14.8	17.2	19.4	22.2	24.1	27.8	33.4	38.1	43.3
0.17	10 min	16.4	18.6	25	29.1	32.8	37.5	40.9	47.2	56.9	65.1	74.1
0.25	15 min	21.4	24.2	32.6	37.8	42.7	48.7	53.1	61.3	73.9	84.6	96.3
0.33	20 min	25.3	28.6	38.5	44.7	50.4	57.5	62.6	72.3	87.2	99.7	114
0.42	25 min	28.3	32.1	43.3	50.3	56.8	64.7	70.5	81.4	98	112	128
0.50	30 min	30.8	35	47.3	55	62.1	70.9	77.1	89.1	107	123	139
0.75	45 min	36.2	41.3	56.5	66	74.7	85.4	93	107	129	148	168
1.00	1 hour	39.8	45.7	63.1	74.1	84.1	96.5	105	121	146	167	190
1.50	1.5 hour	44.7	51.7	72.7	86	98.3	114	125	144	173	197	224
2.00	2 hour	48	56	79.8	95	109	127	140	162	195	222	253
3.00	3 hour	52.7	62	90.3	109	127	149	166	192	231	264	300
4.50	4.5 hour	57.7	68.4	102	125	147	176	198	229	275	315	359
6.00	6 hour	61.7	73.5	111	137	163	198	225	260	313	359	408
9.00	9 hour	68.2	81.8	126	158	190	235	270	312	377	432	492
12.00	12 hour	73.7	88.7	139	175	213	265	308	356	430	492	561
18.00	18 hour	83.1	100	159	203	250	315	369	426	514	588	670
24.00	24 hour	91.1	110	176	226	280	354	416	481	579	662	753
30.00	30 hour	98	118	190	245	304	386	455	529	640	735	838
36.00	36 hour	104	126	202	261	325	413	486	567	685	786	897
48.00	48 hour	115	139	223	288	359	455	534	620	746	852	967
72.00	72 hour	130	158	252	326	406	508	592	681	809	913	1030
96.00	96 hour	141	171	272	350	434	539	623	712	837	939	1050
120.00	120 hour	149	180	286	366	451	556	639	728	852	954	1060
144.00	144 hour	154	186	295	375	460	564	646	737	859	965	1070
168.00	168 hour	157	190	300	381	465	567	648	742	863	975	1080

Table 2.1 Catchment Summary

Catchments	Area (m ²)	Catchment Surface	Comments	Runoff Coefficient	1:20 Year Runoff
Catchment A	16,714	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Landfill	0.5	2,340
Catchment B	64,215	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Landfill	0.5	8,990
Catchment C	14,482	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Landfill	0.5	2,027
Catchment D	18,690	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Landfill	0.5	2,617
Catchment E	22,463	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Landfill	0.5	3,145
Catchment F	8,474	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Landfill	0.5	1,186
Catchment G	16,836	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Landfill	0.5	2,357
Catchment H	50,469	Lawns, Clay soil, steep, > 7%	Area directly north of the landfill; to be diverted offsite directly	0.35	4,946
Catchment I	95,913	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Northwestern corner of the Site and CRC	0.5	13,428
Catchment J	57,935	Industrial, Light Areas	CRC Area	0.7	11,355
Catchment K	58,219	Industrial, Light Areas	Greenwaste Hardstand and CRC Service Area. Overflow directed to storage pond	0.65	10,596
Catchment L	34,501	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	C&D laydown area; to drain to storage pond	0.5	4,830
Catchment M	26,659	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Bulky items laydown area; to drain to storage pond	0.5	3,732
Catchment N	5,100	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Area around the leachate pond; to drain to storage pond	0.5	714
Catchment O	4,647	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Area between the storage pond and landfill; to drain to storage pond	0.5	651
Catchment P	3,571	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Run-off from Levee; to drain directly offsite	0.5	500
Catchment Q	43,348	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%	Southern section of Site; to drain directly offsite	0.5	6,069
Catchment R	143,500	Lawns, Clay soil, steep, > 7%	Temporary drain within landfill footprint	0.35	14,063

Total Area (m²) 685,736

Composite Runoff Coefficient 0.487

Table 3.1 Pond Design Events

Minimum Design Event	
Design Period	1:20
Storm Duration	24 hour
Total Rainfall (mm)	280
Maximum Design Event	
Design Period	
Storm Duration	
Total Rainfall (mm)	0

Table 3.2 SW Movement into Ponds

	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6
Catchment A	YES					
Catchment B	YES					
Catchment C	YES					
Catchment D	YES					
Catchment E	YES					
Catchment F	YES					
Catchment G	YES					
Catchment H						
Catchment I	YES					
Catchment J				YES		
Catchment K			YES			
Catchment L	YES					
Catchment M	YES					
Catchment N	YES					
Catchment O	YES					
Catchment P		YES				
Catchment Q		YES				

Table 3.3 Pond Design Details

Aspect	Pond 1 - Storage	Pond 2 - Infiltration	Pond 3 - GW Pond	Pond 4 - CRC Pond
Width [W] (m)	136	136	45	50
Length [L] (m)	155	156	186	92
Height [h] (m)	5.9	4.5	4.4	1.8
Operational depth [d] (m)	3.8	2.0	3.6	1.3
Side Slope (1:V)	3	4	4	3
Freeboard (m)	2.1	2.5	0.8	0.5
Base Width (m)	100.42	99.76	9.8	39.2
Base Length (m)	119.42	119.76	150.8	81.2
Operational Width (m)	123.22	115.76	38.84	47
Operational Length (m)	142.22	135.76	179.84	89
Pond Catchment Area (m ²)	21,080	21,216	8,370	4,600
Calculated Operational Capacity (m ³)	55,752	27,578	14,850	6,611
Design Operational Capacity (m ³)	55,200	36,024	12,973	5,220
Total Capacity (m ³)	96,808	74,123	20,757	6,970

Table 3.4 Pond Capacity Checks

Aspect	Pond 1 - Storage	Pond 2 - Infiltration	Pond 3 - GW Pond	Pond 4 - CRC Pond
Catchment Area (m ²)	328,694	46,919	58,219	57,935
Runoff Coefficient	0.50	0.50	0.65	0.70
Infiltration	NO	YES	NO	NO
Outflow Volume for Storm Duration	0	2,150	0	0
Inflow Volume for Storm Duration	59,343	16,652	12,939	12,643
Minimum Storage Requirement (m ³)	59,516	31,327	12,939	12,817
Storage Check	Overflow	PASS	PASS	Overflow

NOTES:

- Volume of Pond: $V = (h/6) * ((LxW) + ((W+W_b) * (LxL_b)) + (L_b * W_b))$
- Passing Minimum Storage Requirement means Operational Capacity is not exceeded during minimum storm event
- Passing Maximum Storage Requirement means Total Capacity is not exceeded during maximum storm event
- Maximum storage check can be failed provided there is an allowable discharge point

Infiltration Outflow				
	Pond 1	Pond 2		
Length		99.76		
Width		119.76		
A		11947.2576		
P		439.04		
d		2.265		
Soil Type		Medium Clay		
kh	0	3.6	0	0
U	0	2	0	0
D		24		
O	0	2,150	0	0

$$\text{Outflow Volume} = \frac{\left[A_{\text{inf}} + \left(\frac{Pd}{2} \right) \right] U k_h D}{1000}$$

Where:

k_h = point saturated hydraulic conductivity (mm/hr)

A_{inf} = infiltration area (m²)

P = perimeter length of the infiltration area (m)

d = depth of the infiltration system (m)

U = point soil hydraulic conductivity moderating factor

D = storm duration (hours)

Approximation of the required storage volume of an infiltration system can be computed as follows:

$$\text{Required Storage} = \text{Inflow Volume} - \text{Outflow Volume}$$

Table 4.1 Swale Design Characteristics and Modelling Results

Aspect	Swale 1	Swale 2	Swale 3	Swale 4	Swale 5	Swale 6	Swale 7	Swale 8	Swale 9	Swale 10	Swale 11	Swale 12	Swale 13	Swale 14	Swale 15	Swale 16	Swale 17
Swale Flow Timing																	
Flow Length (m)	271	657	177	152	176	135	251	49	327	443	145	149	150	107	195	240	481
ΔRL (m/AHD)	1.58	5.85	2.06	1.33	1.65	1.78	1.37	0.2	2.2	2.78	1.54	0.76	1.44	0.57	1.25	1.57	5.6
Slope	0.006	0.009	0.012	0.009	0.009	0.013	0.005	0.004	0.007	0.006	0.011	0.005	0.010	0.005	0.006	0.007	0.012
Swale Material	Earth channel - clean	Earth channel - clean	Earth channel - clean	Earth channel - gravelly	Earth channel - gravelly	Earth channel - gravelly	Earth channel - gravelly	Earth channel - gravelly	Earth channel - gravelly	Earth channel - clean	Earth channel - clean	Earth channel - clean	Earth channel - clean	Earth channel - clean	Earth channel - gravelly	Earth channel - clean	Earth channel - clean
Manning's Coefficient	0.022	0.022	0.022	0.025	0.025	0.025	0.025	0.025	0.022	0.022	0.022	0.022	0.022	0.022	0.025	0.022	0.022
Time of Conc., Tc-h	10.559	17.741	5.829	5.786	6.308	4.510	10.210	3.246	11.548	14.986	5.179	7.014	5.527	5.345	7.902	9.199	12.585
Combined Flows																	
Min. Total Concentration Time, Tc (min)	17.52	24.70	12.77	12.72	13.25	11.45	17.15	10.18	49.92	33.93	14.99	24.98	26.53	23.10	17.15	15.20	14.22
Intensity for Min. Tc (mm/hr)	58.13	69.99	48.03	47.93	49.16	44.76	57.42	41.37	97.16	81.73	53.05	70.38	72.56	67.60	57.43	53.48	51.38
Flow Rate for Min. Tc (m³/hr)	486	2,832	348	3,093	5,719	7,090	9,578	8,576	1,716	3,919	2,151	2,663	1,252	2,067	1,903	124	92
Peak Flow Rate for Max. Tc (m³/hr)	486	3,318	348	7,360	15,230	24,984	34,562	46,456	1,716	3,919	2,151	2,663	1,252	3,319	5,221	124	92
Max. Total Concentration Time, Tc (min)	17.52	24.70	12.77	24.73	25.25	23.46	29.16	22.19	49.92	33.93	14.99	24.98	26.53	26.35	28.91	15.20	14.22
Intensity for Max. Tc (mm/hr)	58.13	69.99	48.03	70.03	70.77	68.14	76.02	66.19	97.16	81.73	53.05	70.38	72.56	72.31	75.70	53.48	51.38
Flow Rate for Max. Tc (m³/hr)	486	2,832	348	4,520	8,233	10,794	12,682	13,720	1,716	3,919	2,151	2,663	1,252	2,211	2,508	124	92
Peak Flow Rate for Max. Tc (m³/hr)	486	3,318	348	8,787	19,171	32,628	45,310	62,348	1,716	3,919	2,151	2,663	1,252	3,463	5,971	124	92
Max Peak Flow Rate for Tc (m³/hr)	486	3,318	348	8,787	19,171	32,628	45,310	62,348	1,716	3,919	2,151	2,663	1,252	3,463	5,971	124	92
Comments																	
Swale Geometry																	
Swale Bottom Width (m)	1	1	2	3	3	6	6	10.5	3.5	2	2	1	1	1	1	1	1
Depth of Flow w/o Freeboard (m)	0.2	0.5	0.2	0.7	0.9	1.0	1.2	1.5	0.2	0.5	0.3	0.5	0.5	0.6	0.9	0.2	0.1
LHS Slope (1:V)	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
RHS Slope (1:V)	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Freeboard (m)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Freeboard included?	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Design Depth of Swale (m)	0.2	0.5	0.2	0.7	0.9	1	1.2	1.5	0.2	0.5	0.3	0.5	0.5	0.6	0.9	0.2	0.1
Top width, T (m)	2.2	4	3.2	7.2	8.4	12	13.2	19.5	4.7	5	3.8	4	4	4.6	6.4	2.2	1.6
Swale Area, As (m²)	0.320	1.250	0.520	3.570	5.130	9.000	11.520	22.500	0.820	1.750	0.870	1.250	1.250	1.680	3.330	0.320	0.130
Wetted Perimeter, Pw (m)	2.26	4.16	3.26	7.43	8.69	12.32	13.59	19.99	4.76	5.16	3.90	4.16	4.16	4.79	6.69	2.26	1.63
Hydraulic Radius, Rh (m)	0.14	0.30	0.16	0.48	0.59	0.73	0.85	1.13	0.17	0.34	0.22	0.30	0.30	0.35	0.50	0.14	0.08
Hydraulic Depth, Dh (m)	0.15	0.31	0.16	0.50	0.61	0.75	0.87	1.15	0.17	0.35	0.23	0.31	0.31	0.37	0.52	0.15	0.08
Flow																	
Manning's coefficient, n	0.022	0.022	0.022	0.025	0.025	0.025	0.025	0.025	0.022	0.022	0.022	0.022	0.022	0.022	0.025	0.022	0.022
Maximum Velocity, V (m/s)	0.94	1.92	1.44	2.30	2.73	3.72	2.65	2.77	1.15	1.75	1.72	1.46	2.00	1.65	2.01	1.00	0.91
Minimum Flow, Q (m³/s)	0.30	2.40	0.75	8.20	13.98	33.52	30.49	62.22	0.95	3.06	1.50	1.82	2.50	2.77	6.70	0.32	0.12
Minimum Flow, Q (m³/h)	1.085	8.656	2.697	29.507	50.326	120.678	109.775	224.003	3.405	11.029	5.399	6.551	8.988	9.972	24.108	1.149	425
Factor of Safety	2.2	2.6	7.8	3.4	2.6	3.7	2.4	3.6	2.0	2.8	2.5	2.5	7.2	2.9	4.0	9.2	4.6

Table 4.2 Swale Design Event & IFD Coefficients

Design Period	1:100
C _p	1.859921
C _i	0.578334
C ₂	0.358117
C ₃	-0.17415
C ₄	0.03223
C ₅	-0.00266
C ₆	0.000806

NOTES:

Formulae are from:

http://onlinemanuals.txdot.gov/txdotmanuals/hyd/rational_method.htm

<http://www.bom.gov.au/water/designRainfalls/ifa/howtoIFATool.shtml>

<http://www.ce.utexas.edu/prof/maidment/CE365KSP14/Visual/OpenChannels.pdf>

<http://www.efm.leeds.ac.uk/CIVE/CIVE2400/OpenChannelHydraulics2.pdf>

<https://www.oregon.gov/ODOT/GeoEnvironmental/Docs/HydraulicsManual/Hydraulics-07-F.pdf>

Tc-ch = K*(L^{0.770})*(S^{0.385})

K=constant; =0.0195 for SI

ln(I) = A+B(ln(Tc))+C(ln(Tc))^2+D(ln(Tc))^3+E(ln(Tc))^4+F(ln(Tc))^5+G(ln(Tc))^6

I = intensity (mm/hr) Tc = total time concentration (hr) A through G = ARI coefficients (from table at top of spreadsheet)

Q = ((C_i*I*(A/10000))/360)*3600 for m³/hr

A is area of Catchment, C is runoff Coefficient and I is intensity

T = b + (2*S^{0.5})*h; As = (b+S^{0.5})*h; Pw = b + 2*S^{0.5}*sqrt(1+S^{0.5}); Rh = As/Pw; Dh = As/T

V = (1/n)*(Rh^{2/3})*(S^{1/2}) Q = V*As

Fr = V/sqrt(g*Dh), where g = gravitational force; = 9.81 m/s²

Re = V*(As/Pw)*(1/V) = V*Rh*(1/V), where v is kinematic viscosity (m²/s); = 1.787*10⁻⁶ @ 0°C

Parameter	9		10		11		12		13		14		15		Comments
	Swale 10 to 4		GW Pond to Swale 6		Swale 13 to 14		Swale 14 to 15		Swale 8 into SW Pond		Emergency Exit		Site Entrance		
	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units	
Number of culverts	2		4		1		2		5		1		2		
Maximum Inlet Flow Rate, Qi =	3.06	m3/s	1.82	m3/s	2.50	m3/s	2.77	m3/s	12.44	m3/s	0.12	m3/s	0.12	m3/s	Taken from swale design that feeds into culvert from row 39 of Swale Design Tab
Maximum Outlet Flow Rate, Qo =	3.06	m3/s	1.82	m3/s	2.50	m3/s	2.77	m3/s	12.44	m3/s	0.12	m3/s	0.12	m3/s	Use same as inlet flow rate
Rainfall Event, ARI =	1:100	years	1:100	years	1:100	years	1:100	years	1:100	years	1:100	years	1:100	years	
Tail Water, TW =	0.5	m	0.5	m	0.5	m	0.6	m	1.5	m	0.1	m	0.1	m	Height of the water designed for the swales
Box culvert width, Bi =	1.5		1.2		2.1		1.5		2.1		0.9		0.9		
Full box culvert width, B =	3	m	4.8	m	2.1	m	3	m	10.5	m	0.9	m	1.8	m	
Box culvert Height, D =	0.9	m	0.3	m	0.9	m	0.9	m	0.9	m	0.3	m	0.3	m	
Box Culvert crosssectional area, A =	5.4	m2	5.76	m2	1.89	m2	5.4	m2	47.25	m2	0.27	m2	1.08	m2	
Length, L =	17.1	m	30.6	m	24.5	m	25.1	m	13	m	43	m	71.5	m	
ΔRL (mAHD)	0.06		0.1		0.1		0.28		0.1		1		0.3		
Slope, So =	0.004		0.003		0.004		0.011		0.008		0.023		0.004		
Ratio Qi/B =	1.02		0.38		1.19		0.92		1.19		0.13		0.07		
Allowable Head water, AHW =	1	m	0.4	m	1	m	1	m	1	m	0.4	m	0.4	m	Allowing an additional .1m of headwater above the culvert height
HW/D =	0.8	m	1	m	0.85	m	0.7	m	0.9	m	0.55	m	0.4	m	Appendix B, Figure B1, pg 146 Austroads
Hwi =	0.72	m	0.30	m	0.77	m	0.63	m	0.81	m	0.17	m	0.12	m	
Check Hwi < AHW	PASS		PASS		PASS		PASS		PASS		PASS		PASS		
Factor of Safety	1.39		1.33		1.31		1.59		1.23		2.42		3.33		

LEGEND	
	= Input
	= PASS
	= FAIL

Aspect	Swale 4	Swale 5	Swale 6	Swale 7	Swale 8	Swale 15
Maximum Velocity, V (m/s)	2.30	2.73	3.72	2.65	2.77	2.01
Bed Velocity (m/s)	1.61	1.91	2.61	1.85	1.94	1.41
Gradient (%)	0.9%	0.9%	1.3%	0.5%	0.4%	0.6%
Swale Base Material	Earth channel - gravelly	Earth channel - gravelly	Earth channel - gravelly	Earth channel - gravelly	Earth channel - gravelly	Earth channel - gravelly
Minimum Rock Size (mm)	110	150	270	140	150	80
Design Rock Size (mm)	150	150	300	150	150	150
Min. Armouring Layer Depth (mm)	225	225	450	225	225	225

Table 2.1 Catchment Summary

Catchments	Area (m ²)	Catchment Surface	Comments	Runoff Coefficient	1:20 Year Runoff
Catchment J	54,722	Industrial, Light Areas	CRC Area	0.7	4,214
Catchment J1	3,100	Industrial, Light Areas		0.7	239
Catchment J2	7,400	Industrial, Light Areas		0.7	570
Catchment J3	11,400	Industrial, Light Areas		0.7	878
Catchment J4	1,100	Industrial, Light Areas		0.7	85
Catchment J5	200	Industrial, Light Areas		0.7	15
Catchment J6	1,900	Industrial, Light Areas		0.7	146
Catchment J7	16,000	Industrial, Light Areas		0.7	1,232
Catchment J8	4,200	Industrial, Light Areas		0.7	323
				0	0
				0	0
				0	0
				0	0
				0	0
				0	0
				0	0
				0	0

Total Area (m²)	100,022
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Composite Runoff Coefficient	0.700
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Table 3.1 Pond Design Events

Minimum Design Event	
Design Period	1:2
Storm Duration	24 hour
Total Rainfall (mm)	110
Maximum Design Event	
Design Period	1:20
Storm Duration	24 hour
Total Rainfall (mm)	280

NOTES:

Volume of Pond:

$$V=(h/6)*((LxW)+((W+W_b)*(LxL_b)))+(L_b*W_b))$$

Table 3.2 SW Movement into Ponds

	Pond 4				
Catchment J					
Catchment J1	YES				
Catchment J2	YES				
Catchment J3	YES				
Catchment J4	YES				
Catchment J5	YES				
Catchment J6	YES				
Catchment J7	YES				
Catchment J8					

Table 3.3 Pond Design Details

Aspect	Pond 4
W (m)	100
L (m)	50
h (m)	1.3
Side Slope (1:V)	4
Freeboard (m)	0.3
Base Width (m)	89.6
Base Length (m)	39.6
Operational Width (m)	97.6
Operational Length (m)	47.6
Pond Catchment Area (m ²)	5,000
Operational Capacity (m ³)	4,086
Total Capacity (m ³)	5,533

Table 3.4 Pond Capacity Checks

Aspect	Pond 4
Catchment Area (m ²)	41,100
Runoff Coefficient	0.70
Minimum Storage Requirement (m ³)	3,715
Storage Check	PASS
Maximum Storage Requirement (m ³)	9,456
Storage Check	Overflow

NOTES:

- Volume of Pond:
 $V=(h/6)*((LxW)+((W+W_b)*(LxL_b)))+(L_b*W_b))$
- Passing Minimum Storage Requirement means Operational Capacity is not exceeded during minimum storm event
- Passing Maximum Storage Requirement means Total Capacity is not exceeded during maximum storm event
- Maximum storage check can be failed provided there is

Table 4.1 Swale Design Characteristics and Modelling Results

Aspect	Swale 1	Swale 2	Swale 3	Swale 4	Swale 5	Swale 6	Swale 7	Swale 8
Swale Flow Timing								
Flow Length (m)	114	80	140	12	45	55	325	65
ΔRL (m/AD)	1.06	0.31	0.71	0.01	1.03	0.1	2.98	1.2
Slope	0.007	0.004	0.006	0.006	0.020	0.003	0.008	0.015
Swale Material	Earth channel - clean	Earth channel - clean	Earth channel - clean	Earth channel - clean	Earth channel - clean	Earth channel - clean	Earth channel - clean	Earth channel - clean
Manning's Coefficient	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
Time of Conc., Tc-h	5.052	4.771	6.280	0.947	1.649	3.994	10.752	2.444
Combined Flows								
Min. Total Concentration Time, Tc (min)	6.60	6.32	7.83	2.50	3.02	5.37	12.97	4.06
Intensity for Min. Tc (mm/hr)	30.12	29.12	34.30	13.16	15.58	25.53	48.52	20.17
Flow Rate for Min. Tc (m³/hr)	65	214	526	212	253	449	543	59
Peak Flow Rate for Max. Tc (m³/hr)	65	214	526	212	253	449	543	59
Max. Total Concentration Time, Tc (min)	6.60	8.88	12.15	6.82	7.52	9.87	12.97	4.06
Intensity for Max. Tc (mm/hr)	30.12	37.57	46.54	30.89	33.28	40.48	48.52	20.17
Flow Rate for Max. Tc (m³/hr)	65	276	713	497	541	711	543	59
Peak Flow Rate for Max. Tc (m³/hr)	65	342	990	1,211	541	1,749	543	59
Max Peak Flow Rate for Tc (m³/hr)	65	342	990	1,211	541	1,749	543	59
Comments								
Swale Geometry								
Swale Bottom Width (m)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Depth of Flow w/o Freeboard (m)	0.10	0.23	0.32	0.35	0.20	0.47	0.24	0.07
LHS Slope (1:V)	4	4	4	4	4	4	4	15
RHS Slope (1:V)	4	4	4	4	4	4	4	4
Freeboard (m)	0.645	0.67	0.78	0.75	0.57	0.57	0.73	1.01
Freeboard included?	NO	NO	NO	NO	NO	NO	NO	NO
Top width, T (m)	1.06	2.14	2.86	3.1	1.9	4.06	2.18	1.63
Design Depth inc. Freeboard (m)	0.74	0.9	1.1	1.1	0.77	1.04	0.965	1.08
Swale Area, As (m²)	0.065	0.281	0.506	0.595	0.220	1.025	0.291	0.068
Wetted Perimeter, Pw (m)	1.08	2.20	2.94	3.19	1.95	4.18	2.24	1.64
Hydraulic Radius, Rh (m)	0.06	0.13	0.17	0.19	0.11	0.25	0.13	0.04
Hydraulic Depth, Dh (m)	0.06	0.13	0.18	0.19	0.12	0.25	0.13	0.04
Flow								
Manning's coefficient, n	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
Maximum Velocity, V (m/s)	0.58	0.73	1.09	1.15	1.50	0.98	1.04	0.66
Minimum Flow, Q (m³/s)	0.04	0.20	0.55	0.68	0.33	1.00	0.30	0.04
Minimum Flow, Q (m³/h)	135	737	1,982	2,464	1,189	3,599	1,096	161
Factor of Safety	2.1	2.2	2.0	2.0	2.2	2.1	2.0	2.7

Table 4.2 Swale Design Event & IFD Coefficients

Design Period	1:100
C ₀	1.859921
C ₁	0.578334
C ₂	0.358117
C ₃	-0.17415
C ₄	0.03223
C ₅	-0.00266
C ₆	0.0000806

NOTES:

Formulae are from:

http://onlinemanuals.txdot.gov/txdotmanuals/hyd/rational_method.htm

<http://www.bom.gov.au/water/designRainfalls/ifd/howtoifdTool.shtml>

<http://www.ce.utexas.edu/prof/maidment/CE365KSpr14/Visual/OpenChannels.pdf>

<http://www.efm.leeds.ac.uk/CIVE/CIVE2400/OpenChannelHydraulics2.pdf>

[https://www.oregon.gov/ODOT/GeoEnvironmental/Docs/HydraulicsManual/Hydraulic s-07-F.pdf](https://www.oregon.gov/ODOT/GeoEnvironmental/Docs/HydraulicsManual/Hydraulic%20s-07-F.pdf)

$Tc-ch = K*(L^{0.770})*(S^{0.385})$

K=constant; =0.0195 for SI

$ln(I) = A+B(ln(Tc))+C(ln(Tc))^2+D(ln(Tc))^3+E(ln(Tc))^4+F(ln(Tc))^5+G(ln(Tc))^6$

I = intensity (mm/hr) Tc = total time concentration (hr) A through G = ARI coefficients (from table at top of spreadsheet)

$Q = ((C*1*(A/10000))/360)*3600$ for m³/hr

A is area of Catchment, C is runoff Coefficient and I is intensity

$T = b + (2*S^0.5)*h$; $As = (b+S^0.5)*h$; $Pw = b + 2*h*\sqrt{1+S^2}$; $Rh = As/Pw$; $Dh = As/T$

$V = (1/n)*(Rh^{2/3})*(S^{1/2})$ Q = V*As

DRAINS results prepared from Version 2021.031

TABLE 1 - PIT / NODE DETAILS							
Version 8							
Name	Max HGL	Max Pond	Max Surface	Max Pond	Min	Overflow	Constraint
		HGL	Flow Arriving	Volume	Freeboard	(cu.m/s)	
			(cu.m/s)	(cu.m)	(m)		
Pit1	27.92	29.41	0.2	33.3	1.28	0	Inlet Capacity
N20	27.66		0				PASS
Headwall 3	29.08		1.383		0.06	0	None
Node 3	28.92		0				PASS
Headwall 4	28.91		1.129		0.11	0	None
Node 4	28.7		0.055				PASS
N1	31		0				PASS
Headwall 6	28.64		0.533		0.06	0	None
Node 7	27.64		0				PASS
Headwall 8	27.51		0.264		0.36	0	None
Node 8	27		0.869				PASS
Headwall 5	28.7		0.021		0.8	0	None
Node 5	28.7		0				PASS
Headwall 2	29.91		0.463		0.16	0	None
Node 2	29.24		0				PASS
Headwall 1	29.99		0.124		0.26	0	None
Node 1	29.92		0				PASS
Node 0	30.5		0				PASS
N36	29		0				PASS
Node 2b	29.2		0.552				PASS
Headwall with Walkway	28.66		1.277		0.26	0	None
Node Box Culvert with Walkway	28.48		0				PASS

TABLE 2 - SUB-CATCHMENT DETAILS							
Name	Max	EIA	Remaining	EIA	RIA	PA	Due to Storm
	Flow Q	Max Q	Max Q	Tc	Tc	Tc	
	(cu.m/s)	(cu.m/s)	(cu.m/s)	(cu.m/s)	(min)	(min)	(min)
Catchment - Pit 1	0.192	0.192	0	5	5	8	1% AEP, 5 min burst, Storm 1
Catchment 3	1.036	0.439	0.596	5	5	8	1% AEP, 10 min burst, Storm 9
Catchment 4	0.135	0.036	0.099	5	5	8	1% AEP, 10 min burst, Storm 9
Catchment 6	1.016	0	1.016	5	5	8	1% AEP, 10 min burst, Storm 10
Catchment - CRC Basin	0.683	0.203	0.481	5	5	8	1% AEP, 10 min burst, Storm 9
Catchment 8	0.255	0.087	0.169	5	5	8	1% AEP, 10 min burst, Storm 9
Catchment 5	0.04	0.01	0.03	5	5	8	1% AEP, 10 min burst, Storm 9
Catchment 2	0.639	0.304	0.334	5	5	8	1% AEP, 10 min burst, Storm 9
Catchment 1	0.236	0.03	0.206	5	5	8	1% AEP, 10 min burst, Storm 9
Catchment - Walkway	0.128	0.055	0.072	5	5	8	1% AEP, 10 min burst, Storm 9

TABLE 3 - PIPE DETAILS						
Name	Max Q	Max V	Max U/S	Max D/S	Due to Storm	PASS/FAIL
	(cu.m/s)	(m/s)	HGL (m)	HGL (m)		
Pipe1	0.135	2.5	27.836	27.667	1% AEP, 10 min burst, Storm 9	PASS
Box Culvert 3	1.062	1.47	29.004	28.917	1% AEP, 25 min burst, Storm 1	PASS
Box Culvert 4	1.129	1.57	28.823	28.701	1% AEP, 25 min burst, Storm 10	PASS
Box Culvert 6	0.746	2.07	28.402	27.912	1% AEP, 20 min burst, Storm 9	PASS
Box Culvert 7	0.802	1.49	27.818	27.637	1% AEP, 2 hour burst, Storm 9	PASS
Box Culvert 8	0.336	1.87	27.353	27	1% AEP, 15 min burst, Storm 3	PASS
Box Culvert 5	0.037	0.34	28.704	28.701	1% AEP, 10 min burst, Storm 9	PASS
Box Culvert 2	0.539	2	29.794	29.243	1% AEP, 20 min burst, Storm 9	PASS
Box Culvert 1	0.177	0.99	29.962	29.923	1% AEP, 10 min burst, Storm 9	PASS
Box Culvert with Walkway	1.229	1.71	28.534	28.483	1% AEP, 25 min burst, Storm 3	PASS

TABLE 4 - CHANNEL DETAILS						
Name	Max Q	Max V			Due to Storm	
	(cu.m/s)	(m/s)				
NOT APPLICABLE						

TABLE 5 - OVERFLOW ROUTE DETAILS								
Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
Overflow - Pipe 1	0	0	1.222	0	0	0	0	PASS
Swale C8	0.132	0.343	1.721	0.705	0.2	5.64	1.22	1% AEP, 10 min burst, Storm 10
Overflow - Box Culvert 3	0	0	1.492	0	0	0	0	PASS
Swale C4	1.063	1.128	0.294	0.811	0.35	6.49	0.43	1% AEP, 25 min burst, Storm 10
Overflow - Box Culvert 4	0	0	0.27	0	0	0	0	PASS
Swale C6b	1.166	1.166	0.13	0.708	0.55	4.25	0.79	1% AEP, 25 min burst, Storm 3
Swale C7	0	0.831	0.934	0.838	0.37	6.71	0.89	1% AEP, 15 min burst, Storm 8
Overflow - Headwall 6	0	0	1.412	0	0	0	0	PASS
Swale 4b	0.8	0.799	0.157	0.642	0.42	3.85	0.66	1% AEP, 2 hour burst, Storm 9
Overflow - Box Culvert 8	0	0	0.204	0	0	0	0	PASS
Overflow - Box Culvert 5	0	0	0.17	0	0	0	0	PASS
Swale C6a	0.049	0.049	0.38	0.701	0.07	4.2	0.33	1% AEP, 20 min burst, Storm 5
Overflow - Box Culvert 2	0	0	1.355	0	0	0	0	PASS
Swale C3a	0.539	0.539	1.384	0.496	0.4	3.97	1.16	1% AEP, 20 min burst, Storm 9
Overflow - Box Culvert 1	0	0	0.202	0	0	0	0	PASS
Swale C2	0.184	0.563	0.619	0.812	0.17	6.5	0.21	1% AEP, 15 min burst, Storm 8
Swale C1	0	0.213	0.892	0.515	0.13	4.12	0.48	1% AEP, 10 min burst, Storm 9
Swale C5	0	0.038	0.24	0.185	0.07	1.11	0.37	1% AEP, 10 min burst, Storm 9
Swale C3b	0.545	0.864	0.527	0.899	0.27	7.19	0.54	1% AEP, 25 min burst, Storm 3
Overflow - with walkway	0	0	1.497	0	0	0	0	PASS
Swale C6	1.203	1.702	0.678	0.567	0.82	4.54	1.59	1% AEP, 20 min burst, Storm 3

TABLE 6 - DETENTION BASIN DETAILS						
Name	Max WL	MaxVol	Max Q	Max Q	Max Q	PASS/FAIL
			Total	Low Level	High Level	
CRC Basin	27.91	5564.3	0.802	0.802	0	PASS

Run Log for TC21049_Broome CRC_2.0 run at 11:18:35 on 21/9/2022 using version 2021.031
No water upwelling from any pit. Freeboard was adequate at all pits.
The maximum flow in these overflow routes is unsafe: Swale C6b, Swale C6a, Swale C4, Swale C3a, Overflow - Box Culvert 2, Overflow - Pipe 1, Overflow - Box Culvert 5, Swale C1, Swale C2, Swale C3b, Swale C6, Swale C8, Swale 4b, Swale C7



Assets | Engineering | Environment | Noise | Spatial | Waste

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Groundwater Management Plan

Regional Resource Recovery Park



Prepared for Shire of Broome


22 August 2022

Project Number: TW21177

DOCUMENT CONTROL

Version	Description	Date	Author	Reviewer	Approver
0.1	Internal review	11/08/2022	TM	GR	GR
1.0	First approved release	22/08/2022	TM	GR	GR

Approval for Release

Name	Position	File Reference
G.Ralph	Senior Principal/ Hydrogeologist	TW21177_Groundwater Management Plan_1.0
Signature		

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Figure C-2: Monitoring Network

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APPENDIX C Survey Data

APPENDIX D Baseline Data

Acronyms

Abbreviation	Meaning
ADWG	Australian Drinking Water Guidelines
AHD	Australian Height Datum

ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australia and New Zealand Guidelines
BGA	Broome Groundwater Area
BWR	Broome Water Reserve
CSM	Conceptual Site Model
DWER	Department of Water and Environmental Regulation
GL	Ground Level
GMP	Groundwater Monitoring Plan
HEPA	Heads of Environmental Protection Authority (EPA)
LMP	Leachate Management Plan
NATA	National Association of Testing Authorities
NEMP	National Environmental Management Plan
NEPM	National Environment Protection Measure
NPUG	Non-potable use of groundwater
PFAS	Per and Polyfluoroalkyl Substances
PGWSA	Public Drinking Water Source Area
RRRP	Regional resources Recover Park
SWL	Standing Water Level
SWMP	Surface Water Management Plan
ToC	Top of Casing
WHO	World Health Organisation

1 Introduction

This Groundwater Management Plan (GMP) has been prepared on behalf of the Shire of Broome for the proposed Broome Regional Resource Recovery Park (RRRP, or the Site).

1.1 Background and purpose

The Shire's current landfill at the Buckley's Road Waste Management Facility is approaching the end of its operational life. The Shire identified the opportunity for a new facility that would have the capacity to advance the recycling and resource recovery initiatives as well as the standard of waste treatment services for the Shire and the wider Kimberley area.

In November 2019, the Shire commissioned Talis to undertake a site selection study from which the development option for a fully integrated facility including a Class III landfill, community recycling centre (CRC), and liquid waste facility (LWF) was chosen and for the Site to be located approximately 12km northeast from the town centre at Corner of Broome - Cape Leveque Road and McGuigan Road.

The GMP is required for the Shire's application for Works Approval for the proposed RRRP under Part IV of the *Environmental Protection Act 1986*.

1.2 Objective

The objective of the GMP is to outline the management measures, including ongoing monitoring requirements and contingencies in the event of system failure that will be required for the safe operation of the proposed RRRP with respect to maintaining the quality of groundwater and surface water so that environmental values are protected.

1.3 Scope

The scope of the GMP includes:

- contact details for the person or body corporate responsible for implementing the GMP;
- the timeframe for which the GMP is necessary;
- a summary of the groundwater and surface water environmental values;
- the proposed groundwater and surface water monitoring;
- maintenance actions for the groundwater monitoring network;
- triggers for additional assessment; and
- reporting framework.

1.4 Guidelines

This GMP has been prepared in accordance with the following guideline.

- Assessment and Management of Contaminated Sites - Department of Water and Environmental Regulation (DWER) 2021) Assessment and Management of contaminated sites;

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality - Australian and New Zealand Governments and Australian state and territory governments (ANZG 2018)
- Best Practice Environmental Management - Siting, design, operation and rehabilitation of landfills – Victoria Environmental Protection Authority (Vic EPA 2015)
- National Environment Protection (Assessment of Site Contamination) (ASC NEPM) –, National Environmental Protection Council (NEPC 2013); and
- PFAS National Environmental Management Plan (PFAS NEMP) – Heads of Environmental Protection Authorities (NEMP) (HEPA, 2020);

2 Responsibilities

It is the responsibility of the licensee of the RRRP to follow the Licence Conditions outlined in Licence {Number to be inserted following approval} issued by DWER and the recommendations provided by Talis.

2.1 Timeframes

Ongoing monitoring is required for the duration of the RRRP including post closure monitoring requirements.

A review of the GMP is required on a 5 yearly basis, or in the event of a major change to the operation e.g. Works Approval, and/or legislative framework, or in the event of a trigger for additional site assessment outlined in Section 6.

3 Environmental Setting

The site selection study included detailed assessment of all receptors which could potentially be impacted by operation of the RRRP with the results presented in the peer reviewed “Site Investigation Report” (Talis 2021a) and “Hydrology Assessment” (Talis 2021b). A brief summary of the findings is presented below.

3.1 Land Use

The Broome peninsular in which the Site is situated is host to a number of environmentally sensitive areas including Roebuck Bay which is a Ramsar listed site of international significance (Site No. 479). The Broome Sandstone is the main aquifer providing the town water supply (TWS), private domestic supplies and irrigation water and is an important component of the hydrological cycle.

Surrounding the western border of the Site is land zoned for ‘Culture and Natural Resource Use’ and is governed by Native Title. Approximately 3km to the west is Buckley’s Plain which is a seasonal wetland connected to the Indian Ocean approximately 6 km from the Site.

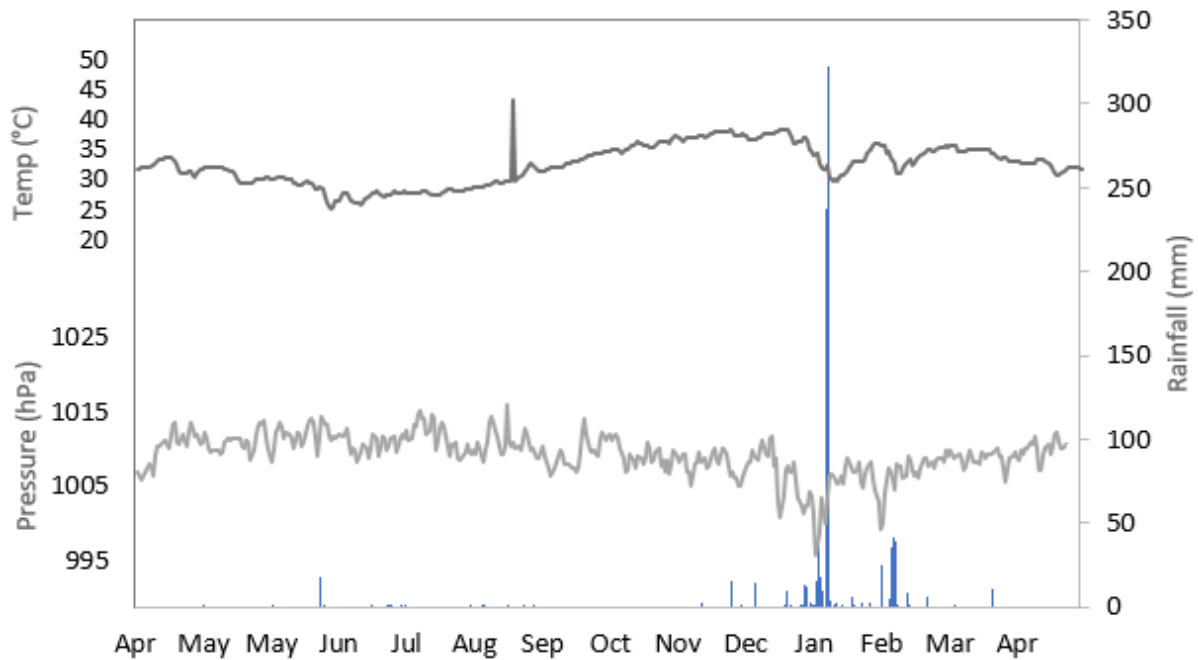
The closest residential dwelling is a single premises approximately 3.7 km to the west of the Site, which is located on the east edge of Buckley’s Plain. Cable Beach North is located approximately 5.5 km to south-west and Coconut Wells is located approximately 5.4km north-west of the Site.

3.2 Climate and Rainfall

The climate is essentially tropical with a distinct wet season from December to March and a dry season that extends from April to November as indicated in the daily weather observations for Broome Airport shown in Figure 3-1. Winter is characterised by low rainfall and moderate temperatures. In summer, the southward movement of tropical low-pressure systems bring thunderstorms and higher rainfall.

CSIRO predict that future climate (around 2030) will be similar to the historical climate across the peninsula. The near future is expected to be warmer, with rainfall events being more intense. Potential evapotranspiration is expected to increase, but runoff and groundwater recharge are expected to be similar to the historical past (CSIRO 2009)

Figure 3-1: Daily weather observations - 2021/22



Source: Rainfall: BoM, Climate Data Online – Broome Airport (3003) 1.5km away i.e. temp and pressure obtained by data logger on-site

3.3 Groundwater and Surface Water

Groundwater occurs in sandstone beneath Pindan sand and is unconfined beneath the Site. The thickness of the sandstone is expected to be over 200m with the underlying Jarlemai Siltstone forming a regional aquitard.

Table 3-1: Groundwater Physico-chemistry

Well ID	DO	EC	pH	ORP	Salinity
	(mg/L)	(μ S/cm)	units	(mV)	(mg/L)
GW1	0.28	43.07	6.44	3	240
GW2	0.11	504	6.06	58.9	282
GW3	0.19	309.8	5.44	104.8	173
GW4	0.46	302.1	6.04	86.2	169
GW5	0.42	228.9	4.88	181.7	128
GW6	0.22	648	6.56	-110.1	363
GW7	0.58	1779	5.86	168.5	990

Data for registered groundwater bores in the area indicate the groundwater is fresh with salinity ranging from 185 to 410 mg/L. Salinity levels recorded at the Site were as low as 173 mg/L as shown in Table 3-1, with an average reported salinity of 335 mg/L. A saltwater wedge exists, beneath the overlying fresh groundwater, which has been assessed by Water Corporation as likely to be over 150m bgl based on Airborne Electromagnetic survey.

The depth to groundwater at the Site is 15.5 to 32m bgl as shown in Table 3-2. Ongoing monitoring has shown levels respond very rapidly to rainfall as indicated in Figure 3-1 with seasonal variability of around 1m. Long-term records available for TWS monitoring bore indicate the groundwater level is unlikely to exceed 7m AHD such that the 2020 levels are close to a long-term maximum.

Table 3-2 Survey Data

Well ID	Co-ordinates (GDA94)		Top of Casing	Ground level	Groundwater Level	Depth to Groundwater
	Northing	Easting	mAHD			mbgl
GW1	422970.088	8023909.123	26.266	25.637	5.566	20.07
GW2	422358.031	8023781.215	21.204	20.629	5.104	15.52
GW3	422799.796	8024690.327	30.956	30.228	5.796	24.43
GW4	423072.993	8024303.778	29.422	28.804	5.822	22.98
GW5	423186.016	8024807.778	34.814	34.205	5.934	28.27
GW6	423274.260	8025258.931	38.555	37.943	6.165	31.78
GW7	422342.910	8025403.053	35.859	35.242	5.759	29.48

mAHD: meters above Australian Height Datum

mbgl: meters below ground level

Groundwater levels are for November 2020. Groundwater flow was assessed using the on-site monitoring network and is consistent with regional water table contour mapping completed by Water Corporation and stormwater runoff modelling completed by Talis shown in Figure A-1 and Figure 3-1 respectively. Overall, the data indicates a flow pattern generally toward the south-west then west toward Buckley's Plain and the Indian Ocean about 3km away. There is no drainage toward Roebuck Bay or Dampier Creek to the south.

Hydraulic testing determined a groundwater seepage velocity beneath the Site of approximately 21 m/year.

Figure 3-2: Hydrograph - 2021/22

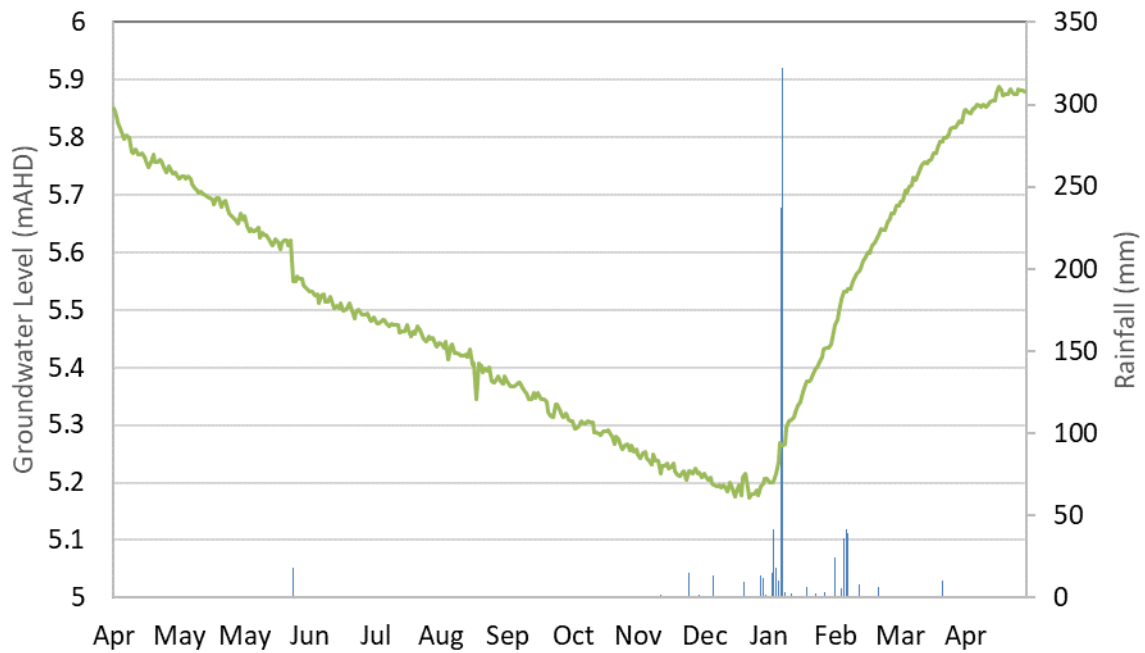
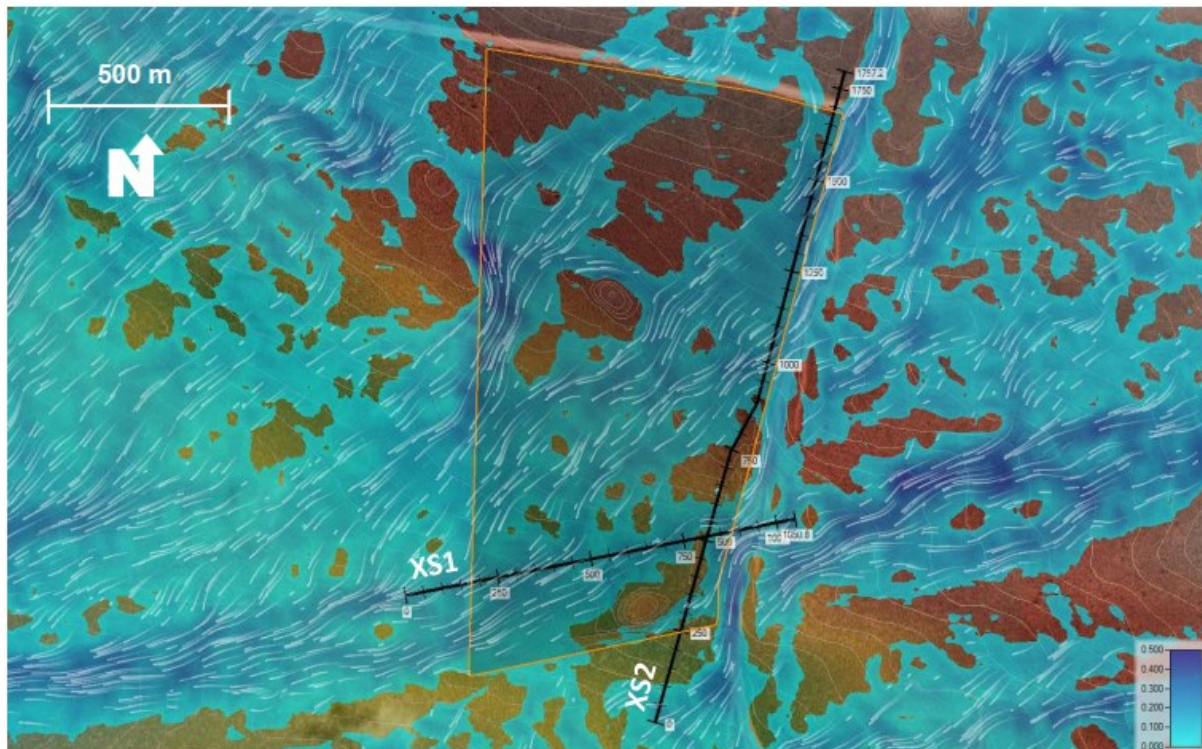


Figure 3-3: Stormwater runoff modelling



3.4 Sensitive Receptors

Potentially sensitive receptors were identified in the general area including the following.

- Roebuck Bay and Dampier Creek
- Waterbank Government Well No.1

- Irrigation bore licensed to Mamabulanjin Aboriginal Corporation (WRI licence 202397)
- Buckley's Plain supratidal wetland
- Domestic supplies at the Buckley's residential dwelling
- Motor Sports complex production bore (WRI licence 202274)
- Broome TWS borefield
- Coconut Wells domestic and irrigation bores
- Terrestrial vegetation, flora and fauna in the immediate vicinity
- Workers and visitors to the Site
- Beneficial use of groundwater beneath the Site for industry e.g. dust suppression, and/or potable supplies

The nearest production bore, which is licensed to Mamabulanjin Aboriginal Corporation (WRI licence 202397) and used for horticulture (tree plantation), is located 500 m to the north. The nearest Broome TWS production bore is located approximately 1.5 km to the east. There is also a production bore to the south within the Motor Sports complex area (WRI licence 202274) and Waterbank – Govt Well No.1 located approximately 1.5km south south-west.

As indicated in Figure A-1 the Waterbank - Govt Well No.1 is the only registered bore located along the regional groundwater flow line and considered potentially within a downflow area from the Site. Roebuck Bay and Dampier Creek are further to the south and are not situated down hydraulic gradient from the Site and are therefore not at risk.

The modelled travel times of a potential contaminant (plume front) to potentially sensitive receptors including the Waterbank – Govt Well No. 1 exceed 72 years and were greater than 100 years at Buckley's Plain and Buckley's residence further to the east as indicated in Table 3-3. These travel times do not take into consideration any dilution, attenuation and/or hydrodynamic dispersion or other factors which would reduce contaminant concentrations along the flow path.

In summary, an unacceptable risk to the identified sensitive receptors has not been identified. There is however a potential risk from impacts to groundwater quality in the immediate vicinity of the Site that may impact non-sensitive uses such as dust suppression or if groundwater at the site is used within the RRRP for potable supply. Additionally, there is a potential for impact to vegetation in the immediate vicinity from stormwater runoff exiting the site.

Table 3-3: Travel time to Downstream Receptors

#	Downstream Receptors	Distance from Site (west)	Travel Time	Commentary
1	Govt Well 1	1.5 km south west	72 Years	Government Well that is used for stock water.
2	Buckley's Plain	3 km west	144 Years	Buckley's Plain is a seasonal wetland
3	Single Dwelling	3.7 km west	177 Years	Single dwelling located on the eastern edge of Buckley's Plain. Based on aerial imagery it is assumed that groundwater is extracted from a small lake on site

4 Baseline Data

An assessment of the baseline condition at the Site has been completed utilising the network of monitoring bores installed as part of the site selection study with the data presented in Appendix C.

5 Sampling, Analytical and Quality Plan

5.1 Suitability of the monitoring network

Monitoring bores installed during the site selection study have been reviewed and are mostly suitable for compliance purposes with the following additional requirements identified.

- Three additional water table monitoring bores (GW8, GW9 and GW10) are proposed to be installed near the western boundary. Note, permission will be needed to install and maintain tracks to these new wells.
- Surface water monitoring stations are required at the surface water collection pond (SW1), surface water infiltration pond (SW2) and surface water infiltration pond overflow (SW3).
- Production bore need to be metered and water quality tested at commissioning and bi-annually.
- Bores denoted 'S' are redundant and should be decommissioned.

Records of construction logs and survey data are presented in Appendix B and C respectively and will need to be updated following installation of the additional abovementioned recommended bores. The location of existing and proposed compliance monitoring points is presented in Figure A-2.

5.2 Maintenance of the monitoring network

The monitoring network is required to be maintained in a serviceable condition.

Production bore (if any) will be required to be licensed under the *Rights in Water and Irrigation Act 1914*. Additionally, Section 26F of the Act “during the currency of a licence issued under section 26D no alterations shall be made in or in connection with the well but works necessary for the maintenance of the well in good order or occasioned by any unforeseen emergency may be carried out if written notice of all such works is given to the Minister within 7 days after the same are commenced”.

If it is determined any additional monitoring bores are required in the future, or the existing or proposed monitoring network is to be altered, then this GMP must be updated with the details of the new bores including surveyed locations, elevation of top of casing, and construction logs.

5.3 Sampling methods

5.3.1 Groundwater sampling

Groundwater sampling should be sampled using low flow (or equivalent) sampling technique in accordance with *AS5667.1.1998 Water Quality Sampling Guidance on the design of sampling programs, sampling techniques and the preservation and handing of samples*, and *Part 11: Guidance on sampling of groundwater*.

All groundwater samples will be collected into appropriately prepared sample containers provided by a National Association of Testing Authorities (NATA) accredited laboratory. Water samples analysed for dissolved metals will be field filtered utilising a *Hydroline* disposable filter and placed into appropriate sample containers. After preparation and labelling, samples will be immediately placed into an ice chilled esky.

All samples will be couriered directly to the testing laboratory at the completion of groundwater sampling event.

To minimise the potential for cross contamination, decontamination of equipment between each location will be conducted with new tubing, pump bladders and filters to be used.

5.3.2 Surface water sampling

Surface water samples from surface water collection, and infiltration ponds (SW1 and SW2) should be collected by telescopic sampler from a depth 0.5m below the surface at a point close to the discharge end.

Sampling from the infiltration pond overflow (SW3) should be collected when overflowing and an estimate of the volumetric rate of discharge made.

5.4 Analytical schedule

The proposed analytical schedule is presented in Table 5-1.

Table 5-1: Analytical schedule

Analytical Suite	Analytes	Frequency
Groundwater hydraulics and Salinity	Standing water level (SWL) and Electrical Conductivity (EC) using data loggers at GW2, GW9 and GW4 only.	'Continuous'
Field parameters	Standing water level (SWL)	Bi-annual (April/Sept)
	pH	
	Temperature	
	Electrical Conductivity (EC)	
	Dissolved Oxygen (DO)	
	REDOX potential (ORP)	
Salinity and Major Ions	Ionic balance (Ca, K, Mg, Na, Hardness-calc, OH, CO ₃ , HCO ₃ , total alkalinity, Cl, SO ₄)	
	Electrical Conductivity (EC)	
	Total dissolved solids (TDS)	
Nutrients	Nutrient Suite Total N, TKN, NO ₂ -N, NO ₃ -N, NO _x -N, NH ₃ -N, Org-N, Total P and PO ₄ -P)	
Petroleum Hydrocarbon	Total Recoverable Hydrocarbons (TRH)	Annual (Sept)
	Benzene, Ethylbenzene, Toluene, Xylene and Naphthalene (BTEXN)	
	Polyaromatic Hydrocarbons (PAH)	
Heavy Metals	Heavy metals - Dissolved (As, B, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Zn)	
Persistent Organic Pollutants (POPS)	Polychlorinated Biphenyls (PCBs)	
	Organochlorine Pesticides (OCP) and Organophosphorus Pesticides (OPP)	

Analytical Suite	Analytes	Frequency
	PFAS indicators [perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), perfluorohexane sulfonate (PFHxS)]	
Solvents e.g. degreasers	Chlorinated Hydrocarbon (PCE, TCE, DCE, VC)	
Detergents	Total Phenolics as Phenols	
Dissolved Landfill Gas	Methane	
Other e.g. indicators of wastewater treatment	Volatile Fatty Acids (VFA); Total Organic Carbon (TOC); Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)	
Pathogens	Thermotolerant coliforms and E.coli	

Note, continuous monitoring is to utilise a data logger installed at the monitoring point with data recorded at a higher frequency e.g. daily.

6 Triggers for additional site assessment

A site assessment seeks to determine whether there are any substances at above background concentrations that present or have the potential to present a risk of harm to human health, the environment or any environmental values (NEPM, 2013). The following triggers for additional site assessment are identified.

Trigger 1 - If any contaminants are detected above tier one screening criteria then further investigation, remediation and/or management is required.

Trigger 2 - If a reversal in the groundwater flow direction is detected within monitoring bores installed across the eastern, or northern side of the site then further investigation, remediation and/or management is required.

7 Reporting Framework

All ongoing reporting will be in accordance with the Licence {Number to be inserted following approval}. Talis recommends annual reporting to include the following aspects:

- Introduction
- Scope of work
- Assessment criteria
- Methodology
- Results and Discussion:
 - Field Observations
 - Analytical Results
 - An interpretive summary and assessment of the results against historical monitoring results including the generation of relevant trend graphs
 - Quality Assurance / Quality Control (QA/QC)
 - Discussion
- Conclusions and recommendations
- All relevant supporting figures and appendices including:
 - Field recording forms;
 - Laboratory certificates; and
 - Tabulated data.

8 References

ANZG (2018) Freshwater and Marine Water Quality Guidelines

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TW19118-Broome RRRP Site Investigation_D2.2a

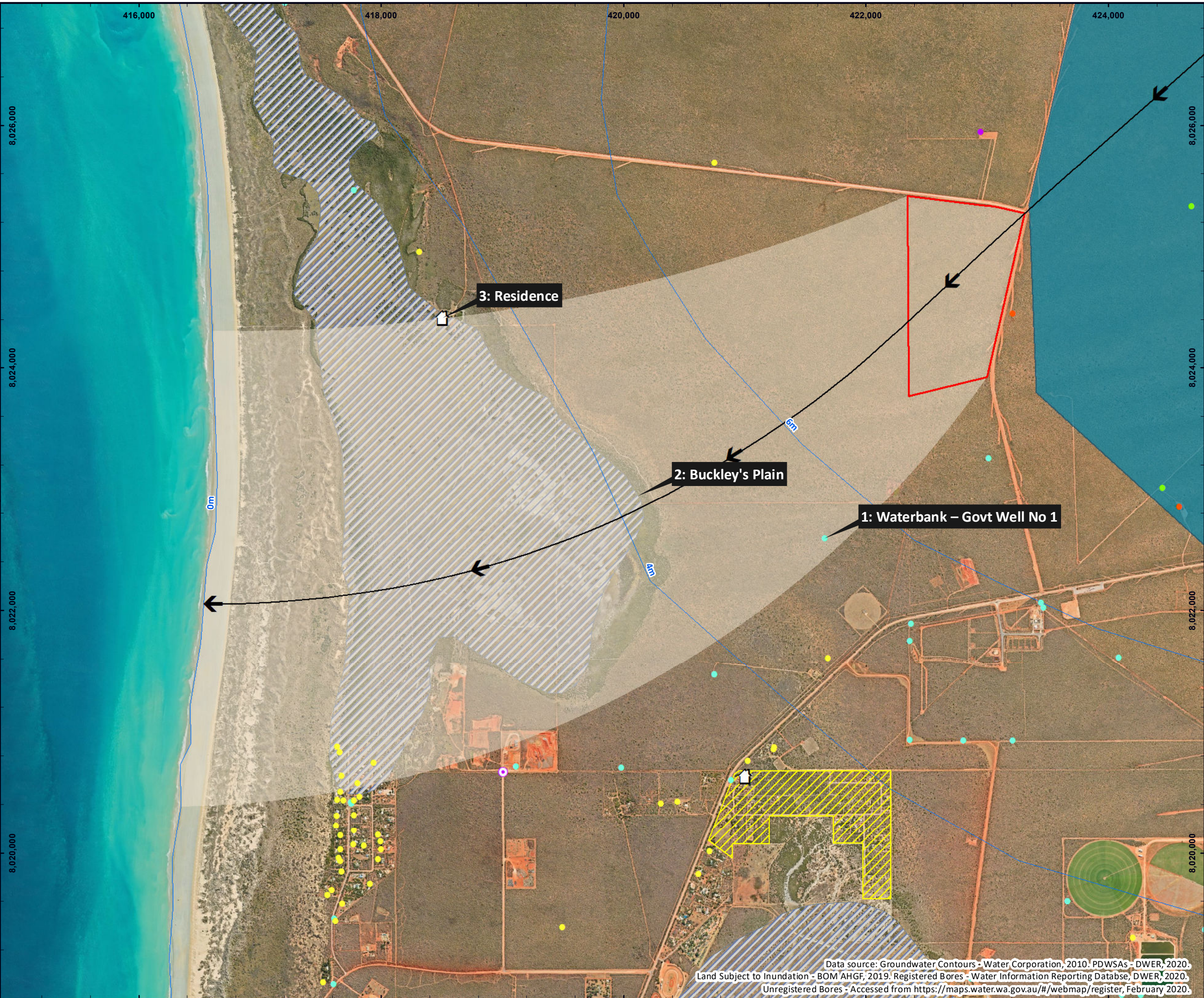
Vogwill, R.I.J., 2003. Hydrogeology and Aspects of the Environmental Geology of the Broome Area, Western Australia, Geology. Curtin University

APPENDIX A

Figures

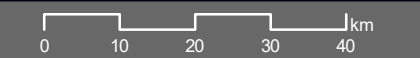
TABLE OF FIGURES

List of Figures in the Appendices
Figure A-1: Groundwater Receptors
Figure A-2: Monitoring Network



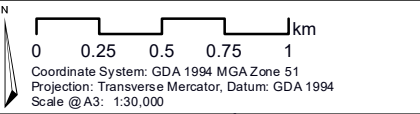
LEGEND

- Site Boundary
- Buckley's Road Landfill
- Groundwater Bores**
 - Broome TWS - Monitoring
 - Broome TWS - Production
 - Horticultural
 - Private
 - Other
- Water Corporaton Groundwater Modelling (2010)**
 - Groundwater Contour (mAH)
 - Regional Groundwater Flow Line
 - Downflow Area
 - Residence
 - Development Zone
 - Land Subject To Inundation
 - PDWSA (P1)



GROUNDWATER RECEPTORS

Broome RRRP
Shire of Broome

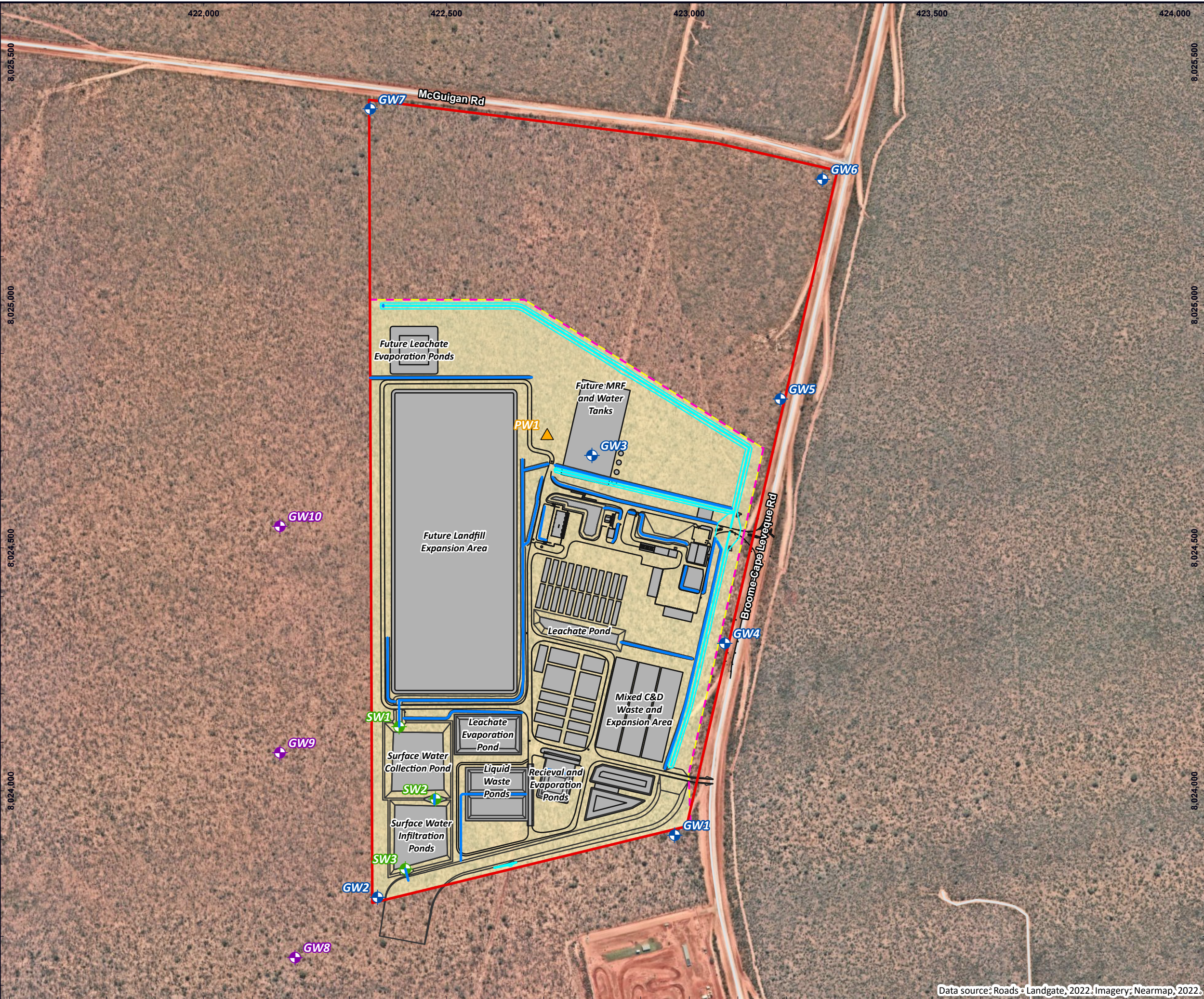


Prepared:	F Walker	Date:	24/02/2021
Reviewed:	G Ralph	Revision:	B
Project:	TW19118		



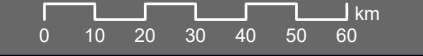
Figure A-1

Data source: Groundwater Contours - Water Corporation, 2010. PDWSAs - DWER, 2020.
Land Subject to Inundation - BOM AHGF, 2019. Registered Bores - Water Information Reporting Database, DWER, 2020.
Unregistered Bores - Accessed from <https://maps.water.wa.gov.au/#/webmap/register>, February 2020.



- ### LEGEND
- Site Boundary
 - Development Footprint
 - Site Plan
 - Perimeter Fence
 - Levee
 - Drainage Path
 - Monitoring Bore (Existing)
 - Monitoring Bore (To Be Installed, Approx. Location)
 - Surface Water Monitoring Point
 - Production Well (Incomplete)

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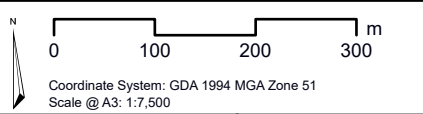


MONITORING NETWORK

Broome RRRP

Shire of Broome

NOT FOR CONSTRUCTION



Prepared:	T Daymond	Date:	22/08/2022
Reviewed:	G Ralph	Revision:	A
Project:	TW21177		



Figure A-2

Data source: Roads - Landgate, 2022, Imagery: Nearmap, 2022.

APPENDIX B

Bore Logs



Talis Consultants
604 Newcastle street Leederville

BOREHOLE NUMBER GW1-D

PAGE 1 OF 1

CLIENT	Shire of Broome	PROJECT NAME	Site Investigation
PROJECT NUMBER	TW19118	PROJECT LOCATION	Broome RRP- Site D2
DATE STARTED	13/10/20	COMPLETED	14/10/20
R.L. SURFACE	25.637	DATUM	m 90A94
DRILLING CONTRACTOR	Soil Mechanics	SLOPE	90°
BEARING	---	EQUIPMENT	
HOLE LOCATION	422354mE 8023783mN	HOLE SIZE	96mm(HQ)
LOGGED BY	MJ	CHECKED BY	G.R

NOTES

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
Diamond Core			24	2		SC	Silty clayey SAND: fine to medium grained, subangular, trace gravel, red (PINDAN SAND)		
			22	4					
			20	6					
			18	8					
			16	10					
			14	12			gravelly		
			12	14			gravels up to cobble in size, pale red		
			10	16			SANDSTONE: fine to medium grained, sub-rounded to rounded, bedded to weakly bedded, variably cemented, very low to medium strength, pale red/yellow (BROOME SANDSTONE)		
			8	18					
			6	20			pale yellow/white, red mottles		
			4	22					
			2	24					
			0	26					
			-2	28					
			-4	30					
			-6	32					
			-8	34					
							Borehole GW1-D terminated at 34.5m		

GW1-D 8-9m

BOREHOLE / TEST PIT TW19118_HYDROGEOLOGICAL D1.GPJ GINT STD AUSTRALIA GDT 25/11/20



Talis Consultants
604 Newcastle street Leederville

BOREHOLE NUMBER GW2-D

PAGE 1 OF 1

CLIENT	Shire of Broome	PROJECT NAME	Site Investigation
PROJECT NUMBER	TW19118	PROJECT LOCATION	Broome RRP- Site D2
DATE STARTED	15/10/20	COMPLETED	15/10/20
R.L. SURFACE	20.629	DATUM	m 90A94
DRILLING CONTRACTOR	Soil Mechanics	SLOPE	90°
BEARING	---	EQUIPMENT	
HOLE LOCATION	422354mE 8023783mN	HOLE SIZE	96mm(HQ)
LOGGED BY	MJ	CHECKED BY	G.R

NOTES

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
Diamond Core			20			SC	Silty clayey SAND: fine to medium grained, subangular, trace gravel, red (PINDAN SAND)		
			18						
			16						
			14						
			12						
			10				Gravelly SAND trace sandstone (Residual). Gravels up to cobble in size, reddish brown changing to pale brown/grey.		
			8						
			6			SC	SANDSTONE: fine to medium grained, sub-rounded to rounded, bedded to weakly bedded, variably cemented, very low to medium strength, pale grey with mottles red (BROOME SANDSTONE)		
			4						
			2						
			0						
			-2						
			-4						
			-6						
			-8						
			-10						
			-12						
			-14				Borehole GW2-D terminated at 33m		

BOREHOLE / TEST PIT TW19118_HYDROGEOLOGICAL D1.GPJ GINT STD AUSTRALIA.GDT 25/11/20



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604 Newcastle street Leederville

BOREHOLE NUMBER GW3-D

PAGE 1 OF 1

CLIENT Shire of Broome PROJECT NAME Site Investigation
PROJECT NUMBER TW19118 PROJECT LOCATION Broome RRP- Site D2

DATE STARTED 16/10/20 COMPLETED 17/10/20 R.L. SURFACE 30.228 DATUM m 90A94
DRILLING CONTRACTOR Soil Mechanics SLOPE 90° BEARING ---
EQUIPMENT _____ HOLE LOCATION 422803mE 8024688mN
HOLE SIZE 96mm(HQ) LOGGED BY MJ CHECKED BY G.R

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
Diamond Core				28	2	SC	Silty clayey SAND: fine to medium grained, subangular, trace gravel, red (PINDAN SAND)	GW3-D 7-7.39m	
			26	4					
			24	6					
			22	8					
			20	10					
			18	12					
			16	14	SC	Gravelly SAND trace sandstone (Residual)			
			14	16	SC	SANDSTONE: fine grained sand, rounded to sub rounded grains, reddish brown with pale grey with depth. Residual.			
			12	18	SC	SANDSTONE: fine to medium grained, sub-rounded to rounded, bedded to weakly bedded, variably cemented, very low to medium strength, pale red/yellow (BROOME SANDSTONE)			
			10	20					
		8	22						
		6	24						
		4	26						
		2	28						
		0	30						
		-2	32						
		-4	34						

GW3-D 7-7.39m

BOREHOLE / TEST PIT TW19118_HYDROGEOLOGICAL D1.GPJ GINT STD AUSTRALIA GDT 25/11/20

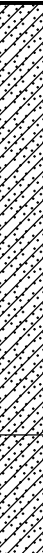



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BOREHOLE NUMBER GW4-D

PAGE 1 OF 1

CLIENT	Shire of Broome	PROJECT NAME	Site Investigation
PROJECT NUMBER	TW19118	PROJECT LOCATION	Broome RRP- Site D2
DATE STARTED	18/10/20	COMPLETED	18/10/20
R.L. SURFACE	28.804	DATUM	m 90A94
DRILLING CONTRACTOR	Soil Mechanics	SLOPE	90°
BEARING	---	EQUIPMENT	
HOLE LOCATION	423072mE 8024306mN	HOLE SIZE	96mm(HQ)
LOGGED BY	MJ	CHECKED BY	G.R

NOTES										
Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations	
Diamond Core			28	2		SC	Silty clayey SAND: fine to medium grained, subangular, trace gravel, red (PINDAN SAND)	 GW4-D 8-9m		
			26	4						
			24	6						
			22	8						
			20	10						
			18	12						
			16	14						
			14	16						
			12	18						
			10	20						
			8	22						
			6	24						
			4	26						
			2	28						
			0	30						
			-2	32						
			-4	34						
			-6							
							Gravelly SAND trace sandstone (Residual). Gravels up to cobble in size, reddish brown changing to pale brown/grey.			
							SC	SANDSTONE: very fine to medium grained, sub-rounded to rounded, bedded to weakly bedded, variably cemented, very low to medium strength, pale grey with mottles reddish brown streaks (BROOME SANDSTONE)		

BOREHOLE / TEST PIT TW19118_HYDROGEOLOGICAL D1.GPJ GINT STD AUSTRALIA GDT 25/11/20



CLIENT	Shire of Broome	PROJECT NAME	Site Investigation
PROJECT NUMBER	TW19118	PROJECT LOCATION	Broome RRP- Site D2
DATE STARTED	19/10/20	COMPLETED	20/10/20
R.L. SURFACE	34.205	DATUM	m 90A94
DRILLING CONTRACTOR	Soil Mechanics	SLOPE	90°
BEARING	---	EQUIPMENT	
HOLE LOCATION	423196mE 8024803mN	HOLE SIZE	96mm(HQ)
LOGGED BY	MJ	CHECKED BY	G.R

NOTES

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
Diamond Core				32	2	SC	Silty clayey SAND: fine to medium grained, subangular, reddish brown changing to pale grey with depth (PINDAN SAND).		
			30	4					
			28	6					
			26	8					
						SC	SANDSTONE: very fine grained, rounded to sub rounded grains, reddish brown with pale grey with depth. Residual.	GW5-D 8-8.5m	
			24	10					
			22	12	SC	SANDSTONE: fine to medium grained, sub-rounded to rounded, bedded to weakly bedded, variably cemented, very low to medium strength, pale grey (BROOME SANDSTONE)			
			20	14					
			18	16					
			16	18					
			14	20					
			12	22					
			10	24					
			8	26					
			6	28					
			4	30					
			2	32					
			0	34					

BOREHOLE / TEST PIT TW19118 HYDROGEOLOGICAL D1.GPJ GINT STD AUSTRALIA.GDT 25/11/20

Borehole GW5-D terminated at 35m




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BOREHOLE NUMBER GW6-D

PAGE 1 OF 1

CLIENT	Shire of Broome	PROJECT NAME	Site Investigation
PROJECT NUMBER	TW19118	PROJECT LOCATION	Broome RRP- Site D2
DATE STARTED	20/10/20	COMPLETED	21/10/20
R.L. SURFACE	37.943	DATUM	m 90A94
DRILLING CONTRACTOR	Soil Mechanics	SLOPE	90°
BEARING	---	EQUIPMENT	
HOLE LOCATION	423276mE 8025261mN	HOLE SIZE	96mm(HQ)
LOGGED BY	MJ	CHECKED BY	G.R

NOTES									
Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
Diamond Core			36	2		SC	Silty clayey SAND: fine to medium grained, subangular, reddish brown changing to pale grey with depth (PINDAN SAND).	<div>GW6-D 5.5-6m</div>	
			34	4					
			32	6					
			30	8					
			28	10		SC	SANDSTONE: fine grained sand, rounded to sub rounded grains, reddish brown with pale grey with depth. Residual.		
			26	12					
			24	14		SC	SANDSTONE: fine to medium grained, sub-rounded to rounded, bedded to weakly bedded, variably cemented, very low to medium strength, pale grey with mottles red (BROOME SANDSTONE)		
			22	16					
			20	18					
			18	20					
			16	22					
			14	24					
			12	26					
			10	28					
			8	30					
			6	32					
			4	34					

BOREHOLE / TEST PIT TW19118_HYDROGEOLOGICAL D1.GPJ GINT STD AUSTRALIA.GDT 25/11/20

Borehole GW6-D terminated at 35m



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BOREHOLE NUMBER GW7-D

PAGE 1 OF 1

CLIENT	Shire of Broome	PROJECT NAME	Site Investigation
PROJECT NUMBER	TW19118	PROJECT LOCATION	Broome RRP- Site D2
DATE STARTED	25/10/20	COMPLETED	26/10/10
R.L. SURFACE	35.242	DATUM	m 90A94
DRILLING CONTRACTOR	Soil Mechanics	SLOPE	90°
BEARING	---	EQUIPMENT	
HOLE LOCATION	422342mE 8025403mN	HOLE SIZE	96mm(HQ)
LOGGED BY	MJ	CHECKED BY	G.R

NOTES									
Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
Diamond Core						SC	Silty clayey SAND: fine to medium grained, subangular, trace gravel, red (PINDAN SAND)		
			34	2					
			32	4					
			30	6					
			28	8			Gravelly SAND trace sandstone (Residual). Gravels up to cobble in size, reddish brown changing to pale brown/grey.		
			26	10		SC	SANDSTONE: fine grained sand, rounded to sub rounded grains, pale grey. Residual.		
			24	12					
			22	14					
			20	16					
			18	18		SC	SANDSTONE: fine to medium grained, sub-rounded to rounded, bedded to weakly bedded, variably cemented, very low to medium strength, pale grey with mottles red (BROOME SANDSTONE)		
			16	20					
			14	22					
			12	24					
			10	26					
			8	28					
			6	30					
			4	32					
		2	34						
							Borehole GW7-D terminated at 34.5m		

BOREHOLE / TEST PIT TW19118_HYDROGEOLOGICAL D1.GPJ GINT STD AUSTRALIA GDT 25/11/20



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BOREHOLE NUMBER PW01

PAGE 1 OF 2

CLIENT Shire of Broome PROJECT NAME Site Investigation
PROJECT NUMBER TW19118 PROJECT LOCATION Broome RRP- Site D2

DATE STARTED 17/11/20 COMPLETED 18/11/20 R.L. SURFACE _____ DATUM _____
DRILLING CONTRACTOR Kimberley Water SLOPE 90° BEARING ---
EQUIPMENT _____ HOLE LOCATION 422808mE 8024710mN
HOLE SIZE _____ LOGGED BY MJ CHECKED BY G.R

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				2		SC	Silty clayey SAND: fine to medium grained, subangular, trace gravel, red (PINDAN SAND)		
				4					
				6					
				8					
				10		SC	Gravelly SAND trace sandstone (Residual)		
				12					
				14		SC	SANDSTONE with gravel: fine to mediueme grained, rounded to sub rounded grains, pale grey with depth. Gravel is weakly cemented, coarse grained, sub-angular to sub-rounded.		
				16					
				18					
				20					
				22					
				24					
				26					
				28					
				30					
				32					
				34					

BOREHOLE / TEST PIT TW19118_HYDROGEOLOGICAL D1.GPJ GINT STD AUSTRALIA GDT 25/11/20



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BOREHOLE NUMBER PW01

PAGE 2 OF 2

CLIENT Shire of Broome PROJECT NAME Site Investigation
PROJECT NUMBER TW19118 PROJECT LOCATION Broome RRP- Site D2

DATE STARTED 17/11/20 COMPLETED 18/11/20 R.L. SURFACE _____ DATUM _____
DRILLING CONTRACTOR Kimberley Water SLOPE 90° BEARING ---
EQUIPMENT _____ HOLE LOCATION 422808mE 8024710mN
HOLE SIZE _____ LOGGED BY MJ CHECKED BY G.R

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				36 38 40 42 44 46 48 50 52 54 56 58 60		SC	SANDSTONE with gravel: fine to medium grained, rounded to sub rounded grains, pale grey with depth. Gravel is weakly cemented, coarse grained, sub-angular to sub-rounded. (continued)		
				62 64 66 68 70			Borehole PW01 terminated at 60m		

APPENDIX C

Survey Data

Our Ref: 41417
 Date: 17/11/2020 Surveyor: NAA MNG Broome
 Datum: MGA94 z51 AHD

Control

BROOME 56 450191.565 8027064.755 21.111 PSM
 UKIM 206 423224.094 8024934.227 34.999 PSM

Control Checks

Observed					Published			Deltas		
1074	423395.767	8025680.15	41.414	PSM	423395.772	8025680.143	41.411	-0.005	0.007	0.003
1075	423395.769	8025680.149	41.413	PSM	423395.772	8025680.143	41.411	-0.003	0.006	0.002

Site D2

Point	Easting	Northing	RL (Top PVC Collar)	Code	RL (Ground Level)	BH ID
1078	423274.26	8025258.931	38.555	BC	37.943	GW6-D
1079	423275.737	8025259.882	38.573	BC	37.978	GW6-S
1080	423187.529	8024806.568	34.899	BC	34.178	GW5-S
1083	423186.016	8024807.778	34.814	BC	34.205	GW5-D
1086	423070.194	8024303.302	29.386	BC	28.743	GW4-S
1087	423072.993	8024303.778	29.422	BC	28.804	GW4-D
1088	422971.259	8023910.04	26.349	BC	25.7	GW1-S
1089	422970.088	8023909.123	26.266	BC	25.637	GW1-D
1094	422358.031	8023781.215	21.204	BC	20.629	GW2-D
1095	422360.473	8023783.051	21.33	BC	20.604	GW2-S
1099	422342.91	8025403.053	35.859	BC	35.242	GW7-D
1100	422343.137	8025404.397	35.909	BC	35.266	GW7-S
1102	422799.796	8024690.327	30.956	BC	30.228	GW3-D
1104	422801.247	8024688.765	30.957	BC	30.251	GW3-S

APPENDIX D

Baseline Data



	Carboxylic Acids							BTEX						TRH						TPH				3&4-Methylphenol (m&p-cresol)
	Formic Acid	Naphthalene (VOC)	Benzene	Toluene	Ethylbenzene	Xylene (m & p)	Xylene (o)							C6-C10 Fraction (F1)	C6-C10 (F1 minus BTEX)	>C10-C16 Fraction (F2)	>C10-C16 Fraction (F2 minus Naphthalene)	>C16-C34 Fraction (F3)	>C34-C40 Fraction (F4)	C6-C9 Fraction	C10-C14 Fraction	C15-C28 Fraction	C29-C36 Fraction	
	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L							µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL	10,000	0.001	1	1	1	2	1							10	10	50	50	100	100	10	50	100	100	2
ANZG 2018 Marine Water 95% LOSP toxicant DGV's		0.07	700	180	80																			
ANZECC 2000 MW 95%		0.07	700		80																			
ANZECC 2000 Irrigation Short Term Trigger Values																								
PFAS NEPM 2020 Interim Marine 95%																								
PFAS NEMP 2020 Recreational Water																								
NEPM 2013 Table 1C GILs, Marine Waters		0.05	500																					

Lab Report Number	Field ID	Date	Sample Type																			
254777	D2-GW1-D	8/12/2020	Normal	-	<0.001	<1	<1	<1	<2	<1	<10	<10	83	83	<100	<100	<10	<50	138	<100	<2	
254470	X1	8/12/2020	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
254777	D2-GW2-D	10/12/2020	Normal	-	<0.001	<1	<1	<1	<2	<1	<10	<10	470	470	130	<100	<10	280	330	<100	<2	
254777	D2-GW3-D	9/12/2020	Normal	-	<0.001	<1	<1	<1	<2	<1	<10	<10	430	430	110	<100	<10	230	310	<100	<2	
254777	D2-GW4-D	9/12/2020	Normal	-	<3	<3	<3	<3	<6	<3	<50	<50	<50	130	160	<100	<50	63	220	<100	<2	
254777	D2-GW5-D	9/12/2020	Normal	-	<1	<1	<1	<1	<2	<1	<10	<10	<10	120	<100	<100	<10	67	<100	<100	<2	
254777	D2-GW6-D	9/12/2020	Normal	-	<3	<3	<3	<3	<6	<3	<50	<50	<50	1300	540	<100	<50	290	1600	<100	<2	
254777	D2-GW7-D	9/12/2020	Normal	-	<1	<1	<1	<1	<2	<1	<10	<10	<10	<50	<100	<100	<10	<50	<100	<100	<2	
259847	D2-GW1-D	1/04/2021	Normal	<10,000	-	<3	<3	<3	<6	<3	<50	<50	760	760	600	<100	<50	94	1,400	<100	<2	
259847	D2-GW2-D	1/04/2021	Normal	<10,000	-	<1	<1	<1	<2	<1	<10	<10	60	60	<100	<100	<10	<50	<100	<100	<2	
259847	Z1	1/04/2021	Field_D (D2-GW2-D)	-	-	<1	<1	<1	<2	<1	<10	<10	<50	<50	<100	<100	<10	<50	<100	<100	-	
2106133	Z11	1/04/2021	Inter_Lab_D (D2-GW2-D)	-	-	<1	<1	<1	<2	<1	<20	<20	<50	<50	<100	<100	-	-	-	-	-	
259847	D2-GW3-D	1/04/2021	Normal	<10,000	-	<1	<1	<1	<2	<1	<10	<10	230	230	<100	<100	<10	130	170	<100	<2	
259847	D2-GW4-D	1/04/2021	Normal	<10,000	-	<1	<1	<1	<2	<1	<10	<10	56	56	<100	<100	<10	<50	<100	<100	<2	
259847	D2-GW5-D	1/04/2021	Normal	<10,000	-	<1	<1	<1	<2	<1	<10	<10	<50	<50	<100	<100	<10	<50	<100	<100	<2	
259847	D2-GW6-D	1/04/2021	Normal	<10,000	-	<3	<3	<3	<6	<3	<50	<50	1,200	1,200	530	<100	<50	680	1,000	<100	<2	
259847	D2-GW7-D	1/04/2021	Normal	<10,000	-	<1	<1	<1	<2	<1	<10	<10	120	120	<100	<100	<10	79	<100	<100	<2	
264262	D2-GW1-D	22/06/2021	Normal	<10,000	-	<1	<1	<1	<2	<1	<10	<10	140	140	270	<100	<10	66	340	<100	<2	
264262	D2-GW2-D	22/06/2021	Normal	<10,000	-	<1	<1	<1	<2	<1	<10	<10	550	550	460	<100	<10	330	670	<100	<2	
264262	D2-GW3-D	22/06/2021	Normal	<10,000	-	<1	<1	<1	<2	<1	<10	<10	220	220	<100	<100	<10	140	120	<100	<2	
264262	Z1	22/06/2021	Field_D (D2-GW3-D)	-	-	<1	<1	<1	<2	<1	<10	<10	250	250	<100	<100	<10	160	120	<100	-	
2111816	Z11	22/06/2021	Inter_Lab_D (D2-GW3-D)	-	-	-	-	-	-	-	<20	<20	200	200	<100	<100	-	-	-	-	-	
264262	D2-GW4-D	22/06/2021	Normal	<10,000	-	<1	<1	<1	<2	<1	<10	<10	210	210	<100	<100	<10	140	150	<100	<2	
264262	D2-GW5-D	22/06/2021	Normal	<10,000	-	<1	<1	<1	<2	<1	<10	<10	54	54	<100	<100	<10	<50	<100	<100	<2	
264262	D2-GW6-D	22/06/2021	Normal	<10,000	-	<1	<1	<1	<2	<1	<10	<10	590	590	450	<100	<10	350	700	<100	<2	
264262	D2-GW7-D	22/06/2021	Normal	<10,000	-	<1	<1	<1	<2	<1	<10	<10	150	150	140	<100	<10	98	150	<100	<2	
268970	D2-GW1-D	14/09/2021	Normal	<10,000	<0.001	<1	<1	<1	<1	<1	<10	<10	<10	<50	<100	<100	<10	<50	<100	<100	<2	
268970	X1	14/09/2021	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2117095	X11	14/09/2021	Inter_Lab_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
269100	D2-GW2-D	15/09/2021	Normal	<10,000	<0.001	<1	<1	<1	<2	<1	<10	<10	130	130	310	<100	<10	67	370	<100	<2	
269100	D2-GW3-D	15/09/2021	Normal	<10,000	<0.001	<1	<1	<1	<2	<1	<10	<10	<50	<50	<100	<100	<10	<50	<100	<100	<2	
269100	D2-GW4-D	14/09/2021	Normal	<10,000	<0.001	<1	<1	<1	<2	<1	<10	<10	<50	<50	<100	<100	<10	<50	<100	<100	<2	
268970	D2-GW5-D	14/09/2022	Normal	<10,000	<0.001	<1	<1	<1	<2	<1	<10	<10	<50	<50	<100	<100	<10	<50	<100	<100	<2	
268970	D2-GW6-D	14/09/2021	Normal	<10,000	<0.001	<1	<1	<1	<2	<1	<10	<10	170	170	260	<100	<10	110	<100	<100	<2	
268970	D2-GW7-D	13/09/2021	Normal	<10,000	<0.001	<1	<1	<1	<2	<1	<10	<10	<50	<50	<100	<100	<10	<50	<100	<100	<2	
282375	D2-GW1-D	25/05/2022	Normal	<10,000	<0.001	<1	<1	<1	<2	<1	<10	<10	<50	<50	<100	<100	<10	<50	<100	<100	<2	
282375	D2-GW4-D	25/05/2022	Normal	<10,000	<0.001	<1	<1	<1	<2	<1	<10	<10	<50	<50	<100	<100	<10	<50	<100	<100	<2	
282375	D2-GW5-D	24/05/2022	Normal	<10,000	<0.001	<1	<1	<1	<2	<1	<10	<10	<50	<50	<100	<100	<10	<50	<100	<100	<2	
282375	X1245	24/05/2022	Field_D (D2-GW5-D)	-	<0.001	<1	<1	<1	<2	<1	<10	<10	-	-	-	-	<10	-	-	-	-	
892696	Z1245	24/05/2022	Inter_Lab_D (D2-GW5-D)	-	<0.005	<1	<1	<1	<2	<1	<20	<20	<50	<50	<100	<100	-	-	-	-	-	
282375	D2-GW6-D	24/05/2022	Normal	<10,000	<0.001	<1	<1	<1	<2	<1	<10	<10	140	140	<100	<100	<10	95	<100	<100	<2	
282375	D2-GW7 -D	24/05/2022	Normal	<10,100	<0.001	<1	<1	<1	<2	<1	<10	<10	<50	<50	<100	<100	<10	<50	<100	<100	<2	

Statistics																		
Minimum Concentration	0	<0.001	<1	<1	<1	<1	<1	<10	<10	<50	<50	<100	<100	<10	<50	100	<100	<2
Maximum Concentration	<10,100	<0.001	<3	<3	<3	<6	<3	<50	<50	1200	1200	600	<100	<50	680	1600	<100	<2
Average Concentration *	<5000	0.1910	0.5921	0.5921	1.1711	0.5921	7.1797	7.1797	7.1797	104.0010	23.2161	155.0886	48.7513	7.1053	118.0811	268.3243	50	1
Standard Deviation *	0.01	0.4601	0.3258	0.3258	0.6604	0.3257	6.2610	6.2610	6.2610	157.1744	6.6748	211.3481	7.8978	6.2202	127.2697	359.0969	0	0

* A Non Detect Multiplier of 0.5 has been applied.

Environmental Standards

PFAS NEPM 2020 Interim Marine 95%	ANZG 2018 Marine Water 95% LOSP toxicant DGV's
PFAS NEMP 2020 Recreational Water	NEPM 2013 Table 1C GILs, Marine Waters
ANZECC 2000 MW 95%	ANZECC 2000 Irrigation Short Term Trigger Values



	Phenols															Halogenated Benzenes		
	2,3,4,6-Tetrachlorophenol	2,4,5-Trichlorophenol	2,4,6-Trichlorophenol	2,4-Dichlorophenol	2,4-Dimethylphenol	2,4-Dinitrophenol	2,6-Dichlorophenol	2-Chlorophenol	2-Methylphenol	2-Nitrophenol	4,6-Dinitro-2-methylphenol	4-chloro-3-methylphenol	4-Nitrophenol	Pentachlorophenol	Phenol	Hexachlorobenzene	Perfluorobutanoic acid (PFBA)	Perfluorohexanoic acid (PFHxA)
	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL	1	1	1	1	1	0.02	1	1	1	1	20	5	20	3	1	0.01	0.002	0.0004
ANZG 2018 Marine Water 95% LOSP toxicant DGV's														22	400	0.1		
ANZECC 2000 MW 95%														22	400			
ANZECC 2000 Irrigation Short Term Trigger Values																		
PFAS NEPM 2020 Interim Marine 95%																		
PFAS NEMP 2020 Recreational Water																		
NEPM 2013 Table 1C GILs, Marine Waters														11	400			

Lab Report Number	Field ID	Date	Sample Type	2,3,4,6-Tetrachlorophenol	2,4,5-Trichlorophenol	2,4,6-Trichlorophenol	2,4-Dichlorophenol	2,4-Dimethylphenol	2,4-Dinitrophenol	2,6-Dichlorophenol	2-Chlorophenol	2-Methylphenol	2-Nitrophenol	4,6-Dinitro-2-methylphenol	4-chloro-3-methylphenol	4-Nitrophenol	Pentachlorophenol	Phenol	Hexachlorobenzene	Perfluorobutanoic acid (PFBA)	Perfluorohexanoic acid (PFHxA)
254777	D2-GW1-D	8/12/2020	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<20	<20	<5	<20	<5	<1	<0.2	0.002	<0.0004
254470	X1	8/12/2020	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
254777	D2-GW2-D	10/12/2020	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	<0.002	<0.0004
254777	D2-GW3-D	9/12/2020	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	0.004	<0.0004
254777	D2-GW4-D	9/12/2020	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	<0.002	<0.0004
254777	D2-GW5-D	9/12/2020	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	<0.002	<0.0004
254777	D2-GW6-D	9/12/2020	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	<0.002	<0.0004
254777	D2-GW7-D	9/12/2020	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	<0.002	<0.0004
259847	D2-GW1-D	1/04/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	<0.002	<0.0004
259847	D2-GW2-D	1/04/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	<0.002	<0.0004
259847	Z1	1/04/2021	Field_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2106133	Z11	1/04/2021	Inter_Lab_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
259847	D2-GW3-D	1/04/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	<0.002	0.0008
259847	D2-GW4-D	1/04/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	<0.002	<0.0004
259847	D2-GW5-D	1/04/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	<0.002	<0.0004
259847	D2-GW6-D	1/04/2021	Normal	<1	<2	<2	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	<0.002	<0.0004
259847	D2-GW7-D	1/04/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.2	<0.002	<0.0004
264262	D2-GW1-D	22/06/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.01	0.004	<0.0004
264262	D2-GW2-D	22/06/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.01	<0.002	<0.0004
264262	D2-GW3-D	22/06/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.01	0.01	<0.0004
264262	Z1	22/06/2021	Field_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2111816	Z11	22/06/2021	Inter_Lab_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
264262	D2-GW4-D	22/06/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.01	<0.002	<0.0004
264262	D2-GW5-D	22/06/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.01	<0.002	<0.0004
264262	D2-GW6-D	22/06/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.01	<0.002	<0.0004
264262	D2-GW7-D	22/06/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.01	<0.002	<0.0004
268970	D2-GW1-D	14/09/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<3	<1	<0.01	<0.002	<0.0004
268970	X1	14/09/2021	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2117095	X11	14/09/2021	Inter_Lab_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.001	<0.0002
269100	D2-GW2-D	15/09/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<3	<1	<0.01	<0.002	0.002
269100	D2-GW3-D	15/09/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<3	<1	<0.01	<0.002	<0.0004
269100	D2-GW4-D	14/09/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<3	<1	<0.01	<0.002	<0.0004
268970	D2-GW5-D	14/09/2022	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<3	<1	<0.01	<0.002	<0.0004
268970	D2-GW6-D	14/09/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<3	<1	<0.01	<0.002	<0.0004
268970	D2-GW7-D	13/09/2021	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<3	<1	<0.01	<0.002	<0.0004
282375	D2-GW1-D	25/05/2022	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.01	<0.004	<0.0004
282375	D2-GW4-D	25/05/2022	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.01	<0.002	<0.0004
282375	D2-GW5-D	24/05/2022	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.01	<0.002	<0.0004
282375	X1245	24/05/2022	Field_D (D2-GW5-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.002	<0.0004
892696	Z1245	24/05/2022	Inter_Lab_D (D2-GW5-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1	<0.05
282375	D2-GW6-D	24/05/2022	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.01	<0.002	<0.0004
282375	D2-GW7 -D	24/05/2022	Normal	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<5	<1	<0.01	<0.01	<0.0004

Statistics																		
Minimum Concentration	<1	<1	<1	<1	<1	<0.02	<1	<1	<1	<1	<20	<5	<20	<3	<1	<0.01	<0.001	<0.0001
Maximum Concentration	<1	<2	<1	<1	<1	<0.02	<1	<1	<1	<20	<20	<5	<20	<5	<1	<0.2	0.01	0.002
Average Concentration *	0.5	0.5143	0.5143	0.5	0.5	0.01	0.5	0.5	0.5	0.7714	10	2.5	10	2.2429	0.5	0.043	0.0029	0.0016
Standard Deviation *	0	0.0845	0.0845	0	0	3.5201	0	0	0	1.6058	0	0	0	0.4434	0	0.0472	0.0081	0.0040

* A Non Detect Multiplier of 0.5 has been applied.

Environmental Standards

PFAS NEPM 2020 Interim Marine 95%	ANZG 2018 Marine Water 95% LOSP toxicant DGV's
PFAS NEMP 2020 Recreational Water	NEPM 2013 Table 1C GILs, Marine Waters
ANZECC 2000 MW 95%	ANZECC 2000 Irrigation Short Term Trigger Values



	Perfluoroalkane Carboxylic Acids									(n:2) Fluorotelomer Sulfonic Acids				Perfluoroalkane Sulfonic Acids					
	Perfluoropentanoic acid (PFPeA)	Perfluoroheptanoic acid (PFHpA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoDA)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTTrDA)	Perfluoroundecanoic acid (PFUnDA)	4:2 Fluorotelomer sulfonic acid (4:2 FTS)	6:2 Fluorotelomer sulfonic acid (6:2 FTS)	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	10:2 Fluorotelomer sulfonic acid (10:2 FTS)	Perfluorobutane sulfonic acid (PFBS)	Perfluoropentane sulfonic acid (PFPeS)	Perfluorohexane sulfonic acid (PFHxS)	Perfluoroheptane sulfonic acid (PFHpS)	Perfluorooctane sulfonic acid (PFOS)	Perfluorodecane sulfonic acid (PFDS)
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL	0.002	0.0004	0.0002	0.002	0.005	0.001	0.05	0.01	0.002	0.001	0.0004	0.0004	0.002	0.0004	0.001	0.0002	0.001	0.0002	0.002
ANZG 2018 Marine Water 95% LOSP toxicant DGV's																			
ANZECC 2000 MW 95%																			
ANZECC 2000 Irrigation Short Term Trigger Values																			
PFAS NEPM 2020 Interim Marine 95%			220															0.13	
PFAS NEMP 2020 Recreational Water			10																
NEPM 2013 Table 1C GILs, Marine Waters																			

Lab Report Number	Field ID	Date	Sample Type																			
254777	D2-GW1-D	8/12/2020	Normal	<0.002	<0.0004	0.0003	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.0005	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0002	<0.002
254470	X1	8/12/2020	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
254777	D2-GW2-D	10/12/2020	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	<0.0004	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0002	<0.002
254777	D2-GW3-D	9/12/2020	Normal	<0.002	<0.0004	0.0004	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	<0.0004	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0003	<0.002
254777	D2-GW4-D	9/12/2020	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	<0.0004	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0003	<0.002
254777	D2-GW5-D	9/12/2020	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	<0.0004	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0005	<0.002
254777	D2-GW6-D	9/12/2020	Normal	<0.002	0.0005	0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	<0.0004	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0020	<0.002
254777	D2-GW7-D	9/12/2020	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.001	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0020	<0.002
259847	D2-GW1-D	1/04/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.014	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
259847	D2-GW2-D	1/04/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.15	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
259847	Z1	1/04/2021	Field_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2106133	Z11	1/04/2021	Inter_Lab_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
259847	D2-GW3-D	1/04/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.28	0.0008	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
259847	D2-GW4-D	1/04/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.11	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
259847	D2-GW5-D	1/04/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.012	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
259847	D2-GW6-D	1/04/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.051	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
259847	D2-GW7-D	1/04/2021	Normal	<0.002	0.002	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.062	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
264262	D2-GW1-D	22/06/2021	Normal	<0.002	<0.0004	0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.002	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0004	<0.002
264262	D2-GW2-D	22/06/2021	Normal	<0.002	<0.0004	0.0003	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.0046	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0004	<0.002
264262	D2-GW3-D	22/06/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.001	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0005	<0.002
264262	Z1	22/06/2021	Field_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2111816	Z11	22/06/2021	Inter_Lab_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
264262	D2-GW4-D	22/06/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.0040	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0027	<0.002
264262	D2-GW5-D	22/06/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.0040	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0042	<0.002
264262	D2-GW6-D	22/06/2021	Normal	<0.002	<0.0004	0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.0048	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.0009	<0.002
264262	D2-GW7-D	22/06/2021	Normal	<0.002	<0.0004	0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.052	<0.0004	<0.002	<0.0004	<0.001	0.0003	<0.001	0.0030	<0.002
268970	D2-GW1-D	14/09/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	<0.0004	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
268970	X1	14/09/2021	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2117095	X11	14/09/2021	Inter_Lab_D (D2-GW1-D)	<0.0002	<0.0008	<0.0002	<0.0002	<0.0004	<0.0004	<0.0004	<0.0004	<0.0002	<0.001	<0.001	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	0.0012	<0.0004
269100	D2-GW2-D	15/09/2021	Normal	<0.002	<0.0004	0.0004	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.0006	<0.0004	<0.002	<0.01	<0.001	<0.0002	<0.001	0.0020	<0.002
269100	D2-GW3-D	15/09/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	<0.0004	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.001	<0.002
269100	D2-GW4-D	14/09/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.0005	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	0.001	<0.002
268970	D2-GW5-D	14/09/2022	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	<0.0004	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
268970	D2-GW6-D	14/09/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	<0.0004	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
268970	D2-GW7-D	13/09/2021	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.0008	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
282375	D2-GW1-D	25/05/2022	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.001	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
282375	D2-GW4-D	25/05/2022	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.0007	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
282375	D2-GW5-D	24/05/2022	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.0040	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
282375	X1245	24/05/2022	Field_D (D2-GW5-D)	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.0040	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
892696	Z1245	24/05/2022	Inter_Lab_D (D2-GW5-D)	<0.05	<0.1	<0.05	-	-	-	-	-	-	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-
282375	D2-GW6-D	24/05/2022	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.003	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002
282375	D2-GW7 -D	24/05/2022	Normal	<0.002	<0.0004	<0.0002	<0.002	<0.005	<0.001	<0.05	<0.01	<0.002	<0.001	0.003	<0.0004	<0.002	<0.0004	<0.001	<0.0002	<0.001	<0.0002	<0.002



	Perfluoroalkyl Sulfonamides							PFAS											
	Perfluorooctane sulfonamide (FOSA)	N-Methyl perfluorooctane sulfonamide (MeFOSA)	N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	N-methyl perfluorooctane sulfonamidoethanol (MeFOSE)	N-Ethyl perfluorooctane sulfonamide (EtFOSA)	N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	Sum of PFHxS and PFOS	Sum of PFAS	Sum of PFAS (PFOS + PFOA)	Hardness	Electrical Conductivity (Non Compensated)	Alkalinity (Bicarbonate as CaCO3)	Alkalinity (Carbonate as CaCO3)	Alkalinity (Hydroxide) as CaCO3	Alkalinity (total)	Ammonia as N	Biochemical Oxygen Demand	Bromide
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L
EQL	0.01	0.005	0.002	0.005	0.01	0.002	0.05	0.0002	0.0002	0.0002	3	1	5	5	5	5	0.005	5	500
ANZG 2018 Marine Water 95% LOSP toxicant DGV's																	0.91		
ANZECC 2000 MW 95%																	0.91		
ANZECC 2000 Irrigation Short Term Trigger Values																			
PFAS NEPM 2020 Interim Marine 95%																			
PFAS NEMP 2020 Recreational Water								2											
NEPM 2013 Table 1C GILs, Marine Waters																			

Lab Report Number	Field ID	Date	Sample Type																			
254777	D2-GW1-D	8/12/2020	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.0002	0.0030	0.0005	55	-	76	<5	<5	76	0.046	14	-
254470	X1	8/12/2020	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
254777	D2-GW2-D	10/12/2020	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.0002	0.0002	0.0002	60	-	40	<5	<5	40	0.046	<5	-
254777	D2-GW3-D	9/12/2020	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.0003	0.0047	0.0007	35	-	39	<5	<5	39	<0.005	<5	-
254777	D2-GW4-D	9/12/2020	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.0003	0.0003	0.0003	36	-	43	<5	<5	43	<0.005	12	-
254777	D2-GW5-D	9/12/2020	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.0005	0.0005	0.0005	25	-	22	<5	<5	22	<0.005	13	-
254777	D2-GW6-D	9/12/2020	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.002	0.0027	0.0022	68	-	130	<5	<5	130	<0.005	26	-
254777	D2-GW7-D	9/12/2020	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.002	0.0030	0.002	150	-	54	<5	<5	54	<0.005	11	-
259847	D2-GW1-D	1/04/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	<0.0002	0.014	<0.0002	47	330	61	<5	<5	61	0.044	15	<500
259847	D2-GW2-D	1/04/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	<0.0002	0.15	<0.0002	51	400	23	<5	<5	23	0.026	9	<500
259847	Z1	1/04/2021	Field_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2106133	Z11	1/04/2021	Inter_Lab_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
259847	D2-GW3-D	1/04/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	<0.0002	0.28	<0.0002	29	1,200	44	<5	<5	44	0.053	11	900
259847	D2-GW4-D	1/04/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	<0.0002	0.11	<0.0002	32	220	33	<5	<5	33	0.14	11	<500
259847	D2-GW5-D	1/04/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	<0.0002	0.012	<0.0002	31	180	11	<5	<5	11	<0.005	9	<500
259847	D2-GW6-D	1/04/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	<0.0002	0.051	<0.0002	48	430	66	<5	<5	66	0.16	16	<500
259847	D2-GW7-D	1/04/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	<0.0002	0.064	<0.0002	150	1,800	56	<5	<5	56	<0.005	11	1,500
264262	D2-GW1-D	22/06/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.0004	0.0066	0.0006	35	280	29	<5	<5	29	0.017	16	<500
264262	D2-GW2-D	22/06/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.0004	0.0053	0.0007	46	490	49	<5	<5	49	0.15	16	<500
264262	D2-GW3-D	22/06/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.0005	0.012	0.0005	19	240	10	<5	<5	10	<0.005	20	<500
264262	Z1	22/06/2021	Field_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2111816	Z11	22/06/2021	Inter_Lab_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
264262	D2-GW4-D	22/06/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.0027	0.0067	0.0027	25	230	12	<5	<5	12	0.042	10	<500
264262	D2-GW5-D	22/06/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.0042	0.0082	0.0042	17	220	6	<5	<5	6	0.01	20	<500
264262	D2-GW6-D	22/06/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.0009	0.0059	0.001	37	2,000	60	<5	<5	60	0.032	17	<500
264262	D2-GW7-D	22/06/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.0033	0.056	0.0032	130	360	44	<5	<5	44	0.012	20	1,300
268970	D2-GW1-D	14/09/2021	Normal	<0.01	<0.005	<0.002	<0.05	<0.01	<0.002	<0.05	0.001	0.001	0.001	30	250	15	<5	<5	15	0.008	<5	<500
268970	X1	14/09/2021	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2117095	X11	14/09/2021	Inter_Lab_D (D2-GW1-D)	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0005	0.012	0.012	-	-	-	-	-	-	-	-	-	
269100	D2-GW2-D	15/09/2021	Normal	<0.01	<0.05	<0.002	<0.05	<0.01	<0.002	<0.05	0.002	0.0050	0.0024	37	330	69	<5	<5	69	0.25	18	<500
269100	D2-GW3-D	15/09/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.001	0.001	0.001	22	200	7	<5	<5	7	<0.005	13	<500
269100	D2-GW4-D	14/09/2021	Normal	<0.01	<0.005	<0.002	<0.005	<0.01	<0.002	<0.05	0.001	0.002	0.001	23	190	8	<5	<5	8	<0.005	17	<500
268970	D2-GW5-D	14/09/2022	Normal	<0.01	<0.005	<0.002	<0.05	<0.01	<0.002	<0.05	<0.0002	<0.0002	<0.0002	24	250	10	<5	<5	10	<0.005	<5	<500
268970	D2-GW6-D	14/09/2021	Normal	<0.01	<0.005	<0.002	<0.05	<0.01	<0.002	<0.05	0.002	0.002	0.002	35	300	25	<5	<5	25	0.007	<5	<500
268970	D2-GW7-D	13/09/2021	Normal	<0.01	<0.005	<0.002	<0.05	<0.01	<0.002	<0.05	0.002	0.0028	0.002	130	1700	56	<5	<5	56	<0.005	<5	1300
282375	D2-GW1-D	25/05/2022	Normal	<0.01	<0.02	<0.002	<0.01	<0.05	<0.002	<0.1	<0.0002	0.001	<0.0002	34	280	12	<5	<5	12	<0.005	16	-
282375	D2-GW4-D	25/05/2022	Normal	<0.01	<0.02	<0.002	<0.01	<0.05	<0.002	<0.1	<0.0002	0.0007	<0.0002	37	320	11	<5	<5	11	0.006	13	-
282375	D2-GW5-D	24/05/2022	Normal	<0.01	<0.02	<0.002	<0.005	<0.05	<0.002	<0.05	<0.0002	0.0040	<0.0002	25	270	10	<5	<5	10	<0.005	<20	-
282375	X1245	24/05/2022	Field_D (D2-GW5-D)	<0.01	<0.01	<0.002	<0.005	<0.02	<0.002	<0.05	<0.0002	0.0040	<0.0002	-	-	-	-	-	-	-	-	
892696	Z1245	24/05/2022	Inter_Lab_D (D2-GW5-D)	-	-	-	-	-	-	-	<0.1	<0.05	-	-	-	-	-	-	-	-	-	
282375	D2-GW6-D	24/05/2022	Normal	<0.01	<0.02	<0.002	<0.01	<0.05	<0.002	<0.1	<0.0002	0.0030	<0.0002	24	280	12	<5	<5	12	<0.005	13	-
282375	D2-GW7 -D	24/05/2022	Normal	<0.01	<0.02	<0.002	<0.005	<0.05	<0.002	<0.05	<0.0002	0.0030	<0.0002	130	1,300	24	<5	<5	24	<0.005	15	-

Statistics


Minimum Concentration	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0005	<0.0002	<0.0002	<0.0002	17	190	6	<5	<5	6	<0.005	0	<500
Maximum Concentration	<0.01	<0.05	<0.002	<0.05	<0.05	<0.002	0.05	0.012	0.064	0.0042	150	2000	130	<5	<5	130	0.25	20	1500
Average Concentration *	0.0049	0.0042	0.0010	0.0057	0.0077	0.0010	0.0264	0.0024	0.0233	0.0009	57.3429	630.3571	39.9429	2.5	2.5	39.9429	0.03	12.3143	576.0870
Standard Deviation *	0.0008	0.0045	0.0001	0.0078	0.0070	0.0001	0.0082	0.0082	0.0538	0.0010	47.1050	651.7184	34.2301	0	0	34.2301	0.06	5.7753	669.7811

* A Non Detect Multiplier of 0.5 has been applied.

Environmental Standards

PFAS NEPM 2020 Interim Marine 95%	ANZG 2018 Marine Water 95% LOSP toxicant DGV's
PFAS NEMP 2020 Recreational Water	NEPM 2013 Table 1C GILs, Marine Waters
ANZECC 2000 MW 95%	ANZECC 2000 Irrigation Short Term Trigger Values





	Inorganics																Organic	Biological	
	Chloride	Chemical Oxygen Demand	Ionic Balance	Kjeldahl Nitrogen Total	Nitrate (as N)	Nitrite (as N)	Organic Nitrogen as N	Nitrogen (Total Oxidised)	Nitrogen (Total)	pH (Lab)	Total Phosphorus (Organic Phosphate)	Reactive Phosphorus as P (Orthophosphate as P)	Sodium (filtered)	Sulphate	Total Dissolved Solids (Lab)	Total Suspended Solids (Lab)	Total Organic Carbon	E. Coli	Thermotolerant Coliforms
	mg/L	mg/L	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	cfu/100 ml	cfu/100 mL
EQL	1	20		0.1	0.005	0.005	0.1	0.005	0.1		0.05	0.005	0.5	1	5	5	1	1	1
ANZG 2018 Marine Water 95% LOSP toxicant DGV's																			
ANZECC 2000 MW 95%																			
ANZECC 2000 Irrigation Short Term Trigger Values																			
PFAS NEPM 2020 Interim Marine 95%																			
PFAS NEMP 2020 Recreational Water																			
NEPM 2013 Table 1C GILs, Marine Waters																			

Lab Report Number	Field ID	Date	Sample Type																			
254777	D2-GW1-D	8/12/2020	Normal	77	<20	-0.89	2.7	0.59	0.14	2.6	0.73	3.4	-	<0.05	0.026	59	5	310	6	8	<10	10
254470	X1	8/12/2020	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
254777	D2-GW2-D	10/12/2020	Normal	100	<20	1.5	1.2	2.7	0.085	1.2	2.8	4.0	-	<0.05	0.030	63	10	380	<5	4	7	>150
254777	D2-GW3-D	9/12/2020	Normal	50	51	7.5	5.6	3.8	0.17	5.6	4.0	9.6	-	<0.05	0.046	46	8	320	<5	20	<1	2
254777	D2-GW4-D	9/12/2020	Normal	49	<20	1.6	7.6	3.7	0.13	7.5	3.8	11	-	<0.05	0.023	38	5	270	10	24	<1	11
254777	D2-GW5-D	9/12/2020	Normal	38	<20	7.0	2.4	3.8	0.014	2.4	3.8	6.2	-	<0.05	0.035	32	7	210	<5	7	<1	1
254777	D2-GW6-D	9/12/2020	Normal	99	64	-6.9	15	1.9	0.033	15	2.0	17	-	<0.05	0.014	75	4	470	<5	64	<1	150
254777	D2-GW7-D	9/12/2020	Normal	410	<20	-1.3	0.7	2.9	0.051	0.7	2.9	3.6	-	<0.05	0.024	250	72	990	9	2	<1	8
259847	D2-GW1-D	1/04/2021	Normal	61	<20	0.029	1.0	0.029	0.054	1	0.083	1.1	6.6	0.06	0.040	47	5	280	-	6	-	-
259847	D2-GW2-D	1/04/2021	Normal	89	<20	1.8	0.5	3.1	0.10	0.5	3.2	3.8	6.2	<0.05	0.025	52	10	360	-	<1	-	-
259847	Z1	1/04/2021	Field_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2106133	Z11	1/04/2021	Inter_Lab_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
259847	D2-GW3-D	1/04/2021	Normal	280	27	-63	1.6	3.6	0.037	1.6	3.6	5.3	6.5	<0.05	0.027	36	50	760	-	8	-	-
259847	D2-GW4-D	1/04/2021	Normal	37	50	5.0	2.4	1.6	0.23	2.3	1.9	4.3	6.5	<0.05	0.031	31	7	260	-	9	-	-
259847	D2-GW5-D	1/04/2021	Normal	31	55	31	0.8	3.9	<0.005	0.8	3.9	4.7	5.9	<0.05	0.047	39	7	270	-	2	-	-
259847	D2-GW6-D	1/04/2021	Normal	75	34	-4.2	5.5	1.4	0.45	5.3	1.8	7.3	6.6	0.06	0.036	57	15	340	-	22	-	-
259847	D2-GW7-D	1/04/2021	Normal	470	27	-1.6	0.6	3.1	<0.005	0.6	3.1	3.7	6.4	<0.05	0.032	280	76	1,100	-	5	-	-
264262	D2-GW1-D	22/06/2021	Normal	60	<20	-9.3	0.3	1.0	0.093	0.3	1.1	1.4	6.7	<0.05	0.007	31	12	190	-	<1	<1	3
264262	D2-GW2-D	22/06/2021	Normal	100	<20	-9.1	0.9	2.1	0.18	0.7	2.3	3.1	6.4	0.07	0.034	57	16	330	-	8	<1	33
264262	D2-GW3-D	22/06/2021	Normal	41	<20	0.50	0.5	4.7	0.009	0.5	4.7	5.2	5.8	<0.05	0.014	28	12	160	-	2	<1	<1
264262	Z1	22/06/2021	Field_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2111816	Z11	22/06/2021	Inter_Lab_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
264262	D2-GW4-D	22/06/2021	Normal	43	<20	2.0	0.7	3.7	0.053	0.6	3.7	4.4	6.0	<0.05	0.018	25	4	120	-	3	<1	<1
264262	D2-GW5-D	22/06/2021	Normal	37	<20	8.0	0.3	5.0	0.007	0.2	5.0	5.3	5.6	<0.05	0.035	28	9	140	-	<1	<1	<1
264262	D2-GW6-D	22/06/2021	Normal	45	29	6.2	3.5	2.7	0.45	3.5	3.1	6.7	6.3	<0.05	0.030	55	14	1,100	-	13	<1	26
264262	D2-GW7-D	22/06/2021	Normal	480	21	-8.9	0.3	3.2	<0.005	0.3	3.2	3.6	6.4	<0.05	0.022	240	72	190	-	6	<1	17
268970	D2-GW1-D	14/09/2021	Normal	56	<20	1.7	0.4	1.8	0.12	0.3	1.9	2.3	5.9	<0.05	<0.005	36	13	210	-	1	<10	<10
268970	X1	14/09/2021	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2117095	X11	14/09/2021	Inter_Lab_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
269100	D2-GW2-D	15/09/2021	Normal	58	<20	-2.1	1.0	0.037	0.016	0.8	0.053	1.1	6.6	0.06	0.012	54	12	280	-	4	<10	<10
269100	D2-GW3-D	15/09/2021	Normal	38	<20	5.7	0.3	2.8	<0.005	0.3	2.8	3.1	5.7	<0.05	0.01	29	16	170	-	<1	<10	<10
269100	D2-GW4-D	14/09/2021	Normal	44	<20	2.9	0.4	3.1	0.005	0.4	3.1	3.6	5.8	<0.05	0.008	25	4	160	-	2	<10	<10
268970	D2-GW5-D	14/09/2022	Normal	52	<20	6.1	0.9	6.4	<0.005	0.9	6.5	7.4	6.8	<0.05	0.015	36	8	200	-	1	<10	<10
268970	D2-GW6-D	14/09/2021	Normal	55	<20	5.2	1.9	4.9	0.27	1.9	5.1	7.1	6.1	<0.05	0.029	47	21	210	-	2	<10	<10
268970	D2-GW7-D	13/09/2021	Normal	480	<20	-2.6	0.9	2.6	<0.005	0.9	2.6	3.5	6.2	<0.05	0.009	290	68	1200	-	4	<10	<10
282375	D2-GW1-D	25/05/2022	Normal	60	<20	4.7	0.4	3.9	0.013	0.4	3.9	4.3	-	<0.05	0.020	37	10	170	-	<1	<1	<1
282375	D2-GW4-D	25/05/2022	Normal	64	<20	5.4	0.4	5.9	0.011	0.3	5.9	6.3	-	<0.05	0.018	39	10	190	-	<1	<1	<1
282375	D2-GW5-D	24/05/2022	Normal	54	<20	6.2	0.4	6.4	0.008	0.4	6.4	6.8	-	<0.05	0.014	37	8	160	-	<1	<1	<1
282375	X1245	24/05/2022	Field_D (D2-GW5-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
892696	Z1245	24/05/2022	Inter_Lab_D (D2-GW5-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
282375	D2-GW6-D	24/05/2022	Normal	51	<20	7.3	0.5	7.9	0.021	0.5	7.9	8.5	-	<0.05	0.027	39	9	170	-	<1	<1	<1
282375	D2-GW7 -D	24/05/2022	Normal	330	<20	-1.3	0.2	4.4	<0.005	0.2	4.4	4.6	-	<0.05	0.009	190	59	760	-	2	<1	<1


Statistics																			
Minimum Concentration	31	<20	-89	0.2	0.029	<0.005	0.2	0.053	0.4	5.6	<0.05	<0.005	25	4	120	<5	<1	<1	<1
Maximum Concentration	480	64	31	15	7.9	0.45	15	7.9	17	6.8	0.07	0.047	290	76	1100	10	64	7	150
Average Concentration *	142.9714	6.39	-0.1246	1.78	3.0899	0.0821	1.7429	3.2479	1.7429	5.0343	6.42	0.0237	84.5143	20.3714	419.1429	5	6.7	0.62	11.4815
Standard Deviation *	170.5345	12.487	13.0768	2.8730	1.8247	0.1171	2.8674	1.8134	2.8674	3.1588	0.5	0.0126	92.2906	22.4265	360.1582	3.3417	11.7061	2.26	28.7701

* A Non Detect Multiplier of 0.5 has been applied.

Environmental Standards

PFAS NEPM 2020 Interim Marine 95%	ANZG 2018 Marine Water 95% LOSP toxicant DGV's
PFAS NEMP 2020 Recreational Water	NEPM 2013 Table 1C GILs, Marine Waters
ANZECC 2000 MW 95%	ANZECC 2000 Irrigation Short Term Trigger Values





	Metals																		
	Aluminium (filtered)	Arsenic (filtered)	Beryllium (filtered)	Boron (filtered)	Cadmium (filtered)	Calcium (filtered)	Chromium (III+VI) (filtered)	Cobalt (filtered)	Copper (filtered)	Lead (filtered)	Lithium (filtered)	Magnesium (filtered)	Manganese (filtered)	Mercury (filtered)	Nickel (filtered)	Potassium (filtered)	Zinc (filtered)	4,4-DDE	a-BHC
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L
EQL	0.01	0.001	0.0005	0.02	0.0001	0.5	0.001	0.001	0.001	0.001	0.0005	0.5	0.005	0.00005	0.001	0.5	0.001	0.01	0.05
ANZG 2018 Marine Water 95% LOSP toxicant DGV's					0.0055				0.0013	0.0044				0.0004	0.07		0.015		
ANZECC 2000 MW 95%					0.0055				0.0013	0.0044				0.0004	0.07		0.015		
ANZECC 2000 Irrigation Short Term Trigger Values	20	2	0.5		0.5	1	1	0.1	5	5	2.5		10	0.002	2		5		
PFAS NEPM 2020 Interim Marine 95%																			
PFAS NEMP 2020 Recreational Water																			
NEPM 2013 Table 1C GILs, Marine Waters					0.0007				0.0013	0.0044				0.001	0.007		0.015		

Lab Report Number	Field ID	Date	Sample Type																	
254777	D2-GW1-D	8/12/2020	Normal	0.05	0.002	<0.0005	-	<0.0001	-	<0.001	-	0.001	<0.001	-	-	1.1	<0.00005	0.005	-	0.006
254470	X1	8/12/2020	Field_D (D2-GW1-D)	0.05	0.002	<0.0005	-	<0.0001	-	<0.001	-	0.066	0.003	-	-	1.0	<0.00005	0.012	-	0.093
254777	D2-GW2-D	10/12/2020	Normal	0.02	0.001	<0.0005	-	<0.0001	-	<0.001	-	0.097	0.003	-	-	0.54	<0.00005	0.012	-	0.069
254777	D2-GW3-D	9/12/2020	Normal	0.06	0.002	<0.0005	-	<0.0001	-	0.001	-	0.067	0.003	-	-	0.45	<0.00005	0.011	-	0.064
254777	D2-GW4-D	9/12/2020	Normal	0.02	<0.001	<0.0005	-	<0.0001	-	<0.001	-	0.094	0.003	-	-	0.63	<0.00005	0.013	-	0.065
254777	D2-GW5-D	9/12/2020	Normal	0.04	<0.001	<0.0005	-	<0.0001	-	<0.001	-	0.12	0.005	-	-	0.099	<0.00005	0.019	-	0.084
254777	D2-GW6-D	9/12/2020	Normal	0.02	0.002	<0.0005	-	<0.0001	-	0.001	-	0.074	0.004	-	-	1.8	<0.00005	0.018	-	0.081
254777	D2-GW7-D	9/12/2020	Normal	0.02	<0.001	<0.0005	-	<0.0001	-	<0.001	-	0.084	0.004	-	-	0.31	<0.00005	0.074	-	0.085
259847	D2-GW1-D	1/04/2021	Normal	<0.01	0.003	<0.0005	-	<0.0001	-	0.001	<0.001	0.014	7.5	1.9	<0.00005	0.002	1.8	0.006	<0.2	<0.2
259847	D2-GW2-D	1/04/2021	Normal	<0.01	<0.001	<0.0005	-	<0.0001	-	0.005	<0.001	0.0029	8.6	0.22	<0.00005	0.008	0.8	0.014	<0.2	<0.2
259847	Z1	1/04/2021	Field_D (D2-GW2-D)	0.02	<0.001	<0.0005	-	<0.0001	-	0.11	0.002	0.0031	-	0.20	<0.00005	0.014	-	0.084	-	-
2106133	Z11	1/04/2021	Inter_Lab_D (D2-GW2-D)	<0.01	<0.001	<0.01	-	<0.0001	-	<0.001	-	0.004	<0.001	<0.01	-	0.20	<0.0001	0.007	-	0.013
259847	D2-GW3-D	1/04/2021	Normal	0.04	0.001	<0.0005	-	0.0001	4.7	<0.001	-	0.054	0.002	0.0094	4.3	0.40	<0.00005	0.012	2.7	0.15
259847	D2-GW4-D	1/04/2021	Normal	0.01	<0.001	<0.0005	-	<0.0001	3.6	<0.001	-	0.001	<0.001	0.023	5.7	0.76	<0.00005	0.002	2.3	0.020
259847	D2-GW5-D	1/04/2021	Normal	0.02	<0.001	<0.0005	-	<0.0001	3.3	<0.001	-	<0.001	<0.001	0.018	5.4	0.39	<0.00005	0.006	1.3	0.017
259847	D2-GW6-D	1/04/2021	Normal	0.05	0.003	<0.0005	-	<0.0001	6.2	<0.001	-	0.059	0.003	0.0078	7.8	1.1	<0.00005	0.017	1.8	0.11
259847	D2-GW7-D	1/04/2021	Normal	<0.01	<0.001	<0.0005	-	<0.0001	16	<0.001	-	0.006	<0.001	0.0033	25	0.074	<0.00005	0.005	2.0	0.031
264262	D2-GW1-D	22/06/2021	Normal	<0.01	<0.001	<0.0005	-	<0.0001	3.9	<0.001	-	0.003	<0.001	0.033	6.2	1.1	<0.00005	0.005	1.6	0.009
264262	D2-GW2-D	22/06/2021	Normal	<0.01	0.002	<0.0005	-	<0.0001	5.5	<0.001	-	0.003	<0.001	0.0037	7.7	0.54	<0.00005	0.005	0.8	0.009
264262	D2-GW3-D	22/06/2021	Normal	<0.01	<0.001	<0.0005	-	<0.0001	2.0	<0.001	-	0.001	<0.001	0.012	3.5	0.095	<0.00005	0.003	0.8	0.015
264262	Z1	22/06/2021	Field_D (D2-GW3-D)	<0.01	<0.001	<0.0005	-	<0.0001	-	<0.001	-	0.002	<0.001	0.012	-	0.097	<0.00005	0.003	-	0.014
2111816	Z11	22/06/2021	Inter_Lab_D (D2-GW3-D)	<0.01	<0.001	<0.01	-	<0.0001	-	<0.001	-	0.002	<0.001	0.01	-	0.10	<0.0001	0.003	-	0.017
264262	D2-GW4-D	22/06/2021	Normal	0.01	<0.001	<0.0005	-	<0.0001	1.8	<0.001	-	0.009	<0.001	0.041	4.9	0.40	<0.00005	0.005	0.9	0.018
264262	D2-GW5-D	22/06/2021	Normal	0.01	<0.001	<0.0005	-	<0.0001	1.5	<0.001	-	0.010	<0.001	0.026	3.2	0.065	<0.00005	0.006	0.6	0.039
264262	D2-GW6-D	22/06/2021	Normal	0.03	0.001	<0.0005	-	<0.0001	4.7	<0.001	-	0.010	<0.001	0.0074	6.1	0.65	<0.00005	0.008	0.8	0.090
264262	D2-GW7-D	22/06/2021	Normal	0.07	<0.001	<0.0005	-	<0.0001	14	<0.001	-	0.012	<0.001	0.0031	23	0.051	<0.00005	0.022	1.6	0.035
268970	D2-GW1-D	14/09/2021	Normal	-	<0.001	-	-	<0.0001	2.9	<0.001	-	<0.001	<0.001	-	5.6	-	<0.00005	0.013	1.4	0.01
268970	X1	14/09/2021	Field_D (D2-GW1-D)	-	<0.001	-	-	-	-	<0.001	-	0.002	<0.001	-	-	-	<0.00005	0.014	-	0.013
2117095	X11	14/09/2021	Inter_Lab_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
269100	D2-GW2-D	15/09/2021	Normal	-	0.002	-	-	<0.0001	4.4	<0.001	-	<0.001	<0.001	-	6.4	-	<0.00005	0.015	1.3	0.014
269100	D2-GW3-D	15/09/2021	Normal	-	<0.001	-	-	<0.0001	2.1	<0.001	-	0.005	<0.001	-	4.0	-	<0.00005	0.051	1	0.032
269100	D2-GW4-D	14/09/2021	Normal	-	<0.001	-	-	<0.0001	1.2	<0.001	-	0.004	<0.001	-	4.9	-	<0.00005	0.002	0.8	0.020
268970	D2-GW5-D	14/09/2022	Normal	-	<0.001	-	-	<0.0001	2.5	<0.001	-	0.003	<0.001	-	4.4	-	<0.00005	0.009	0.6	0.015
268970	D2-GW6-D	14/09/2021	Normal	-	<0.001	-	-	<0.0001	3.3	<0.001	-	0.004	<0.001	-	6.6	-	<0.00005	0.032	0.9	0.024
268970	D2-GW7-D	13/09/2021	Normal	-	<0.001	-	-	<0.0001	13	<0.001	-	0.003	<0.001	-	23	-	<0.00005	0.023	0.7	0.022
282375	D2-GW1-D	25/05/2022	Normal	-	<0.001	<0.0005	0.2	<0.0001	2.8	<0.001	<0.001	0.002	<0.001	-	6.7	0.27	<0.00005	0.007	1.9	0.040
282375	D2-GW4-D	25/05/2022	Normal	-	<0.001	<0.0005	0.2	<0.0001	3.5	<0.001	<0.001	0.001	<0.001	-	6.9	0.14	<0.00005	0.003	1.7	0.012
282375	D2-GW5-D	24/05/2022	Normal	-	<0.001	<0.0005	0.2	<0.0001	1.9	<0.001	<0.001	0.003	<0.001	-	4.8	0.018	<0.00005	0.0099	0.7	0.036
282375	X1245	24/05/2022	Field_D (D2-GW5-D)	-	<0.001	<0.0005	0.2	<0.0001	-	<0.001	<0.001	0.003	<0.001	-	-	0.018	<0.00005	0.01	-	0.035
892696	Z1245	24/05/2022	Inter_Lab_D (D2-GW5-D)	-	<0.001	<0.01	0.15	<0.0001	-	<0.001	<0.001	0.004	<0.001	-	-	0.02	0.0002	0.014	-	0.039
282375	D2-GW6-D	24/05/2022	Normal	-	<0.001	<0.0005	0.23	<0.0001	1.7	<0.001	0.001	0.005	<0.001	-	4.7	0.23	<0.00005	0.011	0.8	0.049
282375	D2-GW7 -D	24/05/2022	Normal	-	<0.001	<0.0005	0.56	<0.0001	11	<0.001	<0.001	0.004	<0.001	-	24	0.018	<0.00005	0.007	1.0	0.039


Statistics																			
Minimum Concentration	<0.01	<0.001	<0.0005	0.15	<0.0001	1.2	<0.001	<0.001	<0.001	<0.001	0.0029	3.2	0.018	<0.00005	0.002	0.6	0.006	<0.01	<0.05
Maximum Concentration	0.07	0.003	<0.01	0.56	0.0001	28	0.001	0.001	0.12	0.005	0.041	25	1.9	0.0002	0.074	2.7	0.15	<0.2	<0.2
Average Concentration *	0.0226	0.0008	0.0007	0.2486	0.0001	6.2571	0.0006	0.0006	0.0220	0.0011	0.0130	9.7821	0.4541	0.00003	0.0123	1.7143	0.0392	0.043	0.055
Standard Deviation *	0.0203	0.0006	0.0014	0.1393	0.0000	6.2012	0.0002	0.0002	0.0353	0.0012	0.0111	8.1062	0.4922	0.00003	0.0132	1.8529	0.0332	0.0472	0.0373

* A Non Detect Multiplier of 0.5 has been applied.

Environmental Standards

PFAS NEPM 2020 Interim Marine 95%	ANZG 2018 Marine Water 95% LOSP toxicant DGV's
PFAS NEMP 2020 Recreational Water	NEPM 2013 Table 1C GILs, Marine Waters
ANZECC 2000 MW 95%	ANZECC 2000 Irrigation Short Term Trigger Values





	Organochlorine Pesticides																			
	Aldrin	β-BHC	Chlordane (cis)	Chlordane (trans)	γ-BHC	DDD	DDT	Dieldrin	Endosulfan I	Endosulfan II	Endosulfan sulphate	Endrin	Endrin aldehyde	Endrin ketone	γ-BHC (Lindane)	Heptachlor	Heptachlor epoxide	Methoxychlor	Azinophos methyl	
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	
EQL	0.01	0.05	0.01	0.01	0.05	0.01	0.006	0.01	0.02	0.02	0.02	0.01	0.2	0.2	0.05	0.01	0.01	0.02	0.01	
ANZG 2018 Marine Water 95% LOSP toxicant DGV's												0.008								
ANZECC 2000 MW 95%												0.008								
ANZECC 2000 Irrigation Short Term Trigger Values																				
PFAS NEPM 2020 Interim Marine 95%																				
PFAS NEMP 2020 Recreational Water																				
NEPM 2013 Table 1C GILs, Marine Waters												0.004								

Lab Report Number	Field ID	Date	Sample Type																			
254777	D2-GW1-D	8/12/2020	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
254470	X1	8/12/2020	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
254777	D2-GW2-D	10/12/2020	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
254777	D2-GW3-D	9/12/2020	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
254777	D2-GW4-D	9/12/2020	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
254777	D2-GW5-D	9/12/2020	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
254777	D2-GW6-D	9/12/2020	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
254777	D2-GW7-D	9/12/2020	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
259847	D2-GW1-D	1/04/2021	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
259847	D2-GW2-D	1/04/2021	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
259847	Z1	1/04/2021	Field_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2106133	Z11	1/04/2021	Inter_Lab_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
259847	D2-GW3-D	1/04/2021	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
259847	D2-GW4-D	1/04/2021	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
259847	D2-GW5-D	1/04/2021	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
259847	D2-GW6-D	1/04/2021	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.2	<0.2	<0.2	
259847	D2-GW7-D	1/04/2021	Normal	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
264262	D2-GW1-D	22/06/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
264262	D2-GW2-D	22/06/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
264262	D2-GW3-D	22/06/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
264262	Z1	22/06/2021	Field_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2111816	Z11	22/06/2021	Inter_Lab_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
264262	D2-GW4-D	22/06/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
264262	D2-GW5-D	22/06/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
264262	D2-GW6-D	22/06/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
264262	D2-GW7-D	22/06/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
268970	D2-GW1-D	14/09/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
268970	X1	14/09/2021	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2117095	X11	14/09/2021	Inter_Lab_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
269100	D2-GW2-D	15/09/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
269100	D2-GW3-D	15/09/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
269100	D2-GW4-D	14/09/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
268970	D2-GW5-D	14/09/2022	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
268970	D2-GW6-D	14/09/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
268970	D2-GW7-D	13/09/2021	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.01
282375	D2-GW1-D	25/05/2022	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.02
282375	D2-GW4-D	25/05/2022	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.02
282375	D2-GW5-D	24/05/2022	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.02
282375	X1245	24/05/2022	Field_D (D2-GW5-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
892696	Z1245	24/05/2022	Inter_Lab_D (D2-GW5-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
282375	D2-GW6-D	24/05/2022	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.02
282375	D2-GW7 -D	24/05/2022	Normal	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	-	-	<0.05	<0.01	<0.01	<0.02	<0.02

Statistics																				
Minimum Concentration	<0.01	<0.05	<0.01	<0.01	<0.05	<0.05	<0.006	<0.01	<0.02	<0.02	<0.02	<0.01	<0.2	<0.2	<0.05	<0.01	<0.01	<0.02	<0.01	
Maximum Concentration	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Average Concentration *	0.043	0.055	0.043	0.043	0.055	0.0418	0.0418	0.043	0.046	0.046	0.046	0.043	0.1	0.1	0.0564	0.043	0.043	0.046	0.0437	
Standard Deviation *	0.0472	0.0373	0.0472	0.0472	0.0373	0.0482	0.0482	0.0472	0.0447	0.0447	0.0447	0.0472	0	0	0.0399	0.0472	0.0472	0.0447	0.0467	

* A Non Detect Multiplier of 0.5 has been applied.

Environmental Standards

PFAS NEPM 2020 Interim Marine 95%	ANZG 2018 Marine Water 95% LOSP toxicant DGV's
PFAS NEMP 2020 Recreational Water	NEPM 2013 Table 1C GILs, Marine Waters
ANZECC 2000 MW 95%	ANZECC 2000 Irrigation Short Term Trigger Values



	Organophosphorous Pesticides											Pesticides	Solvents					
	Bromophos-ethyl	Chlorpyrifos	Chlorpyrifos-methyl	Diazinon	Dichlorvos	Dimethoate	Ethion	Fenitrothion	Malathion	Methyl parathion	Ronnel	Parathion	MTBE	Benzo(b)fluoranthene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene
	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L
EQL	0.2	0.009	0.0002	0.01	0.2	0.1	0.2	0.1	0.002	0.2	0.2	0.0007	0.001	0.0002	0.1	0.1	0.1	0.1
ANZG 2018 Marine Water 95% LOSP toxicant DGV's		0.009															0.4	
ANZECC 2000 MW 95%		0.009																
ANZECC 2000 Irrigation Short Term Trigger Values																		
PFAS NEPM 2020 Interim Marine 95%																		
PFAS NEMP 2020 Recreational Water																		
NEPM 2013 Table 1C GILs, Marine Waters		0.009										20						

Lab Report Number	Field ID	Date	Sample Type																
254777	D2-GW1-D	8/12/2020	Normal	<0.2	<0.2	<0.0002	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.001	<0.2	<0.1	<0.1
254470	X1	8/12/2020	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
254777	D2-GW2-D	10/12/2020	Normal	<0.2	<0.2	<0.0002	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.001	<0.1	<0.1	<0.1
254777	D2-GW3-D	9/12/2020	Normal	<0.2	<0.2	<0.0002	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.001	<0.1	<0.1	<0.1
254777	D2-GW4-D	9/12/2020	Normal	<0.2	<0.2	<0.0002	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.003	<0.2	<0.1	<0.1
254777	D2-GW5-D	9/12/2020	Normal	<0.2	<0.2	<0.0002	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.001	<0.2	<0.1	<0.1
254777	D2-GW6-D	9/12/2020	Normal	<0.2	<0.2	<0.0002	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.003	<0.2	<1.3	<0.3
254777	D2-GW7-D	9/12/2020	Normal	<0.2	<0.2	<0.0002	<0.2	<0.2	<0.3	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.001	<0.2	<0.1	<0.1
259847	D2-GW1-D	1/04/2021	Normal	<0.2	<0.2	<0.0002	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.003	<0.0002	<2.1	<0.1
259847	D2-GW2-D	1/04/2021	Normal	<0.2	<0.2	<0.0002	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.001	<0.0002	<0.1	<0.1
259847	Z1	1/04/2021	Field_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	<0.001	-	-	-
2106133	Z11	1/04/2021	Inter_Lab_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
259847	D2-GW3-D	1/04/2021	Normal	<0.2	<0.2	<0.0002	<0.2	<0.3	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.001	<0.0002	<0.1	<0.1
259847	D2-GW4-D	1/04/2021	Normal	<0.2	<0.2	<0.0002	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.001	<0.0002	<0.1	<0.1
259847	D2-GW5-D	1/04/2021	Normal	<0.2	<0.2	<0.0002	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.001	<0.0002	<0.1	<0.1
259847	D2-GW6-D	1/04/2021	Normal	<0.2	<0.2	<0.0002	<0.2	<0.7	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.003	<0.0002	<0.1	<0.1
259847	D2-GW7-D	1/04/2021	Normal	<0.2	<0.2	<0.0002	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.001	<0.0002	<0.1	<0.1
264262	D2-GW1-D	22/06/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.0007	<0.001	<0.0002	<0.1	<0.1
264262	D2-GW2-D	22/06/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.0007	<0.001	<0.0002	<0.1	<0.1
264262	D2-GW3-D	22/06/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.0007	<0.001	<0.0002	<0.1	<0.1
264262	Z1	22/06/2021	Field_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	<0.001	-	-	-
2111816	Z11	22/06/2021	Inter_Lab_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
264262	D2-GW4-D	22/06/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.0007	<0.001	<0.0002	<0.1	<0.1
264262	D2-GW5-D	22/06/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.0007	<0.001	<0.0002	<0.1	<0.1
264262	D2-GW6-D	22/06/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.0007	<0.001	<0.0002	<0.1	<0.1
264262	D2-GW7-D	22/06/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.0007	<0.001	<0.0002	<0.1	<0.1
268970	D2-GW1-D	14/09/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.007	<0.001	<0.0002	<0.1	<0.1
268970	X1	14/09/2021	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2117095	X11	14/09/2021	Inter_Lab_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
269100	D2-GW2-D	15/09/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.007	<0.001	<0.0002	<0.1	<0.1
269100	D2-GW3-D	15/09/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.007	<0.001	<0.0002	<0.1	<0.1
269100	D2-GW4-D	14/09/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.007	<0.001	<0.0002	<0.1	<0.1
268970	D2-GW5-D	14/09/2022	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.007	<0.001	<0.0002	<0.1	<0.1
268970	D2-GW6-D	14/09/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.007	<0.001	<0.0002	<0.1	<0.1
268970	D2-GW7-D	13/09/2021	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.1	<0.002	<0.2	<0.2	<0.007	<0.001	<0.0002	<0.1	<0.1
282375	D2-GW1-D	25/05/2022	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.15	<0.2	<0.2	<0.05	<0.2	<0.2	<0.004	<0.001	<0.0002	<0.1	<0.1
282375	D2-GW4-D	25/05/2022	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.15	<0.2	<0.2	<0.05	<0.2	<0.2	<0.004	<0.001	<0.0002	<0.1	<0.1
282375	D2-GW5-D	24/05/2022	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.15	<0.2	<0.2	<0.05	<0.2	<0.2	<0.004	<0.001	<0.0002	<0.1	<0.1
282375	X1245	24/05/2022	Field_D (D2-GW5-D)	-	-	-	-	-	-	-	-	-	-	-	-	<0.001	-	-	-
892696	Z1245	24/05/2022	Inter_Lab_D (D2-GW5-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
282375	D2-GW6-D	24/05/2022	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.15	<0.2	<0.2	<0.05	<0.2	<0.2	<0.004	<0.001	<0.0002	<0.1	<0.1
282375	D2-GW7 -D	24/05/2022	Normal	<0.2	<0.009	<0.0002	<0.01	<0.2	<0.15	<0.2	<0.2	<0.05	<0.2	<0.2	<0.004	<0.001	<0.0002	<0.1	<0.1

Statistics																			
Minimum Concentration				<0.2	<0.009	<0.0002	<0.01	<0.2	<0.1	<0.2	<0.01	<0.002	<0.2	<0.2	<0.004	<0.001	<0.0002	<0.1	<0.1
Maximum Concentration				<0.2	<0.2	<0.0002	<0.2	<0.7	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.003	<0.2	<0.2	<0.1
Average Concentration *				0.1	0.0629	0.0427	0.043	0.1086	0.0807	0.1	0.0771	0.0440	0.1	0.1	0.0413	0.0006	0.0172	0.0344	0.05
Standard Deviation *				4.22412	0.0470	0.0475	0.0472	0.0429	0.0393	4.2241	0.0253	0.0471	1.422	4.224	0.0487	0.0003	0.0362	0.0725	2.1121

* A Non Detect Multiplier of 0.5 has been applied.

Environmental Standards

PFAS NEPM 2020 Interim Marine 95% ANZG 2018 Marine Water 95% LOSP toxicant DGV's
PFAS NEMP 2020 Recreational Water NEPM 2013 Table 1C GILs, Marine Waters
ANZECC 2000 MW 95% ANZECC 2000 Irrigation Short Term Trigger Values



	PAH												PCBs						
	Benzo(a) pyrene	Benzo(g,h,i)perylene	Chrysene	Dibenzo(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)pyrene	Naphthalene	Phenanthrene	Pyrene	Benzo(a)pyrene TEQ	PAHs (Sum of positives)	Arochlor 1016	Arochlor 1221	Arochlor 1232	Arochlor 1242	Arochlor 1248	Arochlor 1254	Arochlor 1260
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0005	0.0001	0.01	0.01	0.01	0.01	0.01	0.01	0.01
ANZG 2018 Marine Water 95% LOSP toxicant DGV's	0.2				1.4			70	2										
ANZECC 2000 MW 95%																			
ANZECC 2000 Irrigation Short Term Trigger Values																			
PFAS NEPM 2020 Interim Marine 95%																			
PFAS NEMP 2020 Recreational Water																			
NEPM 2013 Table 1C GILs, Marine Waters								50											

Lab Report Number	Field ID	Date	Sample Type																	
254777	D2-GW1-D	8/12/2020	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.1	<2	<2	<2	<2	<2	<2
254470	X1	8/12/2020	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
254777	D2-GW2-D	10/12/2020	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<2	<2	<2	<2	<2	<2
254777	D2-GW3-D	9/12/2020	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<2	<2	<2	<2	<2	<2
254777	D2-GW4-D	9/12/2020	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<2	<2	<2	<2	<2	<2
254777	D2-GW5-D	9/12/2020	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<2	<2	<2	<2	<2	<2
254777	D2-GW6-D	9/12/2020	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<2	<2	<2	<2	<2	<2
254777	D2-GW7-D	9/12/2020	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<2	<2	<2	<2	<2	<2
259847	D2-GW1-D	1/04/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<2	<2	<2	<2	<2	<2
259847	D2-GW2-D	1/04/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<2	<2	<2	<2	<2	<2
259847	Z1	1/04/2021	Field_D (D2-GW2-D)	-	-	-	-	-	<1	-	-	-	-	-	-	-	-	-	-	-
2106133	Z11	1/04/2021	Inter_Lab_D (D2-GW2-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
259847	D2-GW3-D	1/04/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<2	<2	<2	<2	<2	<2
259847	D2-GW4-D	1/04/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<2	<2	<2	<2	<2	<2
259847	D2-GW5-D	1/04/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<2	<2	<2	<2	<2	<2
259847	D2-GW6-D	1/04/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<2	<2	<2	<2	<2	<2
259847	D2-GW7-D	1/04/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<2	<2	<2	<2	<2	<2
264262	D2-GW1-D	22/06/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
264262	D2-GW2-D	22/06/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
264262	D2-GW3-D	22/06/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
264262	Z1	22/06/2021	Field_D (D2-GW3-D)	-	-	-	-	-	<1	-	-	-	-	-	-	-	-	-	-	-
2111816	Z11	22/06/2021	Inter_Lab_D (D2-GW3-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
264262	D2-GW4-D	22/06/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
264262	D2-GW5-D	22/06/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
264262	D2-GW6-D	22/06/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
264262	D2-GW7-D	22/06/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
268970	D2-GW1-D	14/09/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
268970	X1	14/09/2021	Field_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2117095	X11	14/09/2021	Inter_Lab_D (D2-GW1-D)	-	-	-	-	-	-	-	-	-	-	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
269100	D2-GW2-D	15/09/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
269100	D2-GW3-D	15/09/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
269100	D2-GW4-D	14/09/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
268970	D2-GW5-D	14/09/2022	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
268970	D2-GW6-D	14/09/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
268970	D2-GW7-D	13/09/2021	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
282375	D2-GW1-D	25/05/2022	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
282375	D2-GW4-D	25/05/2022	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
282375	D2-GW5-D	24/05/2022	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
282375	X1245	24/05/2022	Field_D (D2-GW5-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
892696	Z1245	24/05/2022	Inter_Lab_D (D2-GW5-D)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
282375	D2-GW6-D	24/05/2022	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
282375	D2-GW7 -D	24/05/2022	Normal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Statistics

Minimum Concentration	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0005	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Maximum Concentration	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<2	<2	<2	<2	<2	<2
Average Concentration *	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.0743	0.05	0.05	0.0157	0.0315	0.3921	0.5247	0.3921	0.3921	0.3921	0.3921	0.3921
Standard Deviation *	2.1121	2.1121	2.1121	2.1121	2.1121	2.1121	3.5020	0.1032	2.1121	0.0380	0.0235	0.0471	0.4918	0.4095	0.4918	0.4918	0.4918	0.4918	0.4918

* A Non Detect Multiplier of 0.5 has been applied.

Environmental Standards

PFAS NEPM 2020 Interim Marine 95%	ANZG 2018 Marine Water 95% LOSP toxicant DGV's
PFAS NEMP 2020 Recreational Water	NEPM 2013 Table 1C GILs, Marine Waters
ANZECC 2000 MW 95%	ANZECC 2000 Irrigation Short Term Trigger Values



Assets | Engineering | Environment | Noise | Spatial | Waste

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Feral Animal and Vermin Management Plan

Broome Regional Resource Recovery Park

Prepared for: Shire of Broome

Version 3. September, 2022



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EXECUTIVE SUMMARY

The Shire of Broome is proposing to construct and operate a community waste recycling and landfill facility near the intersection of Broome–Cape Leveque Road and McGuigan Roads north-east of Broome. This facility will accept a wide variety of waste material including putrescible waste.

Putrescible waste has the propensity to attract a variety of feral and pest vertebrate species to the site including, dogs, cats, seagulls, crows, kites, mice, rats, and raptors. If left unmanaged some of these species can cause problems for staff, site visitors and neighbours, with pathogens being transport to the town of Broome.

This management plan identifies and discusses vertebrate feral and pest fauna and native fauna (that could become a localised pest species) and could move into the facility from adjacent areas or be transported to the facility with waste being deposited. A series of design aspects and operational procedures are provided to reduce the incursion of feral and pest fauna and native species that could become pest species, and where that is not achieved, will contain the problem to reduce the propensity for these species impacting on native fauna in adjacent areas, and further afield in residential and industrial developments in Broome.

1. INTRODUCTION

1.1 BACKGROUND

The Shire of Broome is proposing to construct and operate a Community Recycling Centre, Liquid Waste Facility and Class III Landfill on Reserve 53878 in an area zoned 'Public Purposes: Water Supply' under the Shire of Broome's Local Planning Scheme No. 6 Site D2 in the Special Control Area (SCA) for the future Broome International Airport. This facility will be located on the south-west corner of the Broome-Cape Leveque Road and McGuigan Road intersection (Figure 1), with the entrance off the Broome-Cape Leveque Road.

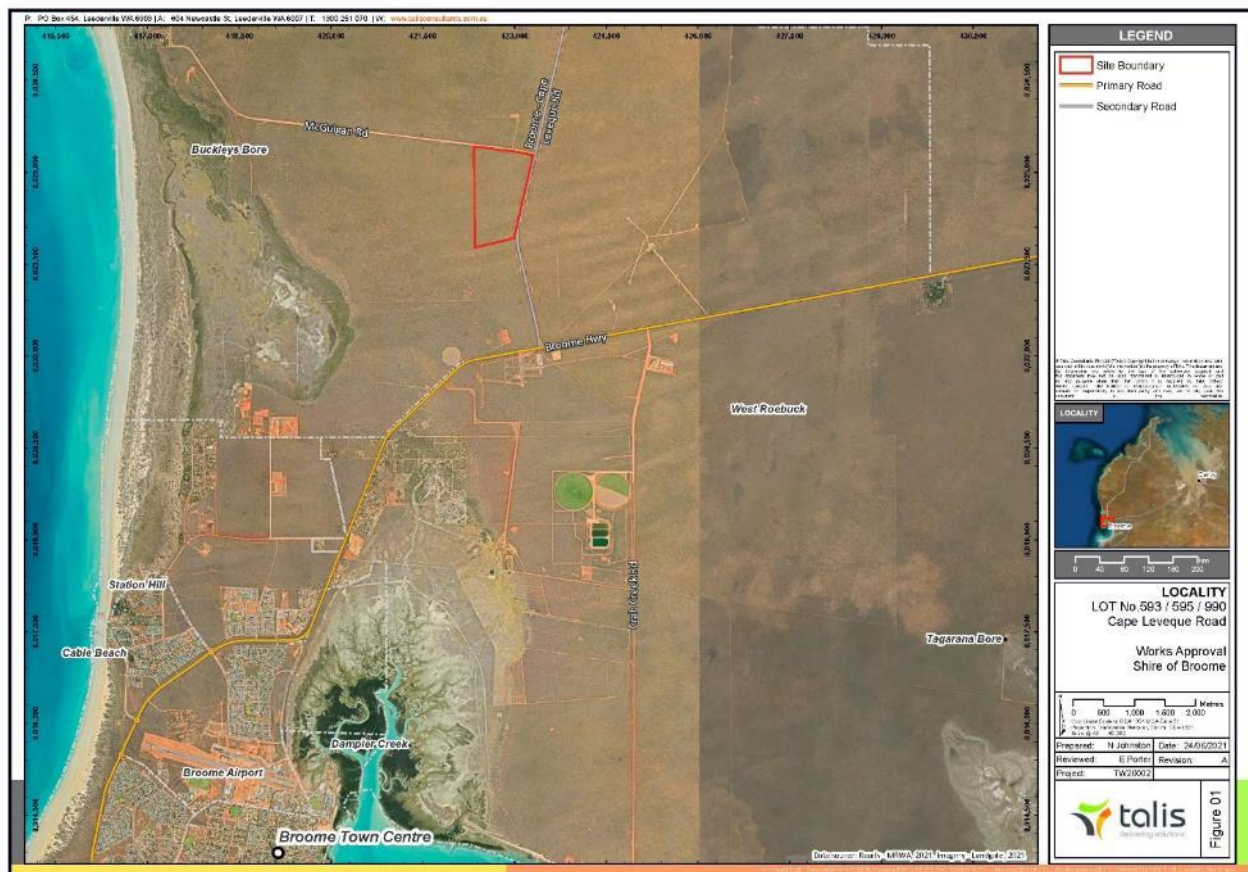


Figure 1. Location of the Broome Regional Resources Recovery Park

The proposed facility will be approximately 5.5km from the ocean to the west, 9.5km to the existing airport in Broome and 3.1km west-north-west of the proposed location for Broome's future airport, which is still many years away from development.

The facility will consist of a community recycling centre, including bulky item drop-off, recycling drop-off, hazardous household storage shed, reuse shop and education centre, surface water management system, liquid waste facility for sullage and industrial waste streams, landfill cells and a leachate evaporation pond.

The ~119ha site is generally flat, silty red Pindan sands.

Immediately to the west and north of the proposed Broome Regional Resources Recovery Park is the Yamuru Birragun Conservation Park that is jointly managed by the Yawuru people [i.e. Banjima Native Title Aboriginal Corporation (RNTBC)] and the Department of Biodiversity, Conservation and Attractions (DBCA) under the *Conservation and Land Management Act 1984 (CALM Act)*.

1.1.1 Proposed waste management facility

The Broome Regional Resource Recovery Park will be operated by the Shire of Broome and be open Monday to Saturday from 0700-1530hrs and on Sunday from 0800-1400hrs.

The Shire of Broome has indicated that the chain mail fencing at the existing facility has precluded entry to the site of larger animals, so this is its preferred fencing around the Broome Regional Resources Recovery Park. All trucks and vehicles entering the Broome Regional Resource Recovery Park to deposit refuse waste material will be required to stop at the weighbridge, located within the Site and accessed via a sealed road.

The Master Plan (Talis 2021) for the Broome Regional Resource Recovery Park indicates that the facility will contain the following facilities (Table 1).

Table 1. Proposed activities at the Broome Regional Resource Recovery Park

Category	Activities
Community recycling area	<ul style="list-style-type: none"> Community reuse and recycling <ul style="list-style-type: none"> Reuse shop Education and admin area Green waste drop-off area Mulch collection area Hazardous household waste (e.g. oil, paint, batteries, fluorescent tubes and globes, etc) aerosols and pesticides etc On-ground recycling drop-off area Light Vehicle Facilities <ul style="list-style-type: none"> Mixed waste drop-off facility Stockpiling and processing areas Weighbridge Tyre moncell
Landfill	Class III landfill and Leachate Management System, including evaporation pond
Liquid water facility	<ul style="list-style-type: none"> Liquid waste facility (e.g. Sullage Liquid Waste Facility, which includes two (2) concrete lined receival ponds and one (1) HDPE lined evaporation pond and Industrial Liquid Waste Facility, which included two (2) HDPE lined liquid waste ponds
Supporting site infrastructure	<ul style="list-style-type: none"> Asbestos moncell Network of groundwater monitoring bores Roads – sealed and unsealed in low use areas Storm water management system Administration building and workshops Firefighting services Solar power system Security (fencing, gates, etc.)

1.1.2 Stakeholders and their expectations

The primary stakeholders for the Broome Regional Resources Recovery Park are the Shire of Broome, its owner and operator, industry and people contributing of waste materials, nearby neighbours including the managers of the Yawuru Birragun Conservation Park.

Immediately to the west and north of the proposed Broome Regional Resources Recovery Park is the Yawuru Birragun Conservation Park that is jointly managed by the Yawuru people and the DBCA under the *Conservation and Land Management Act 1984* (CALM Act). The management plan for this area (Department of Parks and Wildlife 2016) indicates that the vision for the Conservation Park is '*Yawuru people and their partners working together with the wider community to restore, protect and maintain the cultural and natural values of the Yawuru Birragun Conservation Park for the enjoyment and benefit of present and future generations of Yawuru people and the wider population*' and in this context, it would be inappropriate for the Broome Regional Resources Recovery Park to be encouraging feral or pest fauna to the area.

An increase in feral and pest species, and a partial loss of their wariness to human activity can result in species causing a nuisance at nearby residences. Birds feeding on putrescible waste can be hosts to zoonotic and livestock pathogens such as *Salmonella* spp., Newcastle disease virus, avian influenza virus and flaviviruses and therefore pose a health risk to staff and residents at other Broome locations used by these birds, including the potential contamination of water storage facilities. The facility managers will be expected to minimise the facility's impact on native fauna, and pest species propensity to spread disease.

1.2 FERAL AND PEST VERTEBRATE FAUNA

Feral fauna are species of animals that are living in a location in which they are not native. Most feral species persist in an area because they are highly adaptable and can out-compete the native fauna, or occupy a niche not adequately occupied by extant native fauna. Because of their capacity to exploit a broad range of niche(s), their relative abundance often increases to the detriment of native species. Pest species can be native fauna that utilise the facility because it provides easy access to a resource (e.g. food) that is not readily available elsewhere. These native species become pests when their numbers increase to unnatural levels, or they provide a health hazard by moving disease into areas of human habitation or can negatively interact with humans.

Management of some native and feral vertebrate fauna will be required at the waste management facility to avoid some species from becoming pests and inappropriately interacting with native fauna, being vectors for disease, and if present, to reduce, and where practical, eradicate the local population. Some of these species are already present in various densities in the region and the local area adjacent to the proposed waste management facility. Others will be attracted to the waste management facility because it provides a resource (e.g. food, water or shelter) that is either scarce in adjacent areas or is more abundant and thus easier to access at the waste management facility, and a third group will be transported to the facility in the incoming waste. It is generally accepted that an increase in feral species is likely to be detrimental to the native fauna, however, an unnatural increase in native species due to the provision or abundance of food that is typically scarce in the area will also disrupt ecosystem function.

Given the proximity of the waste management facility to the Broome township, it would be undesirable to have a waste management facility that was attracting feral fauna, acting as a source for feral fauna or unnaturally increasing native vertebrate species because they had access to waste food or water resources, or avifauna are transporting pathogens to the town.

The following list of vertebrate species have been recorded in the general area, and could increase in abundance, be attracted to, or be transported to the facility where they will increase in relative abundance and disrupt ecosystem function.

Fox (*Vulpes vulpes*)

The waste management facility is on the northern extremity of the fox's geographic distribution, so if it is present in the area, it will probably be an infrequent visitor to the area. However, if foxes find easy access to a food supply, then they will regularly return and could establish a local higher density population and could become a problem species if not effectively managed.

Foxes will readily climb over or dig under a standard 1.8m high cyclone wire mesh fence, so with this type of fencing, active management strategies will need to be implemented if foxes are found in the facility. If foxes are identified as an issue on site, then a local, suitably equipped, and licensed pest controller will be engaged to implement an eradication program.

Cat (*Felis catus*)

Feral cats are widespread in the vicinity of the proposed waste management facility (GHD 2009). Unwanted kittens can also be dumped at the waste management facility by people unable/unwilling to dispose of a litter of kittens in an appropriate manner. This feral predator will also quickly find the waste management facility if putrescible waste is available, and it will increase in local abundance. Feral cats will be a problem species if not effectively managed.

Cats will readily climb over a standard 1.8m high cyclone wire mesh fence, so with this type of fencing, active management strategies will need to be implemented if cats are found in the facility. If feral cats are identified as an issue on site, then a local, suitably equipped, and licensed pest controller will be engaged to implement an eradication program.

Dogs (*Canis lupus*)

Wild and stray dogs are in the vicinity of the Broome townsite. Many of these dogs may have had a loose attachment to humans at some stage, and either been abandoned or become disassociated with human activity. These dogs can become habituated to human activity, particularly if there is an easy food source and will eventually threaten people coming to the waste management facility or staff.

If a dog is recorded in the facility, then active management strategies will need to be implemented. If a dog is identified as an issue on site, then a local, suitably equipped, and licensed pest controller will be engaged to implement an eradication program.

House Mouse (*Mus musculus*)

House Mice are present in low numbers in adjacent bushland areas. However, their numbers will locally increase if putrescible waste is readily available. In high numbers, House Mice will attract Gwardar (*Pseudonaja mengdeni*) and Mulga Snakes (*Pseudechis australis*) to the waste management facility.

House Mice are difficult to eradicate as they will be present in very low numbers in the adjacent bushland. Stopping mice having access to a food supply is the most cost-effective and humane management strategy, so good housekeeping and covering the putrescible waste daily will help reduce the food source and the rodent population. If house mice are identified as an issue on site, then a local, suitably equipped, and licensed pest controller will be engaged to implement an eradication program.

Black Rat (*Rattus rattus*)

The Black Rats are in low abundance and widespread in adjacent bushland areas and Broome and could be transported to the waste management facility. Once present, they will be difficult to eradicate and could become established in the waste management facility. As with House Mice, good housekeeping and covering of putrescible waste daily will help reduce the food source and the rodent population. If rats are identified as

an issue on site, then a local, suitably equipped and licensed pest controller will be engaged to implement an eradication program.

Rabbit (*Oryctolagus cuniculus*)

Rabbits are present and widespread in adjacent areas, however, it is unlikely to be a pest species in the waste management facility.

Rabbits can be poisoned or infected with rabbit haemorrhagic disease virus (RHDV1 K5) when they become a problem species. A local, suitably equipped, and licensed pest controller will be engaged to implement an eradication program.

Common Pigeon (Rock Dove; *Columba livia*)

The Common Pigeon is an introduced avian pest species that is well established in Australia with higher abundance in the southern and eastern states. They are almost always found in close association with human habitation and are commonly found in seed growing and collecting areas. Pigeons have not been reported as a pest species in Broome, so there is only a very low possibility the Common Pigeon could become a pest species at the waste management facility.

If pigeons become a problem, then a local, suitably equipped, and licensed pest controller will be engaged to implement an eradication program.

Silver Gull (*Chroicocephalus novaehollandiae*)

The Silver Gulls are present along the coastal areas and are attracted to easily accessed food sources such as waste management facilities, particularly if freshwater is available and food is generally scarce in the general area. There are records of the Silver Gulls being recorded in Broome, so they will likely find the waste management facility once putrescible waste becomes available as a food source.

If Silver Gulls become a problem, then a local, suitably equipped, and licensed pest controller will be engaged to implement an eradication program. A 'Fauna causing damage licence' will be required if Silver Gulls are to be impacted by active management.

Ibis (Australian White Ibis; *Threskiornis molucca* and Straw-necked Ibis; *Threskiornis spinicollis*)

The Australian White and the Straw-necked Ibis have both been recorded in Broome. The Australian White Ibis is commonly referred to as a 'bin-chicken' because it is attracted to putrescible waste. If either Ibis species finds easy access to a putrescible waste source combined with a source of fresh water, then they could become a problem species, flying in each day from a coastal over-night roost site.

If Ibis become a problem, then a local, suitably equipped, and licensed pest controller will be engaged to implement an eradication program. A 'Fauna causing damage licence' will be required if Ibis are to be impacted by active management.

Australian Pelicans (*Pelecanus conspicillatus*)

Australian Pelicans could be attracted to the waste management facility due to the availability of putrescible waste. Individual birds that have been successful in accessing food will quickly bring additional conspecifics to the site, and they will readily form a pattern of coming everyday if food is available.

Removing access to freshwater and putrescible waste is likely to be a major deterrent for these species visiting the facility. If Pelicans become a problem, then a local, suitably equipped, and licensed pest controller will be engaged to implement an eradication program. A 'Fauna causing damage licence' will be required if Pelicans are to be impacted by active management.

Raptors (Whistling Kite; *Haliastur sphenurus* and Black Kite; *Milvus migrans*)

Both the Whistling Kite and Black Kite are present in the general area and are scavengers that typically feed on lizards, small mammals and insects, and are often seen patrolling road verges or fire edges in search of dead and dying prey. These raptors will visit the waste management facility if there is putrescible waste available.

There is a low possibility that the presence of raptors at the facility will help to control any developing vermin population, as rodents are typically inactive with raptors are present in the facility. If raptors become a problem, then a local, suitably equipped, and licensed pest controller will be engaged to implement an eradication program. A 'Fauna causing damage licence' will be required if raptors are to be impacted by active management.

Corvids (i.e. Crows; Little Crow; *Corvus bennetti* and Torresian Crow; *Corvus orru*)

Two corvid species have been recorded near Broome and like most corvids, they will eat fruit, invertebrates, eggs, carrion and putrescible waste. If the food supply is abundant, then the local population of these species will increase. They have a propensity to pick up and shift some waste material, which can contribute to the untidiness of the area. Although corvids are wary and easily frightened, they can be persistent and return as soon as people have moved away.

If corvids become a problem, then a local, suitably equipped, and licensed pest controller will be engaged to implement an eradication program. A 'Fauna causing damage licence' will be required if corvids are to be impacted by active management.

Large snakes [i.e. Mulga Snake (*Pseudechis australis*), Gwardar (*Pseudonaja mengdeni*)]

The two most common large snakes in the project area are the Mulga Snake and Gwardar. These large snakes eat small mammals, reptiles and ground dwelling birds. The Gwardar is most likely to move away from humans when disturbed, whereas, the Mulga Snake has a propensity to stay and defend itself. Both snakes are venomous, and if present in the active waste management area, then they pose a significant safety risk to staff and visitors. Both snakes will remain in the area if there is an abundance of food (e.g. House Mice), will often retreat under buildings and infrastructure, and will be active at night during the warmer months.

These snakes can be caught and relocated by a local suitably trained person if observed in the facility. This activity will require a Regulation 28 licence issued by DBCA.

Northern Short-tailed Mouse (*Leggadina lakedownensis*)

The Northern Short-tailed Mouse has not been recorded near Broome, however, there are numerous records of this species inland. It is typically a boom-bust species that will rapidly increase in abundance when conditions are favourable. To the untrained observer, it is easily confused with a House Mouse. An abundance of the Northern Short-tailed Mouse is likely to be short-lived (i.e. a matter of weeks) and removing the food supply will limit their breeding. In the unlikely circumstance it was necessary, they can be trapped and translocated by a suitably experienced and licenced person. This activity will require a Regulation 28 licence issued by DBCA.

Large goannas (Sand Goanna; *Varanus gouldii* and Yellow-spotted Goanna; *Varanus panoptes*)

Large goannas have become pest species on some mining and tourist sites, and around waste management facilities because they have had access to human food (i.e. putrescible waste). These lizards are easily caught by a local suitably trained person with an appropriate Regulation 28 Licence and translocated.

Asian House Gecko (*Hemidactylus frenatus*)

The Asian House Gecko, as the name suggests, originates in south and south-eastern Asia and has been inadvertently but very successfully transported to Australia on multiple occasions. They have been recorded in and around Broome on multiple occasions. No management is required for this species.

Cattle

It is possible that station or stray cattle will endeavour to enter the facility, particularly if it has freshwater. Cattle can be stopped from entering the facility with suitable fencing.

Kangaroos and wallabies

Kangaroos and wallabies are present in the adjacent areas. It is highly improbable that they will be interested in entering a waste management facility that has a high level of anthropogenic activity. If a kangaroo or wallaby enters the facility, it can normally be encouraged to leave through the existing gates unharmed.

1.3 GENERALISED INVASION CURVE

The generalised invasion curve is particularly relevant for pest management at the proposed waste management facility (Plate 1). This widely cited chart clearly indicates that prevention is much more cost-effective than eradication, which is more cost-effective than containment, which is more cost-effective than on-going management.

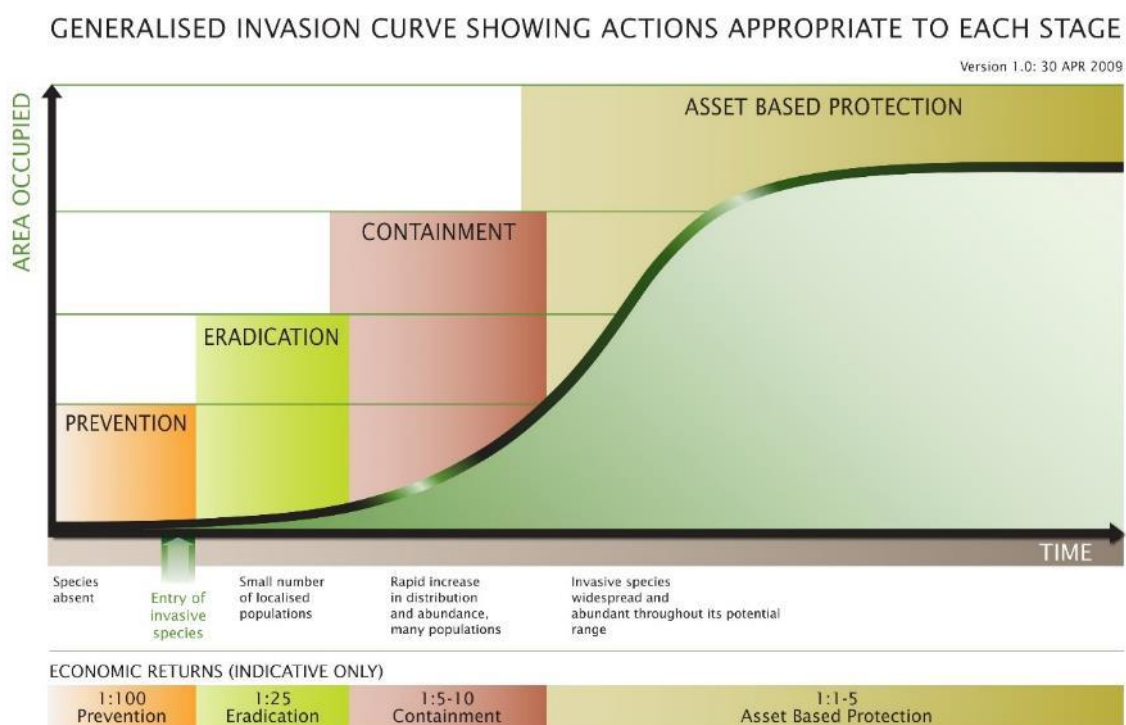


Plate 1. Generalised invasion curve

taken from http://agriculture.vic.gov.au/_data/assets/image/0005/179051/invasion_curve_big.jpg

The most important message from this curve is that stopping the problem before it occurs, and when a pest species arrives, the earlier effective management (e.g. eradication or containment) is implemented the more

cost effective and successful it is likely to be in the long-term. The targets for action outlined in Table 3 are based on this principle.

1.4 SOCIAL LICENCE TO OPERATE

There is a community expectation that all waste disposal facilities are managed and operated in accordance with best practice standards. As this facility will be near to the Broome townsite and owned and managed by the Shire of Broome there will be an expectation that the facility is not attracting, harbouring, or facilitating breeding of feral and pest fauna that will subsequently move into adjacent bushland areas.

1.5 GUIDELINES

There are no Western Australian guidelines that pertain to the management of vertebrate fauna in waste management facilities, although there are multiple more general guidelines on landfill and waste management facility operations (e.g. Cafe 2016; Environmental Protection Authority 2015; Environmental Protection Authority 2016; Wright Corporate Strategy Pty Ltd 2010), but none provide guidance on managing vertebrate fauna.

The ISWA Working Group for Landfill (International Solid Waste Association 2019) *Landfill Operational Guidelines* 3rd Edition includes a useful chapter on bird control and the principles are also applicable to other vertebrate pest species. This guideline makes the following observation 'Birds visiting a landfill site do so mainly for food. They are seen as noisy and messy, and commonly they can be carriers of pathogens, or they can be the cause of local nuisance through fouling of roofs, roof-water supplies, gardens and public open space. Also, in some instances birds can pose a threat to the safety of aircraft where landfills are located near commercial airports.'

The ISWA Working Group for Landfill (2010, p.14) suggested the following hierarchy of controls for pest bird species:

- gas guns;
- heli-kites and balloons;
- distress calls;
- signal pistols and cartridges;
- falcon and raptors;
- wires and screens; and
- culling.

Any disturbance to native fauna would require a 'Fauna causing damage licence' issued under the *Biodiversity Conservation Act 2016* by DBCA or a Regulation 28 Licence to catch/trap and translocate native fauna.

1.6 OTHER PEST MANAGEMENT ISSUES

1.6.1 Evaporation ponds

Freshwater in evaporation ponds will attract a wide range of seed eating (e.g. galahs, corellas, finches) and other birds to drink, particularly in the drier period. If these ponds are toxic to birds, then it is likely that birds will die, and carcasses will be in the surrounding area and on occasion in the ponds.

If the evaporation ponds are potentially toxic to birds, then they should be covered (i.e. wire or netting) to exclude birds drinking the water.

1.6.2 Rodenticides

Rodenticides used to kill mice and rats can have an unintended impact on the native fauna, in particular raptors and corvids (Erickson and Urban 2004; Lohr and Davis 2018; Murray 2011; van den Brink *et al.* 2018; Young and de Lai 1997). Raptors, owls, and corvids eating dead and dying rodents that have been poisoned can result in an accumulation of the poison in the birds, if multiple dead and dying rodents are eaten causing illness and death. So, for small numbers of rodents, trapping is the preferred method, but where rodenticides are to be used, then the pest contractors engaged for the task will only use chemicals with no consequences on native fauna. If these chemicals are not available, then live trapping will be used.

1.6.3 Feeding wildlife and feral fauna

Occasionally, a few of the larger terrestrial mammals (e.g. feral or stray cats) or goannas (*Varanus gouldii*) will lose some of their wariness to the presence of humans, or because of their frequent presence in the area. These animals often carry a diverse range of diseases because they eat carrion and other decaying material, and infections caused by bites can be difficult to treat.

Feeding native fauna is illegal under the *Biodiversity Conservation Act 2016*. Therefore, feeding or leaving food or water for native or feral species will not be allowed, nor will staff be allowed to bring pets to the waste management facility.

1.6.4 Proximity of the proposed airport

Birds, and particularly high-flying birds, that use the thermal air currents (e.g. kites, ibis and pelicans) can be a serious hazard for aircraft (Thorpe 2016). The relocation of the Broome airport had been previously proposed for approximately 3km to the south-east of this waste management facility. However, correspondence with the airport owners suggest this is 20-30 years away, so it will not be a problem in the foreseeable future.

If this new airport is constructed, then its proximity will require that high flying birds that are being attracted to the waste management facility are actively managed.

1.6.5 Building design

Occasionally building design facilitates birds (e.g. pigeons) roosting and breeding on ledges and in sheltered areas, and mice and rats are provided with access into food storage areas. These issues are often addressed in the post construction stage by installing bird spikes, netting and wires to building to stop or at least discourage birds roosting and breeding, and closing off access points for mice and rats.

1.7 HIERARCHY OF EFFECTIVENESS IN CONTROL OF VERTEBRATE FERAL AND PEST SPECIES

Typically, vertebrate feral and pest management plans provide a generic hierarchy of effectiveness in control that is used in the development of specific strategies targeting a particular species likely or potentially to be of concern.

1.7.1 Physical barrier

The most effective strategy to reduce or eliminate the reason why vertebrate fauna come to the waste management facility is to exclude or significantly reduce fauna access to putrescible waste and freshwater. Total exclusion all the time is obviously the best option but, in many circumstances, it is logistically difficult (or

impossible) and cost prohibitive. For example, significantly reducing the putrescible waste available to birds will require some type of covering of the waste materials daily after it has been deposited, as gulls and ibis will learn to access putrescible waste immediately after it is unloaded and before it can be covered.

1.7.2 Scaring and deterrents

Scaring and deterrents (e.g. gas cannons, drones, pyrotechnics, acoustics, lasers, lights mirrors and reflectors, raptor models and taste repellents) will have a limited long-term effectiveness, as the pest birds and large terrestrial mammals (e.g. cats, foxes, wild dogs) will habituate to the scaring source. The time to habituation can be prolonged by using multiple techniques and altering the time, location, and intensity of the source.

1.7.3 Trapping and translocation

For some native species, it is practical to trap and relocate individual pest species, and if the translocation site is appropriate, then these individuals should survive and not return to the facility.

Trapping and translocation of native fauna requires a Regulation 28 licence, which will typically prescribe the translocation site.

1.7.4 Lethal techniques

Lethal techniques such as poisoning/baiting are likely to provide a permanent solution for some species and a temporary solution for others. If pest species are present in the adjacent areas (e.g. feral cats), then the removal of an individual from the waste management facility will open a niche for another individual from the adjacent area to fill that niche. Poisoning and baiting typically do not discriminate among species, so considerable care is required to avoid non-target species being poisoned.

2. DISCUSSION OF MANAGEMENT OPTIONS

The vertebrate fauna likely to become a management problem can be divided into three broad categories based on the management options that should be deployed firstly to stop the incursion and then, if it occurs, to eradicate, contain or control the fauna:

- Avian fauna
 - gulls
 - kites
 - pigeons
 - ibis
 - pelicans
 - corvids
- Large terrestrial fauna
 - feral and stray cats
 - wild and stray dogs
 - foxes
- Small terrestrial fauna
 - mice
 - snakes
 - goannas
 - rats

2.1 AVIAN FAUNA

Gulls and pelicans are readily seen around the Broome townsite, so they may start to visit this facility on a regular basis, but they will only become a pest species if there is ready access to a food supply and freshwater. Similarly, ibis visits to the waste management facility will largely be regulated by the available food and freshwater. Once they learn of a readily accessible food source, then their numbers will increase, as they are willing to fly considerable distances in the morning and evening to access a food source. Pigeons, kites and corvids will find the facility and will visit on a regular basis if a suitable food supply is available.

Active management and disturbing native species will require a licence issued by the DBCA.

2.2 LARGE TERRESTRIAL FAUNA

The Shire of Broome is proposing to erect a 1.8m high cyclone wire fence around the facility. Wild and stray dogs are typically not climbers, but will push and dig under and through fences, whereas, foxes and cats are climbers or will scramble over a reasonably high fence (Giumelli and White 2016). So, a fence that is designed to stop wild and stray dogs will not stop foxes and feral cats.

Feral cats and foxes are typically wary of traps and thus difficult to catch, but it is possible for cats to be caught in baited cage traps and foxes in padded foot-hold traps. If wild and stray dogs and foxes become a problem, then an appropriate permit is required for trapping and baiting programs, and it can only be obtained by individuals with the appropriate qualifications and licence/permit issued by the Department of Health and Department of Primary Industries and Regional Development (DPRID; i.e. Licenced Pest Management Technician – LPMT). There will be a reluctance of the DPIRD to issue a permit to use 1080 bait to poison wild dogs if there is a possibility that domestic dogs will be by-catch.

2.3 SMALL TERRESTRIAL FAUNA

House mice will invade the waste management facility from adjacent areas and their numbers will increase if a food supply is available. Black Rats and kittens could be transported to the facility in waste that is deposited. There is a low possibility that snakes will enter and remain around the waste management facility, given the level of anthropogenic activity, but some may remain if there is an abundance of small mammals, and in particular mice and rats.

Reducing and eliminating access to putrescible waste will stop or reduce the probability of having an issue with mice, and thus large snakes. Removing retreat sites for large snakes will also reduce the possibility that they stay in the waste management facility. If an abundance of rats and mice are observed, then appropriately trained and skilled people will be contracted to remove them. Rats and mice can be trapped and baited.

2.4 FACTORS TO CONSIDER IN PEST MANAGEMENT

The following should be considered when selecting a suitable management option(s):

- Where does the issue sit on the generalised invasion curve, and will it get worse without active management?
- What is the initial capital cost?
- What are the on-going or maintenance costs?
- Is the management option environmentally and socially acceptable?
- Is the proposed approach legal and humane, and in accordance with the *Animal Welfare Act 2002*?
- Will the technique increase occupational health and safety risks and, if so, can these be effectively managed?
- Will the management technique require government approval or licensing, and will approval and licenses be issued by DPRID, Department of Health and DBCA?
- How long will the technique be effective and what is the probability of habituation by the pest species?

Table 2. Usefulness of management options

Options	Target species	Capital cost	Recurrent capital cost	Recurrent cost and frequency	Humaneness	Bycatch issues	Licensing or permit required	Gov't support	Effectiveness
Floppy top, electrified fencing boundary fence	Feral cats, wild dogs, foxes, goannas, rabbits, large herbivores, vehicles, people	Very high	25 years	Low cost (i.e. weekly fence inspections).	Very humane	No	No	Preferred	Very high for large terrestrial species and is a long-term solution.
Floppy top fencing boundary fence (not electrified)	Feral cats, wild dogs, foxes, goannas, rabbits, large herbivores, vehicles, people	High	25 years	Low cost (i.e. weekly fence inspections).	Very humane	No	No	Yes	High for large terrestrial species and is a long-term solution. Some cats or foxes may periodically breach the fence.
Wild dog type fencing	Wild dogs, large herbivores, vehicles	Moderate	25 years	Low cost (i.e. weekly fence inspections).	Very humane	No	No	Yes, but will require other options to be implemented	High, but limited to target species and is not a long-term solution.
Cattle type fencing	Cattle and vehicles	Low	25 years	Low cost (i.e. weekly fence inspections).	Very humane	No	No	Yes, but will require other options to be implemented.	High, but limited to target species and is not a long-term solution.
Netting ponds and water sources	Gulls, kites, ibis, pigeons, ravens and most avian seed eaters	Moderate	2-10 years	Low cost (i.e. weekly net inspections).	Very humane	No	No	Preferred	High for target species, but unlikely to be effective for the smaller seed-

Options	Target species	Capital cost	Recurrent capital cost	Recurrent cost and frequency	Humaneness	Bycatch issues	Licensing or permit required	Gov't support	Effectiveness
									eaters and insectivorous species, unless small cage wire or netting is used. Nets have a limited life.
Trapping	Feral cats, foxes, wild dogs, mice, rats.			Low-moderate, and lower if combined with hand catching and shooting programs. As required.	Acceptable	Yes, always likely to catch native animals	Yes, for native fauna and use of 1080 baits	Yes, but may require other options to be implemented	High, presuming sufficient time and resources are allocated, but often a short-term solution due to re-invasions.
Shooting	Feral cats, foxes, wild dogs, large herbivores, birds			Low to moderate and low if combined with hand catching and trapping programs. As required.	Humane	No	No, except for native birds which require a Fauna causing damage licence	Yes	High, presuming sufficient time and resources are allocated, but a short-term solution.
1080 baiting	Foxes and wild dogs			Low cost. As required.	Tolerated	Potentially	Yes	Yes, but would prefer other alternatives	High, presuming sufficient time and resources are allocated, but a short-term solution.
Baiting	Mice, rats			Low cost. As required.	Tolerated	Yes, particularly the use of rodenticides	Yes	Yes, but would prefer other alternatives	High, presuming sufficient time and resources

Options	Target species	Capital cost	Recurrent capital cost	Recurrent cost and frequency	Humaneness	Bycatch issues	Licensing or permit required	Gov't support	Effectiveness
									are allocated, but a short-term solution.
Hand catching	Snakes, goannas			As required and is often combined with other activities.	Short term stress, acceptable	No	Yes	Yes, if fauna are relocated	Addresses the few occasions there is a problem species.
Covering putrescible waste almost immediately it is delivered	Feral cats, wild dogs, foxes, gulls, kites, ibis, pelicans, ravens, mice and rats.			High cost, but on-site staff would undertake this work as part of normal duties.	Very humane	No	No	Preferred	Very high for all species attempting to access putrescible waste.

3. MANAGEMENT ACTIONS

As is always the case, best practice is often the most expensive in the short-term, but not necessarily so in the longer term. Best practice in managing the feral and pest vertebrate species potentially attracted to and likely to require active management at the Broome Regional Resource Recovery Park, involves:

- ensuring that native wildlife and feral pest species have limited opportunities to access food and water at the facility;
- covering all putrescible waste as fast as possible;
- monitoring for the presence of feral and pest species during daily operations; and
- eradication of feral and pest species is undertaken when the various triggers for management are activated (see Table 3), and when practical, catching and relocating native fauna on the few occasions they become a pest species, as soon as the species is recorded.

The following management actions summarised in Table 3 will be implemented.

3.1 STAFF INDUCTION

A staff induction will:

- explain the importance of stopping and eradicating feral and pest species becoming established;
- advised staff of the availability of this plan, and in particular the triggers requiring action, so that they inform management when appropriate action is required;
- indicate to all staff that feral and native fauna must not be fed on-site nor will containers for water be provided for feral and pest species to access;
- ensure that any physical or near miss interactions / incidents between feral and pest species and staff and visitors is recorded in the provided record management system; and
- ensure that staff or visitors do not remove native fauna from the site. Any removal of fauna is to be undertaken by a specialist contractor and / or with advice from the DBCA District Wildlife Officer in Broome.

3.1.1 Complaints and interactions

Complaints (verbal or in writing) from neighbours, visitors and staff, and all interactions (e.g. bites, scavenging for food, aggressive behaviour, etc) between feral and pest species and staff or visitors to the facility will be recorded in the site complaints register.

3.1.2 Annual review

Good management requires that there is ongoing monitoring against expected outcomes, and the results are recorded in a periodic review of performance. Management of the Broome Regional Resources Recovery Park will require that a report is prepared annually that will document achievements, which feral and pest species required active management and the extent to which that management was effective.

3.2 NON-PROVISION OF FOOD AND WATER FOR NATIVE AND EXOTIC SPECIES

Native and feral species will not be provided food and freshwater by staff or users of the facility. This requirement will be conveyed to all staff as part of the on-site induction program.

3.3 COVER ALL PUTRESCIBLE WASTE WITH SUITABLE MATERIAL

The Broome Regional Resource Recovery Park will implement a procedure that covers all putrescible waste material at the end of each day. The covering of waste materials will be undertaken in accordance with the Environmental Protection Authority (2008) *Best Practice Guidelines for Landfills Accepting Category C Prescribed Industrial Waste* (BPEM Guidelines).

3.4 MONITORING OF FERAL MAMMALS

The presence of any feral and pest species within the Broome Regional Resource Recovery Park is recorded along with the success or otherwise of any eradication programs.

3.5 TRIGGERS AND MANAGEMENT ACTIONS

Some feral and pest species will be difficult to exclude from the facility, but the problem is most cost-effectively managed before these species become a major problem (see Plate 1).

Table 3. Triggers and management actions

Fauna	Trigger	Action
All fauna	No trigger	All staff are provided with an induction and an explanation of what they are required to do regarding feral and pest species management.
All fauna	No trigger	All putrescible waste will be covered before the close of business each day to exclude fauna access, and where it is practical, covered during the day after it has been unloaded.
All fauna	No trigger	An annual written review report is prepared and available if and when requested.
Avifauna		
Gulls	Five gulls present for five days within a seven-day period	A local, suitably equipped, and licensed pest controller will be engaged to have the gulls removed from the facility.
Kites	Ten kites present for five days within a seven-day period	A local, suitably equipped, and licensed pest controller will be engaged to have the kites removed from the facility.
Pigeons	Five pigeons present for five days within a seven-day period	A local, suitably equipped, and licensed pest controller will be engaged to have the pigeons removed from the facility.
Ibis	Ten ibis present for five days within a seven-day period	A local, suitably equipped, and licensed pest controller will be engaged to have the ibis removed from the facility.
Pelicans	Three pelicans present for five days within a seven-day period	A local, suitably equipped, and licensed pest controller will be engaged to have the pelicans removed from the facility.
Corvids	Ten corvids present for five days within a seven-day period	A local, suitably equipped, and licensed pest controller will be engaged to have the corvids removed from the facility.
Large terrestrial fauna		

Fauna	Trigger	Action
Cats	A single cat is recorded within the facility	A local, suitably equipped, and licensed pest controller will be engaged to have the cat removed from the facility.
Dogs	A single dog is recorded within the facility	A local, suitably equipped, and licensed pest controller will be engaged to have the dog removed from the facility.
Foxes	A single fox is recorded within the facility	A local, suitably equipped, and licensed pest controller will be engaged to have the fox removed from the facility.
Goanna	A goanna greater than 1m in length seen on three occasions within a thirty-day period.	This action is not considered urgent. A local, suitably equipped, and licensed person will be engaged to have the goanna removed from the facility.
Cattle	A single cow in the fenced project area.	A local pastoralist will be contacted to remove the cattle. If it is unowned or the pastoralist isn't available, then the Council ranger will be engaged to remove the animal.
Snakes	A snake greater than 1m in length seen on three occasions within a thirty-day period.	A local, suitably equipped, and licensed person will be engaged to have the snake removed from the facility.
Small terrestrial fauna		
Mice	More than 10 house mice are recorded in the facility in a month.	The species is checked to ensure that it is an introduced mouse species. A local, suitably equipped, and licensed pest controller will be engaged to reduce the house mice abundance in the facility.
Rats	More than 10 rats are recorded in the facility in a month.	The species is checked to ensure that it is an introduced rat species. A local, suitably equipped, and licensed pest controller will be engaged to reduce the rats abundance in the facility.
Quolls	A single Northern Quoll identified within the facility area.	Given the conservation status of this species, advice should be sought from a DBCA District Wildlife Officer via 'broome.bdca.wa.gov.au' before taking any action.

3.6 HUMANE EUTHANASIA

No permit or licence is required to shoot feral cats, foxes, and wild dogs, however, baiting and trapping both require appropriate licences/permits.

Euthanising feral and pest species must be undertaken in a humane manner and in compliance with the *Animal Welfare Act (2002)*. Guidance statements provided by Pestsmart (Sharp 2012), the DBCA (Department of Parks and Wildlife 2011) and Department of Agriculture and Department of Local Government and Regional Development (2003) provide useful advice in this regard.

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Weed Management Plan

Regional Resource Recovery Park



Prepared for Shire of Broome


31 August 2022

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Appendices

FIGURE 1 – Site Locality

APPENDIX A Site Inspection Template

APPENDIX B Broome Weed Management Strategy

1 Introduction

1.1 About the Broome Regional Resource Recovery Park

Talis Consultants Pty Ltd (Talis) was commissioned by the Shire of Broome (the Shire) to prepare a Weed Management Plan (WMP) for the Broome Regional Resource Recovery Park (the Site).

The Site will be a Prescribed Premises pursuant to Part V of the *Environmental Protection Act 1986* (EP Act) and will likely undertake the following Prescribed Activities (*Environmental Protection Regulations 1987*), which require the Shire to consider weed management activities:

- Category 62 - Solid Waste Depot; and
- Category 64 Class II and III Putrescible Waste Facility.

The Site is situated on vacant Crown land and prior to construction of the Waste Management Facility, was primarily covered in vegetation, including dense scrub and eucalyptus trees. The land parcel occupies an area of approximately 119 hectares (ha) located over two lots, the northern section of Lot 990 on DP414194 Broome Road and the northern section of lot 593 on DP71791 Broome – Cape Leveque Road. The Site is located approximately 12km northeast of Broome’s town centre as shown in Figure 1.

The Site consists of an integrated Community Recycling Centre (CRC), Liquid Waste Facility (LWF), and Class III Landfill. The CRC will provide the full range of community and light commercial waste acceptance services including recyclable, hazardous waste, bulky waste, greenwaste, scrap metal, used tyres, and construction and demolition waste as well as refuse requiring appropriate disposal. The LWF and Class III Landfill provide waste management services to commercial customers only. At present, there are no waste management facilities located within the Kimberley region with the capacity to provide reuse, recycling, materials processing, and best practice disposal services.

Key activities which have the potential to spread weeds at the Site include:

- Construction and establishment of any new infrastructure;
- Vehicle and machinery movement into, within, and exiting the Site;
- Greenwaste operational activities including receipt, storage and stockpiling of material, mulching, and distribution of product;
- Fauna activity within and around the Site; and
- Rehabilitation activities.

1.2 Objectives of this WMP

Weeds are usually opportunistic plant species that are not native to an area but, once introduced, are able to compete effectively for resources. They can be intentional introductions, such as garden plants, or even commercial crops.

Weeds can create numerous environmental impacts, including resource competition and the prevention of seedling recruitment of native plant species, alteration of geomorphological and

hydrological cycles, changes in soil nutrients, fire regimes and the abundance of indigenous fauna, and genetic changes¹.

The purpose of this document is to:

- Review Baseline Data on existing weed species at the Site;
- Summarise compliance with relevant legislative requirements;
- Ensure that potential environmental hazards and risks are recognised and understood;
- Ensure that a program for activities and monitoring is identified;
- Ensure that all Site personnel are provided with suitable training through the Shire's Site Induction process;
- Identify priority weed species and address how these species will be controlled through prevention and eradication methods; and
- Align with the Shire's Broome Weed Management Strategy (31 March 2022).

¹ Department of Environment and Conservation, *Environmental Weed Strategy for Western Australia*, 1999.

2 Legislative and Regulatory Framework

Laws and regulations pertaining to vegetation, flora and weed management exist at both Commonwealth and State government levels. While each jurisdiction administers their respective legislation, it is the responsibility of the Shire to be aware of the legislation pertaining to their operations.

The Shire's employees and contractors must comply with all relevant environmental Commonwealth and State legislation. There is a range of legislation that relates to weed hygiene and management in Western Australia (WA) (Table 2-1).

Table 2-1: Summary of Commonwealth and State Legislation relating to weed management.

Legislation	Application
<i>Agriculture and Related Resources Protection Act 1976 (WA)</i>	Declared Plants and animals which are nominated by the Agriculture Protection Board as current or potential pests.
<i>Environmental Protection Act 1986 (WA)</i>	Prevention, control, and abatement or pollution and conservation protection and enhancement of environment.
<i>Soil and Land Conservation Act 1945 (WA)</i>	Deals with the conservation of soil and land resources with the mitigation of the effects of erosion.
<i>Biodiversity Conservation Act 2016 (WA)</i>	Provides for the conservation and protection of biodiversity and biodiversity components in Western Australia; and the ecologically sustainable use of biodiversity components in Western Australia.
<i>Environmental Protection and Biodiversity Conservation Act 1999 (Commonwealth)</i>	Protection of environmental matters of national significance.
<i>Biosecurity and Agricultural Management Act 2007</i>	Prevent new pests, weeds and diseases from entering Western Australia. Manage the impact and spread of those pests already present in the state and safely manage the use of agricultural and veterinary chemicals.

3 Key Strategies and Guidelines

Table 3-1 provides a summary of several key strategies and their application to the WMP.

Table 3-1: Key Strategies and Guidelines

Strategy and / or Guideline	Summary
Weeds of National Significance	<p>Weeds of National Significance is a list of the most problematic plant species in Australia as determined by the federal government. Plant species were selected on their basis of their invasiveness and impact characteristics, their potential and current area of spread and their primary industry, environmental and socioeconomic impacts.</p> <p>In Western Australia, many weeds of National Significance are also declared pests under the Biosecurity and Agricultural Management Act 2007.</p>
Australian Weed Strategy 2017-2027	<p>The Australian Weed Strategy provides national guidance on best practice weed management. It aims to guide coordination of effort across all jurisdictions and affected stakeholders and to inform plans and actions by state and territory governments, local governments, regional natural resource management agencies, as well as by industry, landholders and the wider community.</p> <p>The Australian Weed Strategy supports three national goals:</p> <ul style="list-style-type: none"> • prevention, detection and early intervention; • minimise the impact of established weeds; and • enhance Australia's capacity and commitment to weed management. <p>It also identifies priority areas where improving the approach to weed management has the potential to reduce instances of new weeds establishing and spreading in Australia as well as the negative impacts of established weed species.</p>
State Weed Plan 2001	<p>The State Weed Plan has been developed to help achieve coordinated, effective weed management throughout Western Australia. In order to achieve cost-effective weed management, a coordinated approach involving all levels of government, industry, community and individual landholders is required.</p> <p>The State Weed Plan offers such an approach through raising the awareness of all Western Australians of weed problems, by providing opportunities for their involvement in weed management through integrated and prioritised programs, and by support services for landholder and community action.</p>

Strategy and / or Guideline	Summary
Environmental Weed Strategy for Western Australia 1999	<p>Management of environmental weeds in Western Australia is one of the major management issues requiring action if we are to protect our natural environments for future generations. Competition from weeds is a major process affecting threatened flora and threatened ecological communities. Many critically endangered plants have populations restricted to small, disturbed areas (e.g. remnant vegetation on private property and road verges). These are particularly vulnerable to invasion by environmental weeds and will receive priority for weed control, particularly through the implementation of recovery plans developed by the Department of Conservation and Land Management.</p> <p>The Environmental Weed Strategy for Western Australia and the associated environmental weed database provide both the direction and an approach to tackling this large problem. The Environmental Weed Strategy will ultimately contribute to the State Weed Strategy which will address both agricultural and environmental weeds.</p> <p>In developing the Environmental Weed Strategy for Western Australia, criteria for the assessment and ranking of weeds in terms of their environmental impact on biodiversity were formulated. Three criteria were selected to rate weeds:</p> <ul style="list-style-type: none"> • Invasiveness; • Distribution; and • Environmental impacts.
Shire of Broome Weed Management Strategy	<p>The Shire of Broome Weed Management Strategy provides the framework for best practice weed management within the Shire. The Strategy aims to protect the environment, economy, community, and industry from the adverse impacts of weeds.</p> <p>This Strategy defines a weed as - A plant that requires some form of action to reduce its harmful effects on the environment, the economy, human health, and amenity. Weeds are commonly plants that grow in natural ecosystems where they are not naturally occurring and proceed to modify natural processes resulting in the decline of the ecosystem they have invaded. The Weed Management Strategy follows the recommendations of the Shire's State of the Environment Report (2015) which provides both a strategic and operational response to the topic of "Managing Invasive Species".</p>

Within this WMP there are references to 'Contractors' and 'Staff'. Table 3-2 provides a definition of each of these terms.

Table 3-2: Definition Summary

Word	Definition
Contractor	A person(s) or business that provides commercial services independent of the Shire's operations. A Contractor may be engaged by the Shire through to provide goods and / or services i.e., Waste Collection Contractor. Alternatively, a Contractor may provide goods and / or services to the community and require access to the Site for appropriate disposal of materials.
Staff	A person(s) employed by the Shire of Broome.

4 Stakeholder Consultation

The coordination and involvement of all stakeholders, landholders, and community members in the Shire of Broome towards the collective approach of weed management is necessary for the effective long-term control of target species. The Shire aims to engage openly with all identified stakeholders during and post Site operations.

The creation of this WMP was prepared in consultation with the Yawuru Birragun Conservation Park land managers, the native title holders Nyamba Buru Yawuru and the Department of Biodiversity, Conservation and Attractions (DBCA). Ongoing consultation will occur throughout the life of the Site operations with the above stakeholders as required.

A summary of stakeholder consultation undertaken for this management plan is provided below in Table 4-1.

Table 4-1: Stakeholder Engagement Register

Date	Stakeholder	Description of Engagement	Topic/Issue	Stakeholder comments/issues	Proponent Response/Outcome
21/12/2021	Department of Biodiversity, Conservation and Attractions	Letter	Referral of Works Approval – Request For Advice	<p>The DBCA recommended the following:</p> <ul style="list-style-type: none"> • The vegetation clearing permit be submitted and assessed by DBCA to provide comment on direct impacts. • Greater consideration for indirect impacts for adjacent Yawuru Birragun Conservation Park. • Within the broad proposal area, locate the actual project footprint away from Yawuru Birragun Conservation Park as far as practical to reduce indirect impacts. • The risk and impact of introduced plants (weeds) be assessed by the proponent and management measures put in place to address this impact. • A site Environmental Management Plan be developed to address direct and indirect impacts and to include: potential threats, monitoring methods of threat impacts and mitigation responses based on threshold levels 	Noted

Date	Stakeholder	Description of Engagement	Topic/Issue	Stakeholder comments/issues	Proponent Response/Outcome
				<ul style="list-style-type: none"> DBCA would welcome further consultation with DWER and the proponent Shire of Broome to discuss mitigation of impacts 	
24/01/2022	Yawuru Native Title Holders Aboriginal Corporation	Letter	Referral of Works Approval W6606/2021/1.	Yawauru have been consulted throughout the site-selection process and do not have any issues or concerns with this Works Approval.	Noted
31/03/2022	Nyamba Buru Yawuru (NBY) (DBCA) Environs Kimberley Society for Kimberley Indigenous Plants and Animals (SKIPPA) Solway Drain Community Group Roebuck Bay Working Group Main Roads Western Australia (MRWA)	Consultation	Consultation with Key stakeholders for the development of The Broome Weed Management Strategy	Refer to APPENDIX B – Broome Weed Management Strategy	Shire adopted Broome Weed Management Strategy at their Council meeting, held 31 March 2022.

Date	Stakeholder	Description of Engagement	Topic/Issue	Stakeholder comments/issues	Proponent Response/Outcome
10/06/2022 and 17/06/2022	Department of Biodiversity, Conservation and Attractions	Meeting	Referral of Works Approval W6606/2021/1.	The Shire and DBCA held a meeting to review feedback received by the DBCA and ensure that the works being undertaken addressed the items raised.	Shire engaged Talis to review and address items raised and prepare additional information as required.
4/08/2022	Department of Biodiversity, Conservation and Attractions	Letter	Addressing additional scope of works for inclusion in Works Approval Resubmission.	<p>The DBCA recommended the following:</p> <ul style="list-style-type: none"> • The vegetation clearing permit be submitted and assessed by DBCA to provide comment on direct impacts. • Greater consideration for indirect impacts for adjacent Yawuru Birragun Conservation Park. • Within the broad proposal area, locate the actual project footprint away from Yawuru Birragun Conservation Park as far as practical to reduce indirect impacts. • The risk and impact of introduced plants (weeds) be assessed by the proponent and management measures put in place to address this impact. • A site Environmental Management Plan be developed to address direct and indirect impacts and to include: potential 	<p>The Shire prepared a response letter following the undertaking of the meetings held 10 and 17 June 2022.</p> <p>This WMP was prepared to provide supporting information to the Site Operations</p>

Date	Stakeholder	Description of Engagement	Topic/Issue	Stakeholder comments/issues	Proponent Response/Outcome
				<p>threats, monitoring methods of threat impacts and mitigation responses based on threshold levels</p> <ul style="list-style-type: none"> • DBCA would welcome further consultation with DWER and the proponent Shire of Broome to discuss mitigation of impacts 	

5 Flora and Vegetation

5.1 Baseline Study

To understand the ecological attributes of the Site, a Level 1 and Level 2 survey was completed by Spectrum Ecology:

- Broome Regional Resource Recovery Facility - Reconnaissance Flora & Level 1 Fauna Survey (2020); and
- Broome Regional Resource Recovery Park - Detailed Flora & Vegetation Assessment (2020b).

Information from these surveys on the vegetation unit and condition, threatened ecological communities, threatened and priority flora and introduced flora is outlined in the following sections.

5.2 Vegetation Unit and Condition

The vegetation unit within the Site was recorded by Spectrum Ecology (2020b) as *Corymbia greeniana* low open woodland with *Acacia eriopoda* and *Bauhinia cunninghamii* tall open shrubland, over *Triodia schinzii* and *Triodia caelestialis* low sparse hummock grassland and *Chrysopogon pallidus* and *Sorghum plumosum* low sparse tussock grassland. The vegetation unit was considered to have low regional and local significance as the distribution was not restricted within the bioregion and did not provide habitat for restricted significant flora. Spectrum Ecology (2020b) assessed the condition of the vegetation unit of the Site as Excellent (100%) which the EPA (2016) describe as “Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.”

5.3 Threatened and Priority Ecological Communities

In WA, ‘Threatened Ecological Communities’ (TECs) are defined by the WA Threatened Ecological Communities Scientific Advisory Committee (within DBCA) and are assigned to one of four categories: Presumed Totally Destroyed, Critically Endangered, Endangered, Vulnerable. While TECs are not afforded direct statutory protection at a State level (unlike Declared Rare Flora under the Wildlife Conservation Act 1950) their significance is acknowledged through other State environmental approval processes (i.e. Environmental Impact Assessment process pursuant to Part IV of the Environmental Protection Act 1986).

Priority Ecological Communities (PECs) are ecological communities that are under consideration for listing as a TEC, but do not yet meet the criteria. The PEC is placed into a Priority Rating between 1-5 that ranks the PEC based on known occurrences, threats and management of the community.

During the desktop assessment completed for the Detailed Flora and Vegetation Assessment (Spectrum Ecology, 2020), a Mangarr (Minyjuru) Priority 1 (P1) Priority Ecological Community (PEC) was recorded in northwest corner of the Site. Scattered *Sersalisia sericea* (Minyjuru) trees were recorded during the Site visit outside the current PEC; however, it is unlikely that these individuals indicate the presence of the Mangarr PEC. The *Corymbia paractia* (P1) PEC was likely recorded at the Site based on the known distribution of *C. paractia*, abundance recorded in the survey and the location of the Site. No TECs were recorded within the Site.

5.4 Threatened and Priority Flora

Spectrum Ecology (2020) recorded three Priority flora taxa within the Site: *Corymbia paractia* (P1), *Jacquemontia* sp. Broome (A.A. Mitchell 3028) P1), and *Terminalia kumpaja* (Priority 3). The occurrence of these Priority Flora was determined to have low local and regional significance. No Threatened Flora have previously been recorded within the Site. One Threatened Flora taxon was assigned a medium likelihood of occurrence, *Seringia exastia*, but was not found in the current survey and the location of the Site.

5.5 Introduced Flora

Two introduced flora were recorded within and immediately adjacent to the Site's eastern boundary: *Stylosanthes hamata* and *Stylosanthes scabra*. *Stylosanthes hamata* was the most common and was recorded along with seven opportunist collections, especially near the roads. None of the introduced flora species are listed as Declared Pests in WA (Spectrum Ecology, 2020).

6 Risk Assessment

Risk assessments are an ongoing requirement for the successful operation of the Site. Risk assessments are required to assess current systems, management, and monitoring and to ensure measures are in place working effectively to mitigate any hazards. A review of the risk assessment is to be undertaken as part of the Shire's Annual Review process or following significant alterations to operations at the Site. The potential risks associated with the Site were assessed using the risk assessment procedure described in the DWER Guidance Statement for Risk Assessments. Two aspects of environmental risk have been considered in this assessment:

- Likelihood - The likelihood of an impact on the surrounding environment or other receptors; and
- Consequence - The scale or magnitude of the potential impact (i.e. severity/extent) if it were to occur.

The levels for likelihood and consequence are detailed in Table 6-1 and Table 6-2 respectively.

Table 6-1: Likelihood Levels and Description

Likelihood	Description
Rare	The event may only occur in exceptional circumstances
Unlikely	The event will probably not occur in most circumstances
Possible	The event could occur at some time
Likely	The event will probably occur in most circumstances
Almost Certain	The event is expected to occur in most circumstances

Table 6-2: Consequence Levels and Descriptions

Consequence	Description
Slight	Minimal on-site impact, specific consequence criteria (degradation of ecosystems, environmental noncompliance) are likely to be met
Minor	Low level on-site impacts, minimal local off-site impacts, no wider-scale off-site impacts, specific consequence criteria (degradation of ecosystems, environmental noncompliance) are likely to be met
Moderate	Mid-level on-site impacts, low-level local off-site impacts, minimal wider-scale off-site impacts, specific consequence criteria (degradation of ecosystems, environmental noncompliance) are at risk of not being met
Major	High level on-site impacts, mid-level local off-site impacts, low-level wider-scale off-site impacts, adverse environmental effects: degradation of ecosystems and environmental noncompliance

Consequence	Description
Severe	Catastrophic on-site impacts, high-level local scale off-site impacts, mid-level or above wider scale off-site impacts, adverse environmental effects: high level of degradation or environmental noncompliance

The risk matrix in Table 6-3 combines the level of likelihood and consequence to determine the level of associated risk. The following levels of risk are used in this WMP and are based on a qualitative assessment.

- Low - Risk is acceptable and generally not subject to regulatory controls (green);
- Moderate - Risk event is tolerable and is likely to be subject to some regulatory controls (yellow);
- High - Risk event may be tolerated and be subject to multiple regulatory controls (orange); and
- Extreme - Risk event will not be tolerated, DWER may refuse application (red).

Table 6-3: Risk Matrix

Likelihood	Consequence				
	(1) Slight	(2) Minor	(3) Moderate	(4) Major	(5) Severe
(A) Almost Certain	Medium	High	High	Extreme	Extreme
(B) Likely	Medium	Medium	High	High	Extreme
(C) Possible	Low	Medium	Medium	High	Extreme
(D) Unlikely	Low	Medium	Medium	Medium	High
(E) Rare	Low	Low	Medium	Medium	High

All potential risks arising from the establishment of the Site were assessed prior to and following the implementation of proposed management measures. The results of the risk assessment are presented in Table 6.4.

Table 6-4: Summary of WMP Risk Matrix

Aspect	Risk	Source	Receptor	Initial			Management	Residual		
				L	C	R		L	C	R
Flora and Vegetation	Lack of understanding/awareness of location of exotic flora, fauna or disease	Training	Site Staff	B	2	M	<ul style="list-style-type: none"> Awareness of location of exotic flora, fauna or disease and weed management through the Site induction. Training to be provided by the Shire's Weed Officer and / or by a Contractor on an as needed basis Site staff required to adhere to Site Operational and Environmental Management (OEMP) procedures and the WMP Additional training to be provided where necessary and training records maintained and updated on site 	C	1	L
	Lack of understanding/awareness of precautions to be implemented when working near, or travelling through exotic flora, fauna or disease	Vehicle movements, construction and operational activities	Site Staff	C	2	M	<ul style="list-style-type: none"> Awareness of location of exotic flora, fauna or disease and weed management through the Site induction Site staff required to adhere to Sites OEMP procedures and the WMP Vehicles to adhere to established roads and tracks to prevent the spread of weeds within the Site. The Shire will ensure that appropriate signage and information boards (where applicable) are installed at the Site All Plant and equipment will be inspected upon entry and records maintained Additional training to be provided where necessary and training records maintained and updated on site 	C	2	M
	Lack of/ineffective vehicle hygiene	Vehicle movements	Site Staff	B	3	H	<ul style="list-style-type: none"> Vehicles entering the Site will be free of soil, mud, and vegetative material Vehicle and equipment inspection will be completed and recorded Daily Prestart inspection to include visual weed inspection Use of wash down bay to remove any potential introduced flora plants or seeds Vehicles to adhere to established roads and tracks to prevent the spread of weeds within the Site Site speed limits will be maintained 	C	2	M
	Lack of/ineffective policies and procedures relating to exotic flora, fauna or disease	Quality Assurance	Site Staff	C	2	M	<ul style="list-style-type: none"> Awareness training of exotic flora (including weed management), fauna and disease through the Site induction OEMP to outline weed management and policies and procedures All Site staff will adhere to Site OEMP procedures and Shire policies Site inspections and reporting to be carried out in line with the WMP Works will be undertaken in accordance with the control measures outlined in this risk assessment 	C	1	L
	Lack of/ineffective training of individuals working around exotic flora, fauna or disease	Training	Site staff	C	2	M	<ul style="list-style-type: none"> Awareness training of exotic flora (including weed management), fauna and disease through the Site induction Training Register will be maintained and updated on Site Site staff required to adhere to Sites OEMP procedures and the WMP Additional training to be provided where necessary and training records maintained and updated on site 	C	1	L

Aspect	Risk	Source	Receptor	Initial			Management	Residual		
				L	C	R		L	C	R
	Lack of/ineffective detailing of location of exotic flora, fauna or disease captured in contracts with contractors	Training and Management	Site Staff	C	2	M	<ul style="list-style-type: none"> Awareness training of exotic flora (including weed management), fauna and disease through the Site induction Regular monitoring of weeds across the site to be undertaken by all site staff Staff to report establishment of weeds to Site Supervisor 	C	1	L
	Lack of processes/procedures/ requirements detailed in the contracts	Quality Assurance	Site staff	C	2	M	<ul style="list-style-type: none"> Review Site documentation to ensure that legal and contractual requirements are met All Contractors on site to complete awareness training of exotic flora (including weed management), fauna and disease through the Site induction Induction/Training register to be maintained and updated on Site 	C	1	L
	Lack of oversight of contracted organisations	Quality Assurance, Training and Management	Site staff	C	2	M	<ul style="list-style-type: none"> All Contractors to complete Site induction Review Contractor documents (including JHA's and WMS prior to works commencing) to ensure that requirements are met in line with the WMP All Contractors on site to complete awareness training of exotic flora (including weed management), fauna and disease through the Site induction Induction/Training register to be maintained and updated on Site 	D	1	L
	Weather event spreads exotic flora, fauna or disease	Inclement Weather	Vegetation and Flora	A	3	M	<ul style="list-style-type: none"> Inspections will be undertaken during the peak flowering / growing season (January to April) Weed Contractor to complete treatments during the peak flowering / growing season (January to April) and at any other time if requested by the Shire Manual removal or chemical application prior to flowering periods OEMP to outline weed management and monitoring measures 	C	1	L
	Lack of/ineffective contract management of weed contractor	Quality Assurance	Site Supervisor	C	2	M	<ul style="list-style-type: none"> Review Contractor documents (including JHA's and WMS prior to works commencing) to ensure that requirements are met in line with the WMP Works will be undertaken in accordance with the control measures outlined in this risk assessment All Contractors on site to complete awareness training of exotic flora (including weed management), fauna and disease through the Site induction Induction/Training register to be maintained and updated on Site 	D	1	L
	Disturbance of Flora during Construction phase of new infrastructure.	Vehicular Activity, Inadequate inspection and monitoring of Weeds	Site Staff	B	2	M	<ul style="list-style-type: none"> Vehicles will be required to keep to authorised access tracks and roads All access roads and tracks will be clearly identified and marked prior to commencement of work Any clearing undertaken will be confined to the appropriate area onsite during the construction. This will be supervised by the Shire and/or appointed Construction Superintendent 	C	1	L

Aspect	Risk	Source	Receptor	Initial			Management	Residual		
				L	C	R		L	C	R
							<ul style="list-style-type: none"> Incident Register to be maintained and updated on Site and will reflect any disturbance to Flora. 			
	Increased abundance and diversity of introduced species	Vehicular Activity, Inadequate inspection and monitoring of Weeds	Vegetation and Flora	B	2	M	<ul style="list-style-type: none"> Regular monitoring of weeds across the site to be undertaken by all site staff Regular weed management methods to be undertaken via manual removal and/or by chemical application by Weed Contractor 	D	1	L
	Transportation of weeds from Site to the Shire region resulting in spread of weed species	Weeds and seeds introduced through vehicles entering the Site and green waste stockpiles	Site Staff	B	3	H	<ul style="list-style-type: none"> Regular Plant and Equipment inspections Regular monitoring of weeds across the site to be undertaken by all site staff 	C	2	M
	Introduction of weeds to Site from Contractors during operation	Weeds and seeds introduced through plant, equipment and vehicles entering the Site	Site Staff	B	2	M	<ul style="list-style-type: none"> The Shire will undertake spot checks on all plant and equipment for regular / frequent Contractors that attend the Site The Shire will undertake a full inspection of all Plant and equipment for new Contractors that attend the Site Awareness of weed management through the Site induction Regular monitoring of weeds across the site to be undertaken by all site staff Weed Inspections Register to be maintained on Site Regular weed management methods to be undertaken via manual removal and/or or by chemical application prior to flowering periods by Weed Contractor OEMP to outline weed management and monitoring measures 	C	1	L
	Incorrect timing of weed identification, detection and / or control of weeds.	Inclement Weather and Management	Vegetation and Flora, Site Staff and Contractors				<ul style="list-style-type: none"> Regular monitoring of weeds across the site to be undertaken by all site staff Inspections will be undertaken during the peak flowering / growing season (January to April) Weed Contractor to complete treatments during the peak flowering / growing season (January to April) and at any other time if requested by the Shire Manual removal or chemical application prior to flowering periods OEMP to outline weed management and monitoring measures 			
Fauna	Attraction of native fauna, feral animals and vermin causing the potential for weed seed dispersal	Exposed waste, litter, voids and water bodies in the landfill and surface water ponds	Fauna	B	2	M	<ul style="list-style-type: none"> Installation of fencing around perimeter of Site Daily compaction and covering of waste in accordance with best practice guidelines Managed in accordance with measures outlined in the Feral Animal and Vermin Control Management Plan OEMP outlining the management and monitoring measures to be adopted 	C	1	L

7 Environmental Outcomes

Through the implementation of this WMP the Shire is seeking to deliver the following environmental outcomes at the Site:

- To minimise the risk of introducing new weed species at the Site;
- Control and eradicate (or contain on-site) existing weed species at the Site;
- Identify, control, and eradicate (or contain on-site) any new weed species identified at the Site;
- Mitigate (where possible) fauna management to reduce spreading weeds; and
- Mitigate the spread of weeds within the Site to prevent the potential spread of weeds into neighbouring tenures.

8 Environmental Management

The Shire adopted a Weed Management Strategy on 31 March 2022, which provides a framework for best practice weed management within the Shire. The Weed Management Strategy aims to protect the environment, economy, community, and industry from adverse impacts of weeds. The Shire prepared the Weed Management Strategy with consideration from the Shire's State of the Environment Report (2015) and in consultation with numerous stakeholders.

The Shire also provides ongoing community education regarding weed management on the Shire's website (<https://www.broome.wa.gov.au/Community/Parks-and-Gardens/Weed-Control>). The Shire promotes existing local education material offered by external sources including:

- "Kimberley Weeds" index cards (https://d3n8a8pro7vhmx.cloudfront.net/environskimberley/pages/152/attachments/original/1517207387/WeedCards%28150x80mm%29x34_LowRes_.pdf?1517207387);
- Roebuck Bay working Group's "Coastal Gardens: a planting guide for Broome on the Dampier Peninsula" booklet (<https://roebuckbay.org.au/pdfs/coastal-gardens-web-version.pdf>);
- Department of Primary Industry and Regional Development website and "Weeds to Watch" poster (<https://library.dbca.wa.gov.au/static/Journals/080341/080341-20.003.pdf>); and
- Department of Biodiversity Conservation and Attractions "Weed" webpage.

The following table details the environmental management measures required across the Site to manage potential impacts of weeds.

Table 8-1: Environmental Management Measures

Aspect	Environmental Management Measures
Training and awareness	<ul style="list-style-type: none"> • Awareness of weed management through the site induction. The site induction will include information pertaining to weeds occurring at the site as well as the hygiene and reporting requirements associated with weed management.
Management of weed-bearing material	<ul style="list-style-type: none"> • Vehicles entering/exiting the site are free of soil, mud, and vegetative material • Use of wash down bay to remove any potential introduced flora plants or seeds from vehicles and/or equipment • Vehicles to adhere to established roads and tracks to prevent the spread of weeds within the Site • All greenwaste loads to be covered until unloading at Green Waste Processing Facility
Monitoring and control	<ul style="list-style-type: none"> • Regular monitoring of weeds across the site to be undertaken by all site staff • Regular weed management methods to be undertaken via manual removal and/or or by chemical application prior to flowering periods by Weed Contractor

8.1 Training and Awareness

Ongoing training is essential for the continued development of staff knowledge and expertise. The Shire supports further learning through the Shire's induction process and training in weed identification is considered vital for all staff working in the Broome habitat.

Training will be provided to all employees through the Shire's induction process. Training will include weed identification from germination to seeding, understanding of weed lifecycles and appropriate control methods for target species and hygiene protocols for use of machinery and equipment.

Inductions shall be reviewed and updated to reflect activities and risks identified on the Site, including an incident investigation learning. Other required training topics will be developed as appropriate based on Site specific requirements.

8.2 Weed Prevention

To minimise the risk of introducing new weed species and/or spread of weed species at the Site:

- All Contractor Plant and equipment will be inspected to ensure they are free of soil, mud, and vegetative material. Shire vehicles/plant and equipment will use the wash down bay to remove any potential introduced flora plants or seeds;
- Ensure all Site operational staff are trained in the awareness of weed management through the site induction before working at the Site. The Site induction will include information pertaining to weeds occurring at the site as well as the hygiene and reporting requirements associated with weed management;
- All Vehicles will adhere to established roads and tracks;
- All greenwaste loads to be covered until unloading at Greenwaste Drop-off/Processing Facility;
- Regular weed management methods to be undertaken via manual removal and/or or by chemical application during peak active growing periods prior to flowering by a suitable Contractor;
- Twice-yearly and/or during peak active growing periods Whole of Site Weed Inspections to be completed; and
- Regular monitoring of weeds across the site will be undertaken by all site operational staff in accordance with this WMP.

8.3 Monitoring

Monitoring programs will be designed and implemented to demonstrate and communicate compliance with regulatory requirements and achievement of performance indicators to the Site Supervisor and Operational Staff. Table 8-2 provides a summary of the monitoring parameters and further detail on monitoring initiatives is described in Sections 0, 8.3.2, and 8.3.3.

Table 8-2: Summary of Monitoring Parameters

Parameter/Indicator	Location	Procedure	Timing
Plant and Equipment inspections to ensure prevention and spread of weeds	Site	Prestart Inspection	Daily
Vehicles and equipment limit operation to designated tracks and roads (to reduce spread of weeds on site)	Site Roads	Inspection	Daily
All Contractor vehicles, machinery and equipment are to be maintained and cleaned to reduce spreading of potential weed seeds within the Site.	Site	Inspection	Spot checks and / or full checks with new Contractors
Complete Monthly Site Inspection to ensure ongoing compliance with this management plan and identify any new weed infestations in the Site area.	Site	Inspection by Shire Staff	Monthly
Greenwaste, mulch and collection stockpiles maintained as required	Site	Inspection	Daily
New Weed Infestations	Site	Inspection by Shire Staff and/or engagement of Contractor to undertake treatment	Monthly and/or during peak active growing periods prior to flowering
Twice Yearly Whole of Site Weed Inspection/Review	Site	Inspection by Contractor	Twice yearly, and/or during peak active growing periods prior to flowering
Weed Mapping	Site	Inspection by Contractor	Once yearly and/or as required by the Shire
Fauna Management to occur in accordance with the Shire's Feral Animal and Vermin Management Plan an	Site	Inspection	Daily

8.3.1 Site Inspections

Site personnel will conduct Monthly Site inspections (draft included as Appendix A – Site Inspection Template). These inspections will aim to:

- Identify any new weed outbreaks;
- Assess the effectiveness of weed management across the Site;
- Assess the effectiveness of the corrective actions being implemented; and
- Set an agreed timeframe for the close out of any required actions.

Corrective actions shall be assigned to the Site Supervisor and/or a responsible person to action (i.e. Weed Contractor). Records of inspections shall be maintained by the Site Supervisor and uploaded to the Shire's internal information management system. In addition, the Shire's Weed Officer and/or a Contractor will undertake a twice-yearly inspection and mapping at the Site and provide training to Site personnel as required.

8.3.2 Plant and Equipment Inspections

Site personnel will conduct Pre-start inspections on all plant and equipment prior to commencing work at the start of each shift. Cleaning of vehicles will be undertaken when required and must be conducted within the wash-down bay to ensure wastewater containing weeds and/or other contaminants are captured for treatment. The Shire will undertake spot checks on regular/frequent Contractor plant and equipment and full checks for all new Contractor plant and equipment prior to mobilising to the Site.

8.3.3 Weed Mapping

The Shire will implement weed mapping activities to:

- Track weed species across the Site;
- Review and understand how different weed species react to seasonal growth periods, particularly between January – April;
- Understand how different weed species respond to changes in treatment/controls methods; and
- Track management outcomes through time.

The Shire and/or a Contractor will undertake weed mapping on a yearly basis and will coincide with one of the twice-yearly inspections across the Site. Records of weed mapping events shall be maintained by the Site Supervisor and uploaded to the Shire's internal information management system.

8.4 Weed Control

The Site Supervisor is responsible for ensuring that weed control activities are undertaken on a regular basis to prevent the establishment and spread of weeds at the Site and immediate surrounds. Weed control activities will include:

- Preventative Control:
 - Ensuring that activities are implemented as nominated in Section 8.3;

- Ensuring that certified weed free seed and/or flora/vegetation is used within any landscaping or rehabilitation efforts; and
- Ensuring that any accepted clean fill materials, not destined for landfill (i.e. virgin excavated natural material or excavated natural material) has been tested and classified prior to being accepted at the Site;
- Mechanical Control:
 - Ensuring that firebreaks are maintained around the Site; and
 - Ensuring that landscaped and/or grassed areas are maintained within the Site.
- Chemical Control:
 - Engagement of a Contractor to undertake spot spraying/application of a chemical (herbicide) to weeds or soil to control germination.

In addition, the Shire will implement a Species-Specific Weed Control Plan (SSWCP) for any weed species detected on-site by the Shire or their Contractor(s). The SSWCP will include:

- Objectives and Goals of the SSWCP;
- Ecology information of the species;
- Control options and methods for management of the species;
- Proposed management timeframes and reviews; and
- Mapping reference (where applicable).

The Site Supervisor is responsible for maintaining weed control records, preparation and review of any SSWCPs, and ensuring that this information is uploaded to the Shire's internal information management system.

8.5 Compliance

This WMP will be enacted in accordance with approvals, reporting requirements, licence conditions and Shire policies.

When an activity is observed or reported that is non-compliant with this WMP, the Site Supervisor will investigate and document the status of the incident or noncompliance event.

The Site Supervisor will collect the necessary information to report to and/or brief the Shire's Waste Manager. The Shire's Waste Manager will notify the appropriate regulatory agency, as required.

The Site Supervisor will work with the responsible parties to identify actions to reduce the environmental impact resulting from the activity or non-compliance event and to prevent any further or future occurrence of non-compliance.

The Site Supervisor will ensure that inspections and appropriate rectification actions are recorded through the Shire's Information Management System.

9 Roles and Responsibilities

The Shire's Site Supervisor (or delegate) will be accountable for ensuring requirements of this WMP are met. Where responsibilities are delegated to others i.e. third party contractors, this delegation must be clearly recorded and communicated in writing.

Table 9-1: Roles and Responsibilities

Role	Responsibility
Shire of Broome	<ul style="list-style-type: none"> Owns and Operates the Site; Responsible for the overall legislative compliance for the Site and contractual management;
Waste Manager	<ul style="list-style-type: none"> Revising, updating and implementing this WMP; WMP and relevant supporting documentation is reviewed regularly and is updated, as required.
Site Supervisor	<ul style="list-style-type: none"> Are aware of, and conduct their work in compliance with relevant licences, legislation and regulations; Responsible for overseeing and ensuring this WMP is implemented at Site; Contractors to the Site comply with the WMP; Ensure all operational staff complete relevant training and inductions; Document and report on any issues, actions, compliance or incidents related to this WMP; Reporting activities that are not in compliance with this WMP; Responsible for ensuring that Operational Staff and other relevant personnel are aware of their responsibilities and comply with the WMP.
Site Operational Staff	<ul style="list-style-type: none"> Are aware of, and conduct their work in compliance with relevant licences, legislation and regulations; Are aware of, and conduct their work in compliance with the WMP; Conduct Pre-start inspections on all plant and equipment prior to commencing work at the start of each shift; Report any non-conformances to the Site Supervisor as soon as practicable; and Undertake training and induction as directed by the Site Supervisor.
Sub Contractors	<ul style="list-style-type: none"> Are aware of, and conduct their work in compliance with relevant licences, legislation and regulations; Are aware of, and conduct their work in compliance with, the WMP; Report any non-conformances to the Site Supervisor as soon as practicable; and Provide relevant documentation (JHA's, WMS related to this WMP); Undertake training and induction as directed by Site personnel.

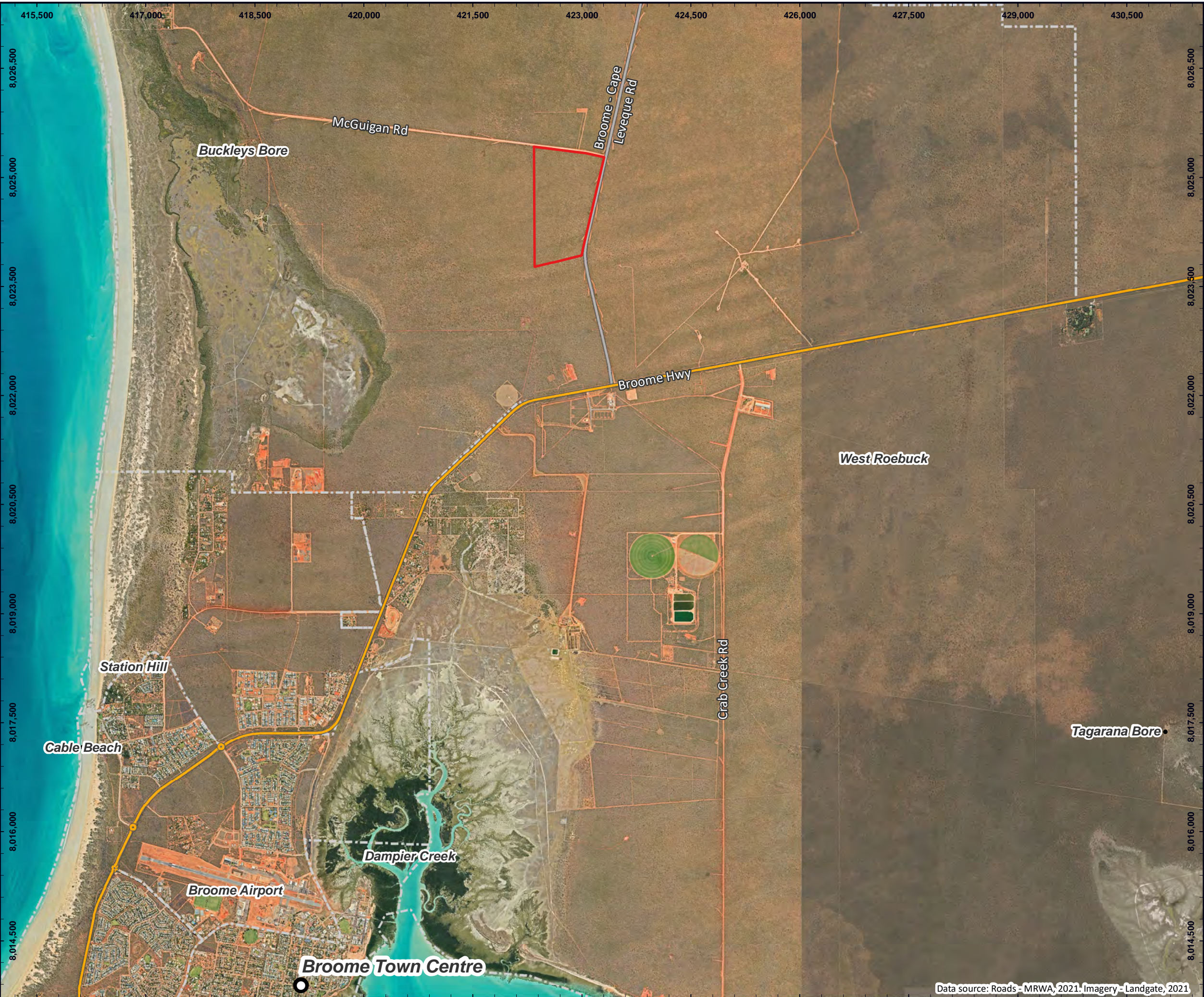
10 Review

It is important that documents are frequently reviewed and revised as the Shire's operations change and opportunities for improved management practices are identified.

This WMP will be reviewed periodically, at a minimum every two years, or when significant additional information comes to hand to assess the effectiveness of its measures and maintain relevance to current works and operations.

Upon review, the document will be revised where appropriate and the revision status will be updated in accordance with the Shire's document control procedures.

FIGURE 1 – Site Locality



LEGEND

- Site Boundary
- Primary Road
- Secondary Road

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LOCALITY

LOCALITY
LOT No.593 / 595 / 990
Cape Leveque Road

Works Approval
Shire of Broome

0 500 1,000 1,500 2,000 Metres

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:50,000

Prepared: N Johnston	Date: 24/06/2021
Reviewed: E Porter	Revision: A
Project: TW20002	

delivering solutions

Figure 01

Data source: Roads - MRWA, 2021. Imagery - Landgate, 2021

Document Path: \\server\\talis\\SECTIONS\\Waste\\PROJECTS\\TW2020\\TW20002 - Broome RRRP CRC Works Approval\\5 GIS\\Maps\\TW20002_01_Locality_RevA.mxd

APPENDIX A

Site Inspection Template

Broome Regional Resource Recovery Park – Weed Inspection Template - DRAFT

Inspection Date and Time: Click or tap here to enter text.		Inspection Location and / or Work Area (if specific): Click or tap here to enter text.	
Inspection Type: Routine <input type="checkbox"/> Compliance follow-up <input type="checkbox"/> Voluntary <input type="checkbox"/>			
Completed By (name and position) Click or tap here to enter text.		Signature: Click or tap here to enter text.	
Corrective Actions Required: Yes <input type="checkbox"/> No <input type="checkbox"/>		Corrective Actions Due by: Click or tap here to enter text.	
Weather Conditions: Click or tap here to enter text.		Photos Attached: Yes <input type="checkbox"/> No <input type="checkbox"/>	
Summary of Actions Arising (where applicable)			
Issue: Click or tap here to enter text.	Risk Rating (i.e. low, medium, high): Click or tap here to enter text.	Recommended Action(s): Click or tap here to enter text.	
Issue: Click or tap here to enter text.	Risk Rating: Click or tap here to enter text.	Recommended Action(s): Click or tap here to enter text.	

TW20002-V2_Broome RRRP_Weed Management Plan Inspection Template_2.0

Last Review Date	System Template Reference Only	Revision Status	Next Scheduled Review Date	Page
August 2022		2.0		1

Item No#	Description	Comments / Issues	Recommended Action Required	Satisfactory
1	Is the Site entry/exit road free of excessive dirt, mud and debris?	Click or tap here to enter text.	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
2	Are inspections records available, current and complete i.e. plant and equipment inspections, Monthly inspections? Are corrective actions documented in the Action Tracking Register?	Click or tap here to enter text.	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
3	Are the internal Site roads being utilised correctly i.e. no unapproved side tracks / detours being established within / around the Site?	Click or tap here to enter text.	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
4	Rehabilitated areas are in good condition i.e. Is there evidence of weeds on rehabilitated area(s), exposed surfaces, erosion?	Click or tap here to enter text.	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
5	Management of greenwaste drop-off and processing of greenwaste stockpiles is occurring routinely (i.e. green waste loads covered)?	Click or tap here to enter text.	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
6	Management of mulch pick-up and processing of mulch stockpile is occurring routinely?	Click or tap here to enter text.	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
7	Is there evidence of weeds within the greenwaste stockpile and processing area(s)?	Click or tap here to enter text.	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
8	Is there evidence of weeds within the Liquid Waste Facility compound or ponds?	Click or tap here to enter text.	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>

TW20002-V2_Broome RRRP_Weed Management Plan Inspection Template_2.0

Last Review Date	System Template Reference Only	Revision Status	Next Scheduled Review Date	Page
August 2022		2.0		2

Item No#	Description	Comments / Issues	Recommended Action Required	Satisfactory
9	Management of the Site's perimeter fences and fire trail is occurring routinely	Click or tap here to enter text.	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
10	Is the Wheel Wash and Wash Down bay being maintained correctly i.e. sediment collected from sump on a regular basis and disposed of within the landfill?	Click or tap here to enter text.	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
11	All reasonable steps are being undertaken to mitigate, manage and/or prevent the establishment of weeds within the Site.	Click or tap here to enter text.	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
Recommendations / Corrective Actions				
Yes <input type="checkbox"/> No <input type="checkbox"/> Please provide explanation: Click or tap here to enter text.				
Overall condition of Site:				
Satisfactory <input type="checkbox"/> Unsatisfactory <input type="checkbox"/>				
Other identified issues (as applicable)				
Click or tap here to enter text.				

TW20002-V2_Broome RRRP_Weed Management Plan Inspection Template_2.0

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APPENDIX B

Broome Weed Management Strategy

Weed Management Strategy



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INTRODUCTION

The Shire of Broome (the Shire) Weed Management Strategy provides the framework for best practice weed management within the Shire. The Strategy aims to protect the environment, economy, community and industry from the adverse impacts of weeds. The strategy will guide weed management funding, planning, monitoring and control.

The strategy focuses on the eradication of weeds whilst outlining a Shire wide approach to achieving the following objectives:

- Providing leadership and resourcing to prevent the introduction, spread and establishment of weeds.
- Reviewing, and promoting current best practice methods for ongoing weed control.
- Reviewing responsibilities of stakeholders in weed management.
- Increasing community awareness and education.
- Facilitating community involvement in weed management.

For the purpose of this Strategy a weed is defined as - *A plant that requires some form of action to reduce its harmful effects on the environment, the economy, human health, and amenity. Weeds are commonly plants that grow in natural ecosystems where they are not naturally occurring and proceed to modify natural processes resulting in the decline of the ecosystem they have invaded.*

The Weed Management Strategy follows the recommendations of the Shire's State of the Environment Report (2015) which provides both a strategic and operational response to the topic of "Managing Invasive Species".

The Report lists the strategic response as, *"To develop a comprehensive Weed Management Strategy to guide the Shire's weed management activities on land under care and control."* The operational responses as, *"To review the Shire's project management plan template for engineering works to include consideration of weed management when undertaking specific projects"* and *"Ensure that areas cleared of native vegetation are managed and mulched to prevent soil erosion and the establishment of weeds."* The State of Environment Report further guides our listed priority weed species based on weeds of national significance.

INTRODUCTION

The Shire's Weed Management Strategy will be guided by these weed management principles:

- Weed management is an integral part to all land management and for maintaining sustainability and natural resources.
- Prevention and early intervention are the most cost-effective techniques of weed management.
- Weed management requires a continuous, long-term commitment that must be prioritised.
- Integrated weed management is the key to achieving successful weed management.
- Combating weeds is a shared responsibility that requires clear understanding of roles and responsibility.
- Co-operation amongst government, land and water managers, industry and community is fundamental for effective weed management
- Successful weed management requires co-ordination of all stakeholders to establish and share legislative frameworks, research, funding and educational outcomes.

As weeds are not bound by land tenure, jurisdictional, legal or legislation boundaries, weed management is a shared responsibility between individuals and landholder/ land user organisations.

Local government's role and responsibility for weed management is the provision of information, education, support and coordination of community groups in addressing weed issues, and the implementation of weed controls within managed areas.

However, the actions of the Shire alone will not be the solution to weed management within the Shire of Broome, a collective approach is necessary for the effective long-term control of target species.



INTRODUCTION



The weed infestations evident within the townsite of Broome indicate that immediate action is required. This strategy focuses predominantly on the Broome townsite, but the key principles are relevant to the Shire as a whole. Certain areas have been identified of increasing concern to the Shire, therefore requiring particular attention for the successful management of weeds.

Areas of increasing concern within the Shire of Broome include:

- Remnant Bushland
- Road Reserves outside of townsite boundaries
- Vacant Crown Land
- Stormwater Drainage Systems
- Private Land that supports significant weed populations

The Weed Management Strategy is designed to provide the framework for the Weed Management Action Plan. The Action Plan will outline and specify actions and resources required for successful weed management within the Shire.

SHIRE OF BROOME

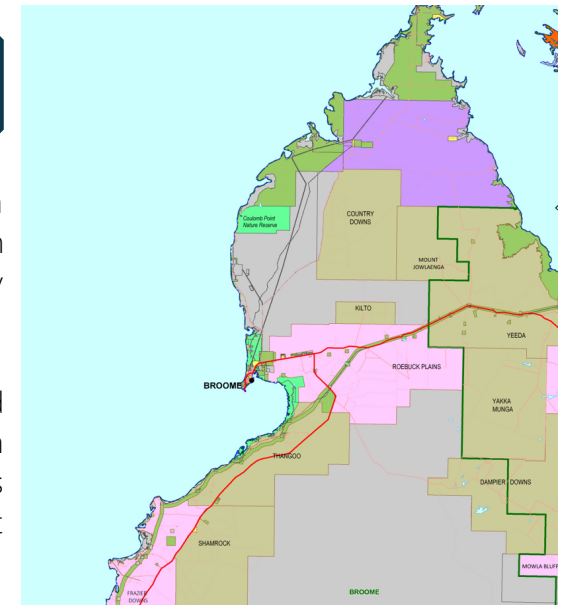
The town of Broome is positioned at the south-west extremity of the Dampier Peninsula, in a transition zone between the inland desert and tropics. Broome has a tropical climate with a distinct “wet” season from November to March, which experiences summer monsoon and tropical cyclones providing heavy rainfall and high humidity.

The “dry” season is from April to October and is typically without rain, lower humidity, cooler nights, and some foggy days. This mix of climatic factors as well as early multicultural development has resulted in an array of exotic tropic plants being introduced for shade, food, and ornamental values. Such species originating in tropics around the world are often devoid of natural control mechanisms and are resilient survivors becoming weeds.

Spatially, Broome’s Peninsula is surrounded and dissected by large areas of both environmentally and culturally significant endemic bushland, experiencing varied levels of urban disturbance. A vast area is foreshore reserve, while green corridors protrude through the town site and peninsula, joining ocean to bay.

The Broome townsite's urban fabric has a unique green infrastructure system that responds to its unique context. The open space includes a network of formalised and informal bush parks, often wide road reserves and a significant large urban drainage system.

The open trapezoidal shaped drains remove the high volumes of overland wet season rainfall to the surrounding bushland reserves, foreshore dunes, tidal creek, and the marine habitats beyond. The urban drainage system provides a significant challenge for weed management as it creates an extensive weed distribution network.



**KIMBERLEY REGION
LAND TENURE**



Figure 1. Land tenure mapping within the Shire of Broome.

STRATEGY BOUNDARIES

This strategy involves all Shire vested land within the boundary shown in *Figure 1*. Weed issues traverse all administrative and land tenure boundaries and as such, effective weed management will require a high degree of coordination and integration between stakeholders.

Increasing public awareness of the causes and appropriate responses to the problems is part of the solution. It is important to identify stakeholder groups and effectively engage with them to optimise responses to weeds across the prevention, eradication, and control spectrums of the strategy.

The success of environmental weed management should be measured by:

- Mapping and monitoring of weed infestations, including emerging invasions and established populations
- Number of weed species present not increasing but being maintained or decreasing.
- New weed species being identified and eliminated quickly
- Number of weed infestations; new infestations are prevented, emerging weed infestations identified and controlled quickly, the reduction in weed density and weed spread; number of species and affected area
- The protection of and active threat abatement for priority environmental and cultural areas
- The degree of community and stakeholder engagement and participation in the process of preventing and controlling weeds.

LEGISLATION & POLICY **FEDERAL**

This section of the strategy outlines various acts and policies from a federal to state level that influence the management of weeds in Broome. **Appendix 1** provides a condensed version of the Context for the hierarchy of roles and responsibilities of weed management from a national to local level.

Environment Protection & Biodiversity Conservation Act (1999)

The Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act) is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places as matters of national environmental significance.

A protected matters search identifies that the following terrestrial areas, flora, fauna and ecosystems are protected under the Act, occurring within the Broome shire area:

- The West Kimberley National Heritage-listed area (Cultural, geological, historical values, ecological values including biological richness) Roebuck Bay, Wetlands of international importance) (Ramsar)
- Nationally important wetlands: Roebuck Bay and Willie Creek wetlands
- Endangered ecosystem: Monsoon vine thickets on the coastal sand dunes of the Dampier Peninsula
- Weeds are identified as a key threat to this ecosystem, particularly as many occurring in the region are highly invasive, smother plants and promote hazard changes to the fire regime. High threat weeds occurring in Broome and noted in the conservation advice as threats include coffee bush (*Leucaena leucocephala*), neem tree (*Azadirachta indica*), siratro (*Macroptilium atropurpureum*), hairy morning glory (*Distimake dissectus*), passionfruit vine (*Passiflora foetida*), buffel grass (*Cenchrus ciliaris*), and mint bush (*Mesosphaerum suaveolens*)
- Critically endangered plant; Fringed fire bush (*Seringia exastia*)

LEGISLATION & POLICY **FEDERAL**

Weeds of National Significance (WoNS)

The Weeds of National Significance (WoNS) is a Federal system to prioritise weed problems for national action as developed in 1999 by a joint Commonwealth Government taskforce. It is regulated by the Biodiversity and Agriculture Management Act 2007. Thirty-two Weeds of National Significance (WoNS) have been agreed by Australian governments based on an assessment process that prioritised these weeds based on their invasiveness, potential for spread and environmental, social, and economic impacts. Consideration was also given to their ability to be successfully managed. The current list of WoNS can be found in **Appendix 2**.

National Environmental Alert List

The National Environmental Alert List for environmental weeds identifies 28 plant species that are in the early stages of establishment and have the potential to become a significant threat to biodiversity if they are not managed.



LEGISLATION & POLICY STATE

Biodiversity Conservation Act (2016)

This Act provides for the statutory listing of Threatened Ecological Communities (TECs). It provides statutory processes for preparing TEC recovery plans, registering critical habitat and penalties for disturbance.

Ecosystems are listed as a Priority Ecological Community (PEC) when there is insufficient information to determine it as a TEC, i.e., not all criteria for a TEC are able to be confirmed due to insufficient documentation OR where the ecosystem is identified as rare but not currently threatened.

The following TEC is known in the Broome Shire

- Monsoon (vine) thickets on coastal sand dunes of Dampier Peninsula, which is also listed under the EPBC Act (1999) with weed threats described as above.

The following PECs are identified in Broome Shire are:

- Dwarf pindan heath community of Broome coast
- *Corymbia paractia* dominated community on dunes
- Relict dune system dominated by extensive stands of *Minyjuru* (*Mangarr* - *Sersalisia sericea*)

Biosecurity and Agriculture Management Act (2007)

The Western Australian Organisms List (WAOL) provides the legal status and control categories of weeds (and other organisms) under the BAM Act (2007).

See: www.legislation.wa.gov.au/legislation/statutes.nsf/law_a146629.html

LEGISLATION & POLICY LOCAL



Kimberley Region Priority Alert Weed List

The Department of Biodiversity Conservation and Attractions (DBCA), has undertaken a species-led prioritisation process to assess the weeds of each region based on ecological impact, invasiveness, current distribution, potential distribution and feasibility and control.

In the Kimberley 13 species were identified as priority alerts of which none are known to occur in Broome.

Local Government

The Shire's Weed Brochure has been developed to educate residents and contractors in Broome of significant weed species.

See: www.broome.wa.gov.au/Community/Parks-and-Gardens/Weed-Control

Other useful weed information can be found through

- Environs Kimberley - weed cards and other identification tools
- Society for Kimberley Indigenous Plants and Animals, and Roebuck Bay Working Group - garden guides to encourage the use of native plants and reduce the opportunity for weed introduction and spread.

ROLES AND RESPONSIBILITIES IN WEED MANAGEMENT

Weed management is a shared responsibility, involving individuals, and all levels of government organisations. The coordination and involvement of all stakeholders, landholders, and community members in the Shire of Broome towards the collective approach of weed management is necessary for the effective long-term control of target species. Clear understanding of the roles and responsibilities of different stakeholders in environmental weed management and control is provided below.



IMPACTS OF ENVIRONMENTAL WEEDS

What are Environmental Weeds?

Environmental weeds are highly invasive and create competition with native plants for light, water, space, moisture, and nutrients. A plant's status as a weed is dependent upon its location and the land use of that place, for example native plants may be weeds in farm and forage lands. Similarly, non-native plants may become useful in the control of erosion, provision of habitat and shade where a native equivalent cannot be identified.

Invasive characteristics of environmental weeds include:

- Abundant seed production
- Rapid population establishment
- Seed dormancy
- Long term survival of buried seed
- Adaptation for spread
- Presence of vegetative reproductive structures
- The ability to release self-protecting toxins that interfere with the growth of surrounding plants
- Ability to occupy sites disturbed by human activities.

Beneficial characteristics of environmental weeds include:

- Soil stabilisation
- Habitat and resources for wildlife
- Aesthetic qualities
- Added organic matter for soils
- Nectar for insects and bird species
- Food resource for agricultural livestock



IMPACTS OF ENVIRONMENTAL WEEDS

Like most plants, weeds can be divided into Annuals and Perennials. Knowing a plant's lifecycle is important in aiding identification and deciding the best forms of control required. Annuals and Perennials can be described as:

Annuals: plants which flower, produce seeds and die in 1 year or less. Annual weeds are mostly opportunists that germinate after the first rains when the soil is at least partially bare through seasonal conditions following, mowing, cultivation, burning or other site disturbances.

Control - should aim to prevent further seeding. Roots are usually shallow, and plants easily hoed, hand pulled or controlled with herbicide.

Perennials live for 3 years or more and may be herbaceous or woody species. Plants have rhizomes, corms, lignotubers, deep roots, or similar structures so can regrow year after year. Most also reproduce through seed.

Control - is difficult due to their underground vegetative structures. Most roots grow as deep as 45cm below ground sometimes as deep as 3-4 meters. Control aims to deplete root reserves so that no new shoots can develop. Those with shallow roots and not prone to sucker can be dug out. Systemic herbicide application may be required for control of deep roots, bulbs, and other underground structures.

Even if not currently present within the Shire they are still relevant to the strategy as they are legislated and under regulation, therefore the Shire should be alert for prompt identification. The categories of environmental weeds include the following:

Target Weeds (Weeds not yet in Australia): is a list of 41 species regarded as serious threats to Australia's productivity, export markets and the environment. It focusses on the potential for weeds to enter Australia from South-East Asian countries through natural or non-conventional pathways including wind currents, migratory animals, traditional vessel movements and illegal fishing activity.

Emerging or Sleeper Weeds(Weeds already in Australia): these are plant species in the early stages of establishment with the potential to become a significant threat to Australian Biodiversity. Sleeper weeds are plants that have not yet increased in their distribution significantly and could be controlled before numbers explode. None of the species identified on the National Environmental Alert List are found in the Shire of Broome.

IMPACTS OF ENVIRONMENTAL WEEDS

Noxious Weeds (Mostly agricultural/horticultural crop weeds): A noxious weed is a plant that has been legally declared under State/Territory legislation. These weeds have a negative impact on crop or animal production and are variously referred to as noxious or declared weeds. Some plants may be noxious in one State or Shire but not in another.

Western agricultural weeds are regulated under the Biosecurity and Agricultural Management Act (2007) and managed in the Kimberley by Department of Primary Industries and Regional Development (DPIRD).

Weeds of National Significance (WoNS): is a list of Australia's worst weeds which have been legally declared by the Federal government with restrictions on their propagation, trade or sale applying to all.

The Australian State and Territory Government have listed thirty-two weeds of National Significance (WoNS), based on weed species impacts, potential to spread, invasiveness, socio-economic and environmental value. **Appendix 2** identifies all species.



IMPACTS OF ENVIRONMENTAL WEEDS

Weeds on National Environmental Alert List: The National Environmental Alert List identifies 28 plant species that are in the early stages of establishment and have the potential to become a significant threat to biodiversity if they are not managed. The Praxelis, *Praxelis clematidea* is found in Broome.

Kimberley Region Priority Alert Weeds: Department of Biodiversity Conservation and Attractions, Parks and Wildlife, has undertaken a species-led prioritisation process to assess the weeds of each region based on ecological impact, invasiveness, current distribution, potential distribution and feasibility and control. This process identified 13 priority weed species for the Kimberley Region, none of which are found within the Shire of Broome.

If any of the Priority Alert Weed Species are identified, please notify the local Department Biodiversity Conservation and Attractions Office on (08) 9195 550



IMPACTS OF ENVIRONMENTAL WEEDS

Shire of Broome - Environmental Priority Weed Species:

Environmental weeds identified as significant within the Shire, are those that are rising in population and prevalent throughout the Shire's open space areas.

Weeds of concern and on the Shire's watch or alert list for their invasiveness, ecological impact, and health risks are listed in **Appendix 2**.



WEED SPECIES INTRODUCTION AND ESTABLISHMENT

Environmental weeds can be introduced and established through various pathways and have different characteristics for spread. Establishment of invasive species within a new area is dependent on the intrinsic characteristics of the weed species and the vulnerability or resilience of the community being invaded. The resilience or vulnerability of a location is determined by factors such as characteristics, dynamics, and history of the area. The biggest cause of weed introduction and spread is human activities and disturbance, the other cause of weed introduction is natural means.

Pathways for introduction and establishment of weed species in the Shire include:

- Transport corridors such as stormwater drain systems during and after rain.
- Accidental through tourism – camping, parking on the side of the road, rest areas and 4-wheel drive tourism.
- Vehicle transport – utility, service, construction, or civil contractors travelling between sites and transporting seed or fragments.
- Feral animals or native wildlife – seeds attached to fur or in faeces, fruit-eating birds and bats.
- Land use and development – construction and maintenance such as grading, land clearing, slashing, mowing, and vehicle/machinery movement.
- Fragmentation (Stem or root) – clearing areas, not fully removing stems and roots, and not properly disposing of weed material.
- Disturbing native vegetation – land clearing, use of vehicles or machinery in bushland and introducing mulch or foreign soil into the area.
- Dumping of garden waste – introduction of garden escapees and spread of common weeds into natural areas.
- Pastoral holdings – cattle, hay and contractors introducing weeds seeds.
- Production of new rhizomes, tubers, and other vegetative reproductive structures by perennial weeds.
- Wind-borne spores or light weight seeds – weeds can be spread over great distances.
- Post fire opportunities – over burning and hot fires can impact revegetation, create bare earth, and stimulate weed seed germination.
- Water distribution – corky, flattened or light weight seeds are transported through water systems and can establish in watercourse banks, coastal areas, and bottom of floodways.

WEED SPECIES INTRODUCTION AND ESTABLISHMENT

Once a weed species has established within an area they can create a seedbank of dormant weed seeds. Seed bank lifecycle is demonstrated in *Figure 2* below. Seeds are triggered to germinate through disturbance by fire, machinery/vehicles, water flow and moisture presence. Germination can be suppressed using a chemical pre-emergent, mechanical scraping/removal, forced germination and chemical control, hot fires, and smothering with mulch.

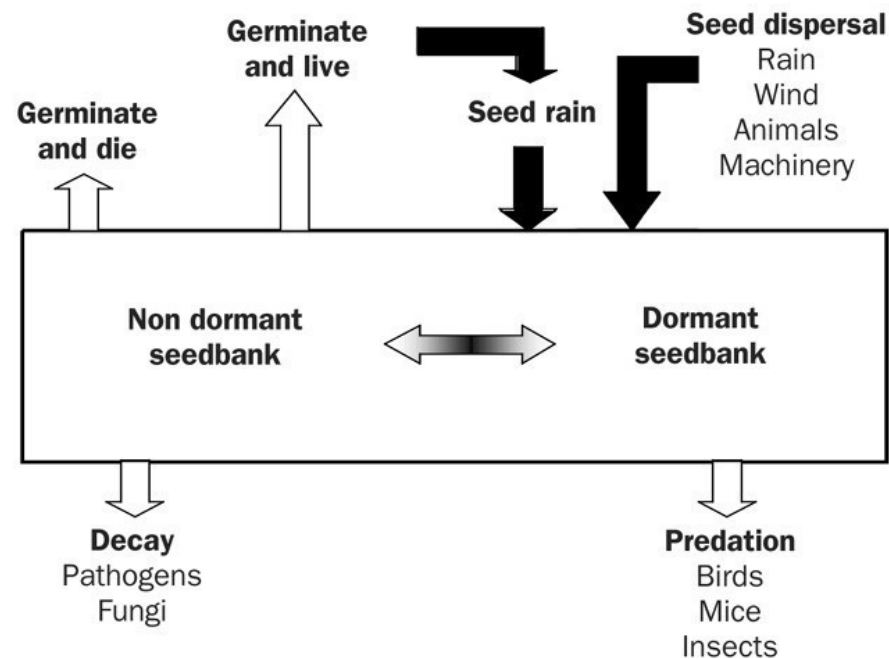


Figure 2. Weed seed bank lifecycle – with input to the seed bank depicted with black arrows and losses of seed to the seed bank with white arrows.

IMPORTANCE OF WEED MANAGEMENT

Weeds are one of the most significant and costly threats to Australia's natural environment and biodiversity. With Australian wide Commonwealth, State and Local Governments spending millions each year on costs for weed monitoring, control, management, and research. Environmental weeds also impact on tourist amenity, agricultural production, public and private infrastructure, as well as economic and social impacts.

As visible through *Figure 3* the greater the weed infestation based on area occupation, the greater the economic impact. It is evident that there are various ways weed species can be introduced or established and due to the invasive nature of weeds; prevention of spread through pathways is a necessary and cost-effective approach to weed management.

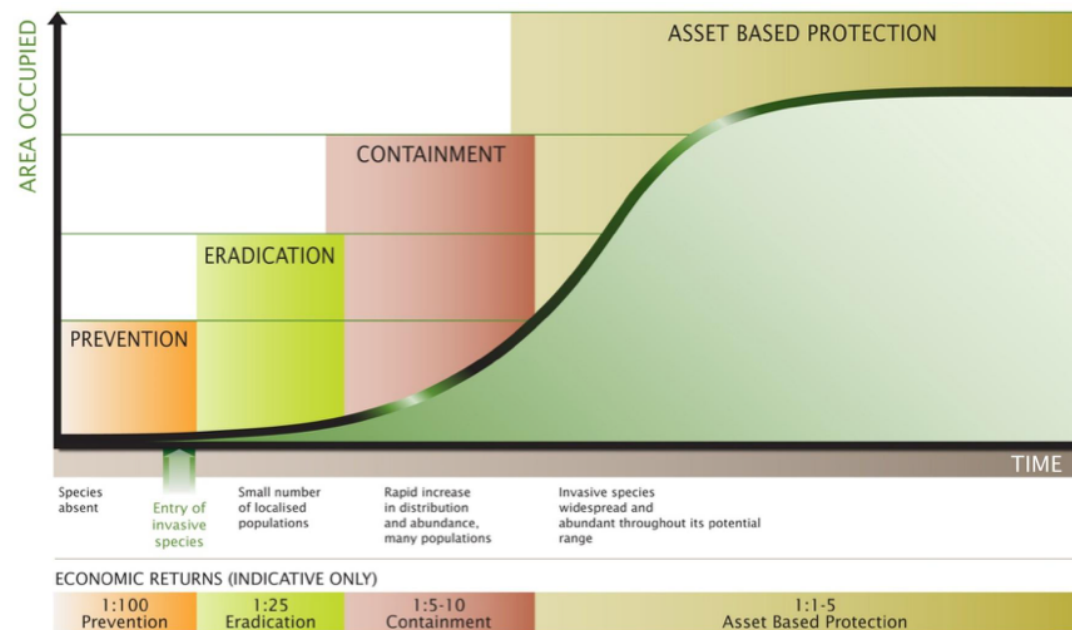


Figure 3. The generalised invasion curve – with the four stages of weed management: prevention, eradication, containment, and asset-based protection (Bailey, 2019).

IMPORTANCE OF WEED MANAGEMENT

In weed management there is an action threshold, which are set levels a weed population must reach before control can begin. These are driven by economic, seasonality and legislative factors. From an economic perspective the action threshold is when the weed density is at a point which some control should be exerted to prevent a weed population from increasing further causing economic loss.

The action threshold for seasonal weeds is based on the time of year and the corresponding temperatures, these aid in predicting the emergence of the first generation of an adult weed. With legislative action the threshold for control is whether the weed is declared therefore by law must be controlled. Action thresholds are important as it assists in resource allocation.

When controlling weeds, timing is a key factor to effectively prevent and manage weed populations establishing. From the weed lifecycle standpoint: control prior to fruiting or seeding and/or control prior to spread pathways – tourism season and wet season. From a weather standpoint: it is important to control weeds whilst the plant is actively growing and prior to it setting seed. It is important to consider weather when choosing your control – use of chemicals in fine weather, conducting prescribed burns in the cooler months, and spraying chemicals on calm days.



IMPORTANCE OF WEED MANAGEMENT

Potential impacts from the introduction and spread of environmental weeds within our public open spaces/reserves:

- Reducing the viability, health and biodiversity of native flora species by competing vigorously for space, water and nutrients.
- Causing human health problems causing asthma, skin irritation, other respiratory issues, and poisoning.
- Water contamination affecting the quality of waters when infestations become prominent in wetlands.
- Social impacts on communities through degradation of parks, verges and public access ways which are impacted by lowering the amenity, functionality and aesthetic appeal.
- Alteration of fire regimes through additional fuel loads through the abundant nature of weeds and ability to spread extensively within a landscape.
- Altering soil nutrients by either removing nutrients from soils impacting intentionally planted flora or nitrogen fixing which can impact on native plant species. Some weeds release self-protecting toxins that interfere with the growth of surrounding plants
- Introduction of pests and diseases from different regions that native species or intentionally planted flora may not have been in contact with.
- Alteration of geomorphological processes with weeds causing increased erosion. When annual weeds die off after outcompeting an ecosystem, leaving the soil exposed and susceptible to being washed away from rains or wind.
- Cultural heritage impacts include alterations of cultural heritage or sacred sites and lowering the availability of bush tucker and native medicines available to indigenous communities.

ENVIRONMENTAL WEED PRESENCE IN SHIRE OF BROOME

Weed Distribution

Monitoring weed distribution is important when attempting to control weeds. Monitoring should be ongoing and must be a collaborative effort between the Shire, industry groups, landholders, community groups and our National Resource Management body

Key observations relating to the distribution of weeds in Broome and surrounds:

- Weeds have been mapped more often along (fence lines, road verges, informal vehicle, and human tracks). More mapping needs to be undertaken to decide the extent of many species from these edge areas.
- Weeds readily invade and establish in disturbed sites (due to livestock, human disturbance, fire, construction, illegal rubbish dumping)
- Weeds establish more easily in wet areas (swales, drains, monsoon vine thicket, back of dunes, near sewer treatment plant)
- Garden escapees contribute to the spread of weeds, including the introduction of new weeds.
- Weeds promote hotter fires which in turn promote the establishment of more weeds.
- Distribution is aided by humans and vehicles, animals which eat seeds or have them become stuck in their fur, inflow from the stormwater drainage system

ENVIRONMENTAL WEED PRESENCE IN SHIRE OF BROOME

Weed Management Prioritisation

Weed prioritisation is assessed and broken down within the Shire of Broome's different managed land categories including stormwater drainage systems, parks and gardens, road reserves and natural bushlands. Current and potential weed distribution, ecological impact, and level of invasiveness (at a landscape and site scale) are important factors in prioritising weed management.

To ensure weeds are managed on a priority basis resources should be allocated based on the following three considerations:

- Priority weeds
- Priority landscape areas
- Priority pathways of spread



ENVIRONMENTAL WEED PRESENCE IN SHIRE OF BROOME

Alert Weeds

For the context of the weed management strategy the Shire defines 'alert' weeds as a species that:

- Not yet naturalised in the shire area
- Has the potential to have a high level of impact if it became established
- Has a reasonable likelihood to arrive in the shire area

The 'weed risk ratings' are based on the following criteria:

- **Invasiveness:** Ability to invade bushland in good or excellent condition or ability to invade waterways.
- **Distribution:** Wide current or potential distribution including consideration of known history of widespread distribution elsewhere in the world.
- **Environmental Impacts:** Ability to change the structure, composition, and function of ecosystems. Particularly the ability to form a monoculture in a vegetation community.

Priority Landscape areas

Landscape areas that require priority management attention within the Shire of Broome are determined using one or more of the following criteria:

- Low incursions of weeds
- Sites of significance for biodiversity conservation
- Significant commercial values
- Very high visitation areas
- Significant cultural and heritage values
- Susceptibility to invasion
- Weed source areas including top of streams and up wind areas
- High value assets

Consideration should be given to several other factors such as the weed species present within the natural area, the characteristics of individual sites such as soil type, proximity to water courses, quality of native vegetation and presence of sensitive species (ecological ranking).

ENVIRONMENTAL WEED PRESENCE IN SHIRE OF BROOME

Priority Pathways for Spread

The main pathways of spread for weeds within the Shire have been identified within *Figure 4*.

Considerations include:

- Physical characteristics of weeds that are likely to be transported by human or natural means
- Which weeds are most likely to be transported into or within the Shire of Broome
- Human activities most likely to spread weeds
- Presence of a physical corridor assisting weed spread



Cause	Pathway of Spread	Example mechanisms of spread along priority pathways
Physical processes	Stormwater drainage systems	Water, wind
	Tidal movement	
Native or feral animals	Native bushland	Feral or native animal movement
	Natural corridors Watercourses	
Land use and development	Pastoral holdings	Cattle, hay, and contractors
	Roads	Construction and maintenance such as grading, slashing, livestock and fodder hauling, high traffic, rest areas and tourism
	Water pipeline	Maintenance activities
	Contractors	Maintenance activities and vehicle machinery movement
Tourism	Accidental	Camping, 4WD tourism, use of rest areas
Use by industry	Nursery industry	Deliberate planting, garden escapees, pastoral escapees, vehicle, and machinery movement
	Garden plants	
	Horticulture	
	Agriculture	

Figure 4: Priority Pathways of Spread within the Shire

WEED CONTROL

This section outlines the common methods used in the control of weeds. There are many aspects that need to be considered when determining the relevant weed control method or combination of methods to implement in parks, urban landscaping areas, natural bushland, and drainage systems. The correct selection and implementation of a control method will ensure that weed infestations are dealt with in a timely manner and minimise the environmental costs to the impacted site or surrounding areas.

Weed control methods used to reduce weed infestations to manageable levels or eradication includes:

- **Physical Weed Control:** the removal of weeds through manual or mechanical processes including slashing, mowing, mulching, tilling or by hand.
- **Chemical Weed Control:** the use of selective, non-selective and pre-emergent herbicides to affect the growth, development and germination of weeds which may result in death of the plant.
- **Thermal Weed Control:** the utilisation of burning with fire as a tool and the application of hot water or steam to cause death of the weed.
- **Biological Weed Control:** the introduction of pest, pathogens, or viruses to reduce weed spread and growth.
- **Land Management Control:** indirect control through good land management practices including hygiene protocols, fire management, quarantine protocols, feral animal controls and prevention of overgrazing.

An important recognition is that whilst the initial implementation of the above methods is an important control, it is ineffective unless follow up controls are programmed. For long term effectiveness of the control, weeds that are removed or reduced, should be replaced with desirable plants such as native species through natural recolonisation of an area or intentional planting to ensure there is less space for re-infestation. Monitoring and follow up control methods can aid in early identification of re-infestation and weeds can be addressed promptly, preserving the area.

A comprehensive list of weed control is outlined in **Appendix 3**.

INTERGRATED WEED MANAGEMENT APPROACH

Integrated weed management (IWM) is a long-term approach, using a combination of different management and control techniques to monitor, prevent and control weeds. The most effective weed management involves the implementation of an integrated approach, as a single control measure will not be effective over the long term. Using a variety of control methods, rather than just one, also ensures weeds are less able to adapt to a single control method. Integrated Weed Management addresses the underlying causes of weed infestations, rather than just focusing on controlling visible weed presence.

This is achieved through targeting the various stages of the weeds lifecycle and undertaking measures that will prevent weed reproduction, reduce weed emergence, promote seed bank depletion, and minimise weed competition with desirable vegetation. Weed management program development can be informed through the interpretation of individual sites, the native plant communities, distribution of weed species and patterns of disturbance.

An integrated approach within the Shire would include:

- Weed Monitoring: mapping, photo monitoring and observational monitoring.
- Weed Prevention: minimising access and disturbance, and hygiene protocols.
- Weed Control: physical, chemical and land management.

INTERGRATED WEED MANAGEMENT APPROACH

Weed Mapping

Weed mapping can be a useful tool in identifying the extent of the weed infestation, identify patterns in distribution and pathways of spread, assist in control and management planning, allocation of resources and effectiveness of control actions (Bailey, 2019). Weed mapping can also assist in defining control cells within priority reserves. Mapping is done in conjunction with monitoring, as weed monitoring provides the data and information required for mapping. Parameters of mapping need to be established whether it be priority species, certain percentage cover or established highly invasive species the use of continuous mapping can determine how successful a control in an area is going and can alert us of outbreaks or when the objective has been reached.

Current Management

Weed mapping has begun in the Shire with the data being collected regularly through observational monitoring and infestation identifications. The weed mapping will assist in informing on ground weed management programs and follow up protocols.

Previous mapping has been conducted by the Environs Kimberley around the Broome townsite, evident from *Figure 5*.

Department of Primary Industries and Regional Development have developed a reporting app "My Pest Guide Reporter" which aids in identification of new or established weed infestations and in the active mapping of an area.



Figure 5 - Environs Kimberley weed map (2013))

INTERGRATED WEED MANAGEMENT APPROACH

Weed Reporting

Weed reporting can be a valuable tool for gaining or confirming identification, sharing knowledge of infestations and ensuring weed management from the responsible stakeholder can occur. Reporting can be done locally - for area specific target weed infestations, regionally – for established weed threats, and nationally – for new incursion threats.

Current Management

Weed reporting is only currently conducted internally. Only weed infestations of a large scale are reported that need substantial control methods, smaller weed populations are dealt with by staff either through physical or chemical controls.

Observational Monitoring

Observational monitoring is a form of surveying and can be conducted through use of permanent transects or quadrats. This type of monitoring tracks new weeds and monitors the effectiveness of weed control programs. Transect surveying involves walking along a fixed pathway or single line whilst recording occurrences of the weed species, this method is applicable to storm water drainage systems.

Quadrat surveying involves random sampling of one square metre of habitat and recording the distribution of weed plant species within the quadrat.

INTERGRATED WEED MANAGEMENT APPROACH

Weed Prevention and Control

Preventing the introduction and spread is one of the key objectives of the weed management strategy, as control methods can be both costly and labour intensive. Weeds can be introduced to an area through transportation by both natural and human sourced mechanisms.

Transport pathways for weed spread and introduction were detailed previously. Through the identification of these pathways, a focused effort on specific methods of weed prevention can be implemented.

Weed prevention management processes can include:

- Minimising access and disturbance
- Weed hygiene protocols
- Drainage system rehabilitation
- Fire management and response
- Education

Community Education

Community education and training for contractors and practitioners in contact with weed infestations is integral to slowing the spread of weeds. Raising awareness, knowledge, motivations, and behaviour will assist in the prevention of weed spread and encourage participation in environmental activities.

INTERGRATED WEED MANAGEMENT APPROACH

The community can prevent weed introductions and spread by:

- Correct disposal of green waste - not dumping garden waste into natural bushland areas, stormwater drain systems and roadsides.
- Minimising access and disturbance to natural areas or weed infestation sites – staying on tracks, not taking vehicles or recreational equipment into undisturbed areas, and not allowing dogs to run off-leash in natural areas.
- Undertaking appropriate hygiene practices when entering and leaving parks, natural bushlands, or stormwater drainage systems. This includes cleaning footwear, removing any seed from clothing, pet fur and recreational equipment such as bike tyres.
- Joining a community group to participate in planting and maintaining some of the stormwater drain systems and other areas.

As it is an offence to deposit litter on land or water, if you see anybody illegally dumping green waste - please contact the Shire via (08) 9191 3456 or shire@broome.wa.gov.au.

Current Management

The current approach to community education regarding weed management by the Shire of Broome includes education through the “Weeds of Broome” brochure and the “Weed Control” page on the Shire website.

There is existing local educational material offered by external sources including the “Kimberley Weeds” index cards, Roebuck Bay Working Group’s “Coastal Gardens: a planting guide for Broome on the Dampier Peninsula” booklet and Department of Primary Industry and Regional Development website and “Weeds to Watch” poster. Further educational information can be found on the Department of Biodiversity Conservation and Attractions “Weed” page on their website.. Weeds Australia provides identification and distribution information on weeds.org.au.

Training

Ongoing training is essential for the continued development of staff knowledge and expertise. Training in weed identification from germination to seeding, understanding of weed lifecycles and appropriate control methods for target species and hygiene protocols for use of machinery and equipment is vital for all staff working in the Broome habitat.

IMPLEMENTATION

An Action plan is being developed to support the Broome Weed Strategy and provide a framework of actions for effective, efficient and sustainable management of weeds within the Shire.





Appendix 1 -

Context for the hierarchy of roles and responsibilities of weed management from a national to local level.



Appendix 1 - Cont.

Context for the hierarchy of roles and responsibilities of weed management from a national to local level.



Appendix 2- Weed Identification & Priority Listing

	WA Declared Class	Shire Priority Weeds for Eradication	Shire Watch/ Alert List	Declaired/ Noxious Weeds	Weeds of National (WoNS) Significance	Weeds of National Significance (WoNS) - Watch List	Priority
Bellyache Bush, <i>Jatropha gossypifolia</i>	Declared S22(2) (C3 Management)	Y		Y	Y		High
Buffel Grass, <i>Cenchrus ciliaris</i>	Permitted S11	Y					High
Caltrop, <i>Tribulus occidentalis</i>	Permitted S11	Y					High
Candle Bush, <i>Senna alata</i>			Y	Y			High
Chinese Apple, <i>Zizyphus mauritiana</i>				Y			High
Coffee Bush, <i>Leucaena leucocephala</i>	Permitted S11	Y					High
Gallon's Curse, <i>Cenchrus biflorus</i>	Permitted S11	Y					High
Hairy Merremia, <i>Distimake aegyptius</i> (previously <i>Merremia aegyptia</i>)		Y					High
Khaki Weed, <i>Alternanthera pungens</i>	Permitted S11	Y					High
Mint Bush, <i>Mesosphaerum suaveolens</i> (previously <i>Hyptis suaveolens</i>)	Permitted S11	Y					High
Neem Tree, <i>Azadirachta indica</i>		Y		Y			High
Praxelis, <i>Praxelis clematidea</i>	Declared S12 Prohibited (C1 Exclusion)		Y	Y	Y		High
Rubber Bush, <i>Calotropis procera</i>		Y		Y			High
Rubber Vine, <i>Cryptostegia grandiflora</i>	Declared S12 Prohibited (C2 Eradication)			Y		Y	High
Siratro, <i>Macroptilium atropurpureum</i>	Permitted S11	Y					High
Snake Vine/White Creeper, <i>Distimake dissectus</i> (previously <i>Merremia dissecta</i>)		Y					High
Water Lettuce, <i>Pistia stratiotes</i>				Y			High
Wild Passionfruit, <i>Passiflora foetida</i>	Permitted S11	Y					High

Appendix 2- Weed Identification & Priority Listing

	WA Declared Class	Shire Priority Weeds for Eradication	Shire Watch/ Alert List	Declaired/ Noxious Weeds	Weeds of National (WoNS) Significance	Weeds of National Significance (WoNS) - Watch List	Priority
Athel Pine, <i>Tamarix aphylla</i>					Y		Medium
Coffee Senna, <i>Senna occidentalis</i>			Y				Medium
Coral Vine, <i>Antigonon leptopus</i>	Permitted S11		Y				Medium
Indian Devil Tree/Cheesewood, <i>Alstonia scholaris</i>	Permitted S11		Y				Medium
Ivy Gourd, <i>Coccinia grandis</i>	Declared S22(2) (C3 Management)		Y				Medium
Kapok Bush, <i>Aerva javanica</i>	Permitted S11		Y				Medium
Lantana, <i>Lantana camara</i>					Y		Medium
Madagascar Rubbervine, <i>Cryptostegia madagascariensis</i>	Declared S22(2)		Y				Medium
Mossman River Grass, <i>Cenchrus echinatus</i>	Permitted S11		Y				Medium
Parkinsonia, <i>Parkinsonia aculeata</i>					Y		Medium
Taylor Fruit, <i>Ziziphus mauritiana</i>	Declared S22(2) (C3 Management)		Y				Medium
Tiger Paw, <i>Ipomoea pes-tigridis</i>	Permitted S11		Y				Medium
Birdwood Grass, <i>Cenchrus setiger</i>	Permitted S11		Y				Low
Butterfly Pea, <i>Clitoria ternatea</i>	Permitted S11		Y				Low
Cabomba, <i>Cabomba caroliniana</i>	Declared S12 Prohibited (C2 Eradication)					Y	Low
Cats Claw Vine, <i>Dolichandra unguis-cati</i>					Y		Low
Gamba Grass, <i>Andropogon gayanus</i>	Declared S12 Prohibited (C2 Eradication)					Y	Low
Hymenachne, <i>Hymenachne amplexiaulis</i>	Declared S12 Prohibited (C1 Exclusion)					Y	Low

Appendix 2- Weed Identification & Priority Listing

	WA Declared Class	Shire Priority Weeds for Eradication	Shire Watch/ Alert List	Declared/ Noxious Weeds	Weeds of National (WoNS) Significance	Weeds of National Significance (WoNS) - Watch List	Priority
Leaf Cactus, <i>Pereskia aculeata</i>	Permitted S11					Y	Low
Madeira Vine, <i>Anredera cordifolia</i>	Permitted S11					Y	Low
Mesquite, <i>Prosopis spp.</i>						Y	Low
Mimosa, <i>Mimosa pigra</i>	Declared S12 Prohibited (C2 Eradication)					Y	Low
Parthenium, <i>Parthenium hysterophorus</i>	Declared S12 Prohibited (C1 Exclusion)					Y	Low
Pond Apple, <i>Annona glabra</i>	Declared S12 Prohibited (C1 Exclusion)					Y	Low
Prickly Pear, <i>Opuntia spp</i>	Declared S12 Prohibited (C2 Eradication)				Y		Low
Salvinia, <i>Salvinia molesta</i>	Declared S12 Prohibited (C2 Eradication)					Y	Low
Water Hyacinth, <i>Eichhornia crassipes</i>	Declared S12 Prohibited (C2 Eradication)					Y	Low

Appendix 3- Weed Control Methods

Physical Weed Control

Manual or physical control involves the physical removal of the weed by human or mechanical effort. Although, physical control is the most appropriate weed control in certain circumstances, it is also the most expensive, as it is the most time consuming and labour-intensive process. Physical control allows for selective removal of weeds and avoids the use of herbicides.

This control method follows the three general principles:

- Work outwards from good bush areas toward areas of weed.
- Make minimal disturbance to the environment.
- Let native plant regeneration dictate rate of weed removal.

This method, however, would not be recommended for species that reproduce by rhizomes, tubers, corms, or areas where soil disturbance would have implications. Gross soil disturbance can lead to weed replacement, which is why revegetation actions are recommended in conjunction with weed removal.

The method also needs adjusting for drainage weeding, where it is recommended to commence where water enters a drain.

Hand removal is commonly prescribed for the control of individual plants, small populations, ecologically sensitive areas, and species that are seeding or flowering. Care must be taken to remove all root matter to ensure regrowth does not occur from remaining roots. All removed weeds should be disposed of appropriately off site.

Mechanical Slashing is a favourable method for control of fast-growing annuals and is a standard control measure for grassweeds. This method can be used on a small scale to de-flower weeds and remove vegetative growth. Mechanical slashing is a relevant method for weeds that have not gone to seed – slashing whilst a weed is in seed will only further contribute to the spread of weed seeds. Mechanical control must be done in conjunction with the relevant hygiene protocols to ensure weed seed is not spread from weed sites to different areas.

Appendix 3- Weed Control Methods

Ploughing or Tilling turns over the soil and buries the weed beneath the soil. This provides a barrier to the sun, therefore killing the weeds. Tilling is a form of physical control that can be easily undertaken over a wide area, using agricultural machinery. Strategic tilling can lower the subsequent weed emergence; however, it can lead to damage in soil structure and exposes the soil to erosion and further invasion by weeds. This is not generally an urban application.

Mulching or smothering is the use of materials such as wood chips, newspaper, black plastic, or organic matter to cover disturbed soils, smothering of weeds or stopping the emergence of plants in the area. The suitability of smothering and mulching needs to be considered in natural areas as it can cause soil disturbance from machinery use preventing native seedling regeneration

Chemical Weed Control

Chemical weed control through use of herbicide application is often the most cost-effective and practical method of weed control in various situations. Herbicides are defined as a 'chemical substance used to destroy or inhibit the growth of plants, especially weeds.' Herbicides can be classified into three categories:

- pre-emergent (residual) – inhibit the germination of pest plants.
- non-selective – broad spectrum and work on wide variety of plants; and
- selective – working on a specific range of plants.

Herbicide application is an effective component in integrated weed management, having higher success rates than other forms of weed control. Herbicide application is carefully considered and should be used in conjunction with a variety of control methods. The best practice for herbicide application involves knowing the target weed, understanding the site conditions, choosing the correct herbicide, choosing the correct application method, ensuring operators are trained and ensuring all regulations and label instructions are followed. The correct percentages of low toxicity herbicides at key points, especially in the proximity of waterways and water catchment sites can have lesser of environmental impact and more success in the management of weeds than other control methods.

Appendix 3- Weed Control Methods

A multi- faceted selection of herbicides and application techniques is recommended. Some chemical weed control methods include:

Broad Acre Spraying is a primary level of control within open areas of little or no native vegetation. This can be undertaken by hand in small areas and by vehicle to cover larger areas. It involves spraying a weak herbicide solution over the foliage of weeds.

Spot Spraying is like broad acre spraying though targets weed infestations amongst germinant rehabilitation or revegetated areas. Care must be taken when spot spraying to avoid off-target spray affecting native vegetation. Careful attention to environmental conditions, particularly wind direction and speed, and strengths of chemical solutions must be taken when spot and broad acre spraying.

Wicker Wiping is a method used to minimise off target damage often caused by spraying of herbicide. This method involves wiping a herbicide-soaked rope or cloth implement against weed foliage. Whilst this is a more targeted treatment, it is also more labour intensive and should be prescribed for areas of highest specific usage only e.g. sport ovals and high amenity areas.

Cut Stump Control is a specific method used for treating large and woody weeds from sensitive bushland areas. Trees and shrubs have foliage cut and often trunks cut to the stump and a herbicide applied by spray or brush to the cut stumps and stems. Weeds can remain intact onsite without requiring further removal if preferred.

Stem Injection/Drill and Pill involves drilling or cutting through the bark into the sapwood tissue in the trunks of woody weeds and trees. Herbicide is immediately placed into the hole or cut, in liquid or pill form. The aim is to reach the sapwood layer just under the bark (the cambium growth layer), which will transport the chemical throughout the plant.

Basal Bark involves mixing an oil-soluble herbicide in diesel and spraying or painting the full circumference of the trunk or stem of the plant. This method is suitable for thin-barked woody weeds and undesirable trees. Basal bark spraying is also an effective way to treat saplings, regrowth and multi stemmed shrubs and trees. This method allows the herbicide to enter underground storage organs and slowly kill the targeted weed.

Appendix 3- Weed Control Methods

Thermal Weed Control

Burning Fire management can be utilised as a tool in weed control. Burning removes the above soil weed body and can be a good control method for wide areas and large infestations of grasses and woody weeds. Prescribed burns can be planned appropriately either before the weed is seeding or in dry soils for maximum intensity leading to destruction of seed bank stores. An integrated approach of herbicide spraying before burning, can assist by increasing the weeds flammability, broadening the burning opportunity. Follow up weed control is recommended after burning activity, as fire can result in vegetation cover loss, expose soil surface to erosion and reduce competition for resources, providing weed species with the opportunity to grow.

Fire is an important and necessary natural feature of the Australian environment and can have negative and positive impacts on weed management. The increased disturbance from hot fires and/or regular fires within a region is destructive and can kill native species leaving an area exposed. This provides opportunities for weed species to establish in these newly disturbed areas. Therefore, quick fire responses and fire prevention activities such as maintaining fire breaks and access ways, reducing fuel loads of nearby natural bushland, and reducing access and disturbance post fire will avoid introduction of weeds into the area.

The Shire operates an annual Bushfire Mitigation Program from May through to the end of December, designed to encourage residents to take action to help minimise the threat of bushfires. Through the participation of Shire of Broome residents within this program can help prevent the impacts of fire and as a by-product the impact of weeds within the shire.

The Shire works in collaboration with the Department of Fire and Emergency Services and local Broome Volunteer Bush Fire Brigade and the Volunteer Fire and Emergency Services, to conduct planned burns to reduce large weed infestations.

If you see fires within the Shire of Broome please call Triple zero (000). To report knowledge of suspicious fires or acts of arson to the police or ring crime stoppers on 1800 333000.

Hot Water involves the application of hot water under pressure on to a weed species, which can result in the breakdown of the plants cellular structure. Hot water application is most relevant to urban environments (eg. footpaths and kerbsides), where herbicide concerns are at highest proportion. This form of thermal control can be fast-acting and a safer alternative to herbicide use; however, has been found to be less effective than chemical controls, greater in cost, non-selective and is impractical for natural areas.

Appendix 3- Weed Control Methods

Biological Weed Control

Biological weed control is the management of weed populations through the introduction and use of natural parasites, predators, and viruses.

Biological control does not eliminate weeds, but aids in the reduction of target populations, lowering their impact. This can be an efficient form of weed management, particularly useful for widespread introduced species where manual control is uneconomical. Biological control can further be advantageous over other methods as it is cost-effective in the long term, reduces requirement for herbicide application and is generally an environmentally friendly option. However, not all weed species have identified biological controls and cannot be used in all circumstances. Limitations of biological controls are recognised within the Shire of Broome, as the seasonal and environmental conditions may impact the effectiveness of biological control agents.

Land Management Control

Land management control focuses on how the modification of land use practices can prevent the spread of weeds. Good land management practices are critical in reducing the incidence and impact of weeds. This control type is most relevant to Indigenous ranger groups, large tenure land managers, grazers, and station owners. The initial increased costs associated with improved land management are counteracted by the reduced weed control required.

Minimising access and disturbance to weed infestations or weed controlled sites will significantly reduce the spread of weeds. Human disturbance is a vector for weed spread, through seeds being attached to clothing, footwear, recreational equipment, machinery or tools and pets. Through preventing or controlling access to infested areas through fencing or blocking of illegal entrances site hygiene can be maintained. The use of external soils or mulch imported into natural bushland areas will only further disturb the area, introducing potential weed spread. The use of wide buffer zones between infestation sites and undisturbed adjoining areas or roadsides can also minimise the disturbance of areas.

Appendix 3- Weed Control Methods

Hygiene Protocol:

Weed hygiene is an important weed prevention tool to ensure weeds, pathogens and pests are not spread from or in parks and urban landscaping areas. Weed seeds and pathogens can be spread through materials such as soil, sand, gravel, and water, captured in footwear, lodged in machinery, vehicles, and other equipment. The appropriate cleaning of all transport mechanisms will reduce the spread of weed seeds between sites. Producing a biosecurity protocol to be used throughout the Shire of Broome by both staff members and independent contractors will be the best prevention method.

A biosecurity/hygiene protocol will target:

- Vehicles, machinery, and equipment
- Materials such as soil, gravel, or sand
- Clothing, boots, or recreational equipment such as bike tires.
- Best practice design and maintenance of all wash down and decontamination areas

Revegetation: Broome townsite has extensive open space areas, which experience heavy wet season monsoonal rains in combination with occasional cyclones and regular fires. The combination of these factors promotes weed incursion. Rehabilitation of the landscape through replanting, mulching, weed control and monitoring reduces weed incursion.

Feral Animal Control: appropriate feral animal control reduces seed distribution that can attach to fur and hooves, also reduces disturbance to soil and native vegetation therefore lowering weed invasion susceptibility.

Quarantine protocols: isolate a weed prone area and limits further weed dispersion and monitoring for early weed identification of neighbouring areas. Quarantine of stock may also be used to limit seed dispersion.

Prevention of overgrazing: maintenance of pastures and or desirable ground covers and grazing management through the prevention of stock will lessen the soil disturbance/deterioration which would allow for weed growth.



Asbestos Management Plan

Broome Regional Resource Recovery Park



Prepared for Shire of Broome


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1 Introduction

This Asbestos Management Plan (AMP) has been prepared to outline the requirements and procedures for asbestos management at the Broome Regional Resource Recovery Park (RRRP). The RRRP is a Prescribed Premise Category 64 Class II and III Putrescible Waste Facility, which is licenced to accept Type 1 Special Waste (asbestos). The AMP is required to outline the correct acceptance, handling and disposal procedures to ensure asbestos is managed safely and in accordance with licence requirements.

Asbestos may also be present within non-declared waste loads brought to the RRRP, which can present a risk to personnel, plant and on-site products. Of particular importance is the identification of asbestos which can present risks to human health. Asbestos is a known carcinogen and requires the implementation of strict and specific management measures to protect the health of all staff and customers. Therefore, this AMP outlines the correct PPE, operating procedures, incident management and record keeping required.

1.1 Objectives

The objectives of the AMP are to:

- Provide guidance on how to manage asbestos and asbestos contaminated material delivered to site or if discovered on-site;
- Ensure appropriate procedures are carried out for the inspection, handling, and disposal of asbestos material;
- Ensure the appropriate management of asbestos related incidents are undertaken; and
- Ensure the appropriate record keeping for asbestos acceptance, rejected, disposal and incidents.

1.2 Legislation and Guidelines

There are a range of regulations and guidelines related to management of asbestos which were considered during the development of this AMP:

- Environmental Protection (Controlled Waste) Regulations 2004;
- Guidelines for Managing Asbestos at Construction and Demolition Waste Recycling Facilities (DEC, 2012);
- Disposal of Material Containing Asbestos (DEC, 2007);
- Code of Practice for the Safe Removal of Asbestos 2nd Edition [NOHSC: 2002(2005)];
- Health (Asbestos) Regulations 1992;
- Code of Practice for the Management and Control of Asbestos in the Workplace [NOHSC: 2018 (2005)]; and
- Department of Health - Guidelines for Asbestos-Contaminated Sites (DOH, 2009).

1.3 Definitions

Table 1-1 provides a summary of the relevant definitions referenced within this AMP.

Table 1-1: Summary of Definitions

Term	Definition*
Asbestos	The asbestiform variety of mineral silicates belonging to the serpentine or amphibole groups of rock-forming minerals and includes actinolite, amosite, anthophyllite, chrysolite, crocidolite, tremolite and any mixture containing 2 or more of those.
Asbestos Containing Material (ACM)	Products or materials (including fragments) that contain asbestos in an inert bound matrix such as cement or resin in a sound condition and in a form that cannot pass through a 7mm x 7mm sieve.
Asbestos fines or fibres	Includes small asbestos fibre bundles, free asbestos fibres and also ACM fragments that can pass through a 7mm x 7mm sieve.
Competent person	A person possessing adequate qualifications, such as suitable training and sufficient knowledge, experience and skill, for the safe performance of the specific work.
Fibrous asbestos	Includes friable asbestos material, such as severely weathered ACM and asbestos in the form of loose fibrous material such as insulation products. Friable asbestos is material that is in a degraded condition such that it can be broken or crumbled to a powder form by hand pressure.
Personal Protection Equipment (PPE)	Equipment and clothing that is used or worn by an individual person to protect themselves against, or minimise their exposure to, workplace risks. It includes items such as facemasks and respirators, coveralls, goggles, helmets, gloves and footwear.

**Definitions sourced from DEC Guidelines for managing asbestos at construction and demolition waste recycling facilities (Dec 2012) and Code of Practice for the Safe Removal of Asbestos 2nd Edition [NOHSC: 2002(2005)].*

1.4 Heath Impacts

Asbestos is a known carcinogen that can cause mesothelioma, lung cancer and asbestosis. Asbestos fibres inhaled deep into the lungs can result in the development of mesothelial cells which may result in cancer. Lung cancer can occur from all types of asbestos and asbestosis is caused by the scarring of the lung tissue from asbestos fibres which reduces the ability of the lungs to transfer oxygen to the blood. The latency periods generally range between 35-40 years for mesothelioma, 20-30 years for lung cancer and 15-20 years for asbestosis.

1.5 Classification of Asbestos

Asbestos is classified as friable asbestos or non-friable asbestos. Friable asbestos is asbestos that can be easily crumbled, pulverised or reduced to powder. Examples of friable asbestos are tiles, clutch plates and pipe insulation. Non-friable asbestos is a common form of asbestos that is held together with a strong binder. Asbestos fibres in non-friable asbestos may be released through damage, mishandling or weathering. Asbestos can also be present in a range of materials called Asbestos Containing Material (ACM). Examples of ACM are provided in Appendix A.

1.6 Responsibilities

The responsibilities of site users and the site personnel regarding asbestos management are as follows:

- Site Users/Customers:
 - Give 24 hours' notice to the gatehouse;
 - Wrap all asbestos in accordance with pre-acceptance requirements (Section 3); and
 - Declare all asbestos, ACM or asbestos contaminated loads to Weighbridge Attendant.
- Site Supervisor:
 - Implement, maintain and update the Asbestos Management Plan as required;
 - Ensure all staff are trained in the identification, handling, correct disposal of asbestos (Section 1.7) and are briefed on the requirements of the Asbestos Management Plan;
 - Ensure asbestos acceptance, correct handling and disposal procedures are implemented;
 - Maintain adequate supply of appropriate PPE; and
 - Maintain adequate supply of asbestos wrapping materials.
- Weighbridge Attendant:
 - Adhere to the Asbestos Management Plan;
 - Question all customers on the potential presence of asbestos in loads;
 - Inspect all loads entering the facility;
 - Wear appropriate PPE when undertaking inspections or handling asbestos;
 - Register all accepted and rejected asbestos loads; and
 - Notify the Site Operator of any accepted load ready for disposal.
- Site Operator:
 - Adhere to the Asbestos Management Plan;
 - Wear appropriate PPE when undertaking inspections or handling asbestos;
 - Assess all non-declared asbestos loads and potential risks;
 - Ensure the appropriate handling and disposal of asbestos; and
 - Maintain an Asbestos Register.

1.7 Training

All personnel must be trained in the appropriate inspection, handling and disposal of asbestos materials. Training must be undertaken by a suitable qualified internal or external training provider. The training shall include but not be limited to:

- Health risks associated with asbestos;
- Sources of asbestos wastes;
- Identification of asbestos waste;
- Roles and responsibilities;
- PPE and correct use;
- Acceptance procedures; and
- Disposal procedures.

2 Personal Protective Equipment

All personnel must ensure appropriate PPE is worn when handling asbestos. A description of each type of PPE required is detailed below. PPE must be put on in the following order:

1. Respirator or mask (minimum of P2);
2. Disposable coveralls;
3. Disposable gloves; and
4. Disposable overshoes or washable boots.

2.1 Safety Goggles

If a full-face respirator is not required, personnel must wear suitable safety goggles. Safety goggles should be decontaminated following use.

2.2 Respirators

Depending on the nature of asbestos handling, concentration of asbestos fibres and facial characteristics (i.e. facial hair, glasses etc.), an appropriate respirator should be worn. The following should be considered for respirator use:

- The requirement for a P2 or P3 respirator should be determined by a competent person;
- Comply with AS/NZS 1716-2003 Respiratory Protective Devices;
- Be maintained in accordance with 'AS/NZS 1715-1994 Selection, Use and Maintenance of Respiratory Protective Devices';
- Worn under fitted hoods;
- Face pieces should be cleaned and disinfected according to the manufacturer's instructions and issued to individuals for exclusive use;
- Defects should be reported immediately for replacement or repair;
- All used filters should be disposed of as asbestos waste; and
- People with prescription glasses must either wear modified spectacles or wear supply hoods instead.

2.3 Disposal Coveralls

Disposable coveralls should be worn to prevent adequate protection against asbestos fibre penetration. Coveralls should be type 5, category 3 (prEN ISO 13982-1) or equivalent. Type 5 protective clothing typically has the following specifications:

- Inward leakage (IL) $\leq 30\%$ IL for 91.1% (or more) of all values measured (all exercises, all sampling positions all suits); and
- Total inward leakage (TILS) $\leq 15\%$ for 80% (or more) of all TILS values.

Coveralls should be one size too big to avoid potential ripping at seams, fitted with a hood and cuffs. The hood should be worn over respirator straps and coverall legs are worn over footwear (i.e., not tucked in). The coveralls once used should be disposed as asbestos waste. The use and washing of

reusable protective clothing is not recommended. If reusable protective clothing is used it must be kept in a sealed container and laundered at a suitable laundering facility.

2.4 Gloves

The requirement for gloves will be determined by a risk assessment. Single use disposable gloves should be disposed of as asbestos waste following use. If latex gloves are to be used it is recommended to wear low protein (powder free) gloves. Following removal and disposal of gloves, all personnel must wash their hands and fingernails thoroughly.

2.5 Footwear

Appropriate footwear should be worn when handling asbestos. The appropriate safety footwear includes laceless washable boots or disposable shoe covers or overshoes. However, the use of disposable overshoes can present a slipping risk therefore should be avoided. Reusable safety footwear should not be used for any other purposes. All reusable footwear should be decontaminated or sealed in double bags.

2.6 Removal of PPE and Personal Decontamination

Prior to removal of used PPE, visible asbestos shall be removed from protective clothing using an asbestos vacuum or wet wiping. PPE should be removed in the following order:

1. Disposable overshoes or washable boots;
2. Disposable gloves;
3. Disposable coveralls; and
4. Respirator or mask.

Coveralls should be removed by taking arms out of the sleeves and rolling the sleeves inside out and then rolling the coveralls down the body. Non-disposable respirators should be thoroughly cleaned, and any contaminated filters are removed for disposal.

Used disposable PPE is to be placed in a sealed heavy-duty 200µm (minimum thickness) polythene bag no more than 1,200mm long and 900mm wide. The outside of the bag should be wiped down using a damp cloth. The bag should then be sealed with duct tape and labelled as "Asbestos Waste".

Following removal of PPE, personnel are to thoroughly clean their face, hands and fingernails with soapy water.

3 Pre-Acceptance

Prior to delivery of asbestos loads, 24 hours notification must be given to the gatehouse. All asbestos loads will be inspected by the Weighbridge Attendant on arrival to ensure materials are packaged in accordance with the following requirements:

- Friable asbestos and fragmented non-friable asbestos:
 - Must be wrapped in a minimum 200µm thickness new polythene bags which are:
 - not damaged;
 - not more than half full to minimise the risk of tearing and to assist in manual handling;
 - have all air expelled (carefully to avoid the release of dust);
 - twisted slightly, folded over, and secured with adhesive tape; and
 - double bagged (friable asbestos).
 - Secured in a lined and sealed drum/container or truck clearly labelled with a dangerous goods and asbestos warning label;
 - Asbestos contaminated soils:
 - Must be transported in a sealed container or truck and kept wet at all times;
- Non-friable or bonded asbestos (asbestos sheeting):
 - Must be double wrapped in a minimum of 200µm thickness new and undamaged polythene bags;
 - Labelled appropriately with asbestos warning label; and
 - Placed in a completely sealed double lined skip bin.

4 Acceptance

The following acceptance procedures are relevant to the acceptance of declared asbestos loads and non-declared asbestos loads (i.e., contaminated C&D waste loads).

4.1 Declared Asbestos Loads

All asbestos loads will be inspected by the Weighbridge Attendant to ensure materials are packaged in accordance with pre-acceptance wrapping requirements (Section 3). If the waste load is accepted, it must be entered in the Asbestos Register. The Weighbridge Attendant must then inform the Site Operator of the asbestos load. Following confirmation / approval from the Site Operator, the Weighbridge Attendant is to direct the customer / driver to the dedicated asbestos deposition area.

If the asbestos waste is not appropriately wrapped or bagged, the asbestos load will be rejected. Rejected asbestos loads are to be recorded in the rejected loads register. The requirements for the appropriate wrapping of asbestos will be communicated to the customer prior who will be asked to comply with these requirements before returning the load to the facility for acceptance.

4.2 Non-Declared Asbestos Loads

General waste and Construction and Demolition (C&D) loads have the potential to contain asbestos or ACMs. All general waste and C&D waste loads will be inspected by the Weighbridge Attendant to identify any presence of asbestos.

If asbestos is identified, the Weighbridge Attendant will inspect the load to ensure it has been wrapped appropriately. If the asbestos is not wrapped appropriately, the load will be rejected, and the wrapping requirements communicated to the customer. Once wrapped appropriately, the customer can return to the facility to dispose of the asbestos. If the load has been wrapped correctly, but not declared as asbestos or ACM, the customer may be fined.

Upon acceptance of C&D loads, the risk of each load containing asbestos will be assessed based on the information in the customer declaration. The low and high risk rating for each type of C&D waste category is shown in the table below:

Table 4-1: Asbestos Risk Level Assignment for C&D Waste

Material	Commercial	Skip Bin
Clean concrete	Low	High
Clean brick	Low	High
Clean bitumen	Low	High
Mixed construction waste	High	High
Mixed demolition waste	High	High

Once a risk classification has been allocated, loads will be taken to the appropriate unloading area, with separate designated areas for low and high-risk loads. High risk loads shall be visually inspected during unloading. Low risk loads are to be inspected as soon as practicable and prior to stockpiling and processing. High risks loads must be spread to approximately 30cm thickness for further detailed inspection. The load is to be inspected by trained personnel wearing appropriate PPE.

If asbestos is identified, the Site Operator shall report the asbestos load to the Site Supervisor immediately and identify the customer. If the customer ID is known the Site Operator / Weighbridge Attendant / Site Supervisor shall notify the customer of the breach. The customer will then be fined for failing to declare the asbestos or ACM. The customer will then remove the asbestos from site, wrap or contain appropriately and return the load giving 24 hours notification. If the customer is not identified, the asbestos load shall be wrapped or contained by trained personnel and disposed of in the dedicated asbestos area.

If asbestos is identified during the waste inspection but is not able to be easily removed, the load will be assumed to be contaminated, isolated and wet down. If the suspect material is able to be removed, then it will be assumed to be asbestos, and either put into an appropriate container or wrapped. Contaminated loads must be kept isolated and barricaded/demarcated and wet down with a fine mist and managed by trained personnel only. All contaminated loads will be transported to the dedicated asbestos disposal area as per transport and handling requirements (Section 5) and disposed as per the asbestos disposal procedure (Section 6).

5 Transport and Handling

To minimise the risk of spills and exposure to asbestos, the following measures must be implemented during the transport and handling of asbestos:

- All asbestos loads must be covered during transport;
- All asbestos loads should be wet down prior to disposal;
- All vehicles and machinery must ensure internal air circulation is used and windows are closed on arrival at the tip face and existing the facility;
- The driver must follow the directions of the Site Operator;
- All personnel to wear appropriate PPE (Section 2) when handling asbestos waste or located outside of vehicles or machinery during unloading; and
- Loads must be handled, unloaded and placed in the cell carefully to avoid damaging packaging and potential generation of dust.

6 Disposal

The correct disposal of asbestos will ensure the safety of staff and customers. The requirements for the disposal of asbestos waste are as follows:

- An exclusion zone must be established during the unloading of asbestos;
- All untrained personnel must remain outside the exclusion zone;
- All asbestos loads should be wet down (with a fine mist) prior to unloading;
- Asbestos must be unloaded using either front end loader or excavator;
- Loads should be dropped off as close to the dedicated asbestos disposal area as possible to minimise handling of the material and potential for damage to packaging to occur;
- Asbestos should be offloaded at the foot of the excavation at the landfill site in such a manner as to avoid the generation of dust and the release of asbestos fibres;
- The Geographical Positioning System (GPS) coordinate of each asbestos load greater than 1m³ will be recorded to map the location, type and quantity of all asbestos disposed in the cell on the premises plan;
- The Site Operator / Site Supervisor must witness the disposal and covering of the asbestos load with at least 1.0m of fill or waste as soon as practicable;
- No compaction of asbestos is to occur; however, compaction of the cover material / fill is accepted; and
- After burial, the asbestos should not be disturbed.

7 Incidents

Asbestos related incidents may include the spill or escape of asbestos fibres or exposure to asbestos through the lack of appropriate PPE. The following management measures are to be undertaken in the event either of these incidents occurs.

7.1 Asbestos Spills

In the event friable asbestos escapes during handling or unloading the following procedure must be undertaken:

1. Clear the area or site personnel and vehicles;
2. Notify the Site Supervisor immediately;
3. Trained personnel wearing appropriate PPE shall are to manage the spill / escape;
4. All asbestos and dust to be wet down with a fine mist;
5. Cover the asbestos with a 1m deep layer of fill / waste;
6. Do not compact the asbestos;
7. Ensure earthmoving equipment does not come into direct contact with asbestos; and
8. Complete an incident report which includes but is not limited to the following information:
 - Date;
 - Personnel involved;
 - Type of asbestos;
 - Quantity of asbestos;
 - Description of incident;
 - Actions / management measures undertaken; and
 - Future preventative measures.

7.2 Exposure to Asbestos

If a person is exposed to asbestos without the use of appropriate PPE, the following decontamination procedure must be undertaken:

1. Immediately wet down the person with fine spray / mist of water;
2. The person must then walk to the nearest shower facility (if not, vehicles or machinery may become contaminated);
3. Gently remove all contaminated clothing and place in a sealed bag;
4. Shower to remove all dust and asbestos fibres with particular focus on the hair, face, hands and fingernails;
5. Change into clean clothing; and
6. The bag must be labelled with "Asbestos Waste" and disposed of appropriately.

All personnel assisting with the decontamination procedure must wear a P2 dust mask. The incident must then be reported to the Site Supervisor. The Site Supervisor must enter the incident into the Asbestos Register / Incident Register.

8 Records

All acceptance, rejection and disposal of asbestos must be recorded in an Asbestos Register. Following inspection of all declared and non-declared waste loads, the Weighbridge Attendant will either accept or rejected loads. Both accepted and rejected asbestos loads are to be entered into the Asbestos Register.

The details required for both accepted and rejected asbestos loads includes:

- Date;
- Name;
- Contact details;
- Vehicle registration;
- Source of asbestos;
- Estimated quantity of asbestos; and
- Accepted or rejected

Following appropriate disposal of asbestos loads, the Site Operator / Site Supervisor must sign the Asbestos Register within 2 hours of burial of the waste to confirm asbestos has been disposed of appropriately according to these procedures.

Any asbestos related incidents must also be recorded in the Asbestos Register. Records of any asbestos incidents must be kept for a minimum of 40 years.

9 Asbestos Management Process

Figure 9-1 summarises the correct asbestos management process.

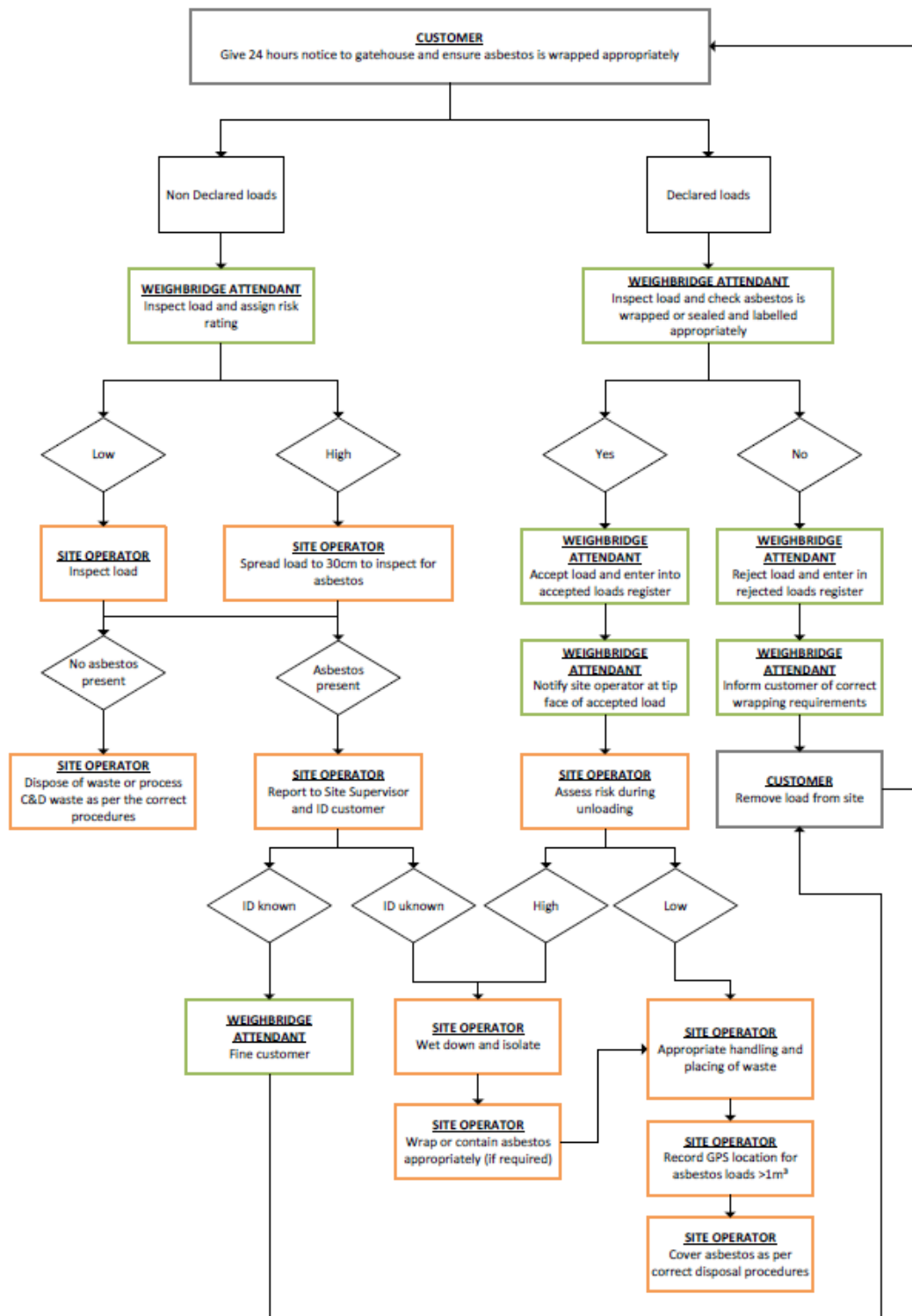


Figure 9-1: Asbestos Management Process

10 References

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Department of Health (2009) Guidelines for Asbestos-Contaminated Sites

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National Occupational Health and Safety Commission (2005) Code of Practice for the Management and Control of Asbestos in the Workplace [NOHSC: 2018 (2005)]

National Occupational Health and Safety Commission (2005) Code of Practice for the Safe Removal of Asbestos 2nd Edition [NOHSC: 2002(2005)]

Worksafe Victoria (2010) Coveralls used for asbestos removal

Worksafe Victoria (2008) Compliance Code: Removing Asbestos in Workplaces

APPENDIX A

Examples of Asbestos Containing Materials

See Next Page

A

Air-conditioning ducts: exterior or interior acoustic and thermal insulation

Asbestos cement sheet underlays for vinyl

Asbestos cement storm drain pipes

Arc shields in lift motor rooms or large electrical cabinets

Asbestos cement water pipes (usually underground)

Asbestos-based plastics products - as electrical insulates and acid-resistant compositions or aircraft seat

Asbestos-containing laminates (e.g. formica) used where heat resistance is required, e.g. ships

Asbestos ceiling tiles

Asbestos-containing pegboard

Asbestos cement conduit

Asbestos felts

Asbestos cement electrical fuse boards

Asbestos marine board, e.g. marinate

Asbestos cement external roofs and walls

Asbestos mattresses used for covering hot equipment in power stations

Asbestos Cement in the use of form work when pouring concrete

Asbestos paper used variously for insulation, filtering and production of fire resistant laminates

Asbestos cement sheet internal over exhaust canopies such as ovens, fume cupboards, etc.

Asbestos cement internal flues and downpipes

Asbestos cement moulded products such as gutters, ridge cappings, gas meter covers, cable troughs and covers

Asbestos roof tiles

Asbestos textiles

Asbestos cement pieces for packing spaces between floor joists and piers

Asbestos textile gussets in air-conditioning ducting systems

Asbestos cement (underground) pits, as used for traffic control wiring, telecommunications cabling, etc

Asbestos yarn

Autoclave / steriliser insulation

Asbestos cement render, plaster, mortar and coursework

Asbestos cement sheet

Asbestos cement sheet behind ceramic tiles

Asbestos cement sheet

Asbestos cement sheet behind ceramic tiles

B

Bitumen-based water proofing such as malthoid, typically on roofs and floors but also in brickwork

Bituminous adhesives and sealants

Boiler gaskets

Boiler insulation, slabs and wet mix

Brake disc pads

Brake linings

C

Cable penetration insulation bags (typically Telecom)

Calorifier insulation

Car body filters (not common)

Caulking compounds, sealant and adhesives

Cement render

Chrysotile wicks in kerosene heaters

Clutch faces

Compressed asbestos cement panels for flooring, typically verandas, bathrooms and steps for demountable buildings

Compressed asbestos fibres (CAF) used in brakes and gaskets for plant and automobiles

D

Door seals on ovens

Gauze mats in laboratories / chemical refineries

E

Electric heat banks - block insulation

Electric hot water services - normally not asbestos but some millboard could be present

Exhausts on vehicles

F

Fire blankets

Fire curtains

Fire door insulation

Fire-retardant material on steel work supporting reactors on columns in refineries in the chemical industry

Fire-rated wall rendering containing asbestos with mortar

Fire-resistant plaster board, typically on ships

Filler in acetylene gas cylinders

Flexible hoses

Floor vinyl sheets

Floor vinyl tiles

Fuse blankets and ceramic fuses in switchboards

G

Gaskets - general

Galbestos™ roofing materials (decorative coating on metal roof for sound proofing)

Gaskets - chemicals, refineries

Gloves - asbestos

H

Hairdryers - insulation around heating elements

Electric light fittings, high wattage, insulation around fitting (and bituminised)

Header (manifold) insulation

Electrical switchboards – see Pitch-based

I

Insulation in electric reheat units for air-conditioner systems

Insulation blocks

L

Laboratory bench tops

Laboratory fume cupboard panels

Lagging in penetrations in fireproof walls

Laboratory ovens - wall insulation

Lagged exhaust pipes on emergency power generators

Limpet asbestos spray insulation

Locomotives - steam; lagging on boilers, steam lines, steam dome and gaskets

M

Mastics

Sprayed insulation - fire retardant sprayed on nut internally, for bolts holding external building wall panels

Millboard between heating unit and wall

Millboard lining of switchboxes

Mortar

P

Packing materials for gauges, valves, etc., can be square packing, rope or loose fibre

Paint, typically industrial epoxy paints

Packing material on window anchorage points in high rise buildings

Penetrations through concrete slabs in high rise buildings

Pipe insulation including moulded sections, water-mix type, rope braid and sheet

Pitch-based (e.g. zelemite, ausbestos, lebah) electrical switchboard

Plaster and plaster cornice adhesives

R

Refractory linings

Refractory tiles

Rubber articles - extent of usage unknown

S

Sealant between floor slab and wall, usually in boiler rooms, risers or lift shafts

Sealant or mastik on windows

Lifts shafts - asbestos cement panels lining the shaft at the opening of each floor, and asbestos packing around penetrations

Sealants and mastics in air conditioning ducting joints

Spackle or plasterboard wall jointing compounds

Sprayed insulation - acoustic wall and ceiling

Sprayed insulation - beams and ceiling slabs

Trains - Harris cars - sprayed asbestos between steel shell and laminex

Trains - country - guards vans - millboard between heater and wall

Stoves - old domestic type; wall insulation

T

Tape and rope - lagging and jointing

Tapered ends of pipe lagging, where lagging is not necessarily asbestos

Tilux sheeting in place of ceramic tiles in bathrooms

Trailing cable under lift cabins

V

Valve, pump, etc. insulation

W

Welding rods

Woven asbestos cable sheath



Assets | Engineering | Environment | Noise | Spatial | Waste

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Construction and Demolition Sampling Plan

Broome Regional Resource Recovery Park



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Appendices

FIGURES Site Locality

APPENDIX A Asbestos Management Plan

APPENDIX B Asbestos Concentration Thresholds

1 Introduction

Talis Consultants Pty Ltd (Talis) was commissioned by the Shire of Broome (the Shire) to prepare a Construction and Demolition (C&D) Sampling Plan for the Broome Regional Resource Recovery Park (the Site), located approximately 12km northeast of Broome's town centre along Cape Leveque Road, as shown in Figure 1.

This C&D Sampling Plan has been prepared to outline the requirements and procedures to manage the risk of asbestos that may be present at the C&D Recycling Facility situated in the southeast corner of the Site. The Site will be a Prescribed Premises pursuant to Part V of the *Environmental Protection Act 1986* (EP Act) and will likely undertake the following Prescribed Activities (*Environmental Protection Regulations 1987*) related to the acceptance of C&D waste:

- Category 13 - Crushing of building material;
- Category 61A - Solid Waste Facility;
- Category 62 - Solid Waste Depot; and
- Category 70 - Screening etc, of material.

It is also important to recognise that the Site will also have the ability to accept asbestos to the site for disposal in an Asbestos Monocell (subject to receiving the relevant approvals). The processes and procedures associated with acceptance of asbestos is managed through a dedicated Asbestos Management Plan (AMP), which is attached in Appendix A.

This C&D Sampling Plan addresses C&D materials brought to the Site that are intended to be recycled.

1.1 Objectives

This C&D Sampling Plan was prepared to guide operational procedures at the Site to:

- Minimise the risk of asbestos being received and processed at the C&D Recycling Facility;
- Provide sampling and testing requirements; and
- Provide ongoing documentation procedures.

The plan is also intended to be provided as part of the supporting documentation to be submitted to the Department of Water and Environmental Regulation (DWER) for approvals under the *Environment Protection Act 1986* (EP Act).

1.2 Methodology

This C&D Sampling Plan has been prepared in accordance with the following guidelines and standards:

- AS 4482.1:1997, Guide to the sampling and investigation of potentially contaminated soil-non-volatile and semi-volatile compounds (AS 4482.1);
- AS 4482.2:1999, Guide to the sampling and investigation of potentially contaminated soil-volatile substances (AS 4482.2);

- Department of Environment and Conservation (DEC), now known as the DWER, *Guidelines for managing asbestos at construction and demolition waste recycling facilities*, 2012 (DWER Asbestos Management Guidelines);
- Department of Health (DoH), 2009: *Guidelines for the Assessment, Remediation and Management of Asbestos Contaminated Sites in Western Australia* (DoH Asbestos Management Guidelines);
- Department of Environmental Regulation (DER), now known as the DWER, *Assessment and management of contaminated sites, Contaminated sites guidelines*, 2014 (DWER Contaminated Sites Guidelines);
- Department of Water and Environmental Regulation, *Landfill Waste Classification and Waste Definitions 1996* (as amended 2018) (DWER Landfill Waste Guidelines); and
- National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013) (NEPM Guidelines).

2 Definitions

2.1 Recycled Road Base

Recycled road base is a sub-base or base course in road and pavement construction and other hardstand areas such as footpaths and car parks for urban residential, public open space and commercial and industrial land uses only. It is generally <19 millimetres (mm) in size.

2.2 Recycled Drainage Rock

Recycled drainage rock is a pipe bedding in underground projects for urban residential, public open space and commercial and industrial land uses only. It is generally used in civil infrastructure and is 20-27mm in size.

2.3 Various Forms of Asbestos

Asbestos refers to the asbestiform of the mineral silicate belonging to the serpentine and amphibole groups of rock forming minerals. This includes actinolite, amosite, anthophyllite, chrysotile, crocidolite, tremolite and any mixture containing two or more of those. Of these fibrous minerals, crocidolite (blue asbestos) is the most common within WA and was mined extensively at Wittenoom in the Pilbara. These minerals have been used in numerous products such as fencing and tiles, and are routinely found in developments constructed pre-1990's.

Asbestos contamination of the product handled and processed obviously presents an environmental and health risk and requires early detection and careful management through the operational processes onsite. The following definitions are relevant to the various forms of asbestos that require consideration as part of the sampling plan.

2.3.1 Asbestos Containing Material

Asbestos containing material (ACM) relates to products or materials that contain asbestos, though possibly broken and fragmented, in an inert bound matrix, such as cement or resin. Commonly throughout WA, it has been used for asbestos cement sheeting. It is restricted to material that cannot pass through a 7mm x 7mm sieve. In this form, where it is in a sound condition, it generally represents a low risk to human health. ACM can often be detected visually.

2.3.2 Fibrous Asbestos

Fibrous asbestos (FA) relates to friable asbestos material, such as severely weathered ACM (e.g. low density asbestos fibre board), and material such as loose fibrous insulation products. It is defined as degraded asbestos material that can be broken/crumbled by hand pressure. Similar to ACM, FA can often be detected visually.

2.3.3 Asbestos Fines

Asbestos fines (AF) relates to free fibres of asbestos, small fibre bundles or ACM fragments that passes through a 7mm x 7mm sieve. Both FA and AF have the potential to generated free asbestos fibres,

which may become an inhalation risk if made airborne. As such, they represent a more significant inhalation risk if made airborne.

2.3.4 Risk to Human Health

The effects of airborne asbestos fibres on the human respiratory system are well-documented. Through inhalation they can enter the deepest parts of the lungs and present a health risk throughout the life of the receptor.

Inhalation of these respirable fibres can lead to several potential health impacts including, but not limited to:

- Asbestosis- Progressive and irreversible scarring of lung tissue that impair breathing;
- Lung Cancer;
- Mesothelioma - A cancer of the lining around the lungs and abdomen; and
- Benign Pleural Diseases – Non-cancerous diseases that affect the lining around the lungs.

3 Operational Control Procedures

The following section details the operational control procedures that should be adopted at the Site to reduce the risk of asbestos being accepted during the recycling of C&D materials.

3.1 Risk Classification

Table 3-1 details the Risk Classification Matrix, outlined in the DWER Asbestos Management Guidelines, to address the potential presence of asbestos within C&D materials.

Table 3-1: Risk Classification Matrix-Asbestos

Material Type	Type of loads		
	Commercial	Public, Utes, Cars & Trailers	Skip Bins
Clean Concrete (without framework)	Low	High	High
Clean Brick	Low	High	High
Clean Bitumen/Asphalt	Low	High	High
Mixed Construction waste	High	High	High
Mixed Demolition waste	High	High	High

The Site will mainly accept commercial loads of clean, source separated C&D materials (i.e., only 'commercial low-risk' type loads). However, mixed C&D materials may also be accepted, which represents a 'high-risk' load. No public, utes, cars, trailers and / or skip bins will be accepted at the Site.

3.2 Pre-acceptance Procedures

On entry to the Site and at the entrance into the Bulk Waste Drop-off Area, where C&D is accepted at the Site's Community Recycling Centre, there will be a 'No Asbestos' sign.

Once a commercial load enters the Site, it will be inspected at the gatehouse via CCTV at the viewing platform. Prior to acceptance, the following information must be provided to the gatehouse attendant:

- Type of the material;
- Source of the material;
- Location of the source site, including the age of any buildings and/or structures;
- For pre-1990's large demolition projects, the pre-demolition hazard material survey where available;
- Current and previous use/s of the source site taking note of potentially contaminated land uses; and
- Whether the source material has been generated from a contaminated site, or if they are any known contamination of the material.

Additionally, the following is undertaken pre-acceptance:

- Advise all customers and potential customers that asbestos or potentially asbestos contaminated material is not accepted at the Site. This is done during telephone enquiries and through information included in other documentation for the Site, such as the website;
- Ensure a 'no asbestos' clause is included in all contracts with C&D waste suppliers; and
- Recording the details of loads arriving / received at the Site, which have been found to contain asbestos.

3.3 Acceptance Procedures

Acceptance procedures at the Site have been developed to ensure that C&D material accepted is consistent with the operating licence, relevant guidance and does not contain asbestos. Once the material has been deemed suitable during the 'pre-acceptance' procedure, the person delivering the material to Site must provide a declaration stating that the load is free of asbestos, with this declaration kept on-site. If a person / operator refuses to sign said declaration, then the waste is refused and turned away.

3.3.1 Acceptance Procedure Assessment

During pre-acceptance, all commercial waste that can clearly be determined to originate from buildings or structures constructed after 1990 then the load can be considered to represent a 'low-risk' of asbestos contamination. Additionally, if material can be fully assessed and no asbestos is identified, then the risk can also be classified as 'low'. All mixed waste loads will be considered to represent a 'high-risk'. If during pre-acceptance, uncertainty exists around the origin and risk, then the material is also considered to represent a 'high-risk'.

3.3.2 Asbestos High-Risk Procedure

Commercial material that passes the pre-acceptance process and is considered a 'high-risk' is unloaded at the 'high-risk' area within the C&D Recycling Facility. All 'high-risk' materials are spread to a maximum depth of 300mm to allow a comprehensive visual inspection, with the material turned over by an excavator. All large fragments of concrete will be inverted to allow for the inspection of underlying or embedded asbestos.

If ACM is identified which cannot be easily removed by hand, the load is rejected. If FA or AF are detected, the load will also be rejected. All rejected loads will be isolated, kept wet and covered to aid in the prevention of asbestos fibres being released. The contractor who delivered the waste will be contacted to collect and remove the material. Alternatively, the material will be transported to the Asbestos Monocell as per the AMP, at the expense of the contractor who delivered the materials.

All ACM that is easily removed from the C&D material is assumed to be asbestos and will be isolated from all other material, labelled, covered and kept wet to prevent the release of fibres. Once all ACM has been removed from the material, the asbestos materials will be disposed of in the Asbestos Monocell as per the AMP. Once all suspected ACM has been removed, the 'clean' material can be added to the stockpile for processing.

As part of the acceptance procedure, the materials will be wetted to minimise the risk of exposure to airborne asbestos.

3.3.3 Asbestos Low-Risk Procedure

The commercial waste material is visually inspected during unloading at the 'low-risk' area within the C&D Recycling Facility. Where ACM is identified or suspected, the material is then managed in accordance with the 'high-risk procedure' (or Section 3.3.2). Should no suspected ACM, AF or FA be identified, then the material is added to the material stockpiles ready for processing.

As part of the acceptance procedure, the materials will be wetted to minimise the risk of exposure to airborne asbestos.

3.3.4 Acceptance Procedure Assessment-Other Contaminants

During both the 'high-risk' and 'low-risk' assessment, the commercial waste is visual and olfactorily assessed, taking note of the following:

- Discolouration of the waste;
- Presence of hydrocarbon staining;
- Presence of asbestos containing materials;
- Presence of odours that would indicate that other contaminants are present in the waste; and
- Presence of non-permitted waste.

This assessment is undertaken to provide a comprehensive visual and odour check of the material.

If the assessment identifies potential contamination and/or odours and/or 'non-permitted waste', then the material is isolated and rejected from Site. Isolated material that has been rejected is placed into a separate stockpile and is labelled as 'isolated material'. The contractor who delivered the waste is then contacted to collect and remove the material. Alternatively, they can deposit the waste at the Site in an appropriate location and at their own cost, following confirmation of its waste acceptance criteria as per DWER Landfill Waste Guidelines.

3.3.5 Rejected Materials

A record of all rejected loads will be kept on Site, available for inspection by the DWER and/or auditor. The information captured will include, as a minimum:

- Name of waste producer;
- Name of the waste carrier;
- Registration of the vehicle that delivered the material; and
- Date of rejection.

Prior to transferring any rejected materials to a contractor, all storage, handling and disposal obligations remain the responsibility of the Site Operator.

At this time, with the final layout of the C&D Recycling Facility not being confirmed, no designated isolation area exists; however, isolation areas will be clearly demarcated, signed and managed accordingly.

3.4 Waste Processing Controls

Once the material is accepted and proven to show no signs of contamination and/or asbestos, it is tipped into stockpiles and sorted for crushing. During this time, the material will be visually assessed. Due to the limited volume of likely C&D waste, stockpiling of material will occur until sufficient volumes are available for processing. All stockpiles will be kept under 3 metres (m) in height.

Once sufficient volumes of C&D waste are available, the material will periodically be processed through a mobile recycling plant, crushed and placed into stockpiles with a maximum weight of up to 4,000 tonnes. This process is undertaken through the creation of smaller 'end of process' stockpiles, which results in the creation of ~70 cubic metres (m³) stockpiles. Once this size has been reached, the conveyor process is stopped and the material is assessed. It is then moved to an appropriate location and the conveyor process recommences. All other smaller stockpiles are then added to the previous one, to a maximum of 4,000 tonnes.

Each stockpile is given a unique identifier that is physically displayed on the stockpile. Once the stockpile has reached its maximum weight, no further material is added to the stockpile until it has been exhausted.

Ongoing visual and odour inspection of the waste occurs during the processing and movement of materials.

3.4.1 Dust Management

Dust management at the Site is undertaken in accordance with the Prescribed Premises Licence and the AMP. However, during operations, if dust generation is noted then the material in question is dampened to minimise the potential generation of airborne asbestos and other particulates. Should this prove ineffective, then waste processing activities will cease until additional measures have been put in place to prevent emissions, or weather conditions change to prevent the generation of dust beyond the Site's Premise boundary.

4 Asbestos Testing

To assess the risk of possible asbestos material within the C&D waste, sampling and testing is conducted as part of the operations at the Site. These procedures are described in the following sections.

4.1 Training Procedures

All staff involved with the sampling of C&D materials will be suitably trained for working with asbestos and will be familiar with the Site's AMP. Additionally, an internal Standard Operating Procedures (SOP) and/or Safe Work Method Statement (SWMS) (or similar) will be developed by the Site Operator.

Furthermore, all personnel are required to complete Asbestos Awareness Training, with training consistent with the Code of Practice developed by Safe Work Australia. This Code of Practice provides practical guidance regarding the management of risks associated with the use of asbestos and ACM in the workplace.

A training register will be kept on-site, while refresher training will be completed on a 2-yearly basis.

4.2 Sampling Method

Due to the risks associated with health and safety and to maintain operational continuity, sampling is not conducted when the material is on the conveyors. Instead, samples are collected immediately at the end of the conveyor system, with each stockpile being ~70m³ in volume as discussed in Section 3.4. This results in a single sample collected per conveyor run. Samples are collected by the following method:

- Completion of a visual inspection of the material, with collection of any larger ACM fragments for asbestos confirmation testing;
- Collection of 10 litre (L) soil samples (minimum). For each sample:
 - The entire collected sample is passed through a 7mm sieve;
 - All material that passes through the 7mm sieve will be wetted;
 - Collection of a 500 millilitre (mL) subsample of material (equivalent to ~750 grams (g)) that has passed through the sieve; and
 - Collection of all material >7mm that has not passed through the sieve.
- The collected >7mm sample will be visually assessed for ACM and FA on Site, by trained personnel, immediately following collection;
- The <7mm subsample will be submitted to the laboratory for further testing;
- A field sample record will be kept for each sample that describes the material conditions and relevant sample information; and
- Place the <7mm samples into an esky, or similar, for submission to the NATA accredited laboratory.

4.3 Sampling Frequency

4.3.1 Drainage Rock

In accordance with DWER Asbestos Management Guidelines, drainage rock is subject to visual inspection for ACM and FA (> 7mm), completed in a systematic 'grid' pattern, where safe to do so. Should a grid walkover not be possible, then the assessment will be undertaken via a systematic fashion round the whole stockpile, assessing both its width and height. The process undertaken during the creation of the drainage rock results in the formation of small ~70m³ stockpiles at the end of the conveyor. At this time, conveyor ceases operation, and the drainage rock product is subject to visual inspection for ACM and FA. If either contaminant is identified, then the small stockpile is isolated and rejected. No sampling and analysis is undertaken on this portion unless it is suspected that asbestos material is present.

4.3.2 Recycled Road-Base

The process undertaken during the creation of the recycled road base will see the creation of small ~70m³ stockpiles at the end of the conveyor. At this time, the recycled road-base product is initially subject to visual inspection for ACM and FA. If either contaminant is identified, then the small stockpile is isolated and rejected. If no suspected ACM and FA is visually identified, then a sample is collected for assessment.

In accordance with DWER Asbestos Management Guidelines and DoH Asbestos Management Guidelines, a total of 14 individual sample per 1,000m³ are collected. These samples are collected immediately at the end of the conveyor system, resulting in approximately 1 sample per 71m³.

Should the crushing and screening for the road-base material produce a product that is > 7mm, and as such sieving via a <7mm sieve cannot be completed, then samples for laboratory analysis will not be collected and the stockpile in question will be visually assessed as per the drainage rock approach.

4.4 Sampling Analysis and Interpretation

4.4.1 Visual Inspection Analysis

During the 'end of conveyor' process stockpile walkover of drainage rock and/or recycled road base, if a piece of ACM and/or FA is identified, then the stockpile will be rejected. Rejected stockpiles will be managed in accordance with the AMP.

4.4.2 Analytical Laboratory

The analytical laboratory will complete the assessment utilising the following technique:

- AS 4964–2004, Method for the Qualitative Identification of asbestos in bulk samples

The laboratory will first utilise the 'detect/non-detect' assessment by Polarised Light Microscopy (PLM) and dispersion staining (DS). Should a 'detect' result occur, then additional testing via gravimetric procedures will be completed in order to achieve the required Limit of Reporting (LOR) of 0.001 % (w/w) for FA and AF estimation.

While this method is not covered by NATA accreditation, it is the industry standard for asbestos testing to achieve the 0.001 % (w/w) LOR.

4.4.3 Analysis

All processed stockpiles that identify any ACM and/or FA will be rejected and not included for processing. These will be managed in accordance with the AMP. As such, the soil asbestos concentration for the ACM and FA (>7mm) will not be calculated on-site.

All AF samples will be submitted to the NATA accredited analytical laboratory who will calculate the soil asbestos concentration for <7mm asbestos, with the LOR threshold being 0.001% (w/w).

Should a single <7mm AF laboratory analysed sample exceed the 0.001% (w/w) LOR threshold but below 0.01% (w/w), then the stockpile will be subject to further assessment with a 'lines of evidence' approach undertaken. Should no other AF (<7mm) samples taken for the same ~4,000 tonnes stockpile exceed the 0.001% (w/w) LOR threshold, then the material will not be deemed as contaminated.

Due to the processes undertaken on-site, including the testing of small 'end of conveyor' stockpiles and subsequent transfer to a larger stockpile of up to 4,000 tonnes, it is not possible to accurately collect a repeat sample from the same area of a stockpile. Therefore, should further samples exceed the 0.001% (w/w) LOR threshold, then the stockpile will be rejected and managed as per the AMP.

Appendix B presents the assessment levels for asbestos.

4.4.4 Ongoing Visual Assessment

During all recycling processes, including sampling and the final product movement, the visual assessment of asbestos will be continuously undertaken. Should possible additional asbestos contamination be identified, then it should repeat the assessment to quantify the risk.

4.4.5 Corrective Action

Any material that is rejected following management of impacted material, corrective action will be implemented to prevent a reoccurrence. This will include the following:

- Assess the source of the material;
- Assess pre-acceptance procedures;
- Assess procedures following acceptance;
- Contact supplier of the impacted material; and
- Further training / refresher courses for all Site staff.

A record of this investigation will be kept on Site, included any management/remediation actions taken for the impacted material.

4.4.6 Laboratory Documentation

A copy of all laboratory analytical reports will be kept on-site, with the reports containing information on the following:

- Analytical results;
- Volume of sample;

- Identification of asbestos, including type and description of material;
- Limit of Reporting (LOR) / Practical Quantitation Limit (PQL);
- Analytical methods;
- Laboratory QA/QC; and
- Other relevant information.

4.5 Disposal of Asbestos Products

All stockpiles that are rejected will be isolated and kept wet until covered to aid in the prevention of asbestos fibres being released. The material will then be transported to the Asbestos Monocell as per the AMP. Records on the volume of asbestos waste disposed of will be kept on-site.

4.6 Asbestos Management Plan

A copy of the Site's AMP is provided in Appendix A.

4.7 Suspected Contamination

Should the material require additional testing, such as material originating from a contaminated site or additional contamination is identified, then a suitably qualified contaminated sites specialist will be engaged to direct the testing and subsequent assessment. This testing will assess if the material presents an unacceptable risk to human health and/or the environment and will be undertaken in accordance with DoH Asbestos Management Guidelines, DWER Contaminated Sites Guidelines, and DWER Landfill Waste Guidelines. These documents provide standard guidelines on possible contaminating industries, generic geochemical guidelines for soils and geochemical guidelines for waste material acceptance, respectively.

The suspect material will be isolated until confirmation of its suitability, or otherwise, is received. If the material is deemed contaminated, then it will remain isolated and disposed of at the Site's Asbestos Monocell as per the AMP.

All information relating to additional testing, including laboratory reports and the outcome of the assessment, will be kept on-site.

5 Management Audits

Relevant training and procedures are to be in place to ensure all employees at the Site comply with this plan. Further to this, all procedures and product specification will be audited annually by an independent specialist (with experience in the assessment of contaminated sites and asbestos management) to ensure compliance. This audit will address whether procedures at the Site comply with the operational procedures, and as a minimum, will address the following:

- Effectiveness and implementation of the operational control procedures;
- Effectiveness and results of the product testing; and
- Retention of relevant records and documents.

6 Record Keeping

The following records will be retained on-site for a minimum period of 5 years:

- Details of all C&D waste to be used for recycling. This includes the type and quantity and all information obtained during the pre-acceptance stage;
- Documentation associated with the inspection, sampling and testing of waste;
- Written determination made by a qualified person when testing for 'suspected contamination'; and
- All audit reports.

All records kept will ensure that all waste can be tracked from its source to the supply of the recycled material to an end user. All reports will be duplicated to ensure a copy is always available for inspection upon request.

7 References

Australian Standard 4482.1:1997, *Guide to the sampling and investigation of potentially contaminated soil-non-volatile and semi-volatile compounds*

Australian Standard 4482.2:1999, *Guide to the sampling and investigation of potentially contaminated soil-volatile substances*

Department of Environment and Conservation (DEC), now known as the DWER, *Guidelines for managing asbestos at construction and demolition waste recycling facilities*, 2012

Department of Environment Regulation (DER) *Assessment and management of contaminated sites* (December 2014)

Department of Health, *Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia* (May 2009)

Department of Water and Environmental Regulation, *Landfill Waste Classification and Waste Definitions 1996* (as amended 2018)

National Environment Protection Council (NEPC) *National Environment Protection (Assessment of Site Contamination) Measure, 1999* (as amended May 2013)

Waste Authority, Recycled Construction Products Program, Product Specification – *recycled road base and recycled drainage rock*, 2018 (WA, 2018c)

FIGURES

Site Locality



LEGEND

Site Boundary

Suburb Boundary

Primary Distributor Road

Regional Distributor Road

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LOCALITY

An inset map showing the location of Broome relative to Derby and Fitzroy Crossing. Broome is marked with a red square, Derby with a black dot, and Fitzroy Crossing with a black dot. The map shows the coastline and major roads.

0 100 200 300 400 500 km

LOCALITY
Site D2

Master Plan
Shire of Broome

N

0 0.5 1 1.5 2 km

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:70,000

Prepared: F Walker

Date: 10/08/2020

Reviewed: A Quispe

Revision: A

Project: TW19106

The logo for Talis Consultants, featuring a stylized 't' and 'c' in green and orange, followed by the text 'talis consultants'.

Figure 01

APPENDIX A

Asbestos Management Plan



Asbestos Management Plan

Broome Regional Resource Recovery Park



Prepared for Shire of Broome

September 2022

Project Number: TW21180

DOCUMENT CONTROL

Version	Description	Date	Author	Reviewer	Approver
1.0	Draft Sent to Client for Review	9/08/2022	MM	CP	CP
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Approval for Release

Name	Position	File Reference
Colleen Panizza	Senior Waste Engineer	TW21180-07 - Broome RRRP - Asbestos Management Plan_2.0
Signature		

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1 Introduction

This Asbestos Management Plan (AMP) has been prepared to outline the requirements and procedures for asbestos management at the Broome Regional Resource Recovery Park (RRRP). The RRRP is a Prescribed Premise Category 64 Class II and III Putrescible Waste Facility, which is licenced to accept Type 1 Special Waste (asbestos). The AMP is required to outline the correct acceptance, handling and disposal procedures to ensure asbestos is managed safely and in accordance with licence requirements.

Asbestos may also be present within non-declared waste loads brought to the RRRP, which can present a risk to personnel, plant and on-site products. Of particular importance is the identification of asbestos which can present risks to human health. Asbestos is a known carcinogen and requires the implementation of strict and specific management measures to protect the health of all staff and customers. Therefore, this AMP outlines the correct PPE, operating procedures, incident management and record keeping required.

1.1 Objectives

The objectives of the AMP are to:

- Provide guidance on how to manage asbestos and asbestos contaminated material delivered to site or if discovered on-site;
- Ensure appropriate procedures are carried out for the inspection, handling, and disposal of asbestos material;
- Ensure the appropriate management of asbestos related incidents are undertaken; and
- Ensure the appropriate record keeping for asbestos acceptance, rejected, disposal and incidents.

1.2 Legislation and Guidelines

There are a range of regulations and guidelines related to management of asbestos which were considered during the development of this AMP:

- Environmental Protection (Controlled Waste) Regulations 2004;
- Guidelines for Managing Asbestos at Construction and Demolition Waste Recycling Facilities (DEC, 2012);
- Disposal of Material Containing Asbestos (DEC, 2007);
- Code of Practice for the Safe Removal of Asbestos 2nd Edition [NOHSC: 2002(2005)];
- Health (Asbestos) Regulations 1992;
- Code of Practice for the Management and Control of Asbestos in the Workplace [NOHSC: 2018 (2005)]; and
- Department of Health - Guidelines for Asbestos-Contaminated Sites (DOH, 2009).

1.3 Definitions

Table 1-1 provides a summary of the relevant definitions referenced within this AMP.

Table 1-1: Summary of Definitions

Term	Definition*
Asbestos	The asbestiform variety of mineral silicates belonging to the serpentine or amphibole groups of rock-forming minerals and includes actinolite, amosite, anthophyllite, chrysolite, crocidolite, tremolite and any mixture containing 2 or more of those.
Asbestos Containing Material (ACM)	Products or materials (including fragments) that contain asbestos in an inert bound matrix such as cement or resin in a sound condition and in a form that cannot pass through a 7mm x 7mm sieve.
Asbestos fines or fibres	Includes small asbestos fibre bundles, free asbestos fibres and also ACM fragments that can pass through a 7mm x 7mm sieve.
Competent person	A person possessing adequate qualifications, such as suitable training and sufficient knowledge, experience and skill, for the safe performance of the specific work.
Fibrous asbestos	Includes friable asbestos material, such as severely weathered ACM and asbestos in the form of loose fibrous material such as insulation products. Friable asbestos is material that is in a degraded condition such that it can be broken or crumbled to a powder form by hand pressure.
Personal Protection Equipment (PPE)	Equipment and clothing that is used or worn by an individual person to protect themselves against, or minimise their exposure to, workplace risks. It includes items such as facemasks and respirators, coveralls, goggles, helmets, gloves and footwear.

**Definitions sourced from DEC Guidelines for managing asbestos at construction and demolition waste recycling facilities (Dec 2012) and Code of Practice for the Safe Removal of Asbestos 2nd Edition [NOHSC: 2002(2005)].*

1.4 Heath Impacts

Asbestos is a known carcinogen that can cause mesothelioma, lung cancer and asbestosis. Asbestos fibres inhaled deep into the lungs can result in the development of mesothelial cells which may result in cancer. Lung cancer can occur from all types of asbestos and asbestosis is caused by the scarring of the lung tissue from asbestos fibres which reduces the ability of the lungs to transfer oxygen to the blood. The latency periods generally range between 35-40 years for mesothelioma, 20-30 years for lung cancer and 15-20 years for asbestosis.

1.5 Classification of Asbestos

Asbestos is classified as friable asbestos or non-friable asbestos. Friable asbestos is asbestos that can be easily crumbled, pulverised or reduced to powder. Examples of friable asbestos are tiles, clutch plates and pipe insulation. Non-friable asbestos is a common form of asbestos that is held together with a strong binder. Asbestos fibres in non-friable asbestos may be released through damage, mishandling or weathering. Asbestos can also be present in a range of materials called Asbestos Containing Material (ACM). Examples of ACM are provided in Appendix A.

1.6 Responsibilities

The responsibilities of site users and the site personnel regarding asbestos management are as follows:

- Site Users/Customers:
 - Give 24 hours' notice to the gatehouse;
 - Wrap all asbestos in accordance with pre-acceptance requirements (Section 3); and
 - Declare all asbestos, ACM or asbestos contaminated loads to Weighbridge Attendant.
- Site Supervisor:
 - Implement, maintain and update the Asbestos Management Plan as required;
 - Ensure all staff are trained in the identification, handling, correct disposal of asbestos (Section 1.7) and are briefed on the requirements of the Asbestos Management Plan;
 - Ensure asbestos acceptance, correct handling and disposal procedures are implemented;
 - Maintain adequate supply of appropriate PPE; and
 - Maintain adequate supply of asbestos wrapping materials.
- Weighbridge Attendant:
 - Adhere to the Asbestos Management Plan;
 - Question all customers on the potential presence of asbestos in loads;
 - Inspect all loads entering the facility;
 - Wear appropriate PPE when undertaking inspections or handling asbestos;
 - Register all accepted and rejected asbestos loads; and
 - Notify the Site Operator of any accepted load ready for disposal.
- Site Operator:
 - Adhere to the Asbestos Management Plan;
 - Wear appropriate PPE when undertaking inspections or handling asbestos;
 - Assess all non-declared asbestos loads and potential risks;
 - Ensure the appropriate handling and disposal of asbestos; and
 - Maintain an Asbestos Register.

1.7 Training

All personnel must be trained in the appropriate inspection, handling and disposal of asbestos materials. Training must be undertaken by a suitable qualified internal or external training provider. The training shall include but not be limited to:

- Health risks associated with asbestos;
- Sources of asbestos wastes;
- Identification of asbestos waste;
- Roles and responsibilities;
- PPE and correct use;
- Acceptance procedures; and
- Disposal procedures.

2 Personal Protective Equipment

All personnel must ensure appropriate PPE is worn when handling asbestos. A description of each type of PPE required is detailed below. PPE must be put on in the following order:

1. Respirator or mask (minimum of P2);
2. Disposable coveralls;
3. Disposable gloves; and
4. Disposable overshoes or washable boots.

2.1 Safety Goggles

If a full-face respirator is not required, personnel must wear suitable safety goggles. Safety goggles should be decontaminated following use.

2.2 Respirators

Depending on the nature of asbestos handling, concentration of asbestos fibres and facial characteristics (i.e. facial hair, glasses etc.), an appropriate respirator should be worn. The following should be considered for respirator use:

- The requirement for a P2 or P3 respirator should be determined by a competent person;
- Comply with AS/NZS 1716-2003 Respiratory Protective Devices;
- Be maintained in accordance with 'AS/NZS 1715-1994 Selection, Use and Maintenance of Respiratory Protective Devices';
- Worn under fitted hoods;
- Face pieces should be cleaned and disinfected according to the manufacturer's instructions and issued to individuals for exclusive use;
- Defects should be reported immediately for replacement or repair;
- All used filters should be disposed of as asbestos waste; and
- People with prescription glasses must either wear modified spectacles or wear supply hoods instead.

2.3 Disposal Coveralls

Disposable coveralls should be worn to prevent adequate protection against asbestos fibre penetration. Coveralls should be type 5, category 3 (prEN ISO 13982-1) or equivalent. Type 5 protective clothing typically has the following specifications:

- Inward leakage (IL) $\leq 30\%$ IL for 91.1% (or more) of all values measured (all exercises, all sampling positions all suits); and
- Total inward leakage (TILS) $\leq 15\%$ for 80% (or more) of all TILS values.

Coveralls should be one size too big to avoid potential ripping at seams, fitted with a hood and cuffs. The hood should be worn over respirator straps and coverall legs are worn over footwear (i.e., not tucked in). The coveralls once used should be disposed as asbestos waste. The use and washing of

reusable protective clothing is not recommended. If reusable protective clothing is used it must be kept in a sealed container and laundered at a suitable laundering facility.

2.4 Gloves

The requirement for gloves will be determined by a risk assessment. Single use disposable gloves should be disposed of as asbestos waste following use. If latex gloves are to be used it is recommended to wear low protein (powder free) gloves. Following removal and disposal of gloves, all personnel must wash their hands and fingernails thoroughly.

2.5 Footwear

Appropriate footwear should be worn when handling asbestos. The appropriate safety footwear includes laceless washable boots or disposable shoe covers or overshoes. However, the use of disposable overshoes can present a slipping risk therefore should be avoided. Reusable safety footwear should not be used for any other purposes. All reusable footwear should be decontaminated or sealed in double bags.

2.6 Removal of PPE and Personal Decontamination

Prior to removal of used PPE, visible asbestos shall be removed from protective clothing using an asbestos vacuum or wet wiping. PPE should be removed in the following order:

1. Disposable overshoes or washable boots;
2. Disposable gloves;
3. Disposable coveralls; and
4. Respirator or mask.

Coveralls should be removed by taking arms out of the sleeves and rolling the sleeves inside out and then rolling the coveralls down the body. Non-disposable respirators should be thoroughly cleaned, and any contaminated filters are removed for disposal.

Used disposable PPE is to be placed in a sealed heavy-duty 200µm (minimum thickness) polythene bag no more than 1,200mm long and 900mm wide. The outside of the bag should be wiped down using a damp cloth. The bag should then be sealed with duct tape and labelled as "Asbestos Waste".

Following removal of PPE, personnel are to thoroughly clean their face, hands and fingernails with soapy water.

3 Pre-Acceptance

Prior to delivery of asbestos loads, 24 hours notification must be given to the gatehouse. All asbestos loads will be inspected by the Weighbridge Attendant on arrival to ensure materials are packaged in accordance with the following requirements:

- Friable asbestos and fragmented non-friable asbestos:
 - Must be wrapped in a minimum 200µm thickness new polythene bags which are:
 - not damaged;
 - not more than half full to minimise the risk of tearing and to assist in manual handling;
 - have all air expelled (carefully to avoid the release of dust);
 - twisted slightly, folded over, and secured with adhesive tape; and
 - double bagged (friable asbestos).
 - Secured in a lined and sealed drum/container or truck clearly labelled with a dangerous goods and asbestos warning label;
 - Asbestos contaminated soils:
 - Must be transported in a sealed container or truck and kept wet at all times;
- Non-friable or bonded asbestos (asbestos sheeting):
 - Must be double wrapped in a minimum of 200µm thickness new and undamaged polythene bags;
 - Labelled appropriately with asbestos warning label; and
 - Placed in a completely sealed double lined skip bin.

4 Acceptance

The following acceptance procedures are relevant to the acceptance of declared asbestos loads and non-declared asbestos loads (i.e., contaminated C&D waste loads).

4.1 Declared Asbestos Loads

All asbestos loads will be inspected by the Weighbridge Attendant to ensure materials are packaged in accordance with pre-acceptance wrapping requirements (Section 3). If the waste load is accepted, it must be entered in the Asbestos Register. The Weighbridge Attendant must then inform the Site Operator of the asbestos load. Following confirmation / approval from the Site Operator, the Weighbridge Attendant is to direct the customer / driver to the dedicated asbestos deposition area.

If the asbestos waste is not appropriately wrapped or bagged, the asbestos load will be rejected. Rejected asbestos loads are to be recorded in the rejected loads register. The requirements for the appropriate wrapping of asbestos will be communicated to the customer prior who will be asked to comply with these requirements before returning the load to the facility for acceptance.

4.2 Non-Declared Asbestos Loads

General waste and Construction and Demolition (C&D) loads have the potential to contain asbestos or ACMs. All general waste and C&D waste loads will be inspected by the Weighbridge Attendant to identify any presence of asbestos.

If asbestos is identified, the Weighbridge Attendant will inspect the load to ensure it has been wrapped appropriately. If the asbestos is not wrapped appropriately, the load will be rejected, and the wrapping requirements communicated to the customer. Once wrapped appropriately, the customer can return to the facility to dispose of the asbestos. If the load has been wrapped correctly, but not declared as asbestos or ACM, the customer may be fined.

Upon acceptance of C&D loads, the risk of each load containing asbestos will be assessed based on the information in the customer declaration. The low and high risk rating for each type of C&D waste category is shown in the table below:

Table 4-1: Asbestos Risk Level Assignment for C&D Waste

Material	Commercial	Skip Bin
Clean concrete	Low	High
Clean brick	Low	High
Clean bitumen	Low	High
Mixed construction waste	High	High
Mixed demolition waste	High	High

Once a risk classification has been allocated, loads will be taken to the appropriate unloading area, with separate designated areas for low and high-risk loads. High risk loads shall be visually inspected during unloading. Low risk loads are to be inspected as soon as practicable and prior to stockpiling and processing. High risks loads must be spread to approximately 30cm thickness for further detailed inspection. The load is to be inspected by trained personnel wearing appropriate PPE.

If asbestos is identified, the Site Operator shall report the asbestos load to the Site Supervisor immediately and identify the customer. If the customer ID is known the Site Operator / Weighbridge Attendant / Site Supervisor shall notify the customer of the breach. The customer will then be fined for failing to declare the asbestos or ACM. The customer will then remove the asbestos from site, wrap or contain appropriately and return the load giving 24 hours notification. If the customer is not identified, the asbestos load shall be wrapped or contained by trained personnel and disposed of in the dedicated asbestos area.

If asbestos is identified during the waste inspection but is not able to be easily removed, the load will be assumed to be contaminated, isolated and wet down. If the suspect material is able to be removed, then it will be assumed to be asbestos, and either put into an appropriate container or wrapped. Contaminated loads must be kept isolated and barricaded/demarcated and wet down with a fine mist and managed by trained personnel only. All contaminated loads will be transported to the dedicated asbestos disposal area as per transport and handling requirements (Section 5) and disposed as per the asbestos disposal procedure (Section 6).

5 Transport and Handling

To minimise the risk of spills and exposure to asbestos, the following measures must be implemented during the transport and handling of asbestos:

- All asbestos loads must be covered during transport;
- All asbestos loads should be wet down prior to disposal;
- All vehicles and machinery must ensure internal air circulation is used and windows are closed on arrival at the tip face and existing the facility;
- The driver must follow the directions of the Site Operator;
- All personnel to wear appropriate PPE (Section 2) when handling asbestos waste or located outside of vehicles or machinery during unloading; and
- Loads must be handled, unloaded and placed in the cell carefully to avoid damaging packaging and potential generation of dust.

6 Disposal

The correct disposal of asbestos will ensure the safety of staff and customers. The requirements for the disposal of asbestos waste are as follows:

- An exclusion zone must be established during the unloading of asbestos;
- All untrained personnel must remain outside the exclusion zone;
- All asbestos loads should be wet down (with a fine mist) prior to unloading;
- Asbestos must be unloaded using either front end loader or excavator;
- Loads should be dropped off as close to the dedicated asbestos disposal area as possible to minimise handling of the material and potential for damage to packaging to occur;
- Asbestos should be offloaded at the foot of the excavation at the landfill site in such a manner as to avoid the generation of dust and the release of asbestos fibres;
- The Geographical Positioning System (GPS) coordinate of each asbestos load greater than 1m³ will be recorded to map the location, type and quantity of all asbestos disposed in the cell on the premises plan;
- The Site Operator / Site Supervisor must witness the disposal and covering of the asbestos load with at least 1.0m of fill or waste as soon as practicable;
- No compaction of asbestos is to occur; however, compaction of the cover material / fill is accepted; and
- After burial, the asbestos should not be disturbed.

7 Incidents

Asbestos related incidents may include the spill or escape of asbestos fibres or exposure to asbestos through the lack of appropriate PPE. The following management measures are to be undertaken in the event either of these incidents occurs.

7.1 Asbestos Spills

In the event friable asbestos escapes during handling or unloading the following procedure must be undertaken:

1. Clear the area or site personnel and vehicles;
2. Notify the Site Supervisor immediately;
3. Trained personnel wearing appropriate PPE shall be to manage the spill / escape;
4. All asbestos and dust to be wet down with a fine mist;
5. Cover the asbestos with a 1m deep layer of fill / waste;
6. Do not compact the asbestos;
7. Ensure earthmoving equipment does not come into direct contact with asbestos; and
8. Complete an incident report which includes but is not limited to the following information:
 - Date;
 - Personnel involved;
 - Type of asbestos;
 - Quantity of asbestos;
 - Description of incident;
 - Actions / management measures undertaken; and
 - Future preventative measures.

7.2 Exposure to Asbestos

If a person is exposed to asbestos without the use of appropriate PPE, the following decontamination procedure must be undertaken:

1. Immediately wet down the person with fine spray / mist of water;
2. The person must then walk to the nearest shower facility (if not, vehicles or machinery may become contaminated);
3. Gently remove all contaminated clothing and place in a sealed bag;
4. Shower to remove all dust and asbestos fibres with particular focus on the hair, face, hands and fingernails;
5. Change into clean clothing; and
6. The bag must be labelled with "Asbestos Waste" and disposed of appropriately.

All personnel assisting with the decontamination procedure must wear a P2 dust mask. The incident must then be reported to the Site Supervisor. The Site Supervisor must enter the incident into the Asbestos Register / Incident Register.

8 Records

All acceptance, rejection and disposal of asbestos must be recorded in an Asbestos Register. Following inspection of all declared and non-declared waste loads, the Weighbridge Attendant will either accept or rejected loads. Both accepted and rejected asbestos loads are to be entered into the Asbestos Register.

The details required for both accepted and rejected asbestos loads includes:

- Date;
- Name;
- Contact details;
- Vehicle registration;
- Source of asbestos;
- Estimated quantity of asbestos; and
- Accepted or rejected

Following appropriate disposal of asbestos loads, the Site Operator / Site Supervisor must sign the Asbestos Register within 2 hours of burial of the waste to confirm asbestos has been disposed of appropriately according to these procedures.

Any asbestos related incidents must also be recorded in the Asbestos Register. Records of any asbestos incidents must be kept for a minimum of 40 years.

9 Asbestos Management Process

Figure 9-1 summarises the correct asbestos management process.

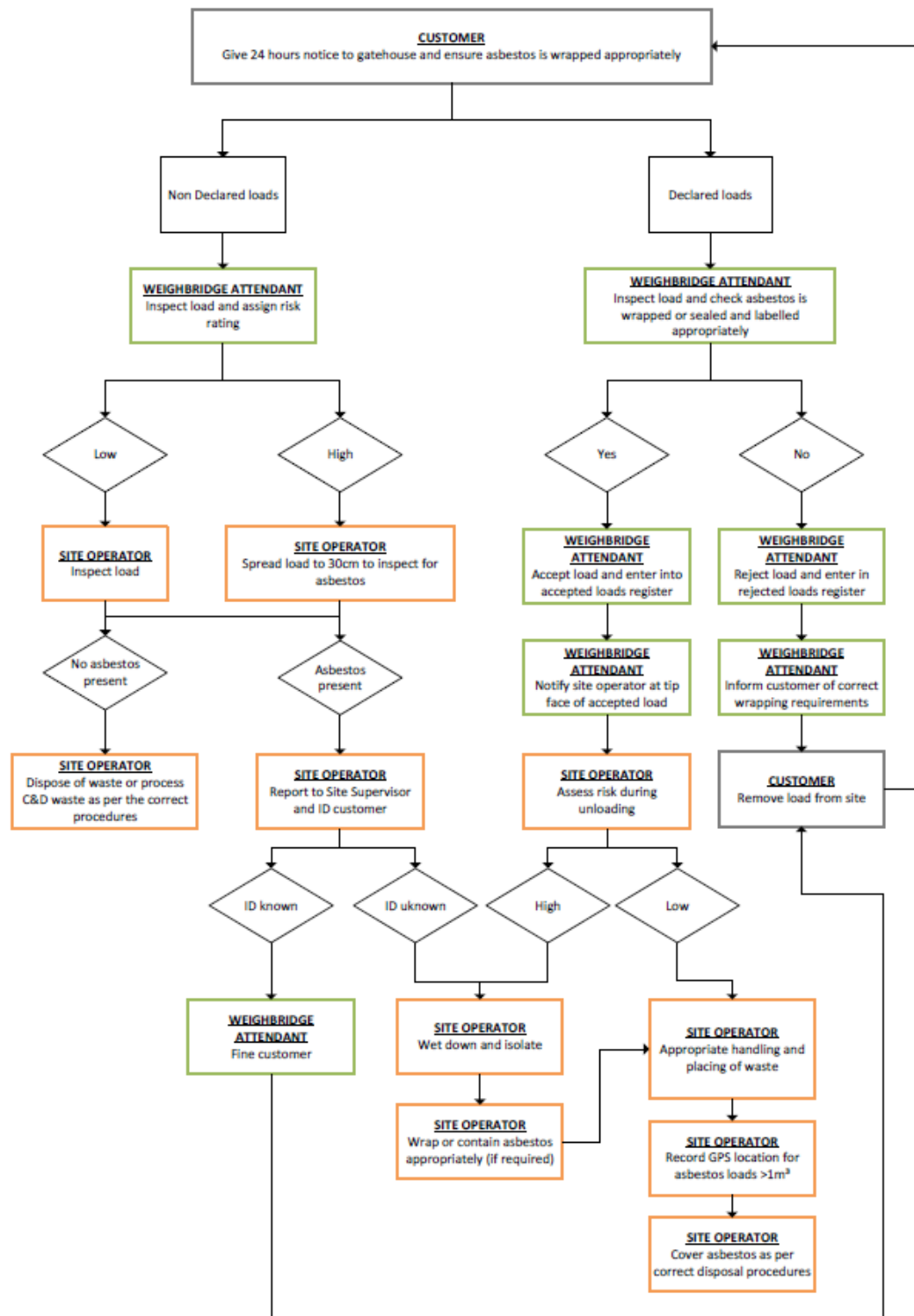


Figure 9-1: Asbestos Management Process

10 References

Department of Environment and Conservation (2012) Guidelines for Managing Asbestos at Construction and Demolition Waste Recycling Facilities

Department of Environment and Conservation (2007) Disposal of Material Containing Asbestos

Department of Health (2009) Guidelines for Asbestos-Contaminated Sites

Environmental Protection (Controlled Waste) Regulations 2004

Health (Asbestos) Regulations 1992

National Occupational Health and Safety Commission (2005) Code of Practice for the Management and Control of Asbestos in the Workplace [NOHSC: 2018 (2005)]

National Occupational Health and Safety Commission (2005) Code of Practice for the Safe Removal of Asbestos 2nd Edition [NOHSC: 2002(2005)]

Worksafe Victoria (2010) Coveralls used for asbestos removal

Worksafe Victoria (2008) Compliance Code: Removing Asbestos in Workplaces

APPENDIX A

Examples of Asbestos Containing Materials

See Next Page

A

Air-conditioning ducts: exterior or interior acoustic and thermal insulation

Asbestos cement sheet underlays for vinyl

Asbestos cement storm drain pipes

Arc shields in lift motor rooms or large electrical cabinets

Asbestos cement water pipes (usually underground)

Asbestos-based plastics products - as electrical insulates and acid-resistant compositions or aircraft seat

Asbestos-containing laminates (e.g. formica) used where heat resistance is required, e.g. ships

Asbestos ceiling tiles

Asbestos-containing pegboard

Asbestos cement conduit

Asbestos felts

Asbestos cement electrical fuse boards

Asbestos marine board, e.g. marinate

Asbestos cement external roofs and walls

Asbestos mattresses used for covering hot equipment in power stations

Asbestos Cement in the use of form work when pouring concrete

Asbestos paper used variously for insulation, filtering and production of fire resistant laminates

Asbestos cement sheet internal over exhaust canopies such as ovens, fume cupboards, etc.

Asbestos cement internal flues and downpipes

Asbestos cement moulded products such as gutters, ridge cappings, gas meter covers, cable troughs and covers

Asbestos roof tiles

Asbestos textiles

Asbestos cement pieces for packing spaces between floor joists and piers

Asbestos textile gussets in air-conditioning ducting systems

Asbestos cement (underground) pits, as used for traffic control wiring, telecommunications cabling, etc

Asbestos yarn

Autoclave / steriliser insulation

Asbestos cement render, plaster, mortar and coursework

Asbestos cement sheet

Asbestos cement sheet behind ceramic tiles

Asbestos cement sheet

Asbestos cement sheet behind ceramic tiles

B

Bitumen-based water proofing such as malthoid, typically on roofs and floors but also in brickwork

Bituminous adhesives and sealants

Boiler gaskets

Boiler insulation, slabs and wet mix

Brake disc pads

Brake linings

C

Cable penetration insulation bags (typically Telecom)

Calorifier insulation

Car body filters (not common)

Caulking compounds, sealant and adhesives

Cement render

Chrysotile wicks in kerosene heaters

Clutch faces

Compressed asbestos cement panels for flooring, typically verandas, bathrooms and steps for demountable buildings

Compressed asbestos fibres (CAF) used in brakes and gaskets for plant and automobiles

D

Door seals on ovens

Gauze mats in laboratories / chemical refineries

E

Electric heat banks - block insulation

Electric hot water services - normally not asbestos but some millboard could be present

Exhausts on vehicles

F

Fire blankets

Fire curtains

Fire door insulation

Fire-retardant material on steel work supporting reactors on columns in refineries in the chemical industry

Fire-rated wall rendering containing asbestos with mortar

Fire-resistant plaster board, typically on ships

Filler in acetylene gas cylinders

Flexible hoses

Floor vinyl sheets

Floor vinyl tiles

Fuse blankets and ceramic fuses in switchboards

G

Gaskets - general

Galbestos™ roofing materials (decorative coating on metal roof for sound proofing)

Gaskets - chemicals, refineries

Gloves - asbestos

H

Hairdryers - insulation around heating elements

Electric light fittings, high wattage, insulation around fitting (and bituminised)

Header (manifold) insulation

Electrical switchboards – see Pitch-based

I

Insulation in electric reheat units for air-conditioner systems

Insulation blocks

L

Laboratory bench tops

Laboratory fume cupboard panels

Lagging in penetrations in fireproof walls

Laboratory ovens - wall insulation

Lagged exhaust pipes on emergency power generators

Limpet asbestos spray insulation

Locomotives - steam; lagging on boilers, steam lines, steam dome and gaskets

M

Mastics

Sprayed insulation - fire retardant sprayed on nut internally, for bolts holding external building wall panels

Millboard between heating unit and wall

Millboard lining of switchboxes

Mortar

P

Packing materials for gauges, valves, etc., can be square packing, rope or loose fibre

Paint, typically industrial epoxy paints

Packing material on window anchorage points in high rise buildings

Penetrations through concrete slabs in high rise buildings

Pipe insulation including moulded sections, water-mix type, rope braid and sheet

Pitch-based (e.g. zelemite, ausbestos, lebah) electrical switchboard

Plaster and plaster cornice adhesives

R

Refractory linings

Refractory tiles

Rubber articles - extent of usage unknown

S

Sealant between floor slab and wall, usually in boiler rooms, risers or lift shafts

Sealant or mastik on windows

Lifts shafts - asbestos cement panels lining the shaft at the opening of each floor, and asbestos packing around penetrations

Sealants and mastics in air conditioning ducting joints

Spackle or plasterboard wall jointing compounds

Sprayed insulation - acoustic wall and ceiling

Sprayed insulation - beams and ceiling slabs

Trains - Harris cars - sprayed asbestos between steel shell and laminex

Trains - country - guards vans - millboard between heater and wall

Stoves - old domestic type; wall insulation

T

Tape and rope - lagging and jointing

Tapered ends of pipe lagging, where lagging is not necessarily asbestos

Tilux sheeting in place of ceramic tiles in bathrooms

Trailing cable under lift cabins

V

Valve, pump, etc. insulation

W

Welding rods

Woven asbestos cable sheath



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APPENDIX B

Asbestos Concentration Thresholds

The following table details the asbestos limit applicable to this sampling plan:

Table B-1: Asbestos Limit

<i>Output</i>	<i>Parameter</i>	<i>Limit</i>
<i>Recycled Drainage Rock</i>	<i>Asbestos (in any form)</i>	<i>0.001% w/w</i>
<i>Recycled Road Base</i>		

The following equation allows for the calculation of Asbestos concentrations based in the weight of ACM for a given soil.

$$\% \text{ Soil Asbestos} = \frac{\% \text{ Asbestos Content} \times \text{ACM (kg)}}{\text{Soil Volume (L)} \times \text{Soil Density (kg/L)}}$$

Where:

% Asbestos Content (within asbestos cement materials) = 15%

Soil Density* (For typical recycled concrete aggregate uncompacted) = 1.2 kg/L

ACM (kg)= provided by the analytical laboratory

Soil Volume (L)= Provided by the analytical laboratory

* Density value sourced from

http://www.alexfraser.com.au/section/Roadbase_and_Aggregate_Materials/Queensland_Product_List



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PROPOSED REGIONAL RESOURCE RECOVERY PARK (RRRP) ODOUR IMPACT ASSESSMENT

SHIRE OF BROOME



Proposed Regional Resource Recovery Park (RRRP) Odour Impact Assessment



Project Ref: EAQ-22005
July 2022



Environment | Air Quality



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Signature

A handwritten signature in black ink, appearing to be "John Hurley", written over a light blue grid background.

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1 Background

Environmental & Air Quality Consulting Pty Ltd (EAQ) was engaged by Talis Consultants Pty Ltd (Talis) on behalf of the Shire of Broome (the Shire) to undertake a Works Approval Odour Impact Assessment (OIA) of the Shire's proposed Regional Resource Recovery Park (the RRRP) which is proposed to be located approximately 12 kilometres north-east of the Town of Broome.

The RRRP will replace the Shire's existing waste management site located on Buckleys Road.

The RRRP will encompass a new Landfill for inerts and putrescible wastes disposal, and a Community Recycling Centre (CRC) allowing the public to drop-off materials for reuse, recycling, and disposal. The RRRP will also have supporting infrastructure for surface water and leachate runoff containment and reuse.

In addition to the proposed Landfill and CRC, the Shire will also have a Liquid Waste Facility (LWF) for the treatment of domestic and commercial liquid wastes. The LWF will comprise of a Sullage Facility, and Industrial Liquid Waste Facility. The Sullage Facility is intended to accept septage, sludges, and grease traps, while the Industrial Liquid Waste Facility will accept other commercial liquid waste streams such as industrial wash-waters and waste oils. The Shire will manage these wastes at the LWF through a series of receival and evaporation ponds.

The Works Approval application process is regulated by the Western Australia (WA) Department of Water and Environmental Regulation (DWER) under Part V of the *Environmental Protection Act 1986* (EP Act). The OIA will support the Shire's application for Environmental Approvals including referral to the Environmental Protection Authority (EPA) and Works Approval to the WA DWER to construct and operate the RRRP.

The Shire has completed preliminary designs for the RRRP, and its intent is to provide a contemporary, best-practice waste facility commensurate with the needs of the Shire of Broome to facilitate improved waste management for residential, commercial and local government waste streams.

The RRRPs' proposed wastes acceptance are listed in **Table 1-1**.

Table 1-1: Proposed Waste Receipts Schedule

Waste Type/Activity	Details	Maximum estimated (tpa)
Landfill		
Class II or III putrescible landfill	20 tonnes or more per annum	25,000
Community Recycling Centre (CRC)		
Construction and Demolition (C&D)	Stockpiling and processing	40,000
Tyres	Recycling Drop-off	6,000
Hazardous Household Wastes	Waste acceptance	100,000
Reuse Shop	Homewares	
Greenwaste	Greenwaste and timbers	
General Recycling	White goods, e-wastes, drums, gas bottles, tyres	
Mixed Wastes	General wastes	
Stockpiling and processing	Clean fill, glass, light vehicles, scrap metal	
Total Waste Acceptance (tpa)		171,000
Waste Type/Activity	Details	Maximum annual estimated (m ³)
Liquid Waste Facility (LWF)		
K110 – Waste from grease traps	Putrescible and organic wastes	5,000
K130 – Sewage wastes	Water Corporation wastes	
K210 – Septage wastes	Septic tank wastes	
L100 – Car and truck wash waters	Industrial wash water	10,500
L150 – Contaminated wash waters		
J120 - Waste oils and water mixture emulsions, and hydrocarbon and water mixtures or emulsions		
Maximum LWF Annual Volume Acceptance (m³)		15,500

For the purposes of this OIA, receipts of putrescible wastes primarily comprised of Shire household kerbside collections, and including commercial putrescible and co-mingled wastes, together with greenwastes, and liquid waste streams are the primary waste receipts of consideration that pose a potential risk of odour emissions from the RRRP.

At this stage of the Shire's progress toward best practices for waste management, Food Organics Garden Organics (FOGO) waste streams are not received and recycled as per other contemporary waste management facilities and metropolitan areas. Greenwastes can be collected through the CRC, however; the current waste bin system for the Shire of Broome utilises a single waste bin for all household wastes which are interned to the Class II Landfill.

1.1 Regulatory Guidance for OIA

The OIA follows the most recent Government of WA DWER Guideline “Odour Emissions” June 2019 document ^[1] where the Guideline provides assessment methods for delivering adequate odour data and information to the DWER for the assessment of applications under Part V of the EP Act; where, *“Part V Division 3 of the EP Act provides the Department with mechanisms for regulating odour, by way of conditions on works approvals and licences applied to prescribed premises”*.

The DWER employs a risk-based approach to its assessment of applications for instruments under Part V of the EP Act.

In determining the risk posed by odour, DWER considers:

- the location, proximity and sensitivity of receptors;
- the management of odour sources and activities;
- the intensity and offensiveness of the odour;
- potential odour impacts from other nearby sources;
- the topography and complexity of terrain;
- the size and / or complexity of the facility when compared with other Australian operations;
- any unusual configuration of odour sources or technology compared with other Australian operations;
- whether the proposal is located in a Strategic Industrial Area (SIA);
- the presence of multiple industry categories which may emit odours on the same site;
- current and cumulative impacts from odour; and
- pathways and impacts on sensitive receptors.

This OIA will comprise a detailed analysis that describes (among others) the processes, odour emission sources, controls and responses in ameliorating potential odour impacts and the pathway(s) for emissions to impact receivers by an analysis of local meteorological trends and problematic conditions.

^[1] [https://www.der.wa.gov.au/images/documents/our-work/licences-and-works-approvals/licensing%20guidelines/Guideline%20-%20Odour%20emissions%20v1.0%20FINAL%20\(June%202019\).pdf](https://www.der.wa.gov.au/images/documents/our-work/licences-and-works-approvals/licensing%20guidelines/Guideline%20-%20Odour%20emissions%20v1.0%20FINAL%20(June%202019).pdf)

2 Broome RRRP Locality

The proposed Broome RRRP is to be located approximately 12 kilometres (kms) north-east from the Broome Township and 3.4 kms north-east from the nearest sensitive receiver (house, public space, etc).

The RRRP will occupy an area of approximately 119 hectares and is separated from sensitive receivers by a flat terrain landscape with negligible terrain height variability of +/-20 metres (m) within a radius of 5 kms from the RRRP. Complex terrain is not evident in the vicinity of the RRRP locality.

The RRRP is to be located 5.7 kms east from the Broome coastline. Ocean circulation of surface air currents across the Broome coastline carries humid air inland that causes fog during the cooler seasonal periods. These dense airflows close to the earth's surface can exacerbate, in general, stagnation of odour plumes at ground level and subsequent extended observations of odours in the vicinity of primary odour sources.

Given the locality of the proposed RRRP, steady-state conditions are likely to prevail. The meteorological conditions are assumed to remain constant during the dispersion pathway from emissions' source to receiver and therefore any odour plume is expected to incrementally disperse as it travels further downwind from the RRRP.

The location of the RRRP satisfies the recommended separation distance for industrial activities where the RRRP, to include the Landfill, CRC and LWF, are within the 1,000 metre screening distance as prescribed within the [DWER Odour Guidance](#).

Structure planning within the locality does not encroach to the location of the RRRP. Local planning opportunities and constraints do not extend to within the RRRP location of north of Broome Road and south of McGuigan Road. Furthermore, the RRRP is not located within an Environmentally Sensitive Area.

The Locality of the RRRP is illustrated in **Figure 2-1** to follow.

Figure 2-2 presents the General Layout Design for the RRRP.

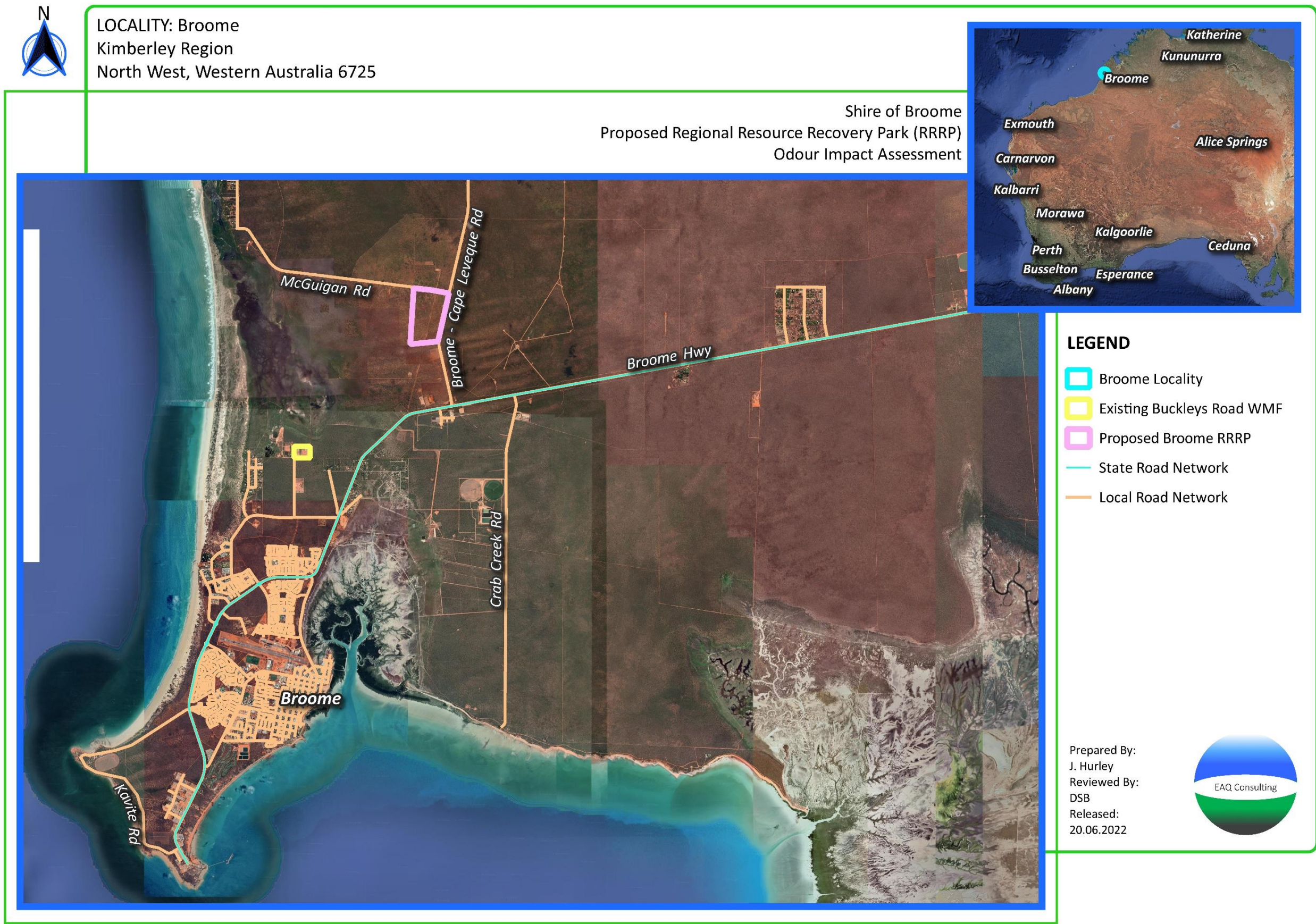


Figure 2-1: Locality of Broome & Proposed RRRP



3 Detailed Analysis

The RRRP will operate within the daily hours of Monday to Saturday 7:30am to 3:30pm, and on Sunday from 8:00am to 2:00pm.

Odours from the RRRP will originate from Landfill activities comprising of daily cover/tarpaulins removal for start-of-shift activities, waste collections' deliveries, active tip face movements and waste internment, and end-of-day daily cover/tarpaulins applications.

The CRC is unlikely to produce odours of a sufficient strength to cause any offsite odour issues, however; greenwastes when shredded, ground and/or composting can generate moderate-high strength odours although these odours are not necessarily offensive as they resemble a clean greenwaste character.

The LWF will be separated into two liquid waste categories comprising Septic wastes and Industrial wastes (Category 61).

Liquid wastes will be received from liquid waste trucks/tankers and/or delivered to the LWF in appropriately designed and sealed containers such as intermediate bulk containers (IBCs). Once received the wastes are unloaded into receival ponds via pipes with shut off valves. Each receival pond has its own truck discharge area, consisting of a three-sided 2 m by 3 m concrete pit with a spillway leading into the receival pond. The solid constituents of the waste will settle in the receival ponds, and the remaining liquid will be directed by gravity into the connected evaporation pond. A transfer pipe from each receival pond leads into the evaporation pond for treatment. The transfer pipe is fitted with a tee piece that is designed to prevent syphoning and transfer of surface crusts. Sunlight and oxygen naturally biodegrade the incoming organic matter and evaporation reduces the volume of liquid waste in the pond system. The remaining sludge will be removed from the ponds and placed in the Class III landfill as required.

3.1 Operational Odour Analysis (OOA)

3.1.1 Proposed RRRP Activities

The RRRP will manage its odour emissions based on the following key procedures:

- Wastes received will be weighed and inspected and must comply with the waste categories set out in the Shire's waste acceptance procedures to include diversion of wastes not meeting the acceptance criteria;
 - Waste type and volumes are monitored by onsite weighbridge operational staff and site operations personnel using waste classification guidelines;
- Discharge of wastes to the Environment are regulated and reported in accordance with the current DWER "Notification of waste discharges" under the EP Act 1986;
- CRC wastes and recyclables are received in accordance with waste acceptance procedures;
- Septic and Industrial Wastes are managed in accordance with the Shire's LWF's acceptance criteria;

- Incoming waste delivery trucks are covered and/or sealed as per contract arrangements;
- Wastes deposited to the Landfill(s) are done so as per designated waste classifications and in accordance with the active face locations;
- Greenwaste are diverted from the Landfill(s) and deposited in designated areas within the CRC (for domestic customers) and the CRC Greenwaste Stockpile and Processing area (for Commercial Customers). Greenwaste at the site is mulched as per the Shire's current operating conditions;
- Litter patrols conducted in accordance with the Shire's management procedures of the RRRP;
- Unsecured loads resulting in lost wastes from incoming/outgoing transport trucks are investigated immediately with cleanup crews deployed as required, contractor is advised of the contractual breach and put on notice;
 - Leachate/waste water trucks cannot leave the RRRP with liquid leaks.
- All outgoing waste transport trucks are covered and secured to control emissions;
- All putrescible (odorous) wastes are received and interned at the Landfill(s) within daily operational timeframes; and
- All putrescible wastes interned at the Landfill(s) will be covered at the end of each day in accordance with Best Practice Environmental Management standards.

The following Operational Odour Analysis **Table 3-1** summarises the proposed RRRP processes, sources of odour emissions, process controls, triggers and corrective actions and overall risk rating for odour impacts.

Table 3-1: Operational Odour Analysis (OOA) of Proposed RRRP Operations & Odour Impact Potential

Odour Source	Dispersion Pathway	Process Description	Process Control	Triggers & Corrective Actions	Corrective Action Evaluation	Contingency Actions	Residual Odour Impact Potential			
							Consequence	Likelihood	Impact Potential (onsite)	Impact Potential (nearest receiver)
Waste Delivery to RRRP for Landfill	Front Gate Ingress – Fugitive losses from Waste Trucks.	Trucks deliver wastes to the RRRP from kerbside collections, council collections and segregated waste streams from public deliveries.	Closed Waste Trucks and covered public loads. Greenwaste deliveries by council and bulk collections unlikely to be covered.	Waste acceptance procedures and protocols – right of refusal.	Regular review of waste acceptance to RRRP.	Right of refusal to remove waste(s) from the RRRP prior to entry to designated waste receival area(s).	Minor	Possible	Medium <i>(localised odours at weighbridge)</i>	Low
Greenwaste Delivery to RRRP for CRC	Front Gate Ingress – Fugitive losses from Public deliveries.	Trucks deliver greenwastes to the CRC Stockpile and Processing Area from council collections and segregated greenwaste streams from public deliveries are accepted at the CRC drop-off area.	Closed Waste Trucks for bulk collections. Greenwaste deliveries by public unlikely to be covered.	Waste acceptance procedures and protocols – right of refusal.	Regular review of waste acceptance to RRRP.	Right of refusal to remove waste(s) from the RRRP prior to entry to designated waste receival area(s).	Minor	Possible		
Landfill Active Face (organic and co-mingled wastes)	Fugitive odours due to: Trucks in motion to the Active Face. Unloading/Tipping of wastes from Trucks. Fugitive losses and odour puffs from stockpiles.	Fugitive losses from Trucks in motion to the Active Face. Unloading of wastes from Trucks creates a 'puff' at the point of tipping and wastes falling from the covered Truck. Loaders interning the wastes agitate the Active Face during spreading, compaction, stacking and daily cover.	Trucks are directed to the Active Face as instructed by onsite operators. The wastes are dumped at designated locations in accordance with the Active Face progression. Minimisation of Active Face working area. Sorting, stacking, compaction of wastes as efficiently as practicable to minimise agitation of wastes and limit Trucks in waiting. Water Carts for dust and subsequent odour suppression at the Active Face as required. Use of Landfill Tarpaulins and/or consideration of use of Alternative Daily Cover (ADC), as required, that can be sprayed onto the tip face providing additional protection by 'sealing' the daily cover. The landfill(s) is only accessed by Site Operators and Commercial customers.	Where an odorous delivery is identified the operators at the Active Face can apply the daily cover to that load to maximise its immediate internment.	Ensuring the Landfill Tarpaulins are effectively applied and within a timely manner, and/or further application of the ADC as efficiently as possible thus avoiding offsite odour complaint.	n/a	Moderate	Possible	Medium	Low

Odour Source	Dispersion Pathway	Process Description	Process Control	Triggers & Corrective Actions	Corrective Action Evaluation	Contingency Actions	Residual Odour Impact Potential			
							Consequence	Likelihood	Impact Potential (onsite)	Impact Potential (nearest receiver)
Greenwastes	Fugitive losses from deliveries. Odour losses as puffs and fugitive, passive emissions from stockpiles.	Commercial Trucks delivering greenwaste to Greenwaste Stockpile and Processing Area. Public trailers delivering greenwaste to the CRC greenwaste drop-off area. Clean green wastes from council collections, commercial and public waste streams. Moderate-High Strength Odours may be generated when the green wastes are being shredded and allowed to accumulate as stockpiles where decomposition will occur.	Negligible other than waste acceptance procedures and protocols. Limited Controls in place due to the nature of the activity: Scheduling of green waste shredding (if applicable/as required) to coincide with favourable wind conditions minimising impacts on nearest sensitive receivers. Processing, shredding, and arrangement of green waste stockpiles (as required) as quickly as practicable to minimise the volume of raw materials in the CRC greenwaste area.	Waste acceptance procedures and protocols – right of refusal.	Regular review of waste acceptance to RRRP.	Right of refusal to remove waste(s) from the RRRP prior to entry to designated waste receipt area(s). Cessation of any grinding/shredding activity under those worst-case conditions where prevailing winds effect sensitive receivers on an ongoing basis.	Moderate	Possible	Medium	Low
LWF	Source of odour emissions – Surface evaporation of liquid surface across waste ponds. Fugitive odour losses from minor spills.	The LWF receives liquid wastes from Septic and Industrial waste streams. Wastes are unloaded directly into the waste ponds where solids will settle to the base of the ponds and the surface liquids are evaporated. Solids in the form of sludge are periodically removed from the ponds and interned to the Class III Landfill.	Liquid wastes are received to the LWF either by liquid waste tankers and/or IBCs. Wastes are piped into the settling and evaporation ponds and remain undisturbed until the pond(s) is sufficiently evaporated such that the settled sludges can be removed and interned to Landfill. The LWF ponds and supporting access ways and traffic routes are designed and built for spill and containment to include site runoff and capture. The LWF is only accessed by Site Operators and Commercial customers.	Negligible requirements other than appropriate waste acceptance procedures and protocols.	Right of refusal of incorrectly classified liquid wastes.	Refusal and removal from RRRP prior to accepting the wastes.	Moderate	Possible	Medium	Low
Sludge Removal from LWF Ponds	Ground level passive odour emissions.	Settled sludges are removed by Site Operators and the sludges agitated and malodour released during upheaval and dumping into Class III Landfill.	Removal of sludges from ponds during preferred climatic conditions i.e., no rain, not under northerly winds.	n/a	n/a	Cessation of sludge removal and immediate internment to Landfill of sludges already removed.	Moderate	Possible	Medium	Low

FIDOL factors are also important in considering the risk of odour impacts on sensitive receivers. These factors are dimensions of odour nuisance, and are:

- Frequency of odour impacts;
- Intensity (or strength) of the odour;
- Duration of the exposure events;
- Offensiveness of the odour; and
- Location of the impacts (the sensitivity of the receiving environment).

When considering the FIDOL factors within this OIA, the following key points are relevant:

- i) Frequency of odour emissions from the Landfill Active Face and internment activities are continuous within operational hours;
 - Intensity of odours from the inert and putrescible co-mingled wastes' Landfill will be localised to within the range of 500 - 1,000 metres based on everyday active face activities.
- ii) Frequency of odour emissions from Greenwaste receivals and stockpiling are unlikely to generate offsite odour impacts unless those greenwastes are ground/shredded and stockpiled where decomposition is allowed to persist;
 - Intensity of odours from the everyday greenwaste activities, not including grinding/shredding will have a negligible malodour impact offsite of the RRRP.
- iii) Frequency of odour emissions from the LWF Ponds' surfaces are continuous daily;
 - Intensity of odours from the LWF Ponds' surfaces will be dependent on atmospheric conditions, in particular ambient temperatures, wind speed and periodic inversion events where cold, dense air is trapped close to ground level that may exacerbate existing ground level odour impacts.

Given the large separation distances between the RRRP and the nearest sensitive receiver at a distance of > 3 kms to the south-west, under normal operating processes and typical atmospheric conditions the likelihood of any odours generated at the RRRP impacting the nearest sensitive receiver is *Unlikely-Rare*.

3.2 Local Meteorological Analysis

The nearest Bureau of Meteorology (BoM) Automatic Weather Station (AWS) is located at the Broome Airport ([AWS # 003003](#)) which is approximately 10 kms south-west of the RRRP.

The terrain features across the Locality where the AWS and RRRP reside are comparable, as are the coastal proximities of the AWS and RRRP such that coastal influences at the AWS would represent weather characteristics at the RRRP.

Atmospheric dispersive conditions that are free of complex terrain influences will exist across the RRRP.

EAQ analysed the last five (5) years of 2017-2022 inclusive to determine dominant meteorological conditions within the Locality.

A Wind Rose analysis of the meteorological output is presented in **Figure 3-1**.

The prominent frequency of winds in the locale are from the west (5-Year Annual Resultant Vector of 263°).

This is also the case in summer and spring. During autumn and winter the winds prevail from the south-east quadrant.

Winter is the seasonal period most likely to bring about an odour complaint offsite from the RRRP given the frequency of calm winds is 9.51 % annually. However, the prevailing winds during winter originate from the south-east. Under this wind direction the nearest sensitive receiver to the north-west is at least 5.3 kms from the RRRP boundary and an even greater distance from the RRRP LWF Ponds. This separation distance is significant and affords a high level of protection from malodour impacts.

The wind vector between 360° and 45° i.e., north through north-east origin is the wind origin needed to push RRRP odours toward the nearest southern receiver and the Town of Broome. This occurs for < 9 % over the 5-year analysis period (**refer Table 3-2**).

Between the daily hours of 7:00am – 6:00pm (inclusive), which represents daily activities at the RRRP, those north through north-east winds occur for < 5 % over the 5-year analysis period.

Figure 3-2 illustrates the 5-year wind trends between the daily hours of 7:00am – 6:00pm (inclusive), which represents start-of-day activities, daily procedures, and end-of-day daily cover and settling and shows that calm wind percentages have decreased from the 24-hour total of 5.20 % to 1.05 % with an average wind speed of 4.73 m/s.

This 1.05 % represents the percentage of calm winds that will occur across 7-days during RRRP operational hours and allowing for the lead-up and shut-down periods of each day.. The RRRP daily operations occur Monday – Saturday during the hours of 7:30am to 3:30pm, and on Sunday from 8:00am to 2:00pm.

Table 3-2: Frequency Count of Wind Speed and Direction (Broome Airport AWS 5-year)

Directions / Wind Classes (m/s)	0.50 - 2.00	2.00 - 4.00	4.00 - 6.00	6.00 - 8.00	8.00 - 10.00	>= 10.00	Total
355 - 5	242	289	91	33	6	0	661
5 - 15	295	216	55	17	2	0	585
15 - 25	288	169	38	16	1	0	512
25 - 35	268	160	38	9	3	2	480
35 - 45	204	137	40	19	3	3	406
45 - 55	158	152	51	23	3	1	388
55 - 65	150	182	105	43	6	0	486
65 - 75	159	231	203	57	7	2	659
75 - 85	163	293	294	131	11	0	892
85 - 95	174	493	407	237	35	1	1347
95 - 105	142	732	410	253	91	13	1641
105 - 115	173	865	489	208	51	12	1798



115 - 125	121	837	731	327	66	17	2099
125 - 135	103	624	689	329	47	16	1808
135 - 145	87	620	513	104	12	8	1344
145 - 155	89	567	377	39	14	0	1086
155 - 165	70	520	273	38	17	4	922
165 - 175	100	581	212	12	4	1	910
175 - 185	70	609	129	6	0	0	814
185 - 195	99	470	146	14	0	0	729
195 - 205	93	436	183	9	5	1	727
205 - 215	82	383	175	14	3	1	658
215 - 225	98	423	235	28	8	0	792
225 - 235	125	477	385	102	7	0	1096
235 - 245	132	607	552	140	14	2	1447
245 - 255	152	706	707	219	39	5	1828
255 - 265	100	691	1217	530	71	14	2623
265 - 275	109	648	1571	640	32	11	3011
275 - 285	82	783	1799	660	22	6	3352
285 - 295	87	844	1374	472	8	0	2785
295 - 305	121	684	953	384	15	1	2158
305 - 315	110	623	715	381	27	3	1859
315 - 325	120	418	461	248	42	1	1290
325 - 335	165	317	278	134	23	1	918
335 - 345	156	205	141	82	20	1	605
345 - 355	146	222	78	36	10	3	495
Sub-Total	5033	17214	16115	5994	725	130	45211
Calms							2487
Missing/Incomplete							85
Total							47783

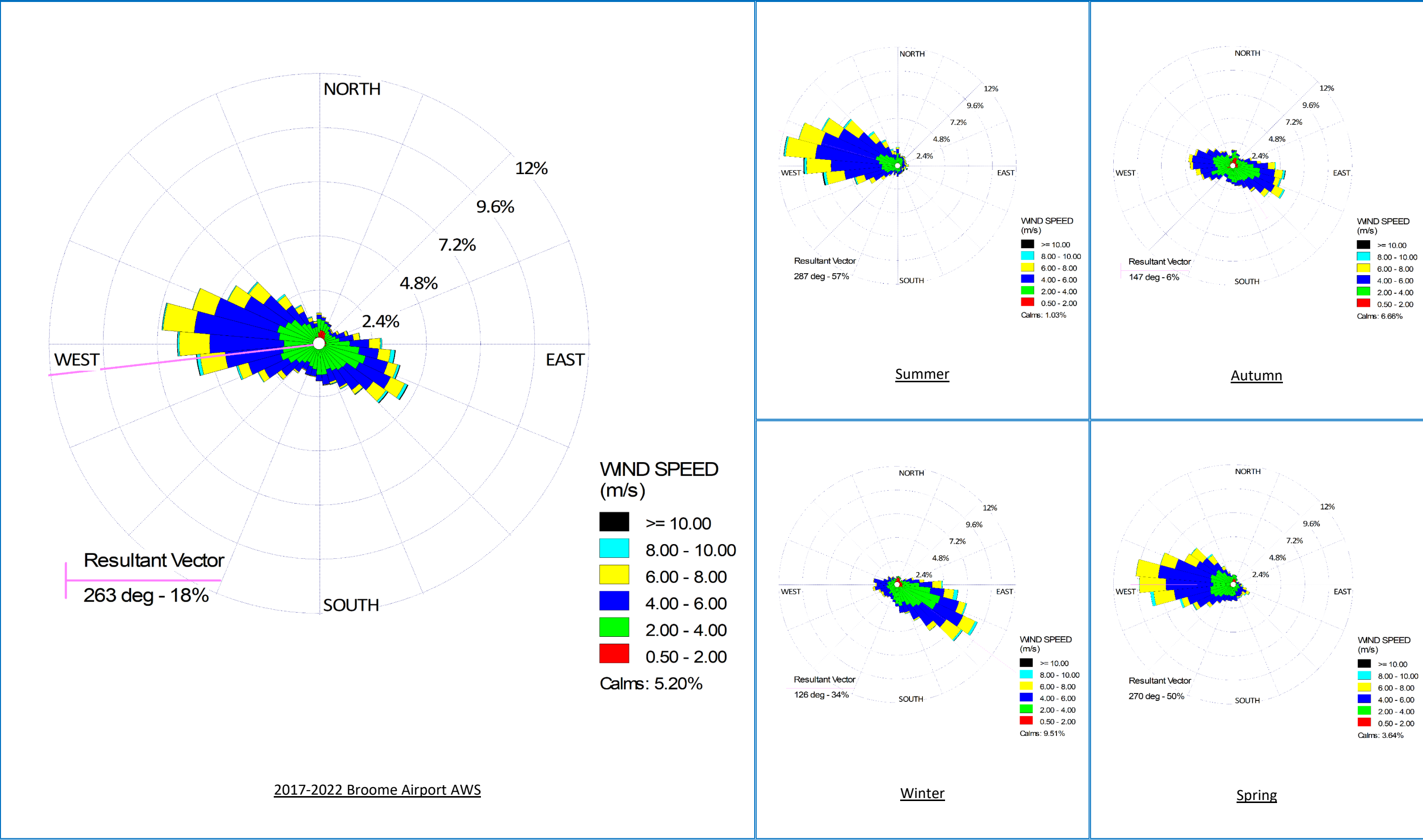


Figure 3-1: Wind Characteristics of Direction and Velocity Frequencies (5-Year Annual and Seasonal)

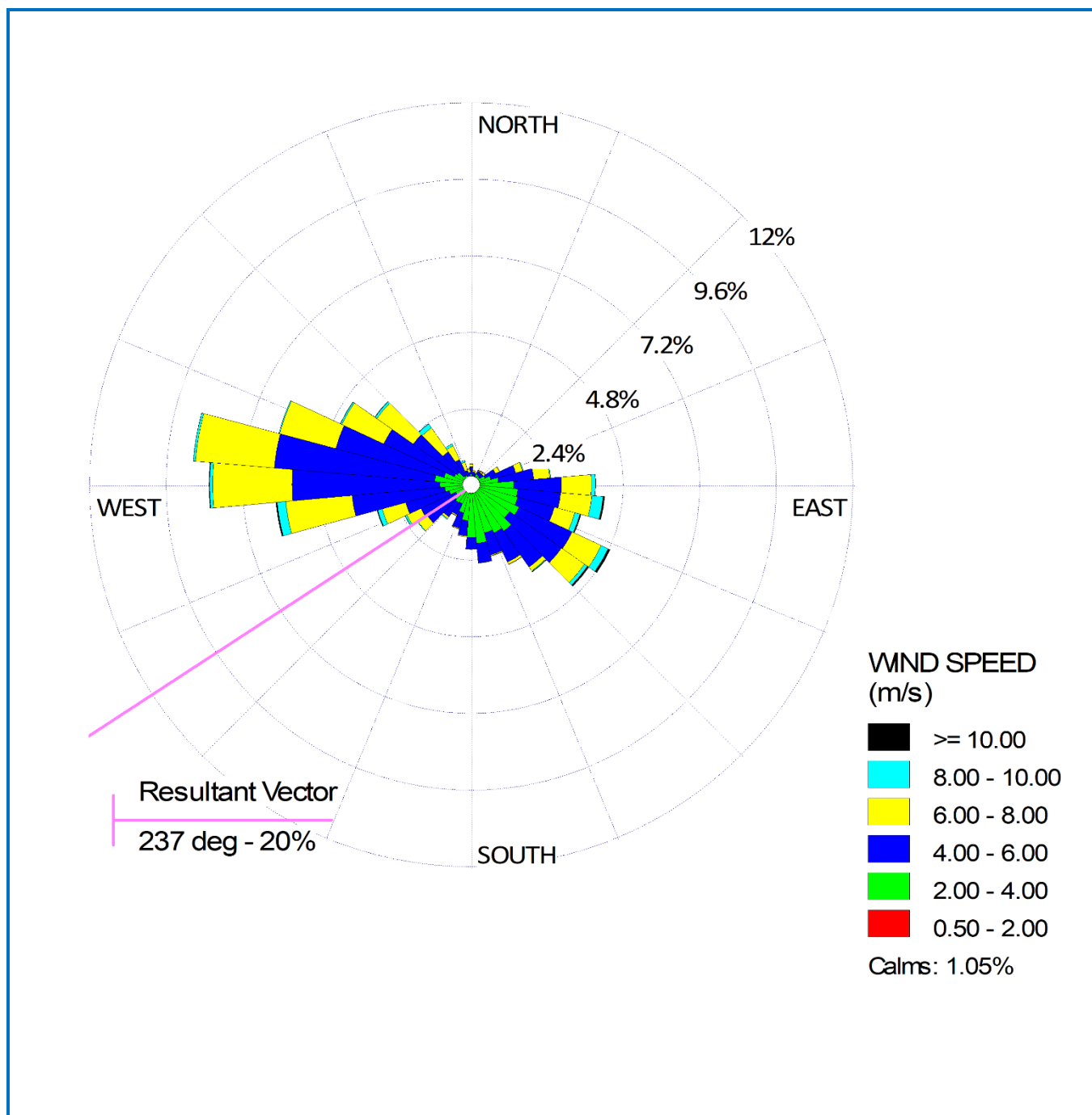


Figure 3-2: Wind Characteristics of Direction and Velocity Frequencies (5-Year 7am-6pm)



3.3 Risk Evaluation

In consideration of the DWERs' Guidance Statement: [Risk Assessments \(2020\)](#), the proposed RRRP, assuming uncontrolled release of odours under normal procedures, *Consequence* of odour impacts at the nearest sensitive receiver is in the view of EAQ Moderate; where:

- Onsite impacts: mid-level;
- Offsite impacts local scale: low-level; and
- Offsite impacts wider scale: minimal.

And, the *Likelihood* of the risk occurring is Rare, where:

- The risk event may only occur in exceptional circumstances.

Based on this assessment of the risk criteria under an exceptional event where uncontrolled odours are released to the environment, the future risk is considered to be Medium.

On this basis the Risk Treatment would therefore be:

- Acceptability – Acceptable, generally subject to regulatory controls; and
- Treatment – Risk event is tolerable. DWER may apply some regulatory controls, including outcome-based conditions where practical and appropriate.

Where;

- Outcome-based conditions for licensing of the RRRP is the most likely and appropriate outcome given the sufficient separation distances and favorable meteorological conditions that affords a high level of protection for offsite sensitive receivers.

4 Summary Table for Detailed Analysis

Detailed analysis tools	Tick if used	Comments
Emission source		
Operational odour analysis (OOA) (priority tool)	<input checked="" type="checkbox"/>	Section 3.1
Odour source assessment (OSA)	<input type="checkbox"/>	n/a
Pathway and receptor		
Location review ("highly recommended")	<input checked="" type="checkbox"/>	Section 2
Meteorological Review	<input checked="" type="checkbox"/>	Section 3.2
Odour field assessment (OFA)	<input checked="" type="checkbox"/>	n/a other than standard site visit for familiarization
Complaints data analysis	<input type="checkbox"/>	n/a
Community surveys	<input type="checkbox"/>	n/a
Comparative dispersion modelling	<input type="checkbox"/>	As required, but not within this OIA
Comparison with similar operations	<input type="checkbox"/>	n/a



Broome Resource Recovery Park and Community Recycling Centre

Environmental Noise Assessment



Prepared for Shire of Broome

8 September 2022

Project Number: TN21051-1

DOCUMENT CONTROL					
Version	Description	Date	Author	Reviewer	Approver
0	Draft – issued for internal review	12/07/2022	LA	GB	
1	First Issue for client review	13/07/2022	LA	MM	GB
2	Second Issue	12/08/2022	LA		GB
3	Third Issue	08/09/2022	LA		GB

Executive Summary

The Shire of Broome is proposing to develop the Broome Regional Resource Recovery Park (the Project) at Site D2, which is located at the intersection of McGuigan Road and Broome-Cape Leveque Road, 12km northeast of Broome.

Development of the Project will consist of a fully integrated waste management facility including Class III landfill for inert and putrescible waste disposal and a Community Recycling Centre (CRC) allowing the public to drop-off materials for reuse, recycling, and disposal. The Project will also have a Liquid Waste Facility (LWF) for the treatment of domestic and commercial liquid wastes. The LWF will comprise of a Sullage Facility, and Industrial Liquid Waste Facility. The Sullage Facility is intended to accept septage, sludges, and grease traps, while the Industrial Liquid Waste Facility will accept other commercial liquid waste streams such as industrial wash-waters and waste oils. The Shire will manage these wastes at the LWF through a series of receival and evaporation ponds. In addition, the RRRP will also have supporting infrastructure for surface water and leachate runoff containment and reuse.

This report summarises an environmental noise impact assessment undertaken for the Project.

Aim

The aim of this study is to assess the potential noise impacts of the Project on surrounding noise sensitive receivers, and where applicable, determine noise management measures that are required to achieve compliance with the Environmental Protection (Noise) Regulations 1997.

Noise Modelling

This report has modelled and assessed the worst-case noise emissions associated with the proposed Project plant, vehicles, and equipment at site D2. It includes noise emissions from fixed plant, mobile equipment and vehicles and trucks on the site. It excludes noise from traffic travelling on gazetted roads (i.e. Broome-Cape Leveque Road).

Model Results

Table E 1 gives a summary of the noise model results at the sensitive receivers identified by the study.

Table E 1 Noise Model Results

Ref	Receiver	Night-time LA10 Assigned	Predicted LA10
R1	Morrell Park	35	18.9
R2	Coconut Wells 1	35	10.5
R3	Coconut Wells 2	35	9.9
R4	Coconut Wells 3	35	8.0
R5	12 Mile	35	4.8

Ref	Receiver	Night-time LA10 Assigned	Predicted LA10
R6	Buckley's Bush Retreat	35	16.7

Outcomes

Based on the outcomes of the noise modelling and analysis, the Project is predicted to comply with the assigned noise levels at all times of day under worst case conditions. As a result, no engineering noise mitigation on the modelled equipment is required or proposed for the Project.

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APPENDIX A Noise Source Levels

1 Introduction

The Shire of Broome is proposing to develop the Broome Regional Resource Recovery Park (the Project) at Site D2, which is located at the intersection of McGuigan Road and Broome-Cape Leveque Road, 12km northeast of Broome (see Figure 2-1).

The development of the Project will consist of a fully integrated waste management facility including Class III landfill for inert and putrescible waste disposal and a Community Recycling Centre (CRC) allowing the public to drop-off materials for reuse, recycling, and disposal. The Project will also have a Liquid Waste Facility (LWF) for the treatment of domestic and commercial liquid wastes. The LWF will comprise of a Sullage Facility, and Industrial Liquid Waste Facility. The Sullage Facility is intended to accept septage, sludges, and grease traps, while the Industrial Liquid Waste Facility will accept other commercial liquid waste streams such as industrial wash-waters and waste oils. The Shire will manage these wastes at the LWF through a series of receival and evaporation ponds. In addition, the RRRP will also have supporting infrastructure for surface water and leachate runoff containment and reuse.

This report summarises an environmental noise impact assessment undertaken for the Project.

1.1 Aim

The aim of this study is to assess the potential noise impacts of the Project on surrounding noise sensitive receivers, and where applicable, determine noise management measures that are required to achieve compliance with the Environmental Protection (Noise) Regulations 1997.

1.2 Scope

This report assesses the noise emissions associated with the Project operations at site D2, in accordance with the Regulations. It includes noise emissions from plant, vehicles, equipment and trucks on the site. It excludes noise from traffic along gazetted roads (i.e. Broome-Cape Leveque Road).

1.3 Applicable Documents

[1] *Environmental Protection Act 1986*.

[2] Environmental Protection (Noise) Regulations 1997.

[3] DWER Draft Guideline “Assessment of environmental noise emissions”, May 2021.

2 Project Overview

The Project Site D2 (shown in Figure 2-1) is located 12 km northeast of the Broome town centre and occupies an area of approximately 119 Hectares. The major areas on-site include:

- Community recycling area
 - Community re-use and recycling
 - Re-use and education shop facilities
 - Waste areas – Mixed waste, green waste, mulch, hazardous waste, recycling.
- Class III landfill
- Liquid waste facility
- Supporting infrastructure

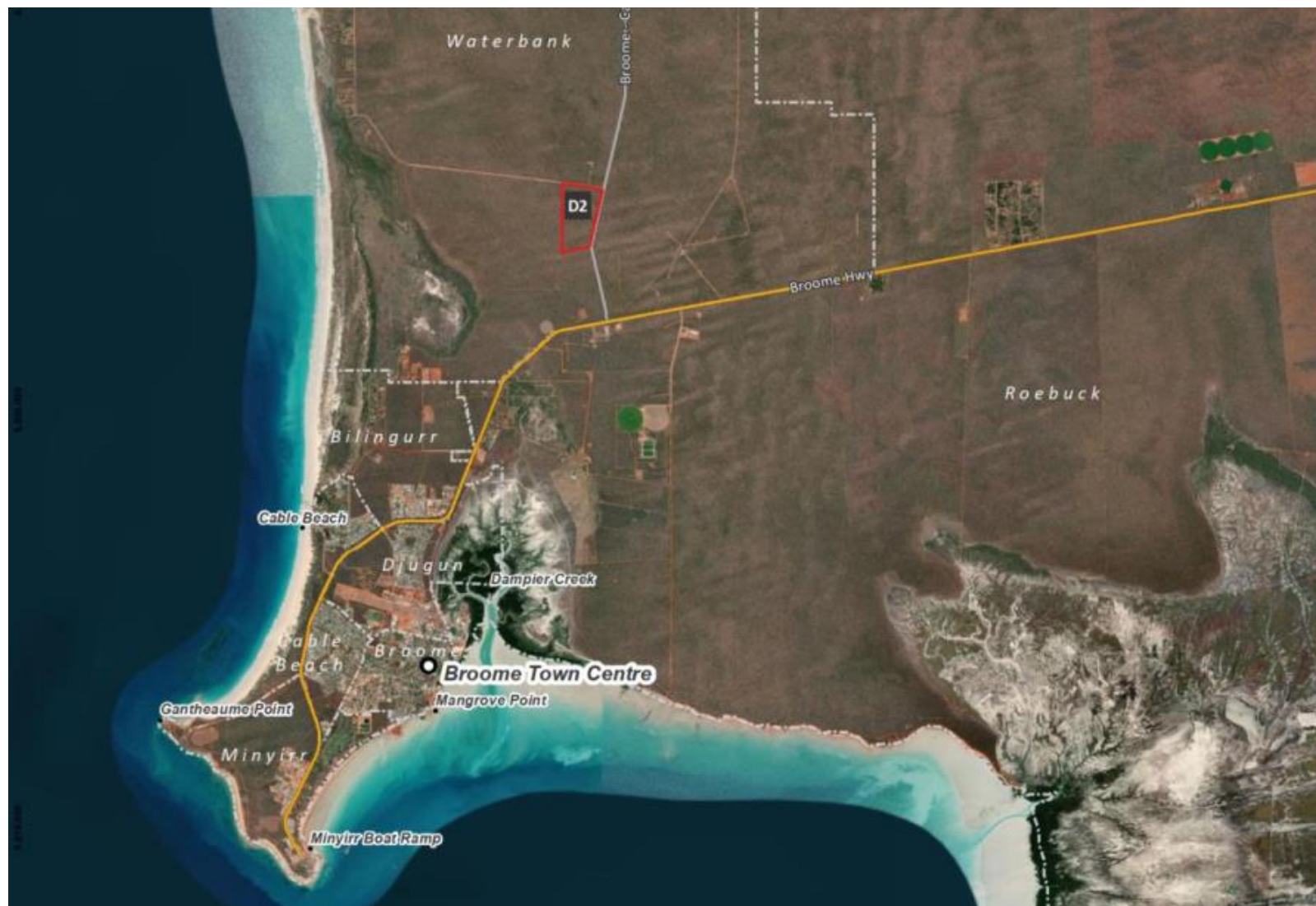


Figure 2-1 Project Location

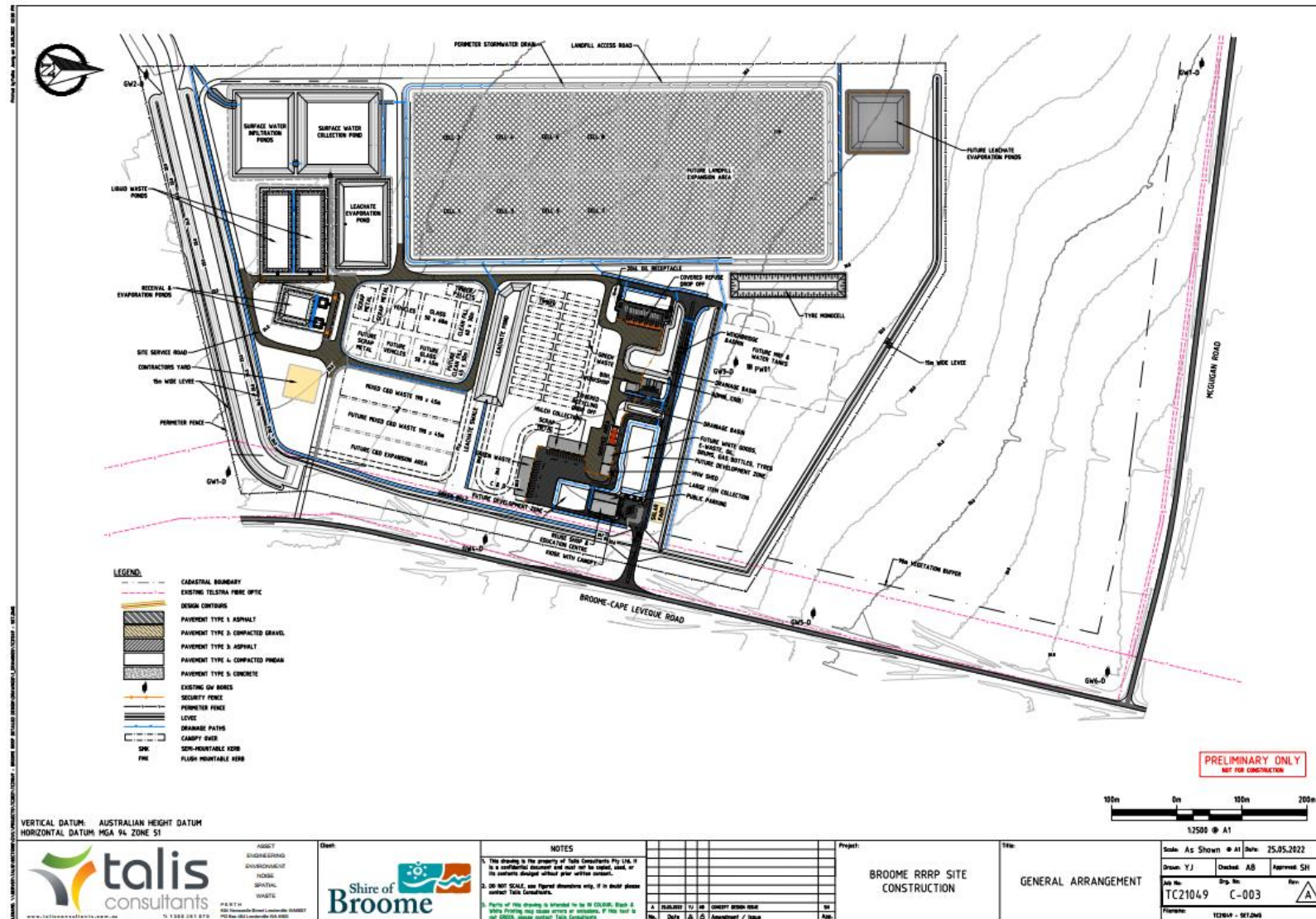


Figure 2-2 Site layout

2.1 Noise generating activities

The operations will comprise landfill activities, compacting, waste sorting, waste storage and community drop-off areas. The major noise generating activities on-site include:

- Mobile equipment - dozers, loaders and landfill compactors.
- Hook-lift trucks / movement of bins.
- Domestic rubbish truck movements.
- Commercial truck movements.
- Light vehicle movements.

There are several other activities which will take place on-site very infrequently (i.e. one day every 6 months or annually) and have therefore not been included in the modelling. These include:

- Scrap metal removal.
- Greenwaste mulching.
- Crushing and screening.
- Bulky item and tyre removal.

2.2 Hours of Operation

The BRRP will operate during the following hours:

- Monday to Saturday 7.30am to 3.30pm.
- Sunday and Public Holidays 8.00am to 2:00pm (note: closed Christmas day and Good Friday).

2.3 Traffic

Table 2-1 provides a summary of estimated daily traffic volumes, which have been provided by the Shire of Broome and have been used in the model.

Table 2-1 Traffic types and volumes

Traffic Type	Quantity / day
Light Vehicles	60
Bin Trucks	8

2.4 Surrounding Communities

An aerial review of the study area has been undertaken to determine the closest residential areas to the facility. Based on this review, six (6) noise sensitive residential receivers have been included in the noise model to represent the nearest communities to the proposed facility. Table 2-2 and Figure 2-3 present the locations used in the model.

Table 2-2 GPS Coordinates of Noise Sensitive Receivers

Ref	Receiver	UTM, MGA94, Zone	
		Eastings	Northings
R1	Morrell Park	422026	8020662
R2	Coconut Wells 1	417252	8027213
R3	Coconut Wells 2	417241	8028304
R4	Coconut Wells 3	417164	8029790
R5	12 Mile	432489	8025400
R6	Buckley's Bush Retreat	418508	8024414



Figure 2-3 Residential Receiver Locations

3 Assessment Criteria

3.1 Environmental Protection (Noise) Regulations 1997

Noise management in Western Australia is implemented via the Environmental Protection (Noise) Regulations 1997 (the Regulations), which operate under the Environmental Protection Act 1986.

The Regulations define maximum allowable noise levels, termed assigned level, which apply to noise received at noise sensitive premises, such as residential areas. These are determined by a combination of a base noise level plus an Influencing Factor (IF).

The assigned noise levels include L_{A1} , L_{A10} and L_{AMAX} noise parameters, defined as:

- L_{ASMAX} means an assigned level which is not to be exceeded at any time.
- L_{AS1} means an assigned level which is not to be exceeded for more than 1% of time.
- L_{AS10} means an assigned level which is not to be exceeded for more than 10% of time.

For noise sensitive premises, the time of day also affects the assigned noise levels. As the facility will operate during night-time hours (i.e. 8:00am-09:00am on Sundays), noise emissions have been assessed against the most stringent night-time assigned levels.

3.2 Assigned Noise Levels

Table 3-1 presents the assigned noise levels defined in the Regulations.

Table 3-1 Environmental Protection (Noise) Regulations - Assigned Noise Levels

Sensitive Receiver	Time of day	Assigned Levels (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Noise Sensitive Premises	0700 to 1900 hours Monday to Saturday	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sundays and public holidays	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours all days	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + influencing factor	45 + influencing factor	55 + influencing factor
Industry Boundary	all times	65	80	90

3.2.1 Influencing Factors

The Influencing Factor (IF) is based on the surrounding land use adjacent to each of the noise sensitive receivers, including the amount (%) of industrial and commercial premises as well as the number and proximity of major and secondary roads.

The following steps were taken to calculate IF.

1. Two circles of radius 100m and 450m centred on each of the identified receivers were drawn.
2. The circles were used to determine and calculate the area of industrial and commercial premises and the presence major/secondary roads within the circles.

Land surrounding the RRRP is public purpose. There is no industrial or commercial areas, nor any major roads. Therefore, no influencing factor is applicable to the assessed receivers.

The calculated IF for all receivers is **0**.

3.2.2 Adjustments for intrusive or dominant characteristics

Received noise levels are subject to adjustments if the noise exhibits intrusive or dominant characteristics i.e. if the noise is impulsive, tonal or modulating. These adjustments, shown in Table 3-2, are cumulative up to a maximum of 15 dB.

Section 9 of the Regulations sets out objective tests to assess whether the received noise is free of these characteristics.

Table 3-2 Adjustments for intrusive and dominant characteristics

Tonality	Modulation	Impulsiveness
+ 5dB	+5 dB	+10 dB

Given the nature of the equipment noise sources on-site and that the distances between the source and receiver is >2.5km, the received noise is not expected to be tonal, impulsive or modulating at the receivers. As a result, no adjustments have been applied to the model predictions in this assessment.

3.2.3 Applicable Noise Criteria

The applicable L_{A10} assigned noise level for all receivers assessed in this study is **35 dB(A)**.

4 Noise Modelling Overview

4.1 Modelling Software

A desktop environmental noise model was created to simulate the facility activities using SoundPlan v8 software program. This software package calculates sound pressure levels at nominated receiver locations and produces noise contours over a defined area of interest. SoundPlan can be used to model industrial noise, traffic noise and aircraft noise.

The inputs required by the SoundPlan modelling software are noise sources, ground topographical and absorption data, meteorological data and sensitive receiver point locations. For this study SoundPlan used ISO9613¹ and the CONCAWE^{2,3} prediction algorithm. The CONCAWE algorithm is accepted by the Department of Water and Environment Regulation (DWER).

The model has been used to predict received noise levels at noise sensitive receiver locations and to generate noise contour maps for the wider area.

4.2 Model Inputs

4.2.1 Noise Sources

The major noise sources on-site include light and heavy vehicle movements, mobile equipment (dozers, compactors, and loaders), hooklift trucks and bin dragging.

For each item, noise source Sound Power Levels (SWLs) have been calculated and allocated to the model using a combination of equipment lists provided which contain the type, make, model and quantities, as well as allocating SWLs from previous noise measurements of similar equipment types. A summary of SWLs used in the modelling are presented in Table 4-1 and spectral data for each source can be found in Appendix A.

For light and heavy vehicles entering and leaving site, a line source has been used to simulate vehicles moving along the site's road infrastructure. This approach has the effect of distributing the energy of the total number of vehicles over a 24hr period along each road for each type of vehicle.

The facility layout, including the modelled source positions, is shown in Figure 4-1.

¹ ISO9613 is used for calculating the absorption of sound during propagation.

² CONCAWE (Conservation of Clean Air and Water in Europe) was established in 1963 by a group of oil companies to carry out research on environmental issues relevant to the oil industry.

³ The propagation of noise from petroleum and petrochemical complexes to neighbouring communities, CONCAWE Report 4/81, 1981.

Table 4-1 SWL's used in modelling

Equipment	Quantity	Location (as shown in Figure 4-1)	SWL per item, dB(A)
Compactor (BOMAG BC572RB)	1	Waste Cell 1	108
Loader (Komatsu WA250PZ)	1		104
Dozer (CAT D6)	1		111
Hooklift Truck (Rhino 500 Bin Lift Truck)	1	Blue Highlighted Track	98.1
Bin Lift Truck (Volvo 450 Bin Lift Truck)	1	Green Highlighted Track	105
Light Vehicles	60 / 8 hr day	Pink Highlighted Track	82 / 51 ⁴
Domestic Bin Trucks	8 / 8 hr day	Yellow Highlighted Track	101 / 70 ⁴

4.2.2 Noise Sensitive Receivers

See section 2.4 for a summary of the noise sensitive receivers used in the model.

4.2.3 Topography and Ground Absorption

Topographical information was imported into the noise model to create a Digital Ground Map (DGM). The acoustic properties of the ground surface influence the propagation of noise. Flat non-porous surfaces such as concrete, asphalt and water are more reflective whereas soft, porous surfaces such as foliage and grass are more absorptive. A ground factor of 0.7 was applied to the model.

4.2.4 Meteorological Conditions

The CONCAWE algorithm has been used to calculate noise levels for user defined meteorological conditions. Table 4-2 gives the worst-case night-time meteorological conditions applied to the model, which are defined in the Department of Water and Environment Regulation (DWER) "Draft Guideline on Environmental Noise for Prescribed Premises".

Table 4-2 Weather conditions applied to the model

Temperature (°C)	Relative Humidity (%)	Wind Speed (m/s)	Wind Direction	Pasquil Stability Class (PSC)
15	50	3	Worst case (source to receiver)	F

4.3 Noise Modelling Scenario

Figure 4-1 presents the noise model layout used to represent the facility noise sources. A conservative approach has been utilised, in that, all equipment is assumed to be operating simultaneously and the model has been run under worst case weather conditions defined in Table 4-2.

⁴Overall SWL / distributed SWL per metre.

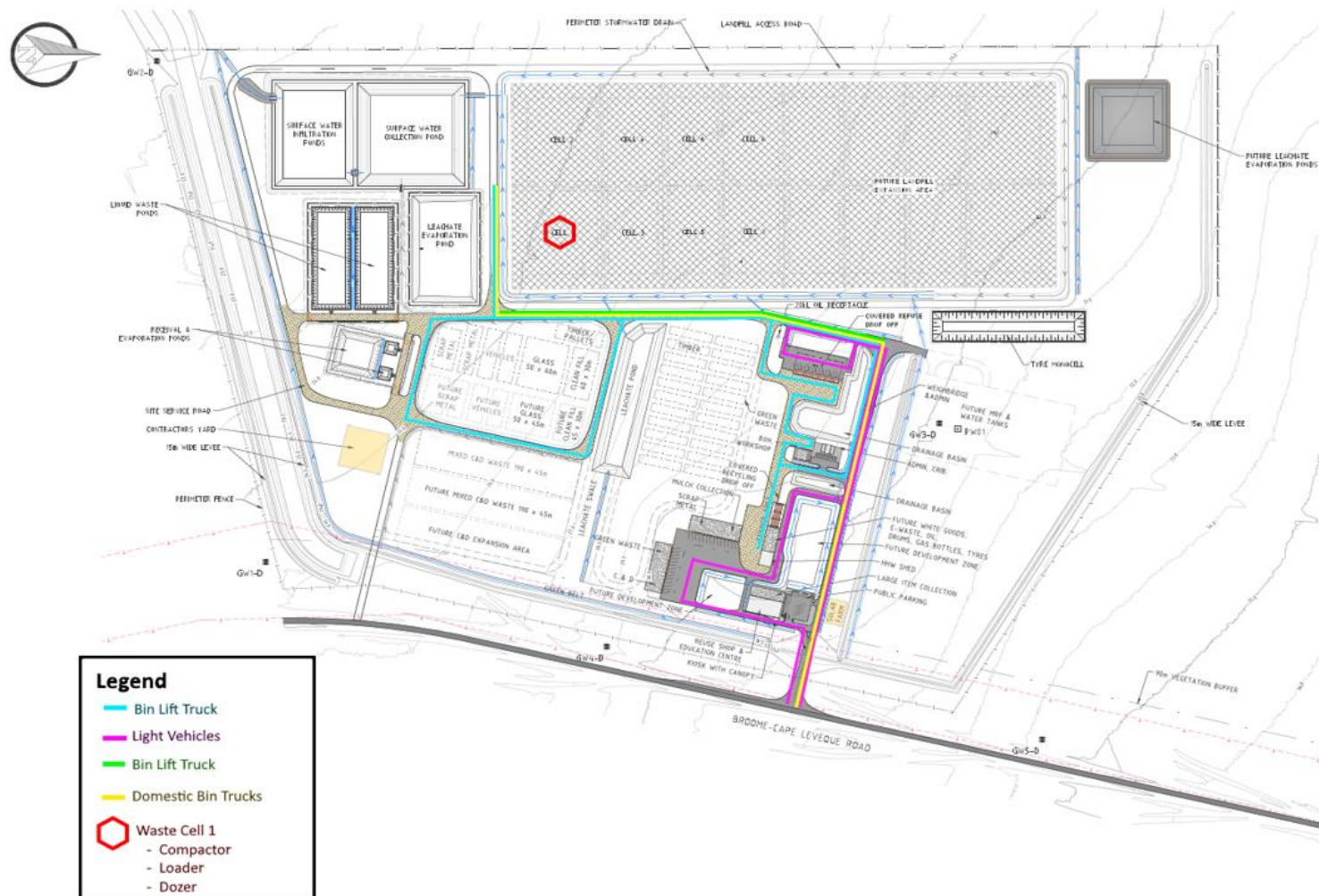


Figure 4-1 Model Layout

5 Noise Modelling Results

Table 5-1 provides the noise model results for the operations, run under worst case meteorological conditions. A noise contour map of the results is provided in Figure 5-1, with the assigned noise level presented as a bold red line.

Table 5-1 Model Results

Ref	Receiver	Night-time LA10 Assigned	Predicted LA10
R1	Morrell Park	35	18.9
R2	Coconut Wells 1	35	10.5
R3	Coconut Wells 2	35	9.9
R4	Coconut Wells 3	35	8.0
R5	12 Mile	35	4.8
R6	Buckley's Bush Retreat	35	16.7

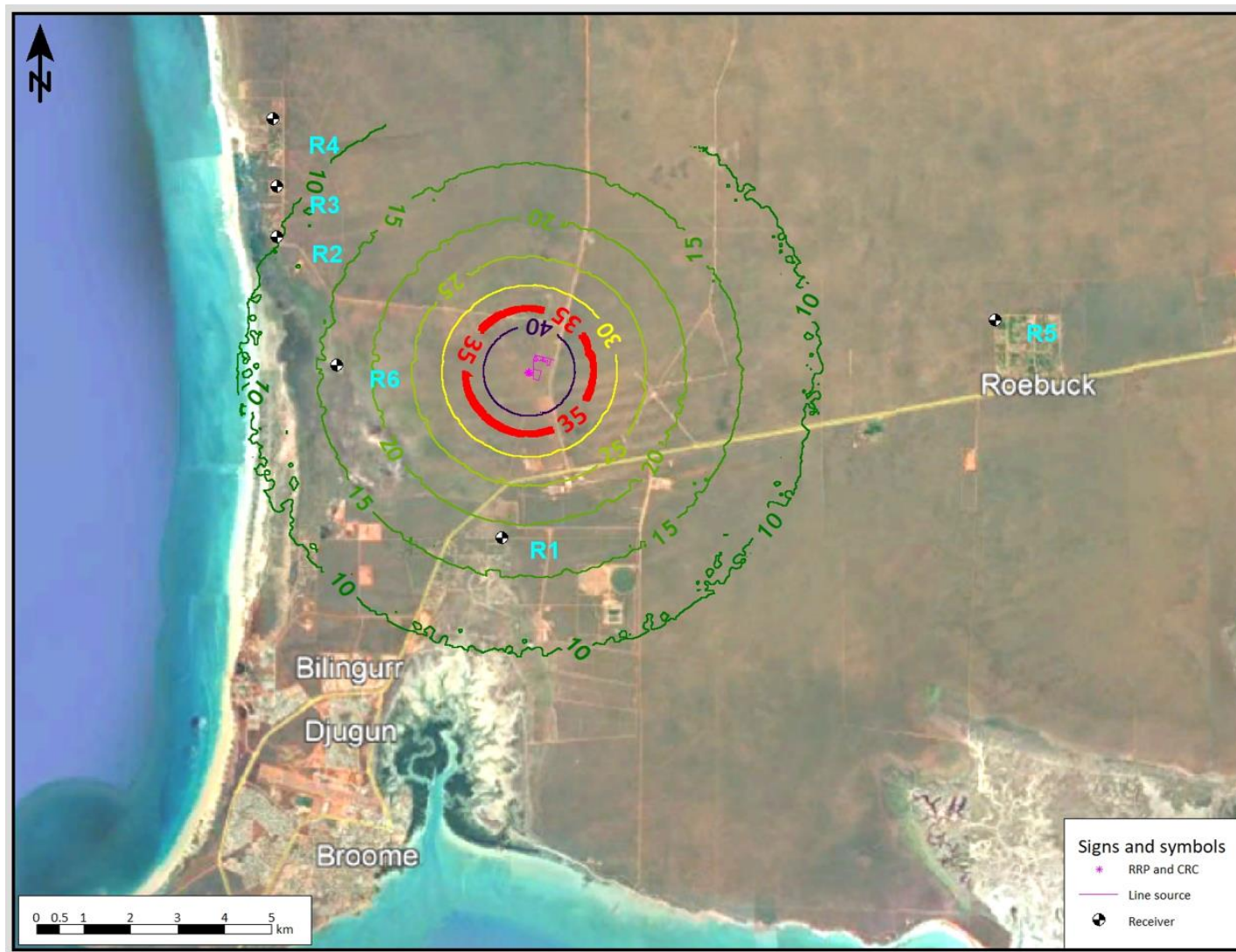


Figure 5-1 Noise Contour Map

6 Conclusions

Based on the outcomes of the noise modelling and analysis, the Broome RRRP Project is predicted to comply with the assigned noise levels at all times of day under worst case conditions.

As a result, no engineering noise mitigation on the modelled equipment is required or proposed for the Project.

APPENDIX A

Noise Source Levels

Noise source	Quantity	Octave Band Levels, dBA									O/A
		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 KHz	2 KHz	4KHz	8KHz	
Bin Trucks	8 / 8hr day	15.6	29.7	30.2	33.1	45.4	46.2	44	36.9	29.2	50.5
Compactor (BOMAG BC572RB-2)	1	81.2	97.9	94.8	93.2	94.6	106.7	98.5	91.2	83.2	108.4
Dozer (CAT D6)	1	85.2	97.1	99.7	96.7	98.1	109.7	101.7	98.5	90.6	111.6
Hooklift Truck	1	61.8	80.5	87.9	89.2	95.2	96.5	94.7	90.3	83.2	101.3
Light Vehicles	60 / 8hr day	15.6	29.7	30.2	33.1	45.4	46.2	44	36.9	29.2	50.2
Loader (Komatsu WA250PZ)	1	77.2	93.9	90.8	89.2	90.6	102.7	94.5	87.2	79.2	104.4



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