GOVERNMENT OF WESTERN AUSTRALIA

Environmental Protection Authority

EPA Referral Form

Form for the referral of a proposal to the Environmental Protection Authority under Section 38 of the *Environmental Protection Act 1986*

Referrer information			
Who is referring this proposal?		☒ Proponent ☐ Decision-making authority ☐ Community member/third party	
Name (print): Kyle Boardman		**Signature:**	
Position	Coordinator Waste Management	Organisation	City of Mandurah
Email	kyle.boardman@mandurah.wa.gov.au		
Address	3	Peel Street	
	Mandurah	WA	6210
Date	9 March 2017		
Does the referrer request that the EPA treat any part of the proposal information in the referral as confidential? *Provide confidential information in a separate attachment.*		☐ Yes ☒ No	

Referral declaration for organisations, proponents and decision-making authorities:

I, Allan Claydon, (Director Works & Services) declare that I am authorised to refer this proposal on behalf of City of Mandurah and further declare that the information contained in this form is true and not misleading.

Part A: Proponent and proposal description

Proponent information

Name of the proponent/s (including Trading Name if relevant)	City of Mandurah
Australian Company Number(s) ☐ **OR** Australian Business Number(s) ☒	43 188 356 365
Contact for the proposal (if different from the referrer) *Please include: name; physical address; phone; and email.*	Andrew Mack 660 Newcastle Street, Leederville, WA, 6007 (08) 6557 5213 andrew.mack@talisconsultants.com.au
Does the proponent have the legal access required for the implementation of all aspects of the proposal?	☒ Yes ☐ No

If yes, provide details of legal access authorisations / agreements / tenure. *If no, what authorisations / agreements / tenure is required and from whom?*	The site is a Crown Reserve that is vested to the City of Mandurah under a Vesting Order (Appendix A in Supporting Document).
Proposal type	
What type of proposal is being referred? For a change to an approved proposal please state the Ministerial Statement number/s (MS No./s) of the approved proposal For a derived proposal please state the Ministerial Statement number (MS No.) of the associated strategic proposal	☐ significant – new proposal ☒ significant – change to approved proposal (MS No./s: ____375____) ☐ proposal under an assessed planning scheme ☐ strategic ☐ derived (Strategic MS No.: _____)
For a significant proposal: • Why do you consider the proposal may have a significant effect on the environment and warrant referral to the EPA?	The project will not have a significant impact on the environment. The S38 referral is a trigger for changes that may be required to the existing Ministerial Statement.
For a proposal under an assessed planning scheme, provide the following details: • Scheme name and number For the Responsible Authority: • What new environmental issues are raised by the proposal that were not assessed during the assessment of the planning scheme? • How does the proposal not comply with the assessed scheme and/or the environmental conditions in the assessed planning scheme?	Not applicable.
Proposal description	
Title of the proposal	Tims Thicket Liquid Waste Facility Upgrade.
Name of the Local Government Authority in which the proposal is located.	City of Mandurah.
Location: a) street address, lot number, suburb, and nearest road intersection; or b) if remote the nearest town and distance and direction from that town to the proposal site.	Approximately 15 kilometres (km) south of Mandurah City, towards the western end of Tims Thicket Road.
Proposal description – including the key characteristics of the proposal *Provide as an attachment to the form*	See attached supporting document.
Have you provided electronic spatial data, maps and figure in the appropriate format? *Refer to instructions at the front of the form*	☒ Yes ☐ No
What is the current land use on the property, and the extent (area in hectares) of the property?	The property is currently used as a septage disposal facility and inert landfill site. The property is approximately 28 hectares in size.

Have you had pre-referral discussions with the OEPA? If so, quote the reference number and/or the OEPA contact.	Robert Hughes

Part B: Environmental impacts

Environmental factors

What are the likely significant environmental factors for this proposal?	☐ Benthic Communities and Habitat ☐ Coastal Processes ☒ Marine Environmental Quality ☐ Marine Fauna ☐ Flora and Vegetation ☐ Landforms ☐ Subterranean Fauna ☐ Terrestrial Environmental Quality ☐ Terrestrial Fauna ☒ Hydrological Processes ☐ Inland Waters Environmental Quality ☐ Air Quality ☒ Social Surroundings ☐ Human Health

For the environmental factors identified above, complete the following table, or provide the information in a supplementary report. Please be sure to complete a separate table per factor identified above.

Potential environmental impacts

1	***EPA Factor***	Refer to Supporting Document
2	***EPA policy and guidance*** - What have you considered and how have you applied them in relation to this factor?	
3	***Consultation*** – Outline the outcomes of consultation in relation to the potential environmental impacts	
4	***Receiving environment -*** Describe the current condition of the receiving environment in relation to this factor.	
5	***Proposal activities*** – Describe the proposal activities that have the potential to impact the environment	

6	***Mitigation -*** Describe the measures proposed to manage and mitigate the potential environmental impacts.	
7	***Impacts*** - Assess the impacts of the proposal and review the residual impacts against the EPA objective.	Refer to Supporting Document
8	***Assumptions*** - Describe any assumptions critical to your assessment *e.g. particular mitigation measures or regulatory conditions.*	

Part C: Other approvals and regulation

State and Local Government approvals

Is rezoning of any land required before the proposal can be implemented? If yes, please provide details.	☐ Yes ☒ No
If this proposal has been referred by a decision-making authority, what approval(s) are required from you?	Not applicable

Proposal activities e.g. clearing, dewatering, mining, processing, dredging,	Land tenure/access e.g. Crown land – LA Act, Min Act, CALM Act specify type	Type of approval e.g. Native Vegetation Clearing Permit, licence, mining proposal,	Legislation regulating the activity e.g. *EP Act 1986* – Part V, *RiWI Act 1914*, *Mining Act 1979*
Category 61 – Liquid Waste Facility	Crown Reserve, vested under a Management Order	Licence	*Environmental Protection Act 1978 – Part V*

Commonwealth Government approvals

Does the proposal involve an action that may be or is a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)?	☐ Yes ☒ No
Has the proposed action been referred? If yes, when was it referred and what is the reference number (EPBC No.)?	☐ Yes ☒ No Date: _____ EPBC No.: _____
If referred, has a decision been made on whether the proposed action is a controlled action? If 'yes', check the appropriate box and provide the decision in an attachment.	☐ Yes ☒ No ☐ Decision – controlled action ☐ Decision – not a controlled action
Do you request that this proposal be assessed under the bilateral agreement or as an accredited assessment?	☐ Yes - Bilateral ☒ No ☐ Yes - Accredited
Is approval required from other Commonwealth Government/s for any part of the proposal? *If yes, describe.*	☐ Yes ☒ No Approval:

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Assets | Engineering | Environment | Noise | Spatial | Waste

Tims Thicket Liquid Waste Facility Upgrade

EPA Referral Supporting Document

City of MANDURAH

Prepared for City of Mandurah

March 2017

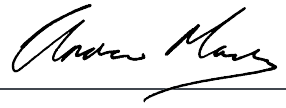
Project Number: TE17007

DOCUMENT CONTROL

Version	Description	Date	Author	Reviewer
0a	Internal Review	27/02/2017	JM	SC/AM
1a	Draft Issue to Client	09/03/2017	JM	AM
1b	Client Comments Incorporated – Final Submission	10/03/2017	JM	AM

Approval for Release

Name	Position	File Reference
Andrew Mack	Associate Director	TE17007_Tims_Thicket_Referral.1b
Signature		



Executive Summary

The City of Mandurah (the City) wishes to undertaken upgrade works before recommencing operations at its Liquid Waste Management Facility (the Facility) at the Tims Thicket Waste Management Facility (the Site). The City previously engaged Talis Consultants Pty Ltd (Talis) to prepare the detailed design and associated documentation for the upgrade works as well as seek a Licence Amendment from the Department of Environment Regulation (DER).

The City currently holds a DER Licence L6860/1995/11) for 'Category 63 - Class I inert landfill' and recently submitted documentation to the DER to amend the Licence to include 'Category 61 - liquid waste facility' to this licence.

Advice received from the DER indicated that the City should refer the project to the Environmental Protection Authority (EPA) pursuant to Section 38 of the *Environmental Protection Act 1986* (EP Act) for environmental impact assessment (EIA). As a result of this request, it has become apparent that there is an active Ministerial Statement that covers the operations (Statement 375). Subsequent discussions with the Office of the EPA (OEPA) confirmed that a referral would be the preferred way to approach the matter.

Statement 375 dates from 1994 and therefore does not reflect the current operations onsite, nor those proposed in relation to the liquid waste facility.

The purpose of this document is to provide information in support of a referral to the EPA for the Tims Thicket Liquid Waste Facility Upgrade pursuant to Section 38 of the EP Act.

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1 Proposal Description

The Tims Thicket Waste Management Facility (the Site) is located approximately 15km south of Mandurah, towards the western end of Tims Thicket Road (Figure 1). The Site covers an area of 28 hectares. The Site has been operational (in various forms) since 1995, with operations currently being managed under contract by Transpacific Cleanaway Pty Ltd (Transpacific). The Site is a Crown Reserve that is vested to the City under a Vesting Order (APPENDIX A).

The Site has historically been utilised under a Department of Environment Regulation (DER) Licence (L6860/1995/11) as both a Category 63 Class 1 inert landfill as well as a Category 61 liquid waste facility. However, in 2014 the Site ceased the acceptance of liquid waste and has since been operating solely as a Class 1 inert landfill.

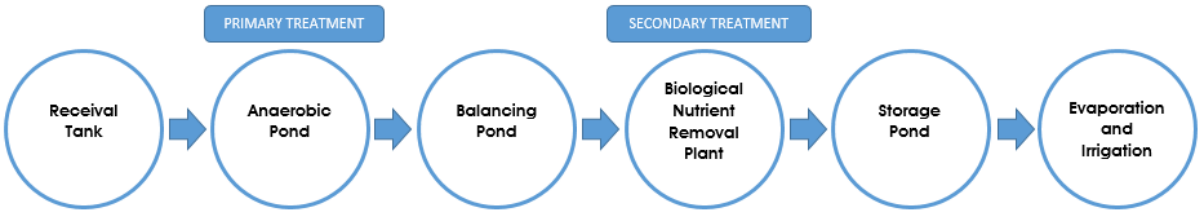
The City of Mandurah (the City) wishes to recommence the acceptance of liquid waste at the Site. In order to do this, the City is aware that a suite of improvements are required including refurbishing and repurposing the existing infrastructure and remediating existing environmental issues on the Site. These works form part of the Tims Thicket Liquid Waste Facility Upgrade Project (the Project).

The Project will include the replacement of the existing pond liners and the installation of an upgraded wastewater treatment system which will consist of a biological nutrient removal plant with a primary anaerobic treatment pond. The upgrades associated with the Project would ensure that the Site is suitable for accepting liquid waste for the next 15 to 20 years. Further detail is provided in the sections below.

1.1 Proposed Site Activities

The proposed Project will have a design capacity of up to 6,500kL of liquid waste per annum which will consist of septage and grease trap waste. Liquid waste is proposed to be disposed of into one of three anaerobic ponds for initial treatment, before undergoing secondary treatment in a biological nutrient removal plant. The treated liquid will then be discharged into a pond where the liquid component of the waste will be allowed to evaporate *in situ* or pumped to an onsite irrigation field for disposal. A simplified process flow diagram can be seen in Plate 1-1 below.

Plate 1-1: Process flow diagram detailing the proposed treatment of liquid waste



The following sections detail each of the components that make up the proposed liquid waste facility (the Facility), also see Figure 2 and Figure 3.

1.1.1 Receival Area

The existing receival area and associated infrastructure will be upgraded and recommissioned. A concrete receival pad will be constructed to accommodate a semi-trailer liquid waste truck and will be graded so as to assist the decanting process. The pad will be designed so as to capture liquid spillage and divert it to a sump system. An existing liquid waste receival tank will continue to be utilised as required and will drain to the sump system by gravity.

P PO Box 454, Leederville WA 6903 | Level 1 660 Newcastle St, Leederville WA 6007 | T 1300 251 070 | W www.talisconsultants.com.au

LEGEND

Boundaries

Current site boundary

LOCALITY

CITY OF MANDURAH

Tims Thicket Liquid Waste Facility Upgrade

SITE LOCALITY

N

0 50 100 200 300 400 metres

Scale @ A4: 1:15,000

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator, Datum: GDA 1994

Prepared:	H Dalla-Costa
Reviewed:	N King
Checked:	F Daly
Project No:	TE15028
Revision:	A
Date:	14/11/2016

Figure 01

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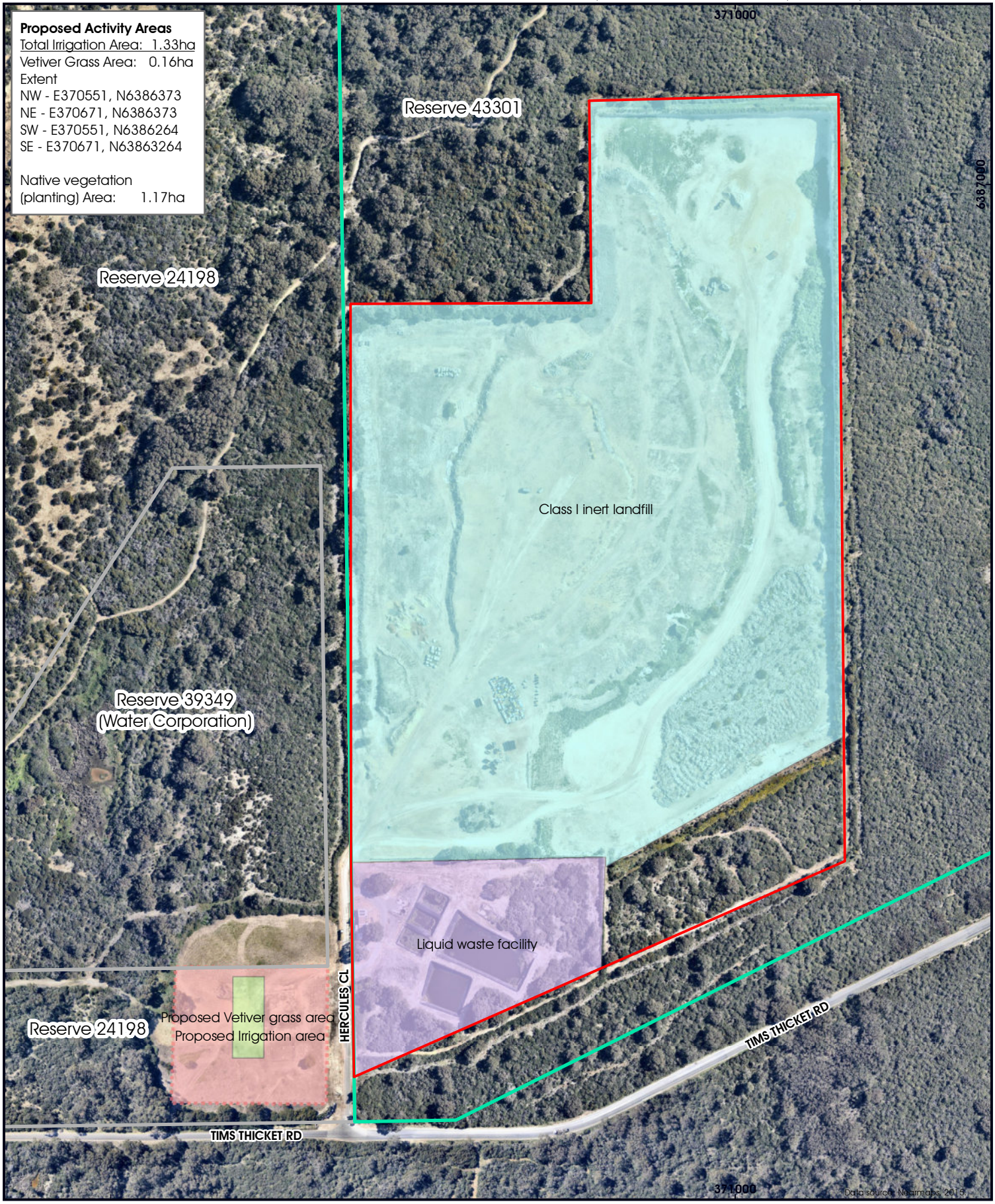

LEGEND

Boundaries

- Existing site boundary
- Reserve 43301
- Other land parcels

Site Activities (Current and Proposed)

- Class I inert landfill
- Liquid waste facility
- Proposed Irrigation area
- Proposed Vetiver grass area

CITY OF MANDURAH

Tims Thicket Liquid Waste Facility Upgrade

SITE LAND USE

N

metres
0 12.525 50 75 100

Scale @ A4: 1:4,000

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator, Datum: GDA 1994

Prepared:	T Murray
Reviewed:	N King
Checked:	S Conway
Project No:	TE15028
Revision:	A
Date:	14/11/2016

Figure 02

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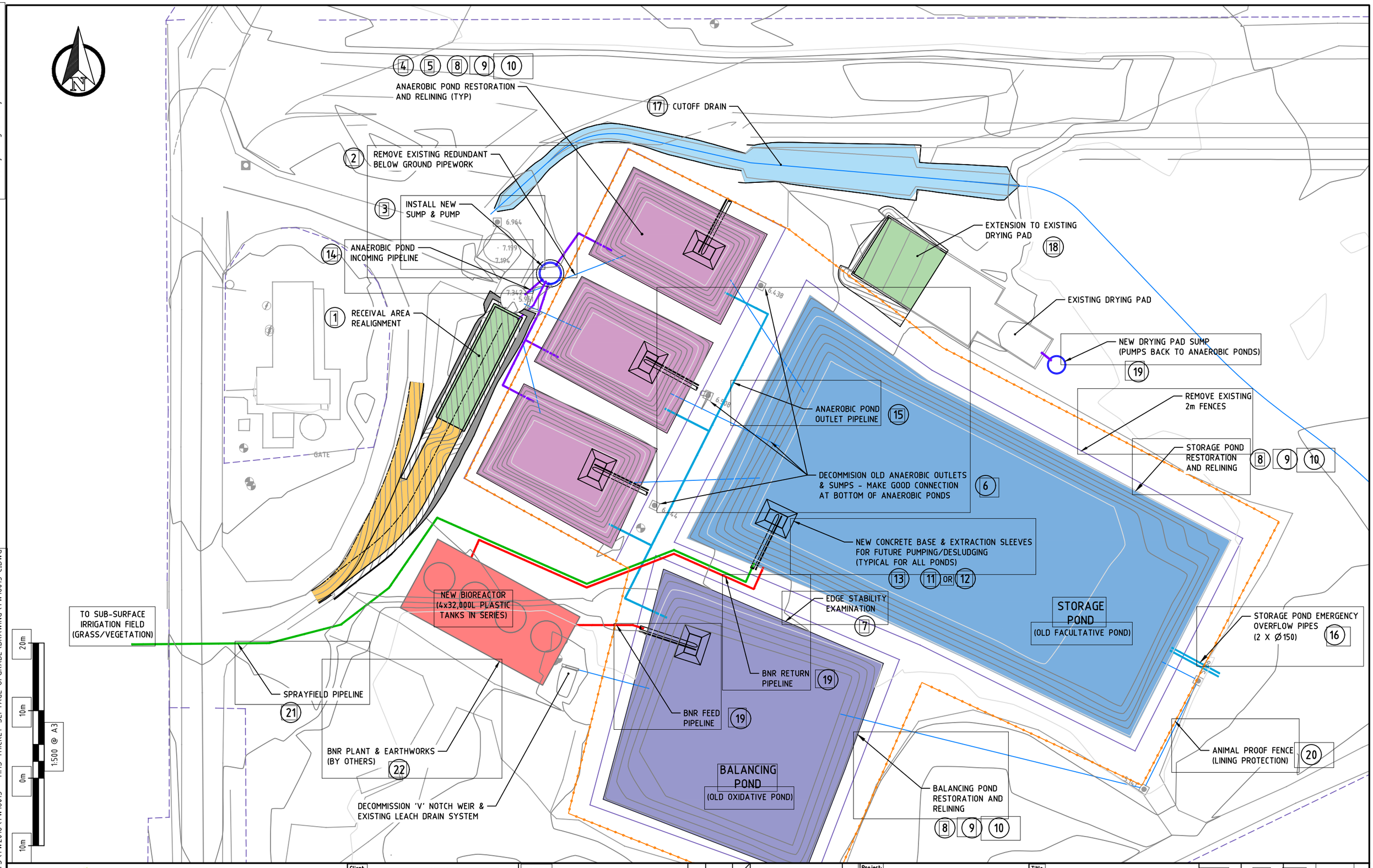
FIGURE 3 - Site Layout



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WASTE MANAGEMENT
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PO Box 454, Leederville WA 6903

Client: City of MANDURAH

NOTES

1. 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.
2. All levels refer to Australian Height Datum.
3. DO NOT SCALE, use figured dimensions only, if in doubt please contact Talis Consultants.

No.	Date		Amendment / Issue	App.
B	26.07.16	CDB	RE-ISSUED FOR CLIENT REVIEW	
A	13.06.16	CDB	ISSUED FOR CLIENT REVIEW	SC

Project: TIM'S THICKET SEPTAGE UPGRADE

Title: PROJECT WORKS OVERVIEW

Drawn by:	CDB	Job No:	TW16015
Checked by:	SC	File No:	TW015-G-005
Approved by:	SC	Drg. No:	G-005
Scale:	1:500	Rev:	B
Date:	26.07.2016		

1.1.2 Anaerobic Ponds

Currently there are three disused anaerobic treatment ponds on site that form the first sequence of the treatment process. As part of the proposed Project, these existing ponds will be fully recommissioned and a new 1.5mm High Density Polyethylene (HDPE) liner will be installed. At the base of the ponds, a geotextile liner will be installed between the new HDPE liner and a 125mm thick reinforced concrete pad for protection.

A below ground gravity fed HDPE pipe network is proposed to be installed between the Anaerobic Ponds and the Balancing Pond for the transfer of primary treated liquids.

The three anaerobic ponds on the Site will be used in a 12-18 month rotation as follows:

- Active receival;
- Retention; and
- Empty after desludging.

1.1.3 Balancing Pond

The Balancing Pond will replace the existing disused Oxidative Pond and form part of the second stage in the liquid waste treatment process. Liquids that have undergone primary treatment in the Anaerobic Ponds will be pumped from the Anaerobic Ponds into the Balancing Pond for holding prior to acceptance into the Biological Nutrient Removal Plant (the BNR Plant).

The Balancing Pond will be lined with 1.5mm HDPE, at the base of the pond a protective geotextile liner will be laid over which a 200mm protective limestone layer will be laid. In addition a pipe pump side riser and over flow pipe will be installed to allow effluent to be pumped to the BNR Plant.

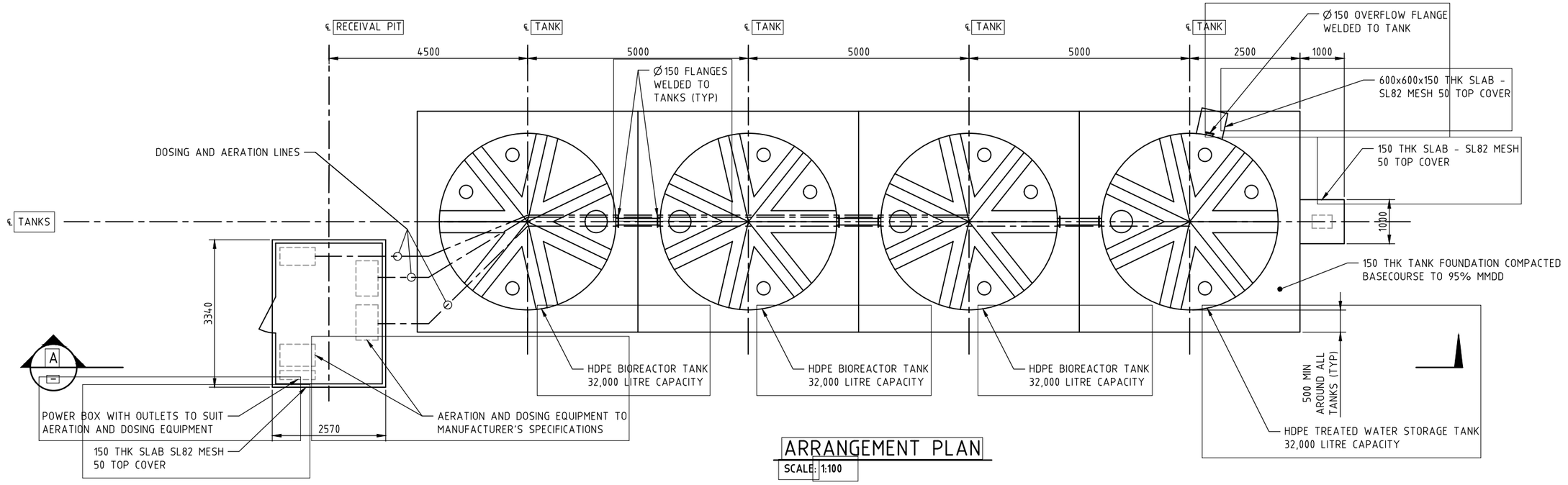
1.1.4 Biological Nutrient Removal Plant

A BNR Plant is proposed to be installed as part of the Project. The effluent will be introduced into the BNR Plant from the Balancing Pond following primary treatment in the Anaerobic Ponds. A conceptual design of a BNR Plant is presented in Figure 4. The proposed system will include four tanks, approximately 32,000L in capacity in a series that are aerated and automatically dosed with bacteria. The tanks will contain anoxic/anaerobic zones and aerobic zones to facilitate biological nutrient removal. Each tank acts as a baffle to prevent short circuiting of inflows and retain solids for treatment.

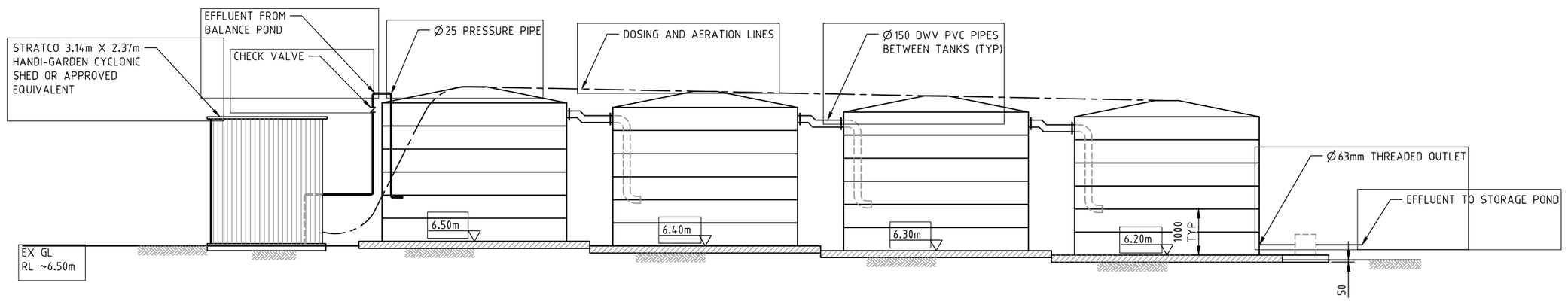
It is estimated that 20,000L of effluent per day will be pumped from the Balancing Pond into the BNR Plant for subsequent treatment. Each tank will contain micro bubble diffusers set at a subsurface level raised above the bottom of the tanks. Ambient air supply to all diffusers will be via a Side Channel Blower that will supply air to the tank diffusers.

The bacteria product will be automatically dosed at programmed times. The addition of the nitrogen cycle bacteria ensures sufficient levels of aerobic and facultative bacteria are present in the bioreactor to process the fats, oils and greases. These bacteria are also essential in reducing biological sludge volumes and decreasing the Total Nitrogen and Total Phosphorus content in accordance with the Department of Water WQPN22.

FIGURE 4 - BNR Plant Conceptual Design



ARRANGEMENT PLAN
SCALE: 1:100



A ELEVATION
SCALE: 1:100

2.0m 0m 2.0m 4.0m
1:100 @ A3

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Client: City of MANDURAH

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No.	Date			App.
A	07.11.16	CDB	ISSUED FOR CLIENT REVIEW	SC

Project: TIM'S THICKET SEPTAGE UPGRADE

Title: BNR PLANT CONCEPTUAL DESIGN

Drawn by:	CDB	Job No:	TW16015
Checked by:	RO	File No:	TW16015-P-002
Approved by:	SC	Drg. No:	P-002
Scale:	1:100 @ A3	Rev:	A
Date:	07.11.2016		

Following secondary treatment, the liquid will be pumped to the Storage Pond, which has a capacity of approximately 4,900kL, for discharge via evaporation and, if there are sufficient volumes, irrigation.

Table 1-1 below provides the expected effluent quality for the various treatment options based on data collected by the City and typical treatment quality.

Table 1-1: Typical Effluent Quality for Treatment Options

Parameter	Units	Treated Effluent Quality[1]
pH	-	6-8
TN	mg/L	<20
TP	mg/L	<10
E. Coli	Faecal coliforms/ 100ml	No data but likely to be <1,000 cfu/100 mL.

1.1.5 Storage Pond

The Storage Pond will replace the existing Facultative Pond and will be the final pond in the wastewater treatment system. Liquids will feed into the pond following primary treatment in the anaerobic ponds and secondary treatment in the BNR Plant. This pond will facilitate evaporation of the treated liquids. A sub-surface pipe will also allow transferral of liquids to the irrigation area.

The Storage Pond will be lined with 1.5mm HDPE, whilst at the base of the pond a protective geotextile liner will be installed over which a 200mm protective limestone layer will be laid. A side riser pump will be installed for the transfer of treated water to the irrigation field.

In the event of a 1 in 10 year annual rainfall event, it is assumed that some of the freeboard will provide temporary storage with emergency overflow to the vegetated area to the east of the Storage Pond.

1.1.6 Drying Pad

An existing drying pad was initially installed on the Site to assist in the desludging of the anaerobic ponds by allowing the removed sludge to be dewatered and dried prior to disposal to landfill. The sludge drying process represents a significant cost saving for the disposal costs due to the weight reduction as well as increasing the anaerobic capacity of the ponds. However, the existing drying pad has not been used for this purpose historically as it was too small for the volume of sludge produced from one anaerobic pond. Therefore, as part of the upgrade works the pad will be extended to accommodate the anticipated volume of sludge to be removed from one of the anaerobic ponds. The pad will be extended to approximately 225m^2 of hard standing with a 400mm high concrete wall to contain all sludge and prevent any spillages. Any leachate from the drying pad will be transferred back to the active anaerobic pond using a newly installed sump and pump.

[1] Based on discussions with *For Earth Pty Ltd* representatives.

1.1.7 Irrigation Field

The proposed irrigation area is fenced and is considered to have “enhanced restricted access” which means the exposure risk is considered Low under the Department of Health (DoH) 2011 Guidelines for the Non-potable Uses of Recycled Water in Western Australia. As the irrigation area is west of the current Site, this will not have any implications on the current or proposed operations, including public access.

Additional clearing of vegetation is not considered to be required as there is a sufficiently sized cleared area of 1.33ha in the required location - greater than the nutrient balance calculation requirement.

For the primary irrigation it is proposed to install a 0.11ha Vetiver Grass System (VGS) to ‘polish’ any treated wastewater that overflows from the Storage Pond. The excess treated effluent will be pumped from the Storage Pond to the VGS using a sub-surface 90mm HDPE. The VGS will be bounded by 0.5ha buffer zone consisting of soil contaminant bunds and access for maintenance. The remaining 1.17ha will be planted with natural vegetation.

The VGS proposed for the irrigation area has the following suitable qualities for volume and residual nutrient removal:

- Grows 3-4m of a very fine root system, protecting it against erosion;
- Tolerance to extreme drought and flood weather conditions;
- Lifespan exceeding 60 years;
- Sterile and non-invasive;
- Fire resistant when green;
- Tolerant of extreme soil conditions; and
- High nitrogen and phosphorus uptake in comparison to native vegetation.

HSE Control Pty Ltd (HSE) was commissioned by Talis to produce a report to appraise the benefits of using the VGS as part of the Tims Thicket Septage Upgrade. The HSE report is presented in APPENDIX B.

2 Environmental Impacts

Talis has undertaken an assessment of the current environmental setting, previous approval processes and the likely impacts associated with the Project and has determined that the following factors are considered to be the likely significant environmental factors for this proposal:

- Marine Environmental Quality;
- Hydrological Processes; and
- Social Surroundings.

These factors primarily relate to the environmental value of the area and the surrounding area both during and after the Site finishes operating.

Given the suite of existing statutory processes regulated by various Decision Making Authorities (DMAs) and the likely impacts associated with the Project, a preliminary assessment of the risks suggests that there are no impacts that are unacceptable or cannot readily be managed appropriately via existing regulatory mechanisms, requirements specified under an amended DER Licence and the City's internal controls. Notwithstanding this, the factors identified above are further considered below as well as in Part B of the referral form.

2.1 Consideration of Potential Environmental Impacts

2.1.1 Marine Environmental Quality

EPA Objective: *To maintain the quality of water, sediment and biota so that environmental values are protected.*

2.1.1.1 EPA Policy and Guidance

The following EPA policy and guidance documentation has been considered in the development of this referral.

- EPA Environmental Factor Guideline – Marine Environmental Quality 2016; and
- EPA Technical Guidance – Protecting the Quality of Western Australia's Marine Environment 2016.

2.1.1.2 Consultation

Given that the site has been operating since 1995 with no known incidents or detrimental impacts to marine environmental quality in the surrounding area and that the Project will not substantially change the operations on the site, no additional environmental impacts to hydrological processes were determined to exist.

2.1.1.3 Receiving Environment

The Indian Ocean is located approximately 500m to the west of the Site.

2.1.1.4 Proposal Activities

The below activities are considered to have the potential to impact marine environmental quality if not appropriately mitigated:

- Wastewater treatment;
- Wastewater storage; and
- Wastewater disposal.

2.1.1.5 Mitigation

Wastewater treatment and storage have the potential to impact marine environmental quality if spill events occur via equipment failure, overflow or other form of system malfunction.

The risk of surface water runoff affecting the marine environment is limited due to both the topography and the densely vegetated land between the facility and the ocean. Notwithstanding this, a surface water management system will be installed as part of the upgrade works which will include a 'V' drain constructed along the northern edge of the Facility, this will ensure that uncontaminated stormwater run-off will be directed away from treatment ponds and released into the environment in a controlled manner.

The higher risk pathway for potential impacts to the marine environment is via groundwater. In addition to the mitigation measures detailed above, all ponds that are to contain treated or untreated effluent will be lined with 1.5mm HDPE liners as well as geotextile and concrete or limestone layers as additional protective measures. The concrete or limestone layers will also facilitate more efficient operation and cleaning of the ponds without significant risk of compromising the HDPE lining. The Project will include the installation of a range of additional measures to ensure that no leaching occurs from the facility including upgrade of receival area and extension of the hard standing area for drying pad, replacement of pipes and installation of concrete sumps.

Wastewater disposal has the potential to impact marine environmental quality if the irrigated water is not of appropriate quality or is discharged in too high a quantity. Based on a soil assessment undertaken on the site by Talis and analysed by E-Precision Laboratories Pty Ltd and in accordance with the Department of Water (DoW) - Water Quality Protection Note 22: Irrigation with nutrient-rich wastewater (WQPN22), the soil layer in the proposed irrigation area is classified as 'coarse grained soils'. In line with WQPN22, the overall eutrophication risk to surface waters within 500 m of the irrigation site has been classified as low while the overall risk category has been classified as 'B'. While the Indian Ocean is approximately 515 m from the irrigation area and is not deemed a sensitive receptor in accordance with Appendix C of WQPN22. No wetlands or other 'sensitive' water bodies were situated within 500 m of the Site. Additionally, all groundwater users were situated up-hydraulic gradient of the irrigational field and represented a 'low' risk.

Subsequently, in line with WQPN22 the recommended nutrient application criteria to control eutrophication is shown in **Table 2-1**.

Table 2-1: Nutrient application

Risk Category	Maximum inorganic nitrogen addition (as N)		Maximum reactive phosphorus addition (as P)	
	Application rate (kg/hectare/year)	*As water concentration (mg/litre)*	*Application rate (kg/hectare/year)*	*As water concentration (mg/litre)*
B	180	11	20	1.2

2.1.1.6 Impacts

In light of the above detailed mitigation measures, no additional impacts to marine environmental quality are expected to occur as a result of the realisation of the Project.

2.1.1.7 Assumptions

It is assumed that any measuring and monitoring requirements for the Project will be stipulated by other DMAs, namely DER and DoW.

2.1.2 Hydrological Processes

EPA Objective: *To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.*

2.1.2.1 EPA Policy and Guidance

The following EPA policy and guidance documentation has been considered in the development of this referral.

- EPA Environmental Factor Guideline – Hydrological Processes 2016.

2.1.2.2 Consultation

Given that the site has been operating since 1995 with no serious public complaints, the main consultation that has taken place with regard to hydrological processes has been in the form of liaison with the DER regarding reapplying Category 61 to the Site's Licence.

2.1.2.3 Receiving Environment

The Site's topography slopes down from the north-west to the south-east. The western portion of the Site sits at approximately 7.5m AHD with the eastern portion at approximately 3.5m AHD.

The nearest surface water body is the Indian Ocean located approximately 500m to the west of the Site. The second closest surface water body is the Peel-Harvey Estuary 2.2km to the east which discharges in to the Indian Ocean. The Site is not located within the Peel Harvey Water Quality Improvement Plan Catchment.

No registered wetlands are known within the immediate area. However, a wetland was identified to the west of the Site, known locally as the 'weed pit'. This feature was utilised for the storage of algal bloom material that was harvested from the Peel-Harvey estuary many years ago (prior to the

construction of the Dawesville Channel). However, Talis understands that this operation is no longer undertaken.

With regard to groundwater, it was identified by Halpern Glick Maunsell (HGM) (1994) that the superficial formations within the area are hydraulically connected and form an unconfined aquifer which is dominated by two flow systems; the Harvey Estuary and Ocean Systems. Commander (1984) in HGM (1994) identify the boundary between the "flow systems is the groundwater divide running approximately north/south and lying equidistant between the Harvey Estuary and the Ocean". The groundwater flow direction beneath the peninsula on which the Site is located varies throughout the year due to variations in seasonal recharge, fluctuations in the level of the estuary and tides (HGM, 1994). Groundwater flow is generally towards the west (Indian Ocean) 10-11 months of the year, with groundwater flowing towards the east (Peel-Harvey Estuary) 1-2 months of the year (HGM, 1994). The small difference in hydraulic gradients (0.5m AHD at the end of winter and 0.1m AHD in summer), result in the net groundwater flow towards the Indian Ocean (HGM, 1994).

2.1.2.4 Proposal Activities

The below activities are considered to have the potential to impact hydrological processes if not appropriately mitigated:

- Wastewater treatment;
- Wastewater storage; and
- Wastewater disposal.

2.1.2.5 Mitigation

The mitigation measures detailed in Section 2.1.1.5 above regarding marine environmental quality will also mitigate the potential impacts associated with hydrological processes.

2.1.2.6 Impacts

In light of the above detailed mitigation measures, no additional impacts to hydrological processes are expected to occur as a result of the realisation of the Project.

2.1.2.7 Assumptions

It is assumed that any measuring and monitoring requirements for the Project will be stipulated by other decision making authorities (DMA), namely DER.

2.1.3 Social Surroundings

EPA Objective: *To protect social surroundings from significant harm.*

2.1.3.1 EPA Policy and Guidance

The following EPA policy and guidance documentation has been considered in the development of this referral.

- EPA Environmental Factor Guideline – Human Health 2016.

2.1.3.2 Consultation

The Site has been operating in some capacity since 1995, primarily through regulation under Part V of the EP Act. In that time, no significant complaints have been made from the surrounding land users. Given that the proposed upgrade works are not substantially different to the previous and existing operations and improve the controls associated with the operations, no additional stakeholder consultation was deemed necessary.

2.1.3.3 Receiving Environment

A review of the Surrounding Land Uses was undertaken as a part of the referral process. The City of Mandurah Town Planning Scheme No. 3 (District Scheme) (TPS No. 3) identifies the Site to be zoned as *Public Purposes – Public Utilities*. Land adjacent to the Site is zoned Regional open space to the north, east and south and *Public Purposes – Public Utilities to the west*.

The recommended separation distances for the Site's proposed and existing activities are shown in **Table 2-2**, as set out in various existing and draft guidance documentation including the EPA Guidance on Separation Distances between Industrial and Sensitive Land Uses (Guidance Statement No. 3), the DER's draft Guidance Statement on Separation Distances (now withdrawn) and the EPA's draft Guideline for Separation Distances Between Industrial and Sensitive Land Uses.

Table 2-2: Recommended separation distances for proposed and existing Site activities

Category	Activity Status	Recommended Separation Distance (m)		
		EPA Guidance Statement No. 3	**DER Draft Guidance**	**EPA Draft Guideline**
61 - Liquid waste facility	Proposed	No distance cited, case by case	1,000m	1,000m
63 - Class I inert landfill site	Licenced (existing)	150 for residential uses & an internal buffer of 25 from boundary	300m	300m

The nearest sensitive receptor is located approximately 1,200m to the east of the boundary of the liquid waste facility, which is well beyond the distances specified within the relevant guidance documents. As detailed above, the City operated the liquid waste facility for ~21 years with no significant complaints received from the surrounding households.

2.1.3.4 Proposal Activities

The below activities are considered to have the potential to impact the social surroundings if not appropriately mitigated:

- Wastewater treatment;
- Wastewater storage; and
- Wastewater disposal.

2.1.3.5 Mitigation

Wastewater treatment, storage and disposal have the potential to impact the social surroundings if from a noise and odour perspective if not appropriately managed.

As detailed above, to date the Site has not received any significant complaints since it began operating in 1995, this is likely due to the isolated nature of the facility. Notwithstanding this, the City remains committed to transparent communication and the public is able to contact the City with any complaints or suggested improvements via phone or the online enquiry process.

In addition to the existing 1.8m security fence around the septage and inert landfill facilities, and to avoid any potential incidents relating to trespassing or other access confusion issues the City will install an additional fence around the pond system. The fence will be 1.8m high, with three rows of barbed wire on the top for general security, and one row at the bottom to prevent animals digging under the fence. The entrance to the Facility will be securely locked when the Site is unattended. The fencing will also stop animals from traversing the Facility, potentially falling into the ponds and compromising the lining system. Damage has occurred in the past with the existing pond lining resulting in the liner being compromised.

3 Conclusion

The above document provides further detail in support of the completed EPA referral form. It is evident that the proposed Project will not cause additional environmental impacts than the historical waste water treatment process through the mitigation measures detailed above and as such is unlikely to cause a significant environmental impact.

The City remains committed to best practice environmental management and commits to maintaining open and transparent communication with the EPA to asset in facilitating an efficient and appropriate review of this referral.

4 References

Halpern Glick Maunsell (HGM), *Consultative Environmental Review for – Proposed Change to Yalgorup National Park Boundary, Septage, Limestone Quarry and Wastewater Treatment Plant*, 1994

APPENDIX A: Facility Vesting Order

L595 1cgg172

LAND ACT 1933

(Section 33(2))

VESTING ORDER

DOLA File 781/955

I, Major General Philip Michael Jeffery, Officer of the Order of Australia, Military Cross, Governor of the State of Western Australia, do hereby in pursuance of the powers enabling me in that behalf, and under and by virtue of the provisions of Section 33(2) of the Land Act 1933, direct that Reserve No 24198 (Murray Location 1943)

vest in and be held by the City of Mandurah

for the designated purpose of "Camping and Recreation"

Given under my hand, at Perth

this 23 day
of MAY 19 1995

GOVERNOR

APPENDIX B: Tims Thicket Septage Upgrade: Vetiver System "Polishing" & Disposal

Tims Thicket Septage Upgrade: Vetiver System "Polishing" & Disposal.

Chrysopogon Zizanioides (Vetiver Grass) Option Appraisal

Prepared by Simeon Kendall

Prepared for Talis Consultants

November 15th 2016

Status: Final Report

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1 INTRODUCTION

HSE Control Pty Ltd has been commissioned by Talis Consultants (Talis) to appraise the benefits of using the Vetiver System (VS) as a "polishing" and end disposal by irrigation treatment to a 1.33[1] ha irrigated area as part of the Tims Thicket Septage Upgrade. For clarity proposes a breakdown of project area and sub areas proposed in this report is set out in Table 1 below.

Area Description	Area (ha)
Irrigated Vetiver System	0.11 ha
Irrigated Local Native Vegetation	1.17 ha
Sub Total (Total Irrigated Area)	**1.28** ha
Vetiver System Buffer Zone (Earthen Bund & Access)	0.05 ha
Total Area	**1.33 ha**

Table 1: Breakdown of Project Areas Proposed in this Report.

The suitability, benefits, costs and conceptional design of the Vetiver System is considered in this report based on information provided in the *Tims Thicket Upgrade Options Appraisal* (Talis, 2016), requirement set out in the *Water Quality Protection Note: Irrigation with Nutrient-Rich Waste Water* ("WQPN22", 2008), Vetiver System literature and experience with two Western Australia waste water treatment Vetiver Systems.

The Vetiver System is dependent on the sterile, non-invasive Vetiver Grass (*Chrysopogon Zizanioides*) that exhibits vigorous growth in Mediterranean climates. Vetiver is reported as being highly tolerant to extreme climatic variations (drought, flooding, and submergence), heavy metals, herbicides, pesticides, and high acidity, alkalinity and salinity. The Vetiver System has been used for the treatment and volume reduction of landfill leachate in Australia, China, Mexico, Morocco, United States and Iran (Truong, Van, and Pinners, 2008) (Truong & Danh, 2015).

Vetiver grass was imported into Western Australia from Queensland in 2007 and has been used as a volume reduction and nutrient uptake treatment at the Mindarie Regional Council's (MRC) Tamala Park Landfill truck wash facility (Kendall & Goldfinch, 2008) (Kendall, 2009), and at the Shire of Waroona Septic Waste Treatment Facility (Watkins & Goldfinch, 2008).

2 SCOPING OF VETIVER SYSTEM REQUIREMENTS

Table 2 and Table 3 in APPENDIX 1: CALCULATIONS show that the expected effluent discharged from the proposed BNR treatment option[2] will meet the required maximum application rates and the adjusted (for lower throughput) maximum water concentration given in "WQPN22," 2008 for nitrogen (as N) and phosphorous (as P). This report will provide an appraisal on the benefits of using the Vetiver System as a primary area of irrigation "polishing system" and provide conceptional design for its implementation.

3 DESCRIPTION AND PROPERTIES OF THE VETIVER SYSTEM:

3.1 ROOT SYSTEM

Figure 1: Massive Root System

Truong & Danh, 2015 report that the Vetiver System and its environmentally beneficial properties is dependent on its massive lacework root system that is abundant, complex, and extensive (Refer Figure 1). The root system can reach 3-4 metres in the first year of planting. This supports its survival under extreme drought conditions as it can utilize deep soil moisture. The root system prevents Vetiver from dislodgement under high velocity flows. In locations with high water availability, its root system will not be as deep as in drier soil. Vetiver roots are very fine with an average diameter of 0.66 mm. The horizontal spreading of lateral roots is in the range of 0.25m. The peculiarity of Vetiver's root system ensures high contact

[1] The includes Vetiver System 0.05 ha earthen bund and access zone.

[2] Calculations in this report are based on the BNR Treatment Option.

surfaces with soil particles and contaminants resulting in efficient phytoremediation. This makes it effective in removing other potential waste water contaminants such as heavy metals (that may occasionally be present in this application) in addition to its nutrient uptake properties.

3.2 Tolerance to Extreme Weather Conditions

Vetiver is highly adaptable to extreme weather conditions. It can thrive and survive under prolonged drought, flood as well as extreme hot and cold weather (Truong & Danh, 2015).

3.3 Longevity

Vetiver is long-lasting, with some plants known to be 60 years old ("Facts Land series: Monto vetiver grass for soil and water conservation," 2006). It can be expected that once established the Vetiver System will easily last the life of the Septage treatment plant.

3.4 Weed Potential

To reduce its weed potential, a sterile cultivar was selected from a number of vetiver cultivars available in Australia and registered as Monto Vetiver[3], its release has been approved by the Environmental Protection Agency.

Vetiver is non-invasive, has no runners nor rhizomes, and only spreads by tillering. Although Vetiver flowers under certain conditions, it sets no viable seed and its sterility has been rigorously tested under climatic conditions ranging from the wet tropics of north Queensland to the temperate region of Victoria. Other varieties available in Australia do set viable seed and therefore should not be used. Buyers should ensure that they are purchasing the correct variety.

Though plants and hedges are long-lasting, with some plants known to be 60 years old, they can be removed with little effort. It is sufficient to simply remove the crown with a shovel or plough blade or treat it with glyphosate herbicide, to which vetiver is very sensitive ("Facts Land series: Monto vetiver grass for soil and water conservation," 2006).

3.5 Fire

Vetiver is resistant to fire when green ("Facts Land series: Monto vetiver grass for soil and water conservation," 2006) which it is expected to be as part of the Septage treatment system. Dry vetiver grass will burn readily but it can survive severe fires and fully recover after burning because its growing point is underground (Truong & Danh, 2015).

3.6 Tolerance to Adverse Soil Conditions

Vetiver has a high tolerance to a wide range of extreme soil conditions, such as high and low pH, high heavy metals, high salinity, and high sodicity (Truong & Danh, 2015).

3.7 Nutrient Uptake Properties;

Truong & Danh, 2015 report that Vetiver Grass is superior in terms of N and P removal as compared to other grasses. Vetiver out-performs other crops and pasture plants, such as Rhodes grass, Kikuyu grass, green panic, forage sorghum, rye grass and eucalyptus trees.

Table 3 in APPENDIX 1: CALCULATIONS shows that the 0.11 ha Vetiver System proposed in this report has the potential to remove 60% to 100% of Nitrogen loading and 49% to 100% of Phosphorous loadings from the irrigated waste water.

The benefits of this are reduced risks of eutrophication. Limited irrigation from the Vetiver System to the surrounding native bushland will be low in nutrient and quantity allowing existing / local vegetation species to be retained thereby minimising impact on the local natural environment.

4 VETIVER SYSTEM SIZING

Table 5 in APPENDIX 1: CALCULATIONS requires a 0.11 ha Vetiver System based on water use at peak growth cycle over a 32 week irrigation window. The peak growth cycle is achieved by harvesting the Vetiver annually (refer section

[3] Throughout this report references to Vetiver refer to the Monto cultivar (Chrysopogon Zizanioides).

8). Whilst peak growth cycle may not always be achieved in this application - there are expected to be some water losses through infiltration[4], and so it can be expected that the 0.11 ha Vetiver System will cope well with these waste water loadings. Any excess volume of water is expected to be greatly reduced in quantity and to be low in nutrients and so very suitable for irrigation to surrounding 0.7 ha native vegetation zone. Storm overflows will further dilute any remaining nutrient loading and follow the natural weather cycle again making it suitable for irrigation to native vegetation. With the design based on a 32 week irrigation window, irrigation can be stopped during winter months when there is high rainfall and when the Vetiver System has less vigorous growth than in spring, summer and autumn.

5 ESTABLISHMENT

Weeds compete with the newly established Vetiver for moisture and nutrients and can shade the young plants out. To eliminate weed competition, the planting area should first be sprayed with glyphosate if necessary. A pre-emergent spray may be used after planting. In Perth planting is best during the winter wet season to avoid the need for irrigation and avoid grazing by kangaroos which will have plenty of other available more palatable grazing over winter. During these colder months leaf growth may be low but the root system will become established ready for rapid growth in the warmer spring. Plants should be placed in a furrow along level rows (1m part) at 200mm intervals into wet or immediately irrigated soil. Cover the roots with 20−30 mm of soil and compact the soil firmly. For infertile soils an application of nitrogen and phosphorus is recommended at planting e.g. DAP (di-ammonium phosphate) at the rate of about 100 g per metre length. Fertilising good soils at the time of planting may encourage competition from weed growth. After planting, if there is no rain, water twice weekly for at least 3−4 weeks. Control weeds around the hedge until the plants are established. Be generous in caring for the plants during the establishment phase. After approximately 18 months to two years, a strong permanent hedge will have formed. A line of vetiver plants cannot function as an erosion control / water distribution barrier until the individual plants have grown together and closed up into a hedge. Trimming the young plants stimulates early tillering and the hedge will close up faster. The mature hedge requires no further fertilising or watering ("Facts Land series: Monto vetiver grass for soil and water conservation," 2006).

6 SOURCING AND VETIVER COSTS IN WA

Vetiver grass is available in WA through HSE Control Pty Ltd at a cost of $2 / plant ($10/m^2) planted in the ground for areas >500m^2. This is comparable to the cost per m^2 of constructed wetland species tube stock which would otherwise be required over a much larger irrigated area. A three months lead time is required to establish sufficient stock for a 0.11 ha Vetiver System. By using Vetiver the remaining irrigated area (if required) can use native vegetation as found naturally at the site, which can be established through the reapplication of top 150mm of cleared topsoil containing a seed bank following contouring at low cost. Re-establishment of existing natural native vegetation ensures lowest impact on the natural environment. If the seed bank in top soil is of a poor quality, scattering a local seed mix may be required at a rate of 20 kg/ha.

7 RECOMMENDED METHOD OF IRRIGATION WITH LAYOUT DRAWING

The Vetiver System lends itself to surface flow irrigation as the Vetiver hedgerows planted on the level causes the formation of natural terraces which facilitates natural distribution of water across the surface of the Vetiver bed (refer Figure 2 and Figure 4 in APPENDIX 3: SITE LAYOUT DRAWINGS). A level distribution pipe across the width of the top of the Vetiver System is required to distribute pumped or gravity fed influent evenly across the width of the Vetiver System.

Outflow from the Vetiver System is expected to be minimal and it is likely that natural surface flow through contouring to 1.17 ha irrigation area will be suitable for water distribution. If erosion or pooling becomes apparent plant additional Vetiver hedgerows across any gullies that form in native vegetation irrigation area to facilitate even discharge distribution.

[4] Infiltrated wastewater is expected to be low in nutrients as it will have to pass through the Vetivers massive root system. This will be verified as part of the treatment plant monitoring program using the Vetiver System central sampling point.

8 MAINTENANCE & MONITORING

A Vetiver hedge should be considered a living barrier which requires some maintenance, but once fully established only minimal maintenance is needed. Due to Vetiver's sensitivity to shading, control of broad leaf weeds may be required during the first year, and climbing weeds should be controlled in subsequent years. To promote spreading and optimum growth cycle, the hedge should be topped to a height of 500 mm every year at the end of winter. Under good growing conditions, hedges may need to be trimmed every 3−4 years (by deep ripping the upper edge of the vetiver contour), to keep their width between 0.3 and 0.5 metres.

Monitor any discharge from Vetiver System for minor erosion gullies or pooling that form in native vegetation area. If this becomes apparent plant additional Vetiver hedgerows across any gullies that form in native vegetation irrigation area to facilitate even discharge distribution of storm / waste water (refer Figure 4 in APPENDIX 3: SITE LAYOUT DRAWINGS).

Undertake monitoring of Nitrogen and Phosphorous levels at overflow discharge point and from sampling point at 3m below Vetiver System as part of treatment plant monitoring program to verify system effectiveness. This can be provided free of charge for 3 year by Simeon Kendall if City of Mandurah decides to participate in the planned Vetiver System PhD research project.

9 RECOMMENDATIONS

- Establish and maintain a 0.11 ha Vetiver System to polish and disposal of Tims Thicket Septage Upgrade waste effluent (refer Figure 2 in APPENDIX 3: SITE LAYOUT DRAWINGS.
- Establish an additional 1.17 ha of contoured local native vegetation around Vetiver System for disposal by irrigation of any excess waste water / stormwater discharged from Vetiver System (refer Figure 4 in APPENDIX 3: SITE LAYOUT DRAWINGS).
- Monitor Vetiver System at middle and storm / waste water overflow discharge (if this occurs) sampling points as part of treatment plant monitoring program to verify system effectiveness.
- Monitor Vetiver System outflows (if they occur) and if minor erosion gullies or pooling becomes apparent plant additional Vetiver hedgerows in native vegetation irrigation area to facilitate even discharge distribution of overflow storm / waste water (refer Figure 4 in APPENDIX 3: SITE LAYOUT DRAWINGS).
- This is a low risk project. City of Mandurah (along with other parties already committed) could support a PhD research project planned by the author of this report at a cost of $2K per annum for 3 years such that the Vetiver System can be more widely adapted for higher risk projects as a cost effective and environmentally beneficial solution for waste water treatment in WA.

APPENDIX 1: CALCULATIONS

MAXIMUM APPLICATION AND WATER CONCENTRATION DATA

Talis, 2016 provide maximum annual irrigation volume, nitrogen & phosphorous effluent quality and annual loading for preferred BNR treatment option. This is replicated in Table 2 below.

Nutrient	Max. Annual Irrigation Volume	Typical Effluent Quality	Annual Nutrient Load
Nitrogen	6923 kL/yr	20.0 (N) mg/L	138.5 (N) kg/yr
Phosphorous		2.0 (P) mg/L	13.9 (P) kg/yr

Table 2: Annual Irrigation Volume, Nitrogen & Phosphorous Effluent Quality and Annual Loading for BNR treatment option.

"WQPN22," 2008 provides the maximum nitrogen and phosphorous application rates (kg / ha / year) per annum and maximum water concentrations (mg / litre). These are replicated in Table 3 below. An adjusted maximum water concentrate is also given calculated on the maximum annual through put of 6923 kL / year being 42% of that assumed by WQPN22 Table 2, note a.

Nutrient	Maximum Application Rate	Maximum Water Concentration (mg/litre)	
		As given[5]	Adjusted for actual volume[6].
Nitrogen (as N)	180 (N) kg / ha / year	11.0 (N) mg/L	26.1 (N) mg/L
Phosphorous (as P)	20 (P) kg / ha / year	1.2 (P) mg/L	2.8 (P) mg/L

Table 3: Based on WQPN-22. Gives Nutrient Application Criteria to Control Eutrophication Risk.

NUTRIENT UPTAKE PROPERTIES AND CALCULATIONS

Truong & Danh, 2015 report that Vetiver removed up to 740 kg N ha-1 and 110 kg P ha-1 over 3 months at a nutrient-rich site and 1,020 kg N ha-1 and 85 kg P ha-1 over 10 months at a lower nutrient site. Table 4 below shows these as an annual rate over the 32 week irrigation window given in 'WQPN22' 2008 and shows the potential removal rate for 0.11 ha Vetiver System proposed.

Nutrient Description	Nutrient Rich		Nutrient Poor	
	Nitrogen (N)	Phosphorous (P)	Nitrogen (N)	Phosphorous (P)
Removal Rate Given (Truong & Danh, 2015)	740kg / ha / 3 mnth	110kg / ha / 3 mnth	1020kg/ha/10 mnth	85kg / ha / 10 mnth
Removal Rate Calculated for Annual 32 Week Irrigation Window per ha	1821 kg / ha / year	270 kg / ha / year	753 kg / ha / year	62 kg / ha / year
Removal Rate Calculated for Irrigation Window for Proposed 0.11 ha VS.	200 kg / year	29.7 kg / year	82.8 kg / year	6.8 kg / year
Maximum Application rate based on proposed BNR treatment system (refer Table 2**).**	138.5 kg / ha / year	13.9 kg / ha / year	138.5 kg / ha / year	13.9 kg / ha / year
Net Application Rate based on proposed BNR treatment system with Max VS treatment.	Zero	Zero	55.7 kg	7.1 kg / year
% Removal	100%	100%	60%	49%

Table 4: Data and Calculations on Vetiver System Potential Nutrient Uptake.

VETIVER SYSTEM AREA SIZING

At the peak of its growth cycle the Vetiver System will use up to 279 kL / ha / day (Truong & Danh, 2015). Vetiver System sizing of 0.11 ha is required based on mean throughput of 31kL per day during 32 annual week irrigation window

Potential VS Water Use	Mean Daily Irrigation Volume Requirements for 32 week Annual Irrigation Window	Land Area (ha) Required for Full VS Disposal of 6500kL / year[7]
279kL / ha / day	31 kL / day	0.11 ha

Table 5: Sizing Based on Vetiver System Water Use.

[5] Based on average of 500 kL of water applied per week over 32 weeks given in 'WQPN22' 2008, Table 2, note a.

[6] 6923 kL of water applied annually adjusts to an actual weekly irrigation volume of 210 kL applied per week over 32 weeks (i.e. 42% of rate given by WQPN-22). The adjustment is calculated as rate given/42*100.

[7] Based on 32 week irrigation period given in 'WQPN22' 2008, Table 2, note a. (31 kL per day / 279 kL per ha par day = 0.11 ha).

APPENDIX 2: REFERENCES

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Water Quality Protection Note 22 (WQPN22) Irrigation with Nutrient Rich Wastewater. (2008). Western Australia: Department of Water

Watkins, I., & Goldfinch, R. (2008, December). *Shire of Waroona: Stabilisation Pond Design Report*. Western Australia: IW Projects Pty Ltd.

APPENDIX 3: SITE LAYOUT DRAWINGS

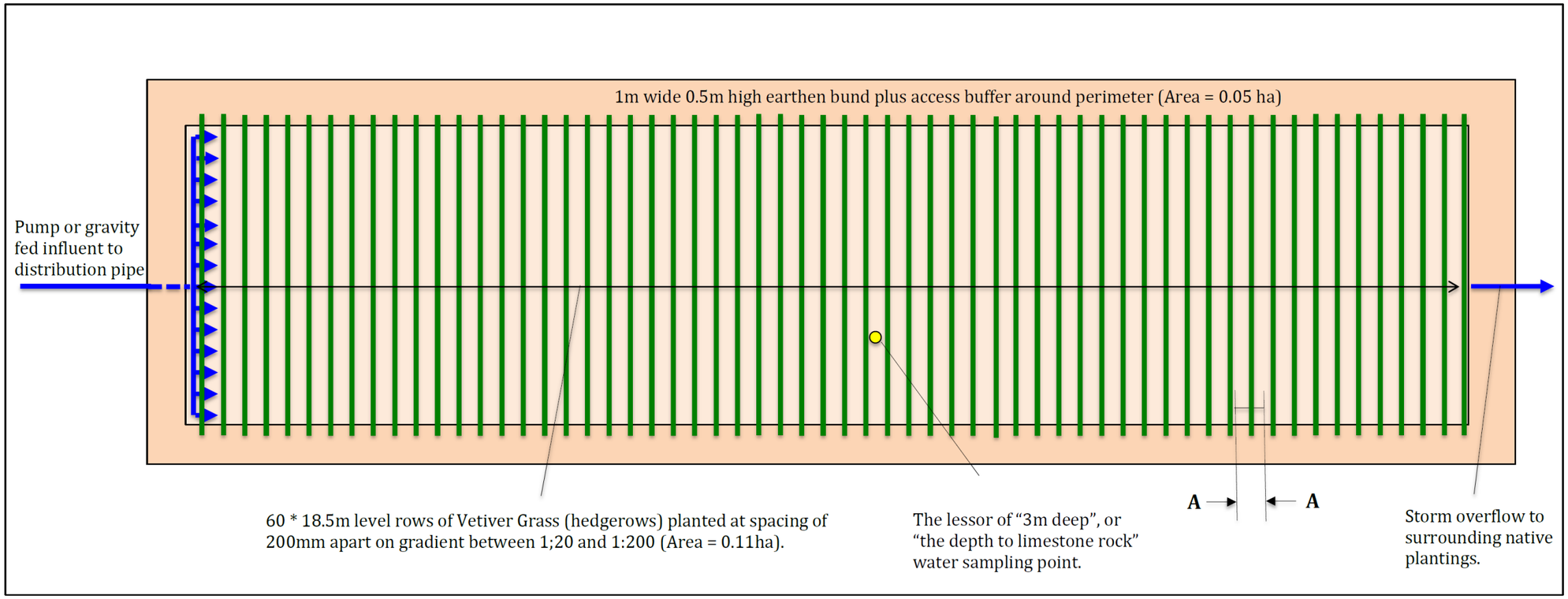

Figure 2: Schematic Showing Proposed Arrangement of 0.11 ha 'Polishing" Vetiver System (NTS).
Additional 0.05 earthen bund / access area gives total area of 0.16 ha

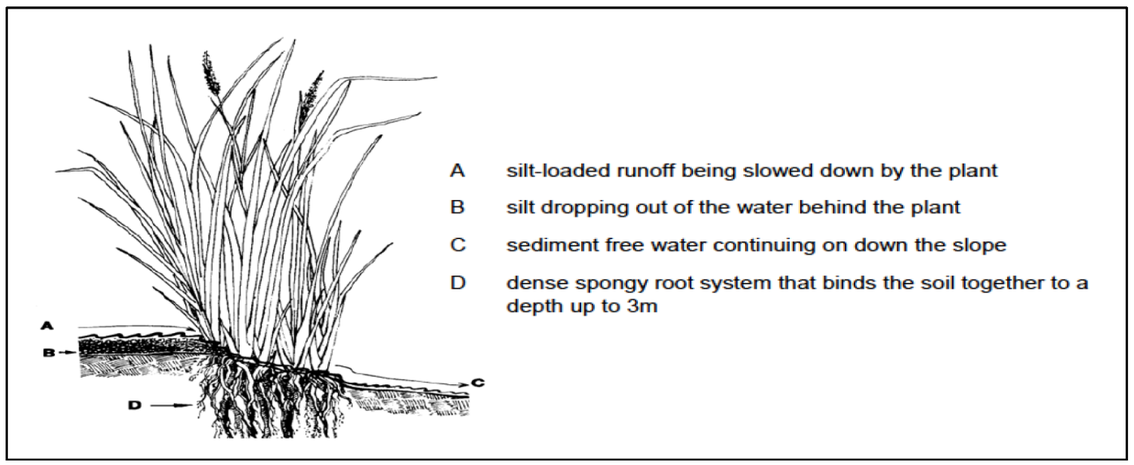

Figure 3: Cross Section A-A through Row of Mature Vetiver Grass.
Illustrates "natural" terraces forming on gradient between rows facilitating even water distribution [NTS].

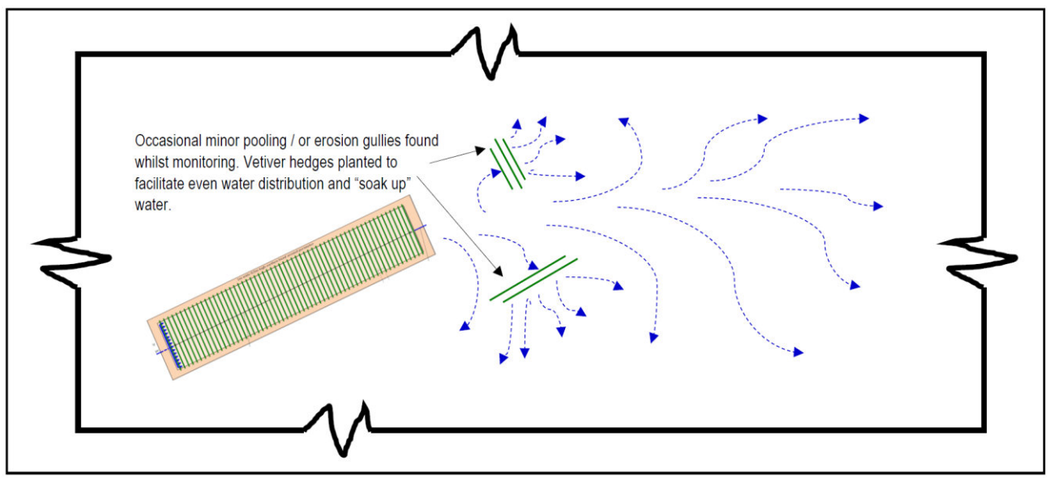

Figure 4: Conceptional Layout - 1.33 ha Total Area.
Final layout to be based on site dimensions and topology (NTS). Gentle gradient between 1:20 and 1:200 away from Vetiver System storm overflow to native vegetation.

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