Decision Report

Application for works approval

Division 3, Part V *Environmental Protection Act 1986*

Works approval number	W6791/2023/1
Applicant	Paul Terrence Reilly and Nicole Sharina Reilly
DWER file number	DER2023/000221
Premises	'Denninup Vale' Cattle Feedlot 4029 Boyup Brook-Kojonup Road SCOTTS BROOK WA 6244
Date of report	14 August 2023
Status of report	Final

1. Purpose and scope of assessment

Paul & Nicole Reilly (the applicant) propose to upgrade their existing cattle feedlot east of Boyup Brook. An application for works approval was submitted under Division 3 Part V of the *Environmental Protection Act 1986* (EP Act) on 28 March 2023.

This report sets out the delegated officer's assessment of potential risk events arising from emissions and discharges during construction and operation of infrastructure relating to the prescribed activity.

In completing the assessment documented in this report, the department has considered and given due regard to its regulatory framework and relevant policy documents which are available at https://dwer.wa.gov.au/regulatory-documents.

2. Application details

2.1 Overview of existing premises

'Denninup Vale' is an existing cattle feedlot that has been operating since 2008 in the small rural location of Scotts Brook, about 280 km southeast of Perth.

The existing premises currently holds 1,600 head across two sites. The pens at the original site (2,000 head capacity) are accredited under the National Feedlot Accreditation Scheme (NFAS), a voluntary, industry-sponsored quality assurance scheme that requires the operator to have in place all relevant state and local government approvals to operate.

A new set of 9 pens have since been constructed at a separate site, with this application seeking to construct an additional 13 pens at this site (22 pens total) and increase the design capacity of the premises to 1,772 head (1,434 standard cattle units, SCU).

Table 1 describes the prescribed premises category that the application is subject, as defined in Schedule 1 of the Environmental Protection Regulations 1987.

Table 1: Prescribed premises category

Classification of premises	Assessed design capacity (as per application)
Category 1: Cattle feedlot: premises on which the watering and feeding of cattle occurs, being premises – (a) situated more than 100 metres from a watercourse; and (b) on which the number of cattle per hectare exceeds 50.	1,772 head (1,434 SCU) at any one time

2.1.1 Background

A set of feedlot pens were constructed at the original site in 2008 with a design capacity of 500 head (without a works approval). Works approval W4875/2011/1 was granted in 2011 for an expansion to a design capacity of 2,000 head.

The works approval expired in 2014; however, stocking of the pens had commenced following their construction, without compliance documentation being submitted. It was also noted the required retention pond had not been constructed or the capacity certified, as per the original plans.

A new set of feedlot pens were constructed at a separate site on the premises in 2021, again without a works approval. The siting and design of these pens is more appropriate (compared to the original pens) in terms of soil types, slope and separation to creek line, and the proposed expansion (of these pens) will supersede the requirement for the pens at the original site, which will be decommissioned.

2.2 Proposal details

The proposal involves constructing 13 new feedlot pens and associated infrastructure for storing and managing effluent runoff and manure.

The applicant has given due regard to the *National Beef Cattle Feedlot Environmental Code of Practice* (MLA 2012a) (the Code) and the accompanying *National Guidelines for Beef Cattle Feedlots in Australia* (MLA 2012b), to ensure the feedlot is appropriately sited, designed, constructed, and managed.

2.2.1 Feedlot design and layout

New and existing feedlot pens

Of the 22 pens in total, 9 are existing and 13 will be constructed. Each of the pens will be partially covered via installation of a solid tin roof where the concrete apron in front of the feed bunk ends.

Pen 1-8 (8 pens): pens 1-7 are existing, pen 8 is to be constructed. Completed pens will measure 24 x 36 m; with a maximum stocking rate of 9 m^2/head, each pen will have a design capacity of 96 head. The proposed shed roof reaches across the full length of the pen (24 m) with a width of 10 m, providing 27% coverage.

Pen 9-17 (9 pens): all pens to be constructed. Completed pens will measure 20 x 40 m; with a design capacity of 88 head. The proposed shed covers the full length of the pen (20 m) with a width of 10 m, covering 25%.

Pen 18-19 (2 pens): already constructed. Pens measure 23 x 30 m; with a design capacity of 76 head. The proposed shed covers the full length of the pen (23 m) with a width of 10 m, covering 33%.

For pens 1-19, given the shed roof represents only partial coverage, stocking density will remain at 9 m^2/head for these pens once sheds are constructed.

Pen 20-22 (3 pens): all pens to be constructed. Completed pens will measure 12 x 12 m, with the proposed shed roof to reach across the full length of the pen (12 m) with a width of 10 m, covering 83%. A covered area of 83% represents predominant coverage and as such a stocking density of 7 m^2/head will be used for these pens, and with an area of 144 m^2, this equates to a design capacity of 20 head.

The floor of the proposed 13 new pens will be constructed with a 300 mm thick compacted clay liner (2 x 150 mm layers). Testing of the proposed construction materials, comprising clays within the vicinity of the proposed feedlot site, indicate a permeability in the order of 3.6 x 10^{-9} m/s.

The applicant advises the floor of the existing 9 pens were constructed using these same clay materials, although, there was no testing conducted prior to, or during, construction and have not been tested since the feedlot has been operating. During the 2 years of operation, the clay surface has been further compacted. No alterations to the floor of the existing 9 pens are proposed in this application.

Effluent holding ponds and effluent catch drains

There are two controlled drainage areas (CDAs) proposed – CDA1 comprises pens 1-17, 20-22 and the western half of the cattle yard area, and CDA2 comprises pens 18-19 and the eastern half of the cattle yard area. The effluent catch drains and holding ponds of each CDA are proposed to use the same clay liners for construction material as the feedlot pens.

CDA1 is designed with a slope of 3%, to facilitate drainage from the pen surface towards the effluent catch drain. This drain is designed to collect runoff from row 1 (pens 1-8) and row 2 (pens 9-17) and will be 10 m wide. The drain is also designed to function as a sedimentation basin, with a wide flat base and gradual slope towards the evaporation pond. This design will encourage solids to settle within the drain in a thin layer to allow for rapid drying.

At the end of the sedimentation drain, a spillway will allow for effluent to enter the evaporation pond. This spillway will be constructed using concrete and measure 2 m in width. A 1.5 m diameter drain will be installed to carry effluent from the spillway to the evaporation pond, under the access road.

The evaporation pond is designed to contain effluent from the feedlot and is designed to spill no more frequently than an average of once in 20 years. The evaporation pond for CDA1 is designed to contain wastewater from:

- Pens 1-17 and 20-22;
- Half of the cattle yard area;
- Cattle yards measuring 6 m wide and located on the lower length of the pens,
- Feed lanes measuring 6 m wide and located on the higher length of the pens,
- Total controlled drainage area of 17,734 m^2.

The pond is designed based on rainfall being collected from the shed area, so the covered area has not been included in the pond calculation. The pond will be constructed with a bywash.

Based on these requirements, the CDA1 pond was calculated by DPIRD using SILO data as shown in Appendix 1. The critical design elements were found to be:

- Pond area of 4,203 m^2;
- Depth of 1.54 m (including a 0.5 m freeboard);
- Design volume of 4,495 m^3.

The design for CDA2 is similar to CDA1 but is sloped towards a drain that runs along the northern side of pen 18 and 19 and will be 3 m wide. The evaporation pond for CDA2 will contain wastewater from:

- Pens 18-19;
- Half of the cattle yard area;
- Total controlled drainage area of 1,920 m^2.

Based on these requirements, the CDA2 pond was calculated by DPIRD using SILO data as shown in Appendix 2. The critical design elements were found to be:

- Pond area of 455 m^2;
- Depth of 1.54 m (including a 0.5 m freeboard);
- Design volume of 487 m^3.

Manure stockpile pad

As part of the solid waste management system of the cattle feedlot, a stockpile pad will be constructed for storage of manure.

The pad will be constructed from the same materials as the pen liners, 300 mm of compacted clay formed by two layers of 150 mm that the applicant states were deemed to be suitably impermeable via testing at a NATA accredited laboratory. Manure will be stored in long, low windrows designed with a triangular cross-section, with a base width of 3 m and height of 2 m.

The applicant proposes the manure stockpile pad is to be included the same CDA as the feedlot pens. It is to be sloped to facilitate run-off towards its own sedimentation drain that will direct the effluent to the main evaporation pond for CDA1.

2.3 Operational aspects

2.3.1 Feedlot operations

Purchased feeder cattle will be grouped into feeding lots, with Wagyu cattle (~1,000 head per year) being on feed for 300-400 days, and domestic cattle (non-Wagyu) being on feed for an average of 90 days, allowing for 3 rotations of domestic cattle per year. The average weight of

cattle in the pens will be 450 kg.

Straw bedding will be used in the 3 winter months to promote cattle comfort, welfare and also to soak up cattle waste. Currently 2 bales of straw are added per pen weekly during the winter months, which is expected to reduce to 1 bale once the sheds are constructed, which equates to roughly 264 bales of straw used for bedding each year.

The applicant proposes a visual check of the pen surface will be made weekly. Repairs to this infrastructure will be made as required. Any repairs to infrastructure will be detailed in an excel spreadsheet and dated.

2.3.2 Surface water management

Clean water diversion

The partially covered nature of the shed roofs will decrease the surface water mixing or coming into direct contact with solid wastes, reducing the size of necessary wastewater containment infrastructure. The rainfall will be captured in gutters and diverted to freshwater tanks.

The applicant proposes diversion drains are to be placed above feed areas to prevent ingress of stormwater. The drains will divert uncontaminated upslope runoff around the feedlot complex.

Effluent runoff and capture

All pens will be constructed with a 3% slope to facilitate drainage of surface water runoff from the pens within the controlled drainage areas. The runoff is firstly directed towards sedimentation drains, that also act as sedimentation basins, then is directed by a gradual slope towards the evaporation ponds. The applicant expects urine will be absorbed within the straw bedding during operation in the cooler months.

2.3.3 Solid waste management

Solid waste removal

The sedimentation basins will be desludged every 4 – 6 weeks, weather dependent. The evaporation ponds are proposed to have sludge removed annually.

Manure generation and feed pen cleaning

Manure is a natural by-product from cattle operation, in this case, the by-product will be a straw/manure combination for 3 months of the year when straw is added to the pens in the winter months. Pens will be cleared every 10 weeks, depending on weather conditions.

Manure storage and processing

Manure harvested from the feedlot will be stockpiled on the proposed designated manure stockpile pad. Manure will be stored in long windrows, where it will be allowed to age, making it more friable and easier to spread than raw manure. The windrows will be designed with a triangular cross-section, with a base width of 3 m and maximum height of 2 m.

Management of deceased animals

The applicant expects a mortality rate of one head every 2 weeks, equating to about 26 mortalities in a year. The applicant states the deceased animals are immediately removed from the pen and taken to a designated burial pit, which is lined with a low permeable clay base – the same clays used to construct the feedlot pens. Mortalities are placed in the burial pit using a front-end loader, covered with at least 300 mm of dirt and left to decompose undisturbed.

2.3.4 Manure utilisation

Aged manure (faeces, urine and spent bedding) will be spread over 230 ha of dryland cropping land, prior to the break of the season. Dryland pasture will be grown and cut to

remove applied nutrients.

Based on the cropping nutrient balance provided with the application, the estimated annual total solids (TS) harvest from the pens will be in the order of 701,460 kg TS/year, comprising a combination of 587,940 kg TS/year from manure dry solids and 113,520 kg TS/year from spent bedding. One third of the manure will be transported off-site to a nearby composting facility and the remaining 469,978 kg TS/year will be spread over dryland cropping land on the premises.

About 9,123 kg/year of nitrogen (N) and 3,189 kg/year of phosphorus (P) will be generated. The nutrient offtake via cropping is 36,800 kg/year of N and 5,520 kg/year of P, meaning the N levels in waste are much below crop requirements, and therefore waste application rates will be based on phosphorus to ensure that no nutrient accumulation occurs. The proposed application rate based on phosphorus content is calculated to be maximum 5.6 t/ha.

The above application rate based on phosphorus is the average expected cropping program for the short term, however, the applicant proposes other crops can be used over the life of the feedlot with different application rates (Table 2). Application rates will be used to ensure the amount of waste does not exceed crop demand which results in environmental contamination.

Table 2. Alternative application rates

Crop	Yield (t/ha)	Aged manure spreading rate (t/ha)
Winter cereal hay	5	3.5
Grain wheat	3	2.8
Grain barley	2.5	1.8
Canola	5	0.4

Manure will not be applied within 25 m of any watercourses, drainage lines or the property boundary. This leaves a potential manure utilisation area of 709 ha over which the 230 ha of manure can be spread.

3. Infrastructure

Table 3: Cattle feedlot infrastructure

Prescribed activity – category 1	
Cattle feedlot: full capacity 1,772 head (1,434 SCU)	
1	New feedlot pens – Pen 8 (96 head), Pens 9-17 (88 head each), Pens 20-22 (20 head each)
2	Existing feedlot pens – Pens 1-7 (96 head each), Pens 18-19 (76 head each)
3	Shed roof – partial coverage of all 22 pens
4	Effluent catch drains x 2 – 10 m width, 3 m width, each with 2 m concrete spillways
5	Effluent holding ponds x 2 – 4,495 m^3 and 487 m^3 storage capacity
6	Manure stockpile pad – 75 m x 29 m

Exclusions to this assessment

The following matters are out of the scope of this assessment and have not been considered within the risk assessment detailed in this report:

- other general farming activities being conducted on the premises, outside of the feedlot complex and manure utilisation areas;
- vehicle (i.e., livestock truck) movements on private or public roads; and
- land use zoning and compatibility with surrounding land uses.

The works approval is related to category 1 activities only and does not offer the defence to offence provisions in the EP Act (see sections 74, 74A and 74B) relating to emissions or environmental impacts arising from prescribed and non-prescribed activities, including those listed above.

4. Consultation

The application was advertised for public comment on the department's website during April 2023. No public submissions were received in the timeframe specified.

5. Location and siting

5.1 Siting context

The premises is located on farming land east of Boyup Brook and is about 1,000 ha in size with a minor river, Dinninup Brook, crossing into the property to the north of the site. The premises is predominantly surrounded by rural farming land and state forest.

5.1.1 Land use and sensitive receptors

The premises and surrounding land have historically been used for agricultural purposes and as a result, are largely cleared of vegetation. The site is zoned 'rural' under the Shire's town planning scheme. The surrounding land uses are agricultural in nature, including cropping, forestry, and a sheep feedlot approximately 3.9 km southwest of the existing feedlot.

The premises is well separated from human sensitive receptors, with three rural dwellings located between 3 km and 3.6 km from the feedlot pens. There is DBCA Legislated Tenure bordering the premises, around 1.5 km (unnamed) and 2.4 km (Wahkinup Nature Reserve) from the feedlot pens. No other specified ecosystems or areas of high conservation value have been identified in proximity that may be directly impacted by the proposed activities.

5.1.2 Climate

Average annual rainfall is about 521 mm/year, with most falling in the winter months at an average of 398 mm, compared to 122 mm in the summer months. Annual evaporation is higher than average rainfall, at an average of about 1397 mm/year, averaging 400 mm in winter and 996 mm in summer.

5.1.3 Physiography

The site's topography is gently sloping and undulating, with elevation levels ranging from a low of 230 m AHD around the river system to 292 m AHD at a small peak near the existing feedlot operation.

5.1.4 Soils and landscape

Broadly, the site lies within the Eastern Darling Range soil-landscape zone (code 253), which is characterised by "Moderately to strongly dissected lateritic plateau on granite with eastward-flowing streams in broad shallow valleys, some surficial Eocene sediments. Soils are formed in laterite colluvium or granite weathered in-situ" (Schoknecht et al, 2004).

Soil-landscape systems present on the site include the Boyup Brook Valleys Systems (253Bv) and the Eulin Uplands System (253Eu). The Boyup Brook Valleys System is characterised as having "valleys with gravel, sandy duplex loamy duplex" soils, while the Eulin Uplands System is characterised as "plateau remnants with gravel, sandy duplex soil and wet soil" (DPIRD, 2022).

More specifically, there are a number of subsystems that intersect the site. The existing feedlot infrastructure is located on the soils of the Boree and Dalmore (Boyup Brook) subsystems. Boree is characterised as "shallow major valleys with sands and sandy gravels" and Dalmore is characterised as "undulating ridges and hill crests on laterite and granite. Soils are gravels, loamy duplex and sandy duplex soils" (DPIRD, 2022).

5.2 Groundwater

The site falls within the Karri groundwater subarea. There is currently one production bore on the property, drilled to a depth of about 10 m below ground level. This bore is about 400 m from the original feedlot site (to be decommissioned after construction of new pens), which is significantly lower than the new feedlot site. It provides 60,000 litres per day. In summer, 80% of bore water is directed to house gardens.

5.3 Surface water

The site sits within the Dinninup Brook subcatchment, which forms part of the wider Hardy Estuary-Blackwood River catchment. The Dinninup Brook, which is classified as a minor river, traverses a small section at the northern extent of the premises, about 1.5 km from the feedlot pens. Smaller tributaries also pass through the property, about 480 m from the feedlot pens. The site is not within a designated public drinking water source area.

5.4 Separation distances

The applicant has calculated the minimum required separation distance from the feedlot to nearby sensitive receptors using a readily applied formula (the 's-factor' formula) outlined in the National Guidelines (MLA 2012a).

The s-factor method was originally devised in Queensland and allows for a rapid and simple assessment of potential air quality impacts (mainly odour) that does not require technically specialised and complex air quality modelling.

When considering the overall feedlot capacity upgrade from 1,600 head capacity to 1,772 head capacity (1,434 SCU), the calculated separation distance to the nearest receptor, being a single rural or farm dwelling, is a minimum of 600 m, which is well within the actual distance of 3 km. This indicates adequate separation distance from the proposed feedlot pens; additionally, in view of the partial covering of the feedlot pens, this calculation is relatively conservative, given it is designed for 100% open-air feedlots.

6. Risk assessment

6.1.1 Determination of emission, pathway and receptor

The department assesses the risks of emissions from prescribed premises and identifies the potential source, pathway and impact to receptors in accordance with the *Guideline: Risk Assessments* (DWER 2020).

To establish a risk event there must be an emission, a receptor which may be exposed to that emission through an identified actual or likely pathway, and a potential adverse effect to the receptor from exposure to that emission.

6.1.2 Risk ratings

Risk ratings have been assessed in accordance with the *Guideline: Risk Assessments* (DWER 2020) for each identified emission source and takes into account identified potential source-pathway and receptor linkages. Where linkages are in-complete they have not been considered further in the risk assessment.

Where the applicant has proposed mitigation measures/controls, these have been considered when determining the final risk rating. Where the delegated officer considers the applicant's proposed controls to be critical to maintaining an acceptable level of risk, these will be incorporated into the works approval as regulatory controls.

Additional regulatory controls may be imposed where the applicant's controls are not deemed sufficient. Where this is the case the need for additional controls will be documented and justified in the below table.

6.1.3 Risk assessment table

The table below describes the risk events associated with the proposal consistent with the *Guideline: Risk Assessments* (DWER 2020). The table identifies whether the risk events are acceptable and tolerated, or unacceptable and not tolerated, and the appropriate treatment and degree of regulatory control, where required.

Risk Event				Consequence rating[1]	Likelihood rating[1]	Risk[1]	Reasoning	Regulatory controls
Source/ Activities	**Potential emissions**	**Potential receptors, pathway and impact**	**Applicant controls**					
Construction works								
Construction of new feedlot pens, shed roofs, controlled drainage areas (including sedimentation drains/basins and evaporation ponds), and manure stockpile pad	Noise and fugitive dust associated with construction civil excavation, earthworks, construction works, etc.	Unreasonable interference with the health, welfare, convenience, comfort or amenity of nearby sensitive receptors (>3 km)	Adequate separation to nearby receptors (>3 km)	Minimal impacts to amenity on local scale **Slight**	Not likely to occur in most circumstances **Unlikely**	**Low** Acceptable, not subject to controls	The delegated officer considers there is sufficient separation in place (>3 km to nearest rural dwelling, >32 km to nearest town), and therefore does not reasonably foresee that noise and dust from construction works will impact on the amenity or health of off-site human receptors.	Works approval controls: None specified.
Time limited operations and full operations								
Category 1: Cattle feedlot operations								
Holding, feeding and watering of animals within partially covered pens	Nutrient-laden leachate (from manure, urine) mobilised by surface water runoff	Seepage/infiltration causing groundwater contamination	Shed roof constructed to partially cover pens Pens, sedimentation drains/basins and evaporation ponds constructed with compacted clay liner Straw-based bedding system to absorb leachates (in winter)	Low-level on-site impacts Minimal off-site impacts on local scale **Minor**	Not likely to occur in most circumstances **Unlikely**	**Medium** Acceptable, subject to regulatory controls	The partially covered nature of the pens is expected to reduce the volume of leachate generated from manure (urine, faeces, spilled feed, etc.), given it will not be fully exposed to rainfall runoff. The clay to be used in liner construction was tested by a NATA accredited laboratory and returned a permeability of $3.66x10^{-9}$ m/s, which is considered to be acceptable given the high annual moisture deficit of the area and there being sufficient depth to groundwater (~10 mbgl). To ensure an acceptable level of risk is maintained during operations and to ensure consistency with the Code (MLA 2012a), the following infrastructure controls will be imposed on the works approval: - Feedlot pens must be partially covered, as per proposed design specifications; - Pen surfaces, drains and ponds must be constructed with a minimum 300 mm thick compacted clay liner. The delegated officer considers the above controls will ensure the risk of groundwater contamination from feedlot activities is acceptable. As the proposed controls are critical for maintaining an acceptable level of risk, they will be imposed on the works approval, and required to be maintained on the licence as minimum infrastructure requirements.	Works approval controls: - Feedlot pens must be partially covered; - Pen surfaces must be constructed as per design plans (CCL), and demonstrated through testing the permeability of the constructed surface; - External perimeter bunds must be constructed; Licence controls: - Pen floors and bunding must be maintained to ensure integrity is sustained.
		Uncontrolled discharge/runoff, causing soil, groundwater, or surface water contamination	Feedlot pens constructed within a controlled drainage area, comprising a sloped surface that diverts surface water runoff to the sedimentation drains/basin, that slopes towards the evaporation ponds	Mid-level on-site impacts Low-level off-site impacts on local scale **Moderate**	Not likely to occur in most circumstances **Unlikely**	**Medium** Acceptable, subject to regulatory controls	Feedlot pens will be located within a controlled drainage area, which will comprise a sloped pens surface in which contaminated surface water runoff will be diverted to a sedimentation system and evaporation ponds. The feedlot pen surfaces, and sedimentation drain/basins have been designed with a gradual slope to facilitate drainage in accordance with the requirements outlined in the Code (MLA 2012a). The delegated officer considers the above controls will ensure the risk of uncontrolled discharges, resulting in soil or groundwater contamination, is acceptable. As the proposed controls are critical for maintaining an acceptable level of risk, they will be imposed on the works approval, and required to be maintained on the licence as minimum infrastructure requirements.	Works approval controls: - Controlled drainage areas must be established, containing all key feedlot infrastructure; - CDA must be sloped to facilitate drainage to a sedimentation system and holding ponds. Licence controls: - Controlled drainage area must be maintained to prevent uncontrolled runoff of contaminated surface water.
		Overtopping of sedimentation drains/basins or evaporation ponds, causing soil or groundwater contamination	Sedimentation basins and holding ponds designed with sufficient storage capacity	Low level impacts to amenity on local scale **Minor**	Likely to occur only in exceptional circumstances **Rare**	**Low** Acceptable, based on applicant controls being implemented	The sedimentation system will comprise two separate drains/basins, with the size of each based on the total area that wastewater will be collected from. The sedimentation drains/basins will each overflow to an evaporation pond, with the critical design elements of the two ponds calculated by DPIRD using SILO data. The design of the ponds are sufficient to ensure they spill no more frequently than an average of one in 20 years. The delegated officer considers the above controls will ensure the risk of overtopping of containment infrastructure, resulting in soil or groundwater	Works approval controls: - Containment infrastructure must be constructed in accordance with critical design elements specified in plan. Licence controls: - Operational freeboard requirement of 0.5 m must be maintained on

Risk Event				Consequence rating[1]	Likelihood rating[1]	Risk[1]	Reasoning	Regulatory controls
Source/ Activities	**Potential emissions**	**Potential receptors, pathway and impact**	**Applicant controls**					
							contamination, is acceptable. As the proposed controls are critical for maintaining an acceptable level of risk, they will be imposed on the works approval, and required to be maintained on the licence as minimum infrastructure requirements.	evaporation ponds.
	Odour, from manure accumulated in feedlot pens	Unreasonable interference with the health, welfare, convenience, comfort or amenity of nearby sensitive receptors (>3 km)	Stocking density 9 m^2/head for Pens 1-19, density 7 m^2/head for the more covered pens 20-22 Straw-based bedding system to absorb leachates (in winter) Pens cleaned at least after every rotation (every 10 to 13 weeks) weather dependent	Low level impacts to amenity on local scale **Minor**	Likely to occur only in exceptional circumstances **Rare**	**Low** Acceptable, based on applicant controls being implemented	The delegated officer considers there is sufficient separation in place (>3 km to nearest rural dwelling, >32 km to nearest town). Providing the stocking density in pens does not exceed 9 m^2/head for Pens 1-19, and 7 m^2/head for the more covered pens 20-22, and providing pens are cleaned after every rotation (every 10 to 13 weeks), the delegated officer considers it unlikely that odour from feedlot operations will significantly impact on the amenity or health of off-site human receptors. As the proposed controls are necessary for maintaining a low level of risk, they will be imposed on the works approval and the licence as operational controls.	Works approval controls: - Must operate covered pens with minimum stocking density of 9 m^2/head for pens 1-19 and 7 m^2/head for the more covered pens 20-22; - Pens must be cleaned out after every rotation, or every 10 weeks, whichever is sooner. Licence controls: As above.
	Odour, from manure and nutrient-laden leachate build up in sedimentation drains/basins		Solid waste collected from sedimentation basins every 4-6 weeks Sedimentation drains/basin constructed with gradual slope to facilitate drainage	Low level impacts to amenity on local scale **Minor**	Likely to occur only in exceptional circumstances **Rare**	**Low** Acceptable, based on applicant controls being implemented	The delegated officer considers there is sufficient separation in place (>3 km to nearest rural dwelling, >32 km to nearest town). Providing the sedimentation drains/basins are maintained in accordance with the Code (i.e. all leachate and surface water runoff from the feedlot pens can freely flow to the sedimentation system without scouring), the delegated officer considers it unlikely that odour from effluent catch drains or the sedimentation system will significantly impact on the amenity or health of off-site human receptors. As the proposed controls are necessary for maintaining a low level of risk, they will be imposed on the works approval and the licence as operational controls.	Works approval controls: - Sedimentation drains/basins must be maintained to ensure all leachate and surface water runoff from the feedlot pens is diverted to the sedimentation system without scouring. - Solid waste must be collected from sedimentation basins every 4-6 weeks Licence controls: As above.
	Odour, from evaporation ponds		Sludge removed from evaporation ponds annually Sedimentation basins in place to settle solids, to ensure cleaner water is stored within holding ponds	Low level impacts to amenity on local scale **Minor**	Likely to occur only in exceptional circumstances **Rare**	**Low** Acceptable, based on applicant controls being implemented	The delegated officer considers there is sufficient separation in place (>3 km to nearest rural dwelling, >32 km to nearest town). Providing the sedimentation basins are maintained (i.e., flow freely after rainfall events, and cleaned of solids every 4-6 weeks), the delegated officer considers it unlikely that odour from the effluent holding ponds will significantly impact on the amenity or health of off-site human receptors. As the proposed controls are necessary for maintaining a low level of risk, they will be imposed on the works approval and the licence as operational controls.	Works approval controls: - Sedimentation drains/basins must be maintained to ensure basins are free flowing after rainfall - Solid waste must be collected from sedimentation basins every 4-6 weeks Licence controls: - Sludge must be removed from evaporation ponds annually.
	Noise, from animals and machinery movements Fugitive dust, from truck movements on gravel/unsealed roads		Sufficient separation distance in place to nearby human receptors	Minimal impacts to amenity on local scale **Slight**	Likely to occur only in exceptional circumstances **Rare**	**Low** Acceptable, not subject to controls	The delegated officer considers there is sufficient separation in place (>3 km to nearest rural dwelling, >32 km to nearest town), and therefore does not reasonably foresee that noise and dust from vehicle movements as part of feedlot operations will impact on the amenity or health of off-site human receptors.	Works approval controls: None specified. Licence controls: None specified.
Burial pit for deceased animals	Nutrient-laden leachate from decomposition	Uncontrolled discharge, causing contamination of shallow groundwater	Pit lined with low permeability clay base	Minimal impacts to amenity on local scale **Slight**	Not likely to occur in most circumstances **Unlikely**	**Low** Acceptable, based on applicant controls implemented	The burial pit for mortalities is lined with a low permeability clay. The delegated officer considers this control to limit the environmental risk to an acceptable level due to average evaporation being higher than average rainfall for the area and sufficient depth to groundwater (~10 mbgl). As the proposed controls are necessary for maintaining a low level of risk, they will be imposed on the works approval and the licence as operational controls.	Works approval controls: None specified. Licence controls: - Burial pit clay lining must be maintained to ensure integrity is sustained.

Risk Event				Consequence rating[1]	Likelihood rating[1]	Risk[1]	Reasoning	Regulatory controls
Source/ Activities	**Potential emissions**	**Potential receptors, pathway and impact**	**Applicant controls**					
	Odour, from decomposition	Unreasonable interference with the health, welfare, convenience, comfort or amenity of nearby sensitive receptors (>3 km)	Mortalities covered with at least 300 mm of dirt and left to decompose undisturbed	Minimal impacts to amenity on local scale **Slight**	Not likely to occur in most circumstances **Unlikely**	**Low** Acceptable, based on applicant controls being implemented	The delegated officer considers there is sufficient separation in place (>3 km to nearest rural dwelling, >32 km to nearest town). Providing the carcasses are placed in the burial pit and covered with 300 mm of dirt as soon as practicable after placement, the delegated officer considers it unlikely that odour from composting operations will significantly impact on the amenity or health of off-site human receptors. As the proposed controls are necessary for maintaining a low level of risk, they will be imposed on the works approval and the licence as operational controls.	Works approval controls: - Mortalities must be covered with at least 300 mm of dirt; Licence controls: As above.
Category 1: Manure management								
Management of manure	Nutrient-laden leachate from manure (faeces urine, spent bedding) mobilised by surface water runoff	Seepage/infiltration causing groundwater contamination	Manure stockpile pad to be constructed on low permeability clay liner Weekly visual checks of stockpile pad surface, recording repairs	Low-level on-site impacts Minimal off-site impacts on local scale **Minor**	Not likely to occur in most circumstances **Unlikely**	**Medium** Acceptable, subject to regulatory controls	The clay to be used in liner construction was tested by a NATA accredited laboratory and returned a permeability of $3.66x10^{-9}$ m/s, which is considered to be acceptable given the high annual moisture deficit of the area and there being sufficient depth to groundwater (~10 mbgl). To ensure an acceptable level of risk is maintained during operations and to ensure consistency with the National Guidelines (MLA 2012a), the following infrastructure controls will be imposed on the works approval: - Manure storage pad must be constructed with minimum 300 mm thick compacted clay layers.	Works approval controls: - Manure stockpile pad must be constructed as per design plans; Licence controls: - Manure stockpile pad must be maintained to ensure integrity is sustained.
		Uncontrolled discharge, causing soil or groundwater contamination	Manure stockpile pad to be constructed within a controlled drainage area, comprising a sloped surface that diverts surface water runoff to the sedimentation drains/basin, that slopes towards the main evaporation pond	Mid-level on-site impacts Low-level off-site impacts on local scale **Moderate**	Not likely to occur in most circumstances **Unlikely**	**Medium** Acceptable, subject to regulatory controls	The manure storage area will comprise a clay pad that slopes toward sedimentation drains/basins, which are sloped to ensure all surface water runoff is contained and diverted to the main evaporation pond. The delegated officer considers the above controls will ensure the risk of uncontrolled discharges, resulting in soil or groundwater contamination, is acceptable. As the proposed controls are critical for maintaining an acceptable level of risk, they will be imposed on the works approval, and required to be maintained on the licence as minimum infrastructure requirements.	Works approval controls: - Manure stockpile pad must be constructed, within the controlled drainage area; - Area must be sloped to facilitate drainage to the evaporation pond; Licence controls: - Manure stockpile pad must be maintained to ensure all contaminated surface water runoff is fully contained within.
	Odour, from stockpiled manure	Unreasonable interference with the health, welfare, convenience, comfort or amenity of nearby sensitive receptors (>3 km)	Manure stockpiled in low profile windrows	Minimal impacts to amenity on local scale **Slight**	Not likely to occur in most circumstances **Unlikely**	**Low** Acceptable, based on applicant controls being implemented	The delegated officer considers there is sufficient separation in place (>3 km to nearest rural dwelling, >32 km to nearest town). Providing the manure and spent bedding is to be stockpiled in low profile windrows the delegated officer considers it unlikely that odour from manure storage or composting operations will significantly impact on the amenity or health of off-site human receptors. As the proposed controls are necessary for maintaining a low level of risk, they will be imposed on the works approval and the licence as operational controls.	Works approval controls: - Manure is to be stockpiled in low profile windrows; Licence controls: As above.
Spreading of aged manure over 230 ha of suitable dryland cropping land	Leaching or runoff of nutrients from spread manure	Contamination of soil, causing contamination of shallow groundwater Runoff from spread areas causing contamination of Dinninup Brook Soil acidification Excessive build-up of soil P	Manure not to be applied within 25m of any watercourses, drainage lines or the property boundary Ensure even spread at yearly application of 5.6 t/ha	Mid-level on-site impacts **Moderate**	Could occur at some time **Possible**	**Medium** Acceptable, subject to regulatory controls	The delegated officer has considered the applicant's proposal to spread aged manure on the premises (see section 2.3) and has determined the yearly application of 5.6 t//ha over a minimum of 230 ha of cropping land is the most appropriate method to maintain the soil's capacity to absorb nutrients and to limit water repellence. As the proposed controls are critical for maintaining an acceptable level of risk, they will be imposed on the works approval for time limited operations, and on the licence as ongoing operational controls.	Works approval controls: - Manure must only be spread at an application rate of no more than 5.6 t/ha/yr; - Must only be spread across specified manure utilisation areas, with even distribution and only onto areas growing crops or pasture; - Must conduct soil testing of nutrients, before and after first application; - Soil testing must be conducted at regular depths down the soil profile; - Manure must not be applied within 25m of any watercourses, drainage lines or the property boundary;

Risk Event				Consequence rating[1]	Likelihood rating[1]	Risk[1]	Reasoning	Regulatory controls
Source/ Activities	**Potential emissions**	**Potential receptors, pathway and impact**	**Applicant controls**					
								Licence controls: As above.
	Odour, from spread manure	Unreasonable interference with the health, welfare, convenience, comfort, or amenity of nearby sensitive receptors (>3 km)	Manure stockpiled in low profile windrows Not to be applied within 25m of any watercourses, drainage lines or the property boundary	Minimal impacts to amenity on local scale **Slight**	Not likely to occur in most circumstances **Unlikely**	**Low** Acceptable, based on applicant controls being implemented	The delegated officer considers there is sufficient separation in place (>3 km to nearest rural dwelling, >32 km to nearest town). Given the proposed controls, the delegated officer considers it unlikely that odour from the spreading of manure will significantly impact on the amenity or health of off-site human receptors. As the proposed controls are necessary for maintaining a low level of risk, they will be imposed on the works approval and the licence as operational controls.	Works approval controls: - Manure is to be stockpiled in low profile windrows; - Manure not to be applied within 25m of any watercourses, drainage lines or the property boundary; Licence controls: As above

Note 1: Consequence ratings, likelihood ratings and risk descriptions are detailed in the Guideline: Risk Assessments (DWER 2020).

7. Decision

The delegated officer has determined the proposal to construct and operate a set of partially covered feedlot pens, with an assessed design capacity of 1,434 SCU, does not pose an unacceptable risk of impacts to on- and off-site receptors. This determination is based on:

- there being sufficient separation to nearby human receptors, as determined by s-factor calculations;
- the set of pens at the original site being decommissioned (following construction of the new pens);
- the proposed new and existing pens will be partially covered (roofed) to reduce direct stormwater runoff, and thereby lower the risk of surface water coming into direct contact with manured surfaces;
- proposed stocking density of 9 m^2/head for pens 1-19 and 7 m^2/head for the more covered pens 20-22;
- feedlot pens, sedimentation drains/basins, evaporation ponds, and manure stockpile pad being constructed with a compacted clay liner;
- key feedlot infrastructure being located within a designated controlled drainage area;
- manure and spent bedding to be stockpiled and aged on a designated pad within a controlled drainage area; and
- aged manure being spread at acceptable application rates, and in accordance with a detailed nutrient management plan.

The above controls proposed by the applicant are considered critical for maintaining an acceptable level of risk of environmental impacts and will be imposed on the works approval as infrastructure controls.

The delegated officer notes that permeability testing of the pen floors of the existing 9 pens was not conducted and no information has been provided to demonstrate the standard of construction. However, according to the applicant, soils similar to that obtained for constructing the new pens were used in the construction (of the existing pens); the delegated officer is satisfied with accepting a lower standard of lining ($3.6x10^{-9}$ m/s) in this instance, given the climate (where evaporation exceeds rainfall) and the pens being mostly covered with a roof that will reduce incident stormwater falling on the pen floors.

7.1.1 Works approval and licence

Works Approval W6791/2023/1 that accompanies this report authorises construction of shed roofs, 13 new feedlot pens, sedimentation drains/basins, evaporation ponds, and a manure stockpile pad. The conditions in the issued works approval, as outlined in the above risk table have been determined in accordance with the *Guidance Statement: Setting Conditions* (DER 2015).

A licence is required to authorise emissions associated with the ongoing operation of the premises, i.e. cattle feedlotting activities. A risk assessment for the operational phase has been included in this report, however licence conditions will not be finalised until the department assesses the licence application. Conditions will be imposed to ensure day-to-day operations do not pose an unacceptable risk of impacts to on- and off-site receptors.

7.1.2 Applicant comments on draft decision

The applicant was provided with drafts of the works approval and this report on 18 July 2023 and provided only minor comments and clarifications.

8. Conclusion

Based on this assessment, it has been determined the issued works approval will be granted subject to conditions commensurate with the determined controls and necessary for administration and reporting requirements.

9. References

1. Department of Primary Industries and Regional Development (DPIRD) 2022, Soil Landscape Mapping (DPIRD-064). Accessed from www.data.wa.gov.au.
2. Department of Environment Regulation (DER) 2015, *Guidance Statement: Setting Conditions*, Perth, Western Australia.
3. Department of Water and Environmental Regulation (DWER) 2019, *Guideline: Industry Regulation Guide to Licensing*, Perth, Western Australia.
4. DWER 2020, *Guideline: Risk Assessments*, Perth, Western Australia.
5. Meat and Livestock Australia (MLA) 2012a, *National Beef Cattle Feedlot Environmental Code of Practice, 2nd Ed.* Meat & Livestock Australia Limited.
6. MLA 2012b, *National Guidelines for Beef Cattle Feedlots in Australia, 3rd Ed.* Meat & Livestock Australia Limited.

Appendix 1: Pond sizing calculations – Pond for CDA1 (provided by applicant)

Site Details				Notes
Catchment Area 1	A_{C1}	17734	m^2	Runoff coeficient is calculated using daily SILO data with a cumulative rainfall model, assuming a 20mm runoff threshold and 1.0 pan evaporation
Catchment Area 2	A_{C2}	0	m^2	factor from the catchment area. The default settings are only applicable to beef cattle feedlot pads.
Catchment Area 3	A_{C3}	0	m^2	Pond is assumed to start empty, with the balance of each month added onto the next.
Irrigation Area	A_I	0	m^2	50 years of SILO data is additional safety net in the calculator given the reduction in rainfall over the past 20 years.
Wastewater Production	Q_D	0.00	m^3/day	
Pond Depth Safety Factor	K_{PA}	10%	[-]	Pond volume is calculated on a 2-year cycle starting in May, with the first year having a 1:20 (evaporation pond) or a 1:10 (irrigation pond) annual
Pond Area Safety Factor	K_{PD}	10%	[-]	rainfall. The third year shows expected water balance for an average year.
Dam Evaporation Factor	K_E	1.00	[-]	Pond depth is does not include the thickness of the liner. Construction should ensure that the liner thickness does impact the design depth of the
Mean (yearly) Crop Factor	K_C	0.4	[-]	pond.
Runoff Coeficient (Catchment 1)	K_{R1}	0.28	[-]	A default 10% pond depth safety factor is applied to cater for any solids buildup in the pond, and 10% pond area safety factor to cater for evaporation
Runoff Coeficient (Catchment 2)	K_{R2}	0.28	[-]	losses due to debris or shade from nearby trees/structures.
Runoff Coeficient (Catchment 3)	K_{R3}	0.28	[-]	

Climate Data

	Symbol	Formula	Units	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
Days in Month	D		days	31	30	31	31	30	31	30	31	31	28	31	30	365
Precipitation Rate	P		mm/month	66	81	89	73	55	34	26	15	16	14	19	32	521
Mean Pan Evaporation	E_P		mm/month	60	45	46	59	77	113	153	201	220	180	152	90	1397
Mean Irrigation Rate	E_T	$(E_P \times K_C) - P$	mm/month	0	0	0	0	0	11	35	65	72	58	42	4	287
Average Winter Precipitation	P_W		mm/cycle	66	81	89	73	55	34							521
1:20 Winter Precipitation	$P_{W,max}$		mm/cycle	86	106	117	96	72	45							683

Pond Balance

Year 1 of 3 (1:20 ARI Winter Rainfall)															
Precipitation	Q_P	$A_P \times (P/1000)$	m^3/month	330	406	448	365	274	173	130	75	82	72	95	158	
Waste Inflow	Q_M	$Q_D \times D$	m^3/month	0	0	0	0	0	0	0	0	0	0	0	0	
Total Catchment Inflow	Q_I	$\sum(A_C \times K_R \times (P/1000))$	m^3/month	432	846	1037	512	162	32	27	22	104	41	81	149	
Pond Evaporation	Q_E	$K_E \times (E_P/1000) \times A_P$	m^3/month	229	171	177	225	295	432	584	768	840	689	581	344	
Irrigation Outflow	Q_O	$E_T \times A_I$	m^3/month	0	0	0	0	0	0	0	0	0	0	0	0	
Total Pond Water	V_P	$Q_P + Q_M + Q_I - Q_E - Q_O$	m^3	532	1613	2920	3573	3714	3487	3061	2390	1736	1160	755	718	
Pond Depth	D_{POND}	V_P/A_P	m	0.14	0.42	0.76	0.94	0.97	0.91	0.80	0.63	0.45	0.30	0.20	0.19	
Year 2 of 3															
Precipitation	Q_P		m^3/month	251	310	342	278	209	132	99	57	63	55	73	121	
Waste Inflow	Q_M		m^3/month	0	0	0	0	0	0	0	0	0	0	0	0	
Total Catchment Inflow	Q_I		m^3/month	329	645	791	391	124	25	21	17	80	32	62	113	
Pond Evaporation	Q_E		m^3/month	229	171	177	225	295	432	584	768	840	689	581	344	
Irrigation Outflow	Q_O		m^3/month	0	0	0	0	0	0	0	0	0	0	0	0	
Total Pond Water	V_P		m^3	1069	1853	2809	3253	3291	3015	2551	1857	1159	557	110	0	
Pond Depth	D_{POND}		m	0.28	0.49	0.74	0.85	0.86	0.79	0.67	0.49	0.30	0.15	0.03	0.00	
Year 3 of 3																
Precipitation	Q_P		m^3/month	251	310	342	278	209	132	99	57	63	55	73	121	4598
Waste Inflow	Q_M		m^3/month	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Catchment Inflow	Q_I		m^3/month	329	645	791	391	124	25	21	17	80	32	62	113	6074
Pond Evaporation	Q_E		m^3/month	229	171	177	225	295	432	584	768	840	689	581	344	10673
Irrigation Outflow	Q_O		m^3/month	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Pond Water	V_P		m^3	351	1135	2090	2535	2573	2297	1833	1139	441	0	0	0	0
Pond Depth	D_{POND}		m	0.09	0.30	0.55	0.66	0.67	0.60	0.48	0.30	0.12	0.00	0.00	0.00	

Outputs

Minimum Pond Area (excl. Safety Factor)	A_P	$\sum Q_P + \sum Q_M + \sum Q_I - \sum Q_E - \sum Q_O = 0$	3820	m^2
Minimum Pond Depth (excl. Safety Factor and Freeboard)	$D_{POND,max}$	Maximum value of D_{POND}	0.97	m
Minimum Pond Volume (excl. Safety Factor & Freeboard)	$V_{P,max}$	Maximum value of V_P	3714	m^3
Required Pond Area	**Area**	$A_P \times (1+K_{PA})$	**4203**	m^2
Pond Depth Including Freeboard	**Depth**	$D_{POND,max} \times (1+K_{PD})$ + Freeboard	**1.57**	m
Required Pond Volume	**Volume**		**4495**	m^3

Appendix 2: Pond sizing calculations – Pond for CDA2 (provided by applicant)

Site Details				Notes
Catchment Area 1	A_{C1}	1920	m²	Runoff coeficient is calculated using daily SILO data with a cumulative rainfall model, assuming a 20mm runoff threshold and 1.0 pan evaporation factor
Catchment Area 2	A_{C2}	0	m²	from the catchment area. The default settings are only applicable to beef cattle feedlot pads.
Catchment Area 3	A_{C3}	0	m²	Pond is assumed to start empty, with the balance of each month added onto the next.
Irrigation Area	A_I	0	m²	50 years of SILO data is additional safety net in the calculator given the reduction in rainfall over the past 20 years.
Wastewater Production	Q_D	0.00	m³/day	
Pond Depth Safety Factor	K_{PA}	10%	[-]	Pond volume is calculated on a 2-year cycle starting in May, with the first year having a 1:20 (evaporation pond) or a 1:10 (irrigation pond) annual
Pond Area Safety Factor	K_{PD}	10%	[-]	rainfall. The third year shows expected water balance for an average year.
Dam Evaporation Factor	K_E	1.00	[-]	Pond depth is does not include the thickness of the liner. Construction should ensure that the liner thickness does impact the design depth of the pond.
Mean (yearly) Crop Factor	K_C	0.4	[-]	
Runoff Coeficient (Catchment 1)	K_{R1}	0.28	[-]	A default 10% pond depth safety factor is applied to cater for any solids buildup in the pond, and 10% pond area safety factor to cater for evaporation
Runoff Coeficient (Catchment 2)	K_{R2}	0.28	[-]	losses due to debris or shade from nearby trees/structures.
Runoff Coeficient (Catchment 3)	K_{R3}	0.28	[-]	

Climate Data															
	Symbol	Formula	Units	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
Days in Month	D		days	31	30	31	31	30	31	30	31	31	28	31	30	365
Precipitation Rate	P		mm/month	66	81	89	73	55	34	26	15	16	14	19	32	521
Mean Pan Evaporation	E_p		mm/month	60	45	46	59	77	113	153	201	220	180	152	90	1397
Mean Irrigation Rate	E_T	$(E_p \times K_C) - P$	mm/month	0	0	0	0	0	11	35	65	72	58	42	4	287
Average Winter Precipitation	P_W		mm/cycle	66	81	89	73	55	34							521
1:20 Winter Precipitation	$P_{W,max}$		mm/cycle	86	106	117	96	72	45							683

Pond Balance															
Year 1 of 3 (1:20 ARI Winter Rainfall)															
Precipitation	Q_P	$A_P \times (P/1000)$	m³/month	36	44	49	40	30	19	14	8	9	8	10	17	
Waste Inflow	Q_M	$Q_D \times D$	m³/month	0	0	0	0	0	0	0	0	0	0	0	0	
Total Catchment Inflow	Q_I	$\sum(A_C \times K_R \times (P/1000))$	m³/month	47	92	112	55	18	3	3	2	11	4	9	16	
Pond Evaporation	Q_E	$K_E \times (E_p/1000) \times A_P$	m³/month	25	19	19	24	32	47	63	83	91	75	63	37	
Irrigation Outflow	Q_O	$E_T \times A_I$	m³/month	0	0	0	0	0	0	0	0	0	0	0	0	
Total Pond Water	V_P	$Q_P + Q_M + Q_I - Q_E - Q_O$	m³	58	175	316	387	402	378	331	259	188	126	82	78	
Pond Depth	D_{POND}	V_P/A_P	m	0.14	0.42	0.76	0.94	0.97	0.91	0.80	0.63	0.45	0.30	0.20	0.19	
Year 2 of 3															
Precipitation	Q_P		m³/month	27	34	37	30	23	14	11	6	7	6	8	13	
Waste Inflow	Q_M		m³/month	0	0	0	0	0	0	0	0	0	0	0	0	
Total Catchment Inflow	Q_I		m³/month	36	70	86	42	13	3	2	2	9	3	7	12	
Pond Evaporation	Q_E		m³/month	25	19	19	24	32	47	63	83	91	75	63	37	
Irrigation Outflow	Q_O		m³/month	0	0	0	0	0	0	0	0	0	0	0	0	
Total Pond Water	V_P		m³	116	201	304	352	356	326	276	201	126	60	12	0	
Pond Depth	D_{POND}		m	0.28	0.49	0.74	0.85	0.86	0.79	0.67	0.49	0.30	0.15	0.03	0.00	
Year 3 of 3															
Precipitation	Q_P		m³/month	27	34	37	30	23	14	11	6	7	6	8	13	498
Waste Inflow	Q_M		m³/month	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Catchment Inflow	Q_I		m³/month	36	70	86	42	13	3	2	2	9	3	7	12	658
Pond Evaporation	Q_E		m³/month	25	19	19	24	32	47	63	83	91	75	63	37	1155
Irrigation Outflow	Q_O		m³/month	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Pond Water	V_P		m³	38	123	226	274	279	249	198	123	48	0	0	0	**0**
Pond Depth	D_{POND}		m	0.09	0.30	0.55	0.66	0.67	0.60	0.48	0.30	0.12	0.00	0.00	**0.00**	

Outputs				
Minimum Pond Area (excl. Safety Factor)	A_P	$\sum Q_P + \sum Q_M + \sum Q_I - \sum Q_E - \sum Q_O = 0$	414	m²
Minimum Pond Depth (excl. Safety Factor and Freeboard)	$D_{POND,max}$	Maximum value of D_{POND}	0.97	m
Minimum Pond Volume (excl. Safety Factor & Freeboard)	$V_{P,max}$	Maximum value of V_P	402	m³
Required Pond Area	**Area**	$A_P \times (1+K_{PA})$	455	m²
Pond Depth Including Freeboard	**Depth**	$D_{POND,max} \times (1+K_{PD})$ + Freeboard	1.57	m
Required Pond Volume	**Volume**		487	m³