Environmental Risk Assessment

Peppimenarti Waste Stabilisation Ponds
2023

PowerWater

Document History

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Glossary

Abbreviation	Explanation
ANZECC	Australian Water Quality Guidelines for Fresh and Marine Waters
ARMCANZ	Agriculture and Resources Management Council of Australia and New Zealand
Assessment end-points	The explicit expressions of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes.
BOD	Biochemical oxygen demand
BUD	Beneficial Use Declaration – the uses of water specified in subsection 3 of the *Water Act* (1992)
BOM	Bureau of Meteorology
CSM	Conceptual site model
Cultural values	To provide water to meet aesthetic, recreational and cultural needs.
d	Day
DEPWS	Department of Environment, Parks and Water Security (NT)
DO	Dissolved oxygen
E. coli	*Escherichia coli*
Environmental Values	To provide water to maintain the health of aquatic ecosystems.
EPBC	Environment Protection and Biodiversity Conservation Act
ERA	Environmental risk assessment
ET	Equivalent Tenement – an average residential dwelling or house. Other developments are converted to an ET value by relating their average water demand (or sewage flow) to demand from one average house.
ICEGs	Indigenous Community Engineering Guidelines
kL	Kilolitre
Km	Kilometre
L	Litre
m	Metre
m^2	Square metre
Macrotidal estuary	Estuaries where the tidal range is in excess of 4 metres.
mg	Milligram
mL	Millilitre
N/A	Not applicable
N/C	Normally closed
NOx	Nitrogen oxides – the sum of nitrate and nitrite ionic species.
NT	Northern Territory
NTU	Nephelometric turbidity units
NT EPA	Northern Territory Environmental Protection Authority
PL	Primary lagoon
PWC	Power and Water Corporation

%	Per cent
Risk characterisation	The culmination of the planning, problem formulation and analysis of predicted or observed adverse ecological effects related to the assessment end-points.
Risk hypothesis	Assumptions made in order to evaluate logical or empirical consequences, or suppositions tentatively accepted to provide a basis for evaluation. They are used to test if an activity (e.g. contaminant discharges) has adverse effects on an assessment end-point.
s	Second
SL	Secondary lagoon
SOCs	Site of conservation significance
SPS(s)	Sewage pump station(s)
SS / TSS	Suspended solids / total suspended solids
TDS	Total dissolved solids – the portion of solids in wastewater that passes through a 2.0 micron filter.
TN	Total nitrogen
TP	Total phosphorous
TPWC	Territory Parks and Wildlife Conservation Act
WDL(s)	Waste discharge licence(s)
WwTP(s)	Wastewater treatment plant(s). All facilities that treat wastewater disposed of to the sewerage system consisting primarily of sewage as well as stormwater inflow and infiltration. These facilities may include a range of different types of treatment technologies e.g. waste stabilisation ponds.
ZOI	**Zone of Influence of the discharge**

Note: Not all abbreviations may be used in this document

Executive Summary

This desktop environmental risk assessment (ERA) provides an assessment of the risks associated with the discharge of secondary treated effluent from the Peppimenarti wastewater treatment plant (WwTP) point into low-lying freshwater swamp and surrounding floodplains.

Based on this ERA and water quality data, there is limited evidence to suggest deleterious impacts on the environmental values identified for this receiving environment.

Risks to the assessment end-points, associated with the source, were assessed as having low to medium risk rankings. Low risk rankings were associated with the very low discharge volumes into a freshwater swamp environment, while higher risk rankings were associated with impacts to cultural values including human health risks through primary and secondary contact (possible algal bloom growth).

The risk rankings may change as uncertainties associated with current assessments are addressed. A range of recommendations have been made in this risk assessment to address knowledge gaps and identify opportunities for improvement.

Introduction

PWC operate the Peppimenarti WwTP pursuant to Waste Discharge Licence (WDL) 220-02 issued on 12 July 2021. This WDL allows for continuous discharge of secondary treated sewage effluent from an authorised discharge point to a low-lying freshwater swamp and surrounding floodplains.

Peppimenarti is located inland along the western coast of the Northern Territory, approximately 325km south-west of Darwin (Figure 1). Peppimenarti has an estimated population of 223 in 2023 (BushTel 2023). The Wastewater Treatment Plant (WwTP) is located approximately 1km north of the Peppimenarti Township (Figure 2).

Figure 1. Peppimenarti locality map (Google Earth 2017)

Figure 2. Peppimenarti site layout including WwTP and outfall location (NT ILIS 2017)

Background

Condition 34 of this WDL requires PWC to update the environmental risk assessment for the Licenced Activity.

Condition 34 of the WDLs specifies that the Environmental Risk Assessment must:

34.1 be conducted in reference to a conceptual site model;
34.2 characterise the impacts of discharge(s) on the relevant Environmental Values;
34.3 inform the development of the Performance Improvement Plan; and
34.4 be submitted to the Administrating Agency at least 60 business days prior to the end date of this licence, with the understanding that the Administrating Agency may require the licensee to revise, amend and/or resubmit the proposed assessment.

Purpose of the desktop ERA

The purpose of the desktop ERA is to:

- identify assessment end-points;
- characterise environmental risks associated with the facility; and
- initiate an ongoing iterative environmental risk process associated with ongoing operation of the facility.

Risk Assessment Methodology

The methodology employed has been adapted from ERAs completed by the PWC Water Quality team and the Victorian EPA *Guidelines for Risk Assessment of Wastewater Discharges to Waterways*

('the guidelines') (VIC EPA 2009). The guidelines utilise a framework (Figure 3) consistent with nationally and internationally accepted risk assessment frameworks by the Australian and New Zealand Environment and Conservation Council and Agriculture and Resources Management Council of Australia and New Zealand (2000).

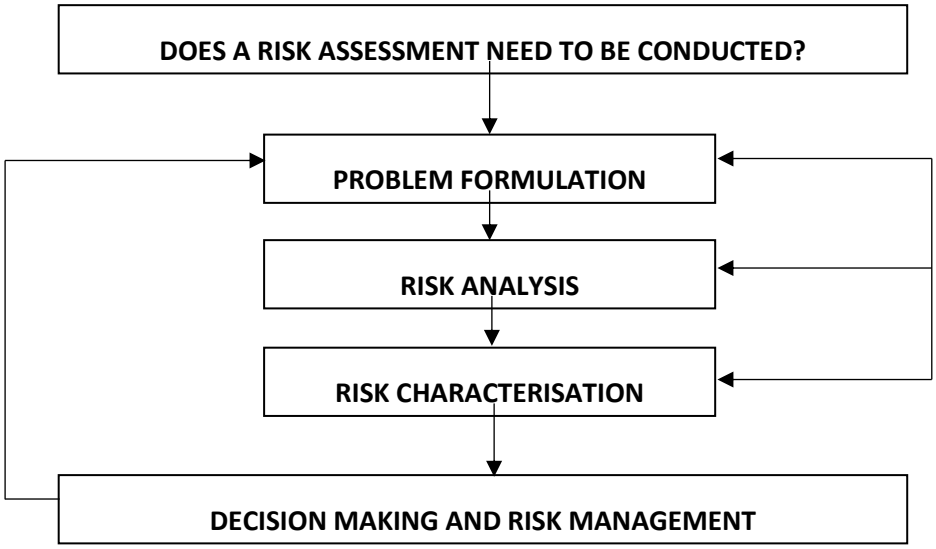

Figure 3. Risk assessment framework for wastewater discharges to waterways (Victoria EPA 2009)

Limitations

The following items have been identified as limitations associated with the preparation of this ERA:

- limited availability of inflow/outflow data;
- use of estimated inputs used in pond performance modelling;
- remoteness of communities impacting on the ability to understand systems due to costs, logistics and available expertise; and
- limited access to pond discharge points and surrounding environment due to climatic, safety and geographic factors.

Problem Formulation

The purpose of this ERA is to characterise the impacts of discharge on the relevant values and has been prepared with reference to section 1.1.

This problem is explored through the following:

- characterisation of the treated effluent discharged to the receiving environment;
- characterisation of the treated effluent discharge regime and subsequent dilution of treated effluent within receiving water; and
- identified values of receiving water and assessment end-points representative of those values.

Peppimenarti Wastewater Treatment Plant

The community utilises a pressure fed sewer reticulation system, which pumps raw sewage from the community to the WwTP (Figure 4). The Peppimenarti WwTP utilises waste stabilisation pond technology to achieve secondary level treatment of sewage effluent. Based on current circumstances, the raw sewage is almost entirely domestic in nature with no chemicals added during the treatment process. The WwTP was constructed in 1984 (PWC 2021a), and consist of a primary facultative pond which gravity feeds into secondary and tertiary maturation ponds before being discharged offsite to a low-lying freshwater swamp.

There is no gross pollutant screening, grit removal, maceration or storm flow separation located on the inlet to the pond system. The majority of the removal process for gross pollutants and other entrained materials is via sedimentation to sludge layers or entrapment in concentrated surface scums that can be physically removed. The Peppimenarti system varies from other sewerage networks, having a series of sewer pits throughout the community, which capture and pump effluent from each zone into the sewer main. Desludging of remote community ponds is conducted periodically where required to remove accumulated solids and increase hydraulic performance, which may result in improved treatment performance. There are no records available for desludging works conducted at Peppimenarti; although a sludge survey was conducted in 2016.

Prior to 2016, no regular wastewater monitoring was undertaken at the site, with no WDL in place. Regular wastewater monitoring commenced in March 2016, consistent with WDL 220. Samples of the secondary maturation pond outlet are collected on a monthly basis. Monitoring results are included in the *PWC Annual Monitoring Report – Remote Community Waste Discharge Licences,* a summary is provided in Appendix E, **Error! Reference source not found.**.

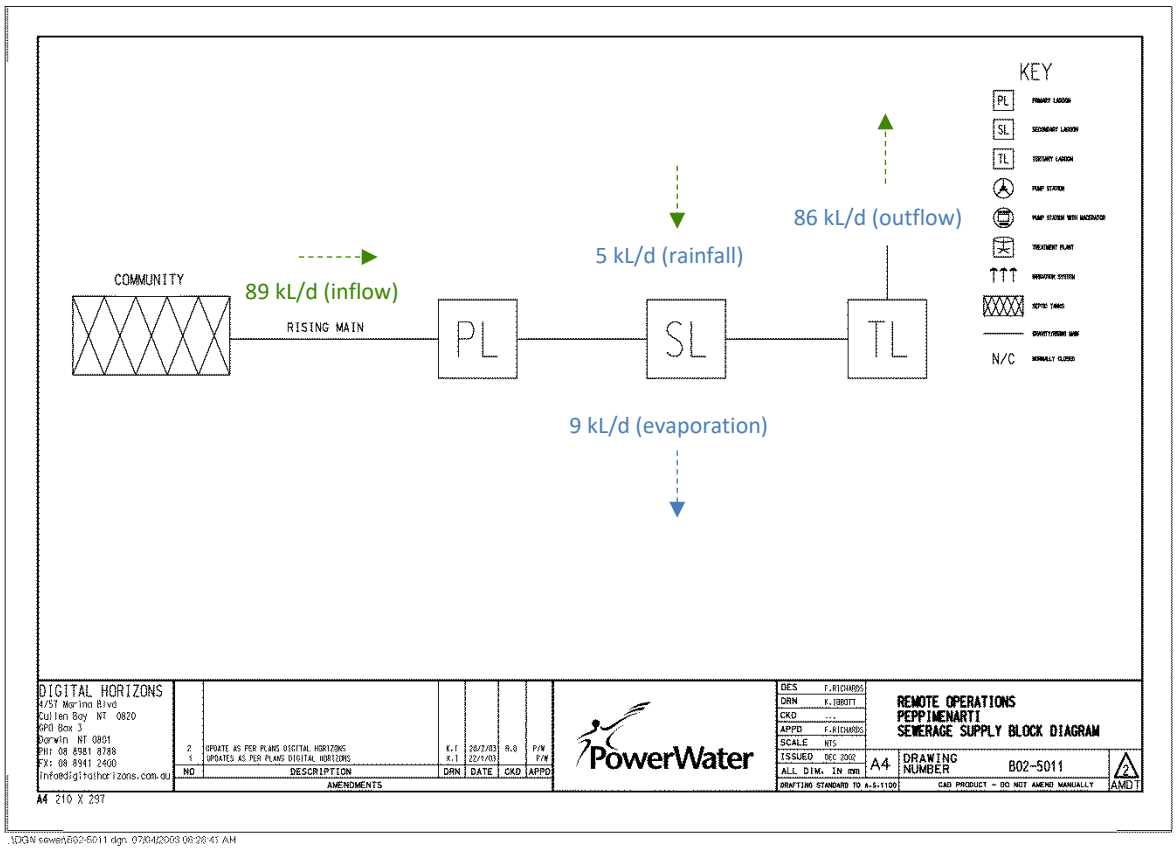

Figure 4. Peppimenarti wastewater collection and treatment configuration including modelled flow (blue) rates.

Discharge Regime

Discharge from the facility occurs from a gravity fed discharge pipe located in the tertiary (maturation) pond (Figure 4). Discharge is continuous on an as-required basis (discharge is all year round) and occurs intermittently into a low-lying freshwater swamp before draining to nearby alluvial floodplains. This area forms a part of Tom Turners Creek, however the discharge point is of significant distance from the actual creek, (approx.. 1.1km). It is unknown if other inputs contribute to this swamp area. The discharge outfall pipe from the secondary maturation pond is 449m in length, west of the ponds (Figure 2).

There is currently insufficient flow meter data available at the Peppimenarti discharge point to determine discharge volumes to the receiving environment. An annual water balance is therefore utilised below.

The annual water balance is estimated based on forecast sewage Equivalent Tenement (ET) flow, estimated total sewer ET, rainfall, evaporation and pond area (Appendix C, Table 7). It is estimated that the mean daily inflow of untreated wastewater into the WwTP is 81 kL/day. This is supplemented by approximate rainfall contribution of 8 kL/d and reduction due to evaporation of 9 kL/d to give the mean measured outflow of 80 kL/day. Due to the small community population (209), Peppimenarti has relatively low discharge volume in comparison to other NT wastewater facilities in major centres (PWC 2015b).

Note that the volume of treated wastewater discharged to the environment varies seasonally with fluctuations in evaporation and rainfall common. During the wet season, it is believed that infiltration of water into the gravity sewer network may occur, however due to the constraints of quantifying this volume and a negligible associated pollutant load it is not included within the flow rate calculations (PWC 2017). Further investigations are required to understand potential for infiltration into the sewer main.

Pond Performance

WSPs offer a low input, cost effective form of wastewater treatment that is particularly applicable in higher temperature environments with sufficient available land area. While the inputs are low, because it is largely driven by solar energy, the processes are no less complex and are largely controlled by the appropriate design and maintenance of the pond system to achieve the treatment performance required.

In the past, a model based prediction of the Peppimenarti WwTP performance was undertaken by Louey-Gung (2011) utilising industry standard design models. The model utilised various pond parameters to predict treated wastewater quality using mean biochemical oxygen demand (BOD) removal performance and mean predicted *E.coli* disinfection performance. This model was utilised in absence of *in-situ* wastewater monitoring data.

The modelled water quality results at the pond outlet for mean BOD removal and *E.coli* disinfection were 62.5 mg/L (53% removal) and 3,386/100 mL (3.2 log removal) respectively (modelled data used as pond performance indicator only).

Since 2020, Power and Water implemented monthlyl wastewater monitoring of the WwTP discharge, which provides a characterisation of the treated effluent discharged to the receiving environment. To date, the mean *in-situ* water quality results for BOD and *E. coli* were 26.5 mg/L and 100/ 100mL respectively. The variation in *E. coli* results between modelled and sampled data demonstrates additional monitoring at the primary pond inlet is required to accurately assess and verify pond performance.

Power and Water have increased wastewater monitoring at a number of remote communities in 2020, however inlet monitoring has yet to be conducted at Peppimenarti WwTP due to restricted funding under Indigenous Essential Services (IES). For the purpose of this risk assessment, the *in-situ* monitoring data illustrated on the conceptual site model (CSM) (Appendix A, **Error! Reference source not found.**).

Receiving Environment

The receiving environment consists of a low-lying freshwater swamp seen in **Error! Reference source not found.**, **Error! Reference source not found.** and Figure 7. Aerial images show the receiving swamp extends approximately 419m west (**Error! Reference source not found.**) to the edge of a seasonal alluvial floodplain. It is believed that the treated effluent reaches a swamp during the Dry Season, and the said swamp connects to the floodplain during the Wet Season, further site inspections are required to confirm seasonal connectivity (PWC 2017). The floodplains downstream extend approximately 547 m towards Tom Turners Creek, which forms part of the Moyle River catchment (NT Gov 2021). The discharge area is a significant distance from the Moyle River headwater; approximately 8km north-west – due to this distance, it is assumed the zone of influence from the Peppimenarti WwTP would be located within Tom Turners Creek.

The receiving environment is classed as dominated by seasonally-inundated grassland and sedge land with areas of paperbark swamp (NT Gov 2021). Vegetation within the area consists initially of open Eucalypt woodland plains, dominated by *Eucalyptus apodophylla* (Whitebark Eucalyptus), *Eucalyptus tetrodonta, Eucalyptus miniata,* and *Corymbia Capricornia. Pandanus spiralis* (Pandanus), among other vines and native grasses. Ti-tree woodland dominated by *Melaleuca viridiflora* or *Melaleuca nervosa, and Pandanus spiralis* (Pandanus) form the common types of native species found in the floodplain downstream of discharge point (TNRM 2011).

The receiving environment is considered to have experienced minor disturbance due to the proximity of Peppimenarti Township and the absence of obvious signs of recreational use (PWC 2017, 2010). An access track located between the ponds and the discharge point that continues further north appears to be well used. According to local knowledge, the area is not commonly known to be utilised for recreational, cultural or fishing purposes (PWC 2021b; PWC 2017).

Figure 5: Further along freshwater swamp toward seasonal alluvial floodplain (PWC 2017)

Figure 6: Peppimenarti freshwater swamp - Wet Season 2021 (PWC 2021)

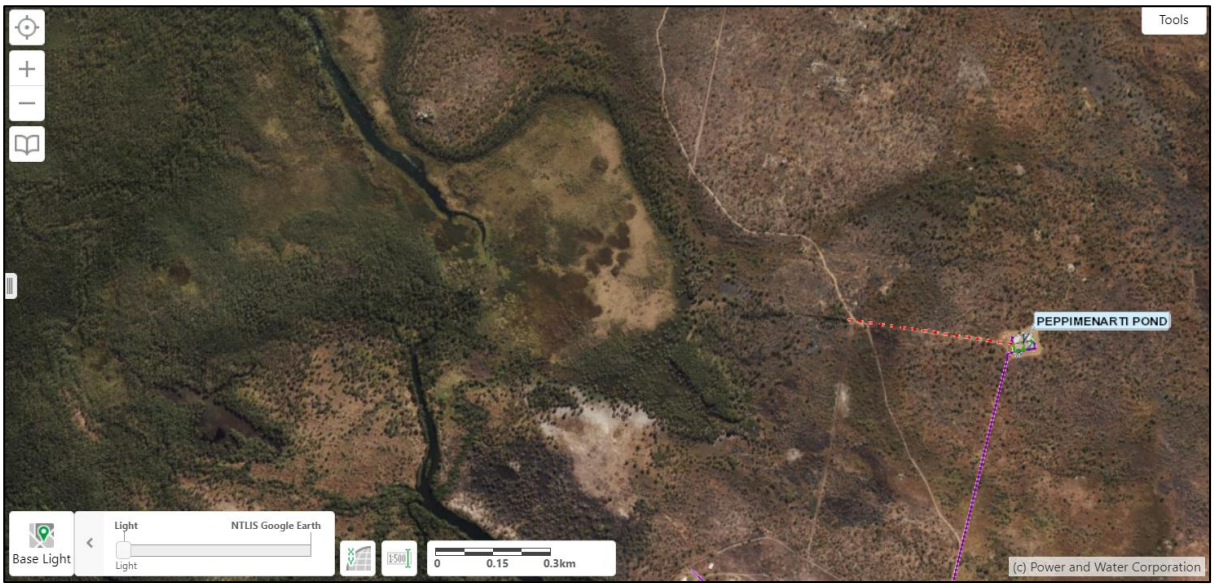

Figure 7:Aerial image of Peppimenarti discharge environment and alluvial floodplain (PWC 2021)

The receiving environment is located within the Hyland Bay and the associated coastal floodplains identified as a Site of Conservation Significance number 1 (Appendix B, **Error! Reference source not found.**). Peppimenarti is considered to be within an alluvial floodplain, and is located within proximity to a major breeding area for colonial nesting waterbird species, including herons, egrets and cormorants (NT Gov 2021). The area contains four threatened native flora and fauna species. The conservation status for these species listed under the Northern Territory Parks and Wildlife Conservation Act 2000 (TPWC) and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC) are summarised below in Table 1.

Table 1: Conservation status of species at risk from the Peppimenarti WwTP.

Common name	Species name	National Status (EPBC)	NT Status (TPWC)
Vertebrates			
Australian Bustard	*Ardeotis australis*	-	VU
Red Goshawk	*Erythrotriorchis radiatus*	VU	VU
Greater Sand Plover	*Charadrius leschenaultii*	VU	VU
Flatback Turtle	*Natator depressus*	VU	DD
Plants			
Cycas	*armstrongii*	-	VU
CR – Critically Endangered, EN – Endangered, VU – Vulnerable, LC – Least Concern, DD – Data Deficient			

Screening Level Risk Assessment

A screening level risk assessment is used to determine if a risk to the assessment end-point exists, that should be further investigated. It is a method for prioritising risks and minimising effort in assessing low risks. **Error! Reference source not found.** provides a summary of the screening level risk assessment.

Risk hypotheses for the stressors identified in the conceptual site model (CSM) (Appendix A, **Error! Reference source not found.**) are defined with respect to their potential effects on the identified beneficial uses of the receiving environment.

The identified beneficial uses of the receiving environment are summarised below in Table 2.

Table 2. Identified values of receiving environment at risk from the Peppimenarti WwTP

Values	**Receptors**	
Cultural **(Recreational Water Quality)**	Humans	Hunting Food Gathering
Cultural **(Aesthetics)**	Humans	Visible water quality Sacred sites
Environment **(Aquatic Ecosystem Protection)**	Terrestrial	Wading birds Invertebrates (water insects) Mammals Reptiles
	Plants	Native vegetation • Open eucalypt woodland • Grassland and sedgeland

Table 3: Screening level risk assessment for key indicators and stressors associated with Peppimenarti WwTP discharge

Indicator (water quality parameter)	Stressor (change to indicator)	Risk Hypothesis		Assessment end-points		Scope of this desktop ERA	Further investigation required?
		ENVIRONMENTAL	CULTURAL	ENVIRONMENTAL	CULTURAL		
Gross pollutants	Presence and accumulation of gross pollutants from influent carried through to effluent	That gross and micro-scale pollutants are ingested by biota resulting in death of animals and environmental degradation.	That gross pollutants are resulting in the reduction of visual amenity in the receiving environment.	To maintain the presence of biota in the environment.	To maintain the visual amenity of the environment.	The WwTP is considered a relatively effective barrier to gross pollutant entry to the receiving environment. This is due to the settling out to sludge layers and accumulation on pond surface where gross pollutants are physically removed as required. No evidence of gross pollutant accumulation during visual monitoring of discharge site (qualitative discharge criteria). No further investigation necessary at this stage.	No
Organic matter	Increase in BOD, decrease in DO	That BOD is leading to oxygen depletion in the environment resulting in loss of biota (e.g. fish kills) and changes to ecosystem structure.	That BOD is leading to odours resulting in the reduction of amenity in the receiving environment.	To maintain the presence of biota in the environment.	To maintain oxygen levels in the environment sufficient to prevent production of odours.	The median concentration of BOD in the discharge of Peppimenarti WwTP is 26.5 mg/L. As BOD is present in the discharge, it is determined at a screening level that a risk is present and further investigation is necessary.	Yes
Nutrients (nitrogen and phosphorus)	Increase in nutrient concentrations	That nutrients are leading to nuisance plant growth (e.g. phytoplankton blooms) resulting in oxygen depletion; displacement of endemic species; diminished light availability; release of toxins; and changes to ecosystem structure.	That nutrients are resulting in the reduction of amenity of receiving environment through reduction in water clarity, objectionable discolouration and odours; toxic blooms that are a public health risk; and blooms of toxin producing species whereby the toxins bio-accumulate in shellfish and fish ingested by humans.	To maintain nutrient levels so that the levels of primary production do not have an adverse impact on ecosystem structure.	To maintain the amenity of the environment.	As nutrients are present in the discharge, it is determined at a screening level that a risk is present and further investigation is necessary.	Yes
Toxicants	Increase in free ammonia concentration	That free ammonia is resulting in toxicity to aquatic organisms in water and sediments.		To maintain the presence of biota in the environment.		The median concentration of free ammonia in the discharge of Peppimenarti WwTP is 1.7 mg/L. At a screening level it is determined that a risk is present and further investigation is necessary.	Yes
Pathogens	Presence of *E.Coli*		That pathogens are leading to the contamination of water resulting in primary and secondary contact recreation a public health risk; and accumulation in shellfish resulting in the consumption of shellfish a public health risk.		To maintain that pathogens from municipal wastewater are not increasing the risk of illness via primary and secondary contact recreation and consumption of shellfish.	The median pathogen concentration in the discharge of Peppimenarti WwTP is 100 mpn /100mL. At a screening level it is determined that a risk is present and further investigation is necessary.	Yes

Risk Analysis and Characterisation

Power and Water Risk Management Framework

PWC has adopted a qualitative risk assessment methodology aligned to the Australia/New Zealand Standard *"AS/NZ 4360: Risk Management"* (PWC, 2009). This process is used to assess and manage activities that have potential to cause environmental harm.

The first step in the ERA process is to identify the aspects (problem formulation i.e. discharge of treated wastewater) (section 2.0) and corresponding potential impacts associated with each assessment end-point identified in the screening level risk assessment as seen in **Error! Reference source not found.**.

This methodology is based on knowledge of the existing environment and incorporates site-specific environmental factors into the analysis of the potential impacts. An assessment of each impact is analysed for likelihood and consequence.

The categories and associated rankings for environmental impact consequences are shown in Table 4 and the likelihood of an event occurring are shown in Table 5. A risk score for each potential impact is determined by combining likelihood with consequence results as seen in Figure 8. The risk assessment for key environmental and cultural assessment end-points associated with Peppimenarti WwTP discharge are seen in **Error! Reference source not found.**.

Low to medium risks can typically be managed by routine procedures and integration into management plans, while high to extreme risks require senior management attention, immediate action or more detailed research and management planning.

Table 4: PWC corporate risk ranking consequence table

	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Severe (5)
Health & Safety	Minor event with or without injury; and/or No on-going impact to health.	Injuries requiring first aid treatment; and/or Minor short term inconvenience.	Medical Treated injury; and/or Short term reversible disabling effect to human health; and/or Lost Time Injury <1 week lost.	Hospitalisation; and/or Injuries resulting in Lost Time Injury > 1 week lost; and/or Long term (chronic) chemical health exceedance or short term chemical exceedance of chemical with acute health impacts; and/or Long term aesthetic exceedance with health impact on supply.	One or more fatalities; and/or One or more persons seriously injured (includes long term disabling effect); and/or Widespread release of untreated water (eg due to disinfection failure).
Financial **(impact on EBITDA)**	Loss less than $500K.	Impact between $500K and $2M.	Impact between $2m and $10m.	Impact between $10m and $40m.	Impact greater than $40m.
Legal/ Regulation	Legal issues managed by corporate procedures or practices; and/or Breach of internal policies or procedures without the need for formal investigation.	Matter requires legal advice to address issues; and/or Internal breach of policies or procedures requiring a formal investigation.	Required to operate under limited regulatory restrictions or orders; and/or Incident which requires legal representation resulting in court proceeding.	Required to operate under significant regulatory restrictions or orders; and/or Government inquiry/ intervention.	Criminal charges / civil litigation against the Corporation and/or Officers; and/or Operating licences revoked.
Environmental	Localised low level damage controlled but no remedial action required.	Localised low level damage controlled and remedied with minimal resources.	Widespread temporary damage with extended resources to remedy.	Long-term detrimental effect on environment and once controlled results in minor permanent damage.	Substantial permanent damage to widespread and sensitive areas.
Service Delivery (external customers only)	Category 1 loss of service (refer to Appendix C of this document)	Category 2 loss of service (refer to Appendix C of this document)	Category 3 loss of service (refer to Appendix C of this document)	Category 4 loss of service (refer to Appendix C of this document)	Category 5 loss of service (refer to Appendix C of this document)
Reputation	No media attention; and/or Isolated community or individual issue-based concern; and/or Localised dissatisfaction which is managed by normal business processes; and/or Short term aesthetic exceedance.	Occasional once-off negative media attention; and/or Localised community impacts and customer concerns; and/or Localised staff dissatisfaction which requires Human Resources in resolution; and/or Long term aesthetic exceedance.	Brief adverse media attention and/or community/customer condemnation (days); and/or Limited, localized loss of confidence by the community; and/or Localised staff dissatisfaction with localised impacts to service deliver and/or Short term chemical health exceedance.	Prolonged adverse media attention and/or community/ customer condemnation (weeks); and/or Prolonged, widespread community/ customer loss of confidence (weeks); and/or Widespread dissatisfaction and loss of confidence by staff resulting in temporary service delivery issues.	Sustained adverse media attention and/or community/customer condemnation (months); and/or Irreconcilable community/ customer loss of confidence; and/or Loss of stakeholder confidence in Board and/or Management; and/or Widespread dissatisfaction by staff resulting in sustained service delivery issues.

Table 5: PWC corporate risk ranking likelihood table

(E) Almost Certain	Event is expected to occur on a regular basis. One or more times per annum.	Not Applicable
(D) Likely	An event is expected to occur from time to time. Once every 1 – 3 years	Probability of occurring is greater than 33%
(C) Possible	An event should occur at some time. Once every 4 – 10 years.	Probability of occurring is greater than 10% and up to and including 33%
(B) Unlikely	An event could occur at some time. Once every 11 to 30 years	Probability of occurring is greater than 3% and up to and including 10%
(A) Rare	An event not expected but possible. Less than once in 30 years	Probability of occurring is up to and including 3%

Likelihood	Consequence: Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Severe (5)
Almost Certain (E)	Medium	High	Very High	Extreme	Extreme
Likely (D)	Low	Medium	High	Very High	Extreme
Possible (C)	Low	Low	Medium	High	Very High
Unlikely (B)	Low	Low	Medium	High	High
Rare (A)	Low	Low	Low	Medium	Medium

Figure 8. Corporate risk matrix

Table 6: Risk assessment for key environmental and cultural assessment end-points associated with Peppimenarti WwTP discharge using corporate risk ranking methodology

Hypothesis	Consequence		Likelihood		Risk Ranking
Environmental					
BOD is leading to oxygen depletion in the environment resulting in **loss of biota** and **changes to ecosystem structure**.	Limited dilution of the treated wastewater occurs during the dry season, the treated effluent may be contained within the immediate discharge area (swamp), potentially causing localised oxygen depletion within the immediate receiving area. During the wet season, discharge may drain to alluvial floodplains. During this period of the year, the estimated dilution volume ratio between the effluent and receiving environment is 1:60 (Appendix D). Based on these figures the dilution ratio is considered relatively good as the wastewater discharge outflow volumes are low, and significant dilution occurs on the floodplains during rainfall, suggesting any observed oxygen demand would be absorbed by the environment.	Minor	Based on sampling data to date, Peppimenarti WwTP BOD discharge water quality is 26.5 mg/L. These BOD concentrations are very low in comparison to concentrations at other remote communities, and is considered to be classified as low effluent strength (<40mg/L) (PWC 2022). It is unconfirmed if the swamp area is a direct result of the WwTP discharge, or if it a naturally occurring waterway. During the dry season, it is possible oxygen depletion will occur within the receiving environment naturally as a result of stagnant water observed during a site inspection (PWC 2017). During the dry season, potential impacts from oxygen depletion as a result of the discharge would be localised to the immediate swamp. The discharge may be a source of water that may benefit aquatic insects and native fauna within the immediate area. During the wet season it is assumed that the swamp connects with the alluvial floodplain and Turners Creek, where it is assumed dilution and mixing with oxygenated waters would occur. Based on the dilution ratio between effluents and receiving environment, low strength BOD levels and the nature of the receiving environment, PWC considers that the likelihood of oxygen depletion in receiving environmental waters may be unlikely.	Unlikely	Low
Free ammonia is resulting in **toxicity to aquatic organisms** in water and sediments.	Toxicity to aquatic organisms may only be applicable to localised invertebrate populations and sediment dwelling organisms located at immediate discharge point. One of the most visible means by which toxicity presents in an aquatic ecosystem is through the occurrence of fish kills. No fish kills have been observed or reported to date.	Minor	Peppimenarti WwTP free ammonia discharge quality is 1.7 mg/L. These ammonia concentrations are low in comparison to concentrations at other remote communities (PWC 2022). Low pH may also be an indicator of increased ammonia toxicity (ANZECC 2000); a mean pH of 9.03 at Peppimenarti suggests the risk of ammonia toxicity to be low Stressor not typically observed with such small discharge volumes, and initial dilution. PWC considers that the likelihood of toxicity to aquatic organisms in water and sediments unlikely.	Unlikely	Low
Nutrients are leading to **nuisance plant growth** resulting in oxygen depletion; displacement of endemic species; diminished light availability; release of toxins; and changes to ecosystem structure.	Based on **WDL sampling to date, Peppimenarti WwTP contributes very low levels of total nitrogen and phosphorus 0.49 and 0.07 tonnes/year respectively. No eutrophication/ algal blooms have been observed at the discharge point, however significant surface scums were observed during the dry season in 2017.** Due to the nature of the receiving environment, this area may intermittently experience algal blooms under desired conditions.	Moderate	Total nitrogen (16.7 mg/L) and total phosphorus (2.5 mg/L) concentrations are low in comparison to concentrations at other remote communities, and is considered to be classified as low effluent strength (<50mg/L;<10mg/L) (PWC 2022). Stressor not typically observed with such small discharge volumes, and some flushing of area occurs as a result of the WwTP discharge input; however area may be stagnant during the dry season. PWC considers that the likelihood of nuisance plant growth as the result of the WwTP may be possible due to flushing restraints within the receiving waters during the dry season. During the wet season additional dilution and flushing would occur. Ongoing sampling will assist to characterise discharge quality.	Possible	Medium
Cultural					

BOD is leading to odours resulting in the **reduction of amenity** in the receiving environment.	Access to the discharge point is limited to unnamed 4wd vehicle track. Observations during ERA inspection suggest track may be used frequently, but site inspections suggest minimal cultural beneficial uses of the receiving environment.	Minor	No odours have been observed or reported at the swamp (PWC 2021b), with any odours being limited to immediate discharge point. Stressor not typically observed with such small discharge volumes. Likelihood greater during dry season where there are flushing constraints. No evidence cultural beneficial uses of the receiving environment observed (i.e rubbish, fires, fishing nets). Not a well-known recreational area, except for hunting. PWC considers that the likelihood of reduction in amenity from BOD is unlikely.	Unlikely	Low
Nutrients are resulting in the **reduction of amenity** of receiving environment through **reduction in water clarity**, objectionable **discolouration** and **odours**.	The receiving swamp has been identified as having minimal cultural beneficial uses, on rare occasions the public may access the immediate discharge site.	Minor	During inspections of discharge site, it was observed that the swamp may be stagnant during the dry season. Algae and surface scum observed within the immediate discharge point in both dry and wet seasons; further inspections are required to determine connectivity to the downstream floodplain. However, no indicators are present that suggest reduction of amenity as a result of the discharge - water clarity is clear, no odours present, healthy aquatic organisms and native vegetation present surrounding the receiving waters (PWC 2021b; PWC 2017). Due to the very low nutrient concentrations and no indicators present, PWC considers that the likelihood of reduction in amenity from nutrients is unlikely.	Unlikely	Low
Nutrients are resulting in **toxic blooms** that are a public health risk; and **blooms of toxin producing species** whereby the toxins bio-accumulate in shellfish and fish ingested by humans.	Minimal cultural beneficial uses of the receiving environment observed, including collection of shellfish and fish. Very low levels of nutrients in discharge to receiving environment. In some rare cases, this area may be prone to naturally occurring nutrient blooms within desired conditions due to stagnant waters during the dry season.	Moderate	Toxic blooms causing a public health risk not observed within the receiving waters. On a rare occasion it is possible people may access this area whilst driving on the 4wd track, however it is unlikely the community utilise the swamp as a source of aquatic foods as Tom Turners Creek is more suitable (PWC 2021b; PWC 2017). Due to the very low nutrient concentrations, the distance of the swamp to the Township, and lack of toxic blooms observed, PWC considers that the likelihood of toxicant exposure through bioaccumulation is unlikely.	Unlikely	Medium
Pathogens are leading to the **contamination of water** resulting in primary and secondary contact recreational a public health risk.	The receiving creek is identified as having minimal cultural beneficial uses for primary and secondary recreation. Community is located near Tom Turns Creek upstream from the WwTP.	Minor	Median pathogen concentrations of 100 mpn/100mL *E. coli* within the Peppimenarti WwTP discharge are very low in comparison to concentrations at other remote Indigenous communities (PWC 2020). Based on the minimal cultural beneficial uses for primary and secondary recreation within this area, the shallowness of the swamp, and low pathogen concentrations, PWC considers that the likelihood of the illness from pathogen exposure is unlikely.	Unlikely	Low

Summary and recommendations

The ERA found that the identified values of the nearby low-lying swamp and seasonal floodplains at risk from the Peppimenarti WwTP discharge are environmental and cultural.

The key stressors that pose a risk to these values were the presence and accumulation of gross pollutants from influent carried through to effluent; increase in BOD; increase in nutrient concentrations; increase in free ammonia concentration and the presence of *E.coli*.

The ERA process has determined that discharge from the Peppimenarti WwTP poses a low to medium risk to the identified values of the receiving area. The influence of the discharge on the receiving environment is considered sustainable given the very low discharge volumes into the low-lying swamp area. Based on this ERA and modelled water quality data, there is limited evidence to suggest deleterious impacts to the receiving environment.

All risk rankings have considerable uncertainties attached to the assessments. The risk rankings may change as uncertainties associated with current assessments are addressed.

Based on the ERA process and outcomes, PWC make the following recommendations:

- continue monitoring quality of wastewater discharged to the environment;
- collect pond performance monitoring data;
- incorporate recommendations into future Performance Improvements Plans;
- implement options to accurately quantify the volume of treated wastewater discharged to the environment; and
- update the ERA and CSM based on new information and additional wastewater quality data.

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Appendix A: Peppimenarti Conceptual Site Model

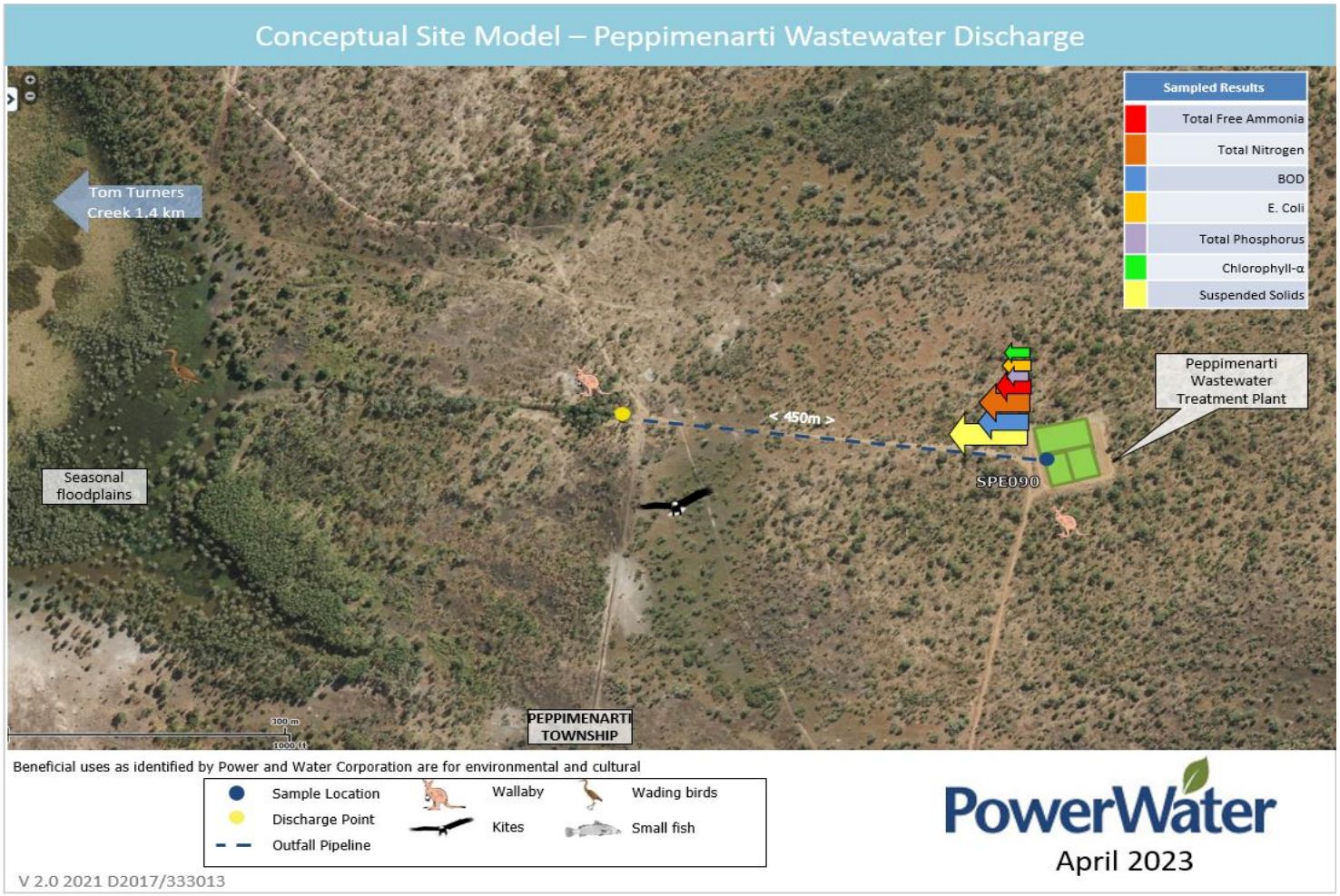

Figure 9: Conceptual site model for the key process that may impact beneficial uses in the receiving environment of Peppimenarti WwTP

Appendix B: Hyland Bay – Site of Conservation Significance

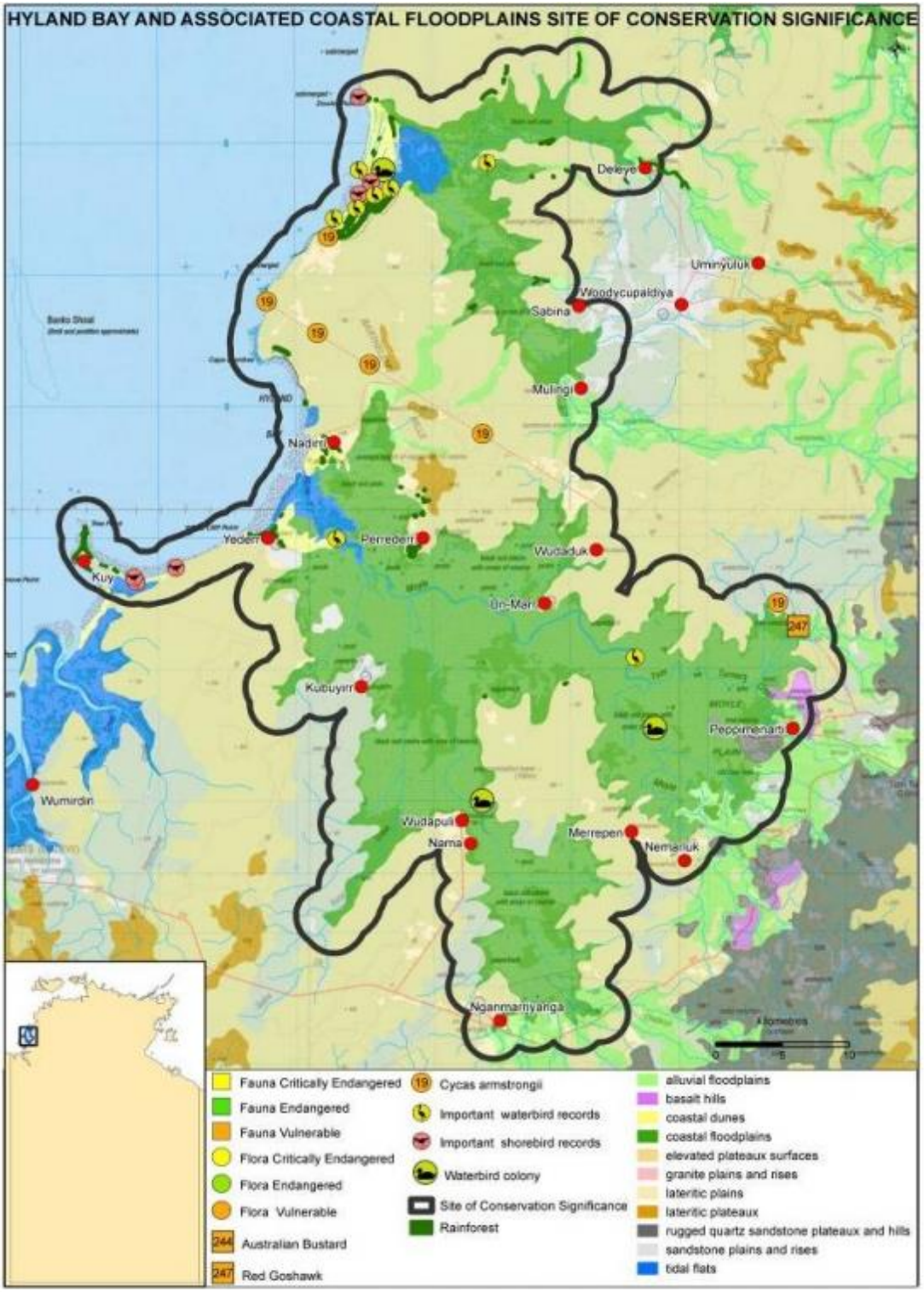

Figure 10: Hyland Bay - Site of conservation significance map (NT Gov 2021)

Appendix C: Estimated flow rates for Peppimenarti WwTP

Assumptions:

Raw wastewater flow rate based on ICEG (2017) forecast sewage ET flow of 850 L/day and estimated total sewer ET for Peppimenarti of 95 (PWC 2021a).

Rainfall catchment estimates are based on mean monthly rainfall for all available years from Bureau of Meteorology (BOM) and total pond surface area (1,463 m^2) (Louey-Gung 2011). Rainfall data was obtained using the Port Keats weather station (station number 14948) located approximately 62 km away.

Rainfall and evaporation estimates are based on mean monthly values for all available years from BOM and total pond surface.

Flow rates are summarised in the table below (Table 7).

Table 7. Estimated average annual flows

Month	Actual Inflow kL/d	Rainfall kL/d	Evaporation kL/d	Total outflow kL/d
January	81	24	9	96
February	81	28	9	100
March	81	11	9	83
April	81	2	9	74
May	81	1	9	73
June	81	0	9	72
July	81	0	9	72
August	81	0	9	72
September	81	0	9	72
October	81	1	9	73
November	81	9	9	81
December	81	18	9	90
Mean	**81**	**8**	**9**	**80**

Appendix D: Dilution Ratio for Peppimenarti WwTP

Treated wastewater is discharged into a low-lying freshwater swamp that drains into nearby seasonal alluvial floodplain. Limited dilution of the treated wastewater would occur during the dry season. It is believed that the treated wastewater would be contained within the immediate swamp area during the dry season, and may filter out to the floodplains during the wet season, this is dependent on environmental conditions (increased rainfall).

Under the scenario where treated wastewater overflows offsite, significant dilution and augmentation of the flow by rainfall may occur. Dilution of the treated wastewater occurs in the disposal area, and due to mixing with rainwater captured in the catchment upstream of the disposal area. The catchment upstream of the overflow point and the path of diluted outflow is identified in Figure 11. A conservative dilution factor is calculated below based on the volume of rainfall falling on this catchment and the disposal area during the wet season. The dilution ratio may be greater than estimated as it was noted by the Essential Services Officer that some freshwater infiltration into the sewer system occurs in the wet season (PWC 2017). Table 8 includes calculation figures for the dilution ratio.

Figure 11. Catchment for Peppimenarti WwTP (NT ILIS 2017)

Table 8 Discharge volume and dilution ratio calculation

Approx. area of swamp/ floodplain downstream from discharge point (m^2)	Mean rainfall (Dec-Mar) (mm/d)	Mean evaporation (Dec-Mar) (mm/d)	Mean treated wastewater outflow (kL/d)
625051	13.7	6.0	80 [1]
Volume of rain fall capture downstream of creek (rainfall-evap) (kL/d)	4813		
Dilution ration prior to entering environment	1:60		

[1] See appendix C for discharge volume calculations.

Appendix E: Wastewater Quality Monitoring Results

Table 9: Summary of PWC wastewater quality results for Peppimenarti 2020-2023

Sample Location/Asset: SPE090 (Pond 3 Outlet)			
Indicator	**Reporting Value**		
	Median Wet Season	**Median Dry Season**	**Median**
Physio-chemical Parameters			
pH	8.99	9.2	9.13
Electrical Conductivity (uS/cm)	360	480	445
Dissolved Oxygen (% Saturation)	59	56	57.5
Turbidity (NTU)	110	250	150
Total Suspended Solids (mg/L)	70	132	85
Biological Parameters			
Biochemical Oxygen Demand (mg/L)	24	43	26.5
Chlorophyll-a (ug/L)	622	1170	723
Nutrient Parameters			
Ammonia (Total[1] as N – NH3-N) (mg/L)	1.7	1.7	1.7
Total Nitrogen[2] (mg/L)	10.95	19.5	16.7
Oxidised Nitrogen (NOx) (mg/L)	0.05	0.1	0.1
Total Phosphorus (mg/L)	2.4	2.7	2.5
Pathogen Indicators			
Escherichia coli (E. coli/100mL)	100	100	100
Enterococci (Enterococci/100mL)	250	3,590	310

Appendix F: Additional Site Inspection Images

Figure 12: Peppimenarti WwTP Pond 3 (PWC 2017)

Figure 13: Peppimenarti WwTP Pond 1 (PWC 2017)

Figure 15: Peppimenarti WwTP (PWC 2017)

Figure 14: Natural algae and surface scum observed within swamp - August 2017 (PWC 2017)

Figure 16: Peppimenarti WwTP (PWC 2021)

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