Environmental Risk Assessment

Pirlangimpi Waste Stabilisation Ponds 2023

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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.**

Executive Summary

This environmental risk assessment (ERA) provides an assessment of the risks associated with the discharge of secondary treated effluent from the Pirlangimpi Wastewater Treatment Plant (WwTP) to land via a monsoon forest.

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 risk rankings. These rankings were associated with the low discharge volumes into a forest environment.

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 Pirlangimpi WwTP pursuant to Waste Discharge Licence (WDL) 221-02 issued on 12 July 2021. This WDL allows for continuous discharge of secondary treated sewage effluent from an authorised discharge point to land via monsoonal forest vegetation.

Pirlangimpi is one of two communities located on Melville Island, forming part of the Tiwi Islands, approximately 124 km north of Darwin (Figure 1). Pirlangimpi has an estimated population of 372 in 2023 (BushTel 2023). The Wastewater Treatment Plant (WwTP) is located approximately 600m south east of the Pirlangimpi Township (Figure 2).

Figure 1. Pirlangimpi locality map (Google Earth 2017)

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Figure 2. Pirlangimpi 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

- 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).

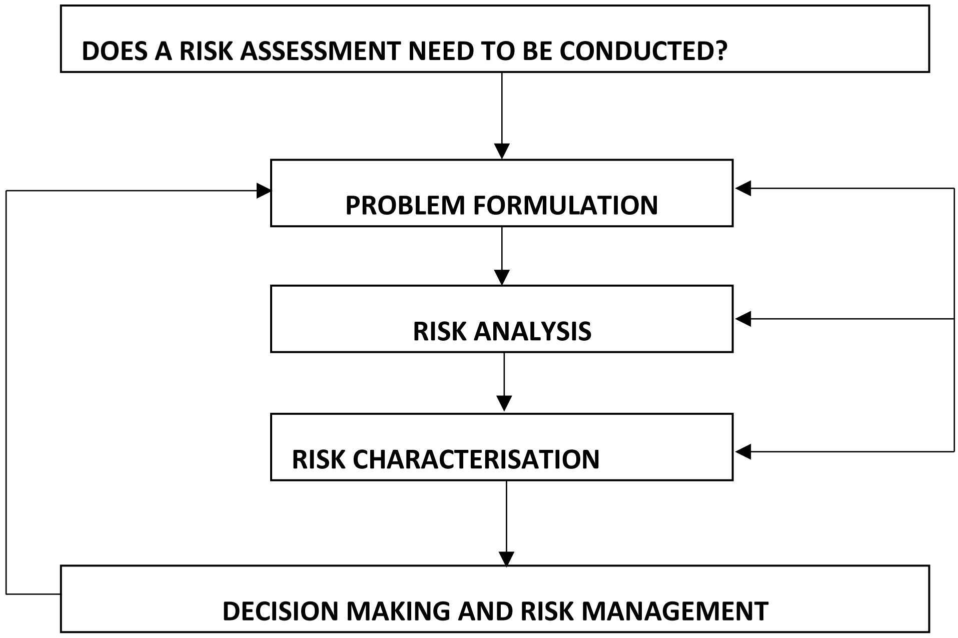

Figure 3. Risk assessment framework for wastewater discharges to waterways (Victoria EPA 2009)

Limitations

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

- absence of historical monitoring data;
- limited availability of inflow/outflow data;
- limited availability of wastewater quality data;
- 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 potential impacts of effluent 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.

Pirlangimpi 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 Pirlangimpi 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 1969 (PWC 2021a). The ponds consist of a primary facultative pond which gravity feeds into a secondary maturation pond before being discharged offsite in monsoon forest vegetation.

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. Desludging of the WSPs is conducted periodically where required to remove accumulated solids and increase hydraulic performance, which may result in improved treatment performance. Desludging was last completed at Pirlangimpi in 2014.

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 221. Samples of the tertiary maturation pond outlet are currently 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, Table 9.

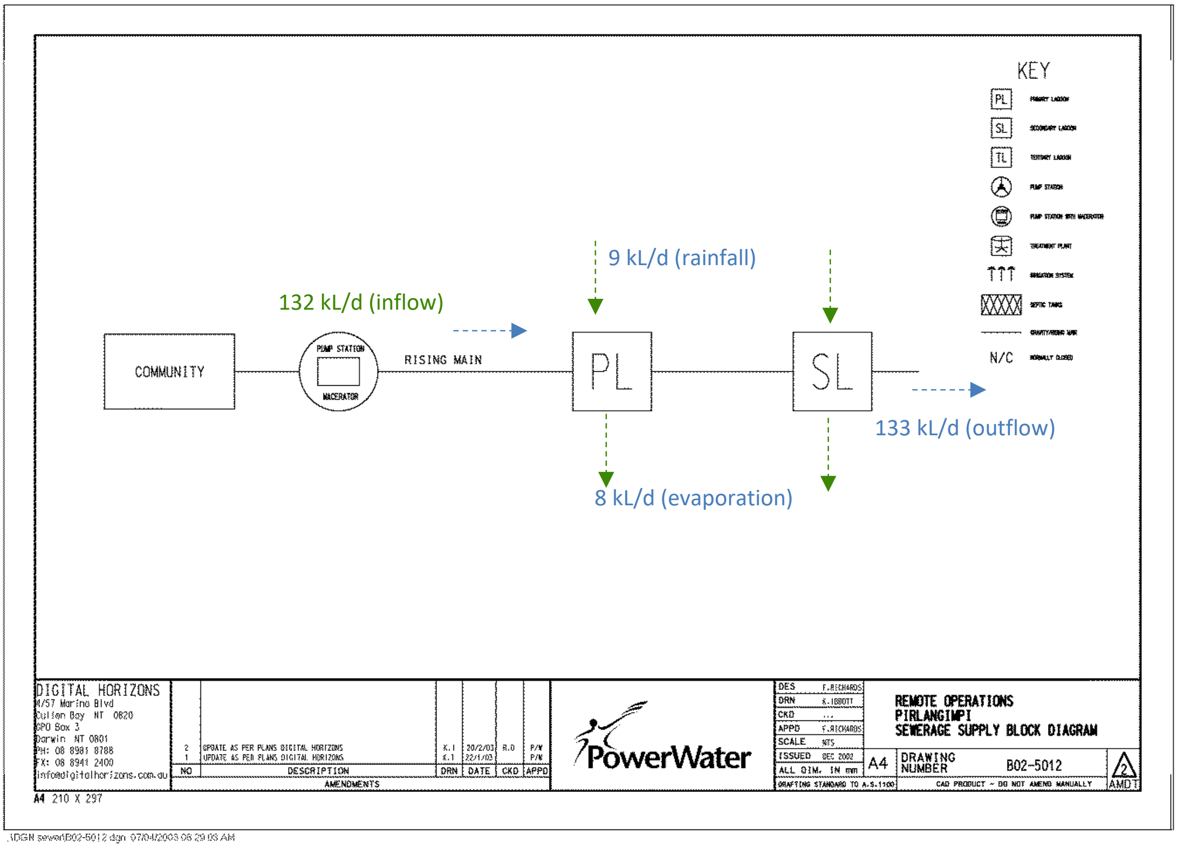

Figure 4: Pirlangimpi wastewater collection and treatment configuration including modelled flow rates

Discharge Regime

Discharge from the facility occurs from a gravity fed discharge pipe located in the secondary pond (Figure 4). Discharge is continuous on an as-required basis (discharge is all year round) and occurs daily onto land within monsoonal forest vegetation. The discharge outfall from the secondary maturation pond is approximately 190 m in length, south-west of the ponds (Figure 2).

There is currently no flow meter data available at the Pirlangimpi 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 132 kL/day. This is supplemented by an approximate rainfall contribution of 9 kL/d and reduction due to evaporation of 8 kL/d to give the mean measured outflow of 133 kL/day. Due to the small community population (372), Pirlangimpi 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 changes in evaporation and rainfall.

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.

Wastewater monitoring at the Pirlangimpi primary pond inlet commenced in August 2018. This data will provide an accurate characterisation of the raw effluent entering the waste stabilisation pond system and an indication of treatment performance.

Pond treatment performance can be measured at remote community sites utilising mean biochemical oxygen demand (BOD) removal performance and mean predicted *E.coli* disinfection performance. The results are a reduction in concentration levels from the primary pond inlet to the final pond outlet.

The average mean removal percentage at the Pirlangimpi WSPs is currently:

- Biochemical Oxygen Demand (BOD): **17%**
- Free Ammonia (NH_3-N): **23%**
- Total Nitrogen (TN): **-5%**
- Total Phosphorus (TP): **-4%**

The average log reduction for the pathogens indicator is:

- *E. coli:* 1.7 log reduction

Further monitoring data, statistical analysis and investigation is required to verify the inconsistent results for TN and TP.

Ultimately the ponds ultimately provide a centralised treatment barrier that prevents direct contamination of the receiving environment and have an important role in the protection of both environmental and public health.

For the scope of this risk assessment, wastewater quality monitoring data collected at the final pond discharge point to the receiving environment are illustrated on the conceptual site model (CSM) (**Error! Reference source not found.**, **Error! Reference source not found.**), and water quality table (**Error! Reference source not found.**, Table 9).

Receiving Environment

The receiving environment is a monsoonal vine forest (approximately 20,000 m^2 in area). A permanent stream has formed as a result of the continuous discharge (PWC 2017), (Figure 5). The receiving environment appears to drain towards an unnamed small brackish creek (approximately 180 m long) which may flow on to Kings Cove, forming part of the estuary between the two Tiwi Islands (PWC 2017). Due to dense vegetation, wet ground within this area, and OHS risks due to dangerous wildlife, access to confirm the layout of the receiving environment *in-situ* has been limited.

The receiving environment is considered to have experienced minor disturbance due to the lack of vehicle and walking tracks and thick vegetation that indicate limited recreational use of the area (PWC 2021b; PWC 2010). Due to land clearing around the pond facilities there is an increased risk of invasive weed species along the fringes of the monsoon vine forest and surrounding Eucalypt open forest.

The receiving environment consists of very dense tree canopy (greater than 70 percent foliage cover) and dominated with evergreen trees, palms and ground floor ferns, sedges and vines (Figure 6). Although not protected, this vegetation type is of regional significance due to its high conservation value, having the highest number of plant species of any vegetation type in NT (NT Gov 2017b).

Figure 5. Pirlangimpi Discharge Outfall Point (PWC 2017)

Figure 6. Surrounding monsoonal forest vegetation in receiving environment (PWC 2017)

The receiving environment is located within the Tiwi Islands Site of Conservation Significance Number 9 (Appendix B, Figure 8), and is considered as having an International Significance rating. The area has high ecological values due to isolation from the mainland Australia and extreme high rainfall resulting in many species present that are not recorded anywhere else in the NT (NT Gov 2017a). The area contains 38 threatened plant and animal species. The conservation status for these species listed under the 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 Pirlangimpi WwTP

Common name	Species name	National Status (EPBC)	NT Status (TPWC)
Plants			
Burmannia	*Burmannia sp.* Bathurst Island	EN	EN
Calochilus	*Calochilus caeruleus*	-	VU
N/A	*Cephalomanes obscurum*	-	EN
Zamia Palm	*Cycas armstrongi*	-	VU
Climbing Mistletoe	*Dendromyza reinwardtiana*	-	VU
Elaeocarpus	*Elaeocarpus miegei*	-	CR
Endiandra	*Endiandra limnophila*	-	VU
Giant Climbing Pandan	*Freycinetia excelsa*	-	VU
Climbing Pandan	*Freycinetia percostata*	-	VU

Native Mangosteen	*Garcinia warrenii*	-	EN
Waxflower	*Hoya australis subsp. oramicola*	VU	VU
N/A	*Luisia teretifolia*	-	VU
N/A	*Mapania macrocephala*	-	VU
N/A	*Mitrella tiwiensis*	VU	VU
N/A	*Tarennoidea wallichii*	-	EN
N/A	*Thrixspermum congestum*	-	VU
N/A	*Typhonium jonesii*	EN	EN
N/A	*Typhonium mirabile*	EN	EN
Xylopia	*Xylopia monosperma*	EN	EN
Vertebrates			
Australian Bustard	*Ardeotis australis*	-	VU
Partridge Pigeon	*Geophaps smithii*	VU	VU
Red Goshawk	*Erythrotriorchis radiatus*	VU	VU
Tiwi Hooded Robin	*Melanodryas cucullata melvillensis*	EN	EN
Tiwi Masked Owl	*Tyto novaehollandiae melvillensis*	EN	EN
Brush-tailed Rabbit-rat	*Conilurus penicillatus*	-	VU
Butler's Dunnart	*Sminthopsis butleri*	VU	VU
False Water-rat	*Xeromys myoides*	VU	DD
Northern Brush-tailed Phascogale	*Phascogale pirata*	-	VU
Merten's Water Monitor	*Varanus mertensi*	-	VU
Yellow-spotted Monitor	*Varanus panoptes*	-	VU
Flatback Turtle	*Natator depressus*	VU	DD
Green Turtle	*Chelonia mydas*	VU	LC
Hawksbill Turtle	*Eretmochelys imbricata*	VU	DD
Olive Ridley Turtle	*Lepidochelys olivacea*	EN	DD
Invertebrates			

Cognate Land Snail	*Amphidromus cognatus*	-	VU
Atlas Moth	*Attacus wardi*	-	EN
Dodd's Azure Butterfly	*Ogyris iphis*	-	EN
Land Snail	*Trochomorpha melvillensis*	-	VU
CR – Critically Endangered, EN – Endangered, VU – Vulnerable, LC – Least Concern, DD – Data Deficient			

2.5 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, Figure 8) 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 Pirlangimpi WwTP

Values	Receptors	
Cultural **(Recreational Water Quality)**	Humans	Fishing (lines, nets spears) Shellfish harvesting (estuary) • Telescopium (longbums) • Periwinkles • Cockles/pipis • Mud crabs Swimming/wading/diving Food gathering and cooking Hunting
Cultural **(Aesthetics)**	Humans	Visible water quality Sacred sites
Environment **(Aquatic Ecosystem Protection)**	Aquatic	Fish Turtles Dugongs Dolphins Macro-invertebrates (mud crabs)

		Crocodiles
	Terrestrial	Wading birds Shorebirds Seabirds Invertebrates (water insects) Mammals Reptiles
	Plants	Native vegetation • Closed monsoon vine forest • Mangroves

Table 3: Screening level risk assessment for key indicators and stressors associated with Pirlangimpi 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 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 Pirlangimpi WwTP is 20 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 average concentration of free ammonia in the discharge of Pirlangimpi WwTP is 16.0 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 Pirlangimpi WwTP is 14,500 mpn/100mL. At a screening level it is determined that a risk is present and further investigation is necessary.	Yes

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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 Table 3.

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 is shown in Table 5. A risk score for each potential impact is determined by combining likelihood with consequence results as seen in Figure 7.

Low to medium risks can be typically 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.

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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 7. Corporate risk matrix

Table 6: Risk assessment for key environmental and cultural assessment end points associated with Pirlangimpi 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 may occur during the dry season. The estimated dilution volume ratio between the effluent and receiving environment (when treated wastewater reaches the end of the creek) is calculated at 1:9 (Appendix D).	Minor	Based on sampling data to date, Pirlangimpi WwTP BOD discharge water quality is 20 mg/L. These BOD concentrations are relatively consistent in comparison to concentrations at other remote communities, these values are considered to be classified as low effluent strength (<40mg/L) (PWC 2022). Based on the dilution ratio between effluent and receiving environment and the nature of the receiving environment, PWC considers that the likelihood of oxygen depletion in receiving environmental waters to be unlikely. While dilution is poor; the volume of wastewater into the receiving environment is relatively low, and onto land within a monsoonal forest. Oxygen depletion is expected to be limited to the immediate discharge point (swamp area within the forest).	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 at immediate discharge point during the wet season.	Minor	Pirlangimpi WwTP free ammonia discharge quality is 16.0 mg/L. These ammonia concentrations are elevated in comparison to concentrations at other remote communities (PWC 2020). Low pH may also be an indicator of increased ammonia toxicity (ANZECC 2000); a mean pH of 7.5 at Pirlangimpi suggests the risk of ammonia toxicity to be lowered. Stressor not typically observed with such small discharge volumes. Likelihood greater during Dry Season where there are flushing constraints, however as the discharge point is 20,000m^2 in forest area and an additional 180m further to the cove, it is considered unlikely that ammonia levels will be high further away from the ponds. Based on water quality results, PWC considers the likelihood of toxicity to aquatic organisms is 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, Pirlangimpi WwTP contributes very low levels of total nitrogen and phosphorus 3.66 and 0.37 tonnes/year respectively. The discharge area is densely vegetated with closed monsoon vine thicket and tall eucalyptus suggesting transpiration and uptake of nutrients from the discharge (PWC 2017). No eutrophication/ algal blooms or scums were observed within the area, which is a good indicator of excessive nutrient loads.	Minor	Total nitrogen (24 mg/L) and total phosphorus (2.9 mg/L) concentrations are elevated 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. During the Dry Season, the discharge may generally infiltrate into soil within forest area. During the Wet Season dilution from rainfall would occur. PWC considers that the likelihood of nuisance plant growth is unlikely due to discharging initially to land.	Unlikely	Low
Cultural					
BOD is leading to odours resulting in the **reduction of amenity** in the receiving environment.	Access to the discharge point is by foot only and as a result, recreational activities are thought to be minimal. Minimal cultural beneficial uses of the receiving environment observed (PWC 2017).	Minor	No odours have been observed or reported at the immediate discharge point (PWC 2021b, PWC 2017).	Unlikely	Low

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			Likelihood greater during Dry Season where there are flushing constraints. However no evidence of odours during monitoring of discharge area (qualitative discharge criteria), and recreational use of the receiving area is minimal. PWC considers that the likelihood of reduction in amenity from BOD is unlikely.		
Nutrients are resulting in the **reduction of amenity** of receiving environment through **reduction in water clarity**, objectionable **discolouration** and **odours**.	Minimal cultural beneficial uses of the receiving environment observed. Unlikely the public access the immediate discharge site or further into forest (PWC 2021b; PWC 2017).	Minor	Good water clarity and no odours observed during monitoring of discharge site (qualitative discharge criteria). The discharge also enters dense forest area with significant leaf litter on the ground. 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. Unlikely the public access the immediate discharge site. The beach located downstream from the discharge area has also been described as having minimal cultural beneficial uses. Dense forest vegetation at discharge point would reduce risk of blooms.	Minor	Based on the minimal primary and secondary contact recreation and cultural uses of the forest and beach, the discharge point being a forest with no main water body, and the distance to Kings Cove beach area, PWC considers that the likelihood of toxicant exposure is unlikely.	Unlikely	Low
Pathogens are leading to the **contamination of water** resulting in primary and secondary contact recreational a public health risk.	Health risk due to exposure to pathogens in the water at the discharge point are considered to be low due to forest environment. The coastline is identified as having minimal cultural beneficial uses for primary and secondary recreation. Pathogens are likely to filter out before reaching a large body of water.	Minor	Based on the minimal secondary contact recreation and cultural uses of the forest and coastline, PWC considers that the likelihood of the illness from pathogen exposure is unlikely.	Unlikely	Low
Pathogens are leading to **accumulation in shellfish** resulting in the consumption of shellfish a public health risk.	Collection and consumption of shellfish occurs along the coastline however, effluent volumes are anticipated to be filtered out before reaching any shellfish harvesting areas. There is no evidence that the effluent travels to the coastline.	Minor	Based on the lack of shellfish in the forest area where the discharge enters the environment, and the distance to Kings Cove, PWC considers that the likelihood of the illness from pathogen exposure through the consumption of shellfish is unlikely.	Unlikely	Low

Summary and recommendations

The ERA found that the identified values of the nearby monsoon forest and beach at risk from the Pirlangimpi WwTP discharge are environmental and cultural.

The key stressors that posed a risk to these values are 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 the discharge from the Pirlangimpi WwTP poses a low 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 and high dilution that occurs in the receiving environment. 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;
- 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: Pirlangimpi Conceptual Site Model

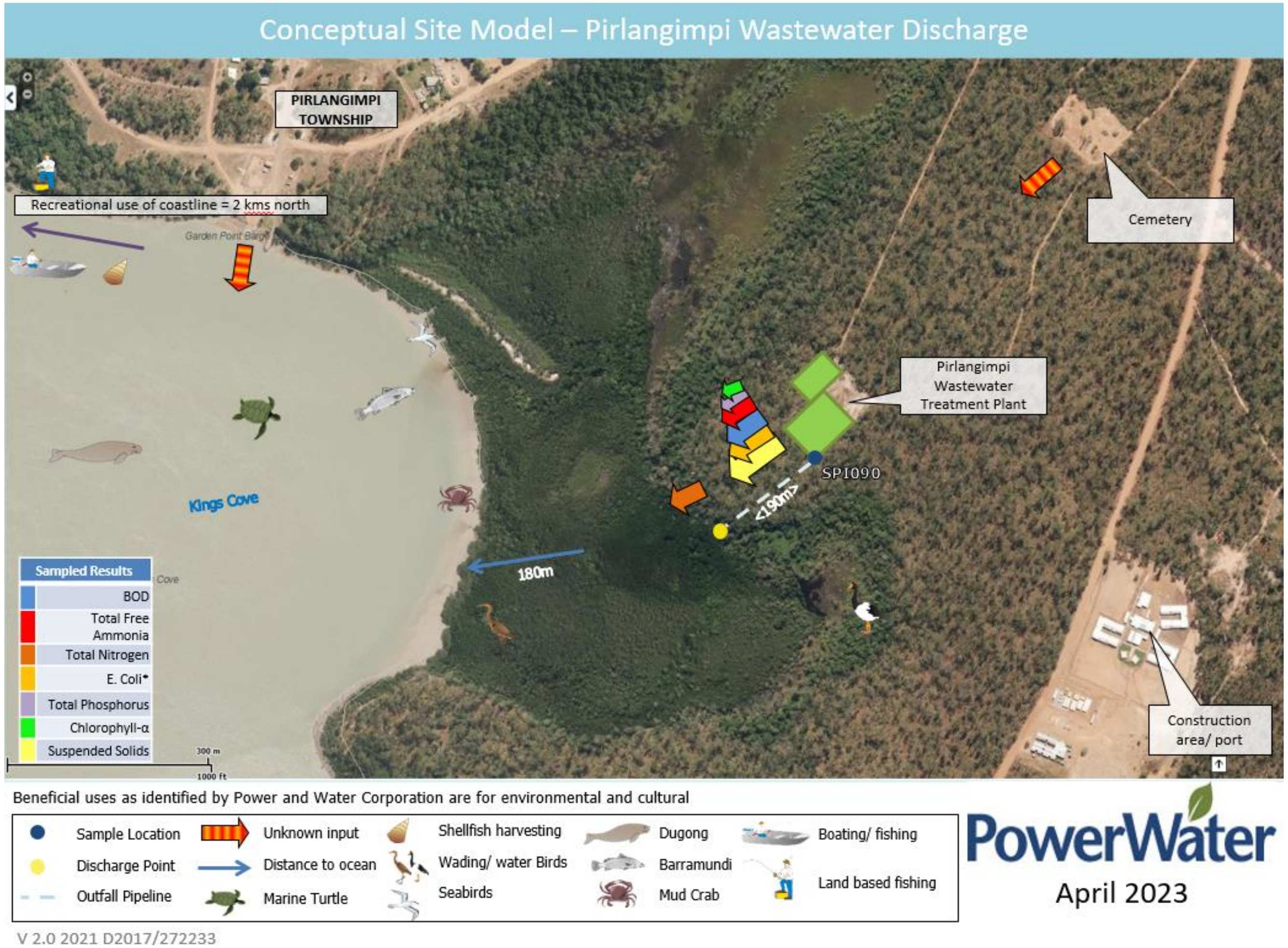

Figure 8: Conceptual site model for the key processes which may impact beneficial uses in the receiving environment of Pirlangimpi WwTP

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Appendix B: Tiwi Islands – Site of Conservation Significance

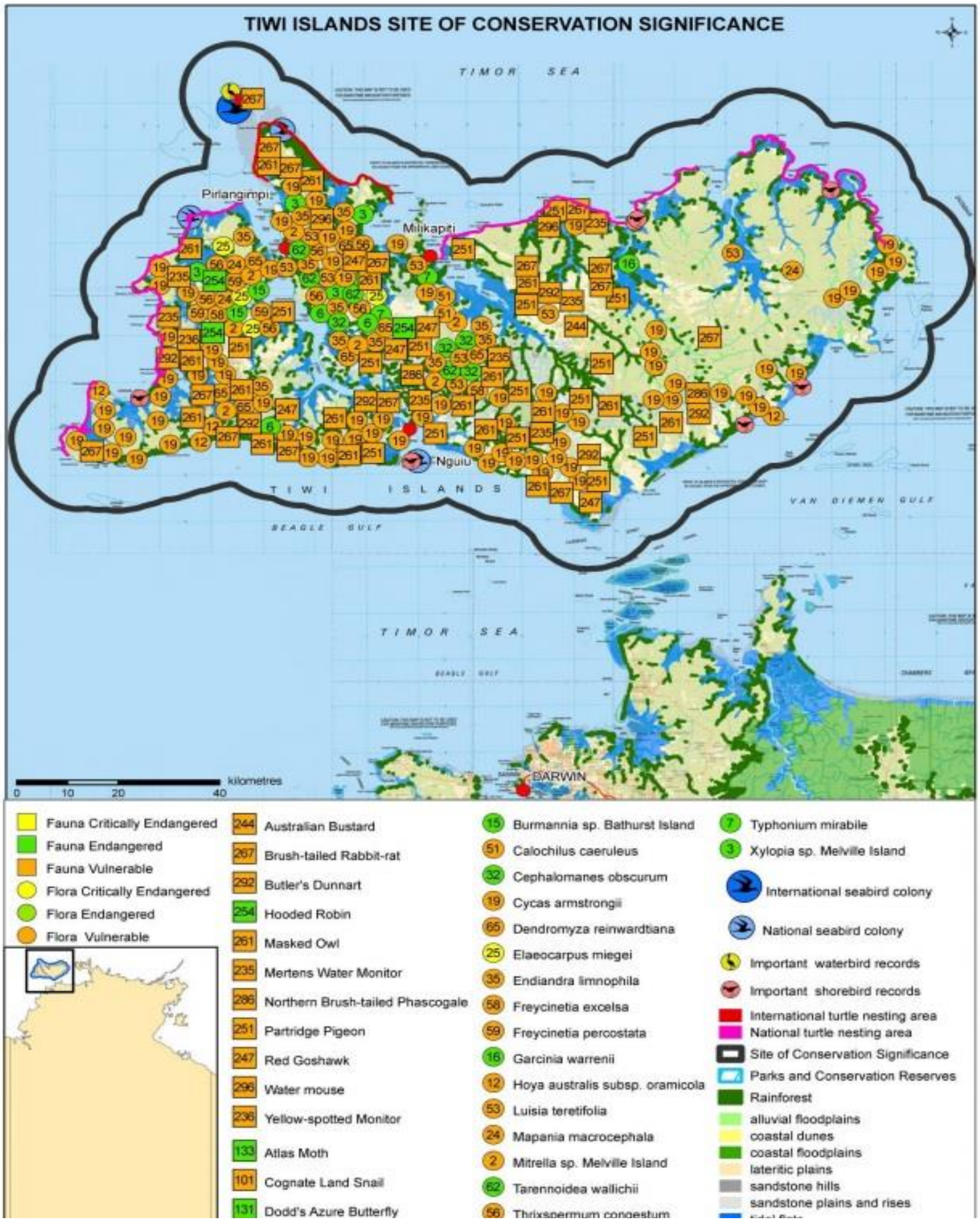

Figure 9: Tiwi Islands - Site of conservation significance map (NT Gov 2017a)

Appendix C: Estimated flowrates for Pirlangimpi WwTP

Assumptions:

Raw wastewater flow rate based on ICEG (2017) forecast sewage ET flow of 850 L/day and estimated total sewer ET for Pirlangimpi of 155 (PWC 2021a).

Rainfall catchment estimates based on mean monthly rainfall for all available years from Bureau of Meteorology (BOM) and total pond surface area (1,120 m^2) (PWC 2021a). Rainfall data was obtained using the Pirlangimpi Airport weather station (station number 14142) located approximately 900 m 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	132	23	8	147
February	132	15	8	139
March	132	12	8	136
April	132	10	8	134
May	132	1	8	125
June	132	2	8	126
July	132	0	8	124
August	132	0	8	124
September	132	5	8	129
October	132	8	8	132
November	132	10	8	134
December	132	18	8	144
Mean	**132**	**9**	**8**	**133**

Appendix D: Dilution ratio for Pirlangimpi WwTP

During times of low rainfall, treated wastewater is likely to be retained on land within nearby rainforest vegetation at the pond outlet, and absorbed through evapotranspiration. It is expected that little or no dilution of the treated wastewater occurs under this scenario; however it is difficult to confirm if there is another source of surface water occurring within this area (i.e. a small spring). Under conditions of high rainfall during the wet season, treated wastewater may be transported further off site, potentially as far as the ocean under some circumstances.

Under the scenario where treated wastewater flows further past the initial discharge area in the wet season, significant dilution and augmentation of the flow by rainfall would occur. Dilution of the treated wastewater would occur both in the disposal area, and due to mixing with rainwater captured in the catchment upstream of the disposal area overflow point. The catchment upstream of the overflow point and the path of diluted overflow is identified in Figure 8. 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. Further significant dilution of the treated wastewater would occur with Kings Cove and with the possibility of freshwater springs upstream of the discharge point.

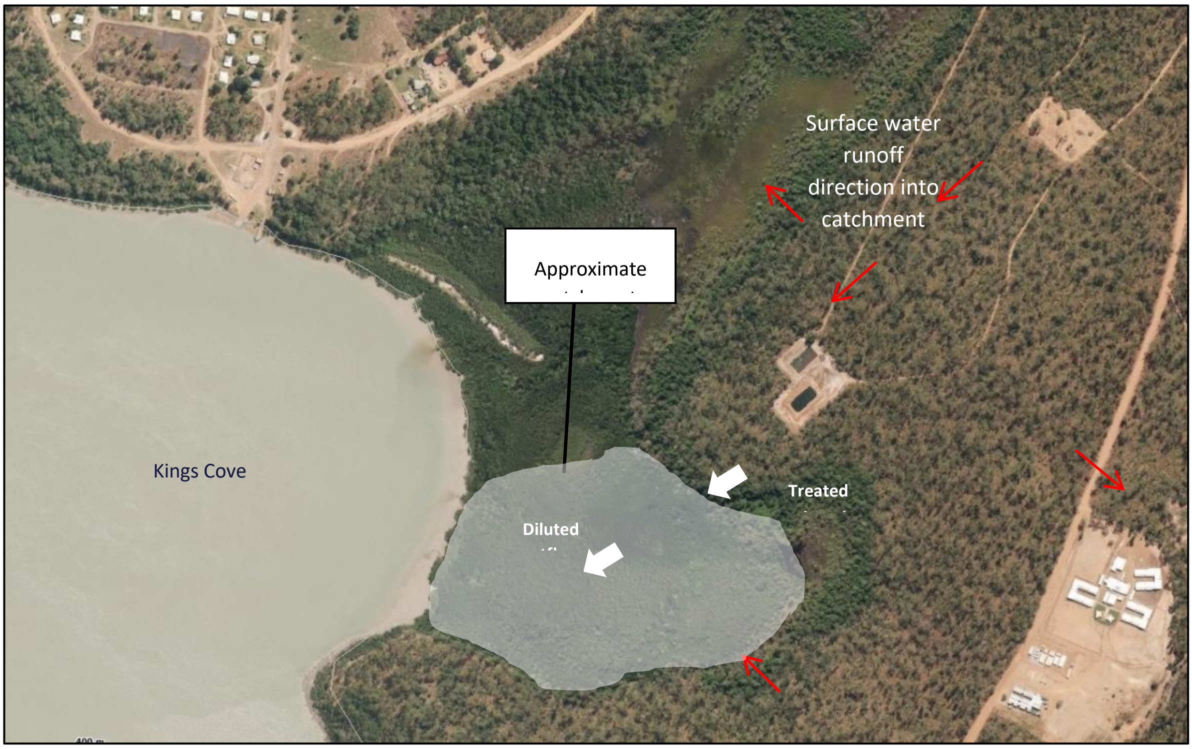

Figure 10. Catchment for Pirlangimpi WwTP (NT ILIS 2017)

Table 8. Discharge volume and dilution ratio calculation

Approx. catchment area downstream of discharge point (m^2)	Mean rainfall (Dec-Mar) (mm/d)	Mean evaporation (Dec-Mar) (mm/d)	Mean treated wastewater outflow (kL/d)
139,193	15.2	7.0	133 [1]
Volume of rain fall capture downstream of discharge point (rainfall-evap) (kL/d)	1141		
Dilution ration prior to entering Kings Cove	1:9		

[1] See Appendix C for discharge volume calculations.

Appendix E: Wastewater Quality Monitoring Results

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

Sample Location/Asset: SPI090 (Pond 2 Outlet)			
Indicator	**Reporting Value**		
	Median Wet Season	**Median Dry Season**	**Median**
Physio-chemical Parameters			
pH	7.41	7.52	7.46
Electrical Conductivity (uS/cm)	285	360	320
Dissolved Oxygen (% Saturation)	20.5	5	5
Turbidity (NTU)	68	58	60.5
Total Suspended Solids (mg/L)	101	47	67
Biological Parameters			
Biochemical Oxygen Demand (mg/L)	20	26	20
Chlorophyll-a (ug/L)	598	200	449
Nutrient Parameters			
Ammonia (Total[1] as N – NH3-N) (mg/L)	14.5	17	16
Total Nitrogen[2]	24.4	23.8	23.98

(mg/L)			
Oxidised Nitrogen (NOx)	0.05	0.05	0.05
Total Phosphorus (mg/L)	2.75	3.1	2.9
Pathogen Indicators			
Escherichia coli (E. coli/100mL)	13,820	16,070	14,500
Enterococci (Enterococci/100mL)	410	410	410

Appendix A: Additional Site Inspection Images

Figure 11. Pirlangimpi WwTP Pond 2 (PWC 2017)

Figure 12. Pirlangimpi WwTP Pond 2 – Wet Season 2021 (PWC 2021)

Figure 13. Pirlangimpi WwTP Pond 1 – brown algae observed over time in the pond – Wet Season 2021 (PWC 2021)

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