Environmental Risk Assessment

Milikapiti Waste Stabilisation Ponds 2023

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

%	Percent
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 desktop Environmental Risk Assessment (ERA) provides an assessment of the risks associated with the discharge of secondary treated effluent from the Milikapiti wastewater treatment plant (WwTP) directly to estuary waters within Snake Bay (Timor Sea).

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. The environmental impacts associated with the very low discharge volumes into a marine environment were rated as low risk rankings.

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 Milikapiti WwTP pursuant to Waste Discharge Licence (WDL) 217-02 issued on 12 July 2021. This WDL allows for continuous discharge of secondary treated sewage effluent from an authorised discharge point to estuary waters within Snake Bay (Arafura Sea).

Milikapiti is one of two communities located on Melville Island, forming part of the Tiwi Islands, approximately 116 km north of Darwin (Figure 1). Milikapiti has an estimated population of 486 in 2023 (BushTel 2023). The Wastewater Treatment Plant (WwTP) is located approximately 270 m south east of the Milikapiti Township (Figure 2).

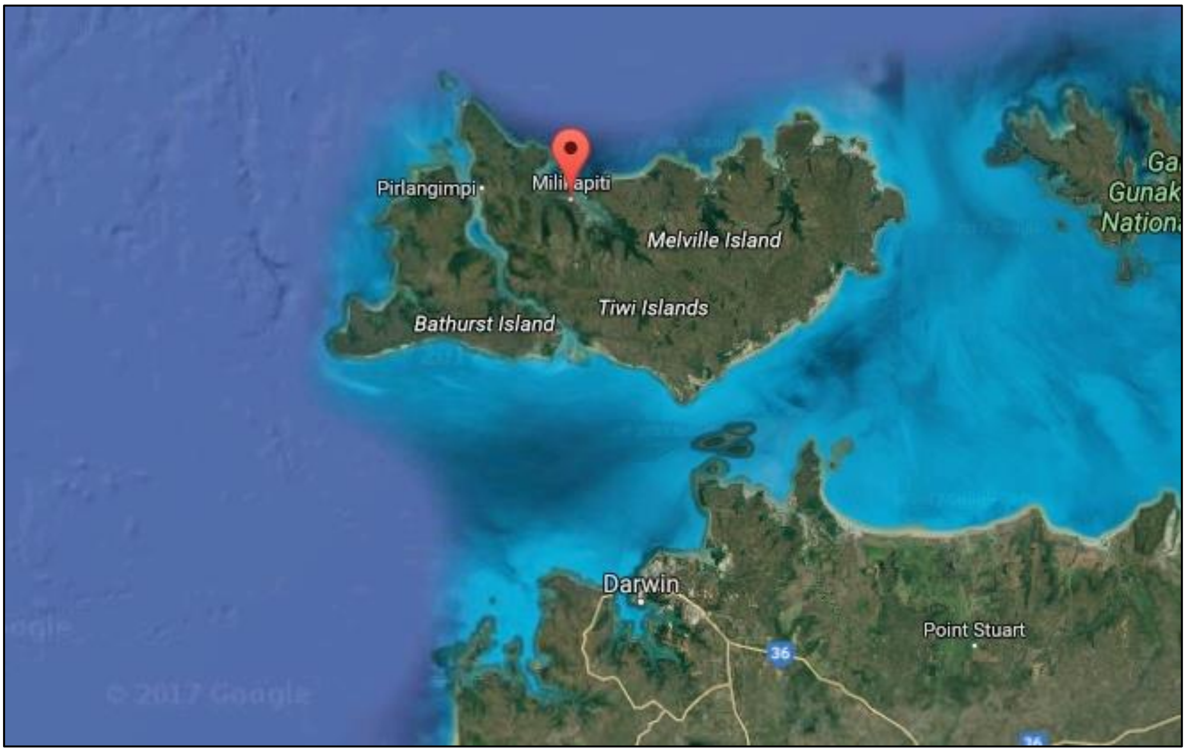

Figure 1. Milikapiti locality map (Google Earth 2017)

Figure 2. Milikapiti 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 licensed activity and submit to the Northern Territory Environment Protection Authority (NT EPA).

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).

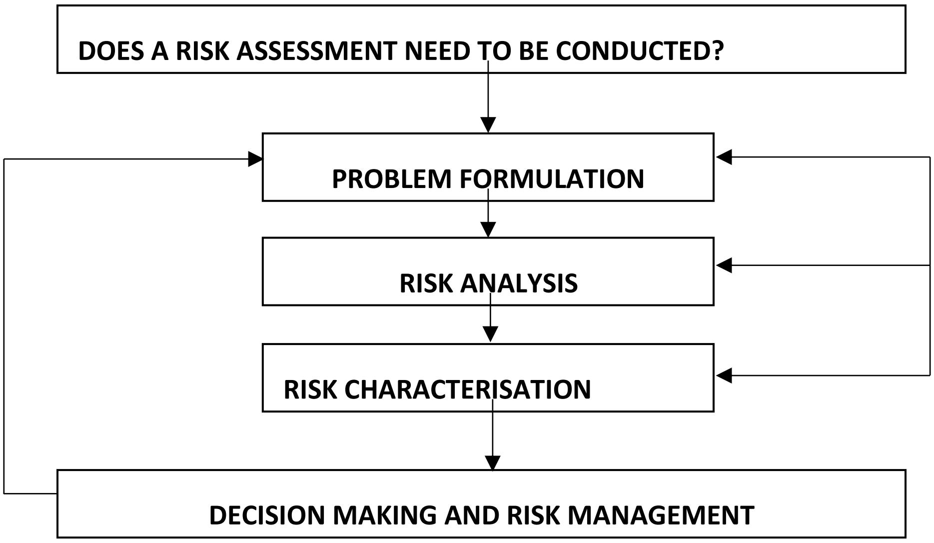

Figure 3. Risk assessment framework for wastewater discharges to waterways (Victoria EPA 2009)

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;
- 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 the relevant WDL conditions.

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.

Milikapiti 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 Milikapiti 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 1971 (PWC 2021a). The ponds consist of two primary facultative ponds which gravity feeds into a secondary maturation pond (pond 3) before being discharged offsite directly to estuary waters.

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 remote community ponds is conducted periodically where required to remove accumulated solids and increase hydraulic performance. Desludging was last completed at Milikapiti in 2015.

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 217. Samples of the tertiary maturation pond outlet are currently collected on a quarterly basis.

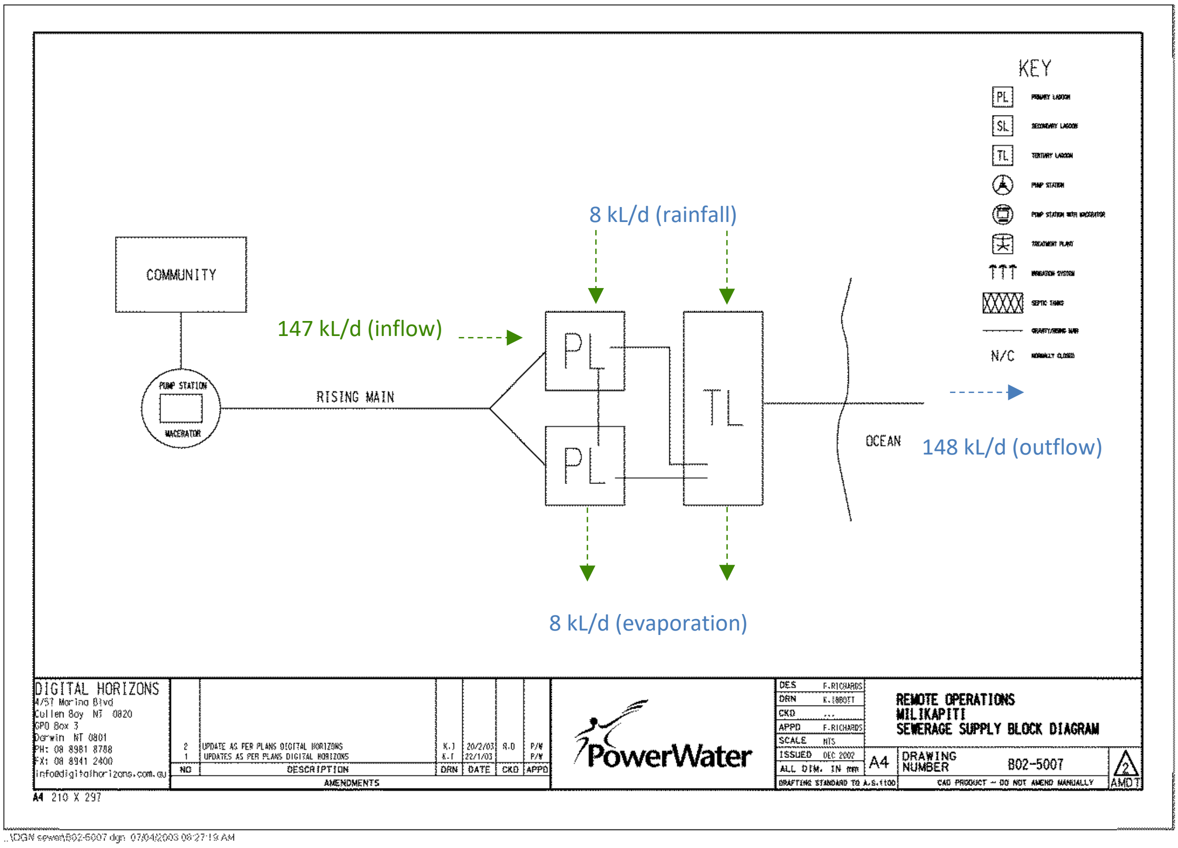

Figure 4. Milikapiti wastewater collection and treatment configuration including modelled flow (blue) rates.

Discharge Regime

Discharge from the facility occurs from a gravity fed discharge pipe located in the tertiary pond (Figure 4). Discharge is continuous on an as-required basis (discharge is all year round) and occurs directly into tidal estuary/ocean. The discharge outfall from the secondary maturation pond is 336 m in length, east of the ponds (Figure 2).

There is currently no flow meter data available at the Milikapiti 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 147 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 148 kL/day. Due to the small community population (486), Milikapiti 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.

In the past, a model based prediction of the Milikapiti 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 58.5 mg/L (71% removal) and 34,222/100 mL (2.2 log removal) respectively (modelled data used as pond performance indicator only).

Since 2020, Power and Water implemented monthly 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 16 mg/L and 7,545/ 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 Milikapiti 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 is a tidal estuary which is fed by the Tjipripu River; the river headwaters are located approximately 16 km south of the WwTP, and the mouth of the river located 11 km north (Figure 5, Figure 6). The estuary then feeds into the Arafura Sea. The river is approximately 26.4 km in length and the wastewater discharge enters at the river mouth which is approximately 1.98 km wide (Geoscience Australia 2016). Snake Bay tides are semi-diurnal and have a mean spring and neap tidal range of 4.51 (1.46, 5.98 m)[1] (BOM 2023).

The receiving environment consists of a beach with rocky outcrops, with a steep 5 m drop off from the ground level of the ponds. The vegetation along the beach at the receiving environment is open Eucalypt forest along the higher side with more riparian species along the beach front side (Figure 6). No mangrove vegetation was observed in this area during inspections.

[1] Estimated based on an average of 14 Medina Inlet South tide heights for 2017

The area is considered to be a pristine environment due to the steep embankment down to the beach area and recreational use known to occur further north of the discharge point. The marine waters may be used for offshore recreational fishing, however this is not a common fishing spot, no regular fishing observed in the waters surrounding the discharge point by PWC Essential Services Officer (ESO) (PWC 2017). Other recreational uses at the immediate discharge point such as swimming or wading have not been observed (PWC 2021b, PWC 2017).

Figure 5. Milikapiti community area (Google Maps 2017)

Figure 6. Coastal vegetation along beach south of discharge point, river in background (PWC 2017)

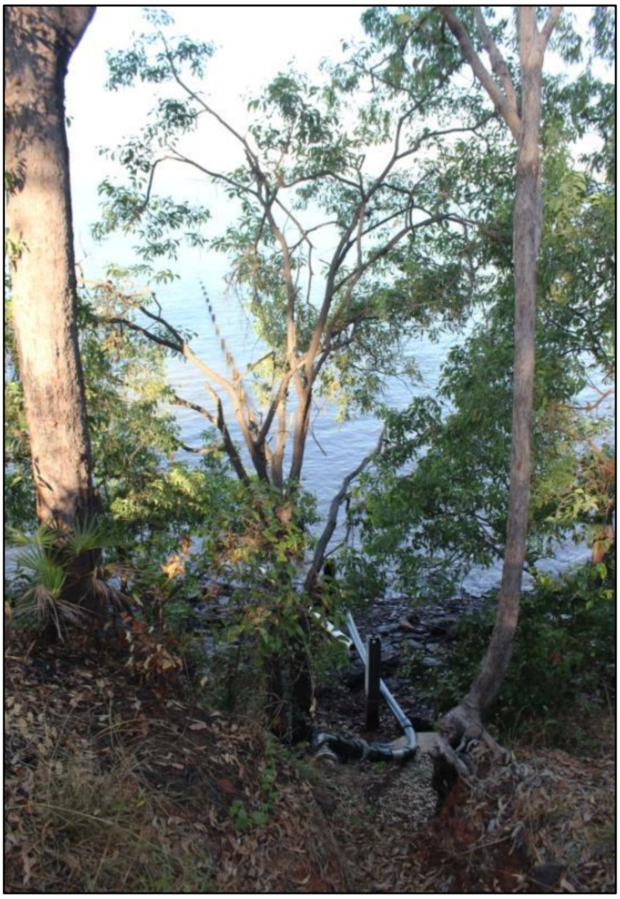

Figure 7. Milikapiti discharge pipeline (PWC 2017)

Figure 8. Milikapiti discharge point outfall (PWC 2021)

The receiving environment is located within the Tiwi Islands Site of Conservation Significance Number 9 (Appendix B, **Error! Reference source not found.**), 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 Milikapiti 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			

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 Milikapiti WwTP

Values	Receptors	
Cultural **(Recreational Water Quality)**	Humans	Fishing (lines, nets spears) 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 • Riparian vegetation • Eucalypts

Table 3: Screening level risk assessment for key indicators and stressors associated with Milikapiti 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). None observed over time by ESO. 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 average concentration of BOD in the discharge of Milikapiti WwTP is 16 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 total free ammonia in the discharge of Milikapiti WwTP is 14 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 Milikapiti WwTP is 7,545/100mL. 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 9.

Low to medium risks can typically be managed by routine procedures and integration into management plants, 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%

Consequence

Likelihood	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 9. Corporate risk matrix

Table 6: Risk assessment for key environmental and cultural assessment end-points associated with Milikapiti 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**.	The estimated preliminary dilution ratio between the effluent and receiving environment is 1:4 in the direct vicinity of the discharge point with further subsequent dilution (see Appendix D), suggesting any observed oxygen demand would be absorbed by the environment.	Minor	Based on sampling data to date, Milikapiti WwTP BOD discharge water quality is 16 mg/L. These BOD concentrations are relatively low in comparison to concentrations at other remote communities, these values are considered to be classified as low effluent strength (<40mg/L) (PWC 2022. Stressor not typically observed with such small discharge volumes, rapid dilution of a tidal ocean environment and a large surface area available for reaeration and efficient coastal flushing (Fernando, 2012). Likelihood greater during low tide where there are short-term flushing constraints however unlikely to be sustained for longer periods. PWC considers that the likelihood of oxygen depletion in the receiving environment is 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 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 (PWC 2015a). No fish kills reported to date.	Minor	Milikapiti WwTP free ammonia discharge quality is 14 mg/L. These ammonia concentrations are relatively consistent 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 7.24 at Milikapiti suggests the risk of ammonia toxicity to be low. Stressor not typically observed with such small discharge volumes, initial high dilution, and efficient coastal flushing (Fernando 2012). PWC considers that the likelihood of toxicity to aquatic organisms in water and sediments 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 to date, Milikapiti WwTP contributes very low levels of total nitrogen and phosphorus 1.175 and 0.157 tonnes/year respectively.** The effects of most ocean discharges are statistically insignificant when compared to total loads in the ocean (ARMCANZ and ANZECC, 2000).	Minor	Total nitrogen (21.75 mg/L) and total phosphorus (2.9 mg/L) concentrations are relatively consistent in comparison to concentrations at other remote communities, and is considered to be classified as low effluent strength (<50mg/L;<10mg/L) (PWC 2022. PWC considers that the likelihood of nuisance plant growth in the receiving environment is unlikely due to ocean receiving environment. **No eutrophication/ algal blooms or scums were observed at the immediate discharge point during ERA inspections, which is an indicator or excess nutrient loads (PWC2021b; PWC 2017). No algae observed within receiving waters within the last few years (PWC 2021b).**	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 down a steep embankment. Minimal cultural beneficial uses of the receiving environment observed by ESO, boating activities such as fishing tend to be conducted further out in the river mouth (PWC 2021b; PWC 2017).	Minor	No odours have been observed or reported at the ocean outfall (PWC 2021b), with any odours being limited to immediate discharge point. Stressor not typically observed with initial high dilution and efficient coastal flushing. Likelihood greater during low tide where there are short-term flushing constraints however unlikely to be sustained for longer periods. 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**.	Minimal cultural beneficial uses of the receiving environment. Some fishing may occur further out to sea but not common. Unlikely the public access the immediate discharge site 336m from shore, the beach area north of the discharge point closer to the community is more popular (PWC 2021b). Crocodiles are also common in the area and limit recreational uses of the beach (PWC 2021b; PWC 2017).	Minor	In past inspections no evidence has been 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). Stressor not typically observed with initial high dilution and efficient coastal flushing. Likelihood greater during low tide where there are short-term flushing constraints however unlikely to be sustained. PWC considers that the likelihood of reduction in amenity from BOD 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 toxic blooms would affect shellfish when the immediate discharge site 336m from shore. Shellfish consumption occurs on the beach further north closer to the community (PWC 2021; PWC 2017).	Minor	Based on the minimal primary and secondary contact recreation and cultural uses of the waters surrounding the discharge point, 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 would be low due to crocodiles inhibiting the waters. The coastline is identified as having minimal cultural beneficial uses for primary and secondary recreation. Pathogens likely to filter out at discharge point.	Minor	Median pathogen concentrations of 7,545 mpn/100mL *E. coli* within the Milikapiti WwTP discharge are low in comparison to concentrations at other remote communities (PWC 2022). Based on the minimal primary and secondary contact recreation and cultural uses of the waters surrounding the discharge point, 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 known to occur at coastline further north 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 collection along the beach surrounding the discharge point and the distance to known shellfish collection areas, 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 key beneficial uses and values identified of the estuary waters and associated beach at risk from the Milikapiti WwTP discharge were environmental and cultural.

The key stressors that posed 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 the discharge from the Milikapiti 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 would occur within estuarine waters in Snake Bay. Based on this ERA and 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;
- conduct pond performance monitoring;
- 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: Milikapiti Conceptual Site Model

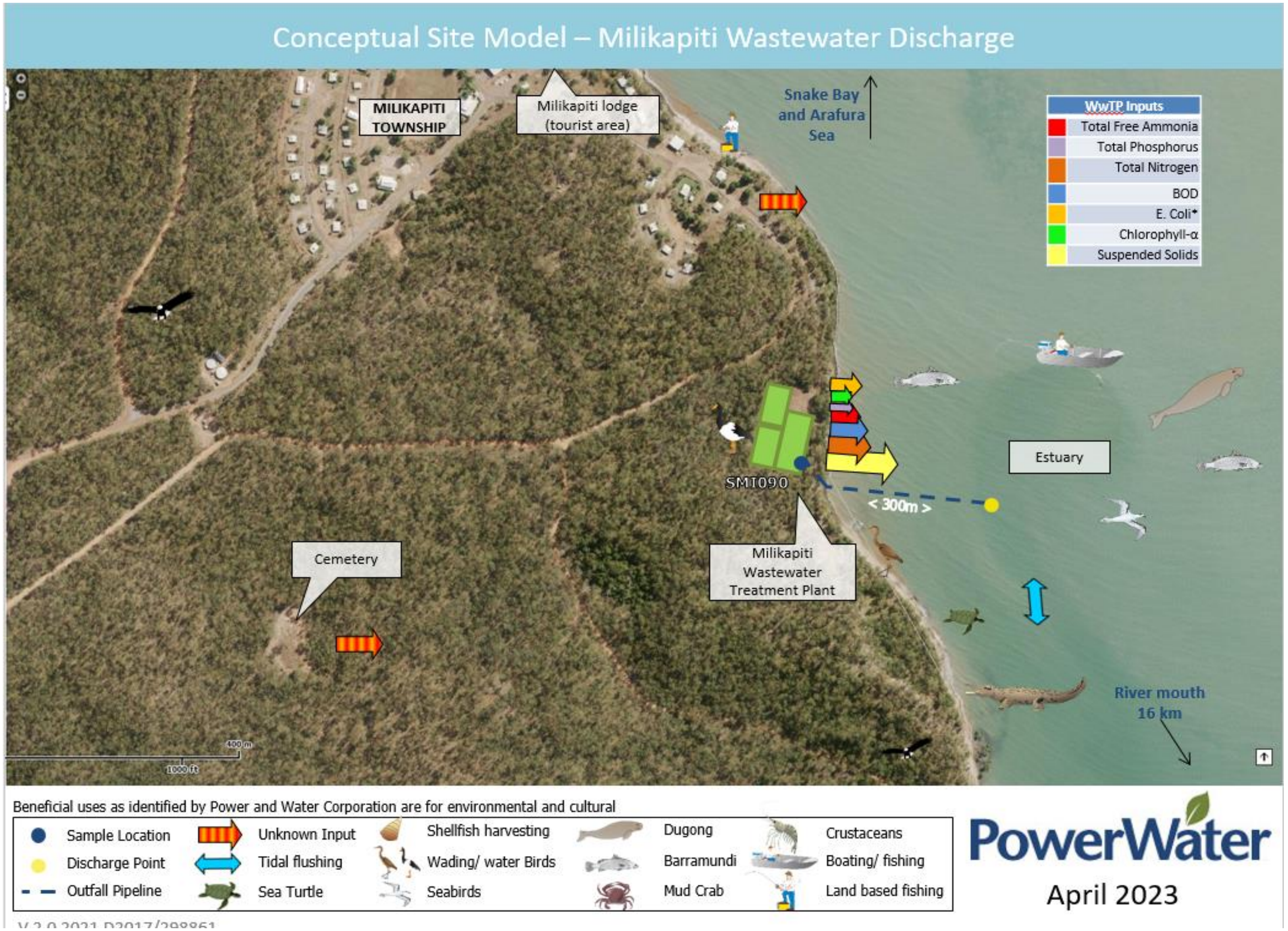

Figure 10: Conceptual site model for the key process that may impact beneficial uses in the receiving environment of Milikapiti

Appendix B: Tiwi Islands – Site of Conservation Significance

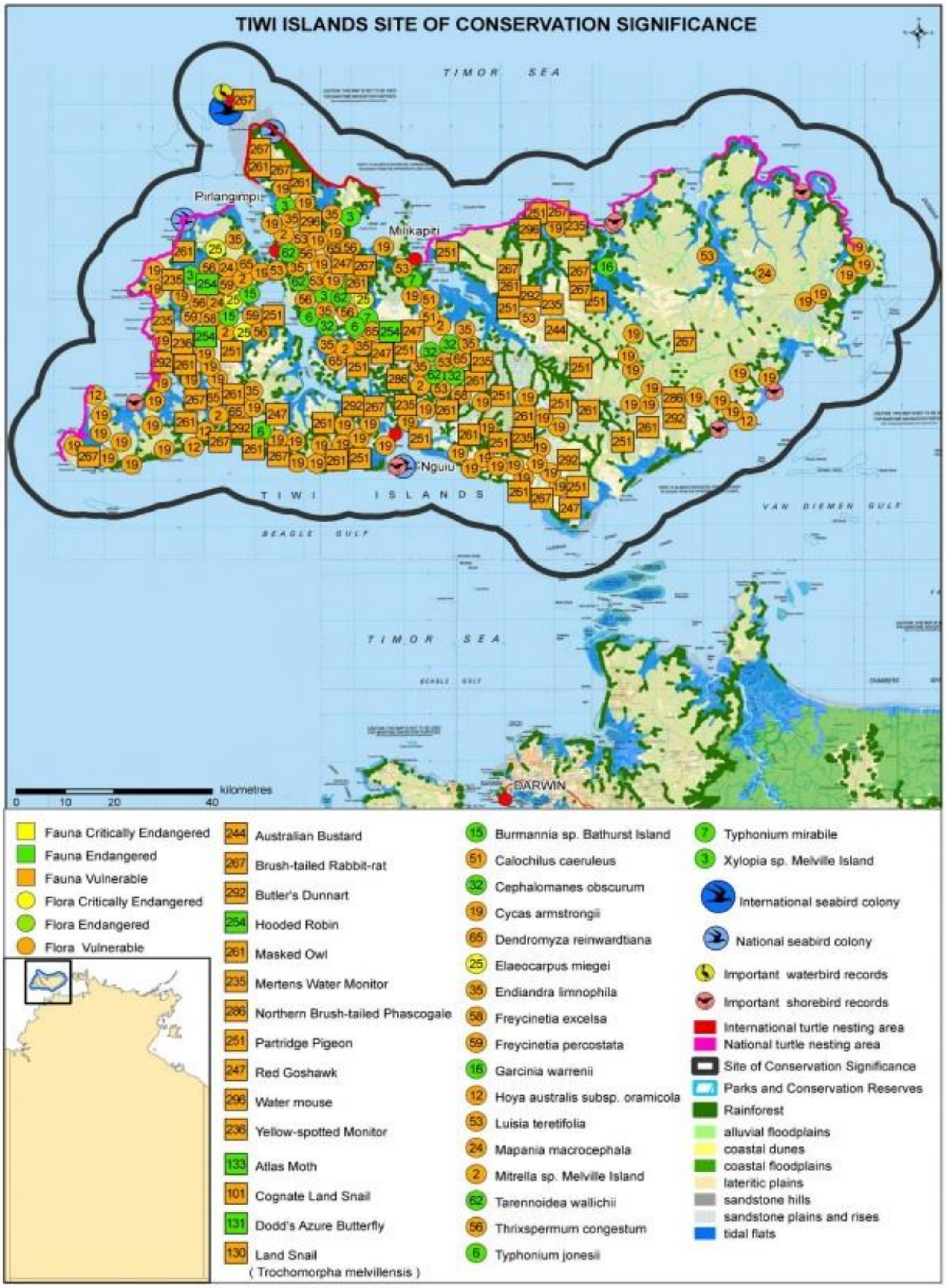

Figure 11: Tiwi Islands - Site of Conservation Significance map (NT Gov 2017a)

Appendix C: Estimated flowrates for Milikapiti WwTP

Assumptions:

Raw wastewater flow rate based on ICEG (2017) forecast sewage ET flow of 850 L/day and estimated total sewer ET for Milikapiti of 173 (PWC 2021a).

Rainfall catchment estimates based on mean monthly rainfall for all available years from Bureau of Meteorology (BOM) and total pond surface area (1,145 m2) (PWC 2021a). Rainfall data was obtained using the Pirlangimpi Airport weather station (station number 14142) located approximately 28 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	147	23	8	162
February	147	15	8	154
March	147	12	8	151
April	147	10	8	149
May	147	1	8	140
June	147	2	8	141
July	147	0	8	139
August	147	0	8	139
September	147	5	8	144
October	147	8	8	147
November	147	10	8	149
December	147	18	8	157
Mean	**147**	**9**	**8**	**148**

Appendix D: Estimated minimum dilution ratio for Milikapiti WwTP and Snake Bay

A model based prediction of Milikapiti outfall dilution was undertaken based on the method outlined by Wood, Bell and Wilkinson (1993). The model utilises site parameters such as outfall flowrate, water and wastewater temperature, outfall diameter and depth of ocean above outfall to predict the outfall plume dilution in the vicinity of the discharge point due to buoyancy led mixing.

The following parameter values were used:

Parameters		Minimum	Maximum	Unit
Depth of Ocean Above Outfall	z	1.08	5	m
Outfall Flowrate	Q	0.0021	0.0026	m^3/s
Wastewater Temperature	T_{wwater}	23.1	27.1	ºC
Ocean Temperature	T_{ocean}	23.6	33.1	ºC
Outfall Diameter	d_p	0.15		m

As boundary conditions for the site vary throughout the range, a Monte Carlo analysis was used to generate 10,000 sets of random input variables to give the median “most probable” dilution for site (Sweeney 2016). The modelled dilution result for the outfall and receiving environment was 1:4.

Note that dilution calculated using this method is worst-case scenario. Any tidal flows or currents will increase degree of mixing and dilution. The value of dilution calculated is the dilution that occurs between the outfall and the sea surface.

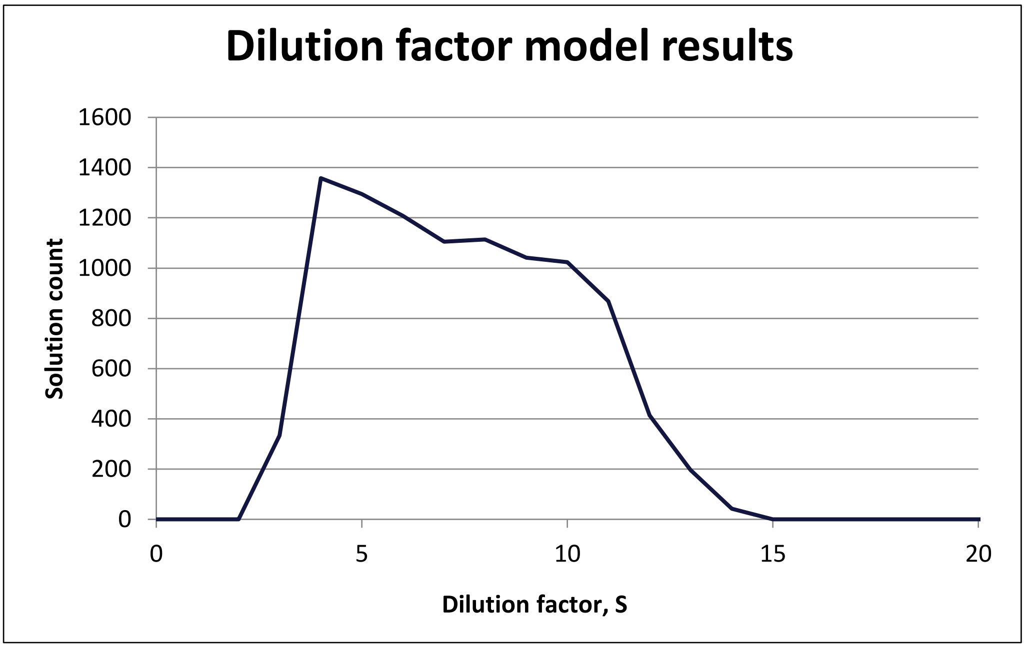

Figure 12. Monte Carlo analysis for Milikapiti WwTP and Arafura Sea dilution ratio distribution

Appendix E: Wastewater Quality Monitoring Results

Sample Location/Asset: SMI090 (Pond 3 Outlet)			
Indicator	Reporting Value		
	Median Wet Season	Median Dry Season	Median
Physio-chemical Parameters			
pH	7.25	7.21	7.24
Electrical Conductivity (uS/cm)	300	340	330
Dissolved Oxygen(% Saturation)	5	5	5
Turbidity (NTU)	38	35	37
Total Suspended Solids(mg/L)	55	57.5	57.5
Biological Parameters			
Biochemical Oxygen Demand (mg/L)	16	16.5	16
Chlorophyll-a(ug/L)	558	738	685
Nutrient Parameters			
Ammonia (Total[1] as N – NH3-N) (mg/L)	12	16	14
Total Nitrogen[2](mg/L)	20.1	23.6	21.75
Oxidised Nitrogen (NOx)	0.05	0.05	0.05
Total Phosphorus (mg/L)	2.7	3.2	2.9
Pathogen Indicators			
Escherichia coli (*E. coli*/100mL)	12,380	5,015	7,545
Enterococci (Enterococci/100mL)	850	585	745

Appendix F: Additional Site Inspection Images

Figure 14: Milikapiti outfall pipe during ERA inspection (PWC 2017)

Figure 13: Milikapiti WwTP Wet Season (PWC 2021)

Contact

WDLCorrespondance.PWC@powerwater.com.au

powerwater.com.au

PowerWater