Environmental Risk Assessment

Barunga Waste Stabilisation Ponds 2023

PowerWater

Document History

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Contents

List of Tables

List of Figures

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 Barunga wastewater treatment plant (WwTP) point to a nearby unnamed freshwater creek (located off Beswick Creek).

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 creek environment with continuous flow, while higher risk rankings were associated with impacts to cultural values including human health risks through primary and secondary contact (pathogen contamination of water and 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 Barunga WwTP pursuant to Waste Discharge Licence (WDL) 214-02 issued on 12th July 2021. This WDL allows for continuous discharge of secondary treated sewage effluent from an authorised discharge point into a small unnamed freshwater creek branching off from Beswick Creek.

Barunga is located in the Katherine region in the Northern Territory, 82 km east of Katherine, approximately 396 km south-east of Darwin (Figure 1). Barunga has an estimated population of 396 in 2023 (BushTel 2023). The Wastewater Treatment Plant (WwTP) is located approximately 510m south-east of the Barunga Township (Figure 2).

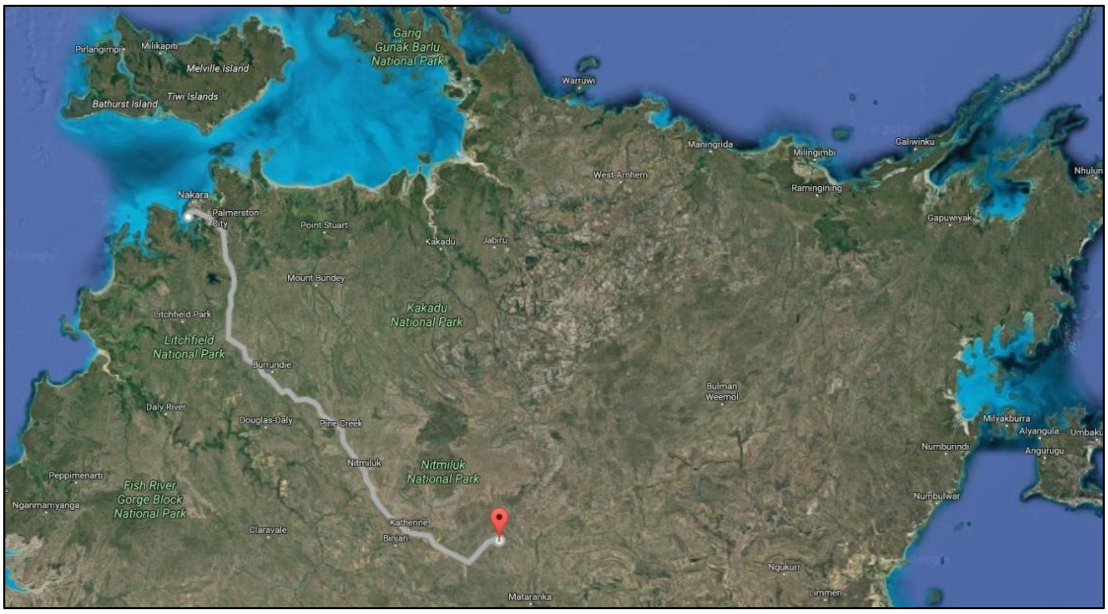

Figure 1: Barunga locality map (Google Earth 2017)

Figure 2: Barunga site layout including WwTP and outfall location (NT ILIS 2017)

Background

Condition 35 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 35 of the WDLs specifies that the Environmental Risk Assessment must:

29.1. be conducted in reference to a conceptual site model
29.2. characterise the impacts of discharges(s) on the relevant Environmental Values,
29.3. inform the development of the Performance Improvement Plan: and
29.4. be submitted to the Administering Agency at least 60 days prior to the end date of this licence, with the understanding that the Administering 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 (**Error! Reference source not found.**) 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).

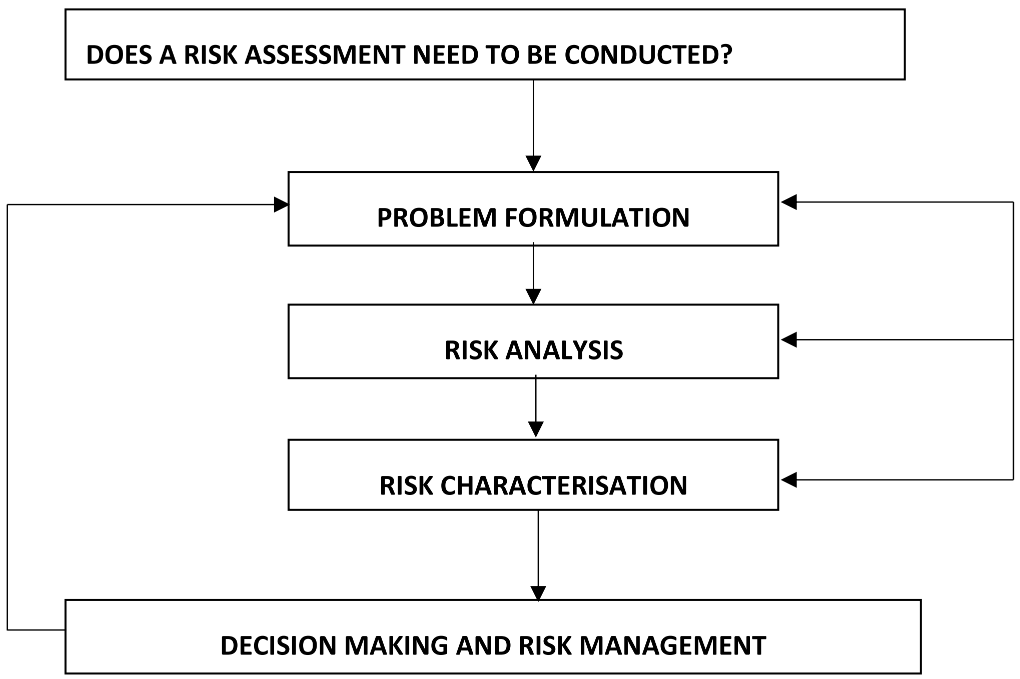

Figure 3: Risk assessment framework for wastewater discharges to waterways

Limitations

The following variables 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 locally 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.

Barunga 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 Barunga 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 1970 (PWC 2021a), and consist of two primary facultative ponds which gravity feed into one secondary maturation pond. The wastewater then drains into two tertiary maturation ponds before being discharged offsite to a freshwater creek. Pond 5 has treatment enhancers installed in the form of baffles.

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 Barunga in 2013.

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 214. Samples of the final maturation pond outlet are currently conducted 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 D, **Error! Reference source not found.**.

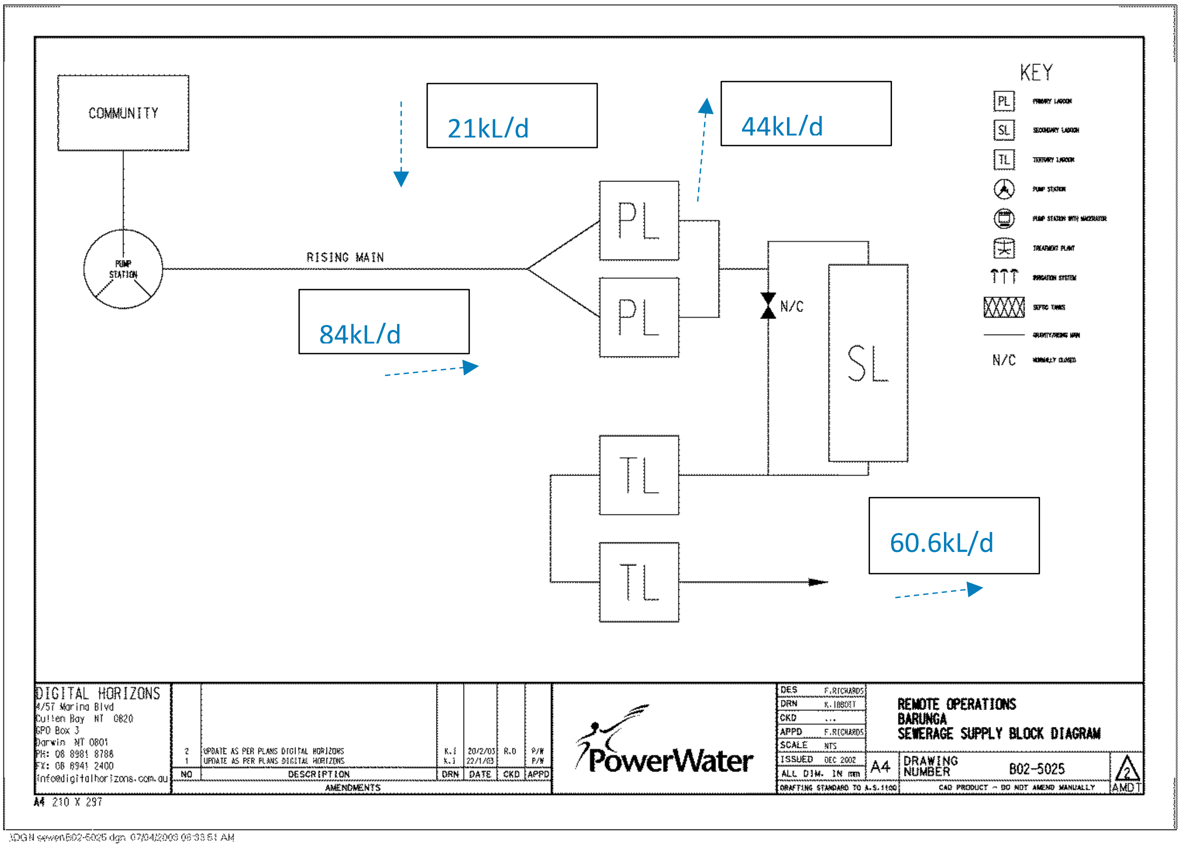

Figure 4: Barunga wastewater collection and treatment configuration including modelled flow rates (blue)

Discharge Regime

Discharge from the facility occurs from a gravity fed discharge pipe located in the final tertiary maturation pond (Pond 5) (Figure 4). Discharge is thought to be continuous or on an as-required basis (discharge is all year round) and occurs into a permanent freshwater creek (and also possibly a spring) approximately 195m north-west of the final pond outlet (Figure 2).

The annual water balance is estimated based on measured outflows, rainfall, evaporation and pond area (**Error! Reference source not found.**). It is estimated that the mean daily inflow of untreated wastewater into the WwTP is 84 kL/day. This is supplemented by an approximate rainfall contribution of 21 kL/d and reduction due to evaporation of 44 kL/d to give the mean measured outflow of 60.6 kL/day (Figure 4). Due to the small community population (399), Barunga has a relatively low discharge volume in comparison to other NT wastewater facilities in major centres (PWC 2017b).

Note that the volume of treated wastewater discharged to the environment varies seasonally with changes in environmental conditions (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.

Previously, a model based prediction of the Barunga 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 49.9 mg/L (75% removal) and 0.0497/100 mL (8 log removal) respectively (modelled data used as pond performance indicator only).

In 2020, Power and Water implemented a monthly wastewater monitoring of the WwTP discharge, which provides a characterisation of the treated effluent discharged to the receiving environment. Since 2020, the mean *in-situ* water quality results for BOD and *E. coli* were 26.48 mg/L and 2,909/ 100mL respectively. The variation in *E. coli* results between the modelled and sampling 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 Barunga WwTP due to restricted funding under the Indigenous Essential Services (IES) model. For the purpose of this risk assessment, *in-situ* monitoring data is illustrated on the conceptual site model (CSM) (Appendix A, **Error! Reference source not found.**).

Receiving Environment

The receiving environment consists of a small, shallow, unnamed freshwater creek, extending from the larger Beswick Creek, both which flows all year round (Figure 5). The unnamed creek runs along the eastern side of the Barunga Township, discharge from the ponds is downstream from the town (south). The main section of town is approximately 400m from the discharge point (PWC 2017). In some sections during the dry season, the creek can be shallow with segregated sections of pooling. The water quality within the receiving environment during the 2017 dry season was observed to be clear and free of contaminants, odours, and algal blooms (Figure 7). The immediate discharge point was providing a healthy habitat for aquatic insects and small guppies (PWC 2017). In April 2021 *Lemna aequinoctialis* (duckweed) was observed within the pond system and receiving environment. The creek was flowing and water was clear (Figure 6) (PWC 2021b).

The receiving environment experience minor disturbance due to the lack of vehicle tracks and observed recreational use of the area (PWC 2017, 2010). During the ERA inspection tracks from wild buffalo were identified, and wild buffalo are considered to enter this area frequently, although the banks of the creek where discharge occurs were largely unaffected by livestock. This is not an area considered to be commonly used by local community members for recreation; however local children do use areas of the creek upstream for swimming (PWC 2021b, 2017). With no observed fencing in this area and the creek being within close vicinity of the Barunga Township, it is thought that children may access the discharge point area of the creek. No other recreational activities such as washing food utensils or drinking creek water have been observed by the local Essential Services Officer (ESO) (PWC 2017). Signage is in place at the discharge point to inform the public regarding the presence and location of the wastewater discharge (Figure 8).

Figure 5: Small freshwater stream receiving outputs of Barunga (PWC 2017)

Figure 7: Clean water immediately downstream of discharge point (PWC 2017)

Figure 6: Receiving environment during 2020-21 wet season (PWC 2021)

Figure 8: Effluent discharge warning signage at Barunga (PWC 2020)

Vegetation within the receiving environment consists of native Eucalypt open woodland, including *Malaleuca leucadendra* (Paperbark trees), *Pandanus spiralis* (Pandanus), *Nymphaea violacea* (Blue water lily) and native grasses (PWC 2017).

The receiving environment contains eight threatened flora and fauna 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 in the Baruna WwTP recieving environment

Common name	Species name	National Status (EPBC)	NT Status (TPWC)
Vertebrates			
Gouldian Finch	*Erythrura gouldiae*	EN	VU
Crested Shrike-tit	*Falcunculus frontatus*	VU	-
White-throated Grasswren	*Amytornis woodwardi*	VU	VU
Partridge Pigeon	*Geophaps smithii*	VU	VU
Yellow-spotted Monitor	*Varanus panoptes*	-	VU
Mitchell`s Water Monitor	Varanus mitchelli	-	VU
Mertens` Water Monitor	Varanus mertensi	-	VU
Plants			
Coastal Plain Spike-rush	*Eleocharis retroflexa*	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) (**Error! Reference source not found.**, **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 **Error! Reference source not found.**.

Table 2: Identified values of receiving environment of Barunga WwTP

Values	Receptors	
Cultural (Recreational Water Quality)	Humans	Swimming/wading (not observed)
Cultural (Aesthetics)	Humans	Visible water quality Sacred sites

Environment (Aquatic Ecosystem Protection)	Aquatic	Fish Turtles Invertebrates (water insects)
	Terrestrial	Wading birds Mammals Reptiles
	Plants	Native vegetation • Open eucalypt woodland

Table 3: Screening level risk assessment for key indicators and stressors associated with Barunga 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 Barunga 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 median concentration of free ammonia in the discharge of Barunga WwTP is 1 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 Barunga 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 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 **Error! Reference source not found.** 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. Risk assessment rankings for key environmental and cultural assessment end-points associated with Barunga WwTP are summarised in Table 6.

Low to medium risks are 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.

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 9: Corporate risk matrix

Risk Assessment for Key Indicators and Stressors Identifies in Screening

Table 6: Risk assessment for key environmental and cultural assessment end - points associated with Barunga 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 dilution volume ratio between the effluent and receiving environment (when treated wastewater reaches Beswick creek during the wet season) is 1:13 (Appendix C). The dilution ratio is considered poor in comparison to other WwTP facilities; however this is reflective of the type of receiving environment (small, shallow creek). Average wastewater discharge outflow volumes are also relatively low, (103 kL/day), suggesting consequences of oxygen depletion would be localised.	Minor	Based on water quality data since 2020, Barunga WwTP BOD discharge quality is 16 mg/L. The BOD concentrations are relatively consistent in comparison to concentrations at other remote communities, and is considered to be classified as medium effluent strength (>40mg/L, <1,500 mg/L) (PWC 2020). Visual observations suggest the receiving environment is providing a healthy habitat for aquatic species (PWC 2017). During the dry season some pooling within the creek occurs, which maybe elevate oxygen depletion within receiving waters, however during this time the creek water was not completely stagnant, suggesting some flow provides flushing at the discharge point. If a spring is present within the creek upstream from the discharge point, continuous flushing may be likely. No odours, mortality of fish or plants observed within the area to date. PWC considers that the likelihood of oxygen depletion in receiving environmental waters 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. No fish kills have been observed or reported to date.	Minor	Free ammonia concentrations in the Barunga WwTP discharge quality is 1.8 mg/L. These ammonia concentrations are very low 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 8.35 at Barunga suggests very low risk of ammonia toxicity in the receiving environment. This particular stressor is not typically observed with such small discharge volumes, with initial dilution. Although the discharge area is a small creek, some flushing occurs all year round. Therefore, PWC considers 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, Barunga WwTP contributes very low levels of total nitrogen and phosphorus 0.59 and 0.096 tonnes/year respectively. No eutrophication/ algal blooms or scums were observed within the creek in 2017, which is a good indicator or excess nutrient loads. Some duckweed has been observed in the ponds in 2021.**	Minor	Median total nitrogen (15.7 mg/L) and total phosphorus (2.5 mg/L) concentrations are low in comparison to concentrations at other remote communities, and this is considered to be classified as low effluent strength (<50mg/L;<10mg/L) (PWC 2020). Stressor not typically observed with such small discharge volumes, as flushing of area would occur from natural creek flows and possibly spring inputs. Creek has some continuous flow within the in dry season. Some algae and duckweed observed in ponds in 2021, however is considered to be floating in the discharge. Based on the sampling results to date, PWC considers that the likelihood of nuisance plant growth as the result of the WwTP would be unlikely.	Unlikely	Low
Cultural					

BOD is leading to odours resulting in the **reduction of amenity** in the receiving environment.	Access to the discharge point is limited to foot. Observations during ERA inspection suggest minimal cultural beneficial uses of the receiving environment. Recreation activities occur in creek upstream of WwTP, closer to the Barunga community.	Minor	No odours have been observed or reported at the creek (PWC 2021b; PWC 2017), with odours being limited to immediate discharge point in creek. Stressor not typically observed with such small discharge volumes. Likelihood greater during occasional dry seasons where there are flushing constraints. With limited recreational use of the receiving area observed, 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 creek has been identified as having minimal cultural beneficial uses of the receiving environment, on rare occasions the public may access the immediate discharge site.	Minor	During inspections of discharge site, there was no evidence of reduction in water clarity, objectionable discolouration of receiving water or odours observed. (PWC 2021b; PWC 2017). Stressor not typically observed with such small discharge volumes. With limited recreational use of the receiving area observed, 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.	The receiving creek has been identified as having minimal cultural beneficial uses of the receiving environment, on rare occasions the public may access the immediate discharge site.	Moderate	Collection of shellfish and fish not observed in the immediate discharge area (PWC 2017). Stressor not typically observed with such small discharge volumes and low nutrient levels. The area has minimal primary and secondary contact recreation and cultural uses at the discharge point, the creek has some flow year round. Local children do play in creek further upstream. On a rare occasion it is possible they may follow the creek down to the discharge point, as it is in reasonable walking distance to the community (approximately 270m from nearest house). With no evidence of collection of shellfish within the discharge area, PWC considers that the likelihood of toxicant exposure is still unlikely.	Unlikely	Medium
Pathogens are leading to the **contamination of water** resulting in primary and secondary contact recreational a public health risk.	Risk of illness from pathogens leading to the contamination of water would be more elevated during the dry season, with risks to health deemed as short-term incapacity (gastrointestinal illness, upper respiratory tract infection etc.) (NHMRC 2008). The receiving creek is identified as having minimal cultural beneficial uses for primary and secondary recreation, however water has low flow during dry season.	Moderate	Median *E.coli* concentrations (100 mpn/100mL) are very low in comparison to concentrations at other remote Indigenous communities (PWC 2020). On the rare occasion that secondary contact recreation and cultural uses of the creek may occur, and areas upstream are deeper and more appealing for children to play, PWC considers that the likelihood of the illness from pathogen exposure is unlikely.	Unlikely	Medium

Summary and Recommendations

The ERA found that the identified values of the nearby unnamed freshwater creek at risk from the Barunga 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 Barunga WwTP poses 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 intermittent and low discharge volumes into a creek which has year round flow. 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;
- 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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Appendices

Appendix A: Barunga Conceptual Site Model

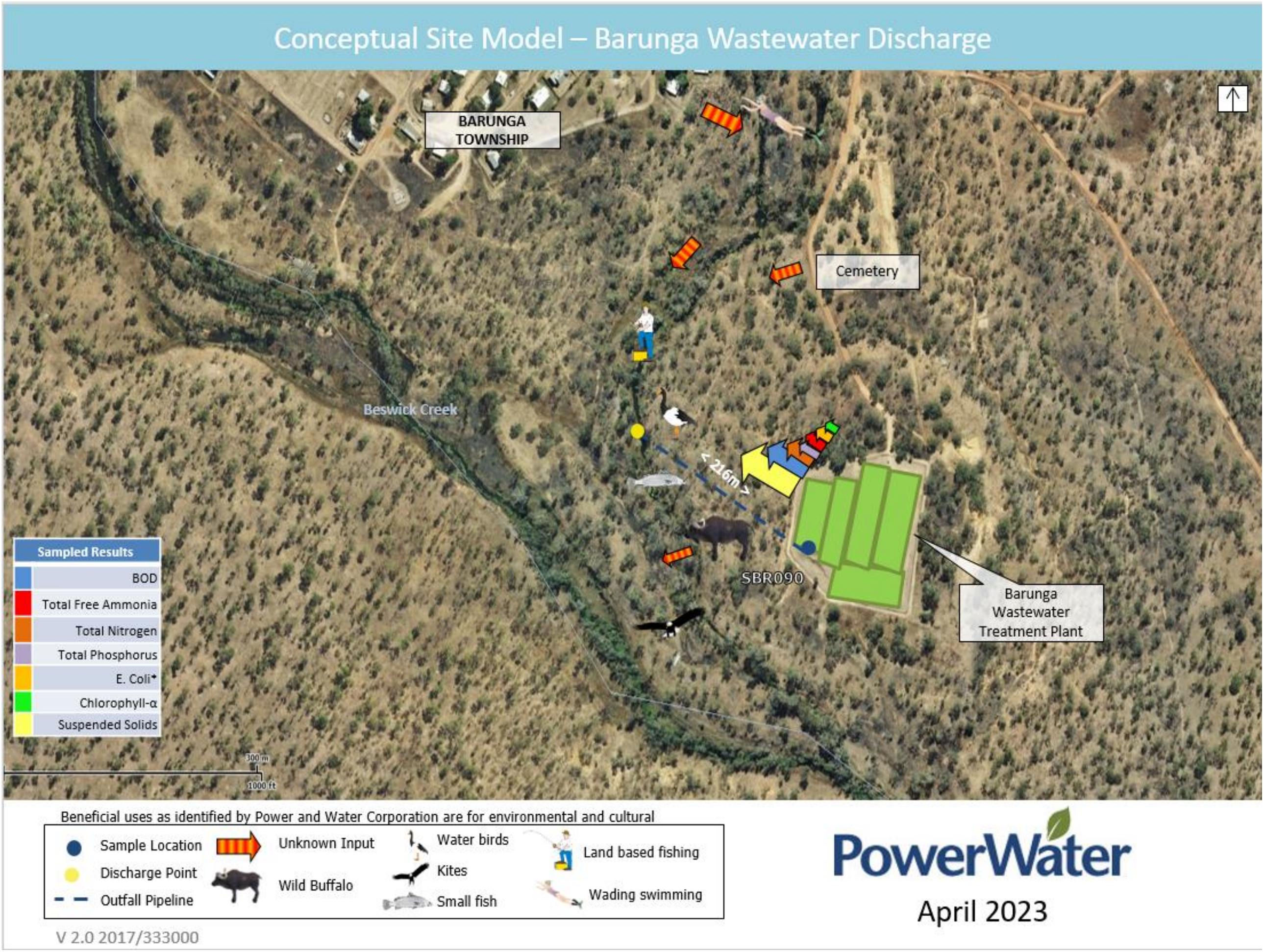

Figure 10: Conceptual Site Model Barunga WwTP

Appendix B: Estimated Flow Rates for Barunga WwTP

Since this site has an operational flow meter, the inflows will be estimated based upon the measured outflows and rainfall and the calculated evaporation volumes.

Assumptions:

Raw wastewater flow rate based on ICEG (2017) forecast sewage ET flow of 850 L/day and estimated total sewer ET for Barunga of 150 (PWC 2021).

Rainfall catchment estimates based on mean monthly rainfall for all available years from Bureau of Meteorology (BOM) and total pond surface area (7,357 m^2) (Louey-Gung 2011). Rainfall data was obtained using the Maranboy Hill weather station (station number 14652) located approximately 47.2 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	Estimated Inflow kL/d	Rainfall kL/d	Evaporation kL/d	Total measured outflow kL/d
January	128[1]	57	44	141[2]
February	128[1]	90	44	174[2]
March	59.5	11	44	26.5
April	63	1	44	20
May	77.3	0	44	33.3
June	102.8	0.6	44	59.4
July	80.7	5	44	41.7
August	66.8	0	44	22.8
September	52	0	44	8
October	75.3	6	44	37.3
November	72.1	21	44	49.1
December	106.1	56	44	118.1
Mean	**84**	**20.6**	**44**	**60.6**

[1]Estimated using ICEG Guidelines (sewage ET flow of 850L/ET/d (ICEG, 2017) and an estimated ET of 150)

[2]No outflow meter data available for this month, estimated based on inflow

Appendix C: Dilution Ratio for Barunga WwTP

Treated wastewater is discharged into a small freshwater creek. Some dilution of the treated wastewater occurs during the dry season and continuous flow was observed in the creek in previous years. The creek connects to the larger Beswick Creek (413m downstream). Beswick Creek seems to form part of the Roper River at Mataranka (45km). It is unknown if the creek is still fully connected within this section throughout the dry season (Google Earth 2017). During peak-wet season it is estimated that treated wastewater may flow down to Beswick Creek, approximately 400m south, and it is believed any impacts from the discharge would be limited to the unnamed creek during the dry season.

Under the scenario where treated wastewater overflows offsite, 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. 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 due to added freshwater from a possible spring. This source of freshwater input into the catchment area is unconfirmed. Table 8 includes calculation figures for the dilution ratio.

Table 8. Discharge volume and dilution ratio calculation

Approx. area of creek downstream from discharge point (m^2)	Mean rainfall (Dec-Mar) (mm/d)	Mean evaporation (Dec-Mar) (mm/d)	Mean treated wastewater outflow (kL/d)
460,555	7.2	6.0	41 [1]
Volume of rain fall capture downstream of creek (rainfall-evap) (kL/d)	552.67		
Dilution ratio prior to entering environment	1:13		

[1] See appendix B for discharge volume calculations.

Figure 11: Catchment for Barunga WwTP (NT ILIS 2017)

Appendix D: Wastewater Quality Monitoring Results

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

Sample Location/Asset: SBR090 (Pond 5 Outlet)			
Indicator	**Reporting Value**		
	Median Wet Season	**Median Dry Season**	**MEDIAN**
Physio-chemical Parameters			
pH	7.58	8.04	7.84
Electrical Conductivity (uS/cm)	305	390	320
Dissolved Oxygen (% Saturation)	46.50	22.00	42.00
Turbidity (NTU)	38	110	64

Total Suspended Solids (mg/L)	39.5	137	75
Biological Parameters			
Biochemical Oxygen Demand (mg/L)	15.5	36	16
Chlorophyll-a (ug/L)	252.5	516	457
Nutrient Parameters			
Ammonia (Total[1] as N – NH3-N) (mg/L)	1.15	1	1
Total Nitrogen[2] (mg/L)	9.45	19.05	10.65
Oxidised Nitrogen (NOx)	0.05	0.05	0.05
Total Phosphorus (mg/L)	1.6	2.5	2
Pathogen Indicators			
			MEDIAN
Escherichia coli (E. coli/100mL)	150	50	100
Enterococci (Enterococci/100mL)	100	514	200

Appendix E: Additional Site Inspection Images

Figure 12: Barunga Pond 2 (PWC 2021)

Figure 13: Barunga Pond 5 (PWC 2021)

Figure 15: Barunga Pond 5, Final outfall (PWC 2021)

Figure 14: Water clarity within creek (PWC 2021)

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