Remote Community Waste Discharge Licences
Waste Stabilisation Ponds

ENVIRONMENTAL RISK ASSESSMENT 2021

Nganmarriyanga (Palumpa) Waste Discharge Licence 219-01

Water Services
Remote Water Planning
April 2021

PowerWater

PowerWater

Document History

Document Title:	Environmental Risk Assessment 2021 - Remote Community Waste Discharge Licences – Nganmarriyanga (Palumpa) Waste Discharge Licence 219-01			
TRIM Container:		F2016/801	Document #	D2021/34022
Version:	**Date Prepared:**	**Prepared by:**	**Version reviewed by/Issued to:**	
Draft 0.1	08/08/2017	Emma Fakes Power and Water Corporation	Annie Andrews & David Sweeney Power and Water Corporation	
Final 1.0	30/08/2017	Remote Water Planning	Department of Environment and Natural Resources Northern Territory Government waste@nt.gov.au	
Draft 0.2	25/03/2021	Emma Fakes Power and Water Corporation	Simon Ruckenstuhl & Jessica Huxley Power and Water Corporation	
Final 2.0	13/04/2021	Remote Water Planning	Department of Environment, Parks & Water Security Northern Territory Government waste@nt.gov.au	

Cover Image: Nganmarriyanga Wastewastewater discharge sampling point 2017 – Power and Water Corporation

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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.

Note: Not all abbreviations may be used in this document.

Executive Summary

This desktop environmental risk assessment (ERA) provides an assessment of the risks associated with the discharge of secondary treated effluent from the Nganmarriyanga wastewater treatment plant (WwTP) point to land and surrounding environment (open Eucalypt woodland) via irrigation sprinkler system.

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. Low risk rankings were associated with the very low discharge volumes into a freshwater swamp environment. Impacts to cultural values including human health risks through primary and secondary contact are considered very low as the immediate receiving environment is fenced off to the public.

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.

1.0 Introduction

PWC operate the Nganmarriyanga (Palumpa) WwTP pursuant to Waste Discharge Licence (WDL) 219-01 issued on 9 July 2019. This WDL allows for continuous year round discharge of secondary treated sewage effluent from an authorised discharge point to the environment via an irrigation sprinkler system.

Nganmarriyanga is located inland along the western coast of the Northern Territory, approximately 362km south-west of Darwin (Figure 1). Nganmarriyanga has an estimated population of 494 in 2021 (DHCD 2017). The Wastewater Treatment Plant (WwTP) is located approximately 800m north of the Nganmarriyanga Township (Figure 2).

Figure 1. Nganmarriyanga locality map (Google Earth 2017)

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

1.1 Background

Condition 29 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 29 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 discharge(s) on the relevant Environmental Values;
29.3 inform the development of the Performance Improvement Plan; and
29.4 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.

1.2 Risk Assessment Methodology

The purpose of the desktop ERA is to:

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

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).

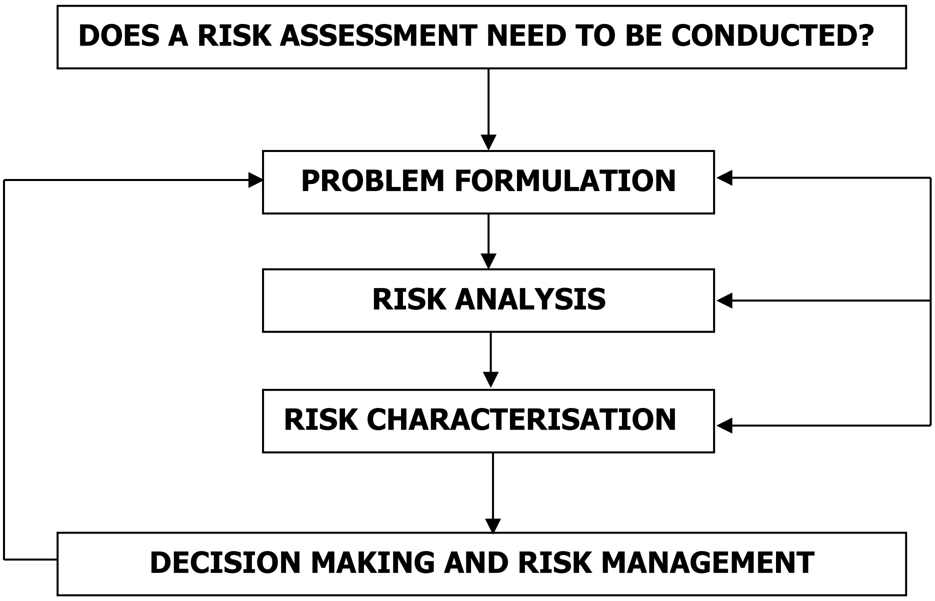

Figure 3. Risk assessment framework for wastewater discharges to waterways (Victoria EPA 2009)

1.3 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 locally available expertise; and
- limited access to pond discharge points and surrounding environment due to climatic, safety and geographic factors.

2.0 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.

2.1 Nganmarriyanga 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 Nganmarriyanga 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 1993 (PWC 2021a), and consist of a primary facultative pond which gravity feeds into a secondary maturation pond before being discharged offsite via an irrigation sprinkler system.

The Nganmarriyanga system varies from other sewerage networks, having a series of sewer pump out pits servicing approximately half of the community, which capture and pump effluent within each zone into the sewer main. The remaining half of the community sewage is pumped directly into the sewer reticulation mains.

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 WSPs is conducted periodically where required to remove accumulated solids and increase hydraulic performance, which may result in improved treatment performance. There are no records available for desludging works conducted at Nganmarriyanga; although a sludge survey was conducted in 2016 which revealed sludge levels to be below 30 percent, deeming desludging works unnecessary at this stage.

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 219. Samples of the secondary maturation pond outlet are currently collected on a quarterly 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.

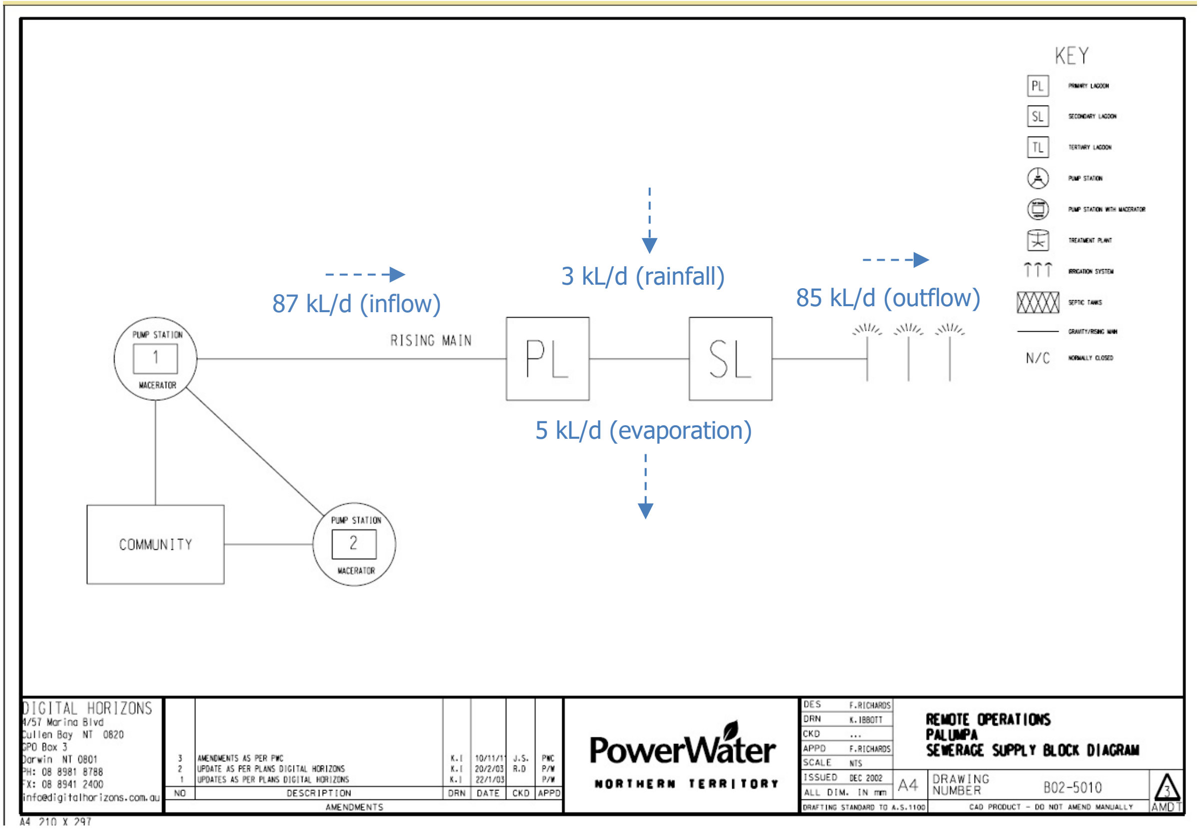

Figure 4. Nganmarriyanga wastewater collection and treatment configuration including modelled flow (blue) rates.

2.2 Discharge Regime

Discharge from the facility occurs from a gravity fed discharge pipe located in the secondary maturation pond (Figure 4). Discharge is continuous on an as-required basis (discharge is all year round) to a gravity fed, ground level irrigation system. The discharge outfall pipe from the secondary maturation pond is approximately 30m in length, located north-west of the ponds (Figure 2). The sprinkler system extends approximately 150m in a straight line, north-west of the final pond.

It is believed that the discharge pipework is operating continuously throughout the dry season, with disposal of the treated wastewater contained within the irrigation area (PWC 2017). During the wet season, the area receives heavy, frequent rainfall (PWC 2017). As a result of increased rainfall during the wet season swamp-like conditions are present within the irrigation area.

There is currently no flow data available at the Nganmarriyanga 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 87 kL/day. This is supplemented by an estimated rainfall contribution of 3 kL/d and reduction due to evaporation of 5 kL/d to give the mean measured outflow of 85 kL/day. Due to the small community population (494), Nganmarriyanga 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. During the wet season, infiltration of water into the gravity sewer network may occur, however due to the constraints of quantifying this volume and a negligible associated pollutant load it is not included within the flow rate calculations.

2.3 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 Nganmarriyanga 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 74.3 mg/L (63% removal) and 340,181/100 mL (1.2 log removal) respectively (modelled data used as pond performance indicator only).

In 2016, Power and Water implemented regular biannual 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 35.2 mg/L and 64,343 mpn/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 Nganmarriyanga 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, Figure 10).

2.4 Receiving Environment

Treated effluent from the Nganmarriyanga WwTP is discharged into the environment within a fenced disposal area via a gravity fed, ground level irrigation system (Figure 5). The discharge area is approximately 15,388 m^2. The sprinkler system forms a line approximately 150m in length to the north-west of the final pond.

A small swamp area is evident within the immediate discharge area; this is thought to be due to the WwTP discharge (Figure 6, Figure 7). During the dry season the treated effluent is contained within the irrigation area (PWC 2017); during the wet season it is unknown if the treated effluent flows past the fence line (further investigation is required). When the ponds fill during the wet season, treated effluent is designed to discharge via a concrete spillway located on Pond 2 (PWC 2017). It is unknown how often this occurs; however, any effluent discharged would receive significant dilution from freshwater stormwater infiltration and rainfall.

Aerial images show a seasonal alluvial floodplain 880m north-east of the irrigation disposal area (Figure 10). It is unknown if irrigation connects to the floodplain during the wet season, further site inspections are required to confirm seasonal connectivity (PWC 2021); however, it is considered unlikely.

Figure 5. Sprinkler irrigation system (PWC 2017)

Figure 6. Receiving environment of Nganmarriyanga WSPs (PWC 2017)

The surrounding vegetation within the receiving environment is Eucalypt woodlands, dominated by *Eucalyptus tetrodonta, Eucalyptus miniata,* and *Corymbia dichromophloia* or *Corymbia Capricornia* (Figure 8). *Pandanus spiralis* (Pandanus), shrubs and grasses are also dominant in the receiving area. The receiving environment is considered to be of a pristine conservation value, due to the lack of recreational use or development of the area (PWC 2017, 2010). The effluent disposal area is fenced off and signposted to prevent public access.

Figure 7. Disposal of effluent occurring to land during 2020-21 wet season (PWC 2021)

Figure 8. Vegetation within receiving environment (PWC 2021)

The receiving environment is located within the Hyland Bay and associated coastal floodplains Site of Conservation Significance Number 1 (Appendix B, Figure 11). Nganmarriyanga is considered to be within an alluvial floodplain, and is considered a major breeding area for colonial nesting waterbird species, including herons, egrets and cormorants (NT Gov 2021). The area contains four threatened plant and animal species. The conservation status for these species listed under the Northern Territory Parks and Wildlife Conservation Act 2000 (TPWC) and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC) are summarised below in Table 1.

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

Common name	Species name	National Status (EPBC)	NT Status (TPWC)
Vertebrates			
Australian Bustard	*Ardeotis australis*	-	VU
Red Goshawk	*Erythrotriorchis radiatus*	VU	VU
Greater Sand Plover	*Charadrius leschenaultii*	VU	VU
Flatback Turtle	*Natator depressus*	VU	DD
Plants			
Cycas	*armstrongii*	-	VU

CR – Critically Endangered, EN – Endangered, VU – Vulnerable, LC – Least Concern, DD – Data Deficient

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. Table 3 provides a summary of the screening level risk assessment.

Risk hypotheses for the stressors identified in the conceptual site model (CSM) (Appendix A, Figure 10) 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 Nganmarriyanga WwTP

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

Table 3. Screening level risk assessment for key indicators and stressors associated with Nganmarriyanga WwTP discharge

Indicator (water quality parameter)	Stressor (change to indicator)	Risk Hypothesis ENVIRONMENTAL	Risk Hypothesis CULTURAL	Assessment end-points ENVIRONMENTAL	Assessment end-points CULTURAL	Scope of this desktop ERA	Further investigation required?
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 gross pollutant accumulation occurs using irrigator sprinkler system. 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 Nganmarriyanga WwTP is 35.2 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 Nganmarriyanga WwTP is 14.0 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 Nganmarriyanga WwTP is 41,060 mpn /100mL. At a screening level it is determined that a risk is present and further investigation is necessary.	Yes

3.0 Risk Analysis and Characterisation

3.1 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 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 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

3.1.1 Risk assessment for key indicators and stressors identified in screening level assessment

Table 6. Risk assessment for key environmental and cultural assessment end-points associated with Nganmarriyanga 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**.	No dilution of the treated wastewater would occur during the dry season. The estimated dilution volume ratio between the effluent and receiving environment is 1:26 (Appendix D), suggesting any observed oxygen demand would be absorbed by the environment during the wet season. The community ESO believes significant infiltration of freshwater into sewer system occurs during wet season (PWC 2021b; PWC 2017). Therefore, it is hypothesised that greater dilution may occur during the wet season.	Minor	Based on sampling data to date, Nganmarriyanga WwTP BOD discharge quality is 35.2 mg/L. These BOD concentrations are consistent in comparison to concentrations at other remote communities, and is considered to be classified as low effluent strength (<40mg/L) (PWC 2020). Based on the dilution ratio between effluent and receiving environment and the nature of the receiving environment being an irrigation site and distance to the floodplain, PWC considers that the likelihood of oxygen depletion in receiving environment would be unlikely.	Unlikely	Low
Free ammonia is resulting in **toxicity to aquatic organisms** in water and sediments.	Toxicity to aquatic organisms may only be applicable to localised invertebrate populations and sediment dwelling organisms at immediate discharge point during the wet season only. Given the nature of the receiving environment, fish kills are highly unlikely.	Insignificant	Nganmarriyanga WwTP free ammonia discharge quality is 14.0 mg/L. These ammonia concentrations are consistent 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 7.65 at Nganmarriyanga suggests the risk of ammonia toxicity to be low. Stressor not typically observed with such small discharge volumes and sprinkler irrigation systems.	Rare	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, Nganmarriyanga WwTP contributes very low levels of total nitrogen and phosphorus 0.72 and 0.12 tonnes/year respectively. The effects of these levels of discharges into a swamp area that is a direct result of effluent discharge is low risk.	Minor	Total nitrogen (23.3 mg/L) and total phosphorus (3.9 mg/L) concentrations are consistent in comparison to concentrations at other remote communities, and is considered to be classified as low effluent strength (<50mg/L;<10mg/L) (PWC 2020). Stressor not typically observed with such small discharge volumes and sprinkler irrigation systems. Some surface scum and growth within the areas of water pooling from the sprinklers has been observed, however would likely accumulate within the immediate discharge area (PWC 2017). No algal blooms observed within the discharge point during the wet or wet seasons; some algae from the pond system observed in the wet season, however not expected to reach floodplains (PWC 2021b; PWC 2017). PWC considers that the likelihood of nuisance plant growth is 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 PWC employees only. Minimal cultural beneficial uses of the areas surrounding the receiving environment observed; the community utilises the creek along the main road into the community for cultural and recreational uses (PWC 2021; PWC 2017). Area can flood significantly during the wet season.	Insignificant	Stressor not typically observed with such small discharge volumes. Odours would be contained within private property during the dry season. During the wet season, further dilution from rainfall would occur. PWC considers that the likelihood of reduction in amenity from BOD is rare.	Rare	Low
Nutrients are resulting in the **reduction of amenity** of receiving environment through **reduction in water clarity**, objectionable **discolouration** and **odours**.	Access to the discharge point is limited to PWC employees only. Minimal cultural beneficial uses of the areas surrounding the receiving environment observed; the community utilises the creek along the main road into the community for cultural and recreational uses (PWC 2021; PWC 2017). Area can flood significantly during the wet season.	Insignificant	Stressor not typically observed with such small discharge volumes and substantial dilution during the wet season. Poor water clarity and discolouration/odours were observed at sprinkler locations, mainly as the sprinklers are at ground level and seep undiluted treated wastewater out to ground which forms pooling (PWC 2017). However, this is expected and contained within the irrigation area, the public do not have access to this area. 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.	Access to the discharge point is limited to PWC employees only. Minimal cultural beneficial uses of the areas surrounding the receiving environment observed. Area can flood significantly during the wet season.	Insignificant	Stressor not typically observed with such small discharge volumes. Public do not have access to the irrigation area. Toxic blooms unlikely to form within irrigation area. PWC considers that the likelihood of toxicant exposure is rare.	Rare	Low

Pathogens are leading to the **contamination of water** resulting in primary and secondary contact recreational a public health risk.	Access to the discharge point is limited to PWC employees only. Minimal cultural beneficial uses of the areas surrounding the receiving environment observed. Area can flood significantly during the wet season.	Moderate	Median pathogen concentrations of 41,060 mpn/100mL *E. coli* within the Nganmarriyanga WwTP discharge are elevated in comparison to concentrations at other remote communities (PWC 2020). Stressor not typically observed with such small discharge volumes within a very shallow swamp area; further UV treatment would be occurring within the irrigation area, with low drip flow to land. PWC considers that the likelihood of the illness from pathogen exposure is unlikely. Further inflow monitoring will characterise discharge water quality.	Rare	Low

4.0 Summary and recommendations

The ERA found that the identified values of the adjacent disposal area and surrounding open Eucalypt woodland at risk from the Nganmarriyanga WwTP discharge were environmental and cultural. However, these values are limited to the wet season only as the immediate discharge area is fenced off to the public.

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 Nganmarriyanga 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 use of a sprinkler irrigation system as an effective wastewater disposal method. 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;
- conduct pond performance wastewater 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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5.0 References

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Appendix A: Nganmarriyanga Conceptual Site Model

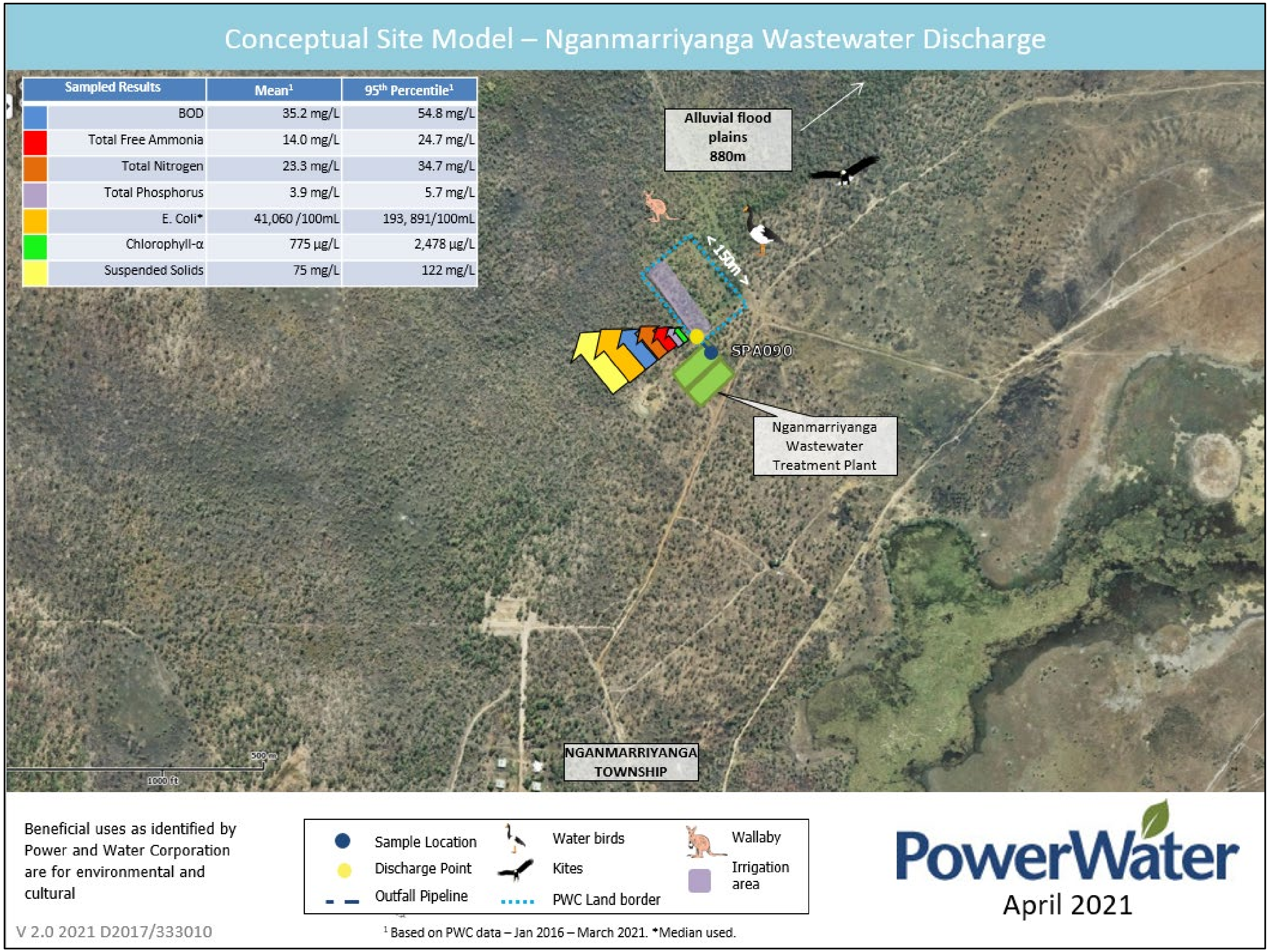

Figure 10. Conceptual site model for the key processes that may impact beneficial uses in the receiving environment of Nganmarriyanga WwTP

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Appendix B: Hyland Bay – Site of Conservation Significance

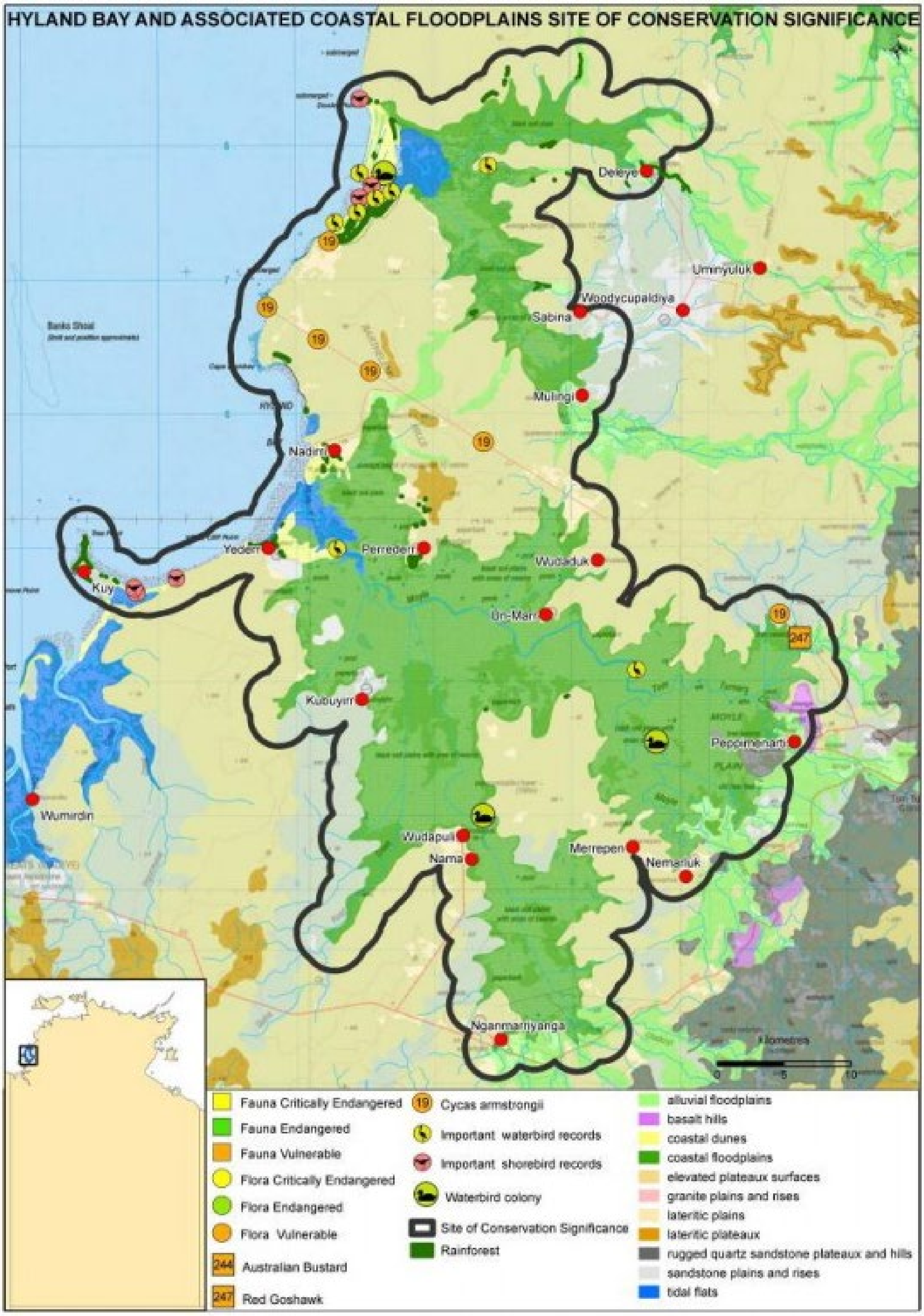

Figure 11. Hyland Bay - Site of conservation significance map (NT Gov 2021)

Appendix C: Estimated flow rates for Nganmarriyanga WwTP

Assumptions:

Raw wastewater flow rate based on ICEG (2017) forecast sewage ET flow of 850 L/day and estimated total sewer ET for Nganmaryanga of 102 (PWC 2021a).

Rainfall catchment estimates based on mean monthly rainfall for all available years from Bureau of Meteorology (BOM) and total pond surface area (771 m^2) (PWC 2021a). Rainfall data was obtained using the Port Keats weather station (station number 14948) located approximately 41 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	87	8	5	90
February	87	8	5	90
March	87	5	5	87
April	87	2	5	84
May	87	0	5	83
June	87	0	5	82
July	87	0	5	82
August	87	0	5	82
September	87	0	5	82
October	87	1	5	83
November	87	2	5	84
December	87	5	5	87
Mean	**87**	**3**	**5**	**85**

Appendix D: Dilution ratio for Nganmarriyanga WwTP

Treated wastewater is discharged iinto a nearby paddock via a gravity fed, ground level irrigation system. It is believed that the discharge pipework is operating continuously throughout the dry season. As a result, this area is inundated with water and is considered a freshwater swamp. During the dry season, disposal of the treated wastewater is contained within the PWC irrigation area.

During the wet season the Nganmarriyanga area receives increased, rainfall events, in which case if the ponds fill to capacity, wastewater leaves site via a concrete spillway from Pond 2 (PWC 2017). Under this circumstance, the ponds would also receive additional dilution from freshwater infiltration.

Using pond outflow and evapotranspiration rates, rainfall and irrigation area size, a calculation can be formulated to estimate net irrigation rates onto the receiving area. Volume of rainfall within this area during the wet season is greater than evapotranspiration rates. The area may also be prone to flooding (PWC 2017). The calculated dilution rate for the treated wastewater entering the environment during the wet season is tabulated in Table 8. For the purposes of estimating the maximum typical amount of treated wastewater discharged to the environment beyond the irrigation area, it is assumed that all treated wastewater entering leaving the ponds enters the environment during the wet season, plus any rainwater in addition to evapotranspiration losses. It is not possible to calculate the volume of water overflowing the spillway from Pond 2; it is assumed that additional outflow from rainwater dilution is included in the flow disposed of through the irrigation area.

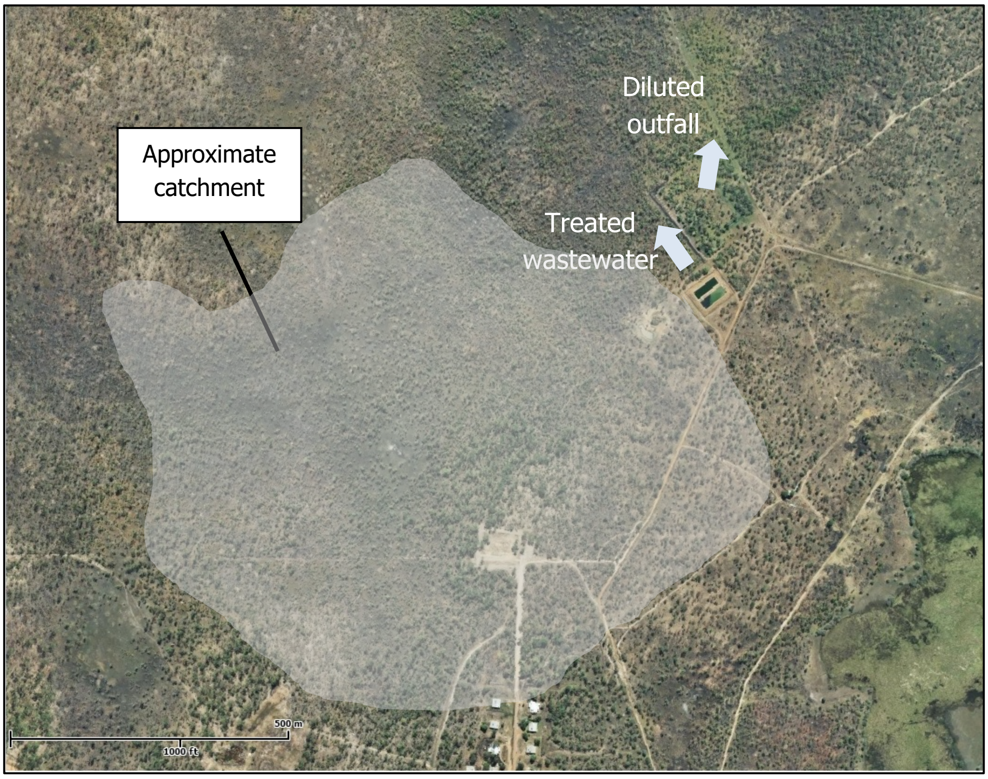

Figure 12. Catchment upstream of treated wastewater overflow point (Google Earth 2017)

Table 8. Discharge volume and dilution ratio calculation

Approx. catchment upstream of overflow point (m^2)	Disposal area (irrigated area) (m^2)	Mean rainfall (Dec-Mar) (mm/d)	Mean evaporation (Dec-Mar) (mm/d)	Mean treated wastewater outflow (Dec-Mar) (kL/d)
841,803	14,250	8.4	6.0	79[1]
Volume of rain fall capture in disposal area and upstream of overflow point (rainfall-evap) (kL/d)	2020			
Dilution ration at overflow point	1:26			

[1] See Appendix C for discharge volumes

Appendix E: Wastewater Quality Monitoring Results

Table 9: Summary of PWC wastewater quality results for Nganmarriyanga WwTP 2016-2021

Sample Location/Asset: SPA090 (Pond 2 Outlet)			
Indicator	**Reporting Value**		
	Average Wet Season	**Average Dry Season**	**MEAN**
Physio-chemical Parameters			
pH	7.51	7.76	7.65
Electrical Conductivity (uS/cm)	424	748	609
Dissolved Oxygen (% Saturation)	24	15	19
Turbidity (NTU)	61	100	83
Total Suspended Solids (mg/L)	62	85	75
Biological Parameters			
Biochemical Oxygen Demand (mg/L)	26.7	41.6	35.2
Chlorophyll-a (ug/L)	386	1,067	775
Nutrient Parameters			
Ammonia (Total[1] as N – NH3-N) (mg/L)	10.27	16.83	14.01
Total Nitrogen[2] (mg/L)	17.60	27.57	23.30
Oxidised Nitrogen (NOx)	0.05	0.12	0.09
Total Phosphorus (mg/L)	2.98	4.56	3.89
Pathogen Indicators			
			MEDIAN
Escherichia coli (E. coli/100mL)	41,060	65,405	41,060
Enterococci (Enterococci/100mL)	730	2,160	1,500

[1]Calculated as NH3-N Free

[2]Calculated NH3-N Organic + NH3-N Free + NOx

Appendix F: Additional Site Inspection Images

Figure 13. Nganmarriyanga WwTP Pond 1 (PWC 2017)

Figure 14. Nganmarriyanga WwTP Pond 2 (PWC 2017)

Figure 15. Pond 1 (PWC 2021)

Figure 16. Pond 2 (PWC 2021)