Environmental Risk Assessment

Gunbalanya Waste Stabilisation Ponds 2023

PowerWater

Document History

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Glossary

Abbreviation	Explanation
ANZECC	Australian Water Quality Guidelines for Fresh and Marine Waters
ARMCANZ	Agriculture and Resources Management Council of Australia and New Zealand
Assessment end-points	The explicit expressions of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes.
BOD	Biochemical oxygen demand
BUD	Beneficial Use Declaration – the uses of water specified in subsection 3 of the *Water Act* (1992)
BOM	Bureau of Meteorology
CSM	Conceptual site model
Cultural values	To provide water to meet aesthetic, recreational and cultural needs.
d	Day
DEPWS	Department of Environment, Parks and Water Security (NT)
DO	Dissolved oxygen
E. coli	*Escherichia coli*
Ebb tide	A falling tide - the phase of the tide between high water and the succeeding low water.
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.
Flood tide	A rising tide - the phase of the tide between low water and the next high tide.
GL	Gigalitre
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
WDL(s)	Waste discharge licence(s)
WSP(s)	Waste stabilisation pond(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 Gunbalanya Wastewater Treatment Plant (WwTP) to a nearby floodplain environment.

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

Risks to the assessment end-points, associated with the source, were assessed as having low to medium risk rankings. These rankings were associated with the low discharge volumes into a seasonally flooded freshwater environment, while higher risk rankings were associated with impacts to cultural values including human health risks through primary and secondary contact.

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 Gunbalanya (Oenpelli) WwTP pursuant to Waste Discharge Licence (WDL) 216-02 issued on 12 July 2021. This WDL allows for continuous discharge of secondary treated sewage effluent from an authorised discharge point to the nearby billabong, which during the wet season expands to form part of a broader ephemeral floodplain environment.

Gunbalanya is located approximately 302km east of Darwin (Figure 1), 60km northeast of Jabiru. Gunbalanya has an estimated population of 1,354 in 2023 (BushTel 2023). The Wastewater Treatment Plant (WwTP) is located approximately 600m west of the Gunbalanya Township (Figure 2).

Figure 1: Gunbalanya locality map (Google Earth 2017)

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

Background

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

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

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

Purpose of the Desktop ERA

- Identify assessment end-points;
- Characterise environmental risks associated with the facility; and
- Initiate an ongoing iterative environmental risk process associated with ongoing operation of the facility.
- Inform recommendations for management goals and the monitoring program
- Allow for identification and prioritisation of key knowledge gaps

Risk Assessment Methodology

The methodology employed has been adapted from ERAs completed by the PWC Water Quality team and the Victorian EPA *Guidelines for Risk Assessment of Wastewater Discharges to Waterways* ('the guidelines') (VIC EPA 2009). The guidelines utilise a framework (Figure 3) consistent with nationally and internationally accepted risk assessment frameworks by the Australian and New Zealand Environment and Conservation Council and Agriculture and Resources Management Council of Australia and New Zealand (2000).

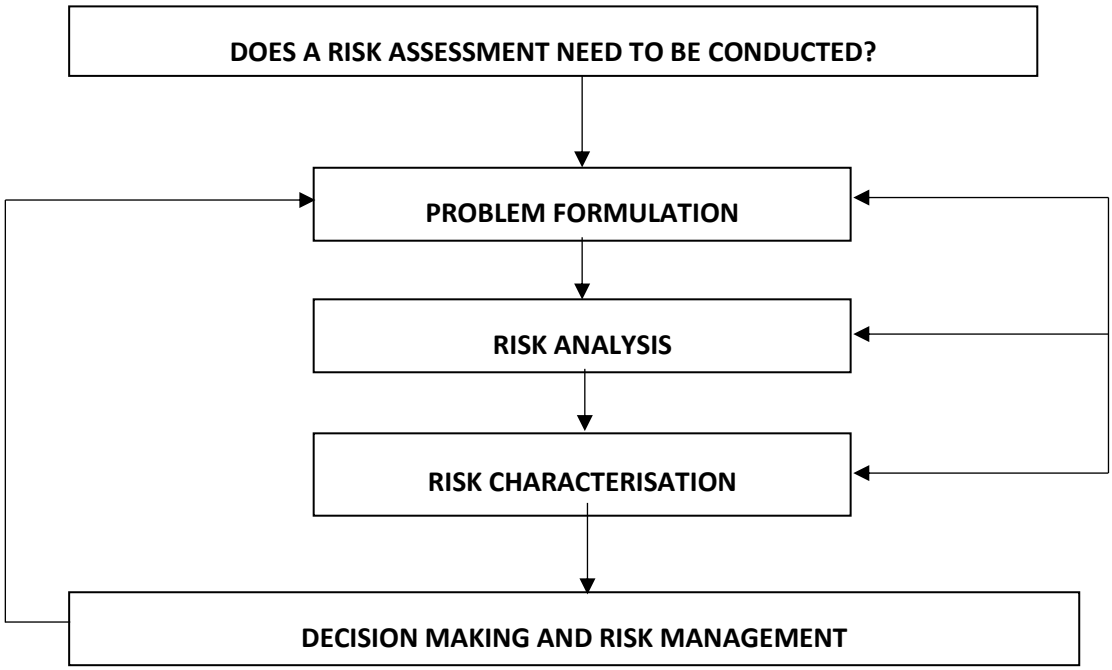

Figure 3: Risk assessment framework for wastewater discharges to waterways (Victoria EPA 2009)

Limitations

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

- limited availability of inflow/outflow data;
- remoteness of communities impacting on the ability to understand systems due to costs, logistics and available onsite 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 discharge licence 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.

Gunbalanya Wastewater Treatment Plant

The community utilises a pressure fed sewer reticulation system, which pumps raw sewage from the community to the WwTP (Figure 4 below). The Gunbalanya 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 1985 (PWC 2021a). The pond design consist of a primary facultative pond which gravity feeds into a secondary maturation pond. The treated effluent is then gravity fed into the tertiary polishing pond before being discharged into a nearby floodplain.

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 are physically removed. Desludging of remote community ponds is conducted periodically where required to remove accumulated solids and increase hydraulic performance, which may result in improved treatment performance. There are no records available for desludging works conducted at Gunbalanya; a sludge survey conducted in 2016 assessed sludge levels in the ponds to be below 30 percent, deeming desludging works unnecessary at that 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 216. Samples of the tertiary maturation pond outlet are currently collected on a monthly basis. Monitoring results are included in the *PWC Annual Monitoring Report – Remote Community Waste Discharge Licences,* a summary is provided in Appendix E, Table 9.

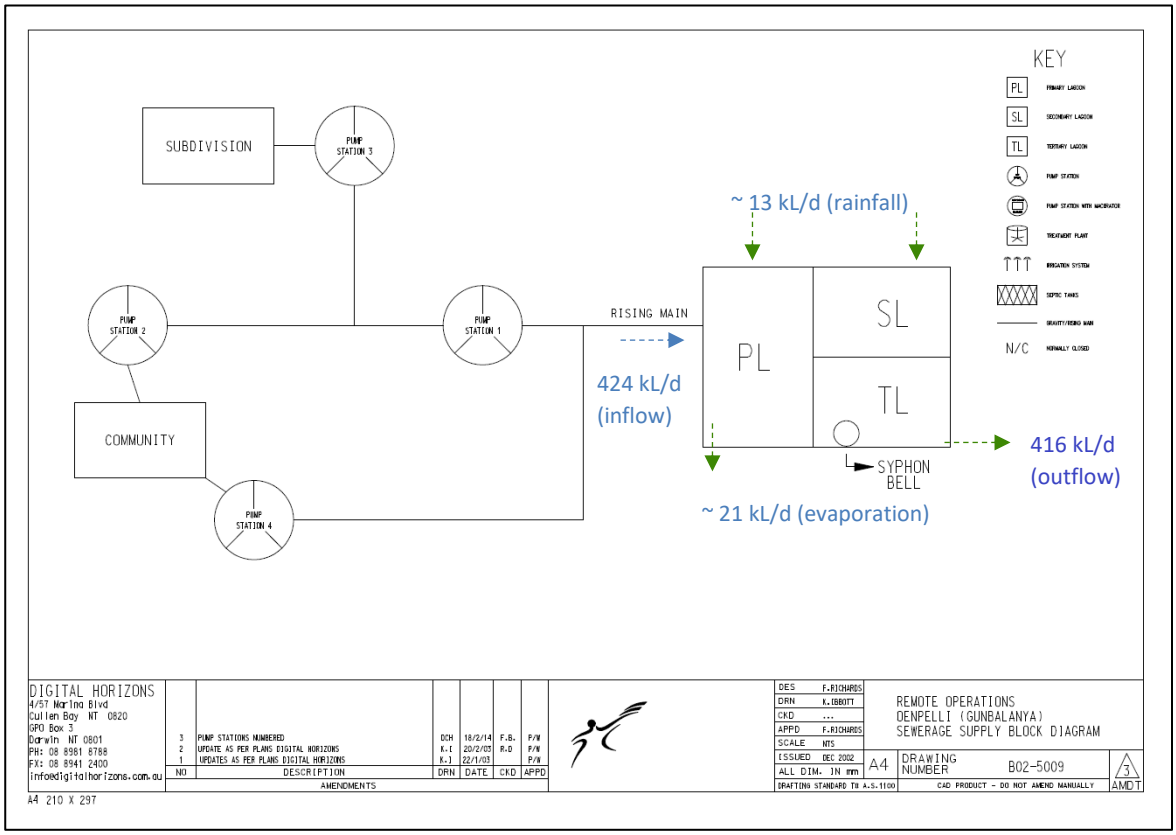

Figure 4: Layout of Gunbalanya wastewater stabilisation ponds, including modelled flow (blue) rates.

Discharge Regime

Discharge from the facility occurs from a gravity fed discharge pipe located in the final tertiary pond (Figure 2). Discharge is continuous on an as-required basis (discharge is all year round) and occurs daily into a nearby floodplain. The floodplain area is zoned as Aboriginal Land (DEPWS, 2021); and livestock have been observed within the discharge area. The discharge outfall from the tertiary maturation pond is approximately 700m in length, south-west of the ponds (Figure 2). The immediate receiving environment is fenced off near the WSP boundary to restrict public access.

The annual water balance is estimated based on measured outflow values from the outflow meter, rainfall, evaporation and pond area; inflows are estimated based upon these three parameters. It is estimated that the mean daily inflow of untreated wastewater into the WwTP is 424 kL/day. This is supplemented by an approximate rainfall contribution of 13 kL/d and reduction due to evaporation of 21 kL/d. The mean measured outflow is approximately 416 kL/day (Appendix C, Table 7).

Note that the volume of treated wastewater discharged to the environment varies seasonally with changes in variables such as evaporation and rainfall.

Pond Performance

WSPs offer a low input, cost effective form of wastewater treatment that is particularly applicable in higher temperature environments with sufficient available land area. While the inputs are low, because it is largely

driven by solar energy, the processes are no less complex and are largely controlled by the appropriate design and maintenance of the pond system to achieve the treatment performance required.

Wastewater monitoring at the Gunbalanya primary pond inlet commenced in August 2020. This data will provide a characterisation of the raw effluent entering the waste stabilisation pond system, and an indication of treatment performance. The dataset for Gunbalanya WSP inflow is currently very limited to date; additional monitoring is required to provide an accurate longer-term assessment and verify results.

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

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

- Biochemical Oxygen Demand (BOD): **17%**
- Free Ammonia (NH_3-N): **2%**
- Total Nitrogen (TN): **1%**
- Total Phosphorus (TP): -**5%**

The average log reduction for the pathogens indicator is:

- *E. coli:* **1.7** log reduction

Further monitoring data, statistical analysis and investigation is required to verify these results.

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

For the scope of this risk assessment, wastewater quality monitoring data at the final pond discharge point to the receiving environment are illustrated on the conceptual site model (CSM) (**Error! Reference source not found.**, Figure 11), and water quality table (**Error! Reference source not found.**, Table 9).

Receiving Environment

The seasonal floodplain that receives effluent discharge contains freshwater and extends approximately 3.2 km north-west along a broader seasonal floodplain during the wet season (seen in Figure 5). The floodplain generally flows in a north-westerly direction towards the East Alligator River, and eventually into the Timor Sea at the Van Diemen Gulf. The river is located approximately 10 km northeast from the far end of the floodplain, 13.2 km from the discharge point. Due to these distances to the East Alligator River any environmental impacts associated with the waste discharge point are thought to be limited to the immediate floodplain.

Figure 5: Floodplain region surrounding Gunbalanya WwTP (NTLIS 2021)

The treated effluent flows through the gravity outfall pipe to land, where it forms into the floodplain.

During the wet season, the area is subject to high rainfall and the surrounding floodplains are often inundated (PWC 2021b). Mapping contours show that the receiving floodplain has a low elevation of 5-6m above sea level, and further towards the river elevation is 6-7m, therefore it is estimated that any discharge from the WwTP can be mostly contained within the floodplain area (Google Earth, 2017).

Images below illustrate the receiving environment of the Gunbalanya WwTP.

Figure 7:Gunbalanya WwTP discharge point in 2017 (PWC 2017)

Figure 6: Recieving environment - billabong/ floodplains (PWC 2017)

Figure 8: Gunbalanya WwTP discharge point during the 2020-21 wet season (PWC 2021)

Figure 9: Recieving environment during the 2020-21 wet season (PWC 2021)

The immediate receiving environment is located within a Site of International Conservation Significance (NT Government 2021) (Appendix B, Figure 12). Gunbalanya is located nearby Kakadu National Park, listed as a UNESCO World Heritage place for environmental and cultural values. The Alligator floodplains are also proposed to be an internationally recognised *Important Bird Area* by Birds Australia (NT Government 2021). The receiving environment is considered pristine due to the minimal disturbance in the area (PWC 2010).

Vegetation within the immediate receiving environment is considered closed tussock grassland, mainly consisting of grasses and sedges, such as spike rush. Herbaceous swamp vegetation may appear in the area during periods of inundation. Pandanus (*spiralis)* and freshwater mangroves (*Barringtonia acutangula*) are also common.

The receiving environment contains 41 threatened 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 **Error! Reference source not found.**.

Table 1: Conservation status of species in the receiving environment on Gunbalanya WwTP

Common name	Species name	National Status (EPBC)	NT Status (TPWC)
Flora			
Zamia Palm	Cycas armstrongii	-	VU
Ectrosia	Ectrosia *blakei*	VU	-
Dienia montana	*Malaxis latifolia*	-	VU
Leaf Pondweed	*Monochoria hastate*	-	VU
Sauropus	*Sauropus filicinus*	VU	-
Fauna			

Australian Bustard	*Ardeotis australis*	-	VU
Emu	*Dromaius novaehollandiae*	-	VU
Gouldian Finch	*Erythrura gouldiae*	EN	EN
Masked Owl	*Tyto novaehollandiae*		
Partridge Pigeon	*Geophaps smithii*	VU	VU
Red Goshawk	*Erythrotriorchis radiates*	VU	VU
White-throated Grasswren	*Amytomis woodwardi*	-	VU
Yellow Chat	*Epthianura crocea tunneyi*	VU	EN
Arnhem Leaf-nosed Bat	*Hipposideros inornata*	-	VU
Arnhem Rock Rat	*Zyzomys maini*	VU	VU
Bare-rumped Sheath-tail Bat	*Saccolaimus saccolaimus*	CR	-
Brush-tailed Rabbit-rat	*Conilurus penicillatus*	-	VU
Northern Brush-tailed Phascogale	*Phascogale pirata*	-	VU
Northern Quoll	*Dasyurus hallucatus*	EN	CR
Arnhem Land Egernia	*Egernia obiri*	EN	EN
Merten's Water Monitor	*Varanus mertensi*	-	VU
Oenpelli Python	*Morelia oenpelliensis*	-	VU
Yellow-snouted Gecko	*Diplodactylus occultus*	EN	VU
Mitchell's Water Monitor	*Varanus mitchelli*	VU	-
Yellow-spotted Monitor	*Varanus panoptes*	-	VU
Plains Death Adder	*Acanthophis hawkei*	VU	VU
Greater Sand Plover	*Charadrius leschenaultii*	VU	VU
Curlew Sandpiper	*Calidris ferruginea*	VU	-
Nabarlek	*Petrogale concinna*	VU	EN
Ghost Bat	*Macroderma gigas*	-	VU
Black-footed Tree-rat	*Mesembriomys gouldii*	VU	EN

Pale Field-rat	*Rattus tunneyi*	VU	-
Flatback Turtle*	*Natator depressus*	VU	-
Green Turtle*	*Chelonia mydas*	VU	LC
Loggerhead Turtle*	*Caretta caretta*	EN	EN
Olive Ridley	*Lepidochelys olivacea*	EN	-
Dwarf Sawfish	*Pristis clavata*	-	VU
Freshwater Sawfish*	*Pristis microdon*	VU	VU
Northern River Shark*	*Glyphis sp. C*	EN	EN
Speartooth Shark*	*Glyphis sp. A*	CR	VU

CR – Critically Endangered, EN – Endangered, VU – Vulnerable

***Some marine species may not exist in the immediate receiving freshwater environment**

Screening Level Risk Assessment

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

Risk hypotheses for the stressors identified in the conceptual site model (CSM) (Appendix A, Figure 11: Conceptual site model for key processes that may impact beneficial uses in Alligator River region floodplain from Gunbalanya WwTP) are defined with respect to their potential effects on the identified values of the receiving environment.

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

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

Values	Receptors	
Cultural **(Recreational Water Quality)**	Humans	Fishing Hunting Food gathering
Cultural **(Aesthetics)**	Humans	Visible water quality Sacred sites
Environment **(Aquatic Ecosystem Protection)**	Aquatic	Fish Turtles

		Macro-invertebrates
	Terrestrial	Wading birds Invertebrates (water insects) Mammals Reptiles
	Plants	Native vegetation

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

Indicator (water quality parameter)	Stressor (change to indicator)	Risk Hypothesis[1]		Assessment end-points[1]		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 by assessing evidence of anoxic conditions such as fish kills and nutrient fluxes.	To maintain oxygen levels in the environment sufficient to prevent production of odours.	The median concentration of BOD in the discharge of Gunbalanya WwTP is 31.5 mg/L. As BOD is present in the discharge, it is determined at a screening level that a risk is present and further investigation is necessary.	Yes
Nutrients (nitrogen and phosphorus)	Increase in nutrient concentrations	That nutrients are leading to nuisance plant growth (e.g. phytoplankton blooms) resulting in oxygen depletion; displacement of endemic species; diminished light availability; release of toxins; and changes to ecosystem structure.	That nutrients are resulting in the reduction of amenity of receiving environment through reduction in water clarity, objectionable discolouration and odours; toxic blooms that are a public health risk; and blooms of toxin producing species whereby the toxins bio-accumulate in shellfish and fish ingested by humans.	To maintain nutrient levels so that the levels of primary production do not have an adverse impact on ecosystem structure.	To maintain the amenity of the environment.	The median concentration of nutrients in the discharge of Gunbalanya WwTP is 27.05 mg/L total nitrogen and 3.45 mg/L total phosphorus. 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 Gunbalanya WwTP is 15.7 mg/L. At a screening level it is determined that a risk is present and further investigation is necessary.	Yes
Pathogens	Presence of *E.coli*		That pathogens are leading to the contamination of water resulting in primary and secondary contact recreation a public health risk; and accumulation in shellfish resulting in the consumption of shellfish a public health risk.		To maintain that pathogens from municipal wastewater are not increasing the risk of illness via primary and secondary contact recreation and consumption of shellfish.	The median pathogen concentration in the discharge of Gunbalanya WwTP is 12,360 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 Table 4and 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 10.

Low to medium risks can typically be managed by routine procedures and 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 10: Corporate Risk Matrix

Table 6: Risk assessment for key environmental and cultural assessment end-points associated with Gunbalanya 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 is 1:39 (Appendix D), suggesting any observed oxygen demand would be absorbed by the environment.	Minor	Based on sampling data to date, Gunbalanya WwTP BOD discharge water quality is 31.5 mg/L. These BOD concentrations are relatively consistent in comparison to concentrations at other remote communities, these values are considered low (<40mg/L) (PWC 2022). Stressor not typically observed with such small discharge volumes and dilution experienced in receiving waters. During the Dry Season, it is assumed the treated effluent generally infiltrates into soil within discharge area, or forms a swamp within the low-lying floodplain, impacting the localised grassed area only (PWC 2021b). During the Wet Season, the floodplain would become inundated with water, providing significant dilution. The Gunbalanya WPSs have a BOD removal rate of 17%. 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. No fish kills have been observed or reported to date.	Minor	Gunbalanya WwTP free ammonia discharge quality is 16 mg/L. These ammonia concentrations are elevated 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 7.41 at Gunbalanya suggests the risk of ammonia toxicity to be lowered. The stressor is not typically observed with such small discharge volumes and dilution experienced in receiving waters. As during the Dry Season, the discharge generally stays localised within the discharge area, and the discharge area is inundated during the wet season. 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.	The discharge area is a shallow floodplain vegetated with native grasses and small trees, this may influence a reduction of nutrients through transpiration and uptake of nutrients from the discharge. **No eutrophication or algal blooms have been observed within the receiving environment, which is an indicator of excessive nutrient loads.**	Minor	Total nitrogen and total phosphorus levels are 27.1 mg/L and 3.6mg/L; concentrations are slightly similar in comparison to concentrations at other remote communities; concentrations are considered to be classified as low effluent strength (<50mg/L;<10mg/L) (PWC 2022). Based on the type of receiving environment, discharge volume and mixing rates during Wet Season flows, PWC considers that the likelihood of increased nuisance plant growth in the receiving environment is unlikely.	Unlikely	Low
Cultural					
BOD is leading to odours resulting in the **reduction of amenity** in the receiving environment.	Access to the floodplain is primarily by foot, and is limited due to PWC fencing on the developed boundaries. Minimal cultural beneficial uses within the receiving environment have been identified or observed.	Minor	Stressor not typically observed with such small discharge volumes. No evidence of odours during monitoring of discharge location at final pond (PWC 2021b; PWC 2017). Local knowledge confirms this area is probably unlikely to be used by community members as a large lake/wetland within the town is a more popular location for recreational purposes, and provides access to deeper water all year round (PWC 2017). No community members have been seen utilising the floodplain area. 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**.	Access to the floodplain is primarily by foot, and is limited due to PWC fencing on the developed boundaries. Minimal cultural beneficial uses within the receiving environment have been identified or observed.	Minor	Reduction in amenity is difficult to assess as discharge may occur to ground or into grasses present on the floodplain. Reduction in water clarity, objectionable discolouration of receiving water or odours affecting cultural uses of the area would be unlikely, given the location of the discharge point (floodplain, swamp area), and filtration of plants. This area is also fenced off to the public, and is believed to be private property. PWC considers the likelihood of reduction in amenity from nutrients is unlikely.	Unlikely	Low
Nutrients are resulting in **toxic blooms** that are a public health risk; and **blooms of toxin producing species** whereby the toxins bio-accumulate in shellfish and fish ingested by humans.	Minimal cultural beneficial uses of the receiving environment were observed for primary and secondary recreation including exposure through exploratory wading, fishing and collecting food, fibres of medicines. There is currently limited available data/evidence to indicate toxic algal blooms occuring in the area during the wet season.	Minor	Aquatic foods would most likely be sourced from the billabong located closer to the community (PWC 2017). From observations it is assumed toxic blooms would unlikely occur within the floodplain as ground grasses within the dry season may consume excess nutrients, substantial freshwater inundation occurs during the wet season and may stir up receiving waters (PWC 2017). Based on the minimal primary and secondary contact recreation and cultural uses of the floodplain, PWC considers that the likelihood of toxicant exposure is unlikely.	Unlikely	Low
Pathogens are leading to the **contamination of water** resulting in a public health risk through primary and secondary contact recreation.	Minimal cultural beneficial uses of the receiving environment have been observed for primary and secondary recreation. Floodplains during the wet season are not considered recreational water bodies due to the presence of dangerous aquatic animals (Campbell 2012).	Moderate	Local knowledge confirms this area is probably unlikely to be used by community members as a large lake/wetland within the town is a more popular location for recreational purposes, and provides access to deeper water all year round (PWC 2017). Based on the minimal secondary contact recreation and cultural uses of the floodplain area, PWC considers that the likelihood of the illness from pathogen exposure unlikely.	Unlikely	Medium

Summary and Recommendations

The ERA found that the identified values of the nearby floodplain at risk from the Gunbalanya WwTP discharge are 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 Gunbalanya WwTP poses a low to medium risk to the identified values of the receiving floodplain. The influence of the discharge on the receiving environment is considered sustainable given the low discharge volumes and increased dilution of contaminants that occur and stay within the boundaries of the surrounding floodplain during the Wet Season. Based on this ERA, wastewater quality monitoring data and visual observations there is limited evidence to suggest deleterious impacts to the receiving environment.

All risk rankings have 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;
- improve datasets 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.

References

BushTel (2023), BushTel – Gunbalanya Profile, viewed 18/04/2023, <https://bushtel.nt.gov.au/profile/329>

Campbell, A. (2012). Sources and pathways of bacteria affecting water quality on Darwin harbour beaches and waterways. Darwin Harbour Beach Water Quality Taskforce Final Report. Northern Territory Government, Darwin.

Department of Environment, Parks and Water Security. (DEPWS). (2021). NRM Maps. Viewed 09/03/2021. https://nrmaps.nt.gov.au/nrmaps.html

EPA Victoria. (2009). Guidelines for Risk Assessment of Wastewater Discharges to Waterways, Publication Number 1287, Environment Protection Authority, Melbourne.

Google Earth 7.1. (2017). Gunbalanya 1219'41.12"S, 13302'05.39"E, elevation 7m. Primary data layer, viewed 1 June 2017 <http://www.google.com/earth/index.html>.

Louey-Gung, J. (2011). Remote Operations Waste Stabilisation Pond Performance Evaluation Modelling. (D2011/73466). Power and Water Corporation, Darwin.

Northern Territory (NT) Government. (2021). Map of sites of conservation significance. Viewed 6 March 2021. <https://nt.gov.au/environment/environment-data-maps/important-biodiversity-conservation-sites/map-sites-conservation-significance>.

PWC (2022), WDL Monitoring Report for Remote Communities (D2022/99769), Power and Water Corporation, Darwin

PWC. (2021a). Sewage Treatment Summary. (D2018/352304). Power and Water Corporation, Darwin.

PWC. (2021b). Discussions held with local Gunbalanya Essential Services Operator (ESO), Peter Hussie, 16th March, 2021.

PWC. (2009). Risk Management Foundation Document – Risk Management Guidelines. (QDOC2009/191). Power and Water Corporation, Darwin.

PWC. (2010). PWC Sewer Pond Discharge Assessment. (D2010/49573). Power and Water Corporation, Darwin.

PWC. (2015a). Desktop environmental risk assessment for the discharge of treated effluent from the Berrimah wastewater treatment plant to Bleesers Creek. (D2013/331809). Power and Water Corporation, Darwin.

PWC. (2015b). Desktop environmental risk assessment for the discharge of treated effluent from the Palmerston wastewater treatment plant to Myrmidon Creek. (D2013/476393). Power and Water Corporation, Darwin.

PWC. (2015c). ET Table Northern Communities. (D2015/490320). Power and Water Corporation, Darwin.

Appendix A: Gunbalanya Conceptual Site Model

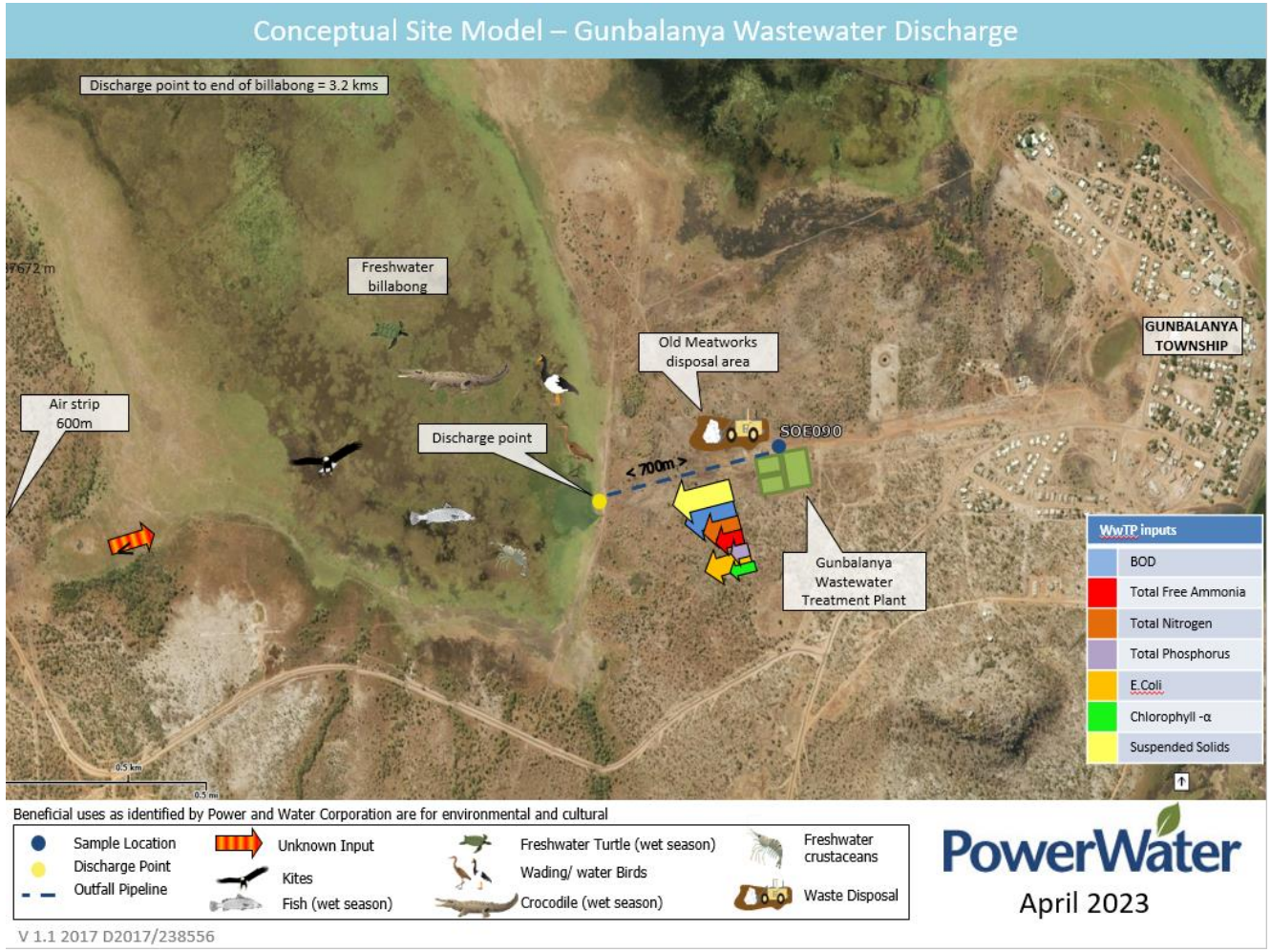

Figure 11: Conceptual site model for key processes that may impact beneficial uses in Alligator River region floodplain from Gunbalanya WwTP

Appendix B: Alligator Rivers Coastal Floodplains – Site of Conservation Significance

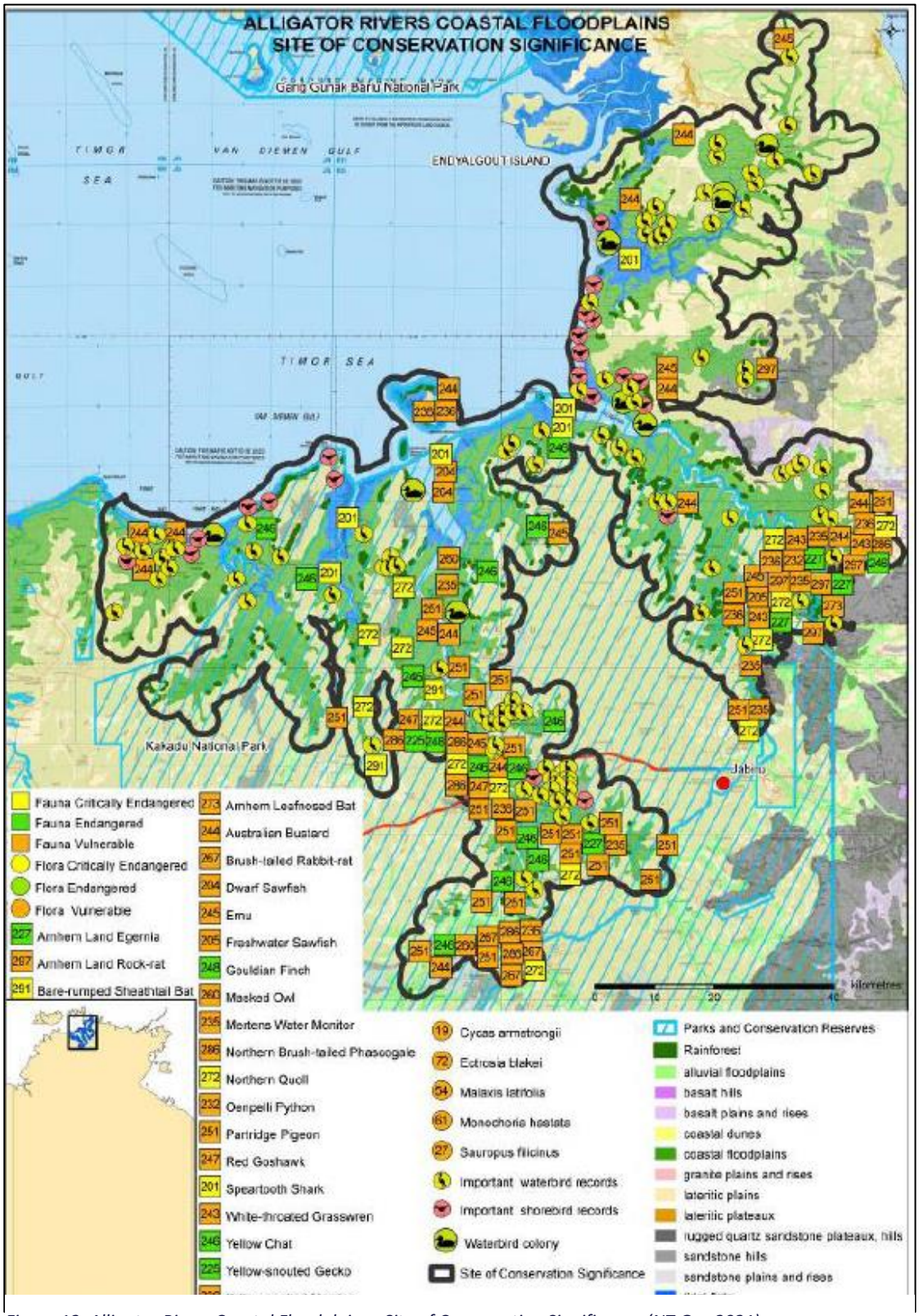

Figure 12: Alligator Rivers Coastal Floodplains - Site of Conservation Significance (NT Gov 2021)

Appendix C: Estimated Flow Rates for Gunbalanya WwTP

In previous assessments, ICEG numbers were used to estimate inflows and, since flowmeter data is available for the previous 12 months, an estimated inflow can be calculated by using the measured outflow adding estimated evaporation and taking away measured rainfall.

Rainfall catchment estimates based on mean monthly rainfall for all available years from Bureau of Meteorology (BOM) and total pond surface area (2,933 m^2) (PWC 2021a). Rainfall data was obtained using the Gunbalanya (Oenpelli) Airport weather station (station number 14310) located 3.4 km away.

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

For the purposes of this assessment evaporation has been assumed to be uniform over the year

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

Table 7: Estimated average annual flows

Month	Inflow kL/d	Rainfall kL/d	Evaporation kL/d	Total outflow kL/d
January	548	31	21	558
February	667	38	21	684
March	622	16	21	617
April	515	6	21	500
May	397	0	21	376
June	320	0	21	299
July	385	0	21	364
August	262	0	21	241
September	267	9	21	297
October	348	3	21	330
November	382	15	21	376
December	361	34	21	374
Mean	**424**	**13**	**21**	**416**

Appendix D: Dilution Ratio for Gunbalanya WwTP

Gunbalanya WwTP discharges to a nearby shallow floodplain and broader floodplain area. Under conditions of low or no rainfall the outflow is contained in the locality of the outfall floodplain, and absorbed largely through evapotranspiration, while under conditions of modest rainfall the outflow is transported and retained further along the northern end of the floodplain. Estimations of the approximate catchment size and distance of flow are given, due to lack of access to the area and large volumes of water present within the Wet Season.

Under the scenario where treated wastewater overflows offsite, significant dilution and augmentation of the flow by rainfall is expected. Dilution of the treated wastewater would occur both in the disposal area, and due to mixing with rainwater captured in the catchment upstream of the disposal area overflow point. The catchment upstream of the overflow point and the path of diluted outflow is identified in Figure 10. 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.

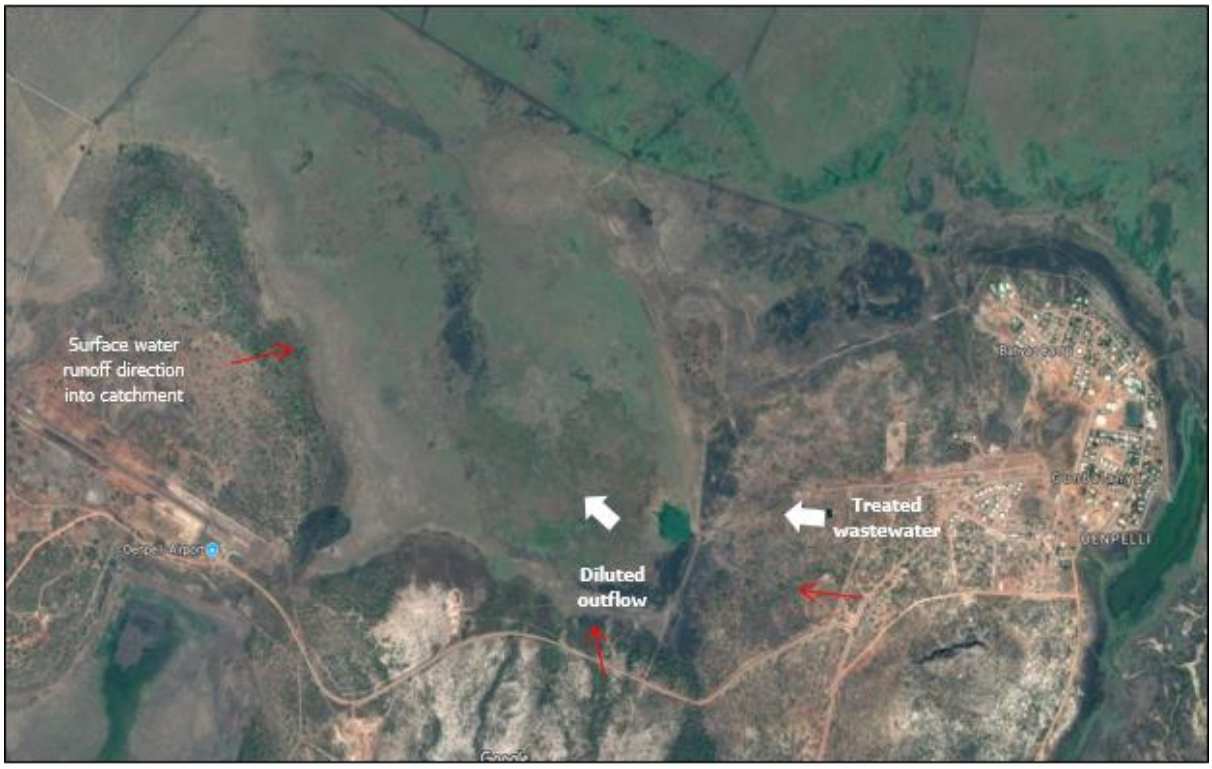

Figure 13: Catchment for Gunbalanya WwTP (Google Earth 2017)

Table 8: Discharge volume and dilution ratio calculation

Approx. area of floodplain downstream from discharge point (m^2)	Mean rainfall (Dec-Mar) (mm/d)	Mean evaporation (Dec-Mar) (mm/d)	Mean treated wastewater outflow (kL/d)
4,325,790	10.4	7.0	555 [1]
Volume of rain fall capture downstream of wetland (rainfall-evap) (kL/d)	14,707		
Dilution ration prior to entering environment	1:27		

[1]See Appendix C for discharge volume calculations

Appendix E: Wastewater Quality Monitoring Results

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

Sample Location/Asset: SOE090 (Pond 3 Outlet)			
Indicator	**Reporting Value**		
	Median Wet Season	**Median Dry Season**	**Median**
Physio-chemical Parameters			
pH	7.16	7.38	7.32
Electrical Conductivity (uS/cm)	290	360	345
Dissolved Oxygen (% Saturation)	5	5	5
Turbidity (NTU)	43	80	54.5
Total Suspended Solids (mg/L)	47	73	65
Biological Parameters			
Biochemical Oxygen Demand (mg/L)	30	42	31.5
Chlorophyll-a (ug/L)	586	943	720.5
Nutrient Parameters			
Ammonia (Total[1] as N – NH3-N) (mg/L)	14	18	16
Total Nitrogen[2] (mg/L)	17.65	29.55	27.05
Oxidised Nitrogen (NOx) (mg/L)	0.05	0.05	0.05
Total Phosphorus (mg/L)	3.33	3.8	3.6
Pathogen Indicators			
Escherichia coli (E. coli/100mL)	24,197	9,090	12,360
Enterococci (Enterococci/100mL)	19,560	18,600	19,560

[1]Calculated as NH3-N Free

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

Appendix F: Additional Site Inspection Images

Figure 14: Gunbalanya Pond 1 - March 2021

Figure 15: Gunbalanya Pond 3 inlet - March 2021

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