MONITORING REPORT 2022-2023

Remote Community Waste Discharge Licences Waste Stabilisation Ponds

PowerWater

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Table 1. Document History

Glossary

Abbreviation	Definition
ANZECC	Australian and New Zealand Environment and Conservation Council
BOD	Biochemical oxygen demand
cfu	Colony forming units (expressed per unit of a specified volume of sample)
Chl-a	Chlorophyll-a, a photosynthetic pigment present in plants, algae and cyanobacteria that is used in oxygenic photosynthesis. It can be used as a measure of algal biomass and subsequently primary production
DEPWS	Department of Environment, Parks and Water Security
DHWQO(s)	Darwin Harbour water quality objective(s)
DO	Dissolved oxygen
EC	Electrical conductivity
E. coli	*Escherichia coli*
EP	Equivalent population
ET	Equivalent tenement - calculation utilised in remote communities for an average residential dwelling or house (Indigenous Community Engineering Guidelines 2017)
ERA	Environmental risk assessment
FRP	Filterable reactive phosphorous (orthophosphate)
kL	Kilolitres
LOR	Limit of reporting for chemical analysis
µg	Micrograms
mg	Milligrams
ML	Mega litres
N	Nitrogen
NH_3-N	Total ammonia as N (NH_3 and $NH4^+$ as N) as per ANZECC and ARMCANZ (2000)
NO_X-N	Oxidised nitrogen as N – the sum of nitrate and nitrite

Abbreviation	Definition
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NTU	National turbidity units
PWC	Power and Water Corporation
RL(s)	Reporting Limit(s)
RM	Rolling Median – of all years of available data; utilised in absence of adequate datasets.
SSTV	Site Specific Trigger Values
TN	Total nitrogen
TP	Total phosphorous
TSS	Total suspended solids
WDL(s)	Waste discharge licence(s)
WSP(s)	Waste stabilisation pond(s)

Table 2. Glossary

Executive Summary

Power and Water Corporation has developed this Monitoring Report to fulfil the requirements stipulated in its remote Indigenous community Waste Discharge Licence conditions. The report presents a trend analysis and comparative assessment of treated effluent monitoring results from all licensed remote communities to enhance understanding of potential environmental impacts arising from the licensed activity. It highlights that the monitoring conducted aligns with the specified licence conditions, ensuring compliance with regulatory standards.

The report examines the discharge volumes from licensed remote Indigenous community Wastewater Stabilization Ponds (WSPs) and correlates them with the low Equivalent Populations (EP) or equivalent tenements in these communities. EP represents an estimation of the number of individuals that a wastewater treatment facility serves, considering factors such as household size, water usage, and wastewater generation rates. In remote Indigenous communities, the population sizes are typically smaller compared to urban areas, resulting in lower EPs associated with these communities. As a result, the design and capacity of WSPs are tailored to accommodate the specific population size, contributing to the observed low discharge volumes. This approach ensures effective treatment while preserving the ecological integrity of the receiving environment.

Power and Water regularly monitor physical-chemical parameters at remote WSP outlets, including pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), turbidity, and Total Suspended Solids (TSS). The report highlights the significance of accurately measuring DO (% Sat.) levels in-situ to avoid compromising its accuracy when samples are cooled or transported to a laboratory for analysis. Low median DO concentrations in the discharged effluent can have adverse effects on aquatic organisms, emphasizing the need for precise measurements to assess the impact correctly.

The report provides an in-depth analysis of various water quality parameters in remote sewage pond monitoring, focusing on pH levels, TSS, chlorophyll-a, BOD, ammonia, NOx, TN, FRP, Enterococci, and E. coli levels. It underscores the importance of maintaining the recommended pH range (6.5 to 8.5 units) to optimize biological processes for breaking down organic matter and removing contaminants. It also acknowledges that site-specific factors should be considered when determining the ideal pH range for each sewage pond system.

Regarding TSS, the report identifies fluctuations in concentrations at different monitoring sites, attributed to sediment mobilization from outside the pond system and weather-induced disturbances. Chlorophyll-a levels are recognized as valuable indicators for assessing environmental impacts,.

The report acknowledges BOD as a crucial indicator for evaluating environmental and public health impacts related to effluent discharge. It discusses both decreasing and increasing trends in BOD levels at different sites, influenced by various factors such as location conditions and treatment processes.

Ammonia levels are emphasized as significant pollutants with detrimental effects on aquatic organisms, necessitating effective control measures in effluent discharge to preserve water quality. The role of dilution rates and natural vegetation in mitigating ammonia effects is highlighted.

Fluctuations in NOx and TN levels are linked to effluent characteristics, treatment processes, environmental conditions, and monitoring frequency. The report stresses the importance of ongoing monitoring to assess potential environmental impacts accurately.

For nutrient enrichment and eutrophication, TN and FRP levels are discussed, emphasizing the importance of reducing inputs into receiving waters to mitigate algal blooms and oxygen depletion.

The presence of Enterococci in sewage pond effluent is highlighted as indicators of fecal contamination, with both decreasing and increasing trends observed at different sites. Continuous monitoring and diligent wastewater treatment practices are recommended to protect water quality and public health.

Overall, the report stresses the importance of continuous monitoring, collaboration, and best management practices to optimize sewage pond operations, minimize environmental impacts, and ensure the long-term health and sustainability of water resources in remote areas. It underscores the significance of understanding water quality dynamics and their interrelationships to implement appropriate measures for treatment efficiency and environmental protection.

Regarding the specific Belyuen - Woods Inlet monitoring point, the report indicates that pH levels consistently remain within the Site Specific Trigger Values (SSTV) specified in the Water Discharge License (WDL) throughout the 2022-2023 period. TSS levels show a correlation with rainfall events and occasional tidal movement but do not suggest significant effluent impact on the receiving environment. Ammonia levels are generally low, with occasional values outside the guideline that may not be attributed to WSP discharge. TN levels exhibit a decreasing trend, with isolated instances of values outside the guideline during periods of no effluent discharge. FRP levels show a decreasing trend, and total phosphorus levels remain below the SSTV, with occasional above trigger values attributed to weather conditions. E. coli levels in Woods Inlet during the wet season show a decreasing trend compared to previous years, but external sources contribute to fluctuations. Enterococci levels remain within the SSTV, with fluctuations linked to weather conditions and tidal movement. Continuous monitoring and optimization efforts are crucial to ensure compliance and protect the receiving environment.

In summary, the Monitoring Report offers a comprehensive overview of sewage pond monitoring in remote Indigenous communities, emphasizing the importance of precise monitoring, compliance with license conditions, and appropriate management practices to safeguard water quality and ecological health.

Regulatory Requirements

Power and Water Corporation (Power and Water) is responsible for the operation of 57 Waste Stabilisation Ponds (WSPs) throughout the Northern Territory (NT). According to the Water Act 1992 (NT), it is strictly prohibited to cause direct or indirect contact between waste and water, or to pollute water resulting in environmental harm, unless specifically authorized to do so. Waste Discharge Licences (WDLs) are regulatory instruments granted under Section 74 of the Water Act 1992 (NT). These licenses authorize Power and Water Corporation to operate WSPs that discharge secondary treated sewage effluent continuously into a designated waterway. Currently, Power and Water holds WDLs for 22 remote Indigenous communities, and there are 2 communities awaiting approval for WDL surrender.

The submission of this report fulfils Power and Water's requirement to provide a Monitoring Report under condition of the WDLs. A list of all current NT remote Indigenous community WDLs this report refers to is included within Appendix A – List of Remote Community WDLs. A single report is to be submitted annually for all of the remote WDLs.

Condition of the WDLs specifies that the Monitoring Report:

- Is prepared in accordance with the requirements of the Administrating Agency 'Guideline for Reporting on Environmental Monitoring'
- Includes a tabulation of all monitoring data required as a condition of this Licence
- Includes long term trend analysis of monitoring data to demonstrate any environmental impact associated with the activity over a minimum period of three years (where the data is available);
- Includes an assessment of environmental impact from the activity.

The main purpose of this report is to present the initial findings from treated effluent monitoring conducted at remote communities, which will be utilised to inform environmental risk assessments in the future.

Monitoring Report Requirements

Provision
This Monitoring Report has been prepared in accordance with the NT EPA 'Guideline for Reporting on environmental Monitoring' (Version 1.0) where practicable and applicable. Some information has been omitted where data may not exist.
A tabulated summary of all monitoring data for remote community WDLs is completed and provided as Appendices B. Also Attachment A – Remote Community WDL Summary Data - 2020 to 2023.
Trend analysis and interpretation of the results is provided in Section 5 - Monitoring Results. Monitoring data included in this report covers a period of 3 years of data where available.

An assessment of environmental impacts from the activity is included in Section 6. Further specific information is available in individual Environmental Risk Assessments for each community.
Review of surface water results and exceedances of trigger values at Belyuen WwTP is included in Section 5.6 - **Error! Reference source not found.**
A record is to be kept of all exceedances of trigger values specified in Schedule 2 at the Belyuen WwTP is included in Attachment A.

Table 3. Monitoring Report Requirements

Background and Objective

The routine wastewater monitoring program for remote communities commenced in 2015 at selected sites and is currently completed at 24 remote facilities in line with WDL requirements. Upon approval, 2 remote facilities (Manthathpe and Nganmarriyanga) will be removed from the reporting requirements however discharge monitoring will continue as per Power and Water's Water & Wastewater Monitoring Plan.

The WSPs offer a low input, cost effective form of wastewater treatment that is particularly applicable in higher temperature environments with sufficient available land area. Being low maintenance and driven by solar energy, WSPs are suitable option for remote Indigenous communities spread across the NT.

WDLs have been issued by Department of Environment, Parks and Water Security (DEPWS) at remote Indigenous communities based on sites that discharge to a waterway utilising a risk ranked approach across all 24 communities:

- Round 1 licences: 8 highest risk sites due to higher discharge volumes (based on Equivalent Population (EP)), continuous discharge and type of receiving environment.
- Round 2 licences: 10 medium risk sites, lower discharge volumes, continuous or intermittent discharge.
- Round 3 licences:6 low risk sites, lower discharge volumes, intermittent or seasonal discharge
- All remaining remote community WSPs operate without a WDL in place as the majority of these do not discharge to waterways – irrigation to land or evaporation occurs. Fifteen communities rely on on-site wastewater treatment systems managed privately or as part of the public housing portfolio.

Wastewater monitoring frequency at remote sites is determined based on license issue dates and monitoring requirements. The details of wastewater monitoring conducted in these communities are documented in Power and Water's internal Wastewater and Reclaimed Water Quality Monitoring Plan for 2022-23. An external contractor is responsible for monitoring the Woods Inlet receiving environment at Belyuen, specifically targeting neap ebb tides to capture near-worst-case scenarios with low tidal range, minimal dilution, and flushing. It is important to consider that logistical and laboratory constraints may also influence monitoring or sample collection times, so the preferred tidal conditions may not always be feasible.

The main objectives of the remote wastewater monitoring program are to:

- Ensure compliance with regulatory requirements;
- Minimise environmental and public health risks associated with sewage; and
- Understand operational performance to inform asset maintenance and improvements.

The data sets utilised for this report vary depending on the community and typically covers the period from June 2020 to May 2023. Frequency of wastewater monitoring at the discharge points vary between communities depending on specified licence conditions at the time and any investigative monitoring conducted. Monitoring at remote sites has progressively increased over time from 6-monthly to quarterly at most communities during the 2019-20 period, with monitoring increased to monthly at selected sites to increase datasets and meet changes to updated licences over time.

Samples were collected from the designated sampling locations at the appropriate frequency as specified. The discharge points for each community are clearly outlined in the respective WDLs. In compliance with Condition of Belyuen WDL215, signage was installed and regularly maintained at all land-based monitoring points, ensuring easy identification of the selected locations at all times. Furthermore, all samples were collected and preserved according to the specified requirements for each water quality parameter, and their analysis was carried out at laboratories accredited by the National Association of Testing Authorities (NATA).

Rainfall recorded within the reporting period varies between regions, records from Darwin, Katherine, Maningrida and Wagait Beach weather stations have been utilised as a general reference in Table 2 below. The 2023 total rainfall was from January 2023 to May 2023 BOM rainfall data.

Region	Weather Station Number	Average annual rainfall per year (mm)						Annual Average
		2018	2019	2020	2021	2022	2023	All years
Darwin	14163	1,654	957	1,795	1,658	1,981	1,010	1,509
Katherine	14902	787	659	849	1,008	602	755	777
Maningrida	14405	1,323	743	1,391	1,558	1028	705	1,125
Wagait	14238	1636	903	2292	1782	1785	974	1562

Table 4. Annual Average Rainfall Data (BOM, 2023)

Assessment Protocols and Limitations

Limitations and considerations associated with the assessment and interpretation of the monitoring data in the report. These limitations affect the statistical analysis and presentation of the results. Here are the key points of the Assessment Protocols and Limitations:

1. Climate sensitivity of sewage pond treatment: refers to how the system's performance is influenced by weather and climate variations, affecting treatment efficiency. Temperature, evaporation, precipitation, and changes in influent composition are key factors that can impact the ponds' effectiveness. Furthermore, climate sensitivity can significantly influence water quality monitoring results. Fluctuations in temperature can affect dissolved substances and biological processes in water bodies. Heavy rainfall and drought can respectively lead to increased runoff and concentration of pollutants. Variations in streamflow can affect the residence time of pollutants. Climate-related factors also contribute to eutrophication and alter salinity in coastal areas. Moreover, extreme

events like storm surges and flooding can introduce pollutants into water bodies, further affecting water quality.

2. Effluent Quality and Water Quality Guidelines: The effluent quality results obtained from monitoring at the final pond outlet provide a representation of the discharged effluent. It is acknowledged that without mixing and dilution in the receiving environment, effluent quality may not meet relevant water quality guideline values for environmental waters.
3. Comparative Analysis: The Berrimah WDL WSPs 2022 Monitoring Report (data period of 2020-2022) was used for comparative purposes to review the wastewater quality data of remote facilities against an urban facility. This comparison provides some context for understanding possible environmental impacts in the absence of sufficient data from remote sites. Darwin Harbour Water Quality Objectives (DHWQO) were utilized where applicable for surface water monitoring results. Selected wastewater references widely acknowledged by wastewater specialists in Australia (Water Futures 2020) were also used.
4. Limitations in Data Assessment: The assessment of the data is affected by limitations such as limited availability of flow data to determine discharge loads, limited monitoring data availability at some sites, small sample sizes, and inconsistencies in monitoring frequencies between communities. These limitations reduce confidence in the data statistics and the ability to establish long-term trends.
5. Logistics of Data Collection: Transportation logistics, including bad weather conditions, access to remote sites, aircraft breakdowns, communication faults, community unrest, and the capacity to conduct sampling, can impact the collection of wastewater samples in remote Indigenous communities. Power and Water make efforts to collect samples as per the license requirements and monitoring schedule, but delays can occur due to these logistical challenges.
6. Data Presentation: Yearly median values are presented for long-term trends of all indicators as recommended in the ANZECC Guidelines. However, due to limited datasets for some communities and years, the Rolling Median (RM) of the preceding three years has been used for comparative purposes. Outliers and abnormalities are not removed from the data for the purpose of the report to avoid bias.
7. Variations in WSP Design: Comparisons between WSPs may be challenging due to variations in design, including differences in pond size, pond numbers, pond depths, inflow concentrations, and volumes. These design variations can impact treatment performance and monitoring results.

These limitations and considerations highlight the challenges in interpreting and analysing the monitoring data, and they emphasize the need for cautious interpretation and understanding of the context and constraints associated with the data presented in this report.

Monitoring Results and Discussion

The Remote WDL Monitoring Report for the period from June 2020 to May 2023 presents monitoring results per analyte and is divided into four groups based on the discharge risk levels: Round 1, Round 2, Round 3, and Belyuen WSP. The purpose of presenting the results over a 12-month data range is to allow for meaningful comparisons and analysis.

Specifically for Belyuen, the monitoring results will be presented on a month-to-month basis, comparing the data from June 2020 to May 2023. This approach helps highlight seasonal variations and fluctuations in the monitoring results, providing insights into the potential influence of different seasons on the observed parameters.

To further assess the seasonal influence on the monitoring results for Belyuen, the data will be compared with the 2022-2023 monthly weather data obtained from the Wagait Beach BOM weather station, which is located approximately 13 km north of the monitoring point. By integrating the weather data into the analysis, it becomes possible to examine any correlations or patterns between the monitoring results and seasonal weather conditions.

Throughout the report's results and discussion section, the reporting limit trigger values will be applied to the Belyuen WwTP monitoring results. This ensures that the data is evaluated based on predefined thresholds or limits, providing a standardized framework for assessing the performance of the treatment plant and identifying any potential compliance issues.

By considering the seasonal variations, weather data, and trigger values, the Remote WDL Monitoring Report aims to provide a comprehensive analysis of the monitoring results for Belyuen and other sites, facilitating a better understanding of the environmental conditions and the effectiveness of wastewater treatment and management practices.

Discharge Volumes

The observation of relatively low discharge volumes from licensed remote Indigenous community Wastewater Stabilization Ponds (WSPs) is in line with the low equivalent populations (EP) or equivalent tenements in these sites. Equivalent population refers to the estimation of the number of individuals that a wastewater treatment facility is designed to serve based on factors such as household size, water usage, and wastewater generation rates.

In remote Indigenous communities, the population sizes are typically smaller compared to urban areas, and as a result, the EP or equivalent tenements associated with these communities are also lower. The design and capacity of WSPs in these areas are typically tailored to accommodate the wastewater needs of the specific population size, which contributes to the relatively low discharge volumes observed.

The low discharge volumes from remote Indigenous community WSPs are reflective of the scale and requirements of these communities. The management and operation of wastewater treatment systems in these areas are designed to meet the needs of the local population while considering the environmental impact and sustainability.

It is important to align the capacity of wastewater treatment facilities with the equivalent population to ensure effective treatment and minimize the environmental impact of wastewater discharge in remote Indigenous communities. This approach helps to maintain the balance between providing adequate sanitation services and preserving the ecological integrity of the receiving environment.

In order to ensure accurate and representative historic flow volume estimates, this report will draw upon the flow volume data obtained from the previous monitoring report. It's essential to acknowledge that updates to the system and instrument calibration might have taken place since the previous report. By utilising the previous data, we aim to provide a more precise estimation of the flow volume, while also considering any potential changes or improvements that may have occurred in the monitoring process. This approach allows us to maintain the integrity of the historical data while accounting for any relevant updates in the system.

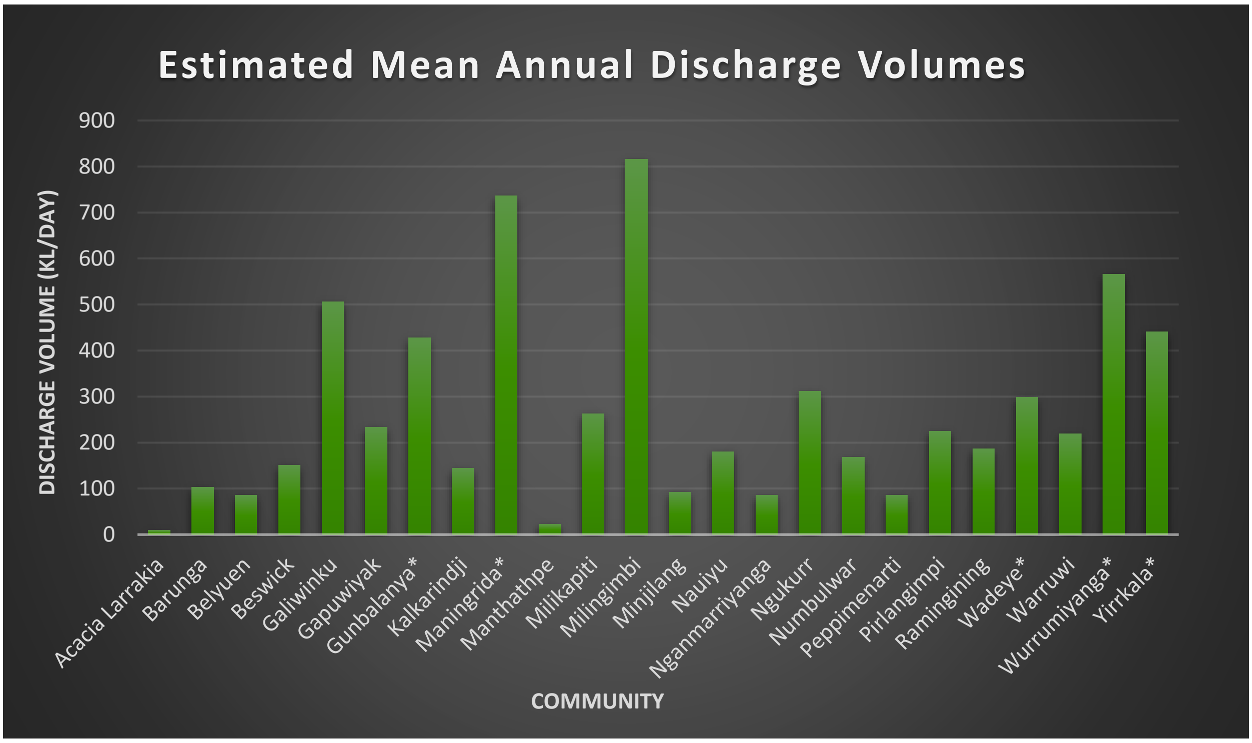

Figure 1. Estimated mean annual discharge volumes at remote sites 2020 - 2021.

Physio-Chemical Parameters

Power and Water regularly monitors several physical-chemical parameters at remote Wastewater Stabilization Pond (WSP) outlets. These parameters include pH, electrical conductivity (EC), dissolved oxygen (DO), turbidity, and total suspended solids (TSS).

Low median DO concentrations in the discharged effluent can have adverse effects on aquatic organisms. However, accurately measuring DO (% Saturation) levels is most reliably done in-situ because the concentration levels can vary significantly when samples are cooled or stored. When samples from remote communities are transported to Darwin for analysis, there are several factors that can affect DO levels, such as algal load, bacterial load, temperature during transportation, and the time between sample collection and laboratory analysis. Consequently, the accuracy of DO measurements may be compromised compared to field measurements (AWQC, 2020).

In addition, the WSPs may experience periods of low flow, resulting in more anaerobic conditions within the ponds (Patterson & Curtis, 2005). Outliers observed in the DO results from remote communities further indicate that these results may not accurately represent the actual DO levels at the pond outlets.

Biochemical Oxygen Demand (BOD) is a key indicator used to assess the level of biodegradable organic matter in wastewater or treated effluent. It measures the oxygen required by microorganisms to break down organic pollutants. BOD is valuable in evaluating the efficiency of wastewater treatment processes. On the other hand, Dissolved Oxygen (DO) is used to assess the level of oxygen present in water bodies, including treated effluent, ensuring sufficient oxygen to support aquatic life. Both BOD and DO are critical in understanding water quality and the effectiveness of wastewater treatment methods.

pH

Changes in pH can have significant implications for various ecological and biological processes within aquatic environments, including sewage ponds. The pH levels directly influence factors such as metal solubility, toxicity, and the ability of aquatic macrophytes and phytoplankton to absorb essential minerals and nutrients. In the context of sewage treatment systems, maintaining an ideal pH range is crucial for ensuring optimal biological processes and efficient treatment of wastewater.

The recommended pH range for sewage ponds typically falls between 6.5 and 8.5 units. Within this range, the biological mechanisms responsible for breaking down organic matter and removing contaminants from wastewater are most effective. A pH value within the specified range promotes the growth and activity of beneficial microorganisms, which play a crucial role in the treatment processes.

However, it's important to note that specific pH requirements may vary depending on the design and operational characteristics of each sewage pond system. Factors such as the type of wastewater being treated, the presence of specific microorganisms, and the desired treatment outcomes can influence the pH range considered ideal for a particular system. Therefore, it is essential to consider site-specific factors when determining the appropriate pH range for sewage ponds.

In the remote water quality monitoring conducted for Round 1, the pH values recorded at the sites fell within the ideal range of 6.5 to 8.5 units, indicating favourable conditions for wastewater treatment. However, in the other monitoring rounds (Round 2 and Round 3), the sites at Peppimenarti and Acacia Larakia exhibited slightly elevated pH levels above 8.5 units.

The observed increase in pH at these sites can be attributed to the elevated primary production, as indicated by the Chlorophyll-a results (Figure 8 Figure 9) in the pond systems. Increased primary production is often associated with higher algae populations. Algae, being photosynthetic organisms, utilize carbon dioxide during photosynthesis and release oxygen as a by-product. This process, known as photosynthetic alkalinisation, can lead to an increase in pH levels.

The influence of algae on pH levels highlights the interconnectedness of biological processes in sewage ponds. While algae play a vital role in oxygen production and nutrient cycling, their proliferation can impact pH dynamics within the water body. Monitoring and managing algae populations in sewage ponds is crucial to maintaining pH levels within the recommended range and ensuring the overall effectiveness of the treatment process.

Understanding the relationship between photosynthetic activity, algae population, and pH levels is essential for optimizing sewage pond operations and minimizing potential environmental impacts. By implementing appropriate measures to control algae growth and managing pH levels, the treatment efficiency of sewage ponds can be enhanced, ensuring the protection of water quality and the receiving environment.

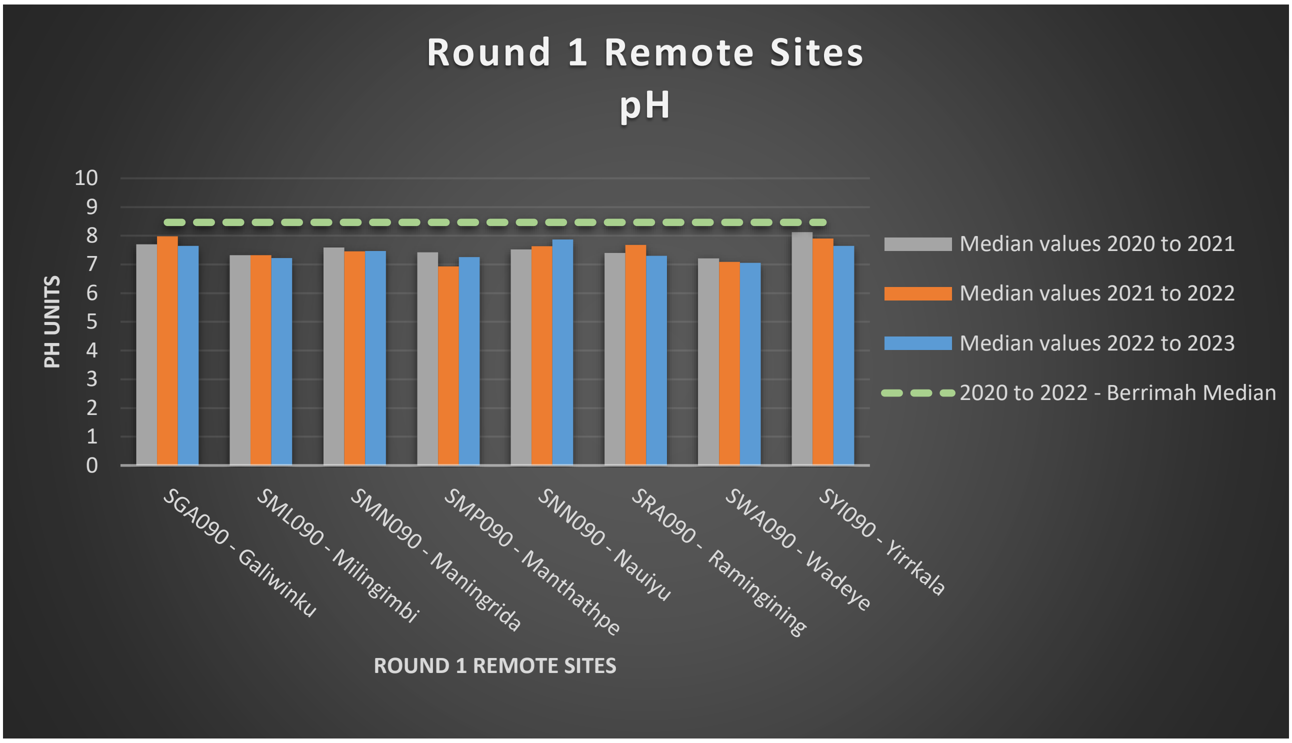

Figure 2. pH: Round 1 Remote Sites

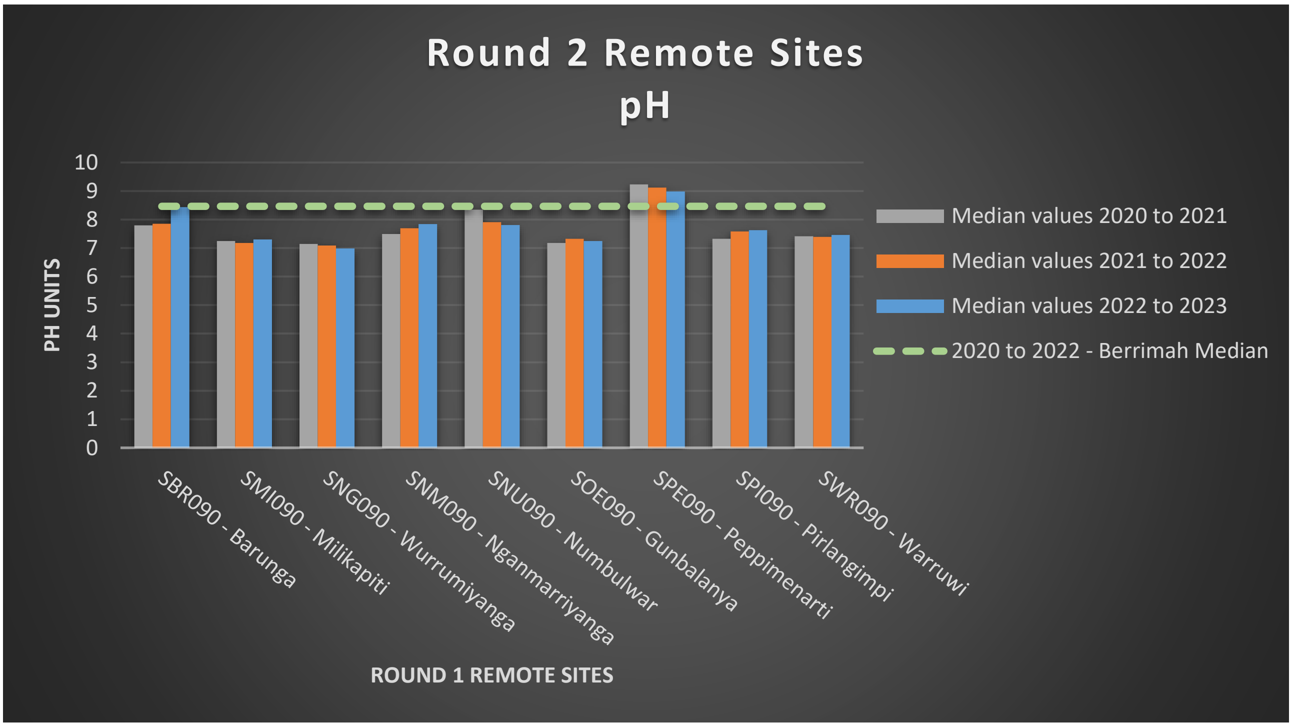

Figure 3: pH: Round 3 Remote Sites

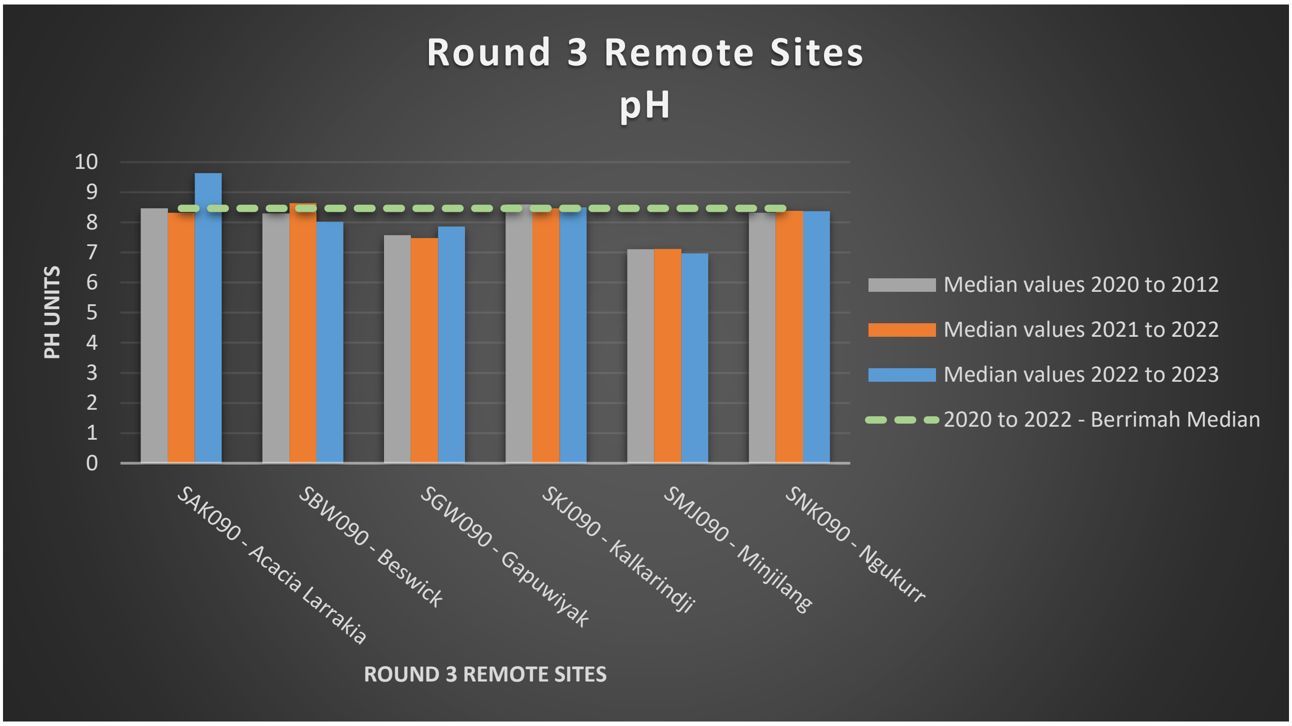

Figure 4. pH: Round 3 Remote Sites

Total Suspended Solids

Total Suspended Solids (TSS) have the potential to reduce light penetration in water bodies, which can, in turn, decrease the photosynthesis of aquatic phytoplankton (ANZECC, 2000). TSS serves as a key indicator associated with the environmental impacts of effluent discharge from Wastewater Stabilization Ponds (WSPs).

In Round 1, most sites showed lower TSS concentrations compared to previous years, except for Maningrida, Nauiyu, and Ramingining. The increased TSS levels at these sites can be attributed to sediment mobilization from outside the pond system and sediment disturbance within the ponds caused by higher rainfall events during the last wet season (2022-2023).

Among the Round 2 WSPs, Peppimenarti stands out as the only site exhibiting higher TSS values compared to previous years. This increase in TSS can be attributed to seasonal variations and the relatively higher rainfall experienced in the area. However, it is important to note that the remaining sites did not show similar increases in TSS despite above-average rainfall events. This indicates that there may be specific factors unique to Peppimenarti WSP that have influenced a considerable rise in TSS levels.

Moving on to the Round 3 WSPs, most sites demonstrated relatively consistent or within-range fluctuation of TSS results, except for Acacia WSP. In July 2022, Acacia WSP recorded a Volatile Suspended Solids (VSS) value of 190 mg/L and a TSS value of 210 mg/L. These elevated values suggest a notable presence of phytoplankton in the pond system, contributing to the increase in TSS levels.

The rise in TSS can be attributed to the growth and abundance of algae within the sewage pond. As algae thrive and multiply, their physical presence contributes to the overall TSS and VSS measurements in wastewater. This relationship is further supported by the Chlorophyll-a results obtained during the same sampling event (refer to Figure 13). Additionally, the decomposition of organic matter, including algae, can release volatile organic compounds, further adding to the VSS levels.

Understanding the interplay between algae growth, TSS, VSS, and Chlorophyll-a levels in sewage ponds is crucial for effective management. Monitoring and analysing these parameters provide valuable insights into the dynamics of the pond systems, aiding in the implementation of appropriate measures to control algal proliferation and maintain optimal treatment performance.

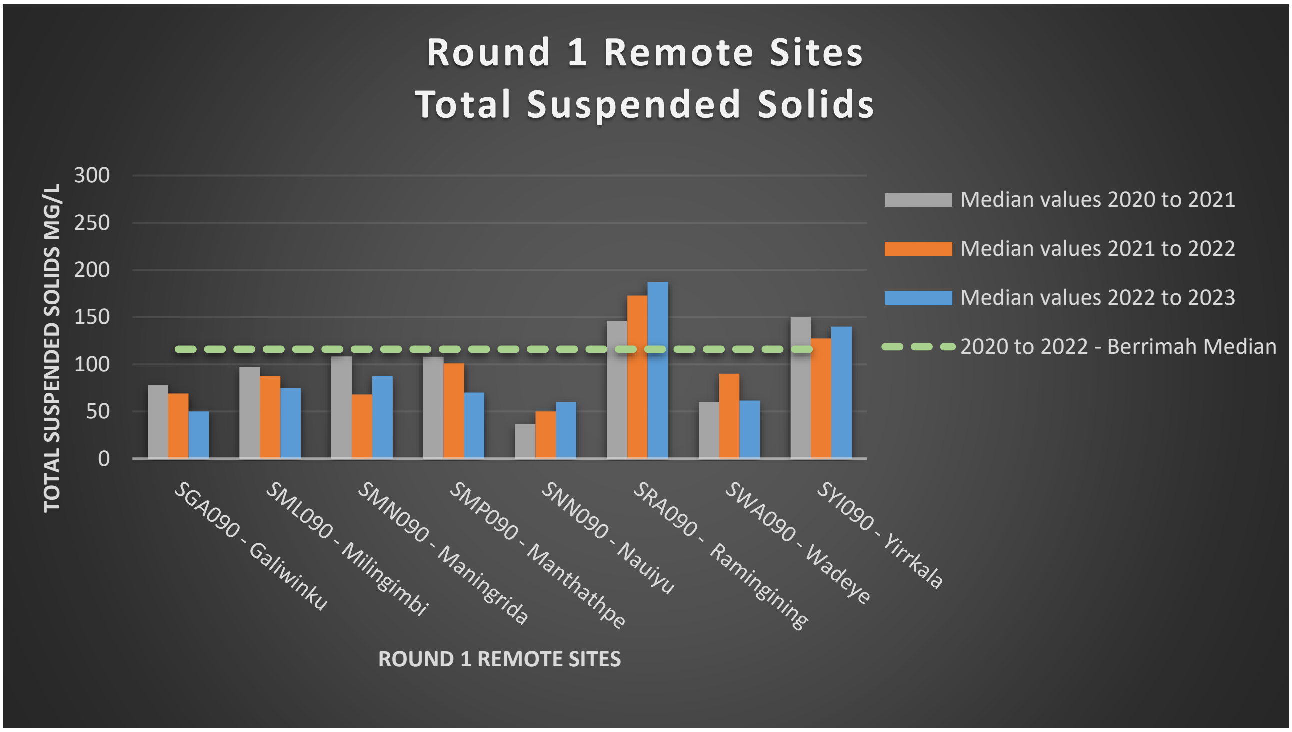

Figure 5. TSS: Round 1 Remote Sites

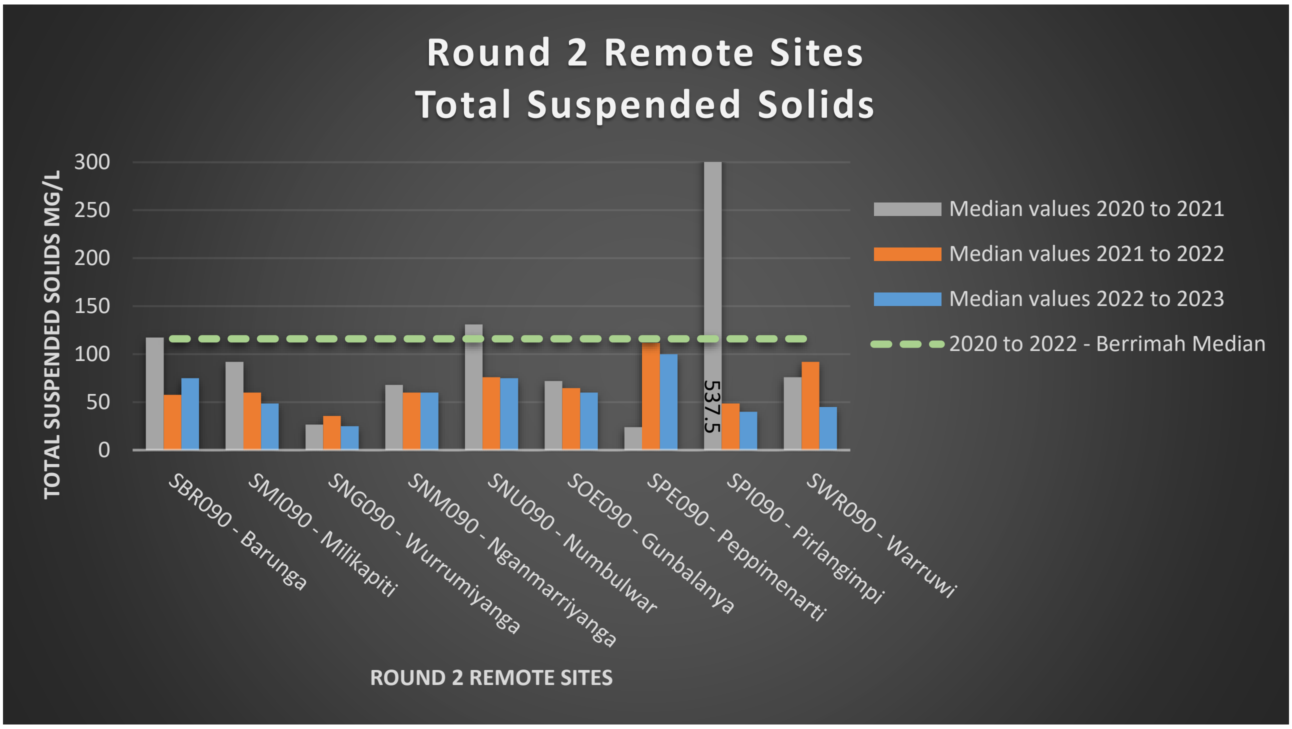

Figure 6. TSS: Round 2 Remote Sites

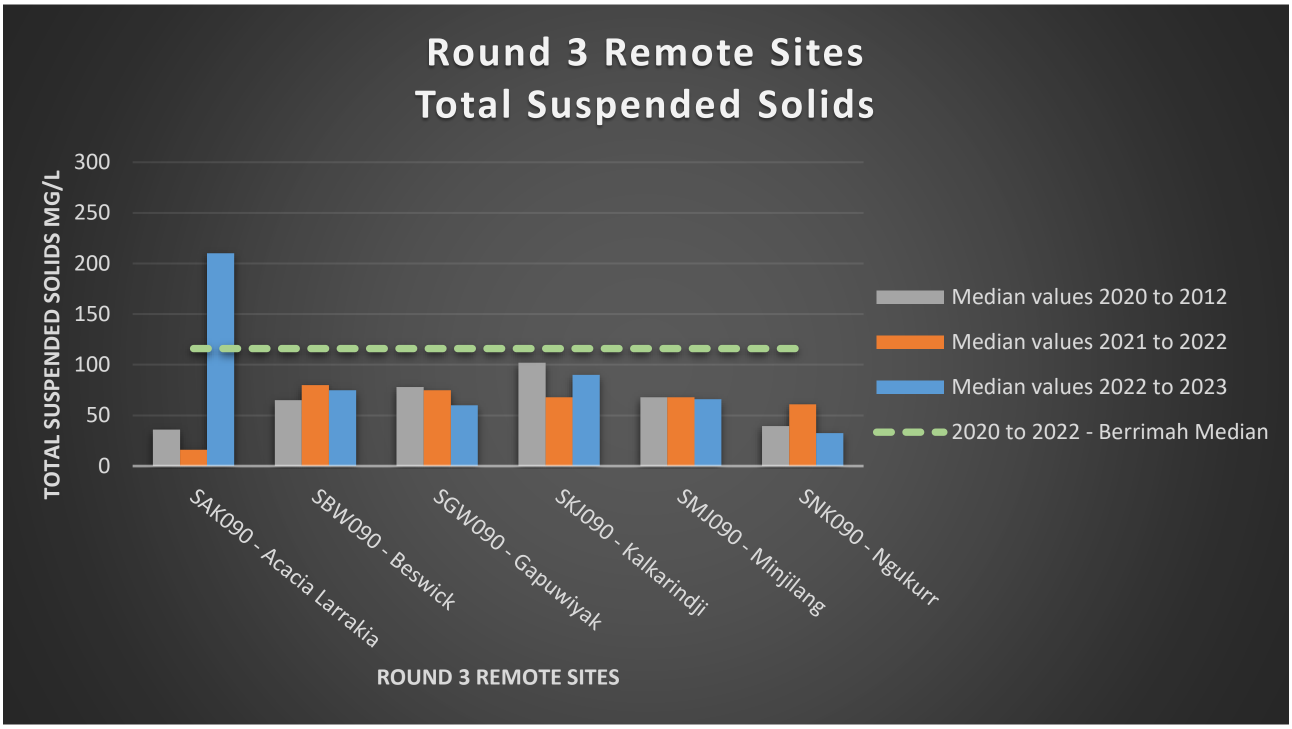

Figure 7. TSS: Round 3 Remote Sites

Biological Parameters

Chlorophyll a

Chlorophyll-a is a measure of the amount of algae present in a waterbody, and it can be used to assess the trophic condition of the waterbody. Excessive growth of algae can lead to aesthetic issues, such as green scums and odours, and can result in decreased levels of dissolved oxygen, which can be detrimental to aquatic organisms. Chlorophyll-a can serve as a stressor response indicator in receiving waters (ANZECC, 2000).

In the context of Waste Stabilization Ponds (WSPs), the aerobic zones rely on algal populations to generate oxygen for the breakdown of organic matter. As a result, the discharged effluent from WSPs often contains a significant concentration of freshwater algal biomass (PWC, 2021). Consequently, using Chlorophyll-a as the sole indicator for assessing the environmental impacts of effluent discharge from remote WSPs may not provide a comprehensive understanding.

Rounds 1 and 2 of monitoring, Chlorophyll-a levels varied among the sites, with some showing an increase and others a decrease. However, these variations fell within an acceptable range, suggesting overall stability.

In Round 3, most sites demonstrated changes in Chlorophyll-a levels that were within an acceptable range. However, Kalkarindji displayed high fluctuations in Chlorophyll-a levels, indicating potential variations in algal biomass dynamics.

It is important to recognize that evaluating the environmental impacts of effluent discharge requires considering additional parameters and indicators alongside Chlorophyll-a. This holistic approach ensures a comprehensive assessment of water quality and trophic conditions, providing a more accurate understanding of the potential environmental effects of remote WSP effluent discharge.

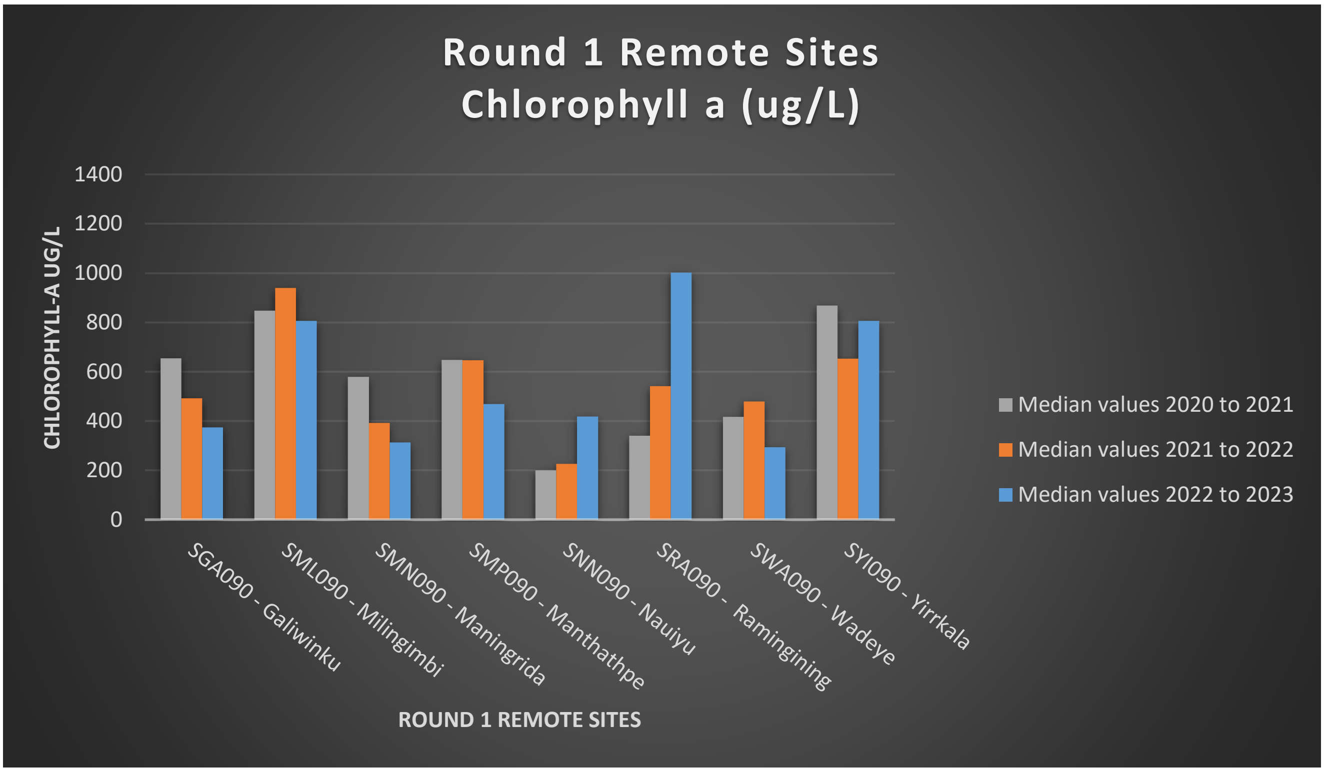

Figure 8. Chlorophyll-a: Round 1 Remote Sites

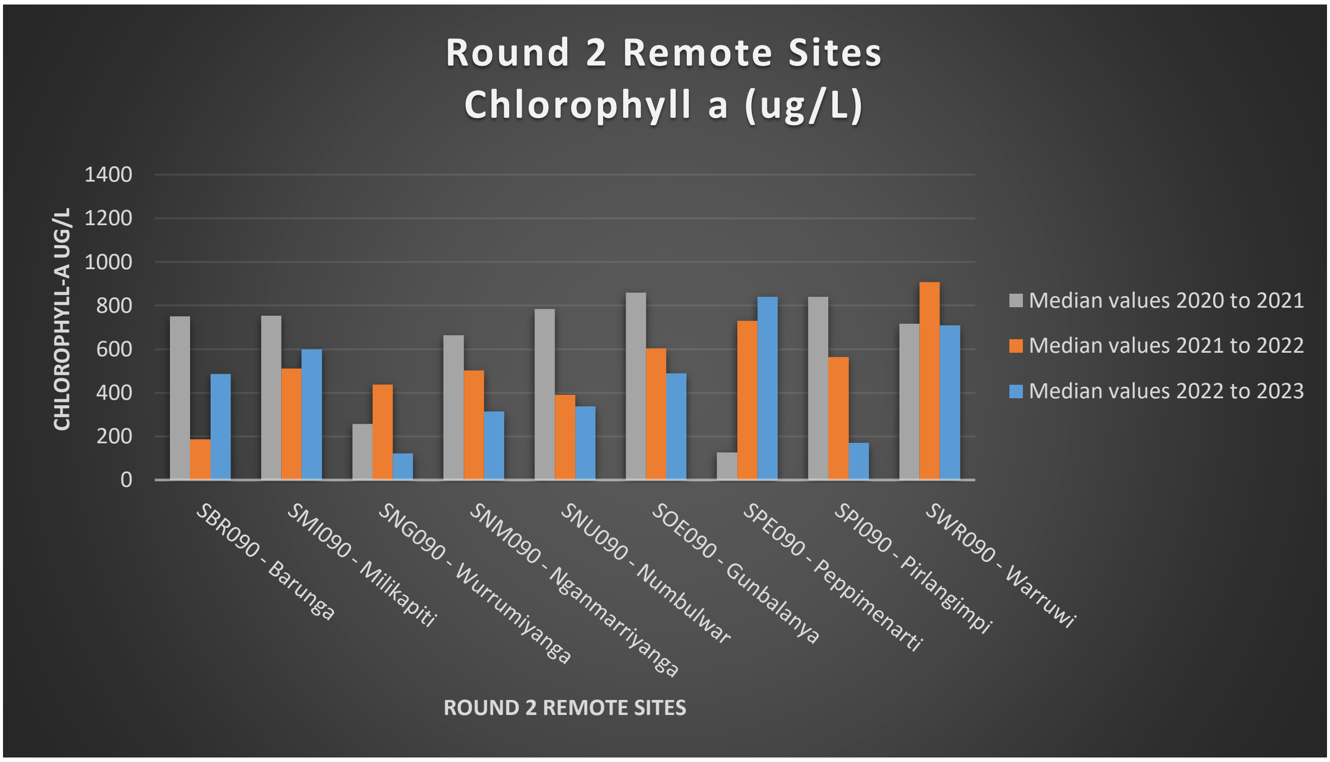

Figure 9. Chlorophyll-a: Round 2 Remote Sites

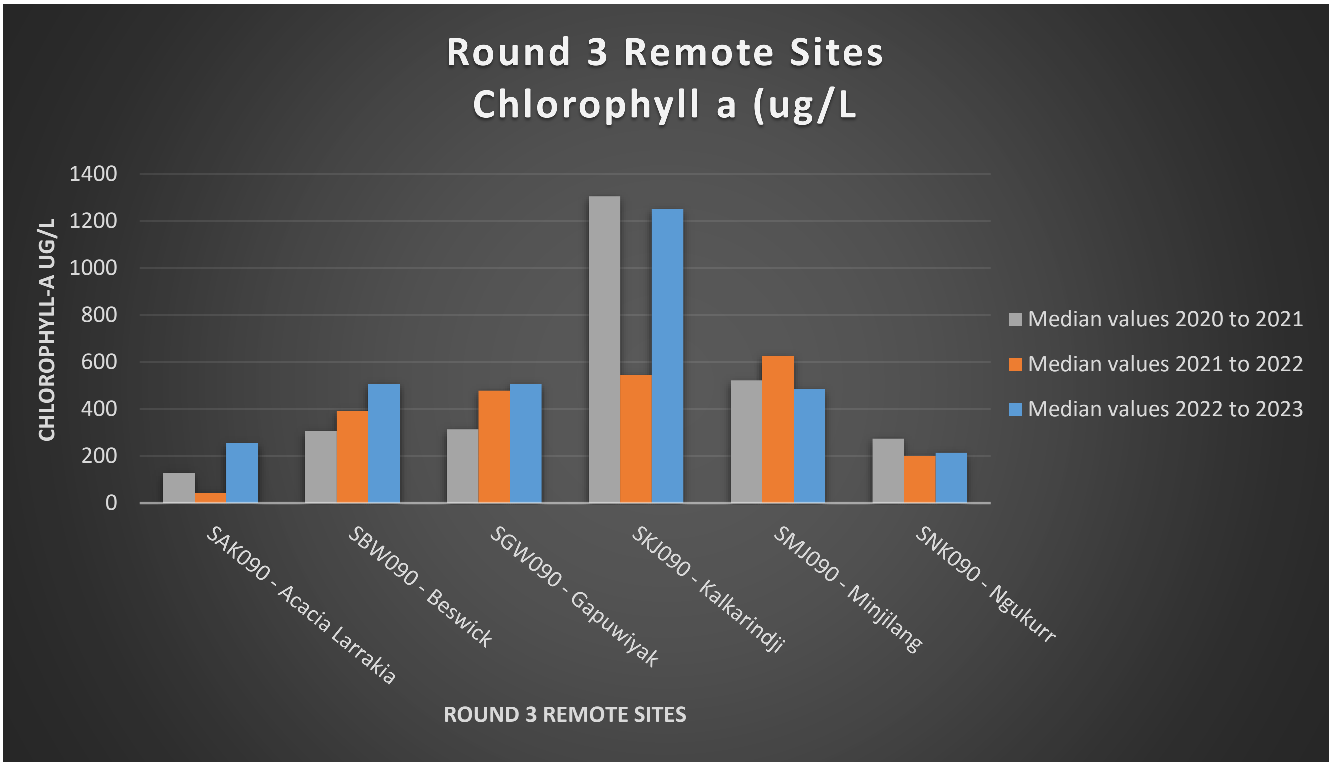

Figure 10. Chlorophyll a: Round 3 Remote Sites

Biochemical Oxygen Demand

BOD (Biochemical Oxygen Demand) serves as a crucial measure of the oxygen consumed by microorganisms within WSPs, indicating the extent of organic matter that remains to be oxidized (PWC, 2021). It is widely employed as an indicator of pond performance (Patterson and Curtis, 2005). Elevated BOD levels can lead to oxygen depletion in receiving waters, potentially resulting in fish kills and increased toxicity of other pollutants (PWC, 2021). Moreover, heightened BOD can contribute to unpleasant odours, thereby reducing the amenity of the receiving environment (Patterson and Curtis, 2005). Consequently, BOD stands as a key indicator associated with the environmental and public health impacts of effluent discharge from WSPs.

In Round 1, the median BOD values at remote sites were generally lower compared to previous years (Figure 11). Notably, Yirrkala exhibited the least reduction in BOD percentage compared to preceding years among the WSPs. Nauiyu's increase falls within an acceptable range when considering factors such as location conditions and weather.

Within Round 2 remote sites, Peppimenarti stood out as the sole WSP displaying higher median BOD values compared to the preceding years (Figure 12).

During Round 3, the Larrakia WSP exhibited higher median BOD values compared to previous years (Figure 13). This finding aligns with the Chlorophyll-a results obtained from the same site, suggesting a potential correlation between elevated BOD levels and algal biomass.

Considering these findings, BOD proves to be an essential indicator for assessing the environmental and public health impacts associated with effluent discharge from remote WSPs.

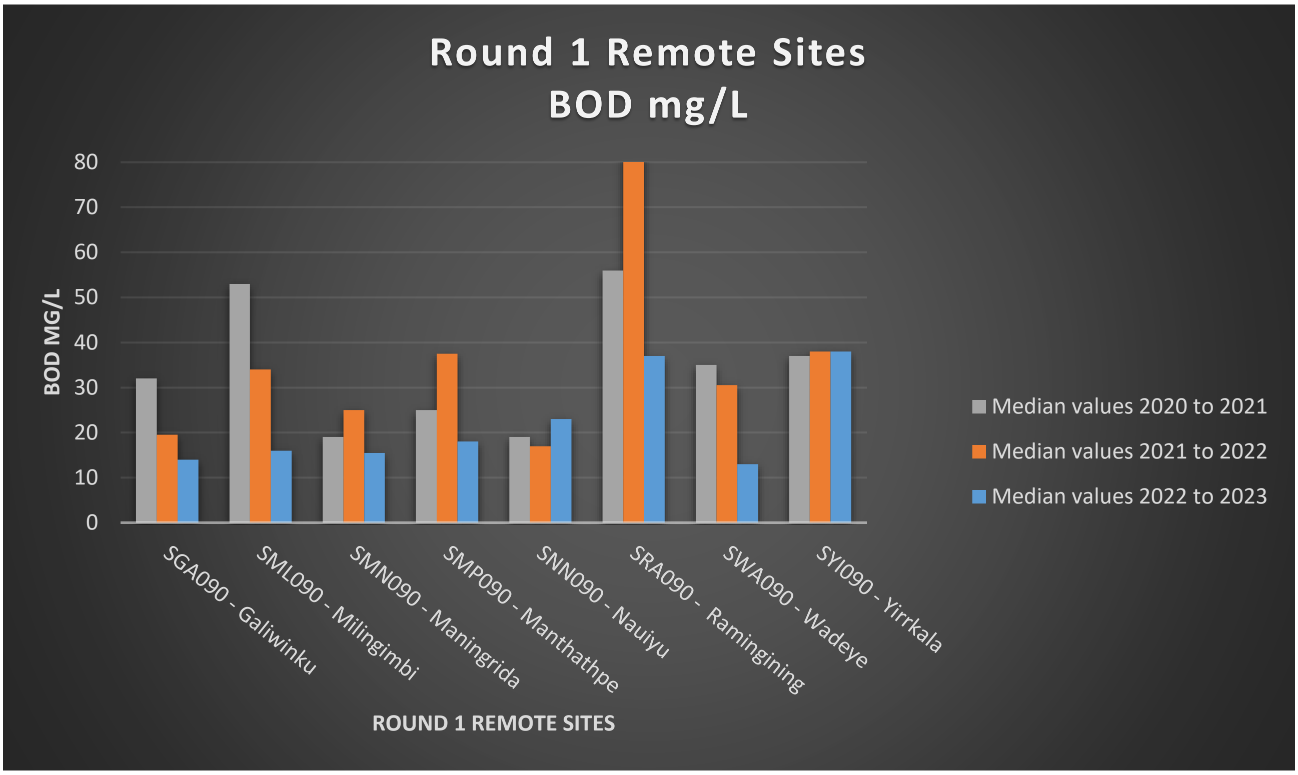

Figure 11. BOD: Round 1 Remote Sites

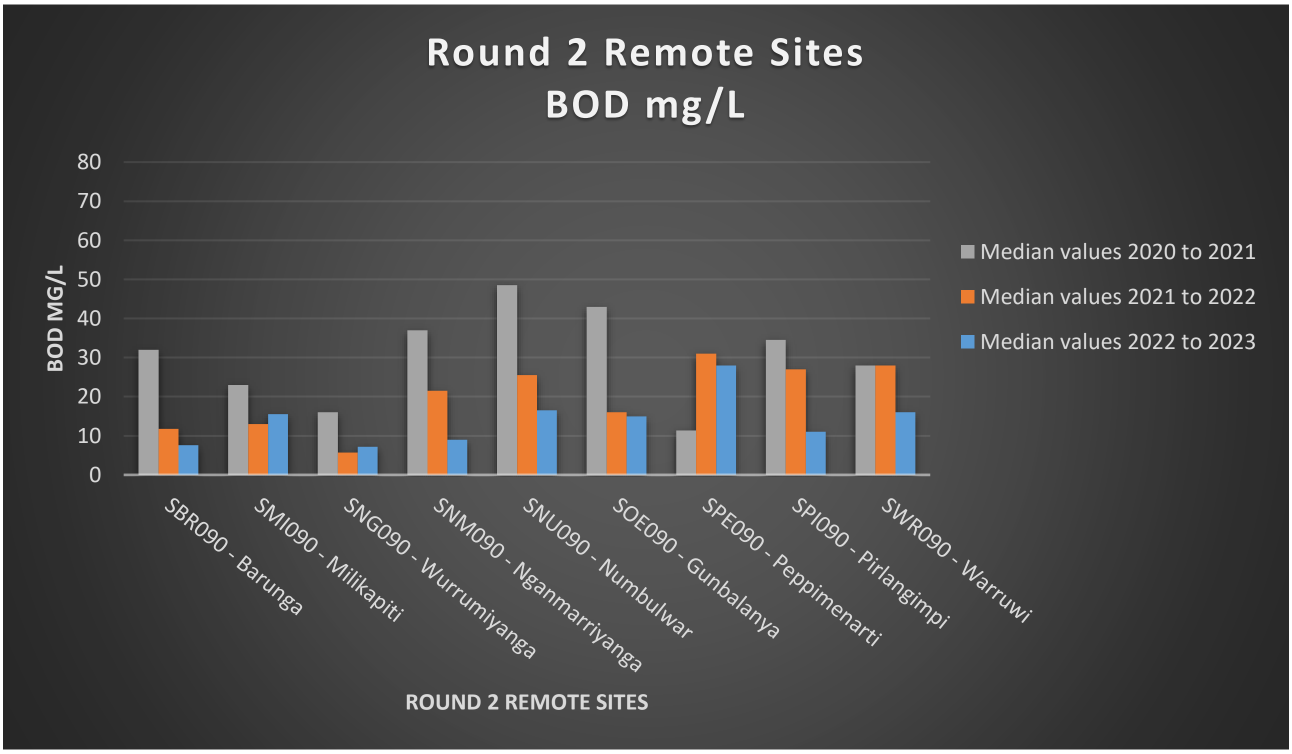

Figure 12. BOD: Round 2 Remote Sites

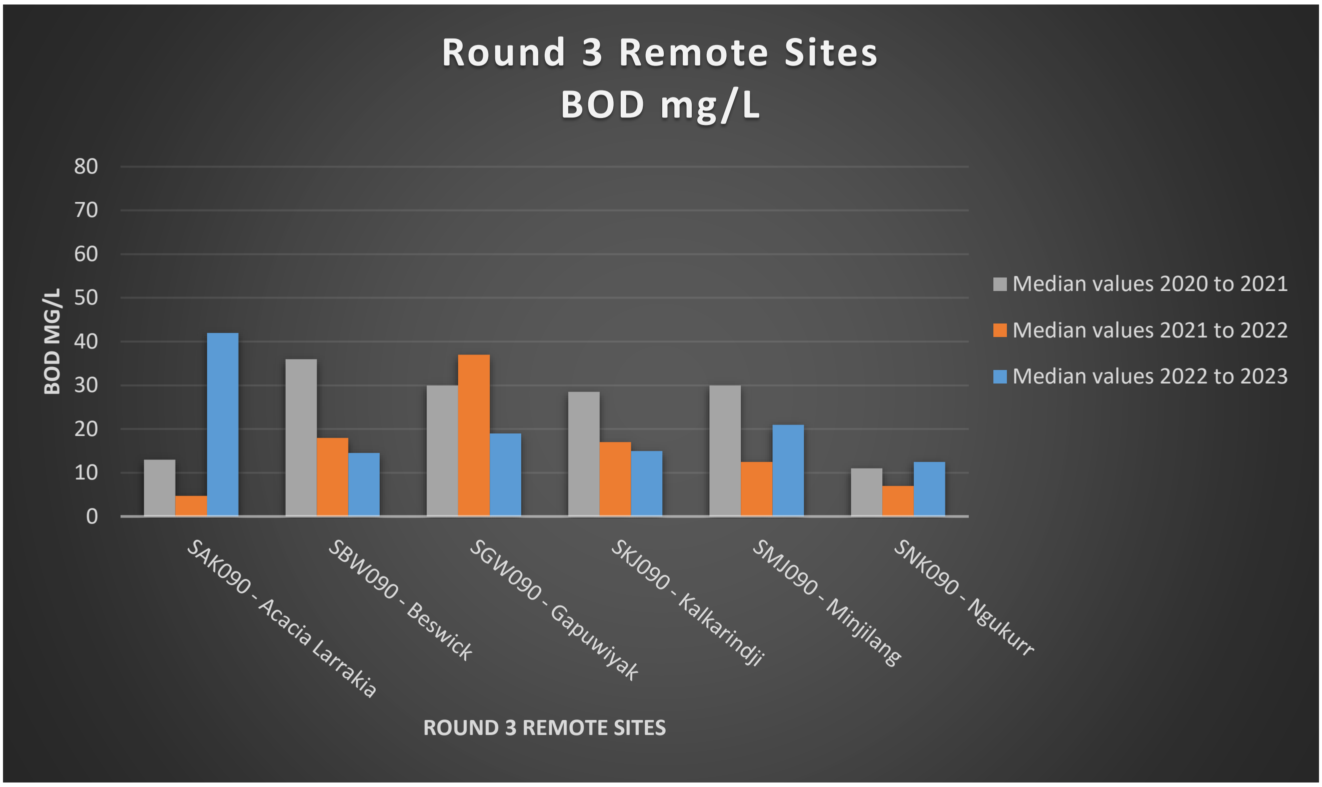

Figure 13. BOD: Round 3 Remote Sites

Nutrients

Ammonia

Elevated levels of ammonia in water can have detrimental effects on the health and survival of aquatic organisms, particularly fish. Ammonia toxicity can inhibit photosynthesis, leading to reduced productivity in aquatic plants. It can also cause damage to tissues and organs, weaken immune systems, and increase susceptibility to diseases and mortality (ANZECC, 2000). Recognizing its toxic nature, ammonia is considered a significant pollutant and a key indicator for assessing the environmental impacts of effluent discharge from remote Wastewater Stabilization Ponds (WSPs) according to the ANZECC Guidelines.

In many WSP receiving environments, the presence of high dilution rates or natural vegetation within the water bodies plays a crucial role in mitigating the effects of ammonia. These factors help to consume a substantial portion of the nutrients present in the effluent before it enters the water. The estimation of dilution rates is regularly updated through the Power and Water Corporation Environmental Risk Assessment Report, which is submitted to the Administering Regulatory Body in compliance with the WSP Discharge Licenses (WDLs) specific to each remote WSP. Annual variations in nutrient median results are influenced by rainfall patterns, which can lead to increased sediment and nutrient mobilization around the sewage ponds, as well as disturbances within the ponds themselves.

Analysing the annual median ammonia results across different groups of remote WSP sites reveals diverse trends and fluctuations. Wadeye and Ngukurr WWTPs exhibit a decreasing trend in ammonia levels over time, suggesting successful management practices or environmental factors that contribute to the reduction of ammonia in the effluent. However, sites displaying fluctuating trends and increasing ammonia levels in the most recent year still remain within acceptable levels of increase when compared to the preceding years of data.

Monitoring and ensuring compliance with regulatory standards for ammonia levels in effluent discharge are of utmost importance to safeguard the well-being of aquatic organisms and maintain the overall health of the receiving environment. By closely monitoring ammonia levels and implementing effective mitigation strategies when necessary, wastewater treatment facilities can minimize the potential ecological risks associated with ammonia toxicity and promote the sustainable management of wastewater discharges.

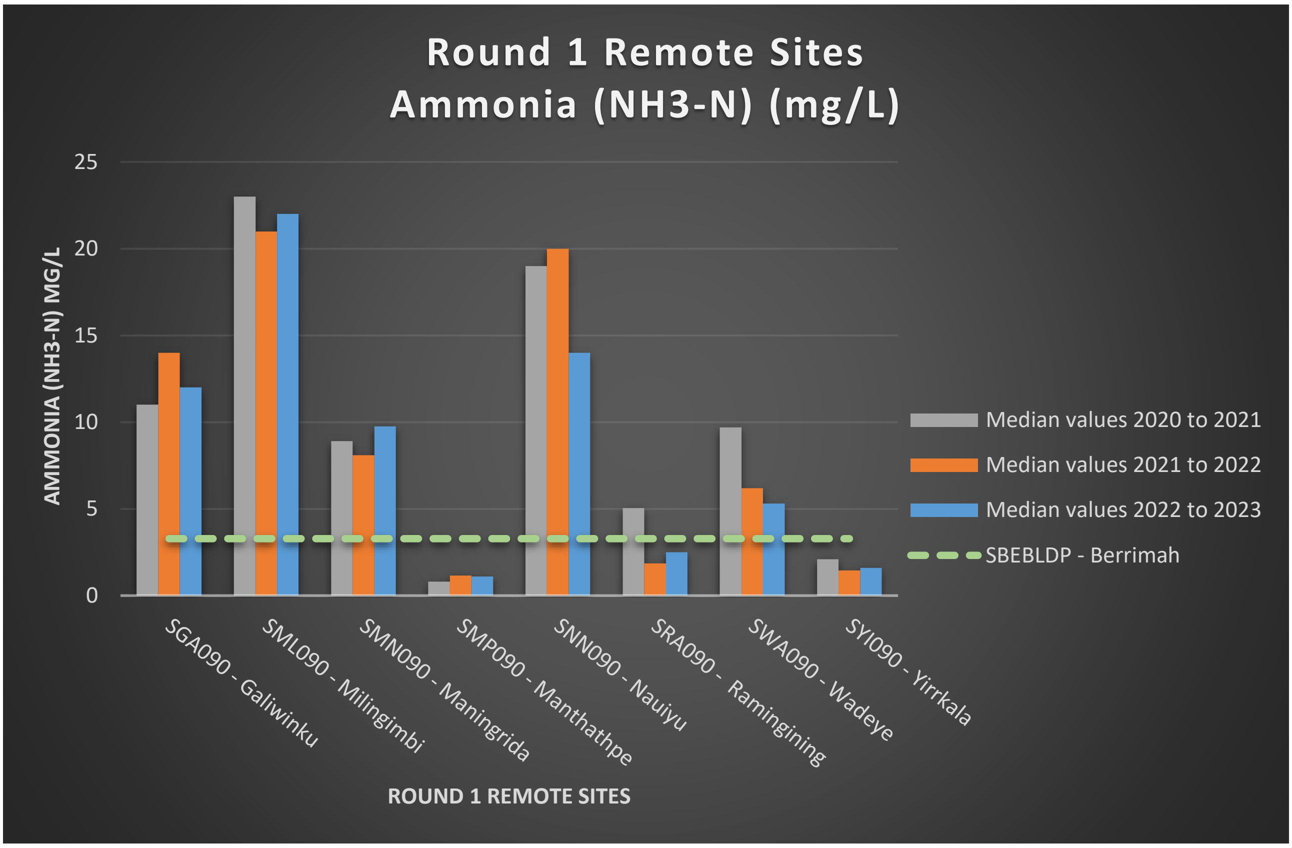

Figure 14. Ammonia: Round 1 Remote Sites

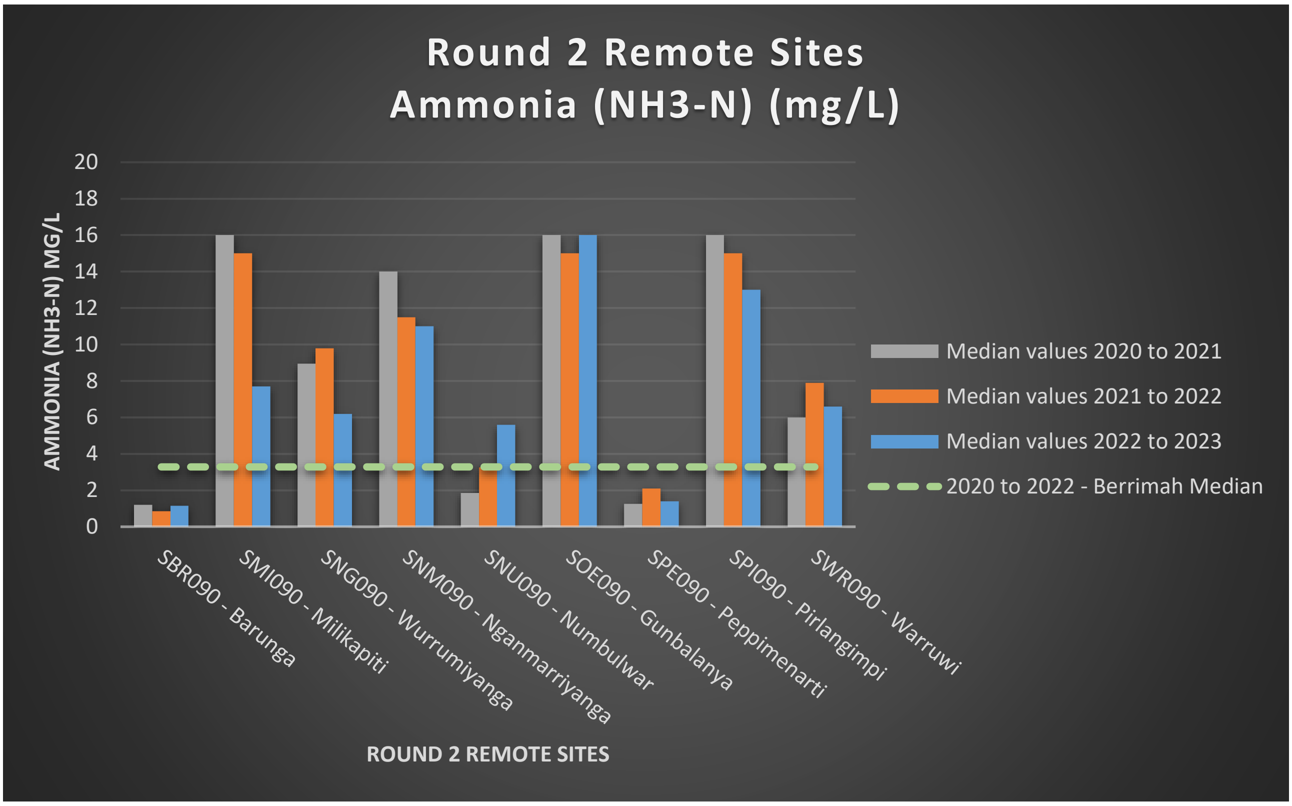

Figure 15. Ammonia: Round 2 Remote Sites

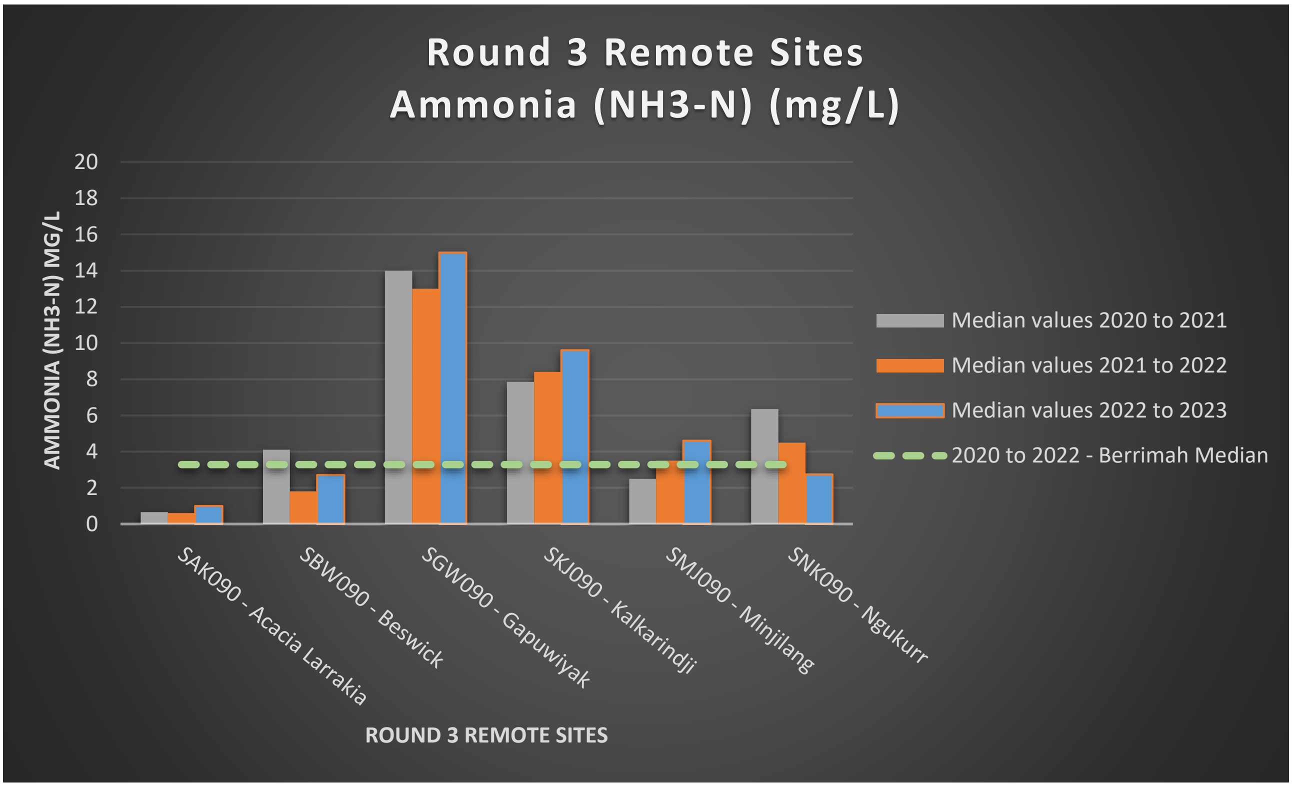

Figure 16. Ammonia: Round 3 Remote Sites

Oxidised Nitrogen (NOx)

Oxidized nitrogen, commonly referred to as NOx, is an important parameter to monitor in the context of effluent discharge and its impacts on the receiving environment or aquatic ecosystems. NOx includes nitrogen compounds such as nitrate (NO3-) and nitrite (NO2-), which are formed through the oxidation of nitrogenous compounds.

The effects of NOx on the receiving environment or aquatic environment can vary depending on the concentration and specific circumstances. Here are some key points to consider:

1. Nutrient Enrichment: Elevated NOx levels can contribute to nutrient enrichment in water bodies. Excessive nutrients, particularly nitrogen, can lead to eutrophication, which is the excessive growth of algae and aquatic plants. This can result in oxygen depletion, harmful algal blooms, and overall degradation of water quality.
2. Altered Ecosystem Dynamics: Increased NOx levels can affect the balance of aquatic ecosystems. Algae and aquatic plants may experience rapid growth, leading to changes in species composition and the dominance of certain species. This can have cascading effects on other organisms in the ecosystem, including fish, invertebrates, and other aquatic life.
3. Dissolved Oxygen Depletion: High levels of NOx can contribute to oxygen depletion in water bodies. Excessive nutrients promote algal growth, and when these algae die and decompose, the process consumes oxygen. This can result in reduced dissolved oxygen levels, which can be harmful or even lethal to fish and other aquatic organisms.

The fluctuating levels of oxidized nitrogen (NOx) observed across different sites can be influenced by various factors, including the characteristics of the effluent, environmental conditions, and treatment processes in place. Here are some possible reasons for the varying trends in NOx levels:

1. Effluent Characteristics: The composition of the effluent, including the nitrogen content, can vary among different wastewater treatment plants (WTPs) or locations. Variations in the types and amounts of nitrogen-containing compounds present in the effluent can contribute to the fluctuating levels of NOx.
2. Treatment Processes: In different geographical locations, sizes of ponds, and water retention times, various WTPs employ different treatment processes to remove or transform nitrogen compounds. The effectiveness of these processes can vary, resulting in variations in the levels of NOx found in the treated effluent. Modifications in treatment processes or operational conditions can also impact the removal or generation of NOx.
3. Environmental Conditions: Environmental factors, such as temperature, rainfall, and seasonal variations, can impact the biological processes involved in nitrogen cycling. These factors can influence the growth and activity of microorganisms responsible for nitrogen transformations, affecting the levels of NOx in the effluent.
4. Monitoring Frequency: Fluctuating NOx levels may also be attributed to the timing and frequency of monitoring. Short-term variations or sampling events during specific conditions may capture temporary spikes or reductions in NOx concentrations, resulting in fluctuating trends.

Regarding the below laboratory detection limit results for NOx, it is important to consider the analytical limitations and interpretation of data, similar to the discussion on ammonia. Results below the laboratory detection limit indicate that the measured NOx concentrations are below the limit of detection for the analytical method used. Monitoring NOx levels, even if below the laboratory detection limit, is still important to track trends and assess potential impacts on the receiving environment.

Total Nitrogen (TN))

Total Nitrogen (TN) refers to the combined concentration of various forms of nitrogen in water, including organic nitrogen, ammonia, nitrate, and nitrite. The effects of elevated TN on the environment and aquatic ecosystems can be significant. Here are some key points regarding the impact of TN:

1. Eutrophication: Elevated TN levels in receiving waters can contribute to eutrophication, which is the excessive enrichment of nutrients in water bodies. Increased nitrogen availability can stimulate the growth of algae and aquatic plants, leading to algal blooms and dense vegetation. This excessive growth can result in oxygen depletion as the decomposing organic matter consumes dissolved oxygen, negatively impacting the survival of other aquatic organisms.
2. Oxygen Depletion: When there is an excess of TN, the decomposition of organic matter by bacteria and other microorganisms increases. This process consumes dissolved oxygen in the water, potentially leading to hypoxic or anoxic conditions. Oxygen-deprived environments can be harmful to fish, invertebrates, and other aquatic organisms that require adequate oxygen levels for survival.
3. Impact on Species Composition: Elevated TN levels can favour the growth of certain species of algae and aquatic plants, leading to changes in species composition. These changes can result in the displacement of endemic species and alter the overall biodiversity and ecological balance of the ecosystem.
4. Water Clarity and Aesthetic Issues: High TN concentrations can contribute to reduced water clarity due to increased algal growth and suspended particles. This reduction in clarity can negatively affect the aesthetic quality of the water, leading to objectionable discolouration, turbidity, and overall degradation of the visual appeal.

Monitoring TN levels in effluent discharge is crucial to assess the potential impacts on water quality and the health of aquatic ecosystems. The observed reducing median TN values at most sites and the relatively low increase in TN levels compared to previous years are positive indicators of effective wastewater treatment and management practices. By minimizing TN inputs into receiving waters, the risks associated with eutrophication, oxygen depletion, and other ecological impacts can be mitigated, promoting the health and sustainability of aquatic environments.

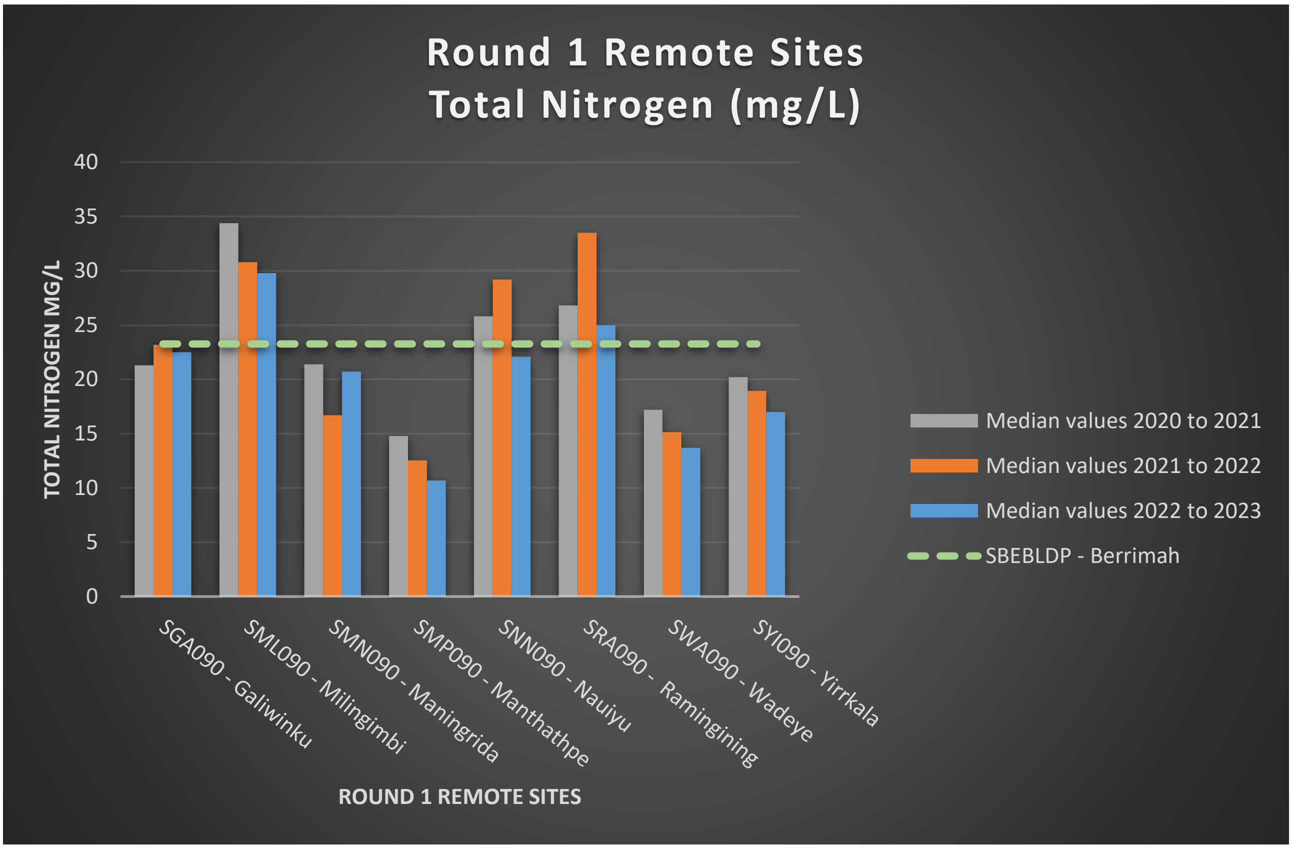

Figure 17. TN: Round 1 Remote Sites

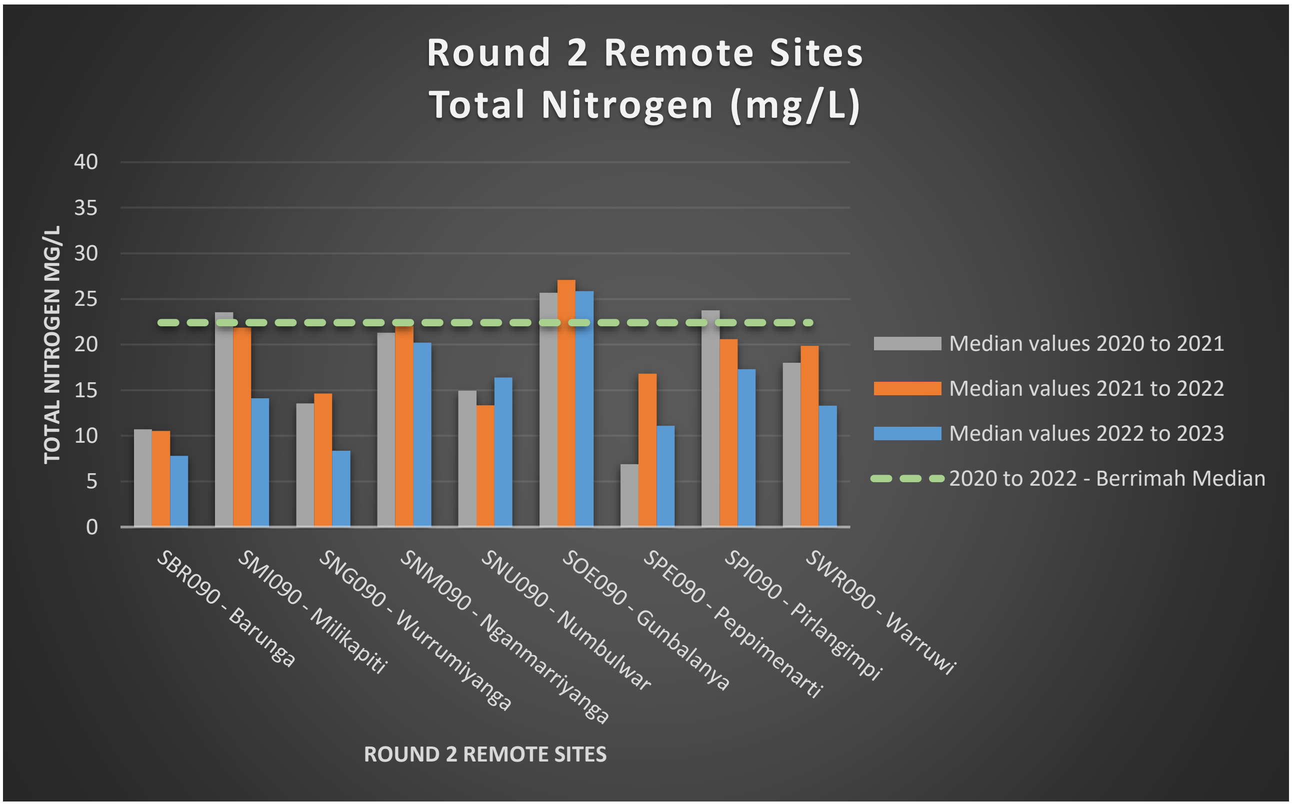

Figure 18: Round 2 Remote Sites

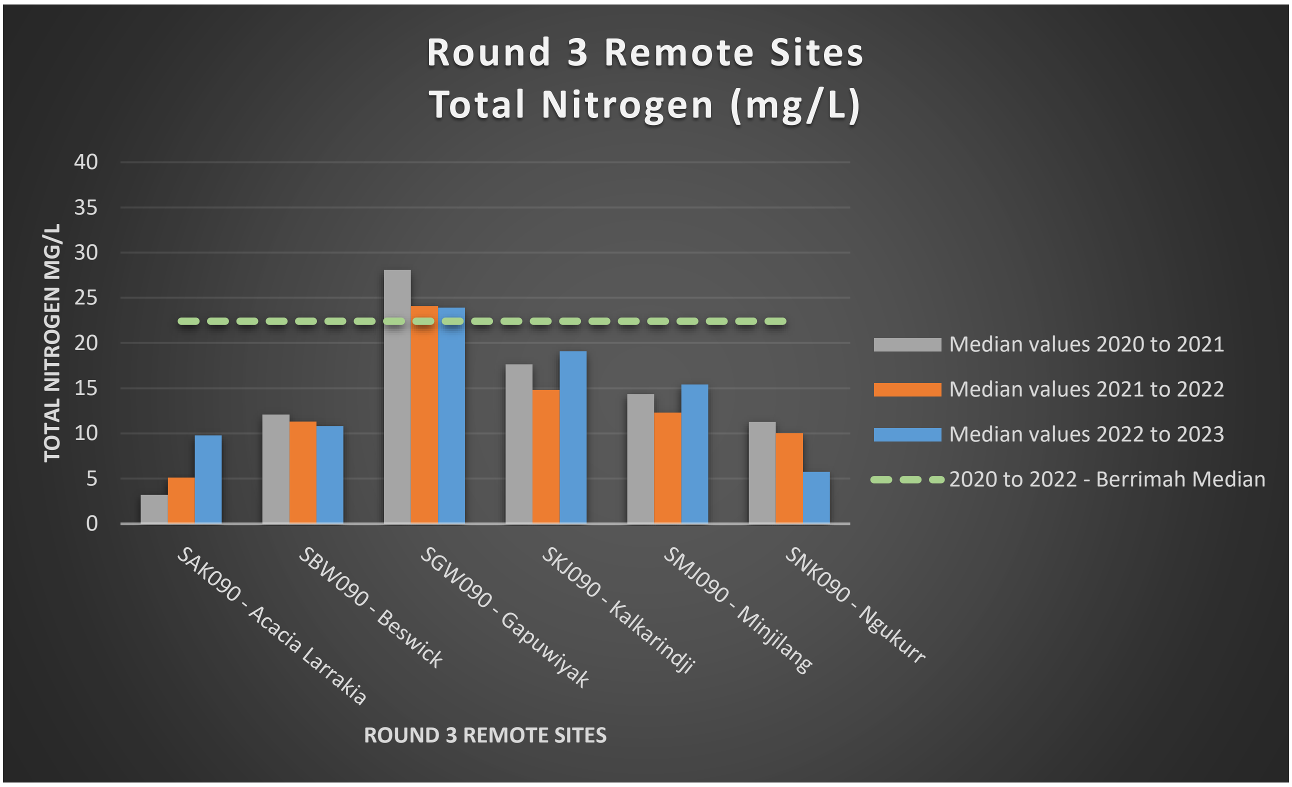

Figure 19. TN: Round 3 Remote Sites

FRP & TP

Increased levels of Filterable Reactive Phosphorus (FRP) and Total Phosphorus (TP) can indeed contribute to the proliferation of algae and algal blooms in water bodies.

The observed fluctuating levels of FRP and TP at different sites can be influenced by various factors, including variations in wastewater treatment processes, natural environmental conditions, and nutrient inputs. Here are some points to consider regarding the fluctuations and reductions in FRP and TP levels:

1. Wastewater Treatment: The effectiveness of wastewater treatment processes in removing phosphorus can vary among different treatment systems and facilities. Fluctuations in FRP and TP levels may indicate variations in treatment efficiency. Significant reductions in FRP and TP levels at some sites could suggest successful phosphorus removal through treatment processes.
2. Nutrient Inputs: The input of phosphorus into wastewater can vary depending on factors such as population size, population activities, and community practices in the catchment area. Fluctuations in FRP and TP levels may reflect changes in nutrient inputs into the wastewater treatment system. Reductions in FRP and TP levels may indicate improved management practices, reduced nutrient inputs, and effective treatment facilities.
3. Environmental Conditions: Natural environmental conditions, such as rainfall patterns, hydrology, and temperature, can influence nutrient dynamics in receiving water bodies. Fluctuations in FRP and TP levels within a certain range may be related to variations in environmental factors that affect nutrient cycling and retention in the ecosystem.

It is important to manage and control FRP and TP levels to minimize the impacts of nutrient enrichment on water quality and the environment. This includes maintaining an effective wastewater treatment facilities and promoting best management practices to reduce nutrient inputs

By monitoring and understanding the fluctuations in FRP and TP levels, appropriate actions can be taken to improve nutrient management, reduce the risk of algal blooms and eutrophication, and protect the health of aquatic ecosystems. Collaboration between wastewater treatment facilities, regulatory bodies, and stakeholders is crucial to implement sustainable nutrient management strategies and ensure the long-term health and sustainability of water resources.

Efforts by Power and Water Corporation to control and manage FRP and TP levels in effluent discharge helps mitigate the impacts of nutrient enrichment on aquatic ecosystems, protect water quality, and support the health of surrounding vegetation and the broader environment.

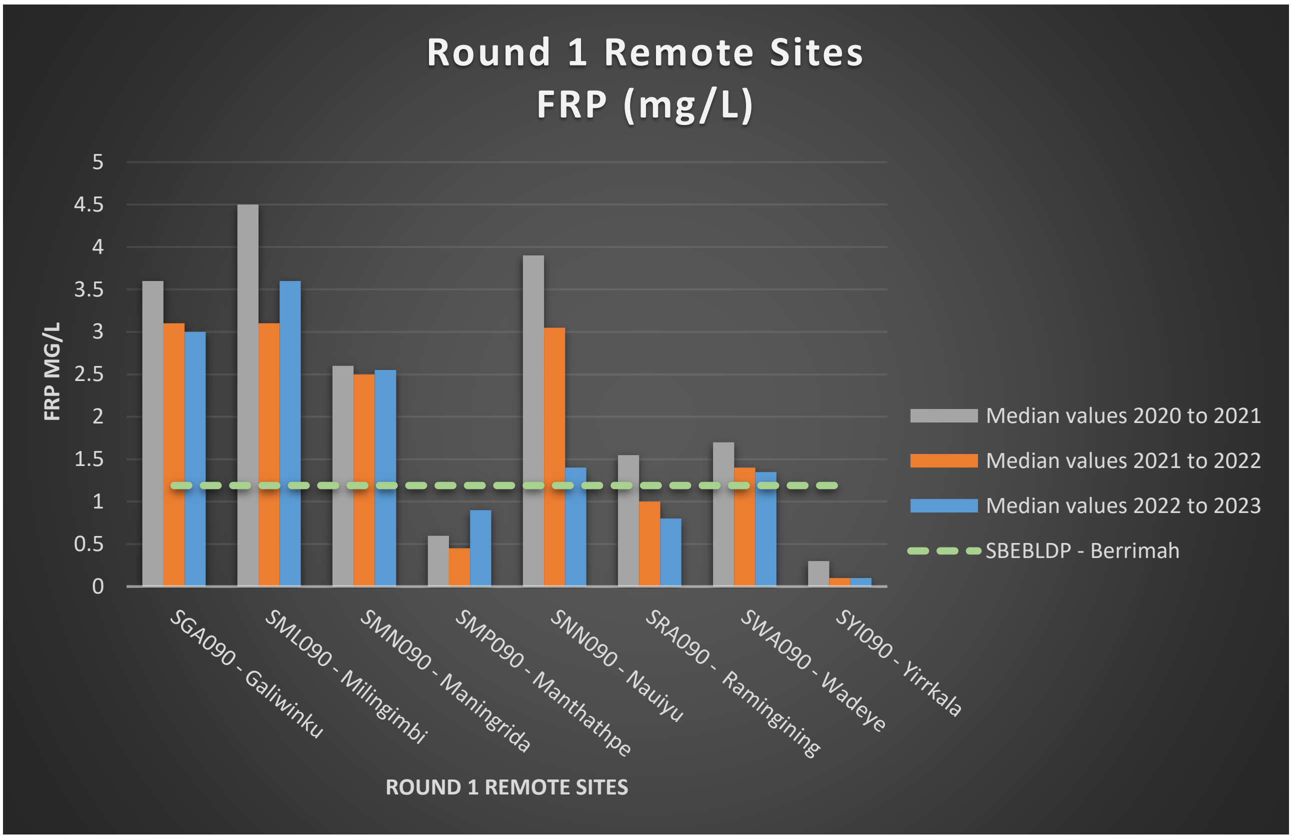

Figure 20. Filterable Reactive Phosphorus: Round 1 Remote Sites

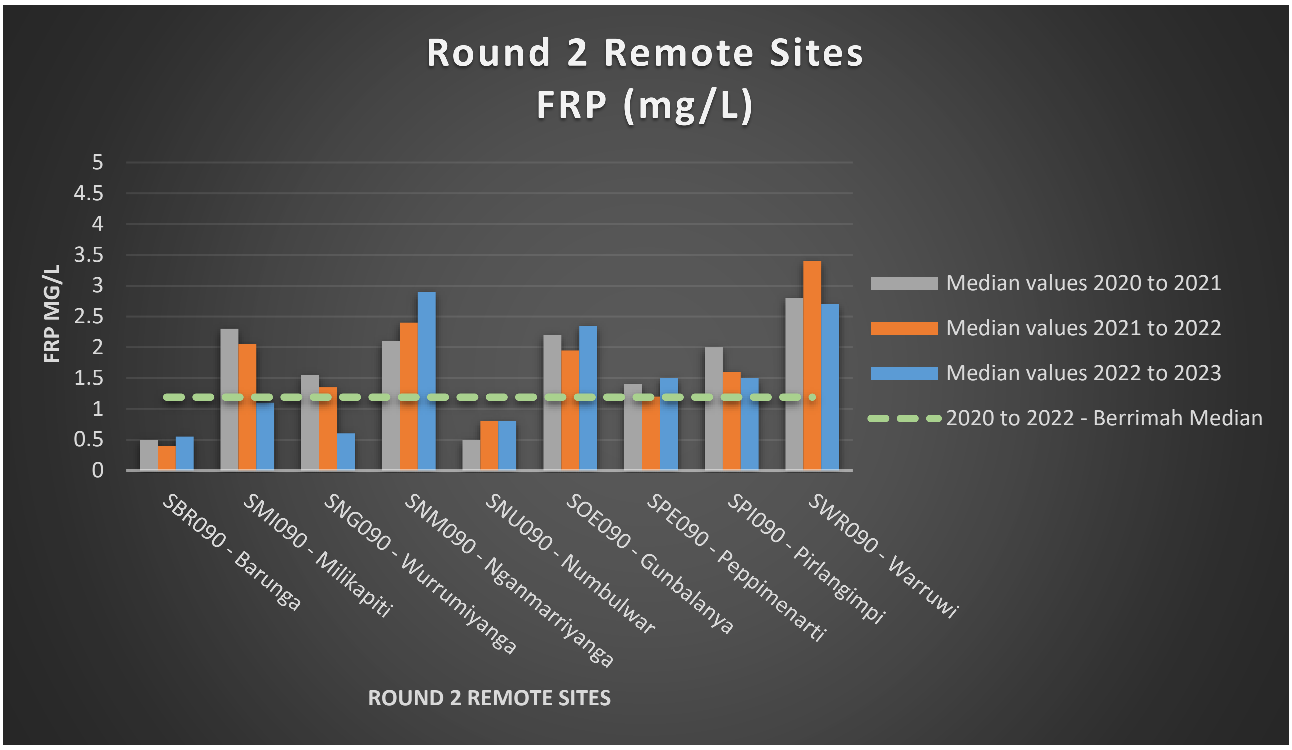

Figure 21. Filterable Reactive Phosphorus: Round 2 Remote Sites

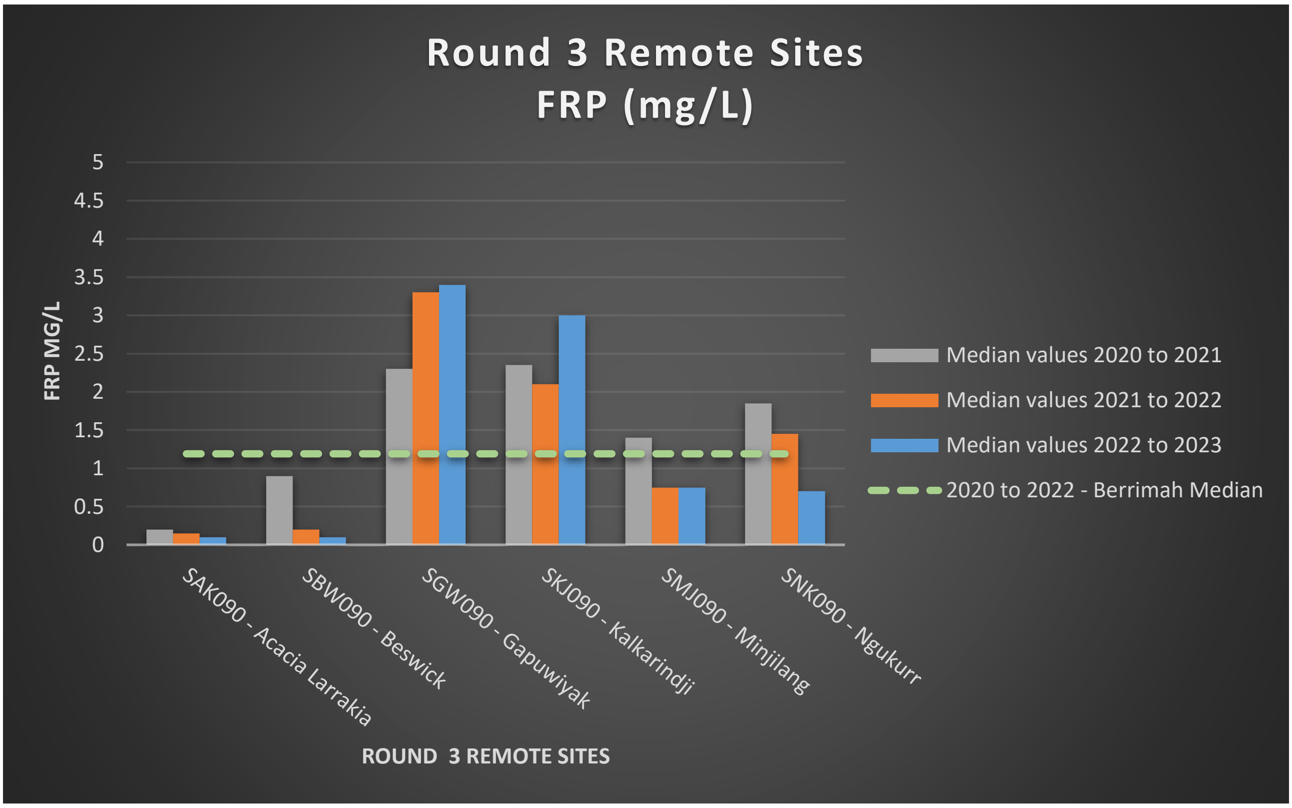

Figure 22. Filterable Reactive Phosphorus: Round 3 Remote Sites

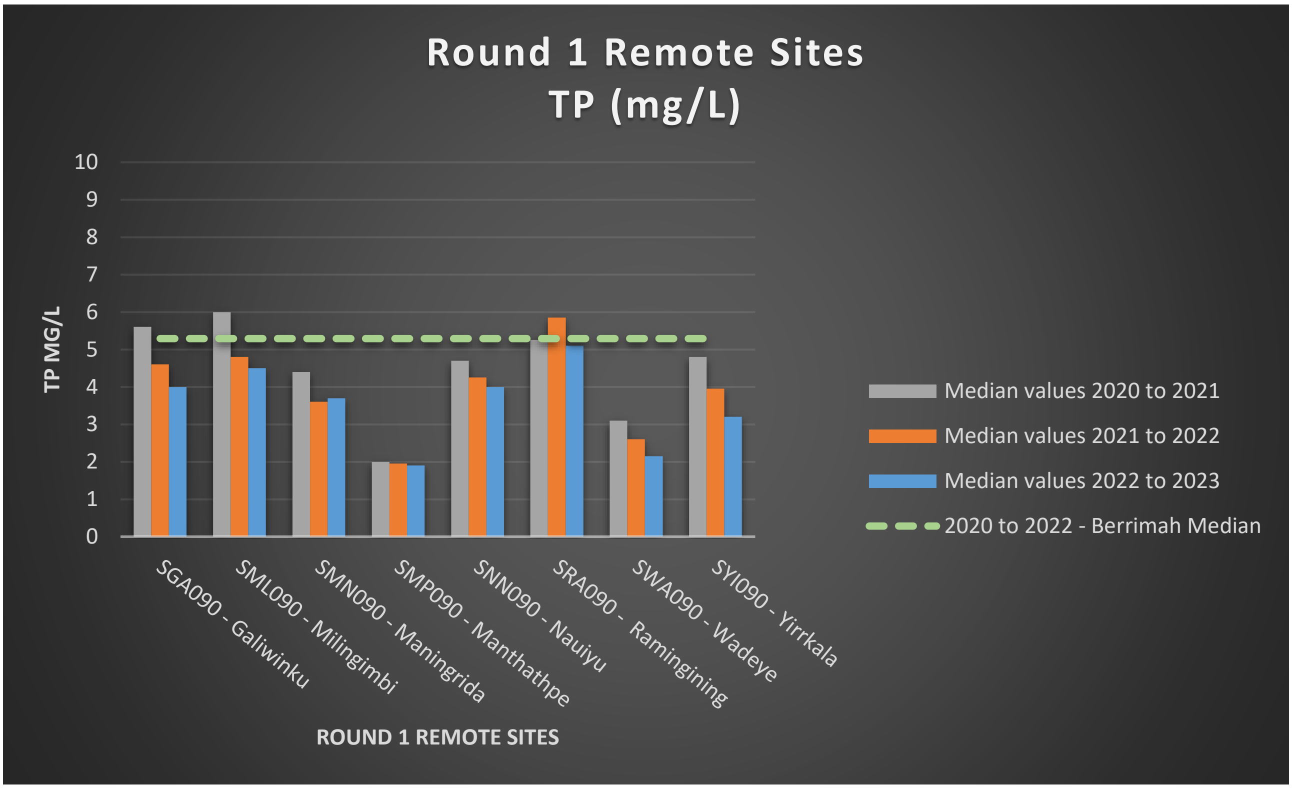

Figure 23. Total Phosphorus: Round 1 Remote Sites

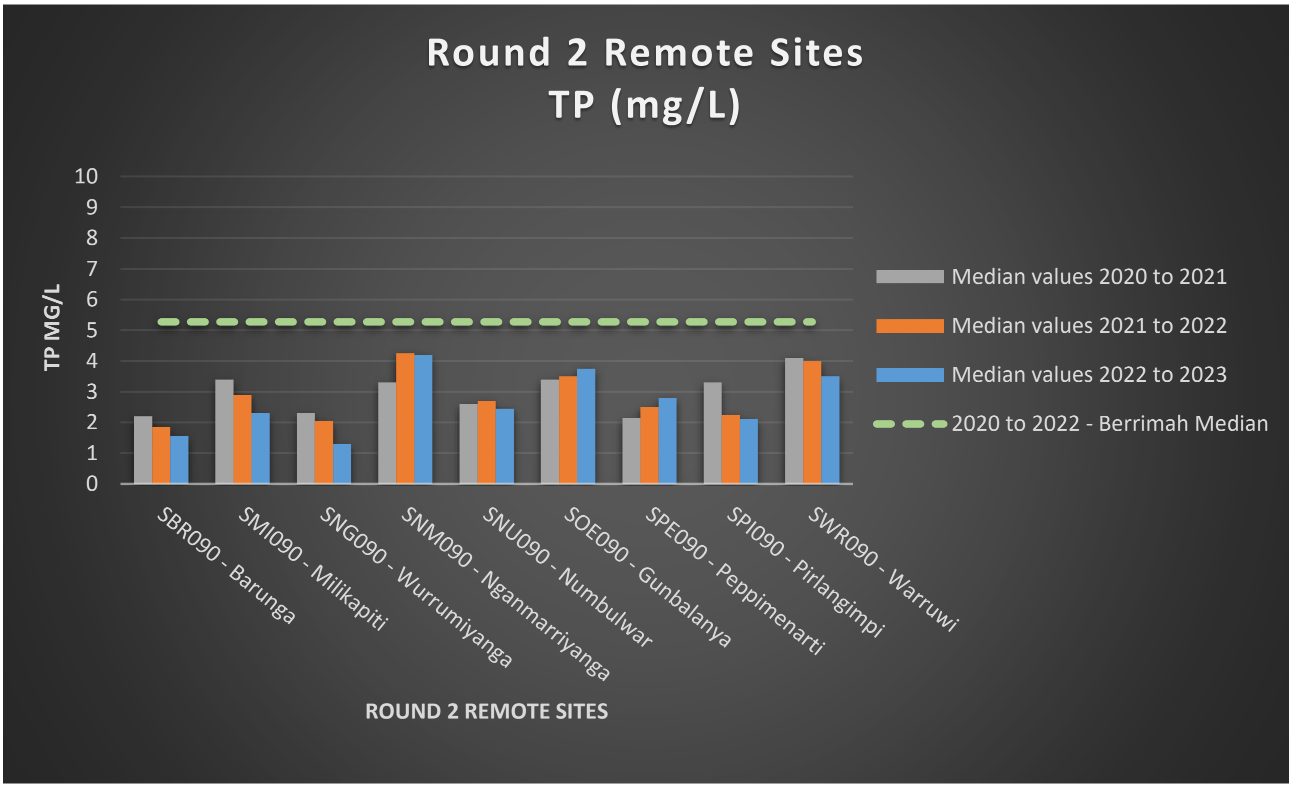

Figure 24. Total Phosphorus: Round 2 Remote Sites

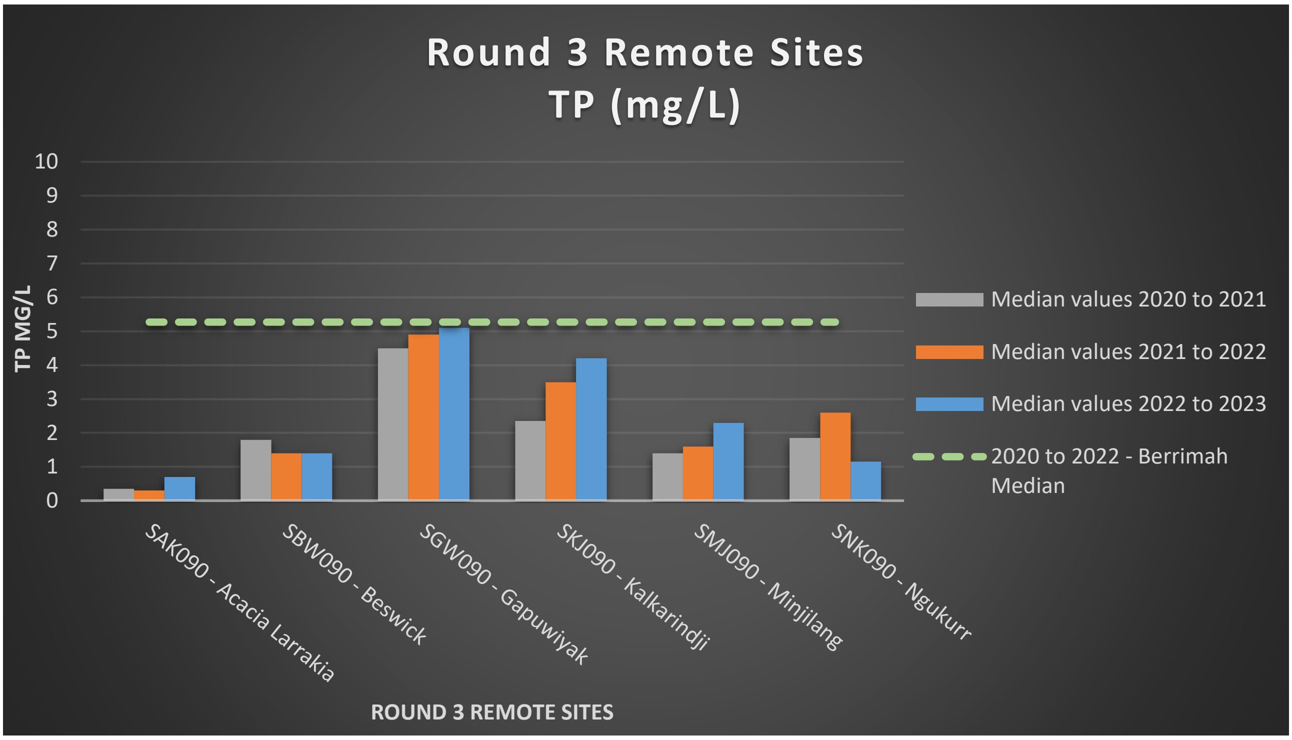

Figure 25. Total Phosphorus: Round 3 Remote Sites

Bacteriological

E. coli

E. coli levels in the sewage ponds effluents of Milingimbi, Nauiyu, and Nganmarriyanga have been consistently high but have shown a decreasing trend in the last three years, while the levels at other sites are fluctuating, the following points can be considered:

1. Effluent Treatment Improvements: The decreasing trend in E. coli levels in Milingimbi, Nauiyu, and Nganmarriyanga suggests that the sewage pond treatment processes have been effective in reducing bacterial contamination over time. This indicates that management to the treatment system have contributed to the reduction in E. coli levels. Continuing to evaluate and optimize the treatment processes at these sites can help maintain the decreasing trend.
2. Operational Best Practices: Consistently high E. coli levels in sewage pond effluent may indicate the need for strict adherence to operational best practices. This includes regular maintenance, proper sludge management, and adherence to recommended operating parameters. Implementing robust operational procedures and conducting regular training for operators can help ensure consistent and effective treatment performance.
3. Monitoring and Reporting: Ongoing monitoring and reporting of E. coli levels in sewage pond effluent are essential to track the effectiveness of treatment measures and identify any variations or trends. Regular sampling and analysis is conducted to ensure compliance with relevant guidelines and regulatory requirements. The data obtained from monitoring can provide valuable insights for further improvement of the treatment processes and overall management of the sewage ponds.
4. Knowledge Sharing and Collaboration: Sharing experiences and knowledge with other sewage pond facilities facing similar challenges can be beneficial. Collaborating with experts, researchers, and

regulatory bodies can help exchange best practices, innovative solutions, and lessons learned in reducing E. coli levels in sewage pond effluent.

By continuously improving treatment processes, implementing operational best practices, controlling contamination sources, monitoring performance, and fostering collaboration, it is possible to maintain the decreasing trend of E. coli levels in the sewage pond effluent of Milingimbi, Nauiyu, and Nganmarriyanga. This will contribute to the protection of the environment by ensuring the safe discharge of treated effluent into the receiving waters and environment.

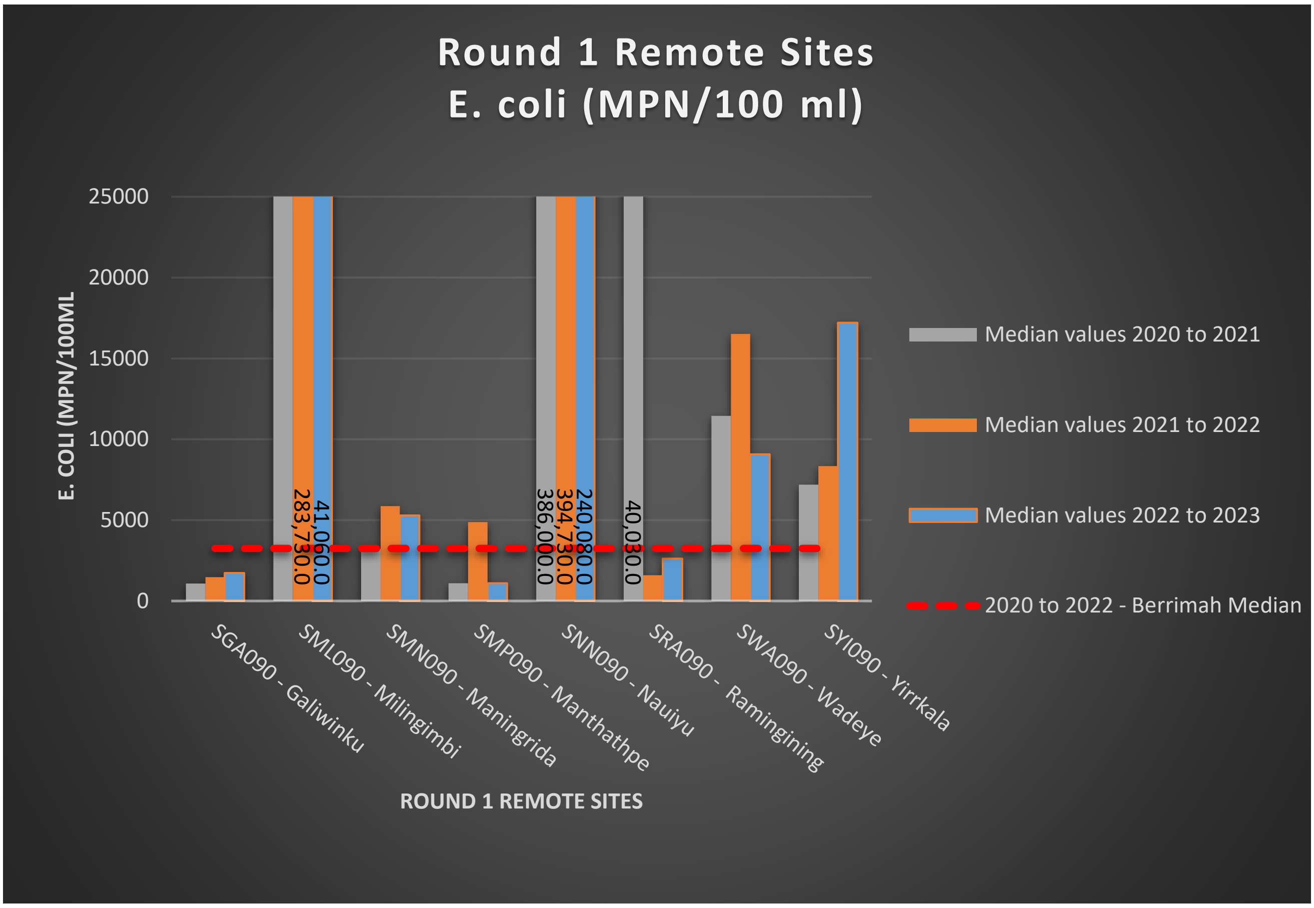

Figure 26. E. coli: Round 1 Remote Sites

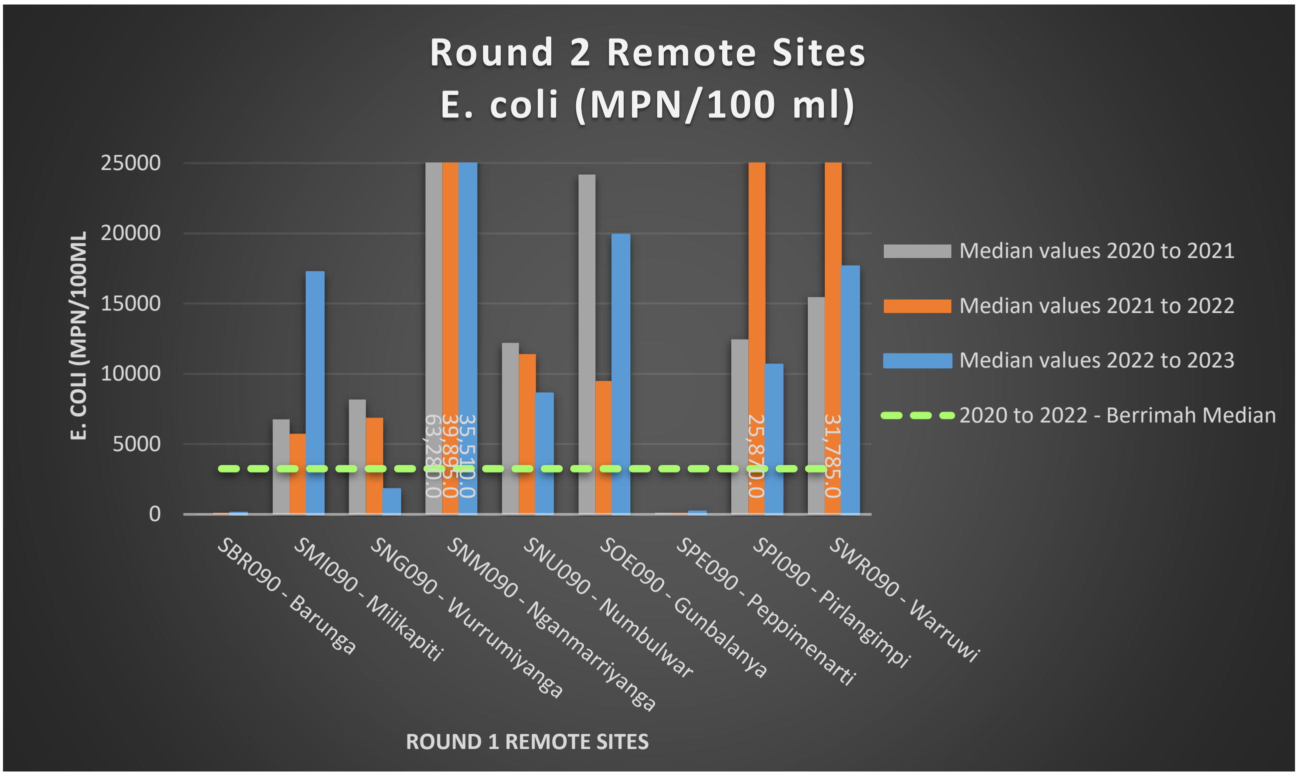

Figure 27. E. coli: Round 2 Remote Sites

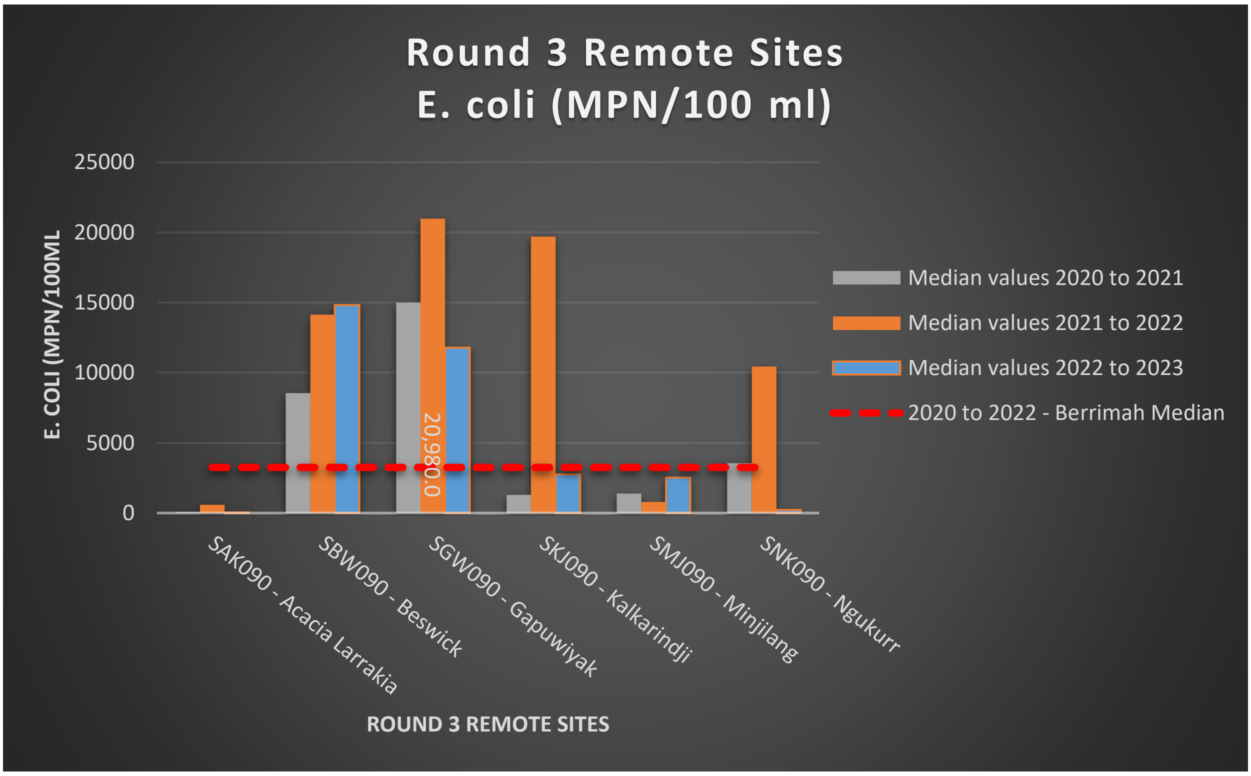

Figure 28. E. coli: Round 3 Remote Sites

Enterococci

The monitoring of Enterococci levels in sewage ponds at various locations has provided valuable insights into their trends and fluctuations over the past three years. Notably, at Nauiyu, Ramingining, Gapuwiyak, Minjilang, and Ngukurr, a consistent decrease in Enterococci levels has been observed. This decline indicates a positive trend in the reduction of Enterococci, which is an encouraging sign of improved water quality in these areas. The efforts and measures implemented to manage and treat sewage ponds at these sites have proven effective in reducing the presence of Enterococci.

In contrast, Nganmarriyanga and Gunbalanya have experienced an increase in Enterococci levels during the same period. This rise can be attributed to various factors, including weather conditions and other environmental influences that can impact the functioning of sewage ponds. It is essential to thoroughly investigate and assess these contributing factors to identify potential remedial actions that can help mitigate the increase in Enterococci levels in these locations. By addressing these factors and implementing appropriate measures, it is possible to bring about a decline in Enterococci and restore the water quality to acceptable levels.

At the remaining monitored sites, Enterococci levels have shown fluctuations within an acceptable range of change. This suggests a relatively stable situation, where the variations in Enterococci are within manageable limits. However, continuous monitoring and regular assessments are necessary to ensure that these fluctuations do not escalate and affect the overall water quality of the sewage discharge.

The presence of Enterococci in sewage ponds can have implications for the receiving environment. Enterococci serve as indicators of fecal contamination, and their elevated levels in discharged effluent can pose risks to both water quality and public health. Therefore, it is crucial to maintain diligent monitoring, adhere to proper wastewater treatment protocols, and implement measures to minimize the impact of sewage ponds on the receiving environment. Through ongoing efforts, such as, optimized operational conditions, and environmental management strategies, it is possible to achieve further reductions in Enterococci levels and ensure the overall health and sustainability of the sewage pond systems.

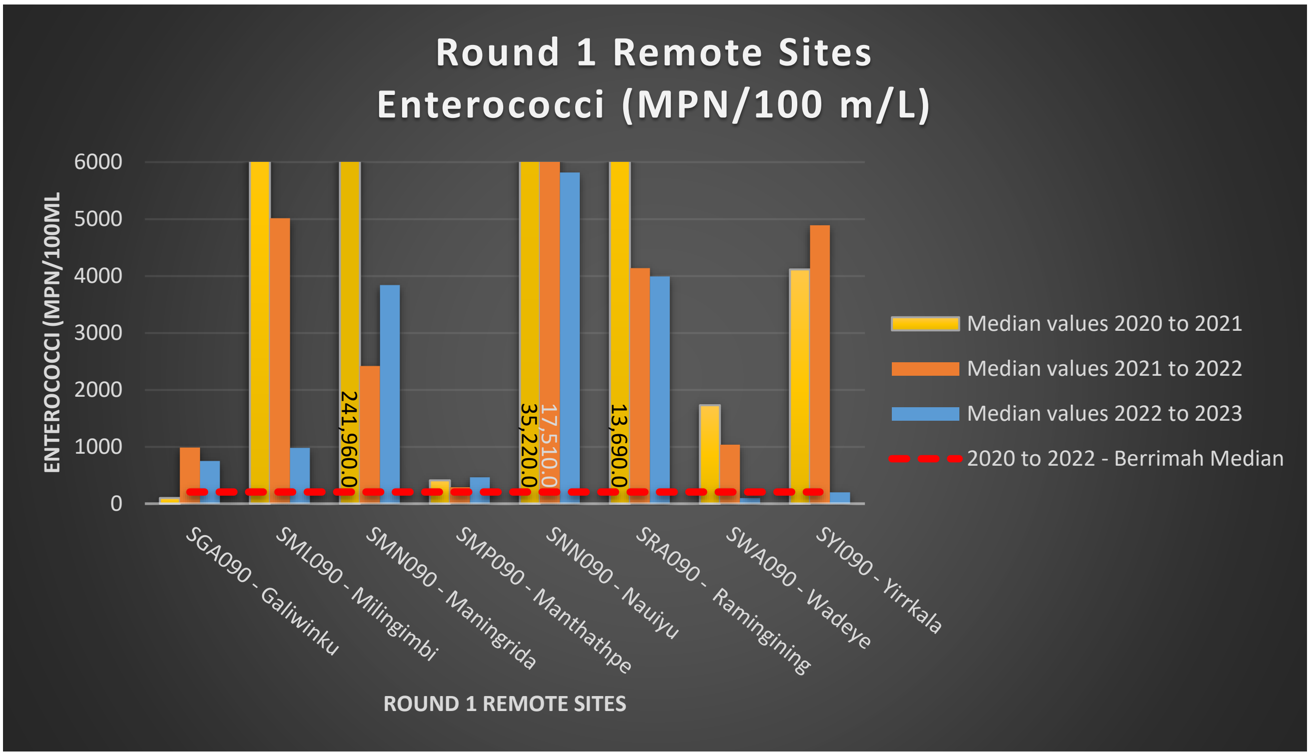

Figure 29. Enterococci: Round 1 Remote Sites

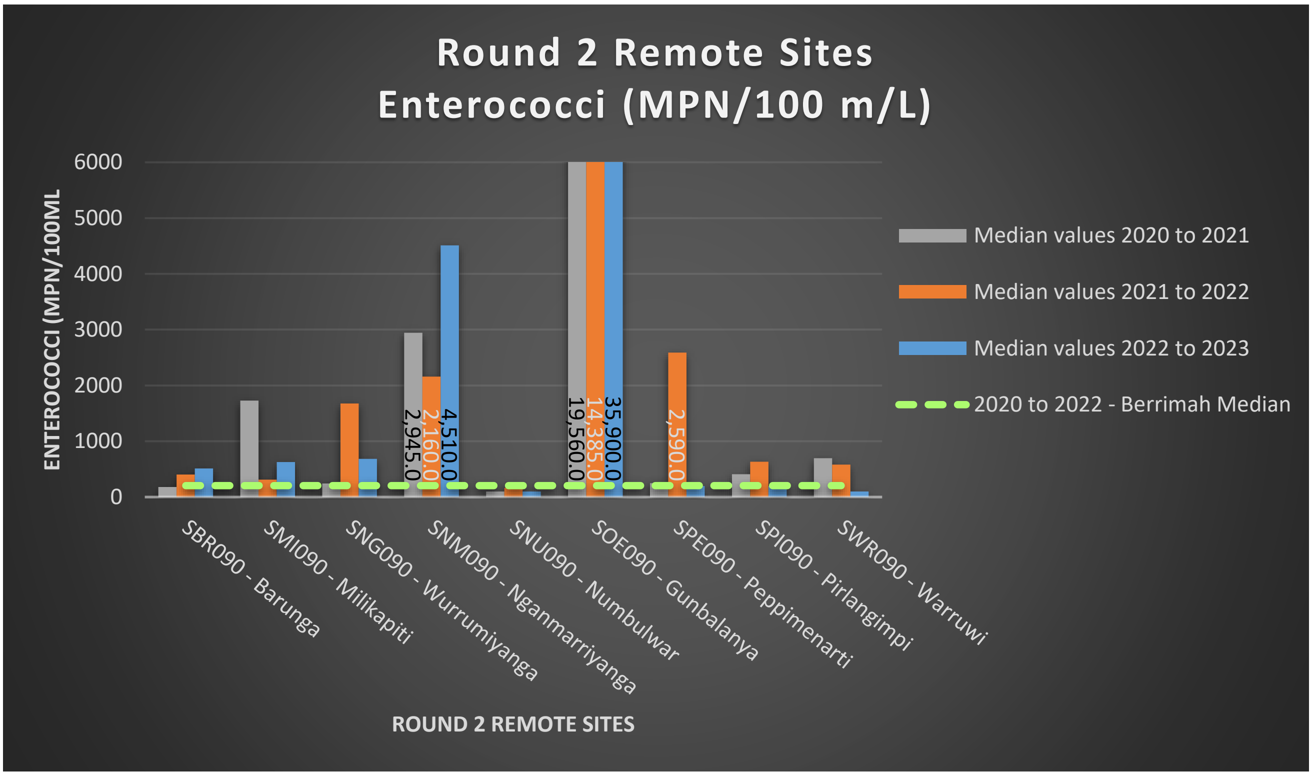

Figure 30. Enterococci: Round 2 Remote Sites

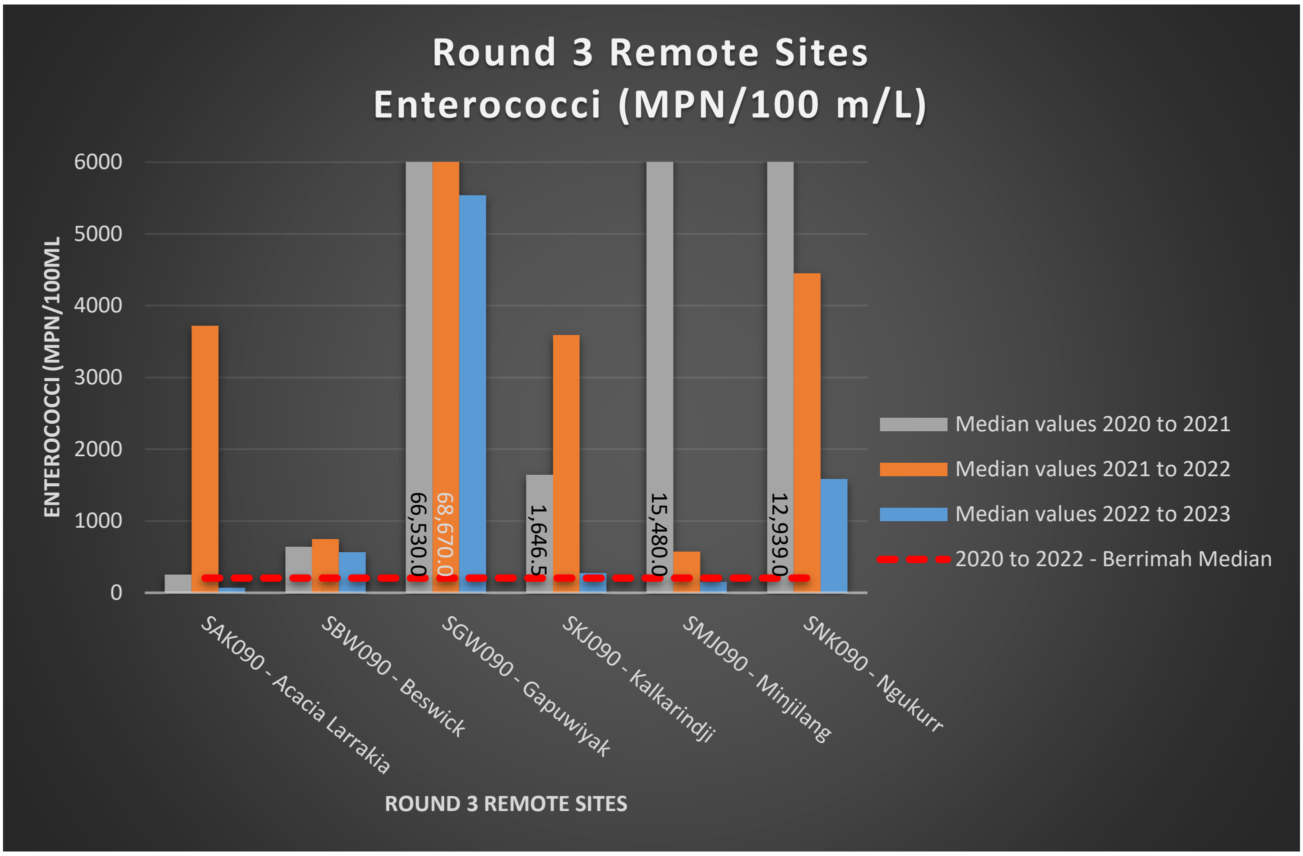

Figure 31. Enterococci: Round 3 Remote Sites

Surface Water (Belyuen – Woods Inlet)

Surface water monitoring was initiated at Woods Inlet in mid-2019 to monitor the discharge from the Belyuen Wastewater Stabilization Ponds (WSPs) in accordance with WDL 215-1 conditions. Woods Inlet, classified as a tidal brackish creek, is recognized as an upper estuary within the Darwin Harbour Region (DENR, 2019). The monitoring results have been reviewed against the Water Quality Objectives established for the Darwin Harbour Region to facilitate the development of site-specific trigger values for this location (Condition 34). It is important to note that these water quality objectives are applicable exclusively during the Dry Season, spanning from May to October (DENR, 2019).

For the purpose of this report, the focus is primarily on the preliminary results obtained thus far, rendering long-term and seasonal trending unsuitable at this stage. It is necessary to accumulate additional data to enable a more accurate assessment in the future. Therefore, ongoing data collection will continue to contribute to a comprehensive evaluation of the water quality conditions at Woods Inlet and aid in refining the understanding of its environmental status.

The monitoring data for the Belyuen Wastewater Stabilization Pond (WSP) indicates that the pH levels have consistently remained within the Site Specific Trigger Values (SSTV) specified in the WDL throughout the 2022-2023 period (Figure 32). It is worth mentioning that in previous years, specifically in December 2020 and February 2021, the recorded pH values fell below the 6.5 pH unit mark. However, when considering the Turbidity Sensor's (Hach 2100Q Portable Turbidimeter) margin of error, which is 5%, these values would still fall within the acceptable pH range according to the SSTV.

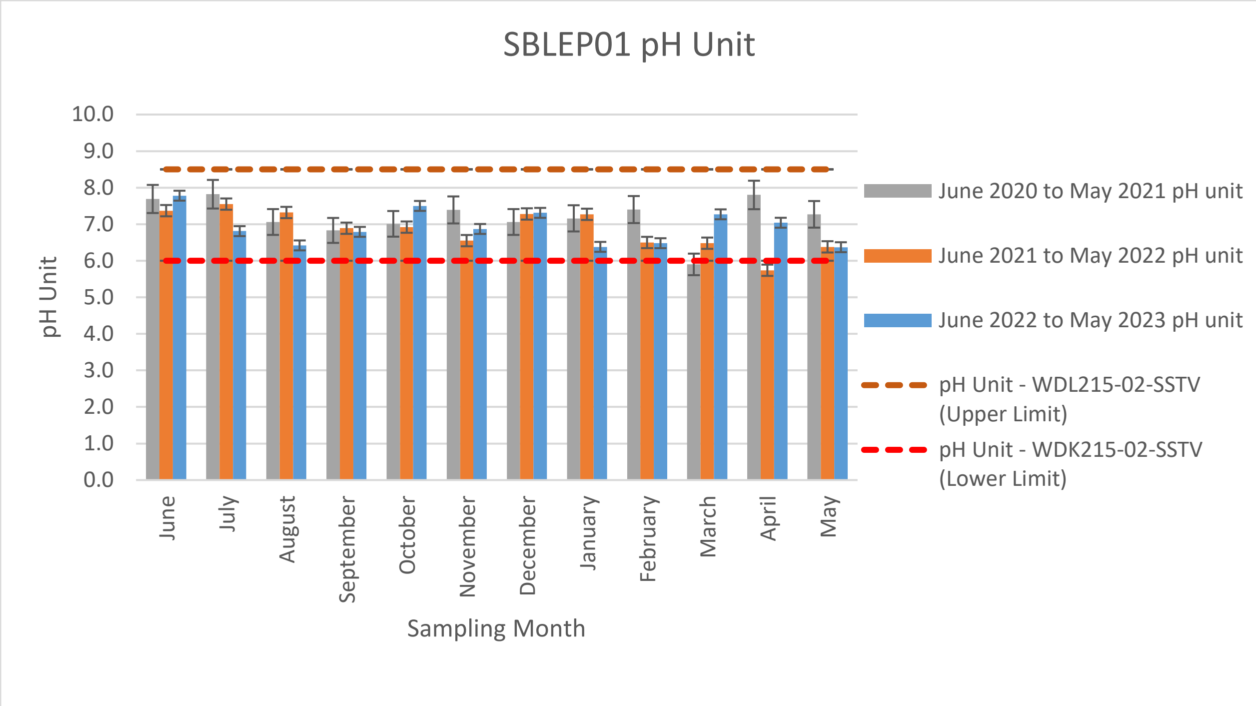

Figure 32. pH: Belyuen - Woods Inlet

Moving on to the Total Suspended Solids (TSS) analysis at the Belyuen WSP, a correlation was observed between TSS levels and the total monthly rainfall data (Figure 33). The increase in TSS levels coincided with the initial rain events of the wet season. During these rain events, sediments and other materials from the surrounding area can become mobilized and contribute to higher concentrations of suspended solids during sampling events.

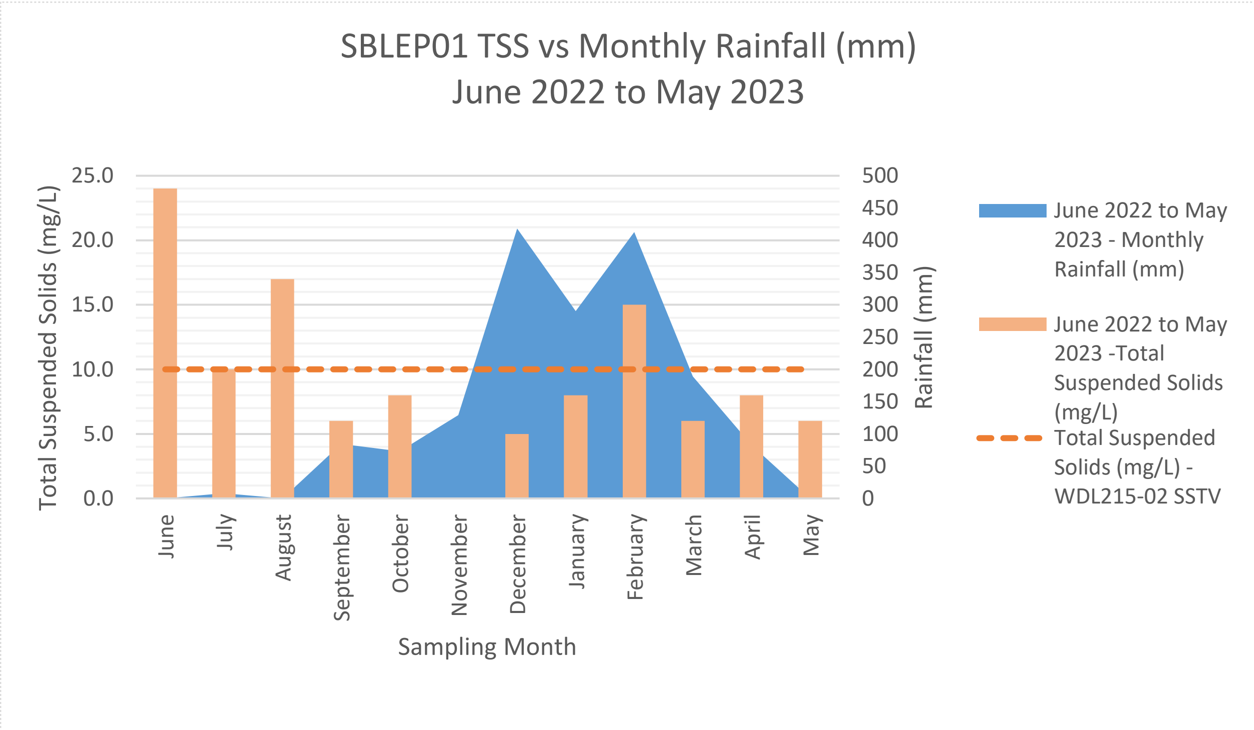

Figure 33. Belyuen-Woods Inlet TSS vs June 2022 to May 2023 Rainfall (mm)

It's important to note that peak tidal movement can also influence TSS results. However, when samples are collected during periods of neap tides or low tidal movement, the effect of tidal movement on TSS levels is less significant. Nevertheless, there were scheduled sampling events that coincided with high tidal movements, which may explain the elevated TSS results observed during the middle of the Dry Season or months with low/no rainfall activity. Sometimes, due to laboratory closure and sample transportation constraints, it becomes unavoidable to collect samples during peak flow levels of tidal movement.

To establish a correlation in monitoring results, a comparison was conducted between the TSS values and the discharge point (Belyuen Pond Outlet/Discharge) and the environmental monitoring point (Belyuen - Woods Inlet) (Figure 34). The results from June 2022 to May 2023 indicated an inversely proportional relationship, suggesting that the effluent from the WSP had no significant effect on the TSS values in the receiving environment.

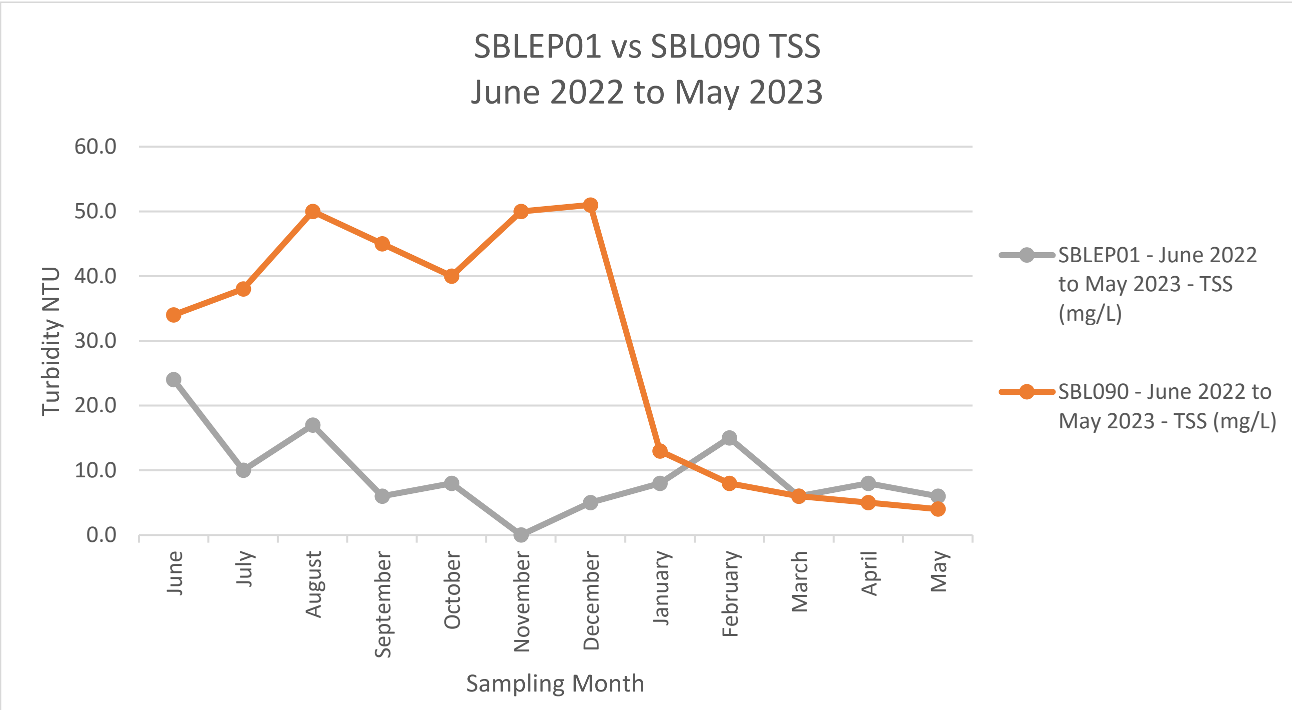

Figure 34. Belyuen - Woods Inlet vs Belyuen WSP Discharge Point TSS

Shifting the focus to ammonia levels, it is positive to note that ammonia levels in Belyuen were generally low during the 2022-2023 monitoring period (Figure 35). Although there were instances where ammonia levels outside the SSTV, it is important to consider the context of WSP discharge. If the WSPs were not discharging during those periods, it suggests that the elevated ammonia levels is not directly attributed to effluent discharge from the WSPs.

Additionally, during the period from July to October 2022, the reported values were below the laboratory limit of reporting, indicating that the measured ammonia levels during that time were below the detection limit of the laboratory's analytical method. In such cases, the reported values would be considered as below the limit of detection rather than 0.005 mg/L (Ammonia). It is essential to understand the analytical limitations and interpretation of data when dealing with lower or undetectable concentrations.

PowerWater

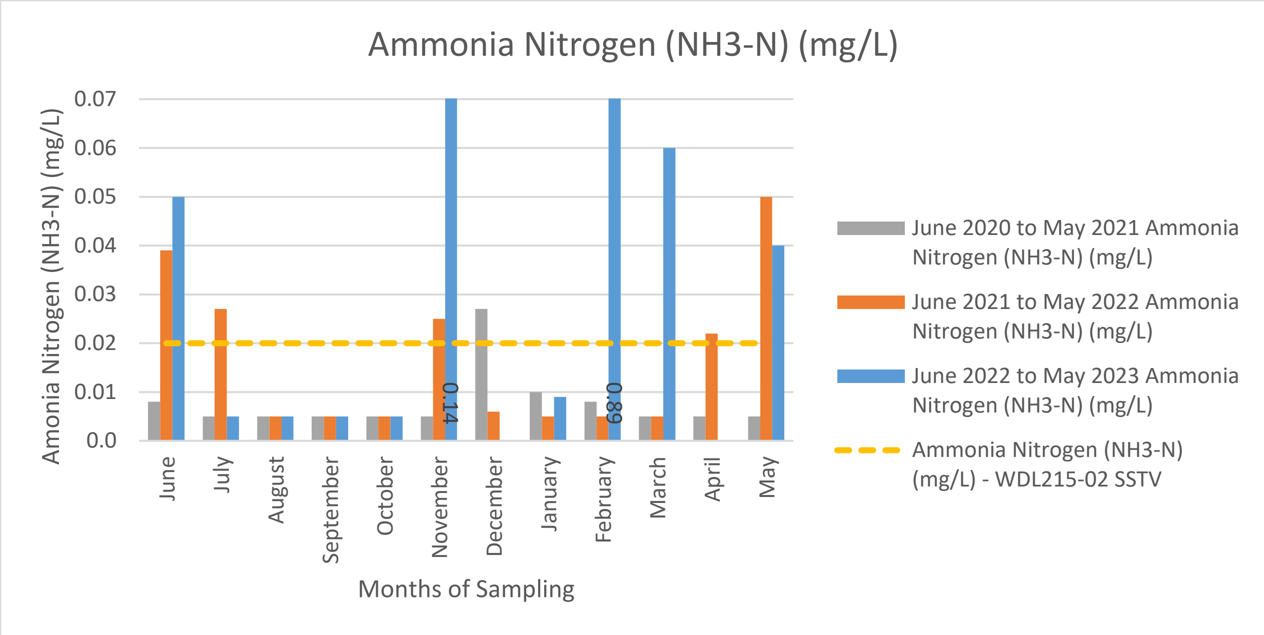

Figure 35. Ammonia: Belyuen - Woods Inlet

Total Nitrogen levels, the monitoring data indicates a decreasing trend at the Belyuen - Woods Inlet Monitoring Point compared to the previous two years of monitoring (Figure 36). This decline in Total Nitrogen levels suggests an improvement in the efficiency of nitrogen introduction and removal processes within the Belyuen – Woods Inlet receiving environment.

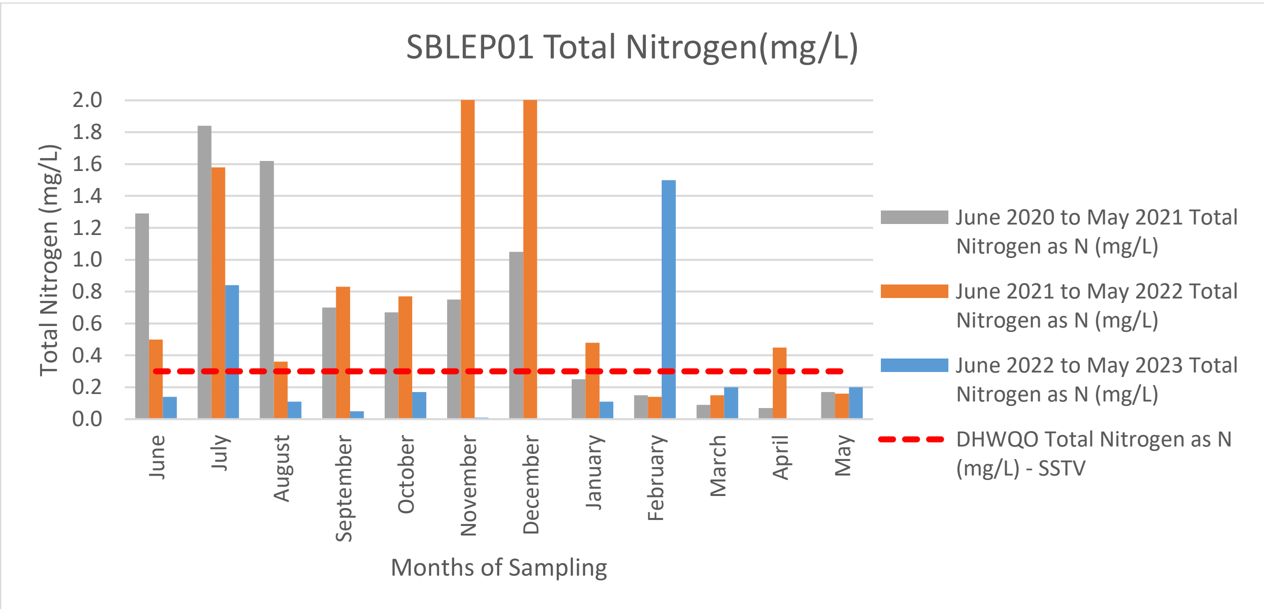

Figure 36. TN: Belyuen Woods Inlet

While there were two sampling occasions in July 2022 and February 2023 where the Total Nitrogen levels were above the SSTV, it is important to consider the specific circumstances surrounding these elevated readings. In particular, during the ten days leading up to the sampling, the Belyuen WSP was not discharging effluent into the environment.

Analysing the Filterable Reactive Phosphorus levels at Belyuen, there is a decreasing trend observed when compared to previous years of monitoring (Figure 37).

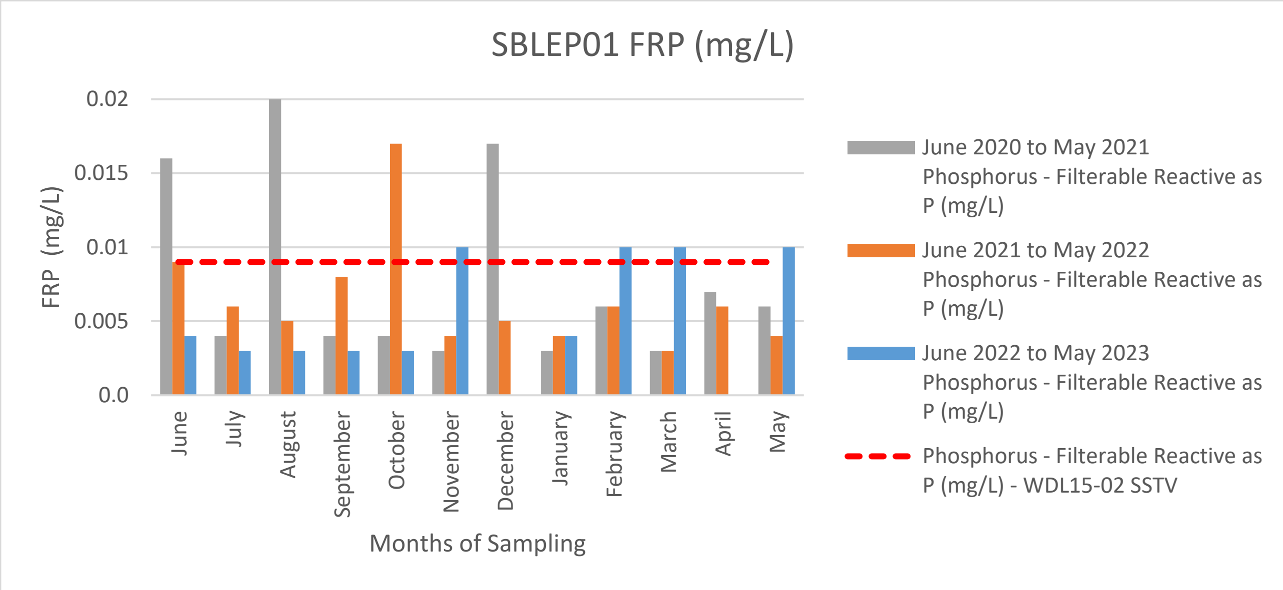

Figure 37. FRP: Belyuen - Woods Inlet

Although there were instances where the Filterable Reactive Phosphorus levels exceeded the SSTV, these occurrences can be attributed to higher limit of reporting values by the laboratories due to variations in the analysis methodology employed. It is essential to consider these factors when interpreting the data and understanding the overall phosphorus dynamics.

The levels of total phosphorus in the Belyuen WSP have generally remained below the SSTV. However, it is worth noting that there were instances where the total phosphorus levels exceeded the SSTV, specifically in November 2022 and February 2023 (Figure 39).

The elevated total phosphorus levels observed during these months can be attributed to weather conditions prevailing at the time of sampling. Weather factors such as increased rainfall or runoff can lead to higher phosphorus concentrations in the wastewater entering the pond system. These fluctuations highlight the influence of external factors on total phosphorus levels and demonstrate the need to consider seasonal variations when interpreting the data.

When comparing the month-to-month and year-to-year data over the past three years of monitoring, a fluctuating trend in total phosphorus levels can be observed. This variability may be attributed to various factors, including changes in weather patterns, variations in storm water and tidal water composition.

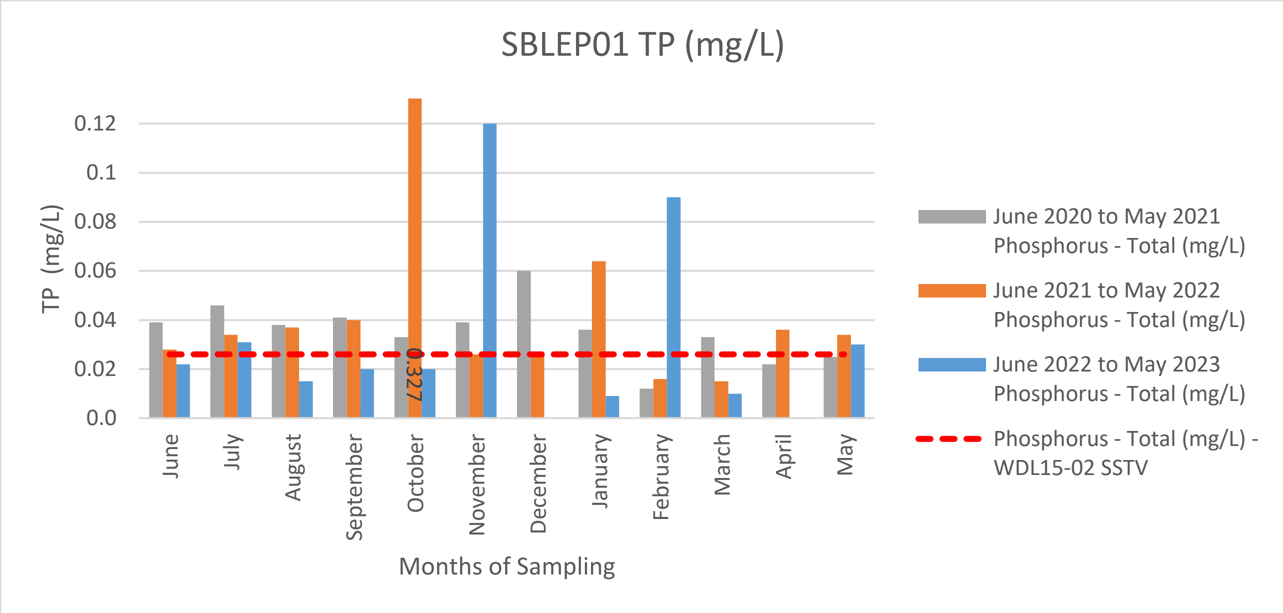

Figure 38. Total Phosphorus: Belyuen – Woods Inlet

The observed E. coli levels in Woods Inlet during the wet season have shown a decreasing trend compared to previous years (Figure 39).

During the wet season, higher E. coli levels in Woods Inlet can be attributed to various factors:

1. Increased Runoff: The wet season typically brings heavy rainfall, leading to increased runoff from the surrounding land into water bodies like Woods Inlet. This runoff can carry contaminants, including fecal matter, from various sources such as agricultural areas, urban areas, and wildlife habitats, which can contribute to higher E. coli levels.

2. Wildlife Contributions: Wildlife, including birds and mammals, can also contribute to the higher E. coli levels during the wet season. Birds, in particular, may gather in water bodies during the wet season, and their fecal matter can introduce E. coli bacteria into the environment.

3. Human Activities: Human activities, such as recreational use of water bodies or improper sanitation practices, can also contribute to E. coli contamination during the wet season. Activities like swimming, boating, or camping near water bodies can introduce fecal matter into the environment.

Regarding results outside SSTV (E. coli) during the wet season, even if the sewage pond is not discharging, it is important to consider that external sources of contamination can still contribute to the E. coli levels in Woods Inlet. These sources, as mentioned earlier, include runoff from surrounding areas, wildlife, and human activities. It is crucial to identify these external sources to better understand contamination and increased E. coli levels during the wet season.

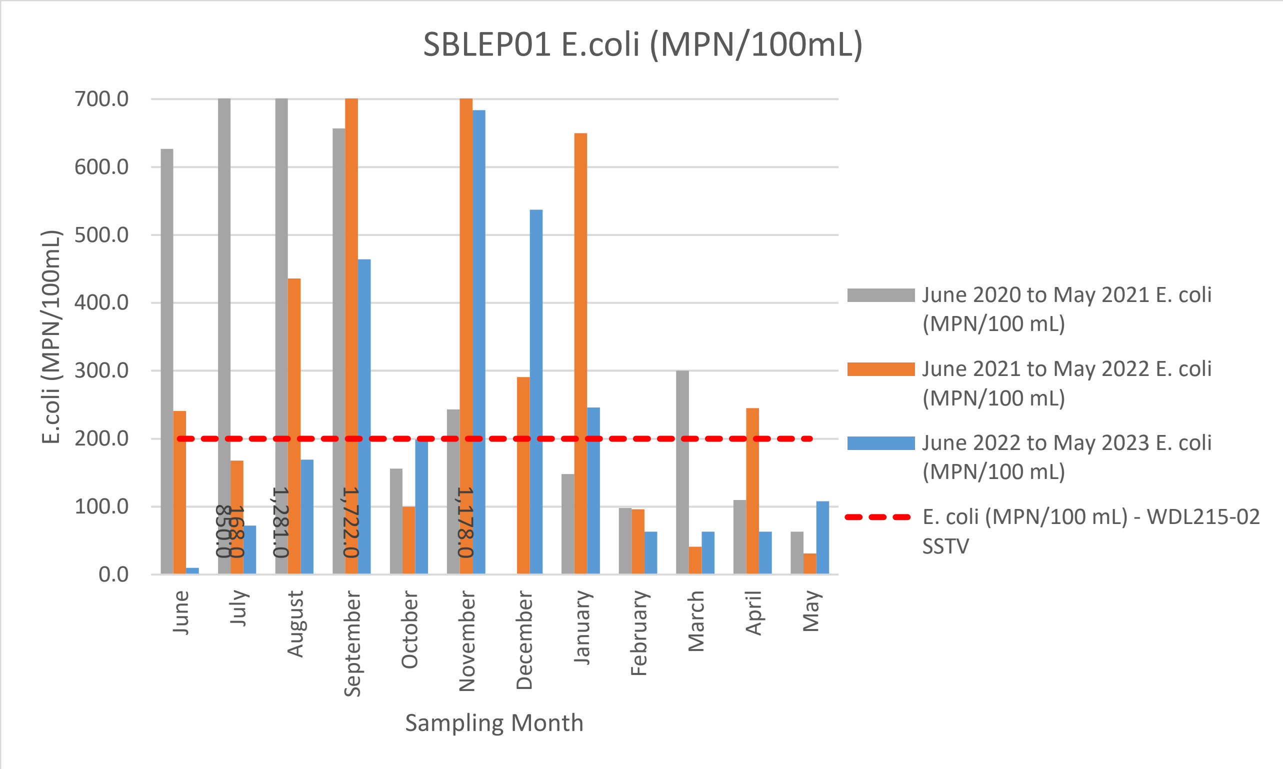

Figure 39. E. coli: Belyuen – Woods Inlet

The Enterococci levels in Belyuen-Woods Inlet have generally remained within the SSTV, with the exception of the months of December 2022 and April 2023 (Figure 40). These deviations from the SSTV can be attributed to environmental and weather factors, particularly during December 2022 when the area experienced significant rainfall. The heavy rainfall likely resulted in runoff and increased microbial loads entering the inlet, leading to higher Enterococci levels.

Overall, there is a noticeable fluctuating trend in the Enterococci levels at Belyuen-Woods Inlet, which is closely linked to weather conditions and tidal movement during and prior to sampling. It is important to consider the influence of these factors as they can significantly impact the microbial dynamics in the monitoring site. Weather events such as rainfall, storms, and tidal variations can affect the dilution, transport, and dispersal of microorganisms in the water. These fluctuations highlight the dynamic nature of the aquatic environment and the need for continuous monitoring and assessment to capture the variations in Enterococci levels accurately.

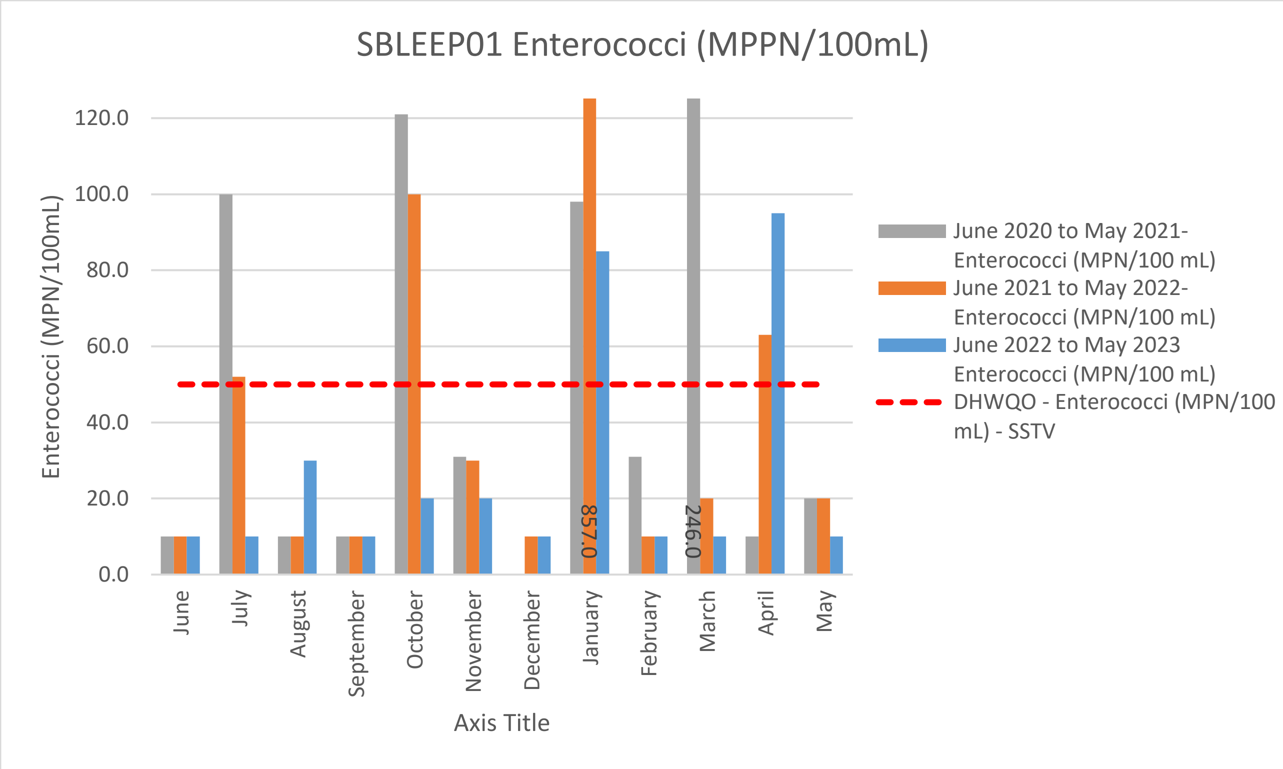

Figure 40. Enterococci: Belyuen – Woods Inlet

Environmental Impacts Summary

Environmental Risk Assessments (ERAs) play a crucial role in evaluating and managing potential environmental risks associated with wastewater discharge from remote community wastewater treatment facilities. In accordance with license conditions, ERAs have been conducted and issued for each of the remote community WDLs. These assessments provide site-specific information and evaluate the potential environmental risks and impacts associated with the wastewater discharges. They also develop conceptual site models to understand the potential pathways and receptors through which the discharges may interact with the environment.

The ERAs provide a comprehensive analysis of the potential environmental impacts of the wastewater discharges. They consider factors such as the characteristics of the wastewater, the receiving environment, and the sensitivity of the surrounding ecosystems. The assessments identify potential risks, such as the presence of pollutants or excessive nutrient loads, and evaluate the likelihood and magnitude of their effects on the environment.

To complement the findings of the ERAs, visual observations have been conducted at each of the remote community wastewater discharge sites. These observations serve as a qualitative assessment of the environmental conditions and help verify the absence of deleterious effects caused by the discharges. The visual inspections involve on-site visits to assess the condition of the waterways and surrounding vegetation.

Based on these visual observations, there have been no indications that the wastewater discharges are causing any immediate or noticeable deleterious effects on the receiving environments. No gross pollutants, fish kills, or impacts on surrounding vegetation have been observed or reported. The waterways at each of the receiving sites visually appear to contain healthy levels of fish and aquatic invertebrates, indicating that the discharges are not adversely impacting the aquatic ecosystems.

These findings provide assurance that the wastewater treatment facilities in the remote communities are effectively managing the environmental risks associated with their discharges. The ERAs and visual observations demonstrate a commitment to environmental stewardship and compliance with regulatory standards, ensuring that the wastewater discharges do not pose significant harm to the receiving environments. Continuous monitoring and assessment will remain essential to identify any potential changes or emerging risks in the future and take appropriate actions to mitigate them.

Figure 41. Effluent warning signage at Nauiyu DP (PWC, 2022)

Appendix A – List of Remote Community WDLs

Community	WDL	Monitoring Point Site Code	Licence Expiry
	Round 1		
Manthathpe	201-3	SMP090	Surrendered - pending approval
Galiwinku	202-3	SGA090	11/07/2028
Maningrida	203-3	SMN090	11/07/2028
Yirrkala	204-3	SYI090	11/07/2028
Wadeye East	205-3	SWA090	11/07/2028
Ramingining	206-3	SRA090	11/07/2028
Nauiyu	207-3	SNN090	11/07/2028
Milingimbi	208-3	SML090	11/07/2028
	Round 2		
Barunga	214-2	SBR090	Licence renewal application submitted (20/04/2023), pending approval.
Belyuen	215-2	SBLEP01	
Gunbalunya	216-2	SOE090	
Milikapiti	217-2	SMI090	
Numbulwar	218-2	SNU090	
Nganmarriyanga	219-2	SNM090	Surrendered - pending approval
Peppimenarti	220-2	SPE090	Licence renewal application submitted (20/04/2023), pending approval.
Pirlangimpi	221-2	SPI090	
Warruwi	222-2	SWR090	
Wurrumiyanga	223-2	SNG090	
	Round 3		
Acacia Larrakia	225-2	SAK090	11/12/2031
Beswick	228-2	SBW090	11/12/2031
Gapuwiyak	230-2	SGW090	11/12/2031
Kalkarindji	231-2	SKJ090	11/12/2031
Minjilang	233-2	SMJ090	11/12/2031
Ngukurr	234-2	SNK090	11/12/2031

Appendix B – Tabulation of Monitoring Results – Treated Effluent

POWER AND WATER CORPORATION WDL Monitoring Report – Remote Community WDLs		
Remote Community WDL Summary Data Sheet	All samples collected are in accordance with Appendix 1 of the WDL's. Data is extracted from the PWC water quality database for assessment and filed on the PWC records management system. A tabulated summary of all year's wastewater monitoring data for remote community WDLs is completed and provided as Appendix B, attached as an Excel file format to the submission of this annual monitoring report.	Internal document number D2023/301436

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