

Ludmilla Wastewater Treatment Plant WDL 150-08

MONITORING REPORT

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Document Details and History

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[Cover photographs](#)

East Point Outfall and effluent channel formed at extreme low tide (outfall at centre of photo):
PWC collection

Abbreviations and Glossary

Abbreviation	Definition
Al	Aluminium
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
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
Cu	Copper
Cu-B	Bioavailable copper in sediment (estimated by dilute acid extraction)
Cu-F	Copper filtered (dissolved fraction)
Cu:Al	Total copper in sediment normalised to total aluminium content of the sediment
Cu-T	Total copper in sediment
DHWQO(s)	Darwin Harbour water quality objective(s)
DO	Dissolved oxygen
EC	Electrical conductivity
E. coli	Escherichia coli
EDC	Endocrine Disrupting Chemical
EP	Equivalent population
ERA	Environmental risk assessment
FRP	Filterable reactive phosphorous (orthophosphate)
HCl	Hydrochloric acid
ISQG	Interim sediment quality guidelines
Kg	Kilograms
kL	Kilolitres
L	Litres
LOP	Level of protection (species %)
LOR	Limit of reporting for chemical analysis
LWwTP	Ludmilla Wastewater Treatment Plant
µg	Micrograms
Mg	Milligrams
ML	Mega-litres
N	Nitrogen
NH3-N	Total ammonia as N (NH3 and NH4+ as N) as per ANZECC and ARMCANZ (2000)
NHMRC	National Health and Medical Research Council
NOX-N	Oxidised nitrogen as N – the sum of nitrate and nitrite
NRETAS	Department of Natural Resources, Environment, The Arts and Sports, Northern Territory
NT	Northern Territory
NT DOH	Northern Territory Department of Health

Abbreviation	Definition
NT EPA	Northern Territory Environment Protection Authority
NTU	Nephelometric turbidity units
Phaeo-a	Phaeophytin-a, a degradation product of chlorophyll-a
PWC	Power and Water Corporation
SMD	A slightly-moderately disturbed aquatic ecosystem. This reflects both the management intent and subsequently the level of protection (ANZECC 95% Species Protection).
SMDZ	Slightly to moderately disturbed zone
SMP	Sediment monitoring program
SSTV(s)	Site specific trigger value(s)
TKN	Total Kjeldahl nitrogen
TN	Total nitrogen
TN:TOC	Total nitrogen to total organic carbon ratio in sediment
TOC	Total organic carbon
TP	Total phosphorous
TSS	Total suspended solids
TV(s)	Trigger value(s)
WDL(s)	Waste discharge licence(s)
WQO(s)	Water quality objective(s)
WSP(s)	Waste stabilisation pond(s)
Zn	Zinc
Zn-B	Bioavailable zinc in sediment (estimated by dilute acid extraction)
Zn-F	Zinc filtered (dissolved fraction)
Zn:Al	Total zinc in sediment normalised to total aluminium content in sediment
Zn-T	Total zinc in sediment
ZOI	Zone of influence of the discharge (disturbed zone 90% species protection level or less)

Executive Summary

Discharges from the Ludmilla Wastewater Treatment Plant (LWwTP) are regulated under conditions specified in a Waste Discharge Licence (WDL) 150-08, granted under Section 74 of the Water Act 1992. In November 2020 WDL 150 was renewed as 150-08. Data reported in this document covers the period between 1/7/2020 and 31/6/2020 with remaining data for the duration of the licence (expires 31/10/22) to be reported in the next monitoring report.

Condition 38 of the WDL150-08 requires the Licensee (Power and Water Corporation) to complete and provide to the Administering Agency a Monitoring Report as prescribed by this licence, within 30 Business Days after the anniversary date of this licence by emailing waste@nt.gov.au.

PWC conducts an extensive receiving water monitoring program within Ludmilla Creek and Darwin Harbour in the vicinity of the two authorised discharge points. Monitoring data from a range of water quality, sediment quality and biological indicator monitoring programs indicates the impact of the discharge is restricted to within the immediate vicinity of the East Point Outfall and that water quality and biological monitoring data indicate that beyond the immediate impact zone (~100 metres) the environment is typical of a 'slightly to moderately impacted' water way as is typical of environments in the immediate vicinity of an urban centre.

- Water Quality highlights
- Sediment quality highlights
- Pore water
- Biological monitoring
- Improvement program implementation
- Exceedance summary
- Risks associated with the Activity

Condition 39 of the WDL150-08 specifies that the monitoring report must:

- 39.1: be prepared in accordance with the NT EPA Guidelines for Reporting on Environmental Monitoring;
- 39.2; include a tabulation of all monitoring data required as a condition of this licence including surface water, sediment and biological monitoring
- 39.3; include long term trend analysis of monitoring data to demonstrate any environmental impacts associated with the licenced activity over a minimum period of three years (where the data is available);
- 39.4: provide and assessment against the annual report reporting criteria notes in Appendix 1 Table 2 of the licence;
- 39.5: include an assessment of environmental impact from the activity;
- 39.6: contain a summary of the licence limit (site specific trigger value) exceedances that have occurred during the reporting period; and
- 39.7: report on annual loads discharged from SLu080 as per Appendix 1 of the licence.

Inflow and discharge volumes:

The influent and effluent volumes for the LWwTP display a distinctive seasonal pattern associated with rainfall in the sewerage catchment and infiltration of stormwater into the sewerage system. The licence period was characterised by average rainfall and average stormwater inflow and hence average discharge to Ludmilla Creek. In the reporting period the discharge to Ludmilla Creek in both the wet and dry seasons represented 0.01% of total discharge (0.0% of the dry season discharge and 0.01% of the wet season discharge). In the reporting period, 27,563 kilolitres of the total discharge was to Ludmilla Creek.

Discharge loads:

Between June 2012 and June 2014 the Ludmilla WwTP received the additional sewage inflow resulting from the closure of the Larrakeyah and an improvement in the hydraulic and treatment capability of the plant.

The increased treatment performance has resulted in no net increase in the removable contaminant load. Annual inflow to the treatment plant is a function of both sewage and rainfall, due to infiltration into the sewerage network from the catchment.

With the exception of oxides of nitrogen (NOX) see Figure 11, there has been a progressive decline in the loads of all contaminants discharged via the East Point Outfall and a decrease in the total contaminant load discharged to Ludmilla Creek.

The NO_x load discharged has increased from approximately 0.59 to 1.96 tonne per annum, and forms a small component of the nitrogen load discharged, which overall has generally decreased measured in the effluent discharged from the treatment plant. From the peak total nitrogen discharge in the 2012-2013 financial year and the 2020-2021 financial year, where there was comparable rainfall, the total nitrogen discharge has decreased from 189.14 to 176.85 tonnes per annum, a 6.5% load reduction.

Water Quality:

The dissolved oxygen levels at the upstream sites in Ludmilla Creek was significantly below the site-specific trigger value of a minimum level of 80% saturation however this was not associated with discharges from the treatment plant as the highest percent saturation at the site were during the periods of discharge to the creek.

The pathogens indicators (*E. coli* and *enterococci*) exceeded the levels for the protection of the declared beneficial uses of swimming (cultural) at all Ludmilla Creek sites and food collection and food production in Ludmilla Creek at the discharge point and upstream on a few occasions but these were not during periods of discharge.

All monitoring sites exceeded at least one of the secondary nutrient objectives but none were reportable non-compliances.

Sediment and pore water:

Chlorophyll-a in sediment exceeded 2x Reference 80th percentile at sites SLuLC01 and at SLUEP02, SLUEP03, and SLUEP04.

Total organic carbon at the Ludmilla Creek and East Point sites was significantly lower than at the reference sites. Total Nitrogen and Total Phosphorus was below the 2X80th percentile of reference at all sites. The low TOC is a factor in the TN to TOC ratio exceeding reference values at Darwin Harbour SLUEP04.

No Total Copper or Total Zinc in sediment values were below the ANZECC ISQG-Low at all sites and also below the 2X Reference site assessment criteria. All bioavailable Copper met the reference assessment criteria.

Filterable reactive phosphorus in pore water was above the 2X 80th percentile of reference sites assessment criteria at the Ludmilla Creek upstream site (SLuLC01) and at the East Point Outfall (SLUEP03).

All East Point SMD sites were above the 2X 80th percentile of reference assessment trigger for Total Nitrogen.

All sites were below the ANZECC trigger for zinc and copper

Benthic infauna:

Benthic infauna monitoring and ecotoxicology monitoring is specialised monitoring requiring expertise that is not available in the Northern Territory. Due to Covid-19 related border closures this reporting period, no benthic infauna monitoring or ecotoxicology monitoring for the 2021 period could be reasonably planned and delivered. It should be noted that an independent assessment carried out by SLR environmental consultants dated 27/10/2020 recommended that current water and effluent monitoring carried out by PWC under the WQMMP is a sufficient early warning indicator and that further actions, which could include benthic infauna monitoring, is only necessary if PWC water and effluent monitoring indicate that further investigation is required.

The biological monitoring programs for WDL 150-08 is included in Appendix 3 of the licence. The environmental approval (EPBC2009-5113) requires the implementation of the Ecotoxicological Assessment Plan, and this condition is subsequently reflected in the biological monitoring program in Appendix 3 of WDL

150-08. The full monitoring results are contained in the notification sent to waste@nt.gov.au on 01/12/2020 (D2020/564514). The executive summary has been included in section 4.1 in order to avoid duplication.

Ludmilla WwTP Performance Improvement Plan Implementation:

All actions that were identified in the Darwin Harbour Water Quality Protection Plan (DLRM 2014) and Ludmilla Wastewater Treatment Plant's management goals (PWC 2019a) have been completed or have been implemented and are ongoing.

Licence Exceedances:

Assessment of all exceedances of Site Specific Trigger Values (SSTVs) specified in the licence found that for the reporting period there were a total of 199 exceedances none of which were reportable exceedances or non-compliances with conditions as specified in Appendix 1 of 150-07.

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1. Introduction

Power and Water is established by the *Power and Water Corporation Act 2002* and is a Northern Territory Government Owned Corporation under the *Government Owned Corporations Act 2001*.

Power and Water owns and operates the large dams and groundwater fields to deliver clean drinking water to households and businesses and receives and treats wastewater before disposing of it in an environmentally responsible manner.

1.1 Ludmilla Wastewater Treatment Plant

The Ludmilla Wastewater Treatment Plant (LWwTP) is located at 21 Dick Ward Drive Ludmilla and serves a catchment loading of 43,950 equivalent persons (EP), with population increasing due to additional high-density development and infill development within this region. The LWwTP location and the catchment serviced (highlighted in green) are shown in Figure 1 below.

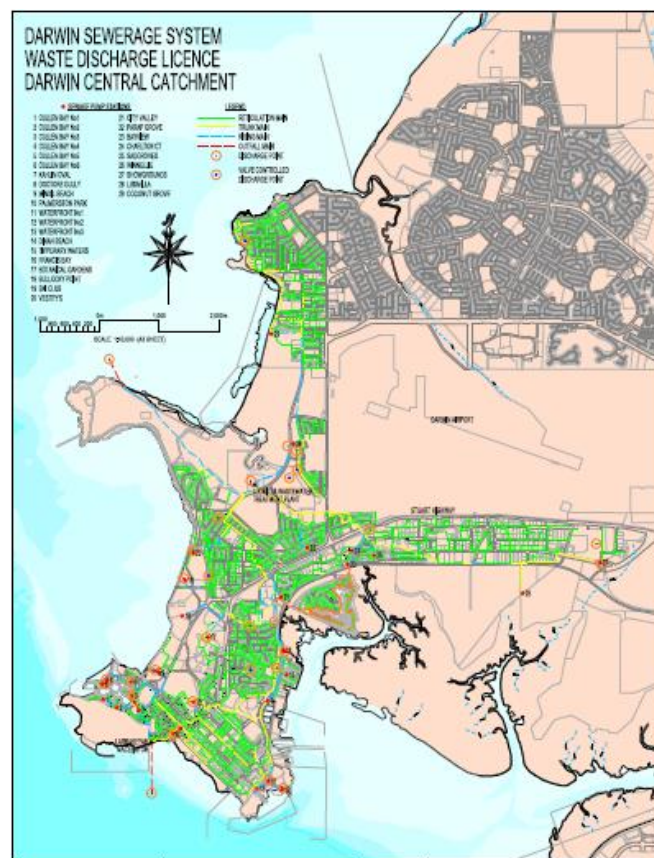


Figure 1 Darwin Central Sewerage Catchment Map

LWwTP is the second largest sewage treatment plant in Darwin, receiving and treating sewage from residential and commercial premises in central Darwin and the inner suburbs of Larrakeyah, the Gardens, Parap, Stuart Park, Fannie Bay, Ludmilla, Coconut Grove, Nightcliff and Winnellie (Figure 1).

The Ludmilla Wastewater Treatment Plant (LWwTP) was commissioned in 1977 and upgraded in 2012 to allow for the additional inflow of wastewater following the closure of the Larrakeyah Outfall in May 2012. The upgrade works were completed in December 2012 and commissioned between January 2013 and June 2014.

The upgrade to LWwTP expanded the plant's hydraulic and chemical treatment capacity to cater for an average dry weather inflow (ADWF) of 17.5 ML per day, representing a connected equivalent population of approximately 58,000 meeting the community's needs until at least 2030.

The LWwTP provides primary treatment including screening, odour control by disinfection through chlorination and chemically assisted sedimentation using polymer and coagulants to reduce the suspended solids, pathogen and chemical contaminant content of the wastewater prior to disposal to Darwin Harbour via the East Point Outfall (EPO). Biosolids produced from sedimentation are de-watered by centrifugation, the liquid returned to the treatment process and biosolids transported off site for further treatment and storage. During periods of high inflow or in emergency events, excess treated wastewater may be discharged to Ludmilla Creek.



Figure 2: Ludmilla Wastewater Treatment Plant Dick Ward Drive Ludmilla

1.2 Ludmilla Wastewater Treatment Plant Discharge Licensing

While the wastewater treatment process reduces the public health and environmental risks associated with the discharge of treated wastewater (The Activity) risks to the declared Beneficial Uses remain; unless authorised under provisions of the *Water Act*, discharges are considered as pollution of waters.

The discharge of treated wastewater from the LWwTP is authorised through provisions of a Waste Discharge Licence (WDL) under provisions of Section 74 of the *Water Act 1992* (NT).

The *Water Act 1992* (NT) prohibits a person from allowing waste to come into contact with water or to pollute waters, except where specifically authorised to do so through the granting of a Waste Discharge Licence (WDL).

The Waste Discharge Licence issued with respect to the Ludmilla Wastewater Treatment Plant is WDL150, WDL150-07 was issued and commenced on 9 August 2019.

WDL150-07 (the licence) contains conditions specifying, among other things, authorised discharge points (Condition 18); requirements for discharges to Ludmilla Creek (Condition 20); qualitative discharge requirements for all discharges (Condition 21) and monitoring requirements Condition 22 and Appendix 1 for

Surface Water monitoring; Condition 23 and Appendix 2 for Sediment Monitoring and Condition 24 and Appendix 3 for Biological Monitoring.

Licensed monitoring reporting requirements are specified Conditions 38 and 39 of WDL150-07.

1.3 Monitoring and Reporting Requirements

The submission of this report fulfils Power and Water Corporation's (PWC's) requirement to provide a Monitoring Report a minimum of 30 Business Days after the anniversary of the commencement date of Waste Discharge Licence (WDL) 150-08, pursuant to Condition 38, due on 20 September 2021.

Condition 39 of WDL 150-08 requires that the Monitoring Report:

- 39.1 is prepared in accordance with the requirements of the NT EPA 'Guidelines for Reporting on Environmental Monitoring;
- 39.2 includes a tabulation of all monitoring data required as a condition of this licence including surface water, sediment and biological monitoring;
- 39.3 Includes long term trends analysis of monitoring data to demonstrate any environmental impact associated with the Licensed Activity over a minimum of three years (where data is available);
- 39.4 Provides an assessment against the annual report reporting criteria notes in Appendix 1 Table 2;
- 39.5 Includes an assessment of the environmental impact of the Activity;
- 39.6 Contains a summary of the licence limit (site specific trigger value) exceedances that have occurred during the reporting period; and
- 39.7 Report on annual loads discharged from SLu080 as per Appendix 1 of the licence.

A summary of the monitoring data required under WDL150-08 trends and how it has been interpreted is provided within this Licence Report is provided in Table 1 below.

Table 1: Summary of all tabulated monitoring data required under the Ludmilla WDL

Data Type	Data :WDL 150-07 Ludmilla
Surface water and discharge monitoring	Summary provided as Section 2 of this report
Sediment and sediment pore-water monitoring	Sediment summary Section 3 of this report
	Pore-water summary Section 3 of this report
Biological Monitoring	Section 4
Ecotoxicology	Section 4.1 No analysis in this reporting period
Benthic Infauna	No analysis in this reporting period

Plots with trend analysis and interpretation (assessment against RLs where applicable) are provided for all surface water and discharge monitoring parameters in relevant sections of this report. In addition, summary baseline condition assessments have been undertaken on a seasonal basis for all parameters with pertinent water or sediment quality criteria. These historical data sets are comprised of 9 years (from February 2012 to August 2021) of water quality data however due to the 'step change' in performance of the LWwTP following commissioning of the upgraded treatment plant, only data from June 2014 onwards is used for the purposes of performance comparison, additionally Commonwealth Department of the Environment and Energy approval to commission the augmented East Point rising main was received in July 2016 and specific changes in discharge patterns following this approval are noted. In addition, the 2020 annual dry season sediment data and the most recent biota data are assessed.

The assessment of surface water quality is in accordance with WDL 150-08 Appendix 1 and sediment quality in accordance with Appendix 2 of WDL150-08 and are included in this report.

A summary of biota data in accordance with Appendix 3 of WDL150-07 is included in Section 4 of this report.

Table 2: Baseline condition assessment tables against relevant water quality and sediment quality criteria

Parameter type	Matrix	WDL 150-08: Ludmilla
Total discharge volume	Water (influent and Effluent)	Section 2.1 Table 4 and 5
Discharge loads	Water (influent and Effluent)	Section 2.2 graphs data Appendix 4
Physico-chemical	Water/effluent	Section 2.3 Table 6
Pathogen indicators	Water/effluent	Section 2.4 Table 7
Nutrients	Water/effluent	Section 2.5 Table 8
	Sediment	Section 3.1 Tables 12 and 14
	sediment pore-water	Section 3.1 Table Tables 12; 14 + 15
Metals	Water/effluent	Section 2.6 Table 9
	Sediment	Section 3.1 Table 16; 17 and 18
	Sediment pore-water	Section 3.1 Table 20
Endocrine disruptors	Water (effluent and outfall)	Section 2.7 Table 10
Biological	Water/effluent: Ecotoxicology	Section 4.1 Tables 22 and 23
	Benthic Infauna	Section 4 no data in reporting period

The discharge parameters and reporting frequency for surface water parameters are listed in Licence Appendix 1 of this report.

Table 3: Total annual discharge quality, annual trends and the mass load estimates

Parameter type	Matrix	WDL 150-08: Ludmilla
Total discharge (volume)	Influent	Section 2.1 Table 4 and 5 and Figures (Fig) 3 and 4
	Effluent	
Discharge loads (tonne per year)	Influent	Section 2.2 Figures 8 to15 and Appendix 4
	Effluent	
pH	Effluent Receiving Water Impact	S 2.3 T 6 and S 2.3.1 T 6 and Fig 16-19
Dissolved oxygen	Effluent Receiving Water Impact	S 2.3 T 6 and S 2.3.3 T6 and Fig 23-27
Suspended solids	Effluent Receiving Waters Impact	S 2.3 T 6 and S 2.3.5 and Fig 29-32
Total biochemical oxygen demand (BOD)	Loads Influent and Effluent	S 2.2 T6 and Fig 8 and App 4
	Effluent Receiving Waters Impact	S 2.3 T 6 and S 2.3.6 Fig 33-36
Escherichia coli	Effluent Receiving Waters Impact	S2.4 T 7 and S 2.4.1 Fig 37- 43
Enterococci	Effluent Receiving Waters Impact	S2.4 T 7 and S 2.4.2 Fig 44 - 48
Chlorophyll-a	Effluent and Impacts	S 2.5 T 8 and S 2.5.1 Fig 49-52; and S 4.3 Table 23-24
Total nitrogen (TN)	Loads Influent and Effluent	S 2.2.2 Fig 10 and App 4
	Receiving Water Impacts	S 2.5 T 8 and S2.5.2 Fig 53-67
Oxides of nitrogen (NOx)	Load Influent and Effluent	S 2.2.2 Fig 11 and App 4
	Receiving Water Impacts	S 2.5 T 8 and S 2.5.3 Fig 58-61
Ammonia (NH ₃ -N)	Loads Influent and Effluent	S 2.2.2 Fig 9 and App 4
	Receiving Waters Impacts	S 2.5 T 8 Nutrient and S2.5.4 Fig 62-64 S 2.6 T 9 Toxicant S2.6.1 Fig 73-75
Total phosphorous (TP)	Load Influent and Effluent	S 2.2.2 Fig 12 and App 4
	Receiving Water Impacts	S 2.5 T 8 and 2.5.5 Fig 65-68
Filterable Reactive Phosphorus (FRP)	Load Influent and Effluent	S 2.2.2 Fig 13 and App 4
	Receiving Water Impacts	S 2.5 T 8 and 2.5.6 Fig 69-72
Copper load	Load Influent and Effluent	S 2.2.3 Fig 14 and App 4
	Receiving Water Impacts	S 2.6 T 9 and 2.6.2 Fig 76-79
Zinc load	Load Influent and Effluent	S 2.2.3 Fig 15 and App 4
	Receiving Water Impacts	S 2.6 T 9 and 2.6.3 Fig 80-83
Endocrine Disrupting chemicals Maximum	Effluent	S 2.7 T 10

1.4 Monitoring Methods

1.4.1 Sampling Sites

The data considered within this Licence Report pertains to the sampling sites identified in Appendix 4 of WDL150-08 and shown in Figure 3 (below).

1.4.2 Discharge and Surface Waters

Sampling of Ludmilla Creek and Darwin Harbour in the vicinity of the East Point Outfall is undertaken consistently on neap ebb tides. This sampling is timed to capture as near to worst-case that can be measured (i.e. low tidal ranges, minimal dilution and flushing). The timing is somewhat consistent with water quality sampling undertaken by the Aquatic Health Unit for Darwin Harbour Report Card assessment purposes, except that they would target one hour either side of a neap ebb tide while PWC specifically

targets the ebb tide only due to the presence of the discharge within the tidal creek i.e. attempt to capture consistent influence on sites during specific stage of the tidal cycle.

The surface water data set considered for long term trends typically covers the period from June 2012 to 31 August 2021 i.e. 9 years of data, the period following the closure of the Larrakeyah Outfall and redirection of wastewater from the inner city and Larrakeyah sewage catchments to Ludmilla for treatment; more detailed assessment is undertaken on the data set from June 2014 onwards as this is the period following commissioning of the hydraulic and treatment upgrades at the Ludmilla WwTP.

All data has been collected at the frequencies defined in the Surface Water and Discharge Monitoring schedule, Appendix 1 of WDL 150-08. Surface water samples are collected at a consistent depth of 0.2 m below the surface in the receiving environment. Duplicate samples are collected at one site on each run. Additionally, the analysis type such as: nutrients, metals, bacteriological are collected in accordance with WDL 150-08 Appendix 1.

The assessment protocol and surface water trigger values for the surface water quality Monitoring section of the Licence Report are specified in WDL 150-08 in Appendix 1 (water quality) and Appendix 2 (sediments). Appendix 3 of WDL150-07 references the Benthic Infauna and Seagrass triggers as specified in the Benthic Infauna Monitoring and Management Plan as approved by the Commonwealth Minister (or delegate) under the Environment Protection and Biodiversity Convention (EPBC) and approvals under this convention including Approval EPBC 2009-5113 and the Ecotoxicology Assessment Plan as approved under EPBC 2009-5113.

WDL 150-08 Section 4.3 Table includes enumeration of total phytoplankton and cyanobacteria and bio-volumes.

Maps defining the monitoring locations for the Water Quality Monitoring and Management Plan and the Benthic Infauna Monitoring and Management Plan sites are included in Appendix 2 of this report.

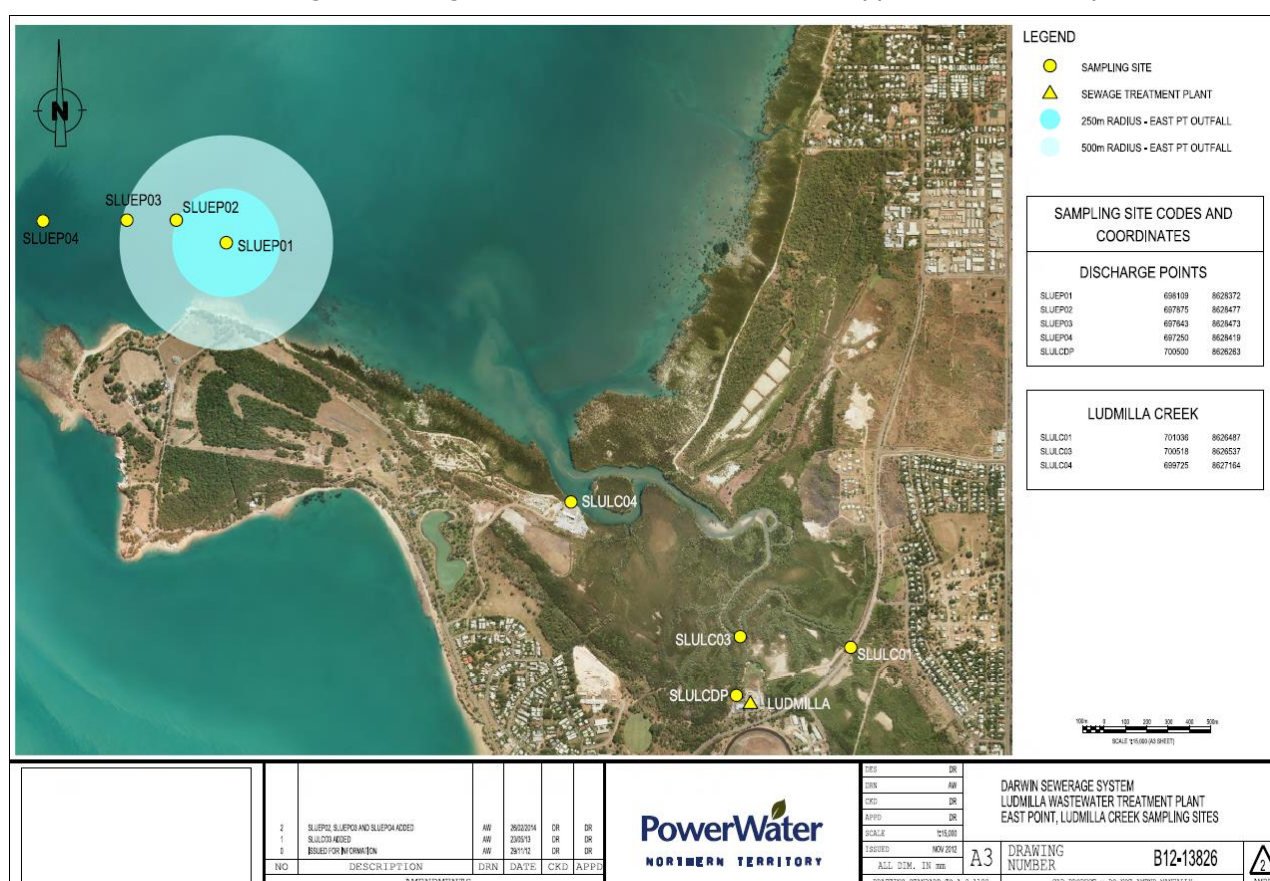


Figure 3: WDL150-07 Sampling sites: authorised discharge point and receiving environment

1.4.3 Sediment

Sediment samples are collected in the dry season annually in accordance with the Sediment Monitoring Plan in Appendix 2 of WDL 150-08. Sediment sampling is undertaken during spring tides to facilitate sufficient temporal access to the sites. This program includes test sites in Ludmilla Creek the receiving waters for the discharge to the creek, and Darwin Harbour in the vicinity of the East Point Outfall and as no suitable, substantially natural creeks similar to Ludmilla Creek have been identified the control/reference sites in Short and King Creeks are used for comparison.

The sediment data set covers sampling undertaken in the period from 2014 to 2020 dry seasons for most parameters and covers the period following commissioning of the treatment plant upgrade. Earlier programs from 2012 onwards was conducted under an interim sediment monitoring program (SKM 2013). The interim program was revised and implemented consistently from 2014 based on the recommendations of independent experts (Alongi 2013a, Moss 2013) and a monitoring design developed for isotope monitoring in sediment in these receiving waters (Munksgaard 2014). Sediment samples from each 'site' are a composite sample of multiple 10 cm depth cores collected from both sides of the channel (Ludmilla Creek) or a triangle around the site Darwin Harbour. The pH of the composite sample is recorded in-situ (average of 3 in-situ readings utilised). Triplicate composite samples are taken at two sites at East Point and the test creek (Ludmilla Creek) and at one site in each control creek (Short Creek and Kings Creek), while the controls are geographically and environmentally discrete from East Point and Ludmilla Creek, the most similar creek in the vicinity, Rapid Creek is both impacted by catchment activities and is physically different in that it flows all year.

It is generally understood that the water quality criteria considered protective of beneficial uses may not be achieved and therefore that beneficial uses may not be protected in the mixing zones for discharges (ANZECC and ARMCANZ 2000a, EPAVIC 2009). Default criteria were not intended to be used as 'instruments to assess compliance' in these contexts. However, they can be useful in these zones for 'enhancing inference about the level of disturbance (enhance early detection and predictive capabilities)' (ANZECC and ARMCANZ 2000a) and confirming the extent of the likely mixing zone under specific conditions in this high variability context.

All surface water quality assessments in this Monitoring Report have been undertaken based on valid protocols defined in relevant guidelines (ANZECC and ARMCANZ 2000a, b, NHMRC 2008, NRETAS 2010, DOH 2011). The sediment and sediment pore-water assessment protocols are performed in accordance with relevant guidelines (ANZECC and ARMCANZ 2000a)

Reference site based Darwin Harbour Water Quality Objectives (DHWQOs) for the mid Estuary water types apply to Ludmilla Creek and outer estuary water type applies to Darwin Harbour at East Point (NRETAS 2010). The management intents slightly-moderately disturbed (SMD) for all Darwin Harbour waters. The assessment statistic for reference site based WQOs is the median of the test site data. Toxicity based trigger values (TVs) (ANZECC and ARMCANZ 2000a, b) are assessed using the 95th percentile of test site data. Long-term microbial water quality assessment categories for recreational contact were similarly assessed using 95th percentiles (Hazen Method) (NHMRC 2008). Local alert level guidance (DOH 2011) based on these categories were assessed using the maximum test site value i.e. any exceedance and are further considered in the Risk Assessment for this facility.

For assessment purposes, it is useful to further group the receiving water sites for the discharge into various zones. These sub-zones have been identified based on long-term assessments of monitoring data, and independent expert judgement (Moss 2013):

The effluent, within the treatment plant prior to discharge is SLu080 which is the same point as site SLuLCDP, the re-carbonation chamber where effluent is directed to the East Point Outfall or in periods of high inflow, excess treated effluent is directed to the Ludmilla Creek discharge drain.

The zone of influence inclusive of sites SLuEP01 and SLuLC03 which are more proximal to the authorised discharge points.

The slightly – moderately disturbed zone (SMDZ) inclusive of Darwin Harbour sites SLuEP02; SLuEP03 and Ludmilla Creek sites SLuLC01 and SLuLC02 (upstream of the discharge point) and SLuLC04 (downstream of the discharge point), the upstream site SLuLC01 is upstream of Dick Ward Drive and only receives tidal waters at tides above 6.0 metres and was intended to capture potential upstream stormwater influences

prior to mixing with the discharge, site SLuLC02, added in 2018 and is immediately downstream of Dick Ward Drive.

These zones are formally recognised in WDL 150-08 in terms of the differential Reporting Limit protocols to apply to specific sites in these zones are specified in Appendix 1 of WDL 150-07.

All sediment assessments have been undertaken in accordance with relevant guidelines (ANZECC and ARMCANZ 2000a). The assessment protocols have been summarised in Appendix 2 of WDL 150-07. In brief, sediment metals are assessed against Interim Sediment Quality Guideline (ISQG) TVs (ANZECC and ARMCANZ 2000a). Where no TVs are available (i.e. sediment nutrients), then a 2 x reference site TV is applied for assessment purposes (ANZECC and ARMCANZ 2000a).

1.4.4 Sampling Artefacts

All data assessments should be considered in the context of relevant operational history and other factors that may temporarily influence water quality. A summary is included below:

- Redirection of the Larrakeyah and Darwin sewage catchments to Ludmilla WwTP following closure of the Larrakeyah Outfall, 31 May 2012.
- Upgrading of the Ludmilla WwTP to increase treatment and hydraulic capacity required due to the increased inflow following closure of Larrakeyah; works completed December 2012;
- Commissioning of upgraded treatment plant completed May 2014;
- Augmentation of East Point rising main to accommodate increased discharge via East Point Outfall, works completed August 2015;
- Effluent discharge pumps augmentation completed February 2015;
- Commonwealth Department of the Environment and Energy approval to commission augmented main received July 2016;
- Commissioning to increased flow commenced wet season (November) 2016;
- Ongoing work to improve performance to meet design expectation – which has occurred during in the 2018- 2019 and 2019 - 2020 wet seasons;
- Ongoing work to balance the plant performance in low flow conditions, occurring in both the wet and dry seasons with the objective of minimising black plume events (due to low flow in the main) with preventing discharges to Ludmilla Creek resulting from sudden rainfall events.

2 Water Monitoring

Water Quality monitoring requirements are included in Appendix 1 of WDL150-08 and is reproduced in Appendix 1 of this report.

2.1 Influent and Effluent Volumes Trends

The LWwTP undertakes continuous treatment of wastewater and while there is some retention capacity within the system this is limited to the capacity of the CAS tank treatment train and some upstream retention capacity within in-system pump stations. The treated effluent is discharged via two discharge points, the primary discharge point is the intertidal East Point Outfall with a secondary discharge point in high inflow and emergency shut down situations, into Ludmilla Creek via a bypass drain. Following augmentation of the East Point rising main (EPRM), during the dry season (May to September inclusive) more than 99.99% of the treated wastewater is transferred via the EPRM to the intertidal East Point Outfall (EPO) for discharge to the waters of Darwin Harbour; the percentage of the total treated effluent discharged via the EPO reduces to 97.4% in the wet season, representing a significant improvement on the pre-commissioning discharges where 99.987% of dry season flows and 99.87% of wet season flows were via the EPO. Table 4 and Figure 4 below indicate the volume in kilolitres entering the LWwTP and discharging to Darwin Harbour at East Point and to Ludmilla Creek during the licence period.

Table 4: Monthly discharge schedule for LWwTP WDL 150- 08

WDL150-08		Inflow	Discharge		
Month	Days	Ludmilla WwTP Monthly Total kL	Ludmilla Creek Monthly Total kL	East Point Outfall Monthly Total kL	Total Monthly Total kL
Jul-20	31	353,334	0	330,851	330,851
Aug-20	31	353,055	0	346,936	346,936
Sep-20	30	341,535	0	336,365	336,365
Oct-20	31	439,075	0	439,833	439,833
Nov-20	30	376,211	0	352,018	352,018
Dec-20	31	626,510	2,217	605,808	608,025
Jan-21	31	1,226,426	21,738	1,180,761	1,202,499
Feb-21	28	1,013,476	3,698	999,602	1,003,300
Mar-21	31	584,058	0	610,412	610,412
Apr-21	30	474,801	0	490,202	490,202
May-21	31	433,478	0	388,987	388,987
Jun-21	30	391,645	0	346,655	346,655
Licence Period Total	365	5,648,426	27,563	6,428,430	6,455,993

Table 5: Seasonal Inflow and Outflow WDL 150-08

Seasonal Totals	Days	Inflow	Ludmilla Creek discharge	EPO discharge	Total Discharge
Total	365	5,648,426	27,563	6,428,430	6,455,993
% Total	100	100	100	100	100
Wet Season	181	4,301,482	27,563	4,238,802	4,266,365
% of seasonal discharge			0.65	99.35	100
% Total	49.59	76.15	0.004	65.66	66.08
Dry Season	245	3,370,981	0	3,290,242	3,290,242
% of seasonal discharge			0	100	100.00
% total	67.12	59.68	0	34.34	50.94
WDL Total	365	5,648,426	60,827	6,428,430	6,455,993

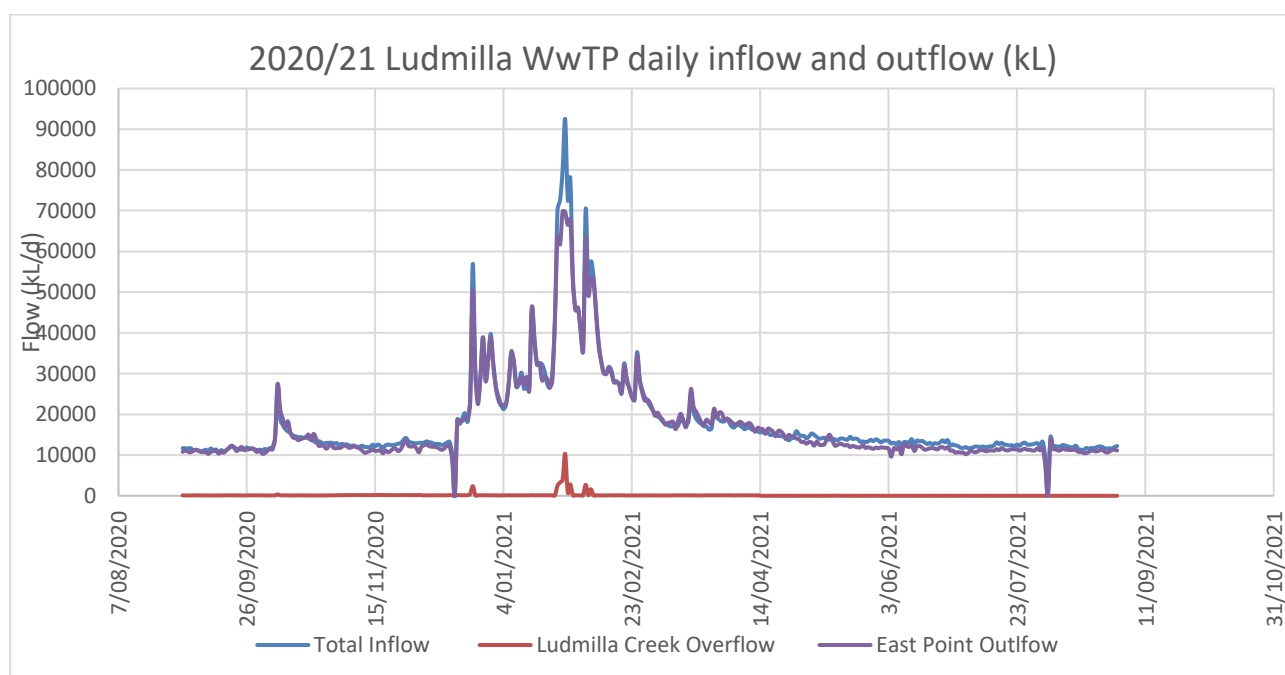


Figure 4: Daily inflows and outflow Ludmilla Wastewater Treatment Plant 1/09/2020 & 1/09/2021

During the reporting period moderate to minor discharges occurred to Ludmilla Creek, these discharges occurred during monsoonal events on December 16th, 22nd, 23rd and January 25th – 30th and February 5th and 7th.

Figure 5 (below) shows the changing discharge regime for the Ludmilla WwTP for the period prior to the closure of the Larrakeyah Outfall on 31 May 2012 and redirection of wastewater previously disposed via the Larrakeyah outfall to Ludmilla WwTP for treatment and discharge via the East Point Outfall and or the Ludmilla WwTP Ludmilla Creek discharge.

Ludmilla Wastewater Treatment Plant Monthly Inflow and Outflow 2011 to current

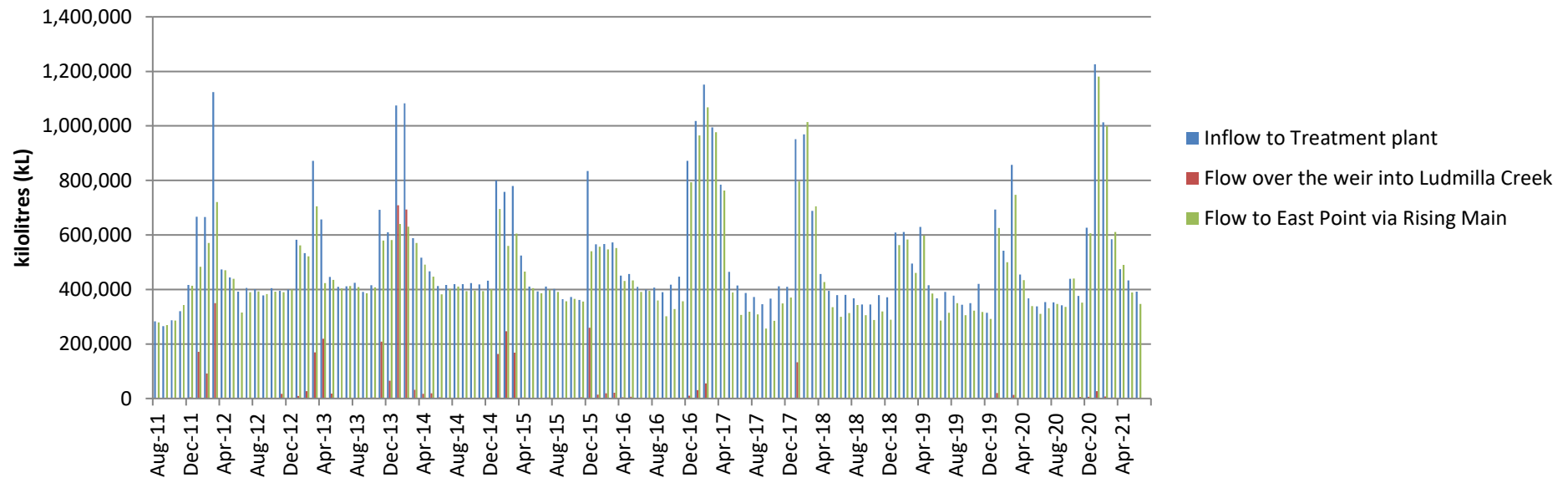


Figure 5: Trends in Monthly inflows and outflow at Ludmilla Wastewater Treatment Plant August 2011 to August 2021

2.2 Influent and Effluent Loads LWwTP

Appendix 5 contains a table of influent and effluent loads and percentage reduction for the financial year period from 2011-12 to 2020-21 inclusive.

Graphical representation of the loads trends for the parameters required by the WDL 150-08 are included below.

2.2.1 Rainfall and Influent and Effluent Flow Trends Ludmilla WwTP

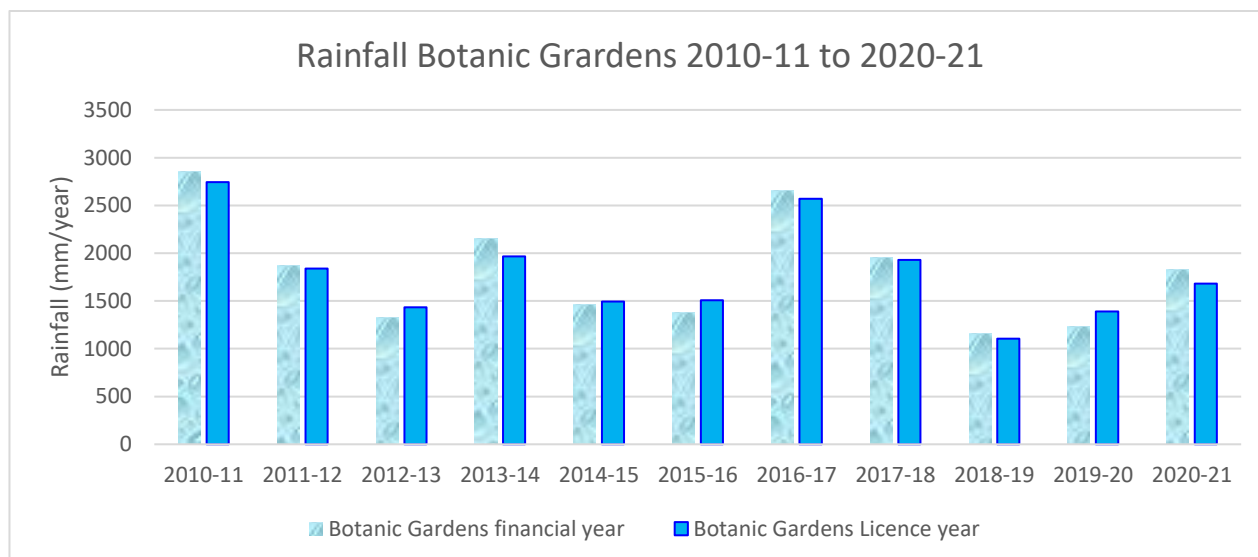


Figure 6: Rainfall at Botanic Gardens monitoring site 2010-11 to 2020-21 by financial year and licence year (1 Nov to 31 Oct). Licence period data until Aug 2021 (Sep and Oct data excluded).

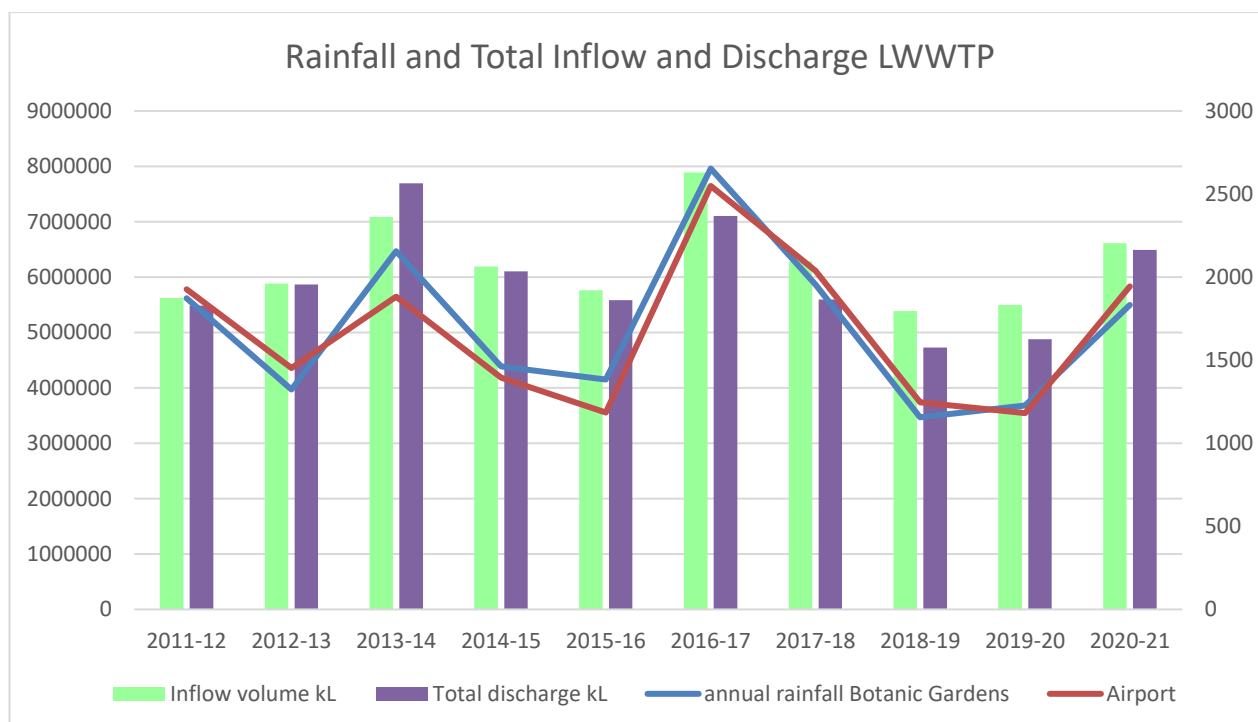


Figure 7: Relationship between Rainfall and Total Inflow and discharges to East Point and Ludmilla Creek 2011-12 to 2020-21

2.2.2 Trends in Organic Matter and Biostimulant (Nutrient) Loads discharged from Ludmilla WwTP

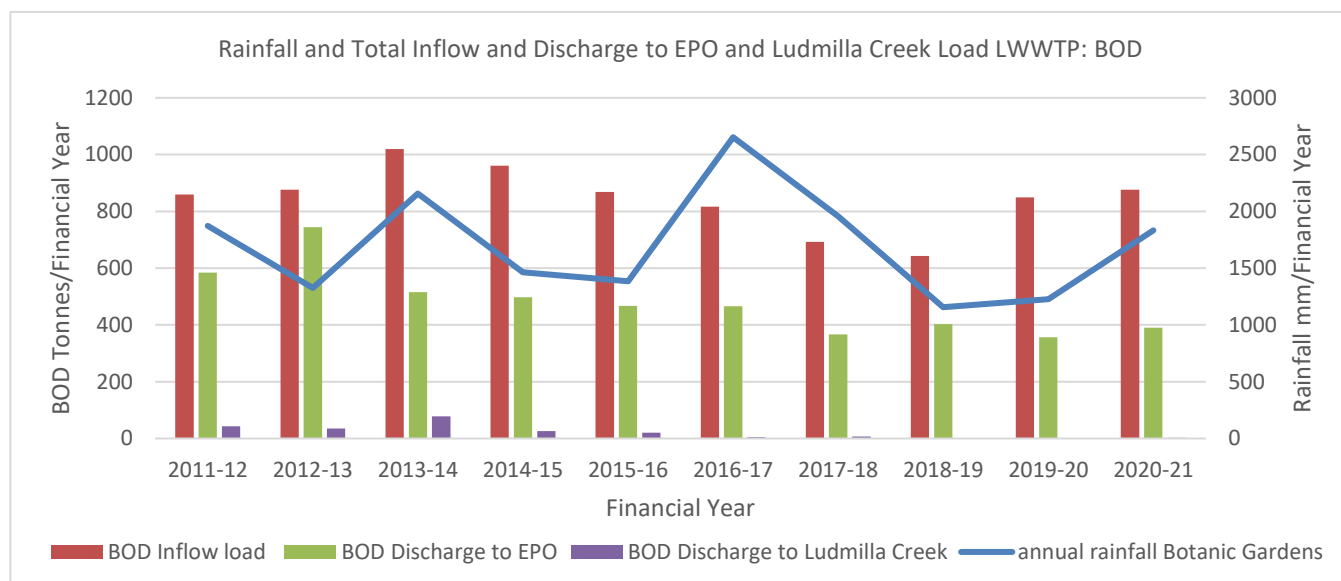


Figure 8: Biological Oxygen Demanding Substances Loads (tonne/year) Inflow and Discharges LWwTP 2011-12 to 2020-21

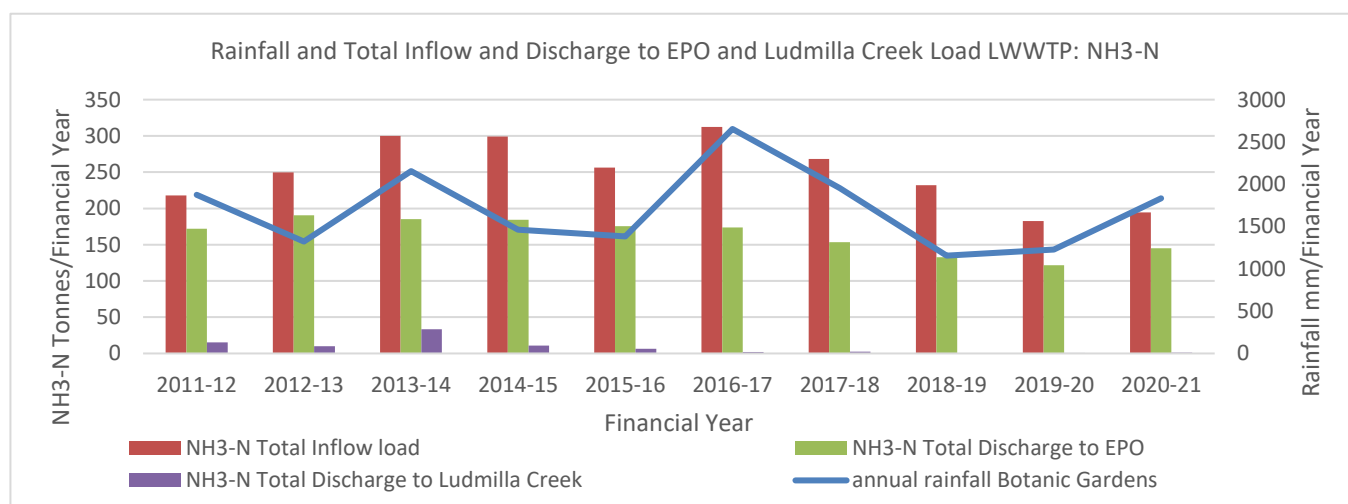


Figure 9: Total Ammonia-N (NH₃-N) Loads (tonnes per year) Inflow and Discharges LWwTP 2011-12 to 2020-21

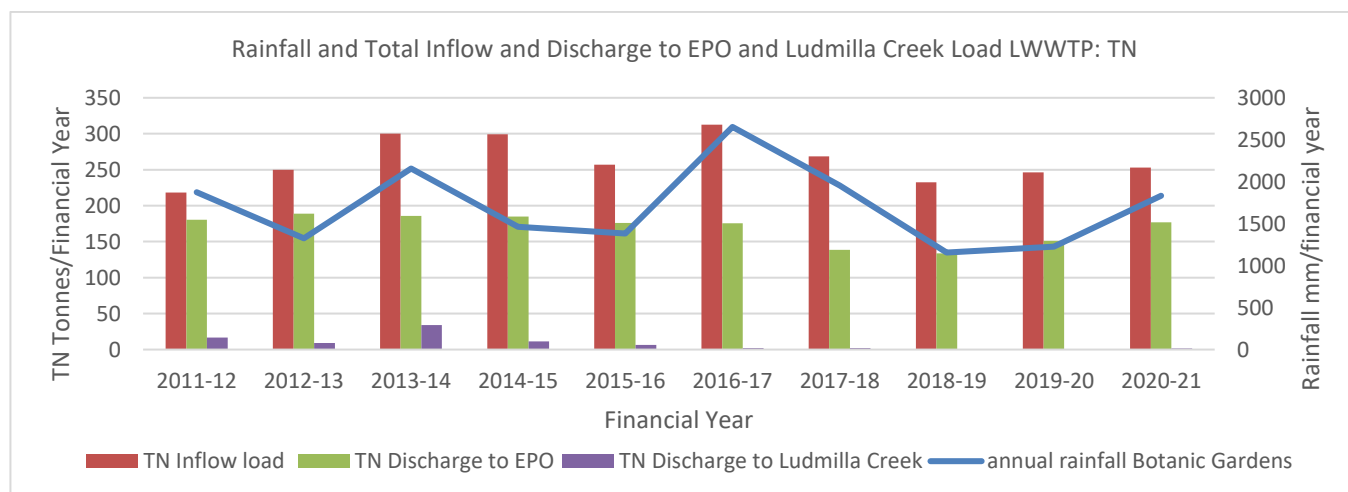


Figure 10: Total Nitrogen (TN) Loads (tonnes per year) Inflow and Discharges LWwTP 2011-12 to 2020-21

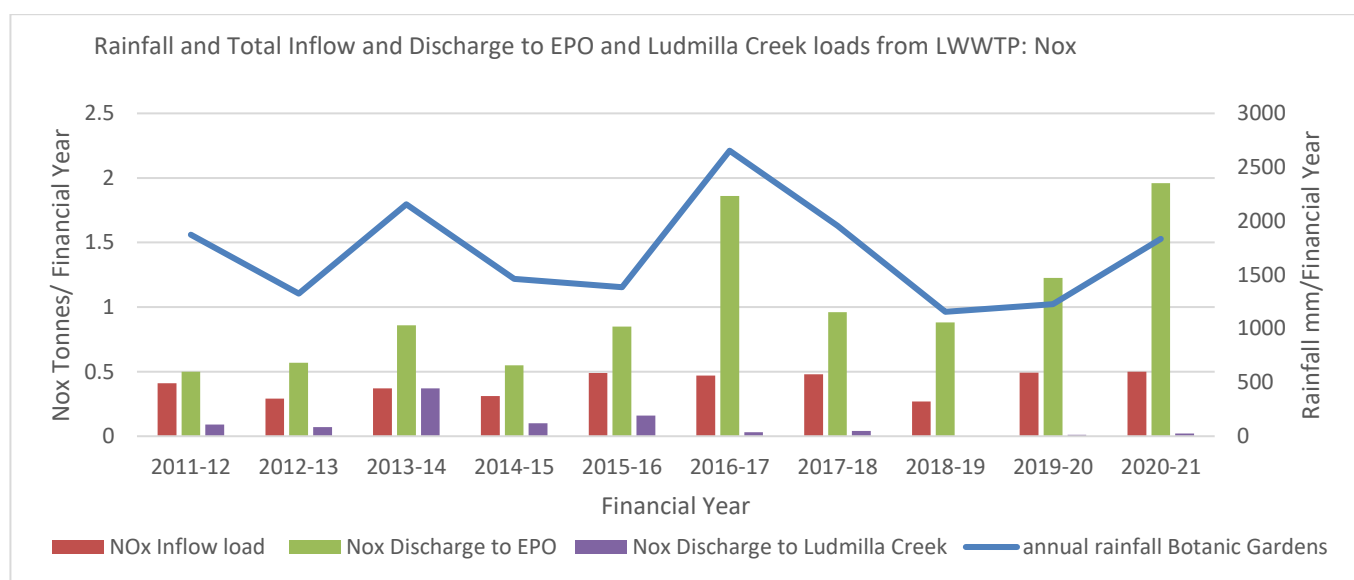


Figure 11: Oxides of Nitrogen (NOx) Loads (tonnes per year) Inflow and Discharges LWwTP 2011-12 to 2020-21

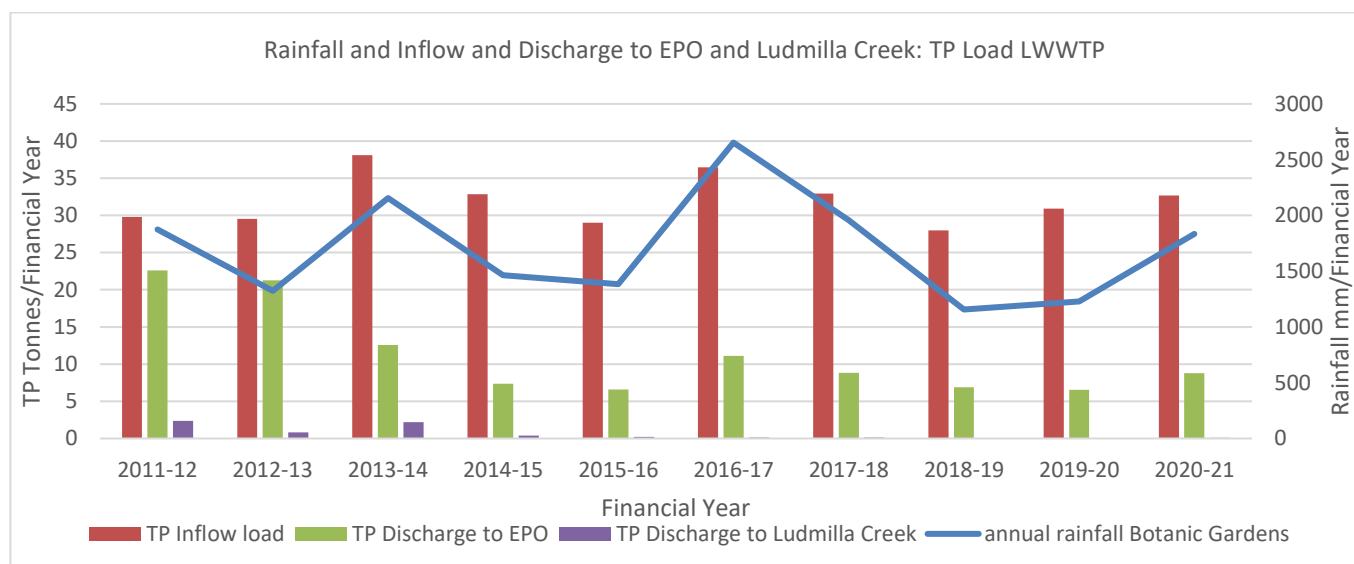


Figure 12: Total Phosphorus (TP) Loads (tonnes per year) Inflow and Discharges LWwTP 2011-12 to 2020-21

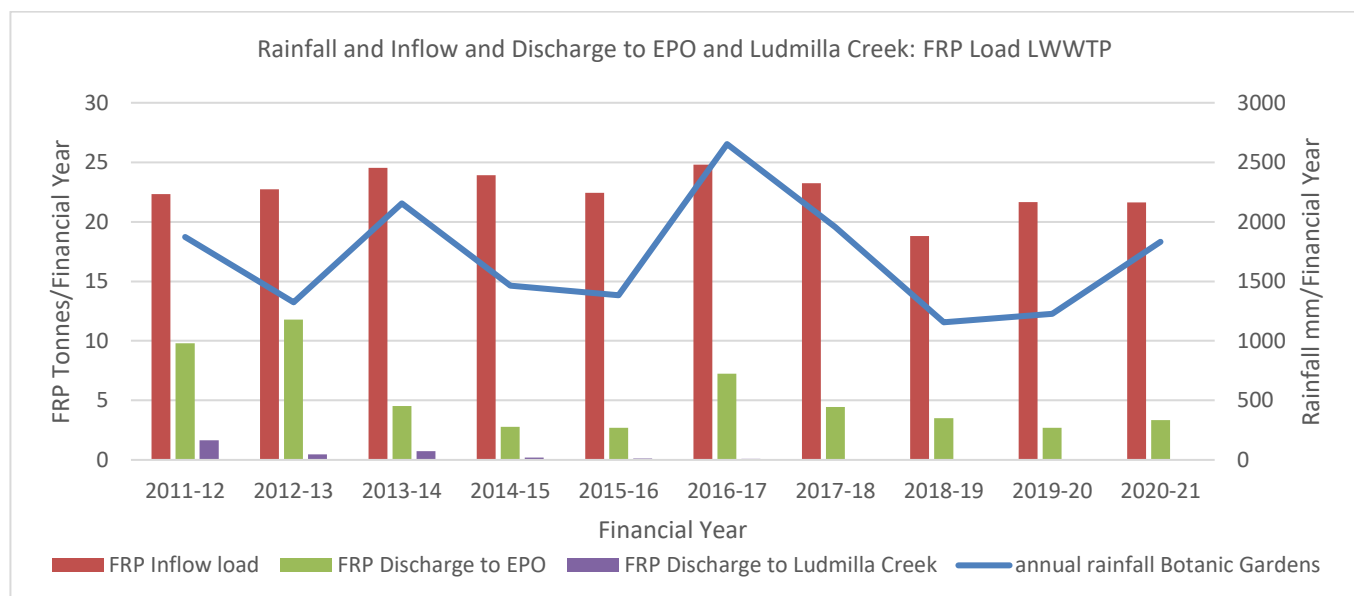


Figure 13: Filterable Reactive Phosphorus (FRP) Loads (tonnes per year) Inflow and Discharges LWwTP 2011-12 to 2020-21

2.2.3 Trends in toxicant (Copper and Zinc) loads discharged from Ludmilla WwTP

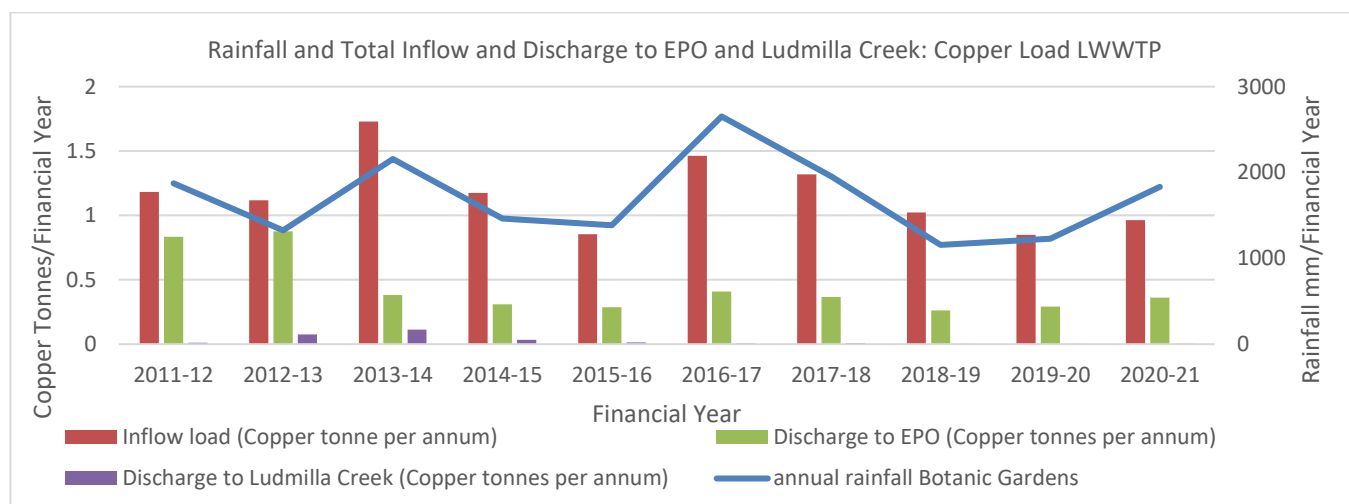


Figure 14: Total Copper (Cu-T) Loads (tonnes per year) Inflow and Discharges LWwTP 2011-12 to 2020-21

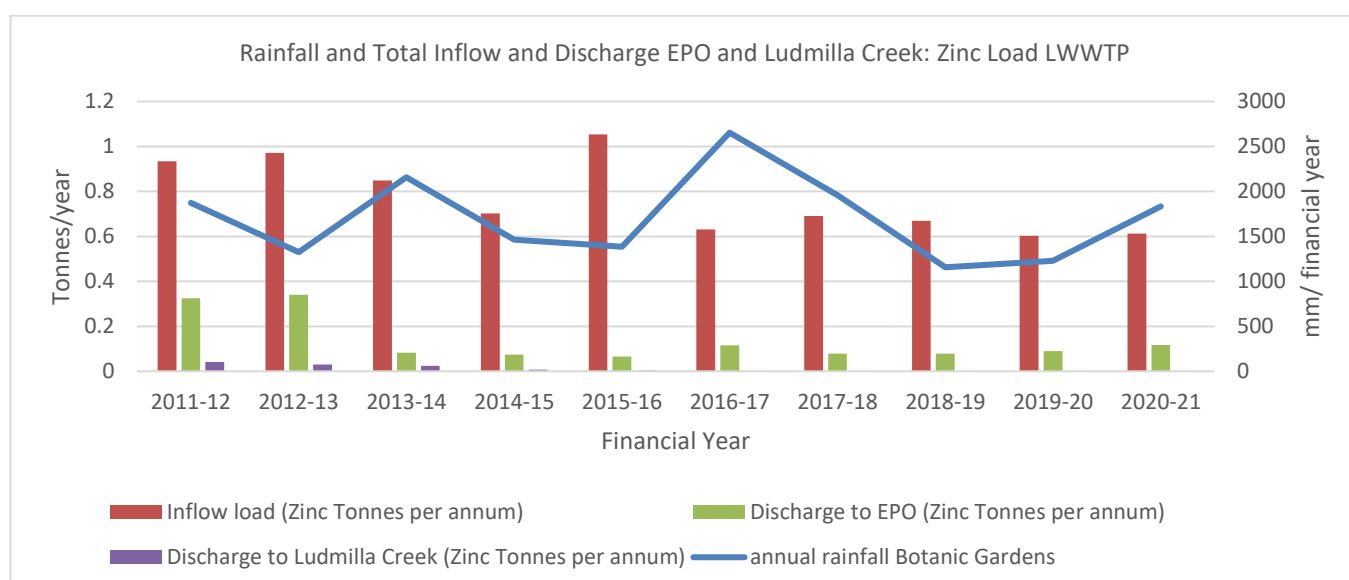


Figure 15: Total Zinc (Zn-T) Loads (tonnes per year) Inflow and Discharges LWwTP 2011-12 to 2020-21

2.2.4 Discussion

Between June 2012 and June 2014 the Ludmilla WwTP received the additional sewage inflow resulting from the closure of the Larrakeyah and an improvement in the hydraulic and treatment capability of the plant. The increased treatment performance has resulted in no net increase in the removable contaminant load. Annual inflow to the treatment plant is a function of both sewage and rainfall, due to infiltration into the sewerage network from the catchment.

With the exception of oxides of nitrogen (NOX) see figure 11, there has been a progressive decline in the loads of all contaminants discharged via the East Point Outfall and a more significant decrease in the total contaminant load discharged to Ludmilla Creek.

The NOx load discharged has increased from approximately 0.59 to 1.24 tonne per annum, and forms a small component of the nitrogen load discharged, which overall has generally decreased load measured in the effluent discharged from the treatment plant. Between the 2012-2013 financial year and the 2019-2020 financial year, where there was comparable rainfall, the total nitrogen discharge has decreased from 198 to 151.77 tonnes per annum, a 23.3% load reduction.

In 2019-2020 the discharge to Ludmilla Creek reduced to 0.01%, due to the poor wet season and hydraulic upgraded at the plant and in the rising main.

2.3 Physico-chemical indicators and Hazard assessment

Table 6: WDL 150-08 indicator data and hazard assessment November 2016 to August 2021

Indicator type	Physico-chemical indicators						
parameter	pH		EC	DO		TSS	BOD
Unit	pH units		µS/cm	% sat		mg/L	mg/L
DHWQO	7	8.5		80	100	6 DH: 10 LC	1653
SSTV Guideline ANZECC3	7	8.5		80-	120		<23
Assessment criteria percentile	20 th %ile	95 th %ile	50th (median)	Low 20th	High 95th	50th	95th
	Discharge point and treated effluent (receiving water quality guidelines is not directly applicable); 3 PER approved treatment plant design criteria, no guideline values for receiving waters <2 is desirable for rivers and marine waters, no guidance available for estuaries due to natural dissolved organic matter availability; 4ANZECC Low Reliability Trigger Values, Section 8 of ANZECC/ARMCANZ Guidelines for Fresh and Marine Waters.						
	Colour code: Meets ANZECC 2000 and Darwin Harbour Water Quality Objectives (DHWQO) light green < guideline; yellow exceeds DHWQO objective; orange exceeds all objectives.						
	Effluent Channel SLu080 and SLuLCDP are the same site the recarbonation chamber						
SLu080	7.75	8.79	1029.50	44.08	61.49	34	94
	Discharge to receiving waters: Ludmilla Creek (bypass drain entry point, upstream and downstream of discharge point)						
SLuLC03	7.64	8.23	52400.00	58.52	86.29	9	1
	Ludmilla Creek Receiving Waters Ludmilla Creek Receiving Waters						
SLuLC01	7.10	7.67	48300.00	35.06	69.23	9	1
SLuLC02	7.25	7.88	50250.00	34.6	67.55	10	1
SLuLC04	8.01	8.35	52800.00	82.6	95.93	3	1
	East Point Outfall (intertidal outfall) within Darwin Harbour receiving waters						
SLuEP01 -outfall	8.02	8.43	51900.00	85.66	95.645	4	1
SLuEP02	8.06	8.43	52750.00	85.08	95.645	2	1
SLuEP03	8.06	8.44	52850.00	83.8	95.5	2	1
	Hazard quotient: Ratio of test statistics to guideline where < 1 indicates the assessment statistic is compliant with the guideline and > 1 indicates exceedance of the guidelines:						
	Ranked by Green <1.0 Pink (low) >1.0 to <1.5; Orange (moderate) exceeds by a factor >1.5 to 10; Red (high) exceeds by factor >10						
	Hazard Quotient applied to treated effluent and discharge point; however the correlation is not directly relevant.						
SLu080		1.03		1.81	1.30	3.40	4.09
	Hazard Quotient Applied to Receiving Waters: Ludmilla Creek						
	Ludmilla Creek Discharge Point						
SLuLC03				1.37			
	Ludmilla Creek Receiving waters						
SLuLC01				2.28	1.16		
SLuLC02				2.31	1.18		
SLuLC04							
	East Point Outfall (intertidal outfall) within Darwin Harbour receiving waters						
SLuEP01							
	Darwin Harbour at East Point Receiving Waters						
SLuEP02							
SLuEP03							

2.3.1 pH Trends

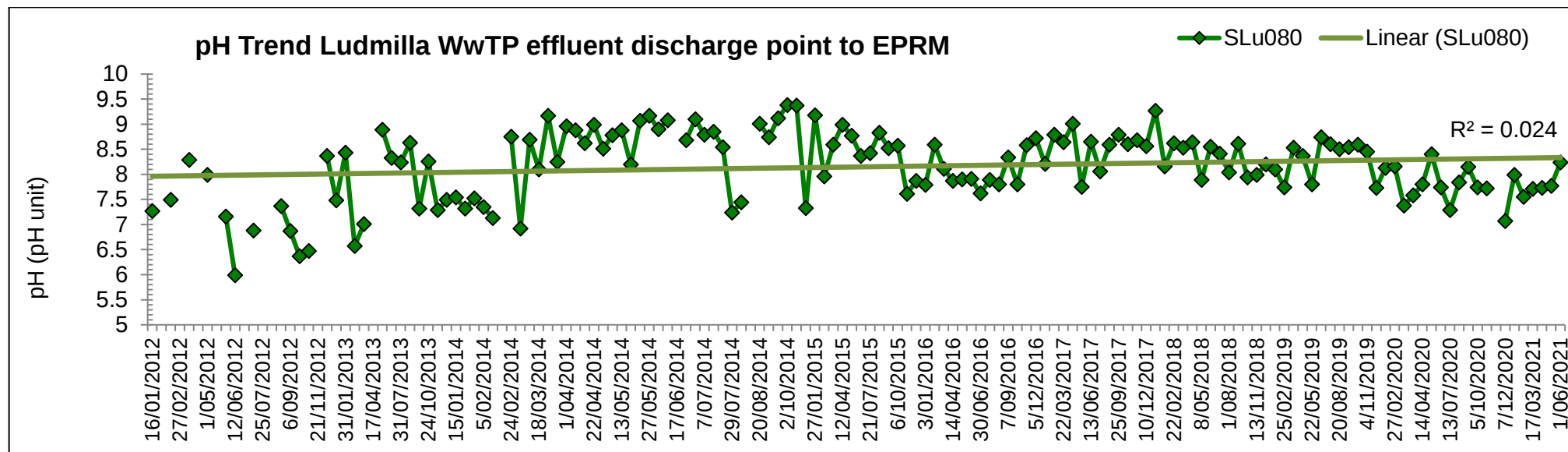


Figure 16: pH Effluent Trends January 2012 to August 2021

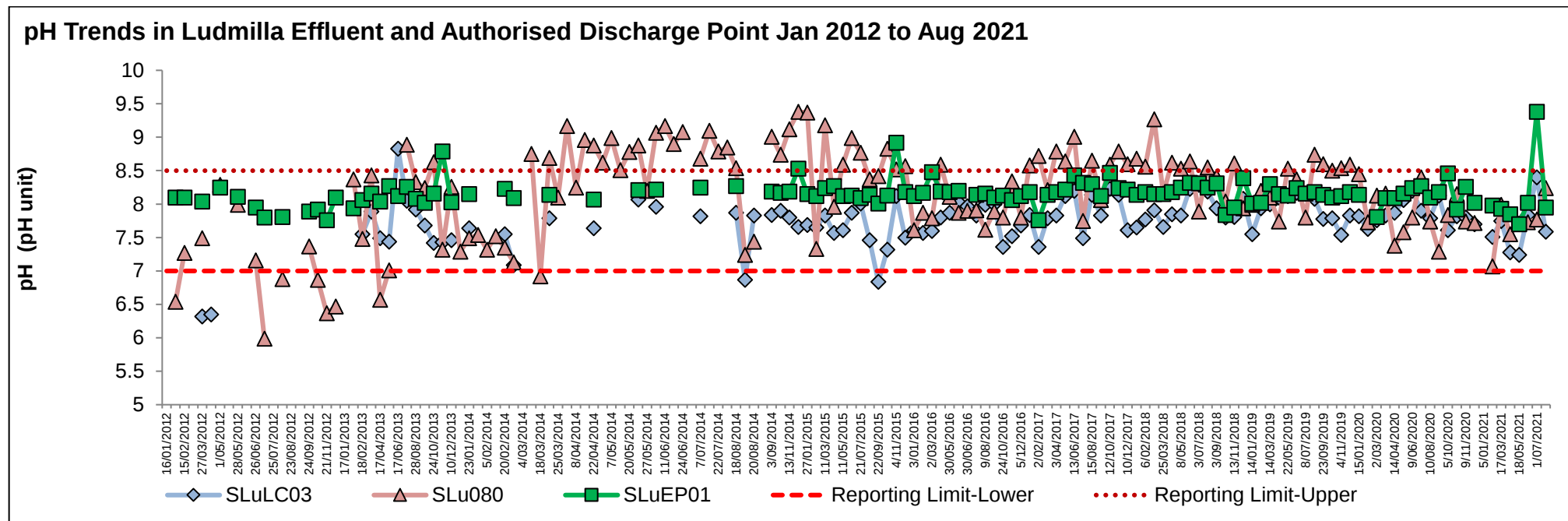


Figure 17: pH Trends in Ludmilla Effluent Discharge at Authorised Discharge Points: Trends January 2012 to August 2021

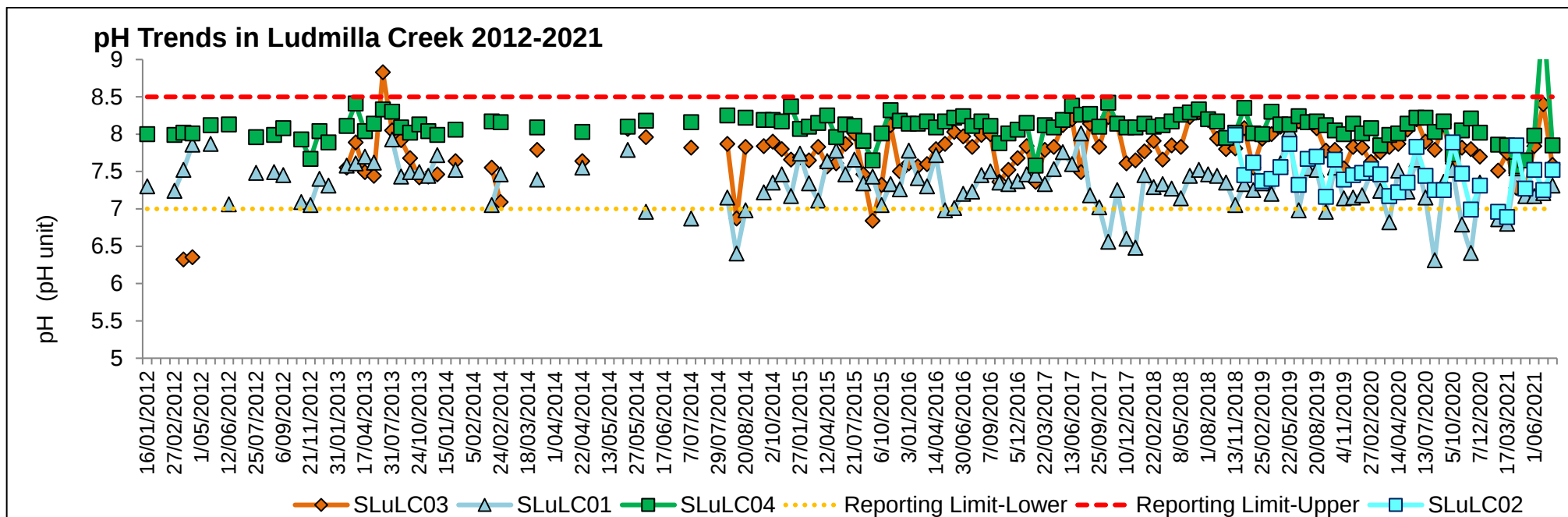


Figure 18: pH Trends in Ludmilla Creek Receiving Waters: Trends January 2012 to August 2021

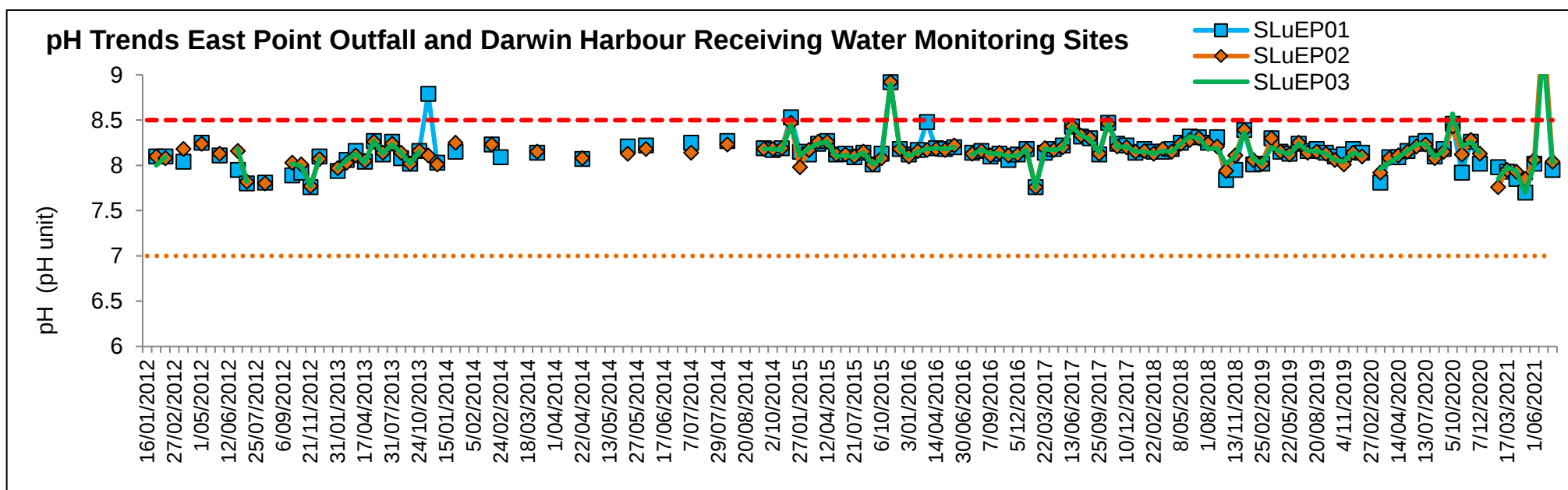


Figure 19: pH Trends in Darwin Harbour Receiving Waters: Trends January 2012 to August 2021

2.3.2 Electrical Conductivity (EC)

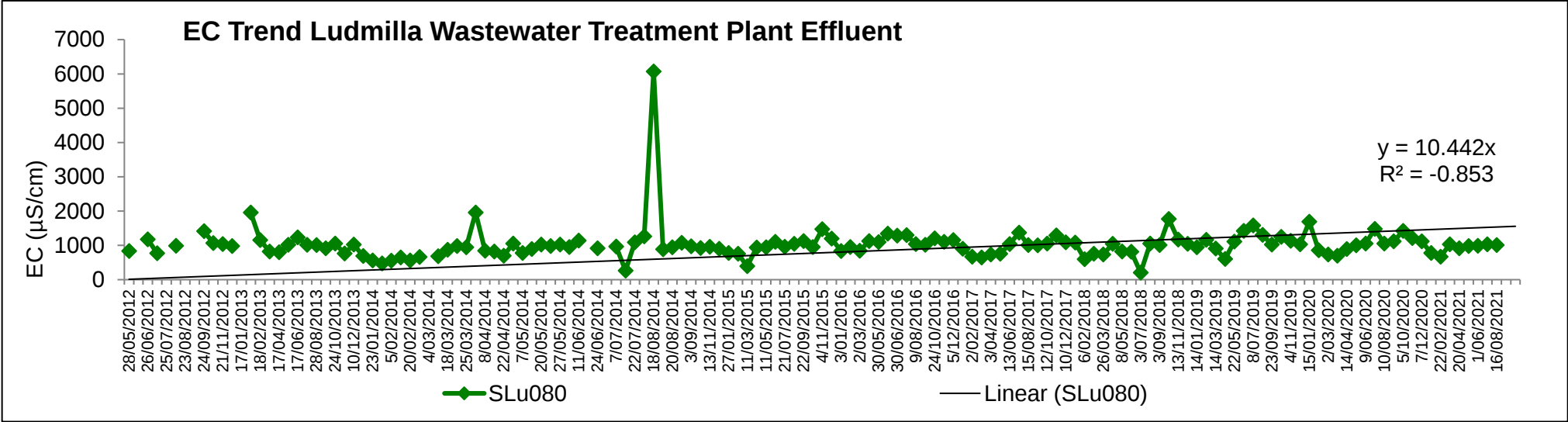


Figure 20: EC Ludmilla Effluent Trends 2012 to August 2021

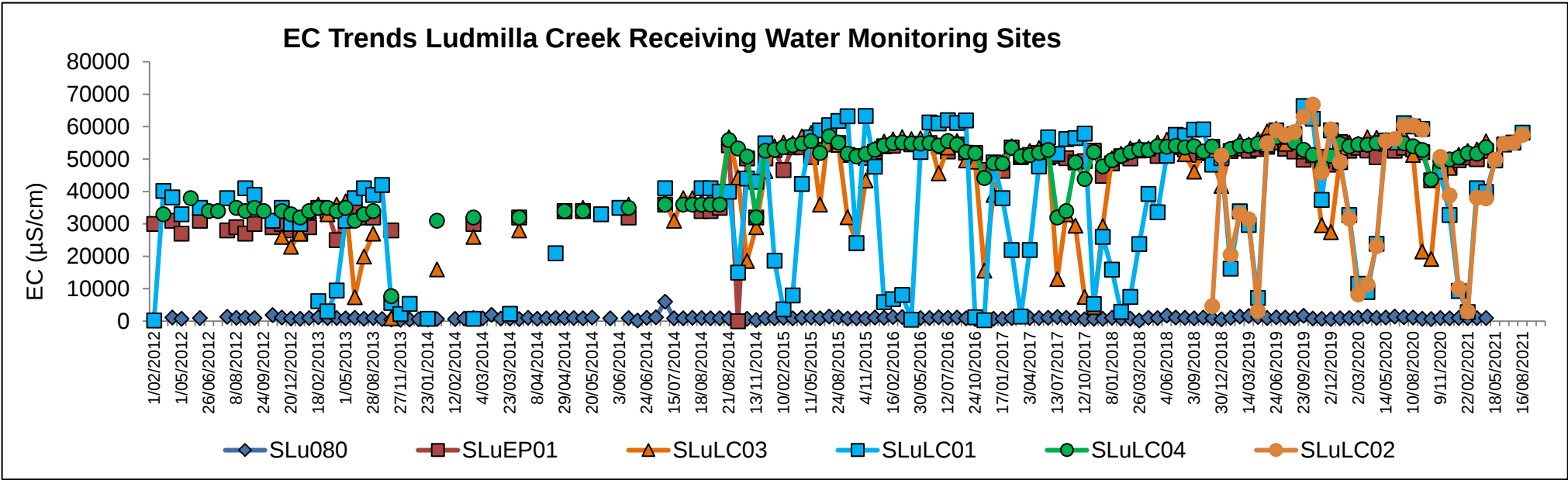


Figure 21: EC Ludmilla WWTP Discharge Receiving Waters: Ludmilla Creek Trends 2012 to August 2021

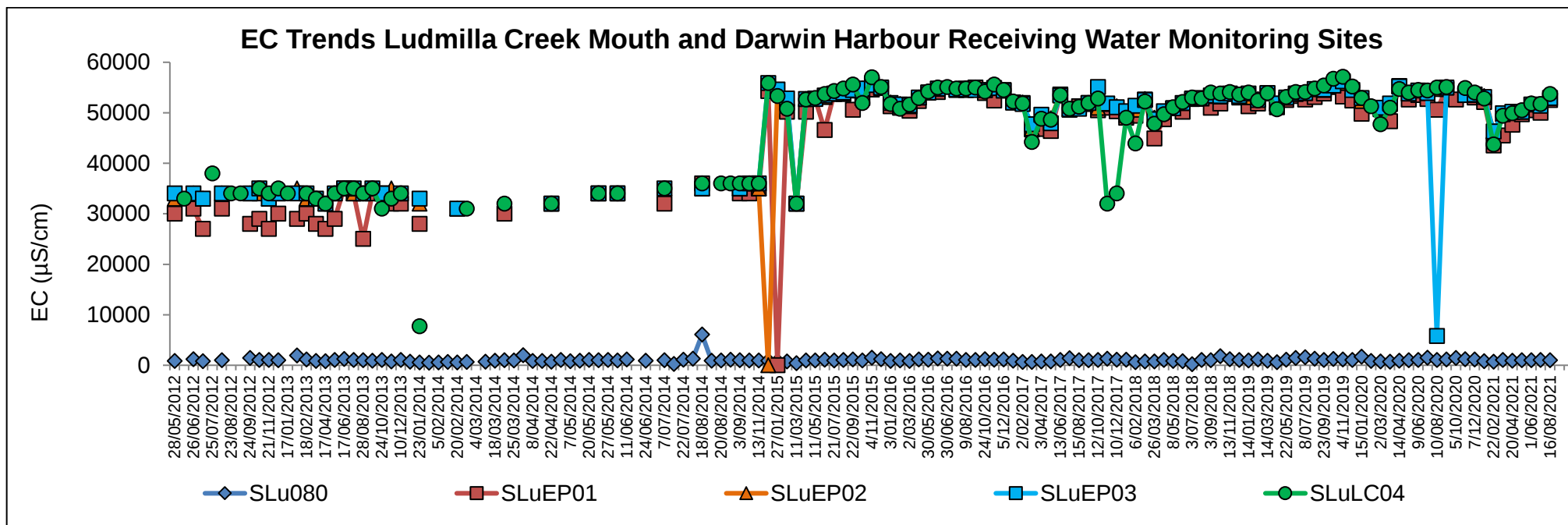


Figure 22: EC Ludmilla WWTP Discharge Receiving Waters: Darwin Harbour Trends 2012 to August 2021

2.3.3 Dissolved Oxygen

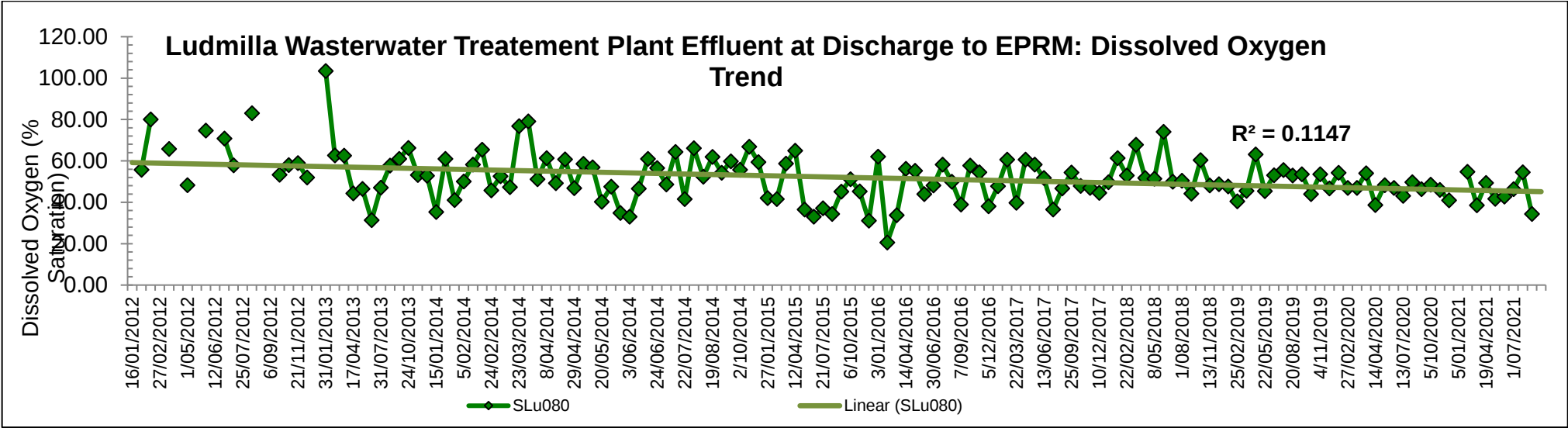


Figure 23: Dissolved Oxygen Ludmilla WWTP Effluent Trends 2012 to August 2021

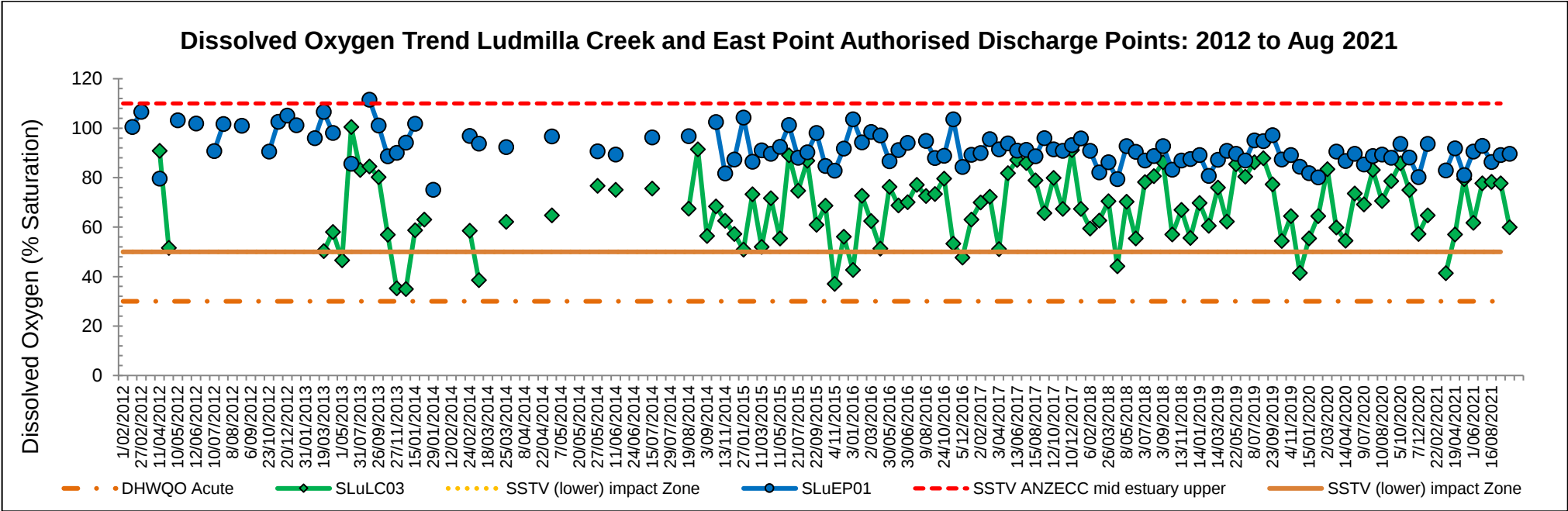


Figure 24: Dissolved Oxygen in Ludmilla WWTP Discharge Receiving Waters: Ludmilla Creek Harbour Trends 2012 to August 2021

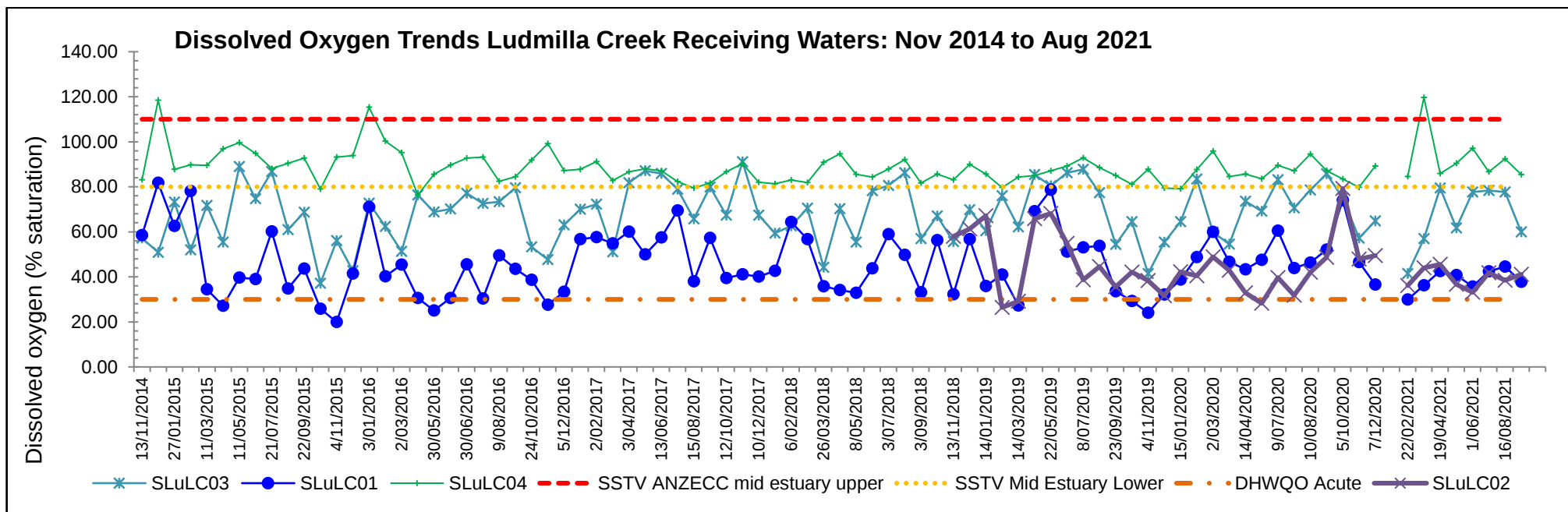


Figure 25: Dissolved Oxygen in Ludmilla WWTP Discharge Receiving Waters: Ludmilla Creek Harbour Trends November 2014 to August 2021

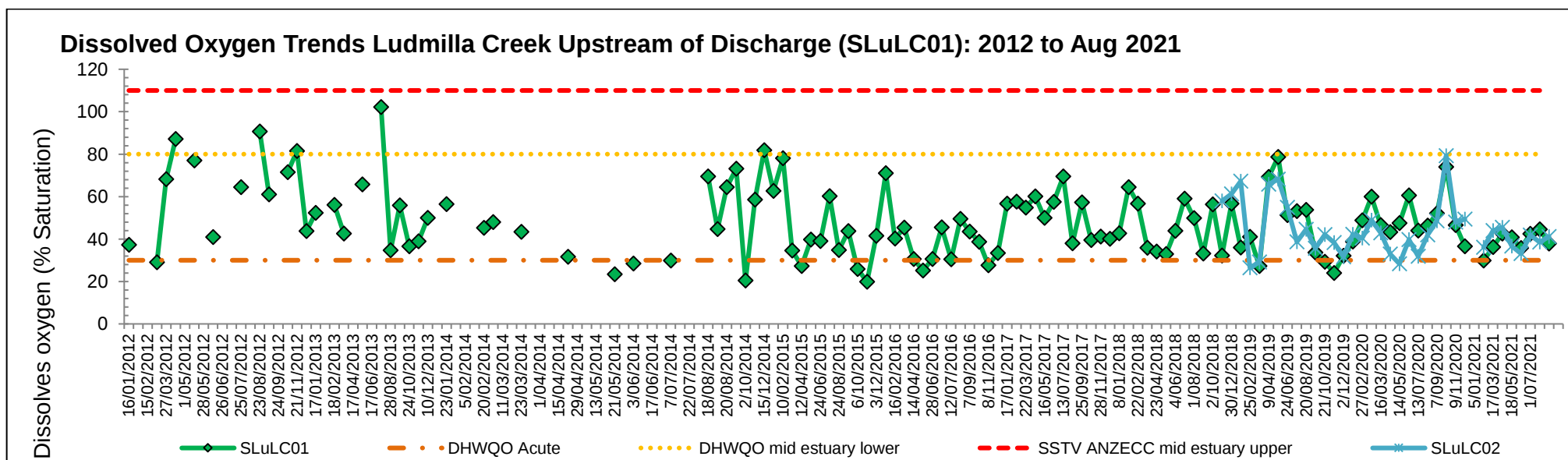


Figure 26: Dissolved Oxygen in Ludmilla Creek upstream of Ludmilla WWTP Discharge Trends 2012 to August 2021

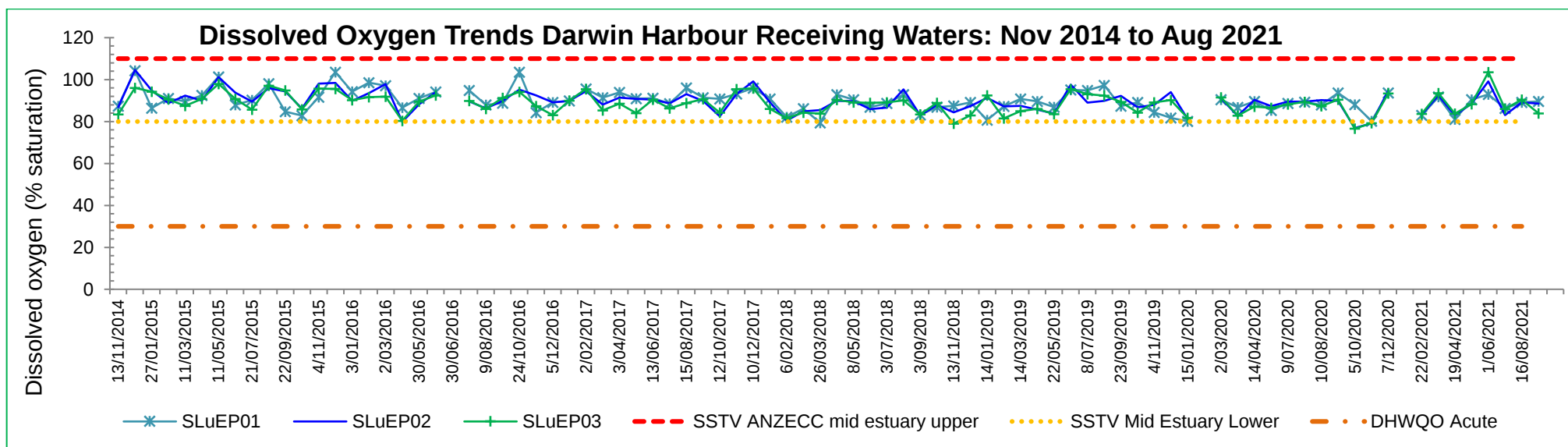


Figure 27: Dissolved Oxygen in Ludmilla WwTP Discharge Receiving Waters: Darwin Harbour Trends November 2014 to August 2021

2.3.4 Temperature

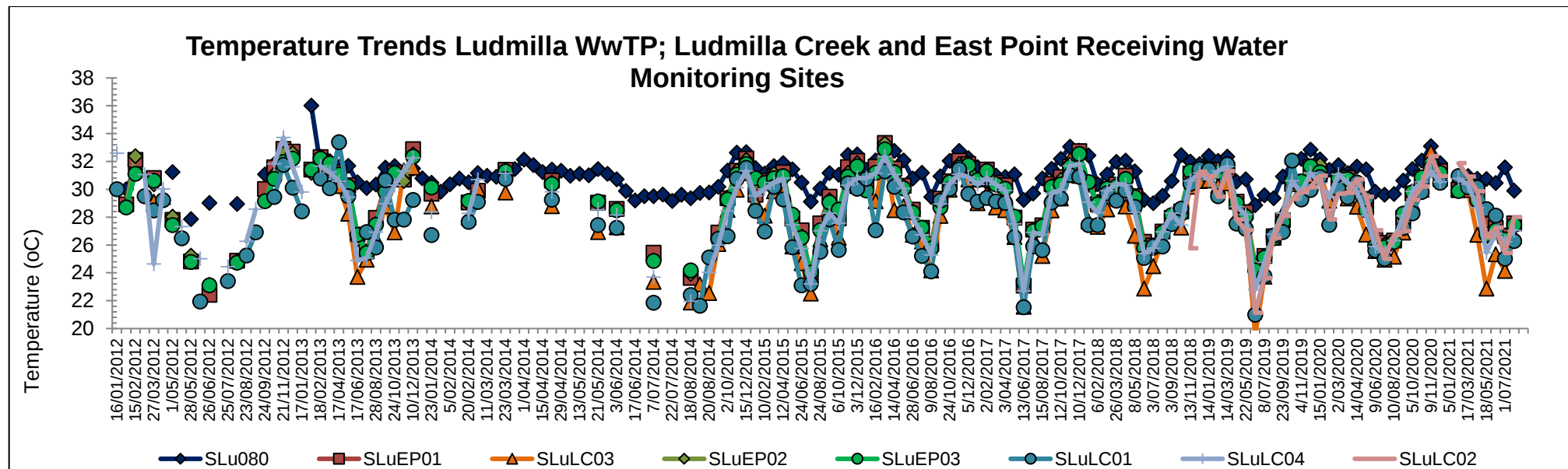


Figure 28: Temperature Trends Ludmilla WwTP Effluent and Discharge Receiving Waters January 2012 to August 2021

2.3.5 Total Suspended Solids (TSS)

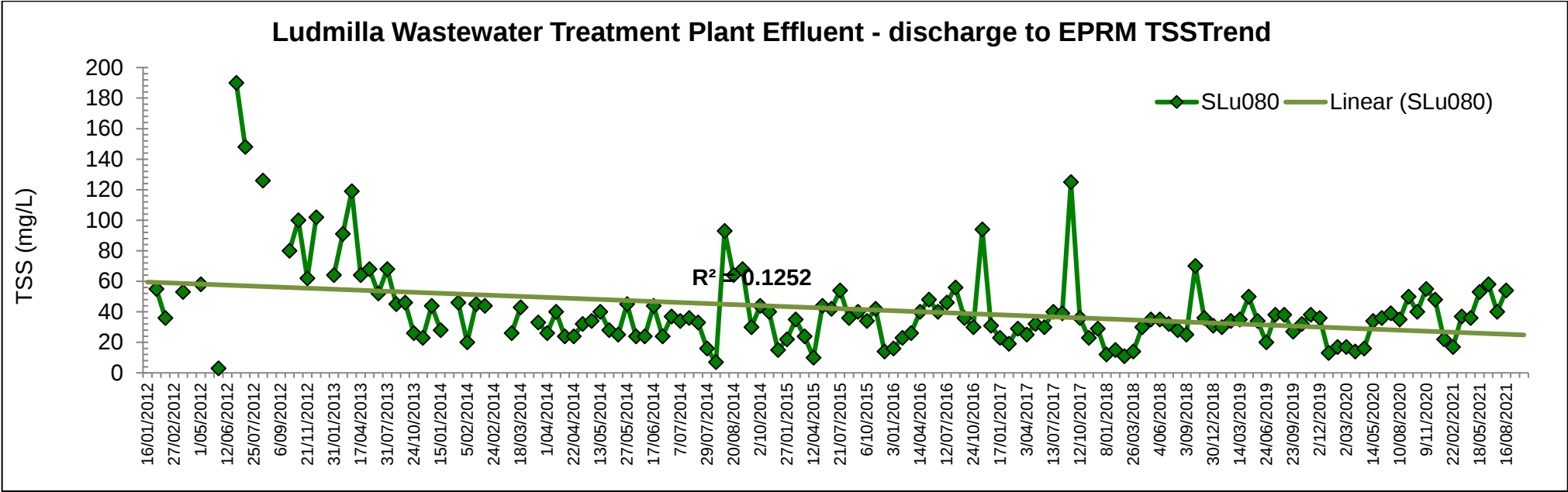


Figure 29: TSS Trend Ludmilla WwTP Effluent 2012 to August 2021

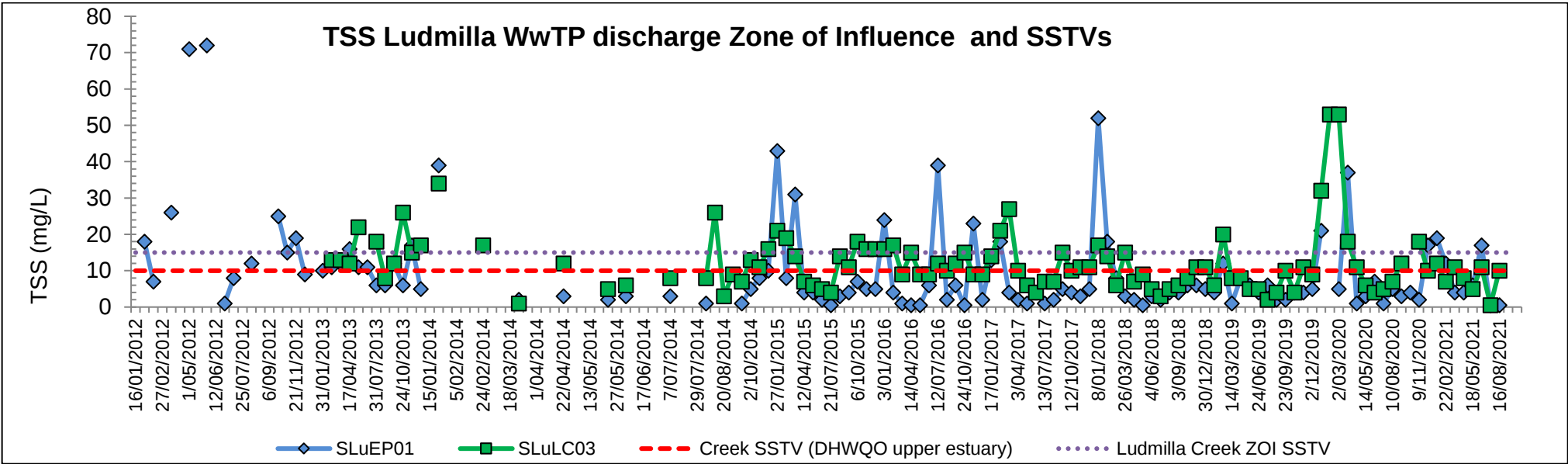


Figure 30: TSS Trends Ludmilla WwTP Authorised Discharge Points SLuEP01 (Darwin Harbour) and SLuLC03 (Ludmilla Creek) 2012 to August 2021

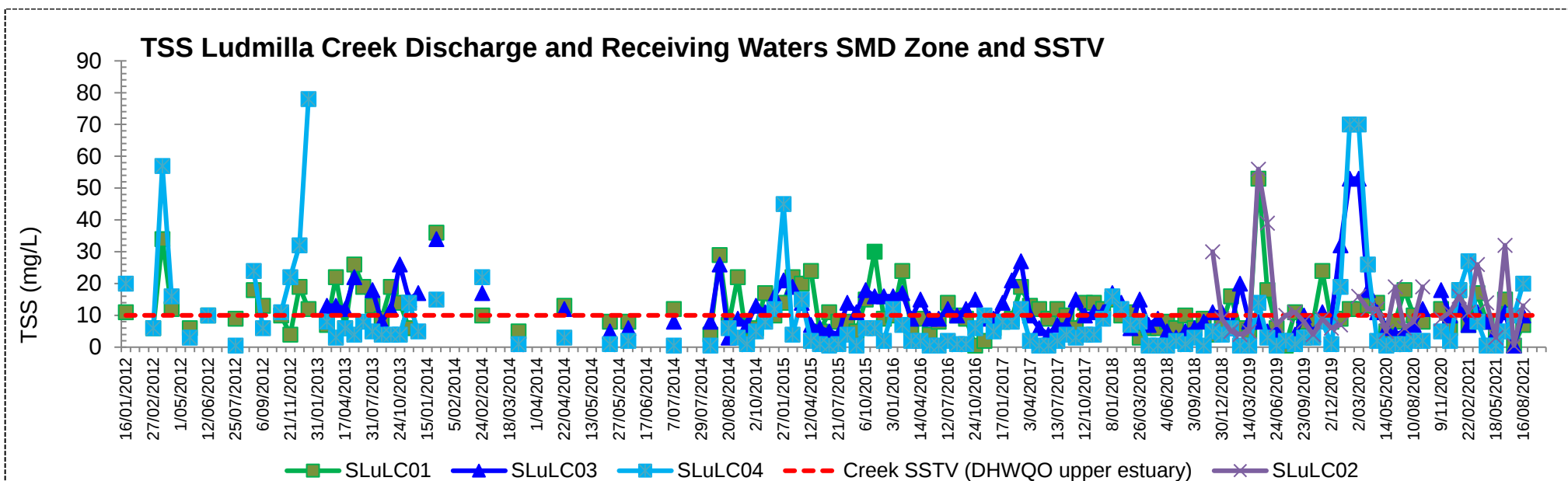


Figure 31: TSS Trends Ludmilla WwTP Discharge Receiving Waters: Ludmilla Creek 2012 to August 2021

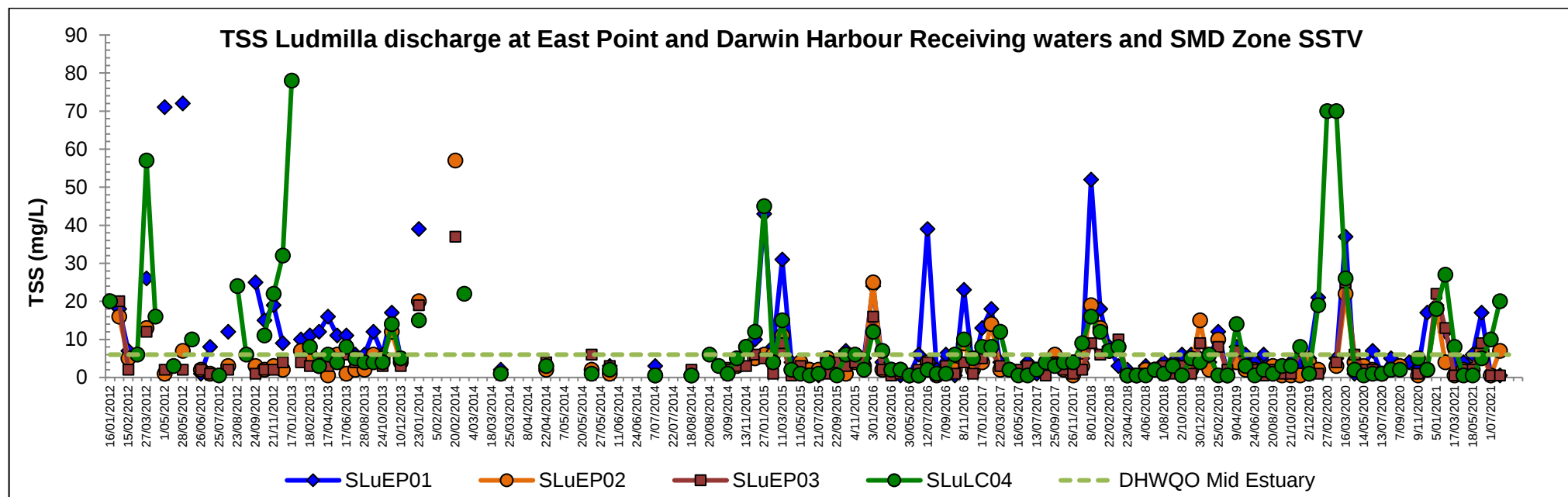


Figure 32: TSS Trends Ludmilla WwTP Discharge at East Point Outfall and Darwin Harbour Receiving Waters 2012 to August 2021

2.3.6 Biological Oxygen Demand (BOD)

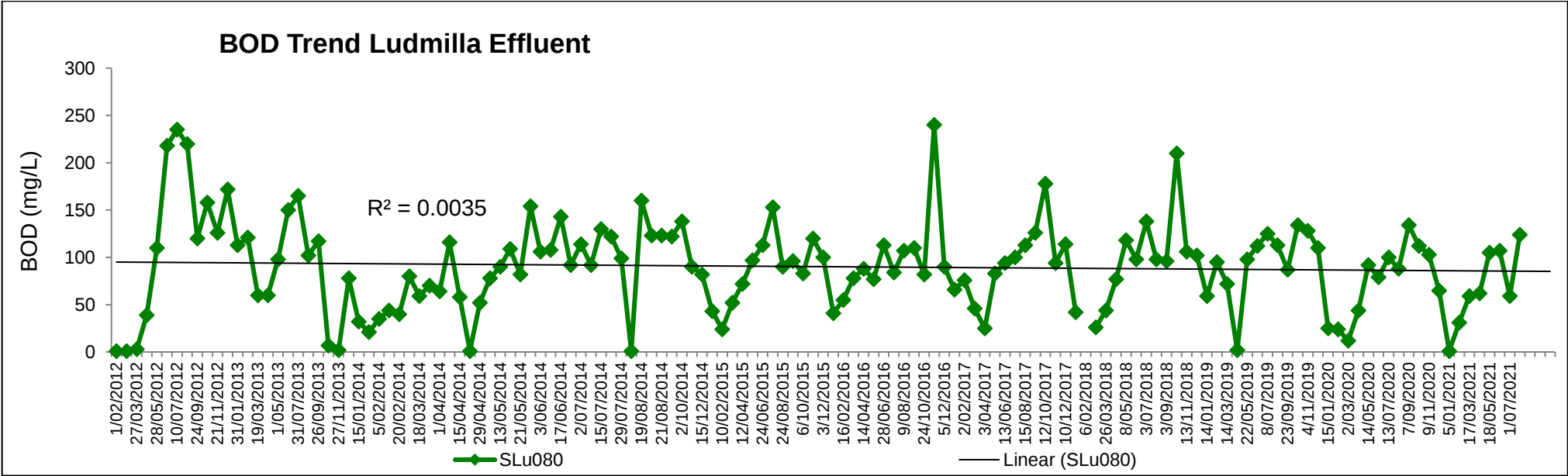


Figure 33: BOD Trend Ludmilla WwTP Effluent (SLu080) 2012 to August 2021

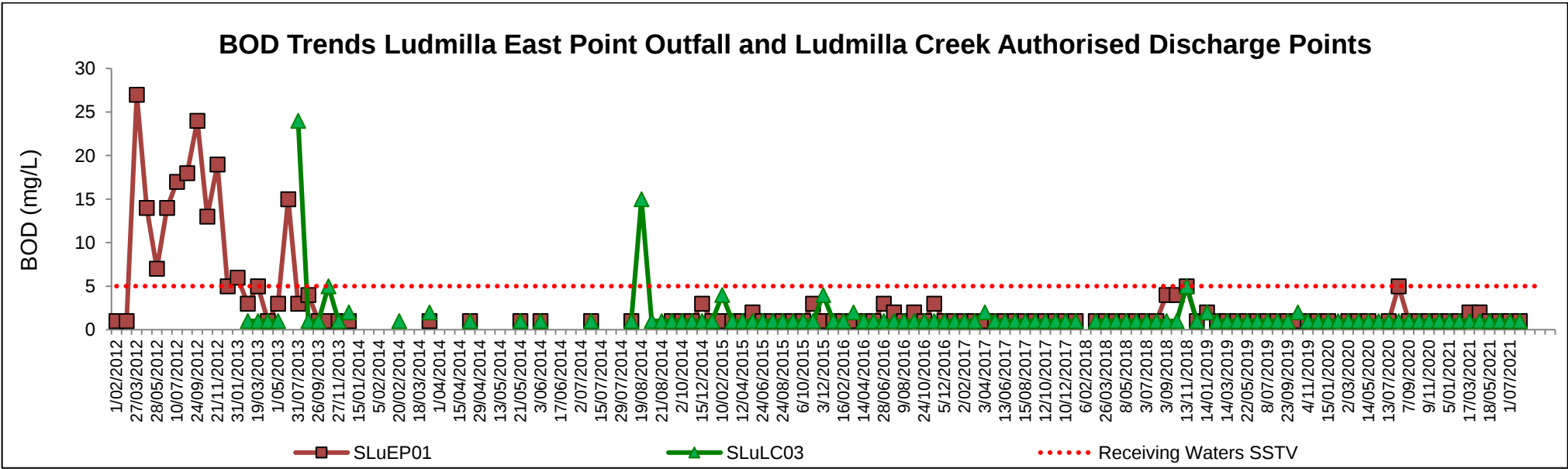


Figure 34: BOD Trends Ludmilla WwTP Authorised Discharge Points: East Point Outfall (SLuEP01) and Ludmilla Creek (SLuLC03) 2012 to August 2021

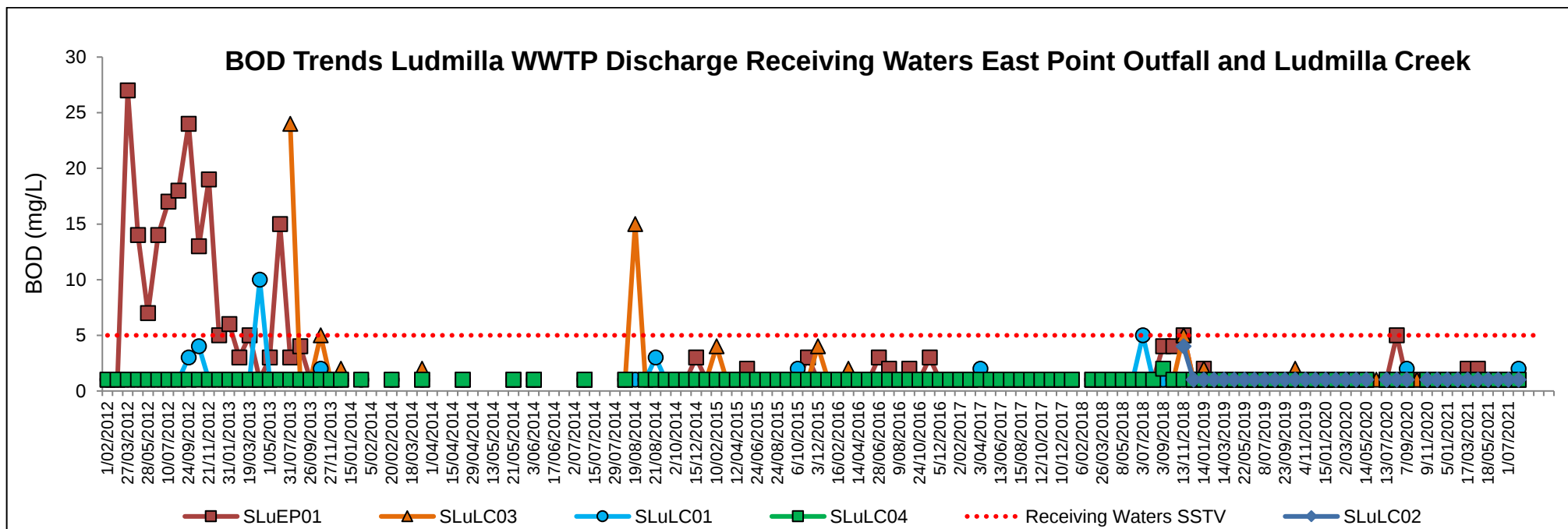


Figure 35: BOD Trends Ludmilla WwTP Discharge to Ludmilla Creek Receiving Waters 2012 to August 2021

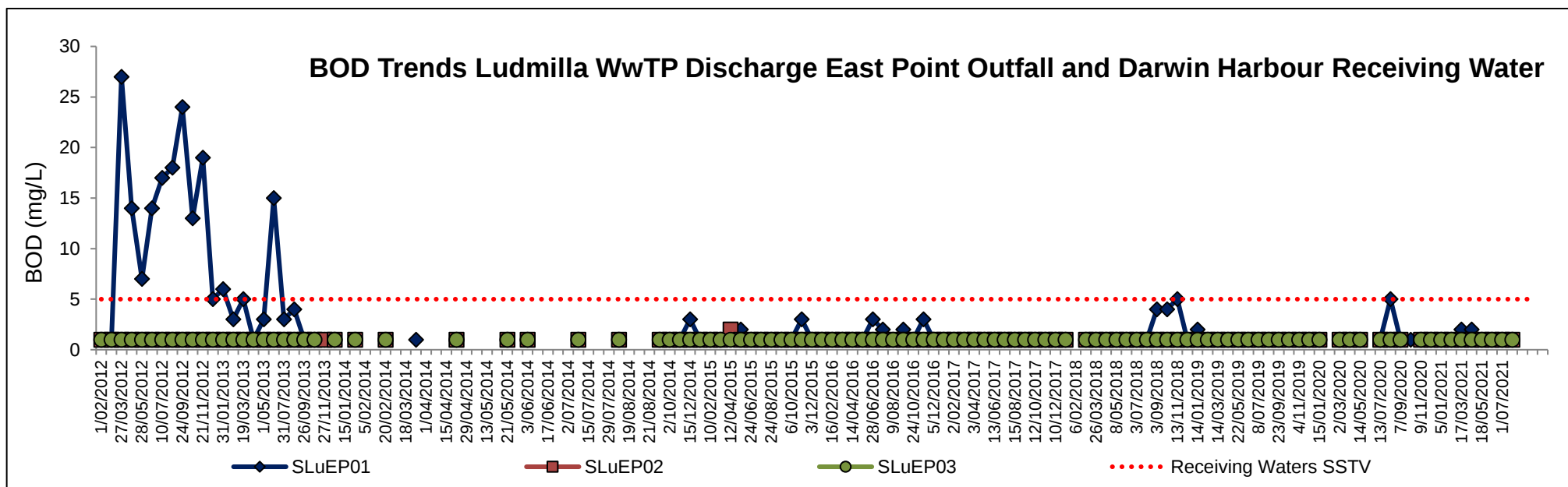


Figure 36: BOD Trends Ludmilla WwTP Discharge to Darwin Harbour Receiving Waters 2012 to August 2021

2.4 Pathogen Hazard and Risk Summary for the Ludmilla WwTP discharge to Darwin Harbour and Ludmilla Creek

Table 7: WDL 150-08 Pathogen risk rating summary review against NHMRC and SSTVs data November 2016 to 31 August 2021

Pathogen Indicators Water Quality Assessment 2016-2020									
parameter	E. coli		Enterococci	Likelihood		Hazard Consequence			Risk Rating
Unit	cfu/100 mL								
1 DHWQO Aquatic food	14 ¹	43 ¹	40 ²						
2 NHMRC primary contact recreation									
Assessment criteria percentile	Aquatic food:		Primary Recreation	Aquatic Food collection and food production (aquaculture)	Primary Contact Recreation	Aquatic Food collection and production (aquaculture)	Primary Contact Recreation	Aquatic food collection and aquaculture	Primary Contact Recreation
	50th	90th	95th						
SLu080	19.0	3530.0	157.0						
SLuLC03 ²	26.0	95.6	393.0						
SLuLC01 ²	58.0	522.0	1668.5						
SLuLC02 ²	61.0	1220.0	3434.5						
SLuLC04 ²	3.0	14.8	66.0						
SLuEP01 ¹ outfall	1.0	13.5	9.0						
SLuEP02 ¹	1.0	1.0	3.0						
SLuEP03 ¹	1.0	2.0	8.0						
Hazard Assessment for pathogen indicators (enterococci and E. coli). Assessment for the suitability of the waters for swimming and the collection of organisms for consumption and the use of the water for aquaculture.									
SLu080	1.4	82.1	3.9	Almost certain	Almost Certain	Moderate (GI illness requiring medical attention or hospitalisation)	> 10% Moderate (GI illness requiring medical attention or hospitalisation)	Extreme (no pathway for use)	Extreme (no pathway for use)
	Aquatic food	10 Recreation (swimming)							
Ludmilla Creek									
SLuLC03	1.9	2.2	9.8	Almost certain	Almost certain	Moderate (GI illness requiring medical attention or hospitalisation)	> 10% GI illness requiring medical attention or hospitalisation- moderate	high	Very High
SLuLC01	4.1	12.1	41.7		(Swimming rare)				Very High
SLuLC02	4.4	28.4	85.9						
SLuLC04			1.7	Possible	Likely	Moderate (GI illness requiring medical attention)	> 10% GI illness requiring medical attention or hospitalisation- moderate	Moderate: high results following rain	Moderate: high results following rain
				Risk <10%	(Swimming rare)				
East Point Outfall									
SLuEP01				Unlikely	Possible	Minor (illness short term inconvenience)	<1% minor (illness short term inconvenience)	Low Sewerage outfall exclusion zone advice	Low
Darwin Harbour in the vicinity of East Point									
SLuEP02				Unlikely	Possible	Minor (illness short term inconvenience)	<1% minor (illness short term inconvenience)	Low	Low
SLuEP03				Unlikely	Possible	Minor (illness short term inconvenience)	<1% minor (illness short term inconvenience)	Low	Low

2.4.1 Escherichia coli

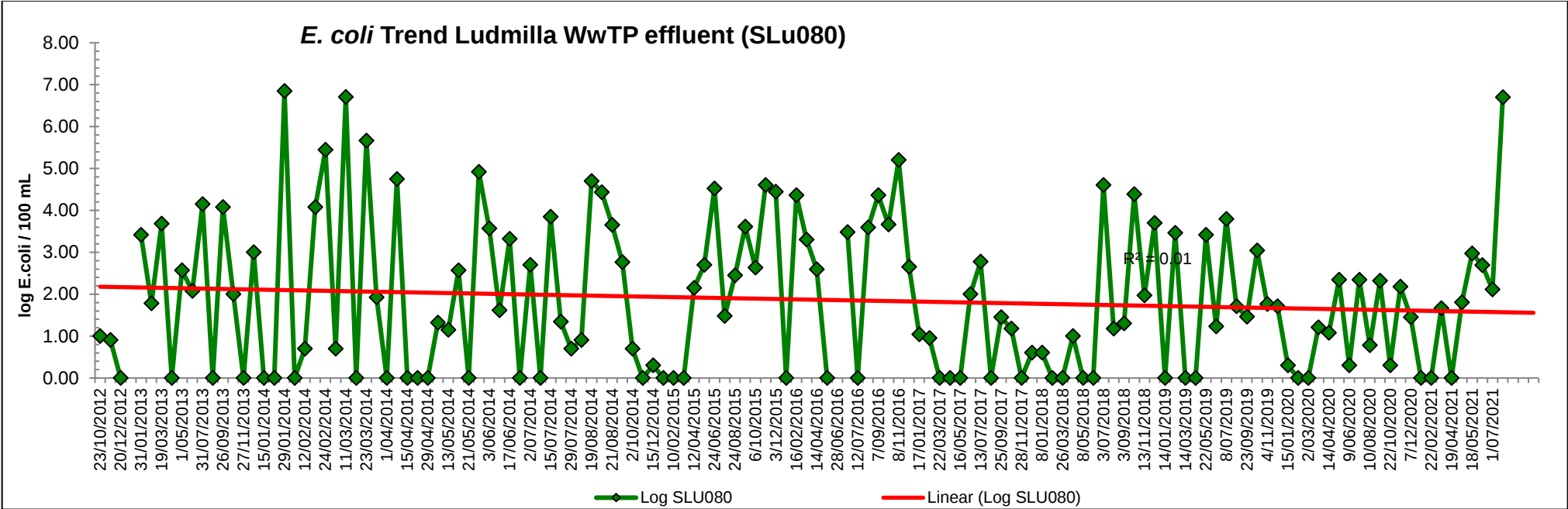


Figure 37: E. coli Trends in Ludmilla WwTP Effluent (SLu080) 2012 to August 2021

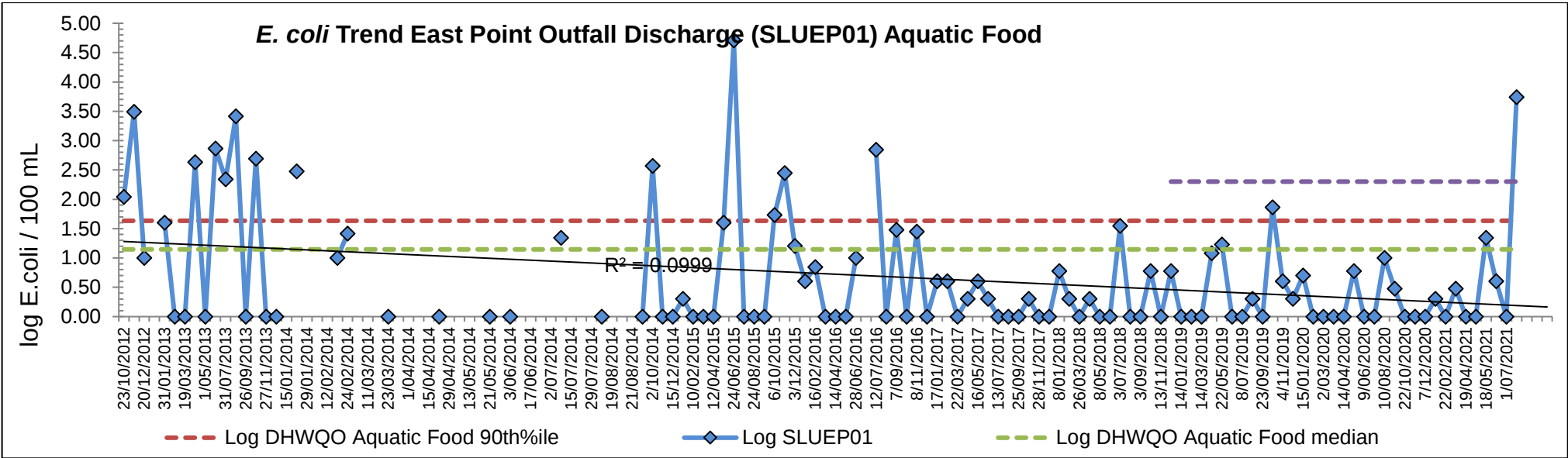


Figure 38: E. coli Trends in Ludmilla WwTP Discharge at East Point Outfall Authorised Discharge Point (SLUEP01) 2012 to August 2021

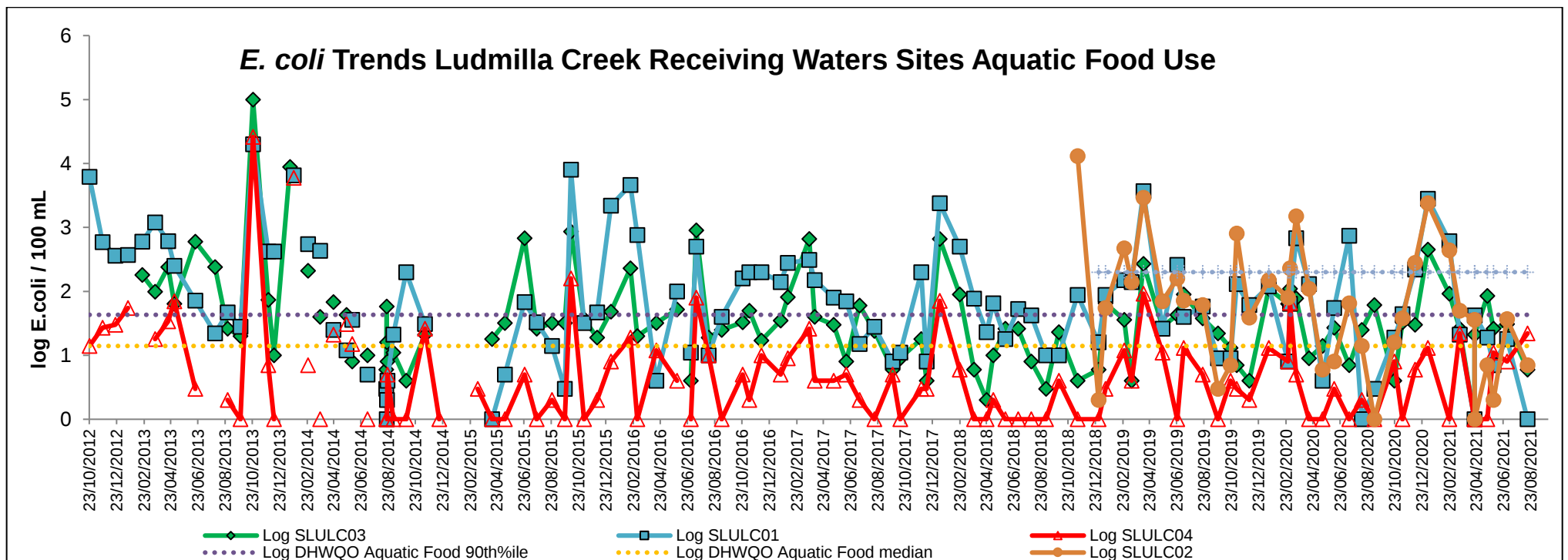


Figure 39: E. coli Trends in Ludmilla WwTP Discharge Receiving Waters: Ludmilla Creek 2012 to August 2021

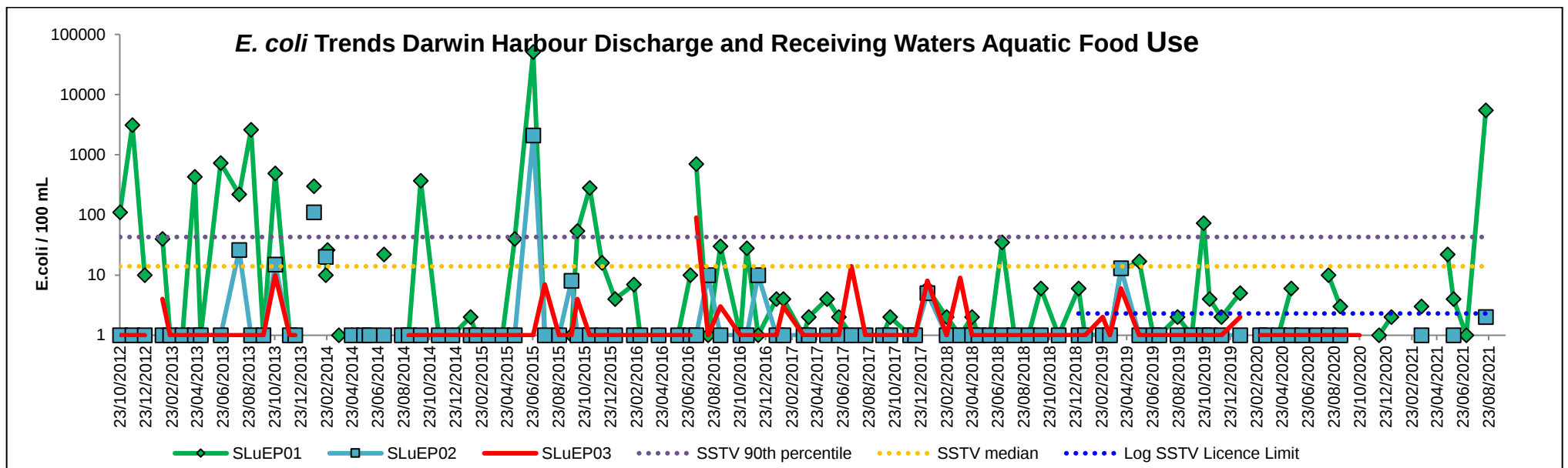


Figure 40: E. coli Trends in Ludmilla WwTP Discharge Receiving Waters: Darwin Harbour 2012 to August 2021

***E. coli* at Discharge East Point Outfall and Darwin Harbour Receiving Waters 2016-2021**

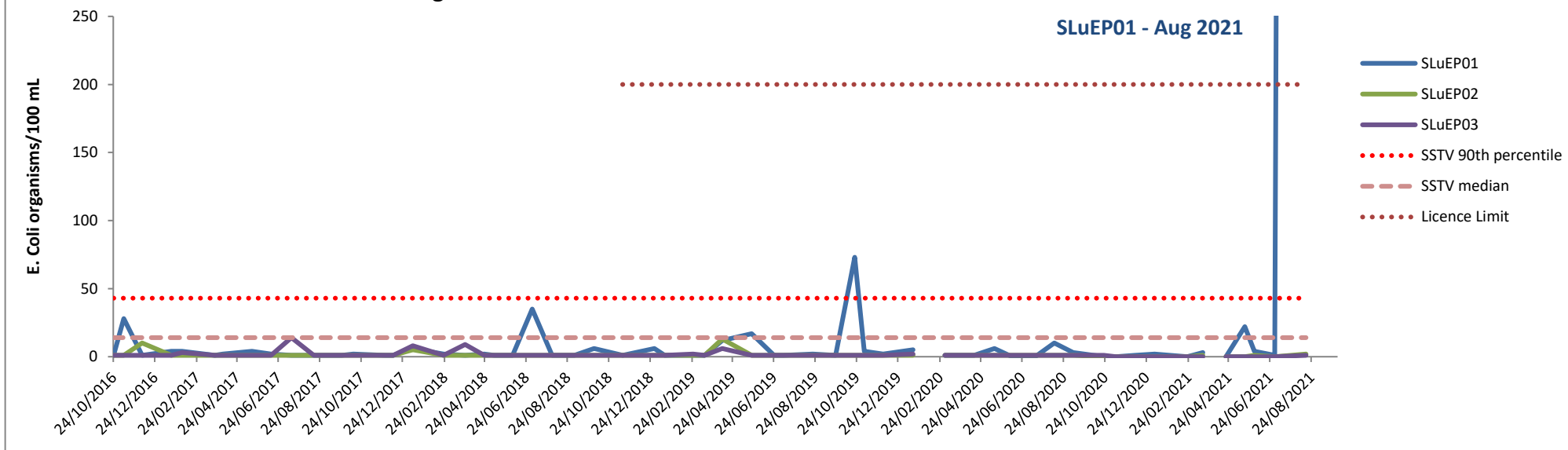


Figure 41: *E. coli* Trends in Ludmilla WwTP Discharge and Darwin Harbour Receiving Waters November October 2020: WDL 150-05; 150-06; 150-07 and 150-08

***E. coli* Trends at the discharge East Point Outfall and Ludmilla Creek Receiving Waters**

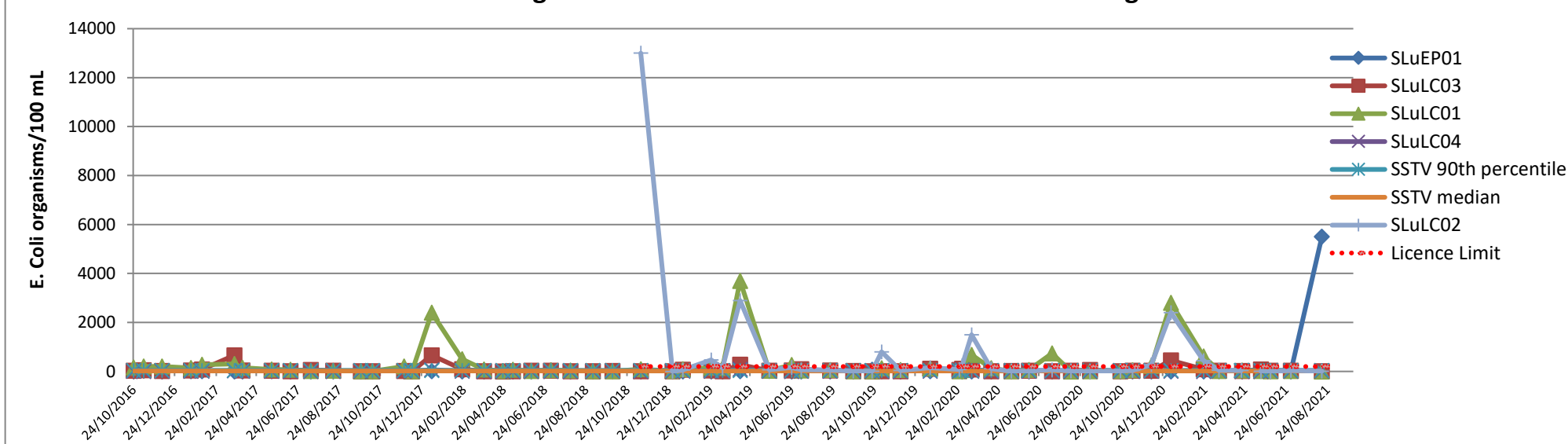


Figure 42: *E. coli* Trends in Ludmilla WwTP Discharge and Ludmilla Creek Receiving Waters November 2016 to October 2020: WDL 150-05; 150-06; 150-07 and 150-08

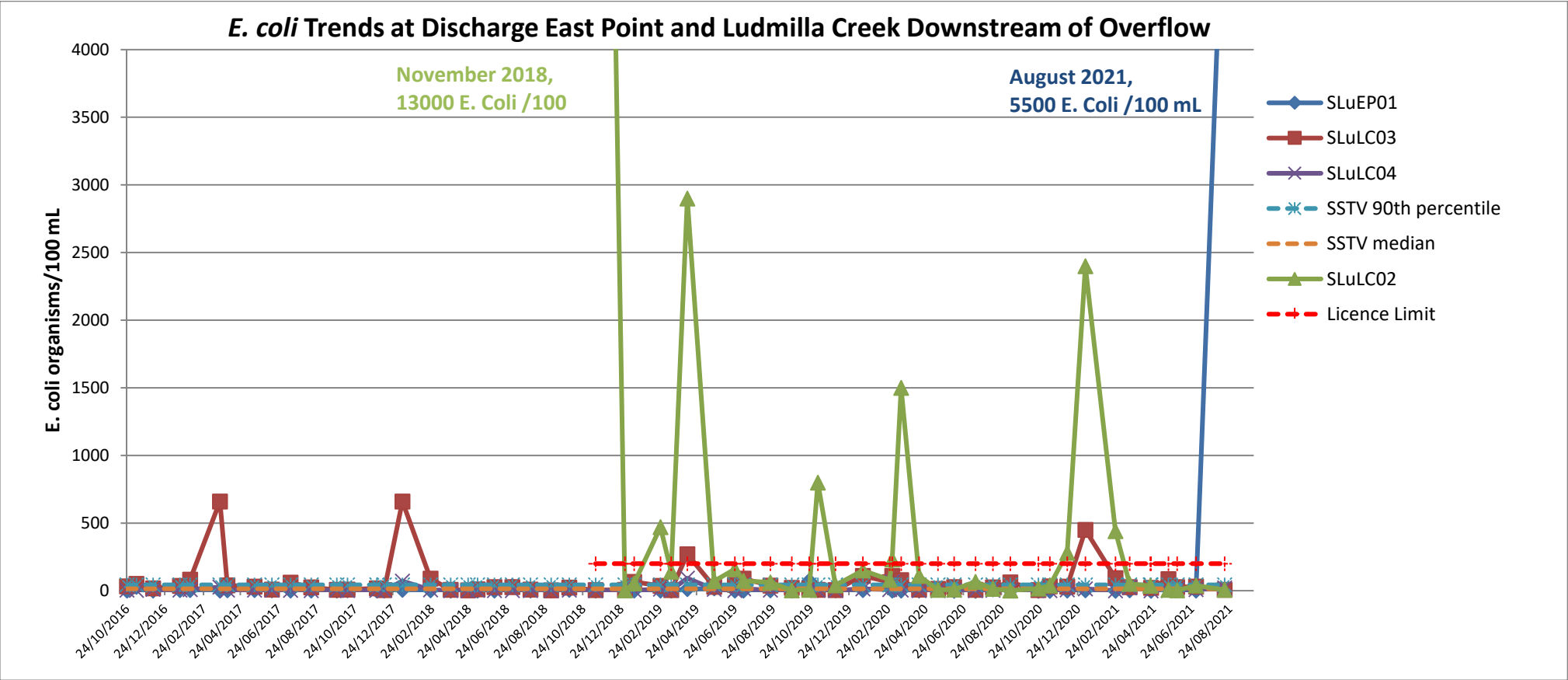


Figure 43: *E. coli* Trends in Ludmilla WwTP Discharge at East point Outfall and in Ludmilla Creek 26 October 2016 to 31 October 2020: WDL 150-05; 150-06; 150-07 and 150-08

2.4.2 Enterococci

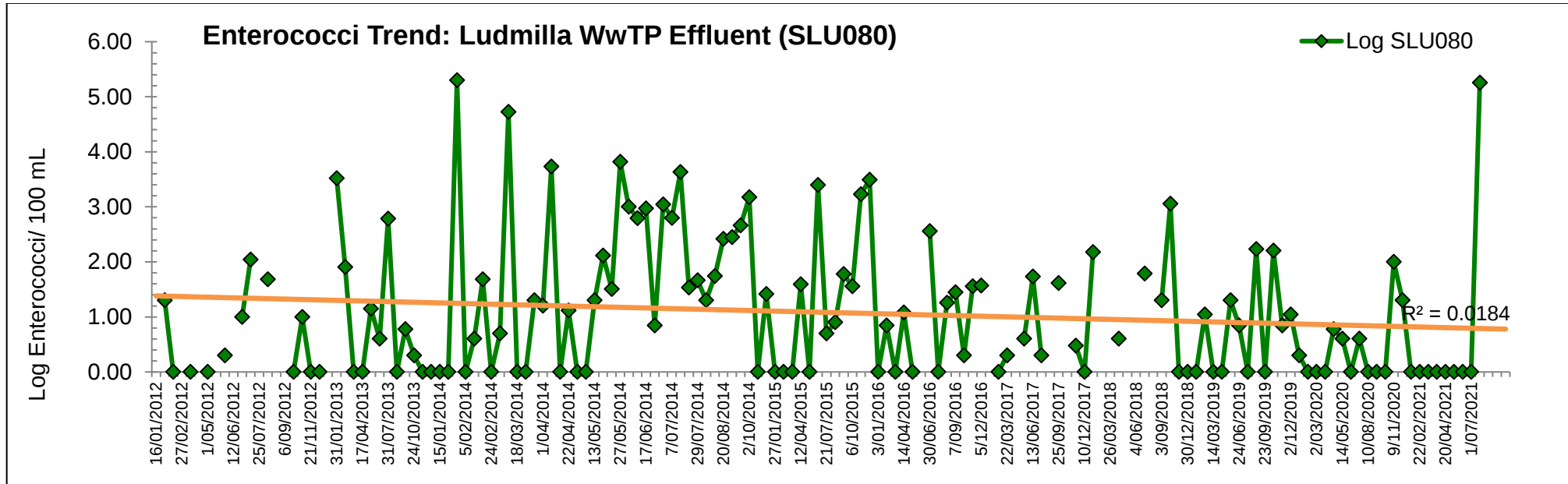


Figure 44: Enterococci Trends in Ludmilla WwTP Effluent (SLU080) 2012 to August 2021

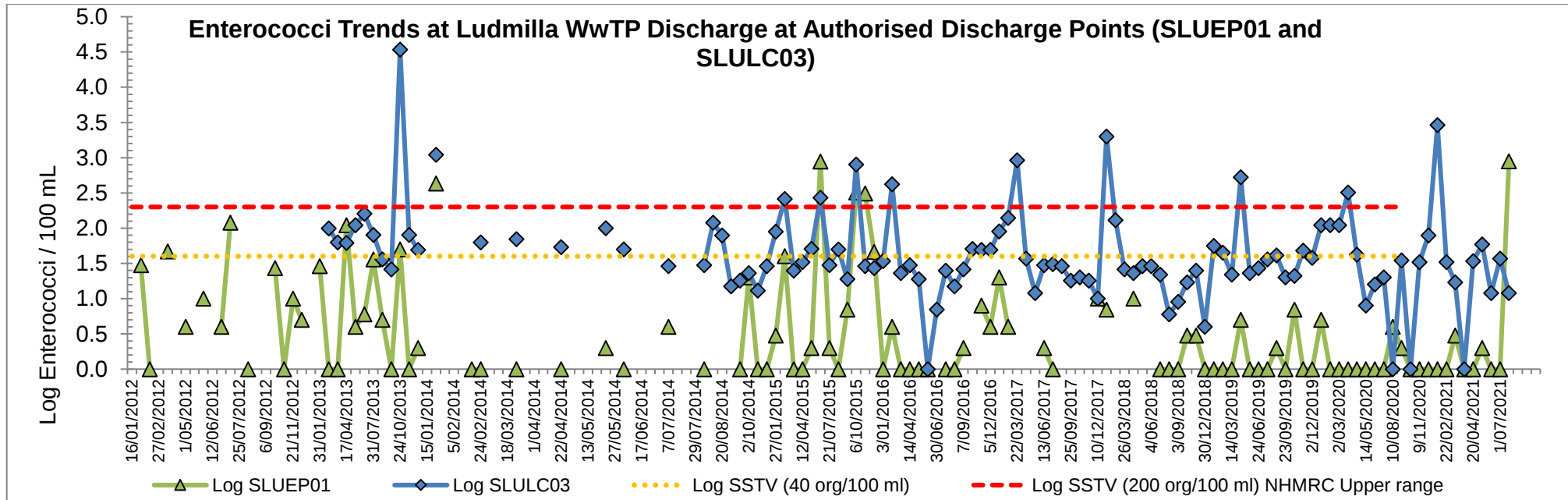


Figure 45: Enterococci Trends Ludmilla WwTP Authorised Discharge Points: East Point Outfall (SLUEP01) and Ludmilla Creek Drain (SLULC03) 2012 to August 2021

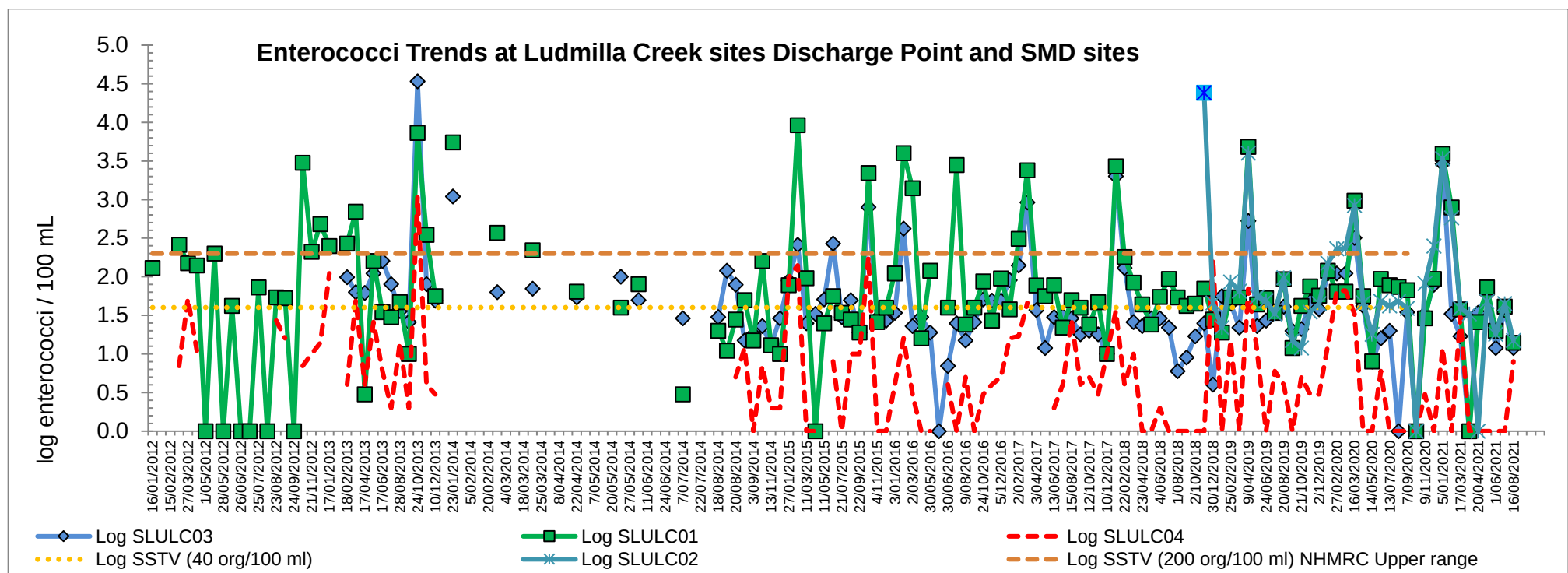


Figure 46: Enterococci Trends Ludmilla WwTP Discharge Receiving Waters: Ludmilla Creek 2012 to October 2020

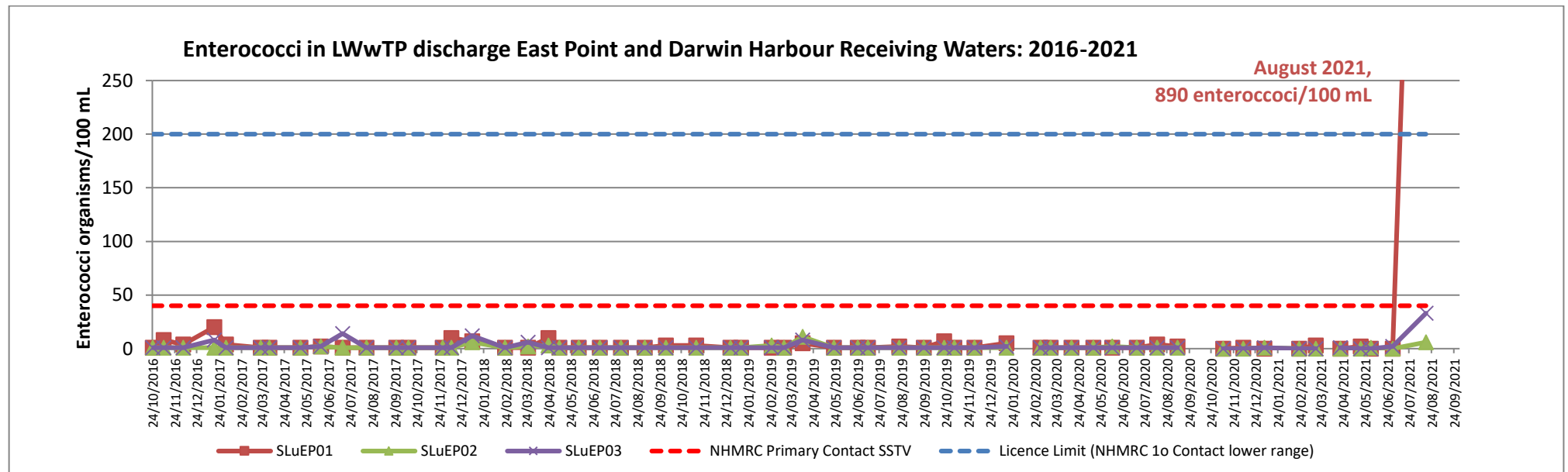


Figure 47: Enterococci Trends Ludmilla WwTP Discharge Receiving Waters: Darwin Harbour October 2016 to August 2021

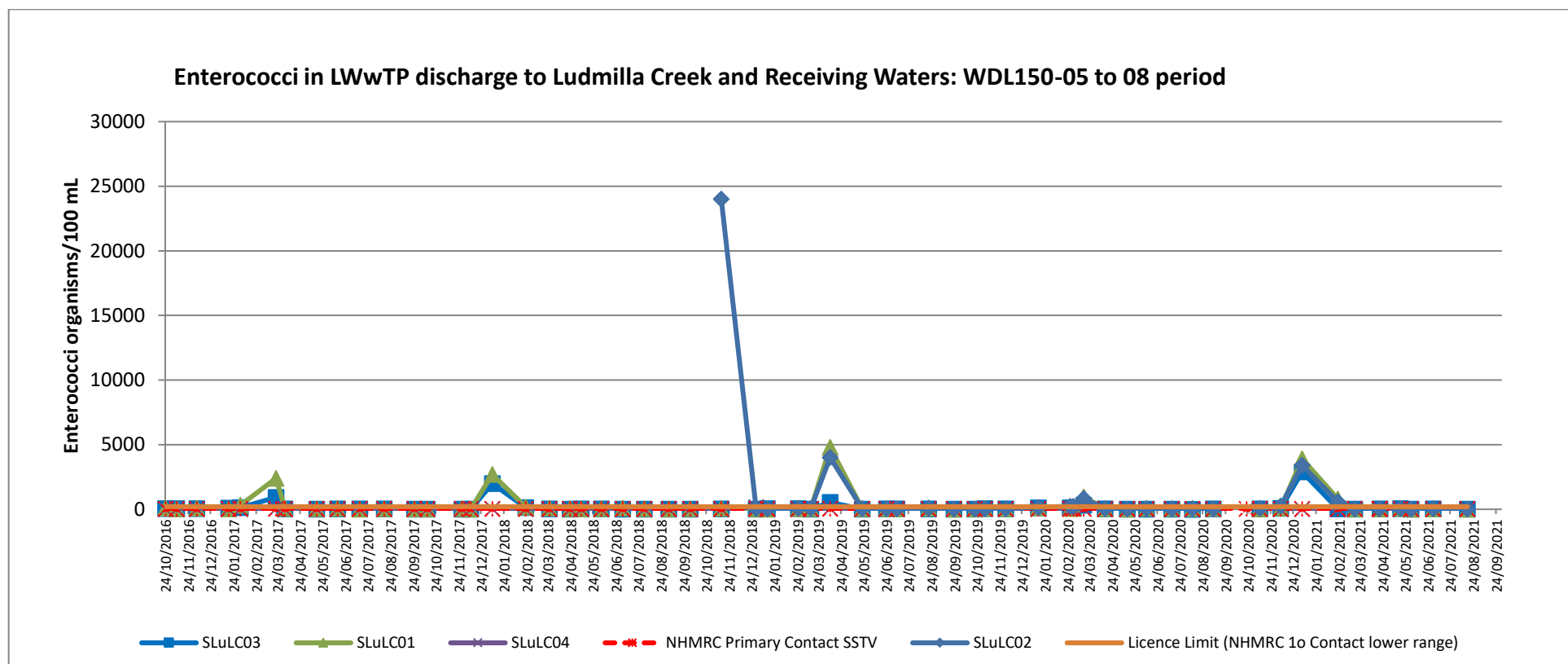


Figure 48: Enterococci Trends in Ludmilla WwTP Discharge at Ludmilla Creek Discharge (SLuLC03) and in Ludmilla Creek Receiving Waters

2.5 Nutrients

Table 8 WDL 150-08 Nutrient risk rating November 2016 to 31 August 2021

Nutrient Water Quality Assessment following commissioning of Ludmilla WwTP upgrade June 2014 onwards									
Indicator Type	Nutrient Indicators						Likelihood	Consequence	Risk Rating
parameter	FRP	TP	NH3-N	TN	NOx	Chl-a			
Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L			
SSTV		20 ¹		270 ¹	17 ¹	2 ¹			
Outer Estuary ¹	5 ¹	30 ²	20	300 ²	20 ²	4 ²			
Mid Estuary ²	10 ²								
ANZECC level of species protection	5	20	15	250	30	2			
Assessment criteria percentile	50 th	50 th	50 th	50 th	50 th	50 th			
Discharge point and treated effluent (receiving water quality guidelines is not directly applicable); Colour code for comparison: Compliant to ANZECC 2000 and Darwin Harbour Water Quality Objectives (DHWQO): light green ≤ guideline; yellow exceeds DHWQO, not ANZECC objectives; ANZECC trigger values pale orange exceeds slightly to moderately (SMD); orange exceeds all objectives and disturbed (D) triggers.									
SLu080	770	1670	29840	36715	164.5	0.56			
Discharge to receiving waters: Ludmilla Creek , discharge upstream and downstream of discharge									
SLuLC01 ²	9	63	5.5	540	11	2.24			
SLuLC02 ²	12	72	2.5	515	1.5	2.52			
SLuLC03 ²	8	52	2.5	375	1.5	4.5			
SLuLC04 ²	5	36	2.5	265	1.5	0.72			
East Point Outfall within Darwin Harbour receiving waters									
SLuEP01 ¹ -outfall	8	64.5	419.5	1070	4.5	0.58			
Darwin Harbour receiving waters									
SLuEP02 ¹	6	39	2.5	225	1.5	0.58			
SLuEP03 ¹	5	34	2.5	220	3	0.65			
Hazard quotient: Ratio of test statistics to guideline where < 1 indicates the assessment statistic is compliant with the guideline and > 1 indicates exceedance of the guidelines: Ranked by Green <1.0 Pink (low) ≥1.0 to ≤1.5; Orange (moderate) exceeds by a factor >1.5 to 10; Red (high) exceeds by factor >10							Hazard assessment risk of eutrophication		
SLu080	77	56	1492	122	8		Almost certain	Moderate impact low dissolved oxygen localised within the plant	high
Hazard Quotient Applied to Receiving Waters and Ludmilla Creek Discharge Point									
Hazard Quotient Applied to Receiving Waters: Ludmilla Creek									
SLuLC01		2.1		1.8		1.1	likely	Localised low DO may be natural	medium
SLuLC02	1.2	2.4		1.7		1.3			medium
SLuLC03		1.7		1.3			likely	Localised elevated chl-a and low DO	medium
SLuLC04		1.2					possible	DO above DHWQO range insignificant	low
Hazard Quotient Applied to Discharge at East Point Outfall									
SLuEP01		3.2	21.0	4.6			possible	Nutrients above DHWQO range no impact on Chl-a - insignificant	low
Hazard Quotient Applied to Receiving Waters - Darwin Harbour									
SLuEP02		2.0					possible	insignificant	low
SLuEP03		1.7					possible	insignificant	low

2.5.1 Chlorophyll-a (Chl-a)

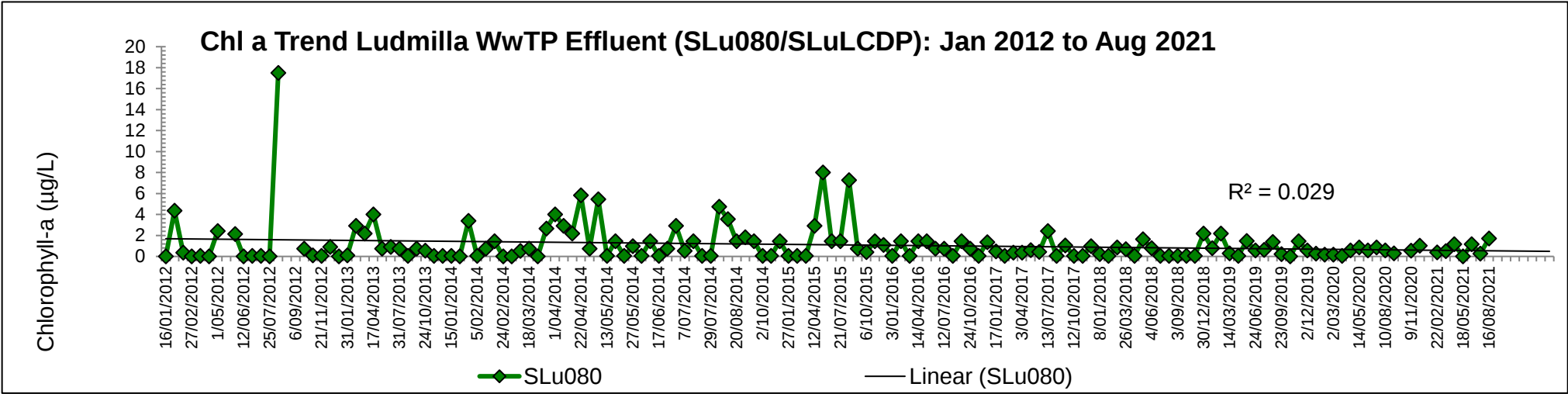


Figure 49: Chl-a Trends in Ludmilla WwTP Effluent (SLu080): January 2012 to August 2021

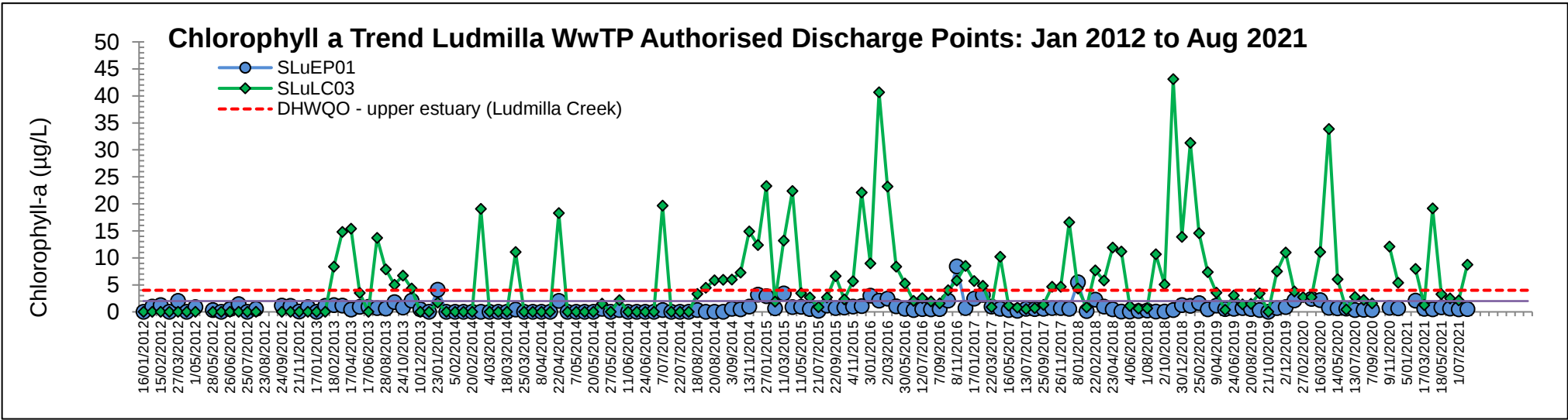


Figure 50: Chl-a Trends at Ludmilla WwTP Authorised Discharge Points SluEP01 (East Point Outfall) and Ludmilla Creek (SLuLC03): January 2012 to August 2021

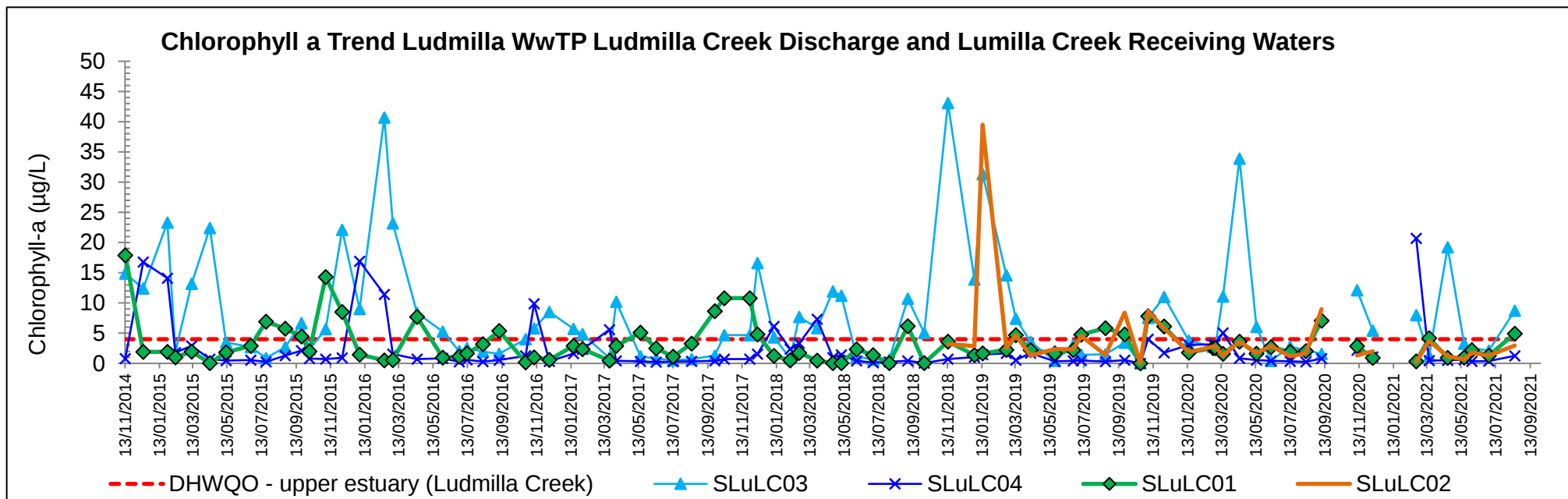


Figure 51: Chl-a Trends in Ludmilla WwTP Discharge Receiving Waters: Ludmilla Creek: November 2014 to August 2021

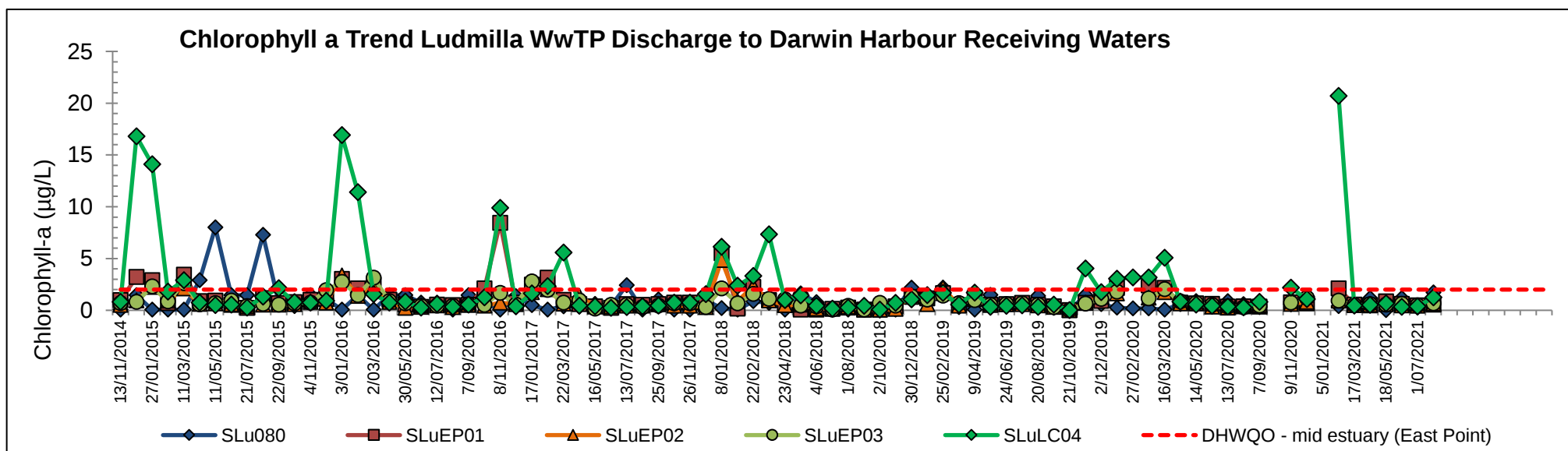


Figure 52: Chl-a Trends in Ludmilla WwTP Discharge Receiving Waters: Darwin Harbour Trends: November 2014 to August 2021

2.5.2 Total Nitrogen

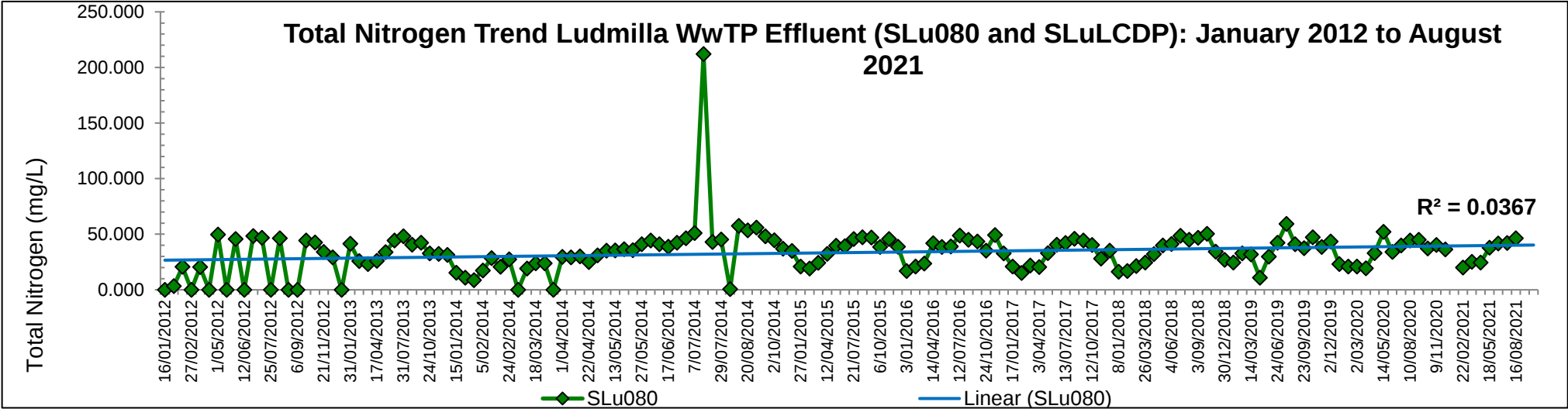


Figure 53: Total Nitrogen Trends in Ludmilla WwTP Effluent (SLu080)

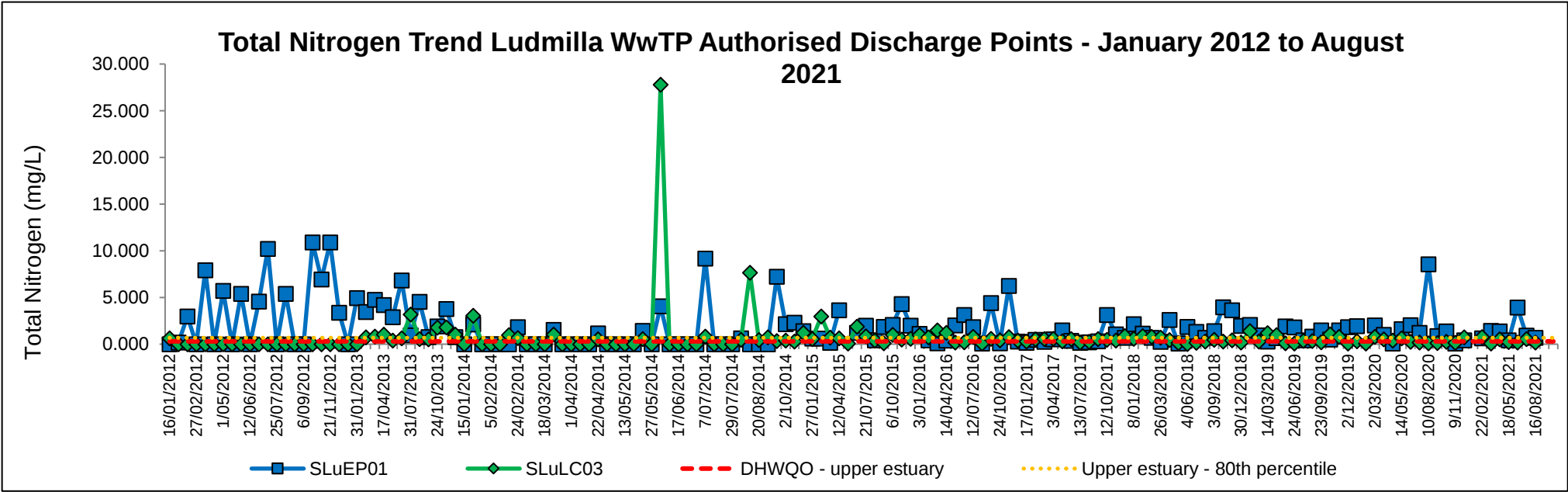


Figure 54: Total Nitrogen Trends Ludmilla WwTP Authorised Discharge Points: East Point Outfall (SLuEP01) and Ludmilla Creek (SuLC03) 2012 to August 2021

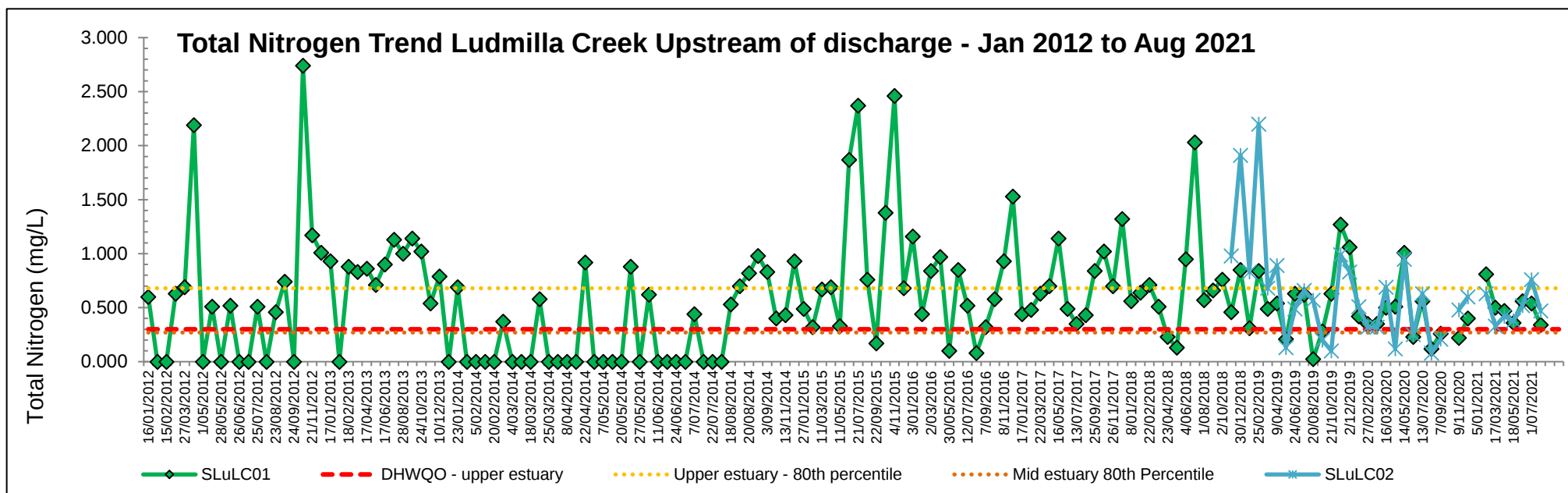


Figure 55: Total Nitrogen Trends Ludmilla Creek Upstream of Discharge 2012 to August 2021

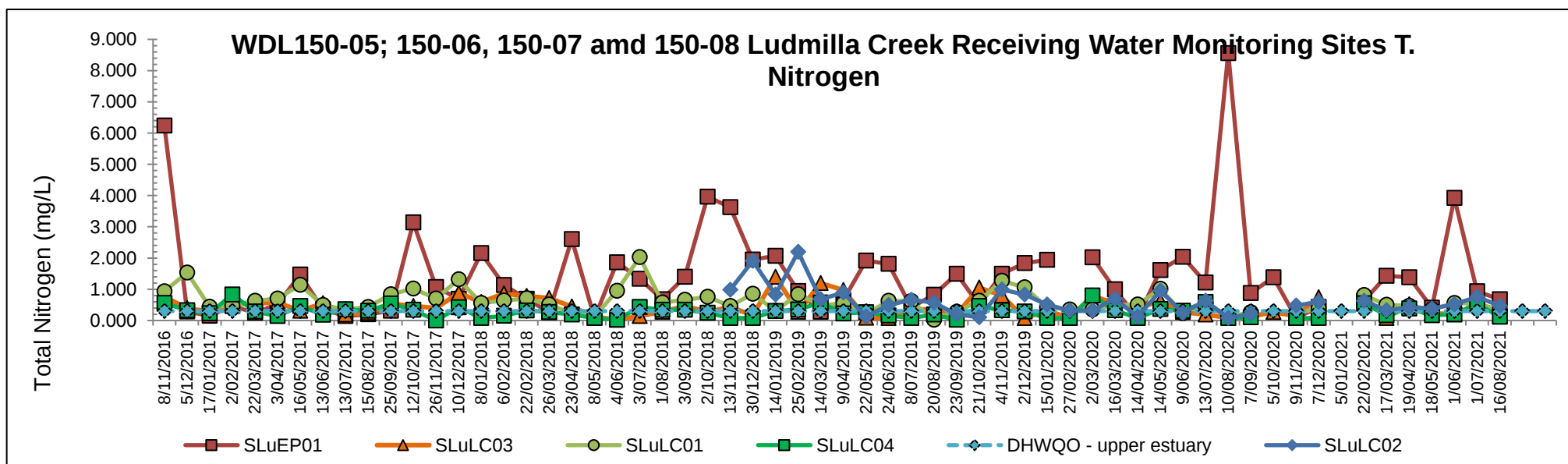


Figure 56: Total Nitrogen Trends in Ludmilla WwTP Discharge Receiving Waters: Ludmilla Creek November 2016 to August 2021

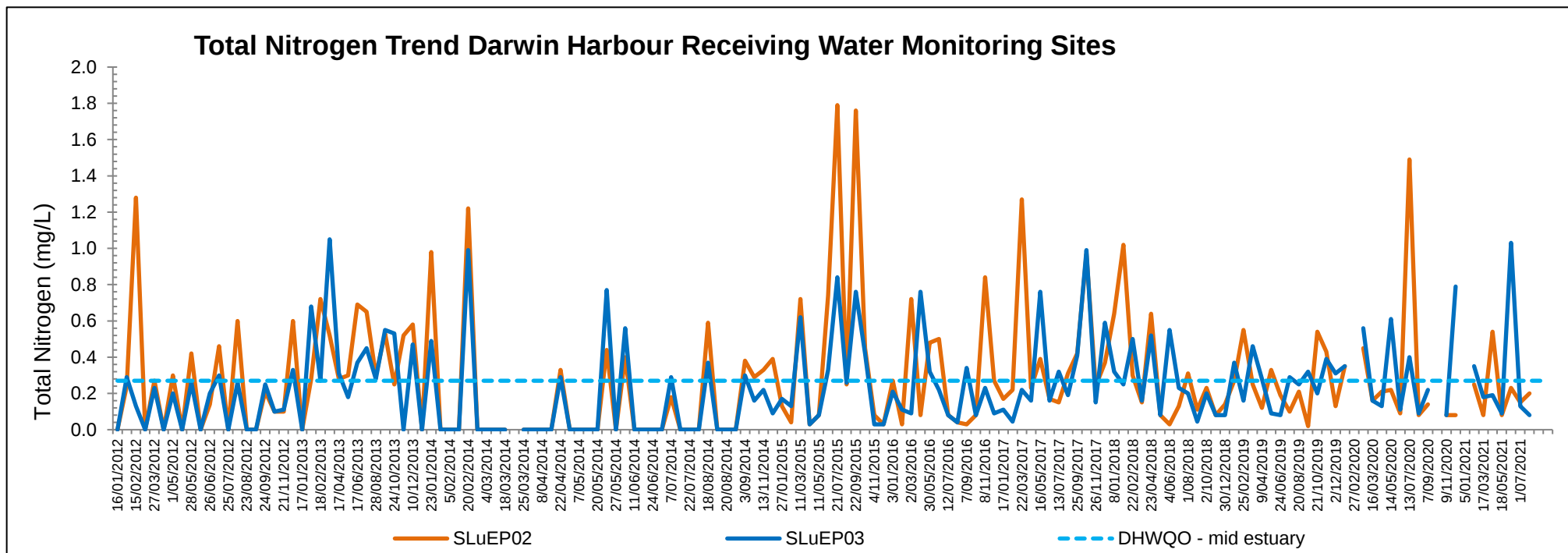


Figure 57: Total Nitrogen Trends in Ludmilla WwTP Discharge Receiving Waters: Darwin Harbour 2012 to August 2021

2.5.3 Oxides of Nitrogen (NO_x)

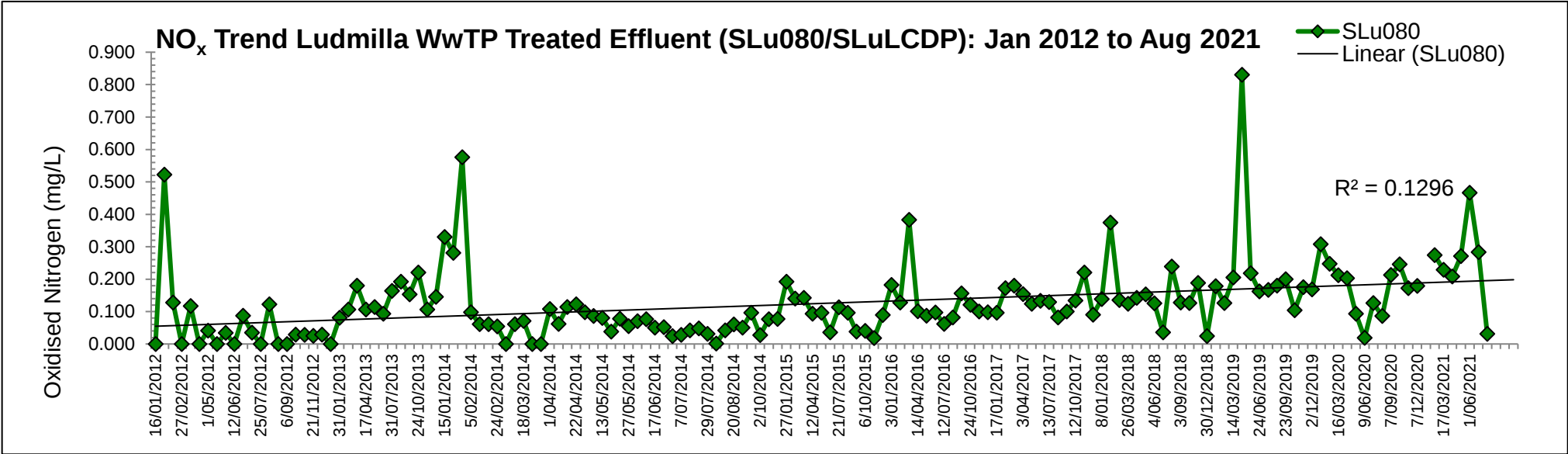


Figure 58: NO_x Trends in Ludmilla WwTP Effluent (SLu080): January 2012 to August 2021

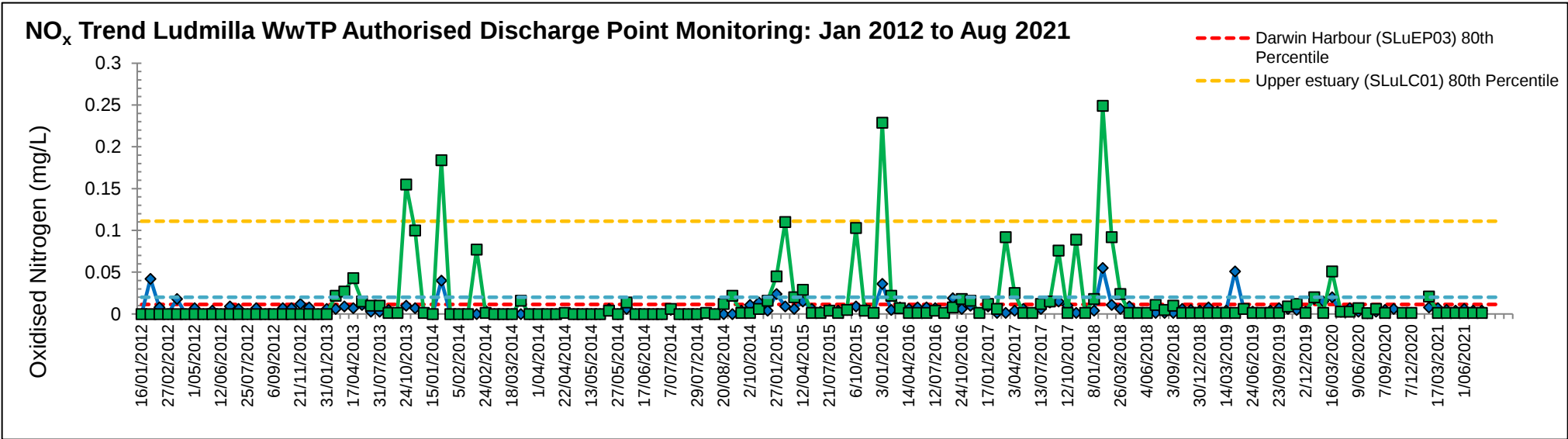


Figure 59: NO_x Trends at Ludmilla WwTP Authorised Discharge Points: East Point Outfall (SuEP01) and Ludmilla Creek (SLuLC03): January 2012 to August 2021

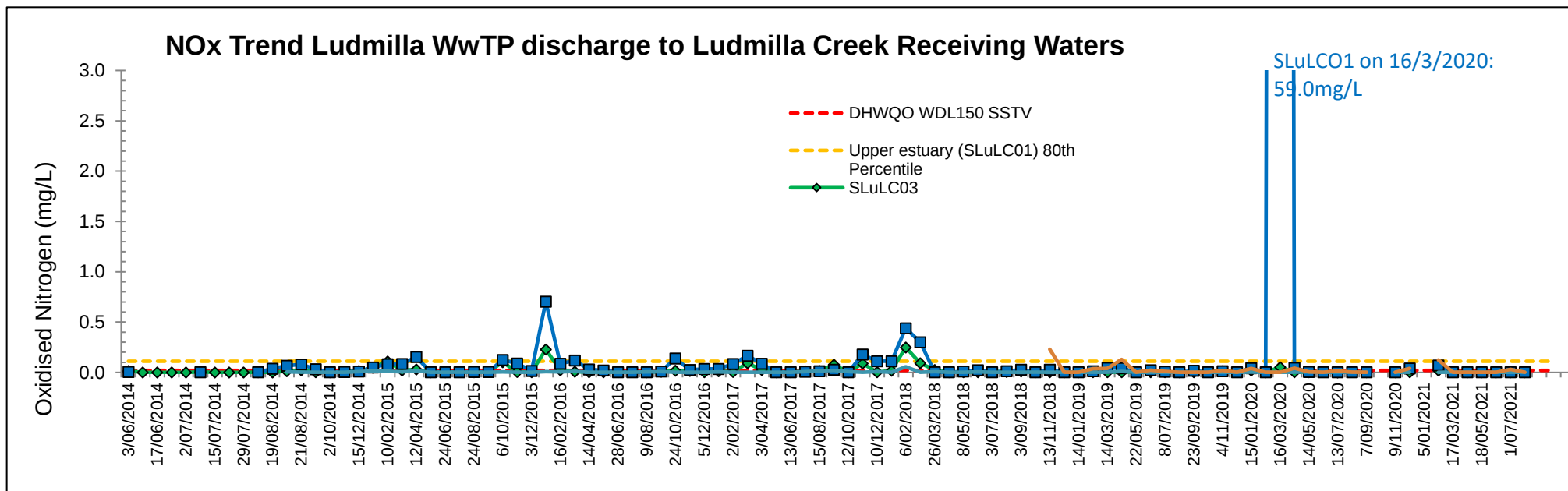


Figure 60: NOx Trends in Ludmilla WwTP Discharge Receiving Waters: Ludmilla Creek June 2014 to August 2021 (post commissioning of plant upgrade)

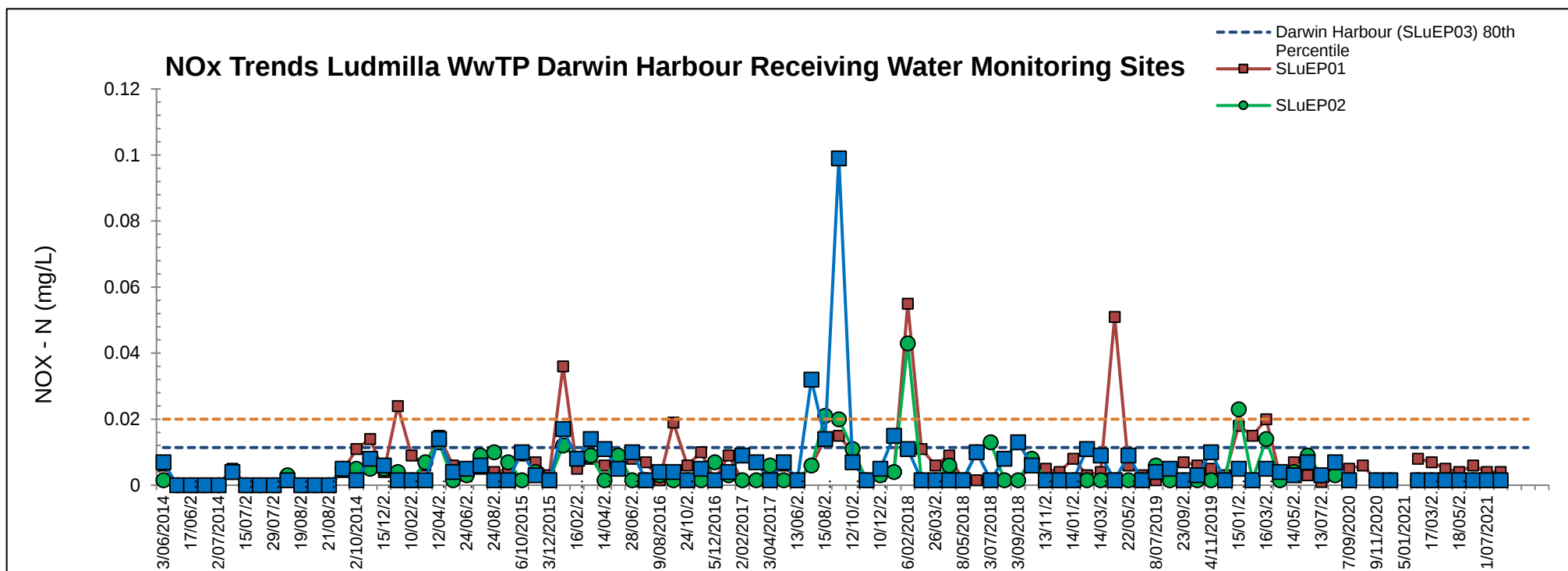


Figure 61: NOx Trends in Ludmilla WwTP Discharge Receiving Waters: Darwin Harbour June 2014 to August 2021 (post commissioning of plant upgrade)

2.5.4 Ammonia

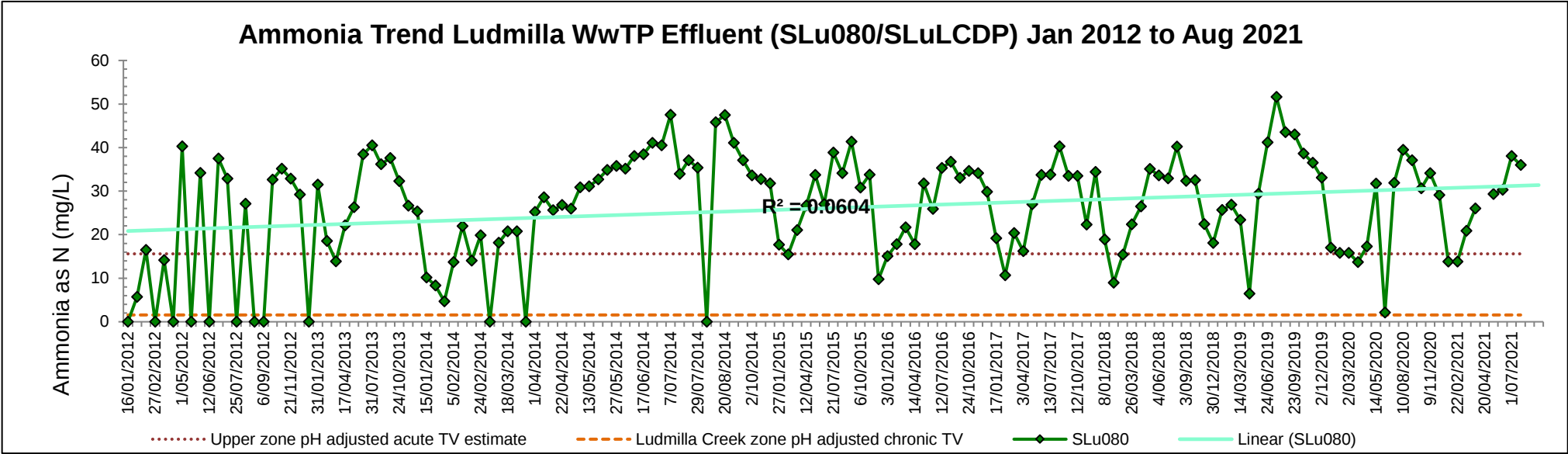


Figure 62: Ammonia Trends in Ludmilla WwTP Effluent (SLu080)

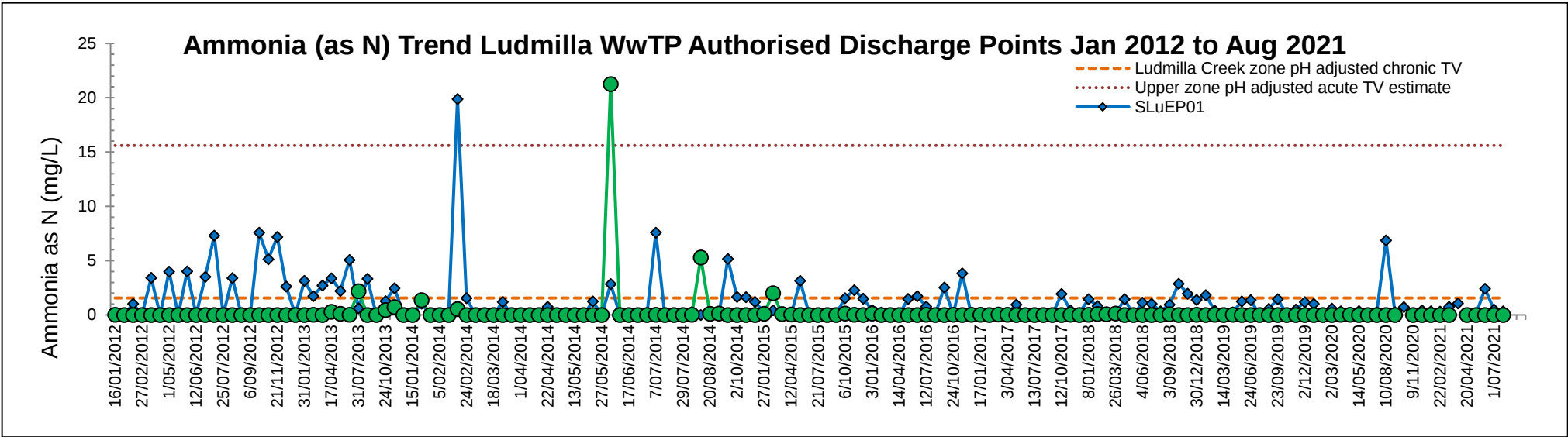


Figure 63: Ammonia Trends at Ludmilla WwTP Authorised Discharge Points: East Point Outfall (SLuEP01) and Ludmilla Creek (SLuLCDP)

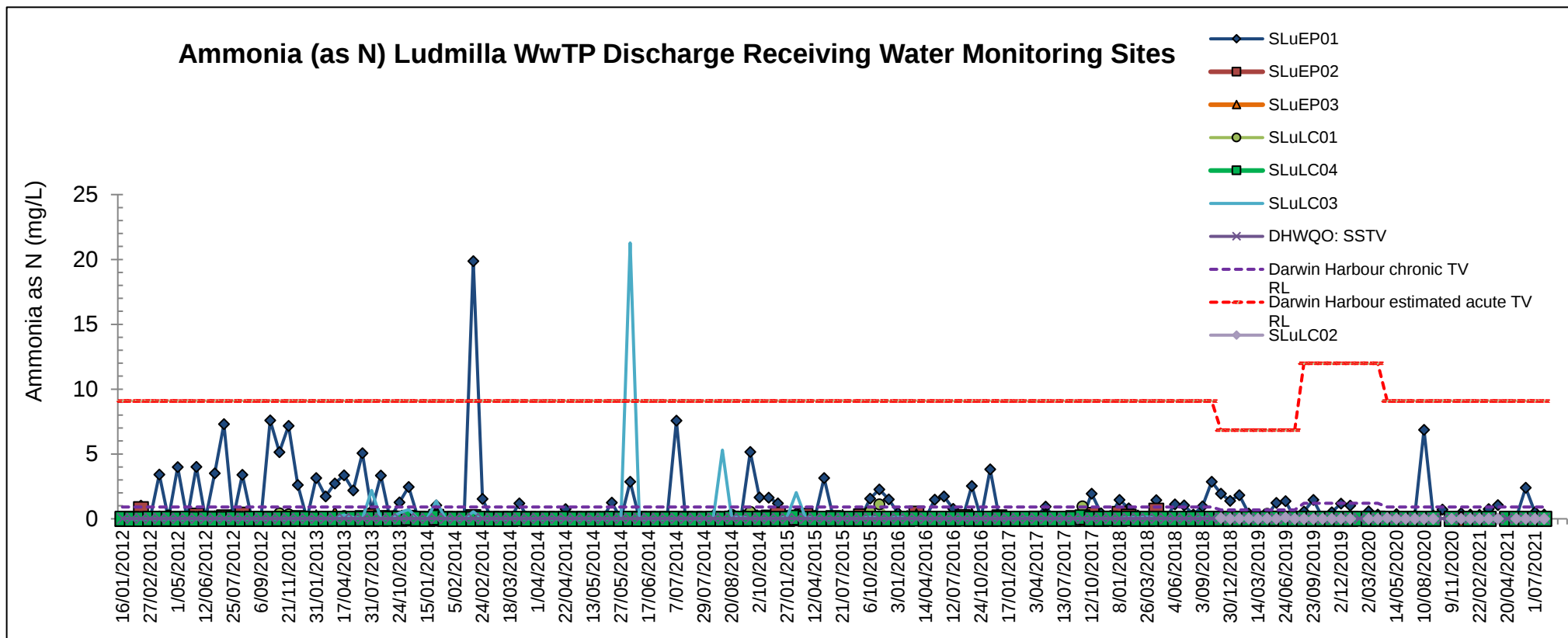


Figure 64: Ammonia Trends in Ludmilla WwTP Discharge Receiving Waters: Darwin Harbour and Ludmilla Creek Trends

2.5.5 Total Phosphorus (TP)

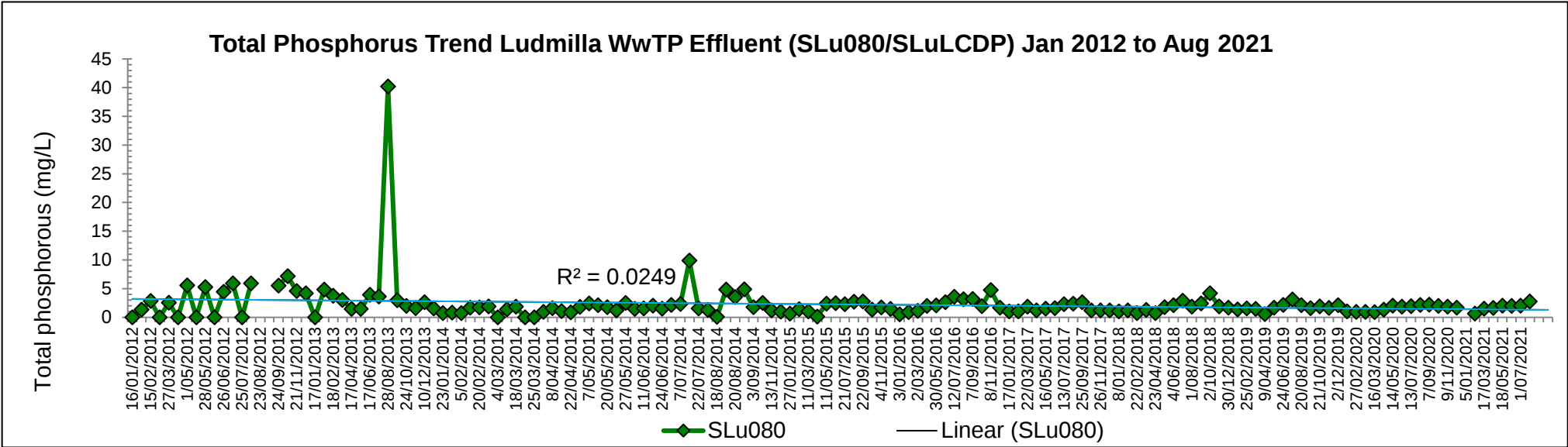


Figure 65: Total Phosphorus Trends in Ludmilla WwTP Effluent (SLu080): January 2012 to August 2021

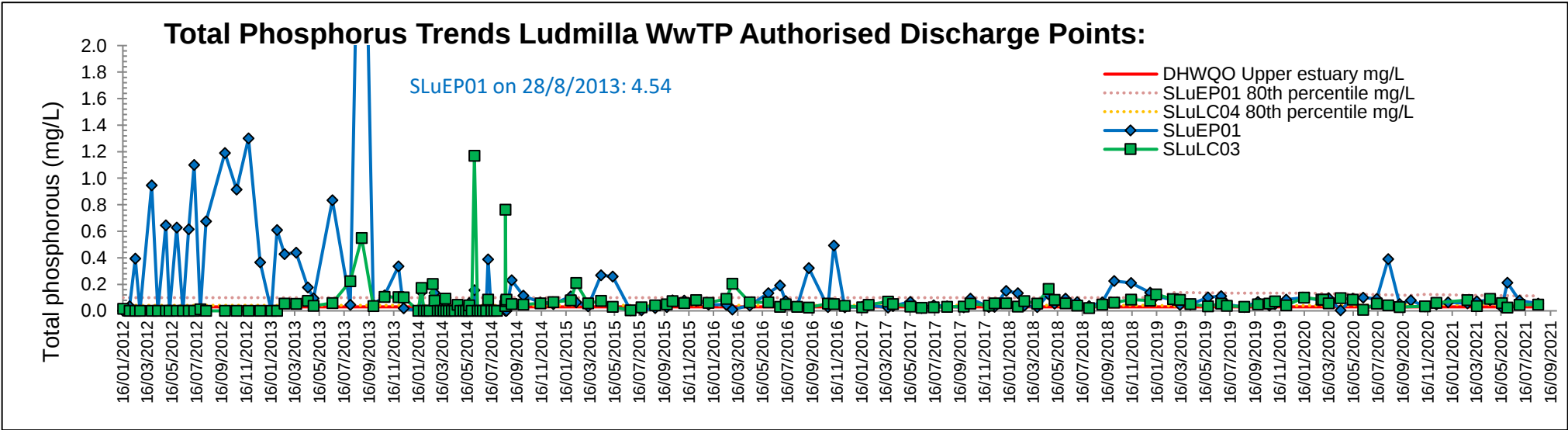


Figure 66: Total Phosphorus Trends at Ludmilla WwTP Authorised Discharge Points: East Point Outfall (SLuEP01) and Ludmilla Creek (SLuLC03)

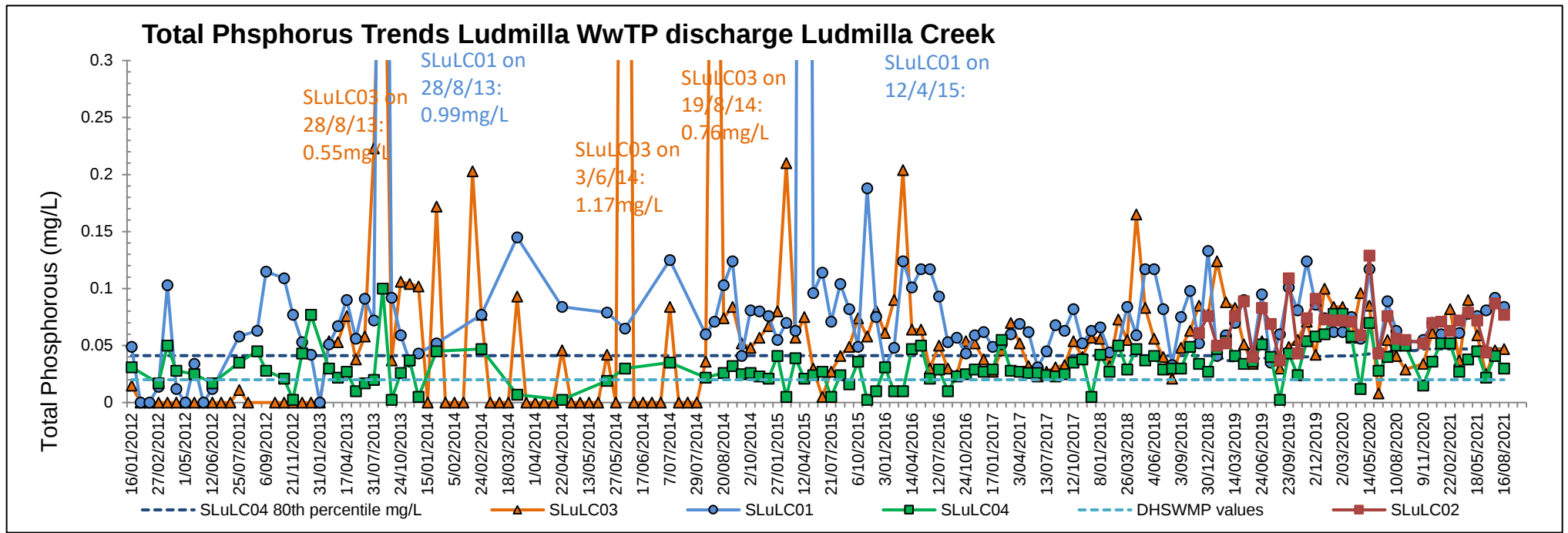


Figure 67: Total Phosphorus Trends in Ludmilla Creek Receiving Waters: October 2016 to August 2021

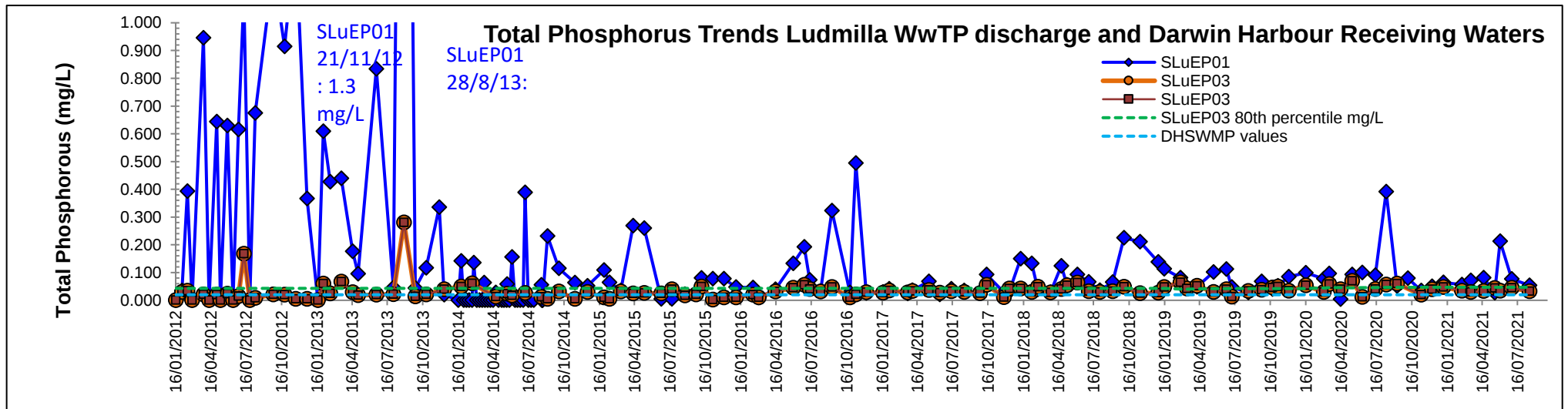


Figure 68: Total Phosphorus Trends Ludmilla WwTP Darwin Harbour Discharge and Receiving Waters: October 2016 to August 2021

2.5.6 Filterable Reactive Phosphorus (FRP)

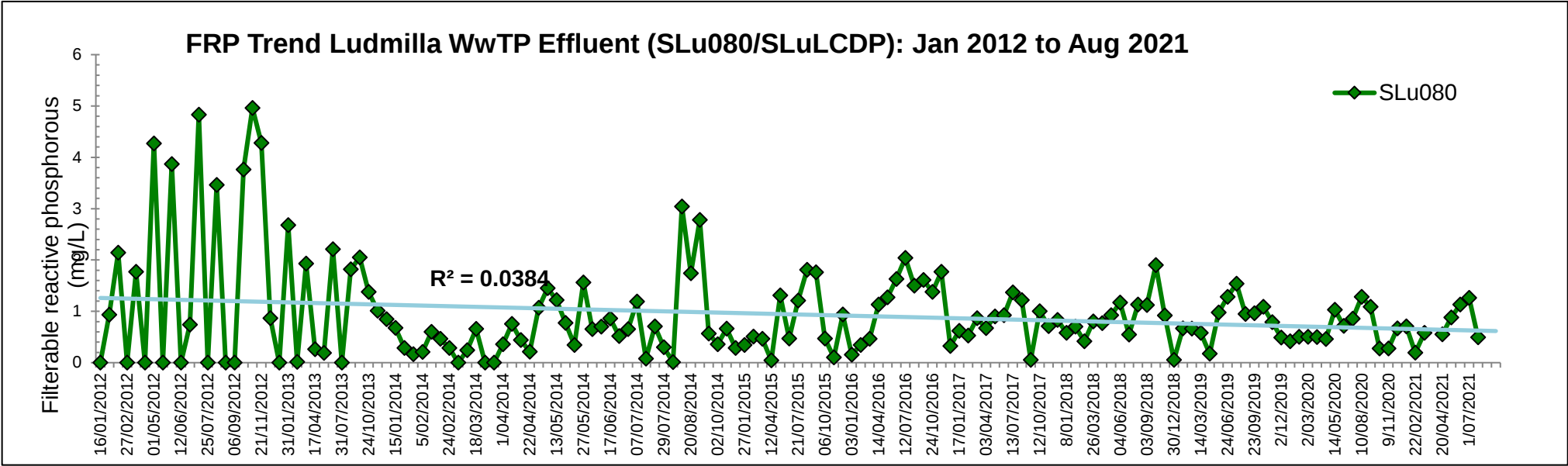


Figure 69: FRP Trends in Ludmilla WwTP Effluent (SLu080)

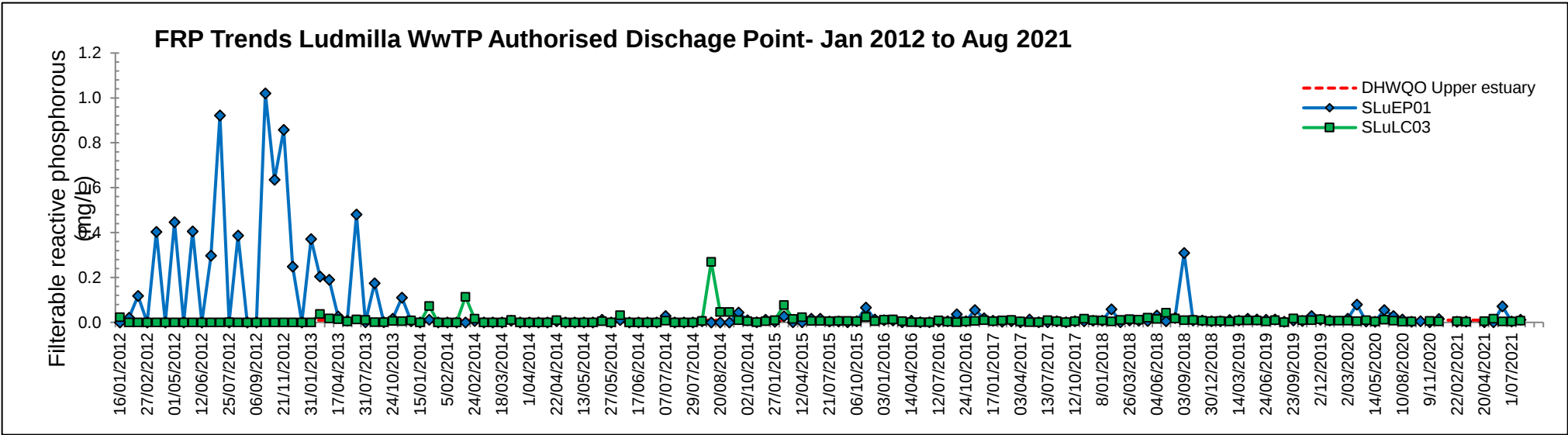


Figure 70: FRP Trends at Ludmilla WwTP Authorised Discharge Points: East Point Outfall (SLuEP01) and Ludmilla Creek (SLuLC03)

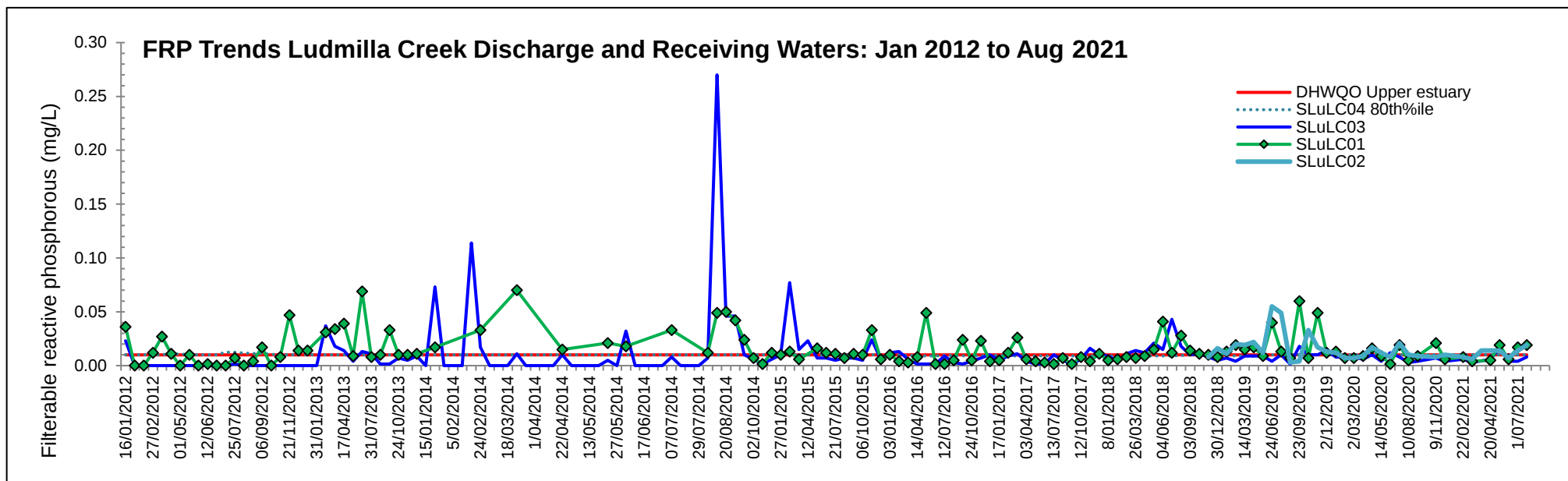


Figure 71: FRP Trends in Ludmilla WwTP Discharge and Ludmilla Creek Receiving Waters

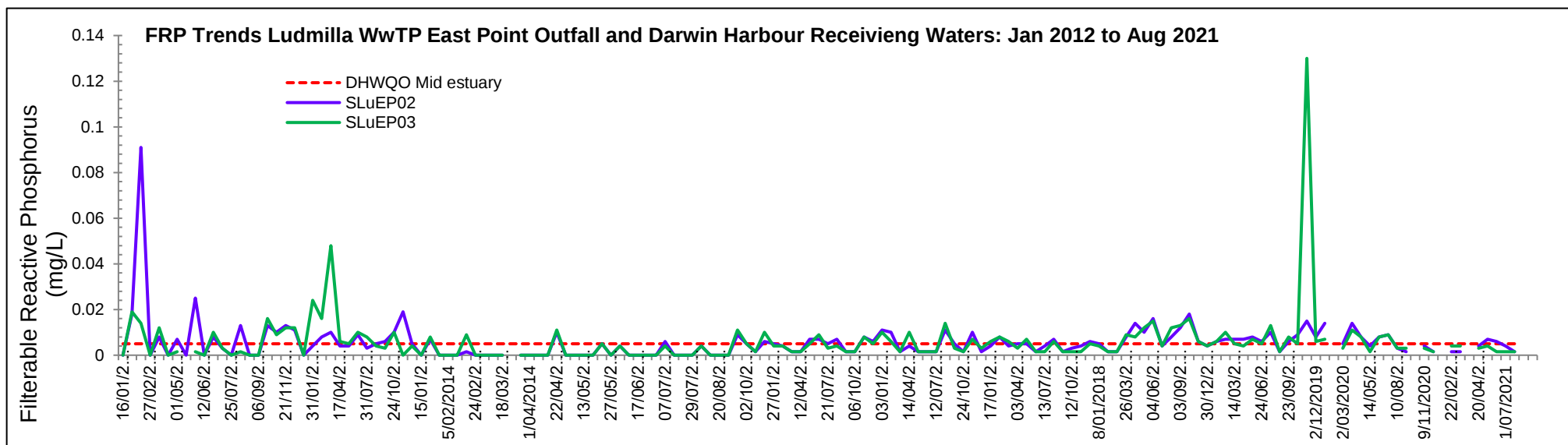


Figure 72: FRP Trends in Ludmilla WwTP Discharge Receiving Waters: Darwin Harbour

2.6 Toxicants Indicators

Table 9: WDL 150-08 Toxicant risk rating following Ludmilla WwTP upgrade commissioning November 2016 to 31 August 2021

Toxicants Water Quality Assessment following commissioning of Ludmilla WwTP upgrade June 2014 onwards							
parameter	pH	NH3-N	Cu (D)	Zn (D)	Likelihood	Consequence	Risk Rating
Unit	pH units	µg/L	µg/L	µg/L			
DHWQO							
Outer Estuary ¹	7.0 - 8.5 ¹ : 6.5 - 8.5 ²						
Mid Estuary ²							
ANZECC level of species protection	7.0 – 8.5	910 - 2840 pH dependent	1.3 –SMD 3.0 –D* 8.0- HD	15- SMD			
Assessment criteria percentile	50th	95th	95th	95th			
SLu080*	8.21	41382.0	59.51	13.01			
Discharge to receiving waters: Ludmilla Creek , discharge upstream and downstream of discharge							
SLuLC01 ²	7.33	124.7	0.60	7.40			
SLuLC02 ²	7.45	71.9	1.45	3.40			
SLuLC03 ²	7.83	63.9	2.00	5.25			
SLuLC04 ²	8.12	20.0	1.00	6.00			
East Point Outfall within Darwin Harbour receiving waters							
SLuEP01 ¹ –outfall*	8.16	2479.0	2.2	5.00			
Darwin Harbour receiving waters							
SLuEP02 ¹	8.15	207.2	0.63	8.30			
SLuEP03 ¹	8.16	21.0	1.00	5.30			
Hazard Assessment:							
SLu080		82.7	7.4		Almost Certainly toxic Ammonia and copper	Toxicity confirmed by ecotoxicology testing. Localised within LWwTP Ammonia likely to be present as mono chloramines due chlorination of ammonia contaminated effluent and median pH 8.59.	Very high
Ludmilla Creek							
SLuLC01					Toxicity Unlikely	insignificant	Low
SLuLC02			1.1		Acute Toxicity Unlikely	Meets Cu 90% species protection	Medium
SLuLC03			1.5		Acute Toxicity Unlikely	Meets Cu 90% species protection	Low
SLuLC04					Toxicity Unlikely	insignificant	Low
East Point Outfall							
SLuEP01		3.3			Almost certain NH3 toxic levels Cu meet D; exceeds SMD levels	Moderate impact Localised to less than 250 m (verified by infauna monitoring)	high
Darwin Harbour in the vicinity of East Point							
SLuEP02					Toxicity Unlikely	insignificant	Low
SLuEP03					Toxicity Unlikely	insignificant	Low

2.6.1 Ammonia as a toxicant (NH3-N)

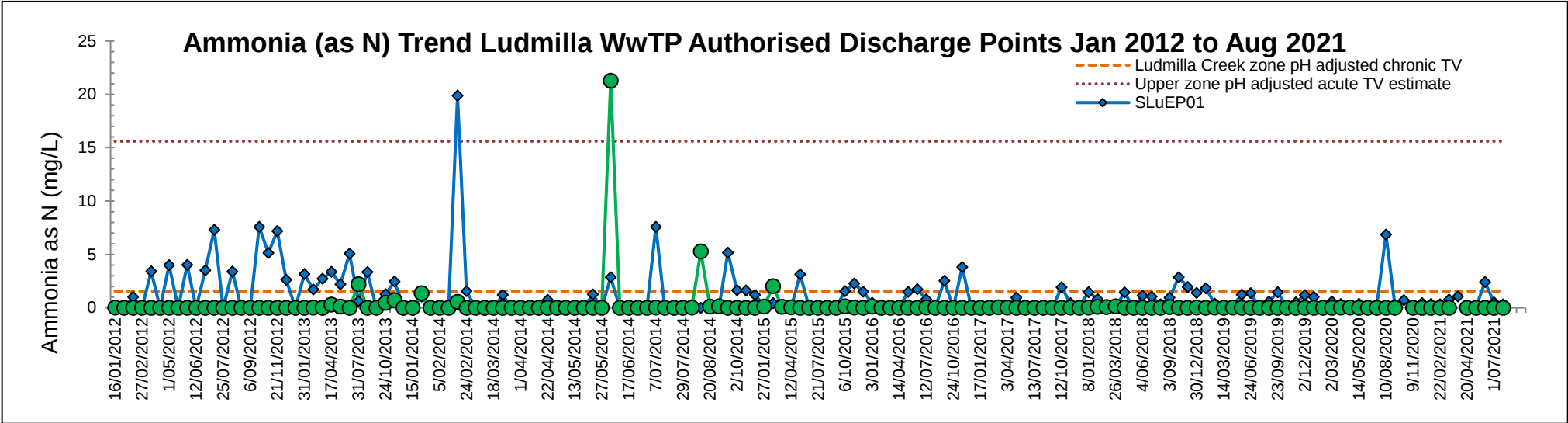


Figure 73: Ammonia Trends in Ludmilla WwTP Authorised Discharge Points: Trends January 2012 to August 2021 compared to Acute and Chronic Toxicity Criteria

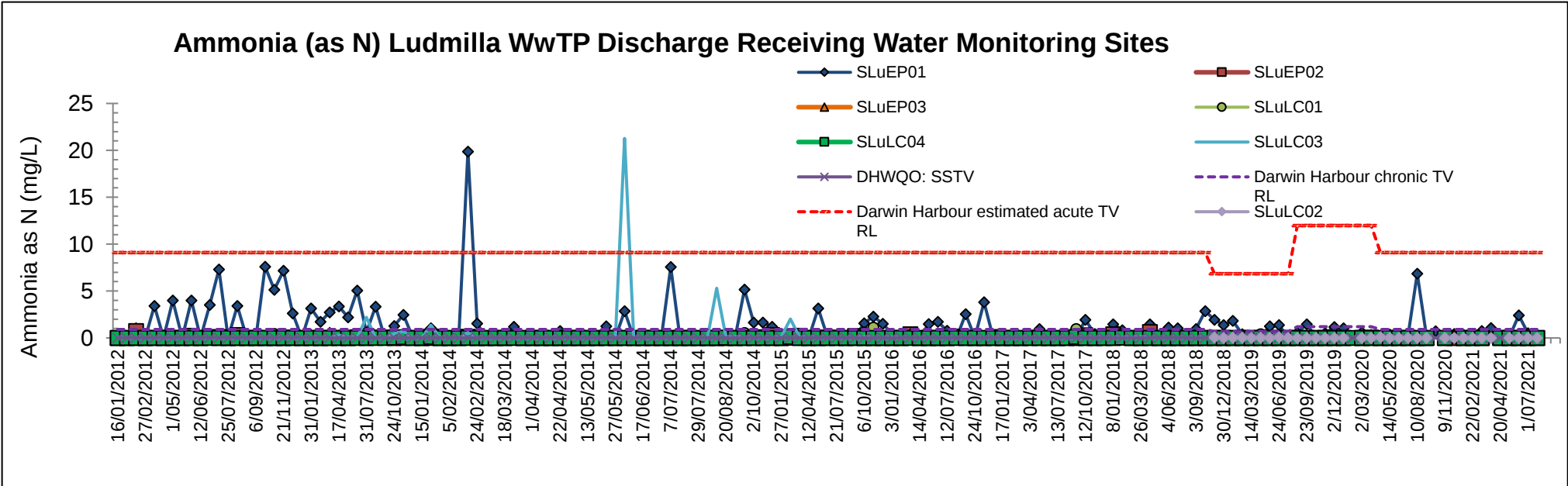


Figure 74: Ammonia Trends in Ludmilla WwTP Discharge and Darwin Harbour Receiving Waters: Compared to Chronic and Acute toxicity criteria

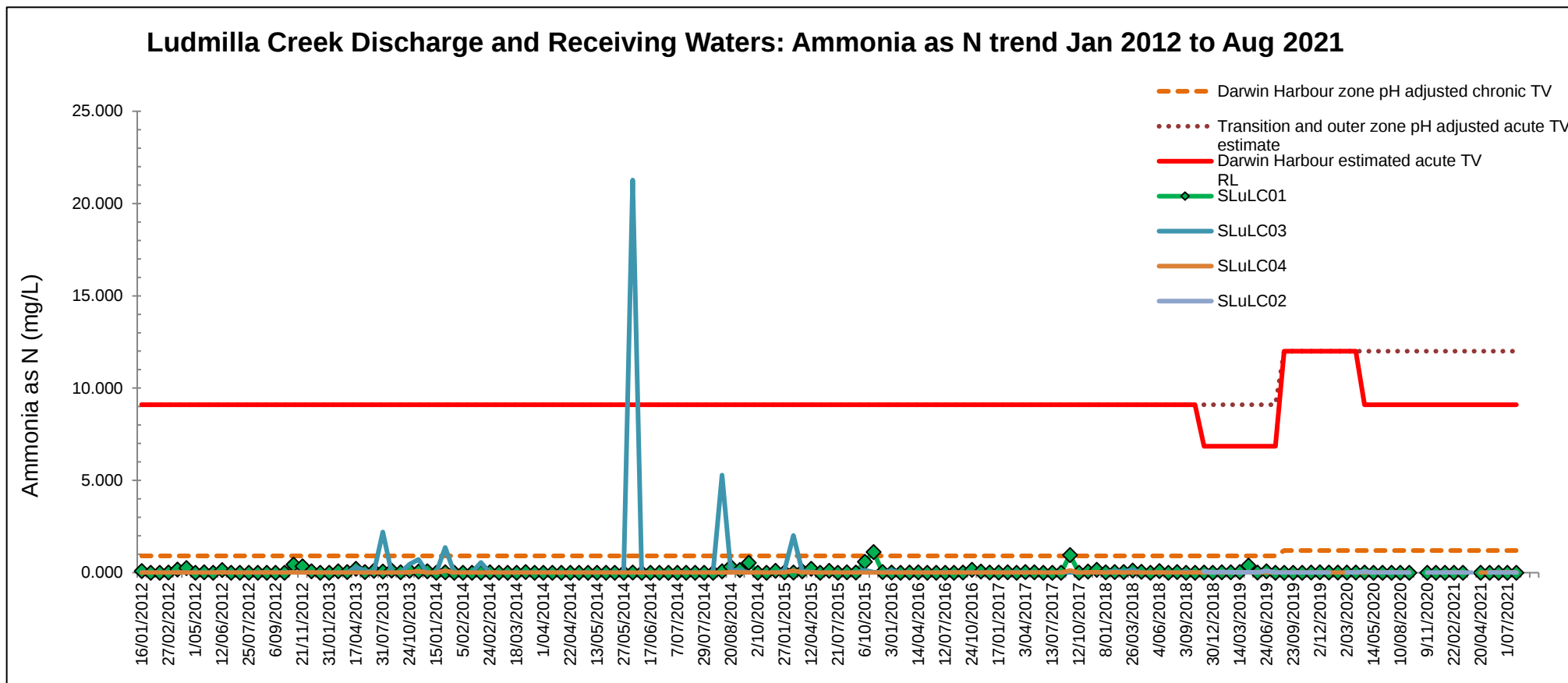


Figure 75: Ammonia Trends in Ludmilla WwTP Discharge Receiving Waters: Ludmilla Creek – Chronic toxicity

2.6.2 Toxicants: Copper (Cu-F)

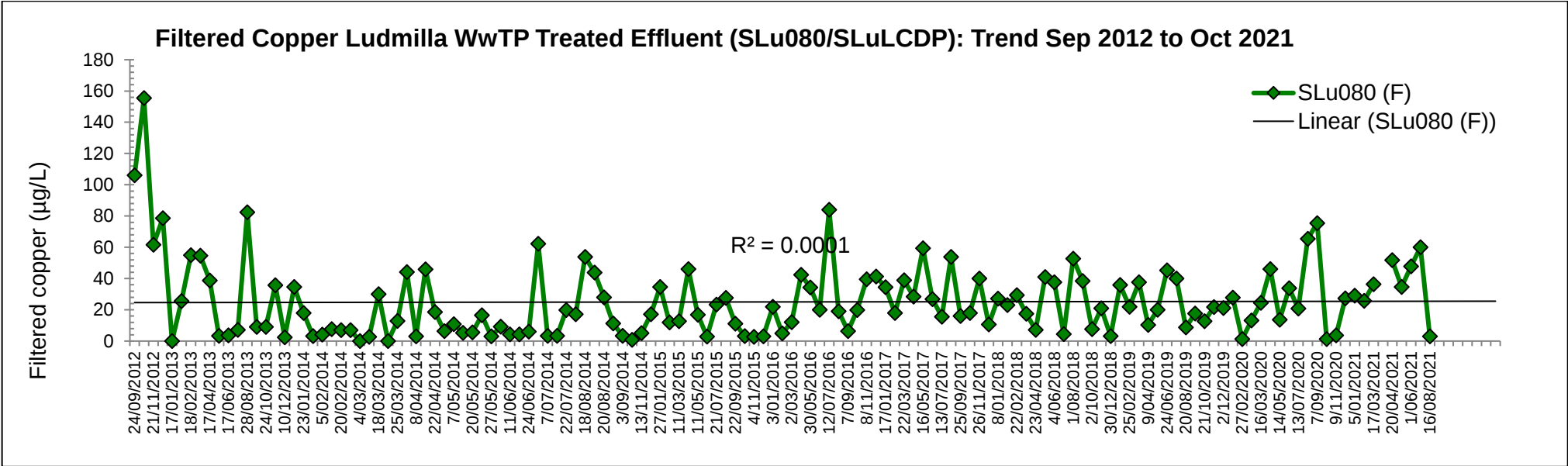


Figure 76: Copper Trends in Ludmilla WwTP Effluent (SLu080): September 2012 to August 2021

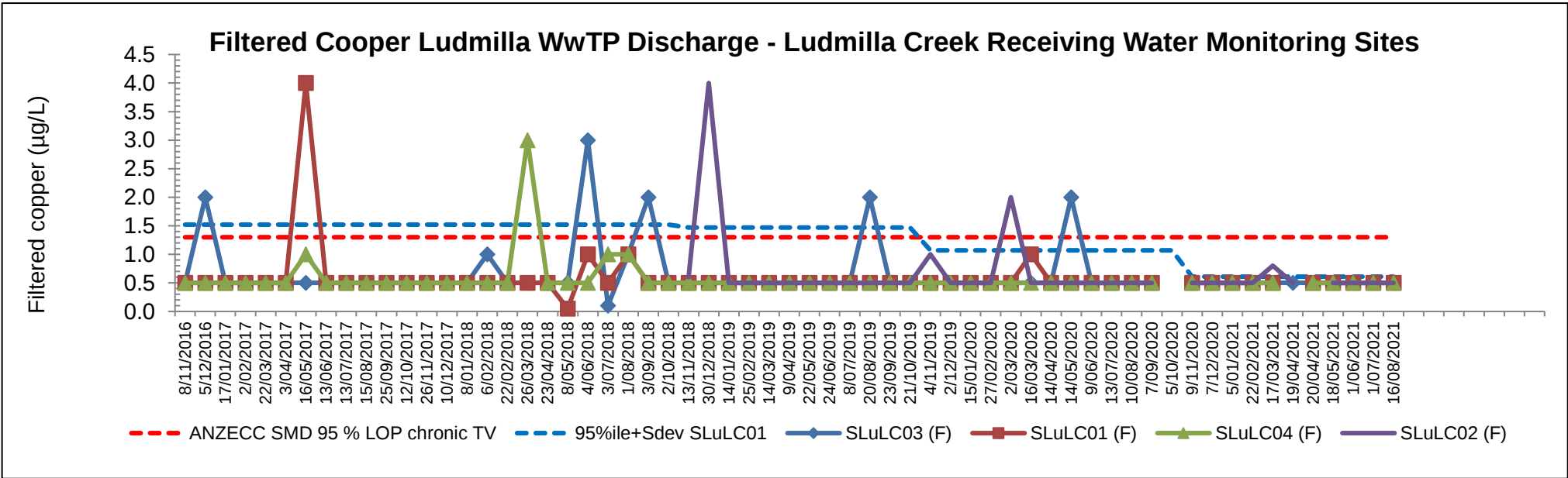


Figure 77: Copper Trends at Ludmilla WwTP Discharge Receiving Waters: Ludmilla Creek November 2016 to August 2021

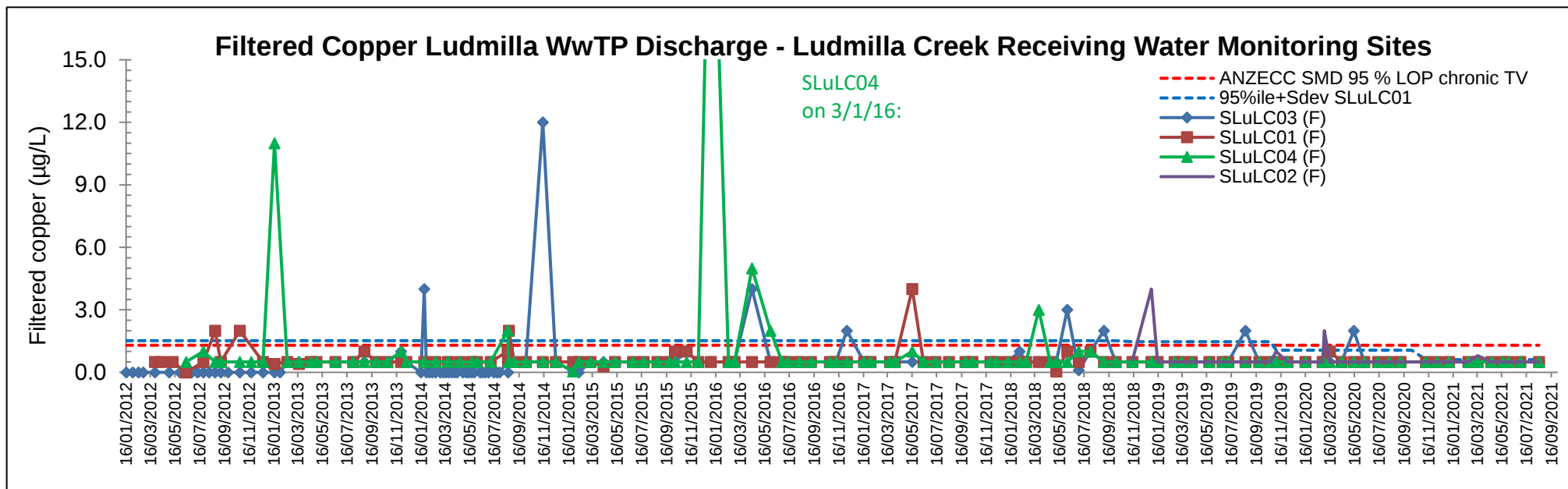


Figure 78: Copper Trends in Ludmilla WwTP Discharge Receiving Waters: Ludmilla Creek January 2012 to August 2021

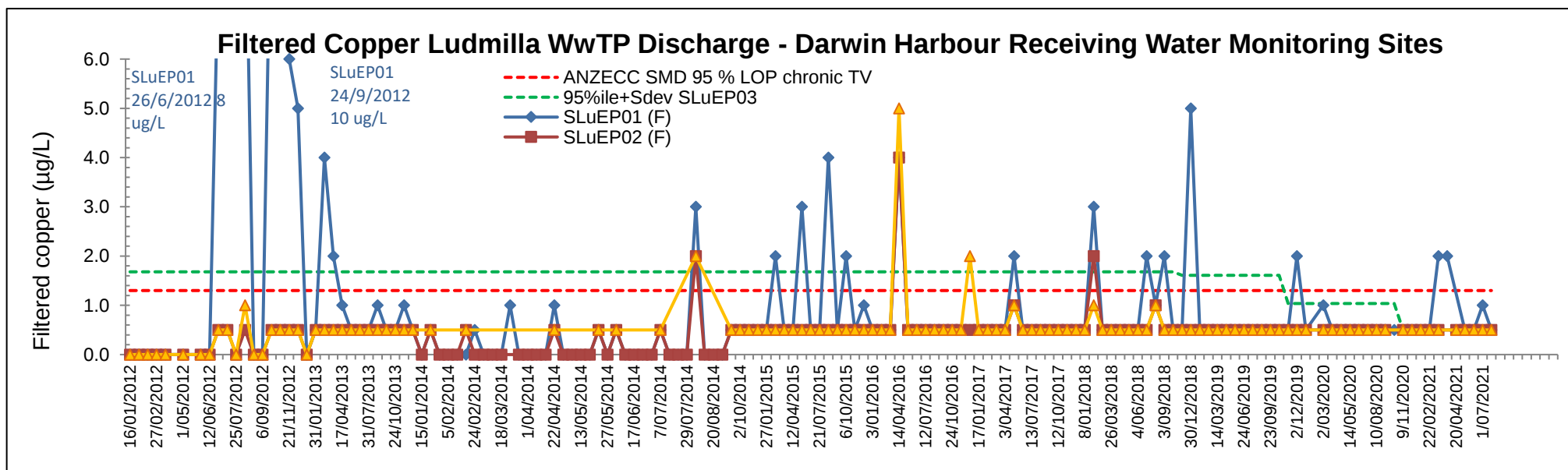


Figure 79: Copper Trends in Ludmilla WwTP Discharge Receiving Waters: Darwin Harbour Trends January 2012 to August 2021

2.6.3 Toxicants: Zinc (Zn-F)

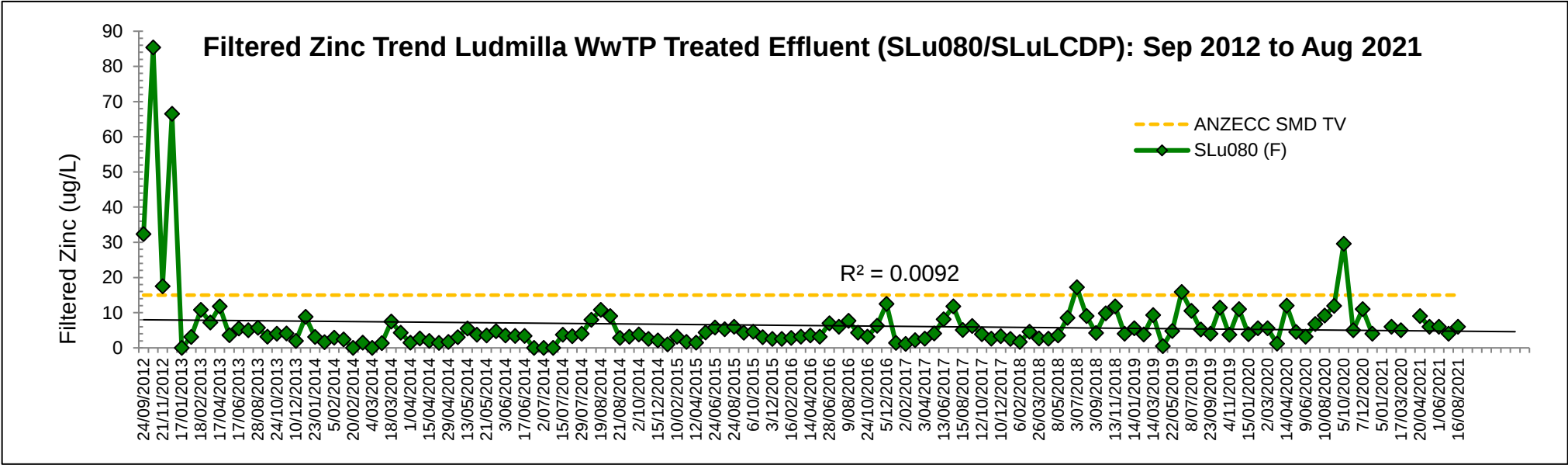


Figure 80: Zinc Trends in Ludmilla WwTP Effluent (SLu080): September 2012 to August 2021

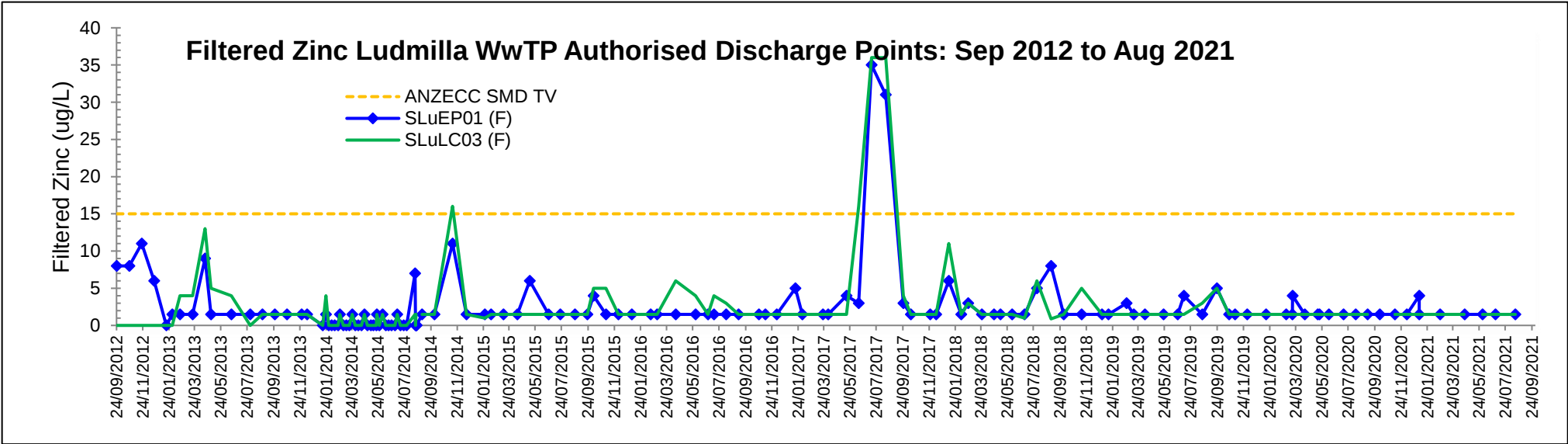


Figure 81: Zinc Trends at Ludmilla WwTP Authorised Discharge Points: East Point Outfall (SuEP01) and Ludmilla Creek (SLuLC03): September 2012 to August 2021

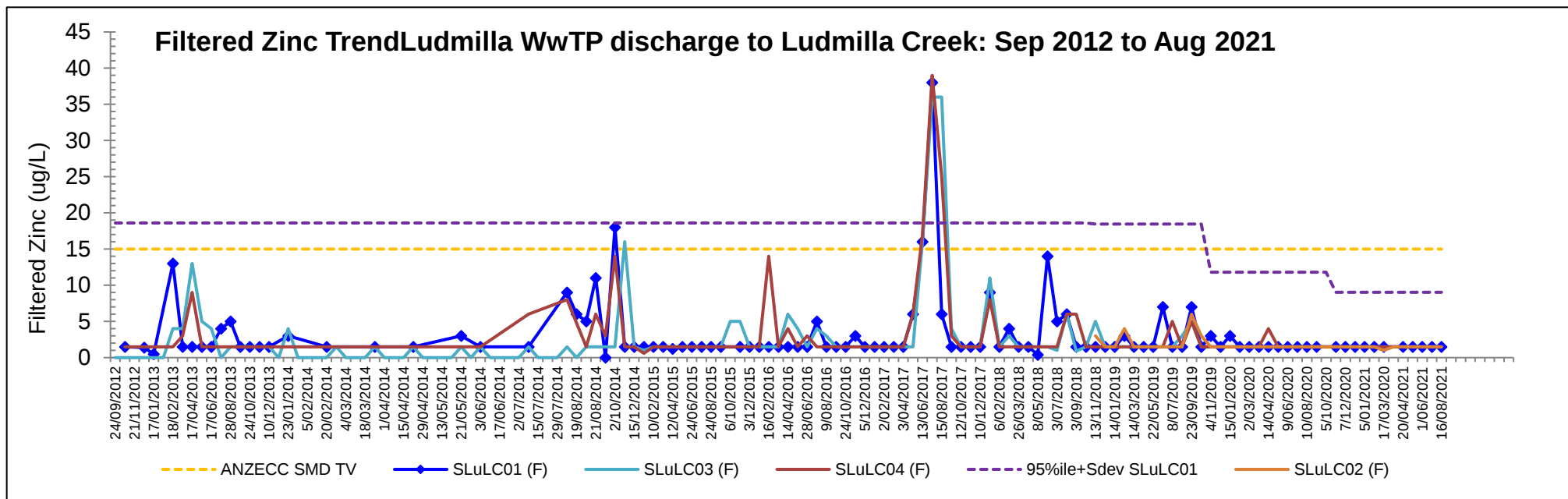


Figure 82: Zinc Trends in Ludmilla WwTP Discharge Receiving Waters: Ludmilla Creek: September 2012 to August 2021

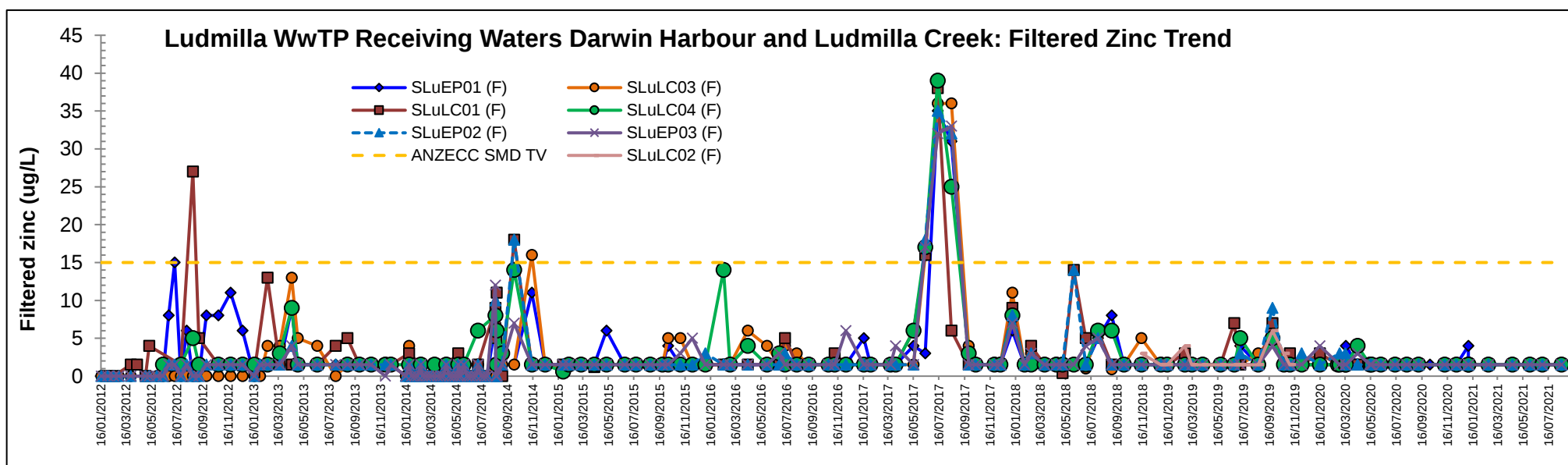


Figure 83: Zinc Trends in Ludmilla WwTP Discharge Receiving Waters: Darwin Harbour November 2016 to October 2020

2.7 Endocrine Disrupting Chemicals in Ludmilla WwTP Effluent

Table 10: EDCs in Ludmilla Effluent and Discharge 2012 to 2021

WWTP Sample Description	Sampled Date	4-t-Octylphenol ng/L	Nonylphenol (Tech.) ng/L	Bisphenol A ng/L	Androsterone ng/L	Etiocholanolone ng/L	Predicted estradiol
Reporting Limits		10	100	10	5	5	2
WDL150-01							
SLu080	41129	<10	3400	880	2600	4500	
SLUEP01	41129	<10	230	77	310	500	
WDL150-02							
SLu080	41352	34	670	<10	6900	3700	<2
SLUEP01	41352	<10	<100	<10	<5	1300	<2
WDL150-03							
SLU080	41514	<10	250	72	2200	1700	<2
SLUEP01	41514	46	710	34	570	420	<2
SLuEPDP (SLu080)	41723	1300	3100	300	4000	2800	11
SLuEPDP (SLu080)	41723	6900	2400	360	<5	<5	<2
SLUEP01	41723	<10	240	<10	<5	<5	<2
SLuEPDP (SLu080)	41869	<10	2300	650	<5	2700	12
SLuEP01	41869	<10	<100	13	<5	<5	<2
SLuEP01 duplicate	41869	<10	<100	<10	<5	<5	<2
WDL150-04							
SLuEPDP (SLu080)	42074	<10	1500	33	1800	1400	3
SLuEP01	42074	<10	<50	<10	<5	<5	<2
SLuEP01 duplicate	42074	<10	<50	<10	<5	<5	<2
SLuEPDP (SLu080)	42239	<10	2700	230	2100	2200	14
SLuEP01	42239	<10	<50	12	<5	<5	<2
SLuEP01 duplicate	42239	<10	<50	<10	<5	<5	<2
SLuEPDP (SLu080)	42431	100	740	<10	3800	960	<2
SLuEP01	42431	10	320	<10	<5	<5	<2
SLuEP01 duplicate	42431	<10	67	41	<5	<5	<2
SLuEPDP (SLu080)	42563	83	3300	300	2400	3000	14
SLUEP01	42563	< 10	1800	23	150	200	< 2
SLuEP01 duplicate	42563	< 10	780	14	63	94	< 2
WDL150-05							
SLuEPDP (SLu080)	42768	67	490	18	1300	1200	<2
SLuEP01	42768	96	52	<10	<5	<5	<2
SLuEP01 (duplicate)	42768	<10	57	<10	<5	<5	<2
SLuEPDP (SLu080)	42929	200	440	82	2600	3100	3
SLuEP01	42929	<10	<50	<10	<5	<5	<2
SLuEP01 (duplicate)	42929	<10	<50	<10	<5	<5	<2
SLUEPDP (SLu080)	43153	14	1300	<10	<5	880	<2
SLUEP01	43153	<10	160	35	58	38	<2
SLUEPDP (SLu080)	43313	<100	3500	190	<50	240	15
SLUEP01	43313	<10	170	<10	<5	37	2
WDL150-06							
SLUEPDP	43538	<72	1600	<14	1400	2000	<14
SLUEP01	43538	<84	760	<17	280	270	<17
SLuEP01 (duplicate)	43538	<87	530	<17	57	65	<17
SLUEPDP	43607	<10	6100	120	2000	2400	<2
SLUEP01	43607	<10	940	<10	<5	<5	<2
SLuEP01 (duplicate)	22/05/2019	Sample Broken in transit					
WDL150-07							
SLUEPDP	43906	<81	<400	<81	1600	1500	<16
SLUEP01	43906	<83	<410	<83	170	99	<17
SLUEPDP	43991	<87	<430	110	2000	3000	<17
SLUEP01	43991	<76	<380	<76	170	300	<15
WDL150-08							
SLULCDP	44327	10	50	10	5	5	2

2.8 Discharge and Receiving Waters Monitoring Summary

Physico-Chemical Indicators

At the upstream Ludmilla Creek site SLuLC01 and SLuLC02 the dissolved oxygen levels are consistently low and at times exceed the toxic threshold for some fish species (30% saturation), the low dissolved oxygen levels are not associated with discharges from the Ludmilla WwTP to Ludmilla Creek, as discharges from the treatment plant do not correspond to periods of very low dissolved oxygen. Site SLuLC03, the authorised discharge point to Ludmilla Creek also was on occasion below the Darwin Harbour Water Quality Objective for ecosystem protection for this reporting period however levels did not approach the toxic threshold.

With the exception of the effluent channel and immediate Zone of Influence (ZOI), where elevated pH and total suspended solids and low dissolved oxygen on occasion did not meet the Darwin Harbour water quality objectives, all other monitoring sites outside of the ZOI met all SSTV objectives.

Pathogens Indicators

Any E. coli or Enterococci exceedances at any sites were not as a result of discharge events. E. coli is above the levels for the protection of the declared beneficial uses of aquatic food collection at Ludmilla Creek sites SLuLC01; SLuLC02 and SLuLC03. Enterococci results exceed the SSTV designed for the protection of the beneficial use of swimming (cultural) at all sites in Ludmilla Creek (SLuLC01; SLuLC02; SLuLC03 and SLuLC04) With the sites upstream in the creek having a greater than 10% increase in the risk of illness requiring medical attention and the downstream site (SLuLC04) having a less than 5% increase in risk of illness or between 1 and 5% increase in gastrointestinal illness and 0.3 to 1% risk of acute febrile respiratory illness), or 1 illness in 20 exposures (full contact swimming including the ingestion of water).

Ludmilla Creek Pathogen indicator levels indicate that the water quality is unsuitable for primary contact recreation (swimming); for aquaculture or the collection of food.

All Darwin Harbour sites were assessed as suitable for primary contact recreation (swimming); for aquaculture or the collection of food.

Nutrient Enrichment Indicators

All sites met the chlorophyll-a SSTV however there were occasional individual exceedances in Ludmilla Creek but none of these were as a result of discharges.

All sites exceeded the SSTV for Total Phosphorus, with only the effluent channel a significant exceedance, while filterable reactive phosphorus only exceeded the SSTV in the effluent channel and in Ludmilla Creek at SLuLC01 and SLuLC02.

Total Nitrogen exceeded the SSTV at all upstream sites in Ludmilla Creek SLuLC01 and SLuLC02.

The compliance with the primary SSTV, chlorophyll-a indicates that the excess nutrients in the receiving waters are not impacting on the waters resulting in excessive algal growth and potential eutrophication.

Toxicant Indicators

Copper exceeded 95% species protection for 'slightly to moderately' (SMD) on one occasion at the Ludmilla Creek upstream site SLuLC02. However it did not exceed the 90% protection limit. The results appear to be unrelated to discharges into the creek suggesting a possible catchment source, possibly related to road runoff as the site above Dick Ward Drive met the SMD trigger.

Endocrine Disrupting Chemicals

2021 monitoring that was conducted in March and the second round was in September and will be presented next report. March EDC was consistent with previous sampling the results showed the presence of some endocrine disrupting substances in the effluent (SLuLCDP/SLU080) and generally lower levels in the discharge point sample (SLUEP01). All samples returned results below the limits of detection for the predicted Estradiol equivalent concentration indicating a low level of EDC activity (Table 10).

3 Sediment and Pore Water Monitoring

The monitoring requirements for WDL150-08 is included as Appendix 2 of the licence.

Results for dry season monitoring are included below.

Assessment criteria for the dilute acid extractable fraction is reported as bioavailable and assessed if the total extractable metals (T) are above ISQG criteria.

No ISQGs are available for nutrients and assessment is made against typical data for Darwin Harbour and Darwin Creeks, and two reference creeks that are sampled for comparison with discharge impacted environments, King and Short Creeks and exceedances noted.

Nutrient Indicators in Sediment

No reference criteria were exceeded for nutrients (2x 80th percentile of reference sites data set)

Metals and Metalloids

Zinc and copper levels in the sediments in Ludmilla Creek and in the vicinity of the East Point Outfall and at the Ludmilla Creek downstream site are below the ISQG levels. All results were below the ISQG-low and the investigation level.

Normalisation to Aluminium 1%

Normalisation is only required if the sample exceeds the Interim Sediment Quality Guideline values (ANZECC 2000), no sites exceeded the guidelines for total or dilute acid extractable metals in sediments (bioavailable fraction).

While not required in assessing the risks associated with the sediments arising from the discharge, normalisation was undertaken to maintain an overall assessment of potential toxic impacts associated with the fine fraction of the sediment and to assess the relationship with sediment type in the discharge receiving environment and the reference sites located in unimpacted creeks which are subjected only to catchment runoff.

3.1.1 Summary of Sediment Results

Results and graphs for sediment and pore water analysis are included in Appendix 3 (Table 16 Table 17 Table 18 Table 19 Table 21 Table 22 Table 23) and 3.2.1 (trend graphs):

The 2021 sampling was conducted in May and the results show that:

Chlorophyll-a in sediment exceeded 2x Reference 80th percentile at sites SLuLC01 and at SLUEP02, SLUEP03, and SLUEP04.

Total organic carbon at the Ludmilla Creek and East Point sites was significantly lower than at the reference sites. Total Nitrogen and Total Phosphorus was below the 2X80th percentile of reference at all sites. The low TOC is a factor in the TN to TOC ratio exceeding reference values at Darwin Harbour SLUEP04.

Total Copper or Total Zinc in sediment values were below the ANZECC ISQG-Low at all sites and also below the 2X Reference site assessment criteria. All bioavailable Copper met the reference assessment criteria.

3.1.2 Summary of Pore Water Results

Results and graphs for sediment and pore water analysis are included in Appendix 3 (Table 17 Table 19 Table 20 Table 24) and 3.2.2 (trend graphs):

Filterable reactive phosphorus in pore water was above the 2X 80th percentile of reference sites assessment criteria at the Ludmilla Creek upstream site (SLuLC01) and at the East Point Outfall (SLUEP03).

All East Point SMD sites were above the 2X 80th percentile of reference assessment trigger for Total Nitrogen.

All sites were below the ANZECC trigger for zinc and only East Point SMD site SLUEP04 exceeded the ANZECC SMD trigger for copper in marine and estuarine waters. However the SLUEP04 did not exceed the 2X 80th percentile reference site assessment criteria for ANZECC SMD value. This site is outside the influence of the outfall but may be in a deposition zone for copper associated with catchment runoff.

3.2 Sediment and Pore Water Monitoring Trend Graphs

3.2.1 Sediment Analysis Graphs 2015 to 2021

WDL 150-08 requires the analysis of sediment collected from four sites within Ludmilla Creek and four sites in Darwin Harbour within the immediate vicinity of the East Point Outfall. The monitoring data for the sediments is included in the tables in Appendix 3

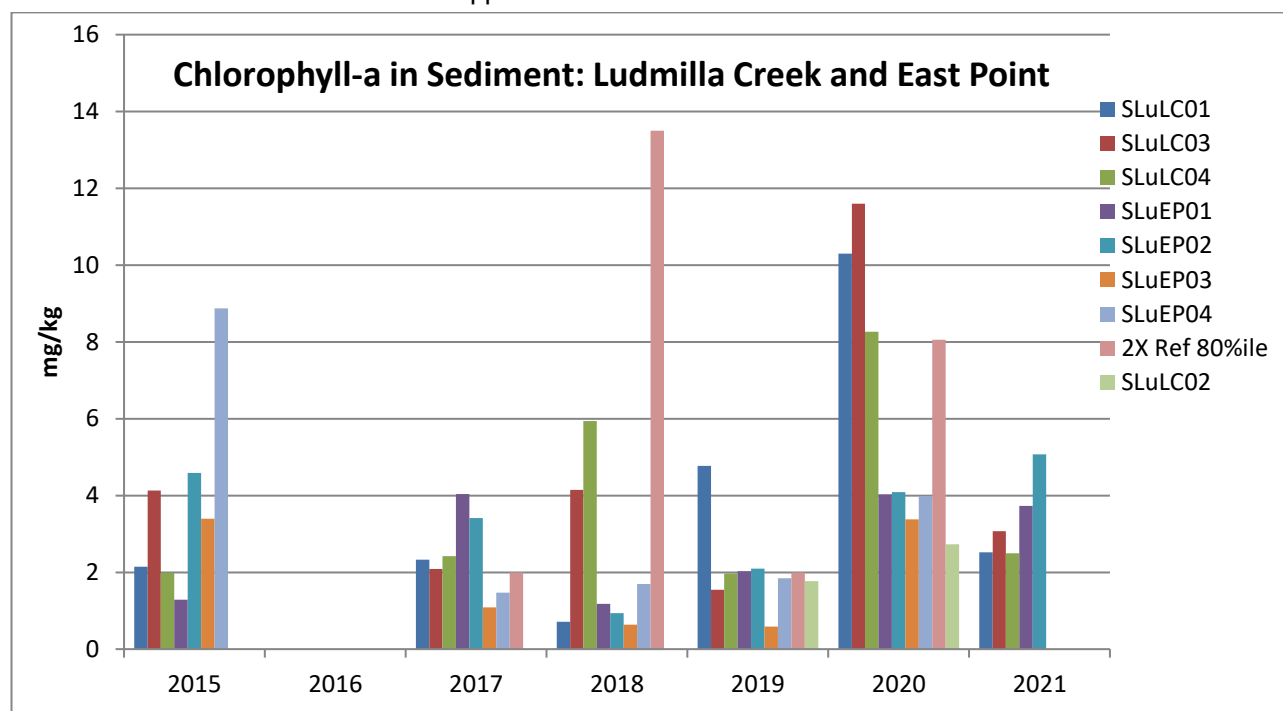


Figure 84: Trends for Chlorophyll-a in Sediment East Point and Ludmilla Creek 2015 to 2021

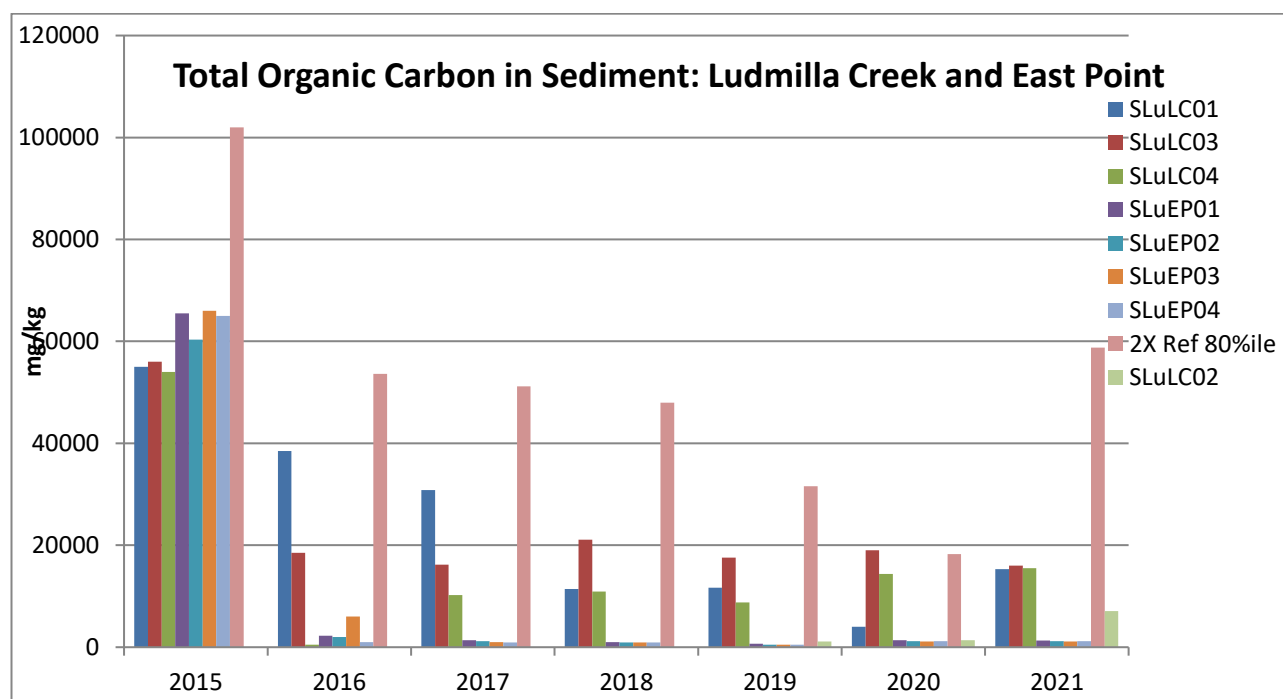


Figure 85: Trends for Total Organic Carbon in Sediment East Point and Ludmilla Creek 2015 to 2021

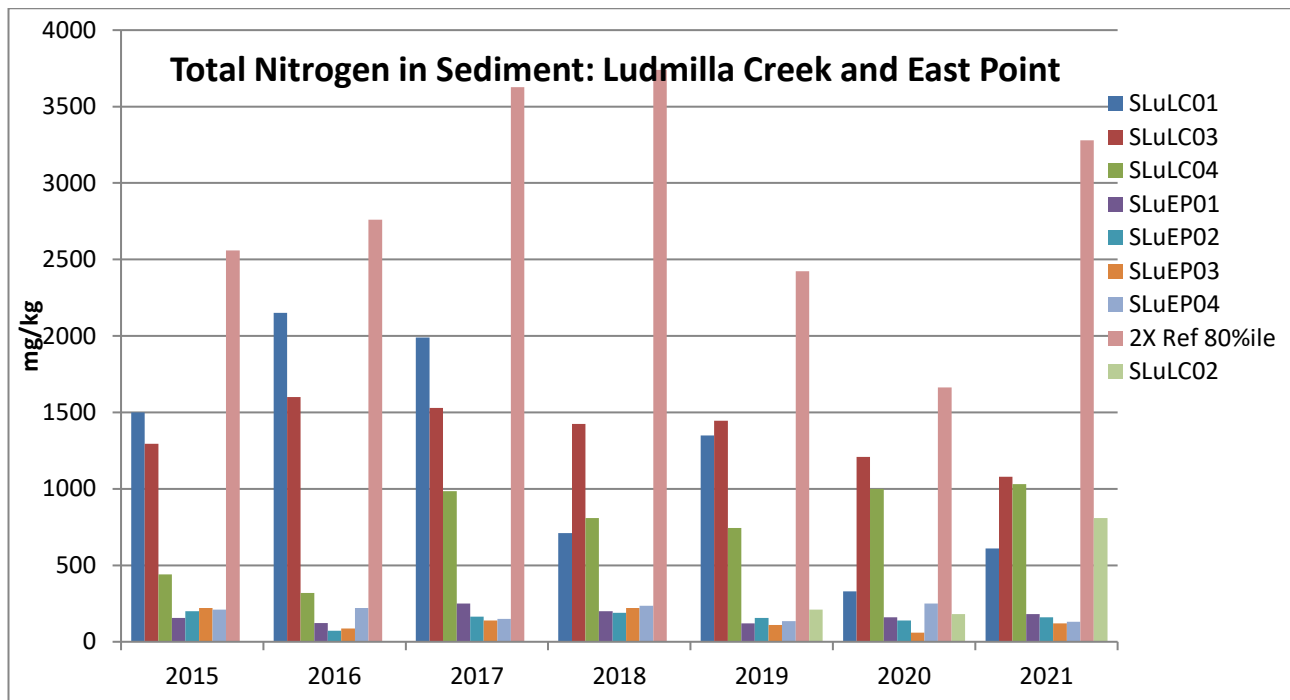


Figure 86: Trends for Total Nitrogen in Sediment East Point and Ludmilla Creek 2015 to 2021

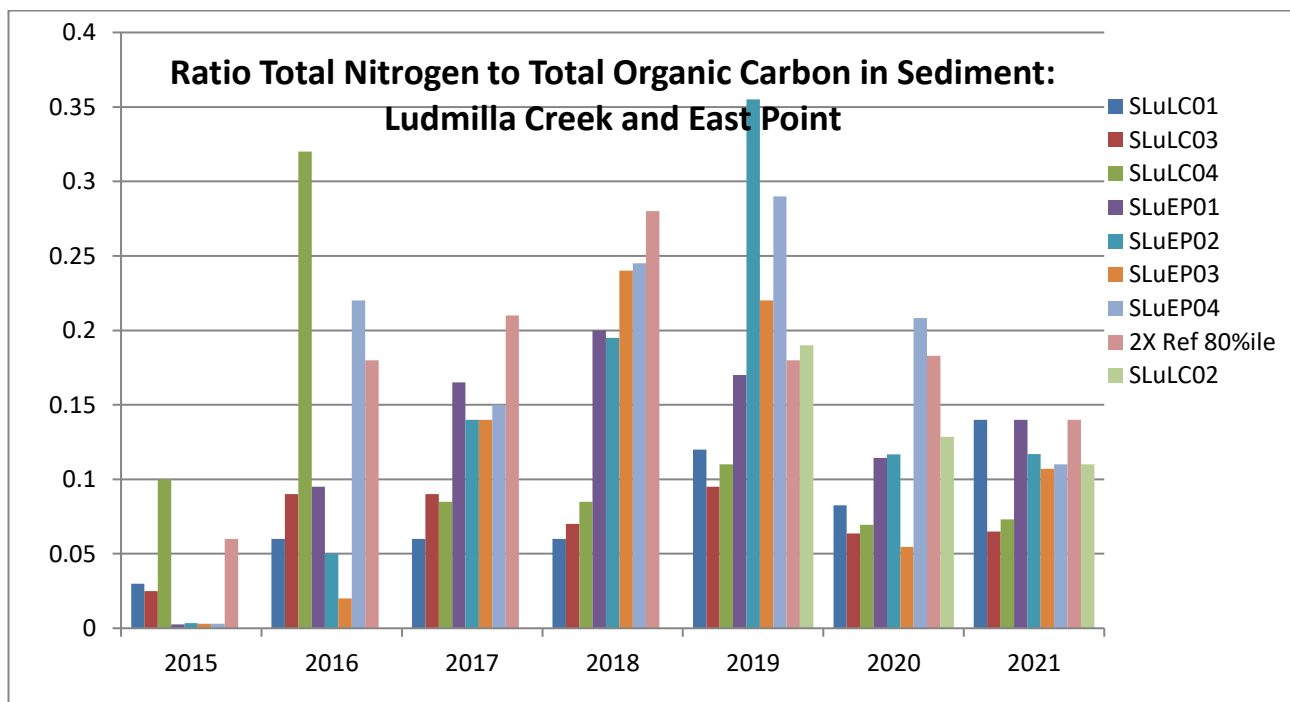


Figure 87: Ratio Trends for Total Nitrogen to Total Organic Carbon in Sediment East Point and Ludmilla Creek 2015 to 2021

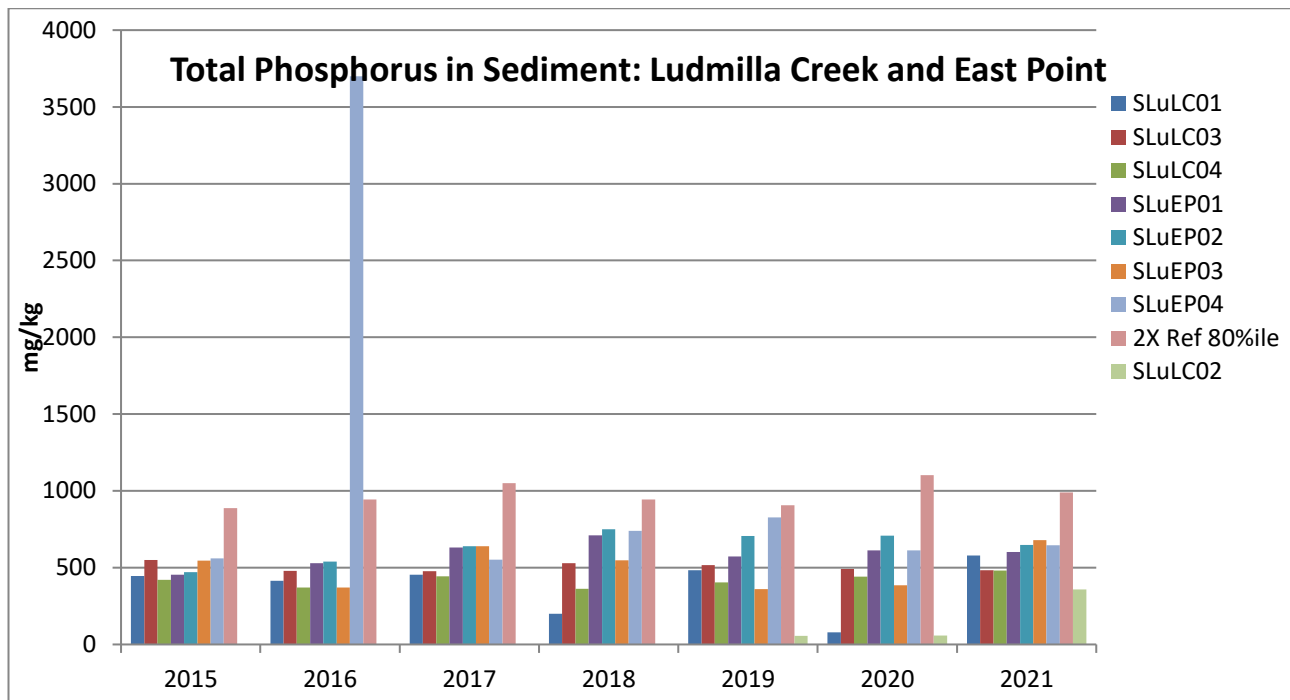


Figure 88: Trends for Total Phosphorus in Sediment East Point and Ludmilla Creek 2015 to 2021

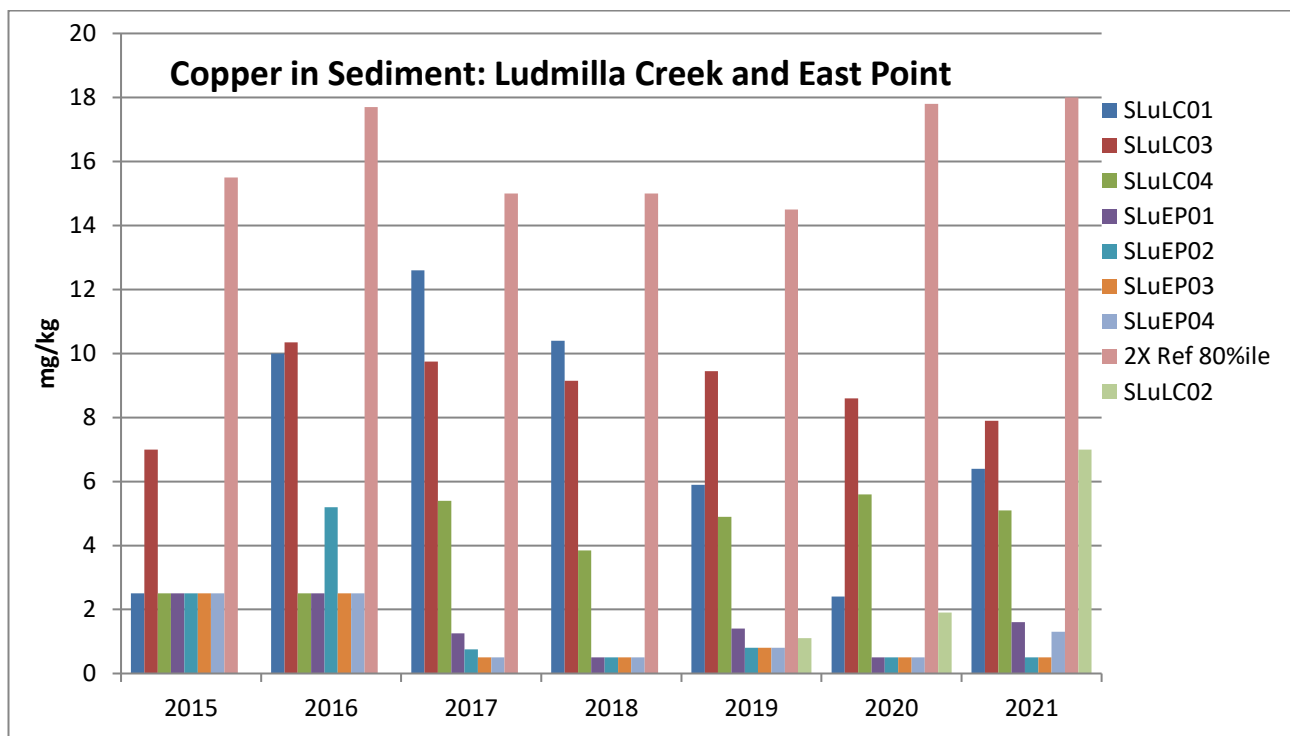


Figure 89: Trends for Total Copper in Sediment East Point and Ludmilla Creek 2015 to 2021

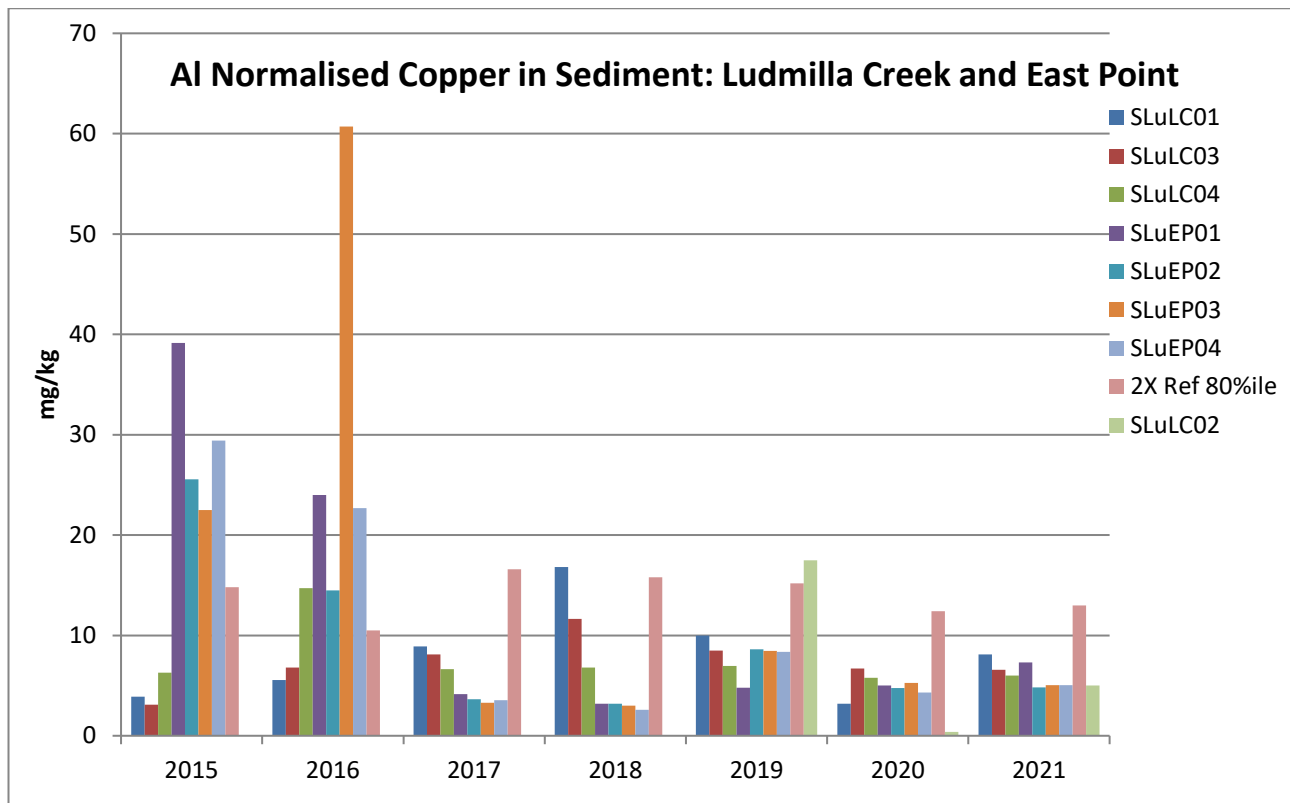


Figure 90: Trends for Aluminium Normalised Copper in Sediment East Point and Ludmilla Creek 2015 to 2021

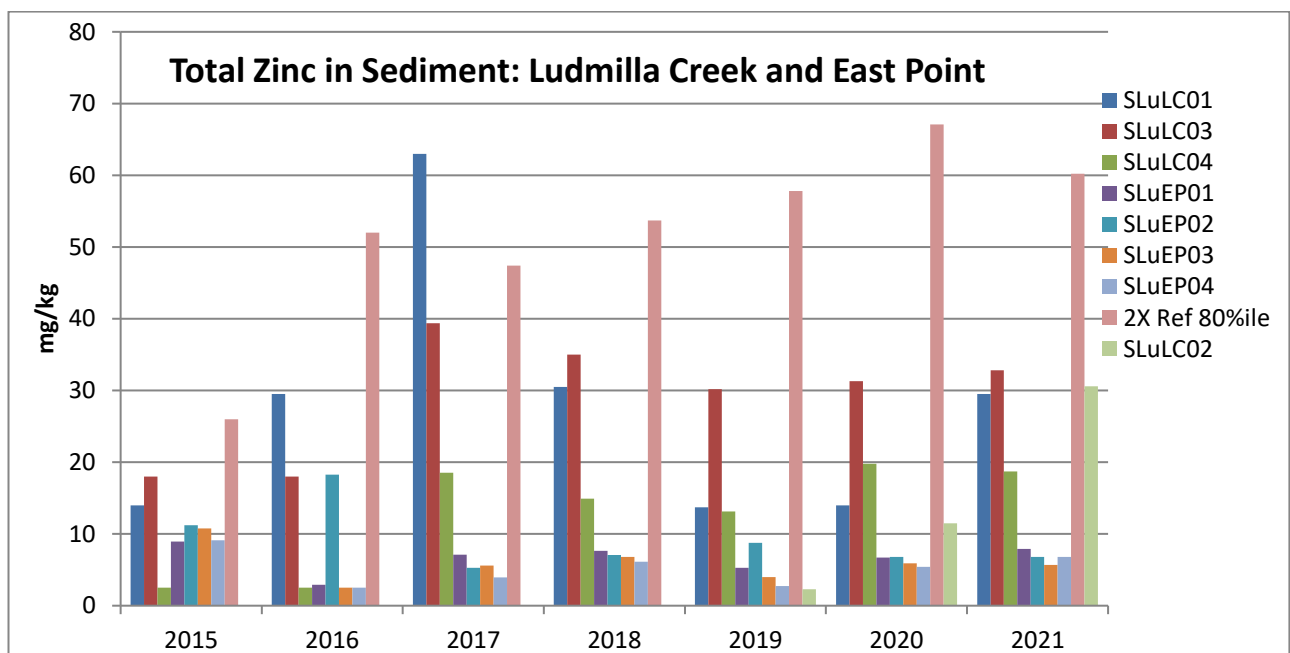


Figure 91: Trends for Total Zinc in Sediment East Point and Ludmilla Creek 2015 to 2021

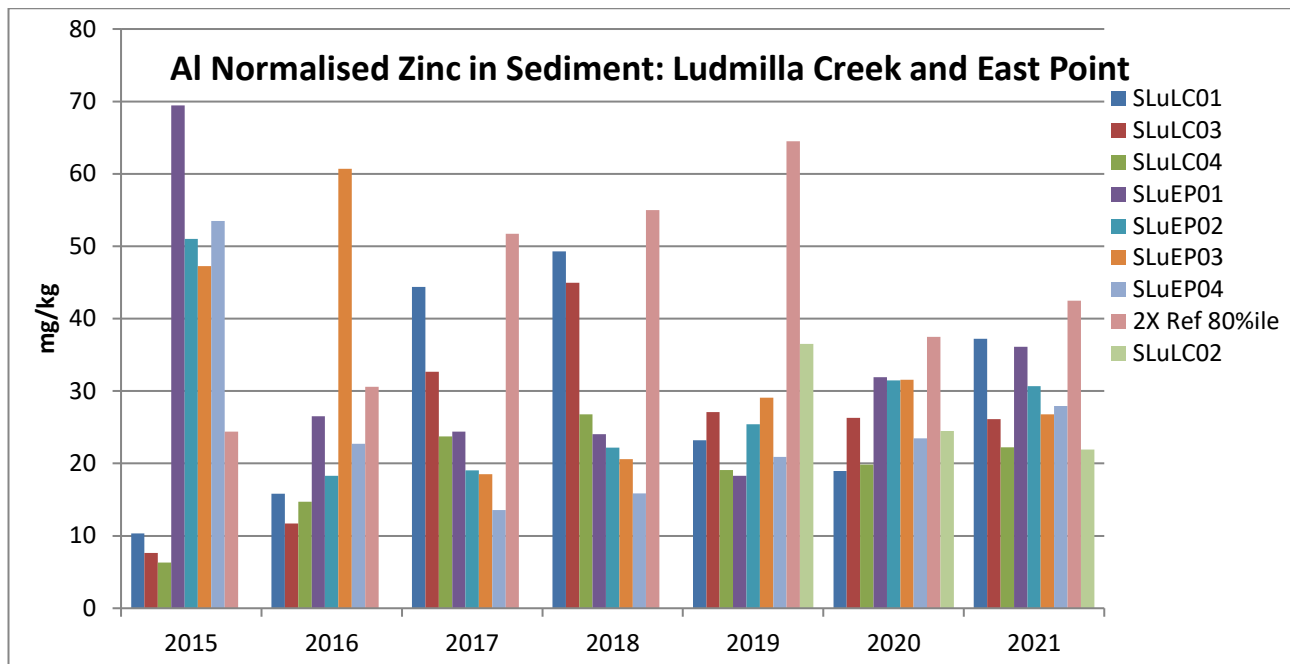
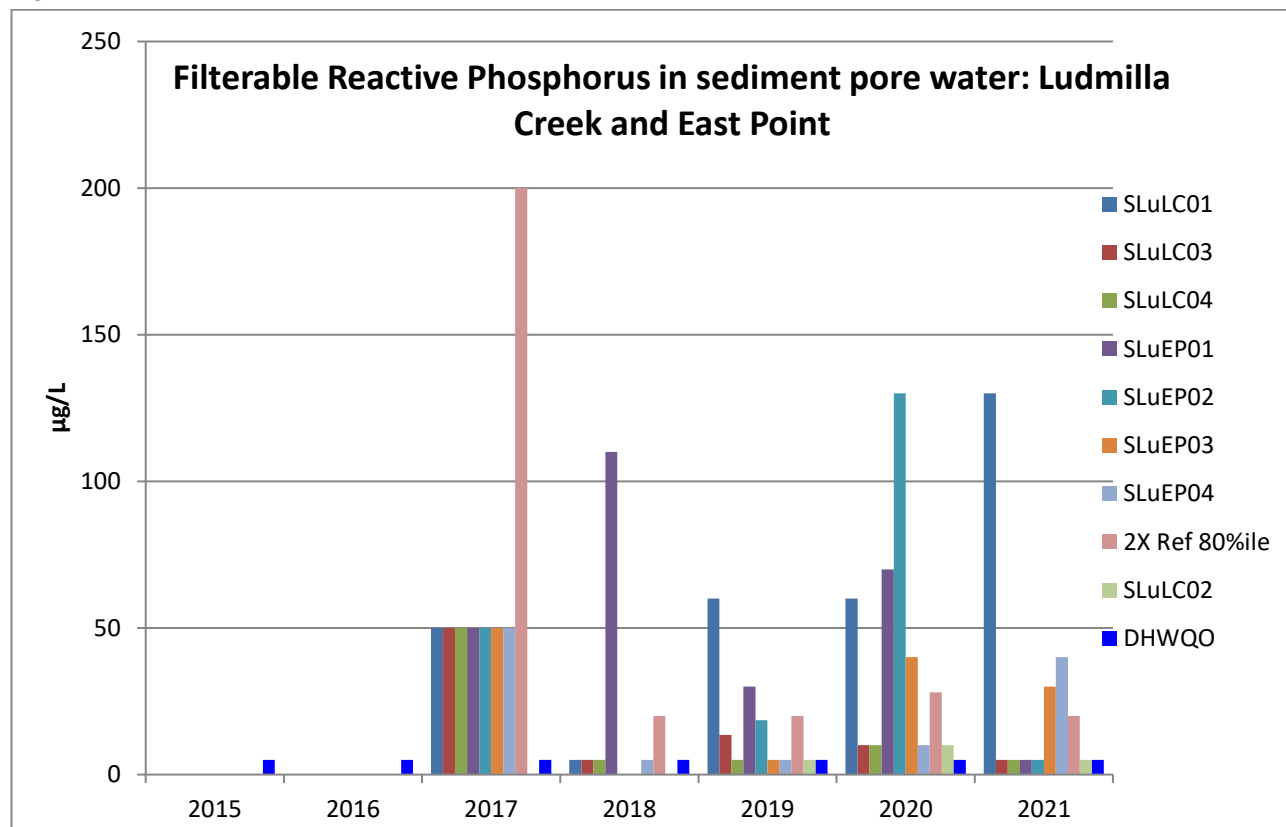


Figure 92: Trends for Aluminium Normalised Zinc in Sediment East Point and Ludmilla Creek 2015 to 2021

3.2.2 Pore Water Analysis Graphs 2015 to 2021

WDL 150-07 requires the analysis of pore water (water present within the sediment column). The pore water is a likely exposure route for burrowing animals or for animals feeding on benthic infauna and contamination in the pore water is a risk to the protection of the declared Beneficial Uses, in particular the protection of ecosystems.

The monitoring data and graphs are included in the Table 17Table 19Table 20Table 24and in Figure 93 to Figure 97 below.



Summary of Results

Figure 93: Trends in Filterable Reactive Phosphorus in Pore Water 2017 to 2021

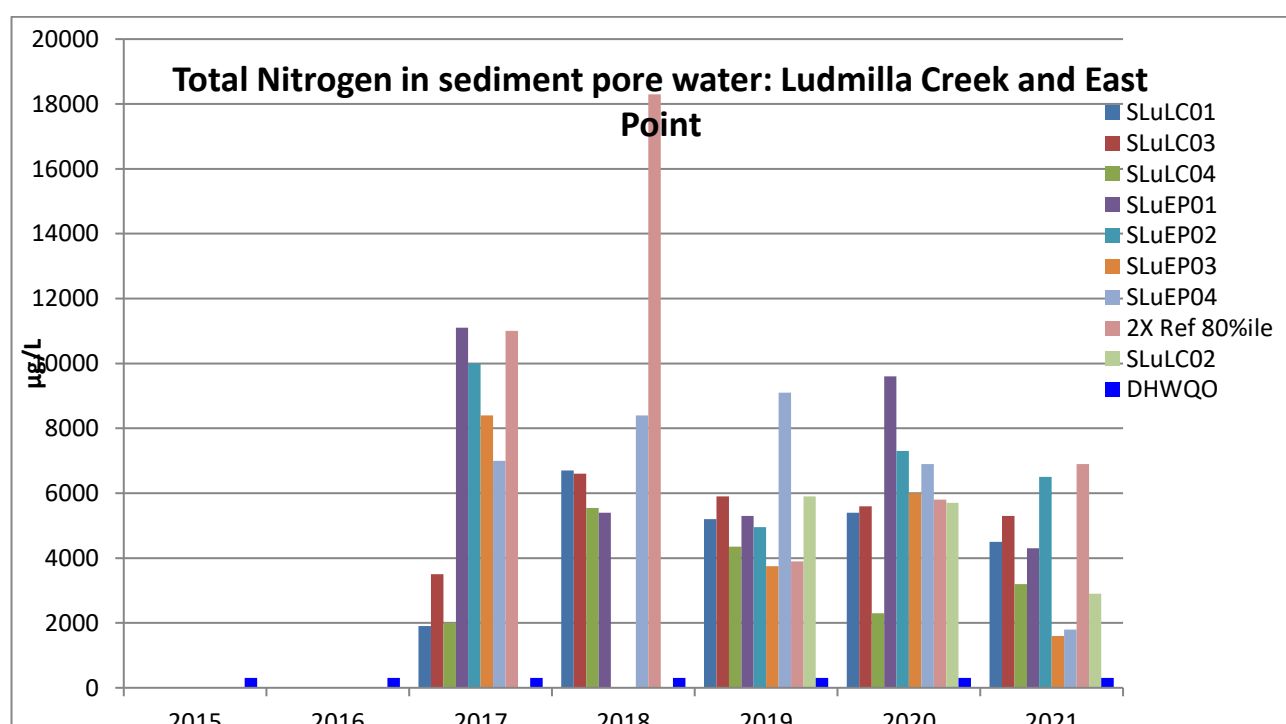


Figure 94: Trends for Total Nitrogen in Pore water 2017 to 2021

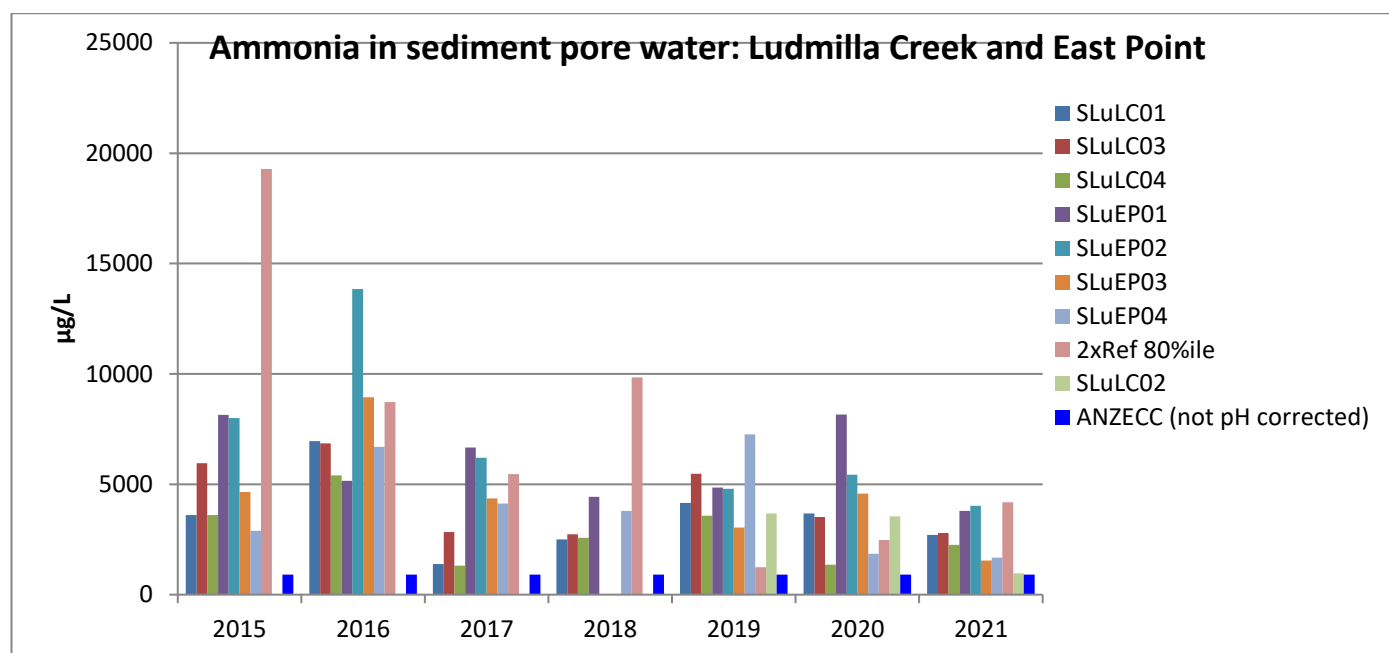


Figure 95: Trends for Ammonia in Pore Water 2015 to 2021

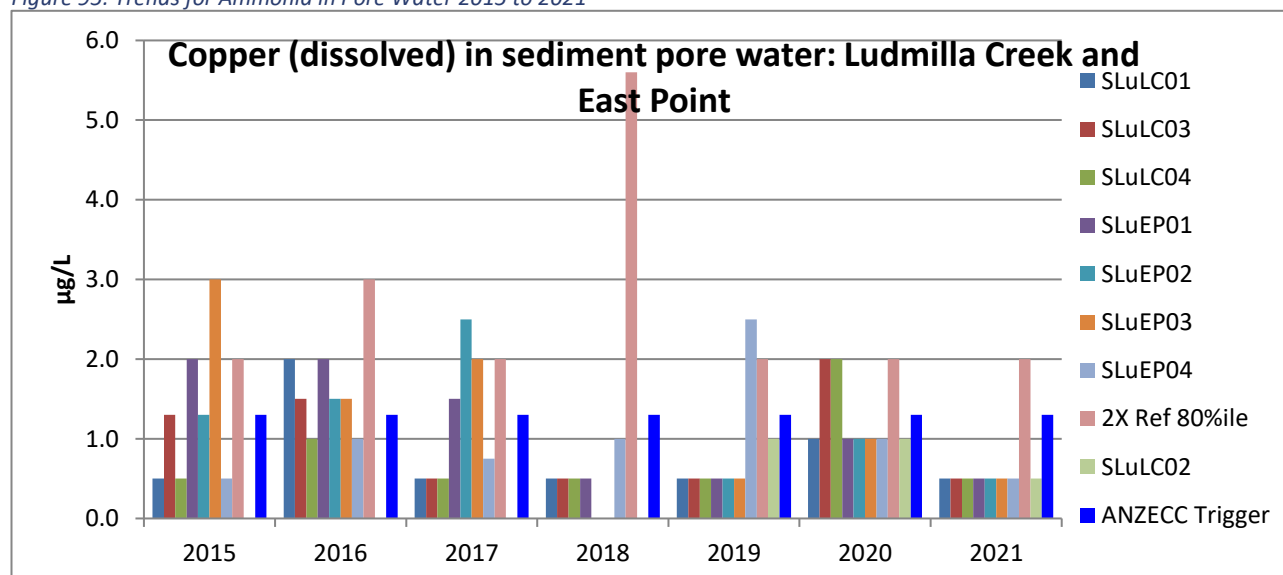


Figure 96: Trends for Copper in Pore Water 2015 to 2021

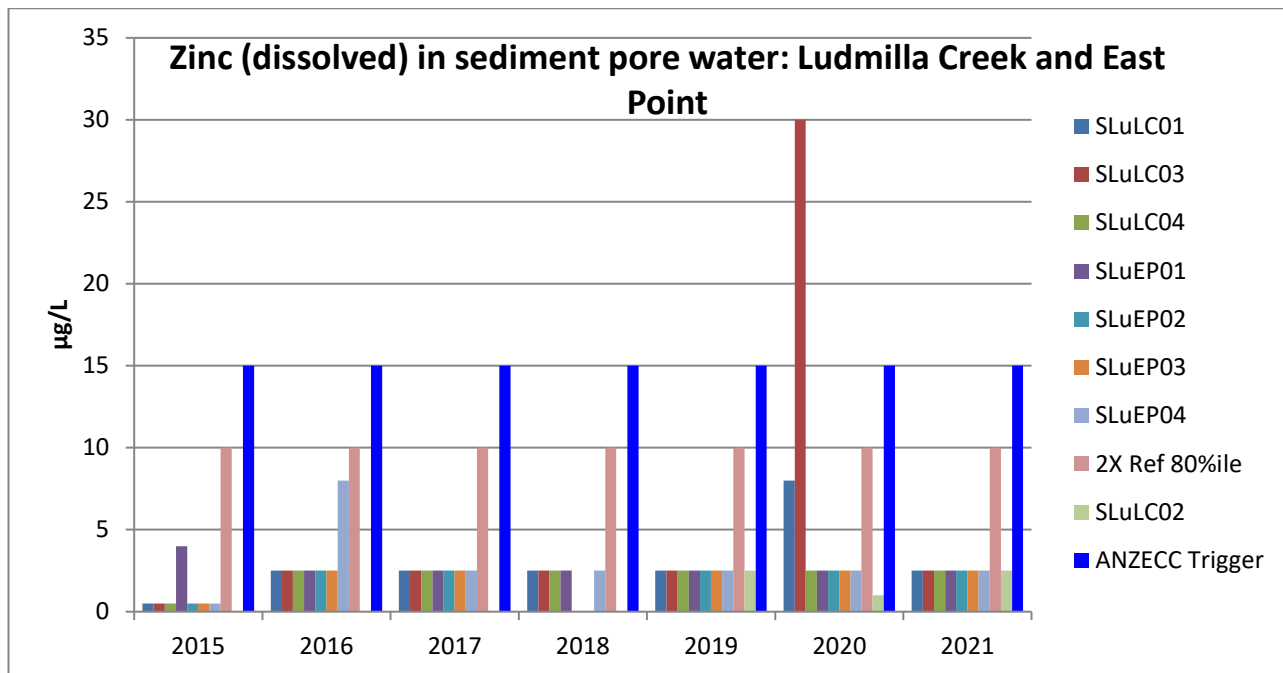


Figure 97: Trends for Zinc in Pore Water 2015 to 2021

4 Biological Monitoring Programs

The biological monitoring programs for WDL 150-08 is included in Appendix 3 of the licences. The environmental approval (EPBC2009-5113) requires the implementation of the Ecotoxicological Assessment Plan and this condition is subsequently reflected in the biological monitoring program in Appendix 3 of WDL 150-08. The full monitoring results are contained in the notification sent of 01/12/2020 (D2020/564514). The executive summary has been included in order to avoid duplication.

4.1 Ecotoxicology

Biological monitoring was unable to be carried out this reporting period due to Covid-19 restrictions. The Commonwealth approved BIMMP was approved in June 2016 and implemented in 2017 and the first wet survey was completed in April 2017. The corresponding 2017 dry survey was completed in August/September 2017. The 2018 surveys were completed in May (wet season) and September (dry season), and the 2019 surveys in April (wet season) and October (dry season). This report presents the results and analyses from the six wet and dry season surveys (2017-2019).

Infauna were sampled at 106/107 sites in each survey. The results of the infauna surveys showed that the composition of the intertidal infauna community was different from the subtidal community. The analysis focussed on the intertidal infaunal community where the effect of the present East Point discharge is most likely to be expressed. Subtidal results are compiled and archived as baseline data for possible future outfall extension programs.

The intertidal surveys showed substantial differences in the characteristics of the infauna and seagrass communities between the wet and dry season surveys.

- Infauna were more abundant in the dry season with an average of 555 individuals per square metre, compared to the wet season with an average of 273 individuals per square metre. There were more infauna species (identified to family level) present in the dry season with an average of 10 species per site, compared to the wet season with an average of 6 species per site.
- Two species of seagrass were present at most seagrass monitoring sites during the dry season surveys, but were either absent or only present in trace abundance during the wet season surveys. Seagrasses were sparse, short and dusted with sediment during the dry season surveys and did not form obvious meadows.

Infauna

Intertidal infauna population numbers have been highest at sites within 100 m of the East Point outfall compared to sites with low or negligible effluent exposure from 350 m to 1000 m from the discharge. Infauna numbers were elevated at some sites between 100 m and 200 m from the discharge compared to reference sites, while others were similar to reference sites. The pattern of higher abundance close to the outfall was strongest in the dry season surveys. Infauna abundances were generally lower across all sites in the wet season surveys. Some species showed a pattern of higher abundance beyond 50 m from the outfall. Elevated infauna abundances have been most apparent along transects to the north, northwest and west from the outfall. This is likely to reflect the predominant direction of effluent dispersal due to wind (particularly during the dry season) and intertidal seabed slope affecting inundation patterns in water movement and exposure to effluent and seawater.

The infauna community across the study area comprised a range of burrowing worms, crustaceans, molluscs and echinoderms. Polychaete worms were the dominant group of infauna and 36 different taxa were identified in the past six surveys. Crustaceans were the next most abundant group of infauna and were more diverse than the polychaetes with 58 taxa identified in the six surveys. Molluscs were less abundant but were diverse with 48 taxa identified to date. Eight echinoderms taxa were identified. Arachnoididae (sand dollars) were the most abundant and dominated the infauna at sandy sites close to the intertidal reefs along the high tide line fringing north and north-eastern East Point.

No infauna taxa were consistently absent from within 200 m from the discharge compared to sites elsewhere on the intertidal bank. Analysis of the 2017 to 2019 data identified 8 potential positive indicator taxa (four polychaete worms, two gastropod molluscs, one amphipod crustaceans, one sand dollar) and two potential negative indicator taxa (one nemertean worm and one amphipod crustacean).

Burrowing marine worms adapted for deposit feeding or predation on other infauna were the most abundant group and all four species showed statistically significant and strong positive responses to effluent exposure. The four species of polychaete worm have shown positive gradients in abundance related to increasing levels of effluent exposure (inverse of distance from outfall) in more than one survey. Polychaete worms are commonly found in elevated abundance in organically enriched environments (positive indicators).

The two gastropod mollusc indicators have also shown a positive response to effluent exposure. Both are adapted for predation on polychaete worms – which are very abundant near the outfall as discussed above. Neither of the other two potential positive indicators show statistically significant responses to effluent exposure, although both the amphipod crustacean and sand dollar are adapted for deposit feeding.

Although abundance of several marine worm taxa shows a positive response to effluent exposure, there has been no evidence of organic enrichment of the sediments in any survey. Total organic carbon concentration and sediment particle size at the outfall sites were similar to those at distant and reference sites elsewhere in Kūlaluk Bay. The values for pH at all sites have shown typical marine pH at all distances from the outfall in all surveys except the 2018 dry season. A positive gradient in pH was detected in sediments between the outfall and 160 m away in the 2018 dry season survey.

Overall, the infauna community showed a strong seasonal pattern of more species and more individuals in the dry season compared to the wet season. The effect of the East Point discharge on the benthic infauna community was expressed in both seasons as an increased abundance of infauna within 200 m, and particularly within 50 m, of the discharge. Certain polychaete worms showed the strongest and most consistent patterns, and two species of predatory snail also show strong patterns.

Seagrass

Seagrass is common although sparse in the area in the dry season, but absent or present in trace abundance in the wet season. Seagrasses are present during the dry season as small, sparse, sediment-coated plants. Intertidal sites were characterised by *Halodule* and *Halophila* seagrass, while *Halophila* was the only seagrass observed at the subtidal sites. There was no pattern in location or abundance of either seagrass that indicated an effect of the effluent discharge, however the closest seagrass documented was 350 metres from the outfall and the closest observed in the BIMMP surveys was 500 metres from the outfall.

Conclusion

The results of the six 2017, 2018 and 2019 surveys showed that the procedure described in the East Point outfall BIMMP can effectively and clearly document the level and extent of the effect of the discharge on the ecosystem indicators. The documented effect using the PWC BIMMP procedure was clearer than the previous, 2013/14 survey procedure. The combined results of the 2017 to 2019 wet and dry season surveys showed that a localised effect of the East Point outfall is consistently detectable on infauna indicators during the wet and dry seasons, which was not previously apparent.

The results of the wet and dry season surveys for the BIMMP provide evidence that the ecosystem is protected from adverse impacts:

“the ecosystem will be protected from ecological impacts if:

- All common infauna taxa at 200 m from the outlet are present in abundances expected of negligible exposure to effluent; and,
- A range of taxa at 200 m from the outfall are present in proportions expected of negligible exposure to effluent”

The value of ongoing wet season monitoring and surveys at distances greater than 500 metres from the outfall should be reassessed.

The data indicates that the subtidal sites, while providing useful data for assessing risks related to a potential relocation of the outfall provide no value in assessing the impact of the discharge arising from the approval to augment the East Point rising main and should therefore be removed from this program.

The benthic infauna results indicate that impacts beyond 200 metres from the outfall are negligible and no documented seagrass beds occur closer than 350 metres from the outfall, the closest recorded between 2017 and 2019 were 500 metres from the outfall.

The results of the 2017 to 2019 surveys indicate that the wet season seagrass survey provides very limited value and should be discontinued in the ongoing program.

The data indicates that the sediment chemistry data is of limited value in determining causal factors in relation to impacts associated with the discharge from the East Point Outfall. The need for sediment chemistry in the ongoing program should be reconsidered and at the most should be confined to sediments within the high and moderate impact zones.

The infauna monitoring indicates negligible impacts at 200 metres from the outfall; sensitive receptor species foraging habitats are over 350 metres from the outfall, therefore benthic infauna changes indicate negligible risk to sensitive receptor species. The WQMMP data provides a more responsive assessment of potential impacts on sensitive receptors.

5 Performance Improvement Program Implementation

5.1 Summary of Progress against Improvement Plan

Condition 41 of WDL 150-08 requires that the Licensee must implement the actions identified in the Improvement Plan 2019. Condition 42 requires that an updated Performance Improvement Plan is submitted to the Administering Agency by 30 June 2022. This report includes a progress assessment against actions of the current Improvement Plan 2019.

Improvement Plan Actions 2019.

Table 11 and Table 12 below, include actions proposed to improve the performance of the Ludmilla Wastewater Treatment Plant and progressively reduce the impact of the Activity on the receiving environments of Darwin Harbour at East Point and Ludmilla Creek.

Actions are split across two tables with Table 13 being PWC commitments to implement Darwin Harbour Water Quality Protection Plan (DLRM 2014) actions and Table 14 focusing on improved hydraulic and treatment of the LWwTP.

The implementation of the Improvement Plan will assist in meeting the objectives of the Ludmilla Wastewater Treatment Plant Management Goals 2019 (PWC, 2019a).

In 2014 the Department of Land Resources Management released the Darwin Harbour Water Quality Protection Plan, which included a number of actions to be implemented by PWC, and progress against these actions, listed in Table 11.

To accommodate the additional wastewater treated at Ludmilla following the closure of the Larrakeyah Outfall in May 2012 the Ludmilla Wastewater Treatment Plant was upgraded in 2012 and commissioned in 2013.

To meet the increased hydraulic load NT and Commonwealth Government approval to augment the East Point rising main and associated pumping infrastructure was received in 2013 and works completed in 2015 with final approval to commission the works received from the Commonwealth Department of Environment in August 2016.

The program to commission the pumps and rising main commenced in 2016 and in the 2017 wet season a number of defects with the main not, as yet, achieving the design performance requirements were identified.

An independent review of the hydraulic performance of the main and pumping infrastructure identified a number of potential issues and proposed potential solutions. Evaluation of the proposed options and where appropriate implement of reasonable and practicable measures to progress towards full commissioning and acceptance of the asset form a key component of the improvement plan in Table 12.

All actions that were identified in the Darwin Harbour Water Quality Protection Plan (DLRM 2014) and Ludmilla Wastewater Treatment Plant's management goals (PWC 2019a) have been completed or have been implemented and are ongoing.

The relocation of the East Point Outfall has been deferred as a result of a Biological Monitoring (Section 4) indicating the ecosystem is protected from adverse impacts outside the 200 m ZOI.

5.2 Performance Improvement Plan 2019 Implementation

Table 11: Darwin Harbour Water Quality Protection Plan (DHWQPP) 2014: Power and Water Actions

Action	Action Area DHWQPP	Action Progress	Time Frame	Complete/ongoing = 
				In progress = 
				No progress, reprioritised = 
				Action is not applicable and will not be progressed for this site = NA
No.	Water Management Actions Identified			Status
1.1	Site Specific Trigger Values	Developed 2014 and ongoing implementation via WDL 150-03 and included in EPBC 2009/51113 approved Water Quality Monitoring and Management Plan 2016	Ongoing	Completed – ongoing implementation 
1.2	Routine Water Quality Monitoring (Aim: to assess impact zone and ensure no increase in zone of impact: Compliance with WDL and WQMMP)	Ongoing since 2011: WDL program 4 Creek and 3 East Point ongoing since 2012 ensure licence compliance (Figure 2)	Ongoing	
		Water Quality Monitoring and Management Plan: compliance assessment for East Point Outfall 12 sites (PWC 2018b)	Ongoing	
1.3	Targeted Sediment Monitoring	Ongoing since 2012	Ongoing	
1.4	Routine Biota monitoring (Aim: to define the zone of impact on the protection of beneficial uses and sensitive receptors: Compliance with WDL and BIMMP and WQMMP)	Ludmilla Creek: Infauna; Stable isotopes and bioaccumulation	2014-2016	Completed
		East Point: Benthic Infauna Monitoring and Management Plan (Environmental Approval 72 and EPBC 2009/5113).	2014 ongoing	
		East Point Stable Isotopes	2014 to 2016	Completed
		East Point Toxicity	2013 ongoing	
		Bioaccumulation	2014 to 2016	Completed
2	Hydrodynamic model (Aim: understand impact zone)	East Point: dye study and Hydrodynamic model developed and ongoing application in East Point Outfall EIS	Ongoing	
3	Assessment of condition of local waters receiving sewage treatment plant discharges	Monitoring reports prepared annually that benchmark water quality to SSTVs and default Darwin Harbour water quality objectives	Ongoing	
4	Darwin Regional Sewage Strategy	PWC is developing a Darwin Region Sewerage Strategy with progress occurring on a catchment by catchment basis. The strategy will document the vision for wastewater treatment, disposal and recycling reforms to a 2030 planning horizon. The strategy will:: Provide capacity for a growing population and industry base; Improve the performance of the region’s wastewater treatment and disposal facilities; and Reduce potential impacts on the environment from sewerage operations.	Strategy development continues on a sub-catchment basis with Ludmilla catchment scheduled for 2010/21	
7	Living Water Smart Program	Program to reduce water use and effluent discharge volume	ongoing	
8	Sludge and Biosolids management strategy	Biosolids Management Strategy developed and submitted to DENR (NT EPA) for endorsement: PWC Management Strategy and Site Action Plans in preparation; NT Code of Practice in preparation (GHD for DENR and PWC)	Ongoing:	
9	Contribute to Integrated monitoring in Darwin Harbour	Ongoing contribution to program through membership of Darwin Harbour Integrated Monitoring Program	Ongoing	
		Ongoing provision of data to Darwin Harbour Report Card	Ongoing	
PWC	Infrastructure Management Action			
3.1	Larrakeyah Closure Plan implementation	Redirect wastewater from Larrakeyah outfall to Ludmilla	Completed 2012	Completed
3.2		Upgrade treatment capacity at Ludmilla WwTP	Ongoing	
3.3		Augmentation (Duplication) of East Point Rising Main		
		Construction	Completed 2014	Completed 

Action	Action Area DHWQPP	Action Progress	Time Frame	Complete/ongoing	= ✓
				In progress	= ✓
				No progress, reprioritised	= ✗
				Action is not applicable and will not be progressed for this site	= NA
3.4		Commonwealth Minister's Approval to commission main	August 2016	Completed ✓✓	
		Commissioning commenced and defects correction options under consideration for implementation of plant upgrade	ongoing	✓	
		East Point Outfall relocation including Environmental Impact Statement in preparation with technical assessment of options for outfall impact reduction under development to assess environmental, economic and social considerations	On hold	✓	
		Technical assessment of impact reduction options	2018	✓	
		Economic; social and environmental assessment of options	2018	✓	
		Submission of EIS for consideration	N/A	N/A	
		EIS decision	N/A	N/A	
		Implementation of EIS decision	N/A	N/A	
3.10	Operational improvement plan	Asset management plan for Darwin Sewerage System 2017. Ongoing review and updating.	Dec 2017 ongoing	✓	
		WDL 150-05 Improvement Plan updated: 150-06 this plan	June 2019	✓	
		WDL Improvement Plan implemented	ongoing	✓	

Table 12: Improved Hydraulic and Treatment Performance Ludmilla Wastewater Treatment Plant

Item	Action Area Description and linkages	Action Progress	Timeframes	Complete/ongoing	= 
				In progress	= 
				No progress, reprioritised due to budgetary constraints	= 
				Action is not applicable and will not be progressed for this site	= NA
1	Improved hydraulic performance of the treatment plant and East Point Outfall	Objective: improved hydraulic performance of the Ludmilla WwTP to maintain treatment performance and compliance with discharge licence requirements.			
		Action: Commence commissioning of augmented East Point rising main and associated pump augmentation.	January 2017 and ongoing		
		Action: assess performance for new pumps and augmented East Point rising main against design criteria.	Feb 2017 and Ongoing		
		Action: Identify options to remediate non-conformances and defects through independent expert assessment.	June 2017 and ongoing		
		Action: Subject to budgetary and resourcing constraints develop a program to progressively assess and where appropriate implement reasonable and practicable measures of defect corrections to progress to acceptance of the Augmentation of the East Point rising main and pump augmentation against the design criteria (1000 litres/second)	Dec 2017 and progressive implementation Ongoing		
		Action: Identify, assess and implement reasonable and practicable actions to improve the sewage flow regime into the LWwTP; effluent screening and the removal of gross pollutants, to improve influent pumping, odour control and chemical dosing and improve the hydraulic performance at the inlet.	Dec 2017 and ongoing		

Item	Action Area Description and linkages	Action Progress	Timeframes	Complete/ongoing
				= 
				In progress
				= 
No progress, reprioritised due to budgetary constraints				
= 				
Action is not applicable and will not be progressed for this site				
= NA				
		Action: Develop a Site Specific Asset Management Plan consistent with ISO55000 developed for LWwTP	2019/2020	
		Action: undertake actions to improve effluent flow through the CAS tanks by removing shot-cutting and dead zones	2019/2020	
2	Treatment Plant Process Improvement:	Objective: continuous improvement of treatment process to maintain and where necessary increase compliance with WDL150 and health and safety requirements.		
		Action: increased understanding of influent and effluent quality through monitoring and assessment of options to reduce the risk of WDL non-compliance associated with low inflow and outflow periods.	January 2017 and ongoing	
		Action: develop a program to assess options/ opportunities to further improve process performance to ensure continued compliance with WDL 150 licence requirements.	Jan 2018 and ongoing	
		Action: Assess discharge impact and report on implementation of the licence monitoring program and the Water Quality and Benthic Infauna Monitoring and Management Plans.	Jan 2017 and ongoing	
		Action: undertake actions to improve effluent flow through the CAS tanks by removing shot-cutting and dead zones	2019/2020	
		Action: Assess options to improve the chemical performance of the plant with improved chemical treatment to improve contaminant removal	2019/2020 and ongoing	
3	Improved asset management	Objective: to reduce the residual risk of operational failure to no greater than medium.		
		Action: Review the Darwin Regional Asset Management Plan and develop a site specific asset management program of monitoring; inspection and condition assessment consistent with the Darwin Regional Asset Management Plan’s objective of reducing the risks associated with the Ludmilla Wastewater Treatment Plan from high to no greater than medium	Ongoing	
4	Environmental Management Plan developed for LWwTP	Action: to support more comprehensive environmental management of LWwTP; develop a site specific Environmental Management Plan for the plant for the Activity	2019/2020	

Summary of Reporting Limit Exceedances

This 2020 Monitoring Report summarises Reporting Limit (RL) exceedances in the period from 1 November 2019 to 31 October 2020, during this period there were a total of 8 reportable non-compliances out of a total of 245 exceedances of the SSTVs.

In WDL 150-06 all exceedances of SSTVs were considered a non-compliance with the licence unless they were at sites in Ludmilla Creek and there had been no discharges to the creek in the previous 10 days or they were an exceedance of the pathogen indicators and followed a period of rain.

WDL150-07 amended the relationship between exceedances of SSTVs and licence non-compliances with a non-compliance being an exceedance of an SSTV on three consecutive occasions; an exceedance of an SSTV by more than three times the SSTV; or and exceedance of a licence limit. The qualifying condition in relation to water quality exceedances in Ludmilla Creek only being considered an exceedance if there has been a discharge to the creek in the preceding 10 days or for bacterial indicators following rainfall remain as an assessment criteria.

A detailed listing of all exceedances of SSTVs and comments as to their status are included in Table 25 in Appendix 4 of this report.

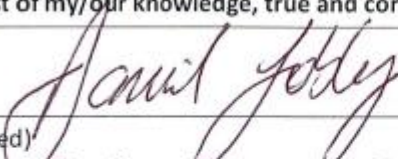
Table 13: Summary of SSTV exceedances in period November 2019 to July 2021

Parameter	Number of Exceedances	Number of reportable non-compliances
pH	4	
Dissolved Oxygen (DO % sat)	24	
Total Suspended Solids (TSS)	22	
Enterococci	31	
E. coli	20	
Copper (Cu-F)	0	
Zinc (Zn-F)	0	
Ammonia – Toxicant (NH ₃ -N)	0	
Ammonia –biostimulant (NH ₃ -N)	0	
Total Nitrogen (TN)	39	
Oxides of Nitrogen (NO _x)	0	
Total Phosphorus (TP)	46	
Filterable Reactive Phosphorus (FRP)	6	
Chlorophyll-a	7	
Total Exceedances	199	0

The majority of exceedances related to the Ludmilla Creek upstream sites, which recorded low dissolved oxygen and exceedance of pathogen guidelines in the absence of inputs from the Ludmilla Wastewater Treatment Plant.

Sites in both the Darwin Harbour and Ludmilla Creek receiving waters exceeded nutrient SSTVs however it was only in Ludmilla Creek that there was a corresponding exceedance of the primary indicator, chlorophyll-a, which indicates whether the impact of increased productivity corresponds to the increased nutrient inputs. The majority of exceedances are assessed as being unrelated to the activity of the discharge of treated wastewater from the Ludmilla Wastewater Treatment plant.

Signature and Certification

I/We hereby declare that the information provided in this Monitoring Report and accompanying documents is to the best of my/our knowledge, true and correct.	
Signature	
Name (printed)	DANIEL LOBLEY
Position	SENIOR MANAGER PERFORMANCE REPORTING & IMPROVEMENT
Date	20/9/2021

References

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- PWC 2019a Management Goals Ludmilla Wastewater Treatment Plant: WDL150-06. D2019/231299
- PWC 2019 Performance Improvement Plan Ludmilla Wastewater Treatment Plant WDL150-06
- Northern Territory Legislative Instruments
- Water Act 1992*
- Waste Management and Pollution Control Act 1998*
- Government Gazette G27, 7 July 2010.
- WDL150-07 Waste Discharge Licence for Ludmilla Wastewater Treatment Plant issued 9 August 2019

Appendix 1: Water Quality Monitoring Requirements

Table 14: Sampling Frequency requirements for 150-07

APPENDIX 1 – SURFACE WATER MONITORING SCHEDULE

Table 1: Sampling locations; parameters and frequency

Sample locations*		LWwTP	East Point Outfall	Ludmilla Creek	Darwin Harbour			Ludmilla Creek									
Site Code		SLu080# / SLULCDP	SLuEP01	SLuLC03	SLuEP02	SLuEP03	SLuLC01	SLuLC02	SLuLC04								
Site location			Locations as per Appendix 4 and described in Discharge Licence Application attachment F(iv)														
Site Description		Effluent Discharge	Zone of Influence		Darwin Harbour beyond zone of influence		Ludmilla Creek U/S	Ludmilla Creek U/S	Ludmilla Creek D/S								
Management Intent		Effluent	Disturbed		Slightly to moderately disturbed zone												
Indicator	Units																
Physico-chemical parameters																	
Flow	kL/day	D		M													
pH	pH units																
Electrical conductivity	µScm ⁻¹																
Dissolved oxygen	%saturation																
Temperature	°C																
Turbidity	NTU																
Total Suspended Solids	mgL ⁻¹																
Biotic parameters																	
Biological oxygen demand	mgL ⁻¹	M															
Chlorophyll-a	µg L ⁻¹																
EDCs 4-t-octylphenol; Nonylphenol; Bisphenol A; Andosterone; Etiocholanolone	ngL ⁻¹	S	NR														
Nutrient parameters																	
Ammonia (as total N)	µg L ⁻¹	M															
Total Nitrogen	µg L ⁻¹																
Oxides of Nitrogen (NOx as N)	µg L ⁻¹																
Total Phosphorus	µg L ⁻¹																
Filterable Reactive Phosphorus	µg L ⁻¹																
Metals parameters																	
Copper (filtered)	µg L ⁻¹	M															
Zinc (filtered)	µg L ⁻¹																
Pathogen Indicators																	
Escherichia coli	Cfu /100 mL or MPN / 100 mL	M															
Enterococci																	

Key: D= daily; M= monthly; S= seasonal 1 wet and 1 dry season sample; NR= not required * as identified in Appendix 4 Sample site location map:

Sites SLu080 and SLULCDP are the same physical location, to allow monthly monitoring both codes are required as SLULCDP is defined as the overflow weir from the recarbonation chamber while DLu080 is the recarbonation chamber.

Table 15: Surface Water Quality Assessment SSTVs; Licence Limits and Assessment Criteria WDL 150-07

Appendix 1 Table 2: Surface Water Quality Assessment: Site Specific Trigger Value and Licence Limits

		Sample Locations ^A										
Management Intent			Zone of Influence (ZOI)		Slightly to Moderately Disturbed (SMD)					All sites		
		Ludmilla WwTP effluent channel	East Point Outfall	Ludmilla Creek	Darwin Harbour		Ludmilla Creek					
		Effluent	Zone of Influence		Darwin Harbour beyond zone of influence		Upstream		Downstream			
	Site Code	SLu080 / SLuLCDP	SLuEP01	SLuLC03 ^B	SLuEP02	SLuEP03	SLuLC01 ^B	SLuLC02 ^B	SLuLC04 ^B			
Indicator	Units		Site Specific Trigger Values (SSTV's) ^B							Licence Limits ^B	Annual Report Reporting Requirements	
Physico-chemical parameters												
Flow	kL/day	kL/day			NR					NR	Annual trends to be reported	
pH	pH units	<7.0- >8.5 ¹	<7.0 - >8.5 ^{2D}		<7.0 - >8.5 ^D					<6.0 - >9.0	Annual trends compare to SSTV's 20 and 95 th percentiles	
Electrical Conductivity	µS/cm	Annual trend to be reported									Annual reporting - interpretive trend only	
Dissolved oxygen	% saturation	Annual trend to be reported ¹	<50 - >110 ²		<80 - >110					<30	Annual trends compare to SSTV's 20 and 95 th percentiles	
Temperature	°C	Annual trend to be reported									Annual reporting - interpretive trend only	
Total Suspended Solids	mg/L	Annual trend to be reported ¹	10 ^D	15	6 ^D		10 ^D			-	Annual trend compare rolling annual median to SSTV	
Biotic parameters												
Biological Oxygen Demand	Mg/L	Annual load to be reported ¹	>5+ annual load		5						Annual report compare 95 th ile to SSTV	
Chlorophyll-a ^C	µg/L	Annual trend to be reported ¹	2 ^D	4 ^D	Annual trend compare rolling annual median to SSTV		4 ^D			-	Annual trend compare rolling annual median to SSTV	
EDCs :4-t-octylphenol; Nonylphenol; Bisphenol A; Andosterone; Etiocholanolone	ng/L	No SSTV reporting of annual maximums		NR								Annual reporting of maximum values only
Nutrient parameters												
Ammonia (as total N) ^C	toxicant	µg/L	Annual load to be reported ¹	1200 ^E	95 th species protection based on pH corrected toxicant marine values as per Table 8.3.7 of ANZECC and ARMCANZ (2000) ^E					-	SMD Reporting statistic 95 th percentile of pH corrected SSTV of most recent 24 monthly samples. ZOI Annual trend based on 90 th percentile of pH corrected SSTV of most recent 24 monthly samples. Annual trend compare rolling annual median to SSTV	
	nutrient								20 ^{C,D}	-		
Total Nitrogen ^C				µg/L						300 ^{C,D}		-
Oxides of Nitrogen (NOx as N) ^C				µg/L						20 ^{C,D}		-
Total Phosphorus ^C				µg/L						30 ^{C,D}		-
Filterable Reactive Phosphorus ^C				µg/L						10 ^{C,D}		-
Metals parameters												
Copper (filtered)	µg/L	Annual load to be reported ¹	3 ^E		1.3 ^E					-	Annual reporting statistic 95 th percentile of most recent 24 monthly samples.	
Zinc (filtered)	µg/L	Annual load to be reported ¹	15 ^E		15 ^E					-		
Pathogen Indicators												
Escherichia coli	Cfu org/100mL or mpn org/100 mL	50 ¹	50 ^{1,D}	50 ^D	Median >14 ^D 90 th percentile > 43 ^D					200 ^B	Annual reporting against SSTV	
Enterococci		500 ^{1,F}	200 ^F	200 ^F	95 th percentile > 40 ^F					200 ^B		

Reporting Triggers

Percentile calculations: All 90 and 95th percentiles calculated as rolling percentile using the most recent 24 months of monitoring data:

Medians calculated as an annual median using the most recent 12 months of monitoring data.

Annual licence reports to include assessment against seasonal trends.

NR	Parameter is not relevant for the site.
1	Treatment train within Ludmilla WwTP at point of transfer to discharge points SLuEP01 or SLu080 / SLuLCDP Annual reporting and source identification only for this site. Annual report annual discharge flow (ML/year) from discharge points; Annual trends for all measured parameters; and Annual loads discharged for all relevant measured parameters.
2	Annual reporting of trends and discharge loads.
A	Site locations as described in Appendix 4.
B	Ludmilla Creek sites only considered as exceedance of SSTVs if effluent discharges to Ludmilla Creek via Ludmilla Creek overflow point from SLuLCDP in the preceding 10 days and / or except when following rainfall in preceding 10 days.
C	Chlorophyll-a is the primary indicator of impacts associated with nutrient enrichment, nutrients outside the SSTV range are only considered as an exceedance of the primary indicator also exceeds the SSTV.
D	Darwin Harbour Water Quality Objectives Table 6 (NRETAS 2010).
E	ANZECC and ARMCANZ Guidelines for Fresh and Marine Water Quality (2000) as amended from time to time.
F	National Health and Medical Research Council, Guidelines for Managing Risks in Recreational Water.

Appendix 2: Monitoring Site Locations (non-WDL programs)

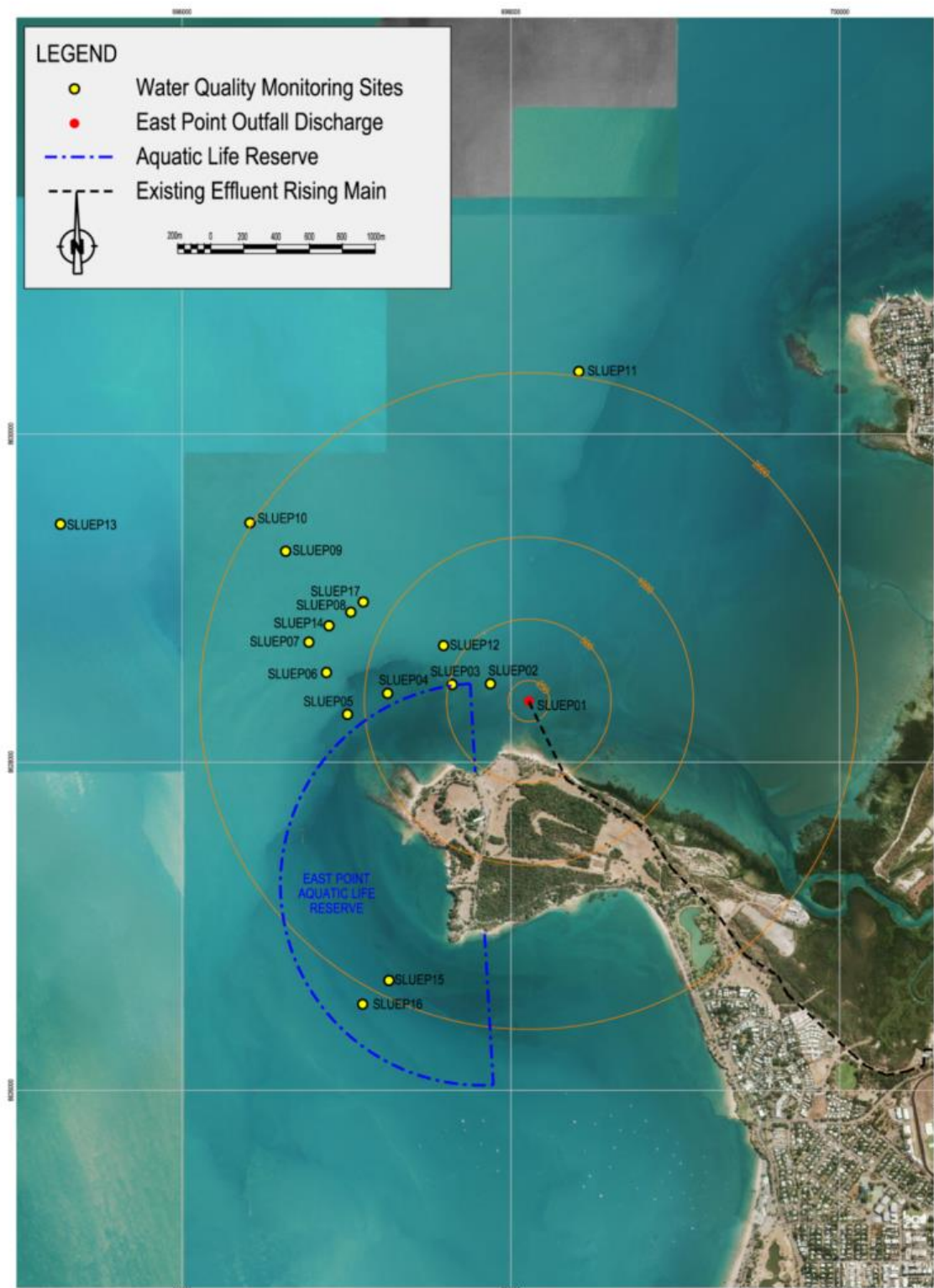


Figure 98: Water Quality Monitoring and Management Plan Monitoring Sites



Figure 99: Benthic Infauna Monitoring and Management Plan Sites

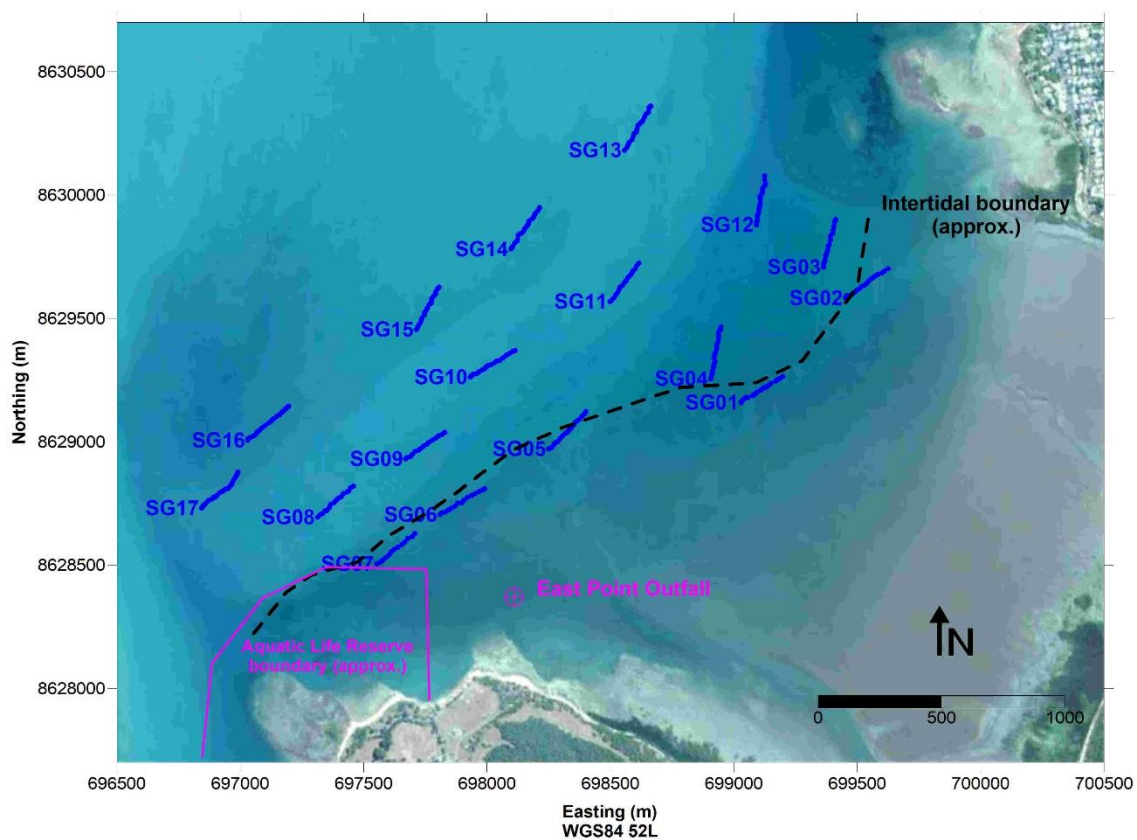


Figure 100: Benthic Infauna Monitoring and Management Plan Seagrass Sites

Appendix 3: Sediment and Pore water Contaminant Assessment

Table 16: WDL 150 Chlorophyll-a in Sediment Ludmilla Creek; East Point and Reference Creeks 2021

Chlorophyll-a IN SEDIMENT	CHL-A (mg/kg)								Chl-A:Pheo-A ^a (dimensionless)							
Analysis type	Chlorophyll a															
Analytical method	Spectrophotometric Analysis of Chlorophyll in Sediment															
LOR or Level of Precision	0.1 mg/kg															
Measures of uncertainty	± 0.3 mg/kg															
Dry Season	2014	2015	2016	2017	2018	2019	2020	2021	2014	2015	2016	2017	2018	2019	2020	2021
Alternative Assessment									Chl-A:Pheo-A ≤ 1 indicates not photosynthetically active (i.e. detrital)							
									Chl-A:Pheo-A > 1 indicates photosynthetically active (i.e. not detrital)							
> 2 x Reference site 80th Percentile	-	-	-	2.0	13.5	2.00	2.10	2.65	-	-	-	0.66	0.53	1.03	0.24	0.56
East Point Outfall site 01 and Ludmilla Creek site 03 is downstream from flow over weir - Concentration in sediment (mg/kg)																
Impact Zone-SLUEP01	-	1.07-1.51	-	3.77-4.30	1.10-1.25	2.03	2.88	3.73	-	0.83-1.75	-	1.50-2.50	1.17-1.42	1.62	0.07	3.39
Impact Zone-SLULC03	-	3.46-4.80	-	1.58-2.59	3.16-5.14	1.04-2.06	1.05-1.26	0.69-3.07	-	0.33-0.38	-	0.24-0.29	0.15-0.28	0.13-0.16	0.1-0.1	0.08-0.54
East Point site 02 is located Zone 1 and sites 03/04 are located Zone 2, both control sites considered outside impact zone. Ludmilla Creek sites 01/02/04 are considered outside impact zone																
SLULC01	-	1.60-2.69	-	2.33	0.71	4.77	6.98	2.52	-	0.40-0.68	-	0.47	0.31	1.15	0.03	0.91
SLULC02	-	-	-	-	-	1.77	1.00	1.33	-	-	-	-	-	0.55	0.06	0.26
SLULC04	-	1.99	-	1.83-3.01	3.92-7.96	1.09-2.86	0.98-1.78	1.66-2.5	-	0.67	-	0.37-0.42	0.33-0.48	0.31-0.41	0.1-0.2	0.36-0.60
SLUEP02	-	3.55-5.62	-	3.04-3.78	0.77-1.10	1.92-2.27	2.87-3.34	3.23-5.07	-	2.24-3.29	-	2.18-3.07	1.74-2.68	2.34-4.47	0.09-0.1	3.76-5.96
SLUEP03	-	3.23-3.56	-	1.09	0.64	0.46-0.71	2.14-2.75	1.41-2.3	-	2.39-2.83	-	0.61	1.22	0.82-1.58	0.08-0.1	1.04-2.50
SLUEP04	-	8.87	-	0.58-2.36	0.96-2.43	1.58-2.11	2.43-2.58	1.47-2.05	-	2.28	-	1.01-1.26	0.35-1.27	2.00-2.92	0.6-0.7	1.24-1.50
Short Creek and Kings Creek reference sites where site 01 is most upper estuary in series - Concentration in sediment (mg/kg)																
SLEKC01	-	-	-	0.87	4.71	1.27	0.86	0.86	-	-	-	0.16	0.29	0.60	0.02	0.17
SLEKC02	-	-	-	0.63	0.49	0.23	0.31	0.46	-	-	-	0.36	0.10	0.29	0.06	0.21
SLEKC03	-	-	-	0.64-0.96	1.09	0.39-1.17	0.15-0.53	0.15-0.7	-	-	-	0.13-0.49	0.05-0.49	0.19-0.57	0.04-0.08	0.08-0.41
SPASC01	-	-	-	0.55	6.30	<0.10	<0.1	0.38	-	-	-	0.09	0.01	0.01	0.01	0.06
SPASC02	-	-	-	0.98	6.86	0.14	0.91	0.55	-	-	-	0.22	0.11	0.03	0.12	0.09
SPASC03	-	-	-	0.86	2.28	0.24	1.15	2.65	-	-	-	0.15	0.16	0.04	0.16	0.30
SPASC04	-	-	-	0.99-1.07	5.18-8.34	<0.10-0.31	1.05-1.72	0.71-1.44	-	-	-	0.15-0.17	0.11-0.16	0.02-0.04	0.01-0.11	0.01-0.14
Chlorophyll at "Control Sites" have not previously been included in the Ludmilla Sediment Monitoring Program so no data prior to 2014;																
^a Ratio of Chlorophyll a to its detritus product Pheophytin a provides information about the relative levels of actively photosynthesizing organisms vs detritus/organic matter. Although sites may vary, samples with values of 1.70 are considered to contain no Pheophytin a, while solutions with values of 1.0 are considered to be pure Pheophytin a;																
Green shading indicates that benthic chlorophyll is not considered photosynthetically active based on ratio to pheophytin a																
wheras orange shading indicates the opposite;																
Red bold text indicates data values that were > 2 x reference site 80th percentiles in that season.																
Ranges (minimum - maximum) indicate site has been sampled in triplicate.																
Site SLULC02 was included in 2018 with the new WDL 150-06																

Table 17: Total Nitrogen and Total Organic Carbon in Sediment and Pore Water 2013 to 2020

NUTRIENTS - TN IN SEDIMENT	TN (mg/kg)									TOC (mg/kg)									TN (mg/L)								
NUTRIENTS - TN IN PORWATER	Total Nitrogen as N Total Nitrogen as N (TKN + NOx) 20 mg/kg ± 50 mg/kg									Total Organic Carbon Total Organic Carbon (TOC) in Soil 200 mg/kg ± 1,600 mg/kg									Total Nitrogen as N Total Nitrogen as N (TKN + NOx) by Discrete Analyser 0.1 mg/L ± 0.5 mg/L								
Dry Season Alternative assessment	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021
> 2 x Reference site 80th Percentile	-	-	2,560	2,760	3,628	3,740	2,424	2,880	3,280	-	-	102,000	53,600	51,160	47,960	31,560	54,200	58,800	-	-	-	-	11.0	18.3	3.9	5.8	6.9
East Point Outfall site 01 and Ludmilla Creek site 03 is downstream from flow over weir - Total concentration in sediment (mg/kg) or concentration in sediment porewater (mg/L)																											
Impact Zone-SLUEP01	220	200-270	110-200	95-150	250-250	190-210	120	160-180	180	-	-	63,000-68,000	<1,000-4,000	1,100-1,700	1,000-1,000	700	1400-1400	1,300	-	-	-	-	6.2-16	5.0-5.8	5.3	9.6	4.3
Impact Zone-SLULC03	230	380-920	990-1,600	1,500-1,700	1,260-1,800	1,200-1,650	1,200-1,690	1210-1410	860-1080	-	-	54,000-58,000	16,000-21,000	15,200-17,200	19,200-23,000	10,200-25,100	17200-19000	14700-16000	-	-	-	-	3.0-4.0	4.3-8.9	4.3-7.5	5.6	2.9-5.3
East Point site 02 is located Zone 1 and sites 03/04 are located Zone 2, both control sites considered outside impact zone. Ludmilla Creek sites 01/02/04 are considered outside impact zone																											
SLULC01	-	-	1,400-1,600	1,900-2,400	1,990	710	1,350	330	610	-	-	53,000-57,000	35,000-42,000	30,800	11,400	11,700	4,000	15,300	-	-	-	-	1.9	6.7	5.2	5.4	4.5
SLULC02	-	-	-	-	-	-	210	180	810	-	-	-	-	-	-	1,100	1,400	7,100	-	-	-	-	-	-	5.9	5.7	2.9
SLULC04	-	-	440	320	870-1,100	580-1,040	550-940	960-1000	710-1030	-	-	54,000	<1,000	8,600-11,900	8,100-13,700	5,600-12,000	11700-14400	9400-15500	-	-	-	-	1.6-2.4	3.8-7.3	3.3-5.4	2.3	2.1-3.2
SLUEP02	-	-	170-230	<10-140	160-170	160-220	140-170	110-140	110-160	-	-	60,000-67,000	1,000-3,000	1,000-1,400	900-1,000	300-700	1200-1600	1000-1200	-	-	-	-	6-14.	*	3.9-6.0	7.3	2.1-6.5
SLUEP03	-	-	220-220	54-120	140	220	100-120	60-150	90-120	-	-	65,000-67,000	3,000-9,000	1,000	900	500-500	1100-1400	1000-1100	-	-	-	-	8.4	*	3.1-4.4	6.0	1.4-1.6
SLUEP04	-	-	210	220	110-190	200-270	130-140	250	110-130	-	-	65,000	1,000	700-1,100	900-1,000	400-600	1,200	1000-1200	-	-	-	-	4.7-9.3	8.4	7.7-10.5	6.9	<1-1.8
Short Creek and Kings Creek reference sites where site 01 is most upper estuary in series - Total concentration in sediment (mg/kg) or concentration in sediment porewater (mg/L)																											
SLEKC01	-	-	1,200	710	930	740	470	920	410	-	-	46,000	11,000	8,700	7,300	9,800	9,600	7,000	-	-	-	-	5.7	10.8	1.2	2.0	3.5
SLEKC02	-	-	220	330	570	390	320	700	420	-	-	81,000	1,000	6,100	1,900	5,400	8,200	5,500	-	-	-	-	2.2	1.4	<0.5	2.9	1.0
SLEKC03	-	-	810-1,000	750-940	800-900	450-780	690-1,010	490-590	440-680	-	-	36,000-48,000	9,000-15,000	7,900-9,000	5,500-13,300	6,300-15,900	7900-9200	7500-16500	-	-	-	-	3.2-4.7	1.6-3.7	<1.0-1.7	3.1	1-1.2
SPASC01	-	-	1,600	1,500	1,670	160	1,420	1,320	1,770	-	-	36,000	27,000	19,100	22,600	15,100	23,700	24,300	-	-	-	-	2.6	9.0	<1.0	2.2	2.2
SPASC02	-	-	870	1,300	1,850	1,890	1,180	1,400	1,660	-	-	51,000	23,000	27,200	24,100	16,400	33,800	25,800	-	-	-	-	5.9	7.7	<2.0	2.0	1.8
SPASC03	-	-	940	1,300	1,970	1,980	1,220	1,660	1,560	-	-	44,000	26,000	29,000	23,500	15,300	23,900	30,300	-	-	-	-	3.5	5.3	2.0	2.8	3.3
SPASC04	-	-	890-1,300	900-1,400	1,560-1,660	1,670-1,790	260-740	1,290-1,450	1440-1540	-	-	47,000-51,000	24,000-42,000	18,200-19,000	20,700-26,200	13,800-14,900	21700-27900	28800-31400	-	-	-	-	2.1-2.5	7.0-9.2	1.0-1.2	1.9-3.8	2.8-3.5

Table 18: Ratio Total Nitrogen to Total Organic Carbon in Sediment 2013 to 2021

Symbol	-	-	-	-	-	-	-	-	-	-	-	-	-	TN:TOC (dimensionless)				-	-	-	-	-	-	-	-	-	-	-	
Alternative assessment											2013	2014	2015	2016	2017	2018	2019	2020	2021										
											Significant difference to reference creek (P< 0.05) - unpaired t-test?																		
	-	-	No, P = 0.97	No, P = 0.62	No, P = 0.07	No, P = 0.15	Yes, P = 0.01	No, P=0.7	Yes P=0.001																				
> 2 x Reference site 80th Percentile	-	-	-	-	-	-	-	-	-	-	-	0.06	0.18	0.21	0.28	0.18	0.16	0.14	-	-	-	-	-	-	-	-	-		
East Point Outfall site 01 and Ludmilla Creek site 03 is downstream from flow over weir - Total concentration in sediment (mg/kg) or concentration in sediment porewater (mg/L)																													
Impact Zone-SLUEP01	-	-	-	-	-	-	-	-	-	-	-	0.002-0.003	0.04-0.15	0.15-0.18	0.19-0.21	0.17	0.11-0.13	0.14	-	-	-	-	-	-	-	-	-		
Impact Zone-SLULC03	-	-	-	-	-	-	-	-	-	-	-	0.02-0.03	0.08-0.10	0.08-0.10	0.06-0.08	0.07-0.12	0.07-0.07	0.05-0.07	-	-	-	-	-	-	-	-	-		
East Point site 02 is located Zone 1 and sites 03/04 are located Zone 2, both control sites considered outside impact zone. Ludmilla Creek sites 01/02/04 are considered outside impact zone																													
SLULC01	-	-	-	-	-	-	-	-	-	-	-	0.03-0.03	0.05-0.07	0.06	0.06	0.12	0.08	0.04	-	-	-	-	-	-	-	-	-		
SLULC02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.19	0.13	0.11	-	-	-	-	-	-	-	-	-		
SLULC04	-	-	-	-	-	-	-	-	-	-	-	0.10	0.32	0.07-0.10	0.07-0.10	0.05-0.17	0.08	0.06-0.08	-	-	-	-	-	-	-	-	-		
SLUEP02	-	-	-	-	-	-	-	-	-	-	-	0.003-0.004	0.03-0.07	0.12-0.16	0.17-0.22	0.24-0.47	0.07-0.11	0.11-0.13	-	-	-	-	-	-	-	-	-		
SLUEP03	-	-	-	-	-	-	-	-	-	-	-	0.003-0.003	0.01-0.03	0.14	0.24	0.20-0.24	0.04-0.13	0.08-0.12	-	-	-	-	-	-	-	-	-		
SLUEP04	-	-	-	-	-	-	-	-	-	-	-	0.003	0.22	0.13-0.17	0.22-0.27	0.23-0.35	0.21	0.11-0.11	-	-	-	-	-	-	-	-	-		
Short Creek and Kings Creek reference sites where site 01 is most upper estuary in series - Total concentration in sediment (mg/kg) or concentration in sediment porewater (mg/L)																													
SLEKC01	-	-	-	-	-	-	-	-	-	-	-	0.03	0.06	0.11	0.10	0.05	0.09	0.06	-	-	-	-	-	-	-	-	-		
SLEKC02	-	-	-	-	-	-	-	-	-	-	-	0.003	0.33	0.09	0.21	0.06	0.08	0.08	-	-	-	-	-	-	-	-	-		
SLEKC03	-	-	-	-	-	-	-	-	-	-	-	0.02-0.02	0.05-0.10	0.09-0.11	0.07-0.14	0.06-0.11	0.05-0.07	0.04-0.07	-	-	-	-	-	-	-	-	-		
SPASC01	-	-	-	-	-	-	-	-	-	-	-	0.04	0.06	0.09	0.08	0.09	0.05	0.07	-	-	-	-	-	-	-	-	-		
SPASC02	-	-	-	-	-	-	-	-	-	-	-	0.02	0.06	0.07	0.08	0.07	0.04	0.06	-	-	-	-	-	-	-	-	-		
SPASC03	-	-	-	-	-	-	-	-	-	-	-	0.02	0.05	0.07	0.08	0.08	0.07	0.05	-	-	-	-	-	-	-	-	-		
SPASC04	-	-	-	-	-	-	-	-	-	-	-	0.02-0.03	0.02-0.05	0.08-0.09	0.07-0.08	0.02-0.06	0.04-0.07	0.05-0.05	-	-	-	-	-	-	-	-	-		
Nutrients at "Control Sites" have not previously been included in the Ludmilla Sediment Monitoring Program so no data prior to 2014;																													
^a Ratio of Chlorophyll a to its detritus product Pheophytin a provides information about the relative levels of actively photosynthesizing organisms vs detritus/organic matter. Although sites may vary, samples with values of 1.70 are considered to contain no Pheophytin a, while solutions with values of 1.0 are considered to be pure Pheophytin a;																													
^b Ammonia toxicant guidelines pH adjusted based on porewater pH as per Table 8.3.7 of ANZECC and ARMCANZ (2000);																													
^c Field pH of composite sample applied in 2015 whereas in previous years lab pH has been applied;																													
^d Change in laboratory methodwhere the former method used K ₂ SO ₄ and H ₂ SO ₄ with a colorimetric finish and the latter method uses a HCl/HNO ₃ digestion with a ICP-OES finish;																													
Orange shading indicates exceedance of ANZECC SMD guidelines;																													
Green shading indicates no exceedance of ANZECC SMD guideline;																													
CALCULATIONS OF: 2 x Reference site 80th Percentile																													
SLEKC01	-	-	1,200	710	930	740	470	920	410	-	-	46,000	11,000	8,700	7,300	9,800	9,600	7,000	-	-	-	-	5.7	10.8	1.2	2.0	3.5		
SLEKC02	-	-	220	330	570	390	320	700	420	-	-	81,000	1,000	6,100	1,900	5,400	8,200	5,500	-	-	-	-	2.2	1.4	<.5	<2.9	<1.0		
SLEKC03	-	-	1,000	640	900	780	1,010	590	680	-	-	48,000	15,000	9,000	13,300	15,900	9,200	16,500	-	-	-	-	4.7	3.7	1.7	3.1	1.2		
SPASC01	-	-	1,600	1,500	1,670	160	1,420	1,320	1,770	-	-	36,000	27,000	19,100	22,600	15,100	23,700	24,300	-	-	-	-	2.6	9.0	<1	<2	<2		
SPASC02	-	-	870	1,300	1,850	1,890	1,180	1,400	1,660	-	-	51,000	23,000	27,200	24,100	16,400	33,800	25,800	-	-	-	-	5.9	7.7	<2	<2	<2		
SPASC03	-	-	940	1,300	1,970	1,980	1,220	1,660	1,560	-	-	44,000	26,000	29,000	23,500	15,300	23,900	30,300	-	-	-	-	3.5	5.3	2.0	2.8	3.3		
SPASC04	-	-	1,300	1,400	1,660	1,790	740	1,450	1,540	-	-	51,000	42,000	19,000	26,200	14,900	27,900	31,400	-	-	-	-	2.5	9.2	1.2	1.9-3.8	3.5		
												TN:TOC (dimensionless)																	
												SLEKC01			0.030	0.060	0.110	0.100	0.050	0.096	0.060								
												SLEKC02			0.003	0.330	0.090	0.210	0.060	0.085	0.080								
												SLEKC03			0.020	0.100	0.110	0.140	0.110	0.064	0.070								
												SPASC01			0.040	0.060	0.090	0.080	0.090	0.056	0.070								
												SPASC02			0.020	0.060	0.070	0.080	0.070	0.041	0.060								
												SPASC03			0.020	0.050	0.070	0.080	0.080	0.069	0.050								
												SPASC04			0.030	0.050	0.090	0.07-0.08	0.060	0.052	0.050								
												Significant difference to reference creek (P< 0.05) - unpaired t-test?																	
												SLULC01	-	-	0.027168	0.063751	0.060	0.060	0.120	0.080	0.140								
												SLULC02	-	-	-	-	-	0.190	0.130	0.110									
												SLULC03	-	-	0.022531	0.088095	0.092051	0.071370	0.093659	0.070000	0.065000								
												SLULC04	-	-	0.100	0.320	0.089700	0.081842	0.094215	0.080000	0.073000								
												SLUEP01	-	-	0.002494	0.102083	0.162815	0.200000	0.170	0.120	0.140								
												SLUEP02	-	-	0.003118	0.050889	0.142294	0.189259	0.361508	0.090000	0.117000								
												SLUEP03	-	-	0.003334	0.029458	0.140	0.240	0.226667	0.085000	0.107000								
												SLUEP04	-	-	0.003	0.220	0.154401	0.246111	0.302778	0.210000	0.110000								
												SLEKC01	-	-	0.030	0.060	0.11	0.100	0.050	0.090	0.060								
												SLEKC02	-	-	0.003	0.330	0.09	0.210	0.060	0.080	0.080								
												SLEKC03	-	-	0.021731	0.073148	0.103347	0.080965	0.082512	0.060000	0.049000								
												SPASC01	-	-	0.040	0.060	0.09	0.080	0.090	0.050	0.070								
												SPASC02	-	-	0.020	0.060	0.07	0.080	0.070	0.040	0.060								
												SPASC03	-	-	0.020	0.050	0.07	0.080	0.080	0.070	0.050								
												SPASC04	-	-	0.022994	0.041758	0.087603	0.075354	0.043991	0.0550000	0.051000								
												-	-	0.97	0.62	0.07	0.15	0.01	0.70	0.00									

Table 19: Total Phosphorus in sediment and pore water 2013 to 2021

NUTRIENTS - TP IN SEDIMENT	TP (mg/kg)									TP (mg/l)									FRP (mg/L)								
NUTRIENTS - TP & FRP IN POREWATER	TP (mg/kg)									TP (mg/l)									FRP (mg/L)								
Analysis type Analytical method LOR or Level of Precision Measures of uncertainty	Total Phosphorus as P Total Phosphorus as P by Discrete Analyser 2 mg/kg ± 20 mg/kg									Total Phosphorus as P Total Phosphorus as P by Discrete Analyser 0.01 mg/L ± 0.02 mg/L									Dissolved Reactive Phosphorus as P Dissolved Reactive Phosphorus as P by DA 0.01 mg/L ± 0.01 mg/L								
Dry Season	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021
> 2 x Reference site 80th Percentile	-	-	888	944	1,050	941	907	1,057	989	-	-	-	-	0.62	0.37	0.62	0.51	0.27	-	-	-	-	0.20	0.02	0.02	0.02	0.02
East Point Outfall site 01 and Ludmilla Creek site 03 is downstream from flow over weir - Total concentration in sediment (mg/kg)																											
Impact Zone-SLUEP01	768	590-630	400-510	460-610	629-635	649-771	573	613-718	603	-	-	-	-	<0.10-1.48	0.31-0.53	0.83	0.22	<0.1	-	-	-	-	<0.10-<0.10	0.10-0.12	0.03	0.07	<0.01
Impact Zone-SLULC03	550	230-440	540-560	450-510	438-515	593-465	435-599	466-577	452-484	-	-	-	-	0.06-0.12	<0.10-0.24	0.50-2.21	0.10	<0.1-0.24	-	-	-	-	<0.10-<0.10	<0.01-<0.01	<0.01-0.02	<0.01	<0.01-<0.01
East Point site 02 is located Zone 1 and sites 03/04 are located Zone 2, both control sites considered outside impact zone. Ludmilla Creek sites 01/02/04 are considered outside impact zone																											
SLULC01	-	-	420-470	380-450	455	199	483	79	579	-	-	-	-	0.13	0.41	0.48	<0.2	0.45	-	-	-	-	<0.10	<0.01	0.06	0.04	0.13
SLULC02	-	-	-	-	-	-	56	58	358	-	-	-	-	-	-	0.33	<0.2	0.26	-	-	-	-	-	-	<0.01	<0.01	<0.1
SLULC04	-	-	420	370	414-474	337-387	292-518	442-490	384-481	-	-	-	-	<0.05-0.22	<0.10-0.26	0.26-0.40	<0.1	<0.1-0.16	-	-	-	-	<0.10-<0.10	<0.01-<0.01	<0.01-<0.01	<0.01	<0.01-<0.01
SLUEP02	-	-	400-540	490-590	575-704	602-895	624-788	665-708	604-648	-	-	-	-	0.42-1.44	*	0.88-1.69	0.28	<0.1-0.4	-	-	-	-	<0.10-<0.10	*	<0.01-0.03	0.13	<0.01-<0.01
SLUEP03	-	-	530-560	170-570	639	548	60-661	385-672	597-679	-	-	-	-	0.88	*	0.50-2.21	0.24	<0.1-<0.1	-	-	-	-	<0.10	*	<0.01-<0.01	0.04	<0.1-0.03
SLUEP04	-	-	560	3,700	433-670	644-835	656-1,000	612	563-646	-	-	-	-	<0.10-0.20	1.11	0.36-0.71	<0.2	<0.1-<0.1	-	-	-	-	<0.10-<0.10	<0.01	<0.01-<0.01	<0.01	<0.01-0.04
Short Creek and Kings Creek reference sites where site 01 is most upper estuary in series - Total concentration in sediment (mg/kg) or concentration in sediment porewater (mg/L)																											
SLEKC01	-	-	450	480	506	418	312	570	286	-	-	-	-	0.19	4.56	0.25	<0.05	0.22	-	-	-	-	<0.10	<0.01	<0.01	<0.01	<0.01
SLEKC02	-	-	420	360	502	421	295	523	372	-	-	-	-	0.37	<0.05	0.31	<0.1	<0.1	-	-	-	-	<0.10	<0.01	<0.01	0.02	<0.01
SLEKC03	-	-	350-490	310-370	450-544	330-465	401-511	256-323	325-413	-	-	-	-	<0.10-0.16	<0.05-<0.10	<0.05-0.22	<0.1-<0.1	<0.1-<0.1	-	-	-	-	<0.10-<0.10	<0.01-<0.01	<0.01-<0.01	<0.01-<0.01	<0.01-<0.01
SPASC01	-	-	400	490	497	472	461	530	507	-	-	-	-	0.06	<0.10	0.22	0.25	0.12	-	-	-	-	<0.10	<0.01	<0.01	<0.01	<0.01
SPASC02	-	-	360	440	467	488	420	458	533	-	-	-	-	0.34	<0.10	0.20	0.21	<0.1	-	-	-	-	<0.10	<0.01	<0.01	<0.01	<0.01
SPASC03	-	-	330	420	530	426	424	515	442	-	-	-	-	0.12	0.12	0.33	0.26	<0.1	-	-	-	-	<0.10	<0.01	<0.01	<0.01	<0.01
SPASC04	-	-	360-390	420-440	449-505	406-462	91-307	440	408-444	-	-	-	-	0.14-0.16	<0.10-0.20	0.20-0.31	0	<0.1-0.14	-	-	-	-	<0.10-<0.10	<0.01-<0.01	<0.01-<0.01	<0.01	<0.01-<0.01
Nutrients at "Control Sites" have not previously been included in the Ludmilla Sediment Monitoring Program so no data prior to 2014; Red bold text indicates data values that were > 2 x reference site 80th percentiles in that season. a Method change from 2015 dry season - former method uses K2SO4 and H2SO4 with a colorimetric finish and the latter method uses a HCl/HNO3 digestion with a ICP-OES finish; b Laboratory change in this year - digestion and finish similar to 2014 method (K2SO4 and H2SO4 with spectrophotometer). Ranges (minimum - maximum) indicate site has been sampled in triplicate. (*) Sample did not have porewater to be extracted. Site SLULC02 was included in 2018 with the new WDL 150-06																											
CALCULATIONS OF: 2 x Reference site 80th Percentile																											
SLEKC01			450	480	506	418	312	570	286	-	-	-	-	0.19	4.56	<0.25	<0.05	0.22	-	-	-	-	<0.1	<0.01	<0.01	<0.01	<0.01
SLEKC02			420	360	502	421	295	523	372	-	-	-	-	0.37	<0.05	<0.31	<0.1	<0.1	-	-	-	-	<0.1	<0.01	<0.01	<0.02	<0.01
SLEKC03			490	370	544	465	511	323	413	-	-	-	-	0.16	<0.1	<0.22	<0.1	<0.1	-	-	-	-	<0.1	<0.01	<0.01	<0.01	<0.01
SPASC01			400	490	497	472	461	530	507	-	-	-	-	0.06	<0.1	<0.22	<0.25	0.12	-	-	-	-	<0.1	<0.01	<0.01	<0.01	<0.01
SPASC02			360	440	467	488	420	458	533	-	-	-	-	0.34	<0.1	<0.2	<0.21	<0.1	-	-	-	-	<0.1	<0.01	<0.01	<0.01	<0.01
SPASC03			330	420	530	426	424	515	442	-	-	-	-	0.12	0.12	<0.33	<0.26	<0.1	-	-	-	-	<0.1	<0.01	<0.01	<0.01	<0.01
SPASC04			390	440	505	462	307	440	444	-	-	-	-	0.16	0.20	<0.31	<0.24	0.14	-	-	-	-	<0.1	<0.01	<0.01	<0.01	<0.01

Table 20: Ammonia in Pore water 2015 to 2021

AMMONIA IN POREWATER	NH ₃ -N (mg/L)								
	Ammonia as N								
	Ammonia as N by Discrete Analyser								
	0.01 mg/L								
	± 0.2 mg/L								
Dry Season	2013	2014	2015	2016	2017	2018	2019	2020	2021
ANZECC & ARMCANZ, ANZG pH Adjusted TVs ^a East Point and Ludmilla Creek	-	-	0.91-2.84 ^b	0.75-2.49 ^b	0.91-4.83 ^b	0.75-4.83 ^b	0.91-3.56 ^b	0.91-3.91 ^b	0.91-4.24 ^b
> 2 x Reference site 80th Percentile	-	-	19.28	8.72	5.44	9.84	1.24	2.86	4.19
East Point Outfall site 01 and Ludmilla Creek site 03 is downstream from flow over weir - Total concentration in sediment porewater (mg/L)									
Impact Zone-SLUEP01	-	-	4.50-7.30	0.31-10.00	5.51-7.83	3.87-4.99	4.85	8.16	3.79
Impact Zone-SLULC03	-	-	2.80-9.10	5.70-8.00	1.74-3.92	1.56-3.25	4.53-6.42	3.52	2.36-2.79
East Point site 02 is located Zone 1 and sites 03/04 are located Zone 2, both control sites considered outside impact zone. Ludmilla Creek sites 01/02/04 are considered outside impact zone									
SLULC01	-	-	2.50-4.70	5.9-8.0	1.38	2.50	4.16	3.68	2.70
SLULC02	-	-	-	-	-	-	3.68	3.55	0.96
SLULC04	-	-	3.60	5.40	0.70-1.91	1.99-3.16	3.13-4.03	1.36	1.82-2.26
SLUEP02	-	-	7.30-8.70	9.70-18.00	4.00-8.39	*	3.91-5.67	5.43	1.85-4.03
SLUEP03	-	-	3.40-5.90	6.90-11.00	4.36	*	2.90-3.18	4.58	1.18-1.55
SLUEP04	-	-	2.90	6.70	3.61-4.65	3.80	6.23-8.30	1.85	0.68-1.68
Dry Season	2013	2014	2015	2016	2017	2018	2019	2020	2021
ANZECC & ARMCANZ, ANZG pH Adjusted TVs ^a Short Creek and Kings Creek	-	-	0.75-3.56 ^b	1.10-3.20 ^b	3.56-5.29 ^b	3.56-3.91 ^b	2.15-3.91 ^b	1.32-4.24 ^b	0.61-3.91 ^b
Short Creek and Kings Creek reference sites where site 01 is most upper estuary in series - Total concentration in sediment porewater (mg/L)									
SLEKC01	-	-	8.20	3.40	3.80	3.87	0.65	1.44	2.42
SLEKC02	-	-	0.73	0.55	1.14	0.68	0.10	1.10	0.94
SLEKC03	-	-	0.88-10.00	1.40-6.90	1.72-2.57	0.59-1.71	0.63-1.12	0.71-1	0.59-0.97
SPASC01	-	-	2.00	1.50	0.94	5.01	0.40	1.32	1.04
SPASC02	-	-	12.00	1.70	2.36	4.56	0.38	0.92	0.96
SPASC03	-	-	2.40	2.40	2.76	2.77	0.45	2.06	2.00
SPASC04	-	-	1.70-6.90	3.40-4.60	2.10-2.41	5.07-5.62	0.35-0.50	1.39	1.74-2.12
Nutrients at "Control Sites" have not previously been included in the Ludmilla Sediment Monitoring Program so no data prior to 2014; ^a Ammonia toxicant guidelines pH adjusted based on porewater pH as per Table 8.3.7 of ANZECC and ARMCANZ (2000); ^b Field pH of composite sample used as it is more correct, in previous years laboratory pH of composite sample had been applied to determine trigger value; Orange shading indicates exceedance of ANZECC SMD guidelines; Green shading indicates no exceedance of ANZECC SMD guideline; Red bold text indicates data values that were > 2 x reference site 80th percentiles in that season; reference site trigger values based on <LOR values are italicised. Ranges (minimum - maximum) indicate site has been sampled in triplicate. (*) Sample did not have porewater to be extracted. Site SLULC02 was included in 2018 with the new WDL 150-06									
CALCULATIONS OF: 2 x Reference site 80th Percentile									
SLEKC01	-	-	8.20	3.40	3.80	3.87	0.65	1.44	2.42
SLEKC02	-	-	0.73	0.55	1.14	0.68	0.10	1.10	0.94
SLEKC03	-	-	10.00	6.90	2.57	1.71	1.12	1.00	0.97
SPASC01	-	-	2.00	1.50	0.94	5.01	0.40	1.32	1.04
SPASC02	-	-	12.00	1.70	2.36	4.56	0.38	0.92	0.96
SPASC03	-	-	2.40	2.40	2.76	2.77	0.45	2.06	2.00
SPASC04	-	-	6.90	4.60	2.41	5.62	0.50	1.39	2.12

Table 21: Total Metals in Sediment Results for Aluminium; Copper and Zinc 2013 to 2021

Metals - Total IN SEDIMENT	Aluminium									Copper									Zinc								
Analysis type	Aluminium									Copper									Zinc								
Analytical method	Total Metals in Sediments by ICP-AES									Total Metals in Sediments by ICPMS									Total Metals in Sediments by ICPMS								
LOR or Level of Precision	50 mg/kg									1 mg/kg									1 mg/kg								
Measures of uncertainty	± 200 mg/kg									± 0.2 mg/kg									±0.5 mg/kg								
Symbol	Al									Cu									Zn								
Dry Season	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021
AZECC & ARMCANZ (2000) ISQG Low Trigger Value	-									65									200								
AZECC & ARMCANZ (2000) ISQG HighTrigger Value										270									410								
2 x Reference site 80th Percentile	-									-	-	15.5	17.7	15.0	15.0	14.6	17.8	18.0	-	-	26.0	52.0	47.4	53.7	57.8	67.1	60.2
Total concencration in sediment (mg/kg)																											
East Point site 01 is the Outfall and Ludmilla Creek site 03 is downstream from flow over weir																											
Impact Zone-SLUEP01	-	2,700-3,600	990-1,800	1,600-2,300	2,880-3,070	2,830-3,410	2,890	1960-2100	2,190	0.2	<5-<5	<5-<5	<5-<5	1.2-1.3	<1.0-<1.0	1.4	<1-<1	1.6	0.2	<5-<5	8.8-9.1	<5-<5	6.9-7.3	7.3-8.0	5.3	6.1-6.7	7.9
Impact Zone-SLULC03	-	22,000-24,0000	18,000-32,000	14,000-16,000	11,800-12,300	7,790-8230	0,100-12,200	11900-14300	11600-12000	0.3	<5-<5	6.8-7.2	9.7-11	9.1-10.4	8.5-9.8	8.9-10.0	7.4-8.6	7.6-7.9	8.2	8.1-12.0	17-19	17-19	36.4-42.4	33.2-36.8	27.9-32.5	31.3-35.6	29.9-32.8
East Point site 02 is located Zone 1 and sites 03/04 are located Zone 2, both control sites considered outside impact zone. Ludmilla Creek sites 01/02/04 are considered outside impact zone																											
SLULC01	-	-	11,000-15,000	18,000-18,000	14,200	6,190	5,900	7,380	7,940	-	-	<5-<5	9.0-11	12.6	10.4	5.9	2.4	6.4	-	-	12-16.	26-33	63.0	30.5	13.7	14.0	29.5
SLULC02	-	-	-	-	-	-	630	4,700	14,000	-	-	-	-	-	-	1.1	1.9	7.0	-	-	-	-	-	-	2.3	11.5	30.6
SLULC04	-	-	8,000	3,400	7,610-8,210	4,740-6,350	6,600-7,530	8790-9990	7240-8360	-	-	<5	<5	4.7-6.1	2.7-5.0	4.4-5.4	5.2-5.6	3.8-5.1	-	-	<5	<5	17.4-19.7	12.4-17.4	12.5-13.8	18.8-19.8	14.8-18.7
SLUEP02	-	-	1,700-2,300	2,000-20,000	2,570-2,980	2,780-3,560	730-2,840	2020-2200	1960-2140	-	-	<5-<5	<5-7.9	<1.0-<1.0	<1.0-1.0	<1.0-1.3	<1-<1	<1-<1	-	-	9.4-13.0	<5-34	4.7-5.9	6.3-7.8	2.6-4.9	5.9-6.8	5.7-6.8
SLUEP03	-	-	2,000-2,500	420-21,000	3,020	3,300	820-2,780	1870-2090	1800-2260	-	-	<5-<5	<5-<5	<1.0	<1.0	<1.0-1.1	<1-<1	<1-<1	-	-	8.5-13.0	<5-<5	5.6	6.8	3.0-5.0	5.9-6.2	4.7-5.7
SLUEP04	-	-	1,700	2,200	2,520-3,220	3,690-4,240	840-2,600	2,300	2280-2550	-	-	<5	<5	<1.0-<1.0	<1.0-1.0	<1.0-1.1	1.0	1.1-1.3	-	-	9.1	<5	3.0-4.9	6.0-6.3	2.3-3.2	5.4	6.4-6.8
Short Creek and Kings Creek reference sites where site 01 is most upper estuary in series																											
SLEKC01	-	-	20,000	16,000	8,010	7,780	8,660	7,000	11,000	-	-	<5	<5	3.5	3.1	3.0	2.1	2.4	-	-	8.4	6.6	18.9	17.4	13.8	12.2	14.3
SLEKC02	-	-	4,000	12,000	5,640	7,660	12,100	5,560	15,600	-	-	<5	<5-<5	2.1	3.0	4.1	1.9	3.1	-	-	<5	<5	13.7	10.6	18.1	10.9	17.5
SLEKC03	-	-	15,000-16,000	11,000-21,000	7,710-8,010	5,100-8,210	0,300-14,300	9740-10700	13300-22100	-	-	<5-<5	<5-<5	3.3-3.6	1.8-3.6	3.4-4.8	2.9-3.2	3-5.3	-	-	6.4-7.6	<5-10	17.4-19.0	12.8-17.8	14.6-19.0	14.1-16	17-27
SPASC01	-	-	14,000	18,000	10,000	9,330	10,200	16,500	14,600	-	-	7.2	8.1	7.6	8.0	7.7	9.0	9.5	-	-	13.0	27.0	26.0	27.5	34.3	33.0	30.5
SPASC02	-	-	11,000	17,000	9,630	9,850	8,920	16,100	15,700	-	-	7.8	9.0	7.0	7.6	6.8	8.4	9.2	-	-	12.0	26.0	23.2	25.8	28.2	33.7	32.9
SPASC03	-	-	10,000	17,000	9,060	11,000	9,490	12,400	12,800	-	-	7.5	8.6	7.7	7.0	7.4	7.9	8.2	-	-	14.0	26.0	23.8	27.1	29.1	27.1	27.3
SPASC04	-	-	13,000-14,000	14,000-16,000	7,080-8,880	8,170-8,910	7,630-8,600	12800-13200	10000-13200	-	-	7.1-7.8	8.5-8.9	5.1-7.0	6.9-7.1	5.4-6.5	6.3-73.1	7.1-8.0	-	-	12-13.	25-26	16.2-22.4	23.9-24.8	22.1-27.6	25.5-71	27.2-28.4

Table 22: Calculation of normalised Total Metals in Sediment & 2x 80th percentile of reference site 2013 to 2021

Al ³ normalised total concentration in sediment (dimensionless) - x 10, 000 mg/kg																											
Alternative assessment										Significant difference to reference creek (P< 0.05) - unpaired t-test?																	
	-	-	-	-	-	-	-	-	-	-	-	Yes, P=0.004	Yes, P=0.01	No, P=0.5	No, P=0.8	Yes, P=0.05	No, P=0.32	No, P=0.15	-	-	Yes, P=0.02	Yes, P=0.02	No, P = 0.9	No, P = 0.3	No, P = 0.9	No, P=0.2	Yes, P=0.00
Symbol	-	-	-	-	-	-	-	-	-	Cu:Al									Zn:Al								
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021
2 x Reference site 80th Percentile	-									-	-	14.8	10.5	16.6	15.8	15.2	12.4	13.0	-	-	24.4	30.6	51.7	55.0	64.5	43.2	42.5
East Point Outfall site 01 and Ludmilla Creek site 03 is downstream from flow over weir																											
Impact Zone-SLUEP01	-	-	-	-	-	-	-	-	-	-	13.9-18.5	27.8-50.5	21.7-26.3	4.1-4.2	2.9-3.5	4.8	4.7-5.3	7.3	-	13.9-18.2	50.0-88.9	21.7-31.3	23.8-25.0	22.3-25.8	18.3	29.0-35	36.1
Impact Zone-SLULC03	-	-	-	-	-	-	-	-	-	-	2.1-2.3	2.3-3.9	6.7-6.9	7.7-8.5	11.1-12.2	8.2-8.8	6.2-7.22	6.3-6.7	-	3.4-5.5	5.9-9.4	11.3-12.1	30.8-34.5	43.4-46.5	26.6-27.6	21.88-29.66	25.1-27.6
East Point site 02 is located Zone 1 and sites 03/04 are located Zone 2, both control sites considered outside impact zone. Ludmilla Creek sites 01/02/04 are considered outside impact zone																											
SLULC01	-	-	-	-	-	-	-	-	-	-	-	3.3-4.5	5.0-6.1	8.9	16.8	10.0	3.2	8.1	-	-	10.0-10.7	14.4-17.2	44.4	49.3	23.2	18.9	37.2
SLULC02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.5	0.4	5.0	-	-	-	-	-	-	36.5	24.5	21.9
SLULC04	-	-	-	-	-	-	-	-	-	-	-	6.3	14.7	5.9-7.4	5.7-7.9	6.7-7.2	5.2-6.36	5.2-6.6	-	-	6.3	14.7	21.9-25.6	26.2-27.4	18.3-19.8	18.8-22.5	25.1-27.6
SLUEP02	-	-	-	-	-	-	-	-	-	-	-	21.7-29.4	4.0-25.0	3.4-3.9	2.8-3.6	3.5-13.7	4.5-4.5	4.7-5.1	-	-	45.5-56.5	11.6-25.0	18.3-19.8	21.7-22.7	15.2-35.6	29.5-34	29.1-32.1
SLUEP03	-	-	-	-	-	-	-	-	-	-	-	20.0-25.0	2.4-119.0	3.3	3.0	3.6-13.4	5-5.5	4.4-5.6	-	-	42.5-52.0	2.4-119.0	18.5	20.6	18.0-40.2	29.5-33.15	25.2-29
SLUEP04	-	-	-	-	-	-	-	-	-	-	-	29.4	22.7	3.1-4.0	2.5-2.7	4.2-12.5	4.3	4.8-5.2	-	-	53.5	22.7	11.9-15.2	14.9-16.8	12.3-29.5	23.5	26.7-28.5
Short Creek and Kings Creek reference sites where site 01 is most upper estuary in series																											
SLEK01	-	-	-	-	-	-	-	-	-	-	-	2.5	3.1	4.4	4.0	3.5	3.0	2.2	-	-	4.2	4.1	23.6	22.4	15.9	17.4	13.0
SLEK02	-	-	-	-	-	-	-	-	-	-	-	12.5	4.2	3.7	3.9	3.4	3.4	2.0	-	-	12.5	4.2	24.3	13.8	15.0	19.6	11.2
SLEK03	-	-	-	-	-	-	-	-	-	-	-	3.1-3.3	2.4-4.5	4.2-4.7	3.5-4.4	3.3-3.4	2.7-3.3	2.2-2.4	-	-	4.3-4.8	4.0-4.8	22.6-23.7	21.1-25.1	13.3-16.4	14.5-16	12.2-12.8
SPASC01	-	-	-	-	-	-	-	-	-	-	-	5.1	4.5	7.6	8.6	7.5	5.5	6.5	-	-	9.3	15.0	26.0	29.5	33.6	20.0	20.9
SPASC02	-	-	-	-	-	-	-	-	-	-	-	7.1	5.3	7.3	7.7	7.6	5.2	5.9	-	-	10.9	15.3	24.1	26.2	31.6	20.5	21.0
SPASC03	-	-	-	-	-	-	-	-	-	-	-	7.5	5.1	8.5	6.4	7.8	6.4	6.4	-	-	14.0	15.3	26.3	24.6	30.7	21.9	21.3
SPASC04	-	-	-	-	-	-	-	-	-	-	-	5.1-5.7	5.3-6.3	6.9-9.6	8.0-8.6	6.3-7.6	4.8-57.1	6.2-7.1	-	-	8.6-10.0	15.6-17.9	22.0-30.9	27.6-29.3	29.0-32.4	19.32-55.5	21.5-27.2
Metals at "Control Sites" have not previously been included in the Ludmilla Sediment Monitoring Program so no data prior to 2014;																											
Data values with red text indicates > 2 x Reference site 80th percentile in that season;																											
Orange cell shading indicates data value exceeds ANZECC & ARMCANZ (2000) ISQG Low trigger value;																											
Green shading indicates data complies with ANZECC ISQG Low;																											
Ranges (minimum - maximum) indicate site has been sampled in triplicate.																											

CALCULATIONS OF: 2 x Reference site 80th Percentile																													
SLEKC01	-	-	20,000	16,000	8010	7,780	8,660	7,000	10,000	-	-	<5	<5	3.5	3.1	3.0	2.1	2.4	-	-	8.4	6.6	18.9	17.4	13.8	12.2	14.3		
SLEKC02	-	-	4,000	12,000	5640	7,660	12,100	5,560	15,600	-	-	<5	<5	2.1	3.0	4.1	1.9	3.1	-	-	<5	<5	13.7	10.6	18.1	10.9	17.5		
SLEKC03	-	-	16,000	21,000	8,010	8,210	14,300	10,700	22,100	-	-	<5	<5	3.6	3.6	4.8	3.2	5.3	-	-	7.6	10.0	19.0	17.8	19.0	16.0	27.0		
SPASC01	-	-	14,000	18,000	10000	9,330	10,200	16,500	14,600	-	-	7.2	8.1	7.6	8.0	7.7	9.0	9.5	-	-	13.0	27.0	26.0	27.5	34.3	33.0	30.5		
SPASC02	-	-	11,000	17,000	9630	9,850	8,920	16,100	15,700	-	-	7.8	9.0	7.0	7.6	6.8	8.4	9.2	-	-	12.0	26.0	23.2	25.8	28.2	33.7	32.9		
SPASC03	-	-	10,000	17,000	9060	11,000	9,490	12,400	12,800	-	-	7.5	8.6	7.7	7.0	7.4	7.9	8.2	-	-	14.0	26.0	23.8	27.1	29.1	27.1	27.3		
SPASC04	-	-	14,000	16,000	8,880	8,910	8,600	13,200	13,200	-	-	7.8	8.9	7.0	7.1	6.5	73.1	8.0	-	-	13.0	26.0	22.4	24.8	27.6	71.0	28.4		
SLEKC01	-	-	-	-	-	-	-	-	-	-	-	2.5	3.1	4.4	4.0	3.5	3.0	2.2	-	-	4.2	4.1	23.6	22.4	15.9	17.4	13.0		
SLEKC02	-	-	-	-	-	-	-	-	-	-	-	12.5	4.2	3.7	3.9	3.4	3.4	2.0	-	-	12.5	4.2	24.3	13.8	15.0	19.6	11.2		
SLEKC03	-	-	-	-	-	-	-	-	-	-	-	3.1	2.4	4.5	4.4	3.4	3.3	2.4	-	-	4.8	4.8	23.7	21.7	16.4	16.0	12.8		
SPASC01	-	-	-	-	-	-	-	-	-	-	-	5.1	4.5	7.6	8.6	7.5	5.5	6.5	-	-	9.3	15.0	26.0	29.5	33.6	20.0	20.9		
SPASC02	-	-	-	-	-	-	-	-	-	-	-	7.1	5.3	7.3	7.7	7.6	5.2	5.9	-	-	10.9	15.3	24.1	26.2	31.6	20.5	21.0		
SPASC03	-	-	-	-	-	-	-	-	-	-	-	7.5	5.1	8.5	6.4	7.8	6.4	6.4	-	-	14.0	15.3	26.3	24.6	30.7	21.9	21.3		
SPASC04	-	-	-	-	-	-	-	-	-	-	-	5.6	5.6	9.6	8.0	7.6	57.1	7.1	-	-	9.3	16.3	25.2	27.8	32.4	55.5	27.2		
												Significant difference to reference creek (P< 0.05) - unpaired t-test?																	
										SLULC01		3.816739	5.500000	8.9	16.8	10.0	3.2	8.1			10.525253	16.666667	44.4	49.3	23.2	18.9	37.2		
										SLULC02						17.5	0.4	5.0						36.5	24.5	21.9			
										SLULC03		3.305556	6.823413	8.198967	11.737963	8.481128	6.710000	6.565000			8.275463	11.783730	33.012670	44.860995	27.073209	25.770000	26.441000		
										SLULC04		6.3	14.7	6.905187	6.530705	7.000872	5.780000	5.991000			6.3	14.7	23.853766	26.856404	19.027720	20.650000	22.236000		
										SLUEP01		36.510943	23.804264	4.170261	3.190570	4.8	5.0	7.3			65.254630	23.804264	24.245612	24.309055	18.3	32.0	36.1		
										SLUEP02		24.626056	18.025062	3.614626	3.196941	7.426041	4.770000	4.831000			52.423467	20.200062	18.930544	22.076011	22.681686	31.750000	30.666000		
										SLUEP03		21.944444	36.757456	3.3	3.0	9.638839	5.250000	5.054000			48.166667	36.757456	18.5	20.6	31.314600	31.325000	26.783000		
										SLUEP04		29.4	22.7	3.615810	2.516636	9.545177	4.300000	5.054000			53.5	22.7	13.694606	15.516332	23.078033	23.500000	27.948000		
										SLEKC01		2.5	3.1	4.4	4.0	3.5	3.0	2.2			4.2	4.1	23.6	22.4	15.9	17.4	13.0		
										SLEKC02		12.5	4.2	3.7	3.9	3.4	3.4	2.0			12.5	4.2	24.3	13.8	15.0	19.6	11.2		
										SLEKC03		3.263889	3.590854	4.363723	3.902645	3.360346	3.000000	2.297000			4.450000	4.435786	23.151000	22.623827	14.619289	15.250000	12.566000		
										SPASC01		5.1	4.5	7.6	8.6	7.5	5.5	6.5			9.3	15.0	26.0	29.5	33.6	20.0	20.9		
										SPASC02		7.1	5.3	7.3	7.7	7.6	5.2	5.9			10.9	15.3	24.1	26.2	31.6	20.5	21.0		
										SPASC03		7.5	5.1	8.5	6.4	7.8	6.4	6.4			14.0	15.3	26.3	24.6	30.7	21.9	21.3		
										SPASC04		5.397436	5.720238	8.138917	8.202227	7.119750	30.950000	6.736000			9.047619	16.577381	26.056099	28.622881	30.479094	37.410000	24.054000		
												0.04	0.01	0.5	0.8	0.05	0.32	0.15			0.02	0.02	0.9	0.3	0.9	0.2	0.0		

Table 23: Bioavailable metals; Copper and Zinc in Sediment 2013 to 2021

Metals - Bioavailable IN SEDIMENT	Copper										Zinc									
Analysis type	Copper										Zinc									
Analytical method	HCl-Extractable Metals by ICPAES										HCl-Extractable Metals by ICPAES									
LOR or Level of Precision	1 mg/kg										1 mg/kg									
Measures of uncertainty	± 0.2 mg/kg										± 0.5 mg/kg									
Symbol	Cu										Zn									
Dry Season	2013	2014	2015	2016	2017	2018	2019	2020	2021		2013	2014	2015	2016	2017	2018	2019	2020	2021	
AZECC & ARMCANZ (2000)	65										200									
ISQG Low Trigger Value																				
AZECC & ARMCANZ (2000)	270										410									
ISQG High Trigger Value																				
2 x Reference site 80th Percentile	-	-	10.0	10.0	7.4	8.2	8.2	7.9	7.4		-	-	11.7	19.8	31.8	46.4	27.5	22.2	27.5	
Bioavailable concentration in sediment (mg/kg)																				
East Point Outfall site 01 and Ludmilla Creek site 03 is downstream from flow over weir																				
Impact Zone-SLUEP01	<5-<5	<5-<5	<5-<5	<5-<5	<1.0-<1.0	<1.0-<1.0	<1.0	<1-<1	<1	<5-<5	<5-<5	<5-<5	<5-<5	3.7-4.0	3.9-4.6	3.5	<1-<1	3.1		
Impact Zone-SLULC03	<5-<5	<5-<5	<5-<5	<5-<5	5.7-7.6	4.7-6.8	3.5-12.7	4.6-6.3	4.2-4.9	<5-<5	<5-<5	5.6-6.7	<5-12	23.5-28.5	24.2-17.6	29.5-36.7	13.6-20.5	14.5-17.2		
East Point site 02 is located Zone 1 and sites 03/04 are located Zone 2, both control sites considered outside impact zone. Ludmilla Creek sites 01/02/04 are considered outside																				
SLULC01	-	-	<5-<5	<5-<5	4.30	1.10	1.40	<1	<1	-	-	10-24	13-19	30.6	19.3	23.0	6.1	20.5		
SLULC02	-	-	-	-	-	-	1.70	<1	2.00	-	-	-	-	-	-	9.5	6.6	16.6		
SLULC04	-	-	<5	<5	2.6-3.4	2.0-3.5	3.0-5.7	2.8-3.9	2-3.3	-	-	<5	<5	7.6-11.0	7.8-12.4	12.8-13.7	7.6-9.2	7.4-9		
SLUEP02	-	-	<5-<5	<5-<5	<1.0-<1.0	<1.0-<1.0	<1.0-<1.0	<1-<1	<1-<1	-	-	<5-<5	<5-28	2.7-3.0	3.4-4.6	3.2-4.1	<1-<1	2.3-3		
SLUEP03	-	-	<5-<5	<5-<5	<1.0	<1.0	<1.0-<1.0	<1-<1	<1-<1	-	-	<5-<5	<5-<5	2.6	4.6	3.3-4.6	<1-<1	2.3-2.4		
SLUEP04	-	-	<5	<5	<1.0-<1.0	<1.0-<1.0	<1.0-<1.0	<1	<1-<1	-	-	<5	<5	<1.0-1.4	2.1-2.4	<1.0-<1.0	<1	2-2.7		
Short Creek and Kings Creek reference sites where site 01 is most upper estuary in series																				
SLEKC01	-	-	<5	<5	1.7	1.2	<1.0	1.5	1.4	-	-	<5	<5	7.3	7.6	4.5	4.7	4.0		
SLEKC02	-	-	<5	<5	1.0	<1.0	2.0	<1	1.3	-	-	<5	<5	4.5	3.5	3.9	2.9	2.6		
SLEKC03	-	-	<5-<5	<5-<5	<1.0-1.6	<1.0-<1.0	<1.0-1.0	<1-<1	<1-1.2	-	-	<5-<5	<5-<5	5.8-6.3	4.1-6.7	5.2-6.1	2.7-3.6	2.6-4.3		
SPASC01	-	-	<5	<5	4.8	4.2	4.4	3.9	3.9	-	-	6.0	10.0	16.3	20.9	14.7	10.9	10.9		
SPASC02	-	-	<5	<5	3.0	4.2	4.0	4.2	3.9	-	-	<5	9.8	15.8	23.6	12.4	11.8	13.8		
SPASC03	-	-	<5	<5	3.7	2.0	4.0	3.5	3.0	-	-	5.7	9.9	15.9	24.7	13.1	11.0	13.6		
SPASC04	-	-	<5-<5	<5-<5	3.2-3.7	3.2-3.8	2.2-4.1	1.9-3.2	2.2-3.0	-	-	5.7-5.9	11-11	13.8-14.2	21.1-21.7	10.8-13.9	8.7-11.1	12.3-13.9		
CALCULATIONS OF: 2 x Reference site 80th Percentile																				
SLEKC01	-	-	<5	<5	1.7	1.2	<1	<2	<1	-	-	<5	<5	7.3	7.6	4.5	4.7	4		
SLEKC02	-	-	<5	<5	1.0	<1	2.0	<1	1.3	-	-	<5	<5	4.5	3.5	3.9	2.9	2.6		
SLEKC03	-	-	<5	<5	1.6	<1	1.0	<1	1.2	-	-	<5	<5	6.3	6.7	6.1	3.6	4.3		
SPASC01	-	-	<5	<5	4.8	4.2	4.4	3.9	3.9	-	-	6.0	10.0	16.3	20.9	14.7	10.9	10.9		
SPASC02	-	-	<5	<5	3.0	4.2	4.0	4.2	3.9	-	-	<5	9.8	15.8	23.6	12.4	11.8	13.8		
SPASC03	-	-	<5	<5	3.7	2.0	4.0	3.5	3.0	-	-	5.7	9.9	15.9	24.7	13.1	11	13.6		
SPASC04	-	-	<5	<5	3.7	3.8	4.1	3.2	3.0	-	-	5.9	11-11	14.2	21.7	13.9	11.1	13.9		

Table 24: Dissolved Metals (Copper and Zinc) in Pore water 2013 to 2021

Metals (Dissolved) IN PORE WATER	Cu-F (µg/L)										Zn-F (µg/L)									
Analysis type Analytical method LOR or Level of Precision Measures of uncertainty	Copper Dissolved Metals in Saline Water by ORC-ICPMS 1 µg/L ± 1 µg/L										Zinc Dissolved Metals in Saline Water by ORC-ICPMS 5 µg/L ± 1 µg/L									
Dry Season	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021		
ANZECC & ARMICANZ (2000) SMD Trigger	1.3										15.0									
ANZECC & ARMICANZ (2000) ZOI Trigger	3.0										15.0									
2 x Reference site 80th Percentile	-	-	2.0	2.0	2.0	5.6	2.0	3.2	2.0	-	-	10.0	10.0	10.0	10.0	10.0	10.0	10.0		
East Point Outfall site 01 and Ludmilla Creek site 03 is downstream from flow over weir - Concentration in porewaters (µg/L)																				
Impact Zone-SLUEP01	-	-	2.0-2.0	2.0-2.0	<1-2	<1-<1	<1	<1	<1	-	-	<1-4.0	<5-<5	<5-<5	<5-<5	<5	<5	<5		
Impact Zone-SLULC03	-	-	<1-2.0	1.0-2.0	<1-<1	<1-<1	<1-<1	<2	<1-<1	-	-	<1-<1	<5-<5	<5-<5	<5-<5	<5-<5	<30	<5-<5		
East Point site 02 is located Zone 1 and sites 03/04 are located Zone 2, both control sites considered outside impact zone. Ludmilla Creek sites																				
SLULC01	-	-	<1-1	2.0-2.0	<1	<1	<1	<1	<1	-	-	<1-<1	<5	<5	<5	<5	<8	<5		
SLULC02	-	-	-	-	-	-	1.0	1.0	<1	-	-	-	-	-	-	<5	<5	<5		
SLULC04	-	-	<1	1.0	<1-<1	<1-<1	<1-<1	<2	<1-<1	-	-	<1	<5	<5-<5	<5-<5	<5-<5	<5	<5-<5		
SLUEP02	-	-	<1-2.0	<1-2.0	<1-5.0	*	<1-<1	<1	<1-<1	-	-	<1-<1	<5-<5	<5-<5	*	<5-<5	<5	<5-<5		
SLUEP03	-	-	2.0-4.0	<1-2.0	2.0	*	<1-<1	<1	<1-<1	-	-	<1-<1	<5-<5	<5	*	<5-<5	<5	<5-<5		
SLUEP04	-	-	<1	1.0	<1-1	1.0	2.0-3.0	<1	<1-<1	-	-	<1	8.0	<5-<5	<5	<5-<5	<5	<5-<5		
Short Creek and Kings Creek reference sites where site 01 is most upper estuary in series - Concentration in porewaters (µg/L) for reference sites																				
SLEKC01	-	-	<1	<1	<1	<1	<1	<1	<1	-	-	<5	<5	<5	<5	<5	<5	<5		
SLEKC02	-	-	<1-<1	<1	<1	3.0	<1	<1	<1	-	-	<5	<5	<5	<5	<5	<5	<5		
SLEKC03	-	-	<1-<1	<1-<1	<1-<1	<1-<1	<1-<1	<2	<1-<1	-	-	<5-<5	<5-<5	<5-<5	<5-6.0	<5-<5	<5-<5	<5-<5		
SPASC01	-	-	<1	<1	<1	2.0	<1	<1	<1	-	-	<1	<1	<5	<5	<5	<5	<5		
SPASC02	-	-	<1	<1	<1	<1	<1	<1	<1	-	-	<1	<1	<5	<5	<5	<5	<5		
SPASC03	-	-	<1	<1	<1	<1	<1	<1	<1	-	-	<1	<1	<5	<5	<5	<5	<5		
SPASC04	-	-	<1-1.0	<1-<1	<1-<1	<1-3.0	<1-<1	<1-<1	<1-<1	-	-	<1-<1	<1-<1	<5-<5	<5-<5	<5-<5	<5-<5	<5-<5		
Metals in porewaters have not previously been included in the Ludmilla Sediment Monitoring Program so no data prior to 2014; Green shading indicates compliance with ANZECC and ARMICANZ (2000) SMD guideline trigger values; Orange shading indicates exceedance of ANZECC and ARMICANZ (2000) SMD guidelines. Red bold text indicates exceedance of 2 x reference site 80th percentile in that season Ranges (minimum - maximum) indicate site has been sampled in triplicate.																				
CALCULATIONS OF: 2 x Reference site 80th Percentile																				
SLEKC01	-	-	<1	<1	<1	<1	<1	<1	<1	-	-	<5	<5	<5	<5	<5	<5	<5		
SLEKC02	-	-	<1	<1	<1	3.0	<1	<1	<1	-	-	<5	<5	<5	<5	<5	<5	<5		
SLEKC03	-	-	<1	<1	<1	<1	<1	<2	<1	-	-	<5	<5	<5	6.0	<5	<5	<5		
SPASC01	-	-	<1	<1	<1	2.0	<1	<1	<1	-	-	<1	<1	<5	<5	<5	<5	<5		
SPASC02	-	-	<1	<1	<1	<1	<1	<1	<1	-	-	<1	<1	<5	<5	<5	<5	<5		
SPASC03	-	-	<1	<1	<1	<1	<1	<1	<1	-	-	<1	<1	<5	<5	<5	<5	<5		
SPASC04	-	-	1.0	<1	<1	3.0	<1	<1-<1	<1	-	-	<1	<1	<5	<5	<5	<5	<5		

Appendix 4: REPORTING LIMIT EXCEEDANCES

Table 25: Reporting Limit exceedances for Darwin Harbour and Ludmilla Creek surface waters, the receiving waters for the Ludmilla WwTP discharge from 1 June 2019 to 31 July 2020

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
pH Individual Result	SLULC01	SMD	22/10/20	Individual result	6.79	<7.00 pH >8.50	Ludmilla Creek upstream site: Not a reportable exceedance as no discharge to Ludmilla Creek in the previous 10 days; catchment cause.
	SLULC01	SMD	09/11/20	Individual result	6.41	<7.00 pH >8.50	Ludmilla Creek upstream site: Not a reportable exceedance as no discharge to Ludmilla Creek in the previous 10 days; catchment cause.
	SLULC01	SMD	22/02/21	Individual result	6.86	<7.00 pH >8.50	Ludmilla Creek upstream site: Not a reportable exceedance as no discharge to Ludmilla Creek in the previous 10 days; catchment cause.
	SLULC01	SMD	17/03/21	Individual result	6.8	<7.00 pH >8.50	Ludmilla Creek upstream site: Not a reportable exceedance as no discharge to Ludmilla Creek in the previous 10 days; catchment cause.
Dissolved oxygen % saturation Individual Result	SLULC01	SMD	10/08/20	Individual result	46.3%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC01	SMD	5/10/20	Individual result	74.4%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC01	SMD	22/10/20	Individual result	46.5%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC01	SMD	9/11/20	Individual result	36.6%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC01	SMD	22/2/21	Individual result	36.2%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC01	SMD	17/03/21	Individual result	42.5%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow.

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
							Not reportable as no discharge to creek in previous 10 days.
	SLULC O1	SMD	19/04/21	Individual result	40.8%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC O1	SMD	18/05/21	Individual result	35.7%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC O1	SMD	01/06/21	Individual result	42.4%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC O2	SMD	5/10/20	Individual result	79.2%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC O2	SMD	22/10/20	Individual result	47.9%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC O2	SMD	9/11/20	Individual result	49.4%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC O1	SMD	22/2/21	Individual result	44.0%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC O2	SMD	17/03/21	Individual result	45.5%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC O2	SMD	19/04/21	Individual result	36.7%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
	SLULC O2	SMD	18/05/21	Individual result	33.1%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULC O2	SMD	01/06/21	Individual result	41.8%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLUEP O3	SMD	05/10/20	Individual result	76.6%	<80.0% :>110.0%	Not Reportable as not in exceedance on three consecutive occasions.
	SLUEP O3	SMD	22/10/20	Individual result	79.2%	<80.0% :>110.0%	Not Reportable as not in exceedance on three consecutive occasions.
	SLULCO 4	SMD	22/10/20	Individual result	79.8%	<80.0% :>110.0%	No results below 80% saturation in the previous 24 months, low risk of environmental harm
	SLULCO 4	SMD	22/02/21	Individual result	119.5%	<80.0% :>110.0%	No results above 110% saturation in the previous 24 months, low risk of environmental harm
	SLULEP O3	SMD	5/10/20	Individual result	76.6%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
	SLULEP O3	SMD	22/10/20	Individual result	79.2%	<80.0% :>110.0%	Ludmilla Creek upstream: Low result typical of site, stagnant pool in times of low inflow. Not reportable as no discharge to creek in previous 10 days.
Total suspended solids mg/L Individual Result	SLUEP O3	SMD	5/01/21	Individual result	7 mg/L	> 6 mg/L	The TSS exceedance at East Point site SLuEP03 (exceeded the Darwin Water Quality Objective, which are not applicable of the wet season) is not reportable (first occurrence).
	SLUEP O3	SMD	22/02/21	Individual result	13 mg/L	>6 mg/L	The TSS exceedance at East Point site SLuEP03 (exceeded the Darwin Water Quality Objective, which are not applicable of the wet season) is not reportable (second occurrence).
	SLUEP O3	SMD	01/06/21	Individual result	9 mg/L	>6 mg/L	The TSS exceedance at East Point site SLuEP03 (exceeded the Darwin Water Quality Objective, which are not applicable of the wet season) is not reportable (first occurrence).
	SLULCO 1	SMD	5/01/21	Individual result	18 mg/L	> 10 mg/L	Ludmilla Creek upstream Not reportable as no discharge in previous 10 days.

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
	SLULC01	SMD	17/03/21	Individual result	17 mg/L	> 10 mg/L	Ludmilla Creek upstream Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	01/06/21	Individual result	15 mg/L	> 10 mg/L	Ludmilla Creek upstream Not reportable as no discharge in previous 10 days.
	SLUEP01	ZOI	8/12/20	Individual result	17 mg/L	> 10 mg/L	The TSS exceedance at East Point site (exceeded the Darwin Water Quality Objective, which are not applicable of the wet season) is not reportable (first occurrence).
	SLUEP01	ZOI	5/1/21	Individual result	19 mg/L	> 10 mg/L	The TSS exceedance at East Point site (exceeded the Darwin Water Quality Objective, which are not applicable of the wet season) is not reportable (first occurrence).
	SLUEP01	ZOI	22/2/21	Individual result	12 mg/L	> 10 mg/L	The TSS exceedance at East Point site (exceeded the Darwin Water Quality Objective, which are not applicable of the wet season) is not reportable (first occurrence).
	SLUEP01	ZOI	1/06/21	Individual result	217 mg/L	> 10 mg/L	The TSS exceedance at East Point site (exceeded the Darwin Water Quality Objective, which are not applicable of the wet season) is not reportable (first occurrence).
	SLULC04	SMD	5/1/21	Individual result	18 mg/L	> 10 mg/L	Ludmilla Creek upstream Not reportable as no discharge in previous 10 days.
	SLULC04	SMD	22/2/21	Individual result	27 mg/L	> 10 mg/L	Ludmilla Creek upstream Not reportable as no discharge in previous 10 days.
	SLUEP02	SMD	8/12/20	Individual result	18 mg/L	> 6 mg/L	The TSS exceedance at East Point site (exceeded the Darwin Water Quality Objective, which are not applicable of the wet season) is not reportable (not after 3 consecutive occasions).
	SLULC02	SMD	7/9/20	Individual result	19 mg/L	> 10 mg/L	Ludmilla Creek upstream Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	22/10/20	Individual result	12 mg/L	> 10 mg/L	Ludmilla Creek upstream Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	8/12/20	Individual result	11 mg/L	> 10 mg/L	Ludmilla Creek upstream Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	5/1/21	Individual result	16 mg/L	> 10 mg/L	Ludmilla Creek upstream

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
ENTEROCOCCI Individual result org/100mL							Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	22/2/21	Individual result	11 mg/L	> 10 mg/L	Ludmilla Creek upstream Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	17/3/21	Individual result	26 mg/L	> 10 mg/L	Ludmilla Creek upstream Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	19/4/21	Individual result	14 mg/L	> 10 mg/L	Ludmilla Creek upstream Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	1/6/21	Individual result	32 mg/L	> 10 mg/L	Ludmilla Creek upstream Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	22/10/2020	95th %ile	842	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC01	SMD	9/11/2020	95th %ile	800	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC01	SMD	8/12/2020	95th %ile	758	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC01	SMD	5/01/2021	95th %ile	715	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC01	SMD	22/02/2021	95th %ile	3,459	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC01	SMD	17/03/2021	95th %ile	3,459	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC01	SMD	19/04/2021	95th %ile	3,268	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC01	SMD	18/05/2021	95th %ile	3,076	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC01	SMD	1/06/2021	95th %ile	3,076	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC02	SMD	13/07/2020	95th %ile	3842	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
	SLULC02	SMD	10/08/2020	95th %ile	3684	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC02	SMD	7/09/2020	95th %ile	3526	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC02	SMD	22/10/2020	95th %ile	3368	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC02	SMD	9/11/2020	95th %ile	3210	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC02	SMD	8/12/2020	95th %ile	3052	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC02	SMD	5/01/2021	95th %ile	17000	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC02	SMD	22/02/2021	95th %ile	16000	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC02	SMD	17/03/2021	95th %ile	15000	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC02	SMD	19/04/2021	95th %ile	2578	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC02	SMD	18/05/2021	95th %ile	2420	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC02	SMD	1/06/2021	95th %ile	2420	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC04	SMD	22/10/2020	95th %ile	69.4	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC04	SMD	9/11/2020	95th %ile	69.2	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC04	SMD	8/12/2020	95th %ile	69	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC04	SMD	5/01/2021	95th %ile	68.8	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
	SLULC04	SMD	22/02/2021	95th %ile	68.6	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC04	SMD	17/03/2021	95th %ile	68.6	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC04	SMD	19/04/2021	95th %ile	68.4	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC04	SMD	18/05/2021	95th %ile	68.2	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC04	SMD	1/06/2021	95th %ile	2420	>40 org/100 mL.	Ludmilla Creek upstream following rain Not reportable as no discharge in previous 10 days
	SLULC03	ZOI	22/2/21	Individual Result	29000	>200 org/100 mL	Ludmilla Creek discharge point, following rain Not reportable as no discharge in previous 10 days
E.coli organisms/100 mL Median of 6 most recent months results 90th percentile of the most recent 24 months results							
	SLULC01	SMD	22/10/2020	Median 90th %ile	512	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	9/11/2020	Median 90th %ile	514	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	8/12/2020	Median 90th %ile	480.8	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	5/01/2021	Median 90th %ile	480.8	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	22/02/2021	Median 90th %ile	631	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	17/03/2021	Median 90th %ile	631	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
	SLULC O1	SMD	19/04/2021	Median 90 th %ile	624	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC O1	SMD	18/05/2021	Median 90 th %ile	617	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC O1	SMD	1/06/2021	Median 90 th %ile	617	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC O2	SMD	22/10/2020	Median 90 th %ile	1220	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC O2	SMD	9/11/2020	Median 90 th %ile	1360	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC O2	SMD	8/12/2020	Median 90 th %ile	1332	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC O2	SMD	5/01/2021	Median 90 th %ile	1332	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC O2	SMD	22/02/2021	Median 90 th %ile	1304	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC O2	SMD	17/03/2021	Median 90 th %ile	1276	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC O2	SMD	19/04/2021	Median 90 th %ile	884	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC O2	SMD	18/05/2021	Median 90 th %ile	842	>14 org/100 mL >43 org/100 mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC O2	SMD	1/06/2021	Median 90 th %ile	842	>14 org/100 mL	Ludmilla Creek upstream.

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
						>43 org/100 mL	Not reportable as no discharge in previous 10 days.
	SLULC03	ZOI	09/11/2021	Individual value	92	>50 org/100mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC03	ZOI	18/05/2021	Individual value	85	>50 org/100mL	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
Copper - filtered	N/A						
Zinc - filtered	N/A						
Total Ammonia as N - Individual	N/A						
Total Ammonia as N – As bio-stimulant Median of the 6 most recent results	N/A						
Total Nitrogen Median of the 6 most recent results							
	SLULC01	SMD	5/10/2020	Rolling median	420	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	9/11/2020	Rolling median	350	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	8/12/2020	Rolling median	400	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	5/01/2021	Rolling median	400	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	22/02/2021	Rolling median	410	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	17/03/2021	Rolling median	420	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	19/04/2021	Rolling median	470	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	18/05/2021	Rolling median	420	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
	SLULC01	SMD	1/06/2021	Rolling median	420	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	5/10/2020	Rolling median	320	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	9/11/2020	Rolling median	320	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	8/12/2020	Rolling median	320	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	5/01/2021	Rolling median	320	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	22/02/2021	Rolling median	400	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	17/03/2021	Rolling median	330	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	19/04/2021	Rolling median	420	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	18/05/2021	Rolling median	420	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	1/06/2021	Rolling median	420	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC03	Z01	2/12/2019	Rolling median	310 µg/L	>300 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
Total Nitrogen Oxides Median of the 6 most recent results	N/A						
Total phosphorous Median of the 6 most							
	SLUEP02	SMD	5/10/2020	Rolling median	37	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
recent results	SLUEP 02	SMD	9/11/2020	Rolling median	36	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 02	SMD	8/12/2020	Rolling median	37	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 02	SMD	5/01/2021	Rolling median	37	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 02	SMD	22/02/2021	Rolling median	37	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 02	SMD	17/03/2021	Rolling median	37	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 02	SMD	19/04/2021	Rolling median	38.5	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 02	SMD	18/05/2021	Rolling median	39.5	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 02	SMD	1/06/2021	Rolling median	39.5	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 03	SMD	5/10/2020	Rolling median	39	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 03	SMD	9/11/2020	Rolling median	39	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 03	SMD	8/12/2020	Rolling median	39	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 03	SMD	5/01/2021	Rolling median	40	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 03	SMD	22/02/2021	Rolling median	39.5	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 03	SMD	17/03/2021	Rolling median	39	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 03	SMD	19/04/2021	Rolling median	39	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLUEP 03	SMD	18/05/2021	Rolling median	39.5	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
	SLUEP 03	SMD	1/06/2021	Rolling median	39	>30 µg/L	Not reportable – Primary response indicator not affected (Chlorophyll-a of 0.73µg/L < 2 µg/L)
	SLULC01	SMD	5/10/2020	Rolling median	68.5	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	9/11/2020	Rolling median	62.5	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	8/12/2020	Rolling median	66.5	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	5/01/2021	Rolling median	66.5	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	22/02/2021	Rolling median	63	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	17/03/2021	Rolling median	62.5	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	19/04/2021	Rolling median	63	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	18/05/2021	Rolling median	63	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	1/06/2021	Rolling median	63	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	5/10/2020	Rolling median	71.5	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	9/11/2020	Rolling median	70	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	8/12/2020	Rolling median	70.5	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	5/01/2021	Rolling median	71	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
	SLULC02	SMD	22/02/2021	Rolling median	71	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	17/03/2021	Rolling median	71	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC01	SMD	19/04/2021	Rolling median	71	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	18/05/2021	Rolling median	71	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	1/06/2021	Rolling median	71	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC04	SMD	5/10/2020	Rolling median	50	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC04	SMD	9/11/2020	Rolling median	46.5	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC04	SMD	8/12/2020	Rolling median	46.5	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC04	SMD	5/01/2021	Rolling median	50	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC04	SMD	22/02/2021	Rolling median	50	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC04	SMD	17/03/2021	Rolling median	50	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC04	SMD	19/04/2021	Rolling median	50	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC04	SMD	18/05/2021	Rolling median	50	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC04	SMD	1/06/2021	Rolling median	50	>30 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.

Indicator	Site	Zone	Date	Reporting statistic	Reporting value	Reporting Limit	Significance
Filterable Reactive Phosphorous Median of the 6 most recent results	SLULC01	SMD	10/08/2020	Rolling median	12.0	>10 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	10/08/2020	Rolling median	12	>10 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	7/09/2020	Rolling median	12	>10 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	5/10/2020	Rolling median	12	>10 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	9/11/2020	Rolling median	11	>10 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
	SLULC02	SMD	18/05/2021	Rolling median	11	>10 µg/L	Ludmilla Creek upstream. Not reportable as no discharge in previous 10 days.
Chlorophyll-a Individual Result	SLUEP01	ZOI	22/02/2021	Individual Result	2.1	2 µg/L Creek	Not reportable as no discharge to creek in previous 10 days
	SLULC03	ZOI	22/10/2020	Individual Result	4.5	4 µg/L Creek	Not reportable as no discharge to creek in previous 10 days
	SLULC03	ZOI	9/11/2020	Individual Result	12.1	4 µg/L Creek	Not reportable as no discharge to creek in previous 10 days
	SLULC03	ZOI	8/12/2020	Individual Result	5.41	4 µg/L Creek	Not reportable as no discharge to creek in previous 10 days
	SLULC03	ZOI	22/02/2021	Individual Result	7.97	4 µg/L Creek	Not reportable as no discharge to creek in previous 10 days
	SLULC03	ZOI	19/04/2021	Individual Result	19.2	4 µg/L Creek	Not reportable as no discharge to creek in previous 10 days
	SLULC01	SMD	17/03/2021	Individual Result	4.19	4 µg/L Creek	Not reportable as no discharge to creek in previous 10 days
	SLULC04	SMD	22/02/2021	Individual Result	20.7	4 µg/L Creek	Not reportable as no discharge to creek in previous 10 days

Appendix 5: Inflow and Discharge Volumes and Loads LWwTP July 2011 to 30 June 2020

Table 26: Inflow and Discharge Volumes and Loads LWwTP July 2011 to 30 June 2020

	Volume kL/year	BOD (tonnes/yr)	COD (tonnes/yr)	NH3-N Free (tonnes/yr)	NH3-N Organic (tonnes/yr)	Total Ammonia -N	NOX - N (tonnes/yr)	Total N tonnes/yr (Calc)	P_Reactive High (tonnes/yr)	P_Total High I (tonnes/yr)	TSS (tonnes/yr)	VSS (tonnes/yr)	Copper (tonnes/yr)	Zinc (tonnes year/1)	Reporting period		Annual Rainfall (Botanical Gardens)
Inflow	6613604.11	876.65	2696.00	194.33	65.56	194.33	0.50	252.82	21.62	32.70	1276.33	1184.45	0.96	0.61	2020-21		1833
Discharge to East Point Outfall	6428430.32	390.72	1046.00	145.05	32.72	145.05	1.96	176.85	3.35	8.79	242.02	185.18	0.36	0.12			
Outflow to Ludmilla Ck	60827.08	2.76	7.65	1.14	0.25	1.14	0.02	1.36	0.03	0.07	2.03	1.51	0.00	0.00			
Total Outflow from Ludmilla into Darwin Harbour	6489257.40	393.48	1053.65	146.19	32.97	146.19	1.98	178.21	3.38	8.86	244.05	186.69	0.36	0.12			
Mass Removed Prior to Discharge		483.17	1642.35	48.14	32.59	48.15	-1.48	74.61	18.24	23.84	1032.28	997.76	0.60	0.49			
Percentage removed prior to discharge		55.12%	60.92%	24.77%	49.71%	24.77%	-296.00%	29.51%	84.37%	72.91%	80.88%	84.24%	62.13%	80.77%			
Inflow	5499184	849.64	2519.38	182.66	63.16	245.81	0.49	246.31	21.667	30.930	1337.38	1246.61	0.85	0.60	2019--20		1228.3
Discharge to East Point Outfall	4846503	356.23	901.92	121.74	28.76	150.49	1.23	151.10	2.700	6.553	175.29	139.77	0.29	0.09			
Outflow to Ludmilla Ck	33408	1.09	3.38	0.51	0.15	0.66	0.01	0.67	0.014	0.025	0.68	0.42	0.002	0.001			
Total Outflow from Ludmilla into Darwin Harbour	4879911	357.32	905.30	122.25	28.90	151.15	1.24	151.77	2.714	6.579	175.97	140.19	0.29	0.09			
Mass Removed Prior to Discharge		492.33	1614.08	60.41	34.26	94.66	-0.74	94.54	18.95	24.35	1161.42	1106.41	0.56	0.51			
Percentage removed prior to discharge	0.00%	57.94%	64.07%	33.07%	54.24%	38.51%	-151.24%	38.38%	87.47%	78.73%	86.84%	88.75%	65.46%	84.93%			
Inflow	5390180	642.48	2271.02	177.11	54.98	232.09	0.27	232.36	18.8	27.98	1032.32	967.73	1.0241	0.6693	2018-19		1156.2
Discharge to East Point Outfall	4724690	402.28	894.96	110	22.7	132.7	0.88	133.59	3.51	6.88	192.99	155.23	0.2609	0.07834			
Outflow to Ludmilla Ck	4070	0.21	0.5	0.07	0.01	0.08	0.0000	0.08	0.0000	0.0000	0.14	0.11	0.0002	0.00007			
Total Outflow from Ludmilla into Darwin Harbour	4728760	402.49	895.46	110.07	22.71	132.78	0.88	133.67	3.51	6.88	193.13	155.34	0.2611	0.078403			
Mass Removed Prior to Discharge		239.99	1375.57	67.04	32.27	99.31	-0.61	98.69	15.29	21.1	839.19	812.4	0.763	0.590897			
Percentage removed prior to discharge		37.35%	60.57%	37.85%	58.69%	42.79%	-227.95%	42.47%	81.33%	75.41%	81.29%	83.95%	74.50%	88.29%			
Inflow	6,284,256	692.78	2,503.61	213.09	55.12	268.21	0.48	268.69	23.25	32.92	1,387.38	1,267.49	1.3194	0.6913	2017-18		1956.3
Discharge to East Point Outfall	5,458,813	366.39	970.79	127.84	25.78	153.62	0.96	138.57	4.45	8.83	194.25	151.49	0.366	0.0783			
Outflow to Ludmilla Ck	135,006	6.88	17.81	2.12	0.42	2.54	0.04	2.04	0.06	0.13	3.3	2.36	0.0091	0.0019			
Total Outflow from Ludmilla into Darwin Harbour	5,593,819	373.27	988.6	129.96	26.2	156.16	1	140.61	4.51	8.96	197.55	153.85	0.3751	0.0803			
Mass Removed Prior to Discharge		319.51	1,515.01	83.13	28.92	112.05	-0.52	128.08	18.74	23.96	1,189.83	1,113.64	0.9446	0.611			
Percentage removed prior to discharge		46.12	60.51	39.01	52.47	42%	-108.33	47.67	80.6	72.78	85.77	87.86	71.58	88.38			
Inflow	7893240	816.81	2559.9	240.02	72.37	312.39	0.47	312.85	24.8	36.47	1293.1	1207.9	1.4642	0.6315	2016-17		2653.2
Discharge to East Point Outfall	7006925	465.66	1133.22	137.38	36.35	173.73	1.86	175.59	7.25	11.12	301.2	238.7	0.4088	0.1149			
Outflow to Ludmilla Ck	100323	4.28	10.28	1.44	0.4	1.84	0.03	1.87	0.1	0.12	5.1	4.3	0.0059	0.0016			
Total Outflow from Ludmilla into Darwin Harbour	7,107,248	469.94	1143.49	138.82	36.75	175.57	1.89	117.47	7.35	11.24	306.3	243	0.4147	0.1166			
Mass Removed Prior to Discharge		346.87	1416.41	101.2	35.62	136.82	1.42	135.38	17.45	25.23	986.8	964.9	1.0495	0.5149			
Percentage removed prior to discharge		42	55	42	49	0.437978168	-302	43	70	69	76	80	71.68	81.54			

	Volume kL/year	BOD (tonnes/yr)	COD (tonnes/yr)	NH3-N Free (tonnes/yr)	NH3-N Organic (tonnes/yr)	Total Ammonia -N	NOX - N (tonnes/yr)	Total N tonnes/yr (Calc)	P_Reactive High (tonnes/yr)	P_Total High I (tonnes/yr)	TSS (tonnes/yr)	VSS (tonnes/yr)	Copper (tonnes/yr)	Zinc (tonnes year/1)	Reporting period		Annual Rainfall (Botanical Gaardens)
Inflow	5766262	868.91	2538.6	190.41	65.92	256.33	0.49	256.81	22.45	29	1129.2	1044.4	0.8534	1.0532	2015-16		1384.4
Discharge to East Point Outfall	5319113	466.79	1095.66	141.15	34.15	175.3	0.85	176.15	2.69	6.6	209.5	169.3	0.2878	0.0659			
Outflow to Ludmilla Ck	263420	20.2	57.11	5.16	1.22	6.38	0.16	6.54	0.11	0.22	9.7	6.2	0.0143	0.0033			
Total Outflow from Ludmilla into Darwin Harbour	5,582,533	487.05	1152.94	146.34	35.38	181.72	1.01	182.72	3.71	6.81	219.4	175.5	0.302	0.0692			
Mass Removed Prior to Discharge		381.86	1385.66	44.07	30.54	74.61	-0.52	74.09	18.74	22.19	909.8	868.9	0.5514	0.984			
Percentage removed prior to discharge		44%	55%	23%	46%	29%	-106%	29%	83%	77%	81%	83%	6461%	9343%			
Inflow	6194074	961.58	2571.51	231.05	68.1	299.15	0.31	299.45	23.92	32.87	1457.6	1344.5	1.1738	0.7024	2014-15		1463.1
Discharge to East Point Outfall	5513508	497.56	1079.57	153.5	30.81	184.31	0.55	184.88	2.78	7.35	216.6	177.7	0.3099	0.0739			
Outflow to Ludmilla Ck	592441	26.02	60.86	8.9	2.14	11.04	0.1	11.15	0.21	0.37	14.6	9.7	0.0333	0.0079			
Total Outflow from Ludmilla into Darwin Harbour	6,105,949	523.58	1140.43	162.4	32.95	195.35	0.65	196.03	3.78	7.72	231.1	187.4	0.3432	0.0818			
Mass Removed Prior to Discharge		438	1431.08	68.65	35.15	103.8	-0.34	103.42	20.15	25.15	1226.4	1157	0.8306	0.6206			
Percentage removed prior to discharge		45.55	55.65	29.71	51.62	0.346983119	-110.72	34.54	84.21	76.51	84.14	86.06	70.76	88.35			
Inflow	7084799	1,019.31	2,668.83	228.77	71.26	300.03	0.37	300.39	24.54	38.11	1456.8	1329.7	1.7287	0.8483	2013-14		2156.3
Discharge to East Point Outfall	5937034	515.15	1,254.31	154.79	30.37	185.16	0.86	186.03	4.54	12.58	304.7	240.6	0.3823	0.0831			
Outflow to Ludmilla Ck	1754617	78.41	231.96	25.38	8.09	33.47	0.37	33.89	0.73	2.19	72	53.1	0.113	0.0246			
Total Outflow from Ludmilla into Darwin Harbour	7,691,651	593.55	1,486.27	180.17	38.46	218.63	1.23	219.92	6.03	14.77	376.8	293.7	0.4953	0.1077			
Mass Removed Prior to Discharge		425.75	1,182.57	48.6	32.8	81.4	-0.86	80.47	18.51	23.34	1080.1	1036	1.2334	0.7406			
Percentage removed prior to discharge		42%	44%	21%	46%	27%	-231%	27%	75%	61%	74%	78%	71.35	87.3			
Inflow	5883150	876.31	2,240.59	193.52	56.08	249.6	0.29	249.9	22.72	29.53	1037.4	960.2	1.1178	0.9707	2012-13		1324.5
Discharge to East Point Outfall	5397581	744.73	1,660.58	149.13	41.41	190.54	0.57	189.14	11.78	21.28	552.6	474.8	0.8758	0.3398			
Outflow to Ludmilla Ck	468987	35.3	81.99	7.97	2.01	9.98	0.07	8.98	0.47	0.8	27.7	21.8	0.0761	0.0295			
Total Outflow from Ludmilla into Darwin Harbour	5,866,568	780.03	1,742.57	157.09	43.41	200.5	0.64	198.12	15.5	22.08	580.3	496.6	0.9519	0.3693			
Mass Removed Prior to Discharge		96.28	498.02	36.43	12.66	49.1	-0.34	51.78	7.22	7.45	457.1	463.7	0.1659	0.6014			
Percentage removed prior to discharge		11%	22%	19%	23%	20%	-117%	21%	32%	25%	44%	48%	14.84	61.96			
Inflow	5627449	859.86	2,132.25	164.85	52.91	217.76	0.41	218.17	22.33	29.79	978.7	901.9	1.1818	0.9342	2011-12		1873.9
Discharge to East Point Outfall	4802493	584	1,636.79	126.22	45.59	171.81	0.5	180.58	9.81	22.6	584.4	434.2	0.8339	0.3246			
Outflow to Ludmilla Ck	622668	42.55	148.99	10.6	4.55	15.15	0.09	16.7	1.66	2.36	45.9	34.7	0.0108	0.0421			
Total Outflow from Ludmilla into Darwin Harbour	5,487,061	634.59	1,812.09	149.59	50.84	200.43	0.59	200.93	17.96	25.38	639.9	476.5	0.95	0.37			
Mass Removed Prior to Discharge		225.27	320.16	15.26	2.07	17.33	-0.18	17.24	4.36	4.41	338.8	425.4	0.229	0.5633			
Percentage removed prior to discharge		26%	15%	9%	4%	8%	-44%	8%	20%	15%	35%	47%	19.38	60.3			