

Challenges for management of treated sewage in NSW Southern Highlands rivers: drinking water catchment, World Heritage Area and platypus habitat

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Key Points

- Southern Highland sewage treatment plants (STPs) discharge effluent with elevated levels of nitrogen, phosphorus, and heavy metals into drinking water catchment waterways, some entering the Greater Blue Mountains World Heritage Area and many being platypus habitat.
- NSW Environmental Protection Authority (EPA) enforces STP discharge limits for nitrogen and phosphorus but not for heavy metals and limits do not reflect ANZECC guidelines for environmental protection.
- There are significant discrepancies between EPA discharge limits for pollutants authorised to be discharge in effluent from Southern Highland compared to western Sydney STPs.

Abstract

This study looked at the impact of four STPs located within the Southern Highlands to identify if environmental regulation was adequate in minimising pollution of waterways of high value. The Southern Highlands, Nattai and Wingecarribee Rivers are major tributaries to drinking water catchment, and Greater Blue Mountains World Heritage Area (Nattai River) as well as being platypus habitat. Results show elevated levels of nitrogen and phosphorus as well as heavy metals such as copper, zinc, iron and aluminium. The NSW EPA are responsible for enforcing discharge limits however, limits for heavy metals are not included in these licences and nitrogen and phosphorus limits significantly exceed ANZECC guidelines for environmental protection. Furthermore, a comparison of discharge limits between Southern Highland STPs and Western Sydney STPs revealed significant discrepancies as Western Sydney STP had tighter limits and included heavy metals despite not discharging into environments of high value. This study highlights the need for improved EPLs that reflect and state clear environmental goals for receiving water ways to ensure adequate environmental protection.

Keywords

Sewage Treatment Plant, World Heritage, Environmental Protection Licence, environmental regulations

Introduction

With the continual growth of populations and growing demand for clean water, the growing discharge of sewage effluent to waterways is one of the biggest environmental management challenges that faces urban development. The Southern Highlands is located approximately 110 kms south-west of Sydney suffers many such challenges. With a growing population of just over 51 000 people (Australian Bureau of Statistics 2019) there are several concerns about the impact of the urban development on the quality of its rivers and highly valued freshwater ecosystems. Several Southern Highland sewage treatment plants (SH STP) discharge effluent into tributaries of either the Nattai or Wingecarribee River. These rivers and their tributaries are known to be home to platypus (*Ornithorhynchus anatinus*) (WSC 2021a). It is an iconic Australian monotreme that is not only an important symbol to the Southern Highland community but also an Australian species that is under serious threat from ongoing changes to freshwater rivers (Woinarski & Burbidge 2016). These changes include water pollution as well as urbanisation, habitat destruction/alteration and disruptions to food sources. The Nattai and Wingecarribee Rivers are also major tributaries that supply water to Sydney's main drinking water catchment, Lake Burragorang. This water catchment provides drinking water to more than 5 million people living in the Sydney, Illawarra and Blue Mountains region (Sydney Water n.d.-b). The

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Nattai River also flows into lands reserved as part of the Greater Blue Mountains World Heritage Area (GBMWA) which in 2000 was assessed as having “outstanding universal value” and is one of the most protected and valued natural areas in the world (Wright et al. 2011). The GBMWA conservation outlook was recently demoted from “good with some concern” to “significant concern” (*Greater Blue Mountains Area / World Heritage Outlook* n.d.). The IUCN report outlines eight major areas of concern including the 2019-20 bushfires that burnt 71% of the protected area and pollution from outside sources such as STP wastewater which was continue to pollute for more than 20km downstream (Wright et al. 2011; 2017; 2018; MWS and DB 1987). The Auditor-General stated in a 2018 report that the Environmental Protection Authority had not done enough to reduce pollution in Sydney’s drinking water catchment further highlighting the risks of poorly regulated effluent can have on high-value areas (see NSW Audit Office 2018).

The purpose of this study was to investigate the impacts of effluent released from four STPs to waterways in the Southern Highlands and compare these results to other pollution source impacts such as urban and rural surface runoff. This study tested for 18 variables across 10 sites in the Southern Highland region, classifying sites based on the type of pollution: rural/urban, STP DS and STP effluent (Mittagong STP and Berrima STP). STP DS represents samples taken downstream of STP discharge points, here dilution has occurred compared to STP effluent in which samples were taken at the point of discharge with little to no dilution from freshwater. This study also examined and compared Environmental Protection Licences (EPLs) that the NSW EPA use to regulate pollution. We compared eight STPs, four located in the environmentally sensitive Southern Highlands and the focus of the study (Berrima, Bowral, Moss Vale and Mittagong) owned and operated by Wingecarribee Shire and four located in less sensitive waterways in western Sydney (Picton, Quakers Hill, Penrith, and West Camden) owned and operated by Sydney Water.

This study aimed to answer two questions:

1. Are the current discharge limits for sewage treatment plants in the Southern Highlands adequate for environmental protection of rivers key values (drinking water catchment, biodiversity, and world heritage values) and
2. How do the EPL limits issued for Southern Highland STPs compare to western Sydney based STPs? Do they reflect a difference in the environmental quality of receiving waters?

Methods

The Southern Highlands region sits entirely within the Wingecarribee Shire and is made up of 16 townships (Figure 1). This area is well-known for its picturesque landscape as well as wine and agricultural commodities. The Wingecarribee and Nattai rivers in this region are vital tributaries for Sydney’s drinking water catchment and Blue Mountains World Heritage Site (Figure 1). They are also known habitats of the iconic platypus with regular sightings reported to the national database PlatypusSPOT.

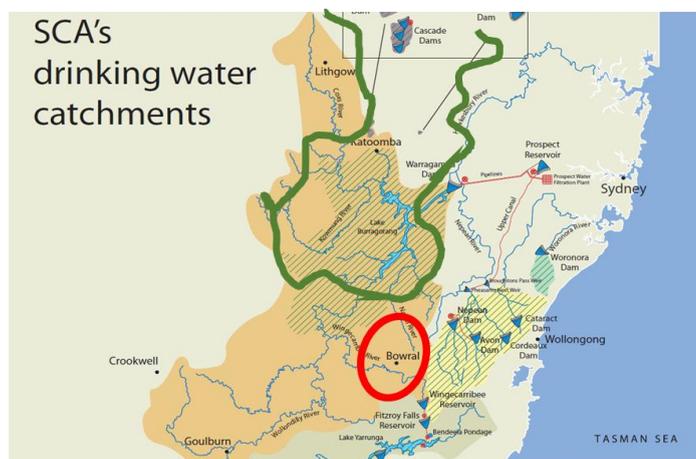


Figure 1: (left) Southern Highland region including townships (source: visitsouthernhighlands.com.au) (right) map of Sydney Catchment Authority drinking water catchment overlaid with Greater Blue Mountains World Heritage area (green outline) and Southern Highlands sampling region (red outline)

Sampling was undertaken at 10 sites located within the Southern Highland region. Six replicates were taken from sites exposed to urban and rural surface run-off. Two sites (Mittagong Creek and Whites Creek) were sampled downstream of Bowral and Moss Vale STP respectively to measure the impact of effluent with dilution. Two sites (Iron Mine and Oldbury Creek) were sampled at the point of discharge for Mittagong and Berrima STP, respectively, and we believe that both were undiluted STP effluent. Sampling occurred in March 2021 prior to major flooding but during wet weather (BOM 2021). Reference data was collected on several occasions (April 2019-June 2020) from the Bargo River, upstream of Tahmoor colliery discharge and from the Nepean River upstream of the Bargo River confluence. In-situ data was collected at all sampling sites with an TPS AQUA-Cond-pH meter for electrical conductivity and pH. We also used a YSI ProODO meter for temperature and dissolved oxygen. Grab samples were collected in sterilized plastic bottles for laboratory analysis in a NATA accredited laboratory for total nitrogen and phosphorus as well as for a selection of metals and major ions.

As per their Environmental Protection Licenses, Sydney Water and Wingecarribee Shire Council are required to monitor the quality of treated sewage effluent and make this data publicly available in accordance with the Protection of Environmental Operations Act (1997) and Environment Legislation Amendment Act (2011). Data was collected from the Wingecarribee Shire website (<https://www.wsc.nsw.gov.au/Services/Water-and-Sewer/Regulatory-Monitoring-Data>) and the Sydney Water website (<https://www.sydneywater.com.au/SW/water-the-environment/how-we-manage-sydney-s-water/wastewater-network/epa-reports/wastewater-treatment-plants/index.htm>). STP effluent data from eight plants (July 2020 until March 2021) was examined to provide comparison about the level of pollution regulations between STPs located in the Southern Highlands and Western Sydney. The western Sydney STP's effluent results were analysed for Picton, West Camden, Quakers Hill, and Penrith. Data was obtained from STPs within Western Sydney and that discharge into Stonequarry Creek, Nepean River, Breakfast Creek and Boundary Creek, all are tributaries of the Hawkesbury Rivers

Results and Discussion

Sydney Water STP (SW STP) effluent had the highest mean concentration of nitrogen and phosphorus (5.6 and 1.35mg/L respectively *see methods) (Sydney Water 2021). In comparison the Southern Highlands STPs (SH STP) had considerably lesser mean concentrations of nitrogen (3.97mg/L* see methods) and Mittagong STP for phosphorus (0.4mg/L) (WSC 2021b). All mean effluent and stream sampling results exceeded ANZECC (2000) guidelines for both nitrogen and phosphorus 0.3 and 0.035mg/L) except for the reference sites (0.4 and 0.01mg/L respectively) (Figure 2). Sampling downstream of STP discharges had the highest concentrations of copper, zinc, and iron (5, 36 and 1200ug/L respectively) (Figure 2; Table 1). However, effluent from Berrima STP did not record concentration above ANZECC guidelines for both copper and zinc (Figure 2). Mittagong STP had the lowest concentration of iron across all sites including the upstream reference site. Unfortunately, there is currently no ANZECC guideline for iron due to insufficient data however the Canadian Water Quality Guidelines place the limit at 300 ug/L (CCREM 1987) which all sites except for Mittagong STP exceeded (Figure 2). 300 ug/L may not be an appropriate limit for this ecosystem given that even the reference site significantly exceeded the guideline. However, this illustrates the importance of establishing individual limits based on background data to ensure adequate environmental protection. ANZECC (2001) also encourages for regulators to obtain background data to generate regional guidelines which may be better suited so particular environments.

STPs in the Southern Highlands and Western Sydney both discharge effluent at concentrations limits enforced by the EPA. We compared their pollutant discharge limits (Figure 2) in their respective EPLs (Table 1). Over the previous 12 months all eight STPs successfully meet their discharge limits. Despite this, the results

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demonstrate that they still discharged above ANZECC guidelines as well upstream reference data. It is evident that the Southern Highlands sites that received effluent from STPs had higher concentrations of nitrogen, phosphorus, copper, aluminium, zinc, and iron compared to sites that received surface run off from other sources such as urban and rural pollution (Figure 2). This indicates that the present EPL limits are not adequate for ensuring environmental protection, as demonstrated by samples exceeding the ANZECC guidelines for protection of aquatic ecosystems for several pollutants (ANZECC, 2001).

The pollutant discharge limits imposed by the NSW EPA in the EPLs at the eight STPs examined in this study differed considerably (see Table 1). The differences included the total number and type of pollutant as well as the permitted pollutant concentration limit. EPLs between Western Sydney and Southern Highland STPs and vary greatly. The four STPs located in the Southern Highlands are operated by Wingecarribee Shire Council (Berrima, Bowral, Mittagong, and Moss Vale), only include seven pollutants with discharge limits. In comparison, Sydney Water STP have between seven and 13 pollutants with discharge limits (Table 1). Southern Highlands STP do not contain any metals with discharge limits but Sydney Water STPs do, and they include between four and six metals (zinc, aluminium, copper, iron, cadmium, and chromium; Table 1). According to the EPA, an EPL is a risk-based licensing system, its aim is to ensure that an “appropriate level of regulation” occurs to suit the “environmental risk of the activity” (EPA 2017). They are designed to find balance between maintaining the environment and ecologically sustainable development (EPA 2020). There are three categories of risk, one being the lowest risk and three being the highest risk and a licence that comes with strict regulations and red tape (EPA 2017). This system is similar to the environmental values the ANZECC guidelines (2000) which acknowledges three different types of protection depending on the value of the environment (high conservation, slightly modified/disturbed and highly disturbed). ANZECC also states that management goals should be unambiguous and represent specific outcomes for community values. EPLs are issued to permit the release of waste to the environment under the Protection of the Environment Operations Act (POEO 1997). One of the aims of the POEO Act is to “protect, restore and enhance the quality of the environment...” (EPA 2020). These aims reflect the same objective; to protect environment by setting achievable goals for industry. However there seems to be disconnect between aims and outcomes for EPL limits. For example, Nitrogen has an ANZECC guideline of 0.3 mg/L but the EPA allows between 7 mg/L 50th percentile concentration limit (Mittagong, Berrima, Moss Vale and Bowral) and 45 mg/L 100 percentile concentration limit (Quakers Hill) with no reference to dilution, potential impact or environmental value of receiving waters (Figure 2; Table 2).

The receiving waters of Sydney Water STPs present multiple pollution problems from sources associated with a major urban development such as motorways, urbanisation, agricultural practices. However, these STPs have a far stricter licence than Southern Highlands STPs despite results revealing similar pollutants in effluent. In Figure 2, water sampled collected from Mittagong STP had higher concentrations of copper, and zinc. In addition, Berrima and Mittagong STPs had higher concentrations of aluminium than Sydney Water STPs. The EPLs for Sydney Water STPs included discharge limits for all these metals as well as iron, cadmium, and chromium. It is curious that the Southern Highland STPs which discharge effluent into Sydney’s drinking water catchment, GBMWA (Nattai River) and its waterways are known platypus habitats have no limits for metals and are not required to monitor these levels. Due to the allusive nature of platypuses, it is not yet known if discharge effluent has impacted populations numbers however future studies are anticipated to examine this avenue more closely with support of the local community as the platypus is an important icon to the region.

Gücker et al. (2014) performed a study that found that the impact of contaminants from STP was heavily influenced by the level of treatment (i.e., secondary or tertiary) and by dilution of receiving waters. STP effluent that entered streams or rivers with high levels of dilution due to background flow volumes were able to tolerate higher concentrations of pollutants than waterways with low flow and consequently lesser dilution. Out of the eight STP EPLs that were examined in this study, only Picton STP considered flow and the EPA licence (EPL) contained a stipulation that discharge could only occur during periods of wet weather and higher levels of receiving stream flow (EPL10555) If stream flow was inadequate the effluent from Picton STP was reused as irrigation on the surrounding agricultural land as part of the Sydney Water agricultural water reuse scheme (Sydney Water, n.d.-a). However, given the human health and ecological importance of the

downstream environments, the Southern Highlands STPs should include more pollutants and consider receiving waterway flow, and dilution as part of their discharge limits.

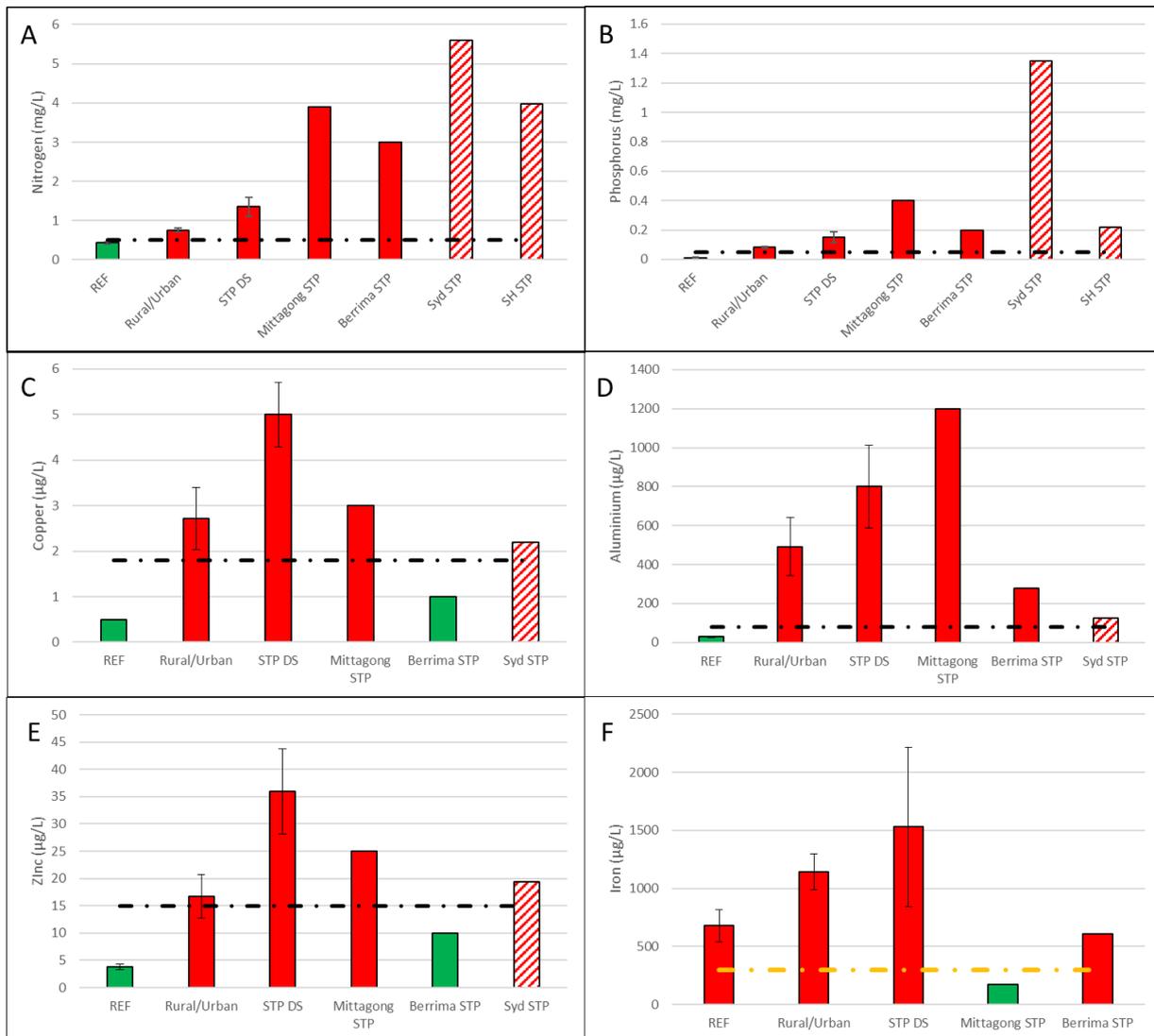


Figure 2: Comparative analysis of the various pollutants from samples collected from 10 sites within the Southern Highlands as well as reference data from Bargo and Nepean River and summary regulatory monitoring data obtained from Sydney Water and Wingecarribee Council (July 2020-March 2021). A. mean Nitrogen (+/- standard error of mean) B mean Phosphorus (+/- standard error of mean) C mean Copper (+/- standard error of mean) D mean aluminium (+/- standard error of mean) E mean Zinc (+/- standard error of mean) F mean Iron (+/- standard error of mean). The black broken line represents ANZECC guidelines for 90% species protection and the yellow broken line in F represents the Canadian water quality guideline (CCREM 1987).

Table 1: Comparison of EPLs between Wingecarribee Shire operated STPs located in the Southern Highlands (black) and Sydney Water operated STP in the Sydney Basin (red). *Picton STP is only allowed to discharge into Stonequarry Creek during wet weather, the water reuse scheme uses treated effluent for agricultural purposes (Sydney Water, n.d.).

Variable	Moss Vale (1731)	Mittagong (10362)	Berrima (3575)	Bowral (1749)	Picton* (10555)	West Camden (1675)	Quakers Hill (1724)	Penrith (1409)
NH ₃ /H ₆ N ₂ (mg/L)	2	2	2	2	2 (5)*	0.9 (1.4)	0.9 (1.4)	0.9 (1.4)
BOD (mg/L)	7 (10)	7 (10)	7 (10)	5 (10)	10 (15)*			10 (15)
Faecal (CFU/100ml)	200	200	-	200	2000* (10000)			200
TN (mg/L)	7 (10)	7 (10)	7 (10)	7.5 (10)	10 (15)*	10 (15)	45	10 (15)
pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-9.5*			
TP (mg/L)	0.5 (1)	0.2 (0.3)	0.5 (1.0)	0.3 (0.5)	8 (9)*	0.3 (1)	5	0.2 (0.4)
TSS (mg/L)	10 (15)	10 (15)	15 (20)	10 (15)	120 (480)*			5 (10)
Al (ug/L)						130 (500)	190	270
Cl (mg/L)						0.1	0.1	0.1
Cu (ug/L)						4 (5)		9
Diazion (ug/L)						0.2 (0.1)		
H ₂ S (ug/L)						30 (60)	60	60
Fe (ug/L)						170 (240)		350
Zn (ug/L)						31 (37)	41	180
Cd (ug/L)							0.3	0.2
Cr (ug/L)							4	

Table 2: Summary statistics including range (minimum to maximum) and mean of water quality results collected from Southern Highland sites in March 2021 and from two reference sites (Bargo and Nepean Rivers from April 2019-July 2020).

	Reference	Rural	STP	Urban	All
Variables (units)	Range (Mean)				
DO (% Saturation)	76.3-102.9 (93.0)	12.6-90.9 (51.8)	57.4-88.5 (74.2)	70.1-81 (75.55)	46.1-85.1 (65.62)
pH (pH units)	6-7.7 (7)	7.72-9.12 (8.42)	7.26-7.79 (7.5)	7.59-7.67 (7.6)	7.65-7.68 (7.7)
EC (µS/cm)	129.2-276.8 (198.1)	166.6-459.7 (313.2)	225.7-326.4 (276.8)	202.9-245.3 (221.9)	252.7-502.2 (377.2)
Iron (µg/l)	0.25-2500 (768.7)	880-1400 (1140)	170-2500 (960)	810-1900 (1176.7)	650-850 (678.7)
Manganese (µg/l)	20-390 (150.9)	76-510 (293)	33-52 (45075)	44-71 (53)	110-260 (185)
Aluminium (µg/l)	5-60 (29.4)	120-630 (375)	280-1200 (770)	330-1400 (696.7)	260-340 (300)
Nickel (µg/l)	0.5-3 (1.18)	3-3 (3)	1-3 (1.75)	1-3 (2)	1-2 (1.25)

Zinc (µg/l)	0.5-8 (3.73)	3-6 (4.5)	10-47 (26.75)	23-26 (24)	5-31 (18)
Strontium (µg/l)	23-42 (30.2)	53-190 (121.5)	53-77 (63.8)	87-100 (95.7)	78-100 (89)
Barium (µg/l)	12-48 (20.9)	35-78 (56.5)	8-37 (21.5)	39-50 (43.7)	49-61 (55)
Lithium (µg/l)	0.5-7 (2.4)	0.5-0.5 (0.5)	0.5-4 (2.4)	0.5-2 (1.5)	0.5-7 (3.75)
Copper (µg/L)	0.5-0.5 (0.5)	0.5-4 (2.25)	1-6 (3.5)	4-5 (4.3)	0.5-1 (0.75)
Sulphate (mg/L)	4-6 (4.32)	2-4 (3)	4-81 (32)	5-7 (6.3)	10-33 (21.5)
Alkalinity (total) (mg/L)	2.5-18 (10.2)	43-160 (101.5)	35-110 (65)	47-82 (70)	63-130 (96.5)
Potassium (mg/L)	1.7-3.4 (2.5)	3.3-6.2 (4.8)	5.1-33 (13.2)	3.5-3.9 (3.6)	5.6-14 (9.8)
Calcium (mg/L)	2.7-4.7 (3.4)	8.6-26 (17.3)	8.5-2 (21.4)	11-20 (17)	14-27 (20.5)
Nitrogen (mg/L)	0.3-0.6 (0.4)	0.6-0.8 (0.7)	103.9 (2.4)	0.8-0.9 (0.87)	0.6-0.7 (0.65)
Phosphorus (mg/L)	0.0025-0.5 (0.01)	0.7-0.8 (0.08)	0.1-0.4 (0.2)	0.09-0.1 (0.1)	0.07-0.09 (0.08)

Conclusions

One but important detail missing from all STP EPLs is that they fail to state a goal or outcome for each licence. It is therefore difficult to impose appropriate STP effluent licence restrictions without knowing what precisely those restrictions are seeking to achieve. The discrepancy between licences seems unreasonable when the Southern Highlands STP discharge effluent into waterways of such environmental value. These include the main drinking water catchment for the Sydney Metropolitan area, the Nattai River flows into the GBMWSHA and rivers in the Southern Highlands are a well-known platypus habitat. This does not downplay the importance of controlling pollution in western Sydney waterways downstream of the Sydney STPs, but this does illustrate the disconnect and inadequacy of regulators to protect environmentally sensitive waterways. Therefore, we recommend including clearly stated aims on all pollution discharge licences. These should include the key environmental values that the discharge licence (EPL) seeks to protect. The pollutant discharge limits should use appropriate guidelines that help achieve the desired level of environment protection. For example, if the desired outcome from discharge of effluent from Mittagong STP was 90% species protection, then a limit for nitrogen and phosphorus would be based around ANZECC guidelines (0.5 and 0.05 mg/L respectively) as well as background data and flow/dilution of Iron Mine creek. This may require regular measurement of flow in the receiving waterway, and also measuring the pollutant concentration in the waterway (above and below the outfall) to ensure that the discharge limit is achieving the recommended pollutant level in the river.

The freshwater rivers and streams in the Southern Highlands are important tributaries containing highly valued biodiversity important water catchments, and also UNESCO World Heritage conservation areas and yet the EPL issued by EPA contains an inadequate selection of contaminants with appropriate discharge limits. This study found that several heavy metals were present at ecologically hazardous concentrations in the effluent of Mittagong and Berrima STP and in downstream receiving waters below Bowral and Moss Vale STP. Both the NSW Auditor General (2018) and IUCN (*Greater Blue Mountains Area | World Heritage Outlook*, n.d.) have stated that reduced water quality as a result of STP effluent is of significant concern to areas of high-value including drinking water catchment and world heritage sites and that better regulation much be implemented. It is unacceptable that the STPs do not have discharge limits in their EPLs to address such pollution. Therefore, we recommend that STPs in the southern highland have revised EPL discharge

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conditions to include pollutants, such as metals such as zinc, aluminium, copper, and iron and reflect the importance of protecting waterways that have such important environmental values.

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