BEFORE THE MANAWATU-WANGANUI REGIONAL COUNCIL

UNDER	the Resource Management Act 1991
IN THE MATTER OF	a review of conditions under section 128(1)(a)(iii) and a change of conditions under section 127 of the Act of the Horowhenua District Council's resource consents for discharges at the Levin Landfill

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SECTION 42A REPORT OF LOGAN BROWN

WATER QUALITY

26 August 2016

A. Introduction

1. My name is Logan Arthur Brown.

2. I have reviewed the Notice of Review dated the 30th October 2015, and the response to the Notice of Review dated the 25th November 2015. In addition I have been on a site visit to the old unlined landfill, the new lined landfill, the Tatana Drain, and the Hokio Stream in the vicinity of the landfill.

3. I am currently employed by the Manawatu-Wanganui Regional Council (Horizons) as the Freshwater and Partnerships Manager. Prior to this role I was a Senior Environmental Scientist – Water Quality. I have been employed by Horizons since June 2010, prior to this I was employed by the Department of Conservation as a Freshwater Technical Officer. I have a Masters in Science – Ecology, a Bachelor of Business Studies majoring in Economics, and a Bachelor of Science majoring in Ecology from Massey University.

4. During my role as a Senior Environmental Scientist – Water Quality I oversaw the delivery of Horizons coastal and estuary monitoring programmes, and the State of the Environment monitoring programmes for biological parameters, which include periphyton, macroinvertebrates and fish. In addition, I was involved in a number of research programmes focused on freshwater systems. I am still heavily involved in these programmes although my focus has now shifted to finding freshwater solutions and working with communities to achieve these.

5. I confirm that I have read the Code of Conduct for expert witnesses in the 2014 Environment Court Practice Notes. My evidence has been prepared in compliance with that code. In particular, unless I state otherwise, the evidence is within my sphere of my expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

B. Scope of evidence

6. This evidence covers the discharge of leachate from the unlined proportion of the Levin landfill to the Tatana Drain and the Hokio Stream. The evidence specifically covers:

a. Summary;

b. The values and water quality targets for the Tatana Drain and Hokio Stream as contained in the One Plan;

c. A description of the Tatana Drain;

d. The effects of the discharge on the Tatana Drain;

e. A description of the Hokio Stream; and

f. The effects of the discharge on the Hokio Stream.

C. Summary

7. Monitoring data provided by MWH on behalf of Horowhenua District Council (HDC) has shown that leachate from the unlined proportion of the landfill is daylighting in the Tatana Drain. This daylighting is resulting in significantly elevated ammonia concentrations that are likely to be having significant adverse effects on the life supporting capacity of this waterway.

8. The monitoring within the Hokio Stream is showing no measureable difference in the monitoring parameters at the sites that are measured along the Hokio Stream. However, the frequency of this monitoring is likely to affect the ability to be able to detect changes.

9. The Tatana Drain and the Hokio Stream both have values that have been identified in the One Plan. The current consent limits for ANZECC guidelines for Livestock Watering will not provide for all of these values.

D. Values and water quality overview

10. The Hokio Stream in the vicinity of the discharge point has a number of values, and associated with these values a number of water quality targets have been identified in the One Plan. This is covered in more detail below.

11. The water management framework of the One Plan recognises the need to manage water bodies within the Region for the different environmental, social and economic values they hold. Water Management Zones (WMZs) are the underpinning geographical component of the integrated water management framework in the One Plan and are located in Schedule A. Forty-three WMZs have been identified and further divided into 124 water management sub-zones.

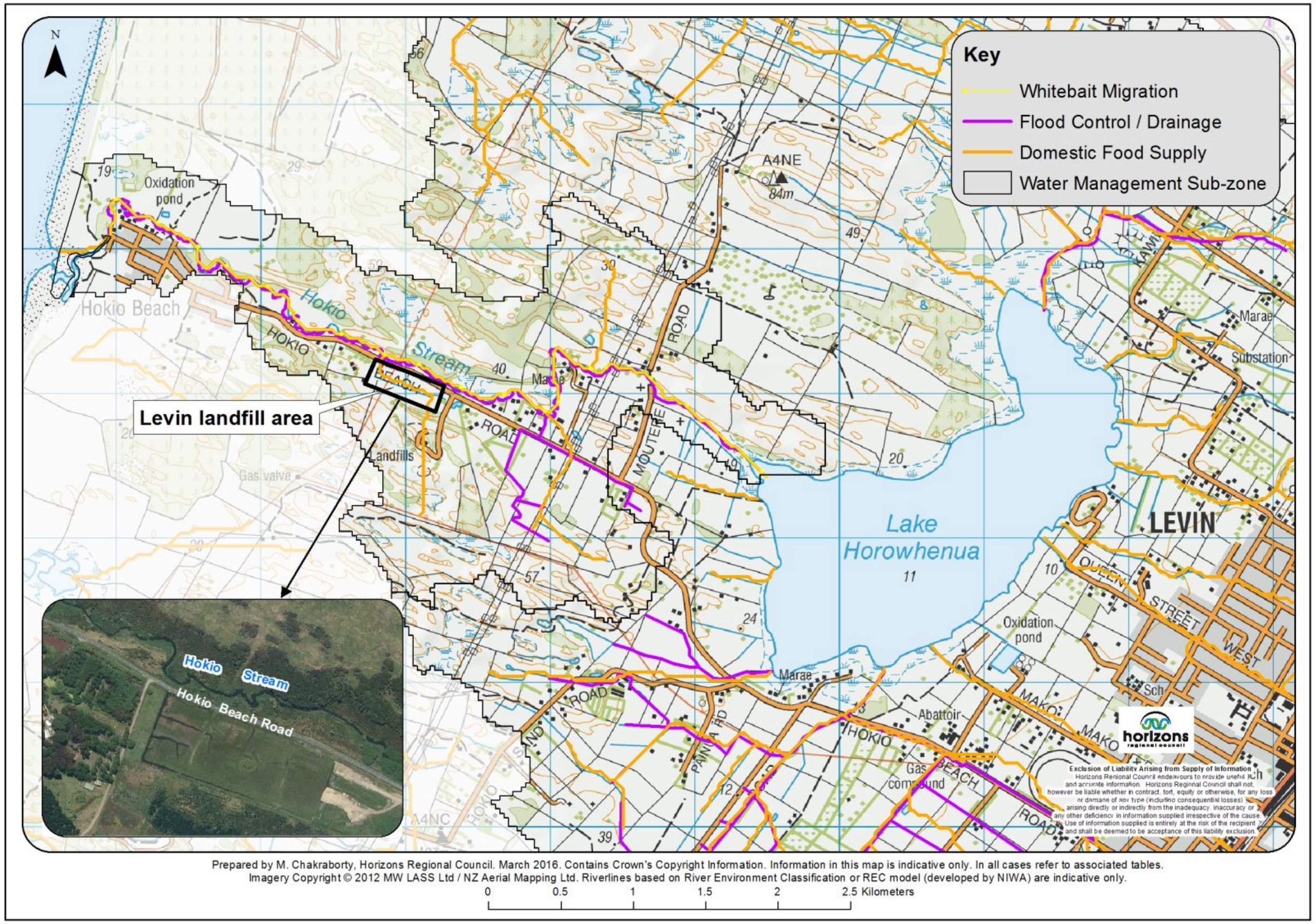
12. Water body values are attached to each WMZs and sub-zones. These values embody the environmental, social, cultural and economic values of each sub-zone. They are defined as either reach or zone specific depending on whether the value is dependent on managing reach-specific effects, or zone-wide effects. The water body values are located in Schedule B of the One Plan.

13. The leachate from the unlined proportion of the Levin landfill occurs within the Hokio (Hoki_1b) sub-zone, which is a water management sub-zone of the Lake Horowhenua (Hoki_1) WMZ (refer Map 2). The following values have been identified in the Hokio Stream and Tatana Drain, in the vicinity of the discharge point (refer Map 1 for reach specific values):

- Life Supporting Capacity – Lowland Sand (LS) geology;
- Amenity (approximately 3.5 km downstream of the discharge);
- Whitebait migration;
- Domestic food supply;
- Inanga spawning (approximately 3.5 km downstream of the discharge);
- Flood control/drainage;
- Aesthetics;
- Mauri;
- Contact Recreation;
- Stockwater;
- Water Supply;
- Industrial Abstraction;
- Existing infrastructure;

- Irrigation; and
- Capacity to Assimilate Pollution.

14. Schedule E of the One Plan (2014) sets out numerical targets to protect the majority of values identified in the Hokio Stream and it's tributaries (Table 1). These targets have been established using the best available science and expert opinion at the time the Plan was developed. The targets are designed to provide the best level of protection for the values within a water management sub-zone (Ausseil and Clark, 2007). As such, if the targets set out in the One Plan are complied with, the effects of an activity on the receiving water body are likely to be no more than minor.



Map 1: Map showing the reach specific values of Flood Control/Drainage and Domestic Food Supply in the Hokio sub-zone.

Table 1: Water Quality targets for all rivers and streams in the Hokio management Sub-zone.

Abbreviations used in Tables D.1A to D.4A		**Full Wording of the Target**
pH	Range	The pH of the *water*^ must be within the range 7 to 8.5 unless natural levels are already outside this range.
	Δ	The pH of the *water*^ must not be changed by more than 0.5.
Temp (^{o}C)	<	The temperature of the *water*^ must not exceed 24 degrees Celsius.
	Δ	The temperature of the *water*^ must not be changed by more than 3 degrees Celsius.
DO (% SAT)	>	The concentration of dissolved oxygen (DO) must exceed 60 % of saturation.
$sCBOD_5$ (g/m^3)	<	The monthly average five-days filtered / soluble carbonaceous biochemical oxygen demand ($sCBOD_5$) when the *river*^ flow is at or below the 20th *flow exceedance percentile** must not exceed 2 grams per cubic metre.
POM (g/m^3)	<	The average concentration of particulate organic matter when the *river*^ flow is at or below the 50th *flow exceedance percentile** must not exceed 5 grams per cubic metre.
Periphyton (*rivers*^)	Chl *a* (mg/m^2)	The algal biomass on the *river*^ *bed*^ must not exceed 200 milligrams of chlorophyll *a* per square metre.
	% cover	The maximum cover of visible *river*^ *bed*^ by periphyton as filamentous algae more than 2 centimetres long must not exceed 30 %.
		The maximum cover of visible river bed by periphyton as diatoms or cyanobacteria more than 0.3 centimetres thick must not exceed 60 %.
DRP (g/m^3)	<	The annual average concentration of dissolved reactive phosphorus (DRP) when the *river*^ flow is at or below the 20th *flow exceedance percentile** must not exceed 0.015 grams per cubic metre, unless natural levels already exceed this target.
SIN (g/m^3)	<	The annual average concentration of soluble inorganic nitrogen (SIN)[1] when the *river*^ flow is at or below the 20th *flow exceedance percentile** must not exceed 0.167 grams per cubic metre, unless natural levels already exceed this target.
Despoiled Sediment Cover[2]	% cover	The maximum cover of visible bed by deposited sediment less than 2 millimetres in diameter must be less than 25%, unless natural physical conditions are beyond the scope of the application of the deposited sediment protocol of Clapcott et al. (2010).
MCI[3]	>	The Macroinvertebrate Community Index (MCI) must exceed 100, unless natural physical conditions are beyond the scope of application of the MCI. In cases where the *river*^ habitat is suitable for the application of the soft-bottomed variant of the MCI (sb-MCI) the targets also apply.
QMCI	% Δ	There must be no more than a 20 % reduction in Quantitative Macroinvertebrate Community Index (QMCI) score between appropriately matched habitats upstream and downstream of discharges to *water*^.
Ammoniacal	<	The average concentration of ammoniacal nitrogen must not exceed 0.4 grams per cubic metre.

1 Soluble inorganic nitrogen (SIN) concentration is measured as the sum of nitrate nitrogen, nitrite nitrogen, and ammoniacal nitrogen or the sum of total oxidised nitrogen and ammoniacal nitrogen.

2 The Deposited Sediment Cover (%) Water Quality Target (or standard where specified under conditions/standards/terms in a rule) only applies for State of the Environment monitoring purposes to determine if the percentage cover of deposited sediment on the bed of the river will provide for and maintain the values for each WMSZ. The effects of deposited sediment on the bed of rivers in relation to resource consent applications should be determined using the deposited sediment protocols of Clapcott et al. (2010).

3 The Macroinvertebrate Community Index (MCI) target applies only for State of the Environment monitoring purposes to determine if the aquatic macroinvertebrate communities are adequate to provide for and maintain the values in each WMSZ. This target is not appropriate for monitoring the effect of activities such as discharges to water on macroinvertebrate communities upstream and downstream of the activity.

Abbreviations used in Tables D.1A to D.4A		Full Wording of the Target
nitrogen[4] (g/m^3) (*rivers*^)	Max	The maximum concentration of ammoniacal nitrogen must not exceed 2.1 grams per cubic metre.
Tox. or Toxicants	%	For toxicants not otherwise defined in these targets, the concentration of toxicants in the *water*^ must not exceed the trigger values for freshwater defined in the 2000 ANZECC guidelines Table 3.4.1 for the level of protection of 95 % of species. For metals the trigger value must be adjusted for hardness and apply to the dissolved fraction as directed in the table.
Visual Clarity (m) (*rivers*^)	% Δ	The visual clarity of the *water*^ measured as the horizontal sighting range of a black disc must not be reduced by more than 30 %.
	>	The visual clarity of the *water*^ measured as the horizontal sighting range of a black disc must equal or exceed 2.5 metres when the *river*^ is at or below the 50th *flow exceedance percentile**.
E. coli / 100 ml (*rivers*^)	< m	The concentration of *Escherichia coli* must not exceed 260 per 100 millilitres 1 November - 30 April (inclusive) when the *river*^ flow is at or below the 50th *flow exceedance percentile**.
	<20th %ile	The concentration of *Escherichia coli* must not exceed 550 per 100 millilitres year round when the *river*^ flow is at or below the 20th *flow exceedance percentile**.

Receiving Environments

E. Tatana Drain

15. This waterway exists to the north of the closed unlined landfill and runs parallel to the landfill site boundary in a western direction, and then turns at a sharp right to the north where it flows through a culvert under Hokio Beach Road and enters the Hokio Stream. This waterway is locally referred to as the Tatana Drain.

16. During a site visit on the 11th March 2016 the Tatana Drain was similar in appearance to many drains (modified watercourses) that run through lowland rural areas with a low (approximately 0.5 l/s at the culvert) but obvious flow to it. The lack of any riparian vegetation and stock access to the waterway was evident. The upper end of the drain was overgrown by grass although water was obvious, and by the time the drain had reached the culvert the presence of overgrown grass was less obvious, although maybe as a result of drain clearance and/or stock disturbance in the area.

17. In terms of the Drain, the question that has been posed to me is whether the drain constitutes a river in terms of the Resource Management Act 1991 definition. In my opinion, the Tatana Drain does meet the following "RMA 1991 definition – river - river means a continually or intermittently flowing body of fresh water; and includes a stream and modified watercourse; but does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal)" because of the following reasons:

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[4] Ammoniacal nitrogen is a component of SIN. SIN target should also be considered when assessing ammoniacal nitrogen concentrations against the targets.

a. When looking at the historical extent of wetlands in the area, the area to the north of the base of the unlined landfill was once a wetland which would have had a flow path to the Hokio Stream, meaning that the river is likely a modified watercourse;

b. At the time of the site visit (in March) the stream had a flow that appeared permanent, although it was small; and

c. As a part of the One Plan process the REC layer was used to identify reaches of waterways and then each of the waterways had values applied to them. The reaches that were identified for the One Plan included the Tatana Drain as a line which suggests that the REC layer used for the development of these layers contained the Tatana Drain as a waterway (refer Map 1).

d. Aerial photography prior to the construction of the landfill appears to show a defined channel at the base of the sand dunes (refer Photo 2) and during the use of the unlined landfill this definition is still present (refer Photo 3).

Photo 1: Aerial photo taken on the 26th May 1995 showing the Levin landfill and Tatana Drain.

Photo 2: Aerial photo taken on the 7th October 1968 showing the area prior to Levin landfill which is to the right of the arrow.

F. Effects on the Tatana Drain as a result of the leachate discharge:

18. The monitoring reports produced by MWH on behalf of HDC have concluded that shallow groundwater was being impacted on by landfill leachate from the unlined proportion of the landfill and that this impacted groundwater was emerging (daylighting) as surface water within the Tatana Drain.

19. For the Tatana Drain three rounds of monitoring have been completed by MWH on behalf of HDC, a copy of these results is included in Table 2.

20. The National Policy Statement for Freshwater Management 2014 (NPSFM) contains a list of attribute tables which also contain national bottom lines. The information that has been provided as part of the monitoring allows us to undertake an assessment for nitrate and ammonia toxicity against these ecosystem health bottom lines. The monitoring undertaken to date only has three sampling rounds being July, October 2015, and January 2016. An assessment against the NPSFM for ammonia-N toxicity requires that a pH adjustment of the data is done. This adjustment of the figures is included in Table 2 below. An assessment against the NPSFM shows:

    a. For ammonia toxicity when using the annual maximum and the annual median, all of the sites fall into Band D (below the national bottom line). Caution should be used with the annual median values as this assessment is only based on 3 sampling rounds. However, confidence can be placed on the maximum values given that the assessment would not change if we had a years worth of monthly data given the high values currently seen in the data set.

    b. For nitrate toxicity when using the annual 95th percentile, sites SW1 and SW4 fall into Band A, SW3 into Band B, and SW2 into Band C (refer to Figure 1 for site locations). When using the annual median sites SW1 and SW4 fall into Band A, SW3 into Band B, and SW2 into Band C. Extreme caution should be used with the annual median values as this assessment is only based on 3 sampling rounds.

Figure A-1: Hokio Stream and Tatana's Property Drain Monitoring Locations
Note: SW5 is not included in the monitoring schedule

Figure 1: Map showing the monitoring locations in the Tatana Drain and the Hokio Stream.

21. Given that the national bottom line value for ammonia is set based on when this level is reached that it “Starts approaching acute impact (i.e. risk of death) for sensitive species”, it is my opinion there is no doubt that the ammonia concentrations would have significant adverse effects on any aquatic life that should be present in the Tatana Drain. Given that the discharge has likely been occurring for a reasonable period of time it is likely that most aquatic life is absent from the Tatana Drain as a result of the leachate.

22. In addition the ammoniacal nitrogen and SIN concentrations seen in the Tatana Drain exceed the One Plan targets for this water management sub-zone.

G. Summary of the effects on the Tatana Drain:

23. Three rounds of water quality monitoring have been undertaken in the Tatana Drain by MWH on behalf of HDC.

24. The monitoring shows that the Tatana Drain has extremely elevated levels of ammoniacal nitrogen at all the sites that were monitored, with the results showing that the Tatana Stream falls into Band D of the Freshwater NPS (below the National bottom line).

Table 2: Monitoring results from the Tatana Drain from July 2015, October 2015 and January 2016.

		July 2015				October 2015				January 2016			
		SW1	SW2	SW3	SW4	SW1	SW2	SW3	SW4	SW1	SW2	SW3	SW4
pH		7.1	7.5	7.2	7.5	**6.9**	7.2	7.4	7.3	7	7	6.7	6.8
Suspended Solids	mg/l	290	175	40	77	65	239	16	20	3320	258	35	53
Conductivity	mS/m	212	147	80.9	88.1								
COD	mg/L	119	146	147	110	111	204	80	71	136	343	59	62
TKN	mg/L	93.9	37.9	10.9	12.1	65.3	45.5	18.9	11.9	152	62.3	11.4	7.6
BOD	mg/L	19	28	11	41	12	37	6	*3*	391	75	7	12
Chloride	mg/L	194	169	80.9	105	162	160	107	81.8	237	157	123	96.2
Nitrite-N	mg/L	0.09	0.15	0.05	0.09	0.03	0.21	0.09	0.02	0.005	0.005	0.005	0.005
Nitrate-N	mg/L	0.39	2.76	0.43	0.72	**0.35**	**3.7**	**1.17**	0.12	0.03	0.005	0.005	0.005
Ammonia-N	mg/L	**80.5**	**30.8**	**3.9**	**6.2**	**63.8**	**40.7**	**17.1**	**10.2**	**136**	**56.1**	**9.2**	**3.6**
Ammonia-N pH adjusted	mg/L	**34.8**	**17.2**	1.76	**3.5**	**25.4**	**18.4**	**8.8**	**4.9**	**56.2**	**23.2**	**3.5**	1.4
SIN	mg/L	**80.98**	**33.71**	**4.38**	**7.01**	**64.18**	**44.61**	**18.36**	**10.34**	**136.035**	**56.11**	**9.21**	**3.61**
Total Nitrogen	mg/L	100	38.4	12	12.2	67.8	50	20.7	12.2	134	53	9.8	6.65
Iron	mg/L	1.78	1.07	1.83	0.99	0.71	0.28	0.59	0.54	3.01	2.23	1.15	1.27
Manganese	mg/L	1.33	0.499	0.0411	0.296	0.954	0.666	0.388	0.491	0.383	0.998	0.37	0.561

H. Hokio Stream

25. The Hokio Stream is the outlet from Lake Horowhenua and plays a vital role in acting as a migratory pathway for a number of New Zealand's freshwater fish species. In addition it provides important aquatic habitat for a number of freshwater organisms.

I. Native Fish Communities and Migrations in the Hokio Stream

26. New Zealand has a highly mobile native fish fauna consisting of a large number of diadromous (migratory) species. New Zealand's native fish communities also display a high degree of endemism (85% of New Zealand's native fish fauna are only found in New Zealand (Jowett & Richardson, 1996)). Many native fish species such as the Galaxiidae spawn within the riparian margins of rivers, streams and estuaries, and upon hatching the larvae, migrate into the coastal marine waters to grow. These species return to freshwater as juvenile whitebait in the spring and migrate upriver into the habitats preferred by adult fish.

27. The juvenile fish, known collectively as whitebait, comprise six species of native fish: common smelt (*Retropinna retropinna*), inanga (*Galaxias maculatus*), koaro (*G. brevipinnis*), giant kokopu (*G. argenteus*), shortjaw kokopu (*G. postvectis*) and banded kokopu (*G. fasciatus*). All of these except shortjaw kokopu and koaro have been found in the Lake Horowhenua catchment in fish surveys conducted within the last 5 years.

28. Other native migratory species which commonly inhabit freshwaters include redfin bully (*Gobiomorphus huttoni*), common bully (*G. cotidianus*), bluegill bully (*G. hubbsi*), giant bully (*G. gobioides*), torrentfish (*Cheimarrichthys fosteri*), longfin (*Anguilla dieffenbachii*), and shortfin eels (*A. australis*). Common bully, torrentfish, longfin, and shortfin eels have been found in the Lake Horowhenua catchment in fish surveys.

29. Estuaries and lower river reaches are very important ecosystems for native fish because diadromous fish temporarily inhabit these habitats during migrations throughout the year, peaking in autumn and spring. Estuaries and tidal river reaches provide habitat for giant bully, inanga and smelt year round, for juvenile eels, particularly in spring and spawning habitat for inanga in autumn. They are the "bottleneck" through which all migratory species have to pass (McDowall, 1976).

30. Estuaries and tidal river reaches are also host to a large number of marine wanderers that will also briefly enter into freshwater environments, including yelloweye mullet (*Aldrichetta forsteri*), grey mullet (*Mugil cephalus*), kahawai (*Arripis trutta*) and black flounder (*Rhombosolea retiaria*) (McDowall, 1990).

31. Due largely to the migratory nature of New Zealand's native fish fauna, lowland waterways have been found nationally to have higher diversity and density of native fish (Jowett & Richardson, 1996). Diversity and density decrease with distance from the sea and elevation (Joy & Death, 2002). Therefore, lowland rivers, streams and estuaries are very important to the overall native fish diversity in all New Zealand river systems.

32. Some of the freshwater fish species found within the Lake Horowhenua catchment are considered to be threatened and are contained within the New Zealand threat classification system (refer Table 3) (Goodman *et al*., 2013*, and Grainger *et al*., 2014).

Table 3: Threat classification of the freshwater species found in the Lake Horowhenua catchment. Freshwater fish threat classification based on 2013 publication* (Goodman *et al*, 2014) and koura and kakahi based on 2013 publication+ (Grainger *et al*, 2014).

Common name	**Scientific name**	**Threat ranking**
Koura	*Paranephrops planifrons*	Not threatened+
Giant kokopu	*Galaxias argenteus*	Declining*
Banded kokopu	*Galaxias fasciatus*	Not threatened*
Brown mudfish	*Neochanna apoda*	Declining*
Inanga	*Galaxias maculatus*	Declining*
Long fin eel	*Anguilla dieffenbachia*	Declining*
Torrentfish	*Cheimarrichthys fosteri*	Declining*
Kakahi	Echyridella menziesi	Declining+
Upland bully	*Gobiomorphus aff. breviceps*	Not threatened*
Common bully	*Gobiomorphus cotidianus*	Not threatened*
Smelt	*Retropinna retropinna*	Not threatened*
Short fin eel	*Anguilla australis schmidtii*	Not threatened*
Grey mullet	*Mugil cephalus*	Not threatened*
Perch	*Perca fluviatilis*	Introduced and naturalized*
Goldfish	*Carassius auratus*	Introduced and naturalized*

33. Migratory pathways between rivers and the sea are extremely important components of healthy riverine ecosystems and aquatic biodiversity in New Zealand. The migration times of diadromous fish (requiring access to the sea at some stage during their life cycle) differ according to species, however, fish are migrating throughout the year in the Horowhenua catchment (refer Table 4).

Table 4: Summary of migration movement of native diadromous fish in the Lake Horowhenua catchment. Arrows pointing to the left indicate downstream migration to estuaries or the sea, arrows pointing to the right indicate upstream migration into freshwaters.

Species	Winter	Spring	Summer	Autumn
Giant kokopu	←	→		←
Banded kokopu	← →	→		←
Torrentfish	→	→	←	←
Eels (Longfin and shortfin)	← →	←		→ ←
Smelt		→	→	←
Inanga	→	→ ←		→ ←

J. Water Quality

34. The Hokio Stream is the only surface water outlet from Lake Horowhenua with the water quality in the stream being largely influenced by factors that are occurring in the lake at the time i.e. the stream carries large loads of planktonic cyanobacteria during late summer and early autumn (refer to Photo 3).

Photo 3: Hokio Stream on the 18th March 2016 showing the high planktonic algae load from Lake Horowhenua (the green colouration).

35. A report produced in May 2015 (Clark *et al*, 2015) assessed the water quality in Lake Horowhenua and it's tributaries of which the Hokio Stream is included. Figure 2 shows the location of the monitoring sites within the Lake Horowhenua catchment and Table 5 summarises the results of the broad scale assessment against the One Plan targets undertaken using data collected between January 2013 and December 2014 regardless of river flows.

36. As stated above, the Hokio Stream plays a vital role as a migratory route for native fish species to access the Lake Horowhenua catchment and in addition the stream itself provides habitat for native fish species. The stream also flows down into the Hokio Estuary which is used for contact recreation purposes. The values of the Hokio Stream as identified in the One Plan are covered in section D above.

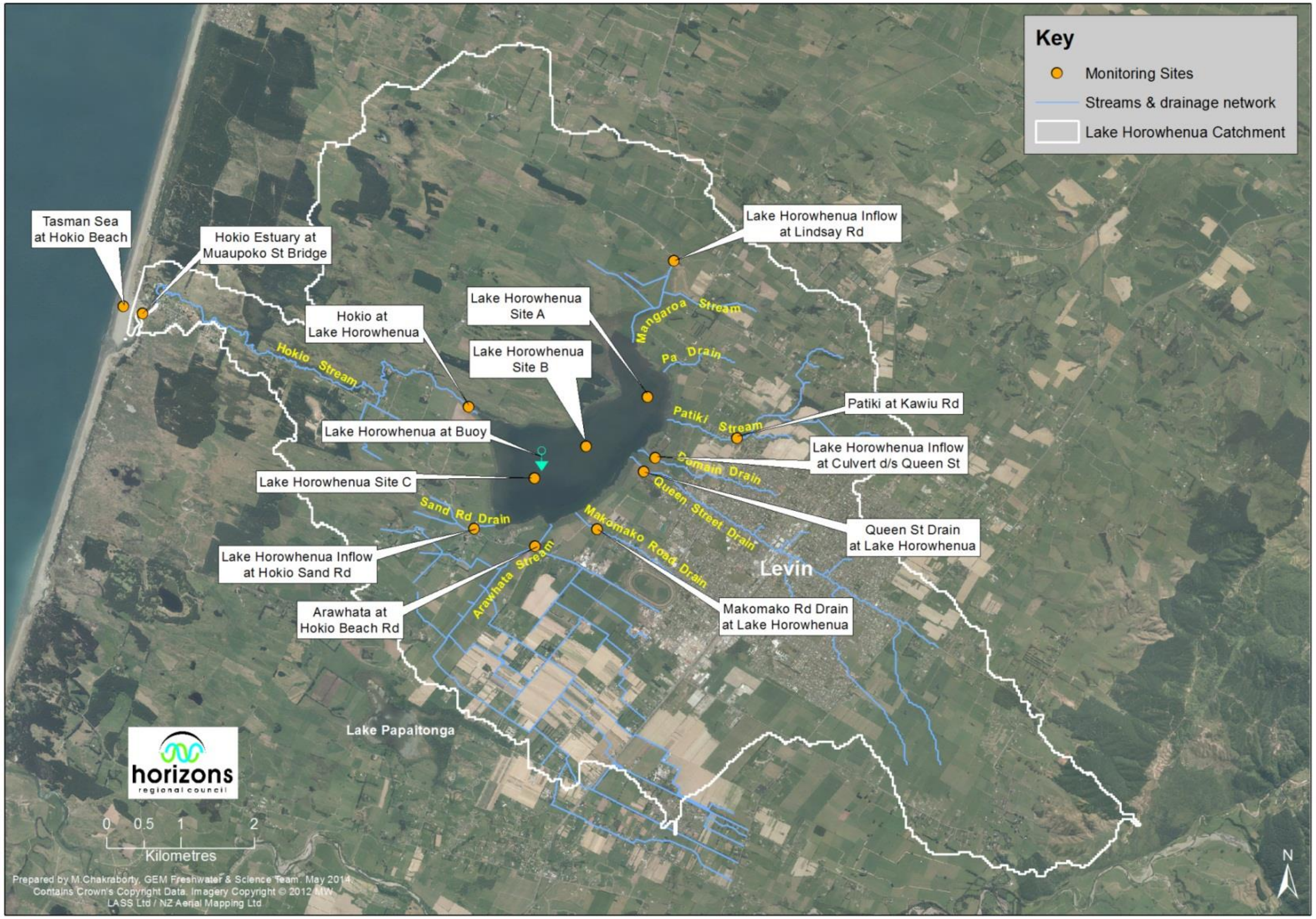

Figure 2: Lake Horowhenua tributaries and outflow showing locations of water quality monitoring sites

Table 5: Summary of the assessment against the One Plan Targets. A green cell indicates compliance with the One Plan target whereas a red cell indicates that the target is not being met.

Parameter	Lake Horowhenua	Mangaroa	Patiki	Domain Drain	Queen St Drain	Makomako Rd Drain	Arawhata Stream	Hokio Sand Road Drain	Hokio Stream
Escherichia coli (Bathing season)									
Escherichia coli (yr round)									
Total nitrogen		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ammoniacal nitrogen									
Ammoniacal nitrogen Max	N/A								
Soluble inorganic nitrogen	N/A								
Total phosphorus		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dissolved reactive phosphorus	N/A								
Chlorophyll *a*		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

37. The consent holder is required to undertake monitoring within the Hokio Stream as part of the resource consent that they hold. This data is reported in the quarterly reports that are sent to Horizons for compliance assessments.

38. The following tables (Table 6 and 7) show the results of HDC monitoring against the One Plan targets for the 2015 year and also from 2011 to 2015 inclusive. As a summary it shows that:

a. The average and maximum ammoniacal nitrogen concentration is complied with at both the upstream and downstream of the confluence with the Tatana Drain locations; and

b. That the average concentration of DRP and SIN are above the One Plan targets both upstream and downstream of the confluence with Tatana Drain.

Table 6: Compliance with the recommended water quality targets for the 2015 year. ✓: the target is met; ×: the target is not met ↓: reduction between upstream and downstream, ↑: increase between upstream and downstream, –: no change between upstream and downstream.

Parameter	Upstream	Downstream	Change between upstream and downstream
Average Ammoniacal Nitrogen (n=4)	✓ 0.055	✓ 0.046	↓
Maximum ammoniacal nitrogen (n=4)	✓ 0.110	✓ 0.100	↓
Average soluble inorganic nitrogen (n=4)	× 1.490	× 1.486	↓
Average dissolved reactive phosphorus (n = 2)	× 0.076	× 0.075	↓

Table 7: Compliance with the recommended water quality targets for the monitoring period 2011 to 2015 inclusive. ✓: the target is met; ×: the target is not met. ↓: reduction between upstream and downstream, ↑: increase between upstream and downstream, –: no change between upstream and downstream.

Parameter	Upstream	Downstream	Change between upstream and downstream
Average Ammoniacal Nitrogen (n=20)	✓ 0.105	✓ 0.088	↓
Maximum ammoniacal nitrogen (n=20)	✓ 0.770	✓ 0.250	↓
Average soluble inorganic nitrogen (n=20)	× 0.913	× 0.918	↑
Average dissolved reactive phosphorus (n = 12)	× 0.121	× 0.117	↓

39. In terms of assessing the effects of the Tatana Drain discharge on the Hokio Stream we are able to undertake an equivalence test which uses a pre-determined threshold (in this case I have taken 10%) to see if the discharge results in a difference between the upstream and downstream monitoring locations and also the strength of this difference. In this situation the test does not tell us whether the discharge is resulting in an adverse effect but whether it is causing a change between the upstream and downstream monitoring sites based on the 10% threshold. The results of this test are discussed below for ammoniacal nitrogen, SIN, and DRP (refer to Appendix 2 for the program outputs).

a. For ammoniacal nitrogen the data shows that the upstream site is greater than the downstream site, although the test strength is weak (inconclusive) and more data is needed.

b. For DRP the data shows that the downstream site is less than the upstream site, although the test strength is weak (inconclusive) and more data is needed.

c. For SIN the data shows that the downstream site is greater than the upstream, although the difference lines within the 10% threshold. This relationship is strong and shows no difference between the upstream and downstream locations within the 10% threshold.

40. In addition you can look at the difference in the metals between the upstream and downstream monitoring locations on each of the monitoring rounds as contained in Appendix 3.

41. The monitoring data overall shows that based on the current monitoring data there is no discernible difference between upstream and downstream of the unlined landfill area. Although the analysis of the data shows that this may be a case of a lack of monitoring data rather than an effect, but without further and more frequent monitoring data this call cannot be made at this stage. The current monitoring in the Hokio Stream is undertaken on a quarterly basis. To allow more accurate information to be gathered as to the effects of the leachate on the Hokio Stream I would recommend that monitoring is undertaken on monthly basis between November to April (inclusive) each year. This timing aligns with when flows in the Hokio Stream are likely to be the lowest and therefore the greatest chance of picking up an effect.

42. The current upstream monitoring location in the Hokio Stream also appears to be in a northerly direction from the landfill. It appears at first glance that the upstream might not be clearly independent from the groundwater flow paths from the unlined proportion of the landfill. It would be my recommendation to move the upstream monitoring point well upstream of any potential influence of the groundwater plume from the unlined proportion of the landfill. To fully inform were this upstream monitoring point should be located it would be useful to have the shallow groundwater paths and contaminate plume mapped to ensure that the upstream monitoring point is not influenced from the landfill.

43. The current limits that apply to the Hokio Stream are ANZECC guidelines for Livestock Watering. These limits will not provide for the values that have been identified in the One Plan and the more appropriate limits would be the ANZECC guidelines for ecosystem health applied at the 95^{th} percentile as per the One Plan for this water management zone, as proposed in Horizons conditions.

K. Summary of the effects on the Hokio Stream

44. The monitoring data overall shows that based on the current monitoring data there is no discernible difference between upstream and downstream of the unlined landfill area. Although analysis of the data shows that this may be a case of a lack of monitoring data rather than an effect, but without further and more frequent monitoring data this call cannot be made at this stage. I would recommend that monitoring is undertaken on monthly basis between November to April (inclusive) each year.

45. Given the values that the Hokio Stream holds, and the important role it plays in facilitating the access to Lake Horowhenua and its tributaries for native fish species, the most appropriate standards/targets for the Hokio Stream and its tributaries would be the ANZECC guidelines for the level of protection of 95% of species as identified in Schedule E of the One Plan for this WMZ.

L. References

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Appendix 1

Table 1: Attribute table from the Freshwater NPS for Nitrate toxicity.

<table>
<tr><td>Value</td><td colspan="3">Ecosystem health</td></tr>
<tr><td>Freshwater Body Type</td><td colspan="3">Rivers</td></tr>
<tr><td>Attribute</td><td colspan="3">Nitrate (Toxicity)</td></tr>
<tr><td>Attribute Unit</td><td colspan="3">mg NO_3-N/L (milligrams nitrate-nitrogen per litre)</td></tr>
<tr><td>Attribute State</td><td colspan="2">Numeric Attribute State</td><td>Narrative Attribute State</td></tr>
<tr><td></td><td>Annual Median</td><td>Annual 95th Percentile</td><td></td></tr>
<tr><td>A</td><td>≤1.0</td><td>≤1.5</td><td>High conservation value system. Unlikely to be effects even on sensitive species</td></tr>
<tr><td>B</td><td>>1.0 and ≤2.4</td><td>>1.5 and ≤3.5</td><td>Some growth effect on up to 5% of species.</td></tr>
<tr><td>C</td><td>>2.4 and ≤6.9</td><td>>3.5 and ≤9.8</td><td rowspan="2">Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects.</td></tr>
<tr><td>National Bottom Line</td><td>6.9</td><td>9.8</td></tr>
<tr><td>D</td><td>>6.9</td><td>>9.8</td><td>Impacts on growth of multiple species, and starts approaching acute impact level (ie risk of death) for sensitive species at higher concentrations (>20 mg/L)</td></tr>
</table>

Table 2: Attribute table from the Freshwater NPS for Ammonia toxicity.

Value	Ecosystem health		
Freshwater Body Type	Lakes and rivers		
Attribute	Ammonia (Toxicity)		
Attribute Unit	mg NH_4-N/L (milligrams ammoniacal-nitrogen per litre)		
Attribute State	Numeric Attribute State		Narrative Attribute State
	Annual Median*	Annual Maximum*	
A	≤0.03	≤0.05	99% species protection level: No observed effect on any species tested
B	>0.03 and ≤0.24	>0.05 and ≤0.40	95% species protection level: Starts impacting occasionally on the 5% most sensitive species
C	>0.24 and ≤1.30	>0.40 and ≤2.20	80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species)
National Bottom Line	**1.30**	**2.20**	
D	>1.30	>2.20	Starts approaching acute impact level (ie risk of death) for sensitive species

* Based on pH 8 and temperature of 20°C.

Compliance with the numeric attribute states should be undertaken after pH adjustment.

Appendix 2

Ammoniacal nitrogen:

T-test (2-sided) of paired samples

Significance level is 0.050

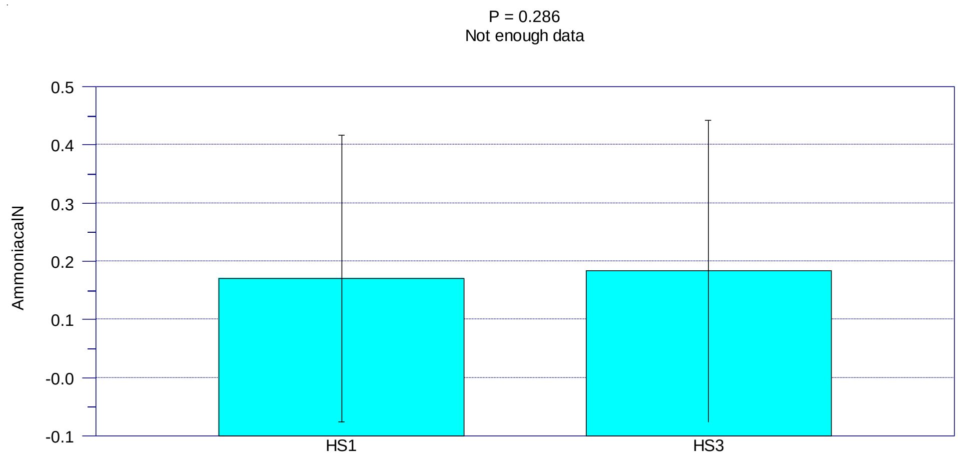
Site HS3 is greater than Site HS1.

Null hypothesis - not confident in direction-of-change:

Equivalence test strength: Weak - inconclusive

Not enough data

Variable: AmmoniacalN			
Grouping variable	HS1	HS3	Sum of paired diff.
N	67	67	
Means	0.170	0.183	-0.013
SD	0.246	0.259	0.189
t,df	0.567,66		
H_0: no difference	Fail to reject, P = 0.286		
H_i: difference lies beyond limits (inequivalence)	Fail to reject, P = 0.528		
H_e: difference lies within limits (equivalence)	Fail to reject, P = 0.569		
Bayesian posterior probability (%) that difference is within limits	47.195		



Dissolved reactive phosphorus (DRP):

T-test (2-sided) of paired samples

Significance level is 0.050

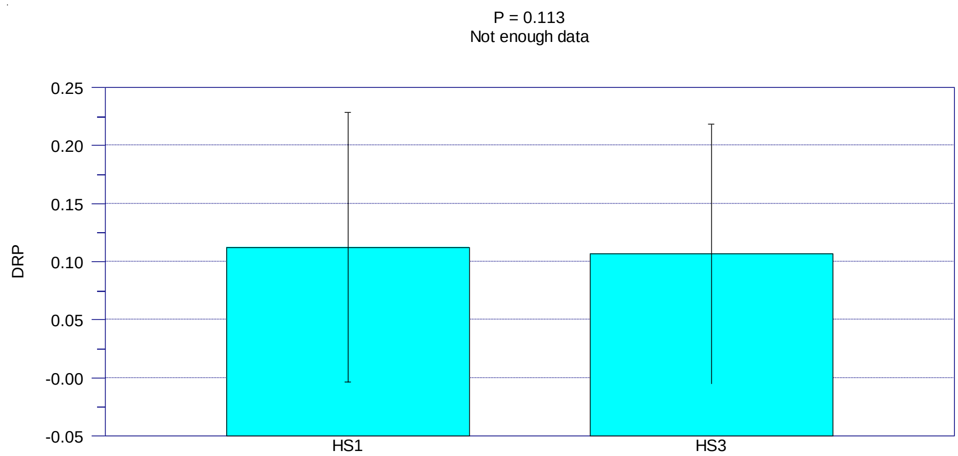
Site HS3 is smaller than Site HS1.

Null hypothesis - not confident in direction-of-change:

Equivalence test strength: Weak - inconclusive

Not enough data

Variable: DRP			
Grouping variable	HS1	HS3	Sum of paired diff.
N	47	47	
Means	0.112	0.107	0.006
SD	0.116	0.112	0.031
t,df	1.227,46		
H_0: no difference	Fail to reject, P = 0.113		
H_i: difference lies beyond limits (inequivalence)	Fail to reject, P = 0.106		
H_e: difference lies within limits (equivalence)	Fail to reject, P = 0.894		
Bayesian posterior probability (%) that difference is within limits	89.371		



Soluble Inorganic Nitrogen (SIN):

T-test (2-sided) of paired samples

Significance level is 0.050

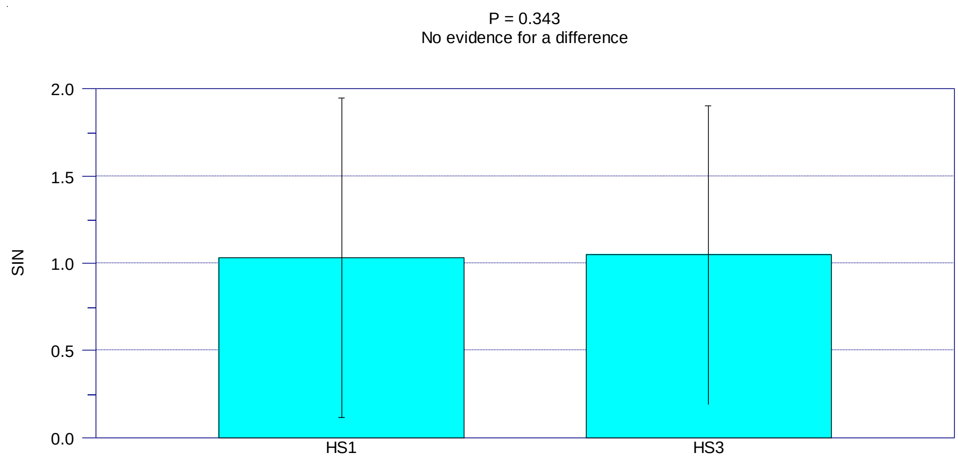
Site HS3 is greater than Site HS1.

Null hypothesis - not confident in direction-of-change:

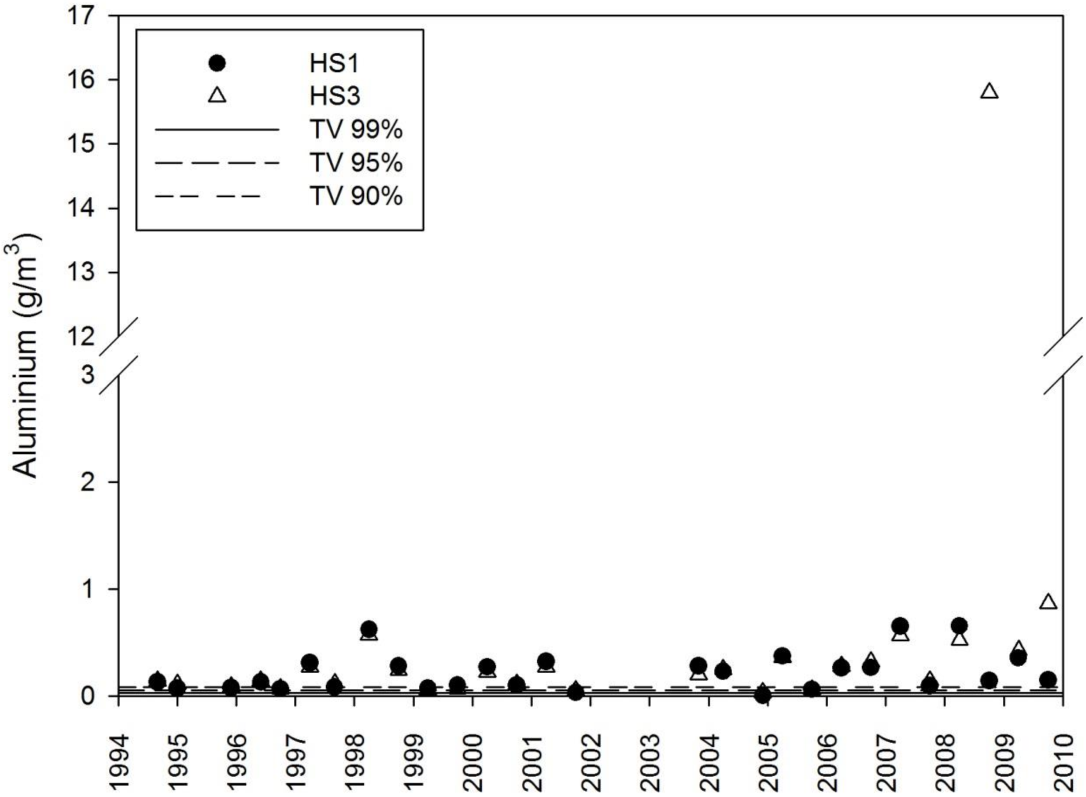
Equivalence test strength: Strong - difference is within equivalence limits

No evidence for a difference

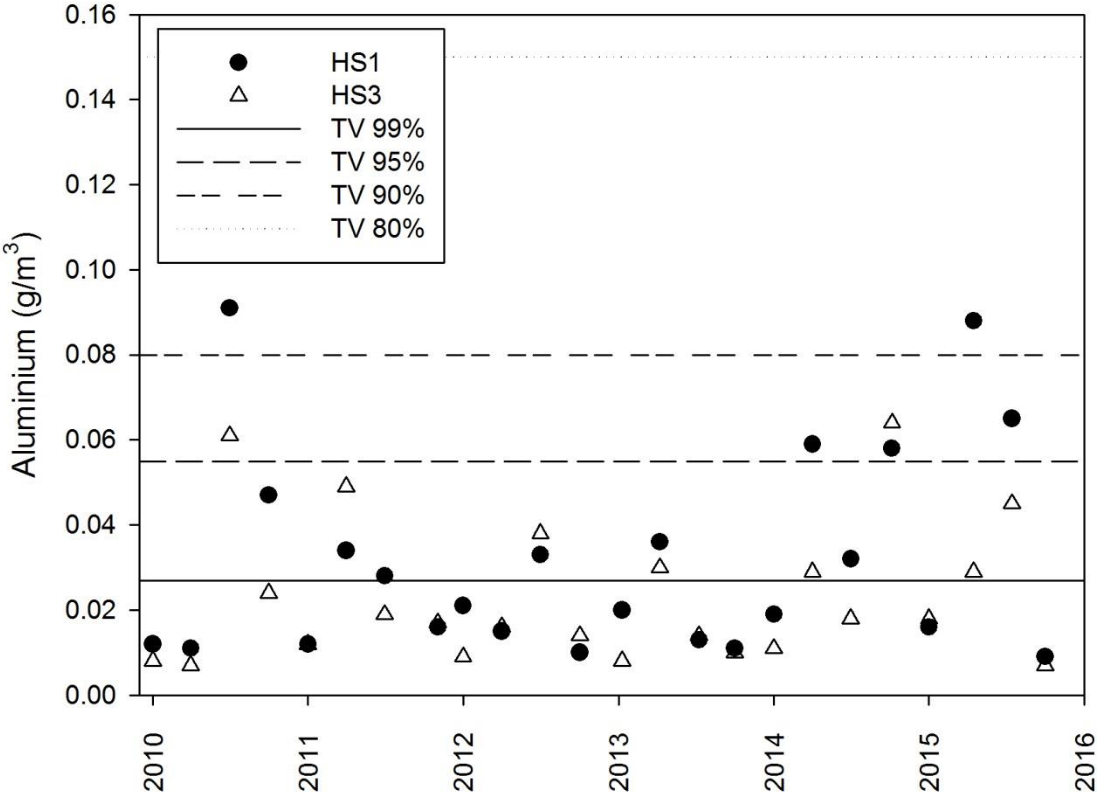
Variable: SIN			
Grouping variable	HS1	HS3	Sum of paired diff.
N	59	59	
Means	1.032	1.048	-0.016
SD	0.914	0.854	0.300
t,df	0.407,58		
H_0: no difference	Fail to reject, P = 0.343		
H_i: difference lies beyond limits (inequivalence)	Reject, P = 0.016		
H_e: difference lies within limits (equivalence)	Fail to reject, P = 0.986		
Bayesian posterior probability (%) that difference is within limits	98.438		



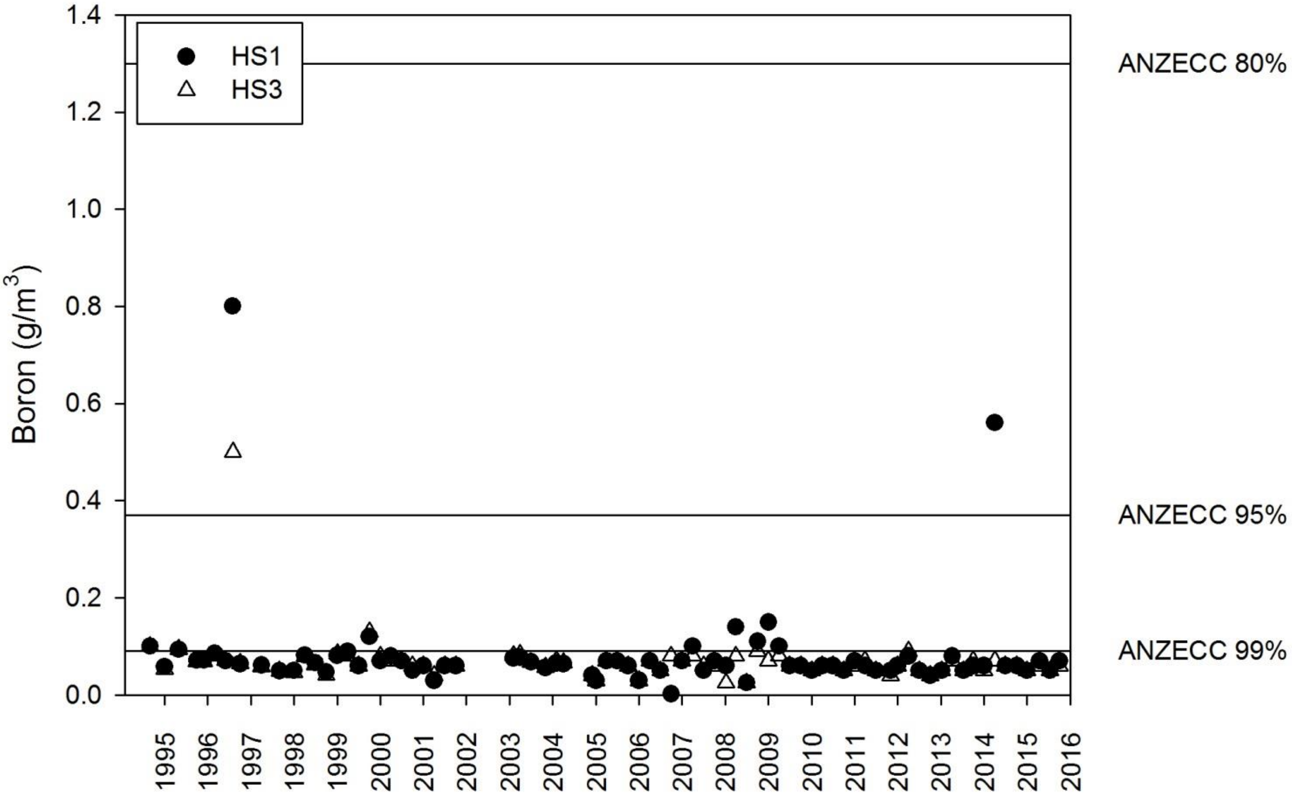
Appendix 3

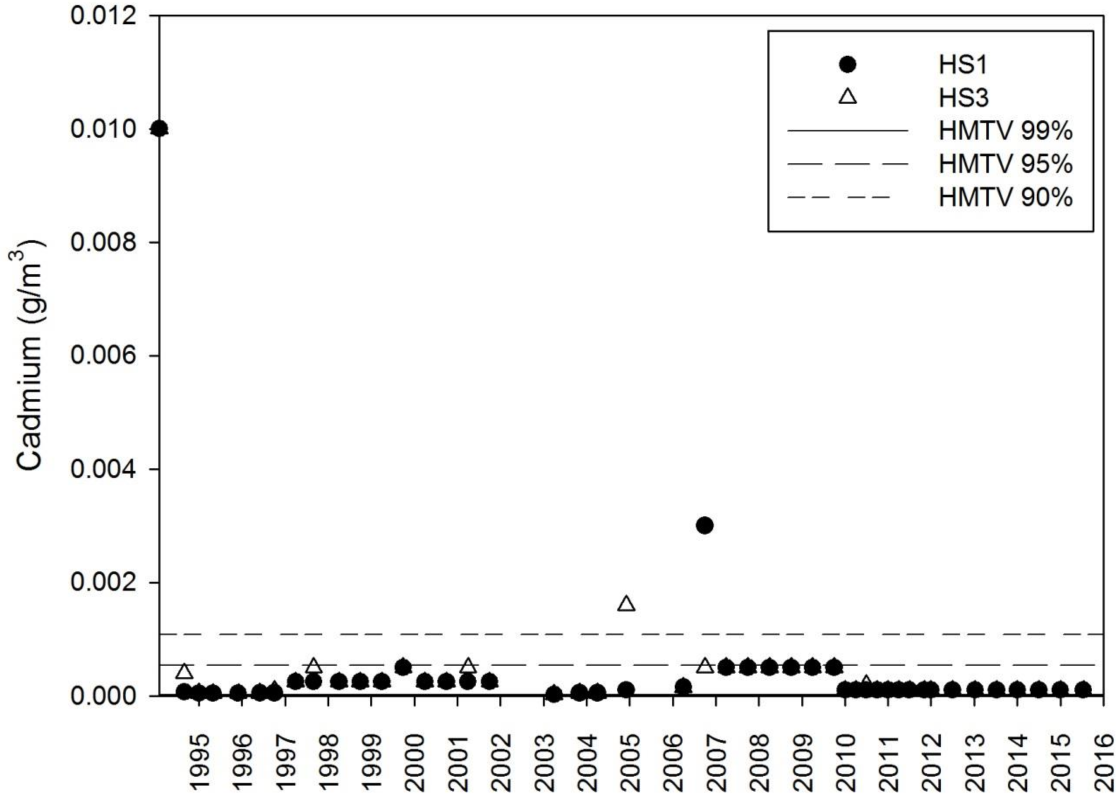


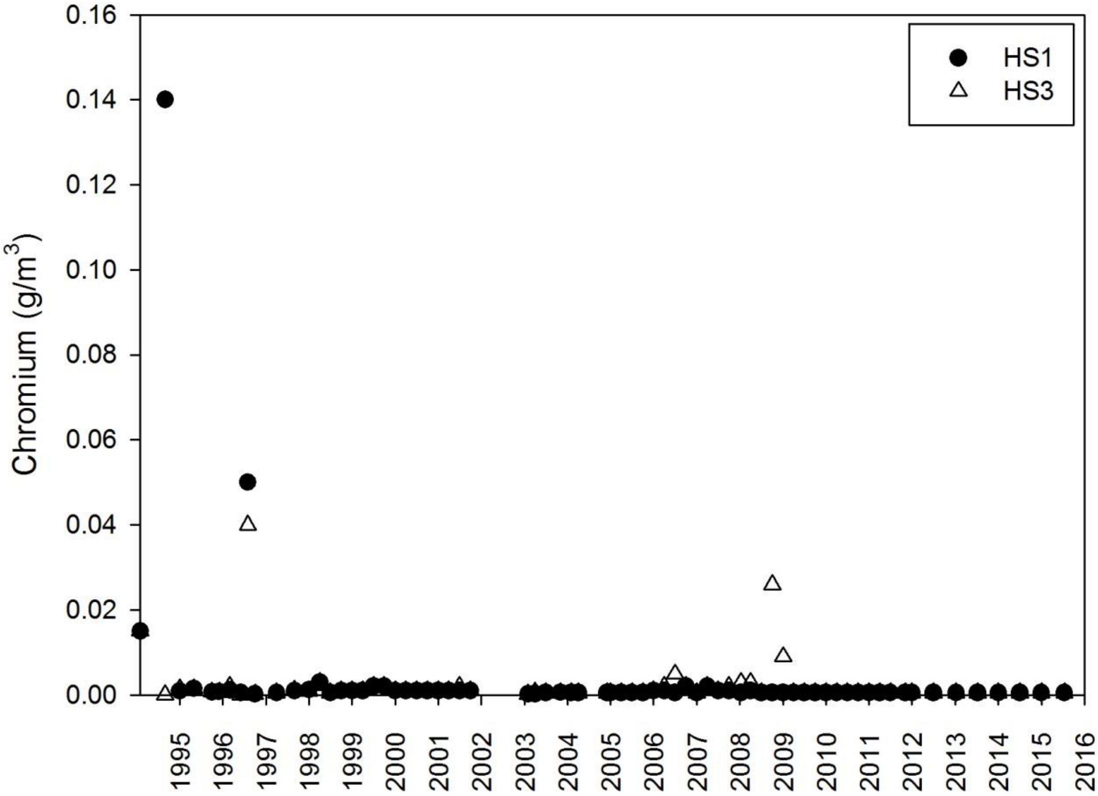
HS1
HS3
TV 99%
TV 95%
TV 90%
Aluminium (g/m3)
17
16
15
14
13
12
3
2
1
0
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010



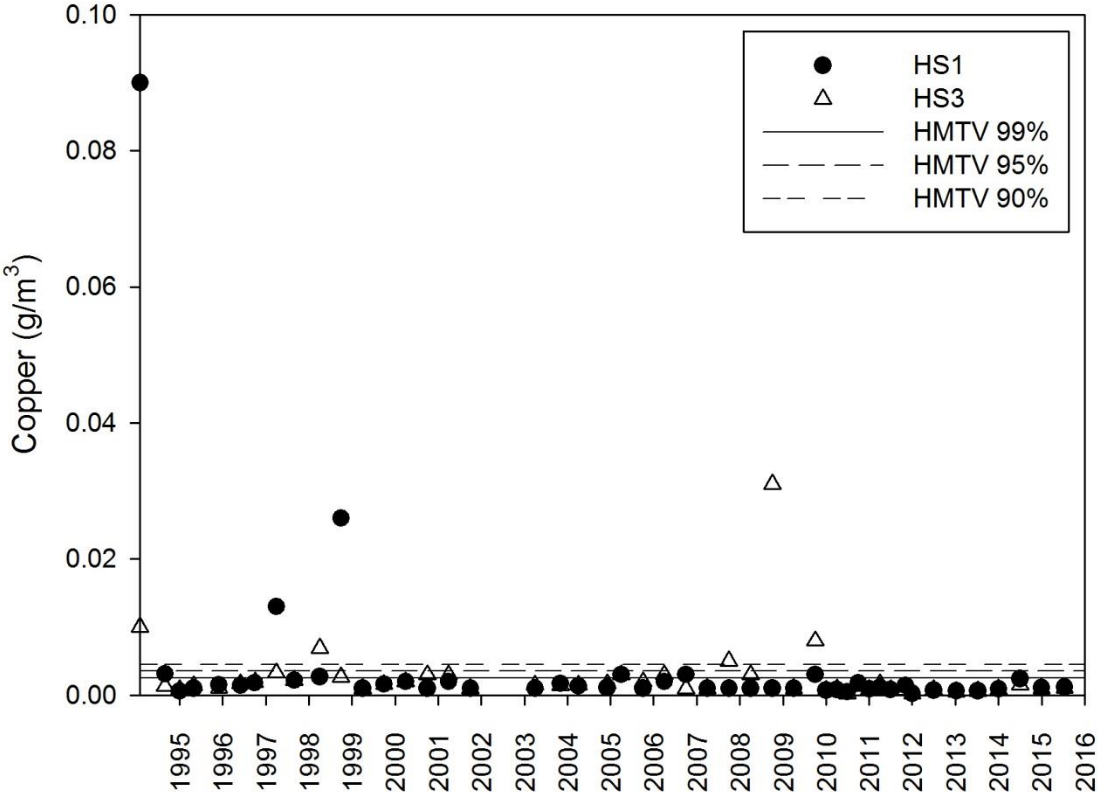
HS1
HS3
TV 99%
TV 95%
TV 90%
TV 80%
Aluminium (g/m3)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
2010
2011
2012
2013
2014
2015
2016


HS1
HS3
ANZECC 80%
ANZECC 95%
ANZECC 99%
Boron (g/m^3)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

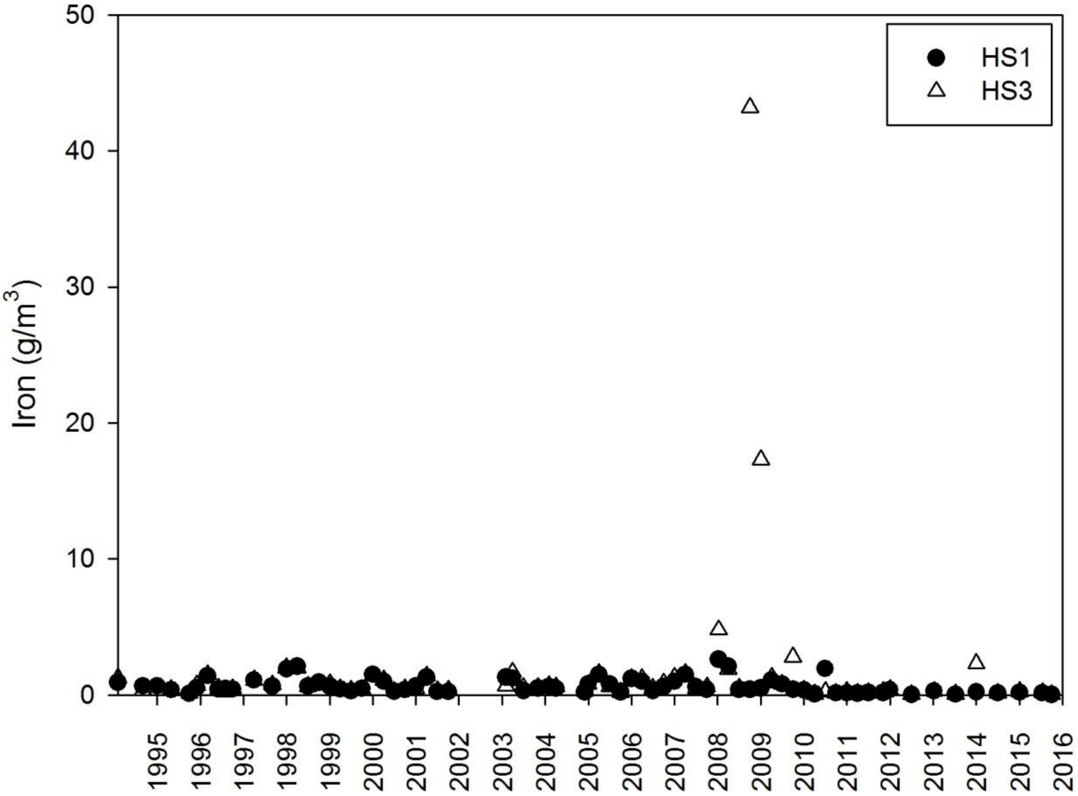

0.012
0.010
0.008
0.006
0.004
0.002
0.000
Cadmium (g/m^3)
HS1
HS3
HMTV 99%
HMTV 95%
HMTV 90%
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016



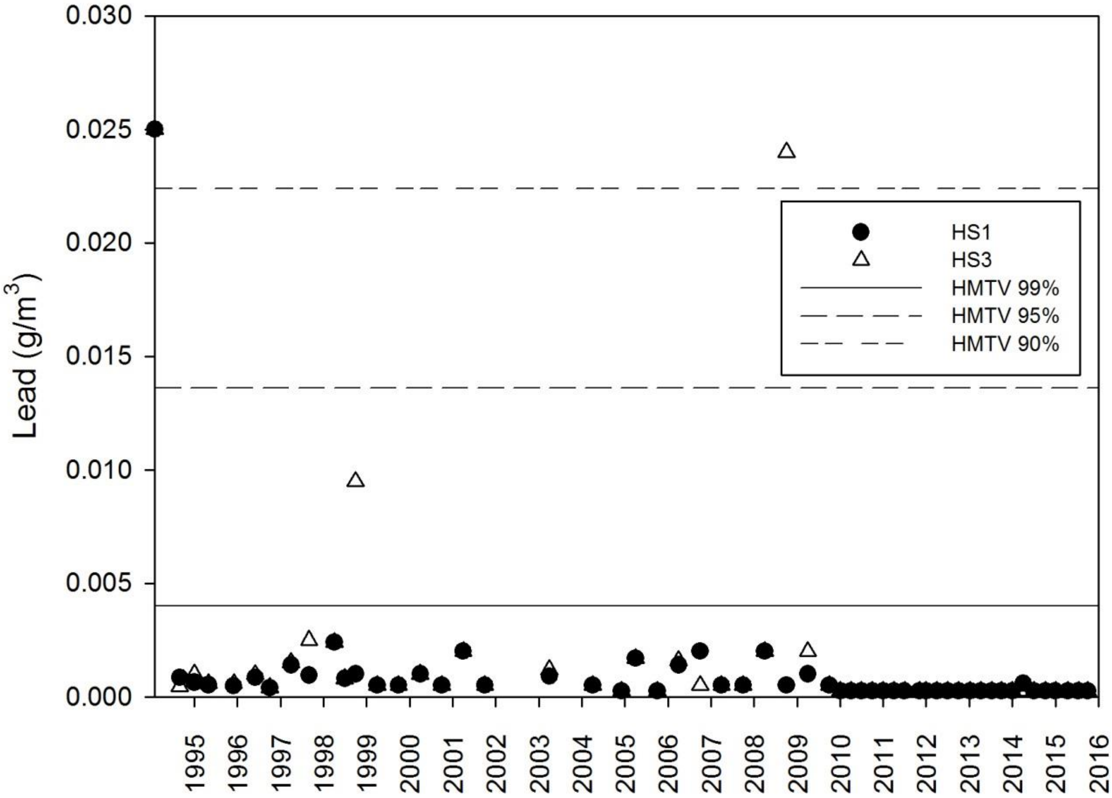
Chromium (g/m3)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
HS1
HS3
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

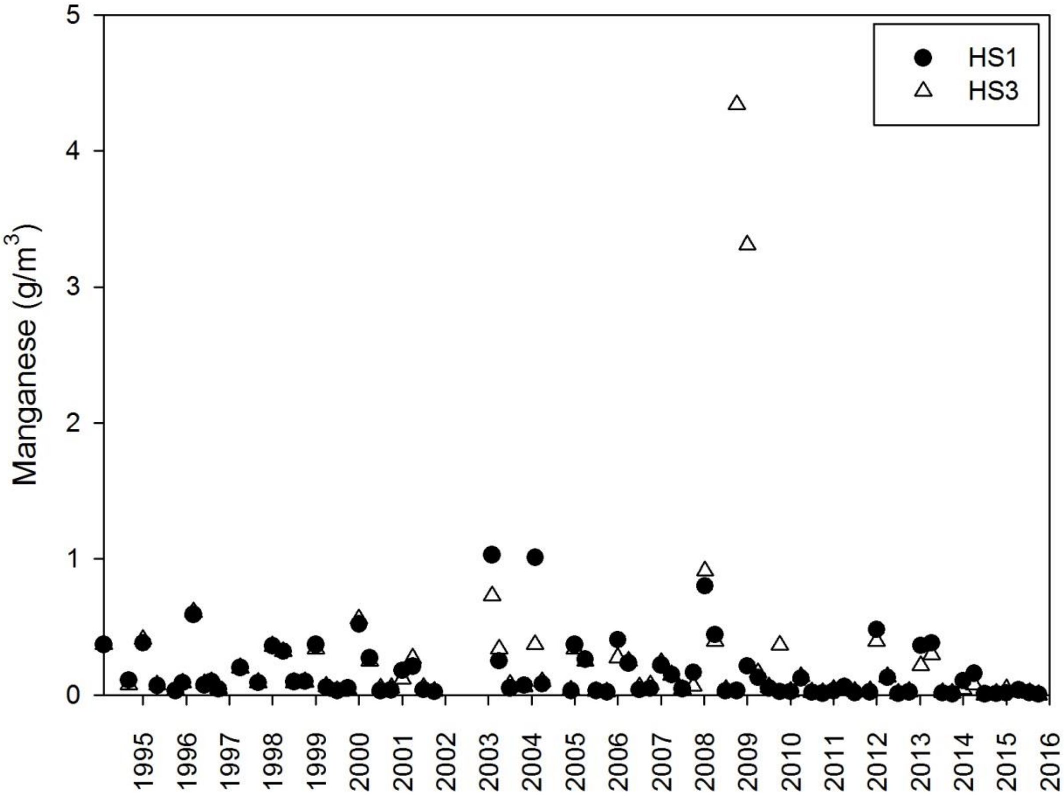


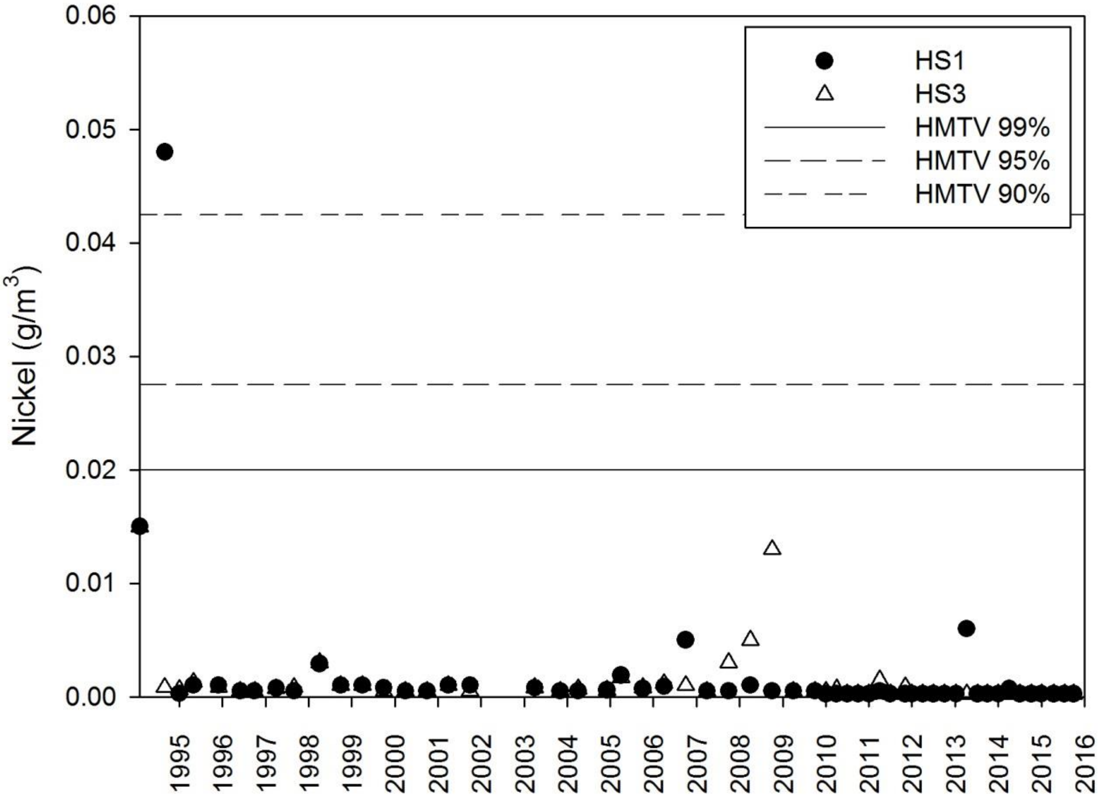
0.10
0.08
0.06
0.04
0.02
0.00
Copper (g/m3)
HS1
HS3
HMTV 99%
HMTV 95%
HMTV 90%
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016



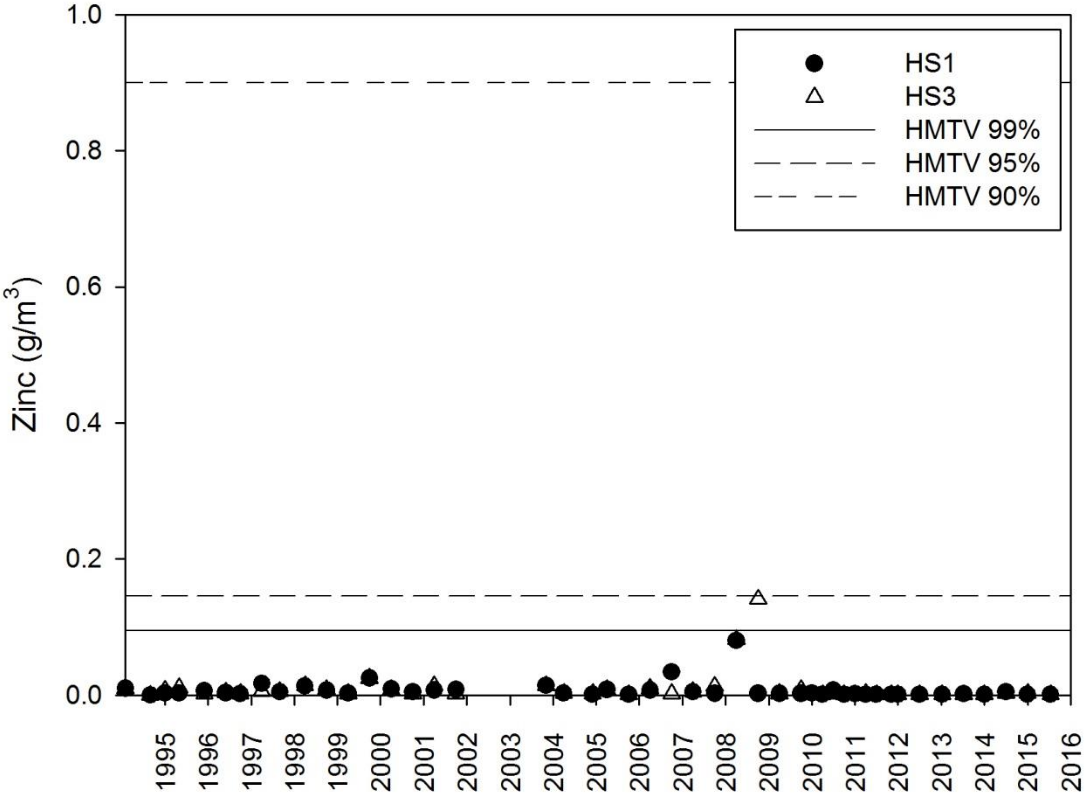
Iron (g/m3)
0
10
20
30
40
50
HS1
HS3
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016


0.030
0.025
0.020
0.015
0.010
0.005
0.000
Lead (g/m3)
HS1
HS3
HMTV 99%
HMTV 95%
HMTV 90%
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

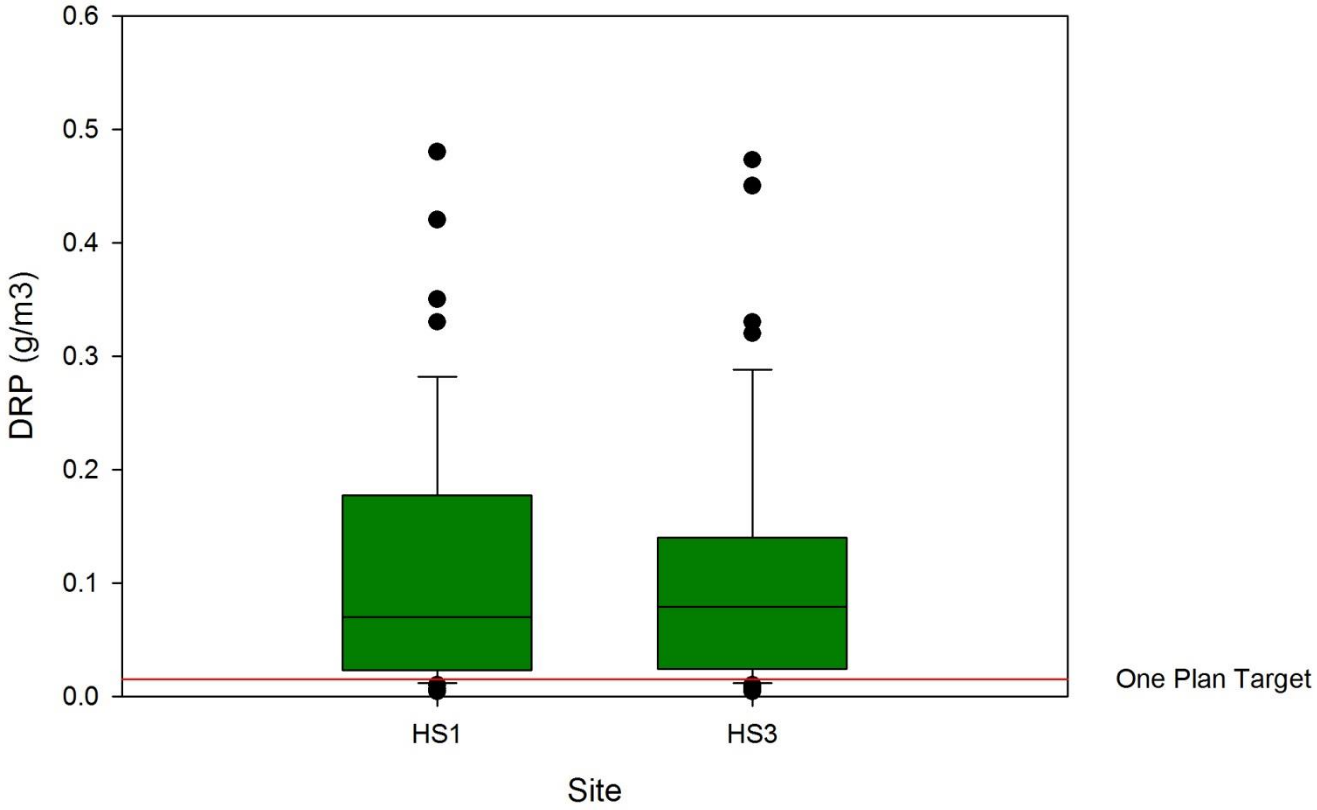

Manganese (g/m3)
HS1
HS3
0
1
2
3
4
5
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

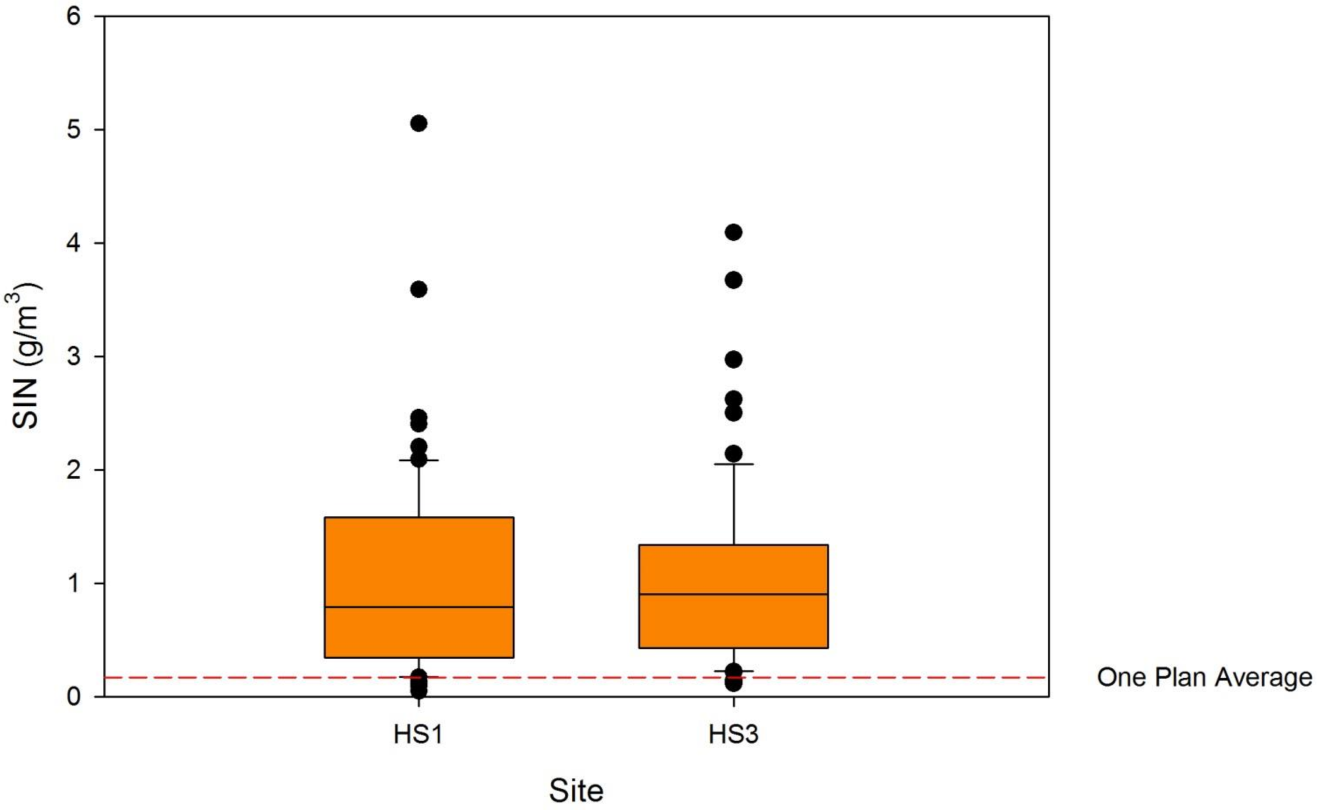


0.06
0.05
0.04
0.03
0.02
0.01
0.00
Nickel (g/m3)
HS1
HS3
HMTV 99%
HMTV 95%
HMTV 90%
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016



HS1
HS3
HMTV 99%
HMTV 95%
HMTV 90%
Zinc (g/m3)
1.0
0.8
0.6
0.4
0.2
0.0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016


0.6
0.5
0.4
0.3
0.2
0.1
0.0
DRP (g/m3)
HS1
HS3
Site
One Plan Target



6
5
4
3
2
1
0
SIN (g/m3)
HS1
HS3
Site
One Plan Average