Upper Waitemata Harbour Contaminant Study: Summary

August 2004 Technical Publication 250

Auckland Regional Council
Technical Publication No. 250, Aug 2004
ISSN 1175 205X ISBN 1-877353-65-5
www.arc.govt.nz

Printed on recycled paper

Upper Waitemata Harbour Contaminant Study : Summary Report

Malcolm Green
Mike Timperley
Rob Collins

Bruce Williamson
(Diffuse Sources Ltd)

Prepared for
Auckland Regional Council, North Shore City Council, Rodney District Council, Waitakere City Council and Transit New Zealand.

NIWA Client Report: HAM2004-129
August 2004

NIWA Project: ARC05233

National Institute of Water & Atmospheric Research Ltd
Gate 10, Silverdale Road, Hamilton
P O Box 11115, Hamilton, New Zealand
Phone +64-7-856 7026, Fax +64-7-856 0151
www.niwa.co.nz

Acknowledgement

This report was prepared for the Auckland Regional Council , the North Shore City Council, the Rodney District Council, the Waitakere City Council, and Transit New Zealand by the National Institute of Water and Atmospheric Research Limited (NIWA).

Contents

Executive Summary

As part of the design of what eventually became the Upper Waitemata Harbour Contaminant Study, the potential effects of catchment development on the Upper Harbour were considered in order to establish agreement on an approach for a comprehensive, catchment-wide environmental risk assessment.

Increased sediment runoff from the land into the harbour during development and ecological effects associated with that runoff were and are clearly of concern. However, full "sedimentation risk" modelling of the type carried out previously at Okura and Whitford was not undertaken due to the likely complexity and cost of modelling the relatively large, mixed-landuse Upper Waitemata catchment, and because the details of catchment development were not available at that time with sufficient precision to warrant that type of study. The management approach advocated in the absence of full sedimentation risk modelling was based on the adoption of high, precautionary-level controls (although some specific modelling at the subcatchment level may be required as more development detail becomes available).

A small companion modelling exercise on sediment-load and the effectiveness of precautionary-level controls associated with proposed rural residential development in the Waiarohia subcatchment was conducted in order to validate the decision not to proceed with full sedimentation risk modelling. The findings of this study are contained in a Working Report, which is available on request.

A further study has since evaluated the effect of uncertainties in the estimates of sediment yield from Rangitopuni subcatchment (which is the largest sediment source in the Upper Waitemata catchment) on the predictions of contaminant accumulation that have been made in the Contaminant Study. In addition, the effect on contaminant predictions of possible landuse change programmed for the Rangitopuni subcatchment has also been evaluated.

Study goal: To predict spatial patterns of zinc, copper and PAH accumulation throughout the Upper Waitemata Harbour under a number of different scenarios, where each scenario is characterised by a particular landuse, sediment controls and stormwater treatment:

- Existing scenario. This is the baseline simulation: it predicts future contaminant concentrations in bed sediments of the harbour based on landuse "frozen" at 2001.
- Development #1 scenario. This is the "realistic" simulation: it predicts contaminant concentrations under development proposed in each subcatchment for each year in the future. The future spatial pattern of earthworks sites and completed (mature) urban land is captured, complete with associated contaminant loads.
- Response-envelope scenario. Here, the sediment and contaminant loads used in the development #1 scenario are run with each of two stormwater treatments, these being zero treatment and maximum-attainable treatment. The two results bracket the results of the development #1 scenario, forming an envelope of responses in the harbour.

A summary of how each scenario is constituted is shown on the next page.

The results are presented in two sections:

- Section 1: Contaminant (Zinc, Copper, PAH) Accumulation in Subestuaries. This presents, for each subestuary in turn, predictions of contaminant (zinc, copper, PAH) concentrations in estuary bed sediments for 108 years from 2001 under each scenario. For each scenario, the times in the future when the concentrations are predicted to breach a number of sediment quality guidelines are tabulated. The principal sources of contaminant and sediment for each subestuary are tabulated. This section shows how rapidly contaminants build up in each subestuary, identifies subestuaries most at risk, and where management efforts should be directed.
- Section 2: Generation of Sediments and Contaminants (Zinc, Copper, PAH) in Subcatchments. This presents information on sediments and contaminants generated in each subcatchment, including a breakdown of urban versus "natural" (i.e., derived from soil weathering) sources of zinc and copper, a ranking of sources, and a comparison of where sediments and contaminants deposited in the subestuaries come from. This section links subestuary effects to subcatchment causes, thus showing where best management practices are most effectively focused.

Section 3 shows some key parameters used in modelling zinc, copper and PAHs (landuse under development #1, contaminant loads assumed in the model).

A second study goal was to predict spatial patterns of organochlorine pesticide accumulation throughout the Upper Waitemata Harbour.

Section 4 shows results for organochlorine pesticides (DDT being a primary one).

Section 5 gives references for the original reports that are summarised herein, as well as a citation for this summary.

Scenarios (Zinc, Copper, PAH)

Scenario	Comment	Landuse	Sediment Controls	Stormwater Treatment
Existing	This is the "baseline" simulation.	Frozen. *Landuse frozen at 2001.*	Frozen. *Earthworks only in Lucas Creek subcatchment. 50 % of earthwork areas subject to a sediment control with an average annual efficiency of about 70%. The remaining 50% of earthworks had no control.*	None.
Development #1	This is the "realistic" simulation.	Projected. *Each TA provided information describing projected landuse change.* *See Section 3 (Key Model Parameters) for details.*	Projected. *50 % of all earthwork areas subject to a sediment control with an average annual efficiency of about 70%. The remaining 50% of earthworks had no control.*	Projected. *Treatments were developed in consultation with the TAs.* *See Section 3 (Key Model Parameters) for details.*
Response Envelope	This scenario actually comprises two simulations. The two results bracket the results of the Development #1 scenario, thus forming an envelope of responses in the harbour.	Projected. *As above.*	Projected. *As above.*	None.
		Projected. *As above.*	Projected. *As above.*	Maximum-attainable. *See Section 3 (Key Model Parameters) for details.*

SECTION 1: Contaminant (Zinc, Copper, PAH) Accumulation in Subestuaries

Contaminant Concentrations

All contaminant concentrations in this section are expressed as mass of contaminant per mass of total sediment in the surface bioturbated layer, which, on the basis of a range of observations, is assumed to be 11 cm thick.

Sediment Quality Guidelines

Environmental response criteria (ERC) are used to assess whether the concentrations of contaminants present in receiving-water sediments are likely to result in adverse environmental effects. The ANZECC (2000)[1] Sediment Quality Guideline approach was used in the development of specific ERC for Auckland. The ERC are trigger values, in that breaches are meant to trigger further investigations. They are not pass–fail numbers, but benchmarks for action.

- Concentrations in the green zone (i.e., below the ERC amber traffic light) are okay and the biology of the site is unlikely to be impacted.
- Concentrations in the amber zone (i.e., above the ERC amber traffic light but below the ERC red traffic light) indicate contaminant levels are elevated and the biology of the site is possibly impacted.
- Concentrations in the red zone (i.e., above the red traffic light) indicate that contaminant levels are high and the biology of the site is probably impacted.
- ISQG-Hi is the ANZECC Interim Sediment Quality Guideline-High value. Breaching this value is regarded as in indication of serious impacts[1].

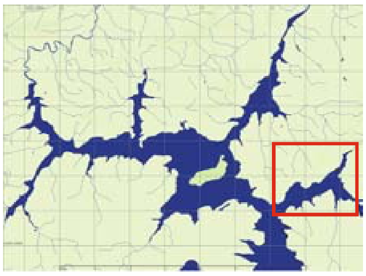
The reader is referred to "Sediment Quality Guidelines for the Regional Discharges Project" (Diffuse Sources Ltd, 2002) for more information.

	ERC Amber (mg/kg)	ERC Red (mg/kg)	ISQG-Hi (mg/kg)
Zinc	125	150	410
Copper	19	34	270
PAH[2]	0.66	1.7	9.6

[1] Refer to http://www.mfe.govt.nz/publications/water/anzecc-water-quality-guide-02/ for more details.
[2] High molecular weight PAH, concentration normalised to 1% TOC

Notes on PAH Predictions

1. PAH predictions are almost certainly over-estimates of future trends, but we cannot quantify the extent of that over-estimation. Hence, the PAH predictions should be treated with caution and not given the same weight as the zinc predictions in the planning process.
2. PAH concentrations are normalised to 1% total organic carbon (TOC) by assuming an average TOC for all UWH sediments of 2%.

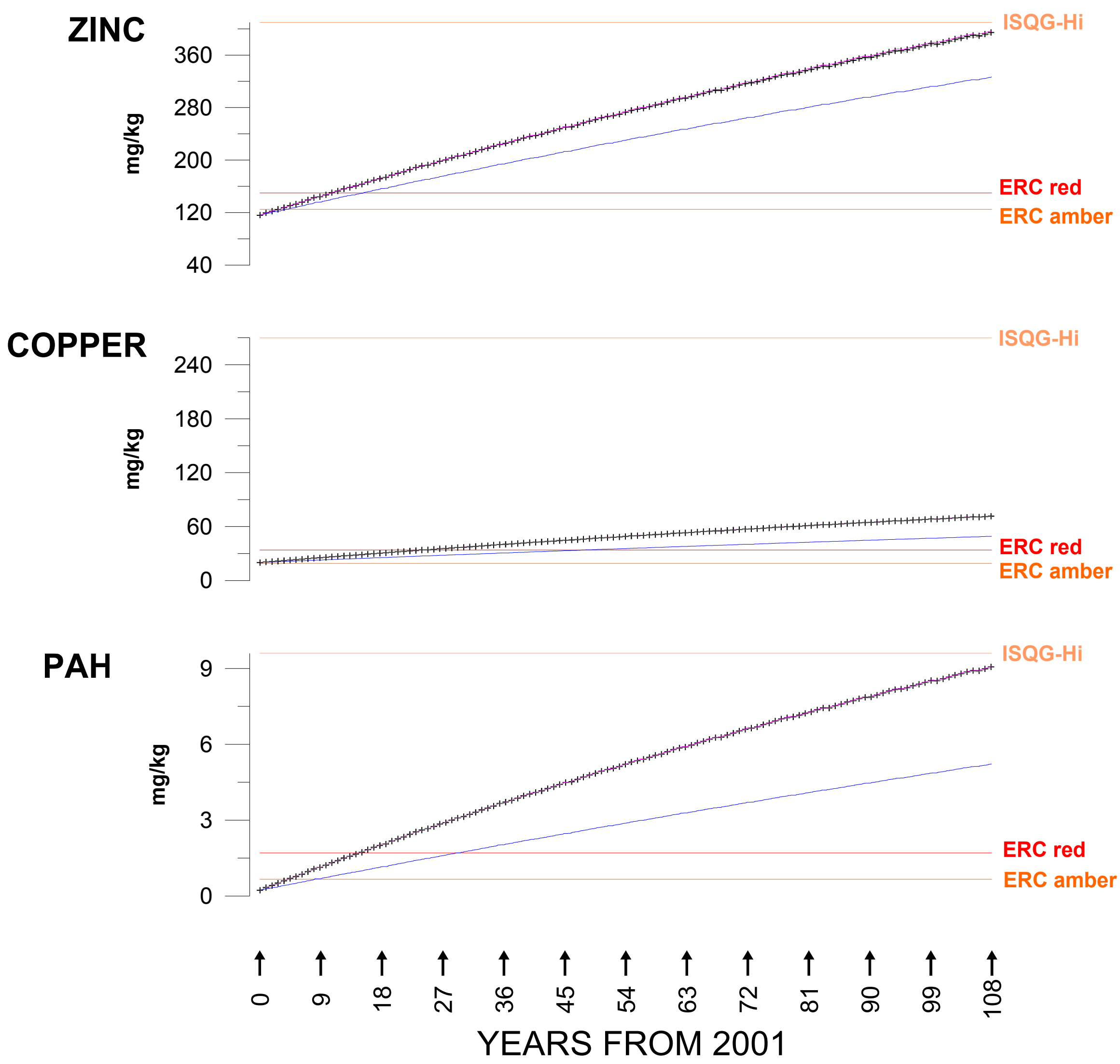


Hellyers Creek

(1) Future contaminant concentrations in estuarine bed sediments

SCENARIO

- Response envelope (no stormwater treatment)
- Development #1
- Response envelope (maximum-attainable stormwater treatment)
- Existing



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Hellyers Creek

(2) Time before sediment quality guidelines breached

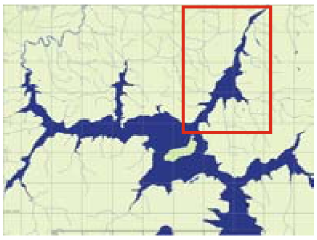
Response envelope

	Existing Scenario	No s/w treatment	Development #1 Scenario	Max. attainable s/w treatment
Years from 2001 to breach ERC amber traffic light				
Zinc	3.1	3.1	3.1	4.0
Copper	*	*	*	*
PAH	4.3	4.3	4.3	8.1
Years from 2001 to breach ERC red traffic light				
Zinc	10.5	10.5	10.5	15.3
Copper	24.4	24.3	24.4	48.5
PAH	14.7	14.7	14.7	28.9
Years from 2001 to breach ANZECC ISQG-Hi				
Zinc	>	>	>	>
Copper	>	>	>	>
PAH	>	>	>	>

* signifies initial concentration exceeds traffic light
> signifies traffic light is not exceeded within 108 years

(3) Principal sources of sediment and contaminant (Development #1 scenario, 108 years)

Subcatchment	Percent	Mass (kg)	Subcatchment	Percent	Mass (kg)
Sediment			***Zinc***		
Hellyers	99	5.30E+07	Hellyers	99.2	4.29E+04
Rangitopuni	0.4	2.07E+05	Waiarohia	0.5	2.28E+02
Paremoremo	0.3	1.57E+05	Lucas	0.1	5.06E+01
Copper			***PAH***		
Hellyers	99.6	7.88E+03	Hellyers	99.6	2.37E+03
Waiarohia	0.2	1.96E+01	Waiarohia	0.3	6.35E+00
Lucas	0.1	5.71E+00	Lucas	0.1	1.45E+00



Lucas Creek

(1) Future contaminant concentrations in estuarine bed sediments

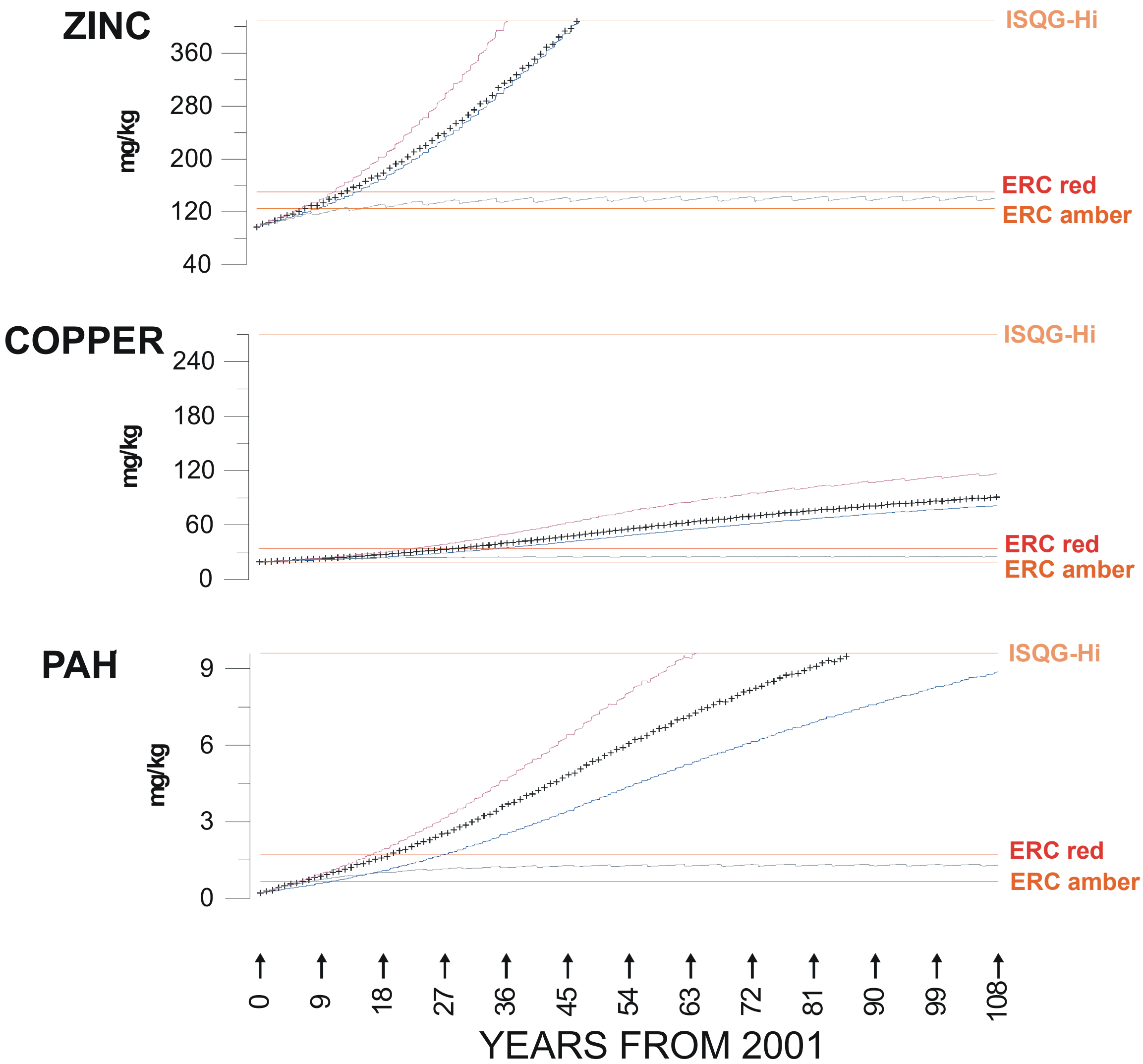
SCENARIO

Response envelope (no stormwater treatment)

Development #1

Response envelope (maximum-attainable stormwater treatment)

Existing



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Lucas Creek

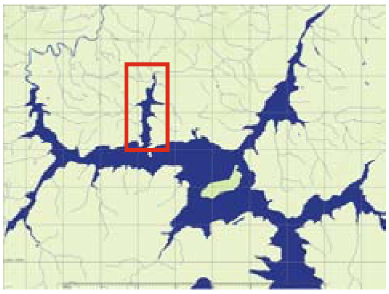
(2) Time before sediment quality guidelines breached

Response envelope

	Existing Scenario	No s/w treatment	Development #1 Scenario	Max. attainable s/w treatment
Years from 2001 to breach ERC amber traffic light				
Zinc	12.7	6.8	7.2	9.2
Copper	*	*	*	*
PAH	7.5	5.5	6.3	10.4
Years from 2001 to breach ERC red traffic light				
Zinc	>	11.4	12.9	14.7
Copper	>	22.7	28.9	35.0
PAH	>	16.6	19.0	26.9
Years from 2001 to breach ANZECC ISQG-Hi				
Zinc	>	36.9	47.3	47.3
Copper	>	>	>	>
PAH	>	63.9	86.7	>
* signifies initial concentration exceeds traffic light > signifies traffic light is not exceeded within 108 years				

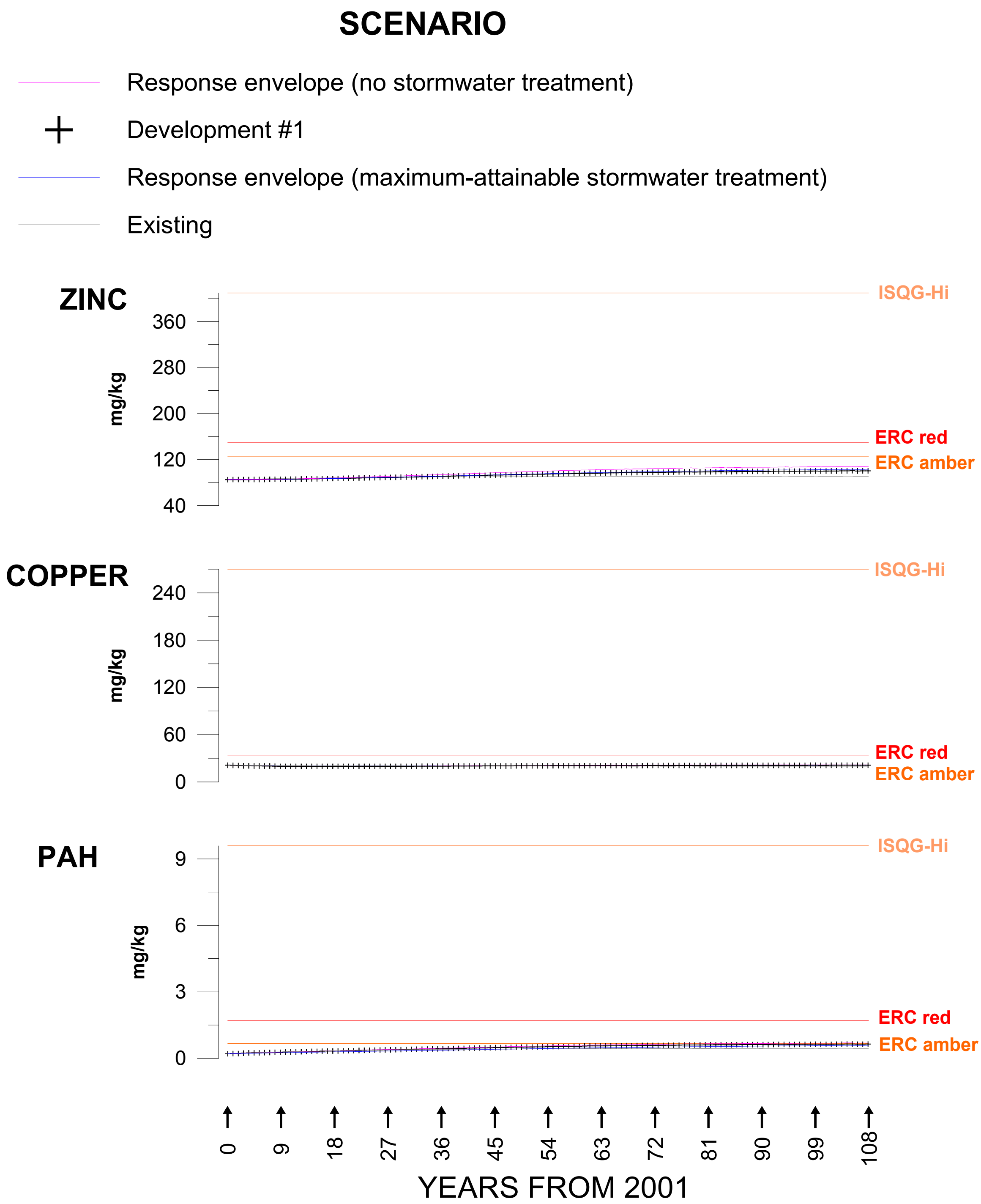
(3) Principal sources of sediment and contaminant (Development #1 scenario, 108 years)

Subcatchment	Percent	Mass (kg)	Subcatchment	Percent	Mass (kg)
Sediment			***Zinc***		
Lucas	95.7	1.97E+08	Lucas	96.6	1.51E+05
Paremoremo	1.6	3.37E+06	Waiarohia	1.9	3.01E+03
Hellyers	1.3	2.58E+06	Hellyers	1.0	1.51E+03
Copper			***PAH***		
Lucas	95.5	1.53E+04	Lucas	95.4	4.09E+03
Hellyers	1.9	3.09E+02	Hellyers	2.1	9.00E+01
Waiarohia	1.6	2.60E+02	Waiarohia	2.0	8.41E+01



Paremoremo

(1) Future contaminant concentrations in estuarine bed sediments



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Paremoremo

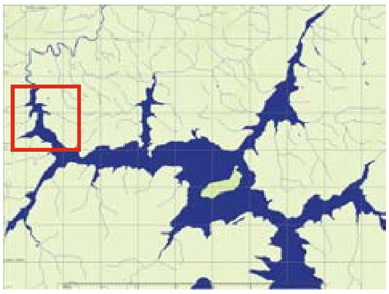
(2) Time before sediment quality guidelines breached

Response envelope

	Existing Scenario	No s/w treatment	Development #1 Scenario	Max. attainable s/w treatment
Years from 2001 to breach ERC amber traffic light				
Zinc	>	>	>	>
Copper	*	*	*	*
PAH	>	86.5	>	>
Years from 2001 to breach ERC red traffic light				
Zinc	>	>	>	>
Copper	>	>	>	>
PAH	>	>	>	>
Years from 2001 to breach ANZECC ISQG-Hi				
Zinc	>	>	>	>
Copper	>	>	>	>
PAH	>	>	>	>
* signifies initial concentration exceeds traffic light > signifies traffic light is not exceeded within 108 years				

(3) Principal sources of sediment and contaminant (Development #1 scenario, 108 years)

Subcatchment	Percent	Mass (kg)	Subcatchment	Percent	Mass (kg)
Sediment			***Zinc***		
Paremoremo	95.4	1.98E+08	Paremoremo	86.3	1.71E+04
Rangitopuni	3.6	7.43E+06	Waiarohia	4.0	7.87E+02
Hellyers	0.6	1.32E+06	Rangitopuni	3.9	7.71E+02
Copper			***PAH***		
Paremoremo	89.1	3.70E+03	Paremoremo	59.7	1.34E+02
Rangitopuni	4.3	1.78E+02	Hellyers	19.8	4.45E+01
Hellyers	3.7	1.54E+02	Waiarohia	9.8	2.20E+01

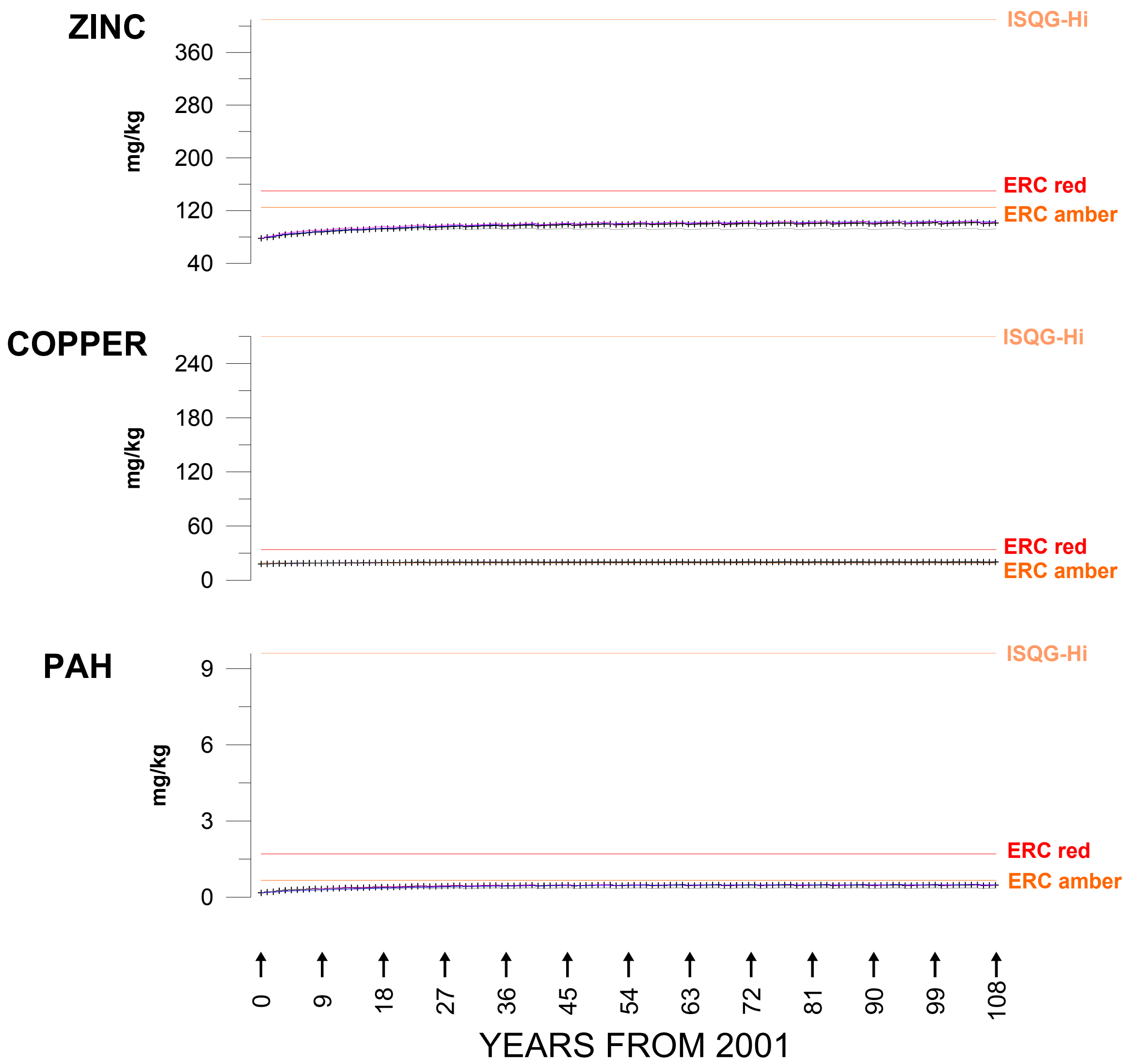


Rangitopuni

(1) Future contaminant concentrations in estuarine bed sediments

SCENARIO

- Response envelope (no stormwater treatment)
- Development #1
- Response envelope (maximum-attainable stormwater treatment)
- Existing



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Rangitopuni

(2) Time before sediment quality guidelines breached

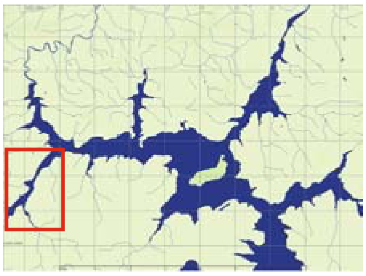
Response envelope

	Existing Scenario	No s/w treatment	Development #1 Scenario	Max. attainable s/w treatment
Years from 2001 to breach ERC amber traffic light				
Zinc	>	>	>	>
Copper	6.9	6.8	8.0	14.1
PAH	>	>	>	>
Years from 2001 to breach ERC red traffic light				
Zinc	>	>	>	>
Copper	>	>	>	>
PAH	>	>	>	>
Years from 2001 to breach ANZECC ISQG-Hi				
Zinc	>	>	>	>
Copper	>	>	>	>
PAH	>	>	>	>

* signifies initial concentration exceeds traffic light
> signifies traffic light is not exceeded within 108 years

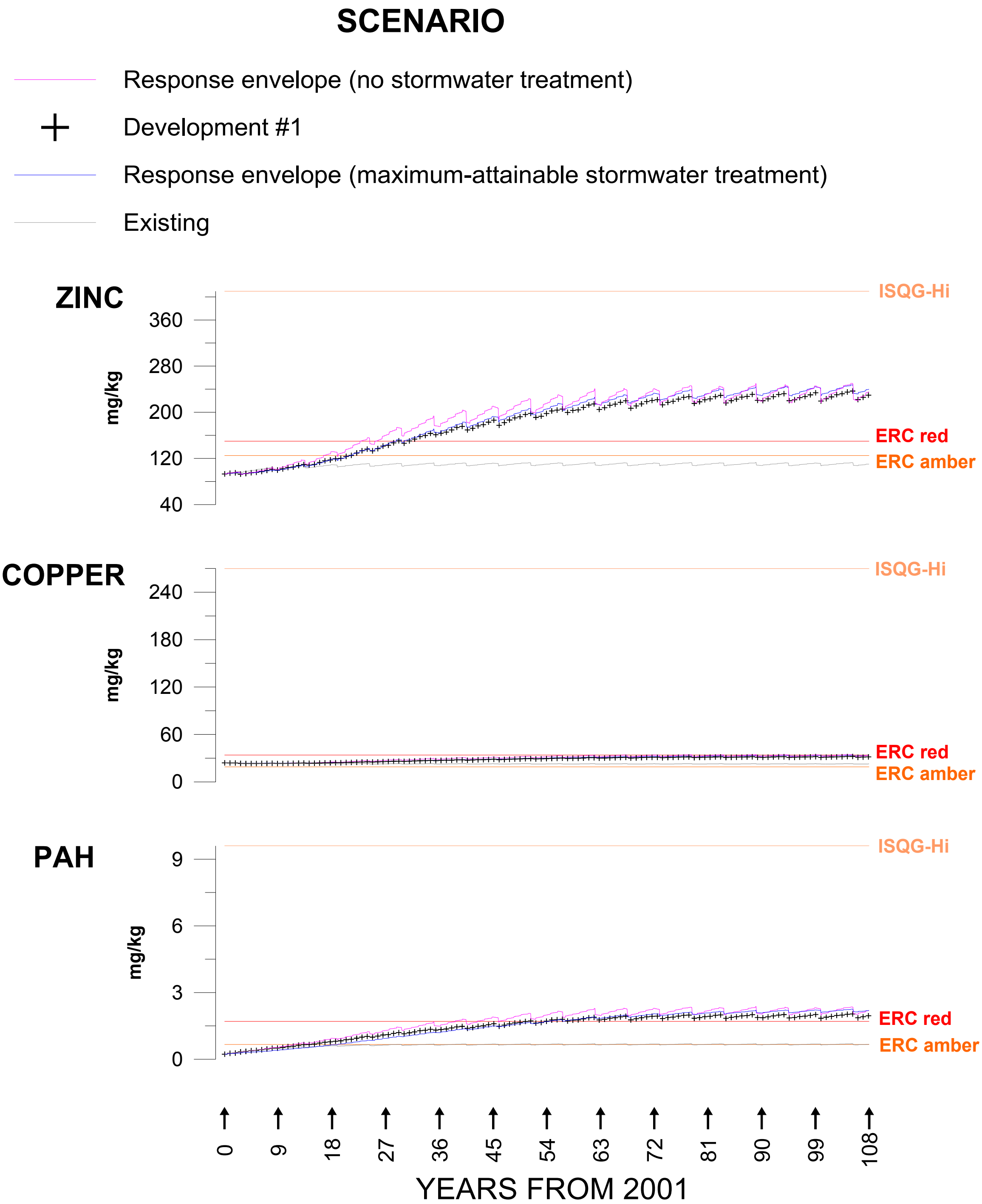
(3) Principal sources of sediment and contaminant (Development #1 scenario, 108 years)

Subcatchment	Percent	Mass (kg)	Subcatchment	Percent	Mass (kg)
Sediment			***Zinc***		
Rangitopuni	99.1	6.90E+08	Rangitopuni	94.3	6.50E+04
Hellyers	0.3	1.93E+06	Waiarohia	2.2	1.52E+03
Brighams	0.2	1.57E+06	Hellyers	1.9	1.29E+03
Copper			***PAH***		
Rangitopuni	96.5	1.51E+04	Rangitopuni	82.2	7.16E+02
Hellyers	1.7	2.60E+02	Hellyers	8.8	7.71E+01
Waiarohia	0.9	1.33E+02	Waiarohia	4.9	4.24E+01



Brighams

(1) Future contaminant concentrations in estuarine bed sediments



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Brighams

(2) Time before sediment quality guidelines breached

Response envelope

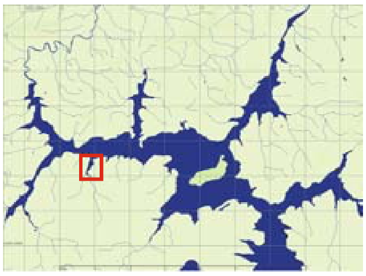
	Existing Scenario	No s/w treatment	Development #1 Scenario	Max. attainable s/w treatment
Years from 2001 to breach ERC amber traffic light				
Zinc	>	16.6	21.1	21.1
Copper	*	*	*	*
PAH	28.9	11.7	14.1	19.0
Years from 2001 to breach ERC red traffic light				
Zinc	>	22.7	28.9	28.8
Copper	>	77.6	>	>
PAH	>	38.7	50.6	54.6
Years from 2001 to breach ANZECC ISQG-Hi				
Zinc	>	>	>	>
Copper	>	>	>	>
PAH	>	>	>	>

* signifies initial concentration exceeds traffic light

> signifies traffic light is not exceeded within 108 years

(3) Principal sources of sediment and contaminant (Development #1 scenario, 108 years)

Subcatchment	Percent	Mass (kg)	Subcatchment	Percent	Mass (kg)
Sediment			***Zinc***		
Rangitopuni	53.1	1.02E+08	Brighams	68.3	2.61E+04
Brighams	45.6	8.73E+07	Rangitopuni	27.6	1.06E+04
Rarawaru	0.6	1.23E+06	Rarawaru	3.1	1.17E+03
Copper			***PAH***		
Brighams	52.6	2.99E+03	Brighams	74.5	5.86E+02
Rangitopuni	42.8	2.43E+03	Rangitopuni	15.8	1.24E+02
Rarawaru	3.5	1.98E+02	Rarawaru	7.9	6.22E+01



Rarawaru

(1) Future contaminant concentrations in estuarine bed sediments

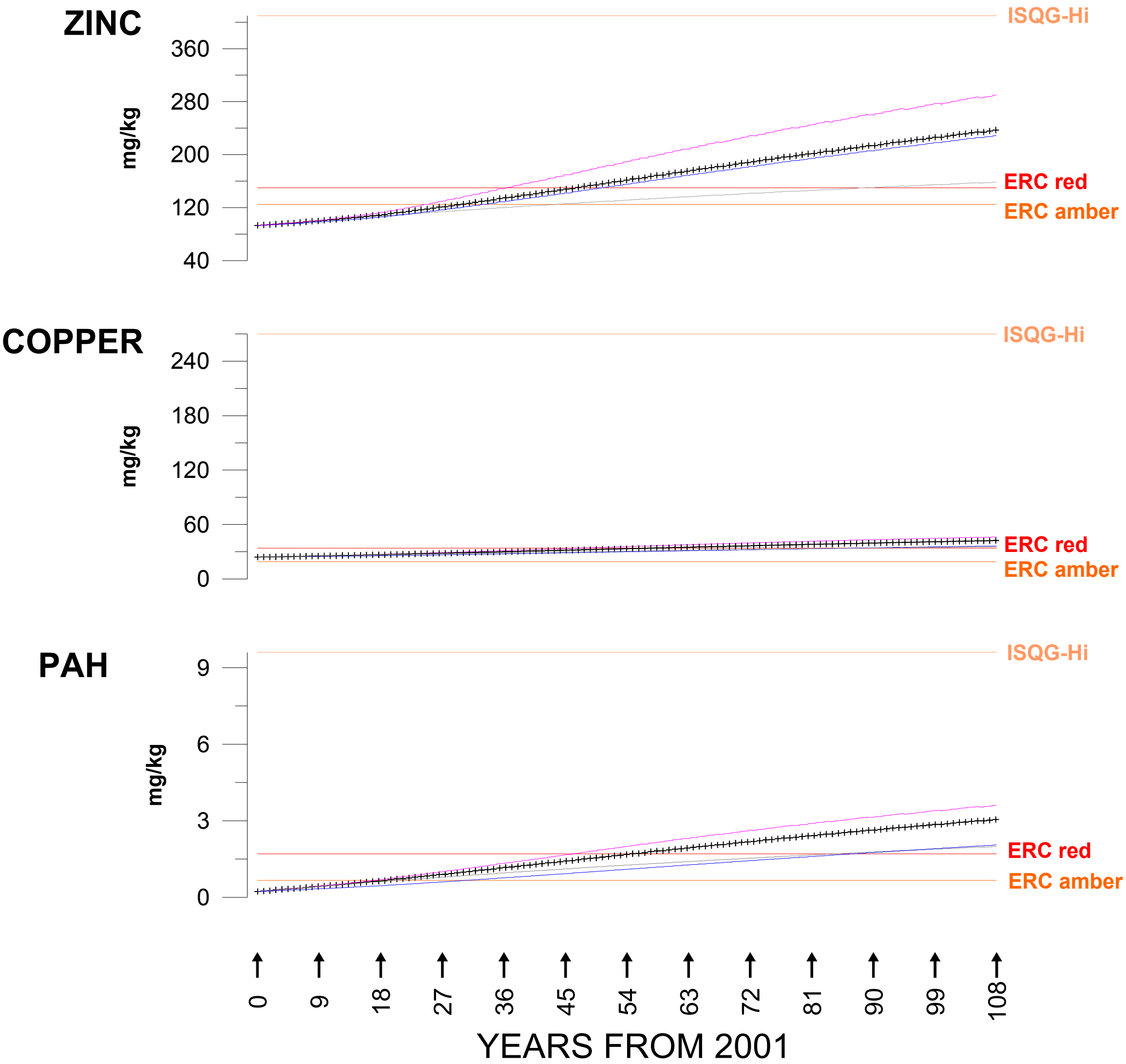
SCENARIO

Response envelope (no stormwater treatment)

Development #1

Response envelope (maximum-attainable stormwater treatment)

Existing



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Rarawaru

(2) Time before sediment quality guidelines breached

Response envelope

	Existing Scenario	No s/w treatment	Development #1 Scenario	Max. attainable s/w treatment
Years from 2001 to breach ERC amber traffic light				
Zinc	43.6	25.2	30.1	33.6
Copper	*	*	*	*
PAH	20.3	16.9	18.9	30.1
Years from 2001 to breach ERC red traffic light				
Zinc	88.9	36.2	46.5	50.6
Copper	91.4	47.8	58.0	88.2
PAH	84.4	46.0	54.6	87.3
Years from 2001 to breach ANZECC ISQG-Hi				
Zinc	>	>	>	>
Copper	>	>	>	>
PAH	>	>	>	>

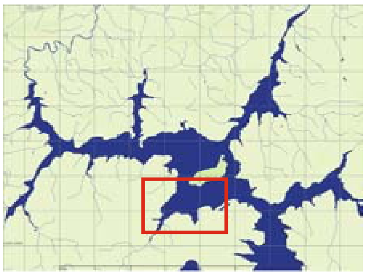
* signifies initial concentration exceeds traffic light

> signifies traffic light is not exceeded within 108 years

(3) Principal sources of sediment and contaminant (Development #1 scenario, 108 years)

Subcatchment	Percent	Mass (kg)	Subcatchment	Percent	Mass (kg)
Sediment			***Zinc***		
Brighams	58.7	3.92E+06	Brighams	43.5	1.23E+03
Rarawaru	23.1	1.54E+06	Rarawaru	43.5	1.23E+03
Rangitopuni	13.7	9.16E+05	Lucas	7.6	2.16E+02
Copper			***PAH***		
Rarawaru	56.3	2.41E+02	Rarawaru	58.6	5.44E+01
Brighams	31.9	1.37E+02	Brighams	31.3	2.91E+01
Lucas	5.2	2.21E+01	Lucas	6.7	6.23E+00

Waiarohia



(1) Future contaminant concentrations in estuarine bed sediments

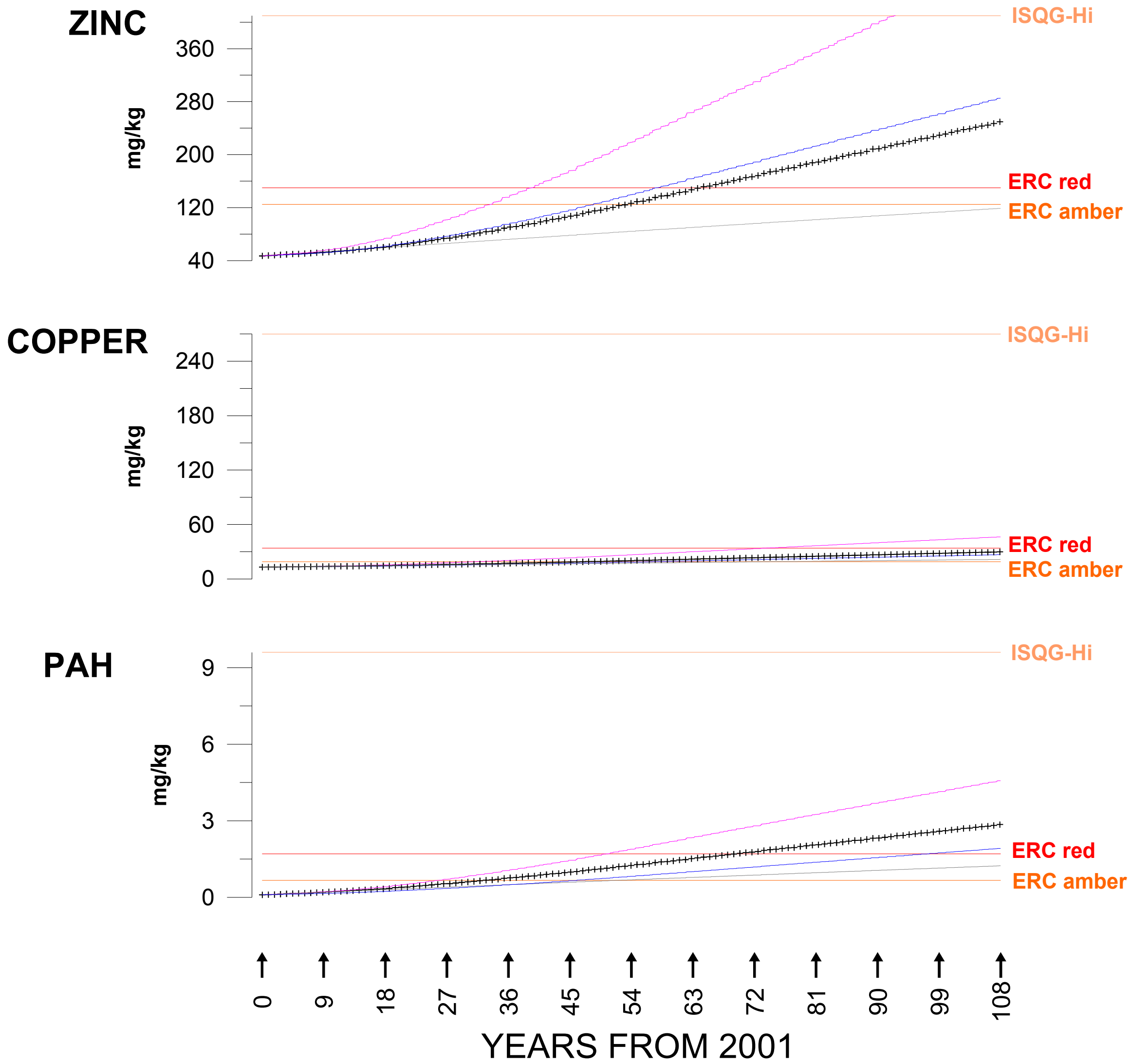
SCENARIO

Response envelope (no stormwater treatment)

Development #1

Response envelope (maximum-attainable stormwater treatment)

Existing



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Waiarohia

(2) Time before sediment quality guidelines breached

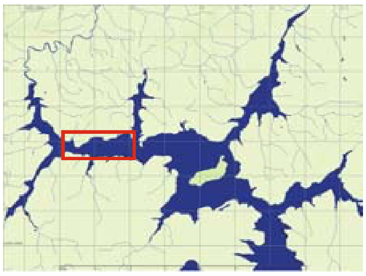
Response envelope

	Existing Scenario	No s/w treatment	Development #1 Scenario	Max. attainable s/w treatment
Years from 2001 to breach ERC amber traffic light				
Zinc	>	33.6	53.4	48.5
Copper	75.5	31.7	47.3	57.4
PAH	52.1	25.9	32.5	46.0
Years from 2001 to breach ERC red traffic light				
Zinc	>	39.4	64.4	57.7
Copper	>	74.3	>	>
PAH	>	50.6	69.4	97.6
Years from 2001 to breach ANZECC ISQG-Hi				
Zinc	>	92.7	>	>
Copper	>	>	>	>
PAH	>	>	>	>

* signifies initial concentration exceeds traffic light
> signifies traffic light is not exceeded within 108 years

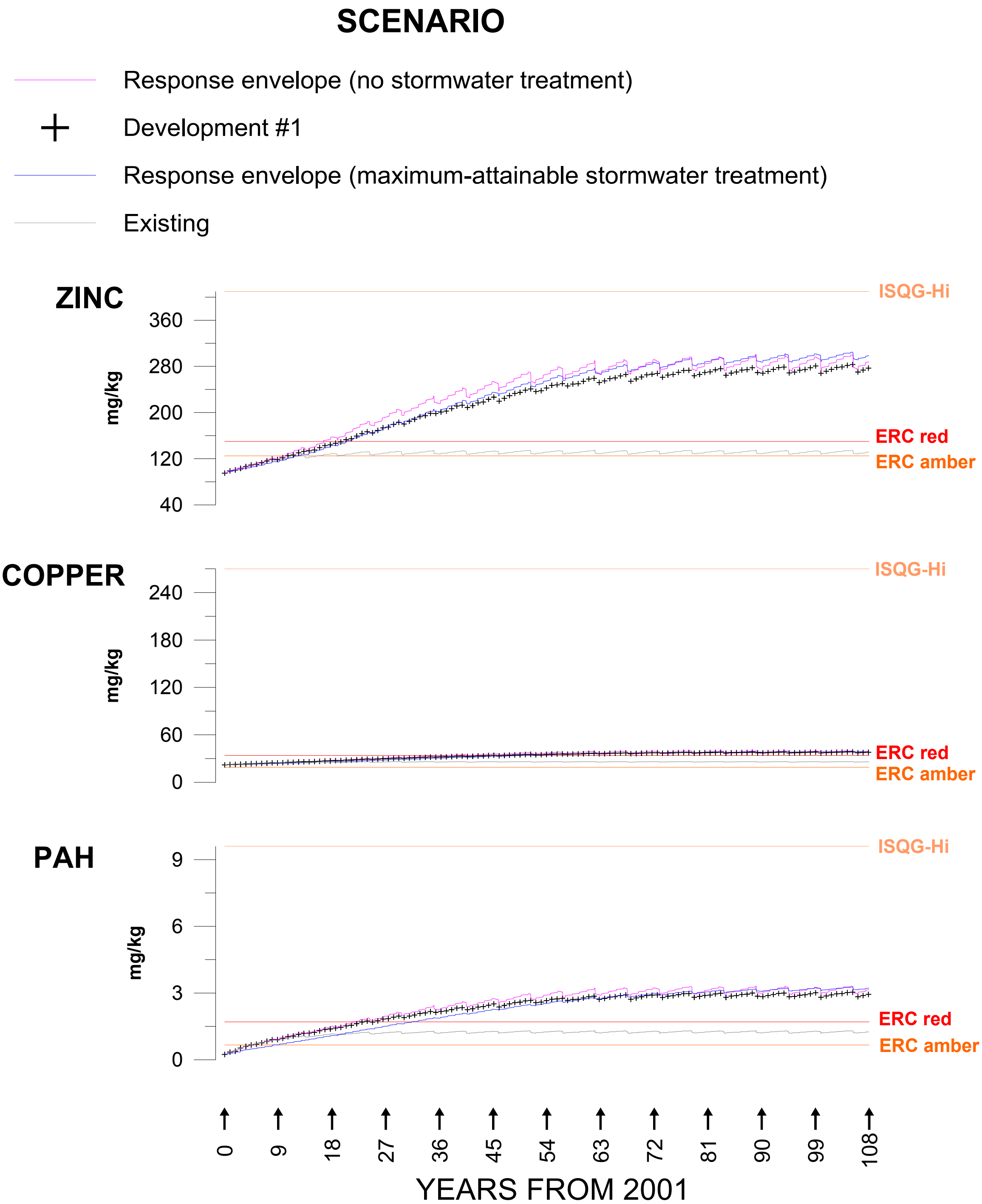
(3) Principal sources of sediment and contaminant (Development #1 scenario, 108 years)

Subcatchment	Percent	Mass (kg)	Subcatchment	Percent	Mass (kg)
Sediment			***Zinc***		
Waiarohia	89.9	8.83E+06	Waiarohia	97.5	2.87E+04
Hellyers	8.5	8.35E+05	Hellyers	2	5.93E+02
Rarawaru	1.3	1.28E+05	Rarawaru	0.4	1.23E+02
Copper			***PAH***		
Waiarohia	94.5	2.39E+03	Waiarohia	94.7	7.52E+02
Hellyers	4.7	1.19E+02	Hellyers	4.5	3.56E+01
Rarawaru	0.8	2.08E+01	Rarawaru	0.8	6.53E+00



Upper Main

(1) Future contaminant concentrations in estuarine bed sediments



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Upper Main

(2) Time before sediment quality guidelines breached

Response envelope

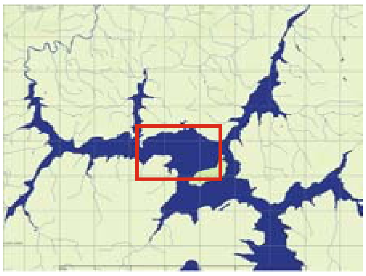
	Existing Scenario	No s/w treatment	Development #1 Scenario	Max. attainable s/w treatment
Years from 2001 to breach ERC amber traffic light				
Zinc	12.9	10.4	10.5	12.1
Copper	*	*	*	*
PAH	4.3	4.3	4.4	8.1
Years from 2001 to breach ERC red traffic light				
Zinc	>	16.6	20.1	20.3
Copper	>	38.7	44.8	50.3
PAH	>	21.4	23.6	31.3
Years from 2001 to breach ANZECC ISQG-Hi				
Zinc	>	>	>	>
Copper	>	>	>	>
PAH	>	>	>	>

* signifies initial concentration exceeds traffic light

> signifies traffic light is not exceeded within 108 years

(3) Principal sources of sediment and contaminant (Development #1 scenario, 108 years)

Subcatchment	Percent	Mass (kg)	Subcatchment	Percent	Mass (kg)
Sediment			***Zinc***		
Rangitopuni	59.4	2.06E+08	Rangitopuni	25.7	2.14E+04
Brighams	19.0	6.61E+07	Brighams	25.0	2.07E+04
Paremoremo	11.2	3.89E+07	Waiarohia	14.6	1.21E+04
Copper			***PAH***		
Rangitopuni	38.6	4.92E+03	Brighams	22.2	4.90E+02
Brighams	18.1	2.31E+03	Hellyers	21.1	4.67E+02
Hellyers	12.4	1.58E+03	Lucas	15.8	3.49E+02



Middle Main

(1) Future contaminant concentrations in estuarine bed sediments

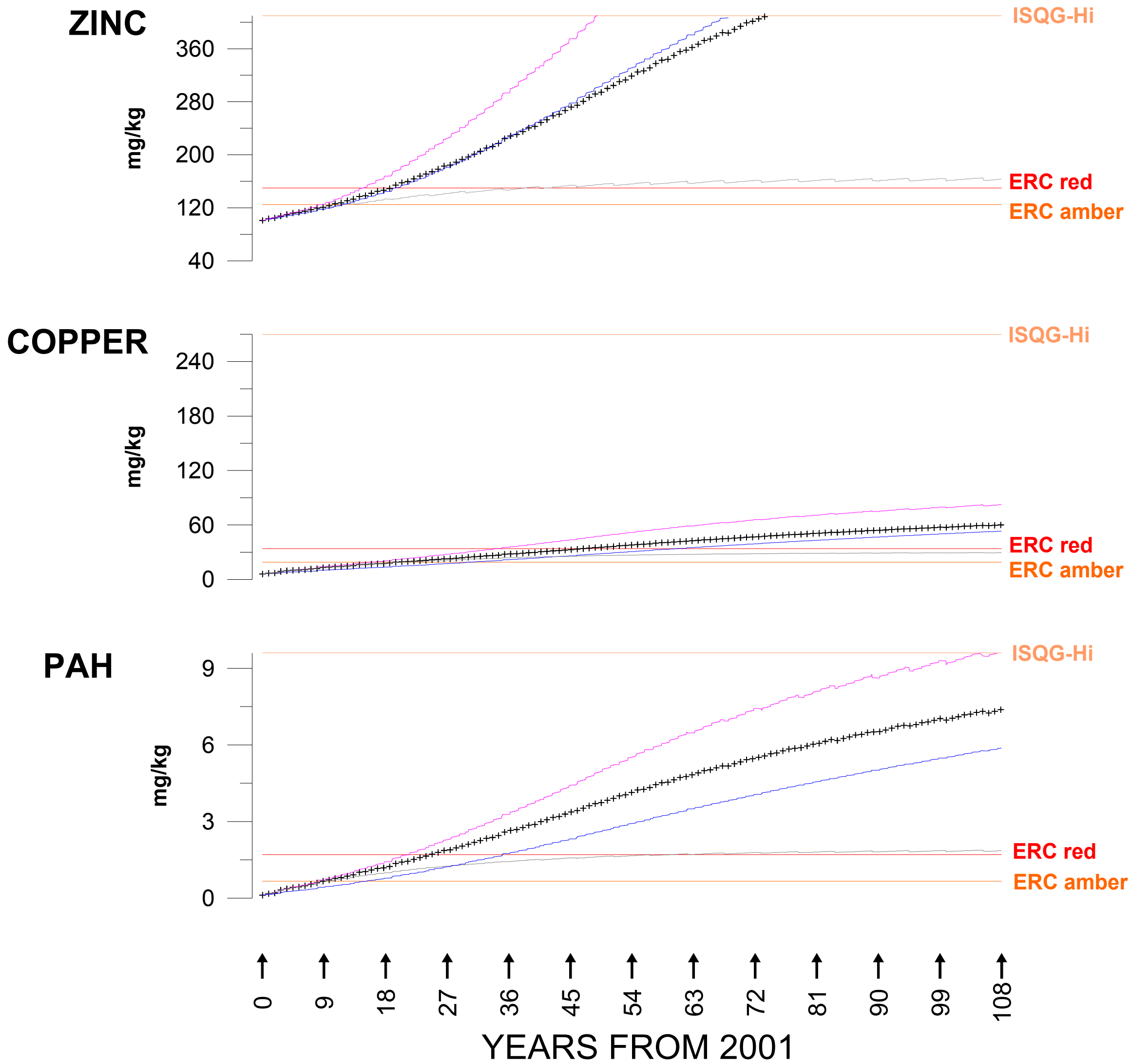
SCENARIO

Response envelope (no stormwater treatment)

Development #1

Response envelope (maximum-attainable stormwater treatment)

Existing



Continued...

Middle Main

(2) Time before sediment quality guidelines breached

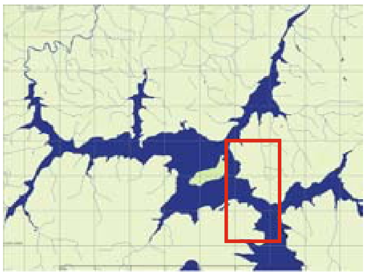
Response envelope

	Existing Scenario	No s/w treatment	Development #1 Scenario	Max. attainable s/w treatment
Years from 2001 to breach ERC amber traffic light				
Zinc	12.2	9.2	10.4	11.7
Copper	20.4	16.3	19.5	30.1
PAH	9.2	8.1	8.1	15.4
Years from 2001 to breach ERC red traffic light				
Zinc	38.7	14.7	18.9	19.5
Copper	>	34.9	47.1	60.8
PAH	59.5	21.4	24.4	35.1
Years from 2001 to breach ANZECC ISQG-Hi				
Zinc	>	49.0	74.1	68.1
Copper	>	>	>	>
PAH	>	104.9	>	>

* signifies initial concentration exceeds traffic light
> signifies traffic light is not exceeded within 108 years

(3) Principal sources of sediment and contaminant (Development #1 scenario, 108 years)

Subcatchment	Percent	Mass (kg)	Subcatchment	Percent	Mass (kg)
Sediment			***Zinc***		
Paremoremo	45.9	5.82E+07	Lucas	60.4	3.91E+04
Lucas	36.1	4.58E+07	Waiarohia	19.7	1.28E+04
Hellyers	6.2	7.85E+06	Paremoremo	8.5	5.50E+03
Copper			***PAH***		
Lucas	52.5	4.02E+03	Lucas	59.6	1.14E+03
Paremoremo	14.7	1.13E+03	Waiarohia	18.7	3.57E+02
Waiarohia	14.4	1.10E+03	Hellyers	12.8	2.45E+02



Lower Main

(1) Future contaminant concentrations in estuarine bed sediments

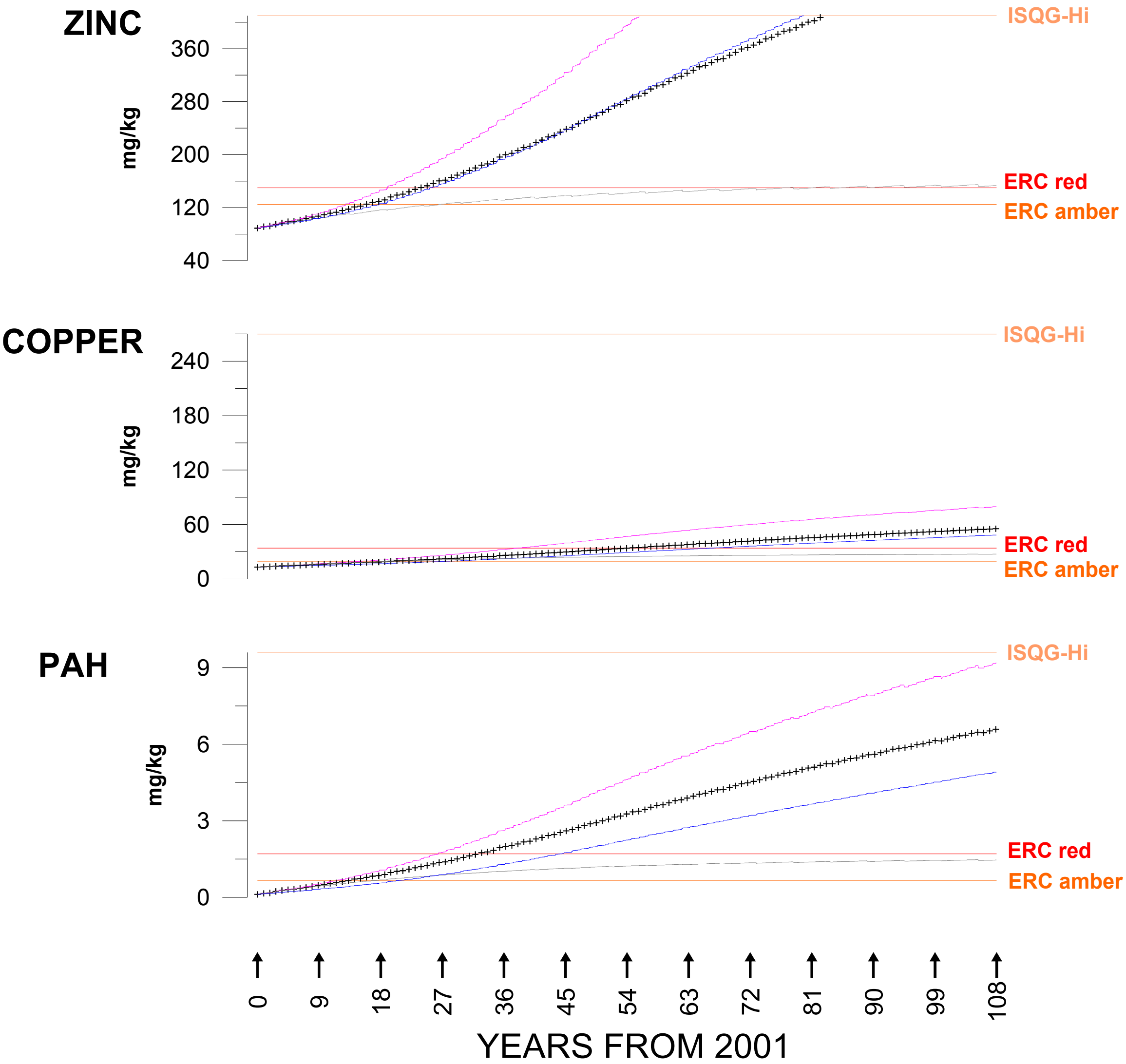
SCENARIO

Response envelope (no stormwater treatment)

Development #1

Response envelope (maximum-attainable stormwater treatment)

Existing



Continued...

Lower Main

(2) Time before sediment quality guidelines breached

Response envelope (No s/w treatment → Max. attainable s/w treatment)

	Existing Scenario	No s/w treatment	Development #1 Scenario	Max. attainable s/w treatment
Years from 2001 to breach ERC amber traffic light				
Zinc	26.9	12.9	15.9	17.8
Copper	18.9	14.1	18.9	26.4
PAH	17.5	11.7	13.5	21.1
Years from 2001 to breach ERC red traffic light				
Zinc	76.7	19.0	23.9	25.3
Copper	>	38.4	54.6	66.9
PAH	>	26.4	32.5	44.2
Years from 2001 to breach ANZECC ISQG-Hi				
Zinc	>	55.9	82.9	79.9
Copper	>	>	>	>
PAH	>	>	>	>

* signifies initial concentration exceeds traffic light
> signifies traffic light is not exceeded within 108 years

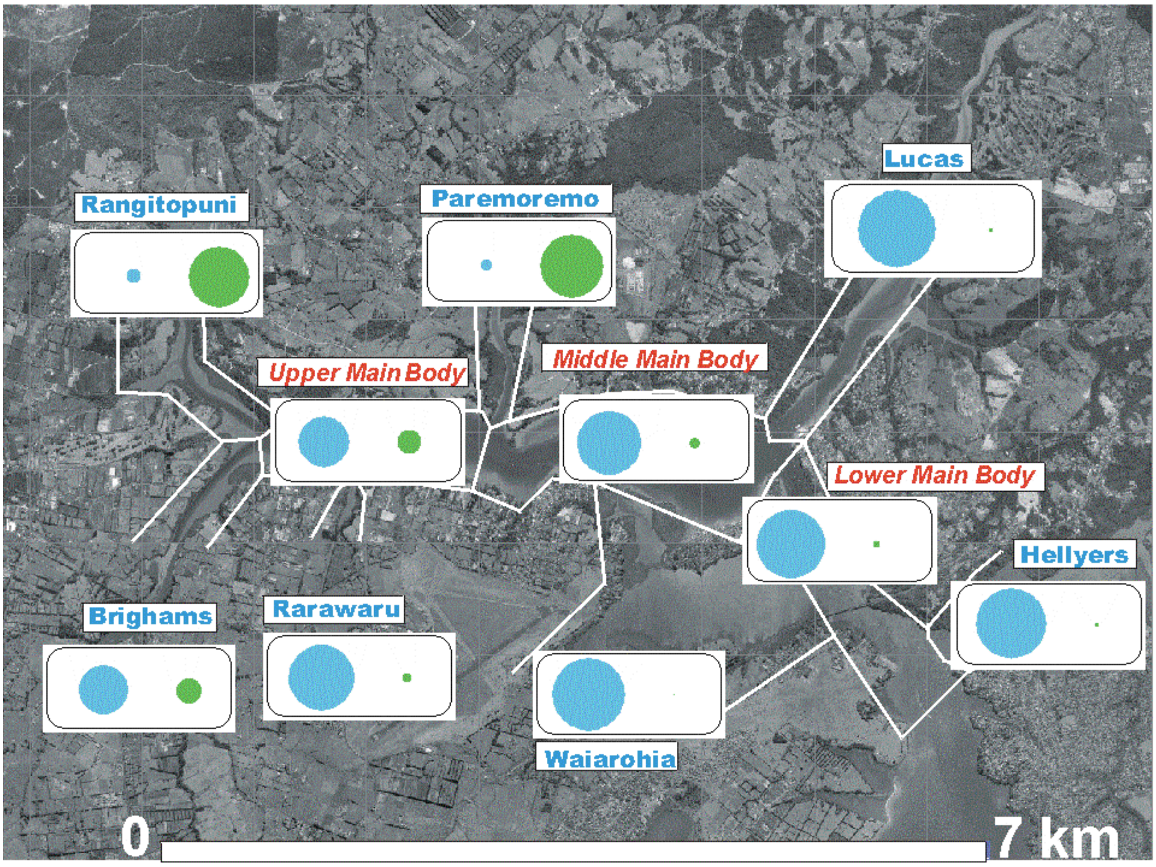
(3) Principal sources of sediment and contaminant (Development #1 scenario, 108 years)

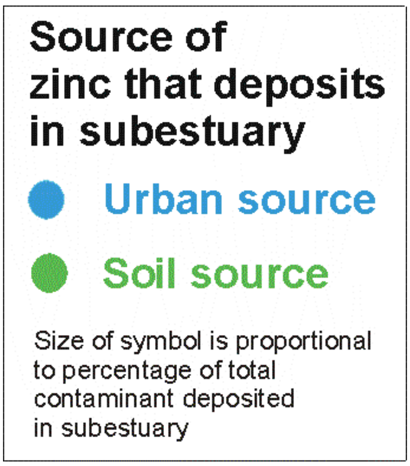
Subcatchment	Percent	Mass (kg)	Subcatchment	Percent	Mass (kg)
Sediment			***Zinc***		
Lucas	69.9	2.79E+07	Lucas	84.8	2.43E+04
Rangitopuni	16.9	6.72E+06	Waiarohia	9.8	2.80E+03
Paremoremo	6.8	2.71E+06	Rangitopuni	2.4	6.79E+02
Copper			***PAH***		
Lucas	81.3	2.49E+03	Lucas	85.6	7.09E+02
Waiarohia	7.8	2.39E+02	Waiarohia	9.4	7.80E+01
Rangitopuni	5.2	1.59E+02	Hellyers	3.4	2.81E+01

SECTION 2: Generation of Sediments and Contaminants (Zinc, Copper, PAH) in Subcatchments

Urban versus "natural" (soil) sources of zinc

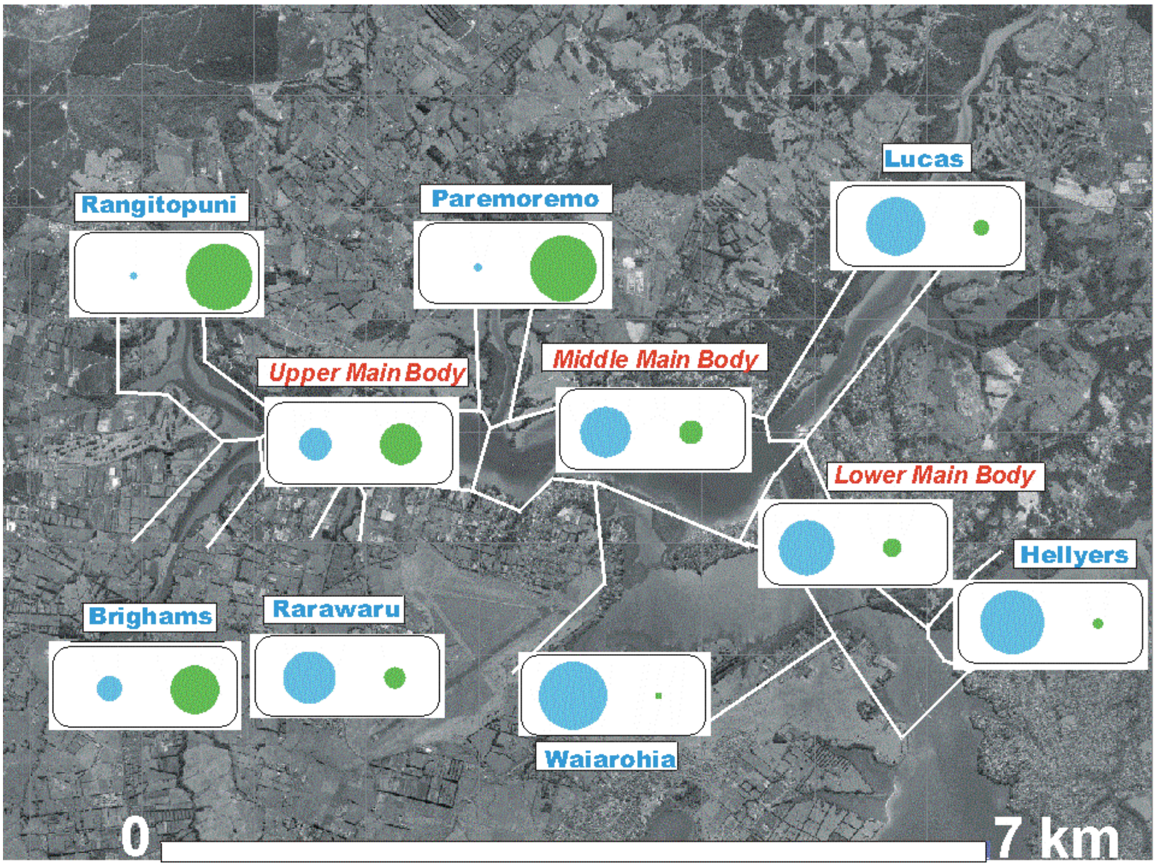
Breakdown of zinc deposited in each subestuary at the end of 108 years under development #1 scenario into zinc from urban sources and zinc from weathering of soil in the catchment.

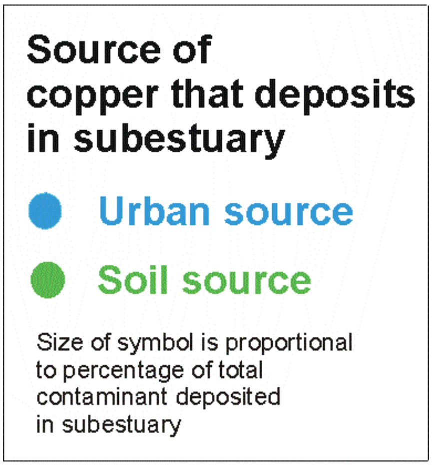




Urban versus "natural" (soil) sources of copper

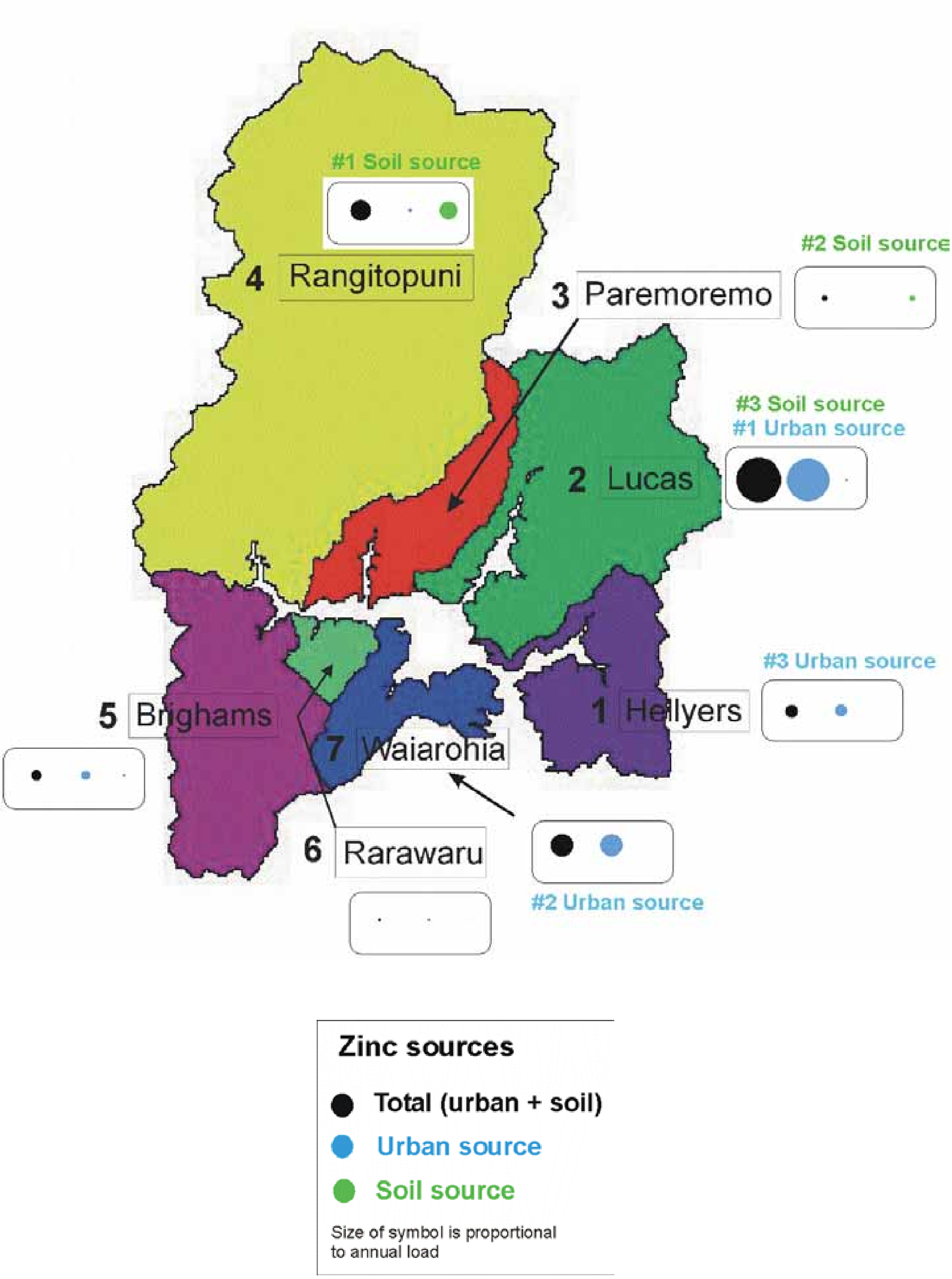
Breakdown of copper deposited in each subestuary at the end of 108 years under development #1 scenario into copper from urban sources and copper from weathering of soil in the catchment.





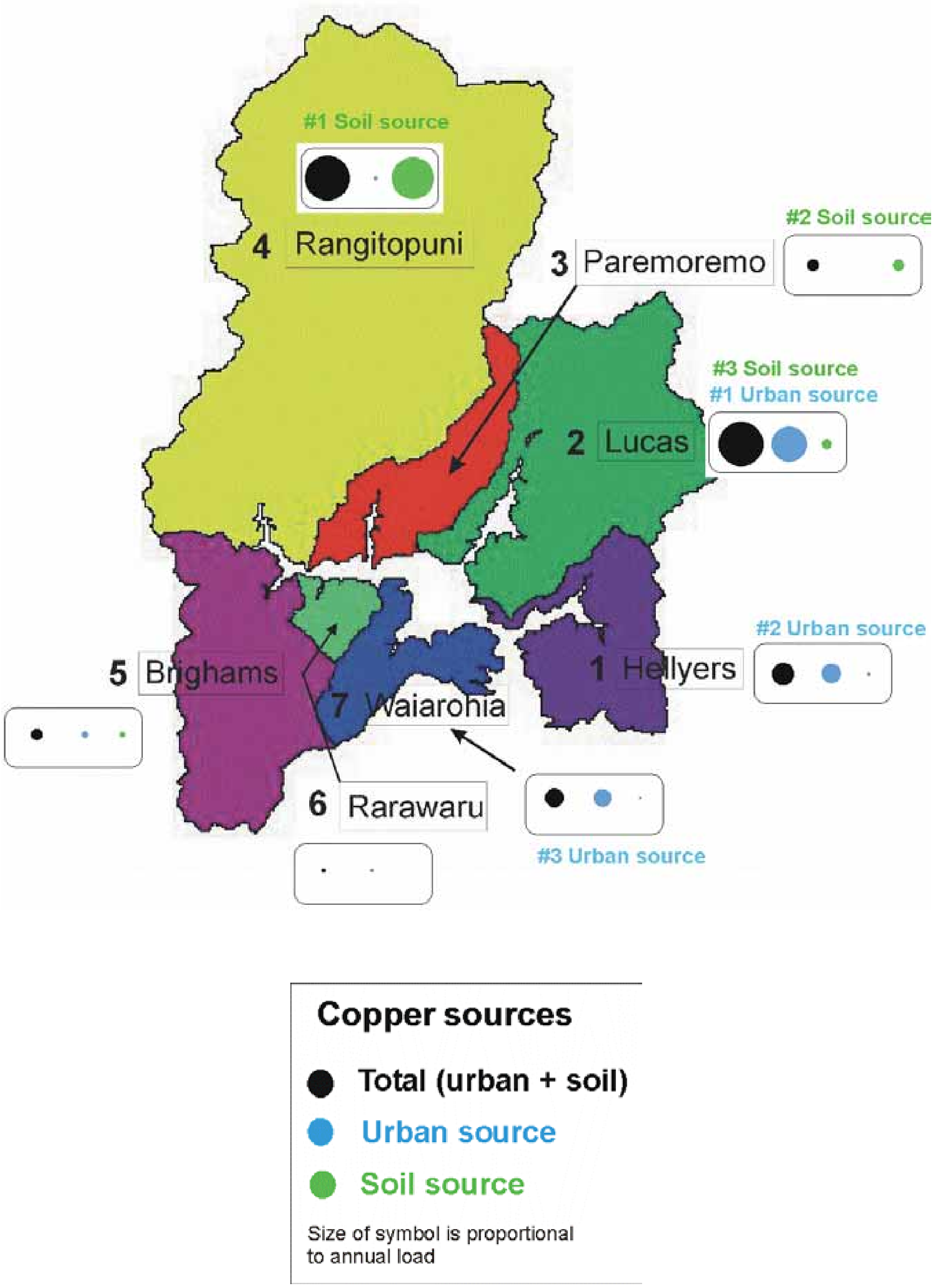
Ranking of zinc sources

Ranking of zinc sources summed over 108 years under the development #1 scenario, after zinc has passed through any controls.



Ranking of copper sources

Ranking of copper sources summed over 108 years under the development #1 scenario, after copper has passed through any controls.



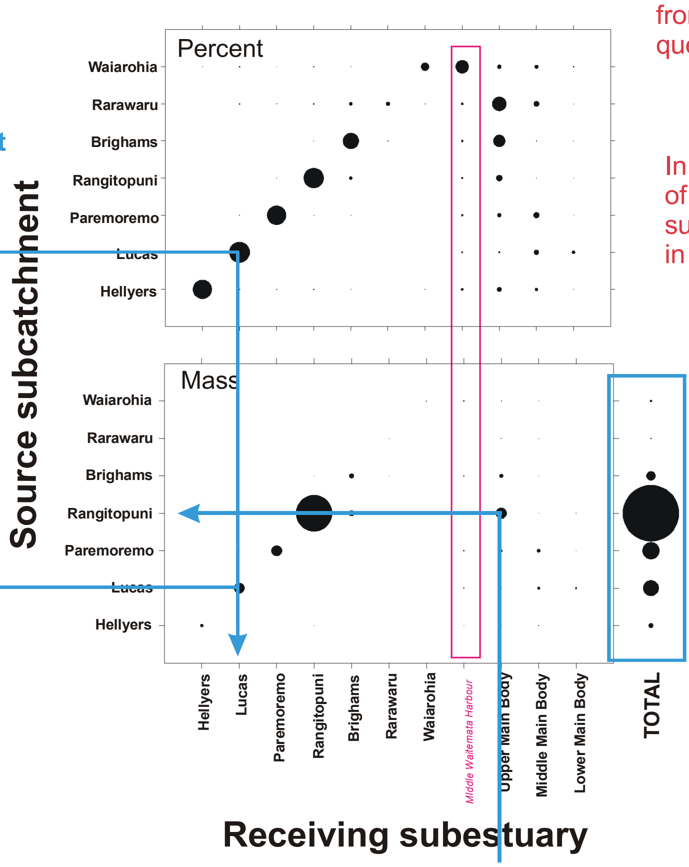
How to read the following graphs:

2. Read across each line to see where sediment / contaminant generated in each subcatchment goes to.

Here, for example, most of the load generated in Lucas subcatchment ends up in Lucas subestuary.

In this top graph, the split of the loads across subestuaries is shown as a percentage of the total load from the subcatchment in question.

In the bottom graph, the split of the loads across subestuaries is shown in terms of actual mass.



1. These symbols show the total load from each subcatchment.

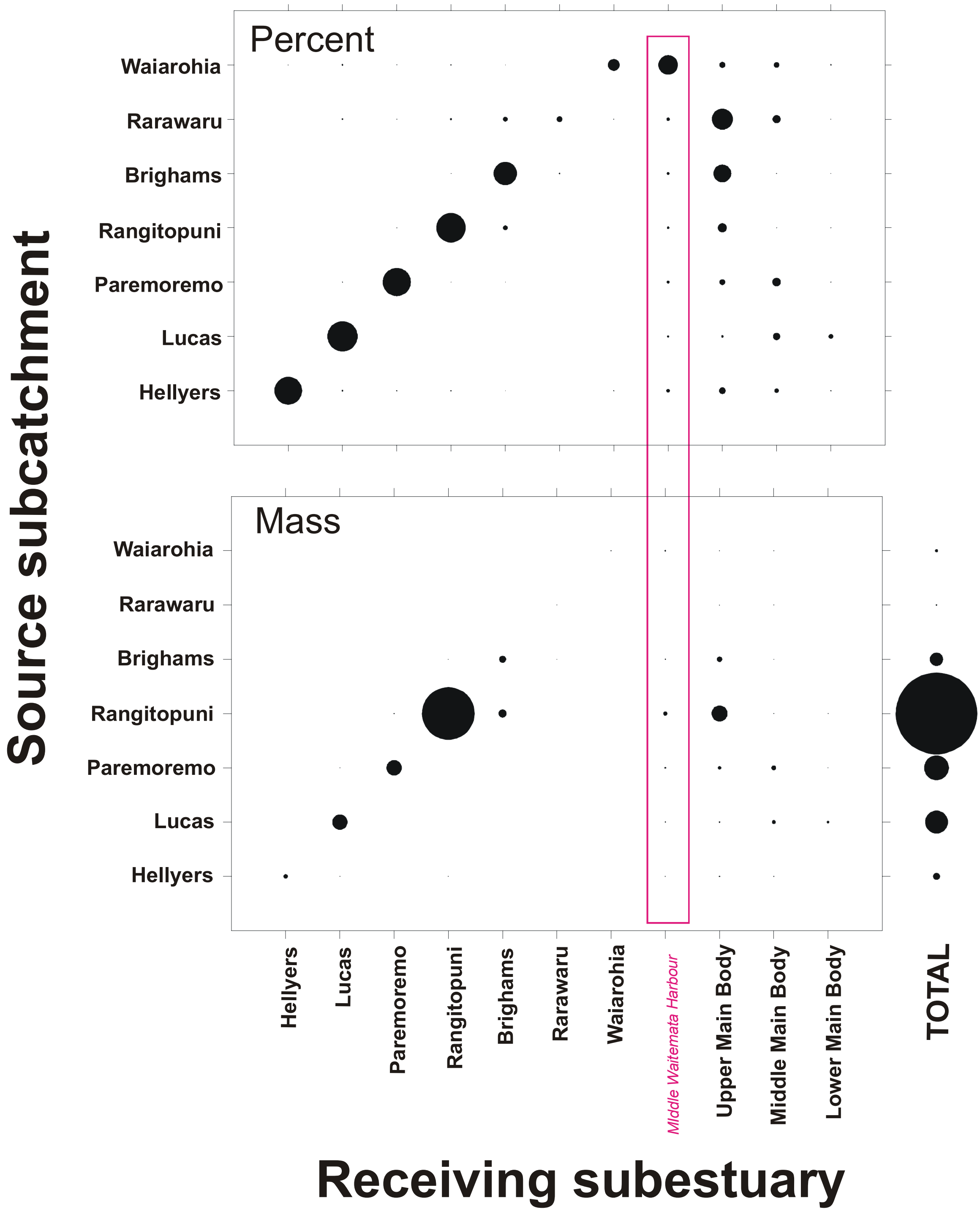
Here, the total load from Rangitopuni subcatchment greatly exceeds all other loads.

3. Read up each column <u>in the botttom plot only</u> to see where sediment / contaminant deposited in each subestuary comes from.

Here, for example, most of the load deposited in the Upper Main Body comes from Rangitopuni subcatchment.

Sources and Fates of Sediment

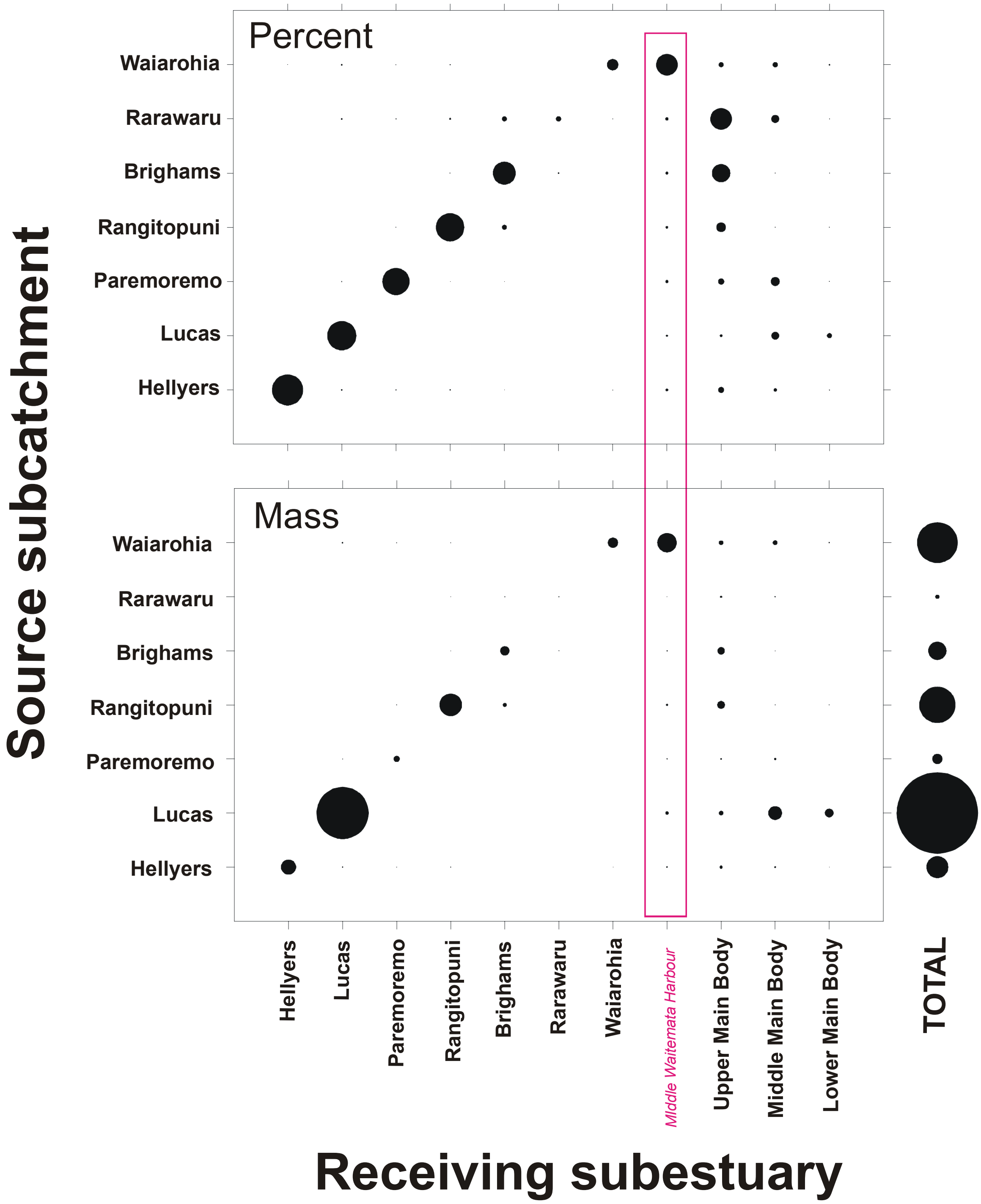
(Development #1 scenario, 108 years)



Sources and Fates of Zinc

(urban + background loads)

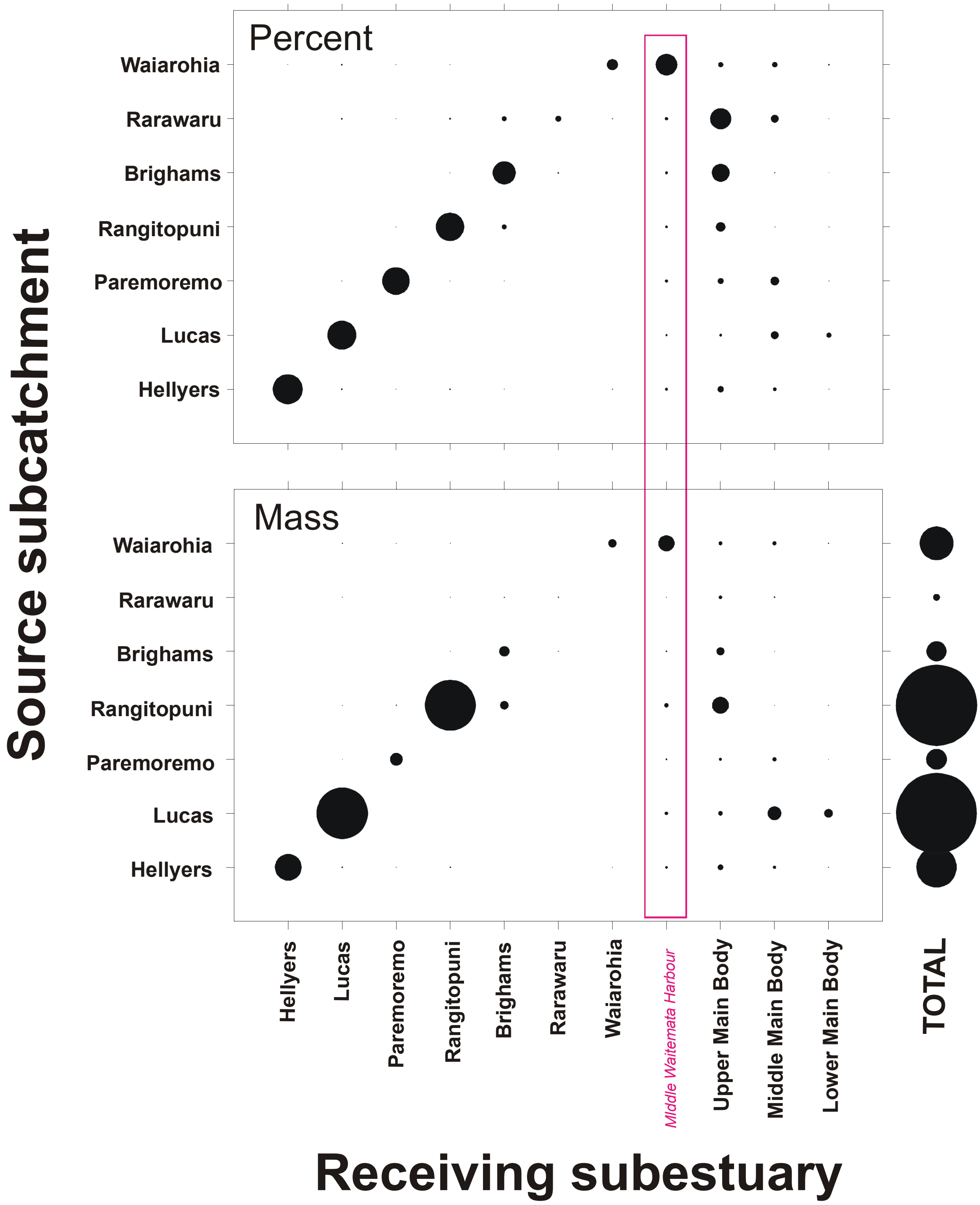
(Development #1 scenario, 108 years)



Sources and Fates of Copper

(urban + background loads)

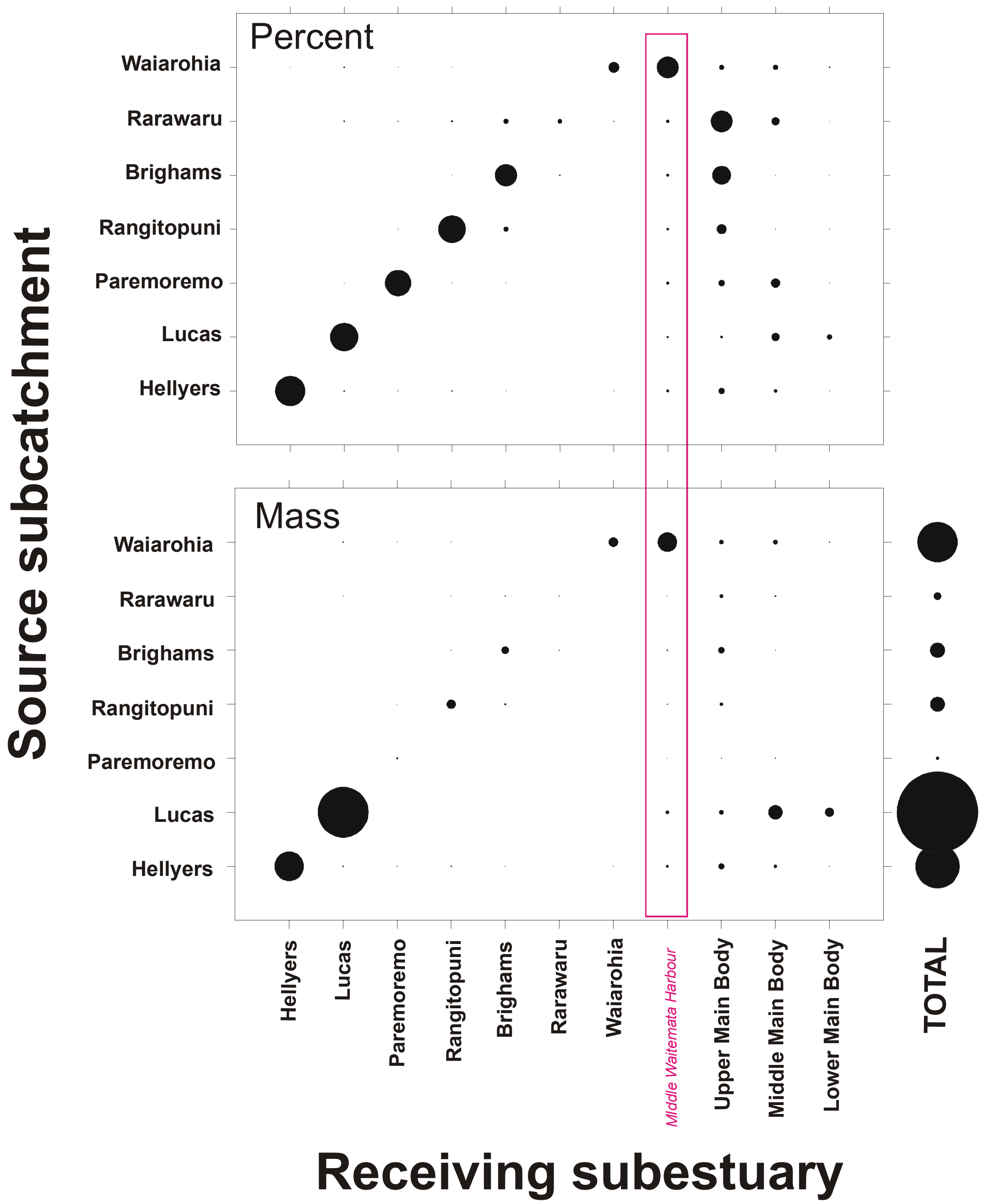
(Development #1 scenario, 108 years)



Sources and Fates of PAHs

(urban + background loads)

(Development #1 scenario, 108 years)



SECTION 3: Key Model Parameters (Zinc, Copper, PAH)

1. Projected Landuse

(as used in Development #1 and Response-Envelope Scenarios)

Each TA provided information describing landuse change under Development #1, which is summarised below. The level of detail of the information varied. Typically it is presented with respect to future changes but, in the case of Lucas Creek, historical changes were also used as part of the model validation exercise[3]. For all subcatchments, 50% of earthwork sites were associated with a sediment control measure with a long-term average efficiency of about 70%. The remaining 50% were modelled without a control.

Lucas Creek: hectares of landuse under mixed development.

Date	Bare earth	Mature urban	Pasture	Bush
1951	0	51	2207	1215
1961	3	81	2190	1198
1971	5	126	2167	1174
1981	9	253	2101	1109
1991	36	505	1961	969
2001	175	1035	1627	635
2011	88	1488	1351	545
2021	40	2365	677	390
2031	24	2768	354	326
2041	19	3011	147	295
2051	14	3138	49	271

[3] See Green, M.O., Williamson, R.B., Timperley, M., Collins, R., Senior, A., Adams, A., Swales, A. and Mills, G., 2004. *Prediction of Contaminant Accumulation in the Upper Waitemata Harbour – Methods*. NIWA Client Report HAM2003-087/1, NIWA Hamilton, June 2004, 97 pp.

Waitakere subcatchments: hectares of bare earth exposed per year under mixed development.

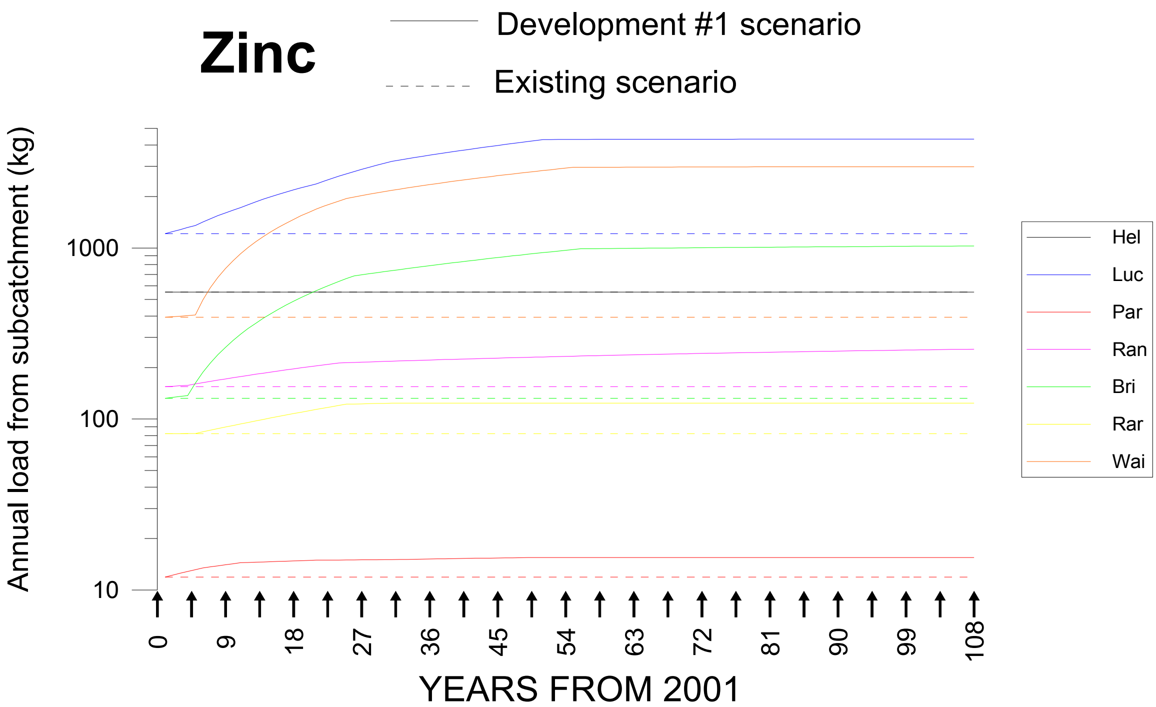
Date	Rarawaru	Brighams	Waiarohia
2000-2020	2.97	9.6	20.8
2020-2050	0.1	9.2	5.1

Paremoremo: hectares of bare earth exposed per year under rural residential.

Date	Paremoremo
2001-2011	2.43
2011-2021	0.48
2021-2031	0.18
2031-2041	0.24
2041-2051	0.18

Rangitopuni: the combination of urban development in the Riverhead area, coupled with rural residential elsewhere, provided a total of 6 hectares of bare earth exposed per year between present day and 2020.

2. Contaminant loads used in modelling



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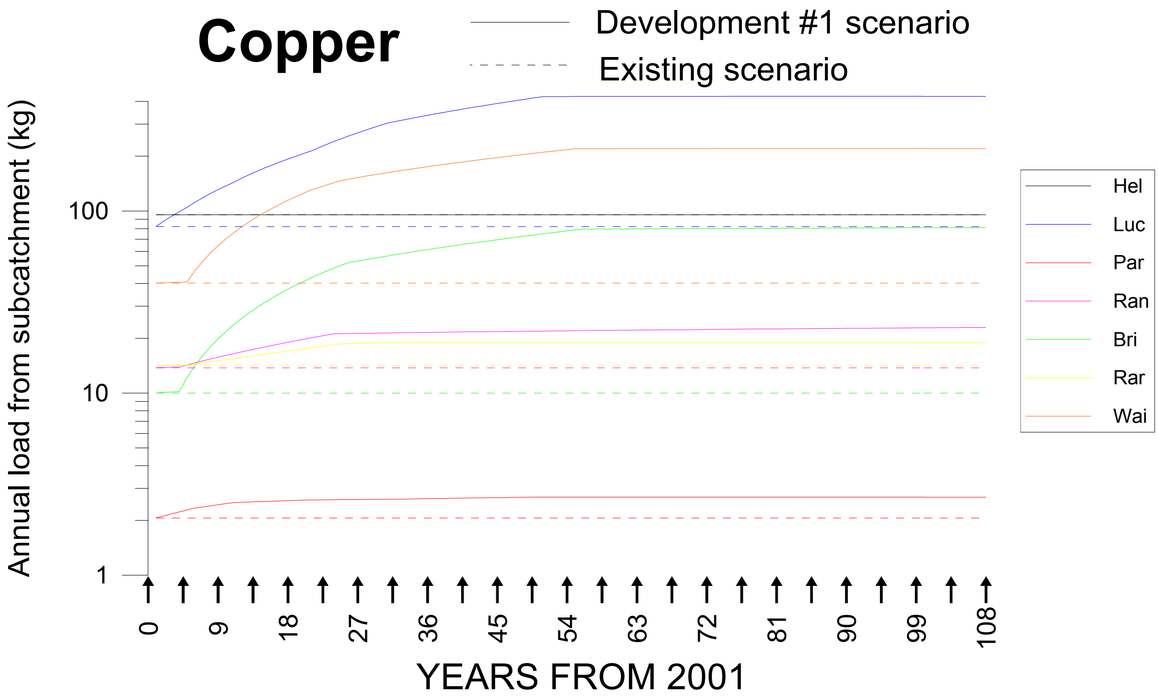
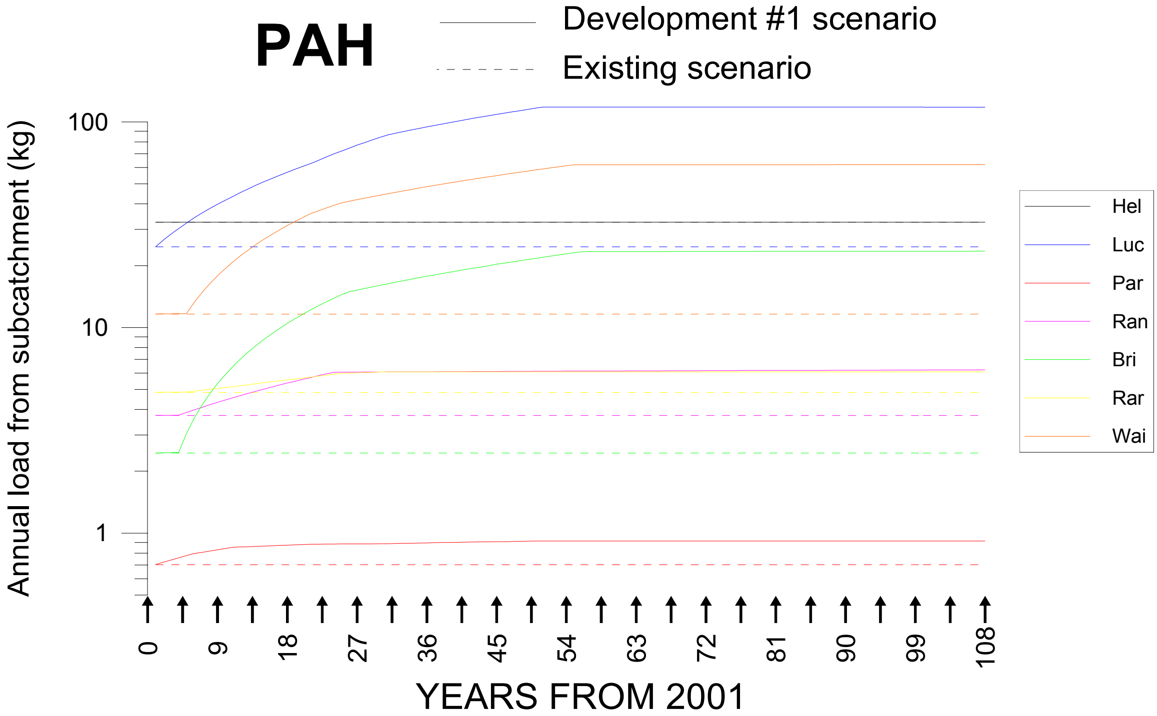

Copper
Development #1 scenario
Existing scenario
Annual load from subcatchment (kg)
100
10
1
Hel
Luc
Par
Ran
Bri
Rar
Wai
0
9
18
27
36
45
54
63
72
81
90
99
108
YEARS FROM 2001


PAH
Development #1 scenario
Existing scenario
Annual load from subcatchment (kg)
100
10
1
Hel
Luc
Par
Ran
Bri
Rar
Wai
0
9
18
27
36
45
54
63
72
81
90
99
108
YEARS FROM 2001

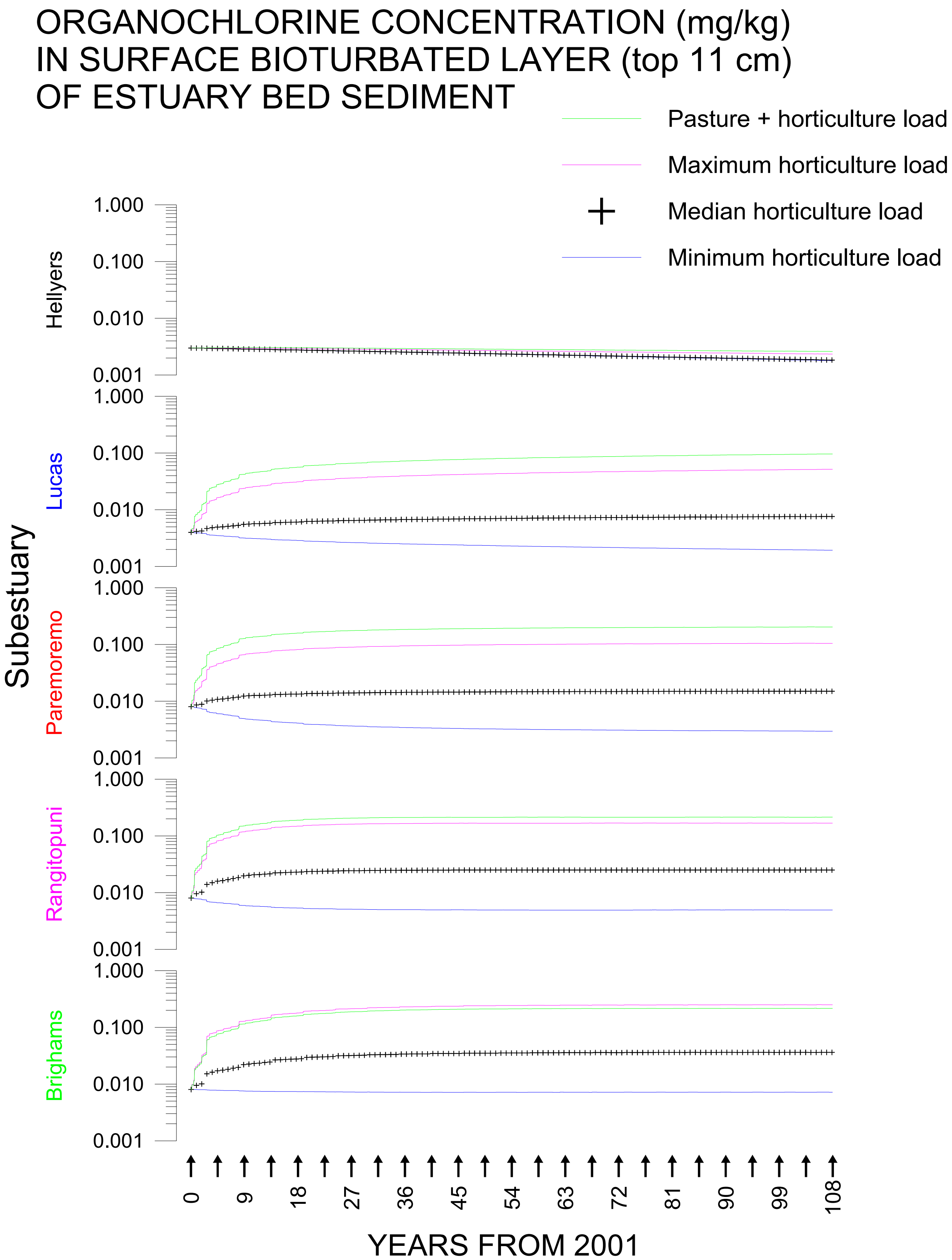
SECTION 4: Organochlorine Pesticides

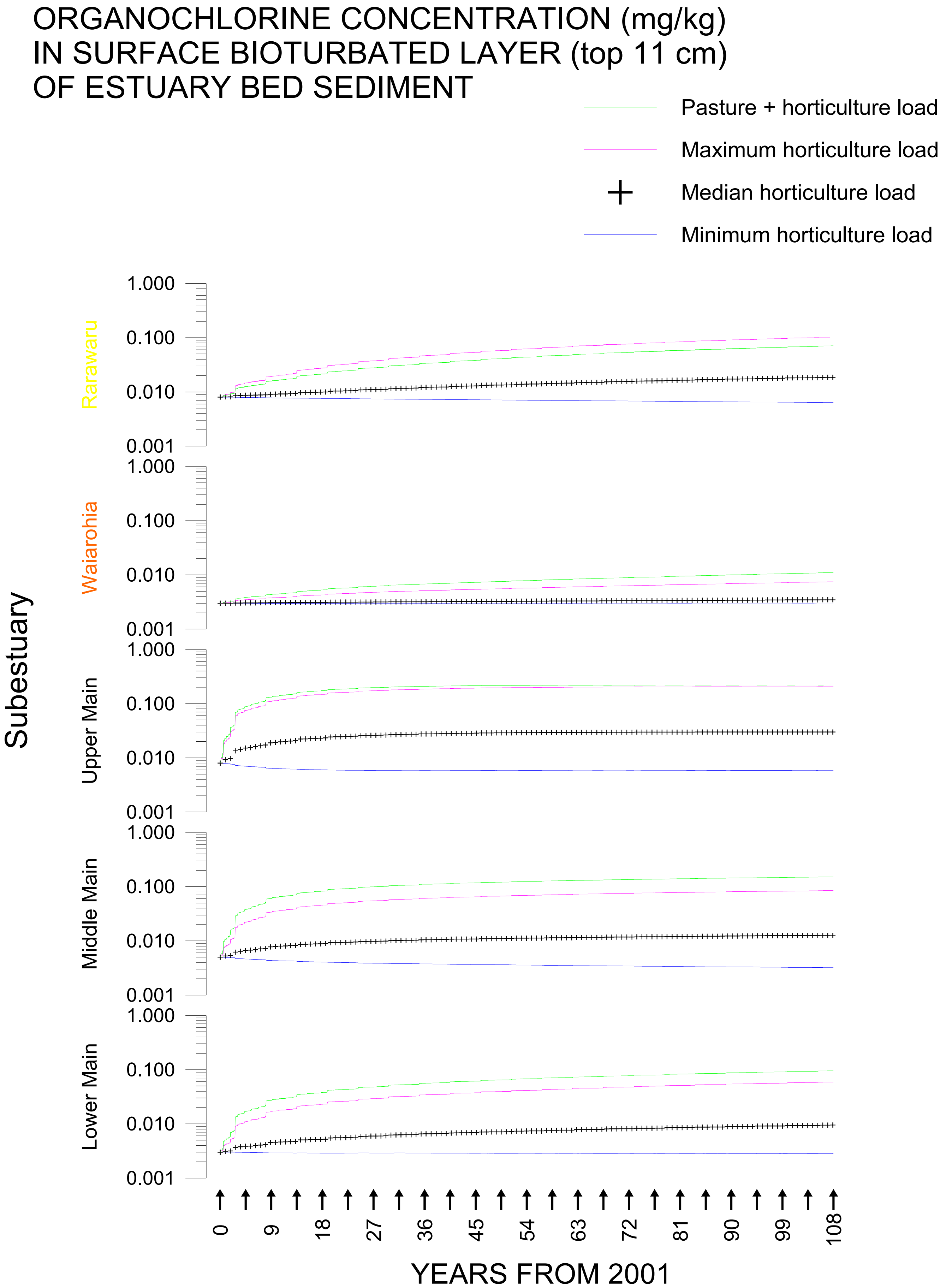
The predictions of organochlorine pesticide (OCP) (e.g., DDT) buildup in estuarine sediments indicate that mobilisation of OCPs during land clearance is likely to result in toxic effects on marine biota. The predictions are summarised in this section together with an evaluation and discussion of prediction uncertainties.

(1) Future contaminant concentrations in estuarine bed sediments

Scenario	Organochlorine Pesticide Load	Landuse	Sediment Controls	Stormwater Treatment
Organochlorine #1	Minimum horticulture.	Projected.	Projected.	Projected.
Organochlorine #2	Median horticulture.	Projected.	Projected.	Projected.
Organochlorine #3	Maximum horticulture.	Projected.	Projected.	Projected.
Organochlorine #4	Pasture + horticulture.	Projected.	Projected.	Projected.

Unlike the other contaminants considered in this study (zinc, copper and PAH), we assume that there are no current or future additions of organochlorine pesticides (OCPs) (e.g., DDT) to catchment soils. All OCPs carried from catchments are assumed to have originated from the historical application of OC pesticides.


ORGANOCHLORINE CONCENTRATION (mg/kg)
IN SURFACE BIOTURBATED LAYER (top 11 cm)
OF ESTUARY BED SEDIMENT
Pasture + horticulture load
Maximum horticulture load
Median horticulture load
Minimum horticulture load
Subestuary
Hellyers
Lucas
Paremoremo
Rangitopuni
Brighams
1.000
0.100
0.010
0.001
0
9
18
27
36
45
54
63
72
81
90
99
108
YEARS FROM 2001


ORGANOCHLORINE CONCENTRATION (mg/kg)
IN SURFACE BIOTURBATED LAYER (top 11 cm)
OF ESTUARY BED SEDIMENT
Pasture + horticulture load
Maximum horticulture load
Median horticulture load
Minimum horticulture load
Subestuary
Rarawaru
Waiarohia
Upper Main
Middle Main
Lower Main
1.000
0.100
0.010
0.001
0
9
18
27
36
45
54
63
72
81
90
99
108
YEARS FROM 2001

(2) Derivation of organochlorine loads used in scenarios

DDT is the most widespread of the OC pesticides presently detectable in soils of the Auckland region. The mean and median concentrations of total DDT (sum of DDT plus its degradation products) measured in soils of the Auckland Region in various surveys over the last 25 years are listed in the following table:

Survey	**Statistic**	**Total DDT concentration mg kg^{-1}**
48 horticultural soils 1979	mean	7.67
48 horticultural soils 1980	median	0.2
Glasshouse 1979	mean	25.2
Orchards 1979	mean	4.34
Market gardens 1979	mean	0.31
vineyards	mean	0.65
Horticulture ARC 2002	mean	1.06
Glasshouse soil Hogg 2000	Low mean	1.1
Glasshouse soil Hogg 2000	High mean	6.2
Farm soil Orchard 1991	mean	1.9
Orchards Gaw 2002	median	1.17
Vineyards Gaw 2002	median	0.25
Paddock South Island	mean	0.27
	10th percentile	0.21
	50th percentile	1.06
	90th percentile	7.38

DDT is not the only OC pesticide present in Auckland soils, so to produce a "total" OCP concentration for catchment loads, the percentile concentrations of total DDT were multiplied by the mean ratio (total OC pesticides/total DDT) obtained for all sediments analysed in the 2003 survey for the ARC long-term marine sediment monitoring programme. This ratio is 1.138, giving 10th, 50th and 90th percentile total OCP concentrations of 0.24 mg kg^{-1}, 1.21 mg kg^{-1} and 8.40 mg kg^{-1}, respectively, in soils containing OCPs.

It has not been possible to estimate the areas of horticultural land exposed to OCPs prior to the prohibition of the use of these compounds. Estimates available for 2002 are used here.

For each catchment, four estimates of annual catchment OCP loads were made:

1. The first estimate, the minimum horticulture load, was calculated as:

    [amount of sediment mobilised (estimated from the sediment model)] x [area of horticultural land/total catchment area in 2002] x [OCP 10%ile concentration (0.24 mg kg^{-1})].

2. The second estimate, the median horticulture load, was calculated as:

    [amount of sediment mobilised (estimated from the sediment model)] x [area of horticultural land/total catchment area in 2002] x [OCP 50%ile concentration (1.21 mg kg-1)].

3. The third estimate, the maximum horticulture load, was calculated as:

    [amount of sediment mobilised (estimated from the sediment model)] x [area of horticultural land/total catchment area in 2002] x [OCP 90%ile concentration (8.40 mg kg-1)]

4. The fourth estimate, the pasture plus horticulture load, was calculated as:

    [amount of sediment mobilised (estimated from the sediment model)] x [(area of pasture + horticulture)/total catchment area in 2002] x ["paddock South Island" OCP concentration (0.27 mg kg-1)].

The OCP loads are, therefore given by [amount of sediment mobilised x "factor"], where the factors (i.e., [contaminated soil area/total catchment area] x OCP concentration) for the four loads are given in the following table:

Sub-catchment	Area of orchards plus vineyards (ha)	Total catchment area (ha)	Area hort land / total catchment area	Minimum hort factor	Median hort factor	Maximum hort factor	Area pasture + hort / total catchment area	Pasture + hort factor
Hellyers	0	1404	0	0	0	0	0.1	0
Lucas	27.7	3610	0.0076	0.0018	0.009	0.064	0.5	0.12
Paremoremo	17.2	1290	0.013	0.0031	0.016	0.11	0.9	0.22
Rangitopuni	219	9920	0.022	0.0053	0.027	0.18	0.95	0.23
Brighams	186	4730	0.039	0.0094	0.047	0.33	0.8	0.19
Rarawaru	0	380	0	0	0	0	0.8	0
Waiarohia	10.3	940	0.011	0.0031	0.013	0.092	0.6	0.16

The areas of pasture + horticulture used here for each catchment are sensible guesstimates for the period 1950 to 2002.

The accuracy of the OCP predictions is limited by at least four major uncertainties:

(1) The actual spatial distribution of OCPs in soils throughout the UWH catchment is unknown. To rectify this, those parts of the UWH catchment that have been used in the past for horticulture need to be identified, and OCP concentrations in soils need to be measured. The biggest unknown here is the extent of OCP contamination of pasture soils.

(2) The distribution of OCPs with depth in soils and the association of OCPs with soil components needs to be measured and understood, so that mobilisation of OCPs can be better predicted.

(3) The dynamics of OCPs attached to soil and organic particles needs to be better understood so that dispersal and deposition of OCPs in the harbour can be better predicted.

(4) The post-depositional behaviour of OCPs in marine sediments needs to be better understood so that ecological effects can be predicted.

SECTION 5: Further Information

The information presented herein is a summary of the more detailed information in the following reports:

Green, M.O., Williamson, R.B., Timperley, M., Collins, R., Senior, A., Adams, A., Swales, A. and Mills, G., 2004. *Prediction of Contaminant Accumulation in the Upper Waitemata Harbour – Methods*. NIWA Client Report HAM2003-087/1, NIWA Hamilton, June 2004, 97 pp.

Green, M.O., Williamson, R.B., Timperley, M., Collins, R., Senior, A., Adams, A., Swales, A. and Mills, G., 2004. *Prediction of Contaminant Accumulation in the Upper Waitemata Harbour – Results: Zinc*. NIWA Client Report HAM2003-087/2, NIWA Hamilton, June 2004, 92 pp.

Green, M.O., Timperley, M. and Williamson, R.B., 2004. *Prediction of Contaminant Accumulation in the Upper Waitemata Harbour – Results: Copper*. NIWA Client Report HAM2003-087/3, NIWA Hamilton, August 2004, 86 pp.

Green, M.O., Timperley, M. and Williamson, R.B., 2004. *Prediction of Contaminant Accumulation in the Upper Waitemata Harbour – Results: PAHs*. NIWA Client Report HAM2003-087/4, NIWA Hamilton, September 2004, 80 pp.