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TE RAUHITANGA TAIAO

Prediction of Contaminant Accumulation in the Upper Waitemata Harbour – Results: Zinc

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Prediction of Contaminant Accumulation in the Upper Waitemata Harbour – Results: Zinc

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Prepared for
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Executive Summary

The background to the Upper Waitemata Harbour contaminant-accumulation study and the methodology used therein to predict contaminant accumulation are reported in NIWA Client Report HAM2003-087/1 – Methods.

The original goal of the Upper Waitemata Harbour contaminant-accumulation study was to predict the temporal development and spatial patterns of contaminant accumulation associated with (1) the existing pattern of landuse in the catchment, and (2) two proposed patterns/sequences of development.

The original goal of the study has matured somewhat over the course of the study. For zinc, this has culminated in pursuing the following scenarios, the results of which are presented herein:

- Existing scenario. This is the "baseline" simulation: it extrapolates the "current-day" (i.e., 2001) landuse into the future based on the assumption that landuse does not change. It also assumes no stormwater contaminant controls. This scenario serves as a baseline, and model test/validation.

- Development #1 scenario. This is the "realistic" simulation: it models development proposed in each subcatchment for each year in the future. At each modelled stage, therefore, the spatial pattern of earthworks sites and completed (mature) urban land is captured, complete with associated contaminant loads and projected stormwater contaminant controls.

- Response-envelope scenario. Here, the sediment loads and contaminant loads used in the development #1 scenario are run with each of two stormwater contaminant controls, these being zero controls and maximum attainable controls. The two results bracket the results of the development #1 scenario, forming an "envelope" of responses in the harbour

Inputs used in the zinc simulations are presented, including sediment loads, contaminant loads, stormwater controls, and initial contaminant concentrations in the harbour bed sediments. There are two simulation periods: 54 years and 108 years.

Results are presented as:

Contaminant concentrations in the harbour
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Origin of sediments / contaminants that deposit in harbour (%)
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Fate of sediments / contaminants that derive from land (%)
(a) Existing scenario versus development #1 scenario
Fate of sediments / contaminants that derive from land (mass)
(a) Existing scenario versus development #1 scenario

Examples of how the results may be used to inform management choices are given. The kinds of questions that may be answered include:

- *Where does zinc deposited in each part of the harbour come from?*
- *Which subestuary is most at risk? Why?*
- *How might this risk be lessened?*
- *Will there be other benefits associated with source control in particular subcatchments?*
- *Which subestuary is least at risk? Why?*

The way the response-envelope predictions may be interpreted is explained by way of example:

- *Are there parts of the harbour where contaminant concentrations still exceed traffic lights even under the maximum attainable controls? What should be done in this case?*
- *Are there parts of the harbour where environmental targets will be reached without any intervention?*
- *Are there subestuaries where significant gains in time-to-traffic-light can be had for modest control improvements?*

1. Introduction

The background to the Upper Waitemata Harbour contaminant-accumulation study and the methodology used therein to predict contaminant accumulation are reported in NIWA Client Report HAM2003-087/1 – Methods.

The original goal of the Upper Waitemata Harbour contaminant-accumulation study was to predict the temporal development and spatial patterns of contaminant accumulation associated with (1) the existing pattern of landuse in the catchment, and (2) two proposed patterns/sequences of development.

The original goal of the study has matured somewhat over the course of the study. For zinc, this has culminated in pursuing the following scenarios, the results of which are presented herein:

- Existing scenario. This is the "baseline" simulation: it extrapolates the "current-day" (i.e., 2001) landuse into the future based on the assumption that landuse does not change. It also assumes no stormwater contaminant controls. In addition to serving as a baseline, this simulation is used as a model test and validation, as described in the Methods report (NIWA Client Report HAM2003-087/1 – Methods) and in the Discussion below.

- Development #1 scenario. This is the "realistic" simulation: it models development proposed in each subcatchment for each year in the future. At each modelled stage, therefore, the spatial pattern of earthworks sites and completed (mature) urban land is captured, complete with associated contaminant loads and projected stormwater contaminant controls.

- Response-envelope scenario. Here, the sediment loads and contaminant loads used in the development #1 scenario are run with each of two stormwater contaminant controls, these being zero controls and maximum attainable controls. The two results bracket the results of the development #1 scenario, forming an "envelope" of responses in the harbour. That is, under the zero-control simulation, contaminant concentrations rise quickly compared to under the maximum-attainable-control simulation, and the concentrations under the realistic simulation (i.e., development #1 scenario) fall somewhere between those two extremes.

2. Simulation Inputs

There are two simulation periods: 54 and 108 years.

The following parameters remain fixed throughout the simulation period:

- subestuary areas over which deposition of sediments and contaminants is allowed to occur;
- freshwater runoff associated with each event;
- pattern of sediment and contaminant dispersal throughout the estuary (*R*);
- pattern of sediment and contaminant redispersal throughout the estuary (*R3*);
- bioturbation depth (*BEDPTH*).

The following are initial conditions:

- Zinc concentrations in estuarine sediments, which are expressed in three ways:
    - mass of zinc attached to size fraction 1 (silt) per total mass of size fraction 1 (silt) sediment;
    - mass of zinc attached to size fraction 2 (sand) per total mass of size fraction 2 (sand) sediment;
    - total mass of zinc per total mass of sediment.
- The initial split of estuarine bed sediments into size fractions.

The following parameters may be varied throughout the simulation period in order to generate the scenarios:

- Sediment load.
    - The existing scenario assumes that sediment yield under the "current" (2001) landuse within the UWH catchment applies for the duration of the simulation. The catchment is characterised predominantly by pastoral land, with bush and pine also present. In addition, both established and ongoing urban development is found, e.g., in Lucas Creek subcatchment. These landuses and their spatial patterns are incorporated within the catchment model. The level of development in 2001 is assumed to continue for the whole period of the simulation. Sediment loss from established urban land is not modelled directly; instead, a constant loss of 150 kg ha-1 yr-1 is assumed. A comparison of predicted mean annual sediment yields

with observed values (e.g., van Roon, 1983) has enabled catchment model validation under the existing scenario to be undertaken for all subcatchments except Hellyers Creek. This validation has confirmed that predicted catchment yields closely match observed values, providing confidence in the parameters used within the model. Under the existing scenario, the model predictions are of hillslope sediment loss only and do not incorporate in-stream sediment dynamics. However, since downstream travel distance is generally short in the UWH subcatchments, it is assumed that sediment generated on hillsides is delivered to the estuary without further attenuation. This is likely to be a reasonable assumption during large storms, and it is these events that transport most of the annual sediment load to the estuary. Furthermore, under the existing scenario the stream banks are likely to be relatively stable.

    - For development #1 scenario, the spatial pattern of earthworks and completed development was incorporated into the model for each different stage of the proposed development. Sediment control measures were applied during the prediction of sediment yield at 50% of earthworks sites. These control measures had an average annual efficiency of 65–70%. The remaining 50% of earthworks sites had no sediment control measures in place. The efficiency and application of sediment controls implemented within scenario #1 was determined through discussions between NIWA, ARC and the TA's. In addition to the simulation of hillside erosion (including earthwork sites), bank erosion, which is caused by increased flows associated with urbanisation, was predicted under the scenario #1 development. This was achieved using a relation between the degree of imperviousness in a catchment and the increase in channel area, derived from the work of Herald (1989) in the Albany basin, coupled with numerous overseas studies.
    - For the response-envelope scenario, sediment loads from development #1 scenario were applied.

- Sediment partitioning. The sediment load was partitioned across particle sizes 1 and 2 based on the GLEAMS output.
- Contaminant load.
    - The existing scenario assumes that the zinc load under the "current" (2001) landuse within the UWH catchment applies for the duration of the simulation. The derivation of the 2001 annual zinc

load for each subcatchment is explained in the next paragraph on the development #1 scenario.

- o The development #1 scenario zinc loads generated within each subcatchment for each year were derived by adding together: (1) the total number of existing and proposed new dwellings in the year multiplied by the dwelling zinc load of 48 g per annum; (2) the existing and proposed new commercial areas in the year multiplied by 1400 g ha-1; (3) the existing and proposed new industrial areas in the year multiplied by 4200 g ha-1, and; (4) the distance travelled by through traffic as vehicle.km in the year multiplied by the zinc load of 0.004 g per vehicle.km.

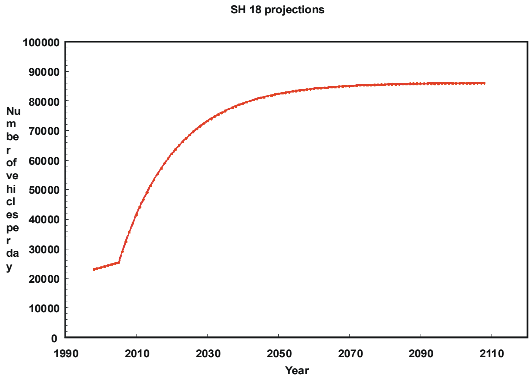
The derivation and validation of the dwelling and landuse zinc loads are described in Appendix F of NIWA Client Report HAM2003-087/1 – Methods.

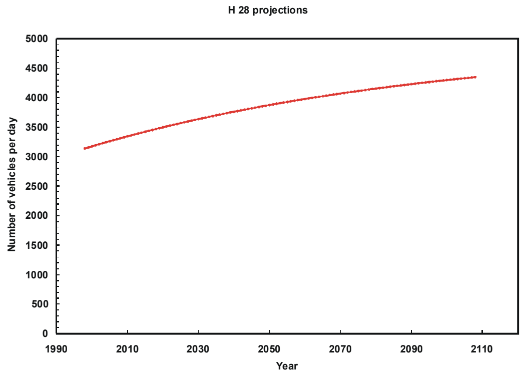
The existing numbers of dwellings and areas of commercial and industrial landuse were derived from the 2001 census data and the future numbers and areas were provided by the participating Councils. These data were provided as totals for periods of several years, so annual data were derived by dividing the total for each period by the number of years in the period.

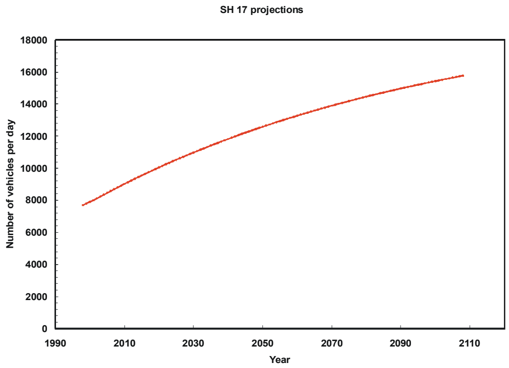
The dwelling, commercial and industrial loads include the loads from vehicles that are associated with the dwellings and commercial and industrial activities. The contaminant loads from vehicles not associated with either dwellings or these other activities, e.g., vehicles passing through the catchments on motorways and major highways, (called "through traffic"), are additional to the dwelling, commercial and industrial loads. The volumes of through traffic were estimated for SH18 through the Lucas and Waiarohia subcatchments, SH16 through the Waiarohia and Brighams subcatchments, and SH17 and H28 through the Rangitopuni subcatchment.

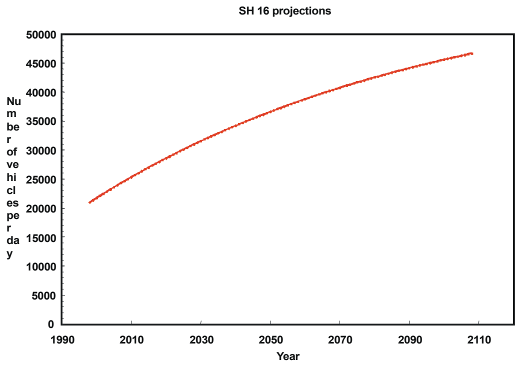
Vehicle counts for these roads for the period 1998 to 2003 were obtained from Ministry of Transport traffic models. A smoothed line was fitted to these data for each road, then the counts were projected into the future as shown in the following figures. Official projections are not readily available, so these projections are based on our estimates of potential growth. For the new SH18 motorway, the count is assumed to plateau in about 70 years time at about half of the present count for SH1 through Auckland City. For the other highways, the projections are simple extrapolations taking into account the potential growth in traffic because of feed from the new motorway sections (SH16 and SH18).

The total annual zinc load from dwellings, commercial and industrial landuses and through traffic for each year is distributed in proportion across all of the rainfall events that are programmed to occur in that year. This means that all of the zinc that is generated each year is washed from the catchment into the estuary. Hence, zinc does not build up in catchment sediments. In addition to the "urban" (dwelling plus through vehicle) zinc load, natural or "background" zinc loads, which originate naturally from soils, are assumed for each subcatchment. The derivation of the natural zinc loads is described in NIWA Client Report HAM2003-087/1 – Methods.









- For the response-envelope scenario, the zinc loads used were the same as those derived for the development #1 scenario.

- Contaminant partitioning. Zinc is distributed between the silt and sand in the catchment soils in the same proportion as was measured in the estuarine bed sediments. For most catchments, this proportion is approximately silt:sand = 3. The specific partitioning used for each subcatchment is given in the model results.

- Stormwater contaminant controls.
    - For the existing scenario, stormwater contaminant controls were set at zero, meaning that there is no retention of sediment and associated contaminants. Although this is not strictly correct, the assumption makes no material difference to the model results; it simply means that all new controls included in the model are additional to those that existed in 2001.
    - The development #1 scenario stormwater contaminant controls are based on the responses to two questionnaires, one from NIWA and one from the ARC, to the participating TLAs. These responses are summarised in Appendix A1. The overall conclusions from these

responses about the levels of future controls are: (1) all road runoff from both kerbed and unkerbed roads will be treated by swales, filter strips, sand filters/rain gardens or, in the case of RDC only, ponds; (2) all houses will have rainwater tanks; (3) all developments will use vegetation/revegetation to control runoff; (4) 50% (RDC), 85% (NSCC) and 100% (WCC) of dwellings within new developments will have community ponds/wetlands for treating stormwater; (5) galvanised roofs will continue to be permitted (although restrictions are being considered).

Subsequent to these questionnaires, the requirement for rainwater tanks was reconsidered. The primary outcome intended from the installation of rainwater tanks is the reduction of peak stormwater discharge, which does not alter contaminant loads entering the stormwater network. Consequently, this requirement was excluded from the list of controls. (The recent prohibition on the use of galvanised roofing iron is included in the response-envelope scenario described below).

The remaining conclusions condense down to: (1) treatment of road runoff to almost the level of efficiency achieved by swales, which is 75–80% for zinc (allowing for the use of less efficient ponds in some places) and; (2) treatment of dwelling, commercial and industrial stormwater to about the efficiency of pond/wetlands systems, i.e., about 50% for zinc.

The development #1 scenario controls are given in the following table. These controls apply only to new development, i.e., retrofitting is excluded.

Zinc source	Realistic controls (% retained)	Explanation
Existing dwellings	0	No retrofitting.
Existing commercial	0	No retrofitting.
Existing industrial	0	No retrofitting.
Existing through traffic	30% to 2005, then 50%	Assumed to follow controls on future traffic because same roads are used.
Future dwellings	40	80% of dwellings connected to controls with 50% retention.
Future commercial	40	As for future dwellings.
Future industrial	40	As for future dwellings.
Future through traffic	30% to 2005, then 50%	Up to 2005, 40% of runoff from new roads controlled with 75% retention. From 2006 on, 60% of runoff treated with 80% retention.

- The response-envelope scenario addressed the two extreme options for contaminant controls; zero and the maximum attainable. Although the zero option (there is no retention of sediment and associated contaminants additional to that which existed in 2001) is recognised as unrealistic because some stormwater treatment has been installed since 2001, this option gives a worst-case result for contaminant accumulation in the estuarine and harbour sediments.

  The other extreme of the envelope assumes that the maximum-attainable controls are implemented. These controls, derived by the ARC and NIWA, are described in the following table. The only control certain to be implemented is the prohibition on galvanised roofing iron. At the present time, the contribution of this roof material to zinc loads in urban catchments is unknown so, for the purposes of this study, a 30% contribution was assumed. Accordingly, the scenario 1 dwelling zinc loads were reduced by 30% to produce the loads for the maximum attainable option.

  As explained above, for dwellings and commercial and industrial landuses, a generic level of control for zinc equivalent to the retention achieved in a wetland, i.e., 50%, was assumed. The maximum attainable controls for roads are the same as for development #1 scenario. Note that the only difference between the controls for development #1 scenario and the response-envelope scenario is the inclusion of retrofitting in the envelope scenario.

Zinc source	Maximum attainable control (% retained)	Explanation
Existing dwellings	30	60% of dwellings connected to controls with 50% retention.
Existing commercial	30	As for existing dwellings.
Existing industrial	30	As for existing dwellings.
Existing through traffic	30% to 2005, then 50%	Assumed to follow controls on future traffic because same roads are used.
Future dwellings	40	80% of dwellings connected to controls with 50% retention.
Future commercial	40	As for future dwellings.
Future industrial	40	As for future dwellings.
Future through traffic	30% to 2005, then 50%	Up to 2005, 40% of runoff from new roads controlled with 75% retention. From 2006 on, 60% of runoff treated with 80% retention.

3. Simulation Inputs – Details

3.1 Simulation period: 54 years (2808 weeks)

For the 54-year simulation, the following inputs were used.

- Total area of each subestuary and area of channel and banks/intertidal flats in each subestuary (Table 4.2 in Methodology Report).
- Bioturbation model – uniform, with a bioturbation depth of 0.11 m .
- Event time series – four different magnitude events (E1, E2, E3, E4; Table 4.3 and Table 4.4 in Methodology Report) spread uniformly throughout simulation period of 54 years (1–2808 weeks, Figure A.3 in Methodology Report).
- R (Figure 4.6 in Methodology Report).
- R3(Figure 4.7 in Methodology Report).

- Contaminant partitioning across size fractions:

				Fraction of contaminant load on each size fraction	
Period #	**Week start**	**Week end**	**Subcatchment**	**Size fraction 1 (silt)**	**Size fraction 2 (sand)**
1	1	2808	1=Hellyers	0.93	0.07
1	1	2808	2=Lucas	0.95	0.05
1	1	2808	3=Paremoremo	0.95	0.05
1	1	2808	4=Rangitopuni	0.96	0.04
1	1	2808	5=Brighams	0.97	0.03
1	1	2808	6=Rarawaru	0.97	0.03
1	1	2808	7=Waiarohia	0.98	0.02

- Sediment partitioning across size fractions:

				Fraction of sediment load on each size fraction	
Period #	**Week start**	**Week end**	**Subcatchment**	**Size fraction 1 (silt)**	**Size fraction 2 (sand)**
1	1	2808	1=Hellyers	0.93	0.07
1	1	2808	2=Lucas	0.88	0.12
1	1	2808	3=Paremoremo	0.90	0.10
1	1	2808	4=Rangitopuni	0.91	0.09
1	1	2808	5=Brighams	0.95	0.05
1	1	2808	6=Rarawaru	0.95	0.05
1	1	2808	7=Waiarohia	0.95	0.05

- Contaminant loads – soil (natural or "background" load):

    - For all subcatchments except Paremoremo (3) and Rangitopuni (4): 40 mg zinc per kg of silt (size fraction 1) yield and 20 mg zinc per kg of sand (size fraction 2) yield. For Paremoremo (3) and Rangitopuni (4): 90 mg zinc per kg of silt (size fraction 1) yield and 40 mg zinc per kg of sand (size fraction 2) yield. As explained in the Methods report, the background zinc load is the primary calibration parameter for model predictions of estuarine sediment zinc concentrations. The different natural loads for Paremoremo (3) and Rangitopuni (4) are discussed below in Section 5.1.

- Initial contaminant concentrations in estuarine bed sediment size fractions:

Subestuary	**Zn conc, mg/kg**	
	Size fraction 1 (silt)	Size fraction 2 (sand)
1 = Hellyers	116	116
2 = Lucas	120	50
3 = Paremoremo	103	47
4 = Rangitopuni	105	45
5 = Brighams	103	61
6 = Rarawaru	103	61
7 = Waiarohia	99	29
8 = MWH	-	-
9 = Upper main UWH	100	100
10 = Middle main UWH	100	100
11 = Lower main UWH	90	90

- Initial split of estuarine bed sediments into size fractions:

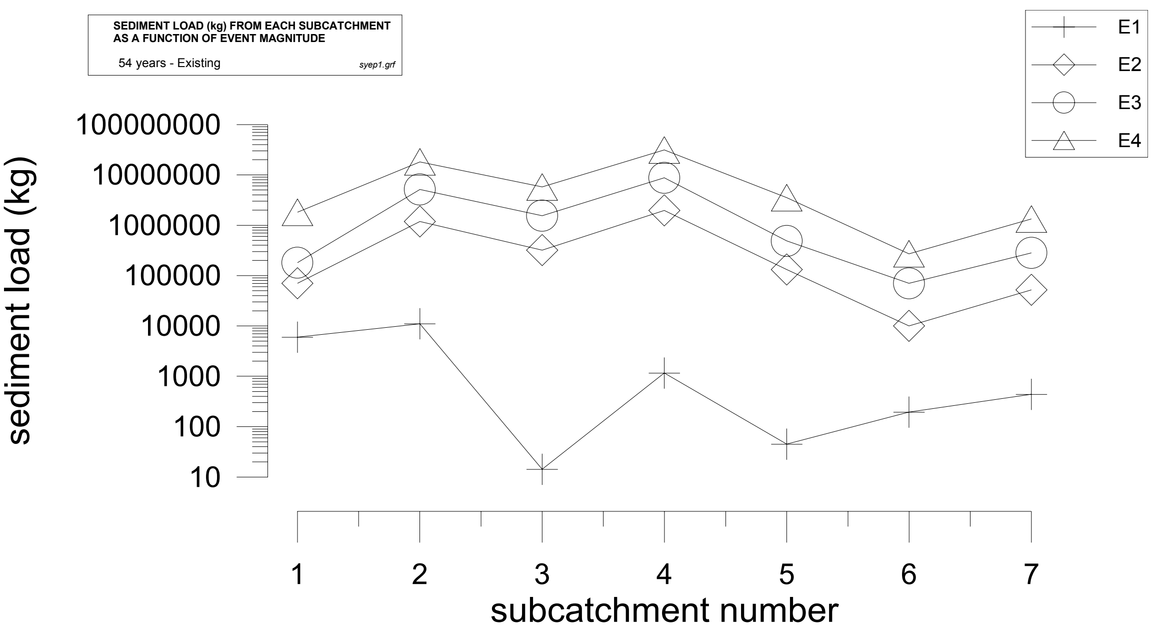
	% of bed sediment in each size fraction	
Subestuary	Size fraction 1 (silt)	Size fraction 2 (sand)
1 = Hellyers	77.77	22.23
2 = Lucas	66.68	33.32
3 = Paremoremo	68.80	31.20
4 = Rangitopuni	56.84	43.16
5 = Brighams	77.30	22.70
6 = Rarawaru	77.30	22.70
7 = Waiarohia	26.09	73.91
8 = MWH	-	-
9 = Upper main UWH	82.34	17.66
10 = Middle main UWH	33.55	66.45
11 = Lower main UWH	33.35	66.65

- Initial contaminant concentrations in estuarine bed sediments – total:

Subestuary	Zn conc, mg/kg
1 = Hellyers	116
2 = Lucas	97
3 = Paremoremo	85
4 = Rangitopuni	78
5 = Brighams	93
6 = Rarawaru	93
7 = Waiarohia	47
8 = MWH	-
9 = Upper main UWH	95
10 = Middle main UWH	101
11 = Lower main UWH	89

- Sediment loads from each subcatchment as a function of event magnitude, 54 years, existing scenario:

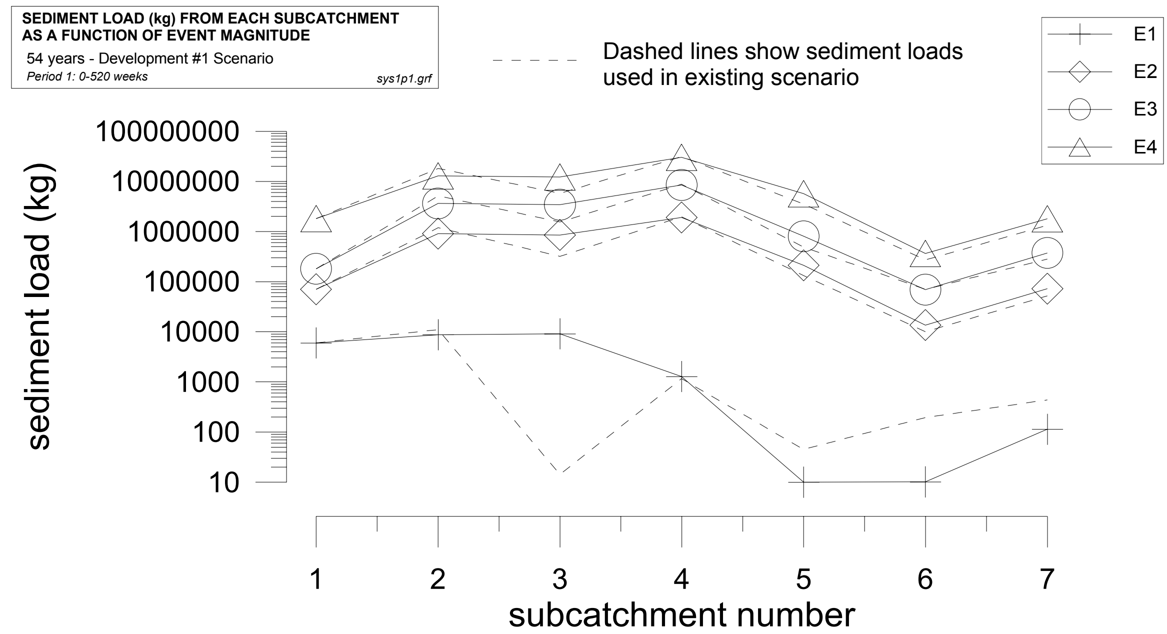
				sediment load, kg			
Period #	Week start	Week end	Subcatchment	Event E1	Event E2	Event E3	Event E4
1	1	2808	1=Hellyers	6,000	70,000	180,000	1,800,000
1	1	2808	2=Lucas	11,037	1,190,000	5,130,000	18,100,000
1	1	2808	3=Paremoremo	14.3	319,000	1,540,000	5,730,000
1	1	2808	4=Rangitopuni	1,160	1,960,000	8,720,000	31,200,000
1	1	2808	5=Brighams	45	132,000	488,000	3,520,000
1	1	2808	6=Rarawaru	195	10,000	69,900	271,000
1	1	2808	7=Waiarohia	437	52,100	282,000	1,330,000

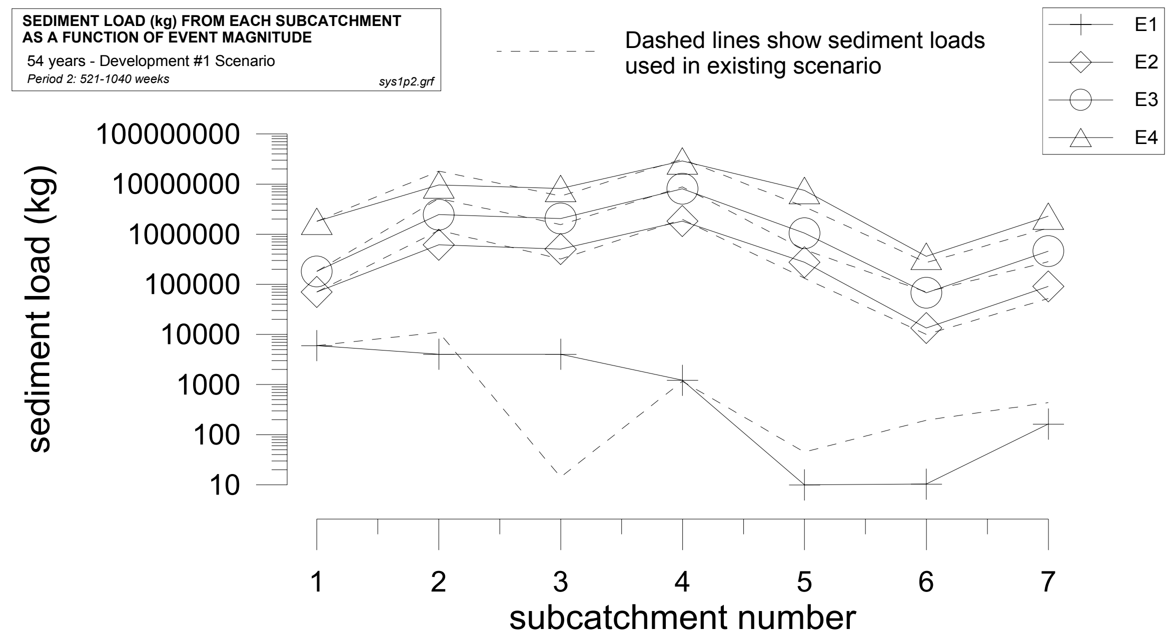


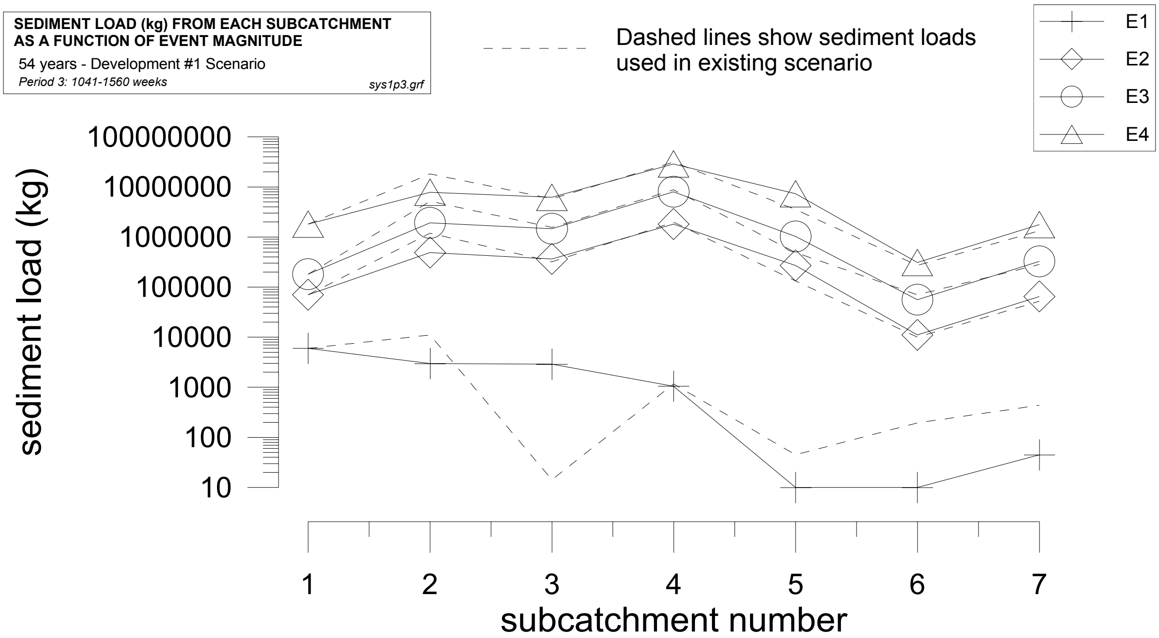
- Sediment loads from each subcatchment as a function of event magnitude, 54 years, development #1 scenario and response-envelope scenario (change in loads through time is a result of landuse change):

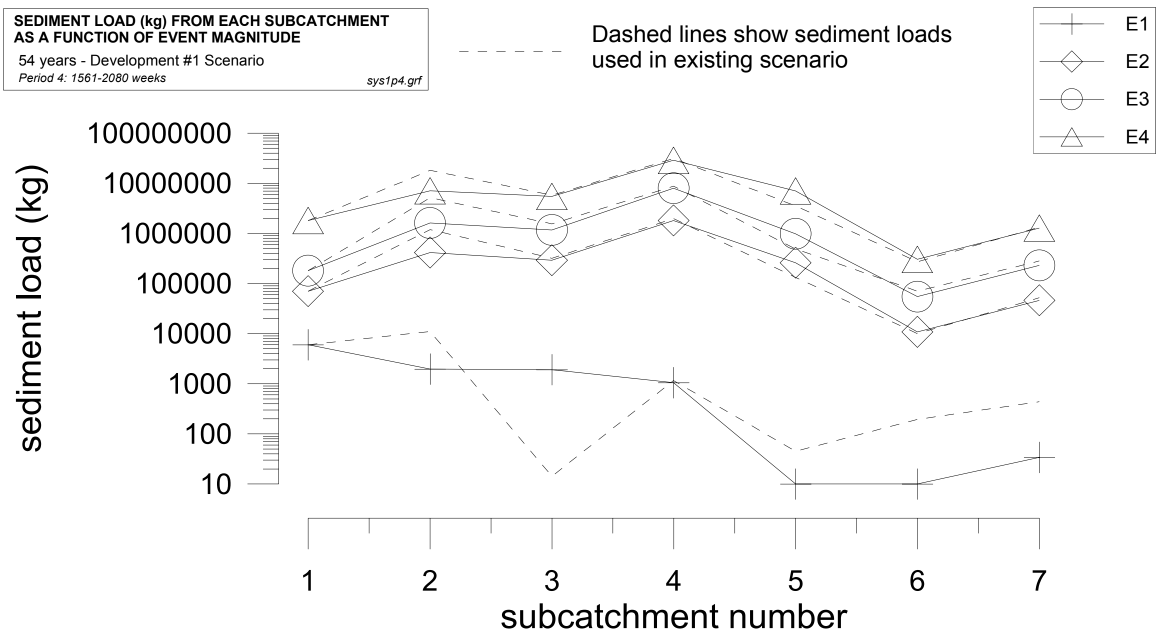
				sediment load, kg			
Period #	**Week start**	**Week end**	**Subcatchment**	**Event E1**	**Event E2**	**Event E3**	**Event E4**
1	1	520	1=Hellyers	6,000	70,000	180,000	1,800,000
1	1	520	2=Lucas	8,726	906,917	3,616,680	12,842,993
1	1	520	3=Paremoremo	9,146	848,914	3,428,741	12,167,005
1	1	520	4=Rangitopuni	1,280	1,901,862	8,414,052	30,149,116
1	1	520	5=Brighams	10	210,801	800,788	5,660,463
1	1	520	6=Rarawaru	10	13,536	68,872	365,385
1	1	520	7=Waiarohia	113	72,258	371,658	1,794,805
2	521	1040	1=Hellyers	6,000	70,000	180,000	1,800,000
2	521	1040	2=Lucas	4,038	611,016	2,443,164	9,575,109
2	521	1040	3=Paremoremo	4,018	500,403	2,048,763	8,169,509
2	521	1040	4=Rangitopuni	1,223	1,818,339	8,045,166	28,886,503
2	521	1040	5=Brighams	10	274,786	1,043,837	7,400,884
2	521	1040	6=Rarawaru	10	13,374	67,732	363,100
2	521	1040	7=Waiarohia	163	90,426	456,730	2,275,890
3	1041	1560	1=Hellyers	6,000	70,000	180,000	1,800,000
3	1041	1560	2=Lucas	2,973	489,639	1,912,042	7,811,152
3	1041	1560	3=Paremoremo	2,874	363,223	1,456,753	6,164,793
3	1041	1560	4=Rangitopuni	1,051	1,798,170	7,985,930	28,667,845
3	1041	1560	5=Brighams	10	268,811	1,019,490	7,256,593
3	1041	1560	6=Rarawaru	10	11,011	55,789	310,707
3	1041	1560	7=Waiarohia	45	64,648	325,179	1,768,049
4	1561	2080	1=Hellyers	6,000	70,000	180,000	1,800,000
4	1561	2080	2=Lucas	1,962	414,417	1,613,499	7,045,243
4	1561	2080	3=Paremoremo	1,913	290,643	1,170,328	5,456,592
4	1561	2080	4=Rangitopuni	1,051	1,798,170	7,985,930	28,667,845
4	1561	2080	5=Brighams	10	258,709	981,120	7,006,161
4	1561	2080	6=Rarawaru	10	10,774	54,577	304,129
4	1561	2080	7=Waiarohia	34	46,081	229,720	1,273,534
5	2081	2808	1=Hellyers	6,000	70,000	180,000	1,800,000
5	2081	2081	2=Lucas	1,569	368,319	1,426,442	6,429,850
5	2081	2081	3=Paremoremo	1,491	238,573	959,891	4,731,769
5	2081	2081	4=Rangitopuni	1,051	1,798,170	7,985,930	28,667,845
5	2081	2081	5=Brighams	10	274,208	1,039,830	7,450,822
5	2081	2081	6=Rarawaru	10	10,756	54,473	303,724
5	2081	2081	7=Waiarohia	38	47,819	235,964	1,337,167

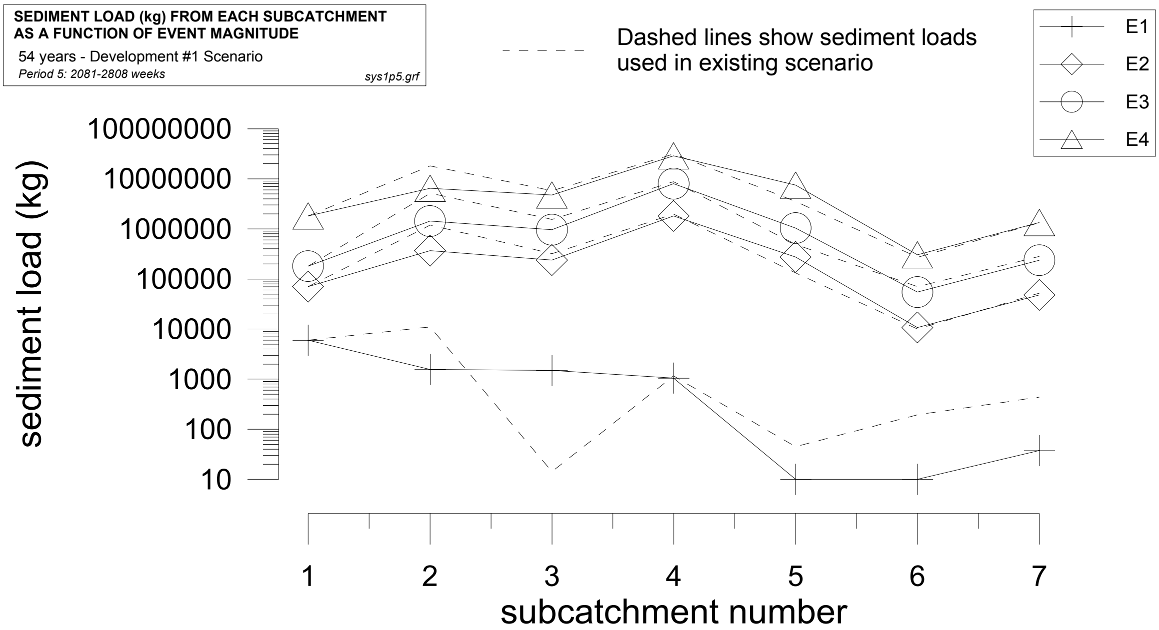
The next pages show plots, with comparisons to sediment loads used in existing scenario.


SEDIMENT LOAD (kg) FROM EACH SUBCATCHMENT
AS A FUNCTION OF EVENT MAGNITUDE
54 years - Development #1 Scenario
Period 1: 0-520 weeks
sys1p1.grf
Dashed lines show sediment loads
used in existing scenario
E1
E2
E3
E4
sediment load (kg)
100000000
10000000
1000000
100000
10000
1000
100
10
1
2
3
4
5
6
7
subcatchment number


SEDIMENT LOAD (kg) FROM EACH SUBCATCHMENT
AS A FUNCTION OF EVENT MAGNITUDE
54 years - Development #1 Scenario
Period 2: 521-1040 weeks
sys1p2.grf
Dashed lines show sediment loads
used in existing scenario
E1
E2
E3
E4
sediment load (kg)
100000000
10000000
1000000
100000
10000
1000
100
10
1
2
3
4
5
6
7
subcatchment number

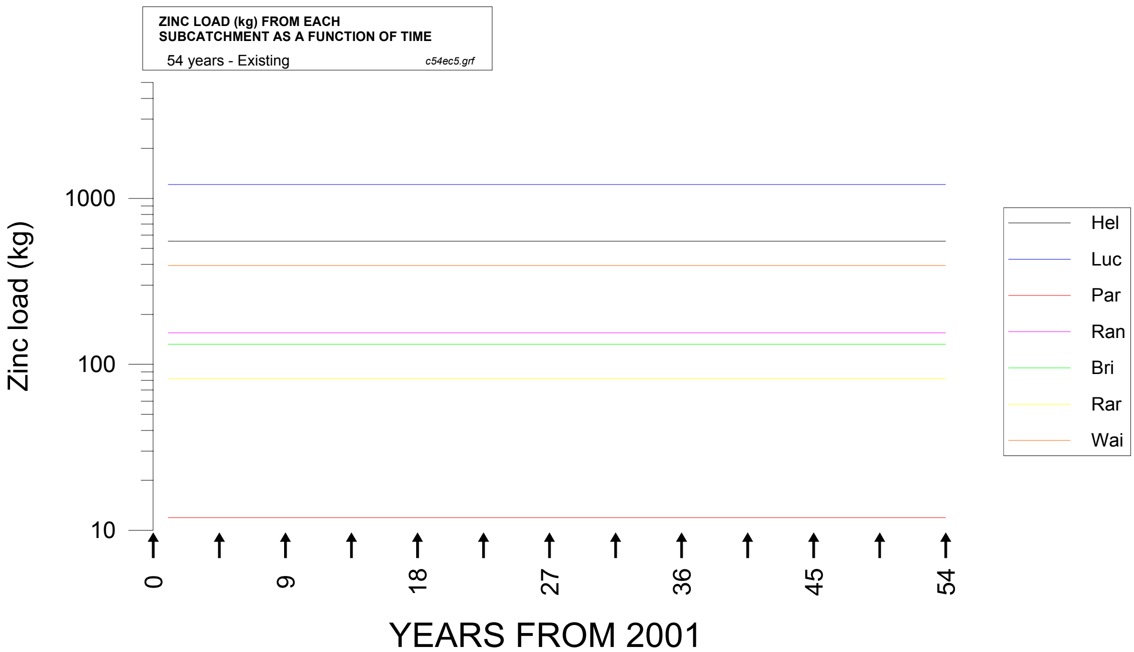

SEDIMENT LOAD (kg) FROM EACH SUBCATCHMENT
AS A FUNCTION OF EVENT MAGNITUDE
54 years - Development #1 Scenario
Period 3: 1041-1560 weeks
sys1p3.grf
Dashed lines show sediment loads
used in existing scenario
E1
E2
E3
E4
100000000
10000000
1000000
100000
10000
1000
100
10
sediment load (kg)
1
2
3
4
5
6
7
subcatchment number


SEDIMENT LOAD (kg) FROM EACH SUBCATCHMENT
AS A FUNCTION OF EVENT MAGNITUDE
54 years - Development #1 Scenario
Period 4: 1561-2080 weeks
sys1p4.grf
Dashed lines show sediment loads
used in existing scenario
E1
E2
E3
E4
100000000
10000000
1000000
100000
10000
1000
100
10
sediment load (kg)
1
2
3
4
5
6
7
subcatchment number



- Contaminant loads – dwellings, roads, traffic ("urban load") – existing scenario:

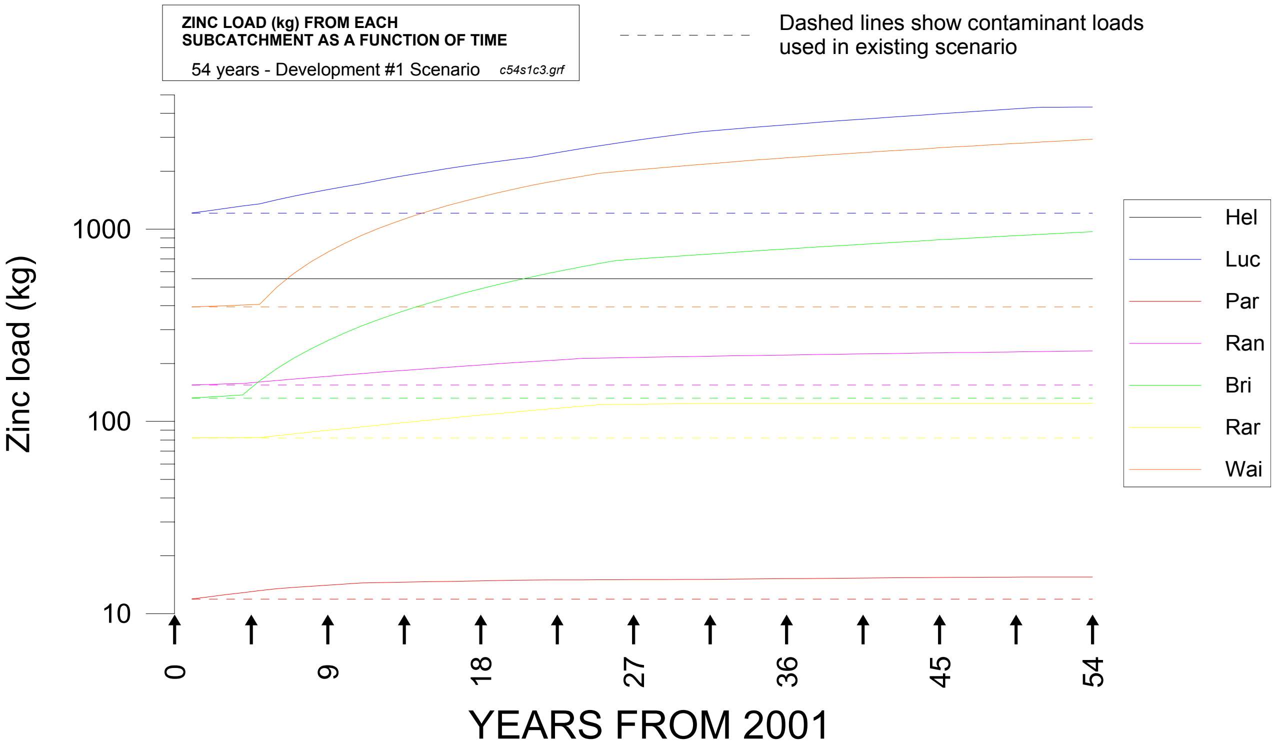
Period #	Week start	Week end	kg zinc from each subcatchment						
			1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1	1	2808	552.0	1212.4	11.9	154.7	132.4	82.1	394.3



- Contaminant loads – dwellings, roads, traffic ("urban load") – development #1 scenario and response-envelope scenario:

Period #	Week start	Week end	kg zinc from each subcatchment						
			1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1	1	52	552.0	1212.4	11.9	154.7	132.4	82.1	394.3
2	53	104	552.0	1247.5	12.2	155.6	134.0	82.1	396.9
3	105	156	552.0	1282.6	12.5	156.6	135.6	82.2	399.5
4	157	208	552.0	1318.5	12.8	157.5	137.2	82.3	403.0
5	209	260	552.0	1353.6	13.2	160.4	162.5	82.3	405.7
6	261	312	552.0	1418.0	13.5	163.2	187.7	84.2	496.9
7	313	364	552.0	1482.4	13.7	166.0	212.8	86.1	586.3
8	365	416	552.0	1545.0	13.9	168.8	238.0	88.0	673.9
9	417	468	552.0	1606.0	14.1	171.7	263.2	89.8	759.7
10	469	520	552.0	1665.3	14.3	174.5	288.3	91.7	844.0
11	521	572	552.0	1723.1	14.4	177.2	313.4	93.6	926.8
12	573	624	552.0	1793.0	14.5	180.0	338.5	95.6	1008.1
13	625	676	552.0	1861.6	14.5	182.8	363.6	97.6	1088.2
14	677	728	552.0	1929.0	14.6	185.6	388.7	99.7	1167.0
15	729	780	552.0	1995.1	14.6	188.3	413.8	101.7	1244.6
16	781	832	552.0	2060.2	14.7	191.1	438.8	103.7	1321.1
17	833	884	552.0	2124.3	14.8	193.8	463.9	105.7	1396.6
18	885	936	552.0	2187.3	14.8	196.5	488.9	107.8	1471.1
19	937	988	552.0	2249.5	14.9	199.2	513.9	109.8	1544.7
20	989	1040	552.0	2310.8	14.9	202.0	538.9	111.8	1617.5
21	1041	1092	552.0	2371.3	15.0	204.7	563.9	113.8	1689.4
22	1093	1144	552.0	2458.3	15.0	207.4	588.9	115.9	1755.3
23	1145	1196	552.0	2544.5	15.0	210.0	613.8	118.0	1820.5
24	1197	1248	552.0	2630.1	15.0	212.7	638.7	120.1	1885.0
25	1249	1300	552.0	2715.1	15.0	213.5	663.7	122.2	1948.9
26	1301	1352	552.0	2799.5	15.0	214.2	686.8	122.5	1987.7
27	1353	1404	552.0	2883.3	15.0	215.0	697.1	122.8	2025.8
28	1405	1456	552.0	2966.6	15.0	215.7	707.4	123.0	2063.5
29	1457	1508	552.0	3049.4	15.0	216.5	717.6	123.3	2100.7
30	1509	1560	552.0	3131.8	15.0	217.2	727.9	123.6	2137.4
31	1561	1612	552.0	3213.7	15.0	217.9	738.1	123.9	2173.6
32	1613	1664	552.0	3269.9	15.1	218.6	748.4	123.9	2209.5
33	1665	1716	552.0	3325.7	15.1	219.3	758.6	123.9	2244.9
34	1717	1768	552.0	3381.1	15.1	220.0	768.8	123.9	2280.0
35	1769	1820	552.0	3436.2	15.2	220.7	779.0	123.9	2314.8
36	1821	1872	552.0	3491.0	15.2	221.4	789.1	123.9	2349.3
37	1873	1924	552.0	3545.5	15.2	222.1	799.3	123.9	2383.4
38	1925	1976	552.0	3599.7	15.2	222.8	809.4	123.9	2417.3
39	1977	2028	552.0	3653.6	15.3	223.4	819.6	123.9	2450.9
40	2029	2080	552.0	3707.3	15.3	224.1	829.7	123.9	2484.2
41	2081	2132	552.0	3760.8	15.3	224.7	839.8	123.9	2517.4
42	2133	2184	552.0	3816.2	15.3	225.4	849.9	123.9	2550.3
43	2185	2236	552.0	3871.4	15.4	226.0	860.0	123.9	2582.9
44	2237	2288	552.0	3926.4	15.4	226.7	870.1	123.9	2615.4
45	2289	2340	552.0	3981.3	15.4	227.3	880.2	123.9	2647.8
46	2341	2392	552.0	4035.9	15.4	227.9	890.3	123.9	2679.9
47	2393	2444	552.0	4090.4	15.4	228.5	900.3	123.9	2711.9
48	2445	2496	552.0	4144.8	15.4	229.1	910.4	123.9	2743.7
49	2497	2548	552.0	4199.0	15.5	229.7	920.4	123.9	2775.4
50	2549	2600	552.0	4253.1	15.5	230.3	930.4	123.9	2807.0
51	2601	2652	552.0	4307.0	15.5	230.9	940.4	123.9	2838.4
52	2653	2704	552.0	4308.9	15.5	231.5	950.4	123.9	2869.7
53	2705	2756	552.0	4310.6	15.5	232.1	960.4	123.9	2900.9
54	2757	2808	552.0	4312.3	15.5	232.6	970.4	123.9	2932.0

The next page shows a plot, with comparisons to contaminant loads used in existing scenario.



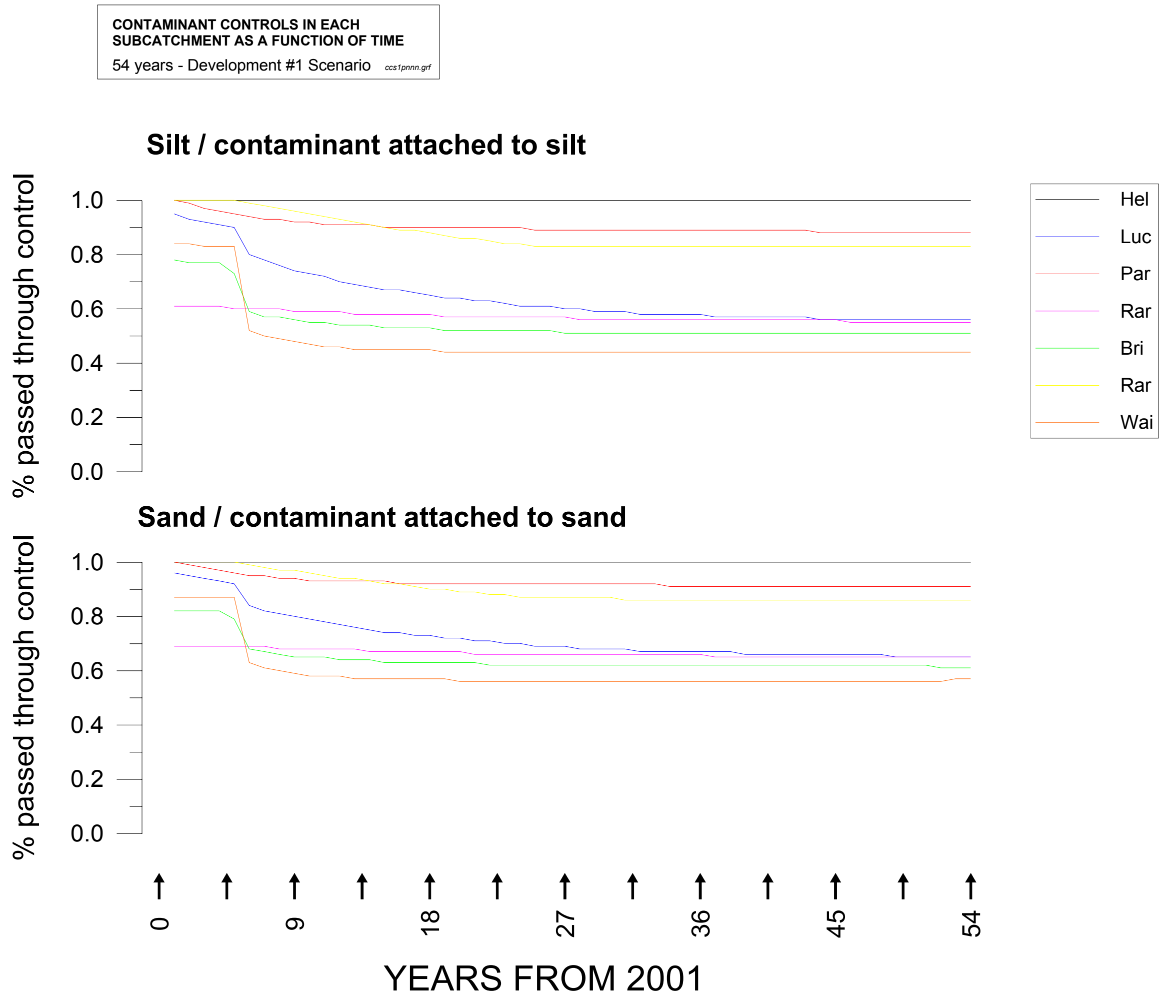
- Stormwater contaminant controls – existing scenario:

				Fraction of sediment load (with attached contaminant) <u>passed</u> through controls													
				1=Hel		2=Luc		3=Par		4=Ran		5=Bri		6=Rar		7=Wai	
Period #	**Week start**	**Week end**	**Events**	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand
1	1	2808	1,2,3,4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

- Stormwater contaminant controls – development #1 scenario:

				Fraction of sediment load (with attached contaminant) passed through controls													
				1=Hel		2=Luc		3=Par		4=Ran		5=Bri		6=Rar		7=Wai	
Period #	Week start	Week end	Events	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand
1	1	52	1,2,3,4	1.00	1.00	0.95	0.96	1.00	1.00	0.61	0.69	0.78	0.82	1.00	1.00	0.84	0.87
2	53	104	1,2,3,4	1.00	1.00	0.93	0.95	0.99	0.99	0.61	0.69	0.77	0.82	1.00	1.00	0.84	0.87
3	105	156	1,2,3,4	1.00	1.00	0.92	0.94	0.97	0.98	0.61	0.69	0.77	0.82	1.00	1.00	0.83	0.87
4	157	208	1,2,3,4	1.00	1.00	0.91	0.93	0.96	0.97	0.61	0.69	0.77	0.82	1.00	1.00	0.83	0.87
5	209	260	1,2,3,4	1.00	1.00	0.90	0.92	0.95	0.96	0.60	0.69	0.73	0.79	1.00	1.00	0.83	0.87
6	261	312	1,2,3,4	1.00	1.00	0.80	0.84	0.94	0.95	0.60	0.69	0.59	0.68	0.99	0.99	0.52	0.63
7	313	364	1,2,3,4	1.00	1.00	0.78	0.82	0.93	0.95	0.60	0.69	0.57	0.67	0.98	0.98	0.50	0.61
8	365	416	1,2,3,4	1.00	1.00	0.76	0.81	0.93	0.94	0.60	0.68	0.57	0.66	0.97	0.97	0.49	0.60
9	417	468	1,2,3,4	1.00	1.00	0.74	0.80	0.92	0.94	0.59	0.68	0.56	0.65	0.96	0.97	0.48	0.59
10	469	520	1,2,3,4	1.00	1.00	0.73	0.79	0.92	0.93	0.59	0.68	0.55	0.65	0.95	0.96	0.47	0.58
11	521	572	1,2,3,4	1.00	1.00	0.72	0.78	0.91	0.93	0.59	0.68	0.55	0.65	0.94	0.95	0.46	0.58
12	573	624	1,2,3,4	1.00	1.00	0.70	0.77	0.91	0.93	0.59	0.68	0.54	0.64	0.93	0.94	0.46	0.58
13	625	676	1,2,3,4	1.00	1.00	0.69	0.76	0.91	0.93	0.58	0.68	0.54	0.64	0.92	0.94	0.45	0.57
14	677	728	1,2,3,4	1.00	1.00	0.68	0.75	0.91	0.93	0.58	0.67	0.54	0.64	0.91	0.93	0.45	0.57
15	729	780	1,2,3,4	1.00	1.00	0.67	0.74	0.90	0.93	0.58	0.67	0.53	0.63	0.90	0.92	0.45	0.57
16	781	832	1,2,3,4	1.00	1.00	0.67	0.74	0.90	0.92	0.58	0.67	0.53	0.63	0.89	0.92	0.45	0.57
17	833	884	1,2,3,4	1.00	1.00	0.66	0.73	0.90	0.92	0.58	0.67	0.53	0.63	0.89	0.91	0.45	0.57
18	885	936	1,2,3,4	1.00	1.00	0.65	0.73	0.90	0.92	0.58	0.67	0.53	0.63	0.88	0.90	0.45	0.57
19	937	988	1,2,3,4	1.00	1.00	0.64	0.72	0.90	0.92	0.57	0.67	0.52	0.63	0.87	0.90	0.44	0.57
20	989	1040	1,2,3,4	1.00	1.00	0.64	0.72	0.90	0.92	0.57	0.67	0.52	0.63	0.86	0.89	0.44	0.56
21	1041	1092	1,2,3,4	1.00	1.00	0.63	0.71	0.90	0.92	0.57	0.66	0.52	0.63	0.86	0.89	0.44	0.56
22	1093	1144	1,2,3,4	1.00	1.00	0.63	0.71	0.90	0.92	0.57	0.66	0.52	0.62	0.85	0.88	0.44	0.56
23	1145	1196	1,2,3,4	1.00	1.00	0.62	0.70	0.90	0.92	0.57	0.66	0.52	0.62	0.84	0.88	0.44	0.56
24	1197	1248	1,2,3,4	1.00	1.00	0.61	0.70	0.90	0.92	0.57	0.66	0.52	0.62	0.84	0.87	0.44	0.56
25	1249	1300	1,2,3,4	1.00	1.00	0.61	0.69	0.89	0.92	0.57	0.66	0.52	0.62	0.83	0.87	0.44	0.56
26	1301	1352	1,2,3,4	1.00	1.00	0.61	0.69	0.89	0.92	0.57	0.66	0.52	0.62	0.83	0.87	0.44	0.56
27	1353	1404	1,2,3,4	1.00	1.00	0.60	0.69	0.89	0.92	0.57	0.66	0.51	0.62	0.83	0.87	0.44	0.56
28	1405	1456	1,2,3,4	1.00	1.00	0.60	0.68	0.89	0.92	0.56	0.66	0.51	0.62	0.83	0.87	0.44	0.56
29	1457	1508	1,2,3,4	1.00	1.00	0.59	0.68	0.89	0.92	0.56	0.66	0.51	0.62	0.83	0.87	0.44	0.56
30	1509	1560	1,2,3,4	1.00	1.00	0.59	0.68	0.89	0.92	0.56	0.66	0.51	0.62	0.83	0.87	0.44	0.56
31	1561	1612	1,2,3,4	1.00	1.00	0.59	0.68	0.89	0.92	0.56	0.66	0.51	0.62	0.83	0.86	0.44	0.56
32	1613	1664	1,2,3,4	1.00	1.00	0.58	0.67	0.89	0.92	0.56	0.66	0.51	0.62	0.83	0.86	0.44	0.56
33	1665	1716	1,2,3,4	1.00	1.00	0.58	0.67	0.89	0.92	0.56	0.66	0.51	0.62	0.83	0.86	0.44	0.56
34	1717	1768	1,2,3,4	1.00	1.00	0.58	0.67	0.89	0.91	0.56	0.66	0.51	0.62	0.83	0.86	0.44	0.56
35	1769	1820	1,2,3,4	1.00	1.00	0.58	0.67	0.89	0.91	0.56	0.66	0.51	0.62	0.83	0.86	0.44	0.56
36	1821	1872	1,2,3,4	1.00	1.00	0.58	0.67	0.89	0.91	0.56	0.66	0.51	0.62	0.83	0.86	0.44	0.56
37	1873	1924	1,2,3,4	1.00	1.00	0.57	0.67	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
38	1925	1976	1,2,3,4	1.00	1.00	0.57	0.67	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
39	1977	2028	1,2,3,4	1.00	1.00	0.57	0.66	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
40	2029	2080	1,2,3,4	1.00	1.00	0.57	0.66	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
41	2081	2132	1,2,3,4	1.00	1.00	0.57	0.66	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
42	2133	2184	1,2,3,4	1.00	1.00	0.57	0.66	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
43	2185	2236	1,2,3,4	1.00	1.00	0.57	0.66	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
44	2237	2288	1,2,3,4	1.00	1.00	0.56	0.66	0.88	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
45	2289	2340	1,2,3,4	1.00	1.00	0.56	0.66	0.88	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
46	2341	2392	1,2,3,4	1.00	1.00	0.56	0.66	0.88	0.91	0.55	0.65	0.51	0.62	0.83	0.86	0.44	0.56
47	2393	2444	1,2,3,4	1.00	1.00	0.56	0.66	0.88	0.91	0.55	0.65	0.51	0.62	0.83	0.86	0.44	0.56
48	2445	2496	1,2,3,4	1.00	1.00	0.56	0.66	0.88	0.91	0.55	0.65	0.51	0.62	0.83	0.86	0.44	0.56
49	2497	2548	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.62	0.83	0.86	0.44	0.56
50	2549	2600	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.62	0.83	0.86	0.44	0.56
51	2601	2652	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.62	0.83	0.86	0.44	0.56
52	2653	2704	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.56
53	2705	2756	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.57

54	2757	2808	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.57



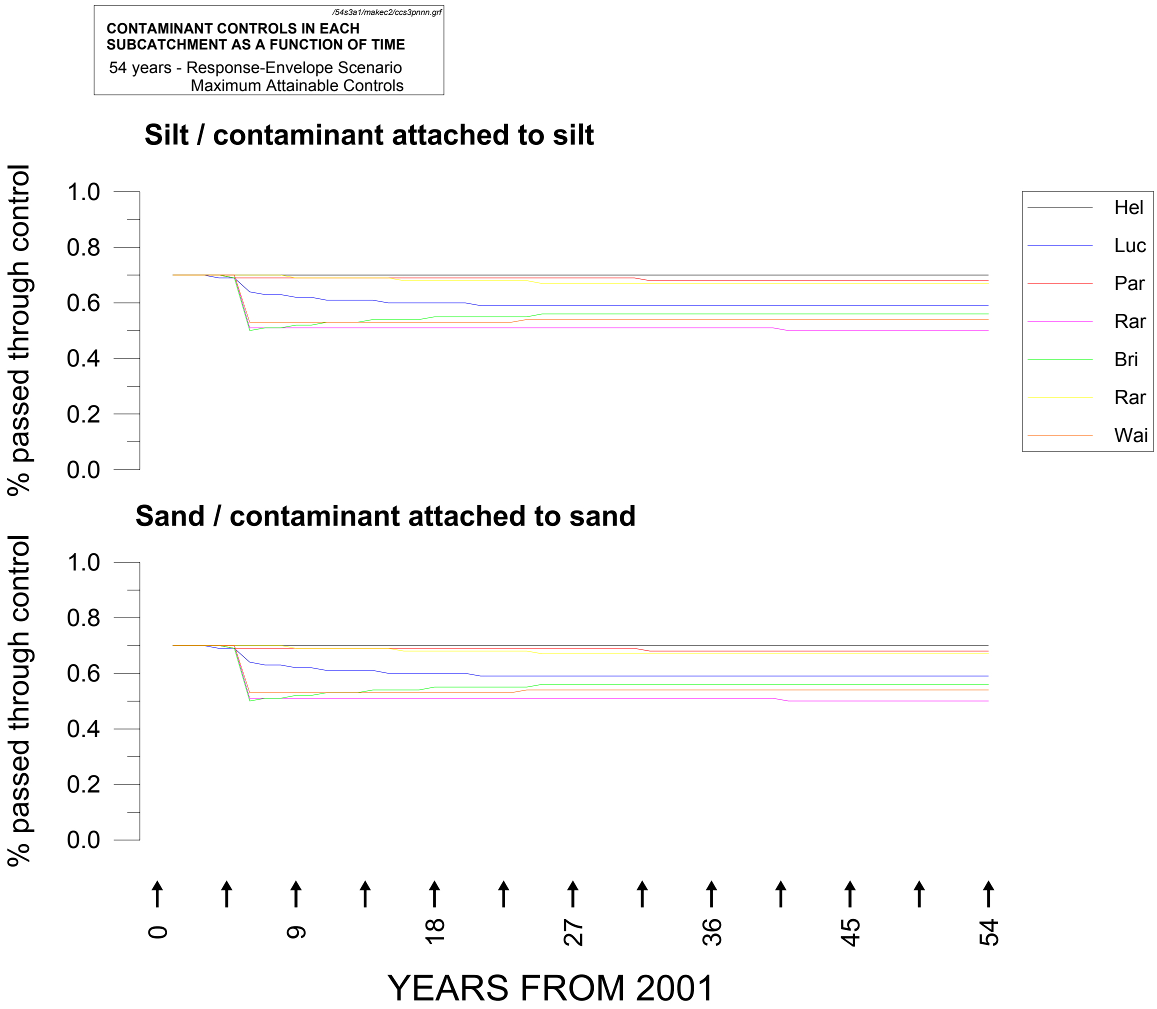
- Stormwater contaminant controls – response-envelope scenario, zero controls:

				Fraction of sediment load (with attached contaminant) <u>passed</u> through controls													
				1=Hel		2=Luc		3=Par		4=Ran		5=Bri		6=Rar		7=Wai	
Period #	**Week start**	**Week end**	**Events**	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand
1	1	2808	1,2,3,4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

- Stormwater contaminant controls – response-envelope scenario, maximum attainable controls:

				Fraction of sediment load (with attached contaminant) <u>passed</u> through controls													
				1=Hel		2=Luc		3=Par		4=Ran		5=Bri		6=Rar		7=Wai	
Period #	**Week start**	**Week end**	**Events**	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand
1	1	52	1,2,3,4	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
2	53	104	1,2,3,4	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
3	105	156	1,2,3,4	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
4	157	208	1,2,3,4	0.70	0.70	0.69	0.69	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
5	209	260	1,2,3,4	0.70	0.70	0.69	0.69	0.69	0.69	0.70	0.70	0.69	0.69	0.70	0.70	0.70	0.70
6	261	312	1,2,3,4	0.70	0.70	0.64	0.64	0.69	0.69	0.51	0.51	0.50	0.50	0.70	0.70	0.53	0.53
7	313	364	1,2,3,4	0.70	0.70	0.63	0.63	0.69	0.69	0.51	0.51	0.51	0.51	0.70	0.70	0.53	0.53
8	365	416	1,2,3,4	0.70	0.70	0.63	0.63	0.69	0.69	0.51	0.51	0.51	0.51	0.70	0.70	0.53	0.53
9	417	468	1,2,3,4	0.70	0.70	0.62	0.62	0.69	0.69	0.51	0.51	0.52	0.52	0.69	0.69	0.53	0.53
10	469	520	1,2,3,4	0.70	0.70	0.62	0.62	0.69	0.69	0.51	0.51	0.52	0.52	0.69	0.69	0.53	0.53
11	521	572	1,2,3,4	0.70	0.70	0.61	0.61	0.69	0.69	0.51	0.51	0.53	0.53	0.69	0.69	0.53	0.53
12	573	624	1,2,3,4	0.70	0.70	0.61	0.61	0.69	0.69	0.51	0.51	0.53	0.53	0.69	0.69	0.53	0.53
13	625	676	1,2,3,4	0.70	0.70	0.61	0.61	0.69	0.69	0.51	0.51	0.53	0.53	0.69	0.69	0.53	0.53
14	677	728	1,2,3,4	0.70	0.70	0.61	0.61	0.69	0.69	0.51	0.51	0.54	0.54	0.69	0.69	0.53	0.53
15	729	780	1,2,3,4	0.70	0.70	0.60	0.60	0.69	0.69	0.51	0.51	0.54	0.54	0.69	0.69	0.53	0.53
16	781	832	1,2,3,4	0.70	0.70	0.60	0.60	0.69	0.69	0.51	0.51	0.54	0.54	0.68	0.68	0.53	0.53
17	833	884	1,2,3,4	0.70	0.70	0.60	0.60	0.69	0.69	0.51	0.51	0.54	0.54	0.68	0.68	0.53	0.53
18	885	936	1,2,3,4	0.70	0.70	0.60	0.60	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.53	0.53
19	937	988	1,2,3,4	0.70	0.70	0.60	0.60	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.53	0.53
20	989	1040	1,2,3,4	0.70	0.70	0.60	0.60	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.53	0.53
21	1041	1092	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.53	0.53
22	1093	1144	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.53	0.53
23	1145	1196	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.53	0.53
24	1197	1248	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.54	0.54
25	1249	1300	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
26	1301	1352	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
27	1353	1404	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
28	1405	1456	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
29	1457	1508	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
30	1509	1560	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
31	1561	1612	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
32	1613	1664	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
33	1665	1716	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
34	1717	1768	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
35	1769	1820	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
36	1821	1872	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
37	1873	1924	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
38	1925	1976	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
39	1977	2028	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
40	2029	2080	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
41	2081	2132	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
42	2133	2184	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
43	2185	2236	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
44	2237	2288	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
45	2289	2340	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
46	2341	2392	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
47	2393	2444	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
48	2445	2496	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
49	2497	2548	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
50	2549	2600	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
51	2601	2652	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54

52	2653	2704	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
53	2705	2756	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
54	2757	2808	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54



3.2 Simulation period: 108 years (5616 weeks)

For the 108-year simulation, the following inputs were used:

- Total area of each subestuary and area of channel and banks/intertidal flats in each subestuary (Table 4.2 in Methodology Report).
- Bioturbation model – uniform, with a bioturbation depth of 0.11 m.
- Event time series – four different magnitude events (E1, E2, E3, E4; Table 4.3 and Table 4.4 in Methodology Report) spread uniformly throughout simulation period of 108 years (1–5616 weeks, Figure A.3 in Methodology Report).
- R (Figure 4.6 in Methodology Report).
- R3 (Figure 4.7 in Methodology Report).

- Contaminant partitioning across size fractions: as 54-year simulation.
- Sediment partitioning across size fractions: as 54-year simulation.

- Initial contaminant concentrations in estuarine bed sediments – size fractions: as 54-year simulation.
- Initial split of estuarine bed sediments into size fractions: as 54-year simulation.
- Initial contaminant concentrations in estuarine bed sediments – total: as 54-year simulation.

- Sediment loads – existing scenario: as 54-year simulation.
- Sediment loads – development #1 scenario and response-envelope scenario: as 54-year simulation.

- Contaminant loads – soil (natural or "background" load): as 54-year simulation.

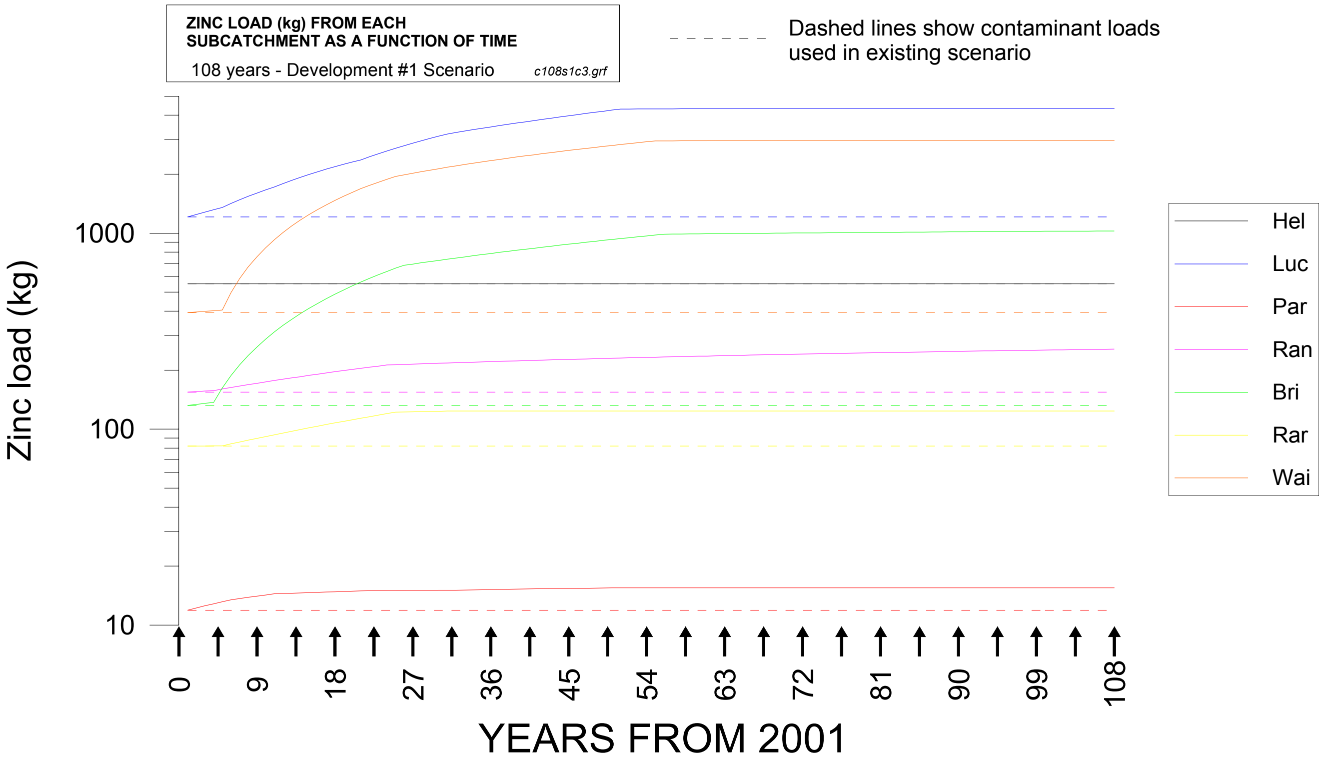
- Contaminant loads – existing scenario, dwellings, roads, traffic ("urban" load): as 54-year simulation.

- Contaminant loads – dwellings, roads, traffic ("urban load") – development #1 scenario and response-envelope scenario:

Period #	Week start	Week end	kg zinc from each subcatchment						
			1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1	1	52	552.0	1212.4	11.9	154.7	132.4	82.1	394.3
2	53	104	552.0	1247.5	12.2	155.6	134.0	82.1	396.9
3	105	156	552.0	1282.6	12.5	156.6	135.6	82.2	399.5
4	157	208	552.0	1318.5	12.8	157.5	137.2	82.3	403.0
5	209	260	552.0	1353.6	13.2	160.4	162.5	82.3	405.7
6	261	312	552.0	1418.0	13.5	163.2	187.7	84.2	496.9
7	313	364	552.0	1482.4	13.7	166.0	212.8	86.1	586.3
8	365	416	552.0	1545.0	13.9	168.8	238.0	88.0	673.9
9	417	468	552.0	1606.0	14.1	171.7	263.2	89.8	759.7
10	469	520	552.0	1665.3	14.3	174.5	288.3	91.7	844.0
11	521	572	552.0	1723.1	14.4	177.2	313.4	93.6	926.8
12	573	624	552.0	1793.0	14.5	180.0	338.5	95.6	1008.1
13	625	676	552.0	1861.6	14.5	182.8	363.6	97.6	1088.2
14	677	728	552.0	1929.0	14.6	185.6	388.7	99.7	1167.0
15	729	780	552.0	1995.1	14.6	188.3	413.8	101.7	1244.6
16	781	832	552.0	2060.2	14.7	191.1	438.8	103.7	1321.1
17	833	884	552.0	2124.3	14.8	193.8	463.9	105.7	1396.6
18	885	936	552.0	2187.3	14.8	196.5	488.9	107.8	1471.1
19	937	988	552.0	2249.5	14.9	199.2	513.9	109.8	1544.7
20	989	1040	552.0	2310.8	14.9	202.0	538.9	111.8	1617.5
21	1041	1092	552.0	2371.3	15.0	204.7	563.9	113.8	1689.4
22	1093	1144	552.0	2458.3	15.0	207.4	588.9	115.9	1755.3
23	1145	1196	552.0	2544.5	15.0	210.0	613.8	118.0	1820.5
24	1197	1248	552.0	2630.1	15.0	212.7	638.7	120.1	1885.0
25	1249	1300	552.0	2715.1	15.0	213.5	663.7	122.2	1948.9
26	1301	1352	552.0	2799.5	15.0	214.2	686.8	122.5	1987.7
27	1353	1404	552.0	2883.3	15.0	215.0	697.1	122.8	2025.8
28	1405	1456	552.0	2966.6	15.0	215.7	707.4	123.0	2063.5
29	1457	1508	552.0	3049.4	15.0	216.5	717.6	123.3	2100.7
30	1509	1560	552.0	3131.8	15.0	217.2	727.9	123.6	2137.4
31	1561	1612	552.0	3213.7	15.0	217.9	738.1	123.9	2173.6
32	1613	1664	552.0	3269.9	15.1	218.6	748.4	123.9	2209.5
33	1665	1716	552.0	3325.7	15.1	219.3	758.6	123.9	2244.9
34	1717	1768	552.0	3381.1	15.1	220.0	768.8	123.9	2280.0
35	1769	1820	552.0	3436.2	15.2	220.7	779.0	123.9	2314.8
36	1821	1872	552.0	3491.0	15.2	221.4	789.1	123.9	2349.3
37	1873	1924	552.0	3545.5	15.2	222.1	799.3	123.9	2383.4
38	1925	1976	552.0	3599.7	15.2	222.8	809.4	123.9	2417.3
39	1977	2028	552.0	3653.6	15.3	223.4	819.6	123.9	2450.9
40	2029	2080	552.0	3707.3	15.3	224.1	829.7	123.9	2484.2
41	2081	2132	552.0	3760.8	15.3	224.7	839.8	123.9	2517.4
42	2133	2184	552.0	3816.2	15.3	225.4	849.9	123.9	2550.3
43	2185	2236	552.0	3871.4	15.4	226.0	860.0	123.9	2582.9
44	2237	2288	552.0	3926.4	15.4	226.7	870.1	123.9	2615.4
45	2289	2340	552.0	3981.3	15.4	227.3	880.2	123.9	2647.8
46	2341	2392	552.0	4035.9	15.4	227.9	890.3	123.9	2679.9
47	2393	2444	552.0	4090.4	15.4	228.5	900.3	123.9	2711.9
48	2445	2496	552.0	4144.8	15.4	229.1	910.4	123.9	2743.7
49	2497	2548	552.0	4199.0	15.5	229.7	920.4	123.9	2775.4
50	2549	2600	552.0	4253.1	15.5	230.3	930.4	123.9	2807.0
51	2601	2652	552.0	4307.0	15.5	230.9	940.4	123.9	2838.4
52	2653	2704	552.0	4308.9	15.5	231.5	950.4	123.9	2869.7
53	2705	2756	552.0	4310.6	15.5	232.1	960.4	123.9	2900.9
54	2757	2808	552.0	4312.3	15.5	232.6	970.4	123.9	2932.0
55	2809	2860	552.0	4313.8	15.5	233.2	980.4	123.9	2963.0
56	2861	2912	552.0	4315.3	15.5	233.8	990.4	123.9	2964.4
57	2913	2964	552.0	4316.6	15.5	234.3	991.3	123.9	2965.8
58	2965	3016	552.0	4317.9	15.5	234.9	992.2	123.9	2967.1
59	3017	3068	552.0	4319.1	15.5	235.4	993.1	123.9	2968.3

60	3069	3120	552.0	4320.2	15.5	236.0	994.1	123.9	2969.4
61	3121	3172	552.0	4321.3	15.5	236.5	995.0	123.9	2970.5
62	3173	3224	552.0	4322.3	15.5	237.0	995.9	123.9	2971.5
63	3225	3276	552.0	4323.2	15.5	237.5	996.7	123.9	2972.4
64	3277	3328	552.0	4324.1	15.5	238.1	997.6	123.9	2973.3
65	3329	3380	552.0	4325.0	15.5	238.6	998.5	123.9	2974.1
66	3381	3432	552.0	4325.7	15.5	239.1	999.3	123.9	2974.9
67	3433	3484	552.0	4326.5	15.5	239.6	1000.2	123.9	2975.6
68	3485	3536	552.0	4327.2	15.5	240.1	1001.0	123.9	2976.3
69	3537	3588	552.0	4327.8	15.5	240.6	1001.9	123.9	2977.0
70	3589	3640	552.0	4328.4	15.5	241.1	1002.7	123.9	2977.6
71	3641	3692	552.0	4329.0	15.5	241.5	1003.5	123.9	2978.2
72	3693	3744	552.0	4329.5	15.5	242.0	1004.3	123.9	2978.7
73	3745	3796	552.0	4330.0	15.5	242.5	1005.1	123.9	2979.2
74	3797	3848	552.0	4330.5	15.5	243.0	1005.9	123.9	2979.7
75	3849	3900	552.0	4331.0	15.5	243.4	1006.7	123.9	2980.1
76	3901	3952	552.0	4331.4	15.5	243.9	1007.5	123.9	2980.5
77	3953	4004	552.0	4331.8	15.5	244.3	1008.2	123.9	2980.9
78	4005	4056	552.0	4332.1	15.5	244.8	1009.0	123.9	2981.3
79	4057	4108	552.0	4332.5	15.5	245.2	1009.7	123.9	2981.7
80	4109	4160	552.0	4332.8	15.5	245.7	1010.5	123.9	2982.0
81	4161	4212	552.0	4333.1	15.5	246.1	1011.2	123.9	2982.3
82	4213	4264	552.0	4333.4	15.5	246.5	1012.0	123.9	2982.6
83	4265	4316	552.0	4333.7	15.5	247.0	1012.7	123.9	2982.9
84	4317	4368	552.0	4334.0	15.5	247.4	1013.4	123.9	2983.1
85	4369	4420	552.0	4334.2	15.5	247.8	1014.1	123.9	2983.4
86	4421	4472	552.0	4334.4	15.5	248.2	1014.8	123.9	2983.6
87	4473	4524	552.0	4334.6	15.5	248.6	1015.5	123.9	2983.8
88	4525	4576	552.0	4334.8	15.5	249.0	1016.2	123.9	2984.0
89	4577	4628	552.0	4335.0	15.5	249.4	1016.9	123.9	2984.2
90	4629	4680	552.0	4335.2	15.5	249.8	1017.5	123.9	2984.4
91	4681	4732	552.0	4335.4	15.5	250.2	1018.2	123.9	2984.5
92	4733	4784	552.0	4335.5	15.5	250.6	1018.9	123.9	2984.7
93	4785	4836	552.0	4335.7	15.5	251.0	1019.5	123.9	2984.8
94	4837	4888	552.0	4335.8	15.5	251.4	1020.2	123.9	2985.0
95	4889	4940	552.0	4335.9	15.5	251.8	1020.8	123.9	2985.1
96	4941	4992	552.0	4336.1	15.5	252.1	1021.4	123.9	2985.2
97	4993	5044	552.0	4336.2	15.5	252.5	1022.1	123.9	2985.3
98	5045	5096	552.0	4336.3	15.5	252.9	1022.7	123.9	2985.4
99	5097	5148	552.0	4336.4	15.5	253.2	1023.3	123.9	2985.5
100	5149	5200	552.0	4336.5	15.5	253.6	1023.9	123.9	2985.6
101	5201	5252	552.0	4336.6	15.5	254.0	1024.5	123.9	2985.7
102	5253	5304	552.0	4336.7	15.5	254.3	1025.1	123.9	2985.8
103	5305	5356	552.0	4336.7	15.5	254.7	1025.7	123.9	2985.9
104	5357	5408	552.0	4336.8	15.5	255.0	1026.3	123.9	2986.0
105	5409	5460	552.0	4336.9	15.5	255.3	1026.9	123.9	2986.0
106	5461	5512	552.0	4336.9	15.5	255.7	1027.4	123.9	2986.1
107	5513	5564	552.0	4337.0	15.5	256.0	1028.0	123.9	2986.2
108	5565	5616	552.0	4337.1	15.5	256.4	1028.6	123.9	2986.2

The next page shows a plot, with comparisons to contaminant loads used in existing scenario.



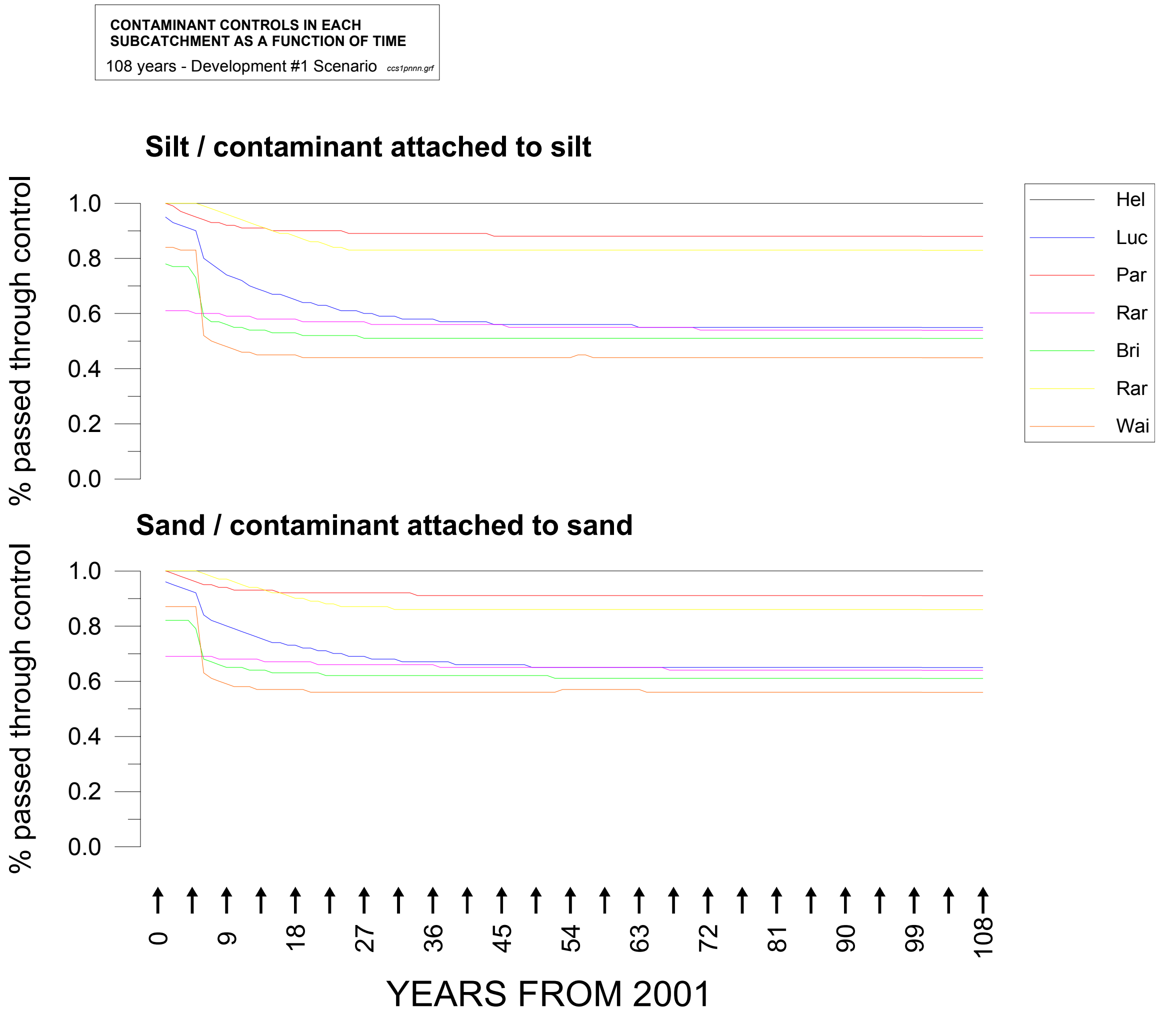
- Stormwater contaminant controls – existing scenario: as 54-year simulation.
- Stormwater contaminant controls – development #1 scenario:

				Fraction of sediment load (with attached contaminant) passed through controls													
				1=Hel		2=Luc		3=Par		4=Ran		5=Bri		6=Rar		7=Wai	
Period #	**Week start**	**Week end**	**Events**	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand
1	1	52	1,2,3,4	1.00	1.00	0.95	0.96	1.00	1.00	0.61	0.69	0.78	0.82	1.00	1.00	0.84	0.87
2	53	104	1,2,3,4	1.00	1.00	0.93	0.95	0.99	0.99	0.61	0.69	0.77	0.82	1.00	1.00	0.84	0.87
3	105	156	1,2,3,4	1.00	1.00	0.92	0.94	0.97	0.98	0.61	0.69	0.77	0.82	1.00	1.00	0.83	0.87
4	157	208	1,2,3,4	1.00	1.00	0.91	0.93	0.96	0.97	0.61	0.69	0.77	0.82	1.00	1.00	0.83	0.87
5	209	260	1,2,3,4	1.00	1.00	0.90	0.92	0.95	0.96	0.60	0.69	0.73	0.79	1.00	1.00	0.83	0.87
6	261	312	1,2,3,4	1.00	1.00	0.80	0.84	0.94	0.95	0.60	0.69	0.59	0.68	0.99	0.99	0.52	0.63
7	313	364	1,2,3,4	1.00	1.00	0.78	0.82	0.93	0.95	0.60	0.69	0.57	0.67	0.98	0.98	0.50	0.61
8	365	416	1,2,3,4	1.00	1.00	0.76	0.81	0.93	0.94	0.60	0.68	0.57	0.66	0.97	0.97	0.49	0.60
9	417	468	1,2,3,4	1.00	1.00	0.74	0.80	0.92	0.94	0.59	0.68	0.56	0.65	0.96	0.97	0.48	0.59
10	469	520	1,2,3,4	1.00	1.00	0.73	0.79	0.92	0.93	0.59	0.68	0.55	0.65	0.95	0.96	0.47	0.58
11	521	572	1,2,3,4	1.00	1.00	0.72	0.78	0.91	0.93	0.59	0.68	0.55	0.65	0.94	0.95	0.46	0.58
12	573	624	1,2,3,4	1.00	1.00	0.70	0.77	0.91	0.93	0.59	0.68	0.54	0.64	0.93	0.94	0.46	0.58

13	625	676	1,2,3,4	1.00	1.00	0.69	0.76	0.91	0.93	0.58	0.68	0.54	0.64	0.92	0.94	0.45	0.57
14	677	728	1,2,3,4	1.00	1.00	0.68	0.75	0.91	0.93	0.58	0.67	0.54	0.64	0.91	0.93	0.45	0.57
15	729	780	1,2,3,4	1.00	1.00	0.67	0.74	0.90	0.93	0.58	0.67	0.53	0.63	0.90	0.92	0.45	0.57
16	781	832	1,2,3,4	1.00	1.00	0.67	0.74	0.90	0.92	0.58	0.67	0.53	0.63	0.89	0.92	0.45	0.57
17	833	884	1,2,3,4	1.00	1.00	0.66	0.73	0.90	0.92	0.58	0.67	0.53	0.63	0.89	0.91	0.45	0.57
18	885	936	1,2,3,4	1.00	1.00	0.65	0.73	0.90	0.92	0.58	0.67	0.53	0.63	0.88	0.90	0.45	0.57
19	937	988	1,2,3,4	1.00	1.00	0.64	0.72	0.90	0.92	0.57	0.67	0.52	0.63	0.87	0.90	0.44	0.57
20	989	1040	1,2,3,4	1.00	1.00	0.64	0.72	0.90	0.92	0.57	0.67	0.52	0.63	0.86	0.89	0.44	0.56
21	1041	1092	1,2,3,4	1.00	1.00	0.63	0.71	0.90	0.92	0.57	0.66	0.52	0.63	0.86	0.89	0.44	0.56
22	1093	1144	1,2,3,4	1.00	1.00	0.63	0.71	0.90	0.92	0.57	0.66	0.52	0.62	0.85	0.88	0.44	0.56
23	1145	1196	1,2,3,4	1.00	1.00	0.62	0.70	0.90	0.92	0.57	0.66	0.52	0.62	0.84	0.88	0.44	0.56
24	1197	1248	1,2,3,4	1.00	1.00	0.61	0.70	0.90	0.92	0.57	0.66	0.52	0.62	0.84	0.87	0.44	0.56
25	1249	1300	1,2,3,4	1.00	1.00	0.61	0.69	0.89	0.92	0.57	0.66	0.52	0.62	0.83	0.87	0.44	0.56
26	1301	1352	1,2,3,4	1.00	1.00	0.61	0.69	0.89	0.92	0.57	0.66	0.52	0.62	0.83	0.87	0.44	0.56
27	1353	1404	1,2,3,4	1.00	1.00	0.60	0.69	0.89	0.92	0.57	0.66	0.51	0.62	0.83	0.87	0.44	0.56
28	1405	1456	1,2,3,4	1.00	1.00	0.60	0.68	0.89	0.92	0.56	0.66	0.51	0.62	0.83	0.87	0.44	0.56
29	1457	1508	1,2,3,4	1.00	1.00	0.59	0.68	0.89	0.92	0.56	0.66	0.51	0.62	0.83	0.87	0.44	0.56
30	1509	1560	1,2,3,4	1.00	1.00	0.59	0.68	0.89	0.92	0.56	0.66	0.51	0.62	0.83	0.87	0.44	0.56
31	1561	1612	1,2,3,4	1.00	1.00	0.59	0.68	0.89	0.92	0.56	0.66	0.51	0.62	0.83	0.86	0.44	0.56
32	1613	1664	1,2,3,4	1.00	1.00	0.58	0.67	0.89	0.92	0.56	0.66	0.51	0.62	0.83	0.86	0.44	0.56
33	1665	1716	1,2,3,4	1.00	1.00	0.58	0.67	0.89	0.92	0.56	0.66	0.51	0.62	0.83	0.86	0.44	0.56
34	1717	1768	1,2,3,4	1.00	1.00	0.58	0.67	0.89	0.91	0.56	0.66	0.51	0.62	0.83	0.86	0.44	0.56
35	1769	1820	1,2,3,4	1.00	1.00	0.58	0.67	0.89	0.91	0.56	0.66	0.51	0.62	0.83	0.86	0.44	0.56
36	1821	1872	1,2,3,4	1.00	1.00	0.58	0.67	0.89	0.91	0.56	0.66	0.51	0.62	0.83	0.86	0.44	0.56
37	1873	1924	1,2,3,4	1.00	1.00	0.57	0.67	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
38	1925	1976	1,2,3,4	1.00	1.00	0.57	0.67	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
39	1977	2028	1,2,3,4	1.00	1.00	0.57	0.66	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
40	2029	2080	1,2,3,4	1.00	1.00	0.57	0.66	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
41	2081	2132	1,2,3,4	1.00	1.00	0.57	0.66	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
42	2133	2184	1,2,3,4	1.00	1.00	0.57	0.66	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
43	2185	2236	1,2,3,4	1.00	1.00	0.57	0.66	0.89	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
44	2237	2288	1,2,3,4	1.00	1.00	0.56	0.66	0.88	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
45	2289	2340	1,2,3,4	1.00	1.00	0.56	0.66	0.88	0.91	0.56	0.65	0.51	0.62	0.83	0.86	0.44	0.56
46	2341	2392	1,2,3,4	1.00	1.00	0.56	0.66	0.88	0.91	0.55	0.65	0.51	0.62	0.83	0.86	0.44	0.56
47	2393	2444	1,2,3,4	1.00	1.00	0.56	0.66	0.88	0.91	0.55	0.65	0.51	0.62	0.83	0.86	0.44	0.56
48	2445	2496	1,2,3,4	1.00	1.00	0.56	0.66	0.88	0.91	0.55	0.65	0.51	0.62	0.83	0.86	0.44	0.56
49	2497	2548	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.62	0.83	0.86	0.44	0.56
50	2549	2600	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.62	0.83	0.86	0.44	0.56
51	2601	2652	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.62	0.83	0.86	0.44	0.56
52	2653	2704	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.56
53	2705	2756	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.57
54	2757	2808	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.57
55	2809	2860	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.45	0.57
56	2861	2912	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.45	0.57
57	2913	2964	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.57
58	2965	3016	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.57
59	3017	3068	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.57
60	3069	3120	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.57
61	3121	3172	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.57
62	3173	3224	1,2,3,4	1.00	1.00	0.56	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.57
63	3225	3276	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.57
64	3277	3328	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.56
65	3329	3380	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.56
66	3381	3432	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.55	0.65	0.51	0.61	0.83	0.86	0.44	0.56
67	3433	3484	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.55	0.64	0.51	0.61	0.83	0.86	0.44	0.56
68	3485	3536	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.55	0.64	0.51	0.61	0.83	0.86	0.44	0.56
69	3537	3588	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.55	0.64	0.51	0.61	0.83	0.86	0.44	0.56
70	3589	3640	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.55	0.64	0.51	0.61	0.83	0.86	0.44	0.56
71	3641	3692	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
72	3693	3744	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
73	3745	3796	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
74	3797	3848	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
75	3849	3900	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56

76	3901	3952	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
77	3953	4004	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
78	4005	4056	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
79	4057	4108	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
80	4109	4160	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
81	4161	4212	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
82	4213	4264	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
83	4265	4316	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
84	4317	4368	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
85	4369	4420	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
86	4421	4472	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
87	4473	4524	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
88	4525	4576	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
89	4577	4628	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
90	4629	4680	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
91	4681	4732	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
92	4733	4784	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
93	4785	4836	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
94	4837	4888	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
95	4889	4940	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
96	4941	4992	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
97	4993	5044	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
98	5045	5096	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
99	5097	5148	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
100	5149	5200	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
101	5201	5252	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
102	5253	5304	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
103	5305	5356	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
104	5357	5408	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
105	5409	5460	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
106	5461	5512	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
107	5513	5564	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56
108	5565	5616	1,2,3,4	1.00	1.00	0.55	0.65	0.88	0.91	0.54	0.64	0.51	0.61	0.83	0.86	0.44	0.56

The next page shows a plot.



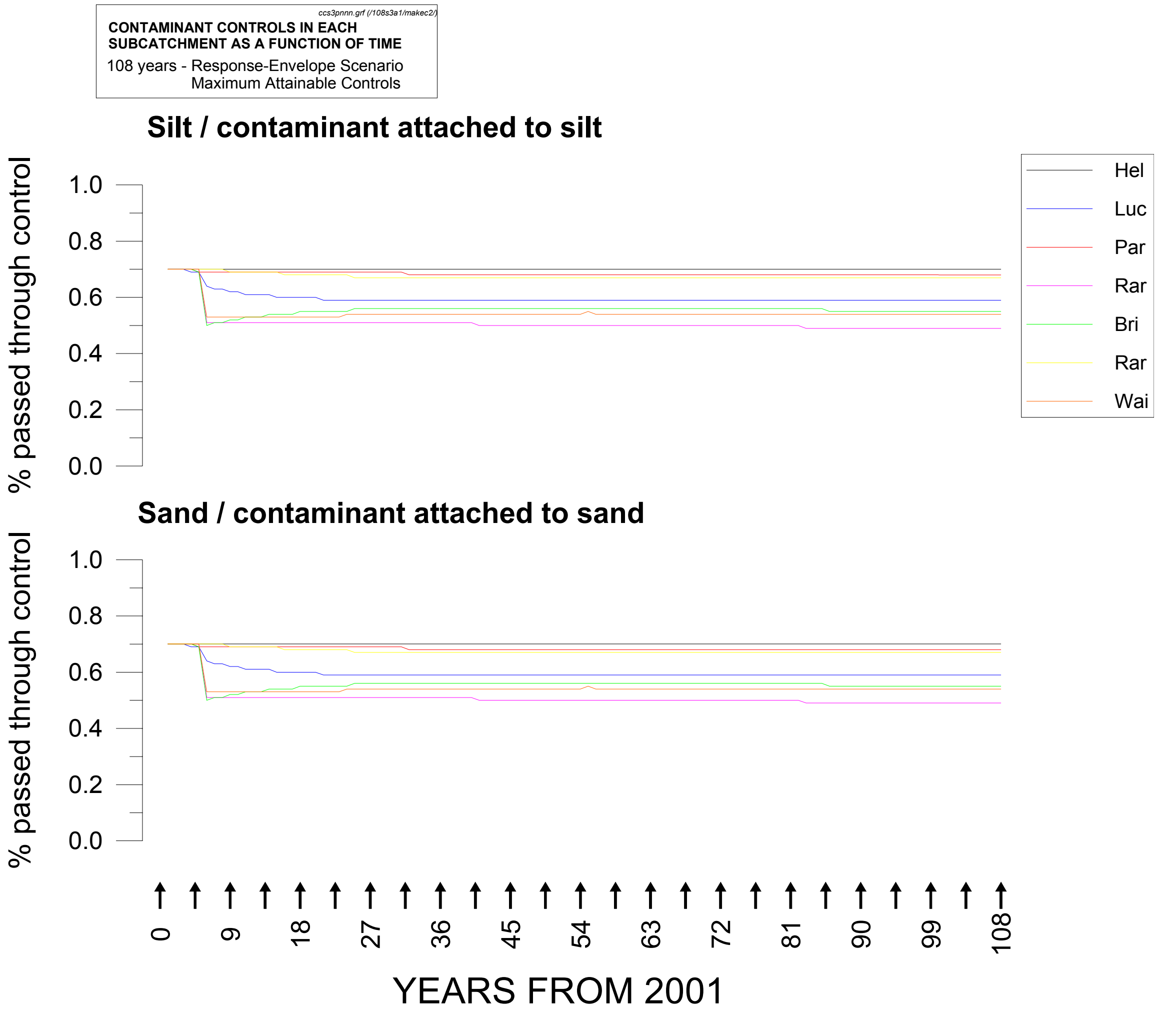
- Stormwater contaminant controls – response-envelope scenario, zero controls: as 54-year simulation.

- Stormwater contaminant controls – response-envelope scenario, maximum attainable controls:

				Fraction of sediment load (with attached contaminant) passed through controls													
				1=Hel		2=Luc		3=Par		4=Ran		5=Bri		6=Rar		7=Wai	
Period #	Week start	Week end	Events	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand	silt	sand
1	1	52	1,2,3,4	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
2	53	104	1,2,3,4	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
3	105	156	1,2,3,4	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
4	157	208	1,2,3,4	0.70	0.70	0.69	0.69	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
5	209	260	1,2,3,4	0.70	0.70	0.69	0.69	0.69	0.69	0.70	0.70	0.69	0.69	0.70	0.70	0.70	0.70
6	261	312	1,2,3,4	0.70	0.70	0.64	0.64	0.69	0.69	0.51	0.51	0.50	0.50	0.70	0.70	0.53	0.53
7	313	364	1,2,3,4	0.70	0.70	0.63	0.63	0.69	0.69	0.51	0.51	0.51	0.51	0.70	0.70	0.53	0.53
8	365	416	1,2,3,4	0.70	0.70	0.63	0.63	0.69	0.69	0.51	0.51	0.51	0.51	0.70	0.70	0.53	0.53
9	417	468	1,2,3,4	0.70	0.70	0.62	0.62	0.69	0.69	0.51	0.51	0.52	0.52	0.69	0.69	0.53	0.53
10	469	520	1,2,3,4	0.70	0.70	0.62	0.62	0.69	0.69	0.51	0.51	0.52	0.52	0.69	0.69	0.53	0.53
11	521	572	1,2,3,4	0.70	0.70	0.61	0.61	0.69	0.69	0.51	0.51	0.53	0.53	0.69	0.69	0.53	0.53
12	573	624	1,2,3,4	0.70	0.70	0.61	0.61	0.69	0.69	0.51	0.51	0.53	0.53	0.69	0.69	0.53	0.53
13	625	676	1,2,3,4	0.70	0.70	0.61	0.61	0.69	0.69	0.51	0.51	0.53	0.53	0.69	0.69	0.53	0.53
14	677	728	1,2,3,4	0.70	0.70	0.61	0.61	0.69	0.69	0.51	0.51	0.54	0.54	0.69	0.69	0.53	0.53
15	729	780	1,2,3,4	0.70	0.70	0.60	0.60	0.69	0.69	0.51	0.51	0.54	0.54	0.69	0.69	0.53	0.53
16	781	832	1,2,3,4	0.70	0.70	0.60	0.60	0.69	0.69	0.51	0.51	0.54	0.54	0.68	0.68	0.53	0.53
17	833	884	1,2,3,4	0.70	0.70	0.60	0.60	0.69	0.69	0.51	0.51	0.54	0.54	0.68	0.68	0.53	0.53
18	885	936	1,2,3,4	0.70	0.70	0.60	0.60	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.53	0.53
19	937	988	1,2,3,4	0.70	0.70	0.60	0.60	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.53	0.53
20	989	1040	1,2,3,4	0.70	0.70	0.60	0.60	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.53	0.53
21	1041	1092	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.53	0.53
22	1093	1144	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.53	0.53
23	1145	1196	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.53	0.53
24	1197	1248	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.55	0.55	0.68	0.68	0.54	0.54
25	1249	1300	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
26	1301	1352	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
27	1353	1404	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
28	1405	1456	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
29	1457	1508	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
30	1509	1560	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
31	1561	1612	1,2,3,4	0.70	0.70	0.59	0.59	0.69	0.69	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
32	1613	1664	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
33	1665	1716	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
34	1717	1768	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
35	1769	1820	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
36	1821	1872	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
37	1873	1924	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
38	1925	1976	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
39	1977	2028	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
40	2029	2080	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.51	0.51	0.56	0.56	0.67	0.67	0.54	0.54
41	2081	2132	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
42	2133	2184	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
43	2185	2236	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
44	2237	2288	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
45	2289	2340	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
46	2341	2392	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
47	2393	2444	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
48	2445	2496	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
49	2497	2548	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
50	2549	2600	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
51	2601	2652	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54

52	2653	2704	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
53	2705	2756	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
54	2757	2808	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
55	2809	2860	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.55	0.55
56	2861	2912	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
57	2913	2964	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
58	2965	3016	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
59	3017	3068	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
60	3069	3120	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
61	3121	3172	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
62	3173	3224	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
63	3225	3276	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
64	3277	3328	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
65	3329	3380	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
66	3381	3432	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
67	3433	3484	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
68	3485	3536	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
69	3537	3588	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
70	3589	3640	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
71	3641	3692	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
72	3693	3744	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
73	3745	3796	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
74	3797	3848	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
75	3849	3900	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
76	3901	3952	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
77	3953	4004	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
78	4005	4056	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
79	4057	4108	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
80	4109	4160	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
81	4161	4212	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
82	4213	4264	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.50	0.50	0.56	0.56	0.67	0.67	0.54	0.54
83	4265	4316	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.56	0.56	0.67	0.67	0.54	0.54
84	4317	4368	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.56	0.56	0.67	0.67	0.54	0.54
85	4369	4420	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.56	0.56	0.67	0.67	0.54	0.54
86	4421	4472	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
87	4473	4524	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
88	4525	4576	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
89	4577	4628	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
90	4629	4680	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
91	4681	4732	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
92	4733	4784	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
93	4785	4836	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
94	4837	4888	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
95	4889	4940	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
96	4941	4992	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
97	4993	5044	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
98	5045	5096	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
99	5097	5148	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
100	5149	5200	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
101	5201	5252	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
102	5253	5304	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
103	5305	5356	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
104	5357	5408	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
105	5409	5460	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
106	5461	5512	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
107	5513	5564	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54
108	5565	5616	1,2,3,4	0.70	0.70	0.59	0.59	0.68	0.68	0.49	0.49	0.55	0.55	0.67	0.67	0.54	0.54

The next page shows a plot.


ccs3pnnn.grf (/108s3a1/makec2/)
CONTAINMINANT CONTROLS IN EACH SUBCATCHMENT AS A FUNCTION OF TIME
108 years - Response-Envelope Scenario
Maximum Attainable Controls
Silt / contaminant attached to silt
% passed through control
1.0
0.8
0.6
0.4
0.2
0.0
Hel
Luc
Par
Rar
Bri
Rar
Wai
Sand / contaminant attached to sand
% passed through control
1.0
0.8
0.6
0.4
0.2
0.0
0
9
18
27
36
45
54
63
72
81
90
99
108
YEARS FROM 2001

4. Results

A range of results is presented in this section, for both 54-year and 108-year simulations, including:

- Contaminant concentrations in the harbour:

  (a) Existing scenario versus development #1 scenario

  (b) Response envelope around development #1 scenario

- Time for total-sediment concentrations to reach "traffic lights":

  (a) Existing scenario versus development #1 scenario

  (b) Response envelope around development #1 scenario

- Sedimentation in the harbour:

  (a) Existing scenario versus development #1 scenario

  (b) Response envelope around development #1 scenario

- Origin of sediments / contaminants that deposit in harbour (%):

  (a) Existing scenario versus development #1 scenario

- Origin of sediments / contaminants that deposit in harbour (mass):

  (a) Existing scenario versus development #1 scenario

- Fate of sediments / contaminants that derive from land (%):

  (a) Existing scenario versus development #1 scenario

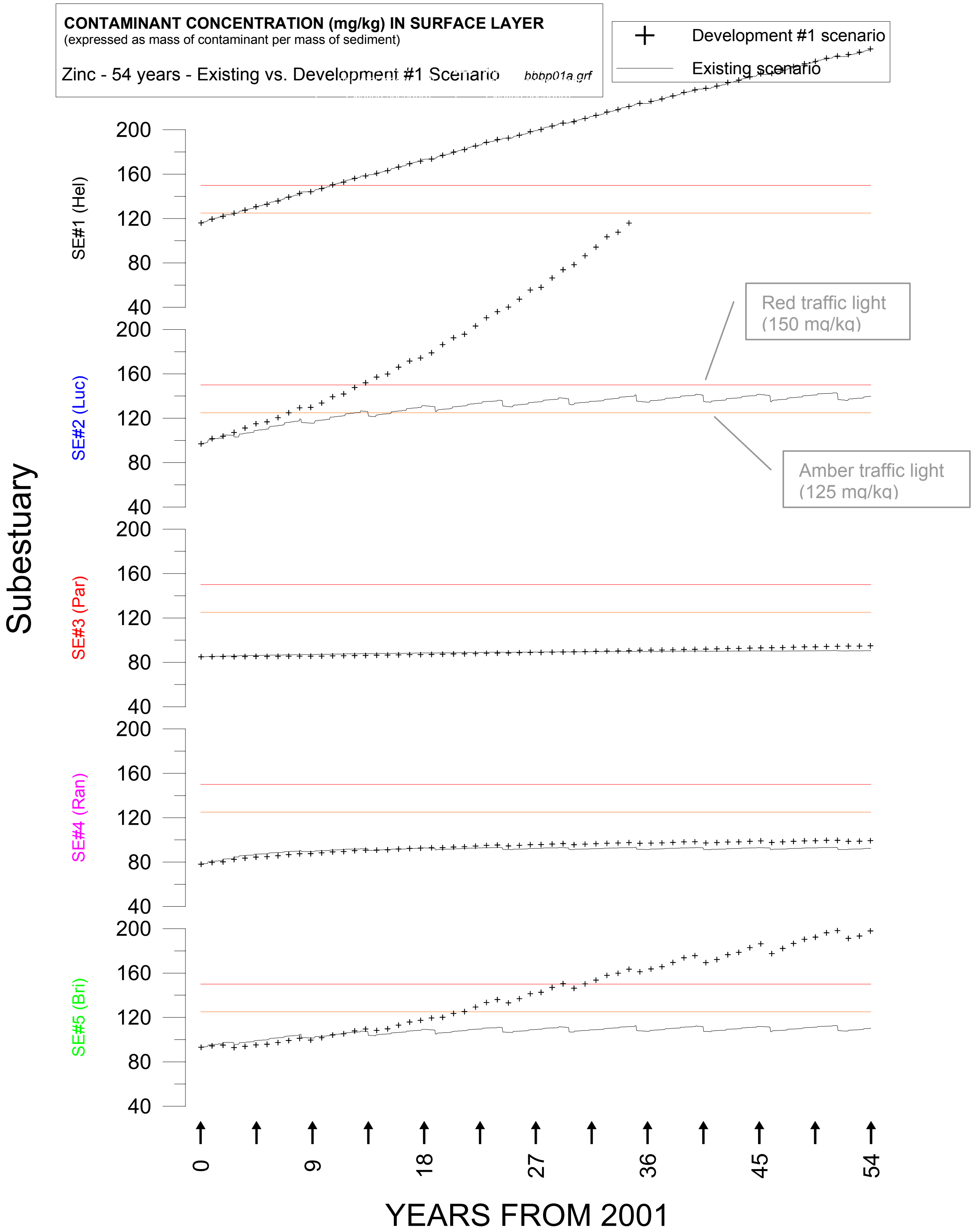
- Fate of sediments / contaminants that derive from land (mass):

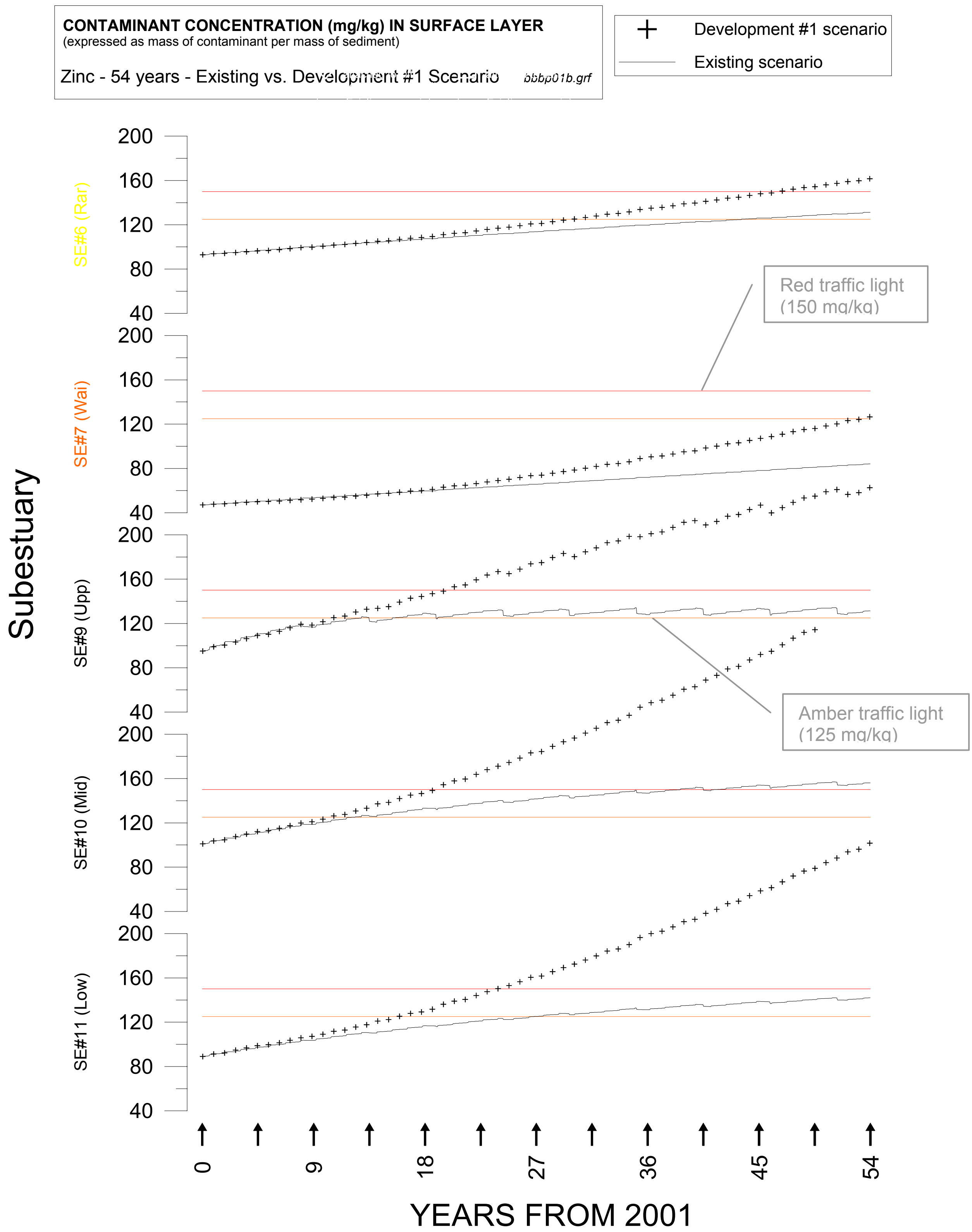
  (a) Existing scenario versus development #1 scenario

4.1 Simulation period: 54 years

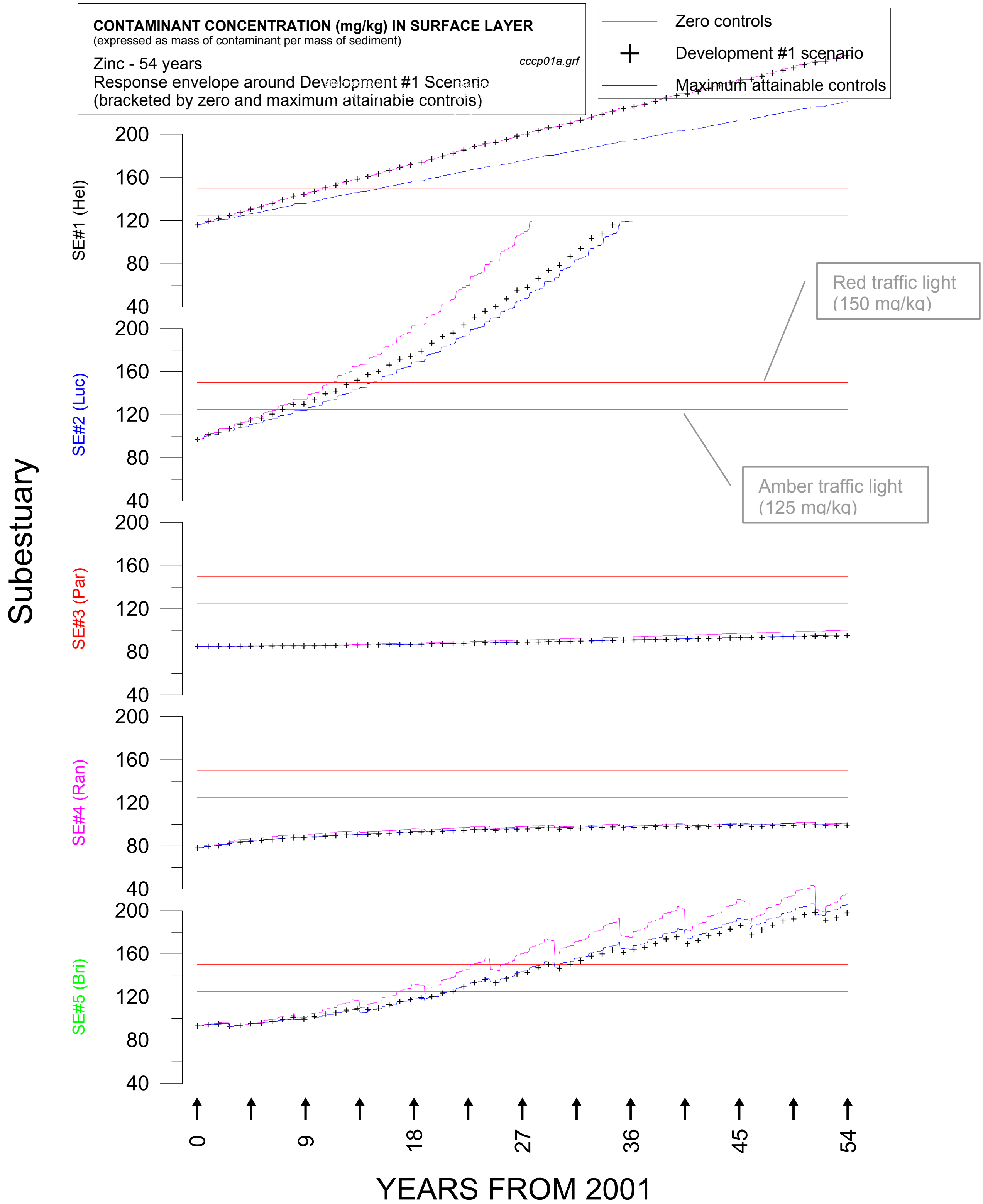
4.1.2 Contaminant concentrations in the harbour

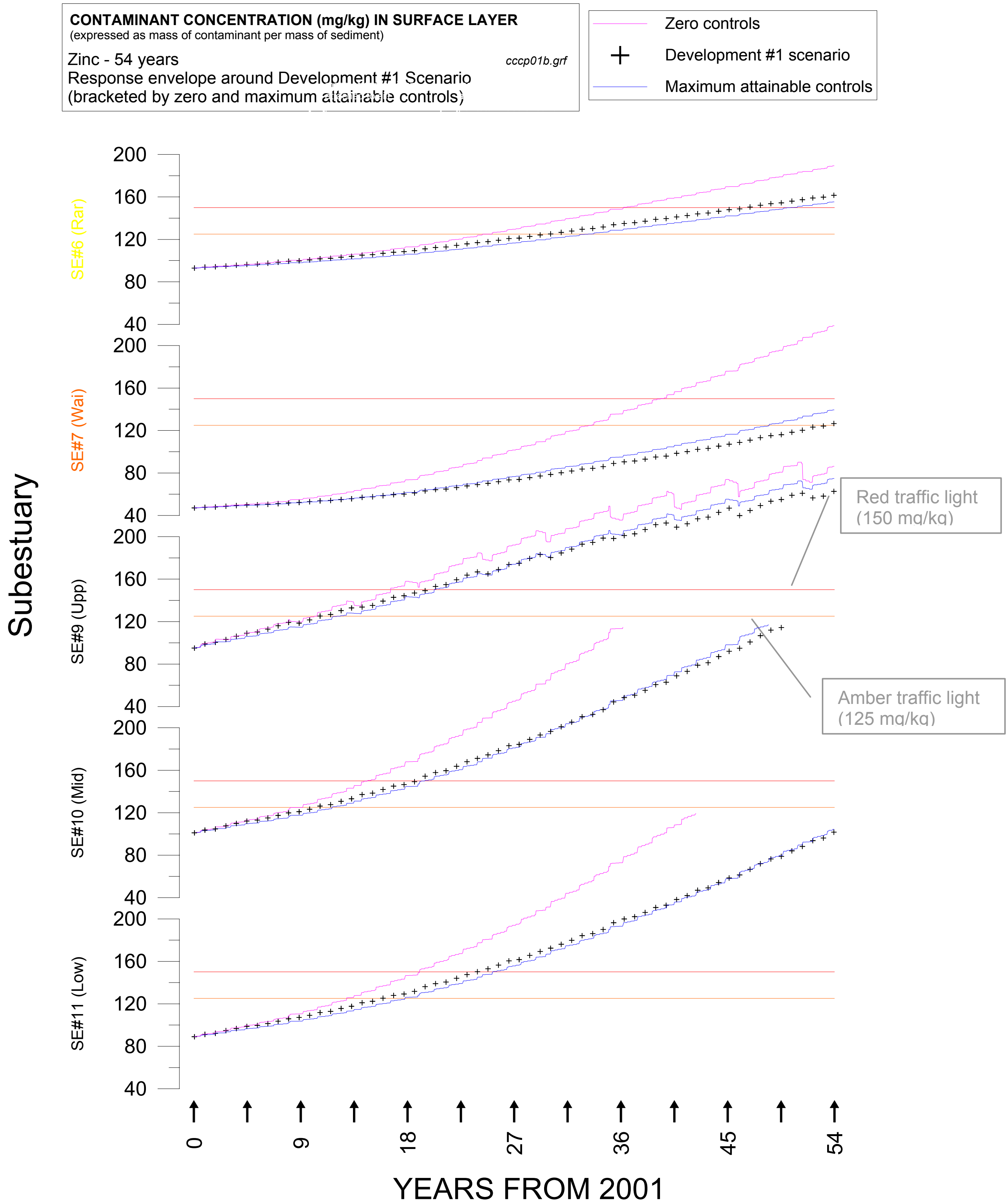
(a) Existing scenario versus development #1 scenario




CONTAMINANT CONCENTRATION (mg/kg) IN SURFACE LAYER
(expressed as mass of contaminant per mass of sediment)
Zinc - 54 years - Existing vs. Development #1 Scenario
bbbp01b.grf
Development #1 scenario
Existing scenario
Red traffic light (150 mg/kg)
Amber traffic light (125 mg/kg)
Subestuary
SE#6 (Rar)
SE#7 (Wai)
SE#9 (Upp)
SE#10 (Mid)
SE#11 (Low)
200
160
120
80
40
0
9
18
27
36
45
54
YEARS FROM 2001

(b) Response envelope around development #1 scenario





CONTAMINANT CONCENTRATION (mg/kg) IN SURFACE LAYER
(expressed as mass of contaminant per mass of sediment)
Zinc - 54 years
cccp01b.grf
Response envelope around Development #1 Scenario
(bracketed by zero and maximum attainable controls)
Zero controls
Development #1 scenario
Maximum attainable controls
Subestuary
SE#6 (Rar)
SE#7 (Wai)
SE#9 (Upp)
SE#10 (Mid)
SE#11 (Low)
200
160
120
80
40
Red traffic light
(150 mg/kg)
Amber traffic light
(125 mg/kg)
0
9
18
27
36
45
54
YEARS FROM 2001

4.1.3 Time for total-sediment concentrations to reach "traffic lights"

(a) Existing scenario versus development #1 scenario

Results from development #1 scenario.

Subestuary	Years to Amber (125 mg/kg)	Years to Red (150 mg/kg)
1=Hellyers	3.08	10.46
2=Lucas	7.23	12.88
3=Paremoremo	0	0
4=Rangitopuni	0	0
5=Brighams	21.08	28.85
6=Rarawaru	30.08	46.48
7=Waiarohia	53.42	0
9=Upper main body of UWH	10.46	20.1
10=Middle main body of UWH	10.42	18.9
11=Lower main body of UWH	15.94	23.9
"0" signifies traffic light is not exceeded within 54 years		

It takes 23.9 years from 2001 for contaminant concentrations to pass through the red traffic light in the Lower main body.

Results from existing scenario.

Subestuary	Years to Amber (125 mg/kg)	Years to Red (150 mg/kg)
1=Hellyers	3.08	10.46
2=Lucas	12.67	0
3=Paremoremo	0	0
4=Rangitopuni	0	0
5=Brighams	0	0
6=Rarawaru	43.6	0
7=Waiarohia	0	0
9=Upper main body of UWH	12.88	0
10=Middle main body of UWH	12.23	38.65
11=Lower main body of UWH	26.87	0
"0" signifies traffic light is not exceeded within 54 years		

(b) Response envelope around development #1 scenario

Subestuary	Years to Amber (125 mg/kg)		
	No controls	Development #1 scenario	Maximum attainable controls
1=Hellyers	3.08	3.08	4.02
2=Lucas	6.75	7.23	9.23
3=Paremoremo	0	0	0
4=Rangitopuni	0	0	0
5=Brighams	16.6	21.08	21.08
6=Rarawaru	25.17	30.08	33.58
7=Waiarohia	33.58	53.42	48.52
9=Upper main body of UWH	10.42	10.46	12.06
10=Middle main body of UWH	9.17	10.42	11.65
11=Lower main body of UWH	12.88	15.94	17.81
"0" signifies traffic light is not exceeded within 54 years			

Subestuary	Years to Red (150 mg/kg)		
	No controls	Development #1 scenario	Maximum attainable controls
1=Hellyers	10.46	10.46	15.37
2=Lucas	11.38	12.88	14.65
3=Paremoremo	0	0	0
4=Rangitopuni	0	0	0
5=Brighams	22.71	28.85	28.75
6=Rarawaru	36.23	46.48	50.63
7=Waiarohia	39.37	0	0
9=Upper main body of UWH	16.6	20.1	20.27
10=Middle main body of UWH	14.65	18.9	19.48
11=Lower main body of UWH	19.04	23.9	25.27
"0" signifies traffic light is not exceeded within 54 years			

It takes 18.9 years from 2001 for contaminant concentrations to pass through the red traffic light in the Middle main body under development #1 scenario.

4.1.4 Sedimentation in the harbour

(a) Existing scenario versus development #1 scenario

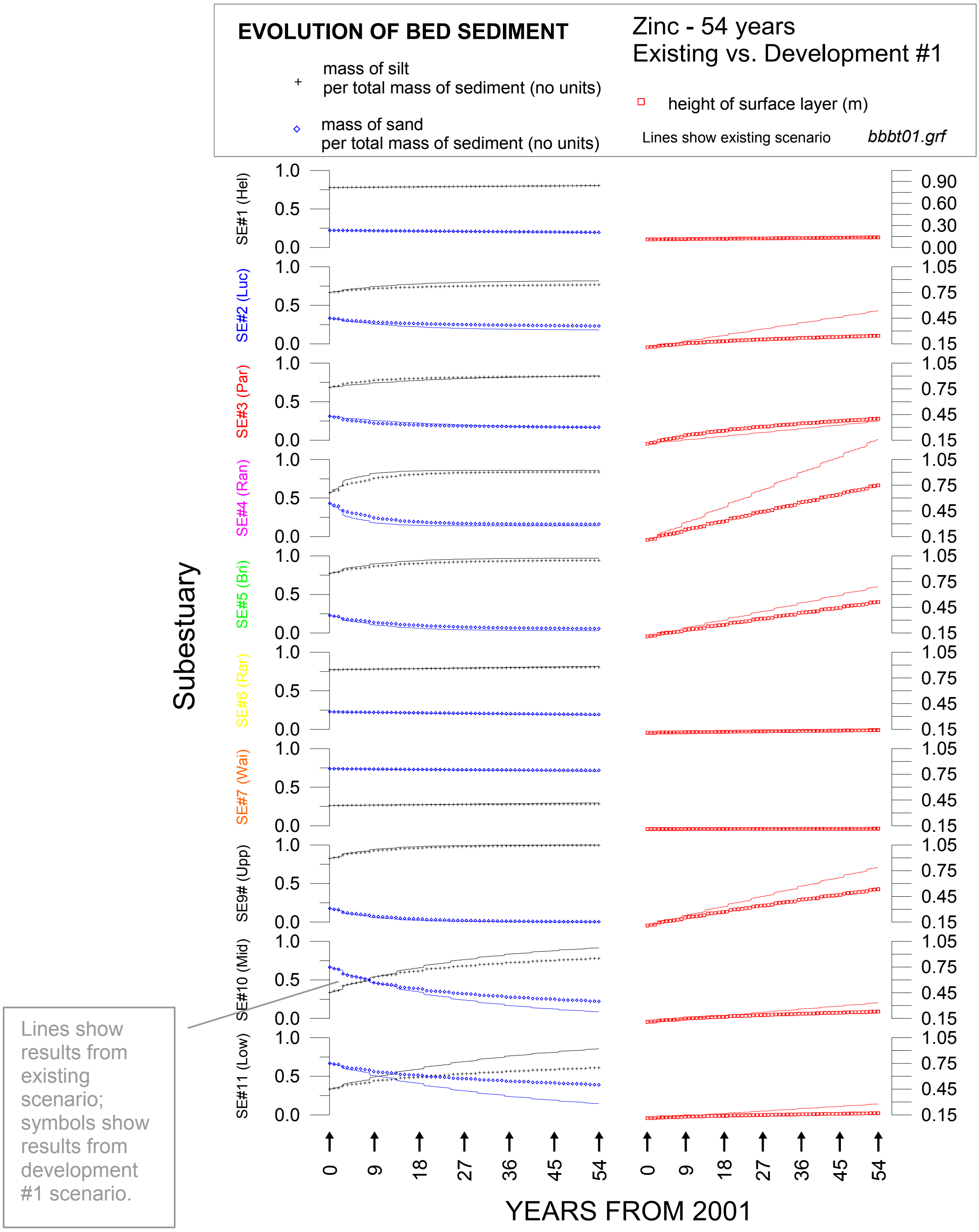
Results from development #1 scenario.

Subestuary	Annual-average sediment-deposition rate over simulation period (mm/year)
1=Hellyers	0.53
2=Lucas	2.50
3=Paremoremo	5.41
4=Rangitopuni	11.82
5=Brighams	7.45
6=Rarawaru	0.56
7=Waiarohia	0.08
8=Middle WH	–
9=Upper main body of UWH	7.84
10=Middle main body of UWH	2.22
11=Lower main body of UWH	1.09

Averaged over the 54-year simulation period, the annual deposition rate in the Lower main body is 1.09 mm/year.

Results from existing scenario.

Subestuary	Annual-average sediment-deposition rate over simulation period (mm/year)
1=Hellyers	0.53
2=Lucas	7.89
3=Paremoremo	4.86
4=Rangitopuni	21.71
5=Brighams	10.73
6=Rarawaru	0.70
7=Waiarohia	0.13
8=Middle WH	–
9=Upper main body of UWH	12.55
10=Middle main body of UWH	4.11
11=Lower main body of UWH	3.07



EVOLUTION OF BED SEDIMENT
mass of silt per total mass of sediment (no units)
mass of sand per total mass of sediment (no units)
Zinc - 54 years
Existing vs. Development #1
height of surface layer (m)
Lines show existing scenario
bbbt01.grf
Subestuary
SE#1 (Hel)
SE#2 (Luc)
SE#3 (Par)
SE#4 (Ran)
SE#5 (Bri)
SE#6 (Rar)
SE#7 (Wai)
SE9# (Upp)
SE#10 (Mid)
SE#11 (Low)
Lines show results from existing scenario; symbols show results from development #1 scenario.
YEARS FROM 2001

4.1.5 Origin of sediments / contaminants that deposit in harbour (%)

(a) Existing scenario versus development #1 scenario

53.8% of the sediment that gets deposited in Brighams subestuary comes from Rangitopuni subcatchment

Results from development #1 scenario.

Subestuary	Percentage of the total amount of sediment (i.e., from all subcatchments) deposited in each subestuary.						
	Subcatchment						
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	98.8	0.2	0.4	0.4	0	0	0.2
2=Lucas	1	96.2	1.6	0.6	0.1	0.2	0.4
3=Paremoremo	0.5	0.2	96.2	2.9	0	0.1	0.1
4=Rangitopuni	0.3	0	0.3	99.1	0.2	0.1	0.1
5=Brighams	0.2	0	0.5	53.8	44.7	0.7	0
6=Rarawaru	0.4	4.6	0	13.7	56.8	24	0.4
7=Waiarohia	7.3	0.1	0.1	0.1	0	1.2	91.2
8=Middle WH	4.9	12.1	19	41.6	7.5	0.7	14.1
9=Upper main body of UWH	3.3	4.7	13.5	57.5	17.9	1.7	1.4
10=Middle main body of UWH	5	37.3	47.4	4.4	1.3	1.5	3
11=Lower main body of UWH	2.4	73.3	6.9	14.2	1.1	0.1	1.9

Subestuary	Percentage of the total amount of contaminant (i.e., from all subcatchments) deposited in each subestuary.						
	Subcatchment						
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	99.4	0.1	0	0	0	0	0.4
2=Lucas	1.1	96.5	0.3	0.1	0	0.2	1.7
3=Paremoremo	3.1	1	89.6	3.2	0	0.5	2.5
4=Rangitopuni	1.8	0.1	0.2	95	0.6	0.5	1.7
5=Brighams	0.5	0	0.3	32.5	62.9	3.4	0.4
6=Rarawaru	0.6	7.5	0	3.9	39.1	47.7	1.3
7=Waiarohia	2.6	0	0	0	0	0.5	96.9
8=Middle WH	5.1	11.8	3.4	8.1	3.5	1.1	67
9=Upper main body of UWH	10.4	13.6	6.2	28.7	21.8	6.8	12.5
10=Middle main body of UWH	7.2	58.4	12	1.2	0.9	3.2	17.2
11=Lower main body of UWH	1.9	84.8	1.2	2.8	0.3	0.2	8.8

Results from existing scenario are shown on next page for comparison.

12% of the contaminant that gets deposited in the Middle main body comes from Paremoremo subcatchment

These are the results from the existing scenario for comparison.

Subestuary	Percentage of the total amount of sediment (i.e., from all subcatchments) deposited in each subestuary.						
	Subcatchment						
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	97.9	0.7	0.3	0.7	0	0	0.3
2=Lucas	0.3	98.6	0.5	0.3	0	0.1	0.2
3=Paremoremo	0.6	0.6	92.4	6.1	0	0.1	0.2
4=Rangitopuni	0.1	0	0.1	99.5	0.1	0	0.1
5=Brighams	0.1	0	0.3	70.5	28.5	0.5	0
6=Rarawaru	0.3	12.5	0	21.3	43.5	21.9	0.5
7=Waiarohia	4.6	0.1	0.1	0.1	0	0.8	94.3
8=Middle WH	2.9	22.8	9.8	45.7	4.1	0.5	14.3
9=Upper main body of UWH	2.1	9.8	7.3	67.8	10.4	1.2	1.4
10=Middle main body of UWH	2.7	66.3	22.2	4.5	0.7	0.9	2.8
11=Lower main body of UWH	0.8	85.9	2.1	9.5	0.4	0.1	1.2

Subestuary	Percentage of the total amount of contaminant (i.e., from all subcatchments) deposited in each subestuary.						
	Subcatchment						
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	99.6	0.1	0	0.1	0	0	0.2
2=Lucas	1.3	96.9	0.3	0.2	0	0.2	1
3=Paremoremo	3.5	1	87	6.6	0	0.5	1.4
4=Rangitopuni	1.1	0.1	0.1	97.8	0.2	0.3	0.5
5=Brighams	0.5	0	0.3	63	32.8	3.2	0.2
6=Rarawaru	0.8	8.7	0	9.4	25.8	54.5	0.9
7=Waiarohia	5.1	0	0	0	0	0.9	94
8=Middle WH	7.3	15.2	4.4	21.3	2.5	1.3	48
9=Upper main body of UWH	10.1	11.6	5.2	50.8	10.5	5.7	6.1
10=Middle main body of UWH	8.6	61.9	12.6	2.7	0.5	3.4	10.4
11=Lower main body of UWH	2.2	85.2	1.3	5.9	0.2	0.2	5

4.1.6 Origin of sediments / contaminants that deposit in harbour (mass)

(a) Existing scenario versus development #1 scenario

Of the sediment that gets deposited in Brighams subestuary, 5.25x10^7 kg comes from Rangitopuni subcatchment

Results from development #1 scenario.

Subestuary	Mass (kg) of sediment deposited in each subestuary. Subcatchment						
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	2.65E+07	5.83E+04	9.81E+04	1.07E+05	1.14E+04	5.60E+03	4.18E+04
2=Lucas	1.29E+06	1.26E+08	2.15E+06	7.29E+05	7.22E+04	2.06E+05	5.84E+05
3=Paremoremo	6.59E+05	2.12E+05	1.27E+08	3.83E+06	5.58E+03	8.60E+04	1.66E+05
4=Rangitopuni	9.66E+05	5.82E+04	9.13E+05	3.56E+08	7.82E+05	2.41E+05	3.44E+05
5=Brighams	1.62E+05	8.16E+03	5.19E+05	5.25E+07	4.36E+07	6.59E+05	4.06E+04
6=Rarawaru	1.38E+04	1.58E+05	6.30E+02	4.73E+05	1.96E+06	8.26E+05	1.40E+04
7=Waiarohia	4.17E+05	3.64E+03	5.46E+03	4.86E+03	5.80E+02	6.86E+04	5.21E+06
8=Middle WH	3.06E+06	7.46E+06	1.18E+07	2.57E+07	4.65E+06	4.59E+05	8.75E+06
9=Upper main body of UWH	6.09E+06	8.74E+06	2.50E+07	1.06E+08	3.30E+07	3.17E+06	2.55E+06
10=Middle main body of UWH	3.92E+06	2.93E+07	3.73E+07	3.47E+06	1.04E+06	1.20E+06	2.37E+06
11=Lower main body of UWH	5.78E+05	1.79E+07	1.68E+06	3.46E+06	2.70E+05	3.57E+04	4.68E+05

Subestuary	Mass (kg) of contaminant deposited in each subestuary. Subcatchment						
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	2.15E+04	2.20E+01	9.07E+00	1.07E+01	2.28E+00	2.82E+00	8.86E+01
2=Lucas	7.56E+02	6.53E+04	2.00E+02	7.29E+01	1.33E+01	1.48E+02	1.17E+03
3=Paremoremo	3.75E+02	1.22E+02	1.08E+04	3.92E+02	1.18E+00	6.35E+01	3.06E+02
4=Rangitopuni	6.44E+02	4.38E+01	8.54E+01	3.31E+04	1.96E+02	1.83E+02	5.93E+02
5=Brighams	7.66E+01	4.78E+00	4.85E+01	5.38E+03	1.04E+04	5.70E+02	5.96E+01
6=Rarawaru	7.61E+00	9.34E+01	5.99E-02	4.85E+01	4.90E+02	5.98E+02	1.60E+01
7=Waiarohia	2.97E+02	1.38E+00	5.06E-01	4.86E-01	1.27E-01	5.98E+01	1.11E+04
8=Middle WH	1.62E+03	3.79E+03	1.10E+03	2.60E+03	1.11E+03	3.53E+02	2.15E+04
9=Upper main body of UWH	3.93E+03	5.17E+03	2.33E+03	1.09E+04	8.26E+03	2.58E+03	4.73E+03
10=Middle main body of UWH	2.07E+03	1.69E+04	3.48E+03	3.48E+02	2.48E+02	9.32E+02	4.97E+03
11=Lower main body of UWH	2.42E+02	1.05E+04	1.55E+02	3.46E+02	3.55E+01	2.18E+01	1.09E+03

Results from existing scenario are shown on next page for comparison.

Of the contaminant that gets deposited in the Middle main body, 3.48x10^3 kg comes from Paremoremo subcatchment

These are the results from the existing scenario for comparison.

Subestuary	Mass (kg) of sediment deposited in each subestuary. Subcatchment 1=Hel	2=Luc	3=Par	4=Ran	5=Bin	6=Rar	7=Wai
1=Hellyers	2.65E+07	1.85E+05	8.81E+04	2.02E+05	1.06E+04	5.61E+03	7.12E+04
2=Lucas	1.29E+06	4.07E+08	1.88E+06	1.38E+06	6.71E+04	2.20E+05	9.89E+05
3=Paremoremo	6.59E+05	7.01E+05	1.10E+08	7.22E+06	5.18E+03	9.22E+04	2.79E+05
4=Rangitopuni	9.66E+05	2.05E+05	7.96E+05	6.56E+08	7.30E+05	2.60E+05	5.74E+05
5=Brighams	1.62E+05	2.74E+04	4.50E+05	9.89E+07	3.99E+07	7.44E+05	6.70E+04
6=Rarawaru	1.38E+04	5.22E+05	6.10E+02	8.91E+05	1.82E+06	9.16E+05	2.27E+04
7=Waiarohia	4.17E+05	1.15E+04	4.92E+03	9.17E+03	5.38E+02	7.48E+04	8.63E+06
8=Middle WH	3.06E+06	2.42E+07	1.04E+07	4.85E+07	4.33E+06	4.91E+05	1.51E+07
9=Upper main body of UWH	6.09E+06	2.89E+07	2.16E+07	2.00E+08	3.08E+07	3.51E+06	4.28E+06
10=Middle main body of UWH	3.92E+06	9.65E+07	3.23E+07	6.54E+06	9.73E+05	1.31E+06	4.03E+06
11=Lower main body of UWH	5.78E+05	5.90E+07	1.47E+06	6.54E+06	2.51E+05	3.68E+04	8.03E+05

Subestuary	Mass (kg) of contaminant deposited in each subestuary. Subcatchment 1=Hel	2=Luc	3=Par	4=Ran	5=Bin	6=Rar	7=Wai
1=Hellyers	2.15E+04	2.12E+01	8.15E+00	1.96E+01	1.17E+00	2.44E+00	4.43E+01
2=Lucas	7.56E+02	5.65E+04	1.76E+02	1.34E+02	6.95E+00	1.26E+02	5.87E+02
3=Paremoremo	3.75E+02	1.08E+02	9.37E+03	7.14E+02	5.97E-01	5.43E+01	1.54E+02
4=Rangitopuni	6.44E+02	3.81E+01	7.45E+01	5.95E+04	9.70E+01	1.56E+02	2.99E+02
5=Brighams	7.66E+01	4.28E+00	4.21E+01	9.78E+03	5.09E+03	4.93E+02	3.02E+01
6=Rarawaru	7.61E+00	8.16E+01	5.72E-02	8.81E+01	2.43E+02	5.12E+02	8.24E+00
7=Waiarohia	2.97E+02	1.32E+00	4.55E-01	8.88E-01	6.40E-02	4.96E+01	5.43E+03
8=Middle WH	1.62E+03	3.40E+03	9.71E+02	4.75E+03	5.54E+02	2.96E+02	1.07E+04
9=Upper main body of UWH	3.93E+03	4.52E+03	2.03E+03	1.98E+04	4.09E+03	2.22E+03	2.38E+03
10=Middle main body of UWH	2.07E+03	1.48E+04	3.02E+03	6.37E+02	1.24E+02	8.03E+02	2.49E+03
11=Lower main body of UWH	2.42E+02	9.19E+03	1.35E+02	6.35E+02	2.02E+01	1.86E+01	5.41E+02

4.1.7 Fate of sediments / contaminants that derive from land (%)

Results from development #1 scenario.

(a) Existing scenario versus development #1 scenario

0.3% of the <u>sediment</u> that <u>originates</u> in Paremoremo subcatchment gets deposited in Brighams subestuary

Subcatchment	Percentage of the total amount of <u>sediment</u> originating in each subcatchment and passing through controls and entering each subestuary.										
	Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	60.7	3	1.5	2.2	0.4	0	1	7	13.9	9	1.3
2=Lucas	0	66.3	0.1	0	0	0.1	0	3.9	4.6	15.4	9.4
3=Paremoremo	0	1	61.6	0.4	0.3	0	0	5.7	12.1	18	0.8
4=Rangitopuni	0	0.1	0.7	64.4	9.5	0.1	0	4.7	19.2	0.6	0.6
5=Brighams	0	0.1	0	0.9	51.1	2.3	0	5.4	38.6	1.2	0.3
6=Rarawaru	0.1	3	1.2	3.5	9.5	11.9	1	6.6	45.6	17.2	0.5
7=Waiarohia	0.2	2.8	0.8	1.7	0.2	0.1	25.4	42.6	12.4	11.5	2.3

Subcatchment	Percentage of the total amount of <u>contaminant</u> originating in each subcatchment and passing through controls and entering each subestuary.										
	Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	68.2	2.4	1.2	2	0.2	0	0.9	5.2	12.5	6.6	0.8
2=Lucas	0	64.1	0.1	0	0	0.1	0	3.7	5.1	16.6	10.3
3=Paremoremo	0	1.1	59.4	0.5	0.3	0	0	6	12.8	19.1	0.8
4=Rangitopuni	0	0.1	0.7	62.2	10.1	0.1	0	4.9	20.5	0.7	0.7
5=Brighams	0	0.1	0	0.9	50.1	2.4	0	5.4	39.8	1.2	0.2
6=Rarawaru	0.1	2.7	1.2	3.3	10.3	10.8	1.1	6.4	46.8	16.9	0.4
7=Waiarohia	0.2	2.6	0.7	1.3	0.1	0	24.4	47.1	10.4	10.9	2.4

Results from existing scenario are shown on next page for comparison.

2.7% of the <u>contaminant</u> that <u>originates</u> in Rarawaru subcatchment gets deposited in Lucas subestuary

These are the results from the existing scenario for comparison.

Subcatchment	Percentage of the total amount of sediment originating in each subcatchment and passing through controls and entering each subestuary.										
	Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	60.7	3	1.5	2.2	0.4	0	1	7	13.9	9	1.3
2=Lucas	0	66	0.1	0	0	0.1	0	3.9	4.7	15.6	9.5
3=Paremoremo	0	1.1	61.3	0.4	0.3	0	0	5.8	12.1	18.1	0.8
4=Rangitopuni	0	0.1	0.7	63.9	9.6	0.1	0	4.7	19.5	0.6	0.6
5=Brighams	0	0.1	0	0.9	50.6	2.3	0	5.5	39	1.2	0.3
6=Rarawaru	0.1	2.9	1.2	3.4	9.7	12	1	6.4	45.8	17.1	0.5
7=Waiarohia	0.2	2.8	0.8	1.6	0.2	0.1	24.7	43.4	12.3	11.6	2.3

Subcatchment	Percentage of the total amount of contaminant originating in each subcatchment and passing through controls and entering each subestuary.										
	Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	68.2	2.4	1.2	2	0.2	0	0.9	5.2	12.5	6.6	0.8
2=Lucas	0	63.7	0.1	0	0	0.1	0	3.8	5.1	16.7	10.4
3=Paremoremo	0.1	1.1	59.2	0.5	0.3	0	0	6.1	12.8	19.1	0.9
4=Rangitopuni	0	0.1	0.7	62	10.2	0.1	0	4.9	20.6	0.7	0.7
5=Brighams	0	0.1	0	0.9	49.8	2.4	0	5.4	40	1.2	0.2
6=Rarawaru	0.1	2.7	1.1	3.3	10.4	10.8	1	6.3	46.9	17	0.4
7=Waiarohia	0.2	2.6	0.7	1.3	0.1	0	24	47.2	10.5	11	2.4

4.1.8 Fate of sediments / contaminants that derive from land (mass)

Results from development #1 scenario.

(a) Existing scenario versus development #1 scenario

Of the sediment that originates in Paremoremo subcatchment, 5.19x10^5 kg gets deposited in Brighams subestuary

Subcatchment	Mass (kg) of sediment originating in each subcatchment. Substuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	2.65E+07	1.29E+06	6.59E+05	9.66E+05	1.62E+05	1.38E+04	4.17E+05	3.06E+06	6.09E+06	3.92E+06	5.78E+05
2=Lucas	5.83E+04	1.26E+08	2.12E+05	5.82E+04	8.16E+03	1.58E+05	3.64E+03	7.46E+06	8.74E+06	2.93E+07	1.79E+07
3=Paremoremo	9.81E+04	2.15E+06	1.27E+08	9.13E+05	5.19E+05	6.30E+02	5.46E+03	1.18E+07	2.50E+07	3.73E+07	1.68E+06
4=Rangitopuni	1.07E+05	7.29E+05	3.83E+06	3.56E+08	5.25E+07	4.73E+05	4.86E+03	2.57E+07	1.06E+08	3.47E+06	3.46E+06
5=Brighams	1.14E+04	7.22E+04	5.58E+03	7.82E+05	4.36E+07	1.96E+06	5.80E+02	4.65E+06	3.30E+07	1.04E+06	2.70E+05
6=Rarawaru	5.60E+03	2.06E+05	8.60E+04	2.41E+05	6.59E+05	8.26E+05	6.86E+04	4.59E+05	3.17E+06	1.20E+06	3.57E+04
7=Waiarohia	4.18E+04	5.84E+05	1.66E+05	3.44E+05	4.06E+04	1.40E+04	5.21E+06	8.75E+06	2.55E+06	2.37E+06	4.68E+05

Subcatchment	Mass (kg) of contaminant originating in each subcatchment. Substuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	2.15E+04	7.56E+02	3.75E+02	6.44E+02	7.66E+01	7.61E+00	2.97E+02	1.62E+03	3.93E+03	2.07E+03	2.42E+02
2=Lucas	2.20E+01	6.53E+04	1.22E+02	4.38E+01	4.78E+00	9.34E+01	1.38E+00	3.79E+03	5.17E+03	1.69E+04	1.05E+04
3=Paremoremo	9.07E+00	2.00E+02	1.08E+04	8.54E+01	4.85E+01	5.99E-02	5.06E-01	1.10E+03	2.33E+03	3.48E+03	1.55E+02
4=Rangitopuni	1.07E+01	7.29E+01	3.92E+02	3.31E+04	5.38E+03	4.85E+01	4.86E-01	2.60E+03	1.09E+04	3.48E+02	3.46E+02
5=Brighams	2.28E+00	1.33E+01	1.18E+00	1.96E+02	1.04E+04	4.90E+02	1.27E-01	1.11E+03	8.26E+03	2.48E+02	3.55E+01
6=Rarawaru	2.82E+00	1.48E+02	6.35E+01	1.83E+02	5.70E+02	5.98E+02	5.98E+01	3.53E+02	2.58E+03	9.32E+02	2.18E+01
7=Waiarohia	8.86E+01	1.17E+03	3.06E+02	5.93E+02	5.96E+01	1.60E+01	1.11E+04	2.15E+04	4.73E+03	4.97E+03	1.09E+03

Results from existing scenario are shown on next page for comparison.

Of the contaminant that originates in Rarawaru subcatchment, 1.48x10^2 kg gets deposited in Lucas subestuary

These are the results from the existing scenario for comparison.

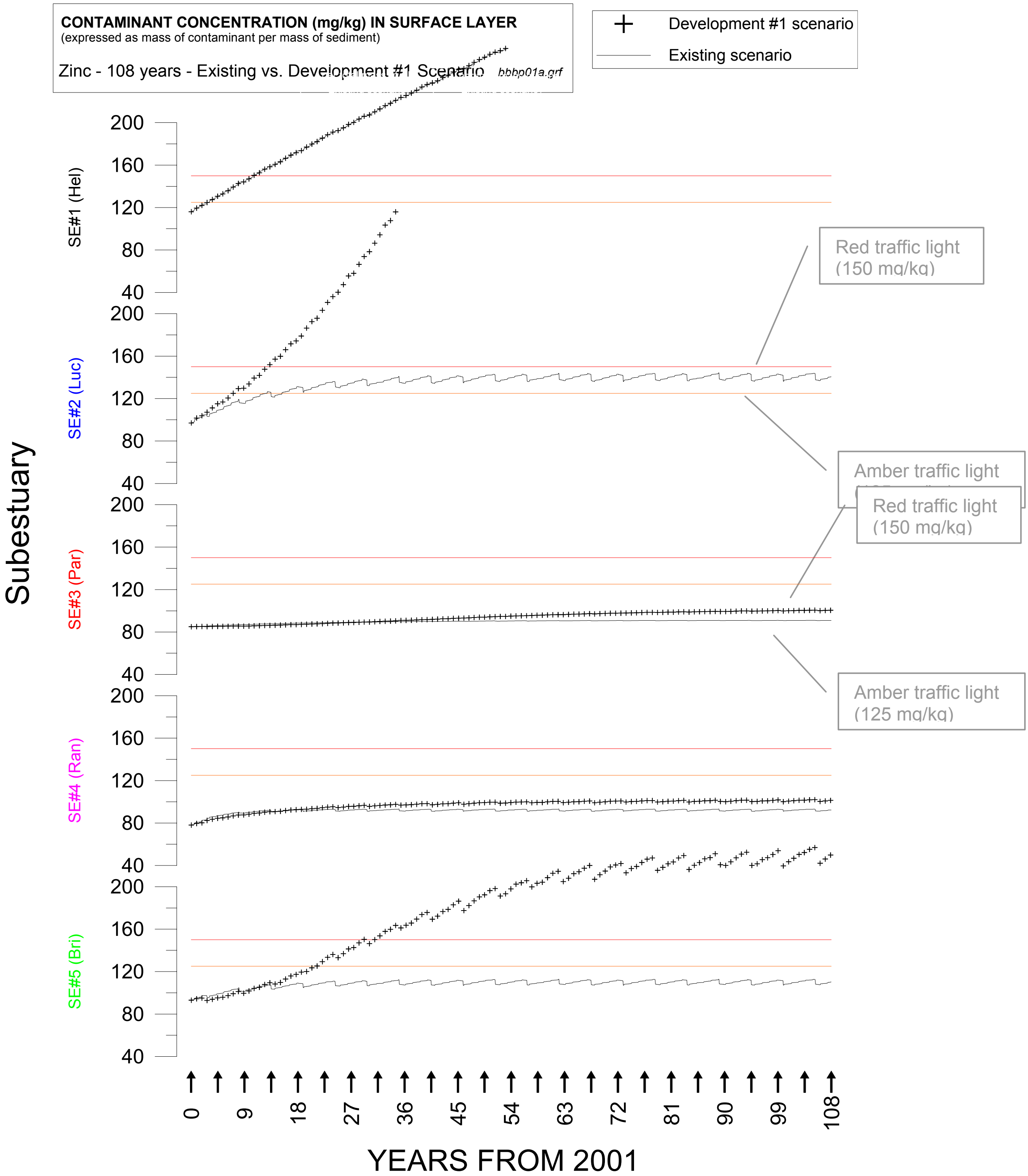
Subcatchment	Mass (kg) of sediment originating in each subcatchment.										
	Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	2.65E+07	1.29E+06	6.59E+05	9.66E+05	1.62E+05	1.38E+04	4.17E+05	3.06E+06	6.09E+06	3.92E+06	5.78E+05
2=Lucas	1.85E+05	4.07E+08	7.01E+05	2.05E+05	2.74E+04	5.22E+05	1.15E+04	2.42E+07	2.89E+07	9.65E+07	5.90E+07
3=Paremoremo	8.81E+04	1.88E+06	1.10E+08	7.96E+05	4.50E+05	6.10E+02	4.92E+03	1.04E+07	2.16E+07	3.23E+07	1.47E+06
4=Rangitopuni	2.02E+05	1.38E+06	7.22E+06	6.56E+08	9.89E+07	8.91E+05	9.17E+03	4.85E+07	2.00E+08	6.54E+06	6.54E+06
5=Brighams	1.06E+04	6.71E+04	5.18E+03	7.30E+05	3.99E+07	1.82E+06	5.38E+02	4.33E+06	3.08E+07	9.73E+05	2.51E+05
6=Rarawaru	5.61E+03	2.20E+05	9.22E+04	2.60E+05	7.44E+05	9.16E+05	7.48E+04	4.91E+05	3.51E+06	1.31E+06	3.68E+04
7=Waiarohia	7.12E+04	9.89E+05	2.79E+05	5.74E+05	6.70E+04	2.27E+04	8.63E+06	1.51E+07	4.28E+06	4.03E+06	8.03E+05

Subcatchment	Mass (kg) of contaminant originating in each subcatchment.										
	Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	2.15E+04	7.56E+02	3.75E+02	6.44E+02	7.66E+01	7.61E+00	2.97E+02	1.62E+03	3.93E+03	2.07E+03	2.42E+02
2=Lucas	2.12E+01	5.65E+04	1.08E+02	3.81E+01	4.28E+00	8.16E+01	1.32E+00	3.40E+03	4.52E+03	1.48E+04	9.19E+03
3=Paremoremo	8.15E+00	1.76E+02	9.37E+03	7.45E+01	4.21E+01	5.72E-02	4.55E-01	9.71E+02	2.03E+03	3.02E+03	1.35E+02
4=Rangitopuni	1.96E+01	1.34E+02	7.14E+02	5.95E+04	9.78E+03	8.81E+01	8.88E-01	4.75E+03	1.98E+04	6.37E+02	6.35E+02
5=Brighams	1.17E+00	6.95E+00	5.97E-01	9.70E+01	5.09E+03	2.43E+02	6.40E-02	5.54E+02	4.09E+03	1.24E+02	2.02E+01
6=Rarawaru	2.44E+00	1.26E+02	5.43E+01	1.56E+02	4.93E+02	5.12E+02	4.96E+01	2.96E+02	2.22E+03	8.03E+02	1.86E+01
7=Waiarohia	4.43E+01	5.87E+02	1.54E+02	2.99E+02	3.02E+01	8.24E+00	5.43E+03	1.07E+04	2.38E+03	2.49E+03	5.41E+02

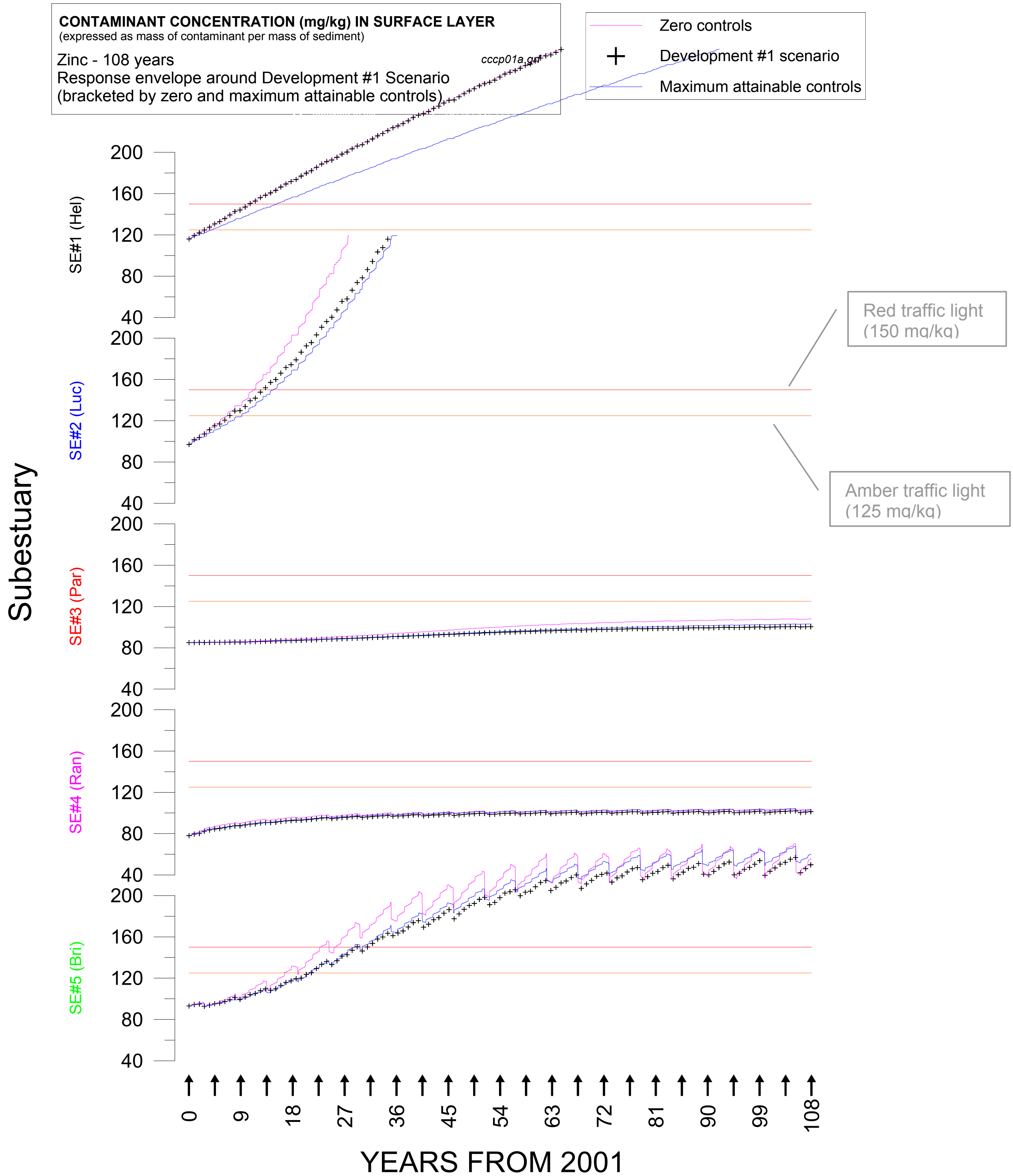
4.2 Simulation period: 108 years

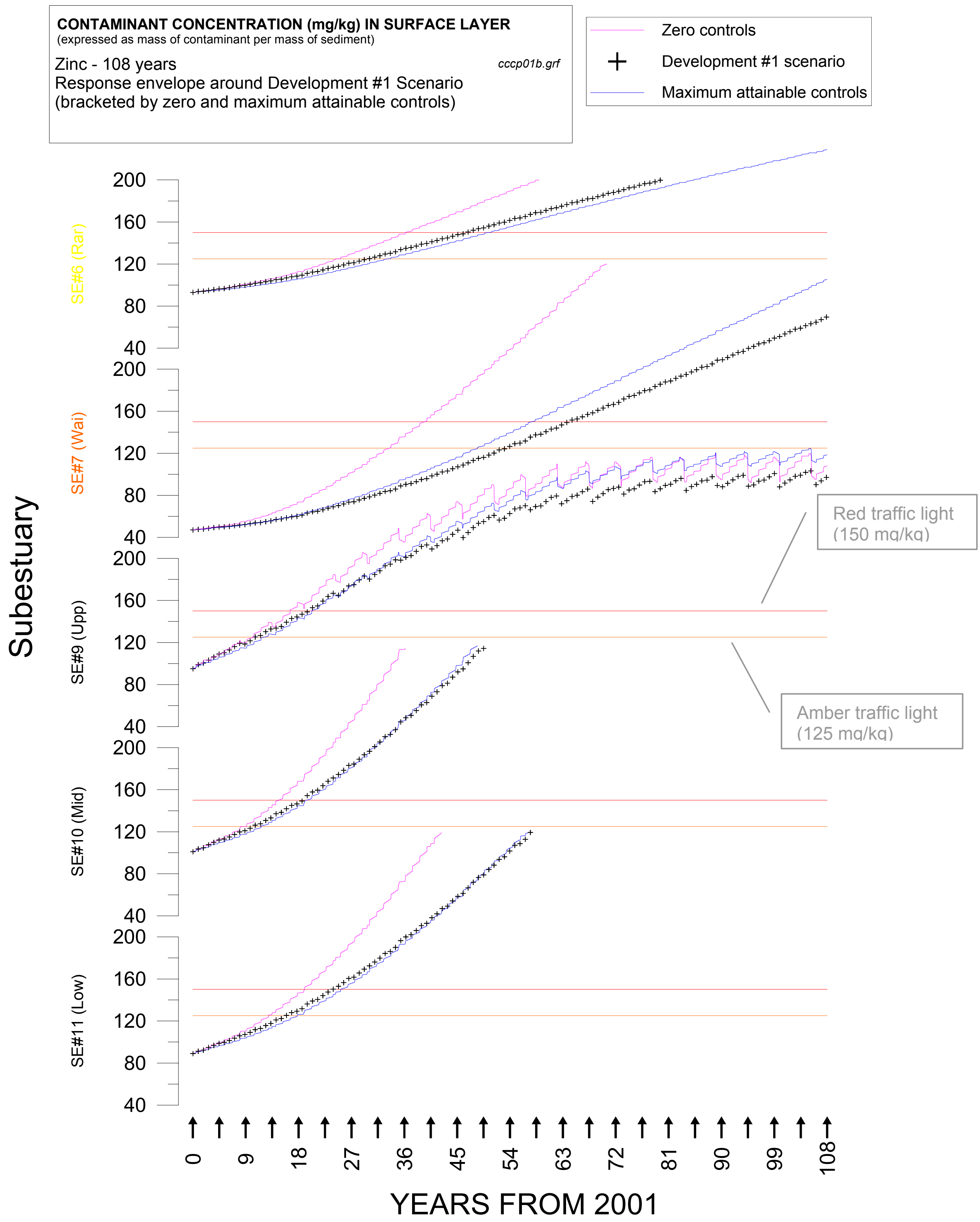
4.2.2 Contaminant concentrations in the harbour

(a) Existing scenario versus development #1 scenario



(b) Response envelope around development #1 scenario





CONTAMINANT CONCENTRATION (mg/kg) IN SURFACE LAYER
(expressed as mass of contaminant per mass of sediment)
Zinc - 108 years
cccp01b.grf
Response envelope around Development #1 Scenario
(bracketed by zero and maximum attainable controls)
Zero controls
Development #1 scenario
Maximum attainable controls
Subestuary
SE#6 (Rar)
SE#7 (Wai)
SE#9 (Upp)
SE#10 (Mid)
SE#11 (Low)
200
160
120
80
40
Red traffic light
(150 mg/kg)
Amber traffic light
(125 mg/kg)
0
9
18
27
36
45
54
63
72
81
90
99
108
YEARS FROM 2001

4.2.3 Time for total-sediment concentrations to reach "traffic lights"

(a) Existing scenario versus development #1 scenario

Results from development #1 scenario.

Subestuary	Years to Amber (125 mg/kg)	Years to Red (150 mg/kg)
1=Hellyers	3.08	10.46
2=Lucas	7.23	12.88
3=Paremoremo	0	0
4=Rangitopuni	0	0
5=Brighams	21.08	28.85
6=Rarawaru	30.08	46.48
7=Waiarohia	53.42	64.42
9=Upper main body of UWH	10.46	20.1
10=Middle main body of UWH	10.42	18.9
11=Lower main body of UWH	15.94	23.9
"0" signifies traffic light is not exceeded within 108 years		

It takes 53.42 years from 2001 for contaminant concentrations to pass through the amber traffic light in the Waiarohia subestuary.

Results from existing scenario.

Subestuary	Years to Amber (125 mg/kg)	Years to Red (150 mg/kg)
1=Hellyers	3.08	10.46
2=Lucas	12.67	0
3=Paremoremo	0	0
4=Rangitopuni	0	0
5=Brighams	0	0
6=Rarawaru	43.6	88.85
7=Waiarohia	0	0
9=Upper main body of UWH	12.88	0
10=Middle main body of UWH	12.23	38.65
11=Lower main body of UWH	26.87	76.71
"0" signifies traffic light is not exceeded within 108 years		

(b) Response envelope around development #1 scenario

Subestuary	Years to Amber (125 mg/kg)		
	No controls	Development #1 scenario	Maximum attainable controls
1=Hellyers	3.08	3.08	4.02
2=Lucas	6.75	7.23	9.23
3=Paremoremo	0	0	0
4=Rangitopuni	0	0	0
5=Brighams	16.6	21.08	21.08
6=Rarawaru	25.17	30.08	33.58
7=Waiarohia	33.58	53.42	48.52
9=Upper main body of UWH	10.42	10.46	12.06
10=Middle main body of UWH	9.17	10.42	11.65
11=Lower main body of UWH	12.88	15.94	17.81
"0" signifies traffic light is not exceeded within 108 years			

It takes 10.42 years from 2001 for contaminant concentrations to pass through the amber traffic light in the Middle main body under development #1 scenario.

Subestuary	Years to Red (150 mg/kg)		
	No controls	Development #1 scenario	Maximum attainable controls
1=Hellyers	10.46	10.46	15.37
2=Lucas	11.38	12.88	14.65
3=Paremoremo	0	0	0
4=Rangitopuni	0	0	0
5=Brighams	22.71	28.85	28.75
6=Rarawaru	36.23	46.48	50.63
7=Waiarohia	39.37	64.42	57.69
9=Upper main body of UWH	16.6	20.1	20.27
10=Middle main body of UWH	14.65	18.9	19.48
11=Lower main body of UWH	19.04	23.9	25.27
"0" signifies traffic light is not exceeded within 108 years			

4.2.4 Sedimentation in the harbour

(a) Existing scenario versus development #1 scenario

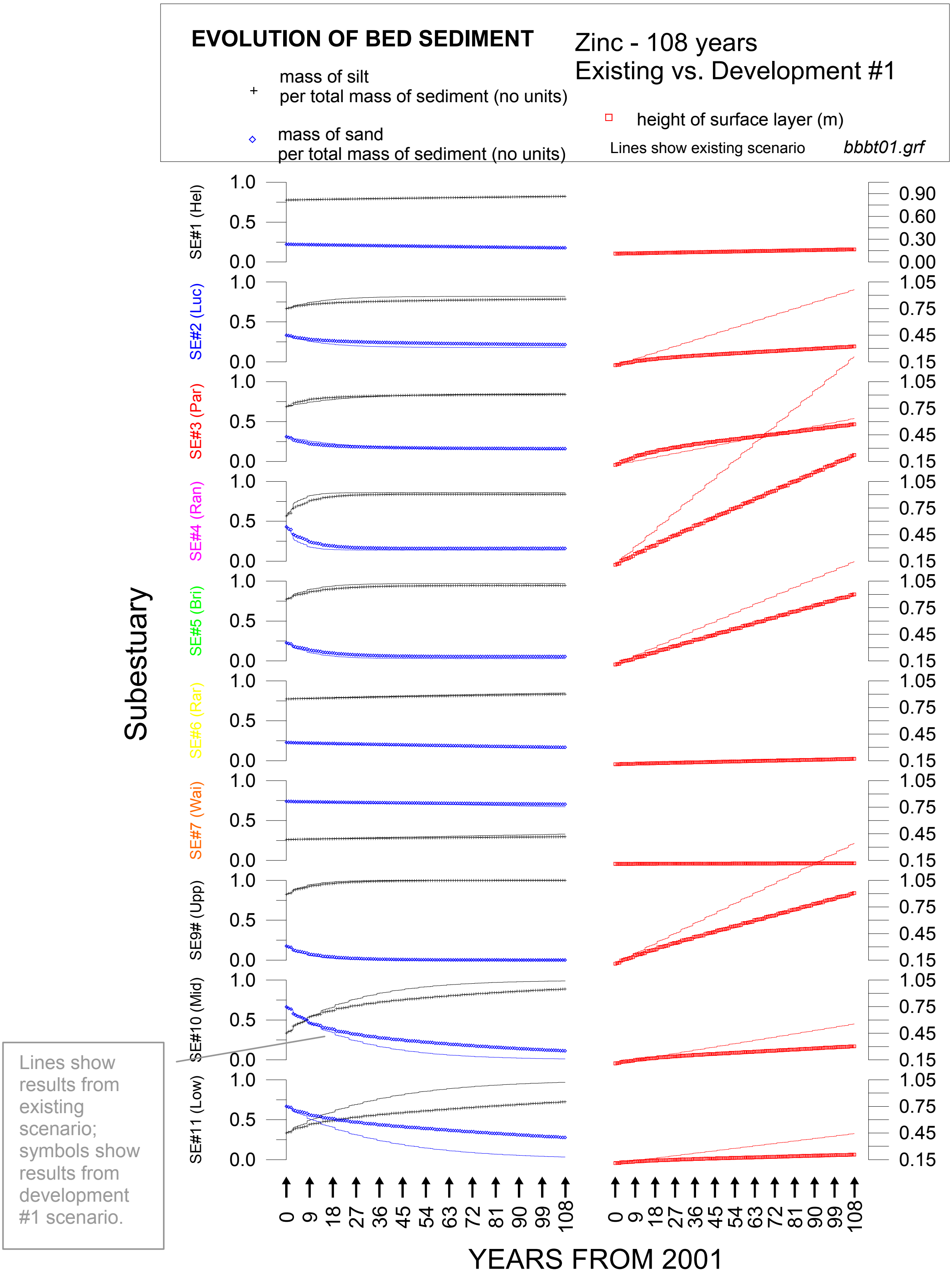
Results from development #1 scenario.

Subestuary	Annual-average sediment-deposition rate over simulation period (mm/year)
1=Hellyers	0.53
2=Lucas	1.97
3=Paremoremo	4.26
4=Rangitopuni	11.47
5=Brighams	7.32
6=Rarawaru	0.56
7=Waiarohia	0.07
8=Middle WH	–
9=Upper main body of UWH	7.37
10=Middle main body of UWH	1.79
11=Lower main body of UWH	0.89

Averaged over the108-year simulation period, the annual deposition rate in the Lower main body is 0.89 mm/year.

Results from existing scenario.

Subestuary	Annual-average sediment-deposition rate over simulation period (mm/year)
1=Hellyers	0.53
2=Lucas	7.89
3=Paremoremo	4.86
4=Rangitopuni	21.71
5=Brighams	10.73
6=Rarawaru	0.70
7=Waiarohia	0.13
8=Middle WH	–
9=Upper main body of UWH	12.55
10=Middle main body of UWH	4.11
11=Lower main body of UWH	3.07


EVOLUTION OF BED SEDIMENT
mass of silt
per total mass of sediment (no units)
mass of sand
per total mass of sediment (no units)
Zinc - 108 years
Existing vs. Development #1
height of surface layer (m)
Lines show existing scenario
bbbt01.grf
Subestuary
SE#1 (Hel)
SE#2 (Luc)
SE#3 (Par)
SE#4 (Ran)
SE#5 (Bri)
SE#6 (Rar)
SE#7 (Wai)
SE9# (Upp)
SE#10 (Mid)
SE#11 (Low)
Lines show results from existing scenario; symbols show results from development #1 scenario.
YEARS FROM 2001

4.2.5 Origin of sediments / contaminants that deposit in harbour (%)

(a) Existing scenario versus development #1 scenario

53.1% of the sediment that gets deposited in Brighams subestuary comes from Rangitopuni subcatchment

Results from development #1 scenario.

Subestuary	Percentage of the total amount of sediment (i.e., from all subcatchments) deposited in each subestuary. Subcatchment						
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	99	0.2	0.3	0.4	0	0	0.1
2=Lucas	1.3	95.7	1.6	0.7	0.1	0.2	0.5
3=Paremoremo	0.6	0.2	95.4	3.6	0	0.1	0.1
4=Rangitopuni	0.3	0	0.2	99.1	0.2	0.1	0.1
5=Brighams	0.2	0	0.4	53.1	45.6	0.6	0
6=Rarawaru	0.4	3.7	0	13.7	58.7	23.1	0.4
7=Waiarohia	8.5	0.1	0.1	0.1	0	1.3	89.9
8=Middle WH	5.5	10.6	16.6	44.9	8.4	0.8	13.3
9=Upper main body of UWH	3.5	3.9	11.2	59.4	19	1.7	1.2
10=Middle main body of UWH	6.2	36.1	45.9	5.3	1.6	1.8	3.2
11=Lower main body of UWH	2.9	69.9	6.8	16.9	1.4	0.2	2

Subestuary	Percentage of the total amount of contaminant (i.e., from all subcatchments) deposited in each subestuary. Subcatchment						
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	99.2	0.1	0	0	0	0	0.5
2=Lucas	1	96.6	0.2	0.1	0	0.2	1.9
3=Paremoremo	3.8	1.4	86.3	3.9	0	0.7	4
4=Rangitopuni	1.9	0.1	0.2	94.3	0.7	0.5	2.2
5=Brighams	0.4	0	0.2	27.6	68.3	3.1	0.4
6=Rarawaru	0.5	7.6	0	3.4	43.5	43.5	1.5
7=Waiarohia	2	0	0	0	0	0.4	97.5
8=Middle WH	4.2	11.3	2.2	6.6	3.6	0.9	71.2
9=Upper main body of UWH	9.5	14.4	4.4	25.7	25	6.4	14.6
10=Middle main body of UWH	6.4	60.4	8.5	1.1	1	3	19.7
11=Lower main body of UWH	1.7	84.8	0.9	2.4	0.3	0.2	9.8

8.5% of the contaminant that gets deposited in the Middle main body comes from Paremoremo subcatchment

Results from existing scenario are shown on next page for comparison.

These are the results from the existing scenario for comparison.

Subestuary	Percentage of the total amount of sediment (i.e., from all subcatchments) deposited in each subestuary.						
	Subcatchment						
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	97.9	0.7	0.3	0.7	0	0	0.3
2=Lucas	0.3	98.6	0.5	0.3	0	0.1	0.2
3=Paremoremo	0.6	0.6	92.4	6.1	0	0.1	0.2
4=Rangitopuni	0.1	0	0.1	99.5	0.1	0	0.1
5=Brighams	0.1	0	0.3	70.5	28.5	0.5	0
6=Rarawaru	0.3	12.5	0	21.3	43.5	21.9	0.5
7=Waiarohia	4.6	0.1	0.1	0.1	0	0.8	94.3
8=Middle WH	2.9	22.8	9.8	45.7	4.1	0.5	14.3
9=Upper main body of UWH	2.1	9.8	7.3	67.8	10.4	1.2	1.4
10=Middle main body of UWH	2.7	66.3	22.2	4.5	0.7	0.9	2.8
11=Lower main body of UWH	0.8	85.9	2.1	9.5	0.4	0.1	1.2

Subestuary	Percentage of the total amount of contaminant (i.e., from all subcatchments) deposited in each subestuary.						
	Subcatchment						
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	99.6	0.1	0	0.1	0	0	0.2
2=Lucas	1.3	96.9	0.3	0.2	0	0.2	1
3=Paremoremo	3.5	1	87	6.6	0	0.5	1.4
4=Rangitopuni	1.1	0.1	0.1	97.8	0.2	0.3	0.5
5=Brighams	0.5	0	0.3	63	32.8	3.2	0.2
6=Rarawaru	0.8	8.7	0	9.4	25.8	54.5	0.9
7=Waiarohia	5.1	0	0	0	0	0.9	94
8=Middle WH	7.3	15.2	4.4	21.3	2.5	1.3	48
9=Upper main body of UWH	10.1	11.6	5.2	50.8	10.5	5.7	6.1
10=Middle main body of UWH	8.6	61.9	12.6	2.7	0.5	3.4	10.4
11=Lower main body of UWH	2.2	85.2	1.3	5.9	0.2	0.2	5

4.2.6 Origin of sediments / contaminants that deposit in harbour (mass)

Results from development #1 scenario.

(a) Existing scenario versus development #1 scenario

Of the sediment that gets deposited in Brighams subestuary, 1.02x10^8 kg comes from Rangitopuni subcatchment

Subestuary	Mass (kg) of sediment deposited in each subestuary. Subcatchment 1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	5.30E+07	9.31E+04	1.57E+05	2.07E+05	2.29E+04	1.05E+04	7.07E+04
2=Lucas	2.58E+06	1.97E+08	3.37E+06	1.41E+06	1.45E+05	3.85E+05	9.90E+05
3=Paremoremo	1.32E+06	3.32E+05	1.98E+08	7.43E+06	1.12E+04	1.61E+05	2.82E+05
4=Rangitopuni	1.93E+06	8.96E+04	1.42E+06	6.90E+08	1.57E+06	4.50E+05	5.84E+05
5=Brighams	3.25E+05	1.28E+04	8.09E+05	1.02E+08	8.73E+07	1.23E+06	6.92E+04
6=Rarawaru	2.75E+04	2.46E+05	9.65E+02	9.16E+05	3.92E+06	1.54E+06	2.39E+04
7=Waiarohia	8.35E+05	5.82E+03	8.72E+03	9.43E+03	1.16E+03	1.28E+05	8.83E+06
8=Middle WH	6.12E+06	1.17E+07	1.85E+07	4.99E+07	9.31E+06	8.57E+05	1.48E+07
9=Upper main body of UWH	1.22E+07	1.36E+07	3.89E+07	2.06E+08	6.61E+07	5.92E+06	4.33E+06
10=Middle main body of UWH	7.85E+06	4.58E+07	5.82E+07	6.72E+06	2.09E+06	2.24E+06	4.02E+06
11=Lower main body of UWH	1.16E+06	2.79E+07	2.71E+06	6.72E+06	5.42E+05	6.67E+04	7.90E+05

Subestuary	Mass (kg) of contaminant deposited in each subestuary. Subcatchment 1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	4.29E+04	5.06E+01	1.46E+01	2.10E+01	5.66E+00	5.77E+00	2.28E+02
2=Lucas	1.51E+03	1.51E+05	3.18E+02	1.43E+02	3.30E+01	3.03E+02	3.01E+03
3=Paremoremo	7.50E+02	2.82E+02	1.71E+04	7.71E+02	2.94E+00	1.30E+02	7.87E+02
4=Rangitopuni	1.29E+03	1.02E+02	1.34E+02	6.50E+04	4.92E+02	3.75E+02	1.52E+03
5=Brighams	1.53E+02	1.11E+01	7.64E+01	1.06E+04	2.61E+04	1.17E+03	1.53E+02
6=Rarawaru	1.52E+01	2.16E+02	9.47E-02	9.52E+01	1.23E+03	1.23E+03	4.10E+01
7=Waiarohia	5.93E+02	3.16E+00	8.15E-01	9.52E-01	3.16E-01	1.23E+02	2.87E+04
8=Middle WH	3.25E+03	8.75E+03	1.74E+03	5.10E+03	2.79E+03	7.23E+02	5.53E+04
9=Upper main body of UWH	7.86E+03	1.20E+04	3.68E+03	2.14E+04	2.07E+04	5.29E+03	1.21E+04
10=Middle main body of UWH	4.14E+03	3.91E+04	5.50E+03	6.82E+02	6.21E+02	1.91E+03	1.28E+04
11=Lower main body of UWH	4.83E+02	2.43E+04	2.51E+02	6.79E+02	8.60E+01	4.47E+01	2.80E+03

Results from existing scenario are shown on next page for comparison.

Of the contaminant that gets deposited in the Middle main body, 5.50x10^3 kg comes from Paremoremo subcatchment

These are the results from the existing scenario for comparison.

Subestuary	Mass (kg) of sediment deposited in each subestuary.						
	Subcatchment						
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	5.30E+07	3.69E+05	1.76E+05	4.03E+05	2.12E+04	1.12E+04	1.42E+05
2=Lucas	2.58E+06	8.15E+08	3.76E+06	2.75E+06	1.34E+05	4.39E+05	1.98E+06
3=Paremoremo	1.32E+06	1.40E+06	2.19E+08	1.44E+07	1.04E+04	1.84E+05	5.59E+05
4=Rangitopuni	1.93E+06	4.09E+05	1.59E+06	1.31E+09	1.46E+06	5.20E+05	1.15E+06
5=Brighams	3.25E+05	5.49E+04	8.99E+05	1.98E+08	7.99E+07	1.49E+06	1.34E+05
6=Rarawaru	2.75E+04	1.04E+06	1.22E+03	1.78E+06	3.65E+06	1.83E+06	4.55E+04
7=Waiarohia	8.35E+05	2.31E+04	9.85E+03	1.83E+04	1.08E+03	1.50E+05	1.73E+07
8=Middle WH	6.12E+06	4.84E+07	2.08E+07	9.70E+07	8.66E+06	9.82E+05	3.03E+07
9=Upper main body of UWH	1.22E+07	5.78E+07	4.33E+07	4.01E+08	6.15E+07	7.02E+06	8.57E+06
10=Middle main body of UWH	7.85E+06	1.93E+08	6.47E+07	1.31E+07	1.95E+06	2.62E+06	8.07E+06
11=Lower main body of UWH	1.16E+06	1.18E+08	2.94E+06	1.31E+07	5.03E+05	7.35E+04	1.61E+06

Subestuary	Mass (kg) of contaminant deposited in each subestuary.						
	Subcatchment						
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai
1=Hellyers	4.29E+04	4.23E+01	1.63E+01	3.92E+01	2.34E+00	4.88E+00	8.86E+01
2=Lucas	1.51E+03	1.13E+05	3.51E+02	2.67E+02	1.39E+01	2.53E+02	1.17E+03
3=Paremoremo	7.50E+02	2.15E+02	1.87E+04	1.43E+03	1.19E+00	1.09E+02	3.08E+02
4=Rangitopuni	1.29E+03	7.61E+01	1.49E+02	1.19E+05	1.94E+02	3.13E+02	5.98E+02
5=Brighams	1.53E+02	8.56E+00	8.42E+01	1.96E+04	1.02E+04	9.85E+02	6.05E+01
6=Rarawaru	1.52E+01	1.63E+02	1.14E-01	1.76E+02	4.85E+02	1.02E+03	1.65E+01
7=Waiarohia	5.93E+02	2.65E+00	9.09E-01	1.78E+00	1.28E-01	9.92E+01	1.09E+04
8=Middle WH	3.25E+03	6.79E+03	1.94E+03	9.49E+03	1.11E+03	5.92E+02	2.14E+04
9=Upper main body of UWH	7.86E+03	9.05E+03	4.05E+03	3.96E+04	8.18E+03	4.44E+03	4.75E+03
10=Middle main body of UWH	4.14E+03	2.97E+04	6.05E+03	1.27E+03	2.47E+02	1.61E+03	4.97E+03
11=Lower main body of UWH	4.83E+02	1.84E+04	2.70E+02	1.27E+03	4.03E+01	3.73E+01	1.08E+03

4.2.7 Fate of sediments / contaminants that derive from land (%)

Results from development #1 scenario.

(a) Existing scenario versus development #1 scenario

0.3% of the sediment that originates in Paremoremo subcatchment gets deposited in Brighams subestuary

Subcatchment	Percentage of the total amount of sediment originating in each subcatchment and passing through controls and entering each subestuary.										
	Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	60.7	3	1.5	2.2	0.4	0	1	7	13.9	9	1.3
2=Lucas	0	66.4	0.1	0	0	0.1	0	4	4.6	15.4	9.4
3=Paremoremo	0	1	61.5	0.4	0.3	0	0	5.7	12.1	18.1	0.8
4=Rangitopuni	0	0.1	0.7	64.4	9.5	0.1	0	4.7	19.2	0.6	0.6
5=Brighams	0	0.1	0	0.9	51.1	2.3	0	5.4	38.6	1.2	0.3
6=Rarawaru	0.1	3	1.2	3.5	9.5	11.9	1	6.6	45.6	17.2	0.5
7=Waiarohia	0.2	2.8	0.8	1.7	0.2	0.1	25.4	42.5	12.4	11.6	2.3

Subcatchment	Percentage of the total amount of contaminant originating in each subcatchment and passing through controls and entering each subestuary.										
	Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	68.2	2.4	1.2	2	0.2	0	0.9	5.2	12.5	6.6	0.8
2=Lucas	0	64.1	0.1	0	0	0.1	0	3.7	5.1	16.5	10.3
3=Paremoremo	0.1	1.1	59.4	0.5	0.3	0	0	6	12.8	19.1	0.9
4=Rangitopuni	0	0.1	0.7	62.2	10.1	0.1	0	4.9	20.5	0.7	0.7
5=Brighams	0	0.1	0	0.9	50.1	2.4	0	5.4	39.8	1.2	0.2
6=Rarawaru	0.1	2.7	1.2	3.3	10.3	10.9	1.1	6.4	46.8	16.9	0.4
7=Waiarohia	0.2	2.6	0.7	1.3	0.1	0	24.4	47.1	10.3	10.9	2.4

Results from existing scenario are shown on next page for comparison.

2.7% of the contaminant that originates in Rarawaru subcatchment gets deposited in Lucas subestuary

These are the results from the existing scenario for comparison.

Subcatchment	Percentage of the total amount of sediment originating in each subcatchment and passing through controls and entering each subestuary.										
	Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	60.7	3	1.5	2.2	0.4	0	1	7	13.9	9	1.3
2=Lucas	0	66	0.1	0	0	0.1	0	3.9	4.7	15.6	9.5
3=Paremoremo	0	1.1	61.3	0.4	0.3	0	0	5.8	12.1	18.1	0.8
4=Rangitopuni	0	0.1	0.7	63.9	9.6	0.1	0	4.7	19.5	0.6	0.6
5=Brighams	0	0.1	0	0.9	50.6	2.3	0	5.5	39	1.2	0.3
6=Rarawaru	0.1	2.9	1.2	3.4	9.7	12	1	6.4	45.8	17.1	0.5
7=Waiarohia	0.2	2.8	0.8	1.6	0.2	0.1	24.7	43.4	12.3	11.6	2.3

Subcatchment	Percentage of the total amount of contaminant originating in each subcatchment and passing through controls and entering each subestuary.										
	Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	68.2	2.4	1.2	2	0.2	0	0.9	5.2	12.5	6.6	0.8
2=Lucas	0	63.7	0.1	0	0	0.1	0	3.8	5.1	16.7	10.4
3=Paremoremo	0.1	1.1	59.2	0.5	0.3	0	0	6.1	12.8	19.1	0.9
4=Rangitopuni	0	0.1	0.7	62	10.2	0.1	0	4.9	20.6	0.7	0.7
5=Brighams	0	0.1	0	0.9	49.8	2.4	0	5.4	40	1.2	0.2
6=Rarawaru	0.1	2.7	1.1	3.3	10.4	10.8	1	6.3	46.9	17	0.4
7=Waiarohia	0.2	2.6	0.7	1.3	0.1	0	24	47.2	10.5	11	2.4

4.2.8 Fate of sediments / contaminants that derive from land (mass)

Results from development #1 scenario.

(a) Existing scenario versus development #1 scenario

Of the sediment that originates in Paremoremo subcatchment, 8.09x10^5 kg gets deposited in s deposited in Brighams subestuary

Subcatchment	Mass (kg) of sediment originating in each subcatchment. Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	5.30E+07	2.58E+06	1.32E+06	1.93E+06	3.25E+05	2.75E+04	8.35E+05	6.12E+06	1.22E+07	7.85E+06	1.16E+06
2=Lucas	9.31E+04	1.97E+08	3.32E+05	8.96E+04	1.28E+04	2.46E+05	5.82E+03	1.17E+07	1.36E+07	4.58E+07	2.79E+07
3=Paremoremo	1.57E+05	3.37E+06	1.98E+08	1.42E+06	8.09E+05	9.65E+02	8.72E+03	1.85E+07	3.89E+07	5.82E+07	2.71E+06
4=Rangitopuni	2.07E+05	1.41E+06	7.43E+06	6.90E+08	1.02E+08	9.16E+05	9.43E+03	4.99E+07	2.06E+08	6.72E+06	6.72E+06
5=Brighams	2.29E+04	1.45E+05	1.12E+04	1.57E+06	8.73E+07	3.92E+06	1.16E+03	9.31E+06	6.61E+07	2.09E+06	5.42E+05
6=Rarawaru	1.05E+04	3.85E+05	1.61E+05	4.50E+05	1.23E+06	1.54E+06	1.28E+05	8.57E+05	5.92E+06	2.24E+06	6.67E+04
7=Waiarohia	7.07E+04	9.90E+05	2.82E+05	5.84E+05	6.92E+04	2.39E+04	8.83E+06	1.48E+07	4.33E+06	4.02E+06	7.90E+05

Subcatchment	Mass (kg) of contaminant originating in each subcatchment. Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	4.29E+04	1.51E+03	7.50E+02	1.29E+03	1.53E+02	1.52E+01	5.93E+02	3.25E+03	7.86E+03	4.14E+03	4.83E+02
2=Lucas	5.06E+01	1.51E+05	2.82E+02	1.02E+02	1.11E+01	2.16E+02	3.16E+00	8.75E+03	1.20E+04	3.91E+04	2.43E+04
3=Paremoremo	1.46E+01	3.18E+02	1.71E+04	1.34E+02	7.64E+01	9.47E-02	8.15E-01	1.74E+03	3.68E+03	5.50E+03	2.51E+02
4=Rangitopuni	2.10E+01	1.43E+02	7.71E+02	6.50E+04	1.06E+04	9.52E+01	9.52E-01	5.10E+03	2.14E+04	6.82E+02	6.79E+02
5=Brighams	5.66E+00	3.30E+01	2.94E+00	4.92E+02	2.61E+04	1.23E+03	3.16E-01	2.79E+03	2.07E+04	6.21E+02	8.60E+01
6=Rarawaru	5.77E+00	3.03E+02	1.30E+02	3.75E+02	1.17E+03	1.23E+03	1.23E+02	7.23E+02	5.29E+03	1.91E+03	4.47E+01
7=Waiarohia	2.28E+02	3.01E+03	7.87E+02	1.52E+03	1.53E+02	4.10E+01	2.87E+04	5.53E+04	1.21E+04	1.28E+04	2.80E+03

Results from existing scenario are shown on next page for comparison.

Of the contaminant that originates in Rarawaru subcatchment, 3.03x10^2 kg gets deposited in Lucas subestuary

These are the results from the existing scenario for comparison.

Subcatchment	Mass (kg) of <u>sediment</u> originating in each subcatchment.										
	Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	5.30E+07	2.58E+06	1.32E+06	1.93E+06	3.25E+05	2.75E+04	8.35E+05	6.12E+06	1.22E+07	7.85E+06	1.16E+06
2=Lucas	3.69E+05	8.15E+08	1.40E+06	4.09E+05	5.49E+04	1.04E+06	2.31E+04	4.84E+07	5.78E+07	1.93E+08	1.18E+08
3=Paremoremo	1.76E+05	3.76E+06	2.19E+08	1.59E+06	8.99E+05	1.22E+03	9.85E+03	2.08E+07	4.33E+07	6.47E+07	2.94E+06
4=Rangitopuni	4.03E+05	2.75E+06	1.44E+07	1.31E+09	1.98E+08	1.78E+06	1.83E+04	9.70E+07	4.01E+08	1.31E+07	1.31E+07
5=Brighams	2.12E+04	1.34E+05	1.04E+04	1.46E+06	7.99E+07	3.65E+06	1.08E+03	8.66E+06	6.15E+07	1.95E+06	5.03E+05
6=Rarawaru	1.12E+04	4.39E+05	1.84E+05	5.20E+05	1.49E+06	1.83E+06	1.50E+05	9.82E+05	7.02E+06	2.62E+06	7.35E+04
7=Waiarohia	1.42E+05	1.98E+06	5.59E+05	1.15E+06	1.34E+05	4.55E+04	1.73E+07	3.03E+07	8.57E+06	8.07E+06	1.61E+06

Subcatchment	Mass (kg) of <u>contaminant</u> originating in each subcatchment.										
	Subestuary										
	1=Hel	2=Luc	3=Par	4=Ran	5=Bri	6=Rar	7=Wai	8 = MWH	9 = Upp	10 = Mid	11 = Low
1=Hellyers	4.29E+04	1.51E+03	7.50E+02	1.29E+03	1.53E+02	1.52E+01	5.93E+02	3.25E+03	7.86E+03	4.14E+03	4.83E+02
2=Lucas	4.23E+01	1.13E+05	2.15E+02	7.61E+01	8.56E+00	1.63E+02	2.65E+00	6.79E+03	9.05E+03	2.97E+04	1.84E+04
3=Paremoremo	1.63E+01	3.51E+02	1.87E+04	1.49E+02	8.42E+01	1.14E-01	9.09E-01	1.94E+03	4.05E+03	6.05E+03	2.70E+02
4=Rangitopuni	3.92E+01	2.67E+02	1.43E+03	1.19E+05	1.96E+04	1.76E+02	1.78E+00	9.49E+03	3.96E+04	1.27E+03	1.27E+03
5=Brighams	2.34E+00	1.39E+01	1.19E+00	1.94E+02	1.02E+04	4.85E+02	1.28E-01	1.11E+03	8.18E+03	2.47E+02	4.03E+01
6=Rarawaru	4.88E+00	2.53E+02	1.09E+02	3.13E+02	9.85E+02	1.02E+03	9.92E+01	5.92E+02	4.44E+03	1.61E+03	3.73E+01
7=Waiarohia	8.86E+01	1.17E+03	3.08E+02	5.98E+02	6.05E+01	1.65E+01	1.09E+04	2.14E+04	4.75E+03	4.97E+03	1.08E+03

5. Discussion

5.1 Validation of predictions

The results of the existing scenario simulation can be used to provide validation in addition to and beyond that reported in NIWA Client Report HAM2003-087/1 – Methods, in which predicted sediment deposition rates were shown to compare favourably with observations, and zinc concentrations in sediment cores from Lucas subestuary were also shown to match predictions.

We can assume that for subcatchments such as Rangitopuni, Brighams and Paremoremo, in which urban and lifestyle development has occurred at a slow rate over relatively small areas, that the estuarine sediment zinc concentrations should be almost in equilibrium with the zinc loads from the subcatchments, i.e. the zinc concentrations in the sediments should be almost equal to the concentrations in the sediment washing from the catchment. Thus, the existing scenario results for these subcatchments should show that the estuarine sediment zinc concentrations do not change much over time from the concentrations that existed in 2001.

For the other subcatchments in which development has been faster and more substantial, the estuarine sediment zinc concentrations would not yet (in 2001) have caught up with the subcatchment zinc loads. Bioturbation is the main reason for this lag as explained in the Methods report. Validating predictions for these "out-of-equilibrium" subcatchment/subestuary pairs is not as simple as it is for the three "near-equilibrium" pairs above, because the only comparison that can be made for the out-of-equilibrium pairs is between the model predictions and an estimate of how long the estuarine sediment zinc concentrations for these pairs should take to reach equilibrium. As is apparent from the discussion of bioturbation in Appendix F of the Methods report, the time-to-equilibrium is a function of the sediment deposition rate (SDR) relative to the depth of bioturbation. The greater the ratio of SDR to bioturbation depth, the faster equilibrium will be reached.

The predictions under the existing scenario are that zinc concentrations in the subestuaries of Paremoremo (3) and Rangitopuni (4) will reach equilibrium sometime between about 2005 and 2010. This prediction is consistent with the slow rate of urban and lifestyle development up to 2001 in these subcatchments. This satisfactory result was achieved, however, only by increasing the natural zinc concentrations in the soils of these two subcatchments to 90 mg zinc per kg of silt and 40 mg zinc per kg of sand. These values are well above those in the pre-urban sediments at the base of the Lucas Creek estuary cores (see Appendix D in the Methods report). This indicates that there is a source of zinc contributing to the estuarine sediments that we have not explicitly accounted for in the model inputs. This source is either in the respective subcatchments or in the harbour, i.e. it comes from the other subcatchments. The hydrodynamic modelling implies that the harbour is unlikely to be the source.

In an effort to resolve this, a small survey of zinc concentrations in soils and stream sediments in Brighams (5), Rangitopuni (4) and Paremoremo (3) subcatchments was undertaken. In these three subcatchments, the soil zinc concentrations (silt fraction) ranged between 16 and 62 mg kg^{-1} whereas the stream sediment zinc concentrations (silt fraction) ranged between 76 and 144 mg kg^{-1}. The stream sediment:soil concentration ratios were 1.22, 3.7 and 2.5 for Paremoremo, Rangitopuni and Brighams subcatchments, respectively.

These results imply that the source of zinc is in the catchments and that zinc is being added to the soils after it has been washed into the streams.

We have not so far identified this source but we are confident that it is not the "dwellings". The simple reason for this is that if the dwelling load is increased to include this source, not only would the residential landuse load be inconceivably greater than all residential loads determined by other means, the validation using the Lucas subcatchment (reported in the Methods report) would have been impossible.

Although this source remains unknown, inclusion of its load in the "natural" load is a valid approach and ensures that the unknown load is correctly dealt with by the model. This load is, of course, included in the model inputs for the development scenarios.

The result for Brighams subestuary, which was obtained without adjusting the initial natural load of 40 mg zinc per kg of silt and 20 mg zinc per kg of sand, is also consistent with its slightly higher and faster rate of urban development compared with Paremoremo and Rangitopuni. The zinc concentration in the Brighams estuarine sediments reaches equilibrium in 20 to 30 years.

Consider now the catchments in which development prior to 2001 was rapid and substantial: Hellyers, Lucas, Waiarohia and Rarawaru. These fall into two groups on the basis of their results: Lucas in one and the rest in the other. The relevant difference between the groups is the sediment deposition rate. The predicted SDR in the Lucas subestuary under the existing scenario is 7.89 mm $year^{-1}$ (Section 4.2.4). Thus, it would take about 110/7.89 = 14 years to add a layer of new sediment equal to the depth of bioturbation. It can be shown by simple calculation that after this period of time, the zinc concentration in the bioturbated layer of the estuary should be approximately 60% of the concentration in the sediment entering the estuary from the subcatchment (remember that this concentration does not change over time in the existing simulation). This 60% is a rough guide only, because it depends on the concentration in the bioturbated layer at the start of the period.

Zinc concentration in Lucas subestuary sediments under the existing scenario reaches equilibrium after about 40 years and the concentration has reached 60% of the equilibrium concentration after about 15 years. Given that the SDR has been validated independently (Section E of the Methods report), this result shows that the model is correctly accumulating zinc in the estuary sediments. Note that this comparison does not validate the actual zinc loads, although for Lucas, these loads have already been validated.

The other group of estuaries, Hellyers, Waiarohia and Rarawaru, all have low predicted SDRs under the existing scenario. As explained above for Lucas, the lower the SDR the longer the estuarine sediment zinc concentration will take to reach equilibrium with the concentrations in the catchment soils. For these three subcatchments with the low SDRs in their estuaries, equilibrium is not reached before 2109. As noted above, this result does not validate the zinc loads, only that the model is correctly accounting for the loads in the estuaries.

5.2 Examples of how to interrogate and interpret results

Considering now the patterns and processes illustrated by these results, the following questions and answers show the kinds of observations that can be made from, for example, the 108-year existing-scenario simulation:

- *Where does zinc deposited in each part of the harbour come from?* These quantities are summarised in tables in Section 4.1.5 (54-year simulation) and Section 4.2.5 (108-year simulation) and . For example, half (50.8%) of the zinc that deposits in the Upper main body comes from Rangitopuni subcatchment, which discharges into the head of the harbour, with other significant sources being Hellyers (10.1%), Lucas (11.6%) and Brighams (10.5%) subcatchments.

- *Which subestuary is most at risk?* The Hellyers subestuary is at most risk because the amber and red traffic lights will be exceeded the earliest, within a couple of years (3.08 years) and within a decade (10.46 years), respectively (Section 4.1.3, Section 4.2.3).

- *Why is Hellyers at such risk?* (1) The dwelling plus through-vehicle zinc load from Hellyers subcatchment of 552 kg per annum is the second-highest of any subcatchment, because the subcatchment is fully urbanised (Section 3.1.1). (2) At the same time, sediment loads are low (Section 3.1.1), which means zinc is not appreciably "diluted" by sediment. (2) Most (99.6%) of the zinc that deposits in Hellyers subestuary originates from Hellyers subcatchment, as does most of the sediment (97.9%) (Section 4.2.5). The high zinc concentration in the sediment originating from the Hellyers subcatchments is not, therefore, diluted in the estuary by less contaminated sediment from some other part of the harbour.

- *How might this risk to Hellyers subestuary be lessened?* Better control of zinc at the principal source, which is Hellyers subcatchment (this supplies 99.6% of the zinc that deposits in Hellyers subestuary) would be the most effective way of reducing the rate of contaminant buildup. (Allowing greater sediment runoff may also achieve the same effect so long as the sediment has a lower zinc concentration, but of course greater sediment yields have serious implications not only for the ecology of the harbour and estuaries, but also for the stability of private property.)

- *Will there be other benefits associated with source control at Hellyers?* Yes, there will be a number of additional benefits. For example, contaminants from Hellyers account for more than 10% of the contaminants that deposit in the

Upper main body (Section 4.2.5), so a reduction will also benefit that area of the harbour.

- *Which subestuary is least at risk?* The modelling indicates that traffic lights will not be exceeded within 108 years for Paremoremo, Rangitopuni and Brighams subestuaries under the existing scenario (Section 4.2.3).

- *Why are these estuaries at least risk?* Looking at just Rangitopuni, we see that nearly 98% of the zinc that settles there comes from the Rangitopuni subcatchment (Section 4.2.5). Now, because the Rangitopuni dwelling plus through-vehicle zinc loads are very low (82.1 kg per annum; Section 3.1.1) and the sediment loads from Rangitopuni subcatchment are very high (Section 3.1.1), of which 62% gets deposited in the Rangitopuni estuary (Section 4.2.7), the natural zinc loads will greatly dominate the zinc concentration in the Rangitopuni estuary sediments. Since we assume that this natural zinc load will not change over time, it follows that the zinc concentration in the Rangitopuni estuary sediment won't change either, that is, it will never reach the "traffic light" concentrations

Any number of similar observations may be made and conclusions drawn by studying the graphs and tables that depict the various results.

The traffic lights represent an environmental target or goal. For instance, one may decide that the red traffic light should not be exceeded for at least 30 years in the future in a particular estuarine habitat. (Note: 30 years is chosen arbitrarily here as an example and is not a recommended time frame, nor does it represent current thinking in the ARC). Inspection of the response-envelope plots will show how this may be achieved.

- For instance, the response envelope for the subestuary in which the habitat of concern is located may show that, even under zero stormwater controls, the red light will not be exceeded within 30 years. Hence, the desired environmental target will be achieved with no management intervention.

- Or, the response-envelope plots may show that, even under the maximum attainable stormwater controls, the time to red traffic light is, say, 15 years. In that case, there is no practicable stormwater control that can be implemented that will achieve the desired outcome. In that case, attention should turn to reducing the contaminant source (generation) to achieve the environmental outcome (viz., stretching the traffic light exceedance out to at least 30 years). Furthermore, efforts at source control must, of course, focus on the subcatchment that supplies the majority of the contaminant that deposits in the subestuary in question. This can also be determined from the results presented herein, as described above.

- Or, the response envelope might bracket the time of 30 years to the red light. This means that there will be some finite, attainable control level that will put the traffic light exceedance right on 30 years. One may estimate what that control level is by visually interpolating the response enveloped, or a series of trial-and-error simulations could be conducted to determine a more precise estimate.

The response-envelope simulations may also be examined to address points such as:

- *Are there parts of the harbour where contaminant concentrations still exceed traffic lights even under the maximum attainable controls?* An example here is the Lower main body of the harbour, which is predicted to exceed the red traffic light within 30 or so years, even under maximum attainable controls (Sections 4.1.2 and 4.1.3). In this case, the focus should shift to the subcatchment(s) that is the largest contributor of contaminants (in this case, Lucas subcatchment, which supplies nearly 85% of zinc that deposits in the Lower main body – Section 4.1.5), which might be a good candidate for source control.

- *Are there subestuaries where significant gains in time-to-traffic-light can be had for modest control improvements?* An example here is Rarawaru, where an extra 15 or so years is gained before the amber traffic light is exceeded by shifting from no controls to maximum attainable controls (Sections 4.1.2 and 4.1.3). In this case, contaminants come principally from Brighams (39.1%) and Rarawaru (47.7%) subcatchments, so these should be the target for control improvement to win this 15 years.

- *What subcatchments are the main polluters?* Lucas subcatchment is the main polluter, as shown by summing the contaminant loads in Section 3.1.1, followed by Hellyers.

- *Would maximum possible controls in these subcatchments have significant benefits throughout the whole harbour (which might justify the expense of maximum possible controls in those subcatchments)?* Yes. For instance, there would be major benefits to other parts of the harbour through controlling zinc loads from Lucas subcatchment. For example, under scenario #1, contaminant loads from Lucas constitute 84.8% of the zinc load to the Lower main body, and 58.4% of the load to the Middle main body over 54 years (Section 4.1.5). Both these parts of the harbour will exceed red traffic lights within 20 years under this scenario (section 4.1.3).

6. Conclusions

The existing scenario extrapolates the "current-day" (i.e., 2001) landuse into the future based on the assumption that landuse does not change. The results from this scenario provide a baseline for comparison against a realistic development scenario developed in consultation with the Working Party. In addition, the same realistic development scenario is bracketed by two extremes (zero stormwater contaminant controls, and maximum attainable stormwater controls) to give an envelope of responses in the harbour.

A range of results is presented, for both 54-year and 108-year simulations, including:

- Contaminant concentrations in the harbour:

  Existing scenario versus development #1 scenario

  Response envelope around development #1 scenario

- Time for total-sediment concentrations to reach "traffic lights":

  Existing scenario versus development #1 scenario

  Response envelope around development #1 scenario

- Sedimentation in the harbour:

  Existing scenario versus development #1 scenario

  Response envelope around development #1 scenario

- Origin of sediments / contaminants that deposit in harbour (%):

  Existing scenario versus development #1 scenario

- Origin of sediments / contaminants that deposit in harbour (mass):

  Existing scenario versus development #1 scenario

- Fate of sediments / contaminants that derive from land (%):

  Existing scenario versus development #1 scenario

- Fate of sediments / contaminants that derive from land (mass):

  Existing scenario versus development #1 scenario

The results of the existing scenario simulation provide validation in addition to and beyond that reported in NIWA Client Report HAM2003-087/1 – Methods, in which predicted sediment deposition rates were compared with observations, and zinc concentrations in sediment cores from Lucas subestuary were also compared with predictions.

The various results presented herein can be used to investigate a number of questions concerning management of the Upper Waitemata Harbour catchment with a view to achieving environment targets in the receiving waters of the harbour. Guidance and examples of how this may be achieved have been given.

7. References

Herald, J.R. (1989). *Hydrological impact of urban development in the Albany Basin, Auckland. Auckland, New Zealand*. Unpublished Ph.D. thesis, University of Auckland.

van Roon, M.R. (1983). *Water Quality in the Upper Waitemata Harbour and Catchment*. Auckland Regional Council.

APPENDIX A1. Control Measures for Stormwaters from Completed Developments: Council Responses to Stormwater Controls Questionnaires

A1.1 Responses to NIWA questionnaires

Rural (approx 2 ha blocks)	**Waitakere**	**Rodney**		**North Shore**	
		Current Practice	*Future Practice*	*Current Practice*	*Future Practice*
Swales, ponds for kerbed and unkerbed roads	Yes for new roads	No	Yes (starting to)	No	Yes (where practical with retrofits or subdivisions)
No constructed controls for roads. Drainage to nearest water way.	Most existing roads	Yes (90%)	No	Yes (95%)	No
Constructed controls for individual dwellings, e.g., swales, wetlands, other treatment devices (not rainwater tanks)	Yes	No	Yes (for sites <2.5 ha)	No	Yes (minor amount)
No constructed controls for individual dwellings. Reticulated or drained to nearest water way.	Controls on new dwellings to Countryside code of practice.	Yes (90%)	No	Yes (99%)	Yes (minor amount)
Catchment-level ponds and wetlands.	No	No	Yes (but on rare occasions)	No	No
Prohibition on galvanised iron.	Not at present. Included in new catchment plans but these are unconsented at present.	No	No	No	No

Urban	Waitakere	Rodney		North Shore	
		Current Practice	*Future Practice*	*Current Practice*	*Future Practice*
Catchment-level ponds, wetlands, etc., for all stormwater.	75% treatment for all green fields development	No	Sometimes (50%)	About 85% area of recent subdivisions at 75% treatment	About the same as now.
No constructed controls. Reticulate all stormwater to stream, estuary or harbour outfalls	Very little of this in Upper Harbour area for either rural or urban.	Yes	No	About 15% area of recent subdivisions (small 2-3 lot subdivisions)	About the same as now.
Swales, rain gardens, sand filters for road runoff only.		No	Yes	Yes (under 5% - includes carparks)	Yes (for heavily trafficked roads)
Prohibition on galvanised iron.	Considering this.	No	No	No	No

A1.2 Responses to ARC questionnaire

	Rural	Rural	Rural	Urban	Urban	Urban
	WCC	*RDC*	*NSCC*	*WCC*	*RDC*	*NSCC*
Swales/filter strips	Yes	Yes	Yes	Yes	Yes	Yes
Sand filters	No	No	No	Yes	?	Yes
Leaf/compost filters		No	No	No	No	No/possibly?
Ponds for kerbed roads	No	Yes	No	Sometimes	Yes	Yes for greenfields, no for retrofitting
Ponds for unkerbed roads	No	Yes	No	Sometimes	Yes	No unkerbed roads in urban areas
Extended detention	Sometimes	?	Yes	Sometimes	?	Yes
Ponds	No	Yes	No	Sometimes	Yes	Yes for greenfields, no for retrofitting
Wetlands	No	Yes	No	Sometimes	Yes	Yes for greenfields, no for retrofitting
Infiltration basins	No	No	No	Sometimes	No	No
Infiltration trenches	No	No	No	No	No	No
Bores and tunnels	No	No	No	No	No	No
Porous pavements	Maybe	No	No	Sometimes	No	Sometimes in carparks
Vegetation/revegeta tion	Yes	Yes	Yes	Yes	Yes	Yes
Oil and water separators	No	No	No	No	Yes	Yes
Rainwater tanks	Yes	Yes	Yes	Yes	Yes	Yes
Greenroof design	I wish	No	No	I wish	No	Would be acceptable but not part of our requirements

APPENDIX A2. Programme Control Information

A2.1 54-year simulation – existing scenario

0. Construct database – **contam** [clcontam.bat to compile/link]	
SUBDIRECTORY	54EA1
Batfile	b54ea1.dat
Output	x54ea1.dat

1. Build estuary sediments – **builde** [clbuilde.bat to compile/link] event-by-event output to one file per ESTUARY

Prefix = aaa			
For tracking origin of sediments: seq='q1'			
For recording buildup of contconcs: seq2='c1'			
a. Average deposition rate over 54 years		Read from screen at end	
b. % sed/cont	seq='q1'	aaaq1e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
c. Cumulative (%) sed/cont	seq='q1'	aaaq1e01-e11.dat	*plots deleted*
f. surface layer cont concs	seq2='c1'	aaac1e01-e11.dat	aaap01a.grf, aaap01b.grf
g. bed sediment evolution	seq2='c1'	aaac1e01-e11.dat	aaat01.grf
h. time to reach traffic lights	seq='c1'	aaac1e01-e11.dat	Compile with extract3 --- traffic.dat

Prefix = aaa			
For tracking origin of sediments: seq='q2'			
For recording buildup of contconcs: seq2='xx'			
d. kg sed/cont	seq='q2'	aaaq2e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
e. Cumulative (kg) sed/cont	seq='q2'	aaaq2e01-e11.dat	*plots deleted*

2. Track catchment sediments – **buildc** [clbuildc.bat to compile/link] event-by-event output to one file per CATCHMENT

Prefix = aaa / seq='q1'			
a. % sediment/contaminant	seq='q1'	aaaq1c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
b. Cumulative (%) sediment/contaminant	seq='q1'	aaaq1c01-c07.dat	*plots deleted*

Prefix = aaa / seq='q2'			
c. kg sediment/contaminant	seq='q2'	aaaq2c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
d. Cumulative (kg) sediment/contaminant	seq='q2'	aaaq2c01-c07.dat	*plots deleted*

A2.2 108-year simulation – existing scenario

0. Construct database – **contam** [clcontam.bat to compile/link]	
SUBDIRECTORY	108EA1
Batfile	b108ea1.dat
Output	x108ea1.dat

1. Build estuary sediments – **builde** [clbuilde.bat to compile/link] event-by-event output to one file per ESTUARY

Prefix = aaa			
For tracking origin of sediments: seq='q1'			
For recording buildup of contconcs: seq2='c1'			
a. Average deposition rate over 54 years		Read from screen at end	
b. % sed/cont	seq='q1'	aaaq1e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
c. Cumulative (%) sed/cont	seq='q1'	aaaq1e01-e11.dat	*plots deleted*
f. surface layer cont concs	seq2='c1'	aaac1e01-e11.dat	aaap01a.grf, aaap01b.grf
g. bed sediment evolution	seq2='c1'	aaac1e01-e11.dat	aaat01.grf
h. time to reach traffic lights	seq2='c1'	aaac1e01-e11.dat	Compile with extrac3 --- traffic.dat

Prefix = aaa			
For tracking origin of sediments: seq='q2'			
For recording buildup of contconcs: seq2='xx'			
d. kg sed/cont	seq='q2'	aaaq2e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
e. Cumulative (kg) sed/cont	seq='q2'	aaaq2e01-e11.dat	*plots deleted*

2. Track catchment sediments – **buildc** [clbuildc.bat to compile/link] event-by-event output to one file per CATCHMENT

Prefix = aaa / seq='q1'			
a. % sediment/contaminant	seq='q1'	aaaq1c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
b. Cumulative (%) sediment/contaminant	seq='q1'	aaaq1c01-c07.dat	*plots deleted*

Prefix = aaa / seq='q2'			
c. kg sediment/contaminant	seq='q2'	aaaq2c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
d. Cumulative (kg) sediment/contaminant	seq='q2'	aaaq2c01-c07.dat	*plots deleted*

A2.3 54-year simulation – development #1 scenario

0. Construct database – **contam** [clcontam.bat to compile/link]	
SUBDIRECTORY	54S1A1
Batfile	b54s1a1.dat
Output	x54s1a1.dat

1. Build estuary sediments – **builde** [clbuilde.bat to compile/link] event-by-event output to one file per ESTUARY

Prefix = bbb			
For tracking origin of sediments: seq='q1'			
For recording buildup of contconcs: seq2='c1'			
a. Average deposition rate over 54 years		Read from screen at end	
b. % sed/cont	seq='q1'	bbbq1e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
c. Cumulative (%) sed/cont	seq='q1'	bbbq1e01-e11.dat	*plots deleted*
f. surface layer cont concs	seq2='c1'	bbbc1e01-e11.dat	bbbp01a.grf, bbbp01b.grf
g. bed sediment evolution	seq2='c1'	bbbc1e01-e11.dat	bbbt01.grf
h. time to reach traffic lights	seq='c1'	bbbc1e01-e11.dat	Compile with extract3 --- traffic.dat

Prefix = bbb			
For tracking origin of sediments: seq='q2'			
For recording buildup of contconcs: seq2='xx'			
d. kg sed/cont	seq='q2'	bbbq2e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
e. Cumulative (kg) sed/cont	seq='q2'	bbbq2e01-e11.dat	*plots deleted*

2. Track catchment sediments – **buildc** [clbuildc.bat to compile/link] event-by-event output to one file per CATCHMENT

Prefix = bbb / seq='q1'			
a. % sediment/contaminant	seq='q1'	bbbq1c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
b. Cumulative (%) sediment/contaminant	seq='q1'	bbbq1c01-c07.dat	*plots deleted*

Prefix = bbb / seq='q2'			
c. kg sediment/contaminant	seq='q2'	bbbq2c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
d. Cumulative (kg) sediment/contaminant	seq='q2'	bbbq2c01-c07.dat	*plots deleted*

A2.4 108-year simulation – development #1 scenario

0. Construct database – **contam** [clcontam.bat to compile/link]	
SUBDIRECTORY	108S1A1
Batfile	b108s1a1.dat
Output	x108s1a1.dat

1. Build estuary sediments – **builde** [clbuilde.bat to compile/link] event-by-event output to one file per ESTUARY

Prefix = bbb			
For tracking origin of sediments: seq='q1'			
For recording buildup of contconcs: seq2='c1'			
a. Average deposition rate over 54 years	Read from screen at end		
b. % sed/cont	seq='q1'	bbbq1e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
c. Cumulative (%) sed/cont	seq='q1'	bbbq1e01-e11.dat	*plots deleted*
f. surface layer cont concs	seq2='c1'	bbbc1e01-e11.dat	bbbp01a.grf, bbbp01b.grf
g. bed sediment evolution	seq2='c1'	bbbc1e01-e11.dat	bbbt01.grf
h. time to reach traffic lights	seq2='c1'	bbbc1e01-e11.dat	Compile with extrac3 --- traffic.dat

Prefix = bbb			
For tracking origin of sediments: seq='q2'			
For recording buildup of contconcs: seq2='xx'			
d. kg sed/cont	seq='q2'	bbbq2e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
e. Cumulative (kg) sed/cont	seq='q2'	bbbq2e01-e11.dat	*plots deleted*

2. Track catchment sediments – **buildc** [clbuildc.bat to compile/link] event-by-event output to one file per CATCHMENT

Prefix = bbb / seq='q1'			
a. % sediment/contaminant	seq='q1'	bbbq1c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
b. Cumulative (%) sediment/contaminant	seq='q1'	bbbq1c01-c07.dat	*plots deleted*

Prefix = bbb / seq='q2'			
c. kg sediment/contaminant	seq='q2'	bbbq2c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
d. Cumulative (kg) sediment/contaminant	seq='q2'	bbbq2c01-c07.dat	*plots deleted*

A2.5 54-year simulation – response envelope – no controls

0. Construct database – **contam** [clcontam.bat to compile/link]	
SUBDIRECTORY	54S2A1
Batfile	b54s2a1.dat
Output	x54s2a1.dat

1. Build estuary sediments – **builde** [clbuilde.bat to compile/link] event-by-event output to one file per ESTUARY

Prefix = ccc			
For tracking origin of sediments: seq='q1'			
For recording buildup of contconcs: seq2='c1'			
a. Average deposition rate over 54 years		Read from screen at end	
b. % sed/cont	seq='q1'	cccq1e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
c. Cumulative (%) sed/cont	seq='q1'	cccq1e01-e11.dat	*plots deleted*
f. surface layer cont concs	seq2='c1'	cccc1e01-e11.dat	cccp01a.grf, cccp01b.grf
g. bed sediment evolution	seq2='c1'	cccc1e01-e11.dat	ccct01.grf
h. time to reach traffic lights	seq='c1'	cccc1e01-e11.dat bbb1e01-e11.dat dddc1e01-e11.dat	Compile with extract4 --- traffic.dat

Prefix = ccc			
For tracking origin of sediments: seq='q2'			
For recording buildup of contconcs: seq2='xx'			
d. kg sed/cont	seq='q2'	cccq2e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
e. Cumulative (kg) sed/cont	seq='q2'	cccq2e01-e11.dat	*plots deleted*

2. Track catchment sediments – **buildc** [clbuildc.bat to compile/link] event-by-event output to one file per CATCHMENT

Prefix = ccc / seq='q1'			
a. % sediment/contaminant	seq='q1'	cccq1c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
b. Cumulative (%) sediment/contaminant	seq='q1'	cccq1c01-c07.dat	*plots deleted*

Prefix = ccc / seq='q2'			
c. kg sediment/contaminant	seq='q2'	cccq2c01-c07.dat	Last line of each file. Compile with extract2 sedm.dat/conm.dat
d. Cumulative (kg) sediment/contaminant	seq='q2'	cccq2c01-c07.dat	*plots deleted*

A2.6 108-year simulation – response envelope – no controls

0. Construct database – **contam** [clcontam.bat to compile/link]	
SUBDIRECTORY	108S2A1
Batfile	b108s2a1.dat
Output	x108s2a1.dat

1. Build estuary sediments – **builde** [clbuilde.bat to compile/link] event-by-event output to one file per ESTUARY

Prefix = ccc			
For tracking origin of sediments: seq='q1'			
For recording buildup of contconcs: seq2='c1'			
a. Average deposition rate over 54 years		Read from screen at end	
b. % sed/cont	seq='q1'	cccq1e01-e11.dat	Last line of each file. Compile with extract1 sedt.dat/cont.dat
c. Cumulative (%) sed/cont	seq='q1'	cccq1e01-e11.dat	*plots deleted*
f. surface layer cont concs	seq2='c1'	cccc1e01-e11.dat	cccp01a.grf, cccp01b.grf
g. bed sediment evolution	seq2='c1'	cccc1e01-e11.dat	ccct01.grf
h. time to reach traffic lights	seq='c1'	cccc1e01-e11.dat bbbc1e01-e11.dat dddc1e01-e11.dat	Compile with extract4 --- traffic.dat

Prefix = ccc			
For tracking origin of sediments: seq='q2'			
For recording buildup of contconcs: seq2='xx'			
d. kg sed/cont	seq='q2'	cccq2e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
e. Cumulative (kg) sed/cont	seq='q2'	cccq2e01-e11.dat	*plots deleted*

2. Track catchment sediments – **buildc** [clbuildc.bat to compile/link] event-by-event output to one file per CATCHMENT

Prefix = ccc / seq='q1'			
a. % sediment/contaminant	seq='q1'	cccq1c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
b. Cumulative (%) sediment/contaminant	seq='q1'	cccq1c01-c07.dat	*plots deleted*

Prefix = ccc / seq='q2'			
c. kg sediment/contaminant	seq='q2'	cccq2c01-c07.dat	Last line of each file. Compile with extract2 sedm.dat/conm.dat
d. Cumulative (kg) sediment/contaminant	seq='q2'	cccq2c01-c07.dat	*plots deleted*

A2.7 54-year simulation – response envelope – maximum attainable controls

0. Construct database – **contam** [clcontam.bat to compile/link]	
SUBDIRECTORY	54S3A1
Batfile	b54s3a1.dat
Output	x54s3a1.dat

1. Build estuary sediments – **builde** [clbuilde.bat to compile/link] event-by-event output to one file per ESTUARY

Prefix = ddd			
For tracking origin of sediments: seq='q1'			
For recording buildup of contconcs: seq2='c1'			
a. Average deposition rate over 54 years		Read from screen at end	
b. % sed/cont	seq='q1'	cccq1e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
c. Cumulative (%) sed/cont	seq='q1'	cccq1c01-c11.dat	*plots deleted*
f. surface layer cont concs	seq2='c1'	cccc1e01-e11.dat	cccp01a.grf, cccp01b.grf
g. bed sediment evolution	seq2='c1'	cccc1e01-e11.dat	ccct01.grf
h. time to reach traffic lights	seq='c1'	cccc1e01-e11.dat bbb1e01-e11.dat dddc1e01-e11.dat	Compile with extract4 --- traffic.dat

Prefix = ddd			
For tracking origin of sediments: seq='q2'			
For recording buildup of contconcs: seq2='xx'			
d. kg sed/cont	seq='q2'	cccq2e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
e. Cumulative (kg) sed/cont	seq='q2'	cccq2e01-e11.dat	*plots deleted*

2. Track catchment sediments – **buildc** [clbuildc.bat to compile/link] event-by-event output to one file per CATCHMENT

Prefix = ddd / seq='q1'			
a. % sediment/contaminant	seq='q1'	cccq1c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
b. Cumulative (%) sediment/contaminant	seq='q1'	cccq1c01-c07.dat	*plots deleted*

Prefix = ddd / seq='q2'			
c. kg sediment/contaminant	seq='q2'	cccq2c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
d. Cumulative (kg) sediment/contaminant	seq='q2'	cccq2c01-c07.dat	*plots deleted*

A2.8 108-year simulation – response envelope – maximum attainable controls

0. Construct database – **contam** [clcontam.bat to compile/link]	
SUBDIRECTORY	108S3A1
Batfile	b108s3a1.dat
Output	x108s3a1.dat

1. Build estuary sediments – **builde** [clbuilde.bat to compile/link] event-by-event output to one file per ESTUARY

Prefix = ddd			
For tracking origin of sediments: seq='q1'			
For recording buildup of contconcs: seq2='c1'			
a. Average deposition rate over 54 years		Read from screen at end	
b. % sed/cont	seq='q1'	cccq1e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
c. Cumulative (%) sed/cont	seq='q1'	cccq1e01-e11.dat	*plots deleted*
f. surface layer cont concs	seq2='c1'	cccc1e01-e11.dat	cccp01a.grf, cccp01b.grf
g. bed sediment evolution	seq2='c1'	cccc1e01-e11.dat	ccct01.grf
h. time to reach traffic lights	seq='c1'	cccc1e01-e11.dat bbbc1e01-e11.dat dddc1e01-e11.dat	Compile with extract4 --- traffic.dat

Prefix = ddd			
For tracking origin of sediments: seq='q2'			
For recording buildup of contconcs: seq2='xx'			
d. kg sed/cont	seq='q2'	cccq2e01-e11.dat	Last line of each file. Compile with extract1 --- sedt.dat/cont.dat
e. Cumulative (kg) sed/cont	seq='q2'	cccq2e01-e11.dat	*plots deleted*

2. Track catchment sediments – **buildc** [clbuildc.bat to compile/link] event-by-event output to one file per CATCHMENT

Prefix = ddd / seq='q1'			
a. % sediment/contaminant	seq='q1'	cccq1c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
b. Cumulative (%) sediment/contaminant	seq='q1'	cccq1c01-c07.dat	*plots deleted*

Prefix = ddd / seq='q2'			
c. kg sediment/contaminant	seq='q2'	cccq2c01-c07.dat	Last line of each file. Compile with extract2 --- sedm.dat/conm.dat
d. Cumulative (kg) sediment/contaminant	seq='q2'	cccq2c01-c07.dat	*plots deleted*