SOURCE CONTROL OR TRADITIONAL BMPS? AN ASSESSMENT OF BENEFITS AND COSTS IN AUCKLAND CITY

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ABSTRACT

Sediment quality monitoring has identified zinc as a contaminant of concern for Auckland's receiving environments. Within Auckland City, Tamaki North, Tamaki South, Whau Estuary and Waterview Inlet have been identified as key receiving environments at threat.

This study compared the total reductions in zinc and total suspended solids (TSS) loads in stormwater runoff achievable by implementing a range of stormwater quality options, including: traditional stormwater quality ponds; on-site treatment of industrial roofs; and source control methods such as galvanised roof replacement, high efficiency street sweeping and increased cesspit cleaning; and looked at the costs of implementing these options. Pond locations were selected for high contaminant load areas and where they could be feasibly sited.

An overall treatment efficiency rate per receiving environment (for zinc and TSS) was determined for each of the individual and combined suites of ponds and source control methods. The likely practical combinations of methods were then assessed and the combined effectiveness and cost calculated, in order to compare the cost-benefit ratio of each option (in terms of annual zinc load reduction achieved per dollar spent).

Results show that while stormwater quality ponds are generally the most cost-effective options within the catchments studied, the relatively small contributing sub-catchment for each pond and upper limits on physical contaminant removal means that significant load reductions can only be achieved through implementing source control.

KEYWORDS

Source control, stormwater treatment, cost-benefit analysis, zinc, total suspended sediments.

1 INTRODUCTION

Sediment quality monitoring has identified zinc as a contaminant of concern for Auckland's receiving environments (NIWA, 2004; ARC, TP203, 2003; ARC, TP246, 2004). Zinc is widespread throughout the ARC estuarine monitoring sites. In some sites adjacent to Auckland City, (the Upper Tamaki Estuary, Upper Whau Creek, Motions and Meola) it exceeds "Probable Effects Levels" where approximately 50% of organisms are expected to be affected. These trends and levels are also generally reflected in complementary monitoring of sub-tidal and inter-tidal areas undertaken for Auckland City and Metrowater by NIWA: levels of contaminants increase in the Tamaki Estuary as you move south toward the inner part of the estuary.

The Auckland Regional Plan: Coastal identifies most of the Whau Estuary, Waterview Inlet and Tamaki Estuary as either a Coastal Protection Area 1 or 2. These management areas are accorded the highest level of protection by the Plan.

Accordingly, within Auckland City; Tamaki North, Tamaki South, Whau Estuary and Waterview Inlet have been identified as key receiving environments with high ecological values at threat. This paper considers options for stormwater quality management with respect to those receiving environments.

In relation to stormwater quality, and the development of detailed options to manage contaminant discharges to sensitive estuarine environments, there is a need to move to an approach that manages specific contaminants of concern, as opposed to the more traditional approach of managing sediment discharges as a surrogate for contaminants. This includes consideration of source control methods, which may result in a significantly greater reduction of contaminants compared to more traditional stormwater treatment methods.

ACC has also recognised the need for stormwater quality treatment in its Strategic Plan and Stormwater Asset Management Plan 2004-2005, and has an identified milestone of being "on track to achieve removal of 27% in the amount of suspended sediments in 70% of stormwater catchments".

The stormwater quality management options considered in this project are:

- Source control of industrial and commercial roofs;
- Source control of industrial and commercial roads;
- On-site treatment within industrial areas;
- Stormwater treatment ponds and wetlands.

This study has been carried out following work by NIWA (see also Reed et al., 2006) on the assessment of contaminant loads from Drainage Management Areas (DMAs) within Auckland City. The NIWA work included the assessment of loads for different land-uses, roads and roofs and different roof types.

This project builds on that work by considering the application of source control and treatment to specific DMAs. It includes providing an assessment of: treatment ponds in specific locations, costs of implementation, factors required to implement those methods and consideration of the various combinations of options across DMAs.

2 METHODOLOGY:

2.1 ASSESSMENT OF ROOF AND ROAD LOADS AND TREATMENT OPTION EFFECTIVENESS FOR PRIORITY CONTAMINANTS

The first stage of this work was largely carried out by NIWA as described in Reed et al. (2006). NIWA first identified the priority contaminants in each of the receiving environments from available monitoring data (NIWA, 2005a). Contaminant loads were then calculated for the 10 Drainage Management Areas (DMAs) within Auckland City discharging to the nominated four receiving environments. The loads are divided by land-use, road/roof areas and roof types. The Tamaki North receiving environment has four DMAs, Tamaki South two, the Whau Estuary three and Waterview Inlet three DMAs. The load assessment involved the characterisation of roof types within industrial and commercial areas and the application of recent work NIWA has carried out for ARC identifying the relative split of contaminant loads between roads and roofs (NIWA, 2005b). NIWA then considered the effectiveness of a range of generic treatment options for reducing contaminant loads on the basis of wide scale implementation across each DMA (NIWA, 2005c).

Industrial and commercial areas have been found to have extensive areas of galvanised and zinc-aluminium coated steel roofs. NIWA and GHD report that approximately 75% of industrial roofs are zinc aluminium coated steel or freshly painted galvanised steel, and approximately 15% are either unpainted galvanised steel or galvanised steel with some degree of weathering (James, 2005, pers. comm.).

NIWA also report that roof painting and roof replacement with low zinc alternatives could reduce runoff concentrations by 75% (NIWA, 2005c). This assumption was also used in the Upper Waitemata Harbour modelling project (Timperley, 2005, pers. comm.).

This option therefore targets the roofs with the highest contaminant loads and the areas with the greatest extent of these roof types. The options considered are:

- Replacement of galvanised iron roofs with zinc-aluminium coated steel roofs in industrial and commercial areas;
- Replacement of galvanised iron roofs and zinc-aluminium coated steel roofs with pre-painted steel roofs in industrial and commercial areas;
- Painting of galvanised iron and zinc-aluminium coated steel roofs with low-zinc paint in industrial and commercial areas.

Two street sweeping scenarios are considered in this study (after PDP, 2005a):

- High efficiency vacuum sweeping of roads 52 times per year, giving an modelled average 76% TSS reduction;
- High efficiency vacuum sweeping of roads 104 times per year, giving an modelled average 85% TSS reduction.

These percentage reductions were the lower bounds of reductions reported in Sutherland, 1995, and Minton, 1998, for weekly and twice weekly sweeping of residential and arterial roads, for simulated annual TSS washoff reduction at downstream watercourses (based on tested sweeper performance and particle size analysis) (PDP, 2005a).

It has been noted that street sweeping is only effective in dry weather, before sediment loads are able to be entrained. One US stormwater programme (Bannerman, 2005, pers. comm.) allows for a 20% reduction in annual suspended solids loads as a result of a comprehensive street sweeping programme in autumn following leaf fall. Costs have been calculated on the basis of laboratory effectiveness of 75-85%. However, to check the costs for different street sweeping effectiveness, values for a lower efficiency of 30% annual TSS reduction have also been calculated.

2.2 ASSESSMENT OF WETLAND AND POND TREATMENT DEVICES

An initial screening assessment of possible pond and wetland locations was carried out. Some pond/wetland options were excluded almost immediately from initial catchment site visits to available land, while others were checked hydraulically before a final nine locations were identified as suitable for further assessment:

- Near Valonia St/ Richardson Rd in the Oakley catchment to service residential areas;
- To service Carr Rd commercial properties in the Oakley catchment;
- Near Miranda Rd in the Whau catchment to service residential areas;
- In or near the Avondale Racecourse in the Avondale catchment to service the nearby commercial area;
- At or near Ruapotaka Reserve below the Glen Innes commercial centre to service the upstream industrial area;
- At or near the Boundary Reserve below the Morrin Rd industrial area;
- To service the Panmure commercial area;
- Near Rakino Way to service part of the Mount Wellington industrial area.

A further site has been investigated at Ireland Road, to try to increase treatment for flows to the Panmure Basin, given that the Panmure commercial area has proven difficult to treat.

PDP considered that the contaminant loads are relatively high in these areas and a further assessment was appropriate. Each assessment consisted of:

- Calculating zinc and TSS load reductions for the pond/wetland;
- Sizing the pond/wetlands for the available area. Checking the levels of inlets and outlet conceptually in relation to existing stormwater pipe levels (provided by Metrowater) and identifying if major drainage services are likely to be conflicted;
- Costing, done on a per unit area basis using rates identified by SPM Consultants (2005) for pond / wetland capital and operation and maintenance costs to determine an NPV cost for 50 years;
- A brief commentary on the risks associated with consenting, geotechnical issues and the construction method.

The ponds were sized on the basis of what is practically achievable within space limitations. The pond efficiency was evaluated based on the space available, up to a maximum 75% TSS removal.

2.3 SOURCE CONTROL ANALYSIS

A desk-top assessment of TSS and zinc reduction was carried out to assess the effects of source control for each of the following methods:

- Source control of roofs for commercial land-uses;
- High efficiency vacuum street sweeping for roads in industrial and commercial land-uses;
- Enhanced cesspit operation and maintenance for roads in industrial and commercial land-uses.

For the source control of roofs, land areas for different land uses were compared to known galvanised iron roof areas in selected consolidated catchments, to identify a relationship between the percentage of industrial and commercial area and the percentage of galvanised iron roof area. Consolidated catchments are the outfall points used for the contaminant Time Series Modelling and are a subset of the DMAs.

A close correlation was found between the percentage of the consolidated catchment area classified as Industrial and Commercial, and the known galvanised iron roof area in the catchment. This relationship was used to calculate the theoretical total area of galvanised roof in each consolidated catchment. Known galvanised iron roof areas were inserted where available for each consolidated catchment, or if unknown the calculated values used, and the areas aggregated by DMA for later use in cost analysis.

The assessment consisted of:

- Calculating TSS and zinc treatment efficiency for the treated land-use area from the DMA contaminant loads for source control options in relation to commercial areas and, in addition, considering the effect of sweeping and enhanced cesspit operation;
- Costing, done on a per unit area basis using the SPM consultants rates (SPM Consultants, 2005) for capital and operation and maintenance costs to determine an NPV cost for 50 years. The percentage of roof area and roof type in these areas was taken from the NIWA/GHD assessment;
- A brief commentary on the relative risks of consenting and implementing the source control methods.

An overall treatment efficiency rate per DMA (for zinc and TSS) was determined for each method, and the combined effectiveness and cost calculated in terms of different levels of service.

2.4 COMPARISON OF OPTIONS

Six Levels of Service (LOS) have been identified for each aspect of the ACC/Metrowater drainage network, ranging from LOS 1 (Basic) to LOS 6 (Very High). The range from ‘basic’ to ‘very high’ addresses the likely span of situations that currently exist and/or may be met in the future. General management objectives are associated with each LOS for a range of environmental objectives such as flooding, stormwater quality, or stream protection. For stormwater quality, Levels of Service have previously been associated with sediment removal objectives. For the purposes of this project, in order to assess levels of source control required, zinc removal rates for equivalent sediment removal were applied by using results from ARC's TP237 (ARC, 2004). An additional LOS 6 has also been included to estimate costs in DMAs where higher removals can be achieved. However, achieving all LOS is not always possible in every area (i.e., where there is no industrial area, there are not enough galvanised roofs or the assumed galvanised roofs do not exist in reality).

The LOS calculations were undertaken in a manner to avoid overlapping of potential treatment options, which would give incorrectly high potential removal potentials. For each consolidated catchment, only one option to treat roof runoff and one option to treat road runoff has been used. Where stormwater quality ponds have been used in combination with both a road and a roof runoff treatment option, the pond removal is assumed to be 50% of its stand alone total. Where stormwater quality ponds have been used in combination with either a road or a roof runoff treatment option, the pond removal is assumed to be 75% of its stand alone total.

3 RESULTS

3.1 POND ASSESSMENTS

The costs, annual load removals and removal efficiencies considered achievable for the ponds sized for the nine locations are given in Table 1. Note that there are two ponds considered for each of three locations; two of the locations have options with a higher cost that use private land bordering the public land available, and there are two alternative options to service the Panmure commercial area.

Table 1: Expected performance of assessed ponds

Pond Name	DMA	Receiving Environment	Cost	Removal Efficiency (%)		Annual Load Removed (kg)		Load Removed (% of Receiving Environment Load from Auckland City)	
				TSS	Zinc	TSS	Zinc	TSS	Zinc
Hendon Park Private	OAK	Waterview	$1,930,000	75%	33%	34,275	73.04	6.12%	4.39%
Hendon Park Public	OAK	Waterview	$930,000	73%	32%	33,361	70.83	5.96%	4.26%
Carr Rd	OAK	Waterview	$490,000	75%	33%	3,660	7.21	0.65%	0.43%
Avondale Central	AVO	Whau	$720,000	75%	33%	4,766	10.38	0.99%	1.19%
Miranda Reserve	WHA	Whau	$900,000	59%	27%	14,408	7.08	3.00%	0.81%
Ruapotaka Reserve	GLI	Tamaki	$754,000	74%	33%	4,575	80.05	0.46%	2.11%
Boundary Reserve Private	ENG	Tamaki	$1,787,000	72%	32%	6,599	48.36	0.67%	1.27%
Boundary Reserve Public	ENG	Tamaki	$907,000	65%	30%	5,957	44.58	0.60%	1.17%
Panmure Lagoon Pool CST	WELN	Tamaki	$479,000	45%	18%	784	4.96	0.08%	0.13%
Panmure Domain Res CST	WELN	Tamaki	$633,000	52%	22%	473	3.60	0.05%	0.09%
Ireland Road	WELN	Tamaki	$543,000	72%	32%	4,125	7.99	0.42%	0.21%
Ian Shaw Park	OTAE	Tamaki	$675,000	75%	33%	2,852	28.11	0.29%	0.74%

3.2 OVERALL LOAD REMOVAL RESULTS

Overall results for zinc removal for the suite of source control methods for the Whau Estuary receiving environment are given in Table 2. Results show that the greatest percentage removals can be achieved by roof repainting or replacement, although significant reductions can also be achieved by utilising on-site BMPs (rain gardens, wetlands, ponds and sand filters) in industrial areas.

Table 2: Annual zinc load reduction (% of receiving environment loads from Auckland City) in Whau Estuary consolidated catchments

	Whau Estuary consolidated catchments			
Zinc reduction options	**AVO1**	**AVO2**	**KIN1**	**WHA1**
Roof painting with low zinc paints	5.7%	24.7%	0.1%	0.3%
Roof replacement	5.7%	24.7%	0.1%	0.3%
On Site Rain garden	2.3%	9.8%	0.0%	0.1%
On Site Wetland	2.3%	9.9%	0.0%	0.1%
On Site Sand filter	2.3%	9.9%	0.0%	0.1%
On Site Wet pond	2.3%	9.9%	0.0%	0.1%
Weekly Road Sweeping	1.2%	1.3%	0.7%	3.9%
Twice weekly Road Sweeping	1.4%	1.4%	0.8%	4.4%
Improved cesspit performance	0.9%	0.9%	0.5%	2.9%

Results for TSS removal are given in Table 3. The greatest percentage removals for TSS can be achieved through weekly or twice weekly road sweeping.

Table 3: Annual TSS load reduction (% of receiving environment loads from Auckland City) in Whau Estuary consolidated catchments

	Whau Estuary consolidated catchments			
TSS reduction options	**AVO1**	**AVO2**	**KIN1**	**WHA1**
On Site Wetland	0.0%	0.0%	0.0%	0.0%
On Site Sand filter	0.0%	0.0%	0.0%	0.0%
On Site Wet pond	0.0%	0.0%	0.0%	0.0%
Weekly Road Sweeping	3.3%	3.7%	2.0%	10.4%
Twice weekly Road Sweeping	3.7%	4.1%	2.2%	11.7%
Improved cesspit performance	1.1%	1.2%	0.6%	3.4%

3.3 COST ANALYSIS

Capital costs and operations & maintenance costs from the 'Stormwater Quality Management Methods: Efficiencies and Costs' report (PDP, 2005a) were used to calculate NPV costs over 50 years at a 10% discount rate. The NPV cost for increased cesspit cleaning was equivalent to the average of the NPV cost assessed for this option in the Medium Level Options Analysis reports for DMAs in the receiving environments considered, divided by the area in hectares of the relevant DMA. NPV costs used in this study are given in Table 4.

The likely costs associated with replacing or painting zinc based roofing materials have been assessed. Costs associated with source control by roof replacement and painting may include:

- Associated upgrades of stormwater guttering/ down-pipes;
- Structural upgrades to the roof;
- Disposal of old materials to ensure they are not re-used;
- Prevention of contaminants, such as old paint, being discharged during roof replacement.

The costs presented here are costs on the community as a whole and are not split between the public and private funding sources. Should source control of roof runoff be implemented, significant costs are likely to be borne by the private sector for the physical roof replacement or painting cost. Furthermore, some of these costs will have been required anyway, as roofs reach the end of their useful life. Further analysis of the process and physical costs of implementing source control is required.

Table 4: Capital, Operations & Maintenance and Net Present Value costs for Stormwater Quality Options (after PDP, 2005a and SPM Consultants, 2005).

Option	Capital cost ($/ha)	Capex life (yrs)	Annual O&M ($/ha)	NPV cost (50 yrs) ($/ha)	comment
Source control of roofs					
Roof painting	$350,000	10	$0	$564,757	Galvanised Iron (GI) roofing waterblast and paint, moderate repairs
Roof replacement	$900,000	30	$0	$927,791	GI roof replacement with coloursteel, median value
On-site treatment of roofs					
Rain garden	$85,626	51	$10,000	$194,689	Note land cost not included.
Wetland	$30,523	51	$1,500	$46,883	Note land cost not included.
Sand filter	$265,426	51	$15,000	$429,021	Note land cost not included.
Wet pond	$13,386	51	$1,200	$26,473	Note land cost not included.
Road sweeping	$258,000	8	$0	$481,280	Vehicle capital cost - 1 vehicle required per 240km. Flat rate (not per ha).
Weekly sweeping		51	$702	$7,656	NZ$13.50 per kerb km (not per ha).
Twice weekly sweeping		51	$1,404	$15,312	NZ$13.50 per kerb km (not per ha).
Increased cesspit cleaning – 6x per annum				$2,233	Average of MLOA costs per ha

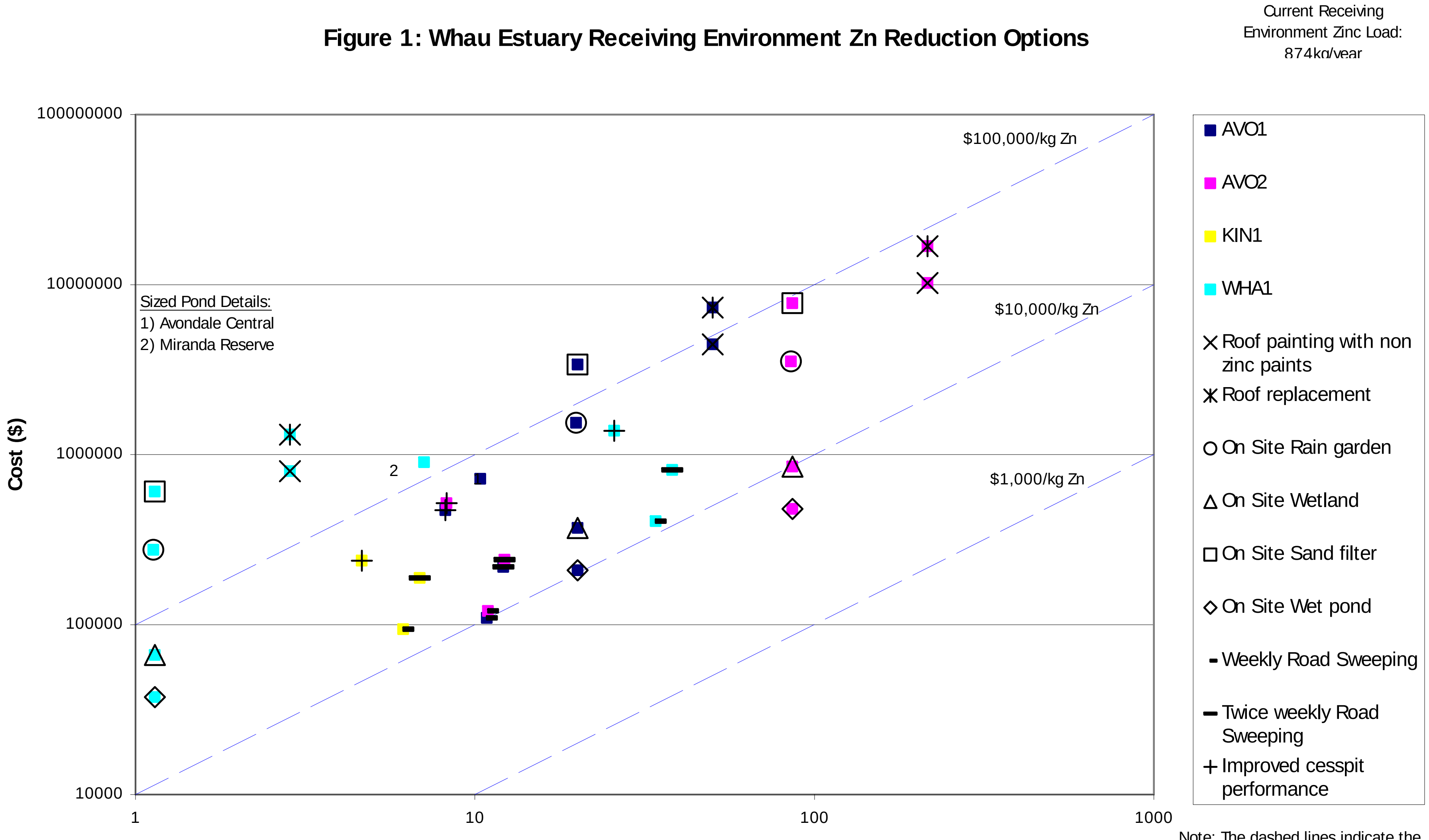
These costs were applied to the total area, the area of galvanised roof (as assessed in PDP, 2005b), and the length of road in each consolidated catchment in order to give total costs for each option, in each consolidated catchment.

3.4 OPTION COMPARISON

Figure 1 shows the total cost ($) vs. zinc load removal efficiency (kg removed per year) for each treatment option for consolidated catchments that discharge to the Whau Estuary receiving environment. Similar results were derived for the Waterview, Tamaki North and Tamaki South receiving environments.

The figure has been presented in a manner to show the range of potential treatment levels, the cost of each level, and the cost/benefit ratio of each option. The treatment potential and cost are on the x and y axes respectively, and both of these are using logarithmic scales. The dashed blue lines represent Cost Benefit Ratio (CBR) contour lines (i.e. lines of equal CBR value). Therefore the most economic options (i.e. options with the lowest CBR) are in the bottom right of each figure, and the least economic options (i.e. options with the highest CBR) are in the top left of each figure. Options which remove the greatest load are on the right of the figures. The CBR in the figures are based on full treatment independent of other methods or devices, and no treatment train approaches have been considered.

Figure 1: Whau Estuary Receiving Environment Zn Reduction Options



Note: The dashed lines indicate the Cost:Benefit Ratio contours.

As discussed in Section 2.4, Six Levels of Service (LOS) have been identified for each aspect of the drainage network, ranging from LOS 1 (Basic) to LOS 6 (Very High). Table 5 shows the stormwater treatment options required to achieve the various LOS in the Whau Estuary receiving environment, the actual removals considered achievable and the costs of implementing these options.

Table 5: Whau Estuary Level of Service Options

LOS	Required Zinc Removal (%)	Options to Provide LOS	Potential Zinc Removal (%)	Cost ($ NPV)
6	60.0%	Not Achievable - maximum Zn removal potential is 40.8%, which would require roof repainting and twice weekly sweeping in all areas, and the stormwater quality ponds at Avondale Central and Miranda Reserve	40.8%	$18,656,000
5	33.0%	Roof repainting in AVO1 and AVO2, twice weekly sweeping in AVO1 and weekly sweeping in AVO2.	33.1%	$15,022,000
4	10.0%	Roof repainting in AVO1 and weekly sweeping in WHA and KIN	10.3%	$4,954,000
		Roof repainting in AVO1, weekly sweeping in AVO1 and improved cesspit performance in WHA	10%	$5,942,000
3	3.3%	Twice weekly sweeping in AVO1 and weekly sweeping in AVO2 and KIN	3.4%	$433,000
		Weekly sweeping in WHA	3.9%	$406,000
2	0.4%	Weekly sweeping in KIN	0.7%	$94,000
		Stormwater Quality Pond at Avondale Central	1.2%	$720,000
		Stormwater Quality Pond at Miranda Reserve	0.8%	$900,000
1	0.2%	As per LOS 2		

4 CONCLUSION

This study assessed the application and costs of source control; roof replacement, roof painting, high efficiency sweeping, cesspit clean-out; and more traditional stormwater treatment ponds/ wetlands for the reduction of zinc and sediment being discharged into those receiving environments. Implementation of traditional treatment measures on individual industrial and commercial sites is also considered for contaminant reduction.

High efficiency sweeping and cesspit clean-out measures require additional field trials to be initiated and to confirm their contaminant removal rates. Removal rates for these options used in this assessment have been based on modelling studies which are often carried out under ideal conditions in a laboratory situation. Specific climatic conditions and particle characteristics in Auckland streets will affect the actual contaminant removal achieved. These may be as low as one third of the modelled removal, increasing the Cost Benefit Ratio (CBR) of these options threefold. Considering the increases in CBR for various other options differ by more than an order of magnitude, street sweeping and increased cesspit clean-out options are likely to remain cost effective for removal of TSS. However, applying a removal efficiency of 30% TSS for street sweeping and improved cesspit performance options means that on-site treatment methods achieve better CBRs for zinc removal.

The reduction in zinc loads required to achieve the Integrated Catchment Study Levels of Service (LOS) for stormwater quality has been identified for each receiving environment and a suite of works proposed to meet those load reduction targets. Many combinations of the methods considered can achieve LOS 3 or 4 on a receiving environment basis. However, most of the ponds on their own can only achieve LOS 2. This is because the pond sites have been selected on an “off-line” basis to avoid potential ecological, amenity and flooding effects. Hendon Park pond, the only on-line pond, can achieve a LOS 3 for the Waterview Inlet receiving environment.

Weekly high efficiency sweeping is identified as a potentially efficient and cost-effective method for removing sediment and particulate zinc associated with larger sediment particles. To achieve LOS 5 or 6 requires some form of source control of roof runoff: roof painting is significantly cheaper than roof replacement and has therefore been included in the suite of works for further consideration. However, roof painting requires careful preparation of roofs to prevent a flush of old paint contaminants, and greater ongoing compliance to require repainting at appropriate intervals.

Recommendations from the project include:

- Once weekly high efficiency street sweeping is considered further in all DMAs except Waterview, for the reduction of both zinc and TSS loads;
- Stormwater quality ponds at Hendon Park, Ian Shaw Park, either Miranda Reserve or Avondale Central, and Ruapotaka Reserve, Boundary Reserve (Private and Public), Ireland Road, and stormwater treatment wetlands at Boundary Reserve (Public) and Ian Shaw Park, are considered further for the reduction of both zinc and TSS loads;
- Improved cesspit performance is considered further in DMAs draining to the Whau Estuary and Tamaki North and South receiving environments, for the reduction of TSS loads, particularly in DMAs with high traffic volumes on arterial roads (notably: Ash St and Great North Road in Avondale; Wolverton, Donovan, White Swan, Richardson and Hillsborough Roads in Whau; Ellerslie Panmure Highway, Mt Wellington Highway and Lagoon Drive in Mt Wellington North; Penrose Road, Great South Road, Mt Wellington Highway and the South Eastern Arterial in Mt Wellington-Southdown; and Great South Road in Otahuhu East);
- Galvanised roof repainting or replacement options are considered further in the industrial and commercial zones of all DMAs, for the reduction of zinc loads to the Waterview Inlet, Whau Estuary and Tamaki Estuary receiving environments.

It is noted that stormwater quality ponds and other treatment options which remove sediment from stormwater may have further benefits in terms of the removal of other contaminants other than zinc.

As a result of these and other recommendations, the following management actions have been proposed in Auckland City Council's Long Term Council Community Plan (LTCCP):

- Make budgetary provision with the City's LTCCP to provide for the development of a statutory regime to control contaminants, particularly zinc, at source and undertake targeted treatment in priority areas, subject to the points below.
- Encourage and support the ARC in the establishment of a statutory regime to control roofing material and associated contaminant runoff.
- Seek to implement provisions within the Auckland City District Plans, as necessary (given bullet point one), to control the future use of roofing and other building materials.
- Implement new stormwater treatment where such treatment:
    - i. can be implemented in practice;
    - ii. will achieve beneficial contaminant load reduction, over and above that of source control measures, in discharges to areas of high ecological value – particularly in the key marine receiving environments of the Tamaki Estuary, Whau Estuary and Waterview Inlet – where these will result in a demonstrable reduction of contaminant accumulation in these areas; and
    - iii. is affordable and cost effective, both in terms of capital investment and long term maintenance costs.

- Investigate options to enhance maintenance of road cesspits to improve sediment and associated contaminant capture efficiency of this source of contaminants.
- Investigate options to improve sediment and road contaminant capture by enhanced road sweeping.
- Undertake further research in collaboration with the ARC to identify sources of other contaminants, particularly copper.
- Undertake long term monitoring of environmental response, complementary to that undertaken by the ARC, to assess the results of the implementation of management actions.

5 ACKNOWLEDGEMENTS

We would like to thank GHD Ltd, particularly Mark James, for their help with the roof characterisation data. Jacquie Reed's work at NIWA on contaminant loads in Auckland City was invaluable and this study could not have been completed without it. Thanks also to Chris Jenkins and SPM Consultants for their work on the unit rate curves used in the costing exercise. This study is part of a PDP contract with Auckland City Council and Metrowater Ltd.

6 REFERENCES

Auckland Regional Council (2004) A Study of Roof Runoff Quality in Auckland, NZ: Implications for stormwater management, Technical Publication 213.

Auckland Regional Council (2004) Management and Treatment of stormwater quality effects in estuarine areas, Technical Publication 237.

National Institute of Water and Atmospheric Research (2004) Stormwater flow and quality monitoring: Cox's Bay and Remuera (Combes Road). NIWA client report HAM 2003-083 to ACC/Metrowater, August 2004.

National Institute of Water and Atmospheric Research (2004) Stormwater flow and quality monitoring: Tamaki, Orakei, Mayoral. NIWA client report HAM 2003-045 to ACC/Metrowater, August 2004.

National Institute of Water and Atmospheric Research (2005a) Whau Estuary, Waterview Inlet and Tamaki Estuary Stormwater Quality Improvement Assessment. NIWA Client Report, 16 November 2005. National Institute of Water and Atmospheric Research Ltd, Auckland.

National Institute of Water and Atmospheric Research (2005b) Time Series Modelling of stormwater contaminants in Auckland City. NIWA Client Report AKL2004-126, 16 November 2005. National Institute of Water and Atmospheric Research Ltd, Auckland.

National Institute of Water and Atmospheric Research (2005c) An assessment of stormwater treatment intervention options in Auckland City. NIWA Client Report AKL2005-94, 17 October 2005. National Institute of Water and Atmospheric Research Ltd, Auckland.

Pattle Delamore Partners Ltd (PDP) (2005a) Stormwater Quality Management Methods: Efficiencies and Costs. Report reference AJ848303, November 2005. Pattle Delamore Partners Ltd, Auckland.

Pattle Delamore Partners Ltd (PDP) (2005b) Citywide Cost Assessment of Zinc Source Control Options for Stormwater Quality. Report reference AJ848307, November 2005. Pattle Delamore Partners Ltd, Auckland.

SPM Consultants Ltd (2005) Unit Rate Curves 2005. SPM Consultants Ltd, Auckland.

Sutherland, R. (1995) Street Sweeper Pick-up Performance. Kurahashi & Associates, Inc., Seattle.

USEPA, 1977. Catchbasin technology overview and assessment, Lager et al, EPA-600/2-77-051