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Environmental Economics: towards a National Standard for stormwater treatment??

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ABSTRACT

Benefits derived from lowered environmental impacts are not assigned an economic value as are congestion and crash reductions. Consequently, environmental and social mitigation is seen as a financial burden adding cost while adversely affecting the benefit-cost-ratio (BCR.)

Domestic and overseas research (Austroads, 2003) has had little effect on valuation methodologies in BCR funding allocations. It is the intent of this paper to demonstrate a value-for-money approach to environmental and social impact mitigation using storm water treatment case studies.

INTRODUCTION

Recently, the public have sought answers to project cost overruns, environmental mitigation was blamed as a significant source. Application of environmental standards has been blamed for excessive cost resulting in too rigid application and stifling innovation resulting in poor value for money and affordability. Because NZTA standards often become de facto national standards additional concerns have been expressed at their use as high-cost solutions to low risk situations (MAG, 2006)

Environmental mitigation costs take many forms; such as, consent applications, assessments of environmental effects, consultation, time delays and monitoring as well as physical works. However, few examples can be found where these costs are accurately measured. The purpose of this work is to evaluate the effects of implementing a national environmental standard for storm water management.

<u>Background: rationale for a Standard</u>
New Zealand Transport Agency (NZTA) business plan has four main outcomes, one of which is to “lower environmental impacts.” Environmental outcome implementation is described in the Environmental Plan (2008) which has four objectives relating to water resources:

- ensure run-off from state highways complies with Resource Management Act requirements;
- limit the adverse effects of run-off from state highways on sensitive receiving environments;
- ensure stormwater treatment devices on the network are effective and
- optimise the value of water management through partnerships with others.

In order to provide a consistent and effective approach to achieving these objectives Stormwater Treatment Standard for State Highway Infrastructure (Standard) was developed.

The Ministerial Advisory Group on Roading Costs (MAG, 2006) determined the need for a balanced and consistent approach to stormwater management which was identified as an emerging cost to roading projects. Currently there are no national guidelines or standards for stormwater management. Thus, between and within projects a wide variety of solutions are applied resulting in difficulties with compliance, uncertain performance, increased maintenance expenses and inadequate consent applications resulting in project delays and increased costs.

A further call for the adoption of standard approaches was made at a Northern Busway project workshop by representatives from the Auckland Motorway Alliance, nine consultants and Highway and Network Operations (Johnson & Dryburgh, 2008.) One of the recommendations was for standards and specifications to be provided for recurring requirements such as stormwater management with consideration for whole life cycle costs.

<u>Adverse environmental effects</u>
Stormwater from roads needs to be treated where high volumes of traffic, generally over 30,000 annualised average daily traffic (AADT) (UK Highways Agency, 2009 and US Department of Transportation, 1990) drain into sensitive receiving environments. Recent research characterised the most significant contaminants are those which come from tyres (Wik & Dave, 2009.) During a tyre's 40,000 km lifecycle, 30% of the tread is worn off releasing millions of kilograms of type particles. The following numbers (table 1) were calculated for several similar countries. Ministry of Transport research concluded stormwater chemistry of New Zealand motorways was similar to that of overseas motorways (MoT, 2003.)

Table 1. Tyre wear emission rates

Country	**Kilograms/yr**
Sweden	10,000,000
Italy	50,000,000
UK	57,000,000
Germany	60,000,000
USA	500,000,000

Tyre particles are complex micron sized porous particles composed of:
- 40-60% synthetic and natural polymers,
- 20-35% carbon black and silica filling agents,
- 15-20% high PAH oils,
- 1-1.5% vulcanisation agents and activators (sulphur, zinc oxide, stearic acid),
- 1% protective agents (antioxidants and antiozonants) and
- <1% peptisers, plasticisers and softeners.

Tyre particles have been found to cause the following adverse environmental effects:
- exceed toxicity limits in sediments and surface water;
- absorption by filter feeders, benthic organisms and plants;
- acutely toxic leachate;
- growth inhibition of plants;
- evidence of human teratogenic, mutagenic and estrogenic activity;

- suggested links to human latex allergy and asthma from respirable air borne particles (note tyres account for 75% global latex consumption.)

METHODOLOGY

Environmental mitigation requirements are managed by means of regional plans under the Resource Management Act (RMA). The inclusion of specific rules in regional plans dealing with stormwater runoff from roads is not widespread. Only six of the 17 regional authorities have rules which specifically relate to stormwater runoff from roads. There is no uniformity in the approach adopted by regional authorities for such rules and accompanying standards and conditions. In particular, the rules vary based on:

- type of road (private, public and state highways),
- discharges to water/land,
- existing or new roads and
- different standards/conditions.

Consent categories for stormwater discharges range from permitted to non-complying activities. All the regional plans have a permitted activity rule for discharges of stormwater, with resource consents of varying activity status required depending on the levels of non-compliance with the standards and terms (Beca, 2008.) Consequently, storm water consent conditions vary greatly between and within regions which contributes to uncertainty, the need to designate and acquire land, and an unclear relationship between temporary erosion control measures and long term storm water management.

A national expert was employed to draft a storm water treatment standard to be compatible with regional plans and reflect current international practices. In order to determine operational impacts of adopting the Standard a value-for-money (VfM) assessment was conducted. The VfM might also be considered to be a regulatory impact analysis; in other words, benefits balanced against costs of imposing additional requirements. The VfM is based on the whole life (30 years) $/vehicle-kilometre-travelled (VKT) between the Standard and current practices on a number of recently completed or active stormwater management projects. Six project sites (table 2) were nominated by regional planners based on recent design or completion, discharge to sensitive receiving environments and availability of project manager and consultants.

Table 2. Nominated projects

Project	**Estimated Cost ($million)**
Christchurch Southern Motorway	160
ALPURT Sectors A2 & B1	365
SH20 Mount Roskill	169
SH2 Dowse to Petone Upgrade	50
SH18 Greenhithe Deviation	110
Avalon Drive By-pass	41

The value-for-money assessment was conducted in two phases. Phase one collected baseline data using a template (table 3) consultatively developed by experts in the field of stormwater management and state highway construction.

Table 3. Baseline data requested from project consultants for selected project sites.

Environmental Factors: catchment description	
terrain	erosion potential
area	flooding
topography	design storm event
drainage features	vehicle kilometres travelled at time of opening
geotechnical	discharge points
soils	National State Highway Strategy classification
sensitivity of the receiving environment per LTNZ Research Report 315 sec. 3.5	
Designed Solutions	
design philosophy	objectives (assumptions
	criteria (water quality/quantity
	references (regional plans, design guides)
stormwater management devices used for	erosion and sediment control during construction
	operational stormwater management (collection/conveyance/attenuation/treatment)
Cost	
resource consents (AEE, council fees, professional services)	
building and other consents (drawings, council fees and professional services)	
final design	
construction (collection, conveyance, attenuation and treatment)	
Time	
to acquire (submission to approval) resource building and other consents required for construction (collection, conveyance and attenuation) of operation and maintenance life expectancy prior to major works or renewal	

Phase two required project consultants to retrospectively apply the Standard. This approach allowed an initial "road test" to measure the effectiveness of the Standard in a variety of regulatory and receiving environments by a range of consultants.

From the consultants project assessment reports listed in the Reference section of this report, a $/VKT was calculated with and without the Standard as well as cost of treatment apart from collection and conveyance.

RESULTS

The following sections highlight potential differences between project baseline assessment reports and potential changes introduced by use of the Standard.

Several reports noted short term design philosophy objectives related to construction are considered alongside planning for erosion and sediment control. However, it should be noted that the Standard does not cover erosion and sediment control.

Christchurch Southern Motorway

The Christchurch Southern Motorway project uses dry basins due to Canterbury's relatively well draining soils; however, the Standard contained no design guidance on dry basins. The design storm event requirements of the Standard and that of the local authorities varied, with the Standard requiring 10mm less than Environment Canterbury's requirements; however, the Standard required attenuation for a 1% annual exceedance probability (AEP) compared with a 2% AEP for Environment Canterbury.

The increase in attenuation to a 1%AEP event and to limit flow rates to 80% of pre-developed peak flow rates is predicted to require a 22% increase in runoff requiring attenuation/detention devices to increase proportionally; therefore, requiring additional land. The project consultant determined incremental cost and time for this more stringent requirement as minimal.

ALPURT sectors A2 and B1

Despite changes to some of the design parameters, the use of the Standard requires no change in the treatment approach. Swales would have required an increase in the minimum hydraulic residence time and the installation of a level spreader at the start of the swale to reduce channel erosion in the swale. Had the Standard applied the berm that separates the forebay and the main pond of the wet ponds would have been designed differently.

SH20 Mount Roskill

The water quality of the ponds could have been improved further with a floating wetland designed for the Beachcroft Avenue pond in the Royal Oak Catchment and the use of flocculation treatment to maintain 75% sediment treatment efficiency, which could lead to a small reduction in the pond size.

However, an increase in pond size would be required to limit discharge flow rates to 80% of pre-developed peak flow rates. Due to corridor restraints, additional land purchases would be required to accommodate the larger ponds, the result being an increase in the cost of land purchase. A slight increase in the cost of the final design and construction would also be incurred.

SH2 Dowse to Petone Upgrade

At the time resource consents were obtained for Dowse to Petone, Greater Wellington Regional Council did not require stormwater treatment. However, if consented today, water quality would have received greater prominence by the Standard due to the sensitivity of the receiving environments, large catchment size, and visibility.

The Standard, and nowadays the regional requirements would require the following from the original design. Dependent upon the availability of land, the capacity of the councils existing hillside attenuation as well as dams that drain into the Western Hills Culvert would have been increased. Property that is currently used for commercial or industrial activity would have been purchased for the construction of an attenuation pond or wetland, within the catchment that drains into Korokoro Stream. Potentially swales, filter strips and rain gardens could have been incorporated into the public car parks, resulting in a reduction in the number of car parks. Several sand filters and other similar treatment devices could have been incorporated, including under the carriageway.

The changes in the design would result in an increase in the cost and time relating to stormwater works on this project. The increases are identified in table 4.

Table 4. Adoption of Standard - Additional costs and time for SH2 Dowse to Petone Upgrade stormwater works

Cost	
Final design Costs	$60,000 attenuation quality control design and drawing production.
Construction Cost	$300,000 attenuation $200,000 quality control (excluding land purchase)
Monitoring Cost	$3,000 pond inspections after monthly storms $5,000 filter inspections $2,500 car park swale inspections $20,000 MSQA fee
Operation and maintenance estimated annual costs	$6,000 pond maintenance after monthly storm $2,000 pond sediment fore-bay clean out $5,000 filter cleaning $20,000 car park swale maintenance
Time	
Final design time	An additional 6 weeks due to the additional attenuation and water quality control items
Construction time	It would take 16 weeks to construct attenuation and water quality items, however much of this would have been concurrent with other construction activities

<u>SH18 Greenhithe Deviation</u>
The adoption of the Standard would have led to the volume of attenuation/detention devices being increased by 50% to manage a 10% AEP runoff event and allow for the effects of climate change. This would have increased the construction costs of the attenuation devices by approximately $152,000 and would have required a larger designation for the devices. If a larger designation had not been sought, construction costs would have increased due to a more complex engineered solution; for example, requiring the use of retaining walls around the ponds. Current consenting authority requirements normally require attenuation of the 10-year storm, which would reduce the relative difference in costs.

<u>Avalon Drive By-pass</u>
The consultant concluded using the Standard would have resulted in minimal changes to the original design. A retention pond could have been reduced from 3,500 to 2,800 m3.

ECONOMIC IMPLICATIONS

During the 1993 revision of NZTA's Economic Evaluation Manual consideration was given to quantify stormwater treatment costs in a manner similar to mitigation of noise and air pollution; however, it was found to be too difficult due to the lack of information and inability to value benefits of stormwater mitigation.

These costs are now known and most accurately expressed as $/VKT, a surrogate for traffic impacts over a section of highway. The potential cost of adopting the Standard per vehicle kilometre travelled (VKT) with the status quo allows different projects to be compared.

Table 5 shows for all six projects the predicted VKT at the time of opening, the actual or the current estimated stormwater system construction costs and the estimated construction costs of the stormwater system had the Standard been applied. Table 6 shows the construction costs and the estimated construction costs from using the Standard per VKT.

Table 5. VKT and stormwater construction costs

Project	**VKT (/1,000)**	**Cost stormwater (/$million)**	**Cost total (/$million)**	**% storm water/total**
Christchurch Southern Motorway	262	11.3	160	7
ALPURT sectors A2 + B1	283	6.1	365	2
SH20 Mount Roskill	200	13.4	169	8
SH2 Dowse to Petone Upgrade	98	2.3	50	5
SH18 Greenhithe Deviation	200	7.7	110	7
Avalon Drive Bypass	50	3.5	41	9
average	**182**	**7.4**	**149**	**6**

Table 6. Stormwater construction cost per VKT

Project	**Current**	**Standard**
	$/VKT	
Christchurch Southern Motorway	43	43
ALPURT sectors A2 + B1	21	21
SH20 Mount Roskill	67	67
SH2 Dowse to Petone Upgrade	23*	29
SH18 Greenhithe Deviation	38	39
Avalon Drive Bypass	70	70
Average	**44**	**45**
Standard deviation	**21**	**20**

(* no attenuation or treatment requirement)

The application of the Standard would have had no or limited effect on the construction costs of the Christchurch Southern Motorway, ALPURT, SH20 Mount Roskill and the Avalon Drive Bypass. Applying the Standard to the SH18 Greenhithe Deviation project would have led to an increase of $1/VKT due to the increase in attenuation devices required to comply with the Standard.

Of note is the observation that ALPURT storm water costs relative to total construction cost and VKT are the lowest of all projects. ALPURT was the project alleged to have "green-plated" stormwater management.

The SH2 Dowse to Petone Upgrade increased by $6/VKT. The difference is due to the project in its current design not requiring any stormwater treatment, which would now be required by the regional authority, Greater Wellington Regional Council. The Dowse to Petone Upgrade therefore provides a case study of the cost of stormwater treatment measures required by the Standard.

Table 7 shows what percentage of the total construction costs that are made-up of attenuation and treatment measures for five of the six projects. The consultant was not able to provide a construction cost breakdown for the Christchurch Southern Motorway because most of the devices were multi-functional. Of the five remaining projects all but the SH2 Dowse to Petone Upgrade required the stormwater runoff to be treated. On average the attenuation and treatment component made-up 21% of the total stormwater system construction cost. When the Standard was applied to the SH2 Dowse to Petone Upgrade, the increase in cost for attenuation and treatment came to be 19% of the total stormwater system construction cost.

Table 7. Percentage of attenuation and treatment cost to
total stormwater construction cost (/$1,000,000)

Project	**Attenuation and Treatment Construction Cost**		**Total Stormwater System Construction Cost**		**Attenuation + Treatment/ Total Construction Cost %**	
	Current	Standard	Current	Standard	Current	Standard
ALPURT sectors A2 + B1	2.2	2.2	6.1	6.1	36	36
SH20 Mount Roskill	0.85	0.85	13.4	13.4	6	6
SH2 Dowse to Petone Upgrade	0.04	0.54	2.3	2.8	(2)*	19
SH18 Greenhithe Deviation	0.6	1.7	7.7	7.8	20	22
Avalon Drive Bypass	0.76	0.76	3.5	3.5	22	22
				average	**21**	**22**

(* not included in average because no attenuation or treatment requirement)

ALPURT and SH20 Mount Roskill are respectively 50% higher and lower than the average of 22%, this can be attributed to environmental factors. ALPURT is a greenfield development in an ecologically sensitive receiving environment. SH20 Mount Roskill is within a highly developed existing urban environment. The other three projects closely align with each other.

CONCLUSION

A comparison of six large projects averaging $150 million each across four regional authorities and a variety of sensitive receiving environments ranging from highly sensitive green fields to industrial land and compiled by four different consultancies found the application of a newly developed Stormwater Treatment Standard would not affect construction cost while saving money and time on design and obtaining consents, decreasing operation and maintenance expenses, whilst improving environmental performance.

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