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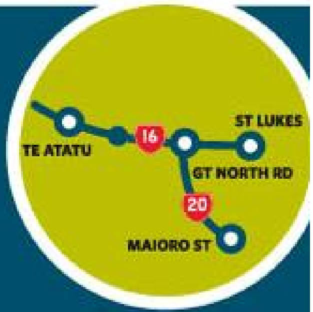
16 20 Western Ring Route – Waterview Connection



Assessment of Associated Sediment and Contaminant Loads

NIWA
Taihoro Nukurangi

newzealand.govt.nz

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1. Introduction

The Waterview Connection Project is the final project to complete the Western Ring Route, a 48 km stretch of motorway linking Manukau, Auckland, Waitakere and North Shore, and comprising the SH 20, SH 16 and SH 18 motorway corridors. The Waterview Connection Project (referred to hereafter as the Project) includes a combined surface motorway and tunnel option linking SH 20 at Maioro Street with SH 16 at the Great North Road Interchange, and also provides for works on SH 16 which include raising the causeway between the Great North Road and Rosebank Interchanges, and creating additional lanes between St Lukes and Te Atatu. For descriptive purposes, the Project alignment has been divided into nine sectors, as shown in Figure 2.1.

Much of the Project lies within the catchment of Oakley Creek which discharges to the Waterview Inlet. This receiving environment, adjacent to the Motu Manawa (Pollen Island) Marine Reserve, is designated as a Coastal Protection Area 1 in the Auckland Regional Plan: Coastal (ARC, 2009), and as such is considered to be particularly vulnerable to any adverse effects of inappropriate subdivision, use and development. Beca Infrastructure, on behalf of the NZ Transport Agency (NZTA), contracted NIWA to undertake an assessment of the potential impact on the Waterview Inlet due to sediment and contaminants in stormwater discharges associated with the Project. The assessment scope includes the above-ground sections of the Project only (i.e., the surface motorway and the tunnel portals), and comprises three separate components:

1. An estimate of the baseline annual sediment and contaminant loads delivered to the Waterview Inlet under the current land-use, representative of the catchment area of the Central Waitemata Harbour in which the Project lies.

2. An estimate of the additional sediment load delivered to the Waterview Inlet due to the construction phase of the Project.

3. An estimate of the annual sediment and contaminant loads delivered to the Waterview Inlet under long-term operation of the Project.

For these purposes, predictive models were employed from the Central Waitemata Harbour Contaminant Study conducted by NIWA for the Auckland Regional Council (ARC). This report describes the calculation methods and summarises the results for each component of the assessment listed above. Where possible the results are presented with a breakdown into the nine descriptive sectors for the project (Figure 2.1).

2. Baseline Sediment and Contaminant Loads

The baseline annual sediment and contaminant loads delivered to the Waterview Inlet under the current land-use, representative of the catchment area in which the Project lies, were calculated using the Contaminant Load Model (CLM), as applied in the Central Waitemata Harbour Contaminant Study (Timperley & Reed, 2008a, 2008b).

Figure 2.1: Western Ring Route: Waterview Connection Project – Sector Diagram.

2.1 Methodology – The Contaminant Load Model

The CLM calculates annual loads of sediment (total suspended solids; TSS) and contaminant metals (zinc; Zn, and copper; Cu) from urbanised catchments. The catchment is divided into a number of source types contained within the model, each of which have a corresponding annual yield (g m^{-2} $year^{-1}$). For each source type, the annual load is then equal to the annual yield multiplied by the source area. If stormwater treatment is present, a load reduction factor is applied to the annual load to determine the value post-treatment.

In the Central Waitemata Harbour Contaminant Study, the harbour catchment was divided into subcatchments according to outfall location within the harbour. Each subcatchment was then further divided into Stormwater Management Units (SMUs). Within each SMU, the area of each source type was either measured or estimated in 2001, and then projected forward according to trends in land-use change and population growth. These areas were then input to the CLM to produce annual sediment and contaminant loads for each year.

For this assessment, the catchment area of the Central Waitemata Harbour representative of the Project was taken to be those SMUs in which the Project lies. These SMUs and their outfall locations are shown in Figure 2. With regard to the alignment:

- Sectors 2 – 3, Sector 4 traversing the Rosebank Peninsula, Sector 5 and Sectors 7 – 9 all lie within the SMUs which discharge to Oakley Creek (and the Waterview Inlet), and

- Sectors 1 and 6 lie within SMUs which discharge to other parts of the harbour.

Note that the representative catchment area defined by the SMUs does not include that part of Sector 4 between Rosebank Road and the Great North Road Interchange (i.e., the causeway and Traherne Island). As a result, the baseline annual sediment and contaminant loads reported may be a slight underestimate, however the effect will be minimal as the area of this piece is very small relative to the wider catchment area.

2.2 Results

The baseline annual sediment and contaminant loads for the representative catchment area defined by the SMUs are those predicted by the CLM for 2009 (which was the current year at the time of the assessment). Having been projected forward from 2001, the source areas for each SMU in this year were reviewed to ensure they remain reasonable at present.

Table 1 contains the estimated baseline annual sediment and contaminant loads by outfall location. A breakdown of the road-source component of these loads is then shown in Table 2. Based on predicted traffic numbers the Project will fall into the land-use category of motorway, 50 000 – 100 000 vehicles per day (vpd); for the SMUs which discharge to Oakley Creek this land-use currently represents less than 8 % of each of the annual sediment and contaminant loads.

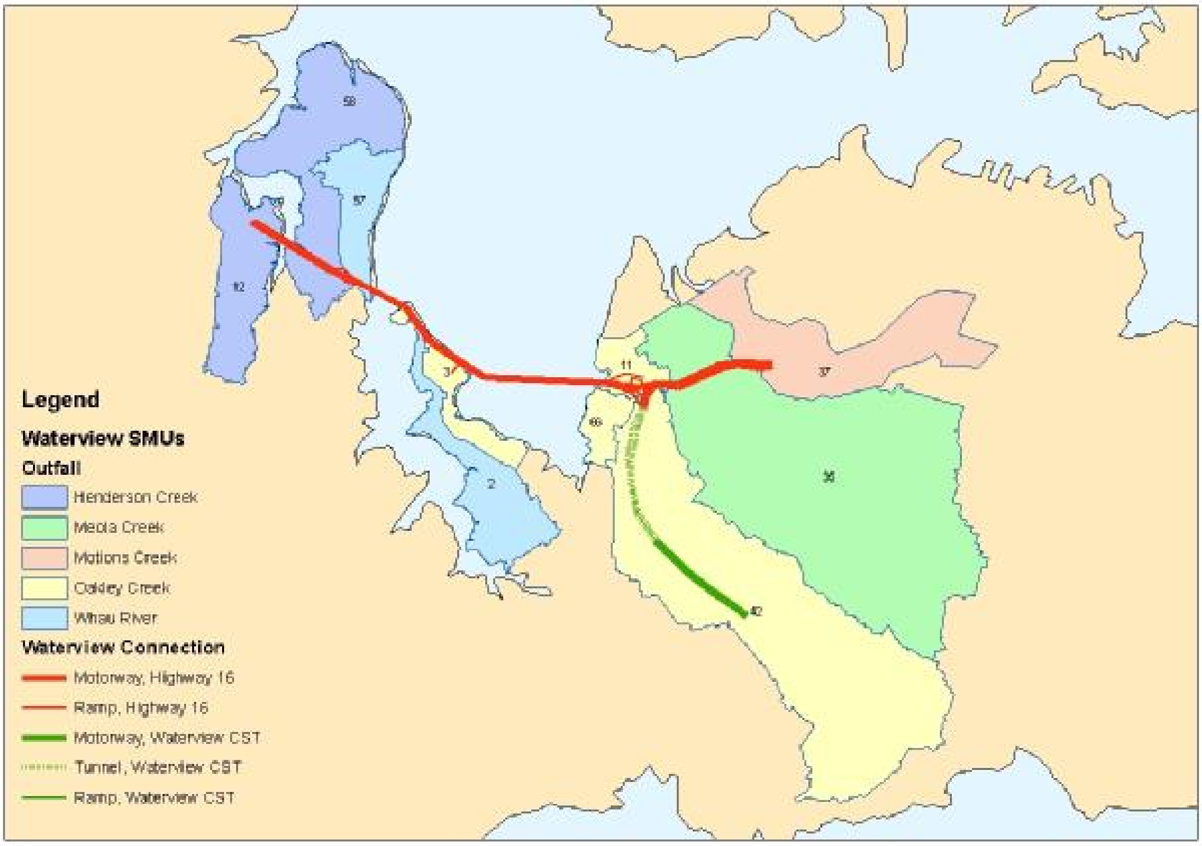

Figure 2.2: The representative catchment area for the Project, as defined by the SMUs in the Central Waitemata Harbour catchment in which the Project lies.

Table 1: Estimated baseline annual sediment loads (tonnes $year^{-1}$) and contaminant loads (kg $year^{-1}$) for the representative catchment area under the current land-use.

Outfall	SMUs	Area (ha)	Sectors	Annual Load		
				TSS	Zn	Cu
Henderson Creek	12, 58	677	1	258	640	76
Meola Creek	35	1 505	6	554	1 025	136
Motions Creek	37	412	6	197	702	87
Oakley Creek (and Waterview Inlet)	3, 11, 42, 66	1 475	2, 3, 4*, 5, 7 – 9	463	1 022	138
Whau River	2, 57	371	1	131	347	43

* Eastbound lanes from Rosebank Park Domain to the Rosebank Road On-Ramp

Table 2: Contribution from roads and motorways to the estimated baseline annual sediment and contaminant loads in under the current land-use.

Outfall	Land-Use	Proportion of Area (%)	Proportion of Annual Load (%)		
			TSS	Zn	Cu
Henderson Creek	Roads (< 50 kvpd)	16.6	14.4	11.3	15.0
	Motorway (50 – 100 kvpd)	1.4	4.8	6.4	8.5
	Motorway (> 100 kvpd)	0.6	3.1	4.3	5.7
	Other	81.4	77.7	78.0	70.8
Meola Creek	Roads (< 50 kvpd)	16.5	14.3	14.5	17.3
	Motorway (50 – 100 kvpd)	0.3	1.2	2.1	2.5
	Motorway (> 100 kvpd)	0.1	0.7	1.4	1.6
	Other	83.1	83.8	82.0	78.6
Motions Creek	Roads (< 50 kvpd)	17.3	12.2	6.8	8.6
	Motorway (50 – 100 kvpd)	9.6	25.8	23.9	30.5
	Motorway (> 100 kvpd)	4.2	16.7	16.1	20.6
	Other	68.9	45.3	53.2	40.3
Oakley Creek (and Waterview Inlet)	Roads (< 50 kvpd)	16.6	17.3	15.1	17.6
	Motorway (50 – 100 kvpd)	1.1	4.3	6.5	7.6
	Motorway (> 100 kvpd)	0.5	2.8	4.4	5.1
	Other	81.9	75.5	74.0	69.7
Whau River	Roads (< 50 kvpd)	17.4	16.6	12.4	15.8
	Motorway (50 – 100 kvpd)	0.4	1.6	2.0	2.6
	Motorway (> 100 kvpd)	0.2	1.0	1.4	1.7
	Other	82.0	80.7	84.2	79.9

3. Construction Sediment Load

During the construction phase of the Project, the sediment load delivered to the Waterview Inlet will be the baseline sediment load over the period plus the sediment generated as a result of the construction. The estimated sediment load generated as a result of the construction is calculated using the Groundwater Loading Effects of Agricultural Management Systems model (GLEAMS; Knisel, 1993). The version of the model applied here was adapted for use in the Central Waitemata Harbour Contaminant Study to simulate sediment generation in the rural parts of the catchment (Parshotam & Wadhwa, 2007a, 2007b, 2008). Input information (including a land-use and slope class breakdown along with assumptions on the earthworks timeframe) was provided through Beca Infrastructure based on the design at the time of the assessment. It is recognised that there may be subsequent design changes, such that these inputs do not necessarily reflect the final design, however the results are still considered appropriate from an effects perspective.

3.1 Methodology – The GLEAMS Model

3.1.1 Model Description

GLEAMS is a physically-based mathematical model developed for continuous simulation of surface runoff and sediment losses from the land on a field scale. The procedure for deriving catchment sediment loads using GLEAMS field-scale predictions involves dividing the catchment into a number of land “cells”, each assumed to be of uniform land-cover, topography (slope) and soil type. The GLEAMS model uses a long-term climate record (rainfall, temperature and solar radiation) together with the land-cover, slope and soil type to calculate a daily series of surface runoff and sediment yields for each cell. The results can then be aggregated for the catchment as a whole. In this case, the long-term climate record is a 50-year time-series which runs from 1 January 1954 – 31 December 2003 (see Parshotam & Wadhwa, 2007a, for the source of the climate data). Use of a long-term series allows the model to capture a suitable range of climate conditions.

The series of surface runoff and sediment yields from each cell may be passed through a post-processing module simulating a sediment retention pond. Within the pond model, the sediment yields are partitioned into ten individual particle size classes. To simulate flocculation ponds (those with chemical treatment), the settling speeds of the smaller particles in the pond are increased, as would be expected due to their clumping as a result of flocculation.

3.1.2 Model Inputs

Each sector was divided into land “cells” according to a breakdown of the area into unique combinations of final-state land-use and slope class (breakdown provided through Beca Infrastructure). During the construction phase, which is assumed to take place entirely over a 12 month period, each cell is subject to a period of earthworks followed by a period of stabilization. Though the actual construction may be phased over longer than 12 months, there will be little difference to the total amount of sediment released because the duration of open earthworks will remain the same. All earthworks are assumed to begin in October, and may run for a maximum of 8 months, though some cells are stabilized well within this length of time. The land-cover during the earthworks period is bare subsoil, however the land-cover under stabilization depends upon the cell's final-state land-use. The final-state land-uses and the methods of stabilization are:

- New motorway – after the earthworks period, cells of this type are stabilized as a sealed road.

- Pervious surfaces (which applies to areas such as grassed verges) – after the earthworks period, cells of this type are stabilized with a vegetative cover which is assumed to be similar to pasture. There will be some time between earthworks and full stabilization whilst the vegetation is growing, however this is not considered as it will make only a minor difference if stabilisation is conducted well.

- Revetments (in Sector 4) – after the earthworks period, cells of this type will be stabilized with rock armour.

- Slope walls (at the tunnel portals) – after the earthworks period, cells of this type are stabilized with concrete, basalt or MSE.

GLEAMS also requires a soil type for each cell, which was determined from the soil classes and maps in the Central Waitemata Harbour Contaminant Study (see Parshotam & Wadhwa, 2007a), with each cell being assigned the dominant soil type for its sector.

GLEAMS was run twice for each cell, once with the earthworks land-cover, and once with the stabilized land-cover. However, for the cells which are new motorway, rock revetments or slope walls, there is no in-built land-cover within GLEAMS that is appropriate during their stabilization period. As a result, the stabilization period for these cells was handled separately (see below). The GLEAMS output for each cell is two 50-year time series of daily surface runoff and sediment yields, one for the earthworks and one for the stabilization. These series were aggregated for each cell as follows:

- Sections of the earthworks series were picked out corresponding to the months when the cell would be subject to earthworks, and similarly, sections of the stabilized series were picked out corresponding to the months when the cell would be under stabilization.

- Next, the daily sediment yields in each of these sections were aggregated separately to produce sediment yields per earthworks period and per stabilization period. If the cell is subject to earthworks for 8 months, then we have sediment yields per 8 months of earthworks and sediment yields per 4 months of stabilization. Alternatively, if the cell is subject to earthworks for 4 months, then we have sediment yields per 4 months of earthworks and sediment yields per 8 months of stabilization.

- Finally, the per earthworks period and per stabilization period sediment yields were averaged over the different years to give the mean sediment yield per earthworks period and the mean sediment yield per stabilization period, then multiplied by the cell area to produce the corresponding mean sediment loads.

The mean sediment loads for each cell were combined to give the values for each sector (without any stormwater treatment). For those sectors which are to be treated by sediment retention ponds, the raw GLEAMS series for each cell were also passed through the post-processing module for pond simulation. This post-processing module produces series of daily treated sediment yields, which are aggregated in the same way as above to give the mean sediment loads for each sector with treatment. Within the post-processing module, all ponds were assumed to be 3 % ponds (i.e., a 3 % ratio of pond volume in m^3 to catchment area in m^2) with chemical treatment, and the average removal efficiency achieved was 94 %. This removal efficiency is consistent with the observed performance of ponds receiving chemical treatment (when correctly managed) at the ALPURT B2 motorway construction site near Orewa in 2007 (Moores & Pattinson, 2008). For those sectors with ponds, additional silt fences and decanting earth bunds were assumed to provide no extra stormwater treatment, a conservative assumption. For Sector 6, which has no pond and is treated by silt fences and decanting earth bunds only, a blanket removal efficiency of 75 % was applied which is consistent with the Erosion and Sediment Control Plan produced by Ridley Dunphy Environmental Ltd.

For the cells which are new motorway, rock revetments or slope walls, there is no appropriate land-cover within GLEAMS for the stabilization period. As a result, the sediment yield per stabilization period for these cells is calculated using the CLM, assuming that they are impervious sealed road with no traffic. The CLM gives an annual sediment yield for each cell, which is converted to a per stabilization period sediment yield using the number of months each cell is expected to be under stabilization. Though the rock-armoured revetments are technically pervious, they will produce little sediment and so treating them as impervious will have only minor effect. A summary of the land cells within each sector, including the length of the earthworks and stabilization periods for each and the stormwater treatment information is given in Table 4.

3.2 Results

3.2.1 Sediment Load for the Project Construction Area

Table 3 contains the estimated sediment load for each sector during the earthworks and stabilization periods, both with and without stormwater treatment. A more detailed breakdown of the sediment loads by land-use and slope class is given in Table 4. It is recognised that these are mean values (averaged across the range of climate conditions in the 50-year time series), and the actual amount will depend upon the severity of storms in the particular year construction is carried out. The input area breakdown provided did not include the proposed contractor's yards in Sectors 1 and 9, and these have not been further considered in the model as they will be stabilized quickly (within 1 month) and will therefore produce little sediment. There are also no load values reported for Sectors 7 and 8, as works in these sectors are entirely associated with the tunnel construction which is outside the scope of this assessment.

Note that the values reported represent a worst-case scenario, for the following reasons:

- There will be progressive stabilization of slopes during the construction, meaning that the earthworks period for some cells will be shorter than that estimated.

- The land cells are defined using final-state slopes, and whilst it is assumed that these slopes will be reached quickly, in reality there will be some intermediate (transient) slopes for the steep cuts which will yield less sediment.

A further note is that the sediment loads reported with treatment assume that the cells continue to be treated under stabilization. This is because it is assumed that the sediment retention ponds will remain online during the entire construction phase due to some areas undergoing earthworks longer than others. This assumption may be less reasonable for Sector 6, which has only silt fences and decanting earth bunds, but will make little difference to the estimated sediment load. Finally, the reported sediment loads for Sector 6 are significantly higher than for other sectors, which is primarily due to the lower treatment efficiency assumed for the silt fences. As described in the Erosion and Sediment Control Plan however, the works in this sector are mostly shoulder widening and will be subject to progressive stabilization, therefore the reported loads are likely to be artificially high.

3.2.2 Sediment Loads by Outfall Location

For each outfall location in the Central Waitemata Harbour, the total sediment load released from the representative catchment area during the construction phase will be the baseline load (see Section 2 of this report) plus that generated as a result of the construction. Combining the sectors which discharge to each outfall location, the total sediment loads released from the representative catchment areas are given in Table 5. It is recognised that the total sediment loads will be a slight overestimate, as the baseline loads include discharges from the construction area under the current land-use which will not be present during the construction phase, however the effect will be minimal.

For Oakley Creek and the Waterview Inlet, the total estimated sediment load released from the representative catchment area during the construction phase of the Project, with treatment, is 493 tonnes (463 tonnes baseline plus 30 tonnes generated as a result of the construction phase). This value represents a 6.5 % increase over the existing baseline. Note that if no treatment were present, the total estimated sediment load would rise to 977 tonnes (more than double the existing baseline), which highlights the importance of including and correctly managing treatment. Furthermore, the sediment loads under stabilization are significantly lower than those while the slopes are exposed (Table 3), therefore stabilizing the slopes as quickly as possible will help to minimize the sediment load released to the Inlet.

Table 3: Estimated sediment load generated during the construction phase of the Project, both with and without the proposed treatment.

Sector	Construction Area (ha)	Load Without Treatment (tonnes)			Load With Treatment (tonnes)		
		Earthworks	Stabilized	Total	Earthworks	Stabilized	Total
1	6.31	201.15	23.58	224.73	11.82	1.39	13.21
2	1.29	18.76	17.50	36.27	0.83	1.38	2.21
3	2.06	37.07	3.98	41.05	2.27	0.14	2.41
4	8.47	55.97	1.61	57.58	3.29	0.09	3.38
5	5.44	154.19	0.41	154.60	9.06	0.02	9.08
6	2.24	78.57	0.17	78.74	19.64	0.04	19.69
7	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-
9	5.74	224.44	0.46	224.90	13.19	0.03	13.21
Total	42.13	770.15	47.41	817.87	60.10	3.09	63.19

Table 4: Input information provided to the GLEAMS model, and the corresponding sediment loads calculated.

Sector	Final-State Land-Use	Earthworks Period	Stabilized Land-Cover	Slope (%)	Area (ha)	Load Without Treatment (tonnes)	Load With Treatment (tonnes)	Treatment Devices
1	New motorway	8 months	Sealed road	0 – 6	3.67	16.80	0.99	Sediment retention ponds, silt fences and decanting earth bunds
	Pervious area	8 months	Vegetative cover	0 – 18	0.87	7.58	0.45	
				18 – 36	1.48	125.58	7.38	
				36 – 54	0.10	15.86	0.93	
				54 – 72	0.01	0.01	0.15	
				72 – 90	0.00	0.03	0.00	
				90 - 105	0.18	56.38	3.31	
2	New motorway	4 months	Sealed road	0 – 6	0.63	1.00	0.06	Sediment retention ponds, silt fences and decanting earth bunds
	Pervious area	4 months	Vegetative cover	0 – 18	0.36	0.61	0.03	
				18 – 36	0.00	0.00	0.00	
				36 – 54	0.14	13.50	0.82	
				54 – 72	0.15	20.49	1.25	
				72 – 90	0.003	0.42	0.03	
				90 - 105	0.002	0.29	0.02	

Table 4 continued.

Sector	Final-State Land-Use	Earthworks Period	Stabilized Land-Cover	Slope (%)	Area (ha)	Load Without Treatment (tonnes)	Load With Treatment (tonnes)	Treatment Devices
3	New motorway	8 months	Sealed road	0 – 6	1.08	4.90	0.29	Sediment retention ponds, silt fences and decanting earth bunds
	Pervious area	8 months	Vegetative cover	0 – 18	0.78	6.78	0.44	
				18 – 36	0.07	5.00	0.30	
				36 – 54	0.12	20.97	1.20	
				54 – 72	0.002	0.47	0.03	
				72 – 90	0.001	0.18	0.01	
				90 - 105	0.01	2.73	0.15	
4	New motorway	2 months	Sealed road	0 – 6	3.83	2.62	0.15	Sediment retention ponds, silt fences and decanting earth bunds (other methods may be employed for the reclamation)
	Revetments	2 months	Rock armour	0 – 18	2.23	1.58	0.09	
				18 – 36	0.03	0.33	0.02	
				36 – 54	0.98	18.01	1.06	
				54 – 72	1.40	34.92	2.05	
				72 – 90	0.003	0.09	0.01	
				90 - 105	0.001	0.03	0.00	

Table 4 continued.

Sector	Final-State Land-Use	Earthworks Period	Stabilized Land-Cover	Slope (%)	Area (ha)	Load Without Treatment (tonnes)	Load With Treatment (tonnes)	Treatment Devices
5	New motorway	8 months	Impervious	0 – 15 30 – 45	4.24 1.20	49.28 105.32	2.90 6.19	Sediment retention pond, silt fences and decanting earth bunds
6	New motorway	8 months	Impervious	0 – 15 30 – 45	1.24 1.00	11.71 67.04	2.93 16.76	Silt fences and decanting earth bunds
7 and 8	Tunnel segments							
9	New motorway	8 months	Impervious	0 – 15 30 – 45	2.79 1.93	32.44 169.51	1.91 9.96	Sediment retention pond and silt fences
	Slope walls	1 month	Impervious	400 600	0.27 0.23	10.38 12.57	0.61 0.74	
	Vertical walls	1 month	Impervious	vertical	0.52	-	-	

Table 5: Total estimated sediment load (to the nearest tonne) delivered from the representative catchment area to each outfall location during the construction phase of the Project.

Outfall	Sectors	Baseline	Construction		Total	
			Without Treatment	With Treatment	Without Treatment	With Treatment
Henderson Creek and Whau River	1	389	225	13	614	402
Meola Creek and Motions Creek	6	751	79	20	830	771
Oakley Creek (and Waterview Inlet)	2 – 5, 7 – 9	463	514	30	977	493

4. Long-Term Operational Sediment and Contaminant Loads

For this component of the assessment, the original intention was to use the Catchment Contaminant Annual Loads Model (C-CALM; Semadeni-Davies et al., 2009a) in anticipation of detailed information being available on the design of the proposed stormwater treatment devices for the operational Project. The annual sediment and contaminant loads calculated by C-CALM without treatment are exactly the same as those that would be calculated by the CLM; the only numerical difference between the models is that C-CALM is capable of applying variable load reduction factors for each treatment device based on its design parameters and the catchment characteristics. At the time the assessment was carried out however, design parameters for the proposed treatment devices were not yet available, and so a modified version of the model was used (see below).

4.1 Methodology – The Catchment Contaminant Annual Loads Model

4.1.1 Model Description

C-CALM is intended as a spatial decision support system, for use in exploring the relative merits of different stormwater treatment scenarios. The model has been developed within a Geographical Information System (GIS) platform to enable visualisation of contaminant sources and treatment scenarios, but can also be run in a spreadsheet format (as was the case here) when spatial variation is not necessary.

The annual sediment and contaminant loads calculated by C-CALM before treatment are exactly the same as those that would be calculated by the CLM, since the models use the same sediment and contaminant yields for load generation (see Timperley, in press). The difference between the models occurs in selection of the load reduction factor to apply for stormwater treatment. Where the CLM uses fixed load reduction factors for each stormwater treatment device (e.g., 75 % sediment removal efficiency for all ponds), C-CALM is capable of using variable load reduction factors based on device design parameters such as pond depth, and catchment characteristics such as particle size distribution. The user selects the most appropriate combination of device and catchment parameters from a pre-defined set, and C-CALM applies the corresponding load reduction factor from a performance rule library containing the values for all possible parameter combinations. Where possible the performance rules have been determined by dynamic modelling, otherwise they are taken from scientific literature.

In this case, the design information anticipated for the proposed stormwater treatment devices under long-term operation of the Project was not yet available at the time of the assessment. It was however specified that the devices would be sized according to TP 10 guidelines, and the design objective for all TP 10 devices is 75 % removal of sediment on a long-term basis (ARC, 2003, p. 1-4). As a result, C-CALM was modified to apply a flat-rate load reduction factor of 75 % for all sediment and particulate contaminant metals. For dissolved contaminant metals the load reduction factor used was the medium removal efficiency defined within C-CALM (see Semadeni-Davies & Altenberger, 2009b).

One further modification was made to the model: both C-CALM and the CLM assign roads and motorways to one of six classes based on vehicles per day (vpd), each with associated sediment and contaminant yields. The vpd classes at the motorway level are fairly broad however, so the sediment and contaminant yields were interpolated using a linear relationship to determine yield values within each class.

4.1.2 Model Inputs

The annual sediment and contaminant loads for a road source are calculated based on its area, total daily traffic volume and type of stormwater treatment. These inputs were provided through Beca Infrastructure under two possible scenarios:

1. *Do Minimum* – this scenario represents the situation where the Project is not built, resulting in no change to the existing road network (traffic volumes may still vary however).

2. *With Project* – this scenario represents the situation where the Project is built and operational.

The total motorway area and type of stormwater treatment for each sector under the two scenarios is summarised in Table 6. There is very little treatment under the *Do Minimum* scenario, and this is proposed to be significantly improved under the *With Project* scenario. The estimated average total daily traffic volume for each sector under the two scenarios is then summarised in Table 7. The values are for the year 2006, which is representative of the current traffic volumes, and also for the years 2016 and 2026 in the future.

4.2 Results

4.2.1 Sediment and Contaminant Loads for the Project Motorway Area

Table 8 contains the estimated annual sediment and contaminant loads for the Project motorway area in each sector under the *Do Minimum* scenario. As the Project is not built in this scenario, the values represent the existing SH 16 motorway area with the existing stormwater treatment – the difference in sediment and contaminant loads between the years is purely due to changing traffic volumes.

Table 9 contains the estimated annual sediment and contaminant loads for the Project motorway area in each sector under the *With Project* scenario. There are no load values reported for Sectors 7 and 8, as these sectors are entirely associated with operation of the tunnel which is outside the scope of the assessment. Note that the sediment and contaminant loads predicted for SH 16 (Sectors 1 – 6) under the *With Project* scenario are significantly less than those under the *Do Minimum* scenario, despite an increase in motorway area and a general increase in traffic volumes. This result is due to the improved stormwater treatment proposed for Sectors 1 – 4, where no treatment currently exists.

4.2.2 Sediment and Contaminant Loads by Outfall Location

The estimated total annual sediment and contaminant loads delivered from the representative catchment area to each outfall under long-term operation of the Project will be the baseline loads from the representative catchment area (see Section 2 of this report) in addition to the operational loads from the Project motorway area. It is assumed that there will be little change to the land-use immediately surrounding the Project motorway area.

The baseline loads, however, already contain a contribution from the Project motorway area in its present state. For SH 16 this can be compensated for by subtracting from the baseline the load for the existing motorway area. As a result, a new baseline is defined for long-term operation of the project which is equal to the existing baseline minus the sediment and contaminant loads from SH16 for 2006 under the *Do Minimum* scenario (i.e., those for the existing SH 16). This new baseline does still, however, contain a contribution from the current land-use of the Project motorway area linking SH 20 and SH 16, though it is expected to be small as this section is largely through Alan Wood Reserve.

The estimated total annual sediment and contaminant loads delivered from the representative catchment area to each outfall under long-term operation of the Project, as calculated from the new baseline in addition to the operational loads for the Project motorway area, are summarised in Table 10, Table 11 and Table 12. Note that the total annual sediment and contaminant loads delivered to the Waterview Inlet under long-term operation of the Project are less than the existing baseline under the current land-use (between 1 and 10 % less). This result is because of the significant improvement to stormwater treatment proposed for the SH 16 upgrade.

Table 6: Motorway area and type of stormwater treatment for each sector under the *Do Minimum* and *With Project* scenarios.

Sector	Do Minimum Scenario			With Project Scenario		
	Motorway Area (ha)	Proportion Treated (%)	Treatment Devices	Motorway Area (ha)	Proportion Treated (%)	Treatment Devices
1	8.26	0	No treatment	12.08	97	Swales and pond
2	1.51	0	No treatment	2.21	100	Cartridge vaults and filter strips
3 and 4	10.72	0	No treatment	15.29	97	Cartridge vaults and filter strips
5	6.15	51	Catchpits, swales and wetland	9.79	69	Catchpits, swales and wetland
6	4.58	62	Swales	5.26	67	Catchpits and wetland
7 and 8	-	-	-	-	-	-
9	-	-	-	6.15	100	Wetland

Table 7: Estimated average total daily traffic volumes in each direction (vehicles per day; vpd) for 2006, and for 2016 and 2026 under the *Do Minimum* and *With Project* scenarios.

Sector	Average total daily traffic volume (vpd)				
	2006	2016		2026	
		Do Minimum	With Project	Do Minimum	With Project
1	41 714	43 129	48 342	48 844	55 629
2	52 650	53 150	59 250	58 300	66 250
3	48 560	48 600	55 860	54 417	62 120
4	50 386	51 129	57 400	56 014	63 971
5	51 100	50 300	37 456	51 850	40 269
6	38 482	38 149	45 927	30 753	48 518
7	-	-	34 950	-	41 100
8	-	-	34 950	-	41 100
9	-	-	33 013	-	39 238

Table 8: Estimated annual sediment load (tonnes $year^{-1}$) and contaminant loads (kg $year^{-1}$) for the Project motorway area at present and in the future under the *Do Minimum* scenario.

Sector	TSS			Zn			Cu		
	2006	2016	2026	2006	2016	2026	2006	2016	2026
1	10.21	10.49	11.63	131	136	153	20	20	23
2	1.52	1.53	1.65	19	19	21	3	3	3
3 and 4	10.58	10.65	11.52	130	131	144	20	20	22
5	3.80	3.76	3.81	52	52	53	7	7	7
6	3.01	2.99	2.52	47	46	37	6	8	5
Total	29.12	29.42	31.13	379	384	408	56	58	60

Table 9: Estimated annual sediment and contaminant loads (tonnes $year^{-1}$) for the Project motorway area in the future under the *With Project* scenario.

Sector	TSS		Zn		Cu	
	2016	2026	2016	2026	2016	2026
1	4.59	5.14	97	111	11	12
2	0.62	0.68	10	11	1	2
3 and 4	4.28	4.66	69	76	9	10
5	3.42	3.59	44	47	6	6
6	3.61	3.78	58	61	8	8
7 and 8	-	-	-	-	-	-
9	1.67	1.92	36	42	4	5
Subtotal (Sectors 1 – 6)	16.52	17.85	278	306	35	38
Total	18.19	19.77	314	348	39	43

Table 10: Estimated total annual sediment load delivered from the representative catchment area to each outfall location under long-term operation of the Project. The total annual load consists of the operational baseline annual load plus the annual load from the Project motorway area.

Outfall	Sectors	Annual Sediment Load (nearest tonne $year^{-1}$)					
		Baseline (Existing)	Baseline (New)	Project Motorway Area		Total	
				2016	2026	2016	2026
Henderson Creek and Whau River	1	389	379	5	5	384	384
Meola Creek and Motions Creek	6	751	748	4	4	752	752
Oakley Creek (and Waterview Inlet)	2 – 5, 7 – 9	463	447	8	9	455	456

Table 11: Estimated total annual zinc load delivered from the representative catchment area to each outfall location under long-term operation of the Project. The total annual load consists of the operational baseline annual load plus the annual load from the Project motorway area.

Outfall	Sectors	Annual Zinc Load (kg $year^{-1}$)					
		Baseline (Existing)	Baseline (New)	Project Motorway Area		Total	
				2016	2026	2016	2026
Henderson Creek and Whau River	1	987	856	97	111	953	967
Meola Creek and Motions Creek	6	1 727	1 680	58	61	1 738	1 741
Oakley Creek (and Waterview Inlet)	2 – 5, 7 – 9	1 022	821	123	134	944	955

Table 12: Estimated total annual copper load delivered from the representative catchment area to each outfall location under long-term operation of the Project. The total annual load consists of the operational baseline annual load plus the annual load from the Project motorway area.

Outfall	Sectors	Annual Copper Load (kg $year^{-1}$)					
		Baseline (Existing)	Baseline (New)	Project Motorway Area		Total	
				2016	2026	2016	2026
Henderson Creek and Whau River	1	119	99	11	12	110	111
Meola Creek and Motions Creek	6	223	217	8	8	225	225
Oakley Creek (and Waterview Inlet)	2 – 5, 7 – 9	138	108	16	18	124	126

5. Summary

This assessment is primarily focussed on the sediment and contaminant loads associated with the Project that are delivered to the Waterview Inlet, however results have also been presented for other outlets into the Central Waitemata Harbour which will receive discharges from the Project. The results are summarised here in relation to the Waterview Inlet.

At present, the estimated baseline annual loads delivered to the Waterview Inlet from a representative catchment area encompassing the Project are 463 tonnes of sediment, 1,022 kg of zinc and 138 kg of copper. The representative catchment area is defined by the Stormwater Management Units (laid out in NIWA's Central Waitemata Harbour Contaminant Study) into which the Project crosses.

It is estimated that, during the construction phase of the Project, an additional 30 tonnes of sediment will be delivered to the Waterview Inlet from the representative catchment area, bringing the total to 493 tonnes (a 6.5 % increase on the existing baseline). The importance of treatment during the construction phase is highlighted by the fact that, without treatment, the estimate of the additional load rises to 514 tonnes, bringing the total sediment load delivered to the Inlet from the representative catchment area to 977 tonnes (more than double the existing baseline).

At present, the existing SH 16 motorway area within the Project is estimated to generate 29 tonnes of sediment, 379 kg of zinc and 56 kg of copper annually. In future years (2016 and 2026), without the Project being built, these numbers are a little higher due to changes in traffic volumes. Alternatively, with the Project built, the estimated future annual loads generated by the SH 16 motorway area are substantially lower (between 20 and 40 % lower each year). This is because of the proposed improvements to stormwater treatment for SH 16 with the Project, where very little treatment currently exists.

During long-term operation of the Project, it is estimated that in 2016 the annual loads delivered to the Waterview Inlet from the Project motorway area will be 18 tonnes of sediment, 314 kg of zinc and 39 kg of copper. The annual loads delivered to the Waterview Inlet from the representative catchment area are then expected to be 455 tonnes of sediment, 944 kg of zinc and 124 g of copper. These values are less than the existing baseline annual loads from the representative catchment area (2 % less for sediment, 8 % less for zinc and 10 % less for copper), which is due to the proposed improvement to stormwater treatment for SH 16 with the Project built. For 2026, the estimated annual sediment and contaminant loads delivered to the Waterview Inlet from the representative catchment area are a slight increase on those for 2016 but still remain less than the existing baseline loads.

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