Updated sediment load estimator for New Zealand

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Contents

Tables

Figures

Executive summary

Background and objectives

As part of a broad call for up-to-date information to support Government aims of improving water quality and flows to improve the health of New Zealand's freshwater environments, the Ministry for the Environment (MfE) commissioned NIWA to develop and apply a new empirical model that estimates mean annual river suspended sediment load[1] at the national scale. The model seeks to improve on a previous generation of similar models by utilising an updated dataset of observed sediment loads. The workstream also included developing a simple, uncalibrated model to estimate the trap efficiency of river/stream sediment in coastal hydrosystems (which include estuaries, coastal lakes, and coastal embayments).

These models are applied to estimating sediment loads from across New Zealand, sediment loads in the river network, sediment entrapment in lakes, sediment delivery to coastal hydrosystems, and net sediment deposition rates in coastal hydrosystems. The models are applied under current conditions as characterised by rainfall and land cover and for both pre-European and pre-human land covers (assuming no change in rainfall) to inform on the magnitude of human enhancement of erosion.

The study objectives included comparing results on national and regional sediment loads, including from large rivers, with equivalent results provided by the empirical estimator of Hicks et al. (2011).

Sediment load modelling approach

The river sediment load modelling approach is a blend of the approaches used by Hicks et al. (2011) and Elliott et al. (2008). It is a raster model that empirically relates the mean annual sediment load generated by a unit (1 ha) grid-cell to the average slope, mean annual rainfall, land cover, and erosion terrain[2] in that grid-cell.

River sediment loads are determined by summing the sediment loads from all raster units upstream and routing these loads down the stream network taking into account entrapment in lakes and reservoirs. The national digital stream network developed for Version 2 of the River Environment Classification (REC2) was used for the routing, along with NIWA's database of lakes and reservoirs.

Sediment entrapment in lakes/reservoirs was estimated from the ratio of lake volume to mean annual water outflow (which equates to water residence time) using an empirical equation. Lake volume was estimated off surface area and maximum depth assuming a simple lake geometry. Mean annual outflow was estimated off a national predictor of mean discharge.

While not explicitly addressed in the model, net sediment supply from eroding streambanks is implicitly included since this is captured at the model calibration sites, along with sediment delivered from upstream hill-slope erosion processes. It is assumed that there are no significant losses of sediment to floodplain storage, since many large New Zealand rivers are currently isolated from their floodplains by flood-protection embankments. Also, the model considers the suspended sediment load only; the contribution of coarse-grained, gravelly sediment moving as bedload is not included.

[1] Load is the mass of sediment passing down a river or into an estuary over a given time, usually per year. In erosion literature this is sometimes referred to as the sediment yield, but we do not use that terminology in this report. In this report, a yield or specific yield is the mean annual load per unit catchment area. Also in this report, we often refer to the mean annual sediment load simply as the sediment load.

[2] An erosion classification developed by Manaaki Whenua / Landcare, with erosion terrain classes distinguished by slope, rock-type, soils, and dominant erosion processes.

The geospatial layers that 'drive' the model include a national 30-year mean annual 'normal' rainfall surface, a 30-m resolution national digital terrain model, the Land Cover Data Base version 3 (LCDB3) land cover layer (referenced to 2008), and Manaaki Whenua/Landcare Research's national erosion terrain classification. To reduce the model parameters to a tractable number, the LCDB3 classification was 'lumped' into six functional groups (*herbaceous* including pasture, *trees and scrub*, *tussock and alpine herbaceous*, *other erodible* land cover, *urban*, and open *water*), while the erosion terrain classification was condensed to 12 groups. The erosion terrains were lumped across different slope classes (since slope is explicitly included in the model), which gave 12 groups essentially reflecting lithology (rock type): *sand country*, *floodplains*, *fans and terraces*; *tephra and loess*; *Tertiary mudstone, sandstone, and soft limestone*; *intensely gullied crushed argillite and greywacke*; *lavas, rhyolite, and volcano slopes*; *greywacke, argillite, and hard limestone*; *schist and South Island greywacke*; *coarse crystalline plutonics and metamorphics*; *deeply weathered plutonics*; *open water*; and all *other* terrains . For model application, pre-human land cover was derived from Manaaki Whenua/Landcare Research's Potential Vegetation of New Zealand dataset, while pre-European land cover was approximated by overlaying on the pre-human land cover a layer estimating the 1840s distribution of tussock grasslands.

The sediment load model was calibrated nationally against river mean annual suspended sediment loads from 273 monitoring sites, which were generally estimated using measured sediment concentrations and flow data. This included data from new sites and updated data from sites used to derive earlier models (Elliott et al. 2008; Hicks et al. 2011; Dymond et al. 2014), which were all based on essentially the same dataset compiled in the late 1990s (reported in Hicks et al. 2011). The representativeness of the calibration data was assessed by analysing the physical characteristics of the calibration catchments with respect to national characteristics. There were 181 calibration catchments in the North Island, covering 49% of the North Island total area. There were 92 in the South Island, covering 35% of the South Island. Northland, Taranaki, and Marlborough have only a small number of sites (6 or less each). Overall, the sites are largely representative of inland reaches on medium to large rivers. The specific sediment yields (loads per unit area) of the calibration catchments ranged between 1.5 and 37,400 t/km^2/y.

The model calibration used the SCEUA machine-learning global-optimisation method, which sought to minimise the root-mean-square error of the natural logarithms of the catchment sediment loads predicted for the calibration sites (i.e., log-RMSE). This optimization essentially uses high-speed "number-crunching" to evaluate a very large number of potential solutions for the model parameters.

Inspection of the spatial distribution of errors from this initial global model identified several regions with systematic over- or under-estimation. Regional adjustments were therefore made to rectify the systematic error in those regions. The boundaries of the adjusted regions were delineated based mainly on distinctive geological terrain and/or recent geological history (glacial cover, tectonic activity).

The regionally adjusted model was run at national scale using the current land cover to produce a national sediment yield grid (raster). This is termed the "uncorrected" model. A special version of this national yield grid was made by locally adjusting the grid across the calibration catchments to ensure that the modelled sediment loads at the outlets of these catchments matched the observed sediment loads. This version is termed the "corrected" model and was used to provide the most reliable estimates of sediment loads across the river network.

Coastal hydrosystem/estuary trap-efficiency modelling approach

The river sediment loads were used to estimate net sediment deposition rates in coastal hydrosystems. Coastal hydrosystems include traditional estuaries (brackish systems) as well as primarily fresh water systems such as coastal lakes and hapua, and marine dominated systems such as coastal embayments, fjords and sounds. Net deposition rates were estimated using a simple, uncalibrated, zero-dimensional (i.e., with no spatial resolution) sediment mass balance model to calculate sediment trap efficiency. The model considered sediment inputs from tributaries, sediment deposition by settling, sediment resuspension by waves, and sediment re-entrainment by currents. Resuspension by waves occurs on inter-tidal areas, re-entrainment occurs in tidal channels, while deposition can potentially occur across both channels and inter-tidal areas. While the model addresses dynamic processes such as tides, waves, and variable river flows, it is static in the sense that there is no feedback between sedimentation and these processes, as could occur as the system geometry evolves through scour and deposition.

The estuary model uses data from two sources: estuary physical characteristics and tidal information from NIWA's Coastal Explorer database, and wind data from NIWA climate data. Wave resuspension is calculated over the range of observed wind speeds and directions and applied as a time-averaged continuous rate. Sediment influxes, deposition, re-entrainment by currents, and export by currents are simulated using a flow-duration curve derived from river and tidal flows. The net sediment accumulation rate is calculated for each point on the flow-duration curve then averaged to obtain mean annual rates.

Results were generated for 399 coastal hydrosystems across New Zealand, using the routed output from the national corrected sediment load model to estimate mean annual river/tributary sediment supply to each coastal hydrosystem. Because the estuary model is uncalibrated, the results are expected to be of greater value in indicating relative sedimentation across different types of coastal hydrosystem rather than providing reliable estimates at individual coastal hydrosystems. In this context, 11 broad groups of coastal hydrosystem from the Hume et al. (2016) classification were assessed: damp sand plain lakes; Waituna-type lagoons; hapua-type lagoons; beach streams; freshwater river mouths; tidal river mouths; tidal lagoons; shallow drowned valleys; deep drowned valleys; fjords; and coastal embayments.

River sediment load model calibration results

The global model calibration produced a log-RMSE of 0.84, which equates to a factorial (×/÷) error of 2.32 on the load predicted for the calibration catchments. After the regional adjustment, the log-RMSE reduced to 0.64 (factorial error of 1.90). This is not quite as good as the log-RMSE of the Hicks et al. (2011) model (1.55), but the present model has been calibrated over more of New Zealand and particularly for the Auckland-Waikato region. The model explains 95% of the variance in the observed log-transformed sediment loads in the North Island and 94% in the South Island.

Key results from the calibration include:

- The sediment yield under trees and scrub is 47% of that under herbaceous/pasture land cover. Compared with some previous New Zealand empirical load models that include the influence of land cover, this is a higher proportion than the 28% derived by Elliott et al. (2008) and the 10% assumed by Dymond et al. (2010). However, it is within the range of measured differences in sediment yield from studies of paired catchments with either pasture or forest land cover (e.g., 22% - 63% from Hicks 1990).

- The greatest sediment load by far is associated with the *intensely crushed argillites and greywacke* erosion terrain in the East Cape area.
- For the other erosion terrains, there is a sensible ordering of coefficients in terms of rock erodibility, with soft sedimentary rocks > deeply-weather plutonic rocks > schist > greywacke and argillite and hard limestone > tephra and loess > lavas > coarse crystalline plutonic and metamorphic rocks.
- The c_{rain} exponent on the mean annual rainfall was 1.31. This aligns well with the findings of Klik et al. (2015) whose results showed that across New Zealand on average the rainfall erosivity parameter used in the Universal Soil Loss Equation is proportional to the mean annual rainfall to the power of 1.30. Also, while the c_{rain} exponent is less than the value of 1.7 obtained by Hicks et al. (2011), the latter's model did not include slope explicitly (it was implicit in the erosion terrains) and so the 1.7 coefficient would also be proxying to some degree for slope, since slope and rainfall are highly correlated in New Zealand. By comparison, Elliott et al. (2008) found a c_{rain} exponent of 2.02.
- The c_{slope} exponent derived for the present model is 0.76 (compared with 1.15 derived by Elliott et al. 2008).

Sediment loads under the current land cover scenario

The estimated national total suspended sediment load (corrected with measured loads where available) delivered to the New Zealand coast is 181.1 Mt/y, with 61% (111.6 Mt/y) from the North Island and 39% (69.5 Mt/y) from the South Island. In the North Island, the highest sediment load occurs in the East Cape region (64.6 Mt/y; 36% of the national load) due to a combination of relatively high rainfall, deforestation, and highly erodible crushed argillite and tertiary mudstone lithologies. In the South Island, the highest sediment loads occur in South Westland (43.3 Mt/y, 24% of the national load) due to a combination of steep slopes, heavy rainfall, friable schist lithologies, and high uplift rates on the eastern side of the Alpine Fault.

The Waiapu and Waipaoa Rivers carry the most sediment in the North Island, transporting 39.6 Mt/y and 9.9 Mt/y, respectively, and their combined load represents 44.8% of the North Island load and 27.3% of the national load. The four largest sediment-carrying rivers in the South Island are in South Westland (Haast, Buller, Whataroa, and Arawhata); the estimated loads for these rivers ranges from 4.4 to 5.1 Mt/y, and their combined load represents 26% of the load delivered to the South Island coast and around 10% of the national total. In Canterbury, the Rakaia and Waimakariri Rivers deliver an estimated 3.9 Mt/y and 2.9 Mt/y respectively, and their combined load represents 10% of the South Island total and 4% of the national total.

These results are broadly similar to those reported by Hicks et al. (2011), albeit somewhat less: with the present national load estimate being 27.6 Mt/y (15%) less than the Hicks et al. (2011) total, and most of the reduction (21.1 Mt/y) stemming from lower estimates on rivers from South Westland.

It is emphasised that these differences between the loads estimated herein and by Hicks et al. (2011) should not be interpreted as indicating a temporal change in mean annual sediment load since the time of the Hicks et al. (2011) study. The differences reflect the use of somewhat different datasets for gauged rivers and different models for the ungauged catchments and are more indicative of how the mean annual load estimate has been refined with the benefit of additional data.

Lakes intercept significant amounts of river sediment load, particularly in the South Island where natural lakes trap sediment at a rate of 18.9 Mt/y and hydro/irrigation storage lakes intercept 2.23 Mt/y. Most of the natural lake entrapment occurs in Lakes Pukaki, Tekapo, Ohau, Hawea, Wanaka, and Wakatipu, all of which have very high trap efficiencies by virtue of their large water residence times (i.e., the ratio of lake volume to mean annual water inflow rate), which provide adequate time for sediment to settle. Most of the artificial lake entrapment occurs in the Clutha catchment (2.0 Mt/y). In the North Island, natural lakes intercept only 0.68 Mt/y of sediment, with most occurring in Lake Taupo, while artificial lakes trap 0.62 Mt/y, mostly due to hydropower reservoirs on the Waikato River – thus most of the North Island lake entrapment occurs in the greater Waikato Catchment. Over New Zealand, natural lakes intercept 9.6% of the sediment delivered to the river network while artificial lakes trap around 1.6%.

Sediment loads under the pre-human and pre-European scenarios

The sediment loads for the pre-human and pre-European land cover scenarios were compared with the loads generated from the "uncorrected" model run with the current land cover. This was to ensure that "apples are compared with apples".

There is very little difference in sediment loads between the pre-human and pre-European land cover scenarios. Greater differences appear between these two historic scenarios and the current land cover scenario, particularly in the North Island where the estimated historical loads are, on average, 78% of the current estimated load and are as low as 52% of the current load in some regions. There is a smaller difference across the South Island, where the loads for both historic scenarios are around 95% of that estimated for the current scenario. In most cases, the loads estimated for the historic scenarios are less than those calculated for the current scenario due to the (approximately factor-of-two) lower erosion rates associated with forest cover. This effect is less in the South Island because forest cover has remained in the high sediment yielding area of South Westland.

There are exceptions to this national pattern for rivers with artificial hydropower reservoirs, notably the Clutha and Waitaki Rivers in the South Island, where the river loads have decreased compared with the historical scenarios because reservoir entrapment has prevailed over the effects of land cover change.

We warn that these comparisons with historical land cover should be interpreted with caution for several reasons. First, the results are generated assuming stable land cover, whereas it is well recorded that massive quantities of sediment were mobilised during the phases of land cover transition (e.g., during European deforestation). While these high transient erosion rates may not be generally occurring today, European deforestation is still contributing "legacy" sediment from erosion of stored sediment deposits (e.g., streambank and floodplain erosion) to varying degrees around the country. Second, an underpinning assumption of the model is that the land cover and erosion terrain coefficients are mutually independent - so that, for example, a change in land cover should have the same effect on sediment load irrespective of the erosion terrain. This is unlikely to always be the case. Third, before the onset of European drainage works and flood-confinement between stopbanks, floodplains and wetlands would have intercepted greater proportions of river suspended loads.

The upshot is that the actual pre-European and pre-human sediment loads to the coast and to coastal hydrosystems will, if anything, have been lower than estimated herein. For example, detailed studies in the Waipaoa catchment at East Cape have estimated that the pre-human sediment load was only about 15% of the contemporary load, with most of the increase occurring following European deforestation.

Sediment trapping in coastal hydrosystems

The geographic pattern of sediment loads delivered to coastal hydrosystems reflects the regional and large-river patterns already described, i.e., they are highest along the east coast of the North Island and the west coast of the South Island. The coastal hydrosystem types that receive the highest sediment loads are generally tidal river mouths and hapua-type lagoons.

The areal "loading" of sediment in coastal hydrosystems (expressed as the inflowing mean annual sediment load per unit estuary area) shows a similar geographic pattern to the catchment loads, but because hapua-type lagoons, beach streams, and tidal river mouths are generally small in area, their areal loading rates are typically high. Conversely, sediment aerial loadings are lowest for fjords and coastal embayments by virtue of their large areas.

The modelled coastal hydrosystem sediment trapping efficiency (ranging from 0 to 1) is the proportion of the suspended sediment delivered to the coastal hydrosystem that deposits and remains within the coastal hydrosystem (and so is not discharged to the open ocean). A trapping efficiency of 1 indicates all river-sourced sediment is retained in the coastal hydrosystem. The sediment mass balance modelling showed that trapping efficiency varies with coastal hydrosystem type in a sensible way:

- Damp sand-plain lakes, Waituna-type lagoons, drowned valleys, and coastal embayments generally have very high (i.e., close to 1) trapping efficiencies.
- Tidal lagoons also have a high trapping efficiency, although there is a wider range in trapping efficiencies for this type of system. Tidal lagoons have large intertidal areas that act as deposition zones, while resuspension in channels limits deposition in subtidal areas. The range in trapping efficiencies is due to differences in intertidal areas and whether the estuary is large enough for significant amounts of wave resuspension.
- Fjords have lower trapping efficiencies than other large systems such as deep drowned valleys and coastal embayments due to higher freshwater input driving strong estuarine circulations which increases export to the open ocean.
- Hapua-type lagoons, beach streams, freshwater river mouths, and tidal river mouths have highly variable trapping efficiencies. Their median trapping efficiencies (ranging from 0 to 0.55) are lower than for the systems discussed above, but they also receive high sediment loads which can result in apparently high deposition rates.

The trap efficiencies and net deposition rates for the morphologically dynamic systems (i.e., hapua-type lagoons, beach streams, freshwater river mouths, and tidal river mouths) are probably over-estimated by the model. This is because the time-averaged trap efficiency in these systems is controlled by coastal and river processes that are not included in the simple mass balance model. While these systems may indeed experience high rates of deposition in their low energy zones on a short-term basis, such deposits are eventually flushed out. Thus, we conclude that the long-term average trap efficiency of most hapua-type lagoons, beach streams, freshwater river mouths, and tidal river mouths are more likely to be zero than the values indicated by our model.

Setting aside these morphologically dynamic systems, the model appears to produce reasonably realistic predictions of mean annual deposition rates. The highest deposition rates tend to occur in tidal lagoons (median 1.9 mm/y), Waituna-type lagoons generally have moderate deposition rates (median 0.7 mm/y, albeit with a wide range), deep systems such as fjords, deep drowned valleys, and coastal embayments generally have low deposition rates (medians of 0.2 to 0.3 mm/y), while shallow drowned valleys have intermediate deposition rates (median 0.7 mm/y).

A comparison at five estuaries where deposition rates averaged over recent decades have been measured by coring (Morrison et al. 2009) showed that our predicted rates are consistent with the observed rates when allowance is made for the uncertainty in both the predicted and observed rates. The predicted rates are less than the observed rates at six other estuaries, but the data from those were all based on longer observation epochs, some extending back to the 1840s, and were likely influenced by European deforestation and legacy effects from that disturbance.

We add the final caution that, as well as the issues with the morphologically dynamic systems, the coastal hydrosystem sediment mass balance model used herein to estimate trap efficiency and deposition rate is a simple model that is bare of complexity, assumes uniform sediment properties everywhere, and has not been calibrated to independent measures of sedimentation rate. Thus, these results are best regarded as indicative for coastal hydrosystem types, and results for individual systems should be used with caution. In particular, while our modelling generally indicates small proportional increases in coastal hydrosystem deposition rates between pre-human/pre-European and current times, this result is driven by our modelled catchment sediment loads with the underpinning assumption that the relationship between sediment yield and land cover was in a stable, equilibrium state during both periods. As discussed above, the current loads are affected by legacy effects of deforestation, so the actual pre-human and pre-European loads were almost certainly less than those we have estimated, and thus the proportional increase in deposition rates since pre-human/pre-European times is almost certainly greater than our predictions.

1 Introduction

Under Workstream 8 (Sediment) of the Water Quality and Flows Programme initiated by the Ministry for the Environment (MfE), MfE commissioned NIWA to develop and apply a new empirical model that estimates mean annual river suspended sediment load at the national scale and its delivery to coastal waters. The over-arching aim of the Water Quality and Flows Programme is to provide up-to-date information to support Government aims of improving the health of New Zealand's freshwater environments. Towards this, estimates of river sediment loads are useful for several purposes, including (i) helping identify catchment areas most in need of mitigation and restoration measures to meet soil conservation objectives to improve water quality (e.g., water clarity) and ecological health in streams and in downstream receiving waters, and (ii) helping assess the extents of sediment load reduction that would be required to meet sediment attribute guidelines that are currently under development (e.g., Dymond et al. 2017). For coastal receiving waters, estimates of sediment delivery and entrapment are used to inform the management of those systems with regard to, for example, estuarine ecosystem health, nearshore fisheries and aquaculture, and coastal erosion.

This report overviews the model development and presents the following model outputs: mean annual sediment losses from across New Zealand; sediment loads into freshwater bodies; and sediment load to coastal hydrosystems including estuaries and coastal embayments. The model is applied under current conditions as characterised by land cover, and for both pre-European and pre-human conditions to inform on the magnitude of human enhancement of erosion. The report also presents an estuary mass balance model to estimate coastal hydrosystem sediment trap efficiency, which is used with the loads delivered to the coastal hydrosystems to estimate sedimentation rates. Both models are described in Section 2.

In overview, the modelling approach followed for the sediment load model (Section 2.1) is a blend of the approaches used by Hicks et al. (2011) and Elliott et al. (2008), and is most similar to that followed for the Waikato, Auckland and Northland Sediment Yield estimator (WANSY; Hoyle et al. 2015; Haddadchi and Hicks 2016). It is a raster (grid-based) model that, for each 1 ha grid cell, empirically relates the mean annual sediment load generated to the slope, mean annual rainfall, land cover, and lithology (represented by erosion terrain) in that grid cell. Catchment loads are determined by summing the loads from grid cells located within each river segment sub-catchment and then routing these loads down the stream network, taking into account entrapment in lakes and reservoirs. For the current land cover scenario, the model was run both with and without entrapment by man-made hydro-power and water supply reservoirs. These artificial reservoirs are listed in Appendix B.

The modelling approach followed for the estuary sediment trap efficiency is described in Section 2.2. It uses a simple, uncalibrated sediment mass balance model that considered sediment inputs from tributaries, sediment deposition by settling, and sediment re-entrainment by waves and currents.

The input data for both models are described in Section 3. The input data for the sediment load model (Section 3.1) has been derived from various national geospatial datasets as detailed in Appendix C. The data required for the estuary mass balance model (Section 3.2) comes from two sources: estuary physiometry from NIWA's Coastal Explorer database and wind data from NIWA climate data.

The sediment load model was calibrated nationally against river mean annual suspended sediment loads estimated generally using measured sediment loads and flow data from 273 monitoring sites (Section 4.1). The calibration uses new and updated data that come from a greater number of sites than were available for previous national sediment load models (Elliott et al. 2008; Hicks et al. 2011; Dymond et al. 2014). These earlier models were based on essentially the same dataset compiled in the late 1990s (reported in Hicks et al. 2011). The representativeness of the calibration data was assessed by analyzing the physical characteristics of the calibration catchments with respect to national characteristics (Appendix E). Since regional bias was found in the calibrated model outputs, the model outputs have been adjusted regionally to improve model fit.

The national overview results from the sediment load model (Section 5) are presented in a similar fashion to those in Hicks et al. (2011) and are compared to these earlier results. For each of the three land cover scenarios, the results presented are mapped specific yields (i.e., mean annual load per unit area) delivered to the stream network and mean annual loads into lakes and coastal receiving waters by major rivers and coastal regions. Summarised results are presented and discussed in the report text while full model results are given in Appendices F (calibration results), G (loads for major rivers – current land cover scenario), H (loads for major rivers – historic land cover scenarios), and I (lake sediment entrapment).

The results for coastal hydrosystem sediment trap efficiency and sediment accumulation rate from the estuary sediment mass balance model are presented in Section 6. Full results for the coastal hydrosystem sedimentation analysis are in Appendix K.

2 Modelling approaches

2.1 River sediment load generation and routing model

The modelling approach is summarised in Figure 2-1. The basic structure of the model relates the sediment generation from a uniform unit area to two types of factor: *driving* factors, which govern the rate at which erosion and delivery processes operate in the landscape; and *supply* factors, which moderate the availability of the sediment in the landscape and the proportion delivered to the stream network. The driving factors (rainfall, slope) relate to the power generated by rainfall and runoff. The supply factors relate to the geology (lithology, induration, weathering, deformation etc.), erosion processes, and land cover.

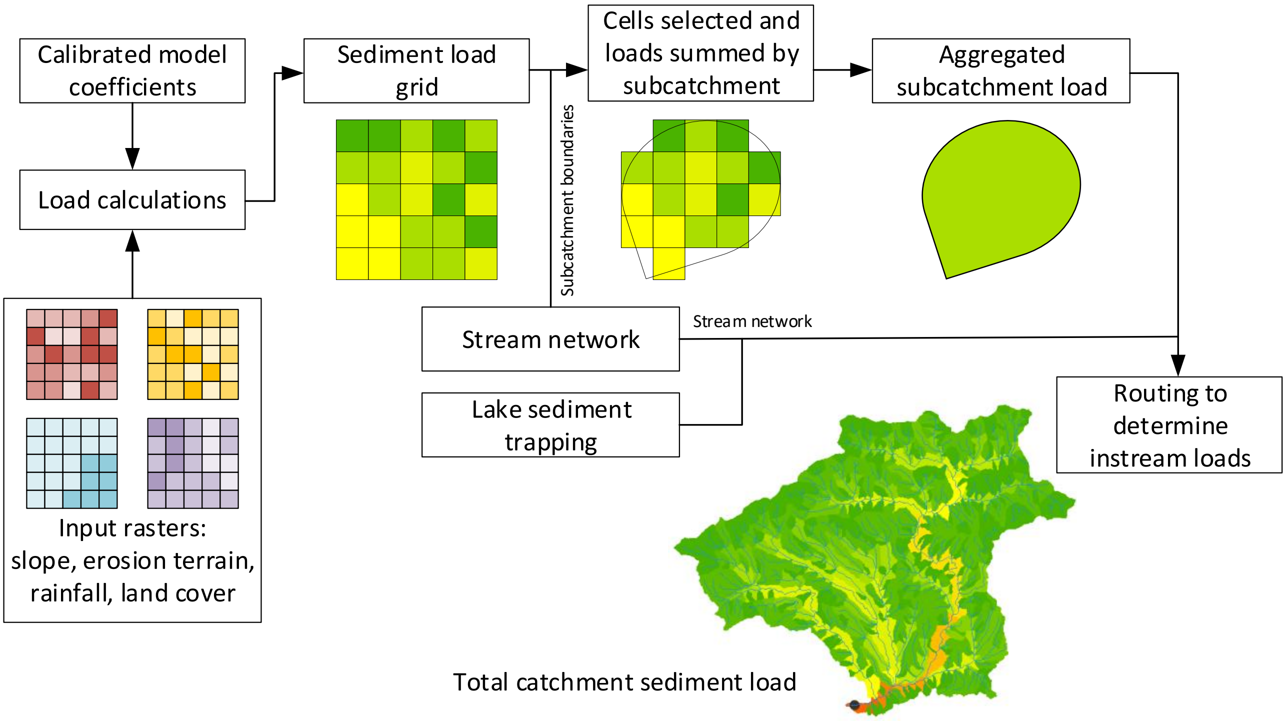

Figure 2-1: Modelling steps for the national sediment load model.

The sediment load for each 1-hectare grid-cell is calculated using:

$$L_i = a\, l_{j,i}\, e_{k,i}\, R_i^{\,c_{rain}}\, S_i^{\,c_{slope}} \tag{1}$$

where L_i is the mean annual sediment load generated by the *i*th 1-hectare grid cell (t/y); a (t/y) is the base coefficient (associated with reference values of land cover and erosion terrain; R_i is the mean annual rainfall (m/y) for the grid-cell; c_{rain} (dimensionless) is the rainfall exponent; S_i is the average slope (rise per horizontal distance, as a percent) for the grid-cell; c_{slope} (dimensionless) is the slope exponent; l_j (dimensionless) is the coefficient for the j^{th} land cover that dominates the grid-cell; and e_k (dimensionless) is the coefficient for the k^{th} erosion terrain that dominates the grid-cell. Six land cover groups and 12 erosion terrain groups were used in the model, as detailed in Sections 3.1.4 and 3.1.5, respectively. Both the erosion terrain and land cover coefficients are for a reference erosion terrain (Greywacke, argillite and hard limestone) and land cover (Herbaceous), respectively, that were assigned coefficients of 1.

The aggregated load for the m^{th} subcatchment within a catchment of interest (e.g., for model calibration or result generation, L_m) is the sum of the loads from all the grid-cells located within the subcatchment. To determine the load passing any stream network segment, the subcatchment loads are routed downstream by progressively adding the subcatchment load to the total load from upstream segments taking into account entrapment in lakes and reservoirs.

As detailed in Section 3.1.1, downstream routing used the national digital stream network[3] that was developed for Version 2 of the River Environment Classification (REC; Snelder and Biggs 2002; Snelder et al. 2010).

Entrapment in lakes and reservoirs is applied at lake/reservoir outlet segments. Generally, this was estimated from the ratio of lake volume to mean annual water outflow using Brune's (1953) 'median' curve method as approximated by Gill (1979):

$$SPF = 1 - \frac{V/_{Qa}}{1.02\left(V/_{Qa}\right) + 0.012} \tag{2}$$

where SPF is the sediment passing factor (equal to 1-T_E, where T_E is the sediment trap efficiency), V is the lake storage volume (m^3), and Qa is the annual mean water outflow (m^3) at the lake outlet. The storage volume was estimated as half the product of lake surface area and maximum depth assuming a simple v-shaped geometry[4]. Both the area and depth are from NIWA's lake database. The mean annual outflow volume was estimated for the lake outlet segment using mean flows calculated by Booker,Woods (2014). Exceptions to the use of Equation (2) were for hydro-lakes in the Clutha and Waikato Catchments, where more refined estimates of lake trap efficiency were available from sediment budgeting studies (Hicks et al. 2000 and Hicks et al. 2001, respectively).

As was done by Hicks et al. (2011), it is assumed that there are no significant losses of sediment to channel or floodplain storage. New Zealand rivers generally have the capacity to transport more fine sediment than is delivered to them, so while transient accumulation of deposited sediments may occur in-channel (e.g., in low energy zones such as pools or within substrate) during flood recessions, this sediment is generally re-entrained during subsequent floods and there is little if any net long-term accumulation. While floodplains naturally intercept some suspended sediment carried by bank-overtopping floods, many large New Zealand rivers are now channelled between flood-protection embankments, which prevent floodplain deposition except during extreme events when the embankments are overtopped or broken.

While not explicitly addressed in the model, net sediment delivery from eroding streambanks is implicitly included in the model, since bank erosion contributions from upstream will be captured at the calibration sites along with sediment delivered from hill-slope erosion sites. It is noted, however, that in many rivers the sediment load contributed by bank erosion associated with channel meandering and migration is offset by sediment deposition on point-bars. Indeed, bank erosion can make little net contribution to the sediment load unless the channel is progressively enlarging in response to a more energetic runoff regime associated with, for example, deforestation, catchment drainage works, or climate-change.

[3] Referred to as the REC2 network in this report, this digital stream network is also known as DN2.
[4] While lake volume data was available directly for some lakes, it was not available for many - which required that their volumes be estimated from their surface area and maximum depth. This approach was used for all lakes for consistency.

All modelling was scripted in Python version 3.6.

2.2 Coastal hydrosystem sediment trap efficiency and sediment accumulation model

Coastal hydrosystem/estuary[5] sediment trap efficiency and accumulation are estimated using a simple, zero-dimensional sediment mass balance model. The model balances the influx of sediment from rivers, deposition in the estuary, resuspension by waves, and entrainment by currents with export through the mouth to the ocean (Figure 2-2).

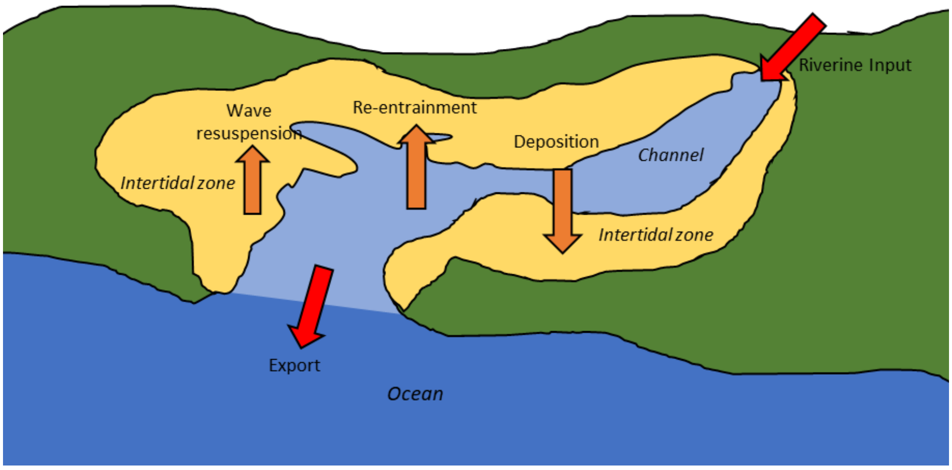

Figure 2-2: Conceptual diagram of an estuary showing the terms in the sediment mass balance model. Sediment is supplied via riverine input and exported to the sea through the mouth. A fraction deposits within the estuary. Resuspension by waves occurs on intertidal areas, and re-entrainment by currents occurs in tidal channels.

The sediment mass balance model is described by the following equation:

$$S_{out} = S_{in} + E_w + E_c - D \quad (3)$$

where

S_{in} = sediment influx from the catchment (kg/s)[6]

S_{out} = sediment export to the ocean (kg/s)

E_w = resuspension of sediment by waves (kg/s)

E_c = re-entrainment by currents (kg/s)

D = settling of sediment in the estuary (kg/s).

[5] We frequently use "estuary" to mean the same as coastal hydrosystem.
[6] The working sediment budget components were calculated with units of kg/s. The final results, providing mean annual values, are reported with units of t/y.

Sediment trap efficiency can be calculated as the fraction of incoming sediment that is retained within the estuary:

$$\eta = \frac{S_{in} - S_{out}}{S_{in}} \quad (4)$$

While all the terms in Equation (3) are time-varying, they occur over different time-scales that are not necessarily coupled. For example, sediment influx is related to river inflow, re-entrainment is determined by both river inflow and tidal flow, and resuspension by waves is driven by wind. These data are not available for all estuaries in a manner that would allow true daily sediment budgets to be calculated. Instead, sediment influxes, settling, re-entrainment by currents, and export are calculated over a range of inflows from a modelled daily flow duration curve, while waves resuspension is applied at an averaged constant rate. A sediment rating curve was developed from the flow duration curve to account for higher sediment inflow concentrations during high flows. River and sediment inputs were treated as quasi-steady for each point on the flow duration curve, with tides superimposed to calculate re-entrainment.

The net rate of sediment accumulation in the estuary is calculated as the difference between the sediment input and export, i.e., $S_{in} - S_{out}$. This is averaged over all inflows to obtain the net average accumulation rate (t/y). To convert this to a deposition rate (mm/y), the net accumulation rate is divided by estuary area and deposited sediment bulk density (ρ_b = 1500 kg/m^3).

Calculation of each term in Equation (3) is detailed in Appendix A.

3 Data

This section describes the data used in developing and applying both the sediment load model and the estuary trap efficiency model.

3.1 Sediment load model

The input data for the national sediment load model consists of a drainage network used for load routing and four raster image files (geo-referenced tagged image file format, .tiff) describing land cover, erosion terrain, slope, and rainfall. The raster datasets were pre-processed from existing spatial data within ESRI ArcMap to ensure that they had the same spatial extents and resolution (100 m) to enable raster arithmetic in the model. The source slope and rainfall datasets were already in raster format but required spatial resampling (and averaging as appropriate) to bring them in line with the common extent and resolution, whereas the land cover and erosion terrain data, which were available as shapefiles, were rasterised. The datasets are detailed below. The total area covered by each of the input data classes reported below was calculated by counting the number of grid cells within each class from the rasterised datasets. Slope and rainfall have been grouped into classes for map display, but the original raster values are used by the model.

3.1.1 Drainage network

The REC2 drainage network used represents the national steam/river network as a series of nodes or confluences linked by network segments. It was generated from a digital terrain model (DEM) with a 30 m resolution. Each segment has a contributing area, referred to here as the segment's sub-catchment. The median segment length is 530 m, and sub-catchments have a median area of 30 ha. There are some 593,000 segments nationally.

River mouths are represented in the REC2 network by "terminal" segments; that is, a terminal segment is the most downstream segment of a river/stream. The sediment load determined for a terminal segment represents the load delivered to the coast by the river. Lakes and reservoirs with an area greater than 1 ha are represented in the REC2 network by labelling the segments that intersect with a lake or reservoir boundary from NIWA's lake spatial database as either an inlet or outlet. As noted above, entrapment in lakes and reservoirs is applied only to those segments identified as outlets. Entrapment was not applied to the segments at outlets of artificial reservoirs (e.g., hydropower and water storage) for the two historic scenarios. These are listed in Appendix B.

3.1.2 Slope

Slope as the percent of rise (i.e., a percent rise of 100% equates to a slope angle of 45°) was determined from the same 30 m DEM used to derive the REC2 drainage network, using the ESRI ArcMap *Slope calculation* tool with the geodesic calculation option. Slope is mapped (Figure 3-1) according to Land Resources Information slope classes (Newsome et al. 2008) as defined in Table 3-1.

3.1.3 Rainfall

Several rainfall 'driving' parameters were considered, including mean annual rainfall (R), rain erosivity (E, as used in the Universal Soil Loss Equation, USLE, and its derivatives, e.g., Renard et al. 1997), and the Modified Fournier Index ($F = \sum R_m^2/R$, where R_m is the monthly average rainfall, Kiassari et al. 2012). The latter two acknowledge the importance of rainfall intensity and seasonality, respectively, on erosion (e.g., the same annual rain depth falling intensely during fewer storms or focussed in a few winter months is expected to produce more erosion than if it fell steadily throughout the year).

Rehnard and Freimand (1994) found that across the continental United States, rain erosivity related non-linearly to mean annual rainfall ($E = 0.048R^{1.6}$). More importantly for this study, Klik et al. (2015) analysed rainfall intensity records from around New Zealand and developed regional power-function relations between E and R (i.e., $E = \alpha R^{b}$) that aligned with broad climatological regions. They identified four regions, with the coefficient b varying between 1.130 and 1.536, averaging 1.30. Since this showed that over much of New Zealand rain erosivity is strongly and reasonably uniformly related to R, in this study we chose to simply use R as the driving factor and we anticipated that we should find a c_{rain} coefficient in our model within the range of b found by Klik et al. (2015)[7]. Also, given that rainfall in New Zealand tends not to be strongly seasonal, and because E and F tend to be inter-related (e.g., Kiassari et al. 2012), we chose not to pursue a relationship explicitly with the Modified Fournier Index.

The mean annual rainfall surface used (mapped in Figure 3-2) was taken from NIWA's national climate normal maps[8] and represents the period 1981-2010. For these maps, rainfall was interpolated from climate station data onto a 500 m raster using a thin-plate smoothing spline routine (Tait and Turner 2005; Tait, Henderson et al. 2006). Rainfall has been classed into quintile (20%) groups for Figure 3-2; the groupings are listed in Table 3-2.

Table 3-1: LRI slope classes and area covered nationally.

Code	Description	Range (degrees)	Range (percent rise)	Total area covered nationally (km² and %)
A	Flat to gently undulating	0-3	0-5.2	65164 (24.9%)
B	Undulating	4-7	5.3-12.3	32666 (12.5%)
C	Rolling	8-15	12.4-26.8	49406 (18.9%)
D	Strongly rolling	16-20	26.9-36.4	28261 (10.8%)
E	Moderately steep	21-25	36.5-46.6	24463 (9.3%)
F	Steep	26-35	46.7-70.0	41298 (15.8%)
G	Very steep	36-42	70.1-90.0	14893 (5.7%)
H	Precipitous	>42	>90.0	5890 (2.2%)

Table 3-2: Rainfall classes and area covered nationally.

Rain Class (quintiles)	Total area covered nationally (km² and %)
Dry (<938 mm/y)	52476 (20%)
Medium dry (939 – 1236 mm/y)	52414 (20%)
Medium (1237 – 1555 mm/y)	52380 (20%)
Medium wet (1556 – 2889 mm/y)	52353 (20%)
Wet (>2890 mm/y)	52419 (20%)

[7] In this context, the model could potentially be used to assess the effects on sediment load of changes in rain erosivity associated with long-term changes in rainfall intensity due to climate change, providing the coefficients of the power- function between mean annual rainfall and rain erosivity remained the same and setting aside the effects of any climate change induced changes in land cover.
[8] https://www.niwa.co.nz/climate/research-projects/national-and-regional-climate-maps (date of last access, 20 August 2018)

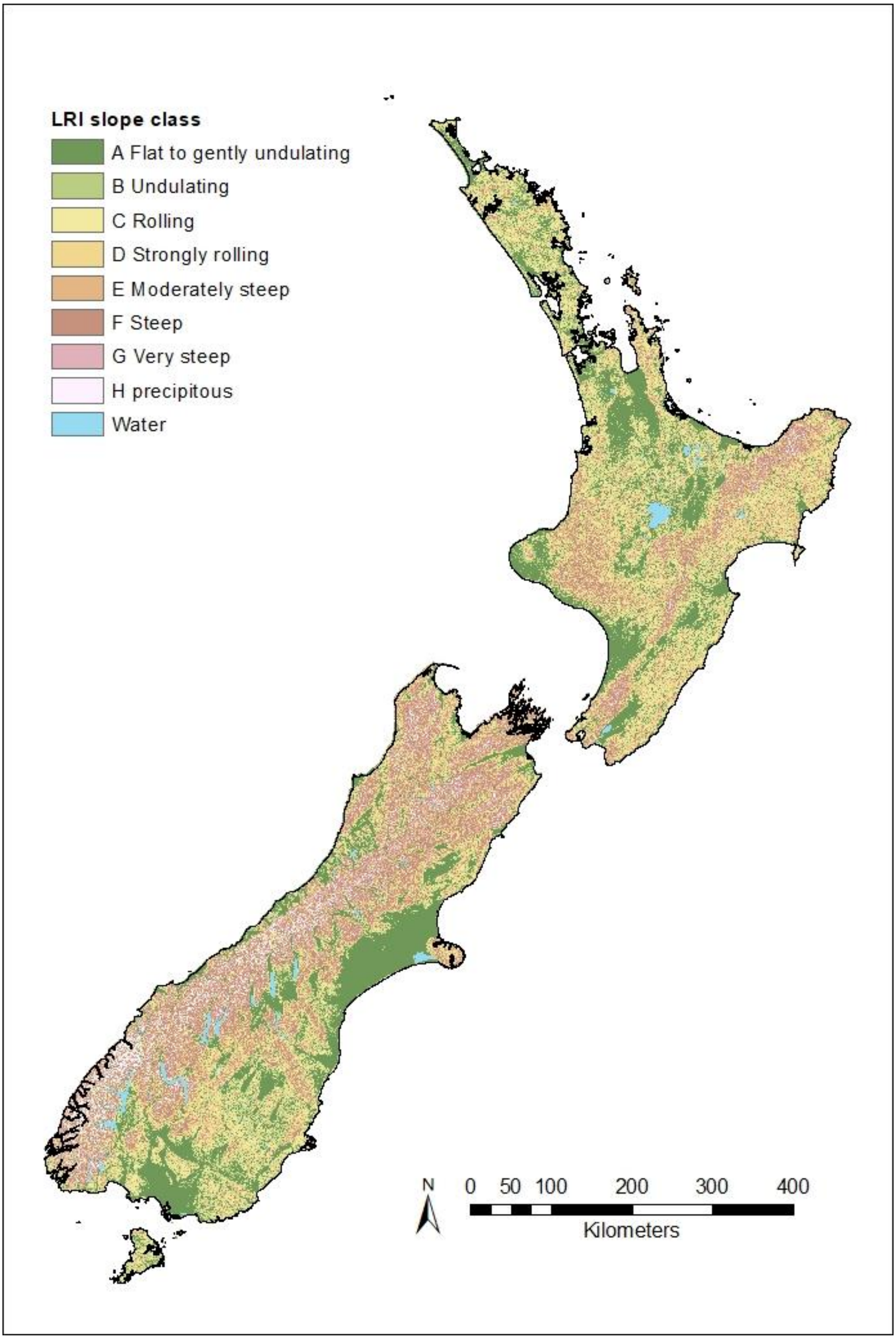

Figure 3-1: Slope mapped by LRI slope class. The range of slope for each class as degrees and percent of rise is listed in Table 3-1.

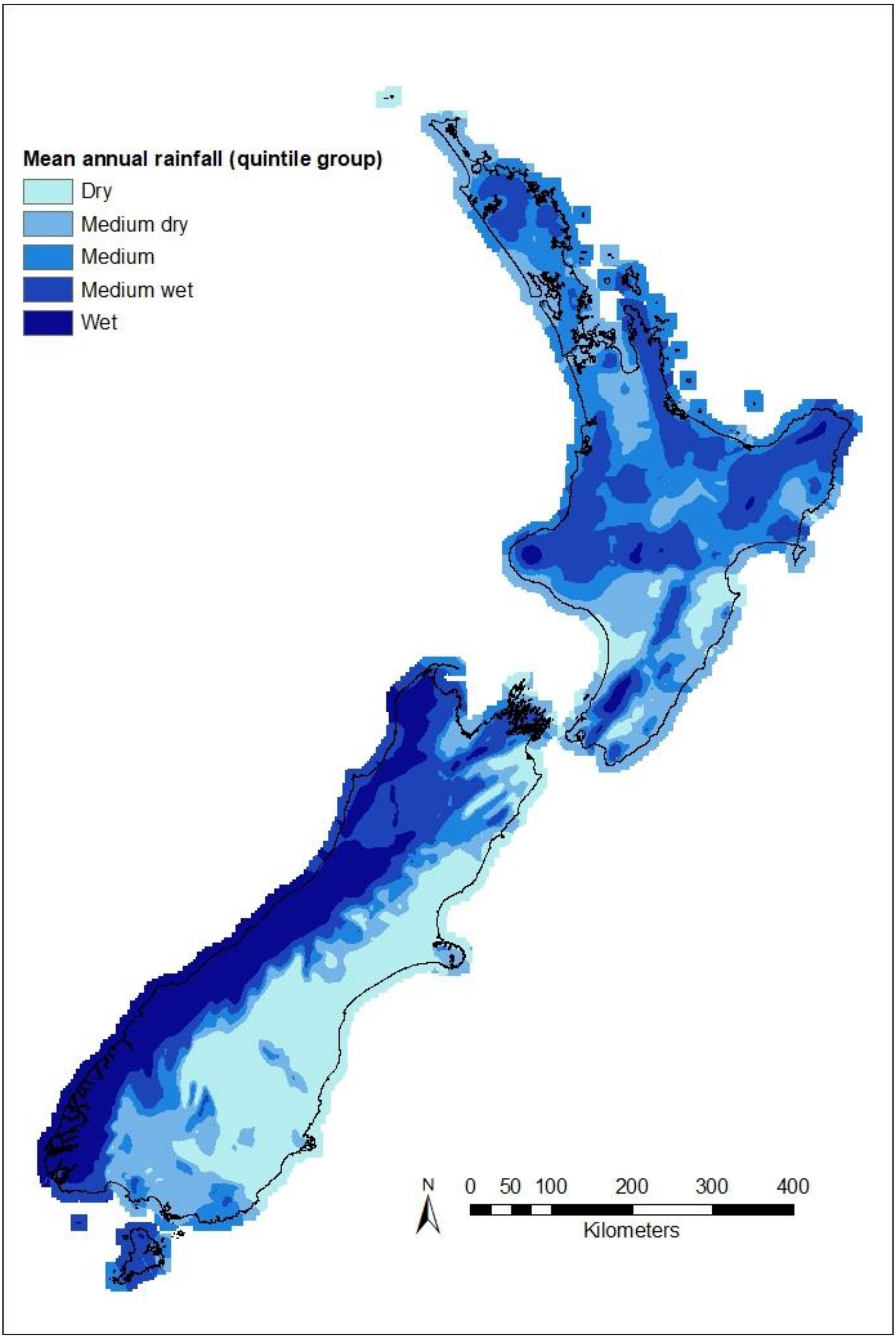

Figure 3-2: Mean annual rainfall grid resampled from NIWA's climate normals. Quintile breaks.

3.1.4 Land cover

The model was developed and calibrated for the current land cover. It was applied nationally for the current land cover and for two historical scenarios representing pre-human and pre-European land covers. These three land cover scenarios are mapped in Figure 3-3 to Figure 3-5, respectively.

The current land cover was taken from the Manaaki Whenua/Landcare Research Land Cover Data Base version 3 (LCDB3)[9] and relates to the reference year 2008. This was used in preference to LCDB4 (reference year 2012) simply because much of the sediment load data used for model calibration predates LCDB4 and it was considered appropriate to align the temporal representativeness of the load and land cover data as close as practicable for model development[10]. The LCDB3 land cover classes were grouped into six functional groups: *herbaceous* (i.e., grassland, pasture); *tussock and alpine herbaceous*; *trees/scrub* (i.e., all scrub, native and exotic forest); *water*; *other erodible* (all other land covers except urban) and *urban* (i.e., urban areas and transport infrastructure). Grouping was necessary to constrain the number of parameters to be solved in Equation (1) and because the calibration site catchments did not sample all LCDB landcover classes. The grouping largely followed the grouping used by Elliott et al. (2008)[11]. The groupings are listed in Table 3-3 along with the area they cover nationally. The classification of the LCDB3 classes into these groups is given in Appendix B.

While open water (e.g., lakes, rivers) is included as a land cover type in the current land cover scenario, no sediment contributions are calculated for water bodies.

The *urban* land cover functional group was assumed to have no sediment discharge. While urban land covers do generate sediment loads, the physical characteristics of urban sediments and their sources are different from those in rural areas and are highly variable (Driscoll et al. 1986; Duncan 1999; Roesner et al. 2007; Semadeni-Davies 2013). The main sources of urban sediments are soils, organic material (e.g., leaf fragments), litter and particles from road and tyre wear and tear, and the importance of these sources will vary with land use (e.g., residential, commercial, or industrial land). Sediment yields from urban soils are generally lower than rural soils due to compaction, the exception being earthworks during urban development, however consenting usually requires that sediment traps are in place before top-soil is removed. Sediment loads from impervious surfaces other than roads, such as roof and pavements, tend to be low. Urban stormwater treatment devices, where present, are often designed to target sediment removal to reduce the level of particulate contaminants such as heavy metals, which have an affinity with sediments. We also note that there is insufficient sediment load data from predominantly urban streams in the calibration dataset with which to calibrate an urban land cover coefficient. Moreover, Land Resource Inventory based data, such as erosion terrains, do not have data for urban areas. For these reasons, sediment loads from urban areas are not estimated by the model. Since urban land use covers less than 1% of the country's land area (Table 3-3), we expect that with the exception of primarily urbanised streams (e.g., Oakley Creek and Waitemata Harbour in Auckland), the sediment load delivered to major rivers and coastal systems from urban sources will be negligible compared to the total.

[9] Downloaded from https://koordinates.com/from/lris.scinfo.org.nz/layer/48304/ (date of last access 11 September 2018).
[10] The calibrated model runs across New Zealand, as reported in Section 5.1, were also based on LCDB3, but an alternative set of results could also be produced using LCDB4.
[11] Note that the empirical sediment yield estimator developed by Hicks et al. (2011) did not include an explicit land cover factor; instead, land cover was assumed to be implicitly included in the erosion terrain.

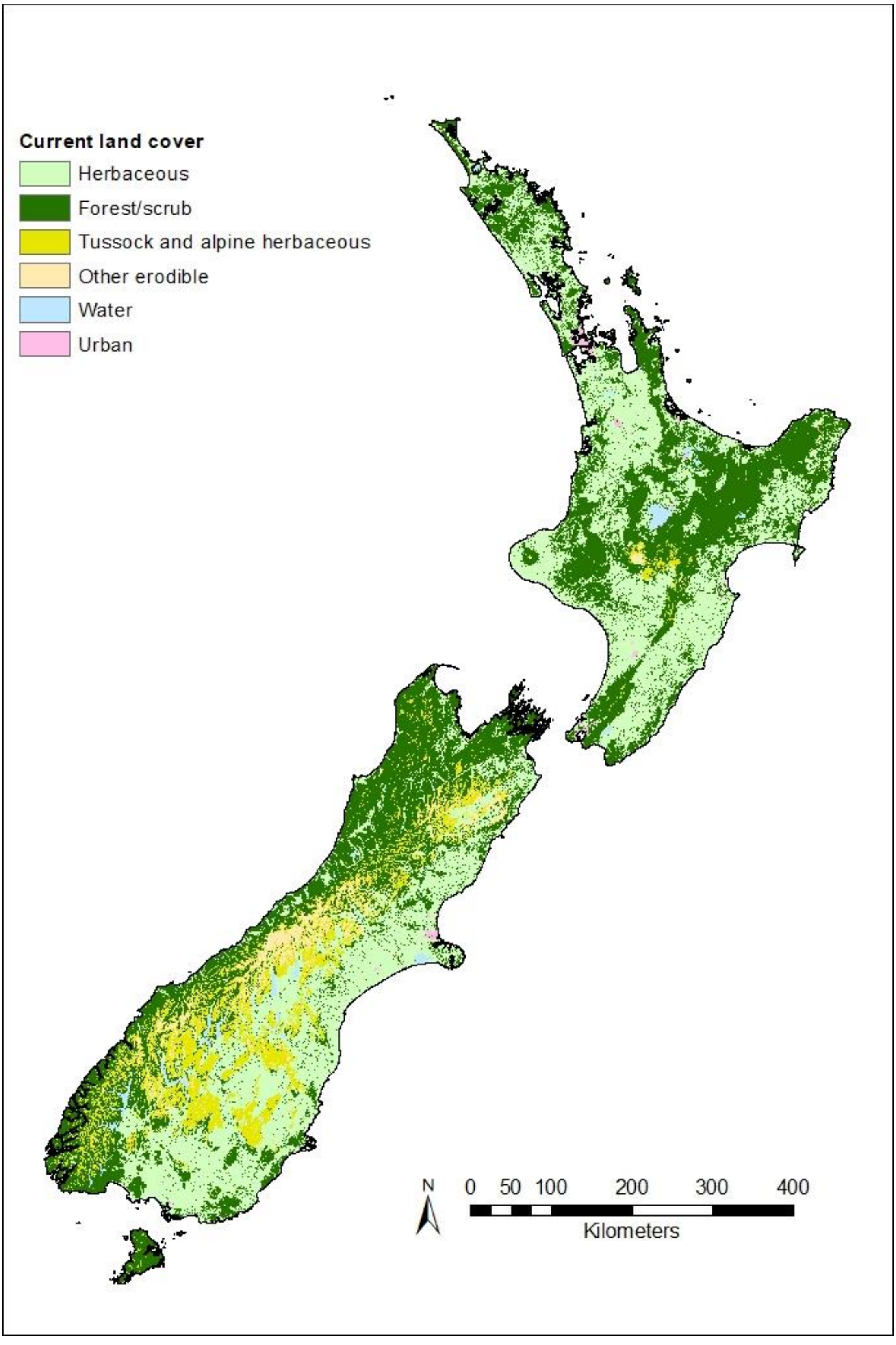

Figure 3-3: Land cover functional groups mapped for the current land cover scenario. Land cover derived from LCDB3.

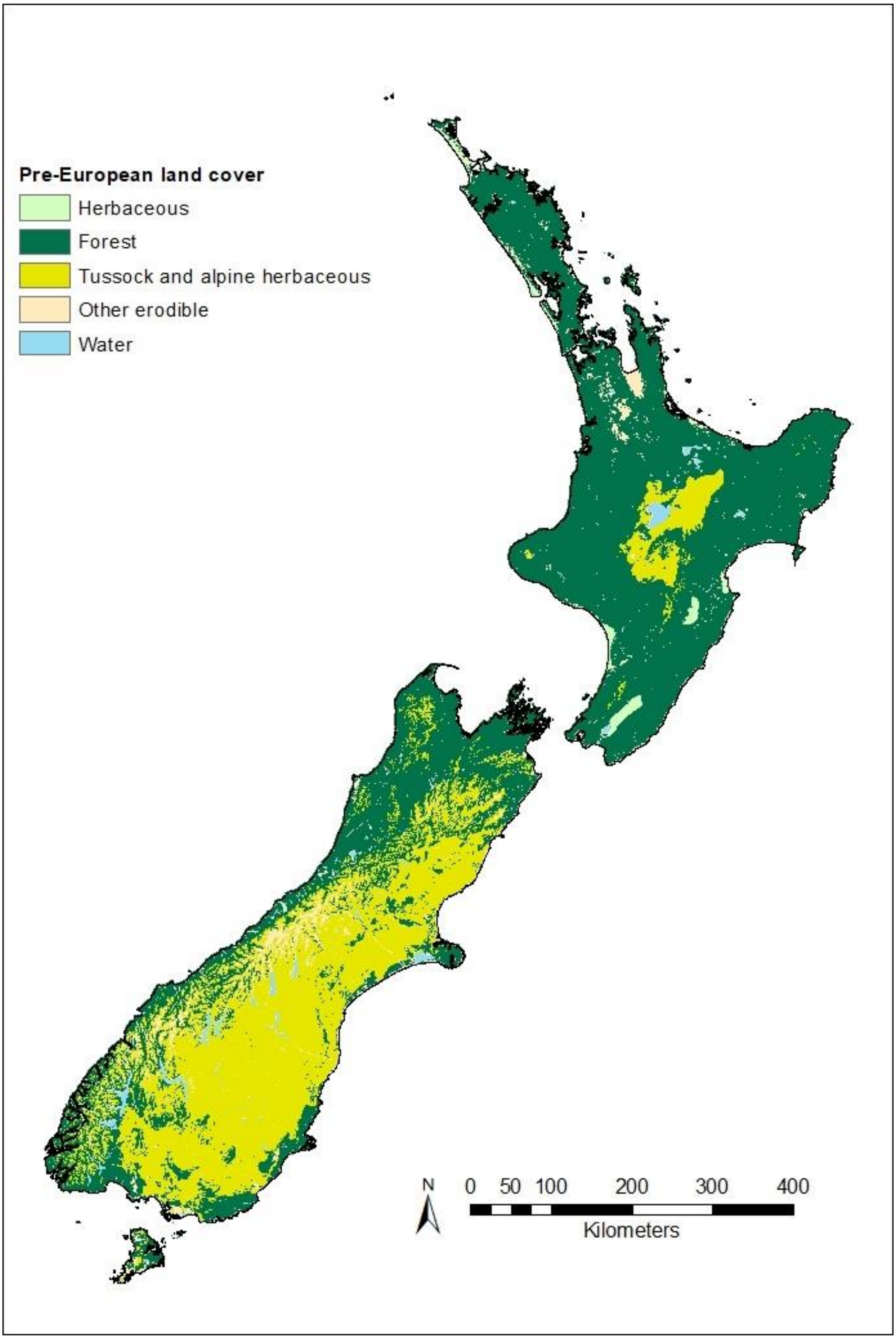

Figure 3-4: Land cover functional groups mapped for the pre-European land cover scenario.

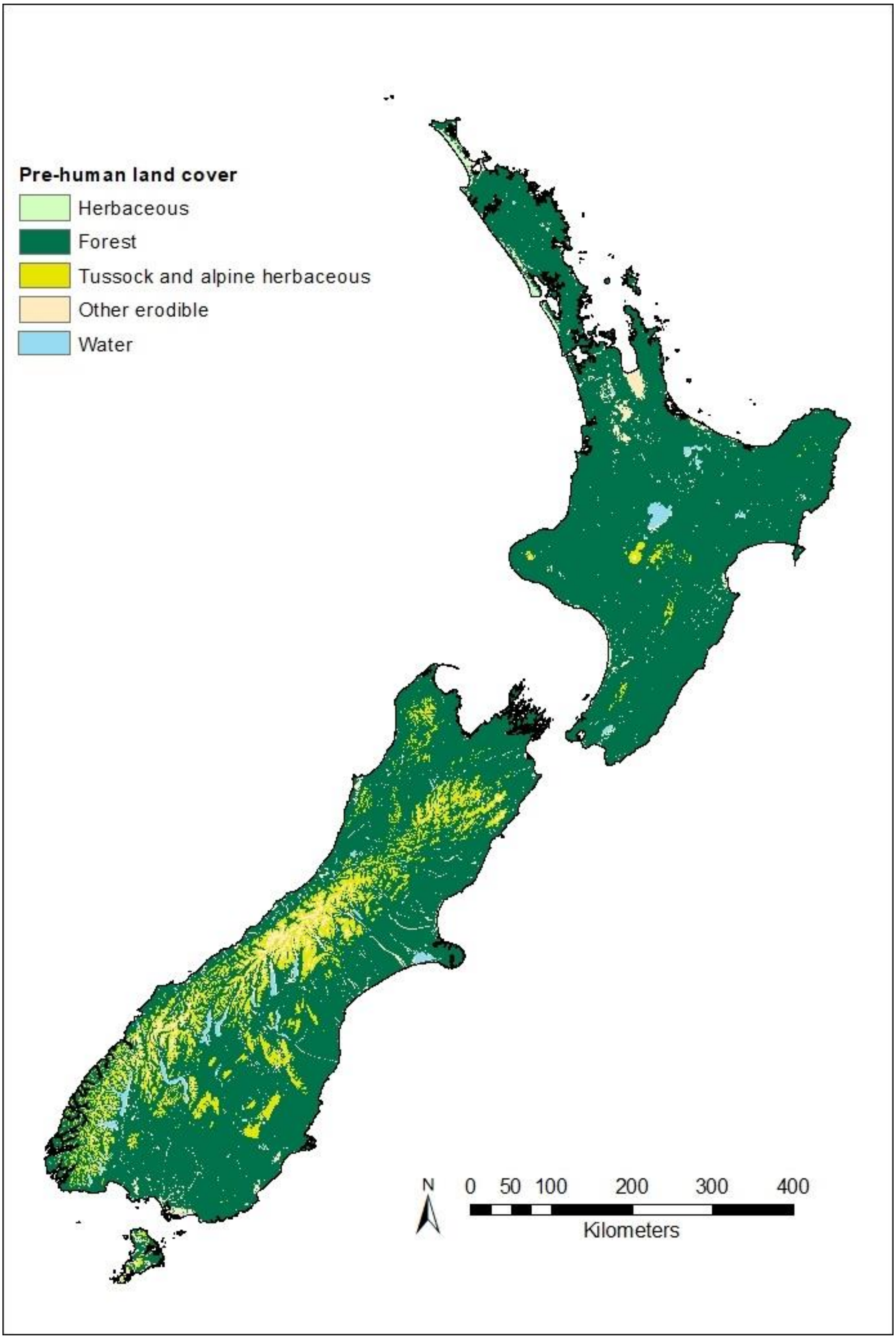

Figure 3-5: Land cover functional groups mapped for the pre-human land cover scenario.

Table 3-3: Land cover modelling functional groups and area covered nationally for the current and historical land cover scenarios.

Associated model parameter	Land cover	Total area covered nationally (km^2 and %) by scenario		
		Current	Pre-European	Pre-human
l_1	Herbaceous	110541 (41.8%)	2868 (1.1%)	1430 (0.5%)
l_2	Trees	110903 (41.9%)	156985 (59.4%)	223725 (84.6%)
l_3	Tussock/alpine	25776 (9.7%)	90421 (34.2%)	22750 (8.6%)
l_4	Other erodible	10388 (3.9%)	14194 (5.4%)	16563 (6.3%)
l_5	Water*	4728 (1.8%)	-	-
l_6	Urban	2133 (0.8%)	-	-

*Water was not included as a separate land cover in the historic scenarios.

3.1.5 Erosion terrains

Erosion terrains are used to represent lithology in the model and were downloaded from the Manaaki Whenua / Landcare Research Land Resources Information portal (https://lris.scinfo.org.nz)[12]. These are geomorphic classes describing susceptibility to erosion as determined from landform, rock type, slope and observed erosion activity (Dymond et al. 2010). The erosion terrains were updated by Manaaki Whenua/Landcare Research in 2015 to amalgamate unique classes for the North and South Islands into equivalent national classes, and therefore they differ somewhat from the earlier classifications used for previous sediment modelling (e.g., Hicks et al. 2011). In all, there are 93 erosion terrains nationally.

Similar to Hicks et al. (2011) and Elliott et al. (2008), the erosion terrains were aggregated for modelling into functional groups. These are listed in Table 3-4 and mapped in Figure 3-6. The grouping was undertaken to both reduce the number of model parameters and because some of the original erosion terrains are not well represented by the calibration sites. The match between the original and grouped erosion terrains is given in Appendix C. As with land cover, it is assumed that there is no sediment generation from cells classified as either *water* or *other* (including urban areas). During the course of model development, the *intensely gullied crushed argillites and greywacke* group was split into two sub-groups, with the East Cape area (from Bay of Plenty to Gisborne) having a group different from the rest of the country due to the high erodibility of this terrain in the East Cape area.

Erosion terrains were not mapped by Manaaki Whenua / Landcare Research for Stewart Island; herein, using personal knowledge of Stewart Island, we approximated that all of Stewart Island could be represented by the *coarse crystalline plutonics and metamorphics* group.

[12] Date of last access 25 September 2018, permission for download required.

Table 3-4: Erosion terrain functional groups used in the national sediment load model and total area covered nationally.

Associated model parameter	Erosion terrain group	Total area covered nationally (km^2 and %)
e_1	Sand country, flood plains, fans and terraces, peat	45407 (17.2%)
e_2	Tephra and loess	50893 (19.2%)
e_3	Tertiary mudstone, sandstone and soft limestone	37315 (14.1%)
e_4	Intensely gullied crushed argillite and greywacke	527 (0.2%)
e_5	East Cape - Intensely gullied crushed argillite and greywacke	2265 (0.9%)
e_6	Lavas, rhyolite, volcanic slopes	8424 (3.2%)
e_7	Greywacke, argillite and hard limestone	63337 (23.9%)
e_8	Schist and South Island greywacke (incl. alpine, ice and snow)	31683 (12%)
e_9	Coarse crystalline plutonics and metamorphics	16389 (6.2%)
e_{10}	Deeply weathered plutonics	468 (0.2%)
e_{11}*	Water	6106 (2.3%)
e_{12}*	Other	1655 (0.6%)

*Assumed no sediment generation in model.

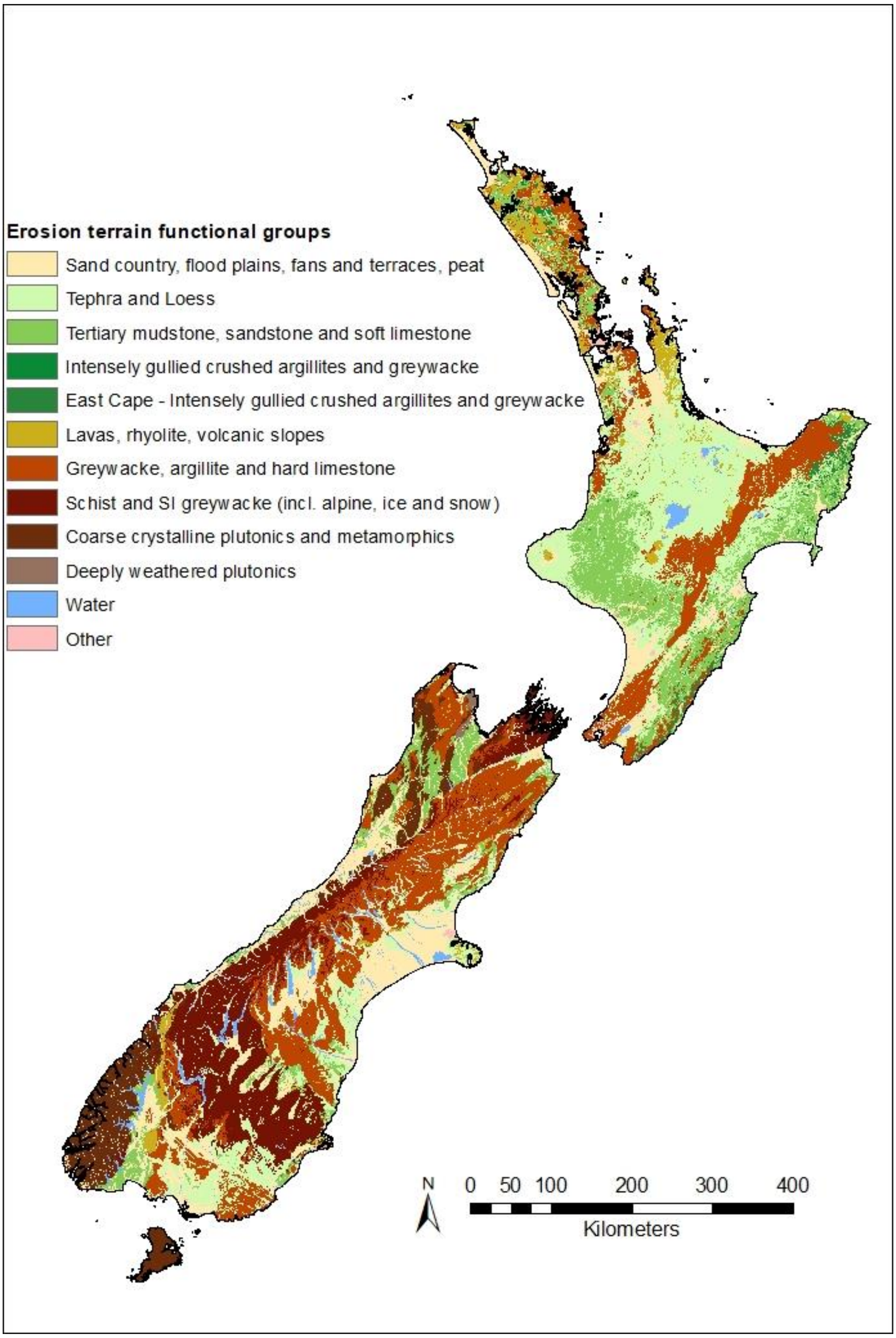

Figure 3-6: Erosion terrain functional groups.

3.2 Coastal hydrosystem / estuary trap efficiency model

The estuary trap efficiency model was developed from information in the database associated with the New Zealand coastal hydrosystem classification (NZCHS) (Hume et al. 2016), which distinguishes between different coastal water bodies. The NZCHS consists of 11 primary types, some of which contain subclasses (Table 3-5). The NZCHS spans a wide variety of systems from fresh to saline. Although some of these systems are essentially freshwater, in this report we often term all coastal hydrosystems ‘estuaries’ for simplicity and brevity.

The report by Hume et al. (2016) classifies 500 estuaries, of which 445 are contained in the Coastal Explorer database (Hume et al. 2007). The information provided for the additional 55 estuaries excludes information required for the model, such as tidal prism, surface area, and intertidal area. Moreover, some of the estuaries in Coastal Explorer are on islands that are not covered by the REC2 digital stream network (notably Chatham Island and Stewart Island). This report, therefore, considers only the 399 estuaries that are contained in the Coastal Explorer database and are covered by the REC2 digital network.

In preparing this report, the classifications of eight estuaries were changed from those suggested by Hume et al. (2016) based on a combination of results from the deposition model, data in Coastal Explorer, and inspection of satellite imagery. We found that some estuaries could fit within more than one classification and some degree of interpretation is required to classify a system. It is also possible that estuary types change over time. The reclassified estuaries are listed in Appendix J.

This reclassification would have had some small effect on the results for three of the reclassified estuaries. This is because the deposition model assumes that there is no main channel re-entrainment for the shallow drowned valley, deep drowned valley, fiord, and coastal embayment estuary types (since these are deep systems where near-bed velocities are low, little resuspension by currents occurs, and a main channel morphology tends to be absent). This would have resulted in slightly higher deposition if an estuary was reclassified to one of those types (as listed in Table J-1, two were reclassified to the shallow drowned valley type while one was reclassified from that type). The impact of these reclassifications (to what we believe are more appropriate classifications) on the summary results by estuary type would have been very small.

Sediment loads to each estuary were accumulated from the modelled loads to the terminal reaches in the REC2 network. The terminal reaches that connected to each estuary were identified manually by overlaying estuary shapefiles from Coastal Explorer on the REC2 network.

Table 3-5: Summary of New Zealand coastal hydrosystem types. For most figures and analysis in this report, we use the primary coastal hydrosystem types. Adapted from Hume et al. (2016).

Symbol	Primary coastal hydrosystem	Subclass
1	Damp sand plain lake	
2A	Waituna-type lagoon	Coastal plain depression
2B		Valley basin
3A	Hapua-type lagoon	Large
3B		Medium
3C		Small
3D		Intermittent
4A	Beach stream	Hillside stream
4B		Damp sand plain stream
4C		Stream with pond
4D		Stream with ribbon lagoon
4E		Intermittent stream with ribbon lagoon
5A	Freshwater river mouth	Unrestricted
5B		Deltaic
5C		Barrier beach enclosed
6A	Tidal river mouth	Unrestricted
6B		Spit enclosed
6C		Barrier beach enclosed
6D		Intermittent with ribbon lagoon
6E		Deltaic
7A	Tidal lagoon	Permanently open
7B		Intermittently closed
8	Shallow drowned valley	
9	Deep drowned valley	
10	Fjord	
11	Coastal embayment	

4 River sediment load model calibration

The model was calibrated against mean annual sediment loads from 273 suspended sediment monitoring sites located across the country. The model was first calibrated nationally to obtain global model parameters. The estimated loads were then adjusted regionally to account for regional biases in the national calibration.

4.1 Calibration data

4.1.1 Data sources and method of load determination

The dataset of measured stream sediment loads at the 273 sites used to calibrate the model (Appendix C) was derived from three sources: (i) the Hicks et al. (2011) dataset, (ii) loads that NIWA has calculated over the past two decades for regional councils and other clients, and (iii) loads calculated for this study from a sediment rating dataset that was compiled for MfE by Hicks et al. (2016). The latter included the 2011 dataset plus new data for some of the sites analysed by Hicks et al. (2011), which provided updated load estimates for those sites, and data from more sites, including data collected by regional councils mainly for Water Quality monitoring programmes. We consider that this pooled dataset should have captured most of the suspended load estimates determined around New Zealand over recent decades.

The Hicks et al. (2011) sediment load dataset was largely derived using sediment rating curves fitted to sediment 'gauging' data – that is, measurements of the cross-section averaged suspended load sampled using depth-integrating samplers at multiple stations across the channel. The loads calculated for other clients used a variety of approaches including rating curves, event sediment rating curves (i.e., relationships between sediment load and water discharge at the runoff-event scale, rather than relationships derived using near-instantaneous measurements, which is more typical for sediment rating curves), semi-continuous flow-proportional water-sampling using automatic samplers, and combining time-series records of suspended sediment concentration (SSC) proxied by turbidity monitoring with water discharge records. Further details of the data collection and load calculation methods are provided in the references listed in Appendix C.

As done by Hicks et al. (2011), we used NIWA's SEDRATE toolbox for fitting rating curves to the updated sediment rating dataset, for calculating mean annual sediment loads from the rating curves and flow duration tables, and to evaluate the reliability of the calculated load. In most cases, the discharge records used to calculate the mean annual sediment load from the sediment ratings span several decades but in some cases the records cover only a few years. The sediment gaugings were typically scattered across the duration of the flow record but in some cases the gaugings were clustered in time. Before fitting sediment ratings, sites were triaged, generally filtering out those that did not meet the following considerations:

- a nearby discharge record
- the number of datapoints on the rating (generally > 5) and the % of variance in SSC explained (typically $r^2 \geq 0.4$);
- the standard factorial error on the load assessed (≤ 2);
- adequate flood sampling (maximum sampled discharge ≥ half the mean annual flood discharge);

- concerns with reliability of the sediment concentration analysis; and
- the portion of the load derived from an extrapolated sediment rating (≤ 50% of the load carried by discharges exceeding the maximum sampled discharge).

Many of the sites in the Hicks et al. (2016) dataset that were not already in the 2011 dataset were discarded because: samples were typically grab-sampled at a single point in the cross-section (without any information on the relationship between the SSC at the sampling point and the cross-section averaged SSC) and mainly at base flows (without any focussed event-sampling, which is when most of the sediment load is transported); samples had their SSC analysed by the Total Suspended Solids laboratory procedure (which involves analysing only an aliquot from the field sample and typically results in erratic or under-represented SSC when suspended sand is present); and a nearby discharge record was often lacking. In contrast, the new sites in the Hicks et al. (2016) dataset that were retained typically had event-focussed sampling strategies, with SSC values based either on multi-vertical, depth-integrated gaugings or automatic sampling adjusted for the point SSC to cross-section average SSC relationship.

The dataset used is a composite of past and present national networks, regional networks, hydro-power company networks, and miscellaneous individual site studies. There is currently no national suspended sediment monitoring network but most regional councils (notably Horizons, Environment Waikato, Environment Southland, Auckland Council, and Greater Wellington) now operate their own network of sites where the focus is on measuring suspended sediment loads during runoff events, typically either by using auto-samplers, turbidity sensors, or both. A common motivation is to determine long-term average load, but there is also interest in annual loads and event loads (e.g., see Hicks 2018, Hicks and Hoyle 2012). It is anticipated that these existing regional council networks will standardise their data acquisition and load calculation methods to those detailed in the soon-to-be-released National Environmental Monitoring Standard (NEMS) for river suspended sediment load (Hicks 2019).

4.1.2 Temporal variability

As detailed in Appendix D, the sediment data collection periods of the calibration sites vary, ranging from 1957 through to 2015, with much collected during the 1960s to 1990s. This broad timespan inevitably captures some variability/change in climate and change in catchment land cover, which will add uncertainty to the model's predictions of contemporary sediment load. We have attempted to mitigate this in several ways: (i) by using the most up-to-date estimates of sediment load where revised estimates were available (e.g., across the Horizons Manawatu region we have used the estimates of Hicks and Hoyle 2012, based on Horizons' current turbidity monitoring network, instead of the sediment rating derived estimates from Hicks et al. 2011); (ii) by using the 30-year-averaged 1981-2010 rainfall normal maps; and (iii) by using the 2008-released LCDB3 land cover layer as more representative of the calibration dataset than more recent releases. In this context, future model runs could be 'driven' with updated land cover and mean annual rainfall layers.

4.1.3 Site spatial distribution and load variability

The calibration sites and their catchments are mapped in Figure 4-1. Of the 273 calibration sites, 181 are in the North Island and 92 are in the South Island. The total upstream area for these sites covers 49% (56,285 km^2) and 35% (52,666 km^2) of the land area for the North and South Islands respectively, providing 41% coverage nationally. The upstream catchment area for the sites varies between 29 ha and 6,621 km^2 (mean = 588 km^2, median = 1,897 km^2)[13].

Figure 4-1 shows that while the monitoring sites are spread across the country, the sites are not evenly distributed spatially, with the regional distribution varying markedly (Table 4-1). This has implications for the national calibration, warning of the need for regional modification as discussed in Section 4.2.4. Waikato has the greatest number of monitoring sites (54), while Marlborough has only three sites.

Most of the calibration sites are located on medium to high order streams (only 30% of sites are located on a stream with an order of three or less). Moreover, over half (159) of the sites are located more than 50 km from the coast, and only 49 of the sites are within 10 km of the coast. Thus, taken together with upstream area, the sites are largely representative of inland reaches of medium to large river networks. However, this distribution of sites is not expected to significantly bias model-predicted sediment delivery to estuaries, since – as the resulting sediment yield grid (Figure 5-1) demonstrates – the bulk of the coastal sediment delivery is sourced from inland areas.

The observed loads (Figure 4-2) are highly variable and range over seven orders of magnitude. The lowest observed load was for the Purukohokohu Stream at Puruki Flume site (4.4 t/y), and the maximum observed load was for the Waiapu River at Rotokautuku (31,220,000 t/y). The median load for all calibration catchments is 42,475 t/y. This variation is driven partly by catchment size and partly by sediment specific yield (load per unit catchment area). The specific yield varies from 1.5 to 37,374 t/km^2/y (Waipaoa at Waipaoa Station), while the median specific yield is 146.3 t/km^2/y.

Table 4-1: Number of calibration sites by region and stream order.

Region	1-3	4-5	>6	Regional total
Northland	2	2	2	6
Auckland	8	7		15
Waikato	5	38	11	54
Bay of Plenty	9	12	7	28
Gisborne		11	7	18
Hawke's Bay		7	9	16
Taranaki	2	1	1	4
Manawatu-Whanganui	1	14	12	27
Wellington	2	6	5	13
Tasman-Nelson	2	11	6	19
Marlborough		2	1	3
West Coast	4	4	11	19
Canterbury	3	13	8	24
Otago	1	5	8	14
Southland	2	6	5	13
National	**41**	**139**	**93**	**273**

[13] Three sites (Nancy Sound, Long Sound and Thompson-Bradshaw Sound) are in fjords, and the catchment area for these was determined by aggregating the catchment areas for all the streams draining into each fjord.

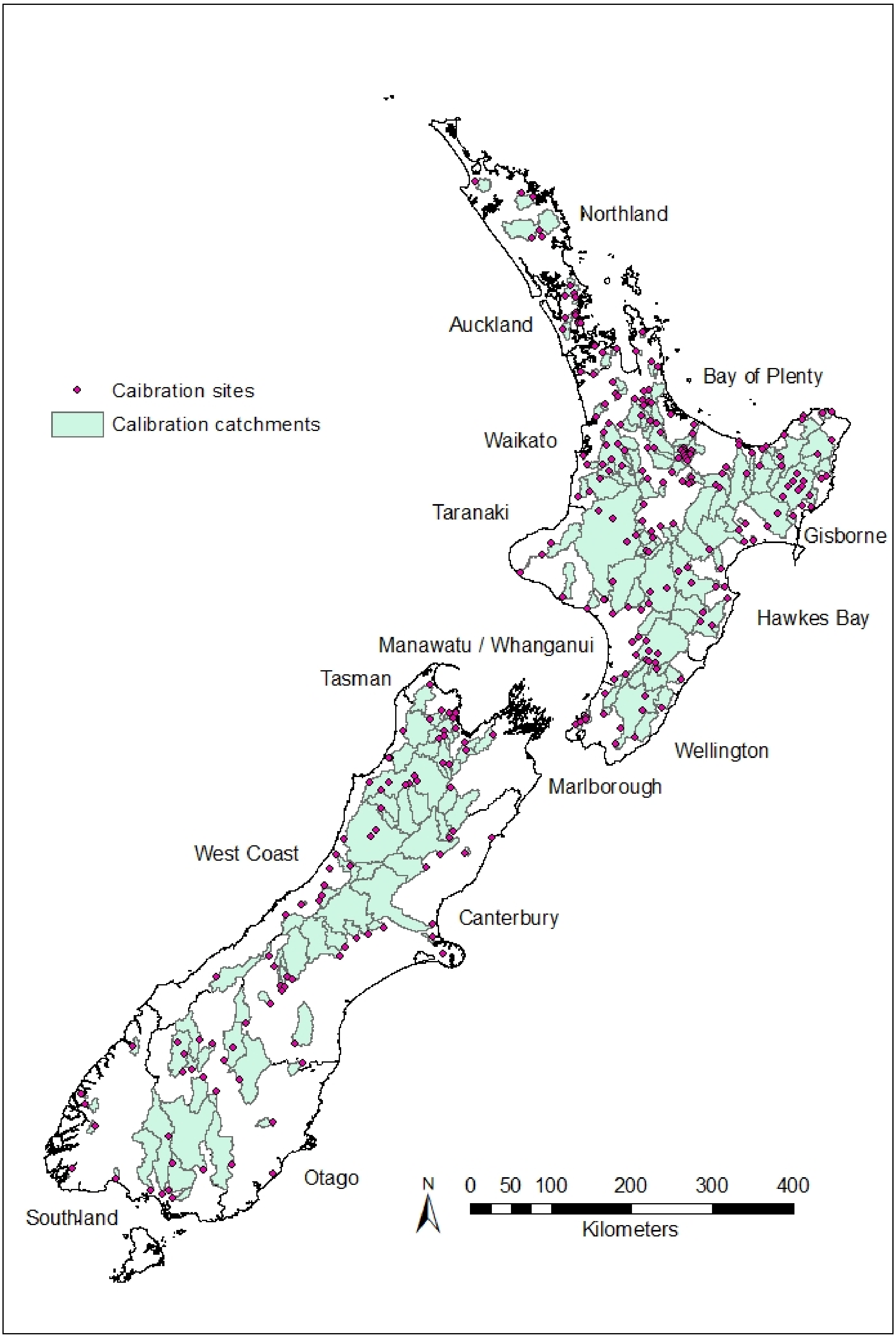

Figure 4-1: Calibration site locations and catchments.

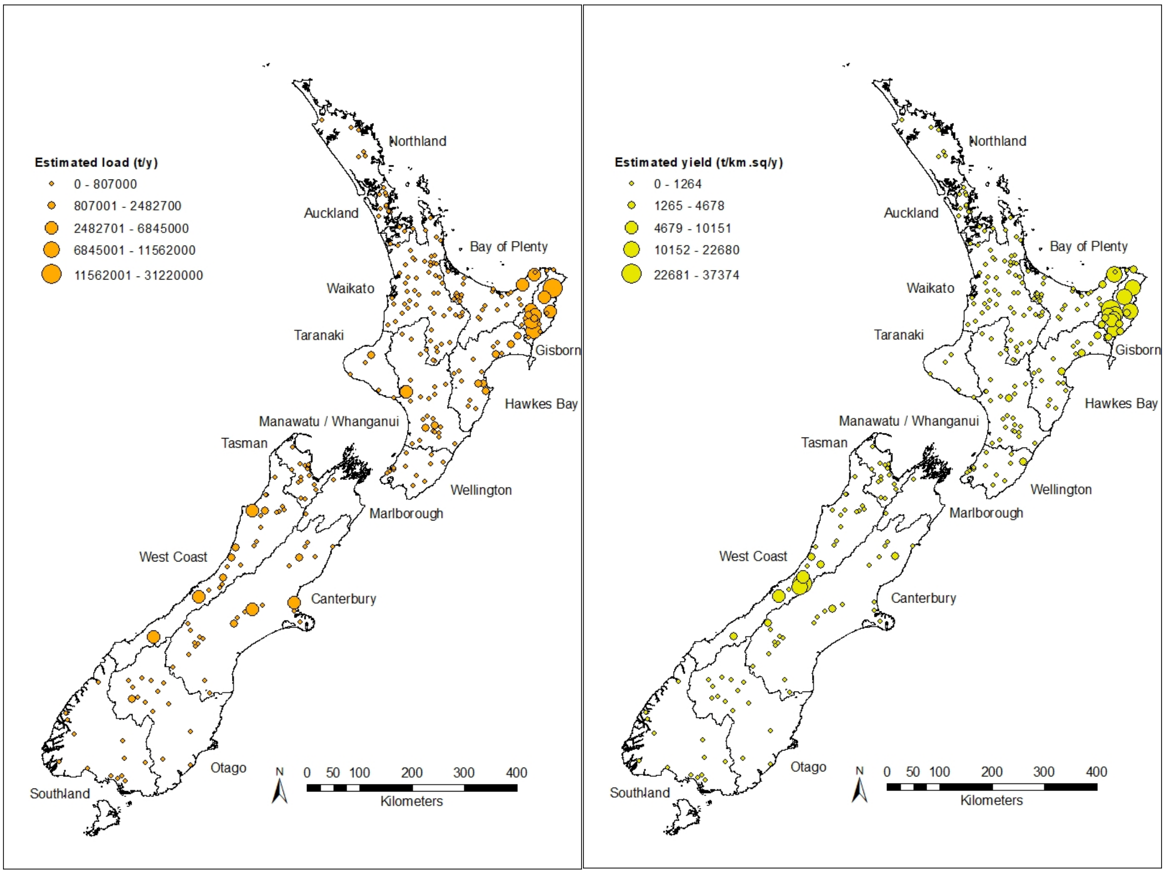

Figure 4-2: Loads and specific yields observed at model calibration sites by region. Left – load (t/y); right – specific yield (t/km^2/y). Symbol-ranges are set using the Jenks natural breaks distribution.

4.1.4 Representativeness of calibration sites

In this section here, we investigate how well the calibration sites capture the range of model input data.

The proportion of the upstream catchment covered by each class (or class-group) of input data was determined for each site from the rasterised data; these proportions are listed in Appendix E. Table 4-2 to Table 4-5 provide for each input dataset the following summaries:

- the number of sites with the data class present upstream;
- the number of sites dominated by the data class, i.e., with an upstream percentage cover of 50% or greater;
- the maximum percentage coverage for each data class (or group) for any site; and
- the mean percentage of coverage for all sites where the data class is present.

Table 4-2 shows that while all the slope classes are represented by the calibration sites, the steeper slope classes are less well represented than are the flat to rolling landscapes. Table 4-3 shows that the sites represent the range of annual rainfalls in New Zealand fairly evenly. Table 4-4 shows that the sites are representative of both *herbaceous* and *forested* land covers for the current land cover scenario used for calibration. *Tussock*, which has a restricted distribution and covers less than 10% of the total land area nationally, is not as well represented by the calibration data. The *Other erodible* group contains a number of land covers that have variable sediment yields. While most of the sites have some of these land covers in their catchments, the percentage cover is fairly low so that they are unlikely to have a significant impact on the sediment loads at the catchment scale.

While all the erosion terrain groups are represented by the calibration sites (Table 4-5), several of the terrain groups are not well represented – which largely reflects their restricted spatial distribution. For example, the *coarse crystalline plutonics* erosion terrain group is mainly located in Fiordland and the West Coast, and the *deeply weathered plutonics* group covers only 466 km^2 nationally.

Table 4-2: Upstream representation: slope.

Slope class	Number of sites with class upstream	Number of sites dominated by class	Maximum coverage (%)	Mean upstream coverage (%)
Flat	272	18	100	17
Undulating	273	0	40	15
Rolling	272	5	61	23
Strongly rolling	271	0	31	13
Moderately steep	268	0	28	10
Steep	255	0	46	16
Very steep	215	0	28	7
Precipitous	138	0	45	4

Table 4-3: Upstream representation: mean annual rainfall.

Rain class (quintiles)	Number of sites with class upstream	Number of sites dominated by class	Maximum coverage (%)	Mean upstream coverage (%)
Dry (<938 mm/y)	47	18	100	41
Medium dry (939 – 1236 mm/y)	119	36	100	38
Medium (1237 – 1555 mm/y)	184	59	100	40
Medium wet (1556 – 2889 mm/y)	175	75	100	47
Wet (>2890 mm/y)	112	47	100	49

Table 4-4: Upstream representation: current land cover.

Land cover	Number of sites with group upstream	Number of sites dominated by group	Maximum coverage (%)	Mean upstream coverage (%)
Herbaceous	263	106	99	40
Trees	272	124	100	49
Tussock/alpine	120	7	74	19
Other erodible	158	2	80	6
Water	155	0	12	1
Urban	115	0	46	2

Table 4-5: Upstream representation: erosion terrain.

Erosion terrain	Number of sites with group upstream	Number of sites dominated by group	Maximum coverage (%)	Mean upstream coverage (%)
Sand country, flood plains, fans and terraces, peat	226	3	99	10
Tephra and Loess	208	67	100	38
Tertiary mudstone, sandstone and soft limestone	149	31	100	29
Intensely gullied crushed argillites and greywacke	17	0	7	1
East Cape - Intensely gullied crushed argillites and greywacke	37	1	52	10
Lavas, rhyolite, volcanic slopes	82	9	95	15
Greywacke, argillite and hard limestone	196	65	100	38
Schist and South Island greywacke (including. alpine, ice and snow)	59	19	100	36
Coarse crystalline plutonics and metamorphics	36	7	98	32
Deeply weathered plutonics	6	2	99	36
Other (including water and urban)	74	0	14	2

4.2 Model fitting

Model fitting was done using a two-step process. First, a national calibration was undertaken to determine the global values of the parameter coefficients for Equation (1). Second, after maps of residuals from the global model showed patches of regional bias and acknowledging the heterogenous distribution of both the monitoring sites and the input data, the sediment yields modelled using the global parameters were then modified for some regions to improve the model fit.

4.2.1 National calibration method

The global calibration seeks to minimise the root-mean-square-error calculated for the residuals between the natural logs of the observed and modelled loads (log-*RMSE*). The calibration uses log-transformed loads to reduce the skew due to the variation in loads. The log-*RMSE* represents the standard deviation of the residuals around the 1:1 line. *RMSE* is used as a standard statistical metric to measure model performance in many fields, including meteorology, air quality, climate research and agriculture, and assumes the errors are unbiased and follow a normal distribution (Moriasi, Arnold et al. 2007; Chai and Draxler 2014). Here, the log-*RMSE* is calculated as:

$$\ln(RMSE) = \sqrt{\frac{\sum_{\mathrm{k=1}}^{\mathrm{n}}\left(\ln(L_{k}) - \ln(L_{ks})\right)^{2}}{n}} \tag{5}$$

where n is the number of monitoring sites and L_k and L_{ks} are the observed and predicted loads respectively from the catchments above the monitoring sites[14].

In all, 13 parameters were calibrated[15]. The initial ranges of coefficients for the erosion terrains were selected from the sediment load predictor developed by Elliott et al. (2008) using the 10% and 90% confidence intervals of the final model coefficients. The ranges for slope and rainfall exponents were selected from the values obtained from several previous models, including the Elliott et al. (2008) and Hicks et al. (2011) sediment yield/load predictors. The range for the *trees/scrub* land cover group coefficient contained the Elliot et al. (2008) 10-90% confidence interval and the 0.1 value assumed by Dymond et al. (2010). The coefficient ranges for the *tussock* and *other erodible* land cover groups were based on subjective comparison with the *trees/scrub* and *herbaceous* groups and were purposely set broad to allow for this subjectivity. The ranges of the initial coefficients are listed in Table 4-6. The Markov Chain Monte Carlo (MCMC) algorithm (Metroplis et al. 1953) was used with 25,000 iterations to narrow the range of the initial coefficient values. The final calibration was undertaken in the Shuffled Complex Evolution - University of Arizona (SCEUA) algorithm (Duan et al. 1994) as part of the SPOTPY calibration library. The SCEUA is a robust, machine learning, global optimisation method widely used for calibrating hydrological models. The SCEUA optimisation, with 11,600 iterations, was deployed to find the optimum coefficient values. Figure 4-3 shows, for example, how the value of the l_2 coefficient for the *trees/shrubs* land cover group was progressively refined to a final value of 0.466 using the SCEUA routine. Both the MCMC and SCEUA routines were undertaken in Python using the SPOTPY calibration library (Houska et al. 2015)[16].

Table 4-6: Initial range and calibrated values of model coefficients.

Parameter		Description	Range	Calibrated value	Type
a		Base coefficient	0 – 50	10.039	Calibrated
c_{rain}		Rain coefficient	1 – 2.3	1.311	Calibrated
c_{slope}		Slope coefficient	0 – 1	0.755	Calibrated
Erosion terrain parameters	e_1	Sand country, floodplains, fans, terraces, peat	0.49 – 2.05	0.816	Calibrated
	e_2	Tephra and Loess	0.32 – 0.59	0.500	Calibrated
	e_3	Tertiary mudstone, sandstone and soft limestone	3.21 – 6.43	3.232	Calibrated
	e_4	Intensely gullied crushed argillites and greywacke	3 – 6.5	3.693	Calibrated
	e_5	East Cape - Intensely gullied crushed argillites and greywacke	164.2 – 369.6	202.380	Calibrated
	e_6	Lavas, rhyolite, volcanic slopes	0.15 – 0.99	0.407	Calibrated
	e_7*	Greywacke, argillite and hard limestone	–	1.000	Reference

[14] Note that $\ln(L_k) - \ln(L_{ks}) = \ln(L_k/L_{ks})$, thus the RMSE from Equation (4) is also the RMSE of the logs of the ratios of the observed to predicted loads.
[15] Note that the *herbaceous* land cover and the *greywacke, argillite and hard limestone* erosion terrain were used as reference parameters in the model and were assigned a value of 1.0. That is, the other land cover and erosion terrain parameters are effectively scalars of these reference values.
[16] http://fb09-pasig.umwelt.uni-giessen.de/spotpy/Tutorial/8-Algorithm_guide/ (date of last access 13 September 2018)

Parameter		Description	Range	Calibrated value	Type
Land cover parameters	e_8	Schist and SI greywacke (incl. alpine_ ice and snow)	0.84 – 2.0	1.450	Calibrated
	e_9	Coarse crystalline plutonics and metamorphics	0 – 0.16	0.061	Calibrated
	e_{10}	Deeply weathered plutonics	4.5 – 31.4	2.760	Calibrated
	e_{11}	Water	–	0.000	No sediment yield
	e_{12}	Other (undefined, urban)	–	0.000	No sediment yield
	l_1*	Herbaceous	–	1.000	Reference
	l_2	Trees / scrub	0.1 – 0.5	0.466	Calibrated
	l_3	Tussock and alpine herbaceous	0.5 – 3.0	0.512	Calibrated
	l_4	Other erodible	0.1 – 2	1.213	Calibrated
	l_5	Water	–	0.000	No sediment yield
	l_6	Urban	–	0.000	No sediment yield

*Pre-set reference values, other coefficients in each parameter class are scalars of these values respectively.

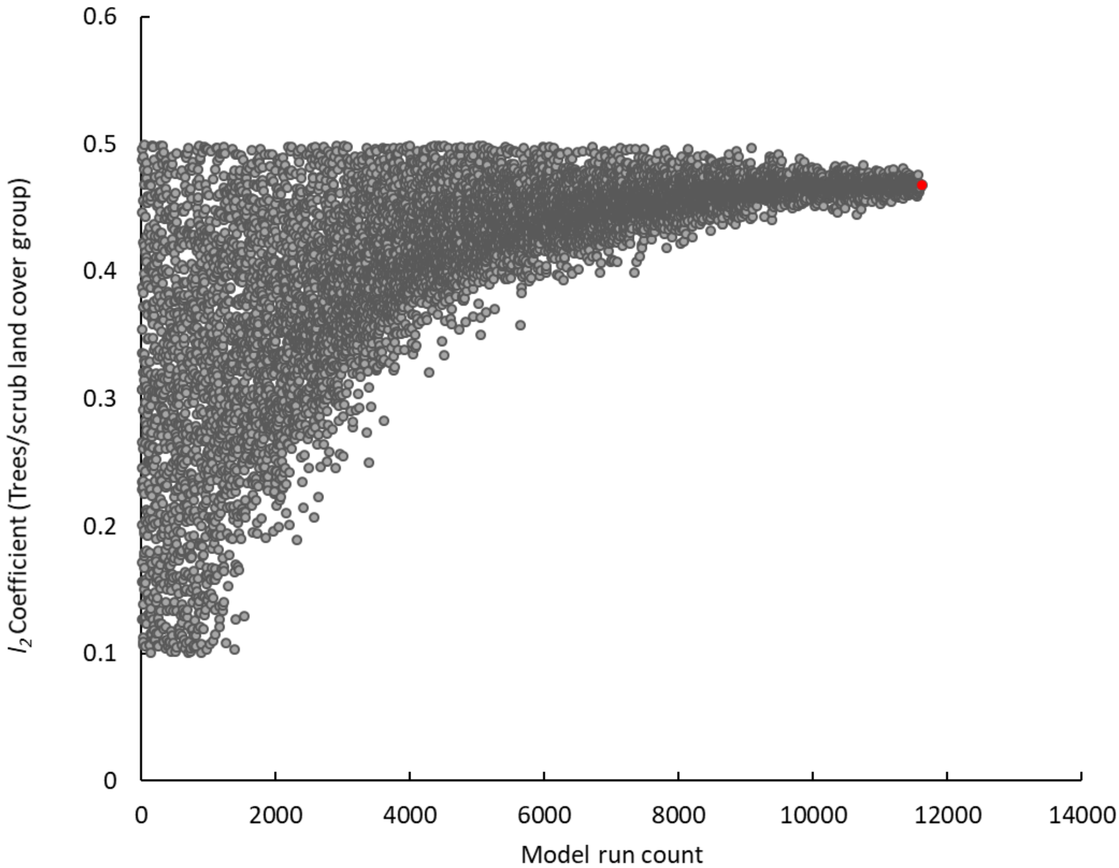

Figure 4-3: Sensitivity of *trees/scrub* land cover group coefficient (l_2) through SCEUA model runs. After 11,600 iterations the value for the *trees/scrub* coefficient converged on 0.466 (shown with red circle).

4.2.2 Model performance metrics

In addition to the log-RMSE, three other performance metrics were used to quantify correspondence between observed and modelled sediment loads for the calibration catchments, however, they were not used as objective functions in the optimization[17]. These were calculated both for the calculated loads and for the log-transformed loads and are:

- Sum of squares of the relative error (*SSRE*): this is the sum of the squared relative differences between each pair of observed and modelled loads:

$$SSRE = \sum_{k=1}^{n} \left[\frac{L_k - L_{ks}}{L_{ks}}\right]^2 \tag{6}$$

  The variables in Equation (6) are the same as those in Equation (5). The SSRE provides another measure of model accuracy. A value of 0 indicates that the modelled and observed values are identical.

- Nash-Sutcliffe efficiency (*NSE*): the *NSE* is commonly used to assess the fit of hydrological models (Krause et al. 2005; Moriasi et al. 2007) and is a normalised statistic that determines the relative variance of the model residuals compared to the variance of the observed data. It also indicates how well the plot of observed versus modelled load fits the 1:1 line. The value ranges from -infinity to one. An *NSE* of one indicates that the modelled and observed values are the same, whereas an *NSE* of zero indicates that the modelled values are only as accurate as the mean of the observed values. A value > 0.5 indicates that the model performance is satisfactory (Moriasi et al. 2007). A negative *NSE* means that the mean of the observed values is a better predictor than the model. The *NSE* is calculated as:

$$NSE = 1 - \frac{\sum_{k=1}^{n} (\boldsymbol{L_k} - \boldsymbol{L_{ks}})^2}{\sum_{k=1}^{n} (\boldsymbol{L_k} - \overline{\boldsymbol{L_k}})^2} \tag{7}$$

  where $\overline{\boldsymbol{L_k}}$ is the mean of the observed loads.

- Percent bias (*PBIAS*): this measures the average tendency of the modelled loads to be larger or smaller than their observed counterparts. This is the ratio of the sum of the model residuals (i.e., observed – modelled) to the sum of the observed loads:

$$PBIAS = \frac{\sum_{k=1}^{n} (L_k - L_{ks})}{\sum_{k=1}^{n} L_k} \times 100 \tag{8}$$

  A *PBIAS* value less than zero indicates a tendency of the model to overestimate; a value greater than zero indicates a tendency to under estimate; a value of zero indicates no bias.

[17] Cross-validation approaches to assess model performance (e.g., by calibrating the model many times by leaving individual or groups of calibration sites out at a time and then computing statistics around the calibration results) were not done because of run-time constraints. For example, each model calibration run required approximately two days of computing time, thus a "leave-one-out" approach using the 273 calibration sites would have required over a year of run-time. Instead, the strategy was to rate model performance off metrics of modelled vs observed loads.

4.2.3 National calibration results

The calibrated global coefficients for the model are listed in Table 4-6. These appear sensible. For example:

- the calibrated c_{rain} exponent on mean annual rainfall (1.31) closely matches the average exponent *b* (1.30) in Klik et al.'s (2015) analysis of the relation between rain erosivity and mean annual rainfall (Section 3.1.3);
- there is a positive, near-linear relationship with slope;
- the *trees/scrub* and *tussock/alpine herbaceous* land cover coefficients are both approximately half those of pasture (signalling approximately twice the sediment load from pasture catchments, other factors being equal), while loads from the *other* land cover group (which includes bare rock and scree) are higher than from pasture; and
- the erosion terrain coefficients generally get smaller as the rock-type hardens – with the highest coefficients (and loads) associated with the intensely sheared and gullied argilltes and greywackes from the East Cape region.

It is of note that the 47% ratio of yield from trees/scrub relative to yield from pasture is higher than reported in some previous New Zealand empirical yield models that include the influence of land cover (e.g., Elliott et al. 2008 derived a forest/pasture ratio of 28%, while Dymond et al. 2010 simply assumed a ratio of 10% in their NZEEM model). However, it is also lower than the 64% (for native forest) and 88% (for exotic forest) coefficient ratios derived by Haddadchi and Hicks (2016; WANSY2C model), using a similar modelling approach to this one, for the Waikato-Auckland-Northland region. Moreover, the 47% ratio is within the range of measured differences in sediment yield from studies of paired catchments with either pasture or exotic forest land cover (e.g., Hicks 1990 found from 14 catchments established in pasture or exotic forest that the specific yields from the forest catchments were between 22% and 63% of those from the paired pasture catchments, while Fahey and Marden 2000 found the specific yield from an exotic forest catchment prior to harvesting was 40% of the yield from a nearby pasture catchment). Indeed, this variability in ratios suggests that some degree of interaction occurs between the sediment yield controlling variables, rather than them being independent as assumed in the modelling approach used herein. For example, a change in catchment land cover may cause an increase in the erosion terrain coefficients and/or the rainfall and slope exponents in Equation (1). As discussed further in Section 5.2.1, this raises a caution around the model's use for predicting or hindcasting the impacts of land cover change on sediment load.

The modelled loads are plotted against observed loads in Figure 4-4, and the performance metrics for the calibration are given in Table 4-7. The log-based performance metrics are generally reasonable, although the log-*RMSE* (0.84) indicates a factorial standard error (i.e., × or ÷) of 2.3, which is higher, for example, than was found for the final model of Hicks et al. (2011).

4.2.4 Regional adjustment of modelled sediment loads

As noted above, the likelihood of regional bias in the model calibration was confirmed by regional clustering of data above/below the 1:1 line in Figure 4-4 and was particularly noticeable when predicted/observed ratios were mapped. This necessitated regional adjustments to better align the modelled sediment loads with the observed loads. The affected areas are mapped in Figure 4-5. Two types of adjustments were made: the first was an adjustment to the calibrated erosion terrain coefficients in specific areas, and the second was a regional optimization procedure. Similar regional adjustments were found necessary by Hicks et al. (2011).

The following regional adjustments to specific erosion terrain coefficients were made:

- *Schist and greywacke* in Fiordland were assigned the same coefficient as was derived for *coarse crystalline plutonics and metamorphics*. This was justified because Fiordland lies in a different geological terrain than the rest of the Southern Alps and much of its regolith has been stripped by relatively recent glaciation.
- The coefficient for *East Cape intensely gullied crushed argillites and greywacke* (e_5) was decreased to a value of 130 after several model interations for 13 sites located in the southeast of the North Island. This acknowledges the more active tectonism in the East Cape area.

Table 4-7: Calibration performance metrics before regional adjustments. Calibration was undertaken to minimise the log-transformed *RMSE*.

Result set	*RMSE*	*SSRE*	*NSE*	*PBIAS*
Log-transformed loads	0.84	2.45	0.91	0
Non-transformed loads	1049542	1514	0.78	35.67

The regional factors were applied to the sediment load determined for each grid cell in the regions and is expressed by adding a regional coefficient a' to L_i in Equation (1):

$$L_m = a' \sum_{i=1}^{I} L_i \tag{9}$$

The value of a' was determined for each of the identified regions using a genentic algorithm (2000 Latin Hypercube Sampling) with 3000 iterations. The Optquest algorithm in Oracle's Crystal Ball software (Oracle 2015) was used for this task. The initial value for all the regional coefficients was one.

A two-step process was used to optimize the regional coefficients. We first minimized the log-*RMSE* of the log-transformed load (*RMSLE$_{Prelim}$*), in similar fashion to the approach used for minimizing the error on national-scale model. We then used the *RMSE* of the un-logged values as an objective function with a requirement to optimize the regional coefficients such that the log-transformed error value was less than or equal to the preliminary error value:

$$RMSE = \sqrt{\frac{\sum_{k=1}^{n}(L_k - L_{ks})^2}{n}} \xrightarrow{while} RMSLE = \sqrt{\frac{\sum_{k=1}^{n}(\ln L_k - \ln L_{ks})^2}{n}} \leq RMSLE_{Prelim} \tag{10}$$

The derived regional adjustment factors and their performance metrics are given in Table 4-8. The adjustment factors range from 0.17 to 2.15, and they effect considerable improvement on the performance metrics.

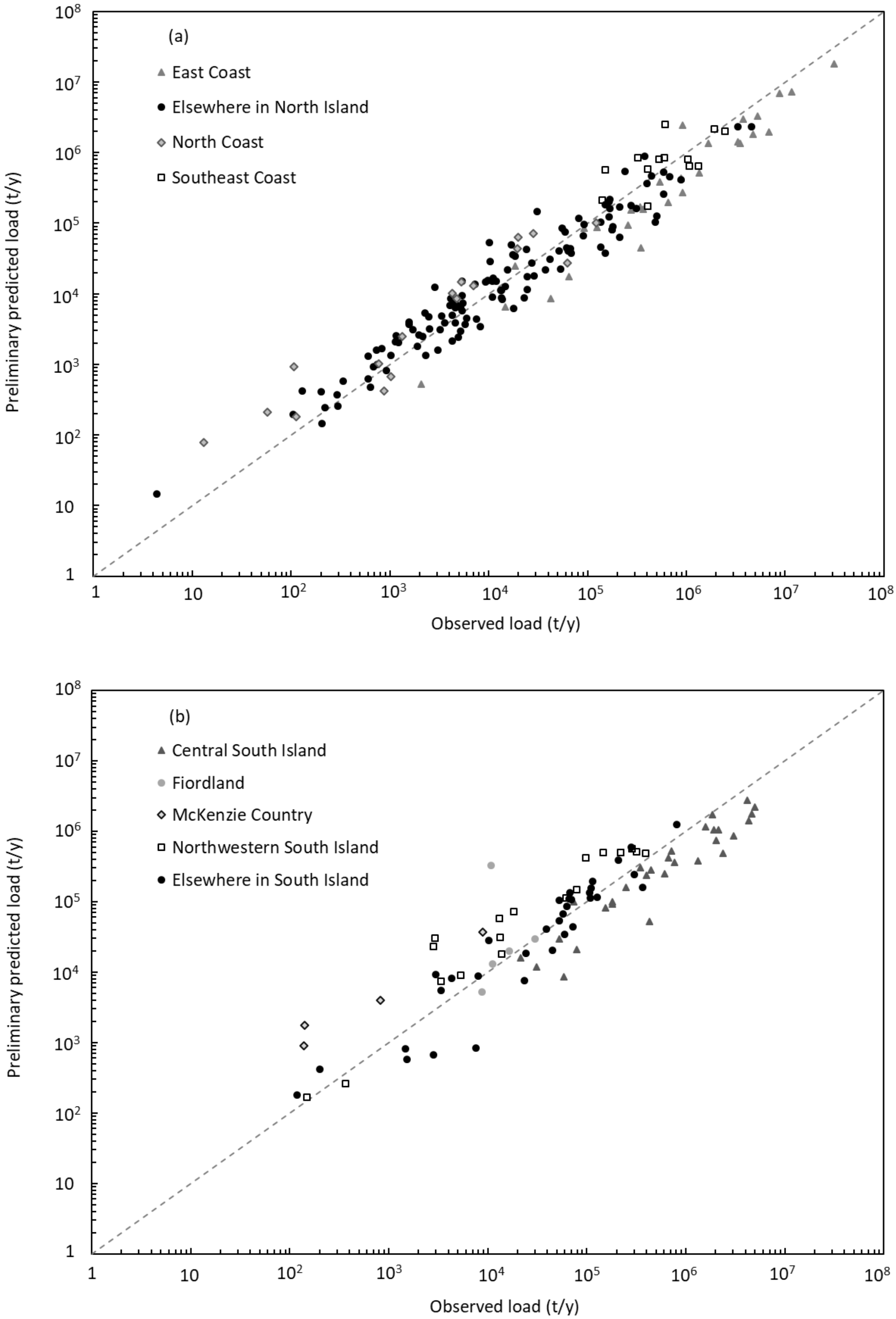

Figure 4-4: Predicted sediment load versus observed load, highlighting data for outlier regions for North Island (a) and South Island (b).

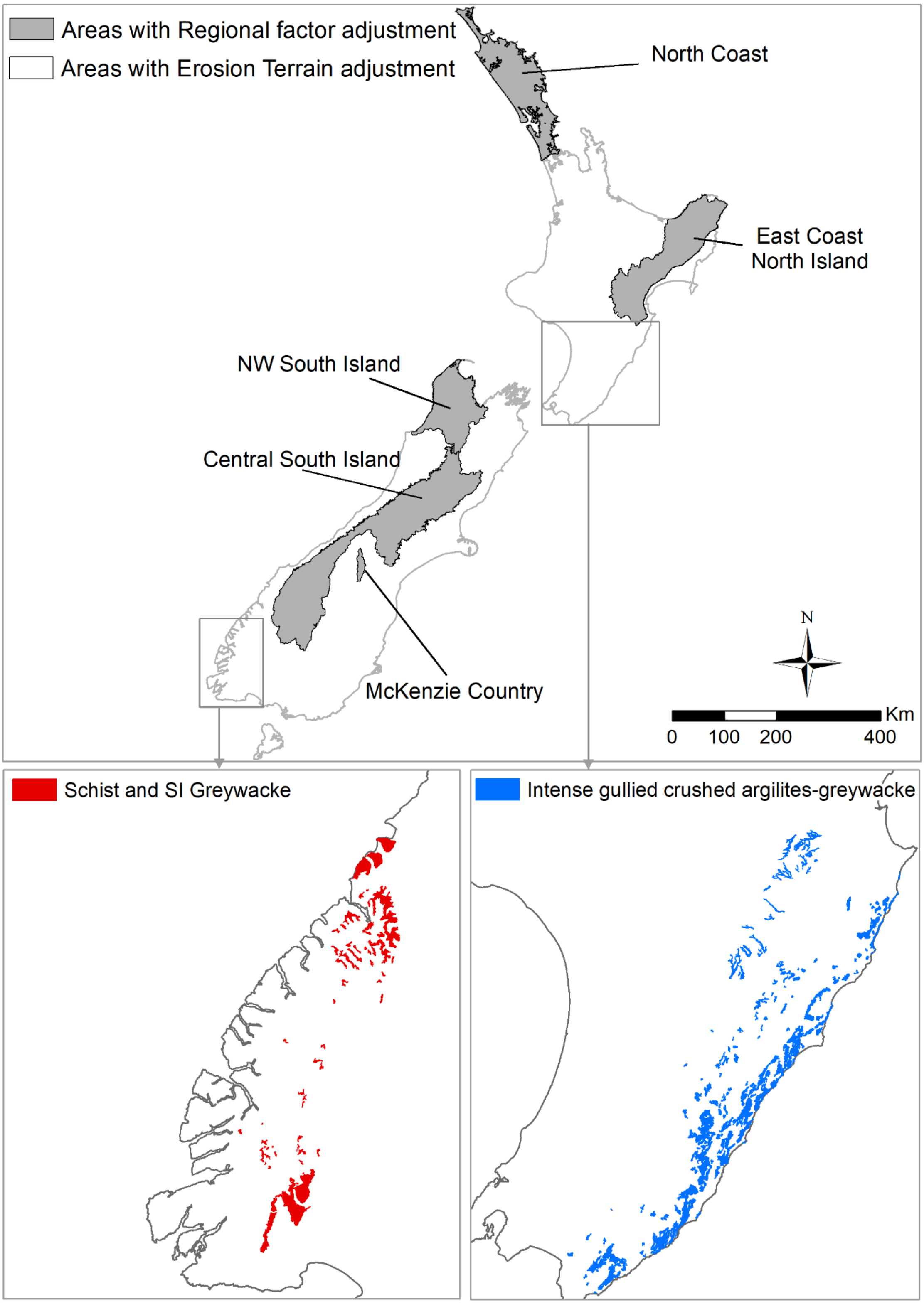

Figure 4-5: Areas requiring adjustment of the global model to correct for regional bias. Top map shows areas where a regional adjustment factor was applied. Lower maps show where specific erosion terrain coefficients were changed (Left - in Fiordland, coefficient e_8 for *schist and greywacke* was replaced by the e_9 coefficient; Right - coefficient e_5 was reduced for the *intensely gullied crushed argillites-greywacke* terrain in the southeast of the North Island.

Table 4-8: Regional coefficients and model performance metrics of sediment load for the five regions adjusted with a regional factor.

Region	Calibration catchments	Regional factor (a')	Performance metrics before adjustment				Performance metrics after adjustment			
			Log-RMSE	*NSE*	*SSRE*	*PBIAS*	*Log-RMSE*	*NSE*	*SSRE*	*PBIAS*
East Coast North Island	30	1.70	0.90	0.78	8.8	44.9	0.56	0.98	7.5	6.5
North Coast	17	0.61	1.00	0.61	107.4	-29.1	0.80	0.59	29.9	21.8
Central South Island	30	2.15	0.96	0.41	7.81	56.3	0.54	0.80	8.2	5.8
McKenzie Country	4	0.17	1.89	-13.5	187.9	-334.8	0.43	0.86	1.34	27.6
North-western South Island	19	0.45	1.09	-0.77	191.5	-110.8	0.66	0.82	25.5	5.1

The national model performance after including the regional adjustments is shown in Table 4-9. Generally, the adjusted model has better precision (lower log-*RMSE* and *SSRE*), explains more of the variance in sediment loads (higher *NSE*), and has less bias (*PBIAS* closer to zero). These improvements in performance are confirmed by visual inspection of observed against predicted values (compare Figure 4-6, Figure 4-4).

Table 4-9: Performance metrics for model calibration before and after regional adjustments.

Model	*Log-RMSE*	*SSRE*	*NSE*	*PBIAS*
Nationally calibrated model before regional adjustment	0.84	1514.4	0.93	35.7
Regionally adjusted model	0.64	211.8	0.96	8.0

Figure 4-6 shows the final predicted load versus observed load for all the calibration sites by island, while Figure 4-7 maps their ratio. For the 92 South Island sites, the model explains 94% of the variance in the observed (log-transformed) loads. Seventy sites had modelled sediment load within a factor-of-two of the measured loads. An outlier site in the South Island was the Waihopai at Kennington (Southland), where the predicted load was only 11% of the observed load. The likely reason for this is severe streambank erosion (a legacy of historical drainage work) that is not captured by the driving factors in this model.

Across the 181 North Island calibration sites, the model explains 95% of the variance in observed loads (when log-transformed). Of these, 127 sites had a modelled load within a factor-of-two of the measured load. A notable outlier is Okura at Awanohi, which had a modelled load about five times greater than the measured load. This site has a large uncertainty in its observed sediment load due to a very short period of measurement (< 2 years). Similarly, two other sites that had overpredicted loads (West Hoe at Hall Farm and Purukohokohu at Puruki Flume) also had a very short period of sediment measurements (approximately 2 years).

As shown in Figure 4-1 and Table 4-1, the Marlborough-Kaikoura, coastal/eastern Otago-Canterbury, Fiordland-South Westland, Taranaki, and Northland regions remain relatively sparse in calibration sites, so there is an expectation of reduced model reliability in these regions. This is confirmed on Figure 4-7 at least for Northland, where the model predicts loads more than a factor-of-two less than the observed loads at four of six calibration sites.

The log-*RMSE* of the adjusted model equates to a standard factorial error (*SFE*) of ×/÷ 1.9, which is greater than the *SFE* = 1.55 for the Hicks et al. (2011) predictor but smaller than the *SFE* = 2.23 for the Elliott et al. (2008) predictor.

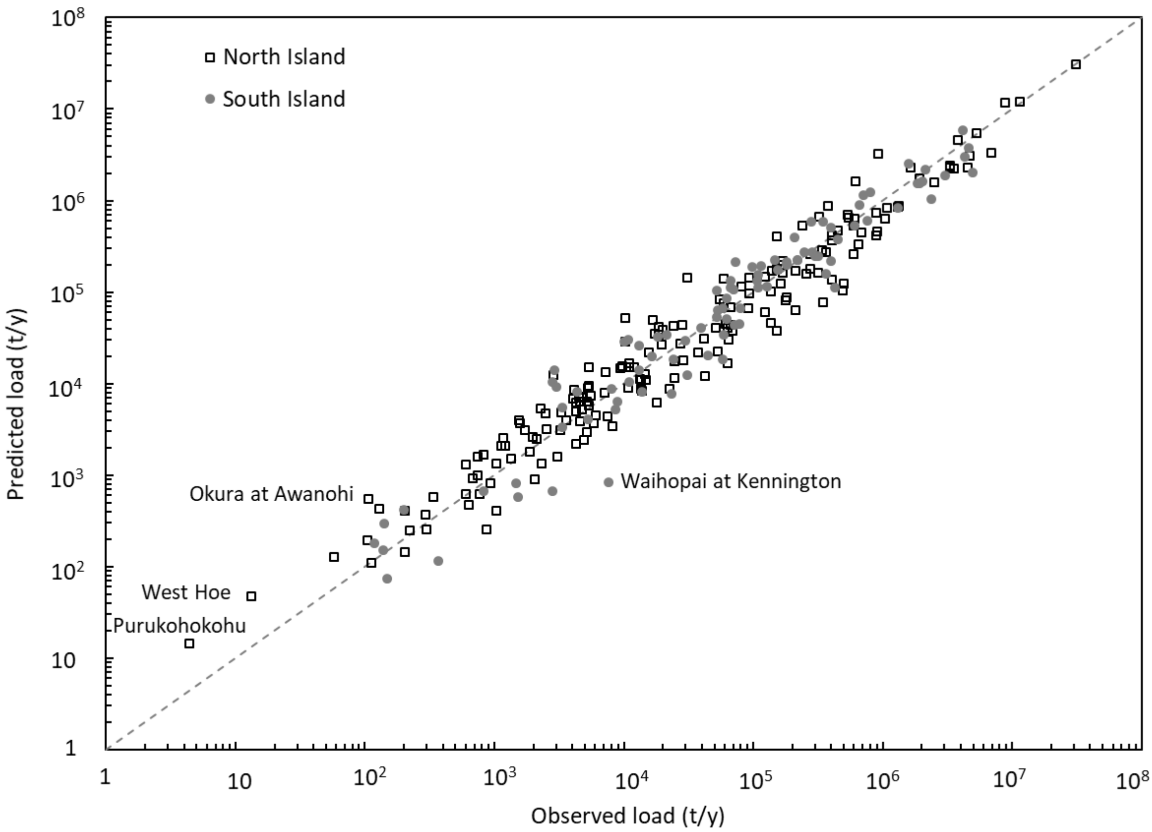

Figure 4-6: Final predicted load versus observed load after regional adjustments.

4.3 Correction to observed sediment loads

A final correction made to the New Zealand wide current suspended sediment load grid was to scale the sediment load over the calibrated site catchments so that the routed modelled loads at each of the calibration sites matched their gauged loads. This adjustment provides the most reliable estimate of the total suspended sediment flux from rivers to New Zealand coasts. The combined upstream catchment area of the monitoring sites covers approximately 41% of the New Zealand land area. With this grid, termed the "corrected" grid, the sediment load from the area covered is therefore derived from in-stream load measurements where they exist and the load from the rest of country (i.e., ungauged areas) is derived from the empirical model estimates. To avoid double-correction from multiple sites nested in the same catchment, and to ensure continuity of sediment delivery throughout the catchment, the adjustment was applied only to non-nested calibration catchments (which amounted to 175 out of the 273 calibration catchments).

The grid generated before this gauged catchment correction was applied is termed the "uncorrected" grid. The gauged-catchment correction was not applied to the grids generated by running the model with the pre-human and pre-European land covers because those corrections are only relevant to the current scenario. Nor was the correction applied for the current land cover scenario when comparing its loads with those of the two historical scenarios.

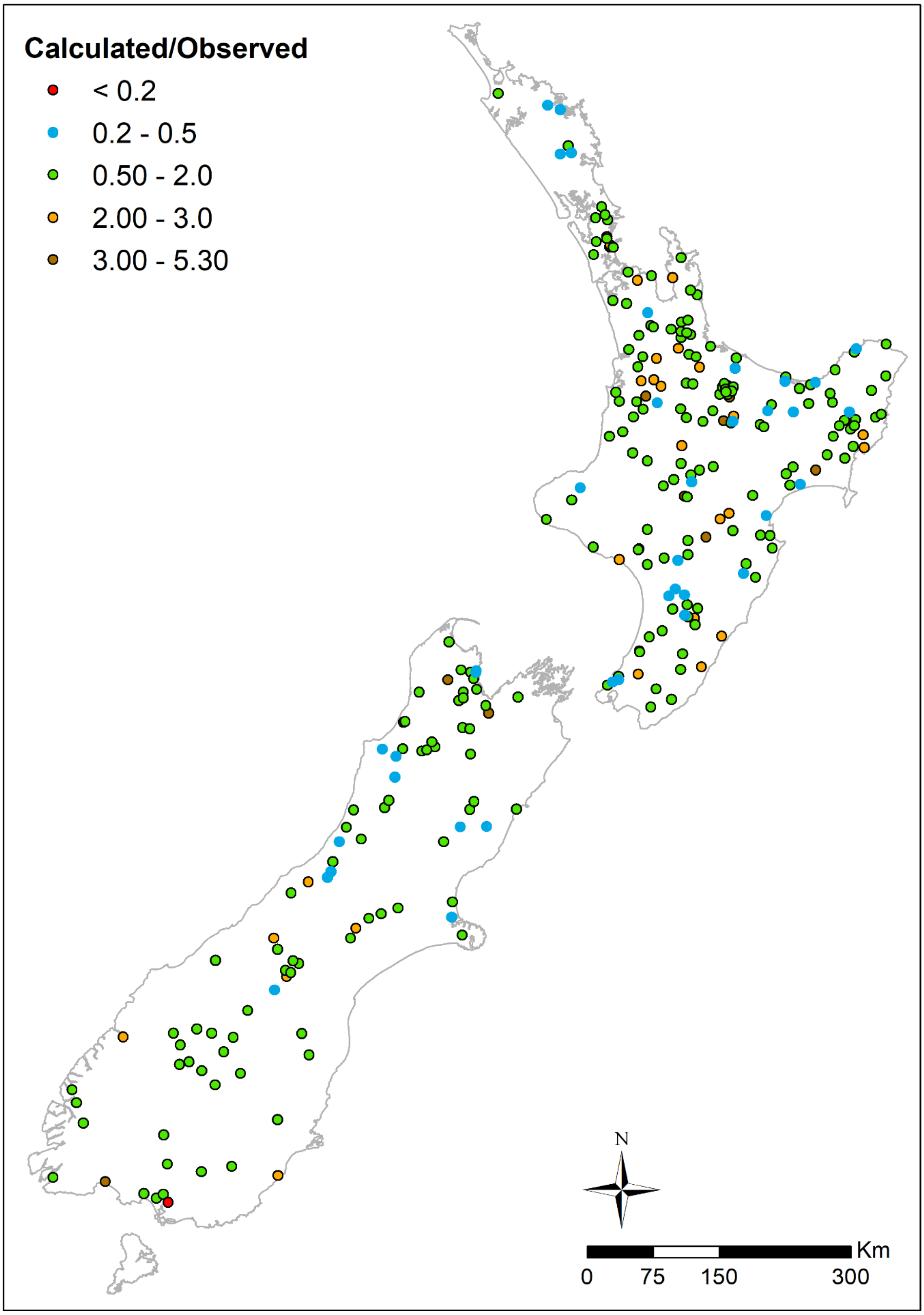

Figure 4-7: Ratio of final model-predicted sediment load to observed sediment load for the calibration sites.

5 Sediment load model results

Calculations to generate national-scale raster layers of the specific sediment load for the three land cover scenarios were undertaken in MATLAB (version R2017B). The calculations applied the regionally-adjusted model. For the current land cover scenario, rasters were produced with and without the correction to observed loads. The MATLAB Mapping Toolbox was used to read the input data (listed in section 3) and produce output rasters. These rasters were then read into a Python script which performed the load routing and reporting.

The model results are presented below for the current land cover scenario (Section 5.1) as well as the two historical scenarios (Section 5.2). For each scenario, the following results are presented:

- raster maps of specific yield, which show where the most sediment is delivered to the stream network (Sections 5.1.1 and 5.2.2);
- loads by major rivers to the coast (Sections 5.1.2 and 5.2.3); and
- loads to the coast totalled by coastal region (Sections 5.1.3 and 5.2.4).

Entrapment in lakes and reservoirs under the current scenario is presented in Section 5.1.4.

All the model results presented here are available as text files, shapefiles or geo-referenced raster images. Access to the modelled stream sediment loads is also available via a web-tool.

5.1 Current sediment loads

The current land cover scenario was used for four model runs: with and without the observed load correction described in Section 4.3 (the latter for comparison with the historic land cover scenarios), and with and without entrapment in artificial lakes/reservoirs. Unless otherwise stated, the results presented below are for the catchment corrected model run with lake entrapment.

5.1.1 Specific yields

Figure 5-1 shows specific yields[18] around New Zealand calculated for the current land cover and after correcting to measured loads. The map also shows the sediment load reaching each coastal region (see Section 5.1.3).

In the North Island, the highest specific yields (up to 250,000 t/km^2/y)[19] occur in the East Cape region due to a combination of relatively high rainfall (mostly *Medium wet* rain class), deforestation, and highly erodible crushed argillite and tertiary mudstone lithologies. The southeast of the North Island also has locally high specific yields (~ 26,000 t/km^2/y) despite lower rainfall, highlighting the influence of slope (*Steep* and *Very steep* classes) and erosion terrain (crushed argillite and greywacke).

[18] The specific yield is the load generated by a catchment divided by the catchment's area.

[19] Note that catchment average specific yields (e.g., as reported in appendix C and by Hicks *et al.* 2011) will be considerably less than these local, 1-hectare raster maxima. For example, the largest observed catchment specific yield in the East Cape area is ~ 37,0000 t/km^2/y from the 183 km^2 Waipaoa at Waipaoa Station Catchment (Appendix C).

Figure 5-1: Specific yield map and load to the coast for current land cover. Sediment loads (Mt/y) delivered to the coast are totalled by coastal region. Coastal region boundaries are the same as in Hicks et al. (2011) and are defined on an arbitrary basis.

In the South Island, the highest specific yields occur in South Westland, with a maximum of 71,000 t/km^2/y. This is due to a combination of steep slopes (*very steep and Precipitous* slope class), heavy rainfall (*wet* rain class), and high uplift rates on the eastern side of the Alpine Fault. The lowest specific yields in the South Island (< 10 t/km^2/y) occur in central mid-south Canterbury due to gentle slopes (*flat to gently undulating* slope class), low rainfall (*dry rain* class) and relatively less erodible moraine lithology.

5.1.2 Loads of major rivers

The modelled sediment loads to the coast were determined for 81 major rivers (Appendix G). The loads for the 20 rivers that deliver the highest sediment loads to the coast (the "dirty 20") are given in Table 5-1 These loads are compared to those determined by Hicks et al. (2011) in Figure 5-2. The rivers delivering the most sediment are from East Cape in the North Island and South Westland. The Waiapu/Poroporo River and the Waipaoa River transport 39.6 Mt/y and 9.9 Mt/y suspended sediment, respectively, and their combined load represents 44.8% of the sediment load from the North Island and 27.3% of the total load to the New Zealand coast. The four rivers in South Westland (Haast, Buller, Whataroa, and Arawhata) deliver between 4.4 to 5.1 Mt/y each, and their combined load represents 26% of the total load delivered to the coast of the South Island and around 10% of the national total. In Canterbury, the Rakaia River and Waimakariri River deliver 3.9 Mt/y and 2.9 Mt/y respectively, and their combined load represents 10% of the South Island sediment contribution and 4% of the national total.

The results for the major rivers are broadly similar to those reported by Hicks et al. (2011), however, there are some notable differences. The load predicted herein for the Waiapu River is some 4.6 Mt/y (32%) greater than the load predicted by Hicks et al. (2011), whereas the load for the Waipaoa River is 4.8 Mt/y (13%) lower. Since both rivers are gauged for sediment, the differences stem largely from the additional data obtained for both rivers, which altered their time-averaged sediment ratings, and the longer period of flow record for which the loads were averaged. The differences for the four major rivers of South Westland listed above ranged from 0.8 to 2.8 Mt/y. No new data was available for these rivers so the differences stem from the model predictions for ungauged parts of their catchments.

Table 5-1: Sediment loads modelled with the current land cover scenario for the 20 rivers with the highest sediment load contributions nationally. Results are provided with and without correcting to observed loads. These rivers are ordered by their percentage contribution to the national total sediment load. Sediment loads for other major rivers are given in Appendix G.

River	Upstream area (km^2)	Uncorrected loads		Corrected to observed loads	
		Load (Mt/y)	Percentage of national total (%)	Load (Mt/y)	Percentage of national total (%)
Waiapu/Poroporo	1734	38.89	22.09	39.62	21.83
Waipaoa	2183	12.70	7.21	9.89	5.45
Haast	1356	6.84	3.88	5.11	2.82
Buller	6427	1.86	1.06	4.56	2.51
Whataroa	594	3.65	2.07	4.39	2.42
Arawhata	933	4.36	2.48	4.36	2.40
Hikuwai / Uawa	539	5.04	2.86	4.25	2.34
Rakaia	2832	2.76	1.57	3.92	2.16
Hokitika	1067	3.15	1.79	3.57	1.97
Motu	1426	2.27	1.29	3.53	1.95
Whanganui	7134	2.43	1.38	3.44	1.89
Waimakariri	3111	1.81	1.03	2.93	1.62
Waiau	3331	1.25	0.71	2.59	1.43
Waiho	290	2.43	1.38	2.43	1.34
Manawatu	5876	1.85	1.05	2.42	1.33
Wairoa (Hawke's Bay)	3674	4.54	2.58	2.30	1.27
Taramakau	1001	2.19	1.24	2.14	1.18
Grey	3927	1.29	0.73	1.59	0.88
Rangitata	1810	2.53	1.44	1.60	0.88
Mohaka	2440	0.89	0.51	1.36	0.75

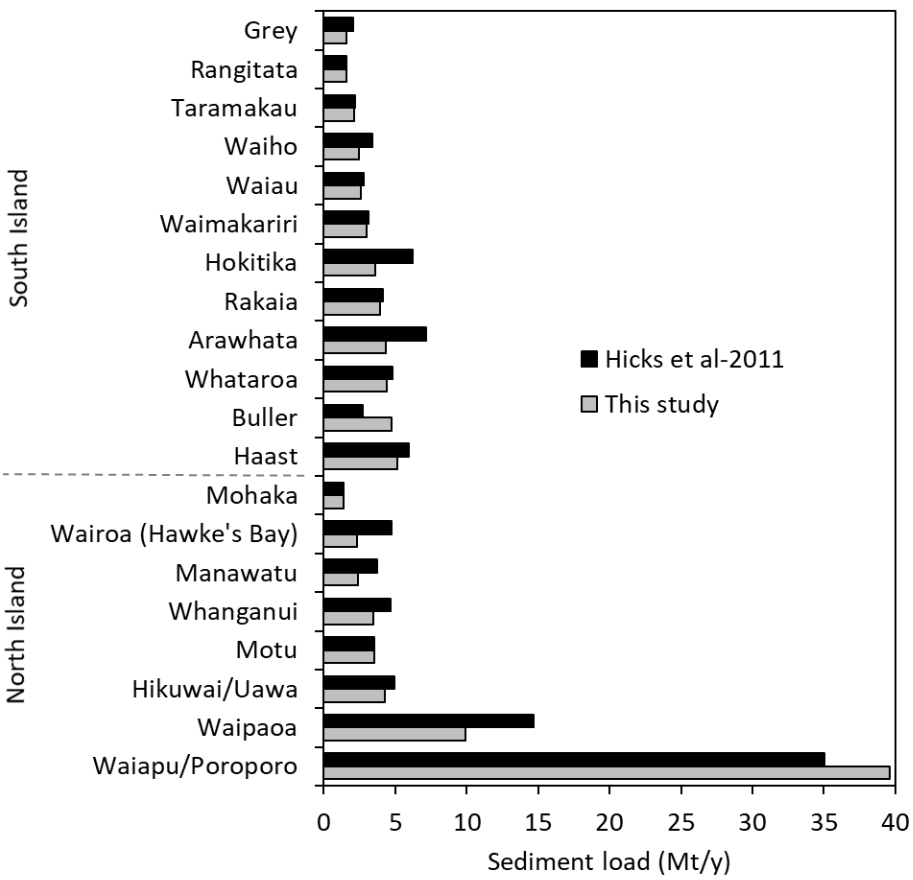

Figure 5-2: Comparison of sediment load of the 20 rivers carrying the largest loads from this study and from Hicks et al. (2011).

5.1.3 Loads delivered to the coast

The loads to the coast were determined by summing the loads from REC2 segments classified as terminal segments (i.e., river mouths) nationally, by island, and by coastal region. These are reported in Table 5-2 and are compared to the loads estimated by Hicks et al. (2011) in Figure 5-3. The coastal regions and their loads are mapped in Figure 5-1.

The national total load delivered to the coast is estimated at 181.1 Mt/y, with 61% (111.6 Mt/y) from the North Island and 39% (69.5 Mt/y) from the South Island. These estimated loads are 6.5 and 21.1 Mt/y less, respectively, than those reported by Hicks et al. (2011). The load from Stewart Island, not modelled by Hicks et al. (2011), is estimated to be approximately 0.01 Mt/y.

Loads to the New Zealand coast are dominated by the East Cape area (64.6 Mt/y; 36%) and South Westland (43.3 Mt/y, 24%). Together, these coastal regions contribute 59% of the national load. Hicks et al. (2011) also found that the same two coastal regions had the greatest contribution to the national total, however, their estimated loads were, respectively, 4.2 and 19.0 Mt/y more than those estimated here and together accounted for 63% of the national load.

It is emphasised that these differences between the loads estimated herein and by Hicks et al. (2011) reflect the use of different datasets for gauged rivers and different models for the ungauged catchments. They should not be interpreted as indicating a temporal change in mean annual sediment load since the time of the Hicks et al. (2011) study. They are more indicative of how the mean annual load estimate has been refined with the benefit of additional data.

Table 5-2: Modelled sediment load delivered to coastal regions for current land cover corrected and uncorrected with observed loads. Results are provided for the actual loads, which are influenced by entrapment in artificial lakes, and for the hypothetical case of no entrapment by artificial lakes.

Coastal Region	Un-corrected sediment load (Mt/y)		Corrected sediment load (Mt/y)		
	Actual	Without entrapment in artificial lakes	Actual	Without entrapment in artificial lakes	Percentage contribution to national total (actual, corrected)
North Island					
Coromandel / Bay of Plenty	10.42	10.49	14.01	14.15	7.7%
East Cape	67.99	67.99	64.59	64.59	35.6%
Hauraki Gulf	0.18	0.18	0.21	0.21	0.1%
Hawkes's Bay	9.00	9.00	8.39	8.39	4.6%
Northeast coast	0.41	0.42	0.44	0.44	0.2%
Northwest coast	0.79	0.79	0.81	0.82	0.4%
South coast	1.01	1.01	0.82	0.82	0.5%
Southeast coast	11.93	11.93	10.64	10.64	5.9%
Southwest coast	6.89	7.20	9.00	9.32	5.0%
West coast	2.32	2.45	2.70	2.85	1.5%
TOTAL	**110.93**	**111.46**	**111.61**	**112.23**	**61.5%**
South Island					
Bank's Peninsula	0.04	0.04	0.04	0.04	<0.1%
Fiordland	0.72	0.72	0.70	0.70	0.4%
Kaikoura coast	4.00	4.00	5.27	5.27	2.9%
Marlborough Sounds	0.56	0.56	0.57	0.57	0.3%
Mid-south Canterbury	6.30	6.47	6.38	6.55	3.5%
North Westland	4.34	4.34	7.43	7.43	4.1%
Otago	0.93	2.58	0.87	2.93	0.5%
Pegasus Bay	2.14	2.14	3.27	3.27	1.8%
South Westland	43.87	43.87	43.26	43.26	23.8%
South coast	1.17	1.17	0.98	0.98	0.5%
Tasman	0.80	0.81	0.73	0.74	0.4%

Coastal Region	Un-corrected sediment load (Mt/y)		Corrected sediment load (Mt/y)		Percentage contribution to national total (actual, corrected)
	Actual	Without entrapment in artificial lakes	Actual	Without entrapment in artificial lakes	
TOTAL	**64.85**	**66.7**	**69.5**	**71.73**	**38.3%**
Stewart Island	0.01	0.01	0.01	0.01	<0.1%
National	**175.78**	**178.15**	**181.12**	**183.97**	

5.1.4 Sediment entrapment in lakes

Lakes intercept significant amounts of river sediment load, particularly in the South Island. The estimated sediment passing factors[20], sediment inflows (derived for the current land cover), and entrapment rates for significant lakes are listed in Appendix K.

Natural lakes[21] trap sediment at a rate of 18.9 Mt/y in the South Island. This equates to 20.9% of all the sediment delivered to the river network across the South Island. Most of this occurs in Lakes Pukaki, Tekapo, Ohau, Hawea, Wanaka, and Wakatipu – all of which have very high trap efficiencies by virtue of their large residence times (i.e., the ratio of lake volume to mean annual water inflow rate) which provide adequate time for sediment to settle. In the North Island, natural lakes intercept only 0.68 Mt/y of sediment, with most being trapped in Lake Taupo. This equates to 0.6% of the sediment delivered to the North Island river network. Over New Zealand, natural lakes intercept 9.6% of the sediment delivered to the river network.

Artificial lakes (mainly hydro-power lakes and large irrigation reservoirs) in the South Island intercept 2.23 Mt/y, which equates to 3.2% of the load to the South Island coast. This is mostly due to the hydropower reservoirs on the Clutha River (2.0 Mt/y). In the North Island, artificial lakes trap 0.62 Mt/y (mostly due to hydropower reservoirs on the Waikato River), which equates to 0.6% of the load to the North Island coast. Nationally, entrapment in artificial lakes represents around 1.6% of the sediment load to the coast.

[20] The sediment passing factor equals 1 – trap efficiency.
[21] Natural lakes are those that are of natural origin and/or existed prior to human arrival. Lakes such as Pukaki and Taupo that existed naturally but have had their levels regulated by hydro-power control structures are included.

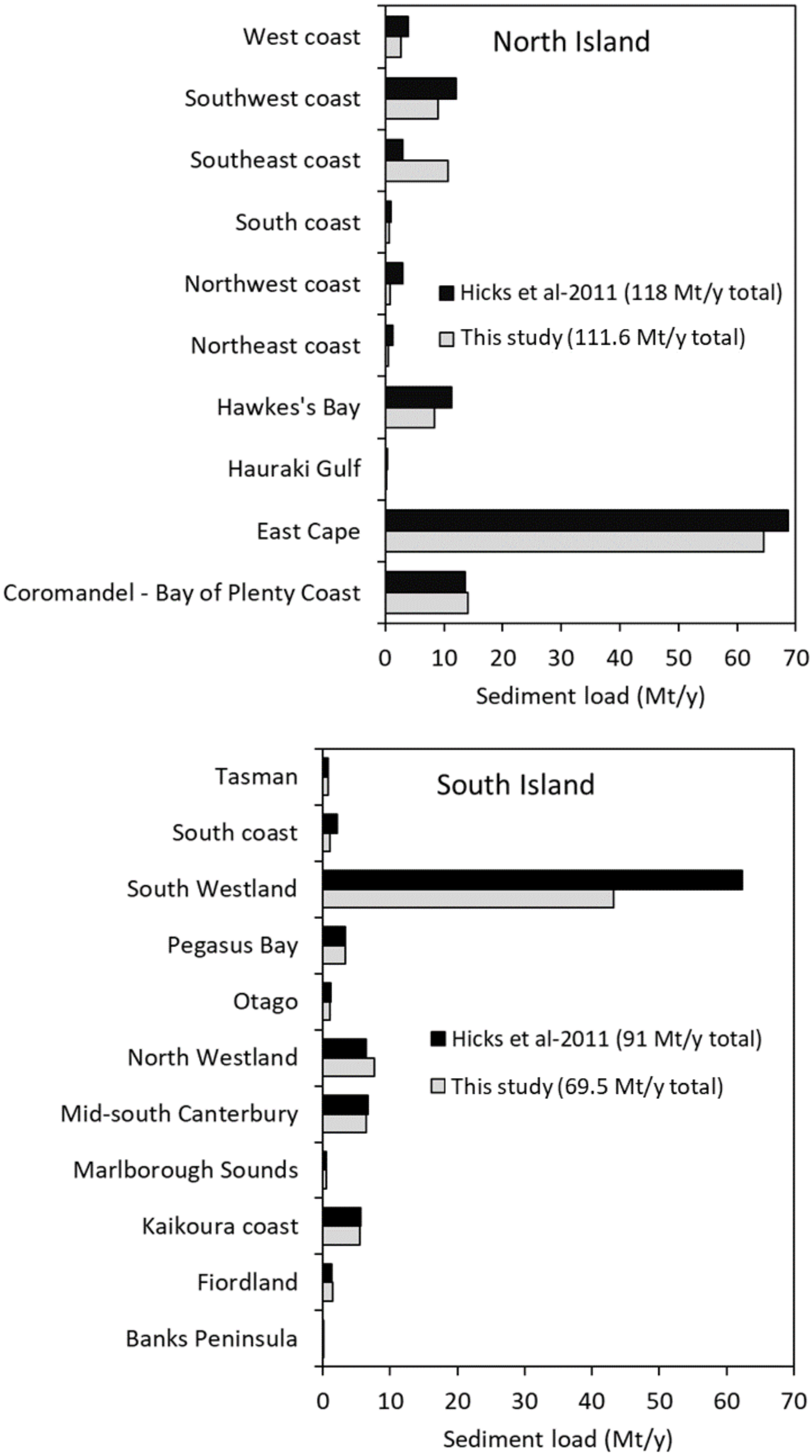

Figure 5-3: Comparison of suspended sediment delivery to the New Zealand South and North Island coasts by region from this study and from Hicks et al. (2011). Total loads for each island are shown in the legends.

5.2 Historic land cover scenarios

Sediment loads were determined for the pre-human and pre-European scenarios by running the final raster model with the pre-human and pre-European land cover layers, assuming no change in mean annual rainfall and slope. For these two historical scenarios, downstream routing included the natural lakes but excluded artificial lakes (since they did not exist historically).

The results from the historical sediment load grids are compared with those generated from the uncorrected current load grid to ensure that "apples are compared with apples"[22].

5.2.1 Preliminary caution

We warn that these comparisons should be interpreted with caution for several reasons.

First, the results are generated assuming that in each scenario, stable equilibrium states have been established in the relationship between sediment yield and land cover. It is well recorded that large quantities of sediment were mobilised during periods of land cover transitions (e.g., European deforestation). While these high transient loads are not captured in the current loads, to varying degrees around the country European deforestation will still be contributing "legacy" sediment from erosion sites activated by the land cover conversion and from erosion of stored sediment deposits (e.g., streambank and floodplain erosion).

Second, an underpinning assumption of the model-fitting approach is that the land cover and erosion terrain coefficients in the model (i.e., l_j and e_k coefficients in Equation (1) and Table 4-6) are mutually independent - so that, for example, a change in land cover should have the same effect on sediment load irrespective of the erosion terrain. This may not always be the case, however.

A good example of both of these effects is provided by the Waipaoa Catchment at East Cape. There, deforestation during the early European settlement period promoted extensive gully erosion in the *intensely gullied crushed argillite and greywacke* erosion terrain and shallow landsliding in the *Tertiary mudstone* erosion terrain. More sediment was generated than could be transported by the river network, leading to channel and floodplain deposition. Erosion of this stored legacy sediment, along with continuing erosion of untreated gullies and landsliding after heavy rainstorms, dominate the present-day sediment budget of the Waipaoa River (Marden 2011). Moreover, the Waipaoa deforestation lowered erosion thresholds in these erosion terrains (Hicks et al. 2000), which would have promoted a greater increase in sediment load than is indicated by the approximately factor-of-two difference in the global coefficients derived for the l_1 (*herbaceous*) and l_2 (*trees/scrub*) parameters in Table 4-6. Therefore, the erosion terrain coefficients may have been lower under forested, pre-European conditions, particularly on the *intensely gullied crushed argillite and greywacke* erosion terrain.

Third, before the onset of European catchment drainage works and flood-confinement between stopbanks, floodplains and wetlands would have intercepted greater proportions of river suspended loads, thus a lesser proportion would have been delivered downstream.

Thus, the pre-European and pre-human loads will, if anything, have been lower than indicated herein. Indeed, for the Waipaoa example, Kettner et al. (2007) estimated that the pre-human catchment sediment load was only about 15% of the contemporary load, with most of the increase occurring following European deforestation.

[22] It is not appropriate to correct the historical load grids by overlaying the observed loads during the current regime, thus the historical results should be compared with the results from the current landcover model uncorrected for observed loads.

5.2.2 Specific yields

Figure 5-4 and Figure 5-5 show the specific yields for the pre-European and pre-human land cover scenarios, respectively. The maps also show the sediment loads to each coastal region for each scenario.

Like the current land cover scenario, both historical scenarios have their highest specific yields in the East Cape region of the North Island and the South Westland region of the South Island (maximum of ~ 51,000 $t/km^2/y$ for both scenarios). Again, this is due to the combination of highly erodible argillite and tertiary mudstone lithologies and relatively high rainfall for East Cape and steep slopes and high rainfall for South Westland – and so land cover change does not exert a dominating influence in these two regions, particularly in South Westland where there has been minimal change in land cover.

Again, for both historical land cover scenarios the lowest specific yields (< 10 $t/km^2/y$) occur in mid-South Canterbury due to gentle slopes, low rainfall and relatively less erodible lithologies – with historical changes in land cover having minor effect.

Figure 5-4: Map of the pre-European land cover specific yield and sediment loads (Mt/y) delivered to the coast by coastal region.

Figure 5-5: Map of the pre-human land cover specific yield and sediment loads (Mt/y) delivered to the coast by coastal region.

5.2.3 Loads of major rivers for historic land cover scenarios

The historic sediment loads delivered to the coast by 81 selected major rivers are given in Appendix H. Table 5-3 compares the uncorrected loads for the 20 highest yielding rivers for the current land cover scenario with the loads modelled using the historic land cover scenarios.

The results for both scenarios are very similar for most of the rivers (with the historic cases having loads between 52% and around 100% of the current loads), however, there are some minor differences for rivers in Canterbury and Otago, in particular, due to increased tussock in the pre-European scenario compared to the pre-human scenario. Like the current land cover scenario, the Waiapu/Poroporo River system and Waipaoa River have the highest loads to the coast (28.0 and 9.56 Mt/y respectively).

Table 5-3: Comparison of sediment loads for major rivers modelled with the current and historical land cover scenarios. These are the same 'dirty 20' rivers as presented in Table 5-1.

River	Current land cover load, uncorrected (Mt/y)	Pre-European land cover		Pre-human land cover	
		Load (Mt/y)	Percentage of current load (%)	Load (Mt/y)	Percentage of current load (%)
Waiapu/Poroporo	38.89	28.00	72%	28.00	0.72
Waipaoa	12.70	9.56	75%	9.56	0.75
Haast	6.84	6.25	91%	6.33	0.93
Buller	1.86	1.77	95%	1.77	0.95
Whataroa	3.65	3.29	90%	3.37	0.92
Arawhata	4.36	4.28	98%	4.37	1.00
Hikuwai / Uawa	5.04	3.66	73%	3.66	0.73
Rakaia	2.76	2.37	86%	2.37	0.86
Hokitika	3.15	3.16	101%	3.19	1.01
Motu	2.27	1.81	80%	1.81	0.80
Whanganui	2.43	1.88	78%	1.88	0.78
Waimakariri	1.81	1.45	80%	1.44	0.79
Waiau	1.25	1.02	82%	0.99	0.79
Waiho	2.43	2.21	91%	2.25	0.93
Manawatu	1.87	1.04	56%	1.04	0.56
Wairoa (Hawke's Bay)	4.54	2.64	58%	2.64	0.58
Taramakau	2.19	2.03	93%	2.03	0.93
Grey	1.29	1.25	97%	1.24	0.96
Rangitata	2.53	2.20	87%	2.21	0.87
Mohaka	0.89	0.85	95%	0.85	0.95

In most cases, the loads estimated for the historic scenarios are less than those calculated for the current land cover scenario due to the lower erosion rates associated with forest cover. However, there are some notable exceptions for rivers with artificial hydropower reservoirs, notably the Clutha and Waitaki Rivers in the South Island and the Rangitaiki River in the North Island (see Appendix H). That is, the apparent decrease in the current load compared to the historic load is due to reservoir entrapment rather than land cover change. As noted above, entrapment in the Clutha hydropower lakes is in the order of 2 Mt/y and so the potential current load (i.e., without hydrolakes) is around seven times more than the actual load is with hydrolakes. The modelled historic loads for this river (1.68 and 1.63 Mt/y respectively) are around four times greater than the current actual load. On the other hand, the historic loads are around 80% of what the current load would be without any hydrolakes, showing that while there has been an increase in loads reaching the river network due to changed land cover, the bulk of this sediment is no longer reaching the coast.

There are also some minor differences between the historic and current land cover scenario loads in some catchments due to the difference in resolution in the input datasets used to develop the land cover scenarios. The Hokitika River (Table 5-3) is an example: its land cover is a mix of forest and tussock in all three scenarios, but the proportion of tussock is greater in the historic landcover maps, which leads to slightly higher sediment loads. Also, catchments with significant proportions of urban land cover may have lower current sediment loads simply because the model does not simulate this land cover.

5.2.4 Loads delivered to the coast

The historical sediment loads delivered to the coast are reported in Table 5-4 by coastal region, island, and nationally - along with the current load uncorrected for observed loads for comparison. These results are also plotted in Figure 5-6 and are mapped in Figure 5-4 and Figure 5-5.
The loads modelled for the two historic scenarios are very similar. The national total load to the coast is estimated at 139.86 Mt/y for the pre-European scenario and 140.30 Mt/y for the pre-human scenario, with around 56% of the load from the North Island and 44% from the South Island for both scenarios. The North Island load is around 78% of the estimated current load, and the differences between the coastal regions ranges from 64% (Southeast Coast) to 79% (South Coast). The South Island total load for both scenarios is around 95% of that estimated for the current scenario, however, the percentage differences by coastal region range from being around half the current load (Bank's Peninsula) to more than double (Otago). The high difference in loads compared to the current load for Otago are due mostly to entrapment in the Clutha hydropower reservoirs. Without this entrapment, the historic loads modelled for Otago would be around 90% of the current load.

As with the current scenario, the coastal regions with the greatest historic load contributions are East Cape (49.6 Mt/y) and South Westland (41.9 Mt/y). The loads from these regions are around 73% and 95% of the load modelled for the current land cover, respectively.

The apparent decrease in current loads estimated for Stewart Island compared to the historic scenarios is due to minor urban land cover which is not simulated in this model.

Table 5-4: Comparison of sediment load to coastal regions modelled with the current, pre-human, and pre-European land cover scenarios. Uncorrected loads modelled for the current land cover scenario.

Region	Current land cover load (Mt/y)	Pre-European land cover		Pre-human land cover	
		Load (Mt/y)	Percentage of current load	Load (Mt/y)	Percentage of current load
North Island					
Coromandel / Bay of Plenty	10.42	7.03	67.5%	7.03	67.5%
East Cape	67.99	49.59	72.9%	49.59	72.9%
Hauraki Gulf	0.18	0.14	76.6%	0.14	76.6%
Hawkes's Bay	9.00	5.82	64.6%	5.78	64.2%
Northeast coast	0.41	0.30	72.6%	0.30	72.6%
Northwest coast	0.79	0.54	68.3%	0.54	68.3%
South coast	1.01	0.80	79.8%	0.79	78.4%
Southeast coast	11.93	7.63	64.0%	7.63	64.0%
Southwest coast	6.89	5.04	73.2%	5.03	73.0%
West coast	2.32	1.78	76.7%	1.78	76.6%
TOTAL	**110.93**	**78.67**	**70.9%**	**78.60**	**70.9%**
South Island					
Bank's Peninsula	0.04	0.02	55.3%	0.02	54.7%
Fiordland	0.72	0.72	101.2%	0.73	102.2%
Kaikoura coast	4.00	3.04	76.0%	2.97	74.4%
Marlborough Sounds	0.56	0.52	94.1%	0.52	94.1%
Mid-south Canterbury	6.30	5.43	86.1%	5.41	85.8%
North Westland	4.34	4.18	96.3%	4.17	96.2%
Otago	0.93	2.06	222.1%	1.99	215.5%
Pegasus Bay	2.14	1.69	78.9%	1.66	77.5%
South Westland	43.87	41.88	95.5%	42.60	97.1%
South coast	1.17	0.88	75.5%	0.85	72.9%
Tasman	0.80	0.76	95.2%	0.76	95.1%
TOTAL	**64.85**	**61.18**	**94.3%**	**61.69**	**95.1%**
Stewart Island	0.01	0.01	131.3%	0.01	132.2%
National	**175.78**	**139.86**	**79.6%**	**140.30**	**79.8%**

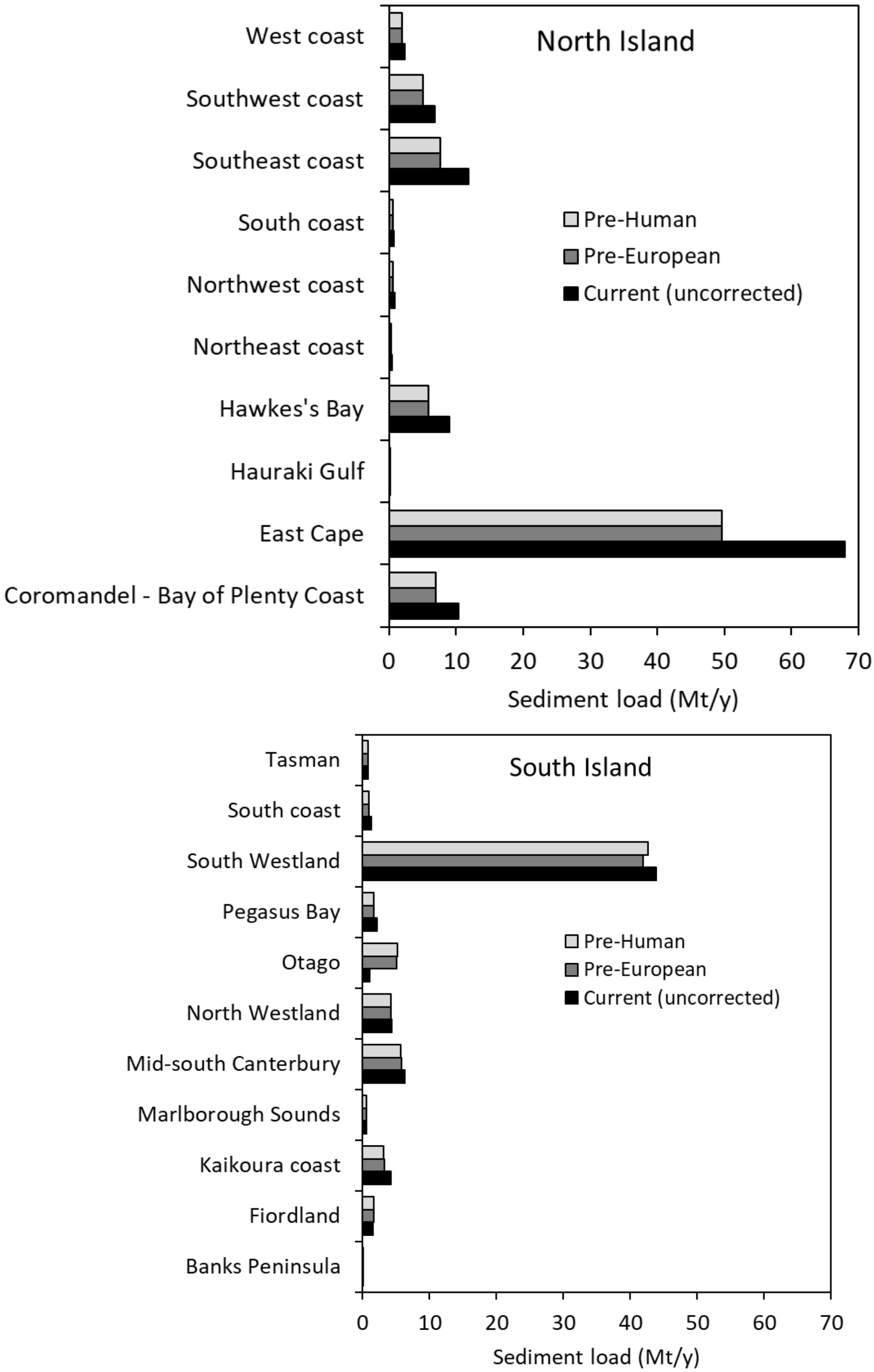

Figure 5-6: Comparison of suspended sediment delivery to the New Zealand South and North Island coasts by region for the current, pre-human, and pre-European land cover scenarios.

6 Coastal hydrosystem results

All results from the coastal hydrosystem sediment trap efficiency modelling are listed in Appendix K.

6.1 Sediment yields from coastal hydrosystem catchments

Current specific yields (t/km^2/y) for the catchments of the 399 coastal hydrosystems in the Coastal Explorer database are shown in Figure 6-1. The specific yields are highest along the east coast of the North Island and the west coast of the South Island. The estuaries that receive the highest sediment yields are generally tidal river mouths and hapua-type lagoons.

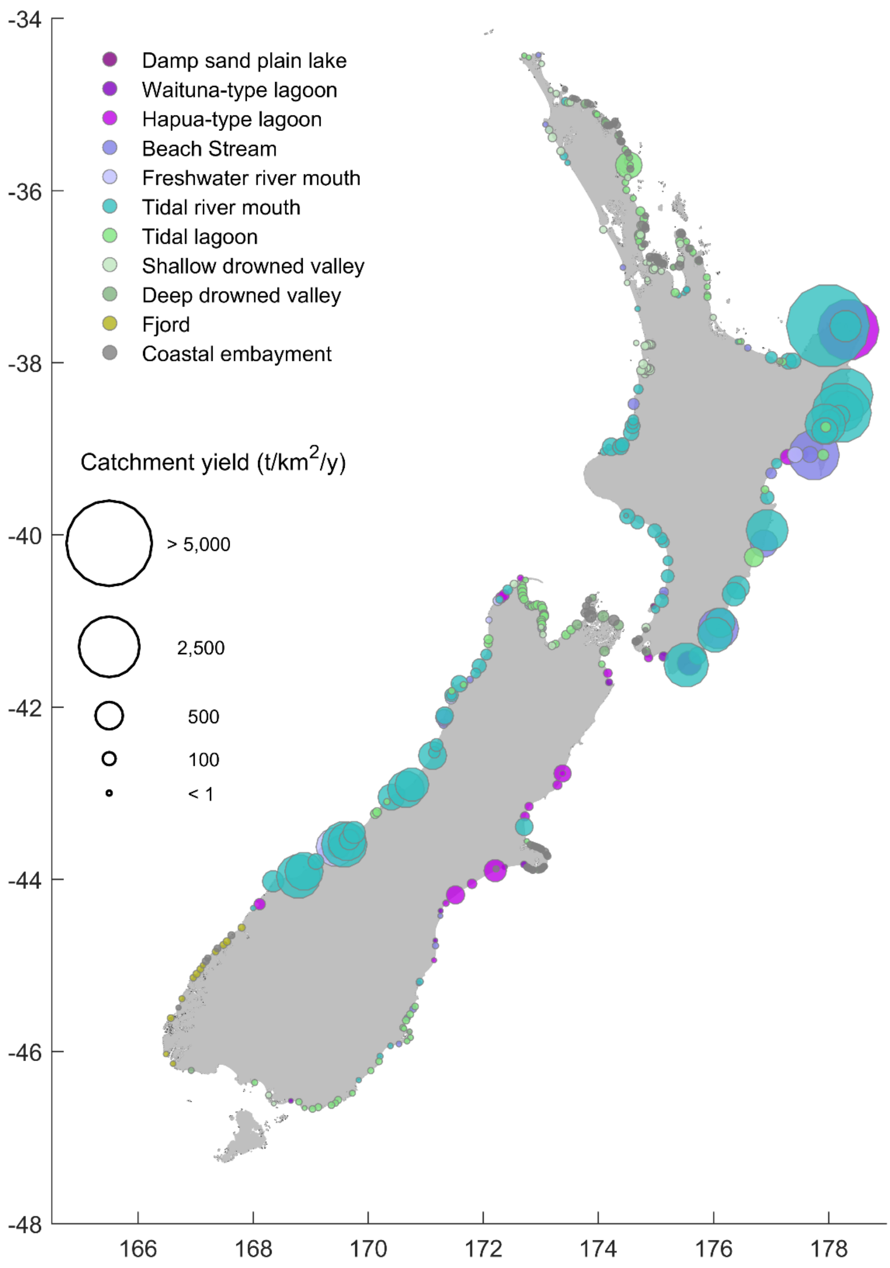

Figure 6-1: Catchment specific sediment yields to coastal hydrosystems for current land cover scenario. The coastal hydrosystem types are indicated by marker colour. Catchment specific yields are scaled by marker size.

6.2 Coastal hydrosystem sediment loadings

A common indicator of the sediment loading rate to coastal hydrosystems is the mean annual inflowing sediment load per unit estuary area. The present-day loading rate to each coastal hydrosystem is plotted in Figure 6-2. The geographic distribution of loading rates is similar to that for catchment specific yields, but because hapua, beach streams, and tidal river mouths are generally small in area, their areal loading rates are typically high.

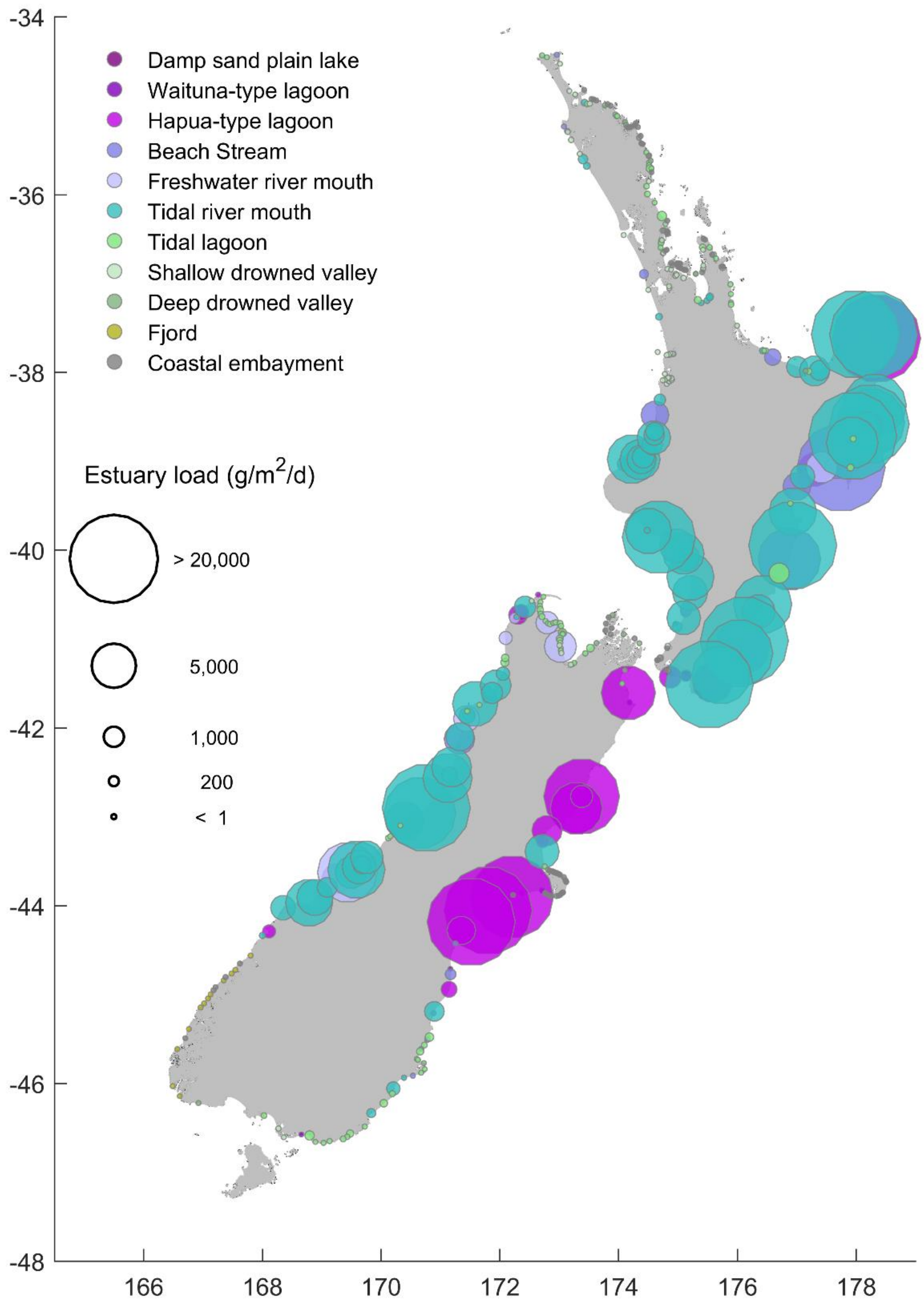

Figure 6-2: Sediment loading (per unit estuary area) by coastal hydrosystem. The coastal hydrosystem types are indicated by marker colour. Sediment loading rates, indicated by marker size, are shown for the current land cover scenario and are calculated from the mean annual sediment load divided by the estuary area.

Pre-human, pre-European, and current sediment loading rates are compared for each coastal hydrosystem type in Figure 6-3. Note that a log-scale is used because of the large range in loading rates. For all coastal hydrosystem types, there has been an increase from pre-human/pre-European loadings to current loadings. Loading rates are highest for tidal river mouths and hapua-type lagoons, and lowest for fjords and coastal embayments. There is only one damp sand-plain lake identified in the Coastal Explorer database, and this received a low loading rate.

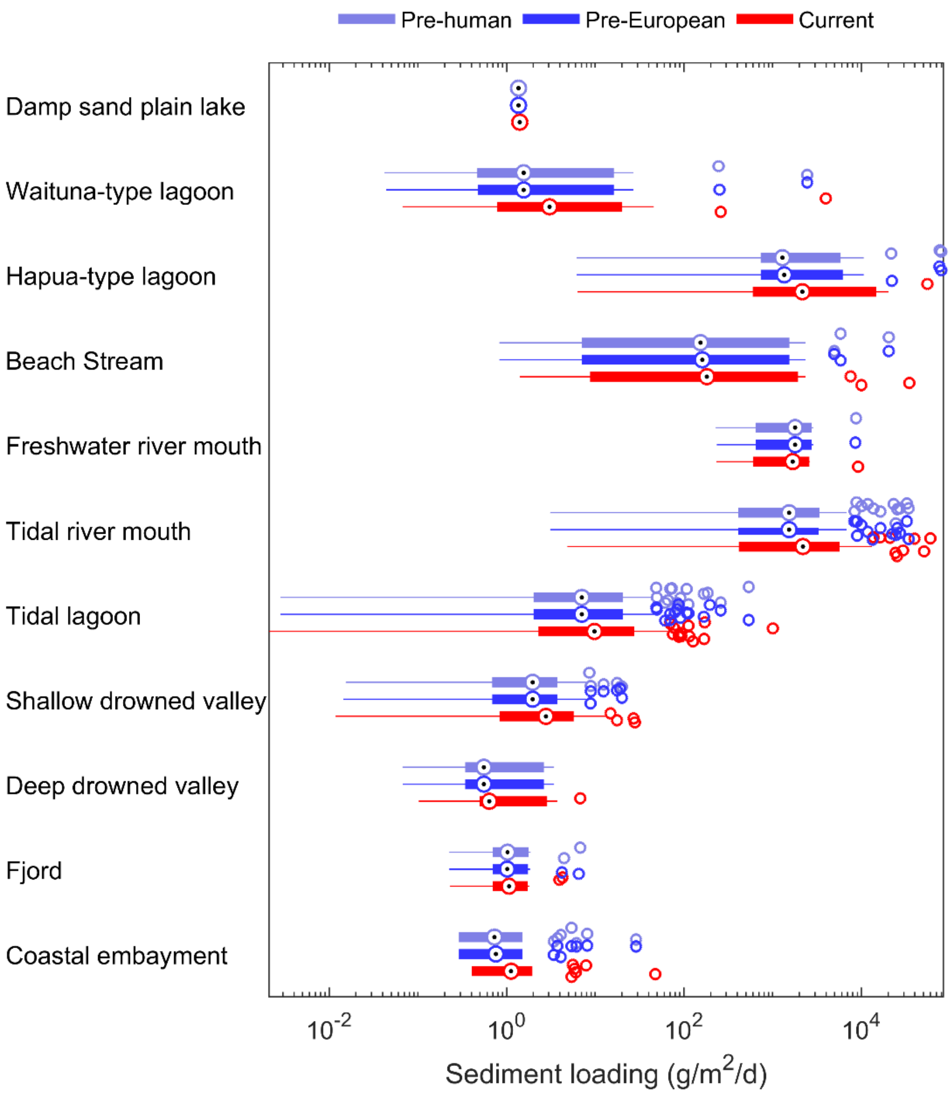

Figure 6-3: Sediment loading rate (per unit estuary area) by coastal hydrosystem type. Shown for the pre-human, pre-European, and current scenarios. Circles-with-dots show median values; bars span 25th and 75th percentiles; lines span 0.5th and 99.5th percentiles; isolated circles are outliers. Note log-scale for sediment loading. Note that 1 g/m²/d equates to 0.365 kg/m²/y.

6.3 Trap efficiency

The sediment trapping efficiency (ranging from 0 to 1) is the proportion of the suspended sediment delivered to the coastal hydrosystem that deposits and remains within the coastal hydrosystem. Trapping efficiency varies with coastal hydrosystem type.

Damp sand-plain lakes, Waituna-type lagoons, drowned valleys, and coastal embayments generally have very high (i.e., close to 1) predicted trapping efficiencies.

Tidal lagoons also have a high trapping efficiency, although there is a wider range in trapping efficiencies for this type of system. Tidal lagoons have large intertidal areas that act as deposition zones, while resuspension in channels limits deposition in subtidal areas. The range in trapping efficiencies is due to differences in intertidal areas and whether the estuary is large enough for significant amounts of wave resuspension.

Fjords have lower trapping efficiencies than other large systems such as deep drowned valleys and coastal embayments due to higher freshwater input to fjords which drives strong estuarine circulations which increases export to the ocean.

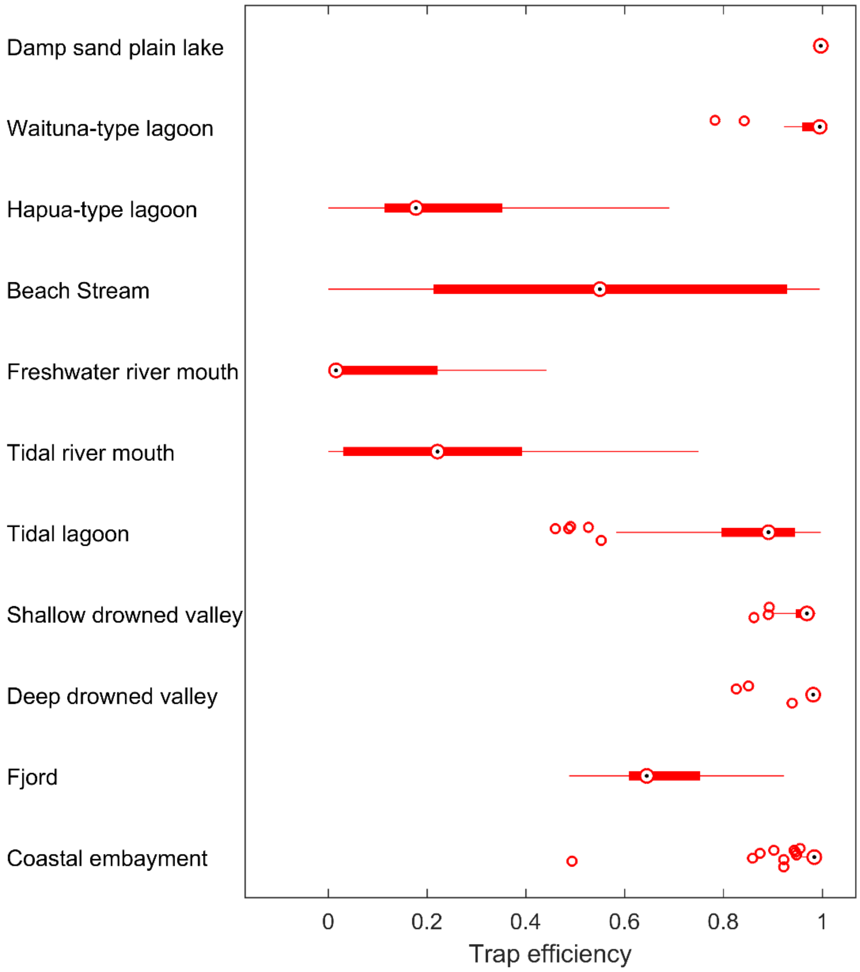

Figure 6-4: Predicted sediment trap efficiency by coastal hydrosystem type. Trap efficiency is the proportion of the incoming sediment load that is retained and settles within the water body. Circles-with-dots show median values; bars span 25th and 75th percentiles; lines span 0.5th and 99.5th percentiles; isolated circles are outliers.

Hapua-type lagoons, beach streams, freshwater river mouths, and tidal river mouths have highly variable trapping efficiencies. Their median trapping efficiencies (ranging from 0 to 0.55) are lower than for the systems discussed above, but they also receive high sediment loads which can result in apparently high deposition rates.

We consider, however, that the trap efficiency and deposition rate results calculated by the model for these morphologically dynamic systems are over-estimated. This is because the time-averaged trap efficiency in these systems is controlled by processes that are not included in the simple mass balance model. In particular, hapua, beach streams, and fresh and tidal river mouths commonly experience channel migrations, shifts in mouth position, and breaching of coastal barriers – which alter the coastal hydrosystem morphology and outlet pathway to the ocean. These events are driven by river floods, coastal storms, or a combination, and they focus current or ocean wave energy that flushes deposited sediment to the ocean on a periodic basis. Thus, while these systems may indeed experience high rates of deposition in their low energy zones on a short-term basis, these deposits are eventually flushed out so that on a long-term average basis their trap efficiency is zero. The highly dynamic form of these systems is also partly due to their high sediment bed loads (coarse sand, gravel) which deposit and build up, forcing channel shifts and subsequent re-working of deposited material.

Some examples of these systems are shown in Figure 6-5, Figure 6-6, and Figure 6-7. The Karakatuwhero River is a small hapua-type lagoon (NZCHS type 3C) with a very high sediment loading of 94 kg/m^2/y. A sequence of satellite images shows how the river channel and mouth shift over time, and the size and shape of the lagoon also change (Figure 6-5). The images illustrate how mobile these systems are, with sediment being deposited then eroded. Deposition tends to occur in side arms (sometimes termed "dead arms") that are isolated from the river's pathway to the outlet (e.g., middle image in Figure 6-5). Outlet migration, typically forced by ocean wave driven longshore transport, will eventually route the river outflow through the dead arm again, flushing accumulated fine sediment.

Figure 6-5: Karakatuwhero River, NZCHS type 3C hapua-type lagoon – small, showing changes in mouth opening, river channel, and lagoon that trap or release fine sediment. Images from 25 Oct 2009, 11 Jan 2013, 14 Oct 2014.

The Nuhaka River is a beach stream with pond (NZCHS type 4C) that receives a very high sediment loading of 34.7 kg/m^2/y. A sequence of satellite images (Figure 6-6) shows how the pond increases and decreases in size over time, is variously connected with the ocean or is blocked by a beach barrier, and has side arms that vary in size and can become disconnected from the main stem (due to the actions of the river in flood and to barrier sediment overwash by storm-waves). Deposition tends to occur when the outlet is blocked or in the side arms even when the outlet is open. Sediment flushing occurs when floods force a wide channel through the beach barrier.

Figure 6-6: Nuhaka River, NZCHS type 4C beach stream – stream with pond, showing changes in mouth opening and pond size that trap or release fine sediments. Images from (top row) 2 Feb 2003, 24 Nov 2006, (bottom row) 12 Feb 2011 and 30 Dec 2013.

The Pahaoa River is a barrier beach enclosed tidal river mouth (NZCHS type 6C) with a loading rate of 8.7 kg/m^2/y. The image sequence in Figure 6-7 shows three different mouth opening states – a narrow channel, a wide channel with turbid flow indicating that this is likely to be during a flood, and a closed mouth (Figure 6-7). The central image illustrates how during high flows, when much of the fine sediment is delivered, the sediment is delivered straight to the ocean.

Thus, we conclude that the long-term average trap efficiencies of most hapua-type lagoons, beach streams, freshwater river mouths, and tidal river mouths are more likely to be zero than the values indicated by our simple mass-balance model – due to its neglect of morphological dynamics and associated coastal and river processes.

Figure 6-7: Pahaoa River, NZCHS type 6C tidal river mouth – barrier beach enclosed, showing changes in mouth openings that trap or release fine sediment. Images from 25 Mar 2010, 10 Jan 2012, 19 Feb 2016.

6.4 Deposition rates

Figure 6-8 shows the estimated mean annual net deposition rates in coastal hydrosystems around New Zealand, while Figure 6-9 shows the range of deposition rate by coastal hydrosystem type. Median deposition rates by each coastal hydrosystem type are reported in Table 6-1, and results for individual estuaries are listed in Appendix K.

Most noticeable is that, despite their relatively low trap efficiencies, the model predicts that many tidal river mouths, hapua-type lagoons, and beach streams have excessively high deposition rates (in some cases they exceed 1,000 mm/y). While these systems all have high sediment loadings, such high deposition rates are unrealistic (and unsustainable morphologically, since they should fill within several years) and stem from the issues discussed in section 6.3 around our simple model over-estimating the sediment trap efficiencies of these types of hydrosystem. In these systems then, the estimated rates are better regarded as indicative of transient or gross deposition rates, not long-term average net rates.

The model appears to produce more realistic results for other types of coastal hydrosystem where mouths are more stable, or, in the case of Waituna-type lagoons, where mouth openings do not result in removal of much of the accumulated sediment because of the large surface area relative to the size of the channel. Excluding hapua-type lagoons, beach streams, freshwater river mouths and tidal river mouths, sediment deposition rates are highest in tidal lagoons (median 1.9 mm/y). Waituna-type lagoons generally have moderate deposition rates (median 0.7 mm/y), but there is a wide range in deposition rates amongst these systems (inter-quartile range 0.2 to 4.5 mm/y). Deep systems such as fjords, deep drowned valleys, and coastal embayments generally have low deposition rates (medians of 0.2 to 0.3 mm/y), while shallow drowned valleys have intermediate deposition rates (median 0.7 mm/y).

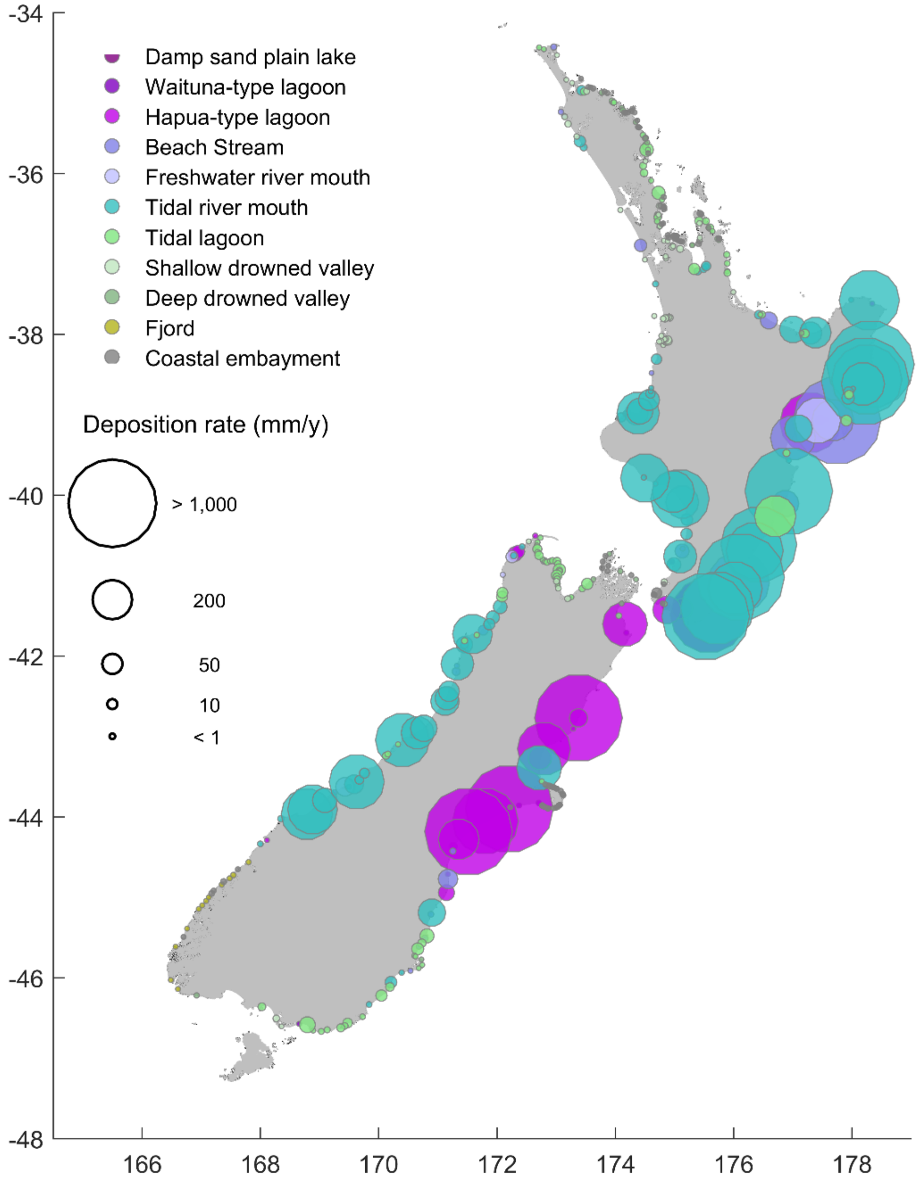

Figure 6-8: Net average annual deposition rate in coastal hydrosystems. Coastal hydrosystem types are indicated by marker colour, and marker area scales with the net deposition rate. Shown for the current sediment load scenario. Axes show latitude and longitude.

Changes in deposition rates between the pre-human, pre-European, and current scenarios are indicated in Figure 6-9 and Table 6-1. For all systems, there is little difference in deposition rates between the pre-human and pre-European scenarios, but median deposition rates for the current scenario have increased for most estuaries except freshwater river mouths. Decreases are largely due to the construction of dams. These findings are discussed further in Section 6.5.

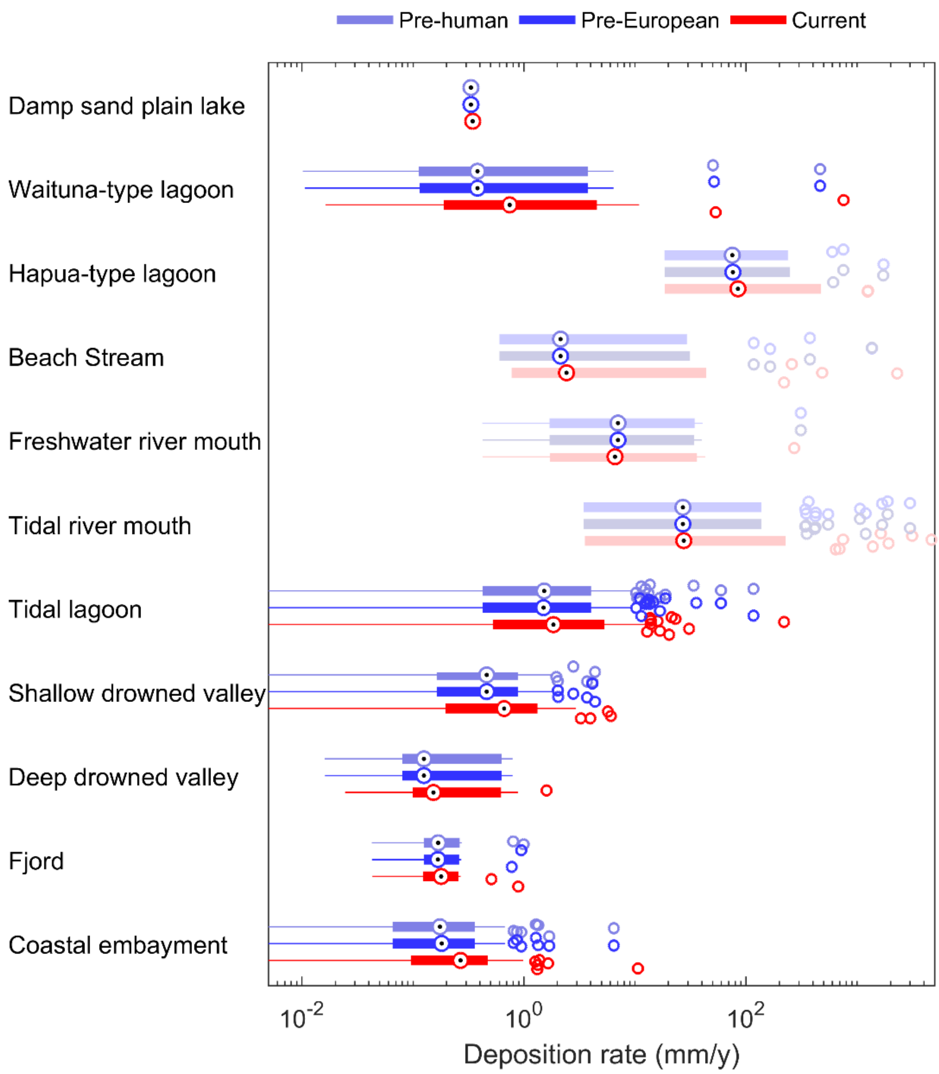

Figure 6-9: Net average annual deposition rates for each NZ Coastal hydrosystem type. Shown for the pre-human, pre-European, and current scenarios. Circles-with-dots show median values; bars span 25th and 75th percentiles; lines span 0.5th and 99.5th percentiles; isolated circles are outliers. Deposition rates for hapua, beach streams, freshwater and tidal river mouths are shown with lighter toning because they likely represent short-term, transient deposition rates between flushing events, not long-term average rates.

Figure 6-10 shows a re-scaled map of deposition rates excluding hapua-type lagoons, beach streams, freshwater river mouths and tidal river mouths where other processes not included in the model may limit long-term sediment accumulation. This map shows that tidal lagoons generally have moderate deposition rates throughout New Zealand. The two Waituna-type lagoons at the bottom of the North Island (Lake Onoke and Oterei River) have high deposition rates, while deposition rates in coastal embayments, fjords, and deep drowned valleys are low nationwide.

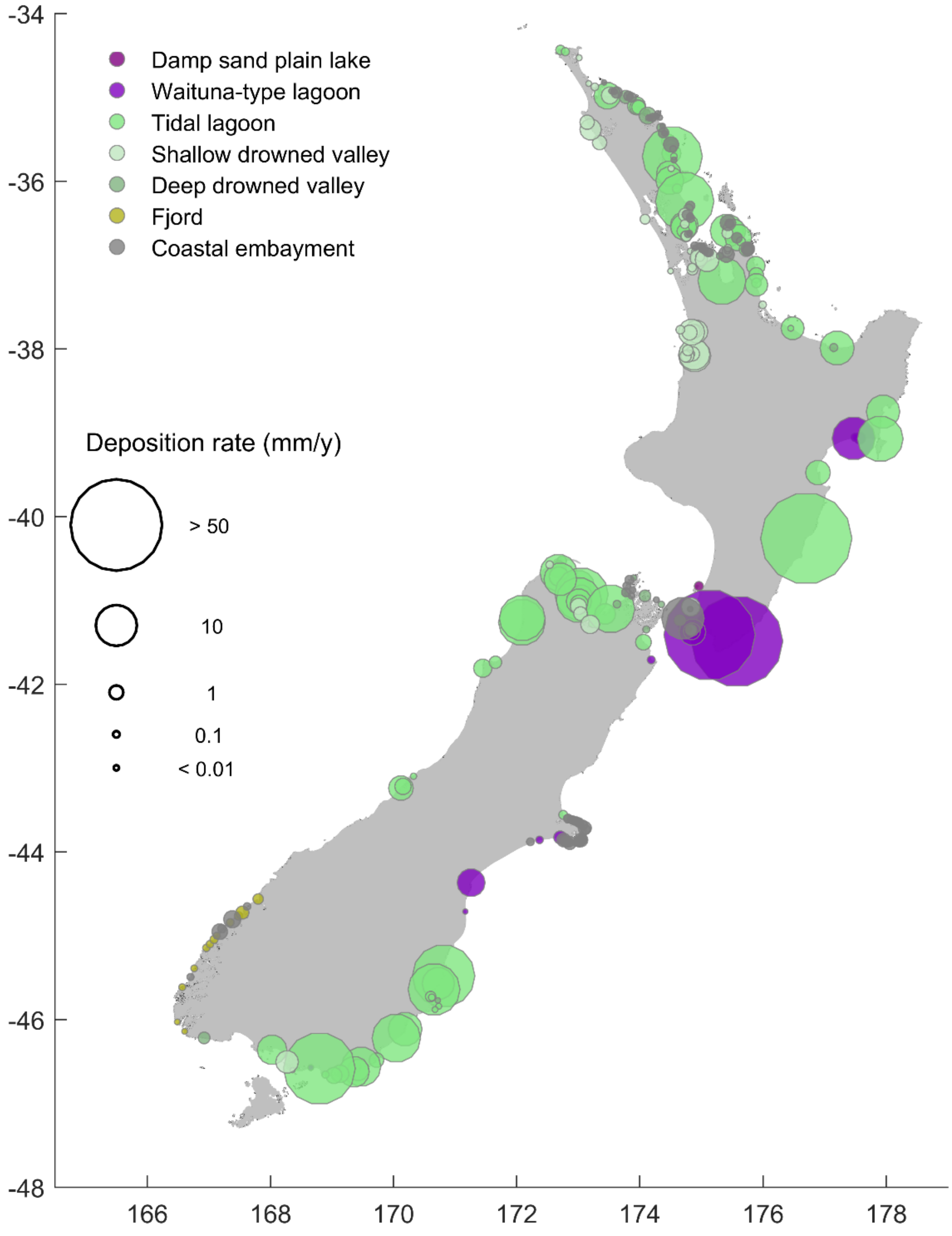

Figure 6-10: Net annual deposition rate in coastal hydrosystems, excluding hapua-type lagoons, beach streams and freshwater river mouths. Coastal hydrosystem type is indicated by marker colour, and marker area shows net deposition rate. Shown for the current load scenario.

Table 6-1: Median annual average deposition rates for each coastal hydrosystem type for the pre-human, pre-European, and current scenarios. Types labelled in italics are systems where erosional events and mouth openings caused by high flows or coastal processes occur periodically and likely control long term net sediment accumulation but are not included in the model.

Type	Pre-human (mm/y)	Pre-European (mm/y)	Current (mm/y)
Damp sand plain lake	0.335	0.332	0.332
Waituna-type lagoon	0.747	0.381	0.381
Hapua-type lagoon	*84.7*	*76.7*	*75.4*
Beach Stream	*2.42*	*2.15*	*2.14*
Freshwater river mouth	*6.64*	*7.09*	*7.09*
Tidal river mouth	*27.6*	*27.1*	*27.1*
Tidal lagoon	1.86	1.51	1.53
Shallow drowned valley	0.664	0.463	0.463
Deep drowned valley	0.153	0.126	0.126
Fjord	0.179	0.167	0.168
Coastal embayment	0.270	0.182	0.175

6.5 Discussion

6.5.1 Representation of processes

The trapping efficiencies produced by the estuary sedimentation model are relatively sensible in regard to coastal hydrosystem type. Systems that are expected to have high trapping efficiencies are large systems such as deep drowned valleys, fjords, and embayments, or those with closed lagoons such as damp sand-plain lakes and Waituna. Tidal lagoons and shallow drowned valleys have slightly lower trapping efficiencies because currents from tidal flushing and freshwater flows cause greater entrainment than in the larger deep systems. However, the trapping efficiencies appear too high in hapua-type lagoons, beach streams, freshwater river mouths and tidal river mouths – and produce deposition rates that are too high. This is because other processes operate to clear sediment that are not captured by the simple mass balance model. These include shifts in the location of the mouth, migration of channels, breaching of coastal barriers and shortening of channels to the sea, and coastal processes – all of which can sweep away sediment on a periodic basis. These systems likely have short term/transient deposition, often at high rates, in low energy zones but near-zero or zero net long-term average rates.

For example, hapua form narrow elongated lagoons that are, except for a narrow, constricted outlet, enclosed by a coarse barrier beach formed by ocean waves and typically strong longshore sediment transport. "Dead arms" of the lagoon isolated from the main river flow are effective sediment traps. During large floods, a wide opening is forced through the barrier opposite the river before longshore transport re-establishes the constriction. The highly mobile outlet can migrate for hundreds of metres to kilometres and reworks sediment in the lagoon as it moves along (Hume et al. 2016). Examples include the Rakaia, Ashburton, and Rangitata River hapua. In the model, the lagoons of hapua act as sediment traps, and while re-entrainment prevents deposition in the main channel, areas outside the channel or considered intertidal allow sediment to accumulate. However, the model does not allow for reworking of sediment as the mouth migrates or for direct discharge of sediment to the sea when a new mouth is formed during high flows.

Thus, although the estimated long-term average trapping efficiencies may be too high for these systems, within a given type it likely gives reasonable indications of short-term deposition rates between flushing events.

6.5.2 Validation check

While calibrating the coastal hydrosystem sediment entrapment model to field observations was beyond the study scope, we did compare predicted deposition rates with European-era rates observed at 11 estuaries as compiled by Morrison et al. (2009) from multiple studies of estuary cores. The results of this comparison are shown in Table 6-2 and Figure 6-11.

Considering all the data together, the initial impression is that the entrapment model under-predicts, with the observed rates exceeding the predicted rates in 10 of 11 cases (and by more than a factor-of-10 in four cases). However, the story changes when regard is given to the time-period over which the observed data were compiled, the uncertainties in the predicted and observed data, and potential sampling bias in the observed data.

When those estuaries with sedimentation data collected over the same broad period (1967 to present) as represented by the catchment sediment load prediction model are isolated (blue points, Figure 6-11), and considering the uncertainties reported in the estuary observations (blue lines, Figure 6-11), then in all five cases the observed values lie within a factor-of-two of the predicted values. Since the standard factorial error on the predicted catchment loads (× or ÷ 1.9) is approximately a factor of two, then agreement is within the bounds of uncertainty, even without considering uncertainty introduced by the approximations involved with the estuary sediment entrapment model itself.

The data points where the predicted deposition rates are much lower than the observed ones (orange and grey points in Figure 6-11) are all for longer epochs (dating back as far as the 1840s), so those will have been influenced (to varying degrees) by the surge in sediment load associated with European deforestation and from ongoing legacy effects as stored sediment mobilised by this historical disturbance is worked through the catchments.

It is not clear how well the coring-based data compiled by Morrison et al. (2009) represent the spatially-averaged rates over the entire estuarine areas (which is what our model does). We might expect the core-based data to be higher, if anything, than the areal average values if there was any bias towards coring where high deposition was suggested by other information. Also, the cores will have included any sediment of marine origin, whereas our model does not.

Weight is given to these latter effects when the observed deposition rates are compared with the predicted loading rates (when these are expressed as sediment-depth equivalents), which effectively assume all inflowing fluvial sediment is deposited (Table 6-2). Even these are substantially smaller than the observed rates over the longer epochs.

Thus, we conclude from this first-order validation check that the predicted sedimentation rates appear consistent with observed rates averaged over recent decades when allowance is made for the uncertainty in both the predicted and observed data.

Table 6-2: Predicted deposition rates for current scenario compared with observed deposition rates compiled by Morrison et al. (2009) for 11 estuaries. Observed data based on coring studies and cover various periods of the European era. Predicted loading rate is predicted estuary sediment inflows divided by estuary surface area and assuming a deposited bulk density of 1500 kg/m^3.

Estuary	Observed deposition rate (mm/y)	Averaging period for observed data	Predicted deposition rate (mm/y)	Predicted loading rate (mm/y)
Waitemata	3	1841 - present	0.07	0.08
Tamaki River	6.25	1840 - present	0.03	0.03
Whangapoua Harbour	0.89-1.5	Not known	0.33	0.35
Wharekawa Harbour	5.0-8.0	1945-1999	1.14	1.30
Whangamata Harbour	5	1940 - present	0.41	0.44
Waituna Lagoon	2.8	1960 - present	0.04	0.04
Waitetuna Creek (Raglan)	2.5-8	1990 - present	2.96	3.18
Waikawa Harbour	3.1-10.7	1967 - 2007	1.71	1.84
Wainui Inlet	2.3-3.3	1979 - present	1.93	2.16
Totaranui Stream	2.3-3.3	1979 - present	5.34	6.31
Awaroa Inlet	2.3-3.3	1979 - present	2.54	2.86

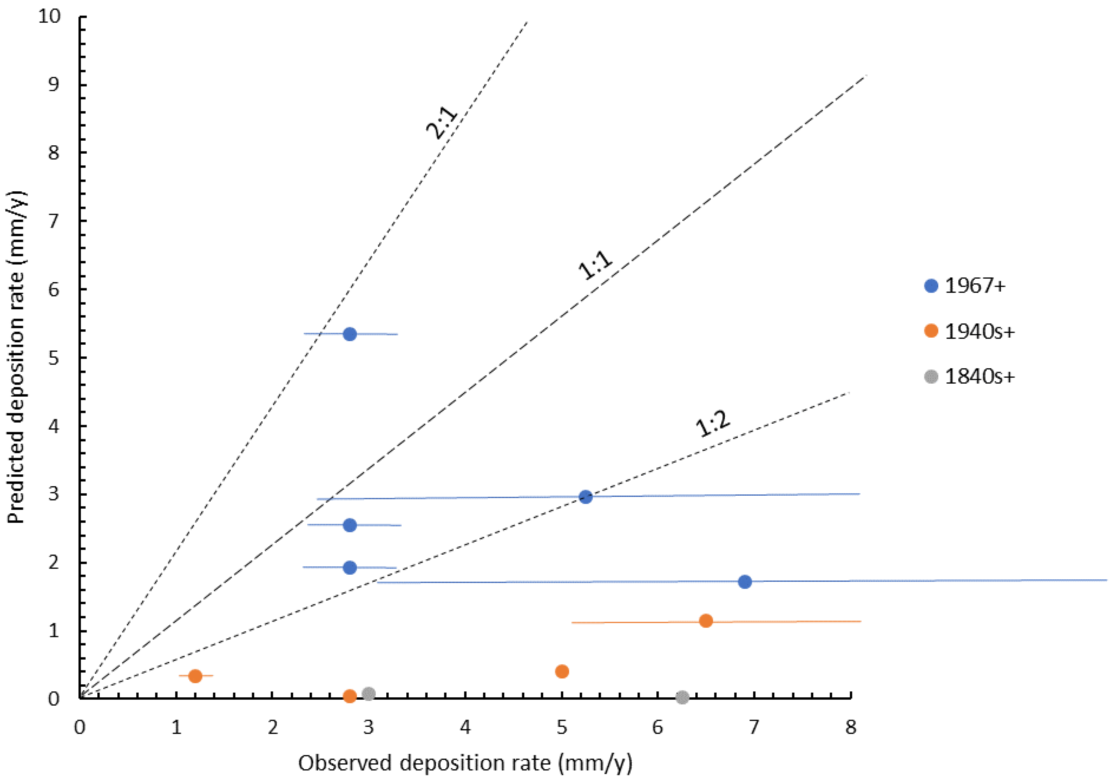

Figure 6-11: Predicted deposition rates for current scenario compared with observed deposition rates compiled by Morrison et al. (2009) for 11 estuaries. Colours of symbols identify the time-range over which the observed deposition was measured. Coloured horizontal lines show the range of observed results; absence of these lines indicates that only one value was reported. Sloping, broken lines show the ratio of predicted to observed deposition rate.

7 Conclusions

The main conclusions from this report are as follows:

1. A new raster-based, national-scale empirical river sediment load estimator has been developed for New Zealand, calibrated using an updated dataset of observed river sediment loads. The model accuracy (standard factorial error of ×/÷ 1.9) is slightly less than an earlier model developed by Hicks et al. (2011), but the present model has been better calibrated over more regions and includes explicit dependence on land cover. Northland, Taranaki, Marlborough, and South Westland remain sparse in sediment monitoring data.

2. The model calibration indicated that, other factors being the same, the sediment yield from trees/scrub land cover should be 47% that from pasture. This is a higher percentage than reported in some previous New Zealand empirical yield/load models (e.g., 28% from Elliott et al. 2008) but is within the range of or close to measured differences in sediment yield from studies of paired catchments with either pasture or exotic forest land. The variability in this ratio, modelled and observed, suggests that some degree of interaction occurs between the sediment yield controlling variables, rather than them being independent as assumed in the modelling used here. This raises a caution around the model's use for predicting or hindcasting the impacts of land cover change on sediment yield.

3. The national total sediment load delivered to the New Zealand coast is 181.1 Mt/y, with 61% (111.6 Mt/y) from the North Island and 39% (69.5 Mt/y) from the South Island. In the North Island, the highest regional sediment loads occur at East Cape (64.6 Mt/y; 36% of the national load) due to a combination of relatively high rainfall, deforestation, and highly erodible crushed argillite and tertiary mudstone lithologies. In the South Island, the highest regional sediment loads occur in South Westland (43.3 Mt/y, 24% of the national load) due to a combination of steep slopes, heavy rainfall, and high uplift rates on the eastern side of the Alpine Fault. These results are broadly similar to those reported by Hicks et al. (2011), albeit somewhat less: with the present national load estimate being 27.6 Mt/y less than the Hicks et al. (2011) total, and most of the reduction (21.1 Mt/y) stemming from lower estimates on rivers from South Westland. These differences are more indicative of how the mean annual load estimate has been refined with the benefit of additional data than any temporal change in actual sediment load.

4. Lakes intercept significant amounts of river sediment load, particularly in the South Island where natural lakes trap sediment at a rate of 18.9 Mt/y and hydro/irrigation storage lakes intercept 2.23 Mt/y. In the North Island, natural lakes intercept only 0.68 Mt/y of sediment, with most occurring in Lake Taupo, while artificial lakes trap 0.62 Mt/y. Over New Zealand, natural lakes intercept 9.6% of all the sediment delivered to the river network, while entrapment in artificial lakes equates to around 1.6% of what is delivered to the coast.

5. There is very little difference in the sediment load results between the pre-human and pre-European land cover scenarios. Greater differences are apparent between these and the current land cover scenario, particularly in the North Island, where the historical loads average 78% of the current load and are as low as 52% of the current load in some regions. There is smaller difference across the South Island. In

most cases, the loads estimated for the historic scenarios are less than those calculated for the current land cover scenario due to the (approximately factor-of-two) lower erosion rates associated with forest cover. This effect is less in the South Island because of the remaining forest cover in the high sediment yielding area of South Westland. Notable exceptions are rivers with artificial hydropower reservoirs, where the river loads have decreased compared with the historical scenarios because reservoir entrapment has prevailed over the effects of land cover change.

6. These comparisons with historical land cover should be interpreted with caution for several reasons. First, the results are generated assuming stable land cover, but current loads include "legacy" sediment from erosion of stored sediment deposits generated during historical deforestation. Second, an underpinning assumption of the modelling is that the land cover and erosion terrain coefficients in the model are mutually independent, but this may not be the case always – as discussed in Conclusion 2 above. Third, before the onset of European drainage works and flood-confinement between stopbanks, floodplains and wetlands would have intercepted greater proportions of river suspended loads. The upshot is that the actual pre-European and pre-human sediment loads will, if anything, have been lower than estimated herein.

7. The geographic pattern of sediment loadings to coastal hydrosystems reflects the regional and large-river load patterns already described, i.e., they are highest along the east coast of the North Island and the west coast of the South Island. The coastal hydrosystem types that receive the highest sediment loadings are generally tidal river mouths and hapua-type lagoons.

8. The modelled coastal hydrosystem sediment trapping efficiencies and sedimentation rates vary sensibly between coastal hydrosystem type. However, the trap efficiency and deposition rate results calculated for morphologically dynamic systems (hapua-type lagoons, beach streams, freshwater river mouths, and tidal river mouths) are over-estimated because the time-averaged trap efficiency in these systems is controlled by coastal and river processes that are not included in the simple mass balance model. While these systems may indeed experience high rates of deposition in their low energy zones on a short-term basis, such deposits are eventually flushed out, and we conclude that their long-term average trap efficiency of is more likely to be zero.

9. As well as these issues with the morphologically dynamic systems, the coastal hydrosystem sediment mass balance model used herein to estimate trap efficiency and deposition rate is a simple, zero-dimensional model that has not been calibrated to independent measures of sedimentation rate. Thus, these results are best regarded as indicative for coastal hydrosystem types, and results for individual systems should be used with caution.

10. Nonetheless, a comparison at five estuaries where actual deposition rates averaged over recent decades have been measured by coring showed that the predicted rates are consistent with the observed rates when allowance is made for the uncertainty in both the predicted and observed data.

8 Acknowledgements

We thank regional/district councils and NIWA clients from across New Zealand for supply of sediment load information used in the sediment load estimator calibration. We thank Manaaki Whenua / Landcare Research for supply of land cover and erosion terrain GIS layers. We also thank Doug Booker and Charlotte Jones-Todd, NIWA, for advice on statistical methods.

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Appendix A Estuary sedimentation model method details

Sediment influx

The mean annual sediment flux to each estuary / coastal hydrosystem is obtained from the sediment load generation and routing model described in 2.1.

Sediment fluxes into an estuary vary with inflow, so the sediment flux into the estuary is apportioned by combining estimated flow-duration and sediment rating curves.

100-point mean daily flow duration curves for the terminal reaches to each estuary are predicted using a random forest statistical model (Booker and Woods 2014). The points on the flow-duration curve are separated by equal increments of 'duration' (actually, percentage of time). Hence, our approach is to determine the source and estuarine transport for each of the points on the curve, and then combine the results in an equally-weighted fashion. For simplicity, if multiple terminal reaches connect to an estuary, the flow duration curves are added (which assumes that flows in the reaches co-vary).

A sediment rating curve is applied to apportion the mean annual sediment load across the different inflows. The sediment input (kg/s) is applied as a function of flow according to

$$S_{in} = aQ^{1+b} \tag{A1}$$

The coefficient *a* is calculated for each estuary as

$$a = n\frac{S_{in\ annual}}{\sum_{i=1}^{n} Q_i^{1+b}} \frac{1000}{365 \times 24 \times 3600} \tag{A2}$$

where *n* is the number of points on the flow duration curve (*n* = 100), $S_{in\ annual}$ is the mean annual sediment load (t/y), and *b* is a coefficient with a value 1.5 (which is reasonably representative of most New Zealand rivers (D. M. Hicks, NIWA, pers. comm.). This is based on the idea that each flow value occurs for a duration of 365/n days in a year, on average.

Once *a* is calculated, the sediment input for each point on the flow duration curve is calculated from Equation (A1).

Settling

The settling rate of fine sediments in the estuary is based on settling velocity, w_s, estuary area available for settling, A_s, and water column sediment concentration, *C*.

$$D = w_s A_s C \tag{A3}$$

Settling velocity is a function of grain size and density, and settling velocities for fine particles in the clay-silt range vary between 0.0004 mm/s and 2 mm/s. However, flocculation processes in estuaries cause fine particles to coalesce and increase settling velocities. In our analysis we use a constant settling velocity of 0.25 mm/s for all estuaries. This settling velocity represents a grain size of 0.023 mm (medium silt), which is reasonably representative of the dominant suspended load size mode in New Zealand Rivers (Hicks et al. 2004).

Because settling occurs only when an area is submerged, the area available for settling is taken as the average of the surface area at high and low tide $A_s = A - A_i/2$, where A = area at high tide and A_i = intertidal area.

The concentration term, *C,* is calculated for each point on the flow duration curve by solving Equation (3), as explained in Section 2.2 in the main text.

Resuspension by waves

Waves typically erode estuarine intertidal flats, which would otherwise accrete (Green and Coco 2014). Wind-generated waves in estuaries are typically short period (1-5 s), and wave-orbital motions are more likely to penetrate down to the bed and resuspend sediments only on intertidal flats, and generally only toward low tide (Green and Coco 2014). In our analysis, we calculate the resuspension of sediments by waves on intertidal areas as a source term (E_w) in the estuary sediment mass balance model.

Resuspension by waves is estimated by first calculating directional distributions of wind-generated wave height and period, using estuary fetch data contained within the Coastal Explorer database, then calculating distributions of bed shear stress on intertidal areas, and finally calculating resuspension rates from the bed shear stress distributions.

Wind data is obtained from the closest meteorological station to the estuary, choosing from meteorological stations that have 3 hourly observations, have at least 8 years of data, and have been active within the last 2 years (i.e., recent data). Wind rose data (frequency distributions of mean wind speed in 10 km/h increments and 10° directional bins) for these 199 meteorological stations were extracted from NIWA's climate database. An example wind-rose is shown in Figure A-1.

The Coastal Explorer database (Hume et al. 2007) contains mean and maximum fetch along four axes of orientation: North – South; Northeast – Southwest; East – West; Southeast – Northwest. The wind-rose data is regrouped to obtain frequency distributions of wind speed along these four axes (Figure A-2).

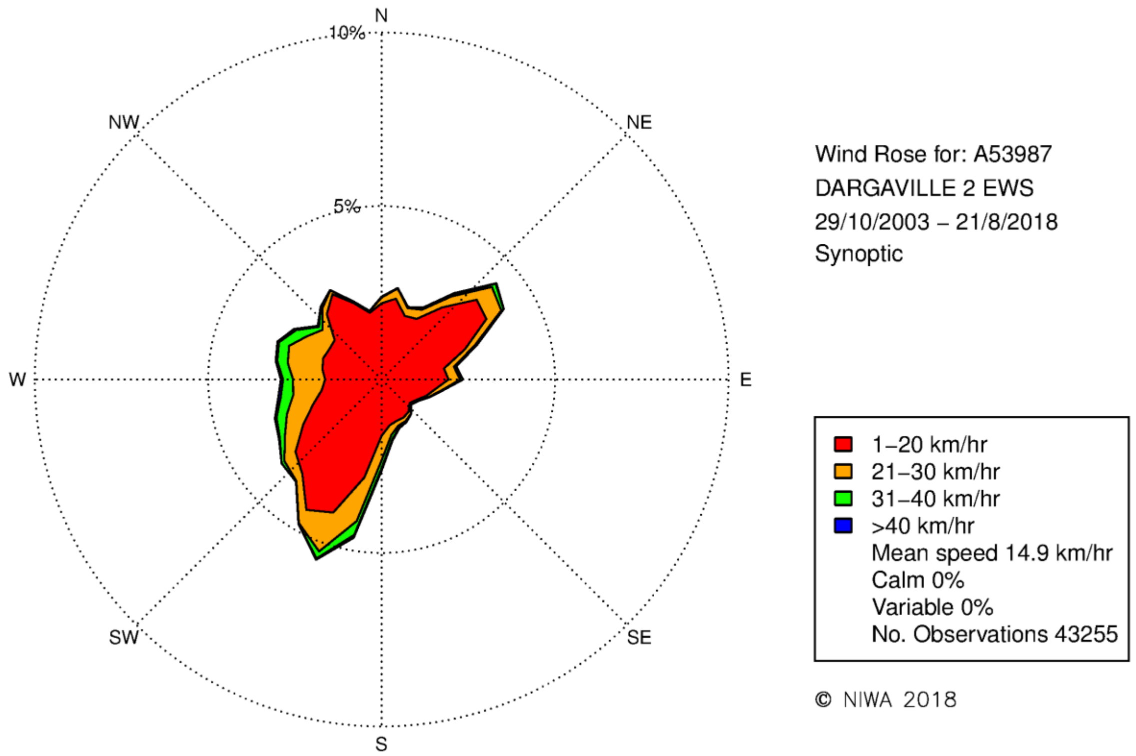

Figure A-1: Example wind rose from Dargaville meteorological station. The wind rose shows a summary of 3 hourly averaged wind speeds in 10 km/h and 10° increments.

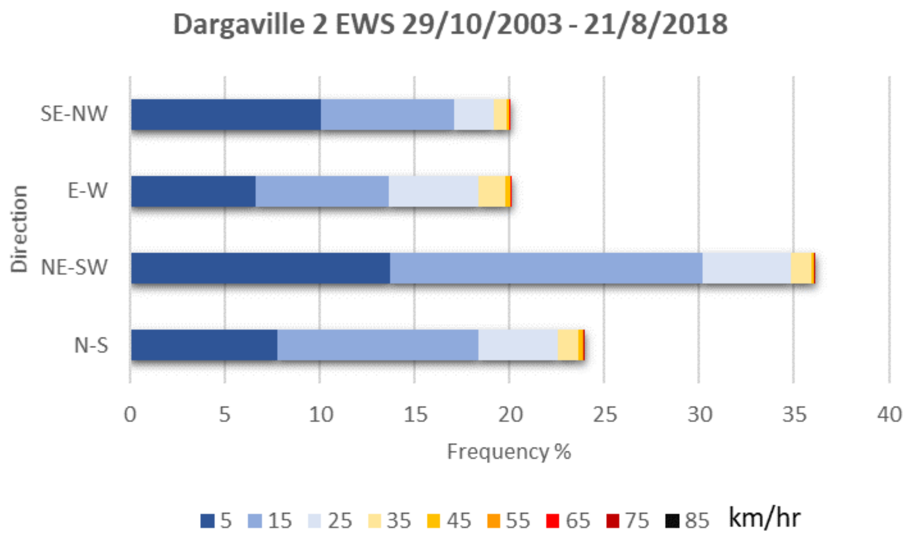

Figure A-2: Example of wind speed distributions oriented along four axes of estuary fetch from Dargaville meteorological station. Wind speeds are indicated by colour and represent the mid-point of each wind-speed band.

Wave height and period are calculated as a function of wind speed and average fetch in each of the four axes of orientation following the US Army Corps of Engineers Coastal Engineering Manual (USACE 2002).

The equations governing wave growth with fetch are

$$\frac{gH}{u_*^2} = 0.0413\left(\frac{gX}{u_*^2}\right)^{\frac{1}{2}} \tag{A4}$$

and

$$\frac{gT}{u_*} = 0.651\left(\frac{gX}{u_*^2}\right)^{\frac{1}{3}} \tag{A5}$$

where

X = fetch (distance over which the wind blows)
H = significant wave height
T = wave period
g = gravitational acceleration (9.81 m/s^2)
u_* = friction velocity.

The friction velocity is calculated from wind speed at 10 m elevation, U_{10}, and drag coefficient, C_D, as

$$C_D = 0.001(1.1 + 0.035U_{10}) \tag{A6}$$

$$u_*^2 = C_D U_{10}^2 \tag{A7}$$

The wave height and period are used to calculate the orbital velocity at the bed. Assuming that wave resuspension occurs only over the intertidal area, the wave number is calculated for a water depth of h = ½ tidal range (Green and Coco 2014) by iteration.

$$(2\pi/T)^2 = gk\tanh(kh) \tag{A8}$$

The peak orbital velocity at the bed is

$$U_{w,b} = \frac{\pi H}{T\sinh(kh)} \tag{A9}$$

The bed shear stress is

$$\tau_w = \frac{1}{2}\rho f_w U_{w,b}^2 \tag{A10}$$

where the wave friction factor f_w is calculated as

$$f_w = 1.39(A_b/k_b)^{-0.52} \tag{A11}$$

with the amplitude of the orbital motion at the bed $A_b = U_{w,b}T$ and the grain roughness $k_b = 2\pi\, D_{50}/12$ (Soulsby 1997). A median grain size of D_{50} = 0.05 mm is assumed.

The resuspension rate (kg/s/m^2) is calculated as a function of excess bed shear stress (Green and Coco 2014), assuming that wave-resuspension occurs only on intertidal areas and only on the down-wind side of the estuary:

$$E_w = M\frac{A_i}{2}\left(\frac{\tau_w}{\tau_c} - 1\right),\ \ \tau_w > \tau_c \tag{A12}$$

τ_c is the critical shear stress for the erosion of cohesive sediments, and *M* is an erosion rate coefficient. In this study, we use the default values for these parameters as used in the DELFT3D sediment modelling software, with τ_c = 0.5 N/m and M = 0.0001 kg/s/m^2 (Deltares 2013).

Using the above equations, the erosion rate for each fetch and windspeed is calculated. Weighted by the number of observations in each windspeed/direction bin, the average wind-wave erosion rate (kg/s/m^2) is then calculated. We also assume that wave-induced resuspension only occurs on the down-wind side of the estuary, therefore the wind-wave resuspension rate is multiplied by ½ the intertidal area to get a total wind-wave erosion (kg/s) for each estuary. Resuspension by waves is applied at a constant rate.

Re-entrainment by currents

Turbulence in the tidal channel inhibits settling and re-entrains sediments. In our model, re-entrainment is modelled as

$$E_c = \beta u_* A_c \tag{A13}$$

where u_* is the shear velocity, A_c the area over which re-entrainment occurs, and β = 1.0 is a re-entrainment rate coefficient (Bagnold 1988). The area over which re-entrainment occurs is defined here as the area of the estuary channel. This area is estimated from thalweg length and estuary mouth width data in Coastal Explorer. Where thalweg length is not given in Coastal Explorer, this is estimated as $\alpha\sqrt{A}$ where α is a multiplier determined by New Zealand Coastal Hydrosystem type (Table A-1), calculated from estuaries for which thalweg lengths are given in Coastal Explorer and the NZCHS (Hume et al. 2007; Hume et al. 2016). Those hydrosystem types where no thalweg data are available are assigned a default value of 1. The channel area is also restricted to a maximum value of the subtidal estuary area (total area – intertidal area).

Table A-1: Average ratio of thalweg length to square-root of estuary area used to estimate estuary channel area. No thalweg data were available for NZCHS types 1, 9, 10, and 11, so a default ratio of 1 is applied.

NZ Coastal Hydrosystem type	Description	Ratio thalweg/$\sqrt{A}$
1	Damp sand-plain lake	*1*
2	Waituna-type lagoon	1.938
3	Hāpua-type lagoon	2.699
4	Beach stream	4.577
5	Freshwater river mouth	3.856
6	Tidal river mouth	5.734
7	Tidal lagoon	3.714
8	Shallow drowned valley	3.359
9	Deep drowned valley	*1*
10	Fjord	*1*
11	Coastal embayment	*1*

We also assume that re-entrainment does not exceed deposition, such that only recently deposited sediment can be re-entrained. This is achieved by restricting

$$\beta u_* \leq w_s \tag{A14}$$

The shear velocity is due to the combination of river flow and tidal flow. This is calculated by assuming that the velocity in the estuary channel can be approximated using the velocity through the estuary mouth.

Velocities due to river discharge are calculated for each daily flow on the flow duration curve, Q_i

$$U_Q = \frac{Q_i}{wH} \tag{A15}$$

where w is the width of the mouth and H the estuary depth.

Tidal flow, which oscillates over the tidal period, is added to daily flow values. A frequency distribution of tidal velocity through the mouth is calculated from tidal prism P as

$$U(p) = \frac{\pi P}{wHT_p} \sin\big(\pi(p - 0.5)\big) \tag{A16}$$

where $U(p)$ is the velocity with an exceedance probability of p ($0<p<1$). Positive velocities are outflows while inflows are negative. The tidal velocity is added to the river discharge term, as illustrated in Figure A-3.

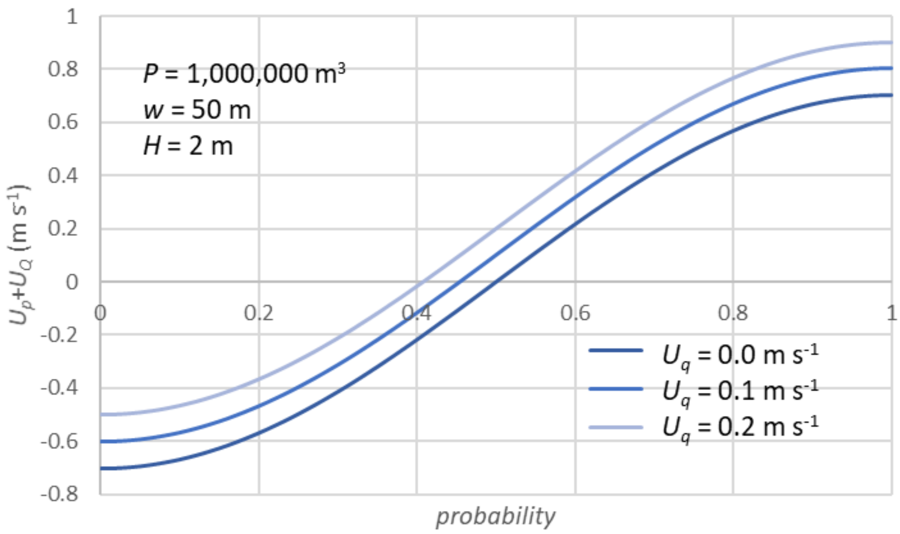

Figure A-3: Example of the probability distribution of velocities through an estuary mouth with different freshwater discharge. The example shows an estuary with tidal prism 1,000,000 m^3, estuary mouth width 50 m depth 2 m. Tidal velocities are added to freshwater velocities of 0, 0.1, and 0.2 m/s, which would represent daily freshwater discharges of 0, 10, and 20 m^3/s.

For each daily flow from the flow duration curve, a distribution of shear velocities is calculated as

$$u_* = \left|U(p) + U_Q\right|\sqrt{C_d} \tag{A17}$$

A bed drag coefficient of C_d = 0.0015 is used (Dyer 1986). The mean shear velocity is obtained for each daily flow from the flow duration curve and is used in Equation (A13).

Export to the ocean

The export of sediment to the ocean from the estuary is calculated for each point on the flow duration curve. The export of sediment is a function of water column sediment concentration in the estuary, C, tidal flow in and out of the estuary, Q, and the return flow fraction, b (i.e., how much of the outgoing tide returns to the estuary on the next incoming tide). Based on the dilution modelling approach developed by Plew et al. (2018), the net export of sediment through the estuary mouth can be expressed as

$$S_{out} = \frac{CQ}{f} \tag{A18}$$

where f is the freshwater fraction in the estuary. The freshwater fraction is obtained from 1/θ, where θ is the dilution factor calculated from

$$\theta = \frac{P(1-b) + \frac{QT_p}{2}(1+b)}{QT_p} \tag{A19}$$

where P is the tidal prism, T_p the tidal period (12.42 hours), and b a 'tuning' factor that accounts for return flow and incomplete mixing (Plew et al. 2018). The dilution factor (and freshwater fraction) is calculated for each point on the flow duration curve.

Solving for estuary sediment concentration

For each flow from the daily flow duration curve, the estuary concentration is obtained by rearranging Equation (3) and inserting Equations A1, A3, A12, A13, and A18.

$$C = \frac{S_{in} + E_w + \beta u_* A_c}{Q/f + w_s A_s}$$

The sediment mass balance is calculated for each point on the flow duration curve. Because each of the 100 flows are equally spaced on the flow duration curve, each value represents 3.65 days per year. The sediment export S_{out} is calculated for each flow, multiplied by the time for each point on the flow duration curve (3.65 days), and added to obtain the annual sediment export from the estuary. Sediment trap efficiency and net deposition rate are then calculated from annual sediment input and export.

Appendix B Artificial reservoirs

The following list of artificial reservoirs includes significant hydropower and water supply/irrigation reservoirs. These are not applied to the two historical scenarios but are applied to the current land cover scenario. Natural lakes artificially controlled for hydro-power are excluded. Note that some reservoirs have two outflow segments on the REC2 network, and so are listed twice.

Table B-1: Artificial reservoir outlets.

Region	Lake name	Segment ID
Northland	Lake Manuwai	1006018
	Lake Waingaro	1007959
Auckland	Cosseys Reservoir	2042441
	Lower Huia Reservoir	2040607
	Lower Huia Reservoir	2040755
	Lower Nihotupu Reservoir	2040111
	Mangatangi Reservoir	3043734
	Upper Huia Reservoir	2040110
	Upper Mangatawhiri Reservoir	3042997
	Upper Nihotupu Reservoir	2039851
	Wairoa Reservoir	2043212
	Waitakere Reservoir	2038665
Waikato	Lake A	3059033
	Lake Arapuni	3083038
	Lake Aratiatia	3129905
	Lake Atiamuri	3111846
	Lake Atiamuri	3110283
	Lake B	3058651
	Lake C	3058389
	Lake D	3058387
	Lake Hinemaiaia	3151431
	Lake Karapiro	3071503
	Lake Kuratau	3149763
	Lake Maraetai	3108396
	Lake Maraetai	3106158
	Lake Waipapa	3100422
	Lake Whakamaru	3112336
Bay of Plenty	Lake Aniwhenua	4104995
	Lake Aniwhenua	4104996
	Lake Matahina	4088344
Taranaki	Lake Rotorangi	6200821
Manawatu/Whanganui	Lake Moawhango	7193069
	Lake Otamangakau	7160702
	Mangahao Lower No 2 Reservoir	7245877
	Mangahao Upper No 1 Reservoir	7246389

Region	Lake name	Segment ID
	Tokomaru No 3 Reservoir	7245450
	Tokomaru No 3 Reservoir	7245439
Wellington	Kourarau Dam	9259903
Tasman/Nelson	Cobb Reservoir	10008205
	No name	10015406
Marlborough	No name	11027742
	Gillows Dam	12037952
West Coast	Kapitea Reservoir	12084326
	Okuku Reservoir	12087397
	Lake Aviemore	13193893
	Lake Benmore	13188655
	Lake Opuha	13153653
Canterbury	Lake Ruataniwha	13171192
	Lake Waitaki	13195636
	No name	13153653
	Wairepo Arm	13171310
	Butchers Dam	14239662
	Conroys Dam	14238864
	Falls Dam	14209682
	Fraser Dam	14234310
	Hawkers Dam	14287335
	Idaburn Dam	14220510
	Knights Dam	14278107
	Lake Dunstan	14232229
	Lake Mahinerangi	14279393
Otago	Lake Onslow	14259116
	Lake Roxburgh	14253850
	Lower Manorburn Dam	14235718
	Malones Dam	14284867
	Manorburn Reservoir	14244667
	Moa Creek Reservoir	14235766
	No name	14256443
	Phoenix Dam	14283888
	Poolburn Reservoir	14239682
	West Eweburn Dam	14218695
	The Reservoir	15320626

Appendix C Land cover and erosion terrain functional groups

Table C-1: Land cover functional groups used in model – current land cover. Land cover classes are from LCDB3.

Group	Name	LCDB land cover classes
1	Herbaceous	Depleted Grassland Herbaceous Freshwater Vegetation Herbaceous Saline Vegetation High Producing Exotic Grassland Low Producing Grassland Short-rotation Cropland
2	Trees / scrub	Broadleaved Indigenous Hardwoods Deciduous Hardwoods Exotic Forest Fernland Flaxland Forest - Harvested Gorse and/or Broom Indigenous Forest Mangrove Manuka and/or Kanuka Matagouri or Grey Scrub Mixed Exotic Shrubland Orchard, Vineyard or other Perennial Crop Sub Alpine Shrubland
3	Tussock and alpine herbaceous	Alpine Grass/Herbfield Tall Tussock Grassland
4	Other erodible	Gravel or Rock Landslide Permanent Snow and Ice Sand or Gravel Surface Mine or Dump
5	Water	Estuarine Open Water Lake or Pond River
6	Urban	Transport Infrastructure Built-up Area (settlement) Urban Parkland/Open Space

Table C-2: Land cover functional groups used in model – pre-human. Land cover classes are from the Potential Vegetation of New Zealand spatial dataset.

Land cover class	Model functional group
Water	Water
Dunelands	Herbaceous
Hall's totara/broadleaf forest	Trees / scrub
Hall's totara/silver-beech-kamahi-southern rata forest	Trees / scrub
Hall's totara-miro/kamahi-southern rata broadleaf forest	Trees / scrub
Hall's totara-miro-rimu/kamahi-silver beech-southern rata forest	Trees / scrub
Hall's totara-miro-rimu/kamahi-southern rata-broadleaf forest	Trees / scrub
Kahikatea-matai/tawa-mahoe forest	Trees / scrub
Kahikatea-pukatea-tawa forest	Trees / scrub
Kahikatea-totara forest	Trees / scrub
Kauri/taraire-kohekohe-tawa forest	Trees / scrub
Matai-kahikatea-totara forest	Trees / scrub
Matai-totara/black/mountain beech forest	Trees / scrub
Matai-totara-kahikatea-rimu/broadleaf-fuchsia forest	Trees / scrub
Mountain beech forest	Trees / scrub
Mountain beech-red beech forest	Trees / scrub
Red beech-silver beech forest	Trees / scrub
Rimu/tawa-kamahi forest	Trees / scrub
Rimu-matai-miro-totara/kamahi forest	Trees / scrub
Rimu-miro/kamahi-red beech-hard beech forest	Trees / scrub
Rimu-miro/tawari-red beech-kamahi-tawa forest	Trees / scrub
Rimu-miro-totara/kamahi forest	Trees / scrub
Scrub, shrubland and tussock-grassland below treeline	Trees / scrub
Scrub, tussock-grassland and herbfield above treeline	Tussock and alpine herbaceous
Silver beech forest	Trees / scrub
Unclassified	Other - erodible
Wetland	Other
Wetlands	Other

Table C-3: Land cover functional groups used in model – pre-European tussock and grass. Land cover classes are from Mark and McLennan (2005).

Land cover class	Model group
Alpine snow	Tussock and alpine herbaceous
Alpine tall red	Tussock and alpine herbaceous
Short	Tussock and alpine herbaceous
Subalpine snow	Tussock and alpine herbaceous
Sward grassland	Herbaceous
Tall red	Tussock and alpine herbaceous

Table C-4: Erosion terrain functional groups used in model. Erosion terrain descriptions and codes are taken from Land Resource Information data.

Code	Island	Erosion terrain class	Model group	Group name
9	SI	Alpine	8	Schist and SI greywacke (incl. alpine, ice and snow)
10	SI	Ice and snow	8	Schist and SI greywacke (incl. alpine, ice and snow)
11	NI	Water	11	Water
	SI	Water	11	Water
12	NI	Other	12	Other
	SI	Other	12	Other
1.1.1	NI	Undifferentiated alluvium from modern overbank depositional events. Parts may be peaty. Includes non-peaty wetlands	1	Sand country, flood plains, fans and terraces, peat
	SI	Alluvium from various sources on active floodplains and fans	1	Sand country, flood plains, fans and terraces, peat
2.1.1	SI	sands and gravels from various sources	1	Sand country, flood plains, fans and terraces, peat
2.1.2	NI	Recent fresh dune sand	1	Sand country, flood plains, fans and terraces, peat
2.1.3	NI	Mature moderately weathered dune sand	1	Sand country, flood plains, fans and terraces, peat
3.1.1	NI	Organic soils on deep peat	1	Sand country, flood plains, fans and terraces, peat
	SI	lowland and upland peat swamps and domed peats	1	Sand country, flood plains, fans and terraces, peat
4.1.1	NI	Gravelly soils on alluvial terrace gravels or on gravelly laharic aprons above the level of modern flood plains	1	Sand country, flood plains, fans and terraces, peat
	SI	Terrace and fan alluvium above the recent floodplain	1	Sand country, flood plains, fans and terraces, peat
4.2.1	NI	Loess mantled terraces and fans	2	Tephra and Loess
	SI	Loess mantled terraces and fans	2	Tephra and Loess
4.2.2	NI	Terraces and fans of young tephra, mostly pumiceous (Waimihia and younger)	2	Tephra and Loess
4.2.3	NI	Basins infilled with Taupo tephra flow deposits - intensely gullied	2	Tephra and Loess
4.2.4	NI	Terraces and fans of mid-aged (late Pleistocene/early Holocene) tephra, older tephra, or tephric loess	2	Tephra and Loess

Code	Island	Erosion terrain class	Model group	Group name
4.3.1	NI	Fine grained, weathered, undifferentiated terrace alluvium—above the level of modern flood plains	1	Sand country, flood plains, fans and terraces, peat
5.1.1	SI	downlands developed on moraine and dissected alluvium	1	Sand country, flood plains, fans and terraces, peat
5.2.1	NI	Downlands developed on Loess	2	Tephra and Loess
	SI	downlands developed on deep >1m loess	2	Tephra and Loess
5.2.2	NI	Downlands developed on Waimihia and younger tephra	2	Tephra and Loess
5.2.3	NI	Downlands developed on Mid-aged (late Pleistocene/early Holocene) tephra, older tephra, or tephric loess	2	Tephra and Loess
5.3.1	NI	Downlands developed on young basalt lava fields and low domes (parts are flatter than typical downland)	6	Lavas, rhyolite, volcanic slopes
5.3.2	NI	Downlands developed on weathered sedimentary and non-tephric igneous rocks	7	Greywacke, argillite and hard limestone
5.3.3	SI	Downlands developed on soft sedimentary rocks	3	Tertiary mudstone, sandstone and soft limestone
5.4.1	SI	Downlands developed on hard sedimentary rocks	7	Greywacke, argillite and hard limestone
5.4.2	SI	Downlands developed on hard schist rocks	8	Schist and SI greywacke (incl. alpine, ice and snow)
5.4.3	SI	Downlands developed on hard, coarse-grained igneous or metamorphic and fine igneous rocks	9	Coarse crystalline plutonics and metamorphics
6.1.1	SI	Hill country developed on moraine and dissected alluvium	1	Sand country, flood plains, fans and terraces, peat
6.2.1	NI	Hill country developed on loess	2	Tephra and Loess
	SI	Hill country developed on deep >1m loess	2	Tephra and Loess
6.2.2	NI	Hill country developed on shallow (0.3–1.0 m) Waimihia or younger tephra, usually over older tephra	2	Tephra and Loess
6.2.3	NI	Hill country developed on deep (>1.0m) Waimihia or younger tephra, usually over older tephra	2	Tephra and Loess
6.2.4	NI	Hill country developed on Mid-aged (late Pleistocene/early Holocene) tephra, or tephric loess, covers	2	Tephra and Loess

Code	Island	Erosion terrain class	Model group	Group name
6.3.1	NI	Hill country developed on young basalt domes and cones	6	Lavas, rhyolite, volcanic slopes
6.4.1	NI	Hill country developed on weak to very weak Tertiary-aged mudstone	3	Tertiary mudstone, sandstone and soft limestone
	SI	Hill country developed on soft sedimentary mudstone	3	Tertiary mudstone, sandstone and soft limestone
6.4.2	NI	Hill country developed on crushed Tertiary-aged mudstone, sandstone; argillite, or ancient volcanic rock (frequently, with tephra covers in the Northern Hawke's Bay–East Coast area)—with moderate earthflow-dominated erosion	3	Tertiary mudstone, sandstone and soft limestone
6.4.3	NI	Hill country developed on crushed mudstone or argillite with severe earthflow-dominated erosion	4-5*	Intensely gullied crushed argillites and greywacke
6.4.4	NI	Hill country developed on crushed argillite, sandstone, or greywacke, with severe gully-dominated erosion	4-5*	Intensely gullied crushed argillites and greywacke
6.4.5	NI	Hill country developed on weak to moderately strong Tertiary-aged sandstone	3	Tertiary mudstone, sandstone and soft limestone
	SI	Hill country developed on soft sedimentary sandstone	3	Tertiary mudstone, sandstone and soft limestone
6.4.6	NI	Non-cohesive Tertiary-aged sandstone	3	Tertiary mudstone, sandstone and soft limestone
6.4.7	SI	Hill country developed on soft sedimentary conglomerate	3	Tertiary mudstone, sandstone and soft limestone
6.4.8	NI	Hill country developed on limestone	3	Tertiary mudstone, sandstone and soft limestone
	SI	Hill country developed on soft calcareous sediments and limestone	3	Tertiary mudstone, sandstone and soft limestone
6.5.1	NI	Hill country developed on unweathered to moderately weathered greywacke/argillite	7	Greywacke, argillite and hard limestone
	SI	Hill country developed on hard sedimentary rocks	7	Greywacke, argillite and hard limestone
6.5.2	SI	Hill country developed on hard schist rocks	8	Schist and SI greywacke (incl. alpine, ice and snow)
6.5.3	SI	Hill country developed on hard, coarse-grained igneous or metamorphic rocks	9	Coarse crystalline plutonics and metamorphics
6.5.4	SI	Hill country developed on hard fine-grained igneous rocks	6	Lavas, rhyolite, volcanic slopes

Code	Island	Erosion terrain class	Model group	Group name
6.6.1	NI	Hill country developed on unweathered to slightly weathered white argillite	7	Greywacke, argillite and hard limestone
6.7.1	NI	Hill country developed on residual weathered to highly (often deeply) weathered Tertiary-aged sedimentary rocks	3	Tertiary mudstone, sandstone and soft limestone
6.7.2	NI	Hill country developed on residual weathered to highly (often deeply) weathered ancient basalt and andesite	6	Lavas, rhyolite, volcanic slopes
6.7.3	NI	Hill country developed on residual weathered to highly (often deeply) weathered welded rhyolite	6	Lavas, rhyolite, volcanic slopes
6.7.4	NI	Hill country developed on residual weathered to highly (often deeply) weathered greywacke/argillite	7	Greywacke, argillite and hard limestone
7.1.1	NI	Hilly steeplands developed on shallow (0.3–1.0 m) Waimihia or younger tephra, usually over older tephra	2	Tephra and Loess
7.1.2	NI	Hilly steeplands developed on deep (>1.0 m) Waimihia or younger tephra, usually over older tephra	2	Tephra and Loess
7.1.3	NI	Hilly steeplands developed on mid-aged (late Pleistocene/early Holocene) tephra covers	2	Tephra and Loess
7.2.1	NI	Hilly steeplands developed on fresh to slightly weathered welded rhyolitic rock, or bouldery andesitic lahar deposits	6	Lavas, rhyolite, volcanic slopes
7.3.1	NI	Hilly steeplands developed on weak to very weak Tertiary-aged mudstone	3	Tertiary mudstone, sandstone and soft limestone
7.3.1	SI	Hilly steeplands developed on soft sedimentary mudstone	3	Tertiary mudstone, sandstone and soft limestone
7.3.2	NI	Hilly steeplands developed on crushed argillite with gully-dominated erosion	4-5*	Intensely gullied crushed argillites and greywacke
7.4.1	NI	Hilly steeplands developed on cohesive, generally weak to moderately strong Tertiary-aged sandstone	3	Tertiary mudstone, sandstone and soft limestone
7.4.1	SI	Hilly steeplands developed on soft sedimentary sandstone	3	Tertiary mudstone, sandstone and soft limestone
7.4.2	SI	Hilly steeplands developed on soft sedimentary conglomerate	3	Tertiary mudstone, sandstone and soft limestone

Code	Island	Erosion terrain class	Model group	Group name
7.4.3	NI	Hilly steeplands developed on non-cohesive Tertiary-aged sandstone, and younger sandy gravels and gravelly sands	1	Sand country, flood plains, fans and terraces, peat
7.5.1	NI	Hilly steeplands developed on unweathered to moderately weathered greywacke/argillite	7	Greywacke, argillite and hard limestone
	SI	Hilly steeplands developed on hard sedimentary rocks	7	Greywacke, argillite and hard limestone
7.5.2	SI	Hilly steeplands developed on hard schist rocks	8	Schist and SI greywacke (incl. alpine, ice and snow)
7.5.3	SI	Hilly steeplands developed on hard, coarse-grained igneous or metamorphic rocks	9	Coarse crystalline plutonics and metamorphics
7.5.4	NI	Hilly steeplands developed on limestone	7	Greywacke, argillite and hard limestone
	SI	Hilly steeplands developed on hard carbonate rocks	7	Greywacke, argillite and hard limestone
7.5.5	SI	Hilly steeplands developed on hard fine-grained igneous rocks	6	Lavas, rhyolite, volcanic slopes
7.6.1	SI	Hilly steeplands developed on weathered hard schist & greywacke rocks Marlborough Sounds esp lower slopes	8	Schist and SI greywacke (incl. alpine, ice and snow)
7.6.2	SI	Hilly steeplands developed on weathered coarse-grained igneous rocks, e.g., Motueka catchment	10	Deeply weathered plutonics
7.6.3	NI	Hilly steeplands developed on unweathered to slightly weathered white argillite	7	Greywacke, argillite and hard limestone
7.7.1	NI	Hilly steeplands developed on residual weathered to highly (often deeply) weathered ancient basalt and andesite	6	Lavas, rhyolite, volcanic slopes
7.7.2	NI	Hilly steeplands developed on residual weathered to highly (often deeply) weathered welded rhyolite	6	Lavas, rhyolite, volcanic slopes
7.7.3	NI	Hilly steeplands developed on residual weathered to highly (often deeply) weathered greywacke/argillite	7	Greywacke, argillite and hard limestone
7.7.4	NI	Hilly steeplands developed on residual weathered Tertiary sedimentary rocks	3	Tertiary mudstone, sandstone and soft limestone

Code	Island	Erosion terrain class	Model group	Group name
8.1.1	NI	Upland plains and plateaux with tephra covers	2	Tephra and Loess
8.2.1	NI	Mountain steeplands developed on greywacke/argillite or younger sedimentary rocks prone to landslide erosion	7	Greywacke, argillite and hard limestone
8.3.1	NI	Mountain steeplands developed on greywacke/argillite or younger sedimentary rocks prone to sheet/wind/scree erosion	7	Greywacke, argillite and hard limestone
	SI	Mountain steeplands developed on hard sedimentary rocks	7	Greywacke, argillite and hard limestone
8.3.2	SI	Mountain steeplands developed on hard schist rocks	8	Schist and SI greywacke (incl. alpine, ice and snow)
8.3.3	SI	Mountain steeplands developed on hard, coarse-grained igneous and metamorphic rocks	9	Coarse crystalline plutonics and metamorphics
8.4.1	SI	Mountain steeplands developed on hard fine grained igneous and tuffaceous sedimentary rocks	6	Lavas, rhyolite, volcanic slopes
8.5.1	SI	Mountain steeplands developed on weathered coarse-grained igneous rocks (e.g., Motueka catchment granite)	10	Deeply weathered plutonics
8.6.1	NI	Mountain steeplands developed on volcanic rocks in mountain terrains and upland hills	6	Lavas, rhyolite, volcanic slopes
8.6.2	NI	Mountain steeplands on the upper flanks of volcanoes	6	Lavas, rhyolite, volcanic slopes

*Intensely gullied crushed argillites and greywacke class has been split into two groups, with the East Cape having a separate class from the rest of the country.

Appendix D Calibration sites and their suspended sediment loads

Table D-1: Calibration sites and suspended sediment loads used to develop sediment load estimator (grouped by region).

Site ID	Site name (river at location)	Suspended sediment load (t/y)	Catchment area (km^2)	Specific yield ($t/km^2/y$)	REC2 Segment	Stream order	Distance to coast (km)	Rating curve fitting method[a]	Monitoring period: Sediment	Monitoring period: Flow	Source[b]
Northland											
1316	Awanui at School Cut	19500.2	220.0	88.6	1004628	5	20.8	i	May 1992 - Jul 1997	Jan 1958 - Jan 1998	7
46645	Kokopu at McBeths	868.8	3.3	267.3	1020097	2	114.9	d	Jan 1982 - Dec 1985	Jun 1977 - Aug 1986	7
46626	Mangakahia at Titoki at Titoki	122481.2	809.7	151.3	1020359	6	102.5	i	Jan 2011 - Jul 2014	Jan 2011 - Jul 2014	10
3506	Maungaparerua at Tyrees Ford	1029.7	11.7	87.9	1007316	3	10.5	i	Jun 1992 - Dec 1996	Nov 1967 - Jan 1996	7
46644	Wairua at Purua	28152.5	543.4	51.8	1018189	6	114.6	i	Jan 2011 - Jul 2014	Jan 2011 - Jul 2014	10
3722	Waitangi at Wakelins	62849.9	300.3	209.3	1008431	5	0.1	i	Jun 1992 - Jun 1997	Feb 1979 - Jan 1998	7
Auckland											
45703	Hoteo at Gubbs	19792.2	266.5	74.3	2031915	5	21.1	e	Jun 2010 - Aug 2014	Jun 2010 - Aug 2014	2
45705	Hoteo at Waiteitei	7042.7	80.8	87.1	2030178	5	45.8	i	Dec 2011 - Jun 2014	Dec 2011 - Jun 2014	10
45311	Kaipara at Waimauku	5243.4	155.3	33.8	2036348	5	29.6	e	Mar 2012 - Sep 2014	Mar 2012 - Sep 2014	2
45415	Kaukapakapa at Taylors	4721.7	61.4	76.9	2034529	5	11.9	e	Jul 2010 - Sep 2014	Jul 2010 - Sep 2014	2
6806	Mahurangi at College	4297.0	49.1	87.6	2032082	4	2.7	b	Apr 1994 - Jul 1995	Jun 1982 - Sep 2008	10
8304	Mangemangeroa at Craigs	740.1	4.4	168.2	2039641	3	1.4	e	Jul 2012 - Jul 2014	Jul 2012 - Jul 2014	2
7502	Okura at Awanohi	106.4	6.0	17.8	2035269	3	0.5	e	Jul 2009 -May-2011	Jul 2009 -May-2011	2
7304	Okura at Weiti Forest	57.4	1.8	31.9	2035020	2	0.4	e	Apr 2008 - Aug 2014	Apr 2008 - Aug 2014	2
8604	Orere at Bridge	6028.2	40.6	148.4	2040444	4	0.8	i	Feb 1979 - Aug 1995	Jun 1978 - Jan 1995	7

Site ID	Site name (river at location)	Suspended sediment load (t/y)	Catchment area (km^2)	Specific yield ($t/km^2/y$)	REC2 Segment	Stream order	Distance to coast (km)	Rating curve fitting method[a]	Monitoring period		Source[b]
									Sediment	Flow	
7202	Orewa at Kowhai Ave	766.8	9.6	80.1	2034156	3	0.0	e	May 2010 - Sep 2014	May 2010 - Sep 2014	2
7506	Vaughan at Lower Weir	111.9	2.5	45.1	2035301	2	1.0	e	May 2004 - Sep 2014	May 2004 - Sep 2014	2
8516	Wairoa at Wairoa at Tourist Road	5403.6	150.7	35.9	2041541	5	11.6	e	Aug 2010 - Jun 2014	Aug 2010 - Jun 2014	2
43602	Waitangi at SH Br	291.4	18.5	15.8	2046356	3	0.4	i	Jun 1984 - Jun 1993	Mar 1966 - Jul 1995	7
45702	Waiwhiu at Dome Shadow	1338.2	8.5	157.4	2031537	3	56.3	i	Jul 2012 - Jul 2014	Jul 2012 - Jul 2014	11
7206	West Hoe at Hall Farm	13.2	0.3	45.3	2033917	1	2.3	e	Jan 2012 - Oct 2014	Jan 2012 - Oct 2014	2
Waikato											
40810	Awakino at Gorge	59109.1	227.2	260.1	3128195	5	19.6	i	Nov 1979 - Sep 1995	Apr 1979 - Jul 1995	7
1143450	Awaroa at Sansom's Br Rotowaro	4711.9	45.6	103.4	3055968	5	88.9	i	Aug 1991 - Sep 1996	Nov 1985 - Jan 1997	7
2743464	Hinemaiaia at Maungatera	5195.4	125.5	41.4	3153061	5	373.6	i	Aug 1990 - Jul 1996	Apr 1987 - Jan 1997	7
1643461	Kaniwhaniwha at Limeworks Rd	3312.5	26.7	124.1	3069744	4	149.0	i	Aug 1990 - Nov 1994	Jun 1984 - Nov 1992	7
1043468	Kuratau at State Highway 41	2476.6	119.8	20.7	3150371	5	385.8	i	Aug 1990 - Sep 1992	Nov 1978 - Oct 1992	7
1043434	Mangakara at Hirsts	2314.3	22.6	102.5	3116290	4	298.6	i	Dec 1964 - May 1993	Jun 1969 - Jan 1994	7
1043427	Mangakino at Dillon Road	14636.8	342.6	42.7	3111462	5	230.7	i	Nov 1964 - Jul 1998	Apr 1964 - Apr 1997	7
40703	Mangakowhai at Kaingapipi	1128.0	15.5	72.6	3110909	3	116.3	i	Jun 1971 - Oct 1990	Jan 1971 - Jan 1996	7
1643462	Mangaokewa at Te Kuiti	9350.5	174.0	53.7	3103339	4	222.5	i	Aug 1990 - Jun 2004	Mar 1983 - Dec 2013	9

Site ID	Site name (river at location)	Suspended sediment load (t/y)	Catchment area (km^2)	Specific yield ($t/km^2/y$)	REC2 Segment	Stream order	Distance to coast (km)	Rating curve fitting method[a]	Monitoring period		Source[b]
									Sediment	Flow	
1543497	Mangaonua at Dreadnought	1551.7	182.5	8.5	3064651	5	124.5	i	Aug 1991 - Aug 2004	Nov 1980 - Dec 2013	9
1043444	Mangapu at SH3 Br	10225.5	444.0	23.0	3091562	5	199.1	a	Dec 2000 - May 2012	Oct 2000 - Dec 2013	9
1943459	Mangatutu at Walker Rd Br	4093.6	121.6	33.7	3083539	5	199.9	a	Jun 2004 - Dec 2013	Jun 2004 - Dec 2013	9
41301	Marokopa at Falls	13218.9	92.7	142.5	3096494	5	18.6	i	Jul 1979 - Apr 1996	Apr 1979 - Jul 1995	7
3043490	Matahuru at Myjers	13791.5	83.4	165.4	3053681	5	82.2	a	Jul 2006 - Dec 2013	Jul 2006 - Dec 2013	9
43489	Matahuru at Waiterimu Rd	5368.6	106.6	50.4	3053073	5	74.7	a	Jul 2003 - Oct 2008	Jul 1984 - Aug 2011	9
40708	Mokau at Totoro Bridge	165634.6	1055.8	156.9	3123396	6	72.8	i	Oct 1979 - Jun 1988	Apr 1979 - Jul 1995	7
9213	Ohinemuri at Karangahake	28774.3	286.3	100.5	3051925	5	53.3	i	May 1986 - Jul 2007	Nov 1956 - Dec 2013	9
11310	Opitonui River at d/s Awaroa	3084.4	28.8	107.0	3036923	5	3.1	a	Jul 1991 - Dec 2013	Jun 1991 - Dec 2013	9
1009213	Oraka at Pinedale	5376.1	130.1	41.3	3081726	5	192.3	i	Apr 1986 - Dec 2003	Jul 1979 - Dec 2013	9
41601	Oteke at Kinohaku	1030.0	8.4	122.0	3088828	3	2.0	i	Jun 1975 - Jun 1977	Mar 1971 - Jan 1993	7
9140	Piako at Paeroa Tahuna Rd	10940.1	538.8	20.3	3054261	6	46.4	i	Apr 1986 - Jun 2004	Jul 1972 - Dec 2013	9
9175	Piako at Kiwitahi	1563.1	108.0	14.5	3059826	5	80.4	i	Sep 1989 - Jul 1991	Apr 1980 - Nov 1996	7
1043419	Pokaiwhenua at Puketurua	7243.8	430.8	16.8	3081022	5	182.2	i	Sep 1963 - May 1990	Feb 1992 - Apr 1994	7
43431	Puniu at Pokuru Br	10329.4	518.9	19.9	3078623	6	182.1	i	Aug 1990 - Jul 1991	May 1985 - Nov 1996	7
1143409	Purukohokohu at Puruki Flume	4.4	0.3	13.2	3114143	1	310.5	i	Sep 1969 - Nov 1971	Dec 1968 - Jan 1993	7
1009246	Rapurapu at Kinlochs Farm	601.3	25.6	23.5	3069998	4	148.3	i	Oct 1989 - Aug 1990	Dec 1985 - Oct 1992	7

Site ID	Site name (river at location)	Suspended sediment load (t/y)	Catchment area (km²)	Specific yield (t/km²/y)	REC2 Segment	Stream order	Distance to coast (km)	Rating curve fitting method[a]	Monitoring period		Source[b]
									Sediment	Flow	
1043428	Tahunaatara at Ohakuri Road	13508.8	197.2	68.5	3105156	6	264.4	i	Dec 1964 - Jul 1995	Apr 1964 - Jul 1995	7
12301	Tairua at Broken Hills	10842.1	117.9	92.0	3043751	5	14.7	i	Jul 1986 - Jun 1992	Apr 1976 - Dec 1996	7
9701	Tapu at Tapu-Coroglen	738.1	26.4	27.9	3040973	4	0.0	i	Jul 1991 - Apr 1999	Jul 1991 - Dec 2013	9
1543413	Tauranga-Taupo at Te Kono	15608.0	196.7	79.3	3155812	5	376.6	i	Aug 1990 - Aug 2010	Feb 1976 - Dec 2013	9
1143427	Te Tahi at Puketotara	202.5	3.3	61.9	3079432	2	178.3	i	Jul 1971 - Sep 1975	Apr 1971 - Jan 1993	7
1043460	Tongariro at Puketarata	176341.2	504.1	349.8	3166846	6	399.5	i	Feb 1960 - Feb 1967	Dec 1959 - Jan 1997	7
1043459	Tongariro at Turangi	137000.4	788.5	173.7	3160279	6	389.2	i	Mar 1957 - Jun 1993	Jan 1957 - Jan 1995	7
1043461	Tongariro at Upper Dam	24278.5	180.7	134.3	3180169	5	422.8	i	Jul 1959 - Aug 1995	Jan 1960 - Jan 1997	7
1543424	Waihaha at SH32	2267.8	134.9	16.8	3136644	5	378.2	i	Aug 1990 - Sep 1992	May 1976 - Oct 1992	7
1043466	Waihohonu at Desert Rd	2869.5	97.0	29.6	3179516	5	424.6	i	Aug 1991 - Nov 1996	Aug 1961 - Jan 1997	7
9224	Waihou at Okauia	41689.4	806.2	51.7	3064061	6	126.4	i	May 1986 - Jul 2006	Mar 1982 - Dec 2013	9
9205	Waihou at Te Aroha Br	63203.4	1106.8	57.1	3055227	6	68.5	i	Apr 1986 - Aug 2007	Mar 1982 - Dec 2013	9
9209	Waihou at Tirohia	67306.1	1198.4	56.2	3052243	6	45.7	i	Apr 1986 - Jan 1995	Mar 1966 - Nov 1996	7
42601	Waingaro at Ruakiwi Road	9784.9	118.5	82.6	3060386	5	2.4	a	May 2002 - Oct 2013	Nov 2001 - Dec 2013	9
9228	Waiorongomai at Old Quarry	338.9	8.6	39.4	3055543	3	81.9	i	Jul 1971 - Aug 1975	Dec 1970 - Jan 1995	7
2043493	Waiotapu at Campbell Rd	1162.2	64.9	17.9	3109925	4	308.7	i	Sep 1991 - May 1997	Dec 1986 - Jan 1997	7
43472	Waiotapu at Reporoa	18000.1	235.9	76.3	3114681	5	300.1	i	Jul 1966 - Jul 1998	Feb 1960 - Apr 1997	7
43435	Waipa at Ngaroma Rd	4308.6	136.0	31.7	3103174	5	213.9	i	Apr 1964 - Nov 1996	Apr 1964 - Nov 1996	7
43481	Waipa at Otewa	52984.6	319.9	165.6	3097862	5	219.2	a	Aug 1990 - Oct 2013	May 1985 - Dec 2013	9
43433	Waipa at Whatawhata	169784.0	2863.2	59.3	3063749	7	126.3	i	May 1990 - Sep 2010	Apr 1972 - Dec 2013	9

Site ID	Site name (river at location)	Suspended sediment load (t/y)	Catchment area (km^2)	Specific yield ($t/km^2/y$)	REC2 Segment	Stream order	Distance to coast (km)	Rating curve fitting method[a]	Monitoring period		Source[b]
									Sediment	Flow	
2043441	Waipapa at Mulberry Rd	5180.1	91.8	56.4	3114712	4	250.0	i	Mar 1986 - Aug 1994	Apr 1970 - Jan 1998	7
9179	Waitoa at Mellon Rd	5520.7	408.9	13.5	3054693	5	50.5	i	May 1986 - Aug 2007	May 1986 - Dec 2013	9
9114	Waitoa at SH26	4037.2	255.1	15.8	3056329	5	60.7	i	Jan 1990 - Jul 1991	Nov 1988 - Nov 1992	7
9112	Waitoa at Waharoa Control	4589.5	122.7	37.4	3062720	5	99.5	i	May 1986 - Jul 1991	May 1984 - Nov 1996	7
1943481	Waitomo at Aranui Caves	4611.0	37.3	123.7	3096889	4	215.6	a	Aug 1990 - Oct 2013	Oct 1986 - Dec 2013	9
1643457	Whakapipi at SH22-Tuakau	1882.7	46.4	40.6	3047236	4	30.6	i	Aug 1991 - Nov 1999	Mar 1984 - Dec 2013	9
1143402	Whangamarino at Slackline	22700.6	131.0	173.3	3049752	6	60.7	i	Dec 1967 - Apr 1992	Dec 1967 - Apr 1992	7
12509	Wharekawa at Adams Farm	1707.8	46.6	36.7	3044838	5	5.2	a	Sep 1991 - Dec 2013	Jun 1991 - Dec 2013	9
Bay of Plenty											
14604	Awahou at Tauranga Rd Bridge	924.7	17.0	54.4	4081667	3	63.2	i	Dec 1974 - Jul 1977	May 1975 - Mar 1978	7
14614	Kaituna at Te Matai	51715.6	973.6	53.1	4064299	6	9.8	i	Feb 1964 - Aug 1979	May 1955 - Dec 1982	7
13901	Mangawhai at Mokoroa	104.6	3.1	33.6	4059081	3	0.5	i	May 1971 - May 1977	Mar 1971 - Jul 1995	7
14628	Mangorewa at Saunders Farm	24669.4	192.9	127.9	4070783	5	28.7	i	Jul 1968 - Mar 1979	Jul 1967 - Nov 1992	7
16501	Motu at Houpoto	3525526.1	1384.2	2547.0	4072149	6	3.7	i	Sep 1956 - Aug 1991	Apr 1957 - Jul 1995	7
1014641	Ngongotaha at SH5 Bridge	3578.8	72.9	49.1	4084419	5	67.5	i	Jun 1975 - May 1996	May 1975 - Jul 1995	7
16006	Otara at Gault Road Br(No.2)	92573.4	321.0	288.4	4082634	5	9.7	i	Feb 1979 - Feb 1984	Oct 1979 - Sep 1982	7

Site ID	Site name (river at location)	Suspended sediment load (t/y)	Catchment area (km²)	Specific yield (t/km²/y)	REC2 Segment	Stream order	Distance to coast (km)	Rating curve fitting method[a]	Monitoring period		Source[b]
									Sediment	Flow	
14625	Puarenga at FRI Bridge	3236.7	74.4	43.5	4090417	5	68.3	i	Dec 1974 - Dec 1977	May 1975 - Jul 1991	7
15432	Rangitaiki at Kopuriki	182273.6	2278.9	80.0	4105182	6	63.6	i	Dec 1967 - Nov 1978	Jul 1966 - May 1980	7
15408	Rangitaiki at Murupara	24706.3	1170.7	21.1	4117490	6	91.0	i	Feb 1965 - Nov 1994	Jun 1948 - Jul 1995	7
17101	Raukokore at SH35 Bridge	4705940.5	351.3	13396.9	4061605	6	1.5	i	Apr 1976 - Sep 1995	Dec 1979 - Apr 1995	7
16511	Takaputahi at Ngawhakatatara	66916.5	141.9	471.5	4090084	5	75.6	i	Feb 1979 - Sep 1983	Oct 1978 - Jan 1984	7
17301	Tauranga at Maruhinemaka	2059.8	4.8	425.6	4060179	2	0.3	i	Feb 1969 - Oct 1987	Sep 1968 - Jan 1993	7
1014647	Utuhina at Hunts Farm	221.4	7.4	30.0	4090415	3	77.5	i	Nov 1976 - Jun 1977	Jun 1976 - Feb 1978	7
14610	Utuhina at SH5 Bridge	4248.4	57.0	74.6	4088642	5	67.0	i	Jan 1969 - Aug 1979	Sep 1967 - Dec 1982	7
16205	Waiaua at Edwards	64689.1	92.6	698.9	4080809	5	1.6	i	Dec 1980 - Sep 1983	May 1983 - Oct 1984	7
15453	Waihua at Gorge	4495.7	46.3	97.1	4099121	4	53.4	i	Jul 1980 - Aug 1994	Dec 1979 - Jul 1995	7
15536	Waimana at Ogilvies Bridge	135915.8	208.1	653.1	4106037	5	63.6	i	Sep 1969 - Feb 1991	Feb 1968 - Jan 1994	7
14606	Waingaehe at SH3none Bridge	629.9	10.0	63.1	4087753	3	65.9	i	May 1970 - Mar 1979	Nov 1975 - Feb 1984	7
15901	Waioeka at Gorge Cableway	653348.8	664.1	983.8	4098572	6	33.5	i	Nov 1963 - Mar 1996	Mar 1958 - Jul 1995	7
14607	Waiohewa at SH3none Bridge	603.9	13.0	46.3	4084076	3	64.7	i	Feb 1974 - Jul 1977	Apr 1975 - Jan 1979	7
15802	Waiotahi at McNabs Road Bridge	11037.0	104.2	105.9	4085816	4	12.4	i	Apr 1976 - Feb 1984	Jun 1980 - Nov 1983	7
1014644	Waiowhiro at Bonningtons Farm	297.3	7.2	41.3	4086209	3	64.4	i	Jan 1976 - Jun 1977	Oct 1975 - Mar 1978	7
1014648	Waipa at Whaka Forest	129.0	11.1	11.6	4093105	3	75.1	i	Jun 1976 - Jun 1977	Nov 1975 - Apr 1978	7

Site ID	Site name (river at location)	Suspended sediment load (t/y)	Catchment area (km²)	Specific yield (t/km²/y)	REC2 Segment	Stream order	Distance to coast (km)	Rating curve fitting method[a]	Monitoring period		Source[b]
									Sediment	Flow	
15534	Wairere at Wainui Road	204.7	3.1	67.1	4076659	3	0.2	i	Nov 1967 - Mar 1979	Sep 1967 - Jan 1994	7
14603	Waiteti at Tauranga Rd Bridge	2137.7	71.5	29.9	4083379	4	57.2	i	Feb 1974 - Aug 1979	Feb 1976 - Feb 1981	7
15514	Whakatane at Whakatane	592416.7	1495.5	396.1	4079931	7	10.0	i	Jul 1963 - Aug 1992	Jan 1957 - Jul 1995	7
15410	Whirinaki at Galatea	68889.5	509.8	135.1	4119252	5	94.4	i	Dec 1963 - Nov 1994	Dec 1952 - Jul 1995	7
Taranaki											
39508	Manganui at SH3	7491.9	14.6	512.8	6182471	3	53.5	i	Oct 1987 - May 1996	May 1972 - Jul 1995	7
36001	Punehu at Pihama	1982.1	28.8	68.9	6195352	3	1.7	i	Sep 1970 - Nov 1994	Dec 1969 - Jul 1995	7
39501	Waitara at Tarata	890046.9	704.2	1263.9	6172598	6	39.1	i	Aug 1966 - Oct 1995	Dec 1968 - Jul 1995	7
34202	Whenuakra at Nicholson Road	275170.8	444.0	619.7	6214194	5	7.4	i	Apr 1987 - Oct 1995	Mar 1983 - Jul 1995	7
Gisborne											
21437	Hangaroa at Doneraille Park	886405.9	599.3	1479.1	8143873	6	76.7	i	May 1974 - Jul 1986	May 1974 - Jan 1995	7
18902	Hikuwai at Willow Flat	3777000.0	307.6	12278.1	5108000	6	19.6	i	Jan 1975 - Jan 2015	Jan 1975 - Jan 2017	12
18913	Mangaheia at Willowbank	81148.5	41.3	1964.4	5111456	4	21.8	i	Jul 1989 - Apr 1996	Dec 1988 - Jan 1993	7
19712	Mangatu at Omapere	1657000.0	183.0	9056.1	5113578	5	79.7	i	May 1968 - Sep 2015	Aug 1983 - Jan 2017	12
18304	Mata at Pouturu	5277000.0	366.0	14418.8	5087073	5	79.1	i	Nov 1988 - May 2015	Feb 1989 - Jan 2014	12
16502	Motu at Waitangirua	123614.0	294.8	419.3	4098075	5	93.7	i	Sep 1963 - Sep 1995	Jun 1960 - Jul 1995	7
19766	Te Arai at Pykes Weir	402000.0	85.9	4677.7	5146495	4	29.4	i	Sep 1981 - Sep 2015	Jan 1984 - Jan 2017	12
18309	Waiapu at Rotokautuku	31220000.0	1376.6	22679.7	5076269	6	32.3	i	Feb 1973 - Oct 1996	Jan 1975 - Jan 2017	12

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									Sediment	Flow	
19706	Waihora at No 3 Br	910000.0	111.7	8145.4	5118736	5	60.7	i	Feb 1982 - July 2015	Dec 1986 - Aug 1998	12
19708	Waikohu at Mahaki	543000.0	146.0	3718.2	5118497	5	70.1	i	Sep 1965 - Sep 2015	Oct 1979 - Jan 2017	12
19602	Waimata at Goodwin's Rd	380300.0	213.7	1779.7	5138374	5	8.9	i	Mar 1979 - Sep 2015	Jan 1984 - Jan 2017	12
19609	Waimata at Monowai	239500.0	105.3	2273.6	5126986	5	37.3	i	Jun 1984 - Sep 2015	Mar 1986 - Jan 2017	12
19711	Waingaromia at Terrace Station	3334700.0	174.2	19145.1	5113284	5	84.5	i	Apr 1963 - Sep 2015	May 1979 - Jan 2017	12
19701	Waipaoa at Kanakanaia Br	8856000.0	1575.3	5621.9	5122005	7	47.4	i	Jan 1962 - Sep 2015	Jun 1968 - Jan 2017	12
19704	Waipaoa at Matawhero	11562000.0	1922.7	6013.4	5136963	7	10.0	i	Aug 1965 - Sep 2015	Jan 1973 - Jan 2017	12
19702	Waipaoa at Waipaoa Stn	6845000.0	183.2	37373.7	5106452	6	90.6	i	Aug 1957 - Jun 2015	Jan 1979 - Jan 2017	12
17601	Wharekahika at Hicks Bay Rd Br	446000.0	149.6	2982.3	5058408	5	0.9	i	Apr 1972 - Sep 1996	Feb 1998 - Nov 2014	12
19741	Wharekopae at Rangimoe Stn	258503.6	176.5	1464.7	5128596	6	83.4	i	Feb 1981 - Aug 1996	Dec 1983 - Jan 1997	7
Hawke's Bay											
22802	Esk at Waipunga Bridge	348257.0	253.0	1376.7	8193732	5	6.0	i	Jun 1963 - Nov 1992	Nov 1963 - Jul 1995	7
21803	Mohaka at Glenfalls	274552.4	1036.8	264.8	8178813	6	94.5	i	Mar 1965 - May 1995	Mar 1962 - Jan 1995	7
21801	Mohaka at Raupunga	1341544.4	2370.1	566.0	8169268	7	12.6	i	Feb 1956 - Oct 1995	Mar 1957 - Jan 1995	7
23150	Ngaruroro at Chesterhope Bridge	1317380.0	2008.8	655.8	8206483	6	2.5	i	Jun 1977 - Mar 1993	Nov 1976 - Jun 1995	7
23102	Ngaruroro at Fernhill	1083916.3	1945.3	557.2	8207058	6	17.5	i	Nov 1958 - Mar 1988	Aug 1952 - Aug 1992	7
23104	Ngaruroro at Papango	58545.3	385.9	151.7	8192265	5	103.2	i	Mar 1964 - Jul 1995	Sep 1963 - Jan 1995	7
23103	Ngaruroro at Whanawhana	339773.9	1110.9	305.8	8204130	6	62.1	i	Dec 1962 - Mar 1988	Sep 1960 - Oct 1992	7

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									Sediment	Flow	
23210	Omakere at Fordale	13545.7	53.6	252.7	8228634	5	78.4	i	Jun 1965 - Oct 1994	Sep 1963 - Jul 1995	7
23209	Otane at Glendon	830.6	23.8	34.9	8223041	4	64.1	i	Aug 1968 - Oct 1994	Apr 1964 - Jul 1995	7
21601	Tahekenui at Glenstrae	42475.6	22.0	1934.2	8169182	4	10.7	i	May 1970 - Sep 1995	Mar 1975 - Jul 1995	7
23106	Taruarau at Taihape Road	18455.0	263.6	70.0	8196062	5	105.5	i	Aug 1968 - Nov 1994	Dec 1963 - Jan 1995	7
23201	Tukituki at Red Bridge	1033230.4	2463.6	419.4	8215013	7	15.8	i	Jul 1961 - Mar 1993	May 1968 - Jul 1995	7
23203	Tukituki at Waipukurau	404425.0	740.8	546.0	8227310	6	77.6	i	Mar 1965 - Mar 1975	Jun 1988 - May 1992	7
21409	Waiau at Otoi	366241.7	534.7	685.0	8159305	6	75.7	i	Jan 1970 - Apr 1995	Aug 1968 - Jul 1995	7
21410	Waihi at Waihi	14717.8	50.6	290.8	8153350	4	76.0	i	Aug 1969 - Jun 1995	Aug 1968 - Jul 1995	7
21401	Wairoa at Marumaru	921393.6	1803.5	510.9	8155870	7	35.3	i	Aug 1968 - Jun 1997	Feb 1980 - Jan 1996	7
Manawatu / Whanganui											
32726	Hautapu at Taihape	18459.5	285.2	64.7	7209800	5	137.9	i	Oct 1990 - Oct 1997	May 1963 - Jan 1996	7
33502	Kaiiwi at Handley Road	16868.4	190.9	88.4	7220928	5	0.0	i	Oct 1988 - Apr 1997	Apr 1978 - Jan 1996	7
32754	Makohine at Viaduct	152014.3	97.2	1563.8	7221282	4	89.2	i	Nov 1990 - Oct 1995	Mar 1977 - Jul 1995	7
1032591	Makuri at Tuscan Hills	90750.0	135.1	671.8	7244003	5	145.9	c	Jun 2000 - Oct 2010	Jun 2000 - Oct 2010	3
32504	Manawatu at Hopelands	605590.0	1263.3	479.4	7238779	6	127.1	c	May 2000 - Sep 2010	May 2000 - Sep 2010	3
1032560	Manawatu at Teachers College	1921600.0	3916.8	490.6	7239110	7	73.3	c	May 2000 - Mar 2010	May 2000 - Mar 2010	3
1232566	Manawatu at Upper Gorge	2482699.2	3191.5	777.9	7237871	7	102.1	i	Aug 1961 - Dec 1966	Jul 1979 - Jul 1995	7
32526	Mangahao at Ballance	177610.0	279.4	635.8	7240715	5	122.0	c	Aug 2006 - Oct 2010	Aug 2006 - Oct 2010	3
5023	Mangahao at Machine	61420.7	82.4	745.2	7245877	5	172.8	j	NA	NA	7
1132511	Mangatainoka at Pahiatua Town Bridge	55090.0	402.7	136.8	7241237	6	128.1	c	Mar 2006 - Jul 2010	Mar 2006 - Jul 2010	3

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									Sediment	Flow	
33111	Mangawhero at Ore Ore	93145.3	510.7	182.4	7203394	5	125.7	i	Oct 1962 - Nov 1995	May 1962 - Jul 1995	7
32106	Ohau at Rongomatane	27470.9	105.3	260.9	7247560	5	20.3	i	Apr 1981 - Oct 1984	Jul 1978 - Jul 1995	7
33314	Ohura at Nihoniho	164170.0	323.8	507.0	7142212	5	271.9	c	May 2007 - Nov 2009	May 2007 - Nov 2009	3
33316	Ongarue at Taringamutu	151710.8	1086.8	139.6	7148401	6	251.0	i	Sep 1962 - May 1993	Aug 1962 - Jan 1995	7
32514	Oroua at Almadale Slackline	210420.0	306.6	686.4	7232926	5	99.4	c	Nov 2003 - May 2010	Nov 2003 - May 2010	3
32563	Oroua at Kawa Wool	488596.6	578.6	844.4	7235064	6	82.3	i	Aug 1961 - Jul 1978	Feb 1967 - Feb 1992	7
25101	Owahanga at Branscombe Bridge	152430.0	316.5	481.6	7247269	5	16.6	c	May 2002 - Sep 2009	May 2002 - Sep 2009	3
32576	Pohangina at Mais Reach	499830.0	487.4	1025.5	7234641	5	105.4	c	Apr 2000 - Oct 2010	Apr 2000 - Oct 2010	3
32702	Rangitikei at Mangaweka	592750.0	2684.9	220.8	7218183	7	112.1	c	Mar 2000 - Aug 2009	Mar 2000 - Aug 2009	3
32763	Rangitikei at Pukeokahu	30750.0	772.1	39.8	7208135	5	160.3	c	Mar 1999 - Dec 2010	Mar 1999 - Dec 2010	3
32529	Tiraumea at Ngaturi	322400.0	760.4	424.0	7241723	6	131.7	c	Feb 2001 - May 2009	Feb 2001 - May 2009	3
33004	Turakina at Otairi	211255.7	510.2	414.1	7220233	6	84.2	i	Aug 1991 - Jun 1995	Apr 1991 - Jan 1993	7
33320	Whakapapa at Footbridge	37348.1	174.4	214.1	7170971	5	298.6	i	Apr 1960 - Aug 1991	Nov 1959 - Jan 1995	7
33101	Whangaehu at Kauangaroa	681258.9	1894.6	359.6	7223467	6	37.9	i	Apr 1987 - Jul 1992	Jun 1971 - Jul 1994	7
33303	Whanganui at Te Rewa	3322120.0	6617.7	502.0	7215327	7	47.9	c	Jun 1999 - Jul 2011	Jun 1999 - Jul 2011	3
33301	Whanganui at Paetawa	4561911.1	6621.9	688.9	7215564	7	46.3	i	Mar 1950 - Apr 1995	Jul 1957 - Jan 1995	7
33347	Whanganui at Te Porere	1215.7	28.0	43.5	7164150	3	304.2	i	Feb 1971 - Sep 1995	Jan 1966 - Jan 1995	7

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									Sediment	Flow	
Wellington											
30912	Horokiri at Snodgrass	5822.0	29.5	197.4	9259111	4	2.1	i	Dec 2012 - Nov 2016	Aug 2012 - Feb 2017	12
29808	Hutt at Kaitoke	17417.3	87.3	199.5	9258504	4	42.3	i	May 1981 - May 1996	Dec 1967 - Jul 1995	7
30516	Mill Creek at Papanui	685.3	9.2	74.3	9261375	3	14.0	i	Jun 1978 - Oct 1990	Apr 1969 - Jul 1995	7
31807	Otaki at Pukehinau	314280.7	306.4	1025.7	9252105	6	14.0	i	Aug 1980 - Nov 1994	Jul 1980 - Jul 1995	7
31803	Otaki at Tuapaka	168530.5	308.9	545.7	9251864	6	12.6	i	Apr 1978 - Aug 1980	May 1972 - Jan 1981	7
27303	Pahao at Hinakura	405333.3	565.1	717.3	9265328	6	21.0	i	Aug 1986 - Jun 1996	Sep 1986 - Jul 1995	7
30802	Pauatahanui at Gorge	8200.0	38.6	212.4	9260167	4	1.7	i	Jun 1975 - Jul 1997	May 1975 - Jul 1995	13
30701	Porirua at Town Centre	4906.0	40.7	120.6	9260668	4	0.4	i	Sep 2012 - Nov 2016	Aug 2012 - Mar 2017	12
29250	Ruakokopatuna at Iraia	2529.2	15.7	161.5	9267034	3	87.8	i	Aug 1979 - Apr 1991	May 1969 - Jul 1995	7
29202	Ruamahanga at Waihenga	534147.6	2362.6	226.1	9262654	7	50.8	i	May 1968 - Mar 1987	Dec 1956 - Jan 1993	7
29231	Taueru at Te Weraiti	140058.1	391.3	357.9	9257216	6	114.2	i	May 1968 - May 1981	Dec 1969 - Jan 1993	7
29244	Whangaehu at Waihi	12010.7	36.8	326.2	9252727	4	132.2	i	May 1968 - Apr 1995	May 1967 - Jan 1995	7
25902	Whareama at Waiteko Bridge	611300.0	400.3	1527.3	9256641	5	17.7	i	Aug 1977 - Jul 2016	Apr 1970 - Jul 1995	13
Tasman											
52003	Aorere at Devils Boot	98065.9	568.0	172.7	10000937	5	12.8	i	Aug 1992 - Mar 1996	Mar 1976 - Jan 1995	7
56905	Apahai at Hickmotts	368.0	0.8	454.3	10007083	1	1.7	i	Sep 1994 - Aug 1996	Sep 1995 - Nov 1996	7
93202	Buller at Longford	217972.6	1402.4	155.4	12036839	6	109.3	i	Nov 1964 - Sep 1988	Oct 1963 - Apr 1995	7
52916	Cobb at Trilobite	2810.2	47.1	59.7	10009387	4	60.9	i	Jun 1969 - Jan 1996	May 1969 - Jul 1995	7

Site ID	Site name (river at location)	Suspended sediment load (t/y)	Catchment area (km^2)	Specific yield ($t/km^2/y$)	REC2 Segment	Stream order	Distance to coast (km)	Rating curve fitting method[a]	Monitoring period		Source[b]
									Sediment	Flow	
56906	Kaiteriteri at Water Supply	149.0	0.7	229.2	10006709	1	1.3	i	Sep 1994 - Aug 1996	Sep 1994 - Nov 1996	7
57536	Lee at Cableway	2908.0	77.5	37.5	10022927	4	27.6	g	Apr 2008 - July 2009	Apr 2007 - Aug 2009	5
93212	Mangles at Gorge	13104.5	284.0	46.1	12040097	5	115.9	i	Apr 1981 - Dec 1985	Jan 1958 - Oct 1990	7
93209	Maruia at Falls	446116.6	983.6	453.6	12042493	6	98.4	i	Nov 1964 - Sep 1985	Dec 1963 - Aug 1991	7
93211	Matakitaki at Mud Lake	759836.8	878.4	865.1	12041710	6	106.7	i	Nov 1964 - Mar 1988	Nov 1963 - Aug 1991	7
57008	Motueka at Gorge	59400.0	166.1	357.7	10030207	4	89.3	f	Apr 2004 - Dec 2009	Mar 1990 - Dec 2009	1
57015	Motueka at Woodmans Bend	284000.0	2014.3	141.0	10008816	6	6.3	f	Dec 2002 - Dec 2009	Mar 1990 - Dec 2009	1
57009	Motueka at Woodstock	315162.8	1760.1	179.1	10013787	6	33.0	i	Jun 1967 - Jul 1992	Feb 1969 - Jul 1995	7
57036	Motupiko at Christies	13200.0	105.0	125.7	10029598	4	89.4	f	Dec 2002 - Dec 2009	Mar 1990 - Dec 2009	1
57101	Moutere at Old House Road	5284.5	59.9	88.3	10012762	4	10.2	i	Nov 1965 - Oct 1969	Dec 1961 - Jan 1986	7
56901	Riwaka at Moss Bush	3342.4	45.9	72.9	10007004	4	8.5	i	Sep 1965 - Jan 1970	Dec 1961 - Oct 1994	7
57014	Stanleybrook at Barkers	13892.0	81.4	170.6	10016208	4	42.6	i	Dec 1969 - May 1995	Jan 1970 - May 1994	7
52902	Takaka at Harwoods	18399.8	258.4	71.2	10006556	5	29.7	i	Oct 1983 - Mar 1996	Mar 1975 - Jan 1995	7
57502	Wairoa at Gorge	61925.0	456.2	135.7	10019298	6	12.8	i	Jan 1976 - Nov 1990	Nov 1957 - Nov 1992	7
57025	Wangapeka at Walter Peak	79200.0	469.1	168.8	10017434	5	51.4	f	Dec 2002 - Dec 2009	Mar 1990 - Dec 2009	1
Marlborough											
62103	Acheron at Clarence	298600.7	975.0	306.3	13069919	6	173.4	i	Oct 1962 - Oct 1983	Apr 1958 - Apr 1995	7
58902	Pelorus at Bryants	126649.5	377.0	336.0	11015853	5	19.6	i	Sep 1982 - Oct 1995	Oct 1977 - Jan 1995	7
60114	Wairau at Dip Flat	109698.4	518.4	211.6	11044291	5	126.4	i	Nov 1965 - Nov 1994	Jun 1951 - Feb 1993	7

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									Sediment	Flow	
West Coast											
91407	Ahaura at Gorge	346159.7	818.9	422.7	12073088	6	66.0	i	Jul 1971 - Nov 1995	May 1968 - Jan 1993	7
89701	Amethyst at Road Bridge	10160.0	16.4	618.4	12109766	3	29.0	h	Aug 2006 - Jun 2008	May 2004 - Jun 2008	4
93203	Buller at Te Kuha	4964126.8	6294.7	788.6	12041365	7	19.2	i	Nov 1965 - Sep 1991	Jul 1963 - Jun 1995	7
93208	Buller at Woolfs	1845723.4	4520.7	408.3	12041118	7	53.4	i	Nov 1964 - May 1990	Oct 1963 - Jan 1993	7
90605	Butchers Creek at Lk Kaniere Road	1529.3	4.1	370.3	12089366	2	15.2	i	Jul 1971 - Nov 1990	Jul 1971 - Jan 1994	7
90607	Cropp at Gorge	424613.0	12.3	34605.8	12104973	3	61.1	i	Dec 1987 - Feb 1997	Dec 1979 - Feb 1995	7
91401	Grey at Dobson	1919590.4	3820.1	502.5	12074262	7	10.6	i	Mar 1968 - Oct 1993	Jul 1968 - Jul 1995	7
91404	Grey at Waipuna	249751.2	640.2	390.1	12069528	5	69.3	i	Aug 1971 - Aug 1994	Mar 1969 - Jul 1997	7
86802	Haast at Roaring Billy	4176090.0	1026.8	4067.2	12152873	6	33.1	i	Aug 1967 - Dec 1995	Apr 1970 - Jan 1995	7
90604	Hokitika at Colliers Creek	2035128.7	348.3	5843.5	12099480	5	40.7	i	Mar 1971 - Apr 1996	May 1971 - Jan 1995	7
93207	Inangahua at Blacks Point	44764.4	233.5	191.7	12057207	5	91.9	i	Nov 1965 - Sep 1994	May 1965 - Jul 1995	7
93206	Inangahua at Landing	366064.4	992.8	368.7	12045683	6	59.9	i	Jul 1966 - Jun 1988	Nov 1963 - Sep 1991	7
90102	Ivory at Ripplerock	31000.0	2.3	13478.3	12107678	2	41.2	j	1976 - 1986	NA	7
95102	Karamea at Gorge	146520.2	1162.2	126.1	12013750	6	11.5	i	Dec 1966 - Oct 1996	Jun 1977 - May 1997	7
94302	Mokihinui at Burkes Creek	218062.2	682.5	319.5	12027184	6	8.6	i	Mar 1973 - May 1976	Mar 1972 - Oct 1980	7
94303	Mokihinui at Welcome Bay	395000.0	670.2	589.4	12026847	6	11.2	i	Mar 1973 - May 2007	Mar 1972 - Mar 1994	6
91103	Taipo at SHB	662080.1	183.3	3612.8	12087927	4	38.4	i	Aug 1971 - Sep 1995	May 1978 - Jan 1995	7

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									Sediment	Flow	
91104	Taramakau at Greenstone Bridge	2143810.2	877.8	2442.1	12082439	6	10.7	i	Dec 1970 - Aug 1995	Feb 1979 - Jan 1995	7
89301	Whataroa at SHB	4594860.7	452.7	10150.8	12115419	6	29.8	i	May 1986 - Oct 1990	Dec 1985 - Jan 1995	7
Canterbury											
71116	Ahuriri at South Diadem	114904.4	568.3	202.2	13183460	5	153.1	i	Jan 1965 - Dec 1995	Sep 1963 - Jul 1995	7
62105	Clarence at Jollies	62393.1	439.4	142.0	13073779	4	182.9	i	Nov 1965 - Nov 1994	Jul 1962 - Jul 1995	7
71129	Forks at Balmoral	8855.6	107.1	82.7	13153055	4	182.9	i	Nov 1965 - Nov 1994	Jul 1962 - Jul 1995	7
71103	Hakataramea at Above Highway Br	39243.7	898.4	43.7	13197656	6	63.5	i	Jun 1966 - Jan 1996	Jan 1964 - Jul 1995	7
66612	Heathcote at Buxton Terrace	2810.0	73.6	38.2	13127753	4	8.6	i	Apr 1995 - Oct 1995	Dec 1989 - Jul 1996	7
71125	Hooker at Ball Hut Road Br	278275.7	105.6	2634.9	13141091	5	201.3	i	Aug 1965 - Mar 1995	Sep 1960 - Jun 1995	7
67602	Hukahuka at Lathams Br	1463.0	12.1	120.5	13138349	3	13.2	i	Apr 1995 - Oct 1995	Apr 1995 - Oct 1995	7
65104	Hurunui at Mandamus	400212.6	1059.3	377.8	13089600	7	75.9	i	Aug 1965 - Nov 1994	Oct 1956 - Aug 1995	7
71128	Irishman at Windy Ridge	828.2	152.2	5.4	13159114	5	163.8	i	Jun 1966 - Jan 1972	Jul 1962 - Jan 1972	7
71135	Jollie at Mt Cook Station	66615.2	140.6	473.7	13147221	5	189.4	i	Aug 1965 - Nov 1994	Dec 1964 - Jul 1995	7
71131	Lake Tekapo at Spillway	807000.0	1437.3	561.5	13154378	6	181.3	j	NA	NA	7
71106	Maerewhenua at Kellys Gully	24030.2	187.0	128.5	13213640	5	55.4	i	Jul 1970 - Jun 1995	Mar 1970 - Jul 1995	7
71127	Maryburn at Maryhill	140.3	91.0	1.5	13161747	4	157.8	i	Nov 1965 - Dec 1971	Dec 1963 - Jan 1972	7

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									Sediment	Flow	
71122	Maryburn at Mt McDonald	139.5	49.2	2.8	13158329	4	166.4	i	Jan 1970 - Jun 1983	Oct 1969 - Jan 1997	7
68810	North Ashburton at Old Weir	155000.0	274.7	564.3	13128695	5	71.1	i	Aug 1986 - Aug 1986	May 1982 - Feb 1999	7
68502	Rakaia at Gorge	4336496.1	2583.6	1678.5	13126088	7	73.1	i	Aug 1965 - Oct 1973	Dec 1957 - Jul 1980	7
69302	Rangitata at Klondyke	1576000.0	1463.5	1076.9	13140415	6	63.6	i	Jan 1980 - Dec 1995	Aug 1979 - Sep 2000	7
63501	Rosy Morn at Weir	118.2	1.8	65.3	13073808	2	0.0	i	Oct 1990 - Jul 1996	Feb 1978 - Jul 1995	7
68001	Selwyn at Whitecliffs	21288.1	164.6	129.3	13122878	5	85.1	i	Aug 1965 - Jul 1996	May 1964 - Jul 1995	7
68806	South Ashburton at Mt Somers	73378.5	537.0	136.7	13133892	6	75.0	i	Apr 1967 - Dec 1973	Apr 1967 - Apr 1995	7
64610	Stanton at Cheddar Valley	58011.4	40.4	1435.2	13082108	3	40.1	i	Jul 1968 - Apr 1996	Jan 1968 - Jul 1995	7
71121	Twizel at State Highway Br	23309.6	152.9	152.4	13169345	5	135.5	i	Jan 1965 - Apr 1970	Jul 1962 - Jun 1970	7
64602	Waiau at Marble Point	2377408.2	2027.8	1172.4	13082120	7	80.3	i	Oct 1967 - Dec 1990	Oct 1967 - Jan 1994	7
66401	Waimakariri at Old HW Bridge	3030000.0	3110.5	974.1	13119371	7	2.6	i	Jan 1967 - Oct 2017	Dec 1966 - Jan 2018	8
Otago											
75272	Arrow at Beetham Creek	78642.0	206.3	381.2	14218435	4	251.8	i	Oct 1981 - Jun 1993	Apr 1981 - Jan 1994	7
75290	Cardrona at Albert Town	52967.0	347.9	152.3	14197921	5	264.7	i	Jan 1979 - Dec 1995	Sep 1978 - Jan 1997	7
75259	Fraser at Old Man Range	8017.5	118.4	67.7	14235000	5	191.7	i	Aug 1971 - Aug 1991	May 1969 - Jan 1994	7
75218	Lindis at Crossing Bridge	69950.5	1015.5	68.9	14211471	6	229.0	i	Nov 1973 - Jul 1976	Nov 1972 - May 1977	7
75219	Lindis at Lindis Peak	57710.0	547.4	105.4	14200716	6	261.1	i	May 1977 - Nov 1994	Sep 1976 - Feb 1995	7
75253	Manuherikia at Ophir	108876.0	2142.8	50.8	14226993	7	197.8	i	Jul 1971 - Dec 1995	Feb 1971 - Jul 1995	7

Site ID	Site name (river at location)	Suspended sediment load (t/y)	Catchment area (km²)	Specific yield (t/km²/y)	REC2 Segment	Stream order	Distance to coast (km)	Rating curve fitting method[a]	Monitoring period		Source[b]
									Sediment	Flow	
75294	Matukituki at West Wanaka	708462.4	803.9	881.3	14194962	6	285.4	i	Oct 1979 - Oct 1996	Aug 1979 - Jul 1997	7
75265	Nevis at Wentworth Station	179568.8	696.8	257.7	14225021	6	229.7	i	Jun 1977 - Jun 1990	Apr 1977 - Jul 1990	7
74701	Noble at Bull Creek Road	200.7	11.8	17.0	14302749	3	3.8	i	Jun 1971 - Dec 1995	Jun 1970 - Jul 1995	7
75232	Pomahaka at Burkes Ford	67300.0	1883.0	35.7	14296596	6	69.6	i	Jul 1971 - Sep 1995	Aug 1961 - Jul 1995	7
75278	Shotover at 16 Mile Gorge	182148.1	168.1	1083.9	14197876	5	315.1	i	Dec 1977 - Jun 1980	Sep 1977 - Apr 1986	7
75276	Shotover at Bowens Peak	1314631.3	1066.5	1232.7	14220583	6	262.4	i	Feb 1965 - Oct 1991	Jun 1967 - Apr 1995	7
75279	Shotover at Strohles	607650.3	562.4	1080.4	14206168	6	296.9	i	Jun 1980 - Dec 1986	Dec 1979 - Jun 1987	7
74338	Sutton Stream at SH 87	3368.1	152.2	22.1	14261484	5	95.2	i	Aug 1992 - Jun 1996	Jul 1986 - Jul 1995	7
Southland											
78901	Aparima at Thornbury	52573.0	1259.1	41.8	15312336	6	16.5	i	Jul 2008 - Nov 2013	Mar 1985 - Jan 2014	7
84701	Cleddau at Milford	10733.9	140.4	76.5	15200625	5	0.0	i	Nov 1971 - May 1980	Mar 1963 - Jun 1980	7
183001	Long Sound (Preservation Inlet)[c]	16330.0	362.0	45.1	15303621	2	0.0	j	NA	NA	12
78634	Makarewa at Counsell Rd	71588.0	1015.5	70.5	15312789	7	32.2	i	Jan 1978 - Dec 2017	Apr 1981 - May 2018	12
77504	Mataura at Gore	208158.0	3594.7	57.9	15299973	7	78.2	i	Jan 1978 - Dec 2017	Jan 1978 - Mar 2018	7
183003	Nancy Sound[c]	8660.0	69.8	124.1	15238437	3	0.0	j	NA	NA	12
78636	Oreti at Lumsden Cableway	52486.0	1125.1	46.7	15273225	7	114.1	i	May 2015 - Feb 2017	Jan 1977 - June 2018	12
78601	Oreti at Wallacetown	106687.0	2151.0	49.6	15314100	7	18.7	i	Sep 2017 - Feb 2018	Oct 1977 - Jun 2018	7
78625	Otapiriri at McBrides Bridge	4334.6	108.3	40.0	15295210	5	94.1	i	Feb 1965 - Mar 1980	Dec 1962 - Jul 1992	7

Site ID	Site name (river at location)	Suspended sediment load (t/y)	Catchment area (km^2)	Specific yield ($t/km^2/y$)	REC2 Segment	Stream order	Distance to coast (km)	Rating curve fitting method[a]	Monitoring period		Source[b]
									Sediment	Flow	
80201	Rowallanburn at Old Mill	2998.1	68.4	43.8	15305977	4	3.7	i	Nov 1971 - Oct 1993	Mar 1989 - Oct 1993	7
79740	Spey at West Arm	11085.4	95.6	115.9	15264121	4	136.1	i	Jun 1995 - Dec 1995	Dec 1991 - Jan 1997	7
183002	Thompson-Bradshaw Sd (Doubtful Sd) [c]	29870.0	401.2	74.4	15248124	5	0.0	j	NA	NA	7
78503	Waihopai at Kennington	7571.5	161.7	46.8	15315518	5	10.7	i	Jul 1971 - Jan 1976	Jul 1958 - Jul 1978	7

[a]Load calculation method: a - Average of Sediment Rating Curve (SRC) and Event Sediment Rating Curve (ESRC); b - Average of SRC, ESRC, and Monte Carlo analysis; c - Calibrated continuous turbidity, adjusted to correct for bias using TSS laboratory analysis but not cross-section (XS) mean adjusted; d - ESRC; e - Flow proportional composite sampling; f - SRC fitted to calibrated turbidity data, corrected for XS mean; g - SRC, depth-integrated & auto-sampled adjusted to XS mean; h - SRC, adjusted to XS mean; I - SRC; j - Stratigraphy.

[b]Source: 1- Basher et al. (2011); 2 - Curran-Cournane et al. (2013); 3 - Hicks and Hoyle (2012); 4 - Hicks (2008); 5 - Hicks (2009); 6 - Hicks et al. (2007); 7 - Hicks et al. (2011); 8 - Hicks et al. (2018); 9 - Hoyle (2014); 10 - Hicks et al. (2009); 11 - Hoyle et al. (2015); 12 - this study with new data; 13 - this study with updated data.

[c]Based on sedimentation rates derived from coring in fjords; the total load and catchment area were determined by summing the loads and catchment areas for all streams draining into the fjords.

Appendix E Areal proportion of input data classes in calibration site catchments

Table E-1: Percentage of calibration site catchment area in each slope class. A - Flat to gently undulating; B - Undulating; C- Rolling; D - Strongly rolling; E - Moderately steep; F - Steep; G - Very steep; H- Precipitous. See also Table 3-1.

Site ID	Site name	A	B	C	D	E	F	G	H
Northland									
1316	Awanui at School Cut	19.6	17	35.6	15.4	7.7	4.6	0.2	0
46645	Kokopu at McBeths	37.8	33.5	28.6	0	0	0	0	0
46626	Mangakahia at Titoki at Titoki	14.7	19.3	35.5	15.3	8.9	5.8	0.5	0
3506	Maungaparerua at Tyrees Ford	49.7	35.6	13.7	0.8	0.3	0	0	0
46644	Wairua at Purua	35	20.9	28.5	10	4.1	1.4	0	0
3722	Waitangi at Wakelins	40	27.8	24.3	5.7	1.7	0.5	0	0
Auckland									
45703	Hoteo at Gubbs	21	23	34.6	13.9	5.6	1.9	0	0
45705	Hoteo at Waiteitei	31.7	32.2	32.5	3.1	0.4	0	0	0
45311	Kaipara at Waimauku	35.7	29.6	30.3	4	0.4	0	0	0
45415	Kaukapakapa at Taylors	33.6	33.4	27.1	3.7	1.6	0.7	0	0
6806	Mahurangi at College	22.9	22.2	36.5	12.7	4.6	1.1	0	0
8304	Mangemangeroa at Craigs	7.3	28.6	53.6	9.8	0.7	0	0	0
7502	Okura at Awanohi	17.4	21.6	51.4	8.4	1.2	0	0	0
7304	Okura at Weiti Forest	21.1	26.1	47.8	3.3	1.7	0	0	0
8604	Orere at Bridge	9.1	12.3	28.9	21	17.9	10.5	0.4	0
7202	Orewa at Kowhai Ave	32.5	39.3	26.4	1.8	0	0	0	0
7506	Vaughan at Lower Weir	24.6	27	45.6	2.8	0	0	0	0
8516	Wairoa at Wairoa at Tourist Road	20.9	20.2	32.5	14.6	8.3	3.3	0.1	0
43602	Waitangi at SH Br	71.6	19.9	7.8	0.6	0.1	0	0	0
45702	Waiwhiu at Dome Shadow	6.5	14.1	39.4	23.2	9.1	7.8	0	0
7206	West Hoe at Hall Farm	0	17.2	55.2	27.6	0	0	0	0
Waikato									
40810	Awakino at Gorge	8.6	10.4	29.4	18.8	15.1	15.1	2.3	0.3
1143450	Awaroa at Sansom's Br Rotowaro	15.5	29.1	40.4	10.4	3.7	0.9	0	0
2743464	Hinemaiaia at Maungatera	24.5	25.6	24.8	10.8	7.7	6.3	0.2	0
1643461	Kaniwhaniwha at Limeworks Rd	6.1	15.6	33.8	19.9	14.2	9.9	0.5	0
1043468	Kuratau at State Highway 41	36.8	30.3	22.6	6.2	2.7	1.4	0	0
1043434	Mangakara at Hirsts	14.8	24.8	34.2	13.9	6.8	4.8	0.7	0
1043427	Mangakino at Dillon Road	26.3	28.8	28.2	9.6	4.6	2.4	0.1	0
40703	Mangakowhai at Kaingapipi	17	28.5	41.1	9.8	2.4	1.3	0	0
1643462	Mangaokewa at Te Kuiti	20.3	23.6	33	11.6	6.9	4.4	0.1	0

Site ID	Site name	A	B	C	D	E	F	G	H
1543497	Mangaonua at Dreadnought	80.3	5.9	9.7	3.1	0.8	0.1	0	0
1043444	Mangapu at SH3 Br	24.5	23.6	34	10.3	4.8	2.7	0.1	0
1943459	Mangatutu at Walker Rd Br	24	20.9	27.3	12.1	8.4	6.5	0.9	0.1
41301	Marokopa at Falls	13.9	17.7	37.7	16.5	8.6	5.2	0.3	0
3043490	Matahuru at Myjers	23.9	15	29.9	18.7	9.3	3.2	0	0
43489	Matahuru at Waiterimu Rd	31.3	15.3	26.8	16	7.9	2.6	0	0
40708	Mokau at Totoro Bridge	19.4	20.4	34	13.5	7.4	5.1	0.2	0
9213	Ohinemuri at Karangahake	22.7	16.8	30.5	15.2	8.6	5.7	0.5	0
11310	Opitonui River at d/s Awaroa	4.8	9.1	33.2	25.9	16.2	9.6	1.1	0.1
1009213	Oraka at Pinedale	24.1	23.9	25.6	10.2	6.8	8.2	1.2	0
41601	Oteke at Kinohaku	10.1	18	46.7	17.2	5.7	2.3	0.1	0
9140	Piako at Paeroa Tahuna Rd	62.2	17.6	15.9	3.4	0.7	0.1	0	0
9175	Piako at Kiwitahi	41.4	28.3	24.6	5	0.7	0.1	0	0
1043419	Pokaiwhenua at Puketurua	44.3	26.6	18.5	5.3	2.5	2.5	0.3	0
43431	Puniu at Pokuru Br	32.7	25.3	26.3	9	4.2	2.2	0.2	0
1143409	Purukohokohu at Puruki Flume	6.1	18.2	60.6	9.1	3	3	0	0
1009246	Rapurapu at Kinlochs Farm	15	20.3	32.6	15	9.6	7.5	0	0
1043428	Tahunaatara at Ohakuri Road	26.4	27.1	26	8.2	5.2	5.8	1.2	0.2
12301	Tairua at Broken Hills	6.8	13.8	31.7	18.8	14.4	12.5	1.8	0.3
9701	Tapu at Tapu-Coroglen	2.1	5.8	26.5	25.7	20.5	17.5	1.7	0.2
1543413	Tauranga-Taupo at Te Kono	9.7	16.5	23.1	14.1	13.1	20.1	3.2	0.1
1143427	Te Tahi at Puketotara	2.8	15.6	54.7	23.9	3.1	0	0	0
1043460	Tongariro at Puketarata	17.8	20.8	21.4	11.3	9.8	15.1	3.6	0.2
1043459	Tongariro at Turangi	21.6	20.6	21.3	11	9	13.2	3.1	0.2
1043461	Tongariro at Upper Dam	12.8	9.8	16.2	13.5	14.1	27	6.3	0.4
1543424	Waihaha at SH32	13	24.4	33.3	15.8	8.6	4.7	0.2	0
1043466	Waihohonu at Desert Rd	20	30.4	25.3	9.2	6.2	7.4	1.5	0
9224	Waihou at Okauia	42.7	21.2	18.8	7	4.6	5.2	0.6	0
9205	Waihou at Te Aroha Br	47.9	17.5	16.2	6.5	4.7	6.1	1.1	0.1
9209	Waihou at Tirohia	48.1	17	16.2	6.8	4.8	6	1	0.1
42601	Waingaro at Ruakiwi Road	9.6	19.7	41.3	19.2	8.1	2.2	0	0
9228	Waiorongomai at Old Quarry	2.9	1.9	12.3	16.7	25.3	34.4	6.4	0
2043493	Waiotapu at Campbell Rd	30.1	26.7	25	9.2	5.7	3	0.3	0
43472	Waiotapu at Reporoa	55.8	17.9	14	5.4	3.6	2.9	0.3	0
43435	Waipa at Ngaroma Rd	32.6	24.6	24.9	9.4	5.3	3.1	0.2	0
43481	Waipa at Otewa	16.5	20.8	28.8	14.1	10.3	8.5	1	0.1
43433	Waipa at Whatawhata	36.3	20.6	25.4	9.3	5	3.2	0.2	0
2043441	Waipapa at Mulberry Rd	36.3	36.7	20.8	3.2	1.4	1.4	0.2	0
9179	Waitoa at Mellon Rd	75.8	11.9	10.1	1.8	0.3	0.1	0	0

Site ID	Site name	A	B	C	D	E	F	G	H
9114	Waitoa at SH26	61.6	18.8	16.2	2.9	0.5	0.1	0	0
9112	Waitoa at Waharoa Control	52.7	22.7	20.3	3.4	0.8	0.2	0	0
1943481	Waitomo at Aranui Caves	8.2	16.3	41.9	18.7	9.7	5	0.2	0
1643457	Whakapipi at SH22-Tuakau	53.6	28.6	15	2.6	0.2	0	0	0
1143402	Whangamarino at Slackline	39	14.5	26.9	13.2	5.1	1.3	0	0
12509	Wharekawa at Adams Farm	5.2	14.7	35.8	19.6	11.5	11.6	1.4	0
Bay of Plenty									
14604	Awahou at Tauranga Rd Bridge	51.6	36.6	10.2	1.3	0.2	0	0	0
14614	Kaituna at Te Matai	42.4	23.7	21.3	7.1	3	2.2	0.2	0
13901	Mangawhai at Mokoroa	16.4	40.2	38.3	4.5	0.6	0	0	0
14628	Mangorewa at Saunders Farm	34.8	25.5	24.5	8.1	3.8	3	0.2	0
16501	Motu at Houpoto	3.4	5.5	13.6	11.8	13.9	32.4	15.4	4
1014641	Ngongotaha at SH5 Bridge	27	26.5	27.8	9.8	4.4	3.7	0.7	0
16006	Otara at Gault Road Br(No.2)	3.7	2.8	8.7	9.4	12.8	37.2	21.3	4.2
14625	Puarenga at FRI Bridge	24.6	27.1	29.1	10.5	5.2	3.5	0.1	0
15432	Rangitaiki at Kopuriki	48.6	15	13.5	6.5	5.3	8.3	2.4	0.4
15408	Rangitaiki at Murupara	70.6	15.6	9.3	2.7	1	0.6	0.1	0
17101	Raukokore at SH35 Bridge	2	4.2	15.3	13.3	14.8	32.8	14.1	3.5
16511	Takaputahi at Ngawhakatatara	2.3	4.7	10	9.6	13.3	40.4	17.3	2.5
17301	Tauranga at Maruhinemaka	14.7	13.8	26.9	23.8	15.7	5.2	0	0
1014647	Utuhina at Hunts Farm	27.7	28.7	29.2	9.5	3.1	1.8	0	0
14610	Utuhina at SH5 Bridge	30.4	28	26.4	8.1	3.5	3.2	0.4	0
16205	Waiaua at Edwards	6.1	7	15.7	13.1	15.4	31.1	9.9	1.8
15453	Waihua at Gorge	2.3	3.1	10.9	12.7	16.9	39.7	12.5	1.9
15536	Waimana at Ogilvies Bridge	1.3	3.7	15.7	15.4	16.2	33.4	12.8	1.6
14606	Waingaehe at SH3none Bridge	18.7	27.9	38.7	10.6	3.4	0.6	0	0
15901	Waioeka at Gorge Cableway	1.7	5.1	16	12.7	13.4	31.4	16.2	3.5
14607	Waiohewa at SH3none Bridge	33.3	26.3	28.9	6.4	2.8	1.8	0.4	0.2
15802	Waiotahi at McNabs Road Bridge	4.5	5.7	15.8	15.1	16.9	30.6	9.9	1.4
1014644	Waiowhiro at Bonningtons Farm	42.5	19	20.6	9.3	3.1	5.4	0.1	0
1014648	Waipa at Whaka Forest	15.5	20.5	32.2	17.5	7.8	6.3	0.2	0
15534	Wairere at Wainui Road	10.8	22.6	46.9	14.1	2.6	2.6	0.3	0
14603	Waiteti at Tauranga Rd Bridge	61.3	28.2	9	1.2	0.3	0.1	0	0
15514	Whakatane at Whakatane	6.5	5.3	14.5	13.7	15.8	32	10.8	1.4
15410	Whirinaki at Galatea	7.4	12.1	23.1	16.1	14.8	21.2	4.7	0.5
Taranaki									
39508	Manganui at SH3	36.2	21.4	12.6	6.6	5.5	14.2	3.1	0.4
36001	Punehu at Pihama	60.6	22.7	8	3.2	2.6	2.7	0.2	0
39501	Waitara at Tarata	7.7	10.9	23.4	17.8	18	21.1	1	0

Site ID	Site name	A	B	C	D	E	F	G	H
34202	Whenuakra at Nicholson Road	9	8.7	15.9	14.2	18	31.9	2.2	0
Gisborne									
21437	Hangaroa at Doneraille Park	6.1	13.7	38.4	21.4	12.2	7.7	0.5	0
18902	Hikuwai at Willow Flat	5.6	8	28.4	24.7	18	13.7	1.4	0.2
18913	Mangaheia at Willowbank	2.7	6.1	25.1	25.2	22.9	16.9	1.1	0
19712	Mangatu at Omapere	2.6	6.8	34.1	23.3	15.8	14.4	2.7	0.3
18304	Mata at Pouturu	8.5	15.7	36.6	20.8	11.5	6.5	0.4	0
16502	Motu at Waitangirua	11.7	15	27.2	16.6	12.6	14.4	2.5	0.1
19766	Te Arai at Pykes Weir	2.4	6.1	33	28.3	19.3	10.6	0.3	0
18309	Waiapu at Rotokautuku	5.7	9.1	28.4	20.4	15.1	17.5	3.2	0.4
19706	Waihora at No 3 Br	2.5	6.6	26.6	26	20.9	16.7	0.6	0
19708	Waikohu at Mahaki	4.4	11.7	36.5	20.7	13.3	12.1	1.3	0
19602	Waimata at Goodwin's Rd	4.2	8.8	28.7	24	18.7	14.8	0.8	0
19609	Waimata at Monowai	3.9	9.5	33.4	25	17	10.8	0.4	0
19711	Waingaromia at Terrace Station	3.8	8.8	35.5	25.3	16.1	9.8	0.7	0
19701	Waipaoa at Kanakanaia Br	6.1	10.6	34.7	22.5	14.4	10.7	1	0.1
19704	Waipaoa at Matawhero	8.8	10.7	33.1	21.9	14.3	10.3	0.9	0.1
19702	Waipaoa at Waipaoa Stn	3.6	8.2	37.9	24.1	13.2	11.6	1.2	0.1
17601	Wharekahika at Hicks Bay Rd Br	8.9	12	25.3	16.8	13.6	18.1	4.6	0.6
19741	Wharekopae at Rangimoe Stn	5.1	12.4	34.5	20.9	14.2	12	0.9	0
Hawke's Bay									
22802	Esk at Waipunga Bridge	8	18	36.8	17.8	11.2	7.7	0.5	0
21803	Mohaka at Glenfalls	7.9	9	19	14.6	15.6	27.7	6	0.3
21801	Mohaka at Raupunga	6.1	8.7	21	15.9	15.7	25.5	6.3	0.8
23150	Ngaruroro at Chesterhope Bridge	18.1	16.9	23	11.3	9.6	16.2	4.4	0.4
23102	Ngaruroro at Fernhill	16.5	17.2	23.2	11.5	9.8	16.7	4.5	0.5
23104	Ngaruroro at Papango	2.8	5.8	14.8	13.6	17.1	36	9.3	0.6
23103	Ngaruroro at Whanawhana	7.7	11.4	21.4	13.9	13.5	24.5	6.9	0.7
23210	Omakere at Fordale	39.2	21.1	26.6	9.1	3.1	0.8	0	0
23209	Otane at Glendon	27.3	33.3	26.3	6.9	3.6	2.5	0	0
21601	Tahekenui at Glenstrae	4.9	6.7	31.1	25	20	12.2	0	0
23106	Taruarau at Taihape Road	17.8	18.2	28.7	15.2	10.1	8.8	1.2	0.1
23201	Tukituki at Red Bridge	37.6	19.8	23.6	7.6	4.2	5.6	1.5	0.1
23203	Tukituki at Waipukurau	50.1	15.5	15.6	5.8	4.5	6.7	1.6	0.2
21409	Waiau at Otoi	2.4	5.6	22.8	18.8	17.6	25.3	6.4	1
21410	Waihi at Waihi	3.7	9.6	35.2	25.1	15.2	10.2	0.7	0.4
21401	Wairoa at Marumaru	5.7	11.5	34.2	22.1	14.2	10.9	1.2	0.2
Manawatu / Whanganui									
32726	Hautapu at Taihape	18.3	24.4	33.6	13.5	6.8	3.3	0	0

Site ID	Site name	A	B	C	D	E	F	G	H
33502	Kaiiwi at Handley Road	10.5	14.9	25.9	17	14.1	16.2	1.5	0
32754	Makohine at Viaduct	2.7	8.1	24.4	23.3	22.4	18.8	0.3	0
1032591	Makuri at Tuscan Hills	5.7	11.3	36.1	23.9	13.3	9	0.6	0.1
32504	Manawatu at Hopelands	27.9	19.9	25.5	11.5	7	6.9	1.1	0
1032560	Manawatu at Teachers College	23	15.7	25.9	14.6	9.6	9.8	1.5	0.1
1232566	Manawatu at Upper Gorge	23.7	16.1	25.9	14.8	9.5	8.7	1.2	0.1
32526	Mangahao at Ballance	10	12.1	17.8	12.6	13.9	26.3	6.6	0.7
5023	Mangahao at Machine	1.7	3.6	9.3	10.3	14.8	43.1	15.6	1.7
1132511	Mangatainoka at Pahiatua Town Bridge	36.3	15.6	19.8	11.3	8.4	8.2	0.6	0
33111	Mangawhero at Ore Ore	31.6	19.6	23.2	11.3	8.1	6	0.3	0
32106	Ohau at Rongomatane	4.5	8.2	17.5	14.3	13.8	31.1	10.2	0.5
33314	Ohura at Nihoniho	9	13.5	32.1	20.2	13.9	10.7	0.6	0.1
33316	Ongarue at Taringamutu	15.8	19.8	34	14.4	8.5	7	0.6	0
32514	Oroua at Almadale Slackline	21.2	17.2	22.6	10.7	7.5	15.8	4.7	0.3
32563	Oroua at Kawa Wool	32.6	17.2	23.2	10.2	5.4	8.7	2.5	0.2
25101	Owahanga at Branscombe Bridge	9.8	17.3	37.1	19.9	10.5	5.1	0.3	0
32576	Pohangina at Mais Reach	7.9	13.7	27.3	15.6	12.1	19.7	3.5	0.1
32702	Rangitikei at Mangaweka	8.5	16	28.1	15.8	11.7	15.1	4.3	0.5
32763	Rangitikei at Pukeokahu	6	12.5	23.7	15.4	13.4	21.9	6.5	0.5
32529	Tiraumea at Ngaturi	8.9	13.1	34.9	23.6	13.1	6.2	0.2	0
33004	Turakina at Otairi	5.4	13.4	29.4	20.3	17	14	0.4	0
33320	Whakapapa at Footbridge	27.1	32.5	21.4	8.1	5	5.1	0.7	0.1
33101	Whangaehu at Kauangaroa	24.7	16.3	22	13.3	11.7	11.2	0.7	0.1
33303	Whanganui at Te Rewa	10.4	12.5	24.9	16.9	15.2	18.4	1.7	0.2
33301	Whanganui at Paetawa	10.4	12.5	24.9	16.9	15.2	18.4	1.7	0.2
33347	Whanganui at Te Porere	16.2	29.5	35.8	12.1	4.5	1.8	0	0
Wellington									
30912	Horokiri at Snodgrass	5.2	8.5	23.8	21.7	18.9	20.8	1	0
29808	Hutt at Kaitoke	1.3	3.1	11.2	11.2	14.4	40	17	1.8
30516	Mill Creek at Papanui	6.8	16.2	33.6	22.2	13.7	6.7	0.4	0.3
31807	Otaki at Pukehinau	0.7	2.4	8.6	10.3	15.3	45.1	16.3	1.3
31803	Otaki at Tuapaka	0.9	2.5	8.8	10.3	15.3	44.7	16.2	1.3
27303	Pahao at Hinakura	12.5	18.5	32.2	19	11.1	6.1	0.5	0
30802	Pauatahanui at Gorge	9	13.3	35.9	21.2	12.7	7.4	0.4	0
30701	Porirua at Town Centre	10.4	20	36.7	17.9	9.7	5.1	0.1	0
29250	Ruakokopatuna at Iraia	1.3	4.2	16.3	22.8	26.9	25.2	3.1	0.2
29202	Ruamahanga at Waihenga	26.8	11.4	23	13.7	9.1	12.1	3.5	0.4
29231	Taueru at Te Weraiti	8.9	16.5	39.9	22.6	9.6	2.5	0	0
29244	Whangaehu at Waihi	6	13.1	39.2	25.7	12.5	3.4	0.1	0

Site ID	Site name	A	B	C	D	E	F	G	H
25902	Whareama at Waiteko Bridge	9.3	13.5	36.9	23.7	12.3	4.2	0.1	0
Tasman									
52003	Aorere at Devils Boot	4.7	6.2	11.5	8.2	10.4	33.3	20.1	5.7
56905	Apahai at Hickmotts	3.7	6.2	25.9	30.9	17.3	16	0	0
93202	Buller at Longford	7	7.5	15.4	12.6	13.3	28.4	12.5	3.4
52916	Cobb at Trilobite	3	4.7	10.1	10.7	14.8	38.7	15.6	2.4
56906	Kaiteriteri at Water Supply	3.1	13.8	35.4	23.1	16.9	7.7	0	0
57536	Lee at Cableway	0.3	1.6	9.5	12.1	15	40.3	16.8	4.4
93212	Mangles at Gorge	4.2	5.3	13.2	12.5	15.9	38.7	9.6	0.6
93209	Maruia at Falls	7.9	7.5	13.1	10.7	12.9	31.1	13.9	2.8
93211	Matakitaki at Mud Lake	3.7	6.1	10.8	8.8	11.8	33.6	19.9	5.4
57008	Motueka at Gorge	0.7	2.3	10.9	13.1	16.8	43.3	12.2	0.8
57015	Motueka at Woodmans Bend	7	8.4	18.7	15.6	15.8	25.3	7.8	1.3
57009	Motueka at Woodstock	6.9	8.2	18.4	16	16.2	25.2	7.8	1.3
57036	Motupiko at Christies	9.4	17.4	30.1	18.3	12.9	10.8	0.9	0
57101	Moutere at Old House Road	24.9	25	34.3	11.7	3.5	0.7	0	0
56901	Riwaka at Moss Bush	3.9	8.2	17	13.9	16	27.8	8.6	4.7
57014	Stanleybrook at Barkers	9.1	9.4	25.6	22	20.7	13.2	0	0
52902	Takaka at Harwoods	3.3	6.4	15.5	12.4	15.2	33.8	11	2.3
57502	Wairoa at Gorge	0.9	2.6	11.4	14.2	18.5	39	11.6	1.7
57025	Wangapeka at Walter Peak	4.6	4.8	12.2	11	13.1	36	15	3.3
Marlborough									
62103	Acheron at Clarence	4.7	5.2	10.3	10.7	15.8	44.4	8.5	0.6
58902	Pelorus at Bryants	0.9	3	12.8	12.4	15.1	38.9	14.2	2.6
60114	Wairau at Dip Flat	1.8	4.1	7.1	6.3	9.2	36.8	26.9	7.8
West Coast									
91407	Ahaura at Gorge	14.8	10.1	10.7	7.1	8.6	26.2	18	4.5
89701	Amethyst at Road Bridge	0.5	2.3	7.7	8.9	12	36.9	21	10.7
93203	Buller at Te Kuha	7	7	13.9	11.6	13.3	30.6	13.4	3.1
93208	Buller at Woolfs	5.9	6.8	13.5	11.4	13.5	31.7	14	3.2
90605	Butchers Creek at Lk Kaniere Road	30.5	30	22.3	11.6	3.9	1.7	0	0
90607	Cropp at Gorge	0.6	1.6	6.8	6.6	13	35.9	22.9	12.7
91401	Grey at Dobson	25.1	11.4	13.8	9.5	9.4	18.8	9.5	2.4
91404	Grey at Waipuna	5.6	7.6	12.4	9.1	11.3	31.6	17.9	4.5
86802	Haast at Roaring Billy	2	3.5	6.9	6.7	11.2	35.3	21	13.4
90604	Hokitika at Colliers Creek	0.7	1.6	5.5	6.9	11.1	35.4	25.9	12.9
93207	Inangahua at Blacks Point	3.7	5.9	13	11.2	13.1	30.9	16.7	5.6
93206	Inangahua at Landing	11.6	6.9	12.6	11.2	13	29	12.7	3.1
90102	Ivory at Ripplerock	3.9	2.2	8.7	4.8	9.1	26.1	22.6	22.6

Site ID	Site name	A	B	C	D	E	F	G	H
95102	Karamea at Gorge	1	2.6	7.7	7.5	10.7	37.7	25.5	7.2
94302	Mokihinui at Burkes Creek	3.1	4	11	10.6	12.9	33.1	20.2	5.2
94303	Mokihinui at Welcome Bay	3	4	10.8	10.6	12.9	33.2	20.3	5.3
91103	Taipo at SHB	1.6	3.3	8.5	7.6	10.6	34.4	27.1	7
91104	Taramakau at Greenstone Bridge	8	6.9	8.7	6.4	8.6	28.7	24.4	8.3
89301	Whataroa at SHB	1.2	3	7.7	6.9	9.6	30.8	22.8	18
Canterbury									
71116	Ahuriri at South Diadem	8.3	6.6	10.9	9	12.4	35	13.7	4.2
62105	Clarence at Jollies	5.9	7	12.2	11.9	16.2	38.9	7.2	0.8
71129	Forks at Balmoral	15	9.6	9.9	7.8	9.6	31	15.4	1.8
71103	Hakataramea at Above Highway Br	20.9	22	23.2	11.1	8.8	13	0.9	0
66612	Heathcote at Buxton Terrace	68.8	4.5	10.5	7.1	5.2	3.9	0.1	0
71125	Hooker at Ball Hut Road Br	4.3	6.6	11.1	5.8	8	21.7	19.7	22.7
67602	Hukahuka at Lathams Br	0.7	3.7	20.6	18.9	28	27.8	0.2	0
65104	Hurunui at Mandamus	5.2	5.5	9.9	9.7	13.5	39.6	15.3	1.4
71128	Irishman at Windy Ridge	47.9	31.2	13.3	4.1	2.2	1.3	0	0
71135	Jollie at Mt Cook Station	1.1	2.6	6.9	7.3	10.5	36.7	22.8	12.1
71131	Lake Tekapo at Spillway	18.8	11.6	12.1	7.2	8.1	23.1	14	5
71106	Maerewhenua at Kellys Gully	2.5	6.6	18.2	16.7	20.5	30.9	4.3	0.4
71127	Maryburn at Maryhill	50.4	31.9	12.7	2.5	1.2	1.3	0	0
71122	Maryburn at Mt McDonald	45.3	39.7	13.4	1.4	0.2	0	0	0
68810	North Ashburton at Old Weir	0.6	2.3	8.8	10.3	14.5	45.5	17.5	0.5
68502	Rakaia at Gorge	14.8	8.2	9.6	6.9	8.4	27.6	18.9	5.5
69302	Rangitata at Klondyke	12.3	7.6	9.9	7.6	9.4	28.8	17.9	6.4
63501	Rosy Morn at Weir	1.7	2.8	16.6	16	18.2	40.3	3.9	0.6
68001	Selwyn at Whitecliffs	12.9	12.9	20.2	14.9	13.7	22	3.2	0.1
68806	South Ashburton at Mt Somers	21.4	15.4	16.2	10	10.5	20.3	5.7	0.5
64610	Stanton at Cheddar Valley	3.9	9.9	29.3	23.7	19.2	13.8	0.2	0
71121	Twizel at State Highway Br	46.4	10	9	6.1	8.2	17.8	2.5	0
64602	Waiau at Marble Point	7.3	5.7	9.9	8.8	12.2	38.5	15.8	1.8
66401	Waimakariri at Old HW Bridge	26.1	6.7	10.2	7.7	9.2	26.1	11.9	2
Otago									
75272	Arrow at Beetham Creek	0.9	2.5	8	12.4	21.4	44.4	9.6	0.8
75290	Cardrona at Albert Town	10.6	6.6	17	18.1	18.9	24.3	4.3	0.3
75259	Fraser at Old Man Range	7.5	26.6	43.1	13.2	6.5	3	0.1	0
75218	Lindis at Crossing Bridge	7.4	8.7	20.3	19.6	19.3	22.1	2.6	0.1
75219	Lindis at Lindis Peak	3.2	6.6	18.6	18.6	20	28.7	4.2	0.2
75253	Manuherikia at Ophir	30.3	18.3	20.7	9.9	8.6	11.4	0.8	0
75294	Matukituki at West Wanaka	3.9	5.4	7.7	7.8	14.1	35.9	15.3	10

Site ID	Site name	A	B	C	D	E	F	G	H
75265	Nevis at Wentworth Station	6.1	10.3	26.9	20.8	15.6	16.5	3.1	0.6
74701	Noble at Bull Creek Road	19.7	29.1	43.2	7.5	0.5	0	0	0
75232	Pomahaka at Burkes Ford	29.1	21	25.7	11.9	7.5	4.6	0.2	0
75278	Shotover at 16 Mile Gorge	2.2	1.5	6.2	7.7	13.7	36.7	18.5	13.5
75276	Shotover at Bowens Peak	1.2	2.1	6.4	8.6	16.4	40.1	18.4	6.8
75279	Shotover at Strohles	1.5	2.4	6.6	8.8	15.8	37.5	17.9	9.5
74338	Sutton Stream at SH 87	23.6	33.7	28.8	8.2	4.1	1.6	0.1	0
Southland									
78901	Aparima at Thornbury	50.2	13.2	17.5	7.8	4.9	5.2	1.1	0.1
84701	Cleddau at Milford	3	5.6	8.7	4.6	5.1	15.2	13.4	44.5
183001	Long Sound (Preservation Inlet)*	2.6	3.8	12	10.9	13.1	31.9	17.2	8.5
78634	Makarewa at Counsell Rd	51.9	17.6	19.8	6.8	3	1	0	0
77504	Mataura at Gore	25.8	11.8	19.1	13.1	11.8	15.3	2.5	0.5
183003	Nancy Sound	1.8	1.2	4.4	4.8	6.4	23.6	27.6	30.2
78636	Oreti at Lumsden Cableway	25.3	9.9	16.4	12	12.2	19.3	4.1	0.8
78601	Oreti at Wallacetown	45.1	9.6	15.6	9	7.6	10.5	2.2	0.4
78625	Otapiriri at McBrides Bridge	12	20	36.8	19.4	9.2	2.5	0.1	0
80201	Rowallanburn at Old Mill	14.7	22.3	39.8	16.1	6.1	1	0	0
79740	Spey at West Arm	1.8	3.7	7.9	7.1	9.3	27.9	21.8	20.5
183002	Thompson-Bradshaw Sd (Doubtful Sound)*	2.1	2.4	7	6.1	8	27.4	23	24
78503	Waihopai at Kennington	99.9	0.1	0	0	0	0	0	0

Table E-2: Percentage of calibration site catchment area in each rain class. Quintile breaks. See also Table 3-2.

Site ID	Site name	Dry	Medium Dry	Medium	Medium wet	Wet
Northland						
1316	Awanui at School Cut	0	0	29.7	70.3	0
46645	Kokopu at McBeths	0	0	100	0	0
46626	Mangakahia at Titoki at Titoki	0	0.9	46.6	52.6	0
3506	Maungaparerua at Tyrees Ford	0	0	0	100	0
46644	Wairua at Purua	0	0	12.7	87.3	0
3722	Waitangi at Wakelins	0	0	17.3	82.7	0
Auckland						
45703	Hoteo at Gubbs	0	0	76.8	23.2	0
45705	Hoteo at Waiteitei	0	0	100	0	0
45311	Kaipara at Waimauku	0	0	100	0	0
45415	Kaukapakapa at Taylors	0	0	100	0	0
6806	Mahurangi at College	0	0	77	23	0
8304	Mangemangeroa at Craigs	0	100	0	0	0
7502	Okura at Awanohi	0	2.3	97.7	0	0
7304	Okura at Weiti Forest	0	0	100	0	0
8604	Orere at Bridge	0	15.5	67	17.5	0
7202	Orewa at Kowhai Ave	0	0	100	0	0
7506	Vaughan at Lower Weir	0	100	0	0	0
8516	Wairoa at Wairoa at Tourist Road	0	0	28.9	71.1	0
43602	Waitangi at SH Br	0	0	100	0	0
45702	Waiwhiu at Dome Shadow	0	0	75.1	24.9	0
7206	West Hoe at Hall Farm	0	0	100	0	0
Waikato						
40810	Awakino at Gorge	0	0	0	9.6	90.4
1143450	Awaroa at Sansom's Br Rotowaro	0	0	100	0	0
2743464	Hinemaiaia at Maungatera	0	0	4.6	95.4	0
1643461	Kaniwhaniwha at Limeworks Rd	0	0	0	51.9	48.1
1043468	Kuratau at State Highway 41	0	0	15.1	84.9	0
1043434	Mangakara at Hirsts	0	0	100	0	0
1043427	Mangakino at Dillon Road	0	0	36.3	63.7	0
40703	Mangakowhai at Kaingapipi	0	0	0	100	0
1643462	Mangaokewa at Te Kuiti	0	0	22.8	77.2	0
1543497	Mangaonua at Dreadnought	0	99.8	0.2	0	0
1043444	Mangapu at SH3 Br	0	0	36.3	63.4	0.3
1943459	Mangatutu at Walker Rd Br	0	7	52.1	40.9	0

Site ID	Site name	Dry	Medium Dry	Medium	Medium wet	Wet
41301	Marokopa at Falls	0	0	0	17.7	82.3
3043490	Matahuru at Myjers	0	44.9	55.1	0	0
43489	Matahuru at Waiterimu Rd	0	56.9	43.1	0	0
40708	Mokau at Totoro Bridge	0	0	30.1	56.9	12.9
9213	Ohinemuri at Karangahake	0	0	0	80.8	19.2
11310	Opitonui River at d/s Awaroa	0	0	0	100	0
1009213	Oraka at Pinedale	0	0	44.9	55.1	0
41601	Oteke at Kinohaku	0	0	14.5	85.5	0
9140	Piako at Paeroa Tahuna Rd	0	88.6	11.4	0	0
9175	Piako at Kiwitahi	0	58.1	41.9	0	0
1043419	Pokaiwhenua at Puketurua	0	0	86.4	13.6	0
43431	Puniu at Pokuru Br	0	15.1	63.3	21.6	0
1143409	Purukohokohu at Puruki Flume	0	0	100	0	0
1009246	Rapurapu at Kinlochs Farm	0	0	0	100	0
1043428	Tahunaatara at Ohakuri Road	0	0	67.1	32.9	0
12301	Tairua at Broken Hills	0	0	0	24.3	75.7
9701	Tapu at Tapu-Coroglen	0	0	28.4	71.6	0
1543413	Tauranga-Taupo at Te Kono	0	0	20.3	79.7	0
1143427	Te Tahi at Puketotara	0	0	0	67.3	32.7
1043460	Tongariro at Puketarata	0	0	0	14.3	85.7
1043459	Tongariro at Turangi	0	0	0	36.5	63.5
1043461	Tongariro at Upper Dam	0	0	0	2.3	97.7
1543424	Waihaha at SH32	0	0	83.8	16.2	0
1043466	Waihohonu at Desert Rd	0	0	0	0	100
9224	Waihou at Okauia	0	1.4	57.8	40.8	0
9205	Waihou at Te Aroha Br	0	1.1	53.5	45.4	0
9209	Waihou at Tirohia	0	2.9	53.6	43.4	0
42601	Waingaro at Ruakiwi Road	0	0	66.6	33.4	0
9228	Waiorongomai at Old Quarry	0	0	0	100	0
2043493	Waiotapu at Campbell Rd	0	0.1	99.9	0	0
43472	Waiotapu at Reporoa	0	19.1	80.9	0	0
43435	Waipa at Ngaroma Rd	0	0	0	100	0
43481	Waipa at Otewa	0	0	4	96	0
43433	Waipa at Whatawhata	0	11.6	43.4	41.8	3.3
2043441	Waipapa at Mulberry Rd	0	2.5	97.5	0	0
9179	Waitoa at Mellon Rd	0	65.2	34.8	0	0
9114	Waitoa at SH26	0	76.9	23.1	0	0
9112	Waitoa at Waharoa Control	0	79.1	20.9	0	0

Site ID	Site name	Dry	Medium Dry	Medium	Medium wet	Wet
1943481	Waitomo at Aranui Caves	0	0	0	75.6	24.4
1643457	Whakapipi at SH22-Tuakau	0	0	100	0	0
1143402	Whangamarino at Slackline	0	73.2	26.8	0	0
12509	Wharekawa at Adams Farm	0	0	0	77	23
Bay of Plenty						
14604	Awahou at Tauranga Rd Bridge	0	0	0	71.4	28.6
14614	Kaituna at Te Matai	0	0	18.6	66.4	15
13901	Mangawhai at Mokoroa	0	0	0	100	0
14628	Mangorewa at Saunders Farm	0	0	0	33	67
16501	Motu at Houpoto	0	0	2.1	71.1	26.7
1014641	Ngongotaha at SH5 Bridge	0	0	0	100	0
16006	Otara at Gault Road Br(No.2)	0	0	2.6	85.7	11.7
14625	Puarenga at FRI Bridge	0	0	83.1	16.9	0
15432	Rangitaiki at Kopuriki	0	9.1	87.2	3.7	0
15408	Rangitaiki at Murupara	0	10.6	88.5	0.9	0
17101	Raukokore at SH35 Bridge	0	0	13.5	30.9	55.6
16511	Takaputahi at Ngawhakatatara	0	0	0	100	0
17301	Tauranga at Maruhinemaka	0	0	100	0	0
1014647	Utuhina at Hunts Farm	0	0	0	100	0
14610	Utuhina at SH5 Bridge	0	0	3.8	96.2	0
16205	Waiaua at Edwards	0	0	9.5	90.5	0
15453	Waihua at Gorge	0	0	7.5	92.5	0
15536	Waimana at Ogilvies Bridge	0	0	0	71.3	28.7
14606	Waingaehe at SH3none Bridge	0	0	100	0	0
15901	Waioeka at Gorge Cableway	0	0	0	70	30
14607	Waiohewa at SH3none Bridge	0	0	8.7	91.3	0
15802	Waiotahi at McNabs Road Bridge	0	0	5.4	94.6	0
1014644	Waiowhiro at Bonningtons Farm	0	0	0	100	0
1014648	Waipa at Whaka Forest	0	0	100	0	0
15534	Wairere at Wainui Road	0	0	100	0	0
14603	Waiteti at Tauranga Rd Bridge	0	0	0	91.7	8.3
15514	Whakatane at Whakatane	0	0	4.7	87.7	7.6
15410	Whirinaki at Galatea	0	6.4	91.8	1.7	0
Taranaki						
39508	Manganui at SH3	0	0	0	0	100
36001	Punehu at Pihama	0	4.4	27.9	16.3	51.4
39501	Waitara at Tarata	0	0	0	67.8	32.2
34202	Whenuakra at Nicholson Road	0	5.1	38.7	56.2	0

Site ID	Site name	Dry	Medium Dry	Medium	Medium wet	Wet
Gisborne						
21437	Hangaroa at Doneraille Park	0	13.8	52.2	28.6	5.3
18902	Hikuwai at Willow Flat	0	0	29.9	70.1	0
18913	Mangaheia at Willowbank	0	0	100	0	0
19712	Mangatu at Omapere	0	19.6	77.3	3.1	0
18304	Mata at Pouturu	0	0	45.3	54.7	0
16502	Motu at Waitangirua	0	0	0	99.9	0.1
19766	Te Arai at Pykes Weir	0	0	43.6	56.4	0
18309	Waiapu at Rotokautuku	0	0	12	60.2	27.8
19706	Waihora at No 3 Br	0	7.2	51.6	41.2	0
19708	Waikohu at Mahaki	0	23.1	46.7	30.2	0
19602	Waimata at Goodwin's Rd	0	8.4	66.5	25.1	0
19609	Waimata at Monowai	0	0	49.1	50.9	0
19711	Waingaromia at Terrace Station	0	0	83.6	16.4	0
19701	Waipaoa at Kanakanaia Br	0	40	49.2	10.8	0
19704	Waipaoa at Matawhero	0	47.7	43.4	8.8	0
19702	Waipaoa at Waipaoa Stn	0	0	90.9	9.1	0
17601	Wharekahika at Hicks Bay Rd Br	0	0	0.1	84	15.9
19741	Wharekopae at Rangimoe Stn	0	30.8	54.5	14.7	0
Hawke's Bay						
22802	Esk at Waipunga Bridge	0.1	20.5	58.9	20.5	0
21803	Mohaka at Glenfalls	0	10.1	24.2	65.7	0
21801	Mohaka at Raupunga	0	5.5	63.4	31.1	0
23150	Ngaruroro at Chesterhope Bridge	20.6	22	23.2	34.2	0
23102	Ngaruroro at Fernhill	18	22.7	23.9	35.4	0
23104	Ngaruroro at Papango	0	0	0.2	99.8	0
23103	Ngaruroro at Whanawhana	0	15.9	30.3	53.8	0
23210	Omakere at Fordale	0	100	0	0	0
23209	Otane at Glendon	100	0	0	0	0
21601	Tahekenui at Glenstrae	0	0	100	0	0
23106	Taruarau at Taihape Road	0	28.4	23.8	47.8	0
23201	Tukituki at Red Bridge	39.6	36.6	9	13.3	1.5
23203	Tukituki at Waipukurau	36.6	33.4	9.3	19	1.6
21409	Waiau at Otoi	0	0	17.4	82.6	0
21410	Waihi at Waihi	0	0	0	100	0
21401	Wairoa at Marumaru	0	4.6	35.9	44.7	14.8
Manawatu / Whanganui						
32726	Hautapu at Taihape	6	94	0	0	0

Site ID	Site name	Dry	Medium Dry	Medium	Medium wet	Wet
33502	Kaiiwi at Handley Road	0	68.9	31.1	0	0
32754	Makohine at Viaduct	0	100	0	0	0
1032591	Makuri at Tuscan Hills	0	0	21.4	78.6	0
32504	Manawatu at Hopelands	0.1	55.3	27.3	17.4	0
1032560	Manawatu at Teachers College	0.4	34.4	39	20.6	5.6
1232566	Manawatu at Upper Gorge	0	32.9	41.7	18.6	6.8
32526	Mangahao at Ballance	0	0.1	34.7	18.9	46.3
5023	Mangahao at Machine	0	0	0	8.6	91.4
1132511	Mangatainoka at Pahiatua Town Bridge	0	13.7	22.5	42	21.8
33111	Mangawhero at Ore Ore	0	11.9	67.4	15	5.7
32106	Ohau at Rongomatane	0	0	18.8	34.4	46.8
33314	Ohura at Nihoniho	0	0	48.6	51.4	0
33316	Ongarue at Taringamutu	0	0	58.2	41.8	0
32514	Oroua at Almadale Slackline	9.3	40.5	18.2	25.6	6.3
32563	Oroua at Kawa Wool	17.4	55.9	9.8	13.6	3.3
25101	Owahanga at Branscombe Bridge	0	36.3	49.4	14.3	0
32576	Pohangina at Mais Reach	0	24.1	31.7	43.6	0.6
32702	Rangitikei at Mangaweka	10.5	41.1	13	20.4	15.1
32763	Rangitikei at Pukeokahu	0.2	36.5	14.4	22.8	26.1
32529	Tiraumea at Ngaturi	0	20.7	61.9	17.4	0
33004	Turakina at Otairi	0	100	0	0	0
33320	Whakapapa at Footbridge	0	0	0	0	100
33101	Whangaehu at Kauangaroa	0	56.9	23	9.7	10.4
33303	Whanganui at Te Rewa	0	2	29.5	61.2	7.3
33301	Whanganui at Paetawa	0	2.1	29.5	61.1	7.3
33347	Whanganui at Te Porere	0	0	0	0	100
Wellington						
30912	Horokiri at Snodgrass	0	11.9	88.1	0	0
29808	Hutt at Kaitoke	0	0	0	5.3	94.7
30516	Mill Creek at Papanui	0	100	0	0	0
31807	Otaki at Pukehinau	0	0	0.9	10.6	88.6
31803	Otaki at Tuapaka	0	0	1.7	10.5	87.9
27303	Pahao at Hinakura	0	65.2	32.8	2	0
30802	Pauatahanui at Gorge	0	72.9	27.1	0	0
30701	Porirua at Town Centre	0	87.2	12.8	0	0
29250	Ruakokopatuna at Iraia	0	0	0	100	0
29202	Ruamahanga at Waihenga	18.2	41	13.4	11.9	15.5
29231	Taueru at Te Weraiti	3	93.8	3.1	0	0

Site ID	Site name	Dry	Medium Dry	Medium	Medium wet	Wet
29244	Whangaehu at Waihi	0	37.1	62.9	0	0
25902	Whareama at Waiteko Bridge	0	84.2	15.8	0	0
Tasman						
52003	Aorere at Devils Boot	0	0	0	0	100
56905	Apahai at Hickmotts	0	0	100	0	0
93202	Buller at Longford	0	0	3.1	70.7	26.2
52916	Cobb at Trilobite	0	0	0	0	100
56906	Kaiteriteri at Water Supply	0	0	100	0	0
57536	Lee at Cableway	0	0	8.1	34.2	57.8
93212	Mangles at Gorge	0	0	0	86.5	13.5
93209	Maruia at Falls	0	0	0	54.4	45.6
93211	Matakitaki at Mud Lake	0	0	0	30.5	69.5
57008	Motueka at Gorge	0	0	0.1	23.4	76.5
57015	Motueka at Woodmans Bend	0	18.4	21.8	36.4	23.4
57009	Motueka at Woodstock	0	17.9	20.8	34.8	26.5
57036	Motupiko at Christies	0	0	7.7	69.7	22.6
57101	Moutere at Old House Road	0	100	0	0	0
56901	Riwaka at Moss Bush	0	0	0	92.9	7.1
57014	Stanleybrook at Barkers	0	99.9	0.1	0	0
52902	Takaka at Harwoods	0	0	0	63.3	36.7
57502	Wairoa at Gorge	0	9.8	29.6	28.9	31.7
57025	Wangapeka at Walter Peak	0	0.2	19.4	37.7	42.6
Marlborough						
62103	Acheron at Clarence	1.2	13.8	50.7	23.8	10.5
58902	Pelorus at Bryants	0	0	5.1	41.9	53
60114	Wairau at Dip Flat	0	0	10.2	89.8	0
West Coast						
91407	Ahaura at Gorge	0	0	0	0.6	99.4
89701	Amethyst at Road Bridge	0	0	0	0	100
93203	Buller at Te Kuha	0	0	0.7	45.5	53.8
93208	Buller at Woolfs	0	0	1	53.6	45.4
90605	Butchers Creek at Lk Kaniere Road	0	0	0	0	100
90607	Cropp at Gorge	0	0	0	0	100
91401	Grey at Dobson	0	0	0	22.4	77.6
91404	Grey at Waipuna	0	0	0	25.2	74.8
86802	Haast at Roaring Billy	0	0	0	0	100
90604	Hokitika at Colliers Creek	0	0	0	0	100
93207	Inangahua at Blacks Point	0	0	0	41.7	58.3

Site ID	Site name	Dry	Medium Dry	Medium	Medium wet	Wet
93206	Inangahua at Landing	0	0	0	37.3	62.7
90102	Ivory at Ripplerock	0	0	0	0	100
95102	Karamea at Gorge	0	0	0	0	100
94302	Mokihinui at Burkes Creek	0	0	0	0	100
94303	Mokihinui at Welcome Bay	0	0	0	0	100
91103	Taipo at SHB	0	0	0	0	100
91104	Taramakau at Greenstone Bridge	0	0	0	0	100
89301	Whataroa at SHB	0	0	0	0	100
Canterbury						
71116	Ahuriri at South Diadem	9.9	23.1	26	12.2	28.8
62105	Clarence at Jollies	0	0	61.7	37.8	0.5
71129	Forks at Balmoral	18.9	9	22.1	50	0
71103	Hakataramea at Above Highway Br	100	0	0	0	0
66612	Heathcote at Buxton Terrace	100	0	0	0	0
71125	Hooker at Ball Hut Road Br	0	0	0	0	100
67602	Hukahuka at Lathams Br	0	100	0	0	0
65104	Hurunui at Mandamus	0.1	23.1	30.2	21.9	24.7
71128	Irishman at Windy Ridge	61.1	23	15.9	0	0
71135	Jollie at Mt Cook Station	0	0	6.8	55.8	37.5
71131	Lake Tekapo at Spillway	24.1	9.5	17.8	23.5	25
71106	Maerewhenua at Kellys Gully	57.8	40.3	1.9	0	0
71127	Maryburn at Maryhill	78.2	17.9	3.9	0	0
71122	Maryburn at Mt McDonald	59.7	33	7.3	0	0
68810	North Ashburton at Old Weir	0	1.4	97.5	1.1	0
68502	Rakaia at Gorge	7.6	16.5	14.6	19.4	41.9
69302	Rangitata at Klondyke	2.7	22.5	17	19.7	38.1
63501	Rosy Morn at Weir	100	0	0	0	0
68001	Selwyn at Whitecliffs	0	100	0	0	0
68806	South Ashburton at Mt Somers	0	37.1	38.7	15	9.3
64610	Stanton at Cheddar Valley	26.7	73.3	0	0	0
71121	Twizel at State Highway Br	77.6	21	1.4	0	0
64602	Waiau at Marble Point	0	17.9	21.8	39.2	21.1
66401	Waimakariri at Old HW Bridge	22.9	17.6	24.1	9.9	25.4
Otago						
75272	Arrow at Beetham Creek	96.5	3.5	0	0	0
75290	Cardrona at Albert Town	100	0	0	0	0
75259	Fraser at Old Man Range	52.1	24.7	21.8	1.3	0
75218	Lindis at Crossing Bridge	92.4	7.6	0.1	0	0

Site ID	Site name	Dry	Medium Dry	Medium	Medium wet	Wet
75219	Lindis at Lindis Peak	85.8	14	0.1	0	0
75253	Manuherikia at Ophir	93.4	6.2	0.5	0	0
75294	Matukituki at West Wanaka	25.6	11.4	7.8	15.6	39.5
75265	Nevis at Wentworth Station	34.5	35.3	25.5	4.8	0
74701	Noble at Bull Creek Road	100	0	0	0	0
75232	Pomahaka at Burkes Ford	59.1	34.9	6.1	0	0
75278	Shotover at 16 Mile Gorge	0	0	0	66.7	33.3
75276	Shotover at Bowens Peak	7.3	11.7	28	47.3	5.7
75279	Shotover at Strohles	0	1.2	17.7	70.2	10.8
74338	Sutton Stream at SH 87	100	0	0	0	0
Southland						
78901	Aparima at Thornbury	4	92.7	3.3	0	0
84701	Cleddau at Milford	0	0	0	0	100
183001	Long Sound (Preservation Inlet)	0	0	0	0	100
78634	Makarewa at Counsell Rd	0	90.5	9.5	0	0
77504	Mataura at Gore	27.2	47.6	22.9	2.3	0
183003	Nancy Sound	0	0	0	0	100
78636	Oreti at Lumsden Cableway	0	74.6	15.7	9.7	0
78601	Oreti at Wallacetown	1.1	85.6	8.2	5.1	0
78625	Otapiriri at McBrides Bridge	0	70	30	0	0
80201	Rowallanburn at Old Mill	0	100	0	0	0
79740	Spey at West Arm	0	0	0	0	100
183002	Thompson-Bradshaw Sd (Doubtful Sd)	0	0	0	0	100
78503	Waihopai at Kennington	0	100	0	0	0

Table E-3: Percentage of calibration site catchment area in each land cover group. 1. Herbaceous; 2. Trees; 3. Tussock and alpine herbaceous; 4. Other erodible; 5. Water; 6. Urban.

Site ID	Site name	1	2	3	4	5	6
Northland							
1316	Awanui at School Cut	54.9	44.9	0	0	0	0.2
46645	Kokopu at McBeths	99.1	0.9	0	0	0	0
46626	Mangakahia at Titoki at Titoki	35.7	64.2	0	0.1	0	0
3506	Maungaparerua at Tyrees Ford	85.2	14.2	0	0.6	0	0
46644	Wairua at Purua	65.2	34	0	0.3	0.1	0.4
3722	Waitangi at Wakelins	69	29.7	0	0.7	0.2	0.5
Auckland							
45703	Hoteo at Gubbs	55.6	43.9	0	0.1	0.1	0.4
45705	Hoteo at Waiteitei	85.5	14.2	0	0.2	0	0.1
45311	Kaipara at Waimauku	62.2	36	0	0	0	1.8
45415	Kaukapakapa at Taylors	79.9	19.8	0	0.1	0.2	0.1
6806	Mahurangi at College	50.3	46.4	0	0.1	0	3.1
8304	Mangemangeroa at Craigs	57	40.9	0	0	0	2
7502	Okura at Awanohi	36.2	63.1	0	0	0	0.7
7304	Okura at Weiti Forest	15.6	84.4	0	0	0	0
8604	Orere at Bridge	41.1	58.8	0	0	0	0.1
7202	Orewa at Kowhai Ave	83.4	16.6	0	0	0	0
7506	Vaughan at Lower Weir	59.3	32.3	0	0	0	8.5
8516	Wairoa at Wairoa at Tourist Road	48.7	49.8	0	1.3	0.1	0.1
43602	Waitangi at SH Br	94.8	5.1	0	0	0	0.1
45702	Waiwhiu at Dome Shadow	0	99.6	0	0	0	0.4
7206	West Hoe at Hall Farm	6.9	93.1	0	0	0	0
Waikato							
40810	Awakino at Gorge	43	56.8	0	0.2	0	0
1143450	Awaroa at Sansom's Br Rotowaro	60.7	23.7	0	0.2	15.4	0
2743464	Hinemaiaia at Maungatera	0.1	99.1	0	0	0	0.8
1643461	Kaniwhaniwha at Limeworks Rd	19.9	80.1	0	0	0	0
1043468	Kuratau at State Highway 41	41.9	57.5	0.4	0	0	0.1
1043434	Mangakara at Hirsts	65.9	33.8	0	0	0	0.3
1043427	Mangakino at Dillon Road	35.2	64.8	0	0	0	0
40703	Mangakowhai at Kaingapipi	86.7	13.3	0	0	0	0
1643462	Mangaokewa at Te Kuiti	72.2	27	0	0	0.2	0.6
1543497	Mangaonua at Dreadnought	87.6	7.9	0	0	0.1	4.4
1043444	Mangapu at SH3 Br	81.1	17.5	0	0.1	0.3	1
1943459	Mangatutu at Walker Rd Br	54.3	45.5	0	0	0	0.1
41301	Marokopa at Falls	30.3	69.7	0	0	0	0

Site ID	Site name	1	2	3	4	5	6
3043490	Matahuru at Myjers	87.8	12.2	0	0	0	0
43489	Matahuru at Waiterimu Rd	89.4	10.6	0	0	0	0
40708	Mokau at Totoro Bridge	75.9	23.9	0	0.1	0	0.1
9213	Ohinemuri at Karangahake	46.1	50.3	0	0.4	1.3	1.8
11310	Opitonui River at d/s Awaroa	3.1	96.9	0	0	0	0
1009213	Oraka at Pinedale	29.4	70.5	0	0	0	0.1
41601	Oteke at Kinohaku	92.3	7.7	0	0	0	0
9140	Piako at Paeroa Tahuna Rd	92.2	6.2	0	0.1	0.1	1.5
9175	Piako at Kiwitahi	84.2	15.3	0	0	0.1	0.4
1043419	Pokaiwhenua at Puketurua	51.5	46.2	0	0	0	2.3
43431	Puniu at Pokuru Br	77.9	21.3	0	0.2	0	0.6
1143409	Purukohokohu at Puruki Flume	12.1	87.9	0	0	0	0
1009246	Rapurapu at Kinlochs Farm	17	83	0	0	0	0
1043428	Tahunaatara at Ohakuri Road	50.5	49.4	0	0	0	0
12301	Tairua at Broken Hills	10.6	89.2	0	0.1	0	0
9701	Tapu at Tapu-Coroglen	3.7	95.8	0	0	0.1	0.4
1543413	Tauranga-Taupo at Te Kono	0.3	97.9	1.4	0	0.2	0.2
1143427	Te Tahi at Puketotara	81.7	18.3	0	0	0	0
1043460	Tongariro at Puketarata	3.3	66.2	16.5	0.5	13.5	0.1
1043459	Tongariro at Turangi	4.6	70.6	12.5	2.6	9.5	0.2
1043461	Tongariro at Upper Dam	1.4	79.4	11.4	0.4	7.4	0
1543424	Waihaha at SH32	4.9	95.1	0	0	0	0
1043466	Waihohonu at Desert Rd	2.8	25.6	38.8	0.6	32.2	0
9224	Waihou at Okauia	56.1	43	0	0	0	0.8
9205	Waihou at Te Aroha Br	58.7	40.4	0	0.1	0	0.8
9209	Waihou at Tirohia	60.3	38.6	0	0.2	0.1	0.9
42601	Waingaro at Ruakiwi Road	52.9	46.8	0	0	0	0.2
9228	Waiorongomai at Old Quarry	5.9	94.1	0	0	0	0
2043493	Waiotapu at Campbell Rd	42.3	56.9	0	0.6	0	0.1
43472	Waiotapu at Reporoa	40.4	59	0	0.3	0	0.3
43435	Waipa at Ngaroma Rd	19.8	80.2	0	0	0	0
43481	Waipa at Otewa	41.8	57.8	0	0	0.3	0.1
43433	Waipa at Whatawhata	74.7	24.1	0	0.2	0.1	0.8
2043441	Waipapa at Mulberry Rd	69	30.7	0	0	0	0.3
9179	Waitoa at Mellon Rd	94	4	0	0	0.2	1.8
9114	Waitoa at SH26	93.1	6.2	0	0.1	0.3	0.4
9112	Waitoa at Waharoa Control	96.1	3.3	0	0	0.6	0
1943481	Waitomo at Aranui Caves	48.4	51.4	0	0.1	0	0
1643457	Whakapipi at SH22-Tuakau	78.2	8.3	0	0	0.8	12.7

Site ID	Site name	1	2	3	4	5	6
1143402	Whangamarino at Slackline	74	25.9	0	0	0	0
12509	Wharekawa at Adams Farm	1.1	98.9	0	0	0	0
Bay of Plenty							
14604	Awahou at Tauranga Rd Bridge	79.8	19.9	0	0	0	0.3
14614	Kaituna at Te Matai	35.3	48.4	0	12	0.1	4.2
13901	Mangawhai at Mokoroa	75.6	23.8	0	0	0	0.6
14628	Mangorewa at Saunders Farm	37.6	62.2	0	0.2	0	0
16501	Motu at Houpoto	17.3	82.2	0	0.3	0.2	0
1014641	Ngongotaha at SH5 Bridge	46	53.4	0	0	0	0.6
16006	Otara at Gault Road Br(No.2)	7.4	92.1	0	0	0.4	0
14625	Puarenga at FRI Bridge	31.4	65.6	0	0.1	0.4	2.5
15432	Rangitaiki at Kopuriki	17.3	82.2	0	0.2	0	0.3
15408	Rangitaiki at Murupara	21.9	77.8	0	0.1	0	0.2
17101	Raukokore at SH35 Bridge	10.1	86.4	0	0.4	3.1	0
16511	Takaputahi at Ngawhakatatara	16.4	83.5	0	0	0	0
17301	Tauranga at Maruhinemaka	16.5	83.5	0	0	0	0
1014647	Utuhina at Hunts Farm	1.4	97.8	0	0	0	0.8
14610	Utuhina at SH5 Bridge	27.8	53.2	0	0	0	19
16205	Waiaua at Edwards	12.3	87.3	0	0	0.5	0
15453	Waihua at Gorge	2.8	97.2	0	0	0	0
15536	Waimana at Ogilvies Bridge	1.1	98.5	0	0	0.4	0
14606	Waingaehe at SH3none Bridge	66.9	32.5	0	0	0	0.6
15901	Waioeka at Gorge Cableway	13.8	86	0	0.1	0.1	0
14607	Waiohewa at SH3none Bridge	57	37.8	0	4.2	0.6	0.4
15802	Waiotahi at McNabs Road Bridge	4.4	95.3	0	0.4	0	0
1014644	Waiowhiro at Bonningtons Farm	26.8	27.1	0	0	0	46.1
1014648	Waipa at Whaka Forest	0	100	0	0	0	0
15534	Wairere at Wainui Road	67.2	26.2	0	0	1.3	5.2
14603	Waiteti at Tauranga Rd Bridge	60.6	25.2	0	11.6	0	2.6
15514	Whakatane at Whakatane	9.4	90	0	0.3	0.3	0
15410	Whirinaki at Galatea	3.2	96.7	0	0	0	0.1
Taranaki							
39508	Manganui at SH3	23.2	60.5	4.6	0	11.7	0
36001	Punehu at Pihama	57.9	37.4	1.6	0	3.1	0.1
39501	Waitara at Tarata	43.5	56	0	0.4	0.1	0
34202	Whenuakra at Nicholson Road	25.6	73.9	0.2	0.2	0	0.1
Gisborne							
21437	Hangaroa at Doneraille Park	68.1	31.5	0	0.4	0	0
18902	Hikuwai at Willow Flat	30.6	67.7	0	0.5	1.2	0

Site ID	Site name	1	2	3	4	5	6
18913	Mangaheia at Willowbank	6.5	93.5	0	0	0	0
19712	Mangatu at Omapere	47.7	49.9	0	0.3	2.1	0
18304	Mata at Pouturu	50	48.2	0	0.7	1	0.1
16502	Motu at Waitangirua	62.5	37.4	0	0	0.1	0.1
19766	Te Arai at Pykes Weir	34.8	65.2	0	0	0	0
18309	Waiapu at Rotokautuku	32.4	63.7	0.2	0.5	3.2	0.1
19706	Waihora at No 3 Br	47.2	52.8	0	0	0	0
19708	Waikohu at Mahaki	76.5	23.5	0	0	0	0
19602	Waimata at Goodwin's Rd	58.8	41.2	0	0	0	0
19609	Waimata at Monowai	65.4	34.6	0	0	0	0
19711	Waingaromia at Terrace Station	22.5	76.6	0	0	0.9	0
19701	Waipaoa at Kanakanaia Br	59	39.8	0	0.2	0.9	0
19704	Waipaoa at Matawhero	60.8	38	0	0.4	0.8	0.1
19702	Waipaoa at Waipaoa Stn	10.1	86.5	0	0	3.3	0.1
17601	Wharekahika at Hicks Bay Rd Br	25.1	73.7	0	0.3	0.9	0
19741	Wharekopae at Rangimoe Stn	83.9	16.1	0	0	0	0
Hawke's Bay							
22802	Esk at Waipunga Bridge	53.2	46.7	0	0.1	0	0.1
21803	Mohaka at Glenfalls	14.8	83.8	0.7	0.2	0.3	0
21801	Mohaka at Raupunga	13.3	85.8	0.3	0.3	0.2	0
23150	Ngaruroro at Chesterhope Bridge	37.3	49.6	11.2	0.5	1.5	0
23102	Ngaruroro at Fernhill	36.4	50.2	11.6	0.4	1.5	0
23104	Ngaruroro at Papango	1	78.7	19.2	0	1.1	0
23103	Ngaruroro at Whanawhana	11.1	67.5	19.6	0.1	1.7	0
23210	Omakere at Fordale	95.8	3.2	0	1	0	0
23209	Otane at Glendon	93.4	6.6	0	0	0	0
21601	Tahekenui at Glenstrae	42.3	57.7	0	0	0	0
23106	Taruarau at Taihape Road	15.8	41	42.9	0	0.3	0
23201	Tukituki at Red Bridge	79.6	18	0.5	0.5	1	0.3
23203	Tukituki at Waipukurau	80.3	17.3	1	0.2	0.9	0.3
21409	Waiau at Otoi	9.8	89.8	0	0.3	0.1	0
21410	Waihi at Waihi	30.3	69.6	0	0.1	0	0
21401	Wairoa at Marumaru	52.8	46.4	0	0.6	0.2	0
Manawatu / Whanganui							
32726	Hautapu at Taihape	62.8	17.9	18.4	0.1	0	0.9
33502	Kai iwi at Handley Road	50.2	49.7	0	0	0	0.1
32754	Makohine at Viaduct	79.2	20.7	0	0	0	0
1032591	Makuri at Tuscan Hills	79.3	20.6	0	0	0	0
32504	Manawatu at Hopelands	85.9	13.2	0	0.3	0.1	0.5

Site ID	Site name	1	2	3	4	5	6
1032560	Manawatu at Teachers College	74.9	23.6	0.2	0.4	0.3	0.6
1232566	Manawatu at Upper Gorge	78.9	20.1	0.1	0.3	0.2	0.3
32526	Mangahao at Ballance	32.2	64.9	1.4	0.6	0.9	0
5023	Mangahao at Machine	1.4	93.3	3.8	0.4	1.2	0
1132511	Mangatainoka at Pahiatua Town Bridge	76.3	22.3	0.1	0.4	0.5	0.4
33111	Mangawhero at Ore Ore	66.8	30	1.9	0.3	0.3	0.7
32106	Ohau at Rongomatane	12.3	87.1	0	0.2	0.5	0
33314	Ohura at Nihoniho	65.9	34.1	0	0	0	0
33316	Ongarue at Taringamutu	40.9	58.9	0	0.1	0	0.1
32514	Oroua at Almadale Slackline	60.8	33.9	4.2	0.6	0.5	0.1
32563	Oroua at Kawa Wool	75.8	20.6	2.2	0.4	0.3	0.6
25101	Owahanga at Branscombe Bridge	79.9	19.8	0	0.1	0	0.1
32576	Pohangina at Mais Reach	49.4	48.9	0.9	0.4	0.3	0
32702	Rangitikei at Mangaweka	43.3	39.1	16.1	0.5	0.8	0.2
32763	Rangitikei at Pukeokahu	32	46.9	20.1	0.4	0.6	0
32529	Tiraumea at Ngaturi	82.8	17.2	0	0	0	0
33004	Turakina at Oteri	84.8	15	0	0.1	0	0
33320	Whakapapa at Footbridge	13.7	43.5	31.6	0	11	0.1
33101	Whangaehu at Kauangaroa	61.8	31.5	2.5	0.6	3.2	0.4
33303	Whanganui at Te Rewa	34.1	63.3	1.5	0.3	0.6	0.2
33301	Whanganui at Paetawa	34.1	63.3	1.5	0.3	0.6	0.2
33347	Whanganui at Te Porere	0.4	72.4	24.6	0	2.6	0
Wellington							
30912	Horokiri at Snodgrass	43.9	56.1	0	0	0	0
29808	Hutt at Kaitoke	0	98	2	0	0	0
30516	Mill Creek at Papanui	84.2	15.7	0	0.1	0	0
31807	Otaki at Pukehinau	2.3	95.3	1.8	0	0.5	0
31803	Otaki at Tuapaka	2.8	94.8	1.8	0.1	0.5	0
27303	Pahao at Hinakura	57.7	42	0	0.1	0.2	0
30802	Pauatahanui at Gorge	59.5	39	0	0	0.2	1.3
30701	Porirua at Town Centre	33.3	33.8	0	0	0.7	32.1
29250	Ruakokopatuna at Iraia	23.9	76.1	0	0	0	0
29202	Ruamahanga at Waihenga	66.6	30.4	1.2	0.3	0.6	0.8
29231	Taueru at Te Weraiti	71.4	28.6	0	0	0	0
29244	Whangaehu at Waihi	80.4	19.6	0	0	0	0
25902	Whareama at Waiteko Bridge	66.7	33.2	0	0	0	0
Tasman							
52003	Aorere at Devils Boot (52nonenone3, error in REC, do not use)	7	83.3	7.4	0.7	1.6	0

Site ID	Site name	1	2	3	4	5	6
56905	Apahai at Hickmotts	16	84	0	0	0	0
93202	Buller at Longford	8.6	69.7	11	2.7	8	0.1
52916	Cobb at Trilobite	1.3	61.4	34	0.4	2.9	0
56906	Kaiteriteri at Water Supply	9.2	90.8	0	0	0	0
57536	Lee at Cableway	0	94.1	5	0	0.9	0
93212	Mangles at Gorge	13.4	86.4	0.1	0.1	0	0
93209	Maruia at Falls	9.8	80.1	8.2	0.5	1.4	0
93211	Matakitaki at Mud Lake	5.5	69.9	14.6	0.5	9.5	0
57008	Motueka at Gorge	0	63	31.5	0	5.4	0
57015	Motueka at Woodmans Bend	16.3	76.7	5.7	0.1	1.1	0.1
57009	Motueka at Woodstock	15.2	77.2	6.2	0.1	1.2	0.1
57036	Motupiko at Christies	28.4	70.1	1.2	0	0.3	0
57101	Moutere at Old House Road	49.1	49.7	0	0.4	0	0.9
56901	Riwaka at Moss Bush	5.7	93.3	1	0	0	0
57014	Stanleybrook at Barkers	19.9	80	0	0	0	0.1
52902	Takaka at Harwoods	1.1	82.7	13.7	1.4	1	0.1
57502	Wairoa at Gorge	5.1	89.1	4.8	0	0.9	0
57025	Wangapeka at Walter Peak	9.4	83.4	6.2	0.1	0.9	0
Marlborough							
62103	Acheron at Clarence	36.1	5.8	44.5	0.1	13.6	0
58902	Pelorus at Bryants	1.5	96.9	0.7	0.1	0.8	0
60114	Wairau at Dip Flat	7.9	33.7	38.5	0.1	19.8	0
West Coast							
91407	Ahaura at Gorge	6.3	72.2	17.5	1.2	2.9	0
89701	Amethyst at Road Bridge	0.2	78.6	20.3	0.2	0.6	0
93203	Buller at Te Kuha	7.4	79.9	7.9	1	3.8	0.1
93208	Buller at Woolfs	8.2	77	8.6	1.2	4.9	0
90605	Butchers Creek at Lk Kaniere Road	0	100	0	0	0	0
90607	Cropp at Gorge	0	36.8	31.5	0	31.7	0
91401	Grey at Dobson	13.1	75.7	7.4	2.1	1.7	0.1
91404	Grey at Waipuna	1.8	82	14.1	0.9	1.3	0
86802	Haast at Roaring Billy	1.8	50	26.9	0.8	20.5	0
90604	Hokitika at Colliers Creek	0	53.4	28.5	0.4	17.7	0
93207	Inangahua at Blacks Point	2	86.2	10.5	0.3	1	0
93206	Inangahua at Landing	6.6	83.7	8	0.4	1.1	0.2
90102	Ivory at Ripplerock	0	0	8.3	12.2	79.6	0
95102	Karamea at Gorge	0.5	87.5	10.5	0.4	1.2	0
94302	Mokihinui at Burkes Creek	0.7	92.1	5.2	0.4	1.6	0
94303	Mokihinui at Welcome Bay	0.7	92.1	5.2	0.4	1.6	0

Site ID	Site name	1	2	3	4	5	6
91103	Taipo at SHB	1	57.6	26.4	0.6	14.4	0
91104	Taramakau at Greenstone Bridge	4.4	64.1	20.3	0.8	10.4	0.1
89301	Whataroa at SHB	0.4	40.1	21.7	0.7	37.1	0
Canterbury							
71116	Ahuriri at South Diadem	22.9	10.2	46.7	0.4	19.7	0
62105	Clarence at Jollies	15.8	19.3	53.5	0.6	10.8	0
71129	Forks at Balmoral	25.2	1.3	30.9	0.2	42.4	0
71103	Hakataramea at Above Highway Br	71.3	8.5	19.5	0.3	0.5	0
66612	Heathcote at Buxton Terrace	41.8	15.7	0	0.1	1.2	41.3
71125	Hooker at Ball Hut Road Br	2.5	8	9.4	1.9	78.2	0
67602	Hukahuka at Lathams Br	70.9	29.1	0	0	0	0
65104	Hurunui at Mandamus	14.4	54.6	23.5	2	5.4	0
71128	Irishman at Windy Ridge	52.3	1.6	44.6	0.2	1.2	0
71135	Jollie at Mt Cook Station	1.6	6.9	43.1	0	48.4	0
71131	Lake Tekapo at Spillway	22.4	3.8	25.2	8.3	40.1	0
71106	Maerewhenua at Kellys Gully	57.2	5.1	37.2	0.3	0.3	0
71127	Maryburn at Maryhill	72.5	2	24.8	0.6	0	0
71122	Maryburn at Mt McDonald	53.8	0.2	45.9	0.1	0	0
68810	North Ashburton at Old Weir	15.8	5.7	40.7	0.1	37.7	0
68502	Rakaia at Gorge	21.3	22.2	23.3	2.4	30.8	0
69302	Rangitata at Klondyke	19	8.9	35.8	0.4	35.9	0
63501	Rosy Morn at Weir	35.9	63.5	0	0	0	0.6
68001	Selwyn at Whitecliffs	60.8	33.2	5.3	0.2	0.5	0
68806	South Ashburton at Mt Somers	45.6	4.3	39.1	1	10	0
64610	Stanton at Cheddar Valley	68.3	31.7	0	0	0	0
71121	Twizel at State Highway Br	57.5	11.7	26.3	0.6	2.4	1.6
64602	Waiau at Marble Point	16.7	52.2	21.9	0.5	8.6	0.1
66401	Waimakariri at Old HW Bridge	32.2	35.5	18.1	0.9	13	0.3
Otago							
75272	Arrow at Beetham Creek	12.5	11.4	74.2	0	1.2	0.7
75290	Cardrona at Albert Town	48.9	7	42.8	0	0.9	0.4
75259	Fraser at Old Man Range	27.2	0.1	72.5	0.1	0.1	0
75218	Lindis at Crossing Bridge	61.8	9.5	27.5	0	1.1	0
75219	Lindis at Lindis Peak	48.9	10.3	39.4	0	1.4	0
75253	Manuherikia at Ophir	60.4	4.3	30.8	0.5	3.9	0.1
75294	Matukituki at West Wanaka	14.6	21.7	49.3	0.9	13.4	0
75265	Nevis at Wentworth Station	19.3	4.6	73.2	0.2	2.7	0
74701	Noble at Bull Creek Road	57.4	42.6	0	0	0	0
75232	Pomahaka at Burkes Ford	73.3	15.1	11.3	0.2	0	0.1

Site ID	Site name	1	2	3	4	5	6
75278	Shotover at 16 Mile Gorge	3.9	13.1	61.2	2	19.7	0
75276	Shotover at Bowens Peak	11.8	14.8	63.3	0.7	9.3	0
75279	Shotover at Strohles	5	8	72.9	0.8	13.3	0
74338	Sutton Stream at SH 87	63.6	0.6	35.7	0	0	0
Southland							
78901	Aparima at Thornbury	64.7	27.7	6	0.4	1.1	0.2
84701	Cleddau at Milford	0.1	39.1	37.4	0.3	23	0.1
183001	Long Sound (Preservation Inlet)	2	73.5	22.3	1.4	0.8	0
78634	Makarewa at Counsell Rd	71.6	26.8	1.3	0.1	0.1	0
77504	Mataura at Gore	57.2	13.2	26.9	0.3	2.1	0.1
183003	Nancy Sound	0	87.6	9.9	0.3	2.1	0.1
78636	Oreti at Lumsden Cableway	35.4	34.6	22.4	0.2	7.3	0
78601	Oreti at Wallacetown	57.8	25.3	12	0.4	4.2	0.2
78625	Otapiriri at McBrides Bridge	57	32.9	10.1	0	0	0
80201	Rowallanburn at Old Mill	0.6	99.4	0	0	0	0
79740	Spey at West Arm	0.1	56.7	40.7	0.7	1.8	0.1
183002	Thompson-Bradshaw Sd (Doubtful Sd)	0.1	74.1	23.3	1.1	1.3	0
78503	Waihopai at Kennington	98.4	1.2	0	0	0	0.3

Table E-4: Percentage of calibration site catchment area in each erosion terrain group. 1. Sand country, floodplains, fans and terraces, peat; 2. Tephra and loess; 3. Tertiary mudstone, sandstone and soft limestone; 4. Intensely gullied crushed argillite and greywacke; 5. East Cape - , Intensely gullied crushed argillite and greywacke; 6. Lavas, rhyolite, volcanic slopes; 7. Greywacke, argillite and hard limestone; 8. Schist and South Island greywacke (including alpine, ice and snow); 9. Coarse crystalline plutonics and metamorphics; 10. Deeply weathered plutonics; 11. Water; and 12. Other.

Site ID	Site name	1	2	3	4	5	6	7	8	9	10	11	12
Northland													
1316	Awanui at School Cut	0	16.8	0	42	0	0	29	12.1	0	0	0	0
46645	Kokopu at McBeths	0	0	0	18.5	0	0	3.4	78.2	0	0	0	0
46626	Mangakahia at Titoki at Titoki	0	6.2	0	16.2	6.9	0	51.8	18.9	0	0	0	0
3506	Maungaparerua at Tyrees Ford	0	7.8	0	0	0	0	70.5	21.7	0	0	0	0
46644	Wairua at Purua	0	27.6	0	6	5.6	0	13.3	47.3	0	0	0	0
3722	Waitangi at Wakelins	0	8.5	1	5.7	4	0	33.8	46.5	0	0	0	0.4
Auckland													
45703	Hoteo at Gubbs	0	9.1	2	62	0	0	0	26.6	0	0	0	0
45705	Hoteo at Waiteitei	0	8.3	6.7	42.9	0	0	0	42.1	0	0	0	0
45311	Kaipara at Waimauku	0	11.2	19.7	23.8	0	0	5.1	39.6	0	0	0	0
45415	Kaukapakapa at Taylors	0	7.8	8	30.9	0	0	0	53.3	0	0	0	0
6806	Mahurangi at College	0	9.4	1.7	54.1	0	0	0	33.1	0	0	0	0
8304	Mangemangeroa at Craigs	0	0	0	90.2	0	0	0	9.8	0	0	0	0
7502	Okura at Awanohi	0	0	0	65.7	0	0	0	34.3	0	0	0	0
7304	Okura at Weiti Forest	0	0	0	48.3	0	0	0	51.7	0	0	0	0
8604	Orere at Bridge	0	5.1	7.2	0	0	0	0	87.7	0	0	0	0
7202	Orewa at Kowhai Ave	0	0	0	17.5	0	0	0	82.5	0	0	0	0
7506	Vaughan at Lower Weir	0	8.9	0	16.1	0	0	0	71.4	0	0	0	0
8516	Wairoa at Wairoa at Tourist Road	0	6.1	27.9	4.1	0	0	0.9	59.1	0	0	0	1.9

Site ID	Site name	1	2	3	4	5	6	7	8	9	10	11	12
43602	Waitangi at SH Br	0	15.9	18.5	0	0	0	65.6	0	0	0	0	0
45702	Waiwhiu at Dome Shadow	0	0	0	100	0	0	0	0	0	0	0	0
7206	West Hoe at Hall Farm	0	0	0	100	0	0	0	0	0	0	0	0
Waikato													
40810	Awakino at Gorge	0	5.6	29.3	19.1	0.9	0	0	45	0	0	0	0
1143450	Awaroa at Sansom's Br Rotowaro	0	3.8	39.8	20.4	0	0	0	32.7	0	0	0	0
2743464	Hinemaiaia at Maungatera	0	0	98.2	0	0	0	0	1.8	0	0	0	0
1643461	Kaniwhaniwha at Limeworks Rd	0	3.9	36.6	20.2	0	0	35.5	3.8	0	0	0	0
1043468	Kuratau at State Highway 41	0	2.3	95.8	0	0	0	1.9	0	0	0	0	0
1043434	Mangakara at Hirsts	0	0	100	0	0	0	0	0	0	0	0	0
1043427	Mangakino at Dillon Road	0	0	91.7	0	0	0	8.2	0	0	0	0	0
40703	Mangakowhai at Kaingapipi	0	3.6	88.2	8.2	0	0	0	0	0	0	0	0
1643462	Mangaokewa at Te Kuiti	0	1.5	86.2	4.6	0	0	0.4	6.3	0	0	0	0
1543497	Mangaonua at Dreadnought	0	35.9	50.1	2	0	0	0.1	10.2	0	0	0	0
1043444	Mangapu at SH3 Br	0	11.3	70.9	11.9	0.5	0	0.2	4.1	0	0	0	0
1943459	Mangatutu at Walker Rd Br	0	8.1	76.2	4.6	0	0	8.2	3	0	0	0	0
41301	Marokopa at Falls	0	1.2	70.3	0	0	0	0	28.5	0	0	0	0
3043490	Matahuru at Myjers	0	7.6	24.8	0	0	0	0	67.6	0	0	0	0
43489	Matahuru at Waiterimu Rd	0	12.2	29.5	0	0	0	0	58.3	0	0	0	0
40708	Mokau at Totoro Bridge	0	8	65.8	19.2	2	0	1.8	3.2	0	0	0	0
9213	Ohinemuri at Karangahake	0	0	64.2	0	0	0	34.1	0	0	0	0	0
11310	Opitonui River at d/s Awaroa	0	3.3	5.8	0	0	0	91	0	0	0	0	0
1009213	Oraka at Pinedale	0	0	96.3	0	0	0	3.7	0	0	0	0	0
41601	Oteke at Kinohaku	0	0	57.7	11.3	0	0	0	31	0	0	0	0
9140	Piako at Paeroa Tahuna Rd	0	25.4	61.2	0.5	0	0	1	11.3	0	0	0	0
9175	Piako at Kiwitahi	0	9.9	85.9	2	0	0	1.6	0.6	0	0	0	0
1043419	Pokaiwhenua at Puketurua	0	0	95.9	0	0	0	2.8	0	0	0	0	0

Site ID	Site name	1	2	3	4	5	6	7	8	9	10	11	12
43431	Puniu at Pokuru Br	0	10.2	83.6	2.4	0	0	2.7	0.9	0	0	0	0
1143409	Purukohokohu at Puruki Flume	0	0	100	0	0	0	0	0	0	0	0	0
1009246	Rapurapu at Kinlochs Farm	0	0.8	95.7	0	0	0	3.6	0	0	0	0	0
1043428	Tahunaatara at Ohakuri Road	0	1.8	91.3	0	0	0	6.9	0	0	0	0	0
12301	Tairua at Broken Hills	0	0	31.2	0	0	0	68.8	0	0	0	0	0
9701	Tapu at Tapu-Coroglen	0	3.2	0	0	0	0	94.9	1.9	0	0	0	0
1543413	Tauranga-Taupo at Te Kono	0	0.2	68.4	0	0	0	0	31.4	0	0	0	0
1143427	Te Tahi at Puketotara	0	0	99.7	0	0	0	0.3	0	0	0	0	0
1043460	Tongariro at Puketarata	0	0	52.1	0	0	0	13.2	34.7	0	0	0	0
1043459	Tongariro at Turangi	0	1.9	55.1	0	0	0	14.2	26.8	0	0	0	2.1
1043461	Tongariro at Upper Dam	0	0	27.2	0	0	0	1.3	71.5	0	0	0	0
1543424	Waihaha at SH32	0	0.1	97.2	0	0	0	2.7	0	0	0	0	0
1043466	Waihohonu at Desert Rd	0	0	60.6	0	0	0	39.3	0.1	0	0	0	0
9224	Waihou at Okauia	0	9.1	88.3	0	0	0	2.2	0	0	0	0	0
9205	Waihou at Te Aroha Br	0	12.7	81.4	0	0	0	5.5	0	0	0	0	0
9209	Waihou at Tirohia	0	13.7	78.4	0	0	0	7.4	0	0	0	0	0
42601	Waingaro at Ruakiwi Road	0	1.9	26.6	9	0	0	0	62.6	0	0	0	0
9228	Waiorongomai at Old Quarry	0	0.9	34.9	0	0	0	64.2	0	0	0	0	0
2043493	Waiotapu at Campbell Rd	0	1.3	98.3	0	0	0	0	0	0	0	0	0.4
43472	Waiotapu at Reporoa	0	4.9	94.8	0	0	0	0.1	0	0	0	0	0.1
43435	Waipa at Ngaroma Rd	0	0	99.2	0	0	0	0.8	0	0	0	0	0
43481	Waipa at Otewa	0	2.2	88.9	0	0	0	1.4	7.6	0	0	0	0
43433	Waipa at Whatawhata	0	16.6	70	4.5	0.1	0	2.9	5.4	0	0	0	0
2043441	Waipapa at Mulberry Rd	0	1	97.5	0	0	0	1.5	0	0	0	0	0
9179	Waitoa at Mellon Rd	0	28.2	69.9	0.8	0	0	0.1	0.1	0	0	0	0
9114	Waitoa at SH26	0	17.8	80.6	1.3	0	0	0.2	0.2	0	0	0	0
9112	Waitoa at Waharoa Control	0	12.7	85.4	1.1	0	0	0.4	0.3	0	0	0	0

Site ID	Site name	1	2	3	4	5	6	7	8	9	10	11	12
1943481	Waitomo at Aranui Caves	0	0	84.4	13	0	0	0	2.5	0	0	0	0
1643457	Whakapipi at SH22-Tuakau	0	8.7	18.2	6	0	0	61.8	0.9	0	0	0	0
1143402	Whangamarino at Slackline	0	25	12.4	0	0	0	0	62.6	0	0	0	0
12509	Wharekawa at Adams Farm	0	0.5	62.4	0	0	0	37.1	0	0	0	0	0
Bay of Plenty													
14604	Awahou at Tauranga Rd Bridge	0	0.7	99.3	0	0	0	0	0	0	0	0	0
14614	Kaituna at Te Matai	0	3.5	74.6	0	0	0	6.7	0	0	0	0	11.8
13901	Mangawhai at Mokoroa	0	0	100	0	0	0	0	0	0	0	0	0
14628	Mangorewa at Saunders Farm	0	1.5	82	0	0	0	16.5	0	0	0	0	0
16501	Motu at Houpoto	0	2.7	16.5	0.8	0	2.1	0	78	0	0	0	0
1014641	Ngongotaha at SH5 Bridge	0	2.2	90.3	0	0	0	7.5	0	0	0	0	0
16006	Otara at Gault Road Br(No.2)	0	3.3	3.6	0	0	0	0	93.1	0	0	0	0
14625	Puarenga at FRI Bridge	0	5.1	93.5	0	0	0	0.7	0	0	0	0	0
15432	Rangitaiki at Kopuriki	0	2.8	76.1	0	0	0	4.8	16.3	0	0	0	0
15408	Rangitaiki at Murupara	0	0.7	97.3	0	0	0	1.8	0.2	0	0	0	0
17101	Raukokore at SH35 Bridge	0	3.1	3.2	12.9	0	8.4	0	72.5	0	0	0	0
16511	Takaputahi at Ngawhakatatara	0	9.6	0.5	0	0	0	0	90	0	0	0	0
17301	Tauranga at Maruhinemaka	0	0	21.7	20	0	0	0	58.3	0	0	0	0
1014647	Utuhina at Hunts Farm	0	0	98.6	0	0	0	1.4	0	0	0	0	0
14610	Utuhina at SH5 Bridge	0	0	83.8	0	0	0	0.3	0	0	0	0	0
16205	Waiaua at Edwards	0	4.8	4.8	0	0	0	0	90.4	0	0	0	0
15453	Waihua at Gorge	0	0.2	11.6	0	0	0	1.2	87	0	0	0	0
15536	Waimana at Ogilvies Bridge	0	3	20.7	0.2	0	0	0	76.1	0	0	0	0
14606	Waingaehe at SH3none Bridge	0	0.3	99.5	0	0	0	0	0	0	0	0	0
15901	Waioeka at Gorge Cableway	0	0.2	18	2.9	0	0.1	0	78.7	0	0	0	0
14607	Waiohewa at SH3none Bridge	0	8.1	83.3	0	0	0	4.7	0	0	0	0	3.8
15802	Waiotahi at McNabs Road Bridge	0	5.6	18.1	0	0	0	0	76.2	0	0	0	0

Site ID	Site name	1	2	3	4	5	6	7	8	9	10	11	12
1014644	Waiowhiro at Bonningtons Farm	0	4.6	50.6	0	0	0	0	0	0	0	0	0
1014648	Waipa at Whaka Forest	0	0	100	0	0	0	0	0	0	0	0	0
15534	Wairere at Wainui Road	0	0	96.4	0	0	0	0	0	0	0	0	0
14603	Waiteti at Tauranga Rd Bridge	0	5.3	80.9	0	0	0	1	0	0	0	0	11.7
15514	Whakatane at Whakatane	0	3.1	27.1	0.1	0	0	0	69.4	0	0	0	0.3
15410	Whirinaki at Galatea	0	3.1	39.7	0	0	0	16	41.3	0	0	0	0
Taranaki													
39508	Manganui at SH3	0	32.9	20.1	0	0	0	46	1	0	0	0	0
36001	Punehu at Pihama	0	21.3	66.4	0	0	0	12.3	0	0	0	0	0
39501	Waitara at Tarata	0	1.1	27.8	70.4	0.6	0	0	0	0	0	0	0
34202	Whenuakra at Nicholson Road	0	0.9	17.7	81.3	0	0	0	0	0	0	0	0
Gisborne													
21437	Hangaroa at Doneraille Park	0	0.6	52.8	45.1	0	1.6	0	0	0	0	0	0
18902	Hikuwai at Willow Flat	0	6.7	5.1	57.5	0	30.6	0	0	0	0	0	0
18913	Mangaheia at Willowbank	0	2.6	15.1	73.5	0	8.9	0	0	0	0	0	0
19712	Mangatu at Omapere	0	2.7	20.5	19.8	0	32.9	0	24.2	0	0	0	0
18304	Mata at Pouturu	0	1.5	37.7	23.7	0	26.7	0	10.4	0	0	0	0
16502	Motu at Waitangirua	0	5.4	60.8	2.5	0	0.3	0	31	0	0	0	0
19766	Te Arai at Pykes Weir	0	1.2	10.7	75	0	13.1	0	0	0	0	0	0
18309	Waiapu at Rotokautuku	0	4.8	12.4	15.8	0	30.2	0	36.8	0	0	0	0
19706	Waihora at No 3 Br	0	1.7	17.5	72.4	0	8.4	0	0	0	0	0	0
19708	Waikohu at Mahaki	0	1	44.8	42.1	0	7.6	0	4.5	0	0	0	0
19602	Waimata at Goodwin's Rd	0	4	9.7	74.1	0	11.1	0	1.1	0	0	0	0
19609	Waimata at Monowai	0	1.8	12.9	69	0	14.1	0	2.2	0	0	0	0
19711	Waingaromia at Terrace Station	0	1.4	16.6	49.3	0	32.7	0	0	0	0	0	0
19701	Waipaoa at Kanakanaia Br	0	4	31.1	41.8	0	18.8	0	4.3	0	0	0	0
19704	Waipaoa at Matawhero	0.2	7.2	27	46.1	0	15.9	0	3.5	0	0	0	0

Site ID	Site name	1	2	3	4	5	6	7	8	9	10	11	12
19702	Waipaoa at Waipaoa Stn	0	3.1	20.3	18.5	0	51.8	0	6.4	0	0	0	0
17601	Wharekahika at Hicks Bay Rd Br	0	11.4	16	23.9	0	6.3	40.4	2	0	0	0	0
19741	Wharekopae at Rangimoe Stn	0	0	57.7	41.4	0	0.9	0	0	0	0	0	0
Hawke's Bay													
22802	Esk at Waipunga Bridge	0	1.3	66.3	31.7	0	0	0	0.7	0	0	0	0
21803	Mohaka at Glenfalls	0	0.4	28	0.9	0.3	0	0	70.3	0	0	0	0
21801	Mohaka at Raupunga	0	0.2	34	4.9	0.1	0.3	0	60.5	0	0	0	0
23150	Ngaruroro at Chesterhope Bridge	0	7.1	28.4	10.2	0	1.5	0	51.2	0	0	0	1.7
23102	Ngaruroro at Fernhill	0	5.4	28.6	10.1	0	1.6	0	52.8	0	0	0	1.4
23104	Ngaruroro at Papango	0	0	4.9	0	0	0	0	95.1	0	0	0	0
23103	Ngaruroro at Whanawhana	0	0	16.8	1.3	0	0	0	81.9	0	0	0	0
23210	Omakere at Fordale	0	19.5	0	66.6	0	0	0	13.8	0	0	0	0
23209	Otane at Glendon	0	4.4	40.2	23.9	0	0	0	31.6	0	0	0	0
21601	Tahekenui at Glenstrae	0	0	19	81	0	0	0	0	0	0	0	0
23106	Taruarau at Taihape Road	0	0	26.6	0.3	0	0	0	73.1	0	0	0	0
23201	Tukituki at Red Bridge	0	21.2	21.9	34.6	0	1.2	0	18.8	0	0	0	2.1
23203	Tukituki at Waipukurau	0	39	21.9	17.1	0	0.9	0	19.8	0	0	0	1.2
21409	Waiau at Otoi	0	0	40.8	5.9	0	0.4	0	52.9	0	0	0	0
21410	Waihi at Waihi	0	0	89.7	6.3	0	0	0	4	0	0	0	0
21401	Wairoa at Marumaru	0	0.9	53	41	0	2.3	0	2.9	0	0	0	0
Manawatu / Whanganui													
32726	Hautapu at Taihape	0	0.2	45.5	31.5	0.8	0	0	21.5	0	0	0	0
33502	Kaiiwi at Handley Road	0	9.6	21.1	69.2	0	0	0	0	0	0	0	0
32754	Makohine at Viaduct	0	5	3.6	91.2	0	0	0	0.1	0	0	0	0
1032591	Makuri at Tuscan Hills	0	4.2	7	73.1	0	0	0	15.8	0	0	0	0
32504	Manawatu at Hopelands	0	19.3	18.1	39	0	2.9	0	20.3	0	0	0	0
1032560	Manawatu at Teachers College	0.1	19.2	14.9	41	0	1.4	0	22.8	0	0	0	0

Site ID	Site name	1	2	3	4	5	6	7	8	9	10	11	12
1232566	Manawatu at Upper Gorge	0	19	14.4	43.8	0	1.7	0	20.8	0	0	0	0
32526	Mangahao at Ballance	0	9.2	19.1	3	0	0	0	68.5	0	0	0	0.1
5023	Mangahao at Machine	0	4.6	1.1	0	0	0	0	93.8	0	0	0	0.4
1132511	Mangatainoka at Pahiatua Town Bridge	0	33.7	17.6	19.6	0	0	0	28.7	0	0	0	0
33111	Mangawhero at Ore Ore	0	2.2	54.8	35.4	0	0	4.3	2.7	0	0	0	0
32106	Ohau at Rongomatane	0	5.6	6.9	0	0	0	0	87.5	0	0	0	0
33314	Ohura at Nihoniho	0	5.1	34.9	60	0	0	0	0	0	0	0	0
33316	Ongarue at Taringamutu	0	0.2	67.8	27.7	0.2	0	0.8	3.2	0	0	0	0
32514	Oroua at Almadale Slackline	0	15	24.6	33.4	0	0	0	27.1	0	0	0	0
32563	Oroua at Kawa Wool	0	18.4	29.4	37.5	0	0	0	14.4	0	0	0	0
25101	Owahanga at Branscombe Bridge	0	7.8	6.6	70.5	0	5.2	0	9.9	0	0	0	0
32576	Pohangina at Mais Reach	0	19.6	6.8	33.8	0.3	0	0	39.2	0	0	0	0.3
32702	Rangitikei at Mangaweka	0	2.3	25.1	26.7	0.3	0	0	45.4	0	0	0	0
32763	Rangitikei at Pukeokahu	0	0.8	23.1	6.6	0	0	0	69.4	0	0	0	0
32529	Tiraumea at Ngaturi	0	9.5	2.2	81.6	0	2.2	0	4.5	0	0	0	0
33004	Turakina at Otairi	0	4.1	14.1	78	0	0	0	3.8	0	0	0	0
33320	Whakapapa at Footbridge	0	0	48.7	1.3	0	0	29.5	20.6	0	0	0	0
33101	Whangaehu at Kauangaroa	0	5.5	38.8	46.3	0.1	0	5.8	3.3	0	0	0	0
33303	Whanganui at Te Rewa	0	1.8	36.2	57.6	0.2	0	2.1	2	0	0	0	0.1
33301	Whanganui at Paetawa	0	1.8	36.2	57.6	0.2	0	2.1	2	0	0	0	0.1
33347	Whanganui at Te Porere	0	0	49.1	0	0	0	45.5	5.4	0	0	0	0
Wellington													
30912	Horokiri at Snodgrass	0	7.6	8.9	0	0	0	0	83.5	0	0	0	0
29808	Hutt at Kaitoke	0	1.5	0	0	0	0	0	98.5	0	0	0	0
30516	Mill Creek at Papanui	0	10.3	0.9	0	0	0	0	88.8	0	0	0	0
31807	Otaki at Pukehinau	0	2.9	1.9	0	0	0	0	95.2	0	0	0	0
31803	Otaki at Tuapaka	0	3.1	1.9	0	0	0	0	95	0	0	0	0

Site ID	Site name	1	2	3	4	5	6	7	8	9	10	11	12
27303	Pahao at Hinakura	0	8.9	1.7	49.5	0	4.5	0	35.3	0	0	0	0
30802	Pauatahanui at Gorge	0	5	34.3	0	0	0	0	60.7	0	0	0	0
30701	Porirua at Town Centre	0	0	10.5	0	0	0	0	58.5	0	0	0	0
29250	Ruakokopatuna at Iraia	0	0	0	1.3	0	0	0	98.7	0	0	0	0
29202	Ruamahanga at Waihenga	0	22.8	16.9	29.2	0	0.5	0	29.8	0	0	0	0.1
29231	Taueru at Te Weraiti	0	8.1	6.9	68.4	0	1.8	0	14.9	0	0	0	0
29244	Whangaehu at Waihi	0	1.9	0.1	94.8	0	0	0	3.2	0	0	0	0
25902	Whareama at Waiteko Bridge	0	9.2	0	46.3	0	29.3	0	15.2	0	0	0	0
Tasman													
52003	Aorere at Devils Boot	0	6.5	0	4.5	0	0	1	68.3	1.5	17.9	0	0.4
56905	Apahai at Hickmotts	0	1.2	0	0	0	0	0	0	0	0	98.8	0
93202	Buller at Longford	0	7.8	1.5	32.1	0	0	0	30	5.3	20.8	0	2.5
52916	Cobb at Trilobite	0	7.1	0	0	0	0	0	92.9	0	0	0	0
56906	Kaiteriteri at Water Supply	0	1.5	0	0	0	0	0	0	0	0	98.5	0
57536	Lee at Cableway	0	0	0	0	0	0	0	46.8	51.2	1.9	0	0
93212	Mangles at Gorge	0	9.8	0	30.1	0	0	0	0.1	0	60	0	0
93209	Maruia at Falls	0	15.4	0	24.2	0	0	0	18.9	10	30.5	0	1
93211	Matakitaki at Mud Lake	0	11.5	0	19.4	0	0	0	37.8	18	12.4	0	0.8
57008	Motueka at Gorge	0	0	0	0	0	0	0	48.7	6.9	44.3	0	0
57015	Motueka at Woodmans Bend	0	11.9	0	36.9	0	0	0	26.5	1.1	13.7	9.6	0.4
57009	Motueka at Woodstock	0	12.3	0	40.4	0	0	0	27.3	1.2	12.8	5.7	0.3
57036	Motupiko at Christies	0	33.8	0	41.2	0	0	0	20	0	5.1	0	0
57101	Moutere at Old House Road	0	19.5	0	80.5	0	0	0	0	0	0	0	0
56901	Riwaka at Moss Bush	0	1.2	0	0	0	0	0	70.4	0	28.3	0	0
57014	Stanleybrook at Barkers	0	13.6	0	85.7	0	0	0	0	0	0	0.7	0
52902	Takaka at Harwoods	0	1.8	0	4.5	0	0	0	90.6	0	2.1	0	1
57502	Wairoa at Gorge	0	0.9	0	0.5	0	0	0	42	44.1	12.5	0	0

Site ID	Site name	1	2	3	4	5	6	7	8	9	10	11	12
57025	Wangapeka at Walter Peak	0	6.2	0	15.8	0	0	0	47.7	0	26.1	4.2	0
Marlborough													
62103	Acheron at Clarence	0	8.4	3.5	0	0	0	0	82.3	4.9	0	0	1
58902	Pelorus at Bryants	0	2.8	0	0	0	0	0	67.5	23.6	6.1	0	0
60114	Wairau at Dip Flat	0	7.9	0.7	0	0	0	0	81.3	9.2	0	0	0.9
West Coast													
91407	Ahaura at Gorge	0	26.8	0	1.9	0	0	0	36.1	22.4	10.1	0	2.7
89701	Amethyst at Road Bridge	0	2.3	0	0	0	0	0	0	97.7	0	0	0.1
93203	Buller at Te Kuha	0	11.8	0.3	27.5	0	0	0	21.5	5.3	32.4	0	1.1
93208	Buller at Woolfs	0	10.4	0.5	30.8	0	0	0	22.3	7.3	27.5	0	1.3
90605	Butchers Creek at Lk Kaniere Road	0	99	0	0	0	0	0	0	0	1	0	0
90607	Cropp at Gorge	0	0	0	0	0	0	0	21.4	78.6	0	0	0
91401	Grey at Dobson	0	38.8	0	13.8	0	0	0	16.9	8.8	18.6	0	2.8
91404	Grey at Waipuna	0	11.9	0	12.4	0	0	0	20.5	9.9	44.8	0	0.4
86802	Haast at Roaring Billy	0	7	0	0	0	0	0	9.3	81.7	0	0	2.1
90604	Hokitika at Colliers Creek	0	3.7	0	0	0	0	0	41	54.8	0.4	0	0.1
93207	Inangahua at Blacks Point	0	11.7	0	2.8	0	0	0	22.6	0	62.8	0	0
93206	Inangahua at Landing	0	18.9	0	12	0	0	0	23.1	0.1	45.2	0	0.6
90102	Ivory at Ripplerock	0	0	0	0	0	0	0	90.9	9.1	0	0	0
95102	Karamea at Gorge	0	1.7	0	7.5	0	0	0	42.2	0	48.3	0	0.3
94302	Mokihinui at Burkes Creek	0	2.7	0	32.5	0	0	0	17	0	47.1	0	0.6
94303	Mokihinui at Welcome Bay	0	2.7	0	32.4	0	0	0	16.8	0	47.5	0	0.6
91103	Taipo at SHB	0	5.8	0	0	0	0	0	33.9	58.7	0	0	1.6
91104	Taramakau at Greenstone Bridge	0	15.6	0	0	0	0	0	43.3	29.3	7.3	0	4.5
89301	Whataroa at SHB	0	5.9	0	0	0	0	0	26	67.8	0	0	0.3
Canterbury													
71116	Ahuriri at South Diadem	0	8.6	7.3	0	0	0	0	69.8	12.6	0	0	1.6

Site ID	Site name	1	2	3	4	5	6	7	8	9	10	11	12
62105	Clarence at Jollies	0	10.5	3.3	0	0	0	0	82.3	2.5	0	0	1.3
71129	Forks at Balmoral	0	19.6	10.1	0	0	0	0	44.1	24.8	0	0	1.4
71103	Hakataramea at Above Highway Br	0	16.6	20.2	4.7	0	0	0	56	0	0	0	2.5
66612	Heathcote at Buxton Terrace	0	48.1	28.2	0	0	0	0.3	0	0	0	0	0
71125	Hooker at Ball Hut Road Br	0	4.5	0	0	0	0	0	16.4	76.6	0	0	2.5
67602	Hukahuka at Lathams Br	0	0.7	25.9	0	0	0	73.3	0	0	0	0	0
65104	Hurunui at Mandamus	0	8.8	3.5	0	0	0	0	83.8	1.1	0	0	2.8
71128	Irishman at Windy Ridge	0	48	41.4	0	0	0	0	10.6	0	0	0	0
71135	Jollie at Mt Cook Station	0	0	12.6	0	0	0	0	41.5	44.7	0	0	1.3
71131	Lake Tekapo at Spillway	0	15.6	11.9	0	0	0	0	32.6	26.1	0	0	13.9
71106	Maerewhenua at Kellys Gully	0	0	3.3	3	0	0	0	93.6	0	0	0	0
71127	Maryburn at Maryhill	0	70.4	25.9	0	0	0	0	3.7	0	0	0	0
71122	Maryburn at Mt McDonald	0	52.1	47.9	0	0	0	0	0	0	0	0	0
68810	North Ashburton at Old Weir	0	0	1.6	0	0	0	0.3	87.6	10.2	0	0	0.3
68502	Rakaia at Gorge	0	15.6	6.5	0	0	0	0	59.8	8.8	0	0	9.3
69302	Rangitata at Klondyke	0	8.7	7.7	0	0	0	0	57.1	17.5	0	0	9
63501	Rosy Morn at Weir	0	0	0	0	0	0	0	100	0	0	0	0
68001	Selwyn at Whitecliffs	0	23.7	5.7	0.8	0	0	2.7	65.2	0	0	0	2
68806	South Ashburton at Mt Somers	0	32.6	10.9	0	0	0	7.3	42.4	4.4	0	0	2.4
64610	Stanton at Cheddar Valley	0	8	0	57.1	0	0	6	29	0	0	0	0
71121	Twizel at State Highway Br	0	48.8	11.7	0	0	0	0	37	2.5	0	0	0
64602	Waiau at Marble Point	0	14.7	2.5	0.1	0	0	0	80.6	1.1	0	0	1.1
66401	Waimakariri at Old HW Bridge	0	25	9.8	0.3	0	0	0.1	56.6	2.8	0	0	5.1
Otago													
75272	Arrow at Beetham Creek	0	3.7	0.4	0	0	0	0	0	95.9	0	0	0
75290	Cardrona at Albert Town	0	16.4	0.1	5.5	0	0	0	0	77.2	0	0	0.8
75259	Fraser at Old Man Range	0	0.7	0	0	0	0	0	0	99.3	0	0	0

Site ID	Site name	1	2	3	4	5	6	7	8	9	10	11	12
75218	Lindis at Crossing Bridge	0	10.9	2.5	0.7	0	0	0	0.1	85.9	0	0	0
75219	Lindis at Lindis Peak	0	1.4	2.8	0	0	0	0	0.1	95.7	0	0	0
75253	Manuherikia at Ophir	0	15.9	10.7	10.5	0	0	0	21.4	40.5	0	0	0.7
75294	Matukituki at West Wanaka	0	8.8	3.1	0	0	0	0	0.4	85.5	0	0	2.2
75265	Nevis at Wentworth Station	0	5.8	0	3.5	0	0	0	0	90.5	0	0	0
74701	Noble at Bull Creek Road	0	0.8	27.7	0	0	0	0	71.5	0	0	0	0
75232	Pomahaka at Burkes Ford	0	7.3	41.8	1	0	0	0	14.6	34.9	0	0	0.3
75278	Shotover at 16 Mile Gorge	0	5.3	0	0	0	0	0	0	93	0	0	1.8
75276	Shotover at Bowens Peak	0	4.8	0.1	0	0	0	0	0	94.2	0	0	0.8
75279	Shotover at Strohles	0	5.3	0.2	0	0	0	0	0	93.1	0	0	1.3
74338	Sutton Stream at SH 87	0	0.1	0	0	0	0	0	0	99.9	0	0	0
Southland													
78901	Aparima at Thornbury	0	31.7	22.2	2.5	0	0	6.6	34.1	1.6	0	0	1.4
84701	Cleddau at Milford	0	5.9	0	0	0	0	0	0	26.5	67.5	0	0
183001	Long Sound (Preservation Inlet)	2.1	7.5	0	0	0	0	0	0	0	89.4	0	1.1
78634	Makarewa at Counsell Rd	0	17.9	47.9	5.3	0	0	0	28.8	0	0	0	0
77504	Mataura at Gore	0	21.2	12.9	0.4	0	0	0.1	27.5	37.1	0.1	0	0.6
183003	Nancy Sound	0.1	1.4	0	0	0	0	0	0	0	98.2	0	0.2
78636	Oreti at Lumsden Cableway	0	24	7.2	0.9	0	0	0.5	49	4.5	12.8	0	1.1
78601	Oreti at Wallacetown	0	35.4	15.5	1	0	0	0.3	36.8	2.4	6.7	0	2
78625	Otapiriri at McBrides Bridge	0	1.6	32.1	0	0	0	0	66.1	0	0	0	0.2
80201	Rowallanburn at Old Mill	0	20.6	0.6	78.9	0	0	0	0	0	0	0	0
79740	Spey at West Arm	0	6.6	0	0	0	0	0	0	0.6	92.4	0	0.4
183002	Thompson-Bradshaw Sd (Doubtful Sd)*	0.1	1.5	0	0	0	0	0	0	0	97.9	0	0.5
78503	Waihopai at Kennington	0	16	84	0	0	0	0	0	0	0	0	0

Appendix F Modelled loads at the calibration sites

Table F-1: Observed and modelled loads for the REC2 segments at the calibration sites.

Site ID	Site name (river at location)	Observed load (t/y)	Modelled load under current land cover with no regional correction (t/y)	Modelled load under current land cover with regional correction (t/y)
Northland				
1316	Awanui at School Cut	19500	19306	26032
46645	Kokopu at McBeths	869	254	254
46626	Mangakahia at Titoki at Titoki	122481	60538	60538
3506	Maungaparerua at Tyrees Ford	1030	404	404
46644	Wairua at Purua	28153	43477	43477
3722	Waitangi at Wakelins	62850	16360	16360
Auckland				
45703	Hoteo at Gubbs	19792	38210	38210
45705	Hoteo at Waiteitei	7043	7873	7873
45311	Kaipara at Waimauku	5243	8908	8908
45415	Kaukapakapa at Taylors	4722	5120	5120
6806	Mahurangi at College	4297	6153	6153
8304	Mangemangeroa at Craigs	740	999	999
7502	Okura at Awanohi	106	555	555
7304	Okura at Weiti Forest	57	127	127
8604	Orere at Bridge	6028	4546	4546
7202	Orewa at Kowhai Ave	767	625	625
7506	Vaughan at Lower Weir	112	109	109
8516	Wairoa at Wairoa at Tourist Road	5404	13419	13419
43602	Waitangi at SH Br	291	373	373
45702	Waiwhiu at Dome Shadow	1338	1495	1495
7206	West Hoe at Hall Farm	13	48	48
Waikato				
40810	Awakino at Gorge	59109	75007	75007
1143450	Awaroa at Sansom's Br Rotowaro	4712	6842	6842
2743464	Hinemaiaia at Maungatera	5195	6309	6309
1643461	Kaniwhaniwha at Limeworks Rd	3313	4793	4793
1043468	Kuratau at State Highway 41	2477	4709	4709
1043434	Mangakara at Hirsts	2314	1343	1343
1043427	Mangakino at Dillon Road	14637	12814	12814
40703	Mangakowhai at Kaingapipi	1128	2094	2094

Site ID	Site name (river at location)	Observed load (t/y)	Modelled load under current land cover with no regional correction (t/y)	Modelled load under current land cover with regional correction (t/y)
1643462	Mangaokewa at Te Kuiti	9351	14595	14595
1543497	Mangaonua at Dreadnought	1552	3974	3974
1043444	Mangapu at SH3 Br	10226	52579	52579
1943459	Mangatutu at Walker Rd Br	4094	8549	8549
41301	Marokopa at Falls	13219	11171	11171
3043490	Matahuru at Myjers	13792	8415	8415
43489	Matahuru at Waiterimu Rd	5369	9354	9354
40708	Mokau at Totoro Bridge	165635	198312	198312
9213	Ohinemuri at Karangahake	28774	17977	17977
11310	Opitonui River at d/s Awaroa	3084	1608	1608
1009213	Oraka at Pinedale	5376	5666	5666
41601	Oteke at Kinohaku	1030	1330	1330
9140	Piako at Paeroa Tahuna Rd	10940	14734	14734
9175	Piako at Kiwitahi	1563	3695	3695
1043419	Pokaiwhenua at Puketurua	7244	13316	13316
43431	Puniu at Pokuru Br	10329	28370	28370
1143409	Purukohokohu at Puruki Flume	4	14	14
1009246	Rapurapu at Kinlochs Farm	601	1318	1318
1043428	Tahunaatara at Ohakuri Road	13509	8689	8689
12301	Tairua at Broken Hills	10842	8993	8993
9701	Tapu at Tapu-Coroglen	738	1592	1592
1543413	Tauranga-Taupo at Te Kono	15608	21783	21783
1143427	Te Tahi at Puketotara	203	409	409
1043460	Tongariro at Puketarata	176341	79666	79666
1043459	Tongariro at Turangi	137000	100855	100855
1043461	Tongariro at Upper Dam	24279	42187	42187
1543424	Waihaha at SH32	2268	5286	5286
1043466	Waihohonu at Desert Rd	2870	11185	11185
9224	Waihou at Okauia	41689	30005	30005
9205	Waihou at Te Aroha Br	63203	39668	39668
9209	Waihou at Tirohia	67306	43101	43101
42601	Waingaro at Ruakiwi Road	9785	15642	15642
9228	Waiorongomai at Old Quarry	339	572	572
2043493	Waiotapu at Campbell Rd	1162	1682	1682
43472	Waiotapu at Reporoa	18000	5156	5156
43435	Waipa at Ngaroma Rd	4309	4952	4952
43481	Waipa at Otewa	52985	22237	22237

Site ID	Site name (river at location)	Observed load (t/y)	Modelled load under current land cover with no regional correction (t/y)	Modelled load under current land cover with regional correction (t/y)
43433	Waipa at Whatawhata	169784	216361	216361
2043441	Waipapa at Mulberry Rd	5180	2970	2970
9179	Waitoa at Mellon Rd	5521	7245	7245
9114	Waitoa at SH26	4037	6707	6707
9112	Waitoa at Waharoa Control	4590	3837	3837
1943481	Waitomo at Aranui Caves	4611	6425	6425
1643457	Whakapipi at SH22-Tuakau	1883	1804	1804
1143402	Whangamarino at Slackline	22701	8766	8766
12509	Wharekawa at Adams Farm	1708	3111	3111
Bay of Plenty				
14604	Awahou at Tauranga Rd Bridge	925	822	822
14614	Kaituna at Te Matai	51716	18203	18203
13901	Mangawhai at Mokoroa	105	194	194
14628	Mangorewa at Saunders Farm	24669	11233	11233
16501	Motu at Houpoto	3525526	2262464	2262464
1014641	Ngongotaha at SH5 Bridge	3579	3921	3921
16006	Otara at Gault Road Br(No.2)	92573	143156	143156
14625	Puarenga at FRI Bridge	3237	3117	3117
15432	Rangitaiki at Kopuriki	182274	88331	88331
15408	Rangitaiki at Murupara	24706	17304	17304
17101	Raukokore at SH35 Bridge	4705941	3049817	3049817
16511	Takaputahi at Ngawhakatatara	66917	68512	68512
17301	Tauranga at Maruhinemaka	2060	893	893
1014647	Utuhina at Hunts Farm	221	246	246
14610	Utuhina at SH5 Bridge	4248	2165	2165
16205	Waiaua at Edwards	64689	29958	29958
15453	Waihua at Gorge	4496	7119	7119
15536	Waimana at Ogilvies Bridge	135916	46220	46220
14606	Waingaehe at SH3none Bridge	630	473	473
15901	Waioeka at Gorge Cableway	653349	331398	331398
14607	Waiohewa at SH3none Bridge	604	435	435
15802	Waiotahi at McNabs Road Bridge	11037	16657	16657
1014644	Waiowhiro at Bonningtons Farm	297	255	255
1014648	Waipa at Whaka Forest	129	423	423
15534	Wairere at Wainui Road	205	146	146
14603	Waiteti at Tauranga Rd Bridge	2138	2461	2461

Site ID	Site name (river at location)	Observed load (t/y)	Modelled load under current land cover with no regional correction (t/y)	Modelled load under current land cover with regional correction (t/y)
15514	Whakatane at Whakatane	592417	257403	257403
15410	Whirinaki at Galatea	68890	37697	37697
Taranaki				
39508	Manganui at SH3	7492	4380	4380
36001	Punehu at Pihama	1982	2592	2592
39501	Waitara at Tarata	890047	414540	414540
34202	Whenuakra at Nicholson Road	275171	176681	176681
Gisborne				
21437	Hangaroa at Doneraille Park	886406	738913	738913
18902	Hikuwai at Willow Flat	3777000	4533531	4533531
18913	Mangaheia at Willowbank	81149	116147	116147
19712	Mangatu at Omapere	1657000	2279078	2279078
18304	Mata at Pouturu	5277000	5509570	5509570
16502	Motu at Waitangirua	123614	148341	148341
19766	Te Arai at Pykes Weir	402000	363140	363140
18309	Waiapu at Rotokautuku	31220000	30501319	30501319
19706	Waihora at No 3 Br	910000	455747	455747
19708	Waikohu at Mahaki	543000	656308	656308
19602	Waimata at Goodwin's Rd	380300	881912	881912
19609	Waimata at Monowai	239500	538201	538201
19711	Waingaromia at Terrace Station	3334700	2402196	2402196
19701	Waipaoa at Kanakanaia Br	8856000	11715252	11715252
19704	Waipaoa at Matawhero	11562000	12142415	12142415
19702	Waipaoa at Waipaoa Stn	6845000	3356299	3356299
17601	Wharekahika at Hicks Bay Rd Br	446000	458620	458620
19741	Wharekopae at Rangimoe Stn	258504	159373	159373
Hawke's Bay				
22802	Esk at Waipunga Bridge	348257	76407	76407
21803	Mohaka at Glenfalls	274552	260047	260047
21801	Mohaka at Raupunga	1341544	874989	874989
23150	Ngaruroro at Chesterhope Bridge	1317380	840457	840457
23102	Ngaruroro at Fernhill	1083916	837928	837928
23104	Ngaruroro at Papango	58545	141717	141717
23103	Ngaruroro at Whanawhana	339774	284007	284007
23210	Omakere at Fordale	13546	10022	10022
23209	Otane at Glendon	831	1656	1656

Site ID	Site name (river at location)	Observed load (t/y)	Modelled load under current land cover with no regional correction (t/y)	Modelled load under current land cover with regional correction (t/y)
21601	Tahekenui at Glenstrae	42476	12219	12219
23106	Taruarau at Taihape Road	18455	41986	41986
23201	Tukituki at Red Bridge	1033230	627321	627321
23203	Tukituki at Waipukurau	404425	137983	137983
21409	Waiau at Otoi	366242	267491	267491
21410	Waihi at Waihi	14718	10966	10966
21401	Wairoa at Marumaru	921394	3261421	3261421
Manawatu / Whanganui				
32726	Hautapu at Taihape	18460	33560	33560
33502	Kaiiwi at Handley Road	16868	45795	45795
32754	Makohine at Viaduct	152014	37483	37483
1032591	Makuri at Tuscan Hills	90750	66007	66007
32504	Manawatu at Hopelands	605590	636101	636101
1032560	Manawatu at Teachers College	1921600	1712301	1712301
1232566	Manawatu at Upper Gorge	2482699	1564237	1564237
32526	Mangahao at Ballance	177610	64207	64207
5023	Mangahao at Machine	61421	28119	28119
1132511	Mangatainoka at Pahiatua Town Bridge	55090	83675	83675
33111	Mangawhero at Ore Ore	93145	96656	96656
32106	Ohau at Rongomatane	27471	27021	27021
33314	Ohura at Nihoniho	164170	123229	123229
33316	Ongarue at Taringamutu	151711	181007	181007
32514	Oroua at Almadale Slackline	210420	63163	63163
32563	Oroua at Kawa Wool	488597	102177	102177
25101	Owahanga at Branscombe Bridge	152430	403390	403390
32576	Pohangina at Mais Reach	499830	124751	124751
32702	Rangitikei at Mangaweka	592750	495860	495860
32763	Rangitikei at Pukeokahu	30750	145163	145163
32529	Tiraumea at Ngaturi	322400	663761	663761
33004	Turakina at Otairi	211256	168752	168752
33320	Whakapapa at Footbridge	37348	21826	21826
33101	Whangaehu at Kauangaroa	681259	451035	451035
33303	Whanganui at Te Rewa	3322120	2303226	2303226
33301	Whanganui at Paetawa	4561911	2304641	2304641
33347	Whanganui at Te Porere	1216	2062	2062
Wellington				

Site ID	Site name (river at location)	Observed load (t/y)	Modelled load under current land cover with no regional correction (t/y)	Modelled load under current land cover with regional correction (t/y)
30912	Horokiri at Snodgrass	5822	3692	3692
29808	Hutt at Kaitoke	17417	35392	35392
30516	Mill Creek at Papanui	685	925	925
31807	Otaki at Pukehinau	314281	160486	160486
31803	Otaki at Tuapaka	168531	160727	160727
27303	Pahao at Hinakura	405333	414190	414190
30802	Pauatahanui at Gorge	8200	3408	3408
30701	Porirua at Town Centre	4906	2447	2447
29250	Ruakokopatuna at Iraia	2529	3180	3180
29202	Ruamahanga at Waihenga	534148	703010	703010
29231	Taueru at Te Weraiti	140058	168567	168567
29244	Whangaehu at Waihi	12011	15206	15206
25902	Whareama at Waiteko Bridge	611300	1633097	1633097
Tasman				
52003	Aorere at Devils Boot	98066	187689	187689
56905	Apahai at Hickmotts	368	117	117
93202	Buller at Longford	217973	156581	156581
52916	Cobb at Trilobite	2810	8870	8870
56906	Kaiteriteri at Water Supply	149	74	74
57536	Lee at Cableway	2908	13906	13906
93212	Mangles at Gorge	13105	26017	26017
93209	Maruia at Falls	446117	369003	369003
93211	Matakitaki at Mud Lake	759837	594448	594448
57008	Motueka at Gorge	59400	34197	34197
57015	Motueka at Woodmans Bend	284000	273454	273454
57009	Motueka at Woodstock	315163	247219	247219
57036	Motupiko at Christies	13200	13994	13994
57101	Moutere at Old House Road	5285	4063	4063
56901	Riwaka at Moss Bush	3342	3353	3353
57014	Stanleybrook at Barkers	13892	8114	8114
52902	Takaka at Harwoods	18400	20869	20869
57502	Wairoa at Gorge	61925	50352	50352
57025	Wangapeka at Walter Peak	79200	66220	66220
Marlborough				
62103	Acheron at Clarence	298601	242350	242350
58902	Pelorus at Bryants	126650	116106	116106
60114	Wairau at Dip Flat	109698	153375	153375

Site ID	Site name (river at location)	Observed load (t/y)	Modelled load under current land cover with no regional correction (t/y)	Modelled load under current land cover with regional correction (t/y)
West Coast				
91407	Ahaura at Gorge	346160	576731	576731
89701	Amethyst at Road Bridge	10160	28547	28547
93203	Buller at Te Kuha	4964127	1925508	1925508
93208	Buller at Woolfs	1845723	1451099	1451099
90605	Butchers Creek at Lk Kaniere Road	1529	573	573
90607	Cropp at Gorge	424613	112521	112521
91401	Grey at Dobson	1919590	1238773	1238773
91404	Grey at Waipuna	249751	220329	220329
86802	Haast at Roaring Billy	4176090	5859991	5859991
90604	Hokitika at Colliers Creek	2035129	1571607	1571607
93207	Inangahua at Blacks Point	44764	20543	20543
93206	Inangahua at Landing	366064	157713	157713
90102	Ivory at Ripplerock	31000	3000	3000
95102	Karamea at Gorge	146520	223615	223615
94302	Mokihinui at Burkes Creek	218062	219238	219238
94303	Mokihinui at Welcome Bay	395000	216913	216913
91103	Taipo at SHB	662080	900725	900725
91104	Taramakau at Greenstone Bridge	2143810	2178261	2178261
89301	Whataroa at SHB	4594861	3548121	3548121
Canterbury				
71116	Ahuriri at South Diadem	114904	189862	189862
62105	Clarence at Jollies	62393	70400	70400
71129	Forks at Balmoral	8856	6385	6385
71103	Hakataramea at Above Highway Br	39244	40240	40240
66612	Heathcote at Buxton Terrace	2810	662	662
71125	Hooker at Ball Hut Road Br	278276	339030	339030
67602	Hukahuka at Lathams Br	1463	810	810
65104	Hurunui at Mandamus	400213	491375	491375
71128	Irishman at Windy Ridge	828	649	649
71135	Jollie at Mt Cook Station	66615	110711	110711
71131	Lake Tekapo at Spillway	807000	19496	19496
71106	Maerewhenua at Kellys Gully	24030	18465	18465
71127	Maryburn at Maryhill	140	294	294
71122	Maryburn at Mt McDonald	140	150	150

Site ID	Site name (river at location)	Observed load (t/y)	Modelled load under current land cover with no regional correction (t/y)	Modelled load under current land cover with regional correction (t/y)
68810	North Ashburton at Old Weir	155000	175235	175235
68502	Rakaia at Gorge	4336496	2769897	2769897
69302	Rangitata at Klondyke	1576000	2514848	2514848
63501	Rosy Morn at Weir	118	181	181
68001	Selwyn at Whitecliffs	21288	34266	34266
68806	South Ashburton at Mt Somers	73379	199009	199009
64610	Stanton at Cheddar Valley	58011	18427	18427
71121	Twizel at State Highway Br	23310	6764	6764
64602	Waiau at Marble Point	2377408	1035064	1035064
66401	Waimakariri at Old HW Bridge	3030000	1837590	1837590
Otago				
75272	Arrow at Beetham Creek	78642	44974	44974
75290	Cardrona at Albert Town	52967	63237	63237
75259	Fraser at Old Man Range	8018	8784	8784
75218	Lindis at Crossing Bridge	69951	106749	106749
75219	Lindis at Lindis Peak	57710	67207	67207
75253	Manuherikia at Ophir	108876	107995	107995
75294	Matukituki at West Wanaka	708462	1092978	1092978
75265	Nevis at Wentworth Station	179569	193416	193416
74701	Noble at Bull Creek Road	201	416	416
75232	Pomahaka at Burkes Ford	67300	133740	133740
75278	Shotover at 16 Mile Gorge	182148	180236	180236
75276	Shotover at Bowens Peak	1314631	781060	781060
75279	Shotover at Strohles	607650	502889	502889
74338	Sutton Stream at SH 87	3368	5470	5470
Southland				
78901	Aparima at Thornbury	52573	53474	53474
84701	Cleddau at Milford	10734	30513	30513
183001	Long Sound (Preservation Inlet)	16330	8798	8798
78634	Makarewa at Counsell Rd	71588	43252	43252
77504	Mataura at Gore	208158	389040	389040
183003	Nancy Sound[c]	8660	5207	5207
78636	Oreti at Lumsden Cableway	52486	103145	103145
78601	Oreti at Wallacetown	106687	133786	133786
78625	Otapiriri at McBrides Bridge	4335	7870	7870
80201	Rowallanburn at Old Mill	2998	9296	9296

Site ID	Site name (river at location)	Observed load (t/y)	Modelled load under current land cover with no regional correction (t/y)	Modelled load under current land cover with regional correction (t/y)
79740	Spey at West Arm	11085	10217	10217
183002	Thompson-Bradshaw Sd (Doubtful Sd) [c]	29870	24993	24993
78503	Waihopai at Kennington	7572	831	831

Appendix G Estimated loads at the mouths of major rivers – current land cover scenario

Table G-1: Modelled loads (Mt/y) for current land cover, corrected to observed loads. 'Actual' modelled loads include entrapment in artificial lakes; 'Potential' modelled loads do not. Contribution percentages to North/South Island and national totals calculated with Actual loads. Hicks et al. (2011) model estimates of Potential loads provided for comparison (NA indicates no estimate available).

River	Area (km²)	Hicks et al. (2011) Potential load (Mt/y)	Modelled load (Mt/y)		Percentage contribution (%)	
			Actual	*Potential*	*Island*	*National*
Northland						
Waitangi	301	0.07	0.06	0.06	0.06	0.03
Auckland						
Hoteo	399	NA	0.04	0.04	0.04	0.02
Waikato	14474	0.37	0.38	0.53	0.34	0.21
Awakino	383	0.10	0.09	0.09	0.09	0.05
Mokau	1446	0.66	0.37	0.37	0.34	0.21
Piako	1482	0.03	0.02	0.02	0.02	0.01
Tairua	223	0.02	0.02	0.02	0.02	0.01
Waihou	1983	0.16	0.12	0.12	0.10	0.06
Waikato	14474	0.37	0.38	0.53	0.34	0.21
Bay of Plenty						
Kaituna	1205	0.04	0.04	0.04	0.03	0.02
Motu	1426	3.51	3.53	3.53	3.20	1.95
Rangitaiki	2990	0.08	0.07	0.21	0.07	0.04
Tarawera	841	0.07	0.03	0.03	0.03	0.02
Waioeka (Otara Branch)	332	NA	0.09	0.09	0.08	0.05
Waioeka (Waioeka Branch)	842	0.69	0.70	0.70	0.64	0.39
Wairoa	3556	1.10	0.33	0.33	0.29	0.18
Whakatane	1745	0.61	0.61	0.61	0.55	0.33
Gisborne						
Hikuwai / Uawa	539	4.96	4.25	4.25	3.85	2.34
Waiapu/Poroporo	1734	35.07	39.62	39.62	35.85	21.83
Waipaoa	2183	14.66	9.89	9.89	8.95	5.45
Hawke's Bay						
Esk	268	0.35	0.35	0.35	0.31	0.19
Mohaka	2440	1.37	1.36	1.36	1.23	0.75
Ngaruroro	2014	1.33	1.31	1.31	1.18	0.72

River	Area (km^2)	Hicks et al. (2011) Potential load (Mt/y)	Modelled load (Mt/y)		Percentage contribution (%)	
			Actual	*Potential*	*Island*	*National*
Porangahau	856	0.41	0.84	0.84	0.76	0.46
Tataekure	835	NA	0.16	0.16	0.14	0.09
Tukituki	2507	1.04	1.02	1.02	0.92	0.56
Wairoa	3556	1.10	0.33	0.33	0.29	0.18
Taranaki						
Patea	1049	0.31	0.10	0.36	0.09	0.05
Waitara	1139	0.97	0.95	0.95	0.86	0.52
Waitotara	1162	0.48	0.52	0.52	0.47	0.29
Manawatu/Whanganui						
Manawatu	5876	3.74	2.42	2.44	2.19	1.33
Rangitikei	3929	1.10	0.82	0.86	0.75	0.45
Turakina	956	0.30	0.29	0.29	0.26	0.16
Whangaehu	1992	0.69	0.69	0.69	0.62	0.38
Whanganui	7134	4.70	3.44	3.44	3.11	1.89
Wellington						
Hutt	638	0.13	0.09	0.09	0.08	0.05
Otaki	358	0.17	0.17	0.17	0.15	0.09
Pahaoa	651	0.44	0.51	0.51	0.46	0.28
Ruamahanga	3434	0.60	0.63	0.64	0.57	0.35
Whareama	532	0.67	1.28	1.28	1.16	0.70
Tasman/Nelson						
Aorere	686	0.11	0.12	0.12	0.17	0.07
Motueka	2061	0.35	0.29	0.29	0.40	0.16
Takaka	870	0.08	0.11	0.12	0.16	0.06
Waimea	770	0.11	0.09	0.09	0.12	0.05
Marlborough						
Awatere	1574	0.21	0.24	0.24	0.33	0.13
Pelorus	890	0.24	0.28	0.28	0.39	0.15
Wairau	4168	0.84	0.78	0.78	1.10	0.43
West Coast						
Karamea	1211	0.15	0.15	0.15	0.21	0.08
Arawhata	933	7.18	4.36	4.36	6.14	2.40
Buller	6427	2.71	4.56	4.56	6.43	2.51
Grey	3927	2.07	1.59	1.59	2.24	0.88
Haast	1356	5.93	5.11	5.11	7.20	2.82

River	Area (km^2)	Hicks et al. (2011) Potential load (Mt/y)	Modelled load (Mt/y)		Percentage contribution (%)	
			Actual	*Potential*	*Island*	*National*
Hokitika	1067	6.20	3.57	3.57	5.03	1.97
Mokihinui	751	0.28	0.41	0.41	0.57	0.22
Taramakau	1001	2.20	2.14	2.14	3.01	1.18
Waiho	290	3.41	2.43	2.43	3.42	1.34
Waitaha	315	2.82	1.24	1.24	1.75	0.68
Whataroa	594	4.82	4.39	4.39	6.18	2.42
Canterbury						
Orari	716	0.06	0.14	0.14	0.20	0.08
Rangitata	1810	1.60	1.60	1.60	2.26	0.88
Ashburton	1597	0.31	0.31	0.31	0.44	0.17
Ashley	1185	0.09	0.22	0.22	0.31	0.12
Clarence	3304	0.65	0.85	0.85	1.20	0.47
Conway	503	0.22	0.07	0.07	0.10	0.04
Hurunui	2669	0.53	0.46	0.46	0.64	0.25
Opihi	2372	0.16	0.12	0.19	0.17	0.07
Pareora	539	0.05	0.03	0.03	0.04	0.01
Rakaia	2832	4.15	3.92	3.92	5.52	2.16
Waiau	3331	2.80	2.59	2.59	3.65	1.43
Waihao	555	0.03	0.03	0.03	0.04	0.02
Waimakariri	3111	3.14	2.93	2.93	4.13	1.62
Waipara	725	0.06	0.10	0.10	0.14	0.05
Otago						
Clutha	20840	2.39	0.33	2.38	0.47	0.18
Kakanui	897	0.11	0.07	0.07	0.09	0.04
Shag	542	0.06	0.03	0.03	0.05	0.02
Taieri	5706	0.32	0.24	0.25	0.33	0.13
Waitaki	11904	0.69	0.13	0.23	0.18	0.07
Southland						
Aparima	1569	0.09	0.06	0.06	0.09	0.04
Mataura	5388	0.69	0.28	0.28	0.40	0.16
Oreti	3532	0.26	0.18	0.18	0.25	0.10
Waiau	3331	2.80	2.59	2.59	3.65	1.43

Table G-2: Modelled loads (Mt/y) for current land cover, uncorrected to observed loads. 'Actual' modelled loads include entrapment in artificial lakes; 'Potential' modelled loads do not. Contribution percentages to North/South Island and national totals calculated with actual loads.

River	Modelled load (Mt/y)		Percentage contribution to island and national totals (%)	
	Actual	*Potential*	*Island*	*National*
Northland				
Wairoa	0.28	0.28	0.25	0.16
Waitangi	0.02	0.02	0.01	0.01
Auckland				
Hoteo	0.06	0.06	0.06	0.04
Waikato	0.42	0.55	0.38	0.24
Awakino	0.11	0.11	0.10	0.06
Mokau	0.41	0.41	0.37	0.23
Piako	0.03	0.03	0.03	0.02
Tairua	0.02	0.02	0.02	0.01
Waihou	0.08	0.08	0.07	0.05
Waikato	0.42	0.55	0.38	0.24
Bay of Plenty				
Kaituna	0.03	0.03	0.03	0.02
Motu	2.27	2.27	2.07	1.29
Rangitaiki	0.04	0.12	0.04	0.03
Tarawera	0.03	0.03	0.03	0.02
Waioeka (Otara Branch)	0.14	0.14	0.13	0.08
Waioeka (Waioeka Branch)	0.38	0.38	0.35	0.22
Waioeka total	0.52	0.52	0.48	0.30
Wairoa	0.28	0.28	0.25	0.16
Whakatane	0.27	0.27	0.25	0.15
Gisborne				
Hikuwai / Uawa	5.04	5.04	4.59	2.86
Waiapu/Poroporo	38.89	38.89	35.42	22.09
Waipaoa	12.70	12.70	11.56	7.21
Hawke's Bay				
Esk	0.08	0.08	0.07	0.04
Mohaka	0.89	0.89	0.81	0.51
Ngaruroroa	0.84	0.84	0.77	0.48
Porangahau	0.84	0.84	0.76	0.47

River	Modelled load (Mt/y)		Percentage contribution to island and national totals (%)	
	Actual	*Potential*	*Island*	*National*
Tataekurea	0.16	0.16	0.14	0.09
Tukituki	0.63	0.63	0.57	0.36
Wairoa	0.28	0.28	0.25	0.16
Taranaki				
Patea	0.10	0.36	0.09	0.05
Waitara	0.47	0.47	0.43	0.27
Waitotara	0.52	0.52	0.47	0.30
Manawatu/Whanganui				
Manawatu	1.85	1.87	1.68	1.05
Rangitikei	0.65	0.68	0.59	0.37
Turakina	0.25	0.25	0.23	0.14
Whangaehu	0.46	0.46	0.42	0.26
Whanganui	2.43	2.43	2.21	1.38
Wellington				
Hutt	0.11	0.11	0.10	0.06
Otaki	0.16	0.16	0.15	0.09
Pahaoa	0.52	0.52	0.47	0.29
Ruamahanga	0.63	0.64	0.57	0.35
Whareama	2.30	2.30	2.09	1.31
Tasman/Nelson				
Aorere	0.21	0.21	0.31	0.12
Motueka	0.28	0.28	0.42	0.16
Takaka	0.12	0.13	0.18	0.07
Waimea	0.08	0.08	0.11	0.04
Marlborough				
Awatere	0.24	0.24	0.36	0.13
Pelorus	0.27	0.27	0.40	0.15
Wairau (Diversion)	0.79	0.79	1.19	0.45
West Coast				
Karamea	0.23	0.23	0.35	0.13
Arawhata	4.36	4.36	6.58	2.48
Buller	1.86	1.86	2.81	1.06
Grey	1.29	1.29	1.95	0.73
Haast	6.84	6.84	10.32	3.88
Hokitika	3.15	3.15	4.75	1.79
Mokihinui	0.24	0.24	0.36	0.13
Taramakau	2.19	2.19	3.30	1.24

River	Modelled load (Mt/y)		Percentage contribution to island and national totals (%)	
	Actual	*Potential*	*Island*	*National*
Waiho	2.43	2.43	3.66	1.38
Waitaha	1.24	1.24	1.86	0.70
Whataroa	3.65	3.65	5.51	2.07
Canterbury				
Orari	0.14	0.14	0.22	0.08
Rangitata	2.53	2.53	3.82	1.44
Ashburton	0.46	0.46	0.69	0.26
Ashley	0.22	0.22	0.33	0.13
Clarence	0.82	0.82	1.24	0.47
Conway	0.07	0.07	0.11	0.04
Hurunui	0.52	0.52	0.78	0.29
Opihi	0.12	0.19	0.18	0.07
Pareora	0.03	0.03	0.04	0.02
Rakaia	2.76	2.76	4.16	1.57
Waiau	1.25	1.25	1.89	0.71
Waihao	0.03	0.03	0.05	0.02
Waimakariri	1.81	1.81	2.73	1.03
Waipara	0.10	0.10	0.14	0.05
Otago				
Clutha (Matau Branch)	0.38	2.03	0.58	0.22
Kakanui	0.07	0.07	0.10	0.04
Shag	0.03	0.03	0.05	0.02
Taieri	0.24	0.25	0.36	0.14
Waitaki	0.12	0.22	0.19	0.07
Southland				
Aparima	0.07	0.07	0.10	0.04
Mataura	0.47	0.47	0.70	0.26
Oreti	0.18	0.18	0.27	0.10
Waiau	1.25	1.25	1.89	0.71

Appendix H Estimated loads at the mouths of major river systems – historic land cover scenarios

Table H-1: Modelled major river loads for the historic land cover scenarios. 'Actual' modelled current loads include entrapment in artificial lakes; 'Potential' modelled current loads do not.

River	Pre-European land cover			Pre-human land cover		
	Load (Mt/y)	Percentage of current scenario		Load (Mt/y)	Percentage of current scenario	
		Actual	*Potential*		*Actual*	*Potential*
Northland						
Wairoa	0.18	64%	64%	0.18	64%	64%
Waitangi	0.01	68%	68%	0.01	68%	68%
Auckland						
Hoteo	0.04	70%	70%	0.04	70%	70%
Waikato						
Awakino	0.08	73%	73%	0.08	73%	73%
Mokau	0.29	71%	71%	0.29	71%	71%
Piako	0.02	62%	62%	0.02	62%	62%
Tairua	0.02	91%	91%	0.02	91%	91%
Waihou	0.06	75%	75%	0.06	75%	75%
Waikato	0.35	85%	64%	0.35	84%	64%
Bay of Plenty						
Kaituna	0.02	76%	76%	0.02	76%	76%
Motu	1.81	80%	80%	1.81	80%	80%
Rangitaiki	0.12	271%	97%	0.12	267%	96%
Tarawera	0.03	89%	89%	0.03	89%	89%
Waioeka (Otara Branch)	0.14	97%	97%	0.14	97%	97%
Waioeka (Waioeka Branch)	0.34	89%	89%	0.34	89%	89%
Waioeka total	0.32	1.61	1.61	0.32	161%	161%
Wairoa	0.18	64%	64%	0.18	64%	64%
Whakatane	0.26	98%	98%	0.26	98%	98%
Gisborne						
Hikuwai / Uawa	3.66	73%	73%	3.66	73%	73%
Waiapu/Poroporo	28.00	72%	72%	28.00	72%	72%
Waipaoa	9.56	75%	75%	9.56	75%	75%
Hawke's Bay						
Esk	0.05	65%	65%	0.05	65%	65%

River	Pre-European land cover			Pre-human land cover		
	Load (Mt/y)	Percentage of current scenario		Load (Mt/y)	Percentage of current scenario	
		Actual	*Potential*		*Actual*	*Potential*
Mohaka	0.85	95%	95%	0.85	95%	95%
Ngaruroro	0.66	79%	79%	0.66	78%	78%
Porangahau	0.44	53%	53%	0.44	53%	53%
Tataekure	0.11	73%	73%	0.11	73%	73%
Tukituki	0.40	63%	63%	0.37	58%	58%
Wairoa	0.18	64%	64%	0.18	64%	64%
Taranaki						
Patea	0.27	278%	75%	0.27	278%	75%
Waitara	0.36	76%	76%	0.36	76%	76%
Waitotara	0.45	86%	86%	0.45	86%	86%
Manawatu/Whanganui						
Manawatu	1.04	56%	56%	1.04	56%	56%
Rangitikei	0.48	73%	69%	0.47	72%	68%
Turakina	0.13	52%	52%	0.13	52%	52%
Whangaehu	0.26	56%	56%	0.26	56%	56%
Whanganui	1.88	78%	78%	1.88	78%	78%
Wellington						
Hutt	0.10	97%	97%	0.10	97%	97%
Otaki	0.16	99%	99%	0.16	99%	99%
Pahaoa	0.40	78%	78%	0.40	78%	78%
Ruamahanga	0.61	76%	76%	0.60	74%	74%
Whareama	1.47	64%	64%	1.47	64%	64%
Tasman/Nelson						
Aorere	0.20	96%	96%	0.20	96%	96%
Motueka	0.26	93%	93%	0.26	93%	93%
Takaka	0.13	103%	96%	0.12	103%	96%
Waimea	0.07	92%	92%	0.07	92%	92%
Marlborough						
Awatere	0.15	62%	62%	0.15	61%	61%
Pelorus	0.26	97%	97%	0.26	97%	97%
Wairau	0.68	85%	85%	0.67	85%	85%
West Coast						
Karamea	0.23	99%	99%	0.23	99%	99%
Arawhata	4.28	98%	98%	4.37	100%	100%

River	Pre-European land cover			Pre-human land cover		
	Load (Mt/y)	Percentage of current scenario		Load (Mt/y)	Percentage of current scenario	
		Actual	*Potential*		*Actual*	*Potential*
Buller	1.77	95%	95%	1.77	95%	95%
Grey	1.25	97%	97%	1.24	96%	96%
Haast	6.25	91%	91%	6.33	93%	93%
Hokitika	3.16	101%	101%	3.19	101%	101%
Mokihinui	0.23	97%	97%	0.23	97%	97%
Taramakau	2.03	93%	93%	2.03	93%	93%
Waiho	2.21	91%	91%	2.25	93%	93%
Waitaha	1.26	102%	102%	1.29	104%	104%
Whataroa	3.29	90%	90%	3.37	92%	92%
Canterbury						
Orari	0.11	74%	74%	0.10	70%	70%
Rangitata	2.20	87%	87%	2.21	87%	87%
Ashburton	0.34	75%	75%	0.33	73%	73%
Ashley	0.16	75%	75%	0.16	71%	71%
Clarence	0.54	66%	66%	0.53	65%	65%
Conway	0.05	66%	66%	0.05	62%	62%
Hurunui	0.40	78%	78%	0.38	74%	74%
Opihi	0.14	116%	75%	0.13	111%	71%
Pareora	0.02	64%	64%	0.02	59%	59%
Rakaia	2.37	86%	86%	2.37	86%	86%
Waiau	1.02	82%	82%	0.99	79%	79%
Waihao	0.02	68%	68%	0.02	63%	63%
Waimakariri	1.45	80%	80%	1.44	79%	79%
Waipara	0.06	61%	61%	0.05	55%	55%
Otago						
Clutha	1.68	438%	83%	1.63	425%	80%
Kakanui	0.04	60%	60%	0.04	55%	55%
Shag	0.02	63%	63%	0.02	58%	58%
Taieri	0.17	71%	67%	0.17	70%	66%
Waitaki	0.16	128%	70%	0.16	127%	70%
Southland						
Aparima	0.05	82%	82%	0.05	80%	80%
Mataura	0.34	72%	72%	0.32	68%	68%
Oreti	0.13	72%	72%	0.12	70%	70%

River	Pre-European land cover			Pre-human land cover		
	Load (Mt/y)	Percentage of current scenario		Load (Mt/y)	Percentage of current scenario	
		Actual	*Potential*		*Actual*	*Potential*
Waiau	1.02	82%	82%	0.99	79%	79%

Appendix I Lake sediment entrapment under current land cover, including artificial lakes

Table I-1: Sediment passing factor, sediment inflow, and sediment entrapment rate in the 100 lakes with the largest entrapment rates. Sediment passing factor is the proportion of the sediment inflow that exits the lake (equal to 1 - trap efficiency). Sediment inflow estimated for current land cover using model results corrected to observed sediment loads. Lakes are listed in order of decreasing sediment entrapment rate.

Lake ID	Name	Region	Type	Sediment passing factor	Sediment inflow (t/y)	Sediment entrapment (t/y)
54672	Lake Wanaka	Otago	Natural	0.02	3635916	3556248
53532	Lake Wakatipu	Otago	Natural	0.02	3188272	3121318
54737	Lake Dunstan	Otago	Artificial	0.11	1987281	1768680
46564	Lake Pukaki	Canterbury	Natural	0.03	1693019	1648495
54736	Lake Hawea	Otago	Natural	0.02	1572247	1539903
45514	Lake Ohau	Canterbury	Natural	0.03	754907	734405
47228	Lake Tekapo	Canterbury	Natural	0.02	478479	466773
52566	Lake Te Anau	Southland	Natural	0.02	451436	441936
47067	Lake Alabaster	Southland	Natural	0.18	450510	369674
7408	Lake Benmore	Canterbury	Artificial	0.04	315982	303479
46723	Lake Moeraki	West Coast	Natural	0.13	340195	294391
54356	Lake Mckerrow	Southland	Natural	0.07	297943	278207
38974	Lake Brunner (Moana)	West Coast	Natural	0.03	284169	276400
7506	Lake Rotorangi	Taranaki	Artificial	0.16	311463	262375
46964	Lake Wahapo	West Coast	Natural	0.08	256285	234849
54486	Lake Williamson	West Coast	Natural	0.15	272678	230635
7633	Lake Roxburgh	Otago	Artificial	0.35	350458	227798
54734	Lake Taupo	Waikato	Natural	0.02	203604	199427
47414	Ice Lake	West Coast	Natural	0.26	262654	193935
54738	Lake Sumner	Canterbury	Natural	0.03	157155	152695
26887	Lake Rotoroa	Tasman-Nelson	Natural	0.02	154073	150248
54435	Lake Wilmot	Southland	Natural	0.13	158935	137956
46725	Lake Paringa	West Coast	Natural	0.04	139809	133761
53353	North Mavora Lake	Southland	Natural	0.05	116243	110904
54735	Lake Manapouri	Southland	Natural	0.02	107420	104817
54741	Lake Matiri	Tasman-Nelson	Natural	0.48	188463	98566
7408	Lake Aviemore	Canterbury	Artificial	0.137	104670	90319
40124	Lake Matahina	Bay of Plenty	Artificial	0.44	156664	87752
46959	Lake Mapourika	West Coast	Natural	0.03	87142	84911

46918	Lake Barrowman	West Coast	Natural	0.46	156784	84073
48451	Lake Coleridge	Canterbury	Natural	0.02	80217	78600
1708	Lake Wairarapa	Wellington	Natural	0.08	84843	78203
47892	Lake Heron	Canterbury	Natural	0.03	69244	67286
None	Lake Opua	Canterbury	Artificial	0.06	70816	66657
40050	Lake Waikaremoana	Hawke's Bay	Natural	0.02	65353	64009
54132	Diamond Lake	Otago	Natural	0.11	69871	62398
27762	Lake Rotoiti	Tasman-Nelson	Natural	0.03	63829	61828
39837	Lake Christabel	West Coast	Natural	0.03	63117	60952
46212	Lake Douglas	West Coast	Natural	0.15	71266	60623
45360	Lucidus Lake	Otago	Natural	0.05	56582	53934
39876	Lake Aniwhenua	Bay of Plenty	Artificial	0.71	181336	53313
13957	Lake Atiamuri	Waikato	Artificial	0.46	98951	53081
54177	Lochnagar	Otago	Natural	0.02	53621	52336
46140	Lake Ellery	West Coast	Natural	0.04	51866	49847
26111	Lake Hauroko	Southland	Natural	0.02	43582	42678
49180	Lake Whangape	Waikato	Natural	0.11	45766	40591
18610	Lake Moawhango	Manawatu-Whanganui	Artificial	0.07	40537	37707
39056	Lake Minchin	Canterbury	Natural	0.37	55021	34816
48660	Lake Pearson	Canterbury	Natural	0.05	31574	29957
13876	Lake Maraetai	Waikato	Artificial	0.40	46596	27958
53062	Lake Ada	Southland	Natural	0.28	38735	27740
26036	Lake Poteriteri	Southland	Natural	0.02	27890	27274
11614	Falls Dam	Otago	Artificial	0.08	25810	23789
53966	Cloudmaker Lake	West Coast	Natural	0.09	26267	23788
45525	Lake Ruataniwha	Canterbury	Artificial	0.05	24805	23564
48395	Ivory Lake	West Coast	Natural	0.24	30360	23054
13873	Lake Whakamaru	Waikato	Artificial	0.50	45684	22842
11133	Lake Rotorua	Bay of Plenty	Natural	0.03	22538	21925
45379	Crucible Lake	Otago	Natural	0.11	23133	20580
52243	Lake Marchant	Southland	Natural	0.08	22072	20284
14546	Lake Arapuni	Waikato	Artificial	0.42	33955	19694
29244	Lake Monowai	Southland	Natural	0.02	18303	17904
36046	Catlins Lake	Otago	Natural	0.06	18732	17620
45151	Lake Mahinerangi	Otago	Artificial	0.03	17130	16659

14680	Lake Karapiro	Waikato	Artificial	0.55	36298	16334
4342	Mangahao Upper No 1 Reservior	Manawatu-Whanganui	Artificial	0.66	47910	16327
38955	Lake Poerua	West Coast	Natural	0.11	17606	15699
54561	Waiuna Lagoon	Southland	Natural	0.48	29536	15499
45541	Lake Poaka	Canterbury	Natural	0.05	16255	15442
47440	Abel Lake	West Coast	Natural	0.63	39759	14872
45362	Lake Castalia	Otago	Natural	0.51	29662	14400
53549	Moke Lake	Otago	Natural	0.03	14061	13656
53877	Lake Mckellar	Otago	Natural	0.07	14277	13300
41679	Lake Eggeling	West Coast	Natural	0.56	28087	12447
26477	Lake Tennyson	Canterbury	Natural	0.03	12373	11978
38502	Lake Kaniere	West Coast	Natural	0.02	11663	11418
25212	Lake Guyon	Canterbury	Natural	0.05	11752	11175
48663	Lake Grasmere	Canterbury	Natural	0.06	11909	11147
26514	Lake Constance	Tasman-Nelson	Natural	0.03	10933	10566
32805	Hatuma Lake	Hawke's Bay	Natural	0.06	11169	10526
43562	Otopotehetehe Lake (Mud Lake)	Gisborne	Natural	0.12	11750	10351
21367	Lake Rotoaira	Waikato	Natural	0.04	10516	10140
45924	Lake Unknown	Otago	Natural	0.03	9701	9452
46775	Lake Rototekoiti	West Coast	Natural	0.09	10393	9431
28835	Lake Widgeon	Southland	Natural	0.12	10596	9361
37855	Lake Ruapapa	Hawke's Bay	Natural	0.61	23740	9338
35662	Lake Poukawa	Hawke's Bay	Natural	0.07	10023	9281
25002	Lake Stanley	Tasman-Nelson	Natural	0.15	10793	9198
54088	Lake Harris	Otago	Natural	0.11	9964	8832
54141	Lake Reid	Otago	Natural	0.10	9416	8474
39225	Lake Haupiri	West Coast	Natural	0.09	9086	8283
53145	Lake Nigel	Otago	Natural	0.32	11791	7978
29547	Loch Maree	Southland	Natural	0.57	18656	7961
54094	Lake Wilson	Otago	Natural	0.05	8003	7621
50782	Lake Waikare	Waikato	Natural	0.03	7830	7585
24795	Lake Jeanette	Tasman-Nelson	Natural	0.59	17945	7305
54128	Lake Mystery	Otago	Natural	0.50	14310	7147
38665	Lady Lake	West Coast	Natural	0.06	7574	7118
39050	Lake Kaurapataka	West Coast	Natural	0.15	8228	7005
46160	Lake Nisson	West Coast	Natural	0.14	8085	6968
54190	Lake Hayes	Otago	Natural	0.02	6964	6798

Appendix J Coastal hydrosystem re-classifications

For this study, some coastal hydrosystems were reclassified from the classifications suggested by Hume et al. (2016). This was based on a combination of results from the deposition model, data in coastal explorer, and inspection of satellite imagery.

Table J-1: Estuaries that have been reclassified in this report. The eight estuaries in this table were re-classified based on results from the deposition model, data in the coastal explorer database, and inspection of satellite imagery.

Estuary ID	Estuary name	Old NZCHS classification	Revised NZCHS classification
8	Ferrer Creek	6C Tidal river mouth, barrier beach enclosed	8 Shallow drowned valley
85	Weiti River	6B Tidal river mouth, spit enclosed	8 Shallow drowned valley
128	Waioeka River	7A Tidal lagoon, permanently open	6A Tidal river mouth, unrestricted
129	Waiaua River	7A Tidal lagoon, permanently open	6B Tidal river mouth, spit enclosed
148	Wairoa River	8 Shallow drowned valley	6C Tidal river mouth, barrier beach enclosed
165	Oterei River	6C Tidal river mouth, barrier beach enclosed	2B Waituna-type lagoon, valley basin
1002	Wairau River	6B Tidal river mouth, spit enclosed	7A Tidal lagoon, permanently open
1136	Anaweka River	5C Freshwater stream, barrier beach enclosed	6C Tidal river mouth, barrier beach enclosed

Appendix K Results of sedimentation modelling of coastal hydrosystems

Estuary number	Estuary/Coastal hydrosystem name	Lat	Long	NZCHS Type	Current sediment load (t/y)	Pre-European sediment load (t/y)	Pre-human sediment load (t/y)	Current deposition (mm/y)	Pre-European deposition (mm/y)	Pre-human deposition (mm/y)	Trap efficiency
1181	Admiralty Bay	-40.945	173.869	11	2816	1738	1738	0.10	0.06	0.06	0.874
152	Ahuriri Estuary	-39.476	176.896	7A	15143	8234	8233	3.53	1.92	1.92	0.961
1028	Akaroa Harbour	-43.894	172.959	9	6468	3635	3628	0.10	0.06	0.06	0.990
1062	Akatore Creek	-46.116	170.193	7A	4064	3935	3708	6.73	6.51	6.14	0.817
157	Akitio River	-40.612	176.429	6B	825406	465099	465099	748.12	421.55	421.55	0.354
1138	Anatori River	-40.701	172.363	3B	19611	19520	19488	18.62	18.54	18.50	0.134
1136	Anaweka River	-40.750	172.285	6C	2804	2604	2559	2.46	2.28	2.24	0.667
211	Aotea Harbour System	-38.018	174.783	8	26590	16721	16721	0.54	0.34	0.34	0.976
151	Aropaoanui River	-39.286	177.005	4C	44803	28471	28471	259.97	165.21	165.21	0.550
1038	Ashburton River	-44.054	171.808	3B	312155	340108	334490	561.11	611.36	601.26	0.114
1008	Ashley River	-43.271	172.727	3D	223003	167011	158754	67.43	50.50	48.00	0.691
1010	Avon-Heathcote River	-43.559	172.759	7A	3685	1045	975	0.32	0.09	0.08	0.969
260	Awaroa Bay	-36.846	175.104	11	1372	816	816	0.32	0.19	0.19	0.982
44	Awahoa Bay	-35.747	174.558	11	47	23	23	0.07	0.03	0.03	0.990
199	Awakino River	-38.666	174.610	6B	94239	80247	80247	0.00	0.00	0.00	0.000
6	Awapoko River	-34.968	173.431	6B	12912	8350	8350	9.76	6.31	6.31	0.705
1153	Awaroa Inlet	-40.852	173.033	7A	10064	10031	10024	2.54	2.53	2.53	0.890
205	Awaroa River KHS	-38.082	174.895	8	23382	15999	15999	6.09	4.17	4.17	0.893
1097	Awarua River	-44.291	168.114	3C	16423	16411	16411	0.00	0.00	0.00	0.000
1003	Awatere River	-41.606	174.167	3B	237867	146752	145843	258.98	159.78	158.79	0.142
166	Awhea River	-41.510	175.529	6C	823360	527268	527268	4692.99	3005.33	3005.33	0.486
1154	Bark Bay	-40.920	173.059	7A	1013	1013	1013	1.03	1.03	1.03	0.780
1135	Big River	-40.764	172.255	5C	21129	21384	20837	16.34	16.54	16.11	0.289
1079	Big River (Lake Hakapoua)	-46.220	166.925	9	6078	6040	6037	0.69	0.69	0.69	0.939
28	Bland Bay	-35.342	174.374	11	124	108	108	0.02	0.02	0.02	0.990
1092	Bligh Sound	-44.765	167.483	10	14026	14250	14462	0.27	0.27	0.28	0.606
1013	Blind/Big Bay	-43.613	172.886	11	309	158	149	0.19	0.10	0.09	0.990
1054	Blueskin Bay	-45.727	170.608	7A	4892	3856	3843	0.51	0.40	0.40	0.970
1075	Bluff Harbour	-46.605	168.360	8	236	289	306	0.00	0.00	0.00	0.979
251	Bon Accord Harbour	-36.424	174.813	11	394	391	391	0.10	0.10	0.10	0.986
1081	Breaksea/Dusky Sound	-45.616	166.569	10	72563	73028	73495	0.13	0.14	0.14	0.791
1126	Buller River	-41.729	171.588	6B	4562899	1766641	1766571	203.39	78.75	78.75	0.160
1098	Cascade River	-44.025	168.349	6B	534024	562888	597683	2.30	2.43	2.58	0.006
1087	Caswell Sound	-45.000	167.130	10	6327	6530	6590	0.13	0.13	0.13	0.524
1180	Catherine Cove	-40.878	173.887	11	702	697	697	0.12	0.12	0.12	0.987
1066	Catlins River	-46.485	169.729	7A	15310	8848	8670	1.15	0.66	0.65	0.883

Estuary number	Estuary/Coastal hydrosystem name	Lat	Long	NZCHS Type	Current sediment load (t/y)	Pre-European sediment load (t/y)	Pre-human sediment load (t/y)	Current deposition (mm/y)	Pre-European deposition (mm/y)	Pre-human deposition (mm/y)	Trap efficiency
1091	Catseye Bay	-44.806	167.382	11	2473	2548	2548	1.65	1.70	1.70	0.859
1080.1	Chalky Inlet	-46.030	166.489	10	9125	9036	9014	0.04	0.04	0.04	0.776
1086	Charles Sound	-45.046	167.086	10	9834	10000	10086	0.24	0.25	0.25	0.612
1064	Clutha River	-46.333	169.839	6B	344473	1688258	1638588	1.38	6.74	6.54	0.037
1082	Coal River	-45.494	166.704	11	784	785	784	0.15	0.15	0.15	0.943
104	Colville Bay	-36.620	175.425	8	4053	3132	3132	0.57	0.44	0.44	0.973
103	Coromandel Harbour	-36.798	175.431	8	6489	6074	6074	0.17	0.16	0.16	0.982
1171	Croisilles Harbour	-41.044	173.633	9	13686	13623	13623	0.20	0.20	0.20	0.982
1083	Dagg Sound	-45.391	166.764	10	3890	3878	3880	0.12	0.12	0.12	0.729
1027	Damons Bay	-43.889	172.992	11	234	142	142	0.22	0.14	0.14	0.990
1018	Decanter Bay	-43.649	173.002	11	376	198	198	0.30	0.16	0.16	0.987
25	Deep Water Cove	-35.198	174.292	11	163	162	162	0.08	0.08	0.08	0.989
1169	Delaware Estuary	-41.161	173.441	7A	12668	11751	11751	2.43	2.25	2.25	0.891
1120	Deverys Creek	-42.195	171.311	4B	1196	1137	1137	5.11	4.86	4.86	0.917
1113	Duffers Creek/Te Rahotaiepa River	-42.992	170.583	6D	4038	3975	3975	0.01	0.01	0.01	0.001
1161	Ferrer Creek	-41.070	173.007	8	498	376	376	1.44	1.09	1.09	0.891
245	Firth of Thames	-36.891	175.303	9	152517	90931	90931	0.14	0.08	0.08	0.969
94	Firth of Thames System	-36.891	175.303	9	152517	90931	90931	0.14	0.08	0.08	0.969
1026	Flea Bay	-43.880	173.020	11	576	380	380	0.55	0.36	0.36	0.983
1156	Frenchman Bay	-40.937	173.058	7A	198	198	198	2.35	2.35	2.35	0.910
253	Gardiner Gap	-36.767	174.889	11	78	38	38	0.14	0.07	0.07	0.984
1090	George Sound	-44.844	167.348	10	15493	15598	15608	0.21	0.21	0.21	0.639
1141	Green Hills Stream	-40.504	172.650	3C	359	349	349	0.93	0.91	0.91	0.600
1177	Greville Harbour	-40.825	173.789	11	3565	3475	3475	0.20	0.19	0.19	0.982
1119	Grey River	-42.441	171.191	6C	1599695	1252964	1248580	53.37	41.80	41.66	0.054
1071	Haldane Estuary	-46.668	169.032	7A	4318	3528	3528	1.43	1.17	1.17	0.936
1134	Heaphy River	-40.988	172.102	5A	14333	14361	14260	0.42	0.42	0.42	0.004
30	Helena Bay	-35.423	174.387	11	2231	1789	1789	0.52	0.42	0.42	0.976
226	Herekino Harbour	-35.297	173.148	8	8587	5730	5730	1.11	0.74	0.74	0.959
84	Hobbs Bay (Gulf Harbour)	-36.632	174.784	11	52	40	40	0.14	0.11	0.11	0.973
224	Hokianga Harbour System	-35.541	173.350	8	182244	134954	134954	1.10	0.82	0.82	0.967
1096	Hollyford River	-44.338	168.001	6B	21471	22811	23639	1.35	1.44	1.49	0.150
1058	Hoopers Inlet	-45.882	170.679	7A	294	180	180	0.05	0.03	0.03	0.982
40	Horahora River	-35.669	174.516	7A	5199	3807	3807	2.03	1.48	1.48	0.862
1031	Horseshoe Bay	-43.882	172.226	11	332	226	226	0.21	0.15	0.15	0.987
3	Houhora Harbour	-34.836	173.174	8	1051	1286	1286	0.05	0.06	0.06	0.981
263	Huruhi Bay	-36.814	175.004	11	36	32	32	0.01	0.00	0.00	0.987
1006	Hurunui River	-42.906	173.292	3B	456523	403757	382889	0.00	0.00	0.00	0.000

Estuary number	Estuary/Coastal hydrosystem name	Lat	Long	NZCHS Type	Current sediment load (t/y)	Pre-European sediment load (t/y)	Pre-human sediment load (t/y)	Current deposition (mm/y)	Pre-European deposition (mm/y)	Pre-human deposition (mm/y)	Trap efficiency
1029	Island Bay	-43.895	172.866	11	282	147	147	0.92	0.48	0.48	0.983
254	Islington Bay	-36.797	174.904	11	12	12	12	0.00	0.00	0.00	0.987
1077	Jacobs River (Riverton) Estuary	-46.361	168.027	7A	64741	54189	52462	5.13	4.30	4.16	0.796
1128	Jones Creek	-41.681	171.771	4E	1356	1258	1258	9.49	8.80	8.80	0.670
1060	Kaikorai Stream	-45.937	170.391	6C	1140	731	731	0.79	0.50	0.50	0.662
221	Kaipara Harbour System	-36.454	174.088	8	498474	302072	302072	0.44	0.27	0.27	0.980
203	Kaitawa Inlet KHS	-38.102	174.850	8	126	59	59	0.14	0.07	0.07	0.982
1160	Kaiteretere Estuary	-41.041	173.020	7A	492	394	394	1.77	1.42	1.42	0.935
1047	Kakanui River	-45.191	170.901	6B	66485	39660	36802	97.00	57.86	53.69	0.417
132	Karakatuwhero River	-37.618	178.346	3C	864311	732827	732827	0.00	0.00	0.00	0.000
1132	Karamea River	-41.262	172.088	7A	167182	243377	242961	12.93	18.82	18.79	0.460
99	Kauranga River	-37.151	175.538	6A	8213	7962	7962	8.56	8.30	8.30	0.401
210	Kawhia Harbour System (KHS)	-38.089	174.745	8	69239	47704	47704	0.66	0.46	0.46	0.973
209	Kawhia Inlet KHS	-38.086	174.778	8	69239	47704	47704	0.84	0.58	0.58	0.962
110	Kennedy Bay Estuary KBS	-36.674	175.603	7A	4022	3929	3929	4.13	4.04	4.04	0.808
109	Kennedy Bay System (KBS)	-36.675	175.579	11	4022	3929	3929	0.53	0.52	0.52	0.971
214	Kerikeri/Waingaro Arm	-37.790	174.909	8	20982	15928	15928	0.93	0.71	0.71	0.969
100	Kirita Bay	-36.873	175.409	11	726	424	424	1.39	0.81	0.81	0.973
1072	Lake Brunton	-46.658	168.894	7B	60	32	37	0.15	0.08	0.09	0.984
1036	Lake Ellesmere (Te Waihora)	-43.859	172.375	2A	56780	45364	42572	0.19	0.15	0.14	0.998
1035	Lake Forsyth (Te Roto o Wairewa)	-43.829	172.710	2B	7342	3687	3683	0.87	0.44	0.44	0.994
1004	Lake Grassmere	-41.712	174.188	2A	4747	2370	2326	0.23	0.12	0.11	1.000
170	Lake Kohangapiripiri	-41.370	174.848	2B	268	218	218	1.61	1.31	1.31	0.989
169	Lake Kohangatera	-41.379	174.857	2B	1381	1268	1268	4.14	3.80	3.80	0.959
167	Lake Onoke/Turanganui River	-41.413	175.136	2A	634816	613737	599318	53.57	51.79	50.57	0.842
1021	Lavericks Bay	-43.718	173.110	11	627	305	305	0.91	0.44	0.44	0.974
1022	Le Bons Bay	-43.734	173.122	11	1511	833	833	0.43	0.24	0.24	0.981
1150	Ligar Bay	-40.819	172.903	7A	551	465	465	0.93	0.78	0.78	0.901
1019	Little Akaloa Bay	-43.651	173.012	11	1096	583	583	0.39	0.21	0.21	0.985
1014	Little Pigeon Bay	-43.622	172.907	11	168	84	81	0.23	0.12	0.11	0.989
1131	Little Wanganui River	-41.390	172.056	6B	58194	57707	57707	22.11	21.93	21.93	0.220
1030	Long Bay	-43.893	172.855	11	376	217	217	0.29	0.17	0.17	0.987
1089	Looking Glass Bay	-44.918	167.212	11	639	647	648	0.28	0.29	0.29	0.948
238	Lucas Creek WHS	-37.772	174.661	8	725	875	875	0.30	0.37	0.37	0.950
172	Lyall Bay	-41.348	174.800	11	0	0	0	0.00	0.00	0.00	0.994
1011	Lyttelton Harbour	-43.597	172.817	9	4974	2962	2837	0.08	0.05	0.04	0.982
14	Mahinepua Bay	-35.001	173.869	11	303	238	238	0.40	0.31	0.31	0.976
1105	Mahitahi River	-43.596	169.586	6B	1163454	1132772	1149258	44.08	42.91	43.54	0.021

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78	Mahurangi Harbour System	-36.512	174.732	8	11730	9108	9108	0.31	0.24	0.24	0.983
1106	Makawhio River (Jacobs River)	-43.566	169.632	6B	677197	719131	733753	391.44	415.68	424.13	0.538
240	Maketu Estuary	-37.754	176.454	7A	193	175	175	0.06	0.05	0.05	0.955
122	Maketu River	-37.756	176.429	6A	35263	23121	23121	6.93	4.54	4.54	0.643
101	Manaia Harbour	-36.842	175.424	8	4758	4585	4585	0.48	0.46	0.46	0.961
1107	Manakaiaua River	-43.541	169.675	6D	65898	68005	69043	7.14	7.37	7.48	0.038
21	Manawaora Bay	-35.247	174.176	11	619	526	526	0.06	0.05	0.05	0.989
182	Manawatu River	-40.482	175.207	6B	2419374	1041559	1041309	14.12	6.08	6.08	0.019
154	Mangakuri River	-39.949	176.935	6B	505323	270320	270320	3144.12	1681.93	1681.93	0.254
207	Mangaora Inlet KHS	-38.059	174.856	8	996	716	716	1.12	0.81	0.81	0.950
48	Mangawhai Harbour	-36.089	174.609	7A	2891	1863	1863	0.38	0.24	0.24	0.949
90	Mangemangeroa Estuary WES	-36.913	174.956	8	1071	834	834	1.15	0.90	0.90	0.970
8	Mangonui Harbour	-34.978	173.518	8	22194	15372	15372	1.60	1.11	1.11	0.940
1176	Manuhakapakapa Bay	-40.904	173.779	11	1700	1356	1356	0.33	0.26	0.26	0.981
219	Manukau Harbour System (MHS)	-37.072	174.503	8	24699	15968	15968	0.04	0.03	0.03	0.985
140	Maraetaha River	-38.792	177.937	6A	144437	88033	88033	17.20	10.48	10.48	0.010
1158	Marahau River	-40.995	173.012	7A	4626	4382	4382	12.09	11.45	11.45	0.760
201	Marakopa River	-38.309	174.699	6B	68223	43762	43762	11.48	7.37	7.37	0.167
5	Matai Bay	-34.823	173.422	11	54	62	62	0.02	0.02	0.02	0.990
53	Matakana River	-36.403	174.743	8	6431	4659	4659	0.99	0.72	0.72	0.968
37	Matapouri Bay MBS	-35.562	174.511	11	831	622	622	1.27	0.95	0.95	0.955
36	Matapouri Bay System (MBS)	-35.558	174.518	7A	831	622	622	0.56	0.42	0.42	0.932
38	Matapouri Estuary MBS	-35.565	174.511	7A	323	231	231	0.42	0.30	0.30	0.969
255	Matiatia Bay	-36.781	174.983	11	87	49	49	0.15	0.09	0.09	0.986
141	Maungawhio Lagoon	-39.072	177.908	7A	20578	17164	17164	12.36	10.31	10.31	0.865
258	Mawhitipana Bay	-36.776	175.042	11	59	31	31	0.10	0.05	0.05	0.986
1017	Menzies Bay	-43.635	172.970	11	468	233	231	0.30	0.15	0.15	0.989
244	Mercury Bay MBS	-36.808	175.756	11	29348	26016	26016	0.98	0.87	0.87	0.946
112	Mercury Bay System (MBS)	-36.808	175.756	11	29374	26036	26036	0.53	0.47	0.47	0.965
1115	Mikonui River	-42.901	170.765	6C	486211	518061	537373	90.23	96.14	99.73	0.018
1095	Milford Sound	-44.564	167.802	10	44561	68154	70459	0.51	0.78	0.81	0.488
52	Millon Bay	-36.400	174.764	11	568	317	317	0.37	0.20	0.20	0.982
195	Mimi River	-38.955	174.418	6B	65895	53013	53013	86.64	69.70	69.70	0.292
31	Mimiwhangata Bay	-35.429	174.405	11	207	117	117	0.03	0.02	0.02	0.990
95	Miranda Stream	-37.187	175.337	7A	1889	998	998	13.73	7.25	7.25	0.803
1102	Moeraki (Blue) River	-43.699	169.255	4C	51917	52599	53474	0.75	0.76	0.77	0.001
197	Mohakatino River	-38.736	174.597	6B	73814	66586	66586	8.52	7.69	7.69	0.012
198	Mokau River	-38.707	174.602	6B	406535	229367	228459	0.00	0.00	0.00	0.000

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1129	Mokihinui River	-41.522	171.933	6B	373181	288195	288195	19.53	15.08	15.08	0.033
1163	Motueka Estuary North	-41.104	173.032	7A	2	1	1	0.00	0.00	0.00	0.974
1164	Motueka Estuary South	-41.129	173.029	7A	1	2	2	0.00	0.00	0.00	0.974
1162	Motueka River	-41.082	173.023	5B	286537	256837	256508	1.32	1.19	1.19	0.002
1149	Motupipi River	-40.833	172.848	7A	3407	2406	2406	1.64	1.16	1.16	0.871
162	Motuwaireka Stream	-41.087	176.087	4C	148872	115414	115414	493.31	382.44	382.44	0.268
1165	Moutere Inlet	-41.157	173.040	8	10593	6515	6515	0.99	0.61	0.61	0.961
1085	Nancy Sound	-45.102	167.019	10	6028	5148	5151	0.18	0.15	0.15	0.648
1168	Nelson Haven	-41.267	173.258	7A	10623	11977	11964	0.53	0.59	0.59	0.937
1076	New River (Oreti) Estuary	-46.507	168.272	8	186685	129809	125577	2.94	2.04	1.97	0.940
1130	Ngakawau River	-41.606	171.873	6B	44306	42089	42069	13.68	13.00	12.99	0.050
153	Ngaruroro River	-39.568	176.936	6B	1520051	803766	796296	0.00	0.00	0.00	0.000
35	Ngunguru River	-35.636	174.518	7A	5093	4025	4025	0.62	0.49	0.49	0.941
250	North Cove	-36.412	174.823	11	55	55	55	0.06	0.06	0.06	0.987
142	Nuhaka River	-39.072	177.749	4C	1445512	853316	853316	2309.77	1363.50	1363.50	0.273
174	Ohariu Bay	-41.214	174.704	11	7676	4663	4663	10.69	6.49	6.49	0.922
243	Ohau Bay	-41.237	174.651	11	286	194	194	0.53	0.36	0.36	0.991
181	Ohau River	-40.664	175.142	4D	31229	28946	28933	0.00	0.00	0.00	0.000
1104	Ohinemaka River	-43.627	169.496	6D	94001	94164	94164	0.00	0.00	0.00	0.000
1108	Ohinetamatatea River (Saltwater Creek)	-43.457	169.761	6E	126223	134282	141201	10.19	10.84	11.39	0.015
126	Ohiwa Harbour	-37.984	177.152	9	9700	7159	7159	0.24	0.17	0.17	0.983
147	Ohuia Lagoon	-39.067	177.474	2A	9248	5439	5439	10.95	6.44	6.44	0.980
1020	Okains Bay	-43.680	173.081	11	2146	1067	1067	0.39	0.19	0.19	0.985
1125	Okari Lagoon	-41.812	171.454	7A	5278	5835	5835	1.89	2.09	2.09	0.775
1110	Okarito Lagoon	-43.221	170.158	7B	49412	50096	51218	1.49	1.51	1.54	0.976
24	Oke Bay	-35.224	174.272	11	47	47	47	0.05	0.05	0.05	0.990
83	Okoromai Bay	-36.621	174.812	11	96	61	61	0.06	0.04	0.04	0.987
176	Okupe Lagoon	-40.829	174.962	1	41	39	39	0.34	0.33	0.33	0.997
86	Okura River	-36.657	174.752	7A	1295	1427	1427	0.60	0.66	0.66	0.948
1100	Okuru River	-43.909	168.885	6B	2051863	2019645	2069927	320.20	315.18	323.02	0.393
50	Omaha Cove	-36.293	174.821	11	160	95	95	0.37	0.22	0.22	0.978
193	Onaero River	-38.982	174.363	6B	37340	28009	28009	68.25	51.19	51.19	0.068
1146	Onahau River	-40.798	172.773	7A	335	256	256	0.53	0.40	0.40	0.831
1221	Onekaka Inlet	-40.747	172.712	7A	2282	2016	2016	6.29	5.56	5.56	0.756
257	Oneroa Bay	-36.775	175.021	11	10	5	5	0.00	0.00	0.00	0.988
1133	Oparara River	-41.212	172.094	7A	24442	24290	24290	12.50	12.43	12.43	0.583
206	Oparau River KHS	-38.067	174.887	8	16428	10667	10667	5.72	3.71	3.71	0.862
1040	Opihi River	-44.281	171.355	3C	119707	139245	133081	214.81	249.87	238.81	0.432

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212	Opotoru River RHS	-37.801	174.866	8	2983	1642	1642	1.03	0.57	0.57	0.943
19	Opua Inlet System	-35.219	174.130	9	129471	64075	64075	1.60	0.79	0.79	0.969
82	Orewa River	-36.595	174.709	7A	1624	948	948	0.80	0.46	0.46	0.942
1048	Orore Creek	-45.212	170.886	4C	136	67	64	1.05	0.52	0.49	0.983
1127	Orowaiti Lagoon	-41.741	171.660	7A	2572	2423	2423	0.80	0.75	0.75	0.862
1056	Otago Harbour	-45.773	170.724	9	1790	1182	1175	0.02	0.02	0.02	0.984
118	Otahu River	-37.237	175.897	7A	5408	4784	4784	2.95	2.61	2.61	0.783
242	Otaki River	-40.763	175.100	6C	170793	161219	161059	142.40	134.42	134.29	0.203
1023	Otanerito Bay	-43.852	173.067	11	456	365	362	0.46	0.37	0.37	0.978
165	Oterei River	-41.490	175.583	2B	104367	64159	64159	759.22	466.72	466.72	0.783
1178	Otu Bay	-40.755	173.836	11	632	625	625	0.37	0.36	0.36	0.976
1159	Otuwhero Inlet	-41.011	173.013	7A	6425	5522	5522	3.65	3.14	3.14	0.763
158	Owahanga River	-40.690	176.358	6B	603302	488968	488968	422.08	342.09	342.09	0.619
256	Owhanake Bay	-36.769	174.991	11	40	21	21	0.09	0.05	0.05	0.986
164	Pahaoa River	-41.404	175.727	6C	509023	402554	402554	697.96	551.97	551.97	0.330
237	Pahurehure Inlet MHS	-37.053	174.858	8	14227	8335	8335	0.60	0.35	0.35	0.963
134	Pakarae River	-38.562	178.253	6B	1117222	606329	606329	640.87	347.81	347.81	0.227
1143	Pakawau Inlet	-40.586	172.686	7A	592	553	553	0.50	0.47	0.47	0.941
49	Pakiri River	-36.241	174.732	7A	5617	3513	3513	20.44	12.78	12.78	0.487
1057	Papanui Inlet	-45.842	170.738	7A	345	207	207	0.06	0.04	0.04	0.980
1145.5	Parapara Inlet	-40.715	172.690	7A	6782	6794	6793	2.13	2.14	2.14	0.862
22	Parekura Bay	-35.241	174.213	11	1372	1250	1250	0.25	0.23	0.23	0.983
2	Parengarenga Harbour System	-34.529	173.016	8	6668	5978	5978	0.07	0.06	0.06	0.977
1103	Paringa River	-43.627	169.433	5C	1510564	1407312	1429465	43.01	40.07	40.70	0.019
20	Paroa Bay	-35.244	174.146	11	172	147	147	0.07	0.06	0.06	0.989
163	Patanui Stream	-41.160	176.030	6D	117770	100463	100463	521.87	445.18	445.18	0.182
41	Pataua River	-35.705	174.531	7A	95955	266698	266698	21.49	59.73	59.73	0.945
189	Patea River	-39.779	174.485	6B	2960	2284	2284	0.73	0.57	0.57	0.087
1139	Paturau River	-40.639	172.428	6B	17506	16826	16826	1.44	1.39	1.39	0.005
1182	Pelorous/Kenepuru Sound	-40.945	174.086	9	457458	420899	420896	0.68	0.63	0.63	0.972
1032	Peraki Bay	-43.879	172.809	11	1043	678	678	0.58	0.38	0.38	0.982
97	Piako River	-37.191	175.493	6A	22111	17153	17153	2.96	2.30	2.30	0.341
1015	Pigeon Bay	-43.625	172.922	11	3712	1951	1934	0.27	0.14	0.14	0.988
1051	Pleasant River	-45.571	170.732	7A	9819	5775	5768	6.13	3.60	3.60	0.911
1112	Poerua River (Hikimutu Lagoon)	-43.047	170.404	6C	482454	451177	468399	378.00	353.49	366.99	0.409
1094	Poison Bay	-44.653	167.623	11	4963	5309	5573	0.19	0.21	0.22	0.494
215	Ponganui/Paihere Creeks	-37.789	174.874	8	1461	784	784	0.97	0.52	0.52	0.972
156	Porangahau River	-40.261	176.706	7A	835644	444888	444888	220.32	117.30	117.30	0.896

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1122	Pororari River	-42.100	171.333	6B	83495	83541	83541	137.59	137.67	137.67	0.280
107	Port Charles	-36.506	175.459	11	2345	2191	2191	0.31	0.29	0.29	0.979
1183	Port Gore	-40.992	174.272	11	5539	4835	4835	0.06	0.05	0.05	0.922
1179	Port Hardy	-40.730	173.903	9	2264	1837	1837	0.05	0.04	0.04	0.986
1012	Port Levy	-43.606	172.840	11	4136	2263	2181	0.33	0.18	0.18	0.988
1142	Port Puponga	-40.527	172.737	7A	181	159	159	0.38	0.33	0.33	0.891
1001	Port Underwood	-41.349	174.109	9	5745	5625	5625	0.16	0.15	0.15	0.993
136	Pouawa River	-38.617	178.190	6B	48491	31905	31905	239.55	157.62	157.62	0.436
155	Pourerere Stream	-40.103	176.879	4C	75280	37335	37335	88.50	43.89	43.89	0.036
1080	Preservation Inlet	-46.142	166.609	10	11207	11159	11170	0.05	0.05	0.05	0.642
246	Puhinui Creek MHS	-37.031	174.852	8	320	230	230	0.31	0.22	0.22	0.925
80	Puhoi River	-36.533	174.725	7A	12808	8572	8572	4.57	3.06	3.06	0.906
1121	Punakaiki River	-42.124	171.324	4C	46186	46219	46215	0.00	0.00	0.00	0.000
1055	Purakunui Inlet	-45.737	170.626	7A	223	136	136	0.13	0.08	0.08	0.985
114	Purangi River	-36.827	175.752	7A	932	548	548	0.46	0.27	0.27	0.948
262	Putiki Bay	-36.818	175.025	11	559	421	421	0.11	0.08	0.08	0.984
1184	Queen Charlotte Sound (Totaranui)	-41.047	174.353	9	55276	53611	53611	0.10	0.10	0.10	0.826
217	Raglan Harbour System (RHS)	-37.806	174.812	8	60424	42539	42539	1.23	0.86	0.86	0.971
216	Raglan Inlet RHS	-37.801	174.842	8	60424	42539	42539	3.98	2.80	2.80	0.925
1037	Rakaia River	-43.902	172.211	3A	3918699	2369483	2369140	1250.19	755.94	755.83	0.292
204	Rakaunui Inlet KHS	-38.101	174.862	8	4090	2793	2793	1.36	0.93	0.93	0.945
4	Rangaunu Harbour	-34.875	173.272	8	31220	24130	24130	0.20	0.15	0.15	0.976
1039	Rangitata River	-44.184	171.521	3B	1603738	2202193	2207745	1258.19	1727.69	1732.05	0.093
183	Rangitikei River	-40.303	175.212	6B	824081	475460	466515	14.59	8.42	8.26	0.010
261	Rocky Bay	-36.831	175.055	11	227	201	201	0.12	0.11	0.11	0.984
46	Ruakaka River	-35.905	174.473	7A	5626	3424	3424	3.38	2.06	2.06	0.746
1145	Ruataniwha Inlet	-40.670	172.684	7A	122526	202130	201912	8.08	13.33	13.32	0.654
1042	Saltwater Creek	-44.427	171.257	4D	330	178	162	1.96	1.06	0.96	0.975
1118	Saltwater Creek/New River	-42.527	171.153	6D	45269	43982	43982	69.97	67.98	67.98	0.490
1111	Saltwater Lagoon	-43.099	170.330	7B	1016	1057	1057	0.09	0.09	0.09	0.997
1155	Sandfly Bay	-40.928	173.057	7A	3000	3000	3000	16.90	16.90	16.90	0.613
1016	Scrubby Bay	-43.634	172.951	11	124	58	58	0.27	0.13	0.12	0.989
1049	Shag River	-45.481	170.818	7A	33537	21134	19534	23.30	14.68	13.57	0.757
1024	Sleepy Bay	-43.854	173.060	11	121	76	76	0.44	0.28	0.28	0.981
252	South Cove Harbour	-36.444	174.826	11	85	85	85	0.22	0.22	0.22	0.984
106	Stony Bay	-36.496	175.434	11	2497	2421	2421	1.33	1.29	1.29	0.969
1025	Stony Bay	-43.860	173.049	11	417	295	291	0.97	0.68	0.67	0.967
1050	Stony Creek	-45.511	170.784	4C	595	293	293	2.42	1.19	1.19	0.948

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1093	Sutherland Sound	-44.725	167.546	10	15755	16698	17633	0.89	0.95	1.00	0.923
10	Taemaro Bay	-34.930	173.584	11	102	96	96	0.09	0.09	0.09	0.985
143	Tahaenui River	-39.068	177.679	4D	37649	20051	20051	221.25	117.83	117.83	0.686
1067	Tahakopa River	-46.563	169.477	7A	24266	22259	22203	9.23	8.47	8.45	0.491
16	Tahoranui River	-35.118	173.967	7A	956	569	569	1.32	0.78	0.78	0.527
1167	Tahunanui Estuary	-41.284	173.222	7A	23	76	76	0.07	0.24	0.24	0.938
1061	Taieri River	-46.056	170.210	6B	237479	169785	167625	15.31	10.94	10.81	0.151
42	Taiharuru River	-35.704	174.556	7A	581	320	320	0.11	0.06	0.06	0.980
7	Taipa River	-34.982	173.475	7A	11906	8327	8327	4.23	2.96	2.96	0.824
115	Tairua Harbour	-37.009	175.886	7A	22073	18673	18673	1.97	1.66	1.66	0.809
1148	Takaka Estuary	-40.821	172.812	7A	101	63	63	0.09	0.05	0.05	0.944
1147	Takaka River	-40.816	172.800	5B	111730	125074	124978	2.93	3.28	3.28	0.010
9	Takerau Bay	-34.926	173.546	11	22	22	22	0.06	0.06	0.06	0.987
15	Takou River	-35.102	173.950	7A	2294	1342	1342	1.82	1.07	1.07	0.702
88	Tamaki River	-36.842	174.887	8	868	695	695	0.03	0.03	0.03	0.982
228	Tanutanu Stream	-35.235	173.083	4C	346	394	394	0.86	0.98	0.98	0.640
0	Tapotupotu Bay	-34.435	172.715	7B	200	199	199	0.38	0.38	0.38	0.691
17	Tapuaetahi Creek	-35.118	173.982	7A	610	364	364	0.99	0.59	0.59	0.926
1117	Taramakau River	-42.565	171.123	6C	2139049	2031428	2031127	103.60	98.39	98.37	0.068
121	Tauranga Harbour System	-37.475	175.998	8	59935	45541	45541	0.20	0.15	0.15	0.981
1068	Tautuku River	-46.601	169.430	7A	3124	3028	3028	2.63	2.55	2.55	0.820
177	Te Awarua-o-Porirua Harbour	-41.077	174.831	8	23015	9205	9205	1.99	0.80	0.80	0.968
173	Te Ikaamaru Bay	-41.236	174.662	11	508	422	422	0.48	0.40	0.40	0.989
102	Te Kouma Harbour	-36.828	175.426	8	283	170	170	0.07	0.04	0.04	0.985
259	Te Matuku Bay	-36.850	175.132	11	958	695	695	0.26	0.19	0.19	0.981
79	Te Muri-O-Tarariki	-36.517	174.722	7A	1278	707	707	3.06	1.69	1.69	0.952
1033	Te Oka Bay	-43.864	172.773	11	592	308	308	0.51	0.27	0.27	0.983
145	Te Paeroa Lagoon	-39.055	177.518	2A	18	20	20	0.02	0.02	0.02	1.000
18	Te Puna /Kerikeri Inlet System	-35.186	174.112	9	8288	4506	4506	0.15	0.08	0.08	0.981
208	Te Wharu Bay KHS	-38.061	174.835	8	518	308	308	0.18	0.11	0.11	0.983
1084	Thompson/Doubtful sound	-45.147	166.961	10	50538	51317	51790	0.18	0.18	0.18	0.730
1109	Three Mile Lagoon	-43.241	170.125	7B	4791	4811	4811	3.54	3.56	3.56	0.935
175	Titahi Bay	-41.104	174.822	11	13	6	6	0.02	0.01	0.01	0.994
1073	Toetoes Harbour	-46.585	168.796	7A	293408	341014	321845	30.81	35.80	33.79	0.747
1063	Tokomairiro River	-46.223	170.049	7A	19315	15403	14489	13.95	11.12	10.46	0.650
1059	Tomahawk Lagoon	-45.914	170.539	4B	102	60	60	0.34	0.20	0.20	0.995
196	Tongaporutu River	-38.816	174.572	6B	164679	150783	150783	55.09	50.44	50.44	0.222
1157	Torrent Bay	-40.945	173.063	7A	2274	2265	2265	0.76	0.75	0.75	0.824

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1116	Totara River	-41.861	171.452	6D	61440	60603	60603	32.71	32.26	32.26	0.750
1124	Totara River	-41.861	171.452	6D	23137	27496	27496	4.49	5.34	5.34	0.030
1152	Totaranui Stream	-40.822	173.016	7A	1254	1248	1248	5.34	5.32	5.32	0.847
1034	Tumbledown Bay	-43.860	172.766	11	262	145	145	0.99	0.55	0.55	0.978
184	Turakina River	-40.087	175.135	6B	290482	129139	128824	136.90	60.86	60.71	0.304
91	Turanga Creek WES	-36.915	174.962	8	4024	2359	2359	1.73	1.02	1.02	0.964
137	Turanganui River	-38.676	178.022	6B	409688	495173	495173	0.00	0.00	0.00	0.000
1137	Turimawiwi River	-40.729	172.310	3B	15249	14700	14628	25.25	24.34	24.23	0.122
39	Tutukaka Harbour	-35.617	174.543	9	191	153	153	0.12	0.10	0.10	0.988
1088	Two Thumb Bay	-44.953	167.178	11	2710	2743	2744	1.34	1.35	1.35	0.902
133	Uawa River (Tolaga Bay)	-38.374	178.314	6B	4254838	3661589	3661589	1392.26	1198.14	1198.14	0.554
194	Urenui River	-38.979	174.388	6B	86519	71901	71901	232.69	193.37	193.37	0.446
105	Waiaro Estuary	-36.591	175.417	7A	1637	1521	1521	6.57	6.10	6.10	0.553
1099	Waiatoto River	-43.969	168.788	6B	2871737	2763008	2832416	340.51	327.61	335.84	0.245
227	Waiatua Stream	-35.286	173.137	4C	133	215	215	0.46	0.75	0.75	0.210
1005	Waiau River	-42.771	173.380	3B	2591916	1019322	992332	1129.26	444.10	432.34	0.314
1078	Waiau River	-42.771	173.380	3B	338983	259270	253487	41.03	31.38	30.68	0.138
129	Waiaua River	-37.978	177.387	6B	65780	29821	29821	124.84	56.59	56.59	0.513
1045	Waihao River	-44.774	171.174	4D	31963	22068	20253	46.87	32.36	29.70	0.788
202	Waiharakeke Stream	-38.130	174.814	8	7308	5471	5471	0.76	0.57	0.57	0.962
123	Waihi Estuary	-37.754	176.484	7A	13606	9591	9591	3.07	2.16	2.16	0.893
98	Waihou River	-37.157	175.535	6A	115112	61067	61067	1.78	0.94	0.94	0.230
149	Waihua River	-39.096	177.297	3D	97741	44809	44809	474.38	217.48	217.48	0.676
178	Waikanae River	-40.862	174.994	6B	20971	19207	19202	22.48	20.58	20.58	0.533
150	Waikari River	-39.172	177.099	6C	76534	46630	46630	97.49	59.40	59.40	0.262
1144	Waikato Estuary	-40.630	172.679	7A	455	356	356	1.38	1.08	1.08	0.937
218	Waikato River	-37.374	174.684	6B	378594	354056	352369	1.93	1.80	1.79	0.139
1070	Waikawa Harbour	-46.648	169.133	7A	17746	12442	12430	1.71	1.20	1.20	0.930
180	Waikawa Stream	-40.695	175.131	4D	7366	6592	6592	23.31	20.86	20.86	0.528
108	Waikawau Estuary	-36.593	175.534	7A	1376	1175	1175	3.09	2.64	2.64	0.807
200	Waikawau River	-38.480	174.615	4C	23237	19857	19857	0.00	0.00	0.00	0.000
92	Waikopua Creek WES	-36.904	174.981	8	886	621	621	0.33	0.23	0.23	0.975
1052	Waikouaiti Lagoon	-45.613	170.683	4B	818	413	413	1.10	0.55	0.55	0.993
1053	Waikouaiti River	-45.643	170.662	7A	35098	20498	19428	16.03	9.36	8.87	0.872
11	Waimahana Bay	-34.943	173.627	11	214	193	193	0.64	0.57	0.57	0.960
1009	Waimakariri River	-43.392	172.715	6B	2936553	1454860	1437676	261.08	129.35	127.82	0.363
223	Waimaukau River	-35.599	173.404	6B	14773	10819	10819	14.50	10.62	10.62	0.340
1166	Waimea Inlet	-41.287	173.197	8	94115	74877	74846	2.00	1.59	1.59	0.936

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1044	Wainono Lagoon	-44.713	171.171	2A	98	64	61	0.02	0.01	0.01	0.997
1151	Wainui Inlet	-40.812	172.942	7A	5907	5475	5475	1.92	1.78	1.78	0.890
168	Wainuiomata River	-41.427	174.875	3C	17730	17858	17858	102.06	102.80	102.80	0.350
128	Waioeka River	-37.984	177.304	6A	796905	478470	478470	62.97	37.81	37.81	0.111
135	Waiomoko River	-38.584	178.226	6B	702052	388660	388660	1922.88	1064.52	1064.52	0.486
191	Waiongana Stream	-38.984	174.185	6B	7874	4321	4321	1.93	1.06	1.06	0.029
127	Waiotahi River	-37.990	177.206	7A	13412	18083	18083	6.89	9.29	9.29	0.767
138	Waipaoa River	-38.716	177.945	6B	9887592	9559255	9559255	10.27	9.93	9.93	0.002
1007	Waipara River	-43.155	172.798	3C	96248	58529	53275	365.35	222.17	202.23	0.653
1069	Waipati Estuary	-46.624	169.361	7A	4710	4246	4246	5.51	4.96	4.96	0.806
222	Waipoua River	-35.676	173.468	6B	2964	2897	2897	3.56	3.48	3.48	0.242
47	Waipu River	-35.993	174.489	7A	15981	10950	10950	4.50	3.08	3.08	0.654
146	Wairau Lagoon	-39.056	177.500	2A	67	50	50	0.24	0.18	0.18	0.998
1002	Wairau River	-41.501	174.062	7A	33722	22144	21629	1.37	0.90	0.88	0.976
93	Wairoa River	-36.938	175.096	8	13672	18317	18317	3.27	4.38	4.38	0.899
148	Wairoa River	-39.070	177.423	5C	2304687	2641104	2641104	271.95	311.64	311.64	0.442
1101	Waita River	-43.796	169.092	6D	83026	83762	83762	76.68	77.36	77.36	0.320
1114	Waitaha River	-42.957	170.659	6C	1242144	1256808	1288929	137.60	139.22	142.78	0.043
241	Waitahanui Stream	-37.829	176.598	4	7021	5700	5700	35.25	28.62	28.62	0.222
1	Waitahora Stream	-34.456	172.795	7B	80	83	83	0.26	0.26	0.26	0.989
96	Waitakaruru River	-37.217	175.394	6A	4467	3326	3326	4.07	3.03	3.03	0.661
220	Waitakere River (Bethells Beach)	-36.894	174.430	4C	1849	1641	1641	17.34	15.39	15.39	0.470
1123	Waitakere River (Nile River)	-41.897	171.443	5C	39477	42135	42135	6.64	7.09	7.09	0.016
1046	Waitaki River	-44.943	171.148	3A	127946	157749	157040	31.07	38.30	38.13	0.213
239	Waitangi Stream	-34.428	172.962	4C	188	204	204	1.98	2.15	2.15	0.933
192	Waitara River	-38.978	174.225	6B	945324	356970	356970	0.00	0.00	0.00	0.000
87	Waitemata Harbour System	-36.836	174.824	8	9082	6790	6790	0.07	0.06	0.06	0.982
213	Waitetuna Creek RHS	-37.793	174.924	8	24421	16805	16805	2.96	2.04	2.04	0.932
187	Waitotara River	-39.856	174.681	6A	520093	447616	447616	0.00	0.00	0.00	0.000
1074	Waituna Lagoon	-46.574	168.656	2A	917	740	805	0.04	0.04	0.04	0.996
190	Waiwakaiho River	-39.032	174.101	6B	15170	12124	12124	8.10	6.47	6.47	0.070
81	Waiwera River	-36.548	174.717	7A	6645	4556	4556	3.90	2.67	2.67	0.873
186	Wanganui River	-39.954	174.981	6C	3438325	1881690	1880633	228.49	125.04	124.97	0.321
1041	Washdyke Lagoon	-44.369	171.264	2A	1708	913	834	4.56	2.44	2.23	0.923
85	Weiti River	-36.655	174.758	8	2115	1330	1330	0.48	0.30	0.30	0.974
171	Wellington Harbour	-41.354	174.834	9	93546	107685	107528	0.62	0.72	0.71	0.851
144	Whakaki Lagoon	-39.065	177.573	2A	4440	2324	2324	0.62	0.33	0.33	0.998
125	Whakatane River	-37.939	177.007	6B	605649	265043	265043	92.95	40.68	40.68	0.347

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32	Whananaki Inlet	-35.523	174.470	7A	3426	2798	2798	0.99	0.81	0.81	0.910
185	Whangaehu River	-40.042	175.096	6B	688046	258631	257980	443.56	166.73	166.31	0.420
13	Whangaihe Bay	-34.984	173.818	11	125	97	97	0.40	0.31	0.31	0.980
117	Whangamata Harbour	-37.213	175.897	7A	2850	2622	2622	0.41	0.38	0.38	0.948
1170	Whangamoa River	-41.101	173.529	7A	14246	14012	14012	13.94	13.71	13.71	0.615
27	Whangamumu Harbour	-35.242	174.329	11	98	92	92	0.03	0.02	0.02	0.991
1140	Whanganui Inlet	-40.574	172.539	8	7571	7252	7243	0.20	0.19	0.19	0.974
225	Whangapae Harbour System	-35.383	173.204	8	41854	29238	29238	2.59	1.81	1.81	0.941
130	Whangaparaoa River	-37.572	177.990	6B	3458269	1877672	1877672	0.00	0.00	0.00	0.000
111	Whangapoua Harbour	-36.718	175.645	7A	6743	4967	4967	0.33	0.24	0.24	0.956
45	Whangarei Harbour System	-35.848	174.513	8	14820	10487	10487	0.09	0.07	0.07	0.987
34	Whangaroa Harbour	-34.995	173.774	9	34756	26672	26672	0.89	0.68	0.68	0.976
29	Whangaruru Harbour	-35.360	174.346	9	4545	4137	4137	0.25	0.23	0.23	0.983
51	Whangateau Harbour	-36.329	174.793	7A	4219	3227	3227	0.37	0.28	0.28	0.974
161	Whareama River	-41.019	176.120	6A	1276956	1473101	1473101	1641.23	1893.32	1893.32	0.228
131	Wharekahika River	-37.576	178.297	6D	437847	297731	297731	469.84	319.49	319.49	0.080
116	Wharekawa Harbour	-37.118	175.894	7A	3784	5011	5011	1.14	1.51	1.51	0.875
188	Whenuakura River	-39.786	174.506	6B	274552	159413	159413	309.26	179.57	179.57	0.236
139	Wherowhero Lagoon	-38.748	177.952	7A	5662	2865	2865	6.60	3.34	3.34	0.901
89	Whitford Embayment System (WES)	-36.890	174.967	8	6285	4011	4011	0.37	0.24	0.24	0.980
113	Whitianga Harbour MBS	-36.812	175.734	7A	28441	25488	25488	1.10	0.99	0.99	0.898