MORPHUM ENVIRONMENTAL LTD

Engineers & Consultants

Plan Compilation and Review

Sediment Attributes and Urban Development

Final

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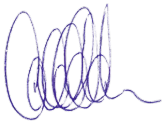
Reviewer: Caleb Clarke **Signature:** 

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Executive Summary

Morphum Environmental Ltd (Morphum) was engaged by The Ministry for the Environment (hereafter, the Ministry) to provide expert advice and analysis on in-stream sediment in urban areas and in-stream sediment effects of urban development. This is the second in a four-part series of reports to support the Ministry which is currently considering a sediment attribute for inclusion within the National Policy Statement: Freshwater Management.

Erosion, sedimentation and sediment transport are components of the natural functioning of waterbodies that maintains natural features, such as gravel bars. However, excess sedimentation (accumulation of deposited sediment) and suspended sediment (entrained sediment in the water column) particularly of fine sand, silt and clay particles, can be a significant environmental problem. Human activities can increase both the rates and quantities of sediment generated, transported and deposited, which can lead to significant adverse environmental effects. Increased suspended sediment can increase water turbidity and reduce visual clarity which can reduce the hunting efficiency of aquatic and avian predators; render freshwater unsafe to drink for farm animals. Increased sedimentation can smoother in-stream habitat and change sediment delivery to intertidal and coastal environment. Excess sediments can reduce amenity values associated with a watercourse by making the watercourse undesirable for contact recreation and can also be a significant cultural concern to Tangata Whenua.

The Resource Management Act 1991 (The RMA), is the primary piece of legislation controlling natural and physical resources management in New Zealand. The RMA contains provisions that relate to controlling sediment to achieve the purpose of the RMA: '*To promote the sustainable management of natural and physical resources,* including section 9 (land use) and section 15 (the discharge of a contaminant). The RMA also establishes a hierarchy of plans involved in natural and physical resource management in New Zealand, including plans at the national level such as the New Zealand Coastal Policy Statement and National Policy Statement for Freshwater Management; regional level such as Regional Policy Statements and Regional Plans and at the District level through the plans of territorial authorities. To support the sediment related provisions within these Plans, most regional councils and some national infrastructure providers have produced guidelines for controlling earthworks and sediment discharges.

In this Task 2 Report Morphum has undertaken a review of existing urban development plans from around New Zealand, including residential, commercial and industrial developments and New Zealand Transport Agency (NZTA) projects. From the review of existing urban development plans, Morphum with feedback from the Ministry, have selected case studies for further review.

Urban development plans are reviewed in regard to their content relating to the natural, development and mature urban reasons for sediment discharge variability. The brief was to assess a variety of urban development plans and specifically referenced structure plans and Assessment of Environmental Effects (AEE) for large developments (subdivision, residential, industrial or commercial) as well as NZTA development plans. In addition to these criteria, case studies have been selected to represent as broad a geographic range across New Zealand as possible and across different proposed sediment attribute classes (Franklin *et al*. 2019 in prep). Where water quality data is available that relates to in-stream

sediment, such as Total Suspended Sediment (TSS) and Turbidity measurements (NTU), the data was also assessed.

Based on the case studies review, little information was available of instream sediment effects. The case studies however, do not contain the necessary information to show changes in suspended sediment loads or concentrations over time. No case study material considered suspended sediment load changes from pre-development, across construction through to mature urban catchment. Larger, more recent consents did include potential effects in the receiving environment associated with construction works as well as stormwater management upon the completion of works and used modelled data to demonstrate that the effects could be managed appropriately. Other resource consents, where they included in-stream effects assessments, noted potential effects associated with changes to water quality in the receiving environment being mitigated through erosion and sediment controls. The case study material was most comprehensive in regard to an assessment of the natural sources of variability and most physical data available was associated with construction monitoring. Little information or assessment was available from the assessed material regarding the long term, post-construction, changes to in-stream sediment indicators.

Content

1.0 Scope and Background

The Ministry for the Environment (hereafter, the Ministry) is currently considering a sediment attribute for inclusion within the National Policy Statement: Freshwater Management. Morphum previously completed a literature review of the sources and variability of sediment in urban catchments, referred to as the Task 1 Report. Sediment discharges over short and long-term development scenarios, as well as the natural sources of variability for sediment discharge and variability attributed to development practice were discussed.

In this Task 2 Report Morphum has undertaken a review of existing urban development plans from around New Zealand, including residential, commercial and industrial developments and New Zealand Transport Agency (NZTA) projects. From the review of existing urban development plans, Morphum with feedback from the Ministry, have selected case studies for further review.

The Task 2 Report builds upon the findings of the Task 1 Report. Urban development plans are reviewed in regard to their content relating to the natural, development and mature urban reasons for sediment discharge variability. Where water quality data is available that relates to in-stream sediment, such as Total Suspended Sediment (TSS) and Turbidity measurements (NTU), the data has been included and assessed.

2.0 Sediment Discharges and Resultant changes in Development Plans

2.1 'Sedimentation' and 'Sediment'

As identified in the Department of Conservation guidance note on the New Zealand Coastal Policy Statement (NZCPS), policy 22, the RMA distinguishes between the deposition of a substance (section 12) and the discharge of a contaminant (section 15). At various stages during the transportation, suspension and re-suspension of the solid mineral and organic matter of which sediment is comprised, sediment can be considered a substance (when deposited on the seabed) or a contaminant (when suspended in the water column). The most consistent interpretation is that the term 'sedimentation' refers to sediment that has settled on the bed of a river or the seabed and is therefore a substance according to the RMA definition (section 12), while the term 'sediment' refers to sediment that is suspended in the water column and is therefore a contaminant according to the RMA definition (section 15). These definitions are adopted in this report for consistency with other related documents from the Department of Conservation and the Ministry.

2.2 Erosion, Sediment and Sedimentation

Erosion takes many forms and generates sediment particles across a wide range of sizes, from boulders and gravels to sand, silt and clay, depending on the substrate type and other erosion factors. Sediment and sediment transport are components of the natural functioning of rivers, and sediment transport is a natural process that forms and maintains natural features, such as gravel bars. However, excess sedimentation (accumulation of deposited sediment) and suspended sediment (entrained sediment in the water column) particularly of fine sand, silt and clay particles, can be a significant environmental problem.

Issues of excess sediment include impacts on ecological functions. Increased suspended sediment can increase water turbidity and reduce visual clarity which can reduce the hunting efficiency of aquatic and avian predators as well as render freshwater unsafe to drink for farm animals. Increased sedimentation can smoother in-stream habitat and change sediment delivery to intertidal and coastal environment. More generally, excess sediments can reduce amenity values associated with a watercourse by making the watercourse undesirable for contact recreation. Changes to the natural functioning of freshwater watercourses can also be a significant cultural concern to Tangata Whenua in their role as kaitiakitanga and the values placed on the mauri and mahinga kai capacity of a watercourse.

Human activities have increased both the rates and quantities of sediment arriving at the coast, causing significant adverse environmental effects. For instance, Hume & McGlone's (1986) study of Holocene subsurface sediments in the Lucas Creek Estuary showed that sediment accumulation rates have increased following forest clearance during Polynesian settlement [sic], and a subsequent tripling with logging, forest clearance and accompanying farming during European settlement. The relationship between land use activities and increased levels of sediment was also established by Hicks (1994). Table 1 below, adapted from Hicks (1994), provides the mean values for turbidity and suspended solids in

urban streams that demonstrates changes in indicators of suspended sediment in urban catchments across developed and developing urban catchments.

Table 1: Mean Values of Turbidity and Suspended Solids in New Zealand Urban Streams During Low Flow

Land use	Turbidity (NTU)	Suspended Solids (g/m^3)	Approximate visual range (m)
Residential	9	14	1
Residential, light industrial, construction	42	53	0.2
Construction	186	159	0.1

Adapted from Hicks (1994)

The way in which land is managed significantly affects erosion and thus the effects of excess sediment.

2.3 New Zealand Planning Framework

The Resource Management Act 1991 (The RMA), is the primary piece of legislation controlling natural and physical resources management in New Zealand. The purpose of the RMA as set out in section 5(1) is: '*To promote the sustainable management of natural and physical resources.* Section 5(2) goes on to clarify that sustainable management means '*managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while—*

(a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
(b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and
(c) avoiding, remedying, or mitigating any adverse effects of activities on the environment.'

Figure 1 shows a hierarchy of plans involved in natural and physical resource management in New Zealand. Existing guidance such as the Ministry's '*An Everyday Guide to the RMA'* series available on-line provides a useful introduction. A more detailed discussion on the contents and relationship between the various plans identified in Figure 1 is available through the NZCPS 2010 and related guidance notes. Of particular relevance to the matters considered in this Task 2 Report is the guidance note on policy 21: Enhance water quality and policy 22: Sedimentation.

Figure 1: The Relationship Between Key Planning Documents in New Zealand (Source: Ministry for the Environment, 2015).

2.4 Application of New Zealand's Governance Framework to Sediment

The effective management of sediment through planning instruments requires an integrated and strategic approach preferably using the hierarchy of the RMA (Ministry for the Environment, 2015). The following section provides a brief overview of how the hierarchy of planning instruments of the RMA can be applied to sediment.

2.4.1 Sediment in the RMA

As set out above the RMA is the primary piece of legislation controlling natural and physical resources management in New Zealand. The following provisions of the RMA are of particular relevance to the matters considered in this Task 2 Report:

- Section 9, which provides that no person may use land in a manner that contravenes a national environmental standard, a regional rule or a district rule.
- Section 15, which provides that no person may discharge any contaminant into water unless the discharge is specifically allowed for in a national environmental standard, a rule in a relevant regional plan, including a proposed plan, or a resource consent.
- Section 30, which sets out the function of regional councils. This includes control of the use of land for the purpose of maintaining and enhancing the quality of water in water bodies.

- Section 31, which sets out the functions of territorial authorities. These include achieving integrated management of the effects of the use, development and protection of land in the district through the preparation and implementation of district plans.

2.4.2 Sediment in the New Zealand Coastal Policy Statement and National Policy Statement for Freshwater Management.

Both the NZCPS 2010 and the National Policy Statement for Freshwater Management 2014 (amended 2017) (NPS:FM) contain measures that relate to sediment.

The purpose of the NZCPS is to state policies in order to achieve the purpose of the RMA in relation to the coastal environment. Of particular relevance to the matters considered in this Task 2 Report are:

- Objectives: 1, 2 and 6
- Policy 21, 22 and 23

The NPS:FM applies to all freshwater resources and contains a number of objectives and policies that relate to managing water quality. Of particular relevance to the matters considered in this Task 2 Report are:

- Objectives A1, A2 and C1 of the NPS:FM
- Policy A1 and A2 of the NPS:FM

2.4.3 Regional Policy Statements and Regional Plans

The Regional Policy Statement (RPS) must state the significant resource management issues for the region. As discussed in the guidance note on policy 22, where excess sediment is identified as a significant issue within a region, this should be identified in the RPS, this then leads to the inclusion of appropriate objectives and policies in the RPS, Regional Plans and district plans. Section 62(3) of the RMA requires that a regional policy statement gives effect to the NZCPS and NPS:FM.

2.4.4 Regional and District Plans

As set out in sections 30 and 31 of the RMA, Regional and territorial authorities have different functions. Unitary authorities are required to meet the requirements of both sections. Regional council responsibilities under section 30 have the functions of controlling the use of land for the purposes of soil conservation, and maintaining and enhancing water quality (including coastal water), as well as controlling the discharge of contaminants, such as sediment, into the water. Under section 31, territorial authorities have the function of controlling any actual or potential effects of the development, use and protection of land.

Regional Plans, including regional coastal plans, may contain policies for controlling sediment arising from land use activities that are designed to guide the implementation of objectives at the regional level to address the identified issues. Regional plans may also contain freshwater objectives to implement the NPS-FM through quantitative or qualitative sediment attributes and/or limits, having regard to the connection between freshwater bodies and coastal waters when setting any such limits.

District plans can also have controls on earthworks and vegetation clearance that contribute to minimising sedimentation from widespread, small-scale activities.

Methods in plans can be regulatory (rules) or non-regulatory (e.g. education, incentives, support for community initiatives). Rules can be used to address both direct and diffuse sediment impacts from land uses or activities. They may refer to management or farm plans, codes of practice, or good management practices. Provisions could also be included in regional or district plans to control or manage land use activities or their effects to help reduce sediment loadings in runoff and stormwater systems. Development standards in plan rules can set minimum requirements for the management of sediment loss from development sites. Restricting the area of land within a catchment area that can be disturbed or have vegetation cleared within a given period of time may assist in reducing runoff, while controlling the amount of new urban development within a catchment can reduce the generation of stormwater and subsequent sedimentation in the coastal environment.

Most regional councils have produced guidelines for earthworks. Auckland Council published 1992/002 *Erosion and Sediment Control Guidelines for Earthworks* (TP2) the first Council guideline for controlling sediment discharges associated with earthworks and the construction phase of urban development. TP2 was significantly revised and republished as Auckland Council 1999/90 *Erosion & Sediment Control Guidelines for Land Disturbing Activities in the Auckland Region* (TP90) in 1999. TP90 underwent minor revisions in 2007 and was subsequently replaced by Auckland Council's Guideline Document 2016/005 *Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region* (GD05). It is expected that development has occurred across this timeline of changing best practice guidance, and as such the erosion and sediment controls for earthworks would have changed over time. For example, hay-bales are listed in TP2 as a sediment control device, in TP90 as an erosion control device, and are not included in GD05 at all.

TP90 has formed the basis of many other guidelines prepared by Regional Councils around the country, including: Bay of Plenty (2010), Waikato (2009), Hawkes Bay (2009), Taranaki (2006), Wellington (2006) and Canterbury (2007).

2.4.5 NZTA Transport Development Plans

The New Zealand Transport Agency (NZTA) is the primary agency responsible for New Zealand's State Highway system. These responsibilities include the planning, design, construction, maintenance and operations of new roading projects. Recent examples include the completed Tauranga Eastern Link, the Puhoi to Warkworth new alignment of State Highway 1 north of Auckland that is currently under construction, the Transmission Gully project, which is also under construction, and the Mt Messenger Bypass for which planning approval has been granted, subject to appeal.

These large roading projects are key pieces of national infrastructure that can require significant areas of land disturbance and generate significant volumes of sediment. The NZTA notes that with careful planning and design, adverse effects of sediment discharges resulting from construction and maintenance activities can be avoided or minimised. To assist in meeting these requirements, the NZTA has developed its own Erosion and Sediment Control guideline *Erosion and Sediment Control Guidelines for State Highway Infrastructure*.

The RMA contains provisions that recognise the unique nature of infrastructure providers. NZTA is recognised as a Requiring Authority under the RMA. A Requiring Authority is able to lodge a Notice of Requirement (NoR) to establish a Designation. A designation has the interim effect of identifying and securing the land required to construct, operate and maintain large roading projects and, if granted, overrides the landuse provisions on a District Plan that allows for the project to be implemented.

3.0 Case Studies

The body of this report focuses on an assessment of the plans and consents associated with a range of large development projects. The plans have been assessed on their content in relation to sediment discharge and management as well as resultant changes in-stream sediment indicators contained within those plans.

In developing this plan compilation and review, focus is placed on the content of the development plans in relation to the Task 1 Report on the sources of sediment production in urban areas schema derived from Task 1 Report as well as any content in relation to water quality measures that may be available.

The brief was to assess a variety of urban development plans and specifically referenced structure plans and Assessment of Environmental Effects (AEE) for large developments (subdivision, residential, industrial or commercial) as well as NZTA development plans. In addition to these criteria, case studies have been selected to represent as broad a geographic range across New Zealand as possible and across different proposed sediment attribute classes (Franklin *et al*. 2019 in prep).

It is important to note that this is an assessment of the development plans themselves and not of the relevant planning documents, although the two are intrinsically linked. Case studies are not intended to be a critique of any one developer, council or the current or legacy planning provisions. It is recognised that this review is based on publicly available information, or information supplied to Morphum.

A brief introduction of each case study site can be found below:

Drury South

In 2017, Drury South Limited received a resource consent from Auckland Council for large scale bulk earthworks and streamworks, amongst other consented activities, to facilitate a planned industrial and residential development referred to as Drury South.

Drury South has been selected for further study here given the large area and volume of earthworks proposed. The consented works include approximately 2.9 million m^3 of earthworks over approximately 291 ha. The Drury South area was subject to previous master planning exercise that resulted in the Drury South Industrial Precinct (DSIP) and the Drury South Residential Precinct (DSRP) planning provisions being incorporated as precinct-specific planning documents within the Auckland Unitary Plan (Operative in Part) (AUP:OP).

The original application material included an AEE that was supported by a series of plans and reports from specialist technical experts including an Erosion and Sediment Control Plan (ESCP), Ecological Assessment and Environmental Management and Monitoring Plan (EEMMP).

The application material, including the ESCP and EEMMP, contained no reference to any measured in-stream sediment indicators.

Puhoi to Warkworth

Ara Tūhono Puhoi to Warkworth (Puhoi to Warkworth), is a large NZTA roading project currently under construction in the North of Auckland. Puhoi to Warkworth was part of the Roads of National Significance programme, and sought to re-route State Highway 1 along an 18.5 km new section from North of the Johnstone's Hill tunnels at Waiwera, to just north of the Warkworth Township.

The Puhoi to Warkworth project was selected for further study based on the large area and volume of earthworks proposed, and the variable catchment characteristics over which the roading project crossed. In addition to this, Auckland Council has 2 State of the Environment (hereafter, SoE) monitoring sites on the Mahurangi River, an identified receiving environment for any sediment-laden flows that could result from the proposed earthworks. As part of the consenting process significant background information was collected, including sediment characteristics in the receiving environment. Consent conditions require monitoring sediment characteristics in the receiving environment.

The application material refers to pre-commencement water quality and sediment monitoring that was to be undertaken.

Lucas Creek

Lucas Creek (Waikahikatea Stream) covers an area of approximately 3,774 ha in the Albany area to the North of Auckland. The area has undergone significant urbanisation beginning in the 1980s and is a relatively rich source of environmental data as a result of being the focus of various environmental monitoring and modelling studies. In 2010, the former Auckland Regional Council and North Shore City Council conducted a stream restoration and enhancement project over a 1 km reach of Lucas Creek to address stream bank erosion.

The catchment provides an example of an urbanised catchment, with some on-going development including some application of Water Sensitive Design Principles, with a range of supporting modelled and measured data sets.

City Rail Link

City Rail Link (CRL) is a rail project currently under construction in the Central Business District of Auckland City. The project consists of the construction of a 3.5 km long double tracked railway tunnel from Britomart Transport Centre to Mount Eden Railway Station. Construction is proposed to be by cut-and-cover trenching methodologies and the use of tunnel boring machinery through an already fully urbanised catchment.

Construction activities began in October 2015.

CRL was selected as a case study based on the surrounding catchment being already developed, public availability of management plans including erosion and sediment control plans as well as conditions on the consent that required daily monitoring for Turbidity (NTU) and weekly monitoring for Total Suspended Solids (TSS) from de-watering activities.

Northlake

Northlake is a large, staged, development south of Lake Wanaka in New Zealand's Otago Region. The development converts predominantly pastoral farming area into predominantly residential areas with a 'village centre' of commercial development. Northlake has progressed in stages. Where specific detail is required, this comes from Highland Capital Partners Ltd 2005 resource consent application for subdivision, including earthworks.

Northlake has been selected for study representativeness across the regions and sediment attribute classes of New Zealand.

The application material contained no reference to any measured in-stream sediment indicators.

Transmission Gully

Transmission Gully is a 27 km long NZTA roading project from MacKays Crossing (Kapiti Coast) to Lindon (Wellington City), which is currently under construction and scheduled to open in 2020. The purpose is to provide another route between Wellington and the lower and central North Island. The project includes 6.3 million m^3 of excavation and 5.8 million m^3 of fill over an area of approximately 200 ha.

The Transmission Gully project was selected for further study as it involves earthworks within nine catchments, most of which drain to the Pauatahanui Inlet and Onepoto Arm, which discharge into the Porirua Harbour. Sediment yield calculations on the catchment and anticipated changes due to the project were undertaken as part of the consenting process. Site Specific Environmental Management Plans (SSEMPs) were required to address erosion and sediment control.

The conditions of consent require monitoring of sediment indicators in the receiving environment and we have been provided with data of the monitoring undertaken to date.

Tauranga Eastern Link

The Tauranga Eastern Link (TEL) was a NZTA roading project to construct 17 kilometres of new road and 6 km of highway up-grades between Te Maunga (near Baypark Stadium), Tauranga and the junction of State Highway 2 and State Highway 33. TEL construction required approximately 3 million m^3 of earthworks and several new bridges, including a new bridge over the Kaituna River.

TEL was selected as a case study based on achieving a geographical spread across the country as well as the works having already been completed in 2015. Conditions of consent required discharges from sediment control devices be monitoring for total solids. Environment Bay of Plenty also have SoE monitoring sites on the Kaituna River.

Mount Messenger Bypass

The Mount Messenger Bypass is an NZTA roading project for new section of SH3, between Uruti and Ahititi to the north of New Plymouth. This new section of SH3 will bypass the existing approximately 7.4 km steep, narrow and winding section of highway at Mt Messenger. The proposed route involves a new tunnel, significant cuttings and native forest removal. Approximately 960,000 m^3 of excavated (cut)

material will be generated from the site. Approximately 890,000 m^3 of material will be placed in fill embankments on-site.

Whilst this project has not commenced and is under appeal, it is selected as a case study as it covers a 36 ha area and has detailed sediment and erosion assessments for all areas on the planned impact route. The case study is based on the consent application documents and aims to achieve best practice against Taranaki Regional Council statutory documents and non-statutory guidelines.

3.1 Assessment of Sediment Discharges

3.1.1 Natural Sources of Variability

The Task 1 Report noted sediment loads in New Zealand are driven primarily by rainfall, topography and geology. Five key natural sources of variability were identified, these were:

- Topography (slope angle and slope length)
- Geology
- Soil type
- Rainfall
- Vegetation/ground cover

The development plans are assessed in respect to the five natural sources of variability. Where relevant, additional information has been provided, noting that the intention of this section of the report is to assess the development plans in terms of sediment discharge and management.

A summary table of the River Environment Classification (REC) climate, topography and geology characteristics as well as the proposed suspended sediment attribute classes and deposited sediment monitoring plan requirement classes can be found in Appendix 2.

Drury South

The application material for the Drury South consent focuses on the effect the proposed earthworks and streamworks would have on the existing environment. In brief:

- Topography: Figures are given for the degree of slope over which earthworks will occur; overall the topography is described as relatively flat.
- Geology: The site is described as being underlain by half South Auckland Volcanic Field and half Puketoka Formation geologies, generally overlain by Taupo Pumice Alluvium.
- Soil: Soils are described as variable and include: recent alluvium, wet silty soils and interbedded silts clays and sands.
- Rainfall: The site is within the Manukau Ecological District which averages 1100 mm of rainfall a year. The ESCP includes rainfall based monitoring measures based on rainfall events greater than 25 mm/day or 15 mm/hr. The 25 mm/day figure is based on this being close to the 1% Annual Recurrence Interval (ARI) event, such that the rainfall based monitoring would be expected to be undertaken approximately once a year.

- Vegetation: The current (at the time of application) land use is described as being dominated by farming, either pastoral or horticulture, as vegetation is correspondingly described as grassland or crops. Specific mention is made that very little original indigenous vegetation is left.

No water quality measures or assessment of background sedimentation level is given. The ESCP includes specific commentary on why a USLE was not undertaken, implying that the USLE's primary use is for identifying areas of higher risk which would be captured in the ESCP.

Puhoi to Warkworth

The application material for the Puhoi to Warkworth describes the existing environment in detail. The Construction Water Assessment Report (CWAR) provides the following information:

- Topography: To the north, the designation land is mostly low, open undulating hill country; in the centre and south the designation land is considered rolling hill country with interconnected ridge and valleys systems. Slope areas within the proposed designation was provided for a total area of 673.8 ha in 3 degree increments. 45% or 54.2 ha of the project area had an underlying slope of over 15 degrees.
- Geology: The majority of the project area is underlain by Waitemata Group, particularly the Pakiri Formation, although the Tauranga Group is also noted.
- Soil: Soil type is a complex arrangement of sandstone mudstones with significantly weaker sheared mudstones, siltstones, sandstones and limestones. The CWAR notes that in conjunction with the steep terrain these overlying soils are considered unstable, or highly susceptible to erosion.
- Rainfall: The application material reported rainfall data from Auckland Council TP108, NIWA's HIRDS V3 and an Auckland Council Rain Gauge. The rainfall volume was not considered significant.
- Vegetation: Each catchment within the project areas was assessed in terms of current land use, with rural production, particularly pastoral farming, being the dominant land use type, although significant areas of plantation forestry were also noted.

The CWAR also includes a series of studies on the background sediment yields for the various catchments. The Groundwater Loading Effects of Agricultural Management Solutions (GLEAMS), adjusted for site specific characteristics, was used to predict a mean annual background sediment yield for the Hill Focus area of 478 t, and 435 t for the Flat Focus area. Background water quality parameters measured included turbidity and clarity.

Lucas Creek

The Lucas Creek catchment was predominantly pastoral farming until the 1980s, when the area, principally the Oteha Stream sub-catchment, underwent rapid urbanisation. Several studies have looked into historic sedimentation levels of the Lucas Creek tidal inlet.

No specific information is available on the natural sources of variability of sediment loads. However, based on published information, the following can be determined:

- Topography: The topography rises from sea level to approximately 120 m in a series of undulating terraces.
- Geology: The geology of the area is primarily Pleistocene Sandstones.

- Soils: Soils are derived from weathered Waitemata Group such as silty clays, sandy silts, and clayey silts, valleys contain alluvial deposits organic silty clays.
- Rainfall: Auckland Council maintains a rainfall gauge within the catchment (Oteha @ Rosedale Ponds). Auckland Council Technical Publication 1999/108 (TP108) also provides modelled rainfall depths for a design 24-hour storm, which shows 80 mm rainfall contour with a 2 year Annual Recurrence Interval (ARI).
- Vegetation: Ground cover has undergone several significant pulsed changes, from predominantly native forest (6500–700 years B. P.), forest clearance during Polynesian settlement (700–110 years B. P.) and logging, gum digging and land clearance accompanying farming during European times (A. D. 1841 to 1980s) and subsequently increasing coverage of impervious surfaces associated with urbanisation since the mid-1980s.

City Rail Link

No specific information is available on the natural sources of variability of sediment loads for the project area covered by CRL. As noted in the resource consent application material:

- Topography: The topography of the area is characterised by ridges and valleys. Along the CRL alignment, the slope averages approximately 2.6% as it rises to a height of 70 m.
- Geology: The geology of the area is predominantly East Coast Bays Formation.
- Soils: Soils consist of fill, alluvial clays and silts.
- Rainfall: No rainfall data is provided in the application material, Auckland Council TP108 provides modelled rainfall depths for a design 24-hour storm, which shows 70 mm rainfall contour for the 2 year ARI.
- Vegetation: Ground cover within the CRL area is noted as being "built up urban environment", it is expected that most of the existing land cover is impervious.

Northlake

The AEE submitted with the resource consent application provides a brief overview of the subject site, that includes reference to some of the sources of natural in-stream sediment variability. The subject sites are described as:

- Rolling pastoral land, typical of the glacial moraine surrounding Wanaka, with a good cover of top-soil and generally used for pastoral farming.

Otago Regional Council (ORC), have a series of rainfall monitoring gauges throughout the region. The closest to the Northlake development is Clutha at Stoney Creek.

Transmission Gully

The AEE for Transmission Gully describes the environment prior to construction as follows:

- Topography: The topography varies along the route from steep slopes to low lying flat plains.
- Geology: The majority of the route is underlain by greywacke bedrock. Locally, areas were underlain by unconsolidated sand dune deposits, alluvial sand, silt and clay deposits
- Soil: Soil type was not defined; however, the greywacke was described as completely to moderately weathered.

- Rainfall: Annual rainfall for the Wellington region is 1,249 mm which was sourced from NIWA climate data from 1971 to 2000.
- Vegetation: The proposed road traverses mainly through pastoral land and pine plantations with localised pockets of indigenous vegetation. A limited portion of the southern section is within the vicinity of residential suburbs.

Tauranga Eastern Link

The application material for Tauranga Eastern Link is no longer publicly available.

The following information has been inferred from publicly available information:

- Topography: The route of the TEL passes through areas of varying environments; however, the overriding quality of the landscape is its relative flatness, with the majority of the route on land below 20 m above sea level.
- Geology: From the existing Te Maunga roundabout to Mangatawa Lane, the route is essentially underlain by Foredune Sand and Alluvium, with the Fluvial Terrace at depth. Other areas comprise Alluvium overlying the Fluvial Terrace.
- Soils: The Alluvium is variable, in some places dominated by silt and elsewhere by sand. From south of Pah Road, the Fluvial Terrace, which is likely to include volcanic air fall deposits, underlies the route.
- Rainfall: Annual rainfall, sourced from NIWA Tauranga Aero AWS monitoring site, shows an annual average rainfall of 1,189 mm.
- Vegetation: Near all of the route was previously in pasture, utilised for dairy farming, or cropping.

The Kaituna Drainage Scheme implemented in the 1900s modified the surrounding catchment and drained the land that had previously been typified by moisture tolerant plant species such as cabbage trees, flax and kahikatea forest.

Mount Messenger Bypass

At the time of writing, the resource consents for Mt Messenger Bypass were under appeal at the Environment Court. The following information is from publicly available information:

- Topography: The proposed route is on steep slopes (>20%) and also valley bottom based (slopes typically <10%). A range of slope classifications were identified as part of the topography risk management for sediment and erosion control.
- Geology: The geology is dominated by papa mudstone, which has a considerable influence on stream substrate.
- Soils: The gravels are soft and there is a relatively high amount of fine sediment cover on the stream bed.
- Rainfall: The nearest rain gauge is 20 km away, so design storms are derived from HIRDS. Annual rainfall equates to approximately 2000 mm with approximately 40% of this falling over the 4-month period from May to August. Lower rainfall in January to March indicates a drier period. The consent requirement is to manage these wetter periods with additional sediment and erosion management controls. The Construction Water Assessment Report estimated that over the planned 4 year project, the likelihood of a 5 year ARI rainfall event is 55% and considered it acceptable.

- Vegetation: The project sits within a wider area of indigenous forest running from the coastal margins inland to the lowland mountains. It primarily includes coastal hardwood-podocarp forest and swamp forest (Mimi catchment). It is estimated that 36 ha of vegetation is to be cleared for the road, access tracks and spoil sites. The project proposed a staged approach with progressive stabilisation works to address this.

3.1.2 Development Sources of Variability

The Task 1 Report noted that urban development goes through a cycle of land-use change which drives a change in sediment yield and stream channel response. Numerous studies were included that identified measures that affected urban development sources of variability. These sources included:

- Area exposed
- Sediment control measures in place
- Erosion control measures in place
- Storm event design sizing
- Sediment control following development completion
- Maintenance and compliance of erosion and sediment controls

The development plans are assessed below based on the content of those plans in respect to the sources of variability during development. The intention of this section of the report is to assess the development plans in terms of sediment discharge and management.

Drury South

The available information for Drury South shows that consent was applied for on an 'Annual Management Plan' (AMP) approach. Enough information was provided to Council to assess the effects and the measures proposed to address those effects. The exact effects, such as the area of earthworks, and the measures proposed to address those effects, such as erosion and sediment controls, were to be certified as meeting the consented outcomes through the AMP. A year 1 AMP was submitted as part of the application material. As such, not all the development sources of variability are explicitly stated in the application material.

- Area: Earthworks area limits for a given year, this would be certified under the corresponding AMP for that year. Specific open areas are placed on earthworks within the 5% Annual Exceedance Probability (AEP) floodplain (5 ha) and land within 20 m of a stream (1 ha that must be stabilised at the end of every work day).
- Sediment / Erosion Controls: Indicative erosion and sediment controls are identified for year one works, again subject to certification under the AMP. A condition of consent requires an ESCP be submitted with the AMP that details: erosion and sediment control measures, construction methodologies as well as areas susceptible to erosion.
- Design Size: The application and conditions of consent refer to Auckland Council's GD05. Under GD05, controls are designed to treat flows up to the 5% Annual Exceedance Probability (AEP) rainfall event.

- Post-Completion Controls: The ESCP submitted with the application material includes reference to stabilising exposed surfaces progressively and upon completion of the earthworks, which are also noted in the consent conditions.
- Maintenance / Compliance: The ESCP submitted with the application material includes specific maintenance and monitoring procedures, which are also included as conditions of consent. Water Quality measurements (NTU, visual clarity and TSS) are proposed to be taken during earthworks in response to rainfall events, and these are conditions on the consent.

Puhoi to Warkworth

The Puhoi to Warkworth application was lodged based on an indicative alignment for the proposed road. As such, a series of application plans and reports provided sufficient information on which to grant consent, although it was not until subsequent detail design that the exact roading alignment and those effects were known.

The Construction Water Assessment Report (CWAR) provides the following information in relation to development sources of variability:

- Area: Based on modelled information (GLEAMS) the CWAR considers a maximum open area of 41 ha for Puhoi Catchment, 41 ha for the hill country and 21.5 ha for the flat country in the Mahurangi Catchments. These open area limits aim to avoid an increase in sediment-yield for the catchments. Earthworked areas were proposed to be stabilised to keep within the open area limits, aggregates, vegetation, mulch were identified for this purpose.
- Sediment / Erosion Controls: The CWAR specifically references erosion and sediment controls in accordance with TP90. TP90 was the relevant best practice guidelines for Erosion and Sediment Control from Auckland Council. Conditions placed on the consent to this effect.
- Design Size: Under TP90, erosion and sediment controls are designed to treat flows up to the 5% AEP rainfall event.
- Post-Completion Controls: Earthworked areas were proposed to be stabilised to keep within the open area limits, aggregates, vegetation, mulch were identified for this purpose.
- Maintenance / Compliance: The application material included reference to monitoring the erosion and sediment controls which was subsequently included as a condition of consent.

Water quality attributes proposed to be monitored through construction included TSS, NTU and the sediments in the receiving environment in response to rainfall triggered monitoring.

Lucas Creek

Significant urbanisation began in the Lucas Creek catchment in the 1980s development, including of greenfield areas, is still occurring. Whilst detailed information is not publicly available as to the area of bare ground exposed at a time, the following information can be determined:

- Area: A review of the 1996 aerial photographs shows an area of approximately 153 ha, or 4% of the catchment undergoing earthworks.
- Sediment / Erosion Controls, Design Size, Post-Completion Controls, Maintenance / Compliance: Given the timing over which urban development has occurred, it is expected that earthworks have been controlled by erosion and sediment controls designed under TP2, TP90 and GD05. All

guidance documents refer to the need for re-vegetation or stabilisation of exposed areas to occur as soon as possible following the completion of earthworks and prior to the removal of erosion and sediment controls. From TP90 onwards, guidance documents include specific maintenance and monitoring requirements for erosion and sediment controls.

City Rail Link

CRL at the time of writing is still under construction, and the information reported here is based off the publicly available application material, including the indicative management plans.

- Area: The application material includes indicative length, depths and construction methodology and sequencing of construction activities. The total area exposed is not reported.
- Sediment / Erosion Controls: The construction management plans are again indicative, but they refer to TP90 erosion and sediment control measures that could be used to control earthworks areas.
- Design Size, Post-Completion Controls, Maintenance / Compliance: TP90 (5% AEP).

Northlake

The application material provides a brief overview of the consented earthworks. The Application material states that a detailed earthworks management plan would be submitted when applying for engineering approval.

- Area: The area subject to earthworks is given, although no staging details are provided.
- Sediment / Erosion Controls: No reference is made to any erosion or sediment control guideline, the plans and reports submitted with the engineering approval show two infiltration ponds, although it is unclear if these devices are for sediment control during construction or for stormwater management post-development.
- Design Size: no design details are provided for the infiltration ponds in relation to storm event sizing.
- Post-Completion Controls: The earthworks management plan refers to the stabilisation of earthworked areas through the re-spreading of a subsequently-vegetated top-soil layer within a month of completion.
- Maintenance / Compliance: Conditions placed on the District subdivision consent require construction traffic to access the site through a vehicle crossing of compacted aggregate and to control and or mitigate any dust, silt run-off and sedimentation that may occur.

Transmission Gully

The AEE describes the key erosion and sediment control principle as minimising the area and length of time that particular areas of ground are open and to stabilise as soon as practicable. It was noted in the AEE that discharges from the construction sites could result in increased sediment discharge to streams, and where the streams discharge into the catchments surrounding the Porirua Harbour, an increase in sediment levels in the Harbour will result.

The Erosion and Sediment Control Monitoring Plan (ESCMP) and the Site Specific Environmental Management Plan (SSEMP), provides the following details:

- Area: Areas exposed at any one time is limited. The total area that may be exposed varies between catchments from 4 ha at any one time to 17 ha.
- Sediment / Erosion Controls: Erosion and sediment controls have referred to the NZTA's Erosion and Sediment Control Standard for State Highway Infrastructure and the Erosion and Sediment Control Guidelines for the Wellington Region.
- Design Size: All sediment retention devices are to achieve efficiencies of at least 70% removal for all storm events, up to and including a 10 year ARI.
- Post-Completion Controls: The site is to be progressively stabilised as works progress. Where possible, the permanent landscaping should be applied to the final slopes. Where is this not possible, temporary stabilisation will utilise a stabilisation polymer mix including paper mâché, seed and fertilizer.
- Maintenance / Compliance: Regular and storm monitoring visits of the works will be undertaken to inspect all erosion and sediment controls on a weekly basis as well as before and after rainfall. Sediment retention measures will be cleaned out when 20% full, and more regularly for higher risk devices. The ESCMP specified monitoring of six catchment sites upstream and downstream of the proposed works with monitoring to be undertaken for at least 12 months prior to works commencing and to continue throughout construction, and for any work that may generate sediment following construction. Parameters to be monitored include turbidity (NTU), total suspended solids (TSS) and project sediment yield in each specific catchment based on assessment of effects. The pre-construction monitoring was used to establish trigger levels and to provide a baseline to determine if the mitigation has been successful.

Tauranga Eastern Link

Little information is publicly available on the construction phase of TEL that relates to development sources of variability. Limited information has been supplied by others.

Notwithstanding the limited information available, in respect to the management of the works it should be noted that consent was granted under the EBOP 2001/03 erosion and sediment control guidance. This document is no longer publicly available, although it is noted in the current EBOP guidance as having errors and deficiencies.

An ESCP is referred to in the consent decision document

- Area: The area of works exposed at any one time cannot be determined based on the available information.
- Sediment / Erosion Controls: Sediment controls were in place, consisting of at least several decanting earth bunds (DEBs) and a sediment retention pond (SRP) as well as a silt curtain.
- Design Size: A condition of consent requires all erosion and sediment controls to be designed in accordance with EBOP 2001/03.
- Post-Completion Controls: Conditions of consent require the stabilisation of earthworked areas following the completion of works.
- Maintenance / Compliance: One monitoring report has been provided which showed TEL fully compliant with the conditions of consent. 6 discharge laboratory reports have also been provided which shows TEL as being compliant with the discharge standards for suspended solids.

Mount Messenger Bypass

- Area: The total earthworks are expected to be 36 ha, split 30% and 70% between the Mimi and the Tongaporutu catchment, respectively. The bulk earthworks are anticipated to be undertaken in a staged approach, limiting exposed areas at any one time to reduce erosion potential.
- Sediment / Erosion Controls: The project has used NZTA's Erosion and Sediment Control Standard for State Highway Infrastructure Guideline, with erosion control is seen as the highest priority as it would reduce sediment generation.
- Design size: Clean water diversion channels are designed to the 20-year ARI with a 300 mm freeboard, with the 300 mm freeboard this standard is reported to thus accommodate a 100-year ARI (Construction Water Assessment Report, December 2017). Sediment ponds are to have spillways to accommodate a 100 year ARI. Despite this, there is no clear design sizing, although it is noted that the 5 year ARI is reported to be the highest risk event for the project.
- Post-Completion Controls: Post construction erosion and sediment generation is not discussed.
- Maintenance / Compliance: A Construction Water Management Plan (CWMP) will be developed to provide the overall approach and guidance for construction water management during construction of the Project. Rainfall triggered monitoring (25 mm rain event) and associated thresholds of in-stream sediment indicators resulting in management actions are provided for the construction period.

3.1.3 Mature Urban Catchment Sources of Variability

The Task 1 Report noted that following development, there is a period of stabilisation as the main construction phase is completed and the urban area matures. During this period, the sediment yield will decrease and reach a new equilibrium as urban areas have high impervious area cover, which provides a barrier to prevent erosion. However, urbanisation introduces other sources of sediment. These include:

- Road deposited sediment from both anthropogenic and natural sources
- Small construction sites (infill development, improvement works)
- Non-consented works
- Minor earthworks/landscaping
- Gravel surfaces (roads, pathways, road shoulders)
- Other urban activities such as grass verge parking, gardening
- Bare earth (road side cuts, pathways)
- Abandoned development sites
- Land slides

The development plans are assessed below based on the content of those plans in respect to the sources of variability during development. Where relevant, additional information has been provided, noting that the intention of this section of the report is to assess the development plans in terms of sediment discharge and management.

Drury South

The application material did not address any of these factors. It is noted that consent BUN60305778 is limited in scope, and that future consents for would be required including stormwater discharge and smaller scale works for final subdivision.

Puhoi to Warkworth

The application material included an 'operation water management' assessment, which detailed how the permanent effects of motor stormwater would be managed.

Rainfall was proposed to be collected and directed to treatment devices. Originally 27 stormwater wetlands were proposed, which would remove 75% TSS and provide extended detention to reduce the potential for in-stream erosion.

Lucas Creek

Land use throughout the Lucas Creek catchment is now predominantly urban. Significant earthworks such as those for the Auckland Northern Corridor are still on-going. As such, it is known that there are consented building works, large scale roading infrastructure (including State Highway 1, the Northern Motorway), and infill development. No information is available that specifically addresses non-consented or non-compliant works, gravels, gardens, parking on grass verges or landslides.

City Rail Link

CRL works would occur in a mature urban catchment. No assessment is provided in the application material around the long-term effect of the proposed works as they relate to sediment indicators or the management of stormwater.

Northlake

The application material infers the potential for increased impervious areas to increase stormwater runoff and note that this will be disposed to ground. No mention is made of future works or consideration of the on-going environmental effects of the proposed activities beyond traffic, stormwater, wastewater and visual amenity.

Transmission Gully

The AEE discussed the actual and potential environmental effect of the proposal following construction. The project includes the increase in impervious surface, permanent stream crossings and permanent stream diversions, which may affect the hydrological regime due to changes in run off and overland flow paths, realigned waterways and new stream crossings, and effects from stream velocity changes causing scour and erosion.

Wetlands are proposed to treat stormwater runoff from the road when in operation. The TSS concentrations were predicted to be slightly higher than pre-development levels but less than if constructed wetlands were not developed.

Tauranga Eastern Link

None of the material review for this project noted any reference to post-completion conditions or requirements. A note on that the TEL enabling works included enlarging the Maranui stormwater treatment pond to cater for the additional runoff generated from proposed future development, including TEL. This work was completed in February 2013.

Mount Messenger Bypass

The application material details the importance of the natural, ecological and habitat values of the project area and the critical management of the discharge of sediment, and other construction related discharges, to avoid or mitigate adverse effects.

The result of 21 culverts and loss of stream habitat and function are noted and mitigated through fish passage design and riparian planting.

The AEE concludes that the combination of the project having a relatively small impervious footprint relative to the catchment and using a stormwater treatment system developed in accordance with NZ Transport Agency guidelines means any effect on receiving environments will be no more than minor.

3.2 Assessment of In-Stream Sediment Effects

Based on the case studies review, little information was available of instream sediment effects. The Task 4 Report describes a water quality modelling analysis of key variables relating to slope, staging of construction and sediment controls to provide further analysis of potential variability of sediment load from land development.

Large NZTA roading projects, such as Puhoi to Warkworth, did include potential effects in the receiving environment associated with construction works as well as stormwater management upon completion of the works. The application material often used modelled data to demonstrate that the effects could be managed appropriately and, in the case of the more recent applications, monitoring provisions that included some in-stream sediment indicators, often Total Suspended Solids (TSS) and Turbidity (NTU).

Application material for other resource consents, where they included in-stream effects assessments, noted potential effects associated with changes to water quality in the receiving environment as being mitigated through erosion and sediment controls.

It should be noted here that the contents of any development plan, such as an application for resource consent, is shaped by the provisions of the plan under which consent is required. For example, the AUP:OP includes a series of objectives and policies around maintaining or enhancing freshwater quality and minimising sediment discharges to the receiving environment. The AUP:OP also includes a series of provisions that an applicant for consent must meet in order to gain consent, including detailing the matters required in an ESCP as well as that earthworks must be controlled by 'best practice' erosion and sediment controls, which is specifically linked to GD05.

3.3 Regulatory Environment – Compliance, Monitoring and Enforcement

Councils also have a duty to undertake compliance, monitoring and enforcement (CME) to ensure compliance with the RMA. It is critical that councils perform their CME functions to promote sustainable management of the natural and physical resources in their region.

As noted above, consents for large earthworks are being granted on the basis that erosion and sediment control mitigate the effects of sediment discharges to the receiving environment. In order for this to hold true, the devices must be installed, maintained and operated properly. Whilst this is the responsibility of the consent holder, Councils that perform their CME activities poorly can significantly undermine investment in good planning, policy-making, and resource consenting processes. Councils' CME activities set clear expectations for the regulated community on the need to comply, and are necessary to achieve desired outcomes, including the sustainable management of natural and physical resources.

The Task 3 Report will build upon the theme of the regulatory environment and includes assessment of compliance, monitoring and enforcement data where available.

3.4 Synthesis

The case study material has been used here in section 3.0 to assess the sources of the of sediment and sedimentation variability across a broad geographic range within New Zealand. The review of the selected urban development plans focused on their content relating to the natural, development and mature urban reasons for sediment discharge variability previously identified in the Task 1 Report. The case studies spanned a wide range of the characteristics.

The case studies however, do not contain the necessary information to show changes in suspended sediment loads or concentrations over time. All the case study material was reviewed for content that specifically considered suspended sediment load changes from pre-development, across construction through to mature urban catchment. No case study material considered suspended sediment load changes from pre-development, across construction through to mature urban catchment.

The case study material was most comprehensive in regard to an assessment of the natural sources of variability and most physical data available was associated with construction monitoring. Little information or assessment was available from the assessed material regarding the long term, post-construction, changes to in-stream sediment indicators.

4.0 Conclusion

The Ministry is currently considering a sediment attribute for inclusion within the National Policy Statement: Freshwater Management. In this report a review of existing urban development plans from around New Zealand, including residential, commercial and industrial developments and New Zealand Transport Agency (NZTA) projects have been reviewed. The review has focused on the contents of the development plans in relation to their identified sources of the natural, development and mature catchment sources of variability identified in the Task 1 Report.

The results of the Task 2 Report highlight that the case study information obtained is data deficient. The case studies do not contain the necessary information to show changes in suspended sediment loads or concentrations over time. No case study material considered suspended sediment load changes from pre-development, across construction through to mature urban catchment.

The case study material was most comprehensive in regard to an assessment of the natural sources of variability and most physical data available was associated with construction monitoring. Little information or assessment was available from the assessed material regarding the long term, post-construction, changes to in-stream sediment indicators.

Where water quality data is available it is focused on short-term, construction related monitoring associated with large infrastructure projects. To overcome this limitation of the data set, the Task 4 Report describes a water quality modelling analysis of key variables relating to slope, staging of construction and sediment controls to provide further analysis of potential variability of sediment load from land development.

5.0 References

Auckland Council. Technical Publication 1999/90: Erosion and sediment control guide for land disturbing activities in the Auckland Region.

Auckland Council. Technical Publication 1999/108: Guidelines for stormwater runoff modelling in the Auckland Region.

Auckland Council Guideline Document GD2016/005: Erosion and sediment control guide for land disturbing activities in the Auckland Region.

Auckland Regional Council. Technical Publication 1994/51: Storm Sediment Yields from Basins with Various Landuses in Auckland Area.

Department of Conservation. 2018. NZCPS 2010 guidance note Policy 21: Enhancement of water quality. retrieved from https://www.doc.govt.nz/globalassets/documents/conservation/marine-and-coastal/coastal-management/guidance/policy-21.pdf

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Environment Bay of Plenty. Guideline 2001/03: Erosion and Sediment Control Guidelines for Land Disturbing Operations.

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Franklin, P., Stoffells, R., Clapcott, J., Booker, D., Wagenhoff, A. Hickey, C. 2019. Deriving potential fine sediment attribute thresholds for the National Objectives Framework. NIWA Client Report No: 2019039, prepared for Ministry for the Environment, February 2019.

Hume, T. and McGlone, M. 1986. Sedimentation patterns and catchment use change recorded in the sediments of a shallow tidal creek, Lucas Creek, Upper Waitemata Harbour, New Zealand. New Zealand Journal of Marine and Freshwater Research, 20:4, 677-687.

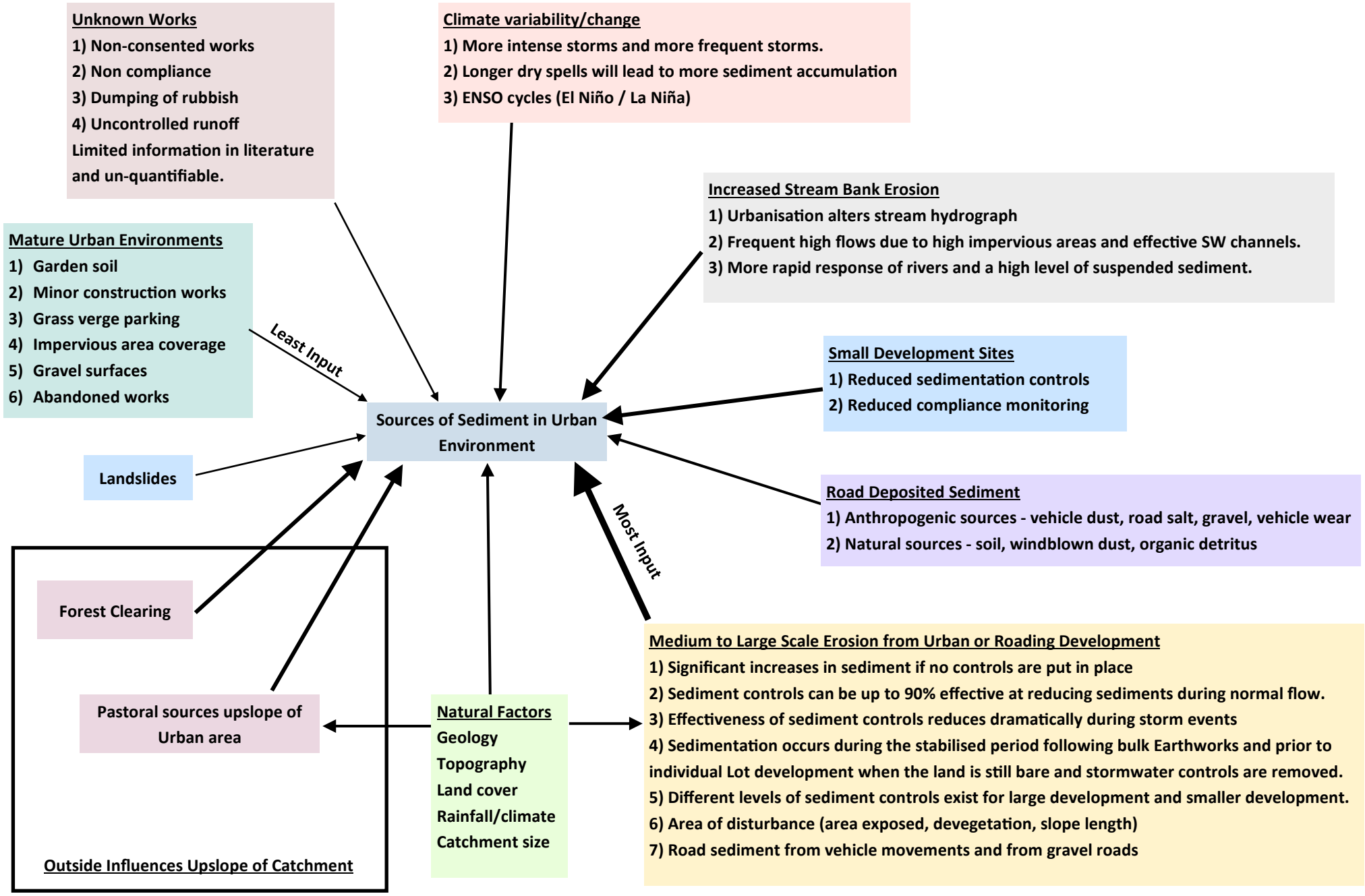
Ministry for the Environment. 2015. Getting in on the Act, An Everyday Guide to the RMA Series 1.1. retrieved from https://www.mfe.govt.nz/sites/default/files/media/RMA/RMA%20Booklet%201.1.pdf

New Zealand Legislation

New Zealand Transport Agency. 2014. Erosion and Sediment Control Guidelines for State Highway Infrastructure.

Resource Management Act. 1991 (NZ)

Appendix 1 Sources of Sediment in an Urban Environment


Unknown Works
1) Non-consented works
2) Non compliance
3) Dumping of rubbish
4) Uncontrolled runoff
Limited information in literature and un-quantifiable.
Climate variability/change
1) More intense storms and more frequent storms.
2) Longer dry spells will lead to more sediment accumulation
3) ENSO cycles (El Niño / La Niña)
Increased Stream Bank Erosion
1) Urbanisation alters stream hydrograph
2) Frequent high flows due to high impervious areas and effective SW channels.
3) More rapid response of rivers and a high level of suspended sediment.
Mature Urban Environments
1) Garden soil
2) Minor construction works
3) Grass verge parking
4) Impervious area coverage
5) Gravel surfaces
6) Abandoned works
Least Input
Small Development Sites
1) Reduced sedimentation controls
2) Reduced compliance monitoring
Sources of Sediment in Urban Environment
Landslides
Road Deposited Sediment
1) Anthropogenic sources - vehicle dust, road salt, gravel, vehicle wear
2) Natural sources - soil, windblown dust, organic detritus
Most Input
Forest Clearing
Pastoral sources upslope of Urban area
Natural Factors
Geology
Topography
Land cover
Rainfall/climate
Catchment size
Medium to Large Scale Erosion from Urban or Roading Development
1) Significant increases in sediment if no controls are put in place
2) Sediment controls can be up to 90% effective at reducing sediments during normal flow.
3) Effectiveness of sediment controls reduces dramatically during storm events
4) Sedimentation occurs during the stabilised period following bulk Earthworks and prior to individual Lot development when the land is still bare and stormwater controls are removed.
5) Different levels of sediment controls exist for large development and smaller development.
6) Area of disturbance (area exposed, devegetation, slope length)
7) Road sediment from vehicle movements and from gravel roads
Outside Influences Upslope of Catchment

Appendix 2 Data Sources

Table 2: Case Studies Data Source

Case Study	Information Requested	Information Received
Drury South	All resource consent application material All compliance data	All resource consent application material All compliance data
Puhoi to Warkworth	All resource consent application material All compliance data	None Publicly available application material used
Lucas Creek		
City Rail Link	All resource consent application material All compliance data	None Publicly available application material used
Northlake	All resource consent application material All compliance data	Various documents relating to multiple resource consents, compliance and engineering approvals
Transmission Gully	All resource consent application material All compliance data	All resource consent application material All compliance data
Tauranga Eastern Link	All resource consent application material All compliance data	None Publicly available application material used Some compliance data
Mount Messenger Bypass	All resource consent application material Any baseline sediment or water quality testing/monitoring data	None Publicly available application material used