Draft Erosion and Sediment Control Standard for State Highway Infrastructure
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Record of amendment

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Foreword

“The Land Transport Management Act 2003, the Land Transport Management Amendment Act 2008 and New Zealand Transport Strategy are signals of a clear focus by the Government on integrated, safe, responsive and sustainable transport. For New Zealand Transport Agency these are positive signals, and they reinforce our beliefs and values. The Act, and the vision, principles and objectives in the New Zealand Transport Strategy, are the high level inspiration for this revised Strategic Plan.”

David Stubbs, Chairperson
June 2004

NZ Transport Agency (NZTA) operates under a “Strategic Plan 2004” that provides goals to reflect the areas of strategic emphasis for Transport. Performance measures have been developed to ensure that achievement of these key goals is increasingly a part of the NZTA’s everyday operations.

NZTA’s five strategic goals under the National State Highway Strategy (2007) are:

1. Ensure state highway corridors make the optimum contribution to an integrated multi-modal land transport system
2. Provide safe state highway corridors for all users and affected communities
3. State highways will enable improved and more reliable access and mobility for people and freight
4. Improve the contribution of state highways to economic development
5. Improve the contribution of state highways to the environmental (emphasis added) and social well-being of New Zealand, including energy efficiency and public health

In the context of erosion and sediment control standards, item five is important. The National State Highway Strategy (June 2007) highlights several points related to the Environment and Communities including aims to:

- Improve the contribution of state highways to the environmental and social wellbeing of New Zealand, and
- Prioritise and address environmental and social issues.

A key outcome is that the NZTA will adopt a set of performance measures that better demonstrates the sustainability of its business.

Following on from the Strategic Plan, an Environmental Plan (Version 2 - June 2008) was developed that focussed on improving environmental sustainability and public health in relation to the state highway network. The Environmental Plan provides significant guidance on erosion and sediment control issues and practices.

The Environmental Plan builds on the NZTA’s solid track record in environmental management and includes objectives to:

- Ensure construction and maintenance activities avoid, remedy or mitigate effects of soil erosion, sediment run-off and sediment deposition.
- Identify areas susceptible to erosion and sediment deposition and implement erosion and sediment control measures appropriate to each situation with particular emphasis on high-risk areas.
- Use bio-engineering and low-impact design practices where practicable.

As stated in the Environmental Plan, NZTA’s role is to ensure careful planning and design to avoid, remedy or mitigate effects of soil erosion, sediment runoff and sediment deposition. NZTA’s intention is to lead in the:

- Promotion and use of appropriate design methods;
- Development and application of practices that minimise risk of erosion and sediment deposition;
- Implementation of erosion and sediment control measures;
- Identification of risk and problem areas;
- Use of best-practice methods unique to each situation to ensure effectiveness;
• Early identification of new projects that have a higher risk of erosion;
• Identification of and support for new techniques and methodologies including research and implementation as appropriate;
• Consultation with local authorities to ascertain problem areas and agree upon solutions; and
• Protection of sensitive receiving environments.

The Environmental Plan further contains an Implementation Plan that provides specific guidance on erosion and sediment control related issues. The Implementation Plan has five NZTA activities, each of which has key methods of meeting the above stated objectives. Those activities and their associated methods include the following:

• National Office Initiatives, which include:
  - Risk assessment
    Identify areas of high risk on a national basis with respect to future proposed projects based on extent and nature of construction works and the values of the receiving environments.
  - Specifications
    Develop specifications for implementation and maintenance of erosion and sediment control measures, including details of resource consent proforma relating to earthworks activities.
  - Education/advocacy
    Undertake educational initiatives with NZTA-employed contractors and consultants to upskill at all levels. Collaborate and form partnerships with the various external providers, research organisations and councils to promote good practice and to further explore technical options and advancements.

• Plan
  - Local authorities’ erosion and sediment control guidelines
    Detailing each local authority’s erosion and sediment control guidelines and extracting key elements from international experience.
  - Collaborative regional planning
    Work with councils to develop regional and district plans that meet the needs of NZTA to ensure that consideration is given to practical and achievable requirements for erosion and sediment control for all projects including maintenance works.
  - Consent conditions
    Ensure that resource consent conditions are appropriate and have considered:
    o Potential effects;
    o Cost effectiveness; and
    o Practicality and achievability.

• Design
  - Control selection
    Seek expert advice and research available literature as necessary to design and advise on appropriate selection of control measures. Follow the ten basic principles and place emphasis on the prevention of sediment generation in the first instance. The less sediment we generate the less we have to capture before it leaves the site.
  - Ongoing advancements
    Collaborate and form partnerships with the councils and private landowners to continually enhance the erosion and sediment control measures while looking for innovative ways of implementation and maintenance.
  - Risk assessment
    Develop a risk matrix for each specific project to allow clear interpretation of the areas where the highest risk exists and how this can be managed to minimise the risk.

• Build
  - Key contacts
    Develop a list of key suppliers and key contacts for your region. Develop partnerships with these parties to secure availability as requested.
  - Consent compliance
Comply with all resource consent conditions and continue to work with all authorities to understand and ensure compliance.

- **Incident reporting and checklists**
  Develop incident reporting and checklists for the various projects to assist with achieving compliance and appropriate objectives and outcomes. Check against the objectives for erosion and sediment control and adjust as necessary.

- **Collaboration**
  Ongoing partnership building with councils and key stakeholders.

- **Maintain and operate**
  - **Only on completion of the construction activity can the erosion and/or sediment control measure be removed. They are short-term measures only and are not designed for long-term placement. Utilise rapid stabilisation techniques to allow for removal of the control measures and to eliminate future sedimentation issues.**

The Land Transport Management Act, 2003, The Strategic Plan (2004), the National State Highway Strategy (2007) and Environmental Plan (Version 2, 2008) clearly demonstrate the NZTA’s commitment to environmental issues as an essential component of state highway construction, operation and maintenance. It is the intent of this “Erosion and Sediment Control Standard for State Highway Infrastructure” to provide guidance on the implementation of project specific erosion and sediment control strategies and practices.

The following sections provide detailed guidance for design, implementation and operation of erosion and sediment control for state highways.
Abbreviations

- ANZECC  Australia New Zealand Environmental and Conservation Council
- ARC  Auckland Regional Council
- BPO  Best Practicable Option
- ESCP  Erosion and Sediment Control Plan
- HAIL  Hazardous Activities and Industries List
- HIRDS  High Intensity Rainfall Design System
- NIWA  National Institute of Water and Atmospheric Research
- NZTA  NZ Transport Agency
- PAC  Poly Aluminium Chloride
- PAHs  Polycyclic Aromatic Hydrocarbons
- RECP  Rolled Erosion Control Products
- RMA  Resource Management Act 1991
- TSS  Total Suspended Solids
- U.S.  United States of America
- USLE  Universal Soil Loss Equation

Acknowledgements

NZTA would like to acknowledge both the Auckland Regional Council and Environment Canterbury for their assistance in the development of this Standard. Auckland Regional Council has allowed photographs and technical figures to be used in the Standard and Environment Canterbury has allowed the Glossary of their Erosion and Sediment Control Guidelines to be used as the basis for the Glossary in this Standard. The Maryland State Highway Administration also provided photographs for use in the Standard.

Their assistance is most appreciated.
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1. Introduction

Sediment from state highway construction sites can have significant detrimental impacts on downstream receiving systems. Adverse impacts from construction sites are caused by the dislodgement and transport of sediment from areas where land clearing and grading occurs. Adverse impacts relate to suspended sediments being transported in stormwater runoff and deposited in areas where water flow energy and carrying capacity is reduced. Another form of erosion is wind (or also called Aeolian after the Greek god of wind) erosion. There are locations in New Zealand where wind erosion can cause significant dislodgement and transport of sediment. The discussion of adverse impacts will be further explored in Section 2 on construction related issues and Section 3 on receiving environments.

There are numerous sources of sediment; some natural and some caused by activities of man. Due to increasing recognition that accelerated sediment discharge from construction sites has potential for significant adverse impacts to receiving systems, a number of regional councils have developed technical guidelines for earthworks in their regions. These technical guidelines assist practitioners with the selection and design of erosion and sediment control practices for construction projects, which would include state highway construction.

Until this Standard, there has not been a technical standard whose focus is specifically on state highway construction erosion and sediment control in New Zealand.

When engaged in state highway construction, site conditions dictate what practices can be used and this Standard identifies state highway erosion and sediment control practices that account for the following considerations:

- Climate,
- Soils,
- Slope,
- Size of disturbance,
- Receiving system that the project drains into,
- Cost,
- Effectiveness of the practice,
- Requirements of regulatory authorities, and
- Constraints of earthworking on linear projects.

The Standard will incorporate the above items into the criteria for both erosion and sediment control practices and provide guidance on specific situations where a given practice is appropriate and how to size the practice. The next section will discuss these items in greater detail.
1.1 Scope

This Standard provides detailed design guidance for erosion and sediment control practice for state highways.

It is comprised of the following sections:

- An introduction,
- Construction related issues,
- Receiving environments,
- Erosion and sediment control concepts,
- Selecting a management approach,
- Hydrological design criteria,
- Project requirements,
- Erosion and sediment control practices, and
- New product consideration.

As a separate document a field guide for contractors providing guidance on construction, operation and decommissioning of site controls is provided.

1.2 Regulatory context

The primary legal mandate for implementation of erosion and sediment control in New Zealand is the Resource Management Act 1991 (RMA). The RMA is the primary environmental Act in New Zealand. There are other acts such as the Local Government Act 2002 and the Government Roading Powers Act 1989, which establish functions, duties and powers of road controlling authorities. However, it is the RMA regime, which establishes the framework of objectives, policies and rules within which the effects of construction related runoff is managed.

The ‘sustainable management’ purpose of the RMA requires those exercising functions, duties and powers under the RMA to manage the use, development and protection of natural and physical resources in a way, or at a rate, that enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety while, among other things, avoiding, remedying or mitigating any adverse effects of activities on the environment. Further, Section 17 of the RMA places a general duty on ‘every person’ to avoid, remedy or mitigate any adverse effects of activities on the environment, whether or not the activity or lawfully established use is in accordance with a national environmental standard, rule in a plan, a resource consent or a designation.

The State highway network, and by implication the local authority road network, is a ‘natural and physical resource’ in terms of the RMA and is required to be sustainably managed. The ‘environment’ is widely defined in the RMA to include all natural and physical resources; ecosystems and their constituent parts, people and communities, amenity values and the social, economic, aesthetic and cultural conditions that affect these matters.

1.3 Local council requirements

Under Section 30 of the RMA, every regional council (including unitary authorities) has a number of functions for the purpose of giving effect to the Act in its region, including:

- The establishment, implementation, and review of objectives, policies and methods to achieve integrated management of the natural and physical resources of the region.
- The control of the use of land for the purpose of (among other things) –
  - Soil conservation,
  - The maintenance and enhancement of the quality of water in water bodies and coastal water, and
  - The maintenance and enhancement of ecosystems in waterbodies.
• In respect to any coastal marine area in the region, the control (in conjunction with the Minister of Conservation) of (among other things) –
  – Land and associated natural and physical resources,
  – The taking, use, damming, and diversion of water,
  – Discharges of contaminants into or onto land, air, or water and discharges of water into water, and
  – Any actual or potential effects of the use, development, or protection of land.
• The control of discharges of contaminants into or onto land, air or water and discharges of water into water

Territorial authorities (which include city councils and district councils) pursuant to Section 31 of the RMA have a number of functions for the purpose of giving effect to the Act in their district, including:

• The establishment, implementation and review of objectives, policies and methods to achieve integrated management of the effects of the use, development or protection of land and associated natural and physical resources of the district.
• The control of any actual or potential effects of the use, development or protection of land.
• The control of any actual or potential effects of activities in relation to the surface of water in rivers and lakes.

As a general statement, regional authorities have responsibility for issues related to water quality and water quantity while territorial authorities have primary responsibility for issues related to subdivision and land use.

The means of implementation of environmental controls, primarily by regional authorities, is through regional plans that specify consenting requirements. These consenting requirements form the basis of erosion and sediment control planning, implementation and decommissioning. Specific council consenting requirements will be discussed in Section 7.

From a territorial authority context, the issue is less direct. Under the RMA their role does not include controlling discharges of contaminants into or onto land, air or water and discharges to water. However, the state highways are often designated in district plans and approval for the notice of requirement (which may include earthworks) will be needed from the territorial authority. Territorial authorities may require an Outline Plan of Works to be submitted and confirmed prior to project initiation.

1.4 Purpose of the Standard

This Standard is intended to provide the minimum standard for erosion and sediment control that state highway construction projects shall comply with. Construction includes new construction and state highway maintenance projects. This standard has been prepared with the intention that it will meet or exceed current local erosion and sediment control guidelines so that compliance with it will minimise consenting related issues. If a local standard is amended and becomes more stringent than this Standard, the more stringent requirements shall be met if required by resource consent.

By using the Standard the following NZTA objectives (as outlined in NZTA’s Environmental Plan) will be met:

• Construction and maintenance activities will avoid, remedy or mitigate effects of soil erosion, sediment runoff and sediment deposition.
• Areas susceptible to erosion and sediment deposition will be identified and erosion and sediment control measures will be implemented that are appropriate to each situation with particular emphasis on high-risk areas.
• Bio-engineering and low impact design elements will be implemented where practicable.

With careful planning and design, adverse effects of sediment discharges resulting from construction and maintenance activities can be avoided or minimised (NZTA Environmental Plan, 2008). Moreover, the Standard will assist in attaining consistency nationwide by removing uncertainty with respect to the standard required for the design, construction and maintenance of erosion and sediment controls.
1.5 Bibliography

NZTA, Environmental Plan: Improving Environmental Sustainability and Public Health in New Zealand, version 2, June 2008.

2. Construction related issues

2.1 Introduction

Problems associated with construction site runoff have been known for many years. There is even a book (Carter, Dale, 1974) that discusses the rise and fall of civilisations in part due to declines in soil fertility due to soil erosion. The book discusses most areas of the world and looks at the civilisations that thrived, then declined and their lack of resources today.

Other studies have been done on tributaries to the Chesapeake Bay in the United States of America (U.S.) and the impact that construction related runoff was having on downstream sedimentation (Fox, 1974). In the early 1980’s the Auckland Regional Council (ARC) studied the Upper Waitemata Harbour to consider the sources of sediment that were infilling the upper harbour.

2.2 Problem discussion

In considering erosion and sediment control, there are two terms that can be considered:

- Erosion, and
- Sediment control.

There is a direct relationship between the two.

Simplistically, erosion is detachment: detachment of soil particles from the ground’s surface. The detached particles become sediment once entrained by water.

Erosion is a natural process and even land covered by native vegetation has erosion. Earthworking activities, however, dramatically increase erosion rates. Natural erosion is generally considered in geological terms (hundreds of years), whilst accelerated erosion from our activities is considered frequently from an annual basis.

When a raindrop strikes a surface, pressure acts to destabilise the particles. The loadings due to impact are not uniform and are concentrated at the edge of the contact area. When the drop strikes a surface, lateral jet streams impinge on adjacent irregular surfaces or dirt particles, further destabilising the surrounding area. Based on typical drop sizes of about 1.5mm, and a terminal velocity of approximately 5.5m/sec, it can be calculated that each drop contains about 3 x 10^4 joules of kinetic energy (Springer, 1976). A 3mm per hour rain delivers about 11 joules/m²/minute, while a 12mm/hour rain delivers about 30joules/m²/minute. Rainfall intensity is a key element in determining the kinetic energy needing to be dispersed (Pitt, Clark, Lake 2007).

Raindrop impact initiates soil erosion, and preventing that erosion is a key element in an overall erosion and sediment control strategy. The primary means of limiting this erosion is to provide either permanent or temporary vegetative cover to dissipate the raindrop impact and reduce soil erosion potential. Erosion control is the key first step in reducing site erosion and reducing the amount of work that sediment control practices have to do. Erosion control is also an important element in reducing potential erosion due to high winds.
Sediment control, on the other hand, provides a process for deposition. Deposition is where the sediments being transported by water are prevented from leaving the site where they were generated through the implementation of practices that, in general, promote sedimentation. A basic premise of most sediment control practices is that they hold water in them until the weight of the sediments conveys the sediments, through gravity, to the bottom of the practice, where they settle.

If sediment is not captured on-site by sediment control practices, sediment loadings to receiving systems are increased. There may be economic impacts associated with the increased deposition of sediments downstream. The sediments can clog culverts and fill in drainage channels, storm drain systems, harbours and marina areas. Significant public expenditure is done maintaining these areas. In addition to economic impacts, there are environmental impacts related to reduction in light penetration due to elevated turbidity and smothering of bottom dwelling aquatic organisms by sediment deposition.

As mentioned in the Introduction, there are a number of site conditions that dictate what practices can be used. A common way of considering potential sediment yield is to consider the Universal Soil Loss Equation (USLE). The USLE is an empirical formula that was developed approximately thirty years ago (Wischmeir, Smith, 1978) and is represented by the following equation.

\[ A = RxKx(\text{LS})xCnP \]

Where:

- \( A \) = soil loss (tonnes/hectare/year)
- \( R \) = rainfall erosion index (\$/hectare)
- \( K \) = soil erodibility factor (tonnes/unit of \( R \))
- \( \text{LS} \) = slope length and steepness factor (dimensionless)
- \( C \) = vegetation cover factor (dimensionless)
- \( P \) = erosion control practice factor (dimensionless)

As can be seen, the factors mentioned in the Introduction Section are key factors in consideration of the erosion process. This Standard identifies state highway erosion and sediment control practices that account for the following:

- Climate,
- Soils,
- Slope,
- Size of disturbance,
- Erosion and sediment control practices,
- Pathway and receiving system that the project drains into,
- Practice effectiveness,
- Regulatory authority requirements,
- Cost, and
- State highway construction constraints.

2.2.1 Climate

Climate has an impact on the approach that is taken for erosion and sediment control. Climate consists of the following items:

- Precipitation intensity, duration and frequency, and
- Temperature.

Precipitation can be either snow or rainfall but from the context of sediment discharge, rainfall is far more of a concern. Erosion potential is directly related to the intensity of a given storm. Greater rainfall intensities relate to greater erosion potential. A low intensity rainfall results in reduced erosion potential. The greatest rainfall
intensity that would be considered is 76 mm/hour as median raindrop size does not increase past this when intensities exceed 76 mm/hour. This peak value is only considering raindrop erosion. Site erosion is also caused by overland flow causing rill, gully and channel erosion, but the point here is that rainfall itself initiates the erosion process.

A common measure of rain erosivity is provided in the USLE (Wischmeier, Smith, 1978). In that equation rain erosivity is a factor that is a product of a total kinetic energy of the storm and the maximum rainfall (variable depending on purpose). The rainfall erosion index is the product of rainfall energy and the rainfall intensity. Rainfall energy is dependent on rain intensities.

A good example of rainfall droplet sizes and velocities for various types of rainfall is shown in Table 2-1 (Goldman, Jackson, Bursztynsky, 1986).

Table 2.1 Rainfall droplet sizes and velocities for various types of rainfall

<table>
<thead>
<tr>
<th>Rainfall</th>
<th>Median diameter (mm)</th>
<th>Velocity of fall (m/s)</th>
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<tr>
<td>Fog</td>
<td>0.01</td>
<td>0.003</td>
</tr>
<tr>
<td>Mist</td>
<td>0.1</td>
<td>0.21</td>
</tr>
<tr>
<td>Drizzle</td>
<td>0.96</td>
<td>0.29</td>
</tr>
<tr>
<td>Light rain</td>
<td>1.24</td>
<td>0.378</td>
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<tr>
<td>Moderate rain</td>
<td>1.6</td>
<td>0.49</td>
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<tr>
<td>Heavy rain</td>
<td>2.05</td>
<td>0.62</td>
</tr>
<tr>
<td>Excessive rain</td>
<td>2.4</td>
<td>0.73</td>
</tr>
<tr>
<td>Cloudburst</td>
<td>2.85</td>
<td>0.87</td>
</tr>
</tbody>
</table>

2.2.2 Soils

Soil texture and other soil characteristics affect the soil’s potential for erosion. Many characteristics of soils, including texture, acidity, moisture retention, drainage and slope have an influence on the soils’ vulnerability to erosion. The following soil characteristics have primary importance in determining soil erodibility:

- Texture
- Organic matter content,
- Structure, and
- Porosity.

Soil maps for New Zealand, as supplied by Landcare Research, are shown in Figure 2.1.
The maps clearly detail the diversity of soils that exist throughout the country.

2.2.2.1 Soil texture

Soil texture relates to the sizes and proportions of the particles making up a soil. Sand, silt and clay are the three major classes of soil particles. Sand has a coarse texture while silts and clays are fine textured. Soil texture relates to erodibility as sands have a higher infiltration potential and reduce the volume of water being discharged and thus have less erosion. Clays are bound tightly together and resist erosion but once erosion starts it is difficult to trap these finer soils.

2.2.2.2 Organic matter content

Organic matter is primarily plant and animal litter in various stages of decomposition. Organic matter improves soil structure and increases permeability, water retention capacity and soil fertility. Organic matter, which is primarily found in topsoil, reduces runoff and erosion potential.

2.2.2.3 Structure

Soil structure includes the arrangement of particles into aggregates (groups of particles) and the size, shape and distribution of pores both within and between the aggregate.

There are a number of factors that influence soil structure (Rowell, 1994). These factors include the following:

- Physical processes,
  - Drying and wetting which cause shrinkage and swelling with the development of cracks and channels,
  - Freezing and thawing which create spaces as ice is formed.
- Biological processes.
- The action of plant roots, which remove water resulting in the formation of spaces by shrinkage, release organic materials, and leave behind organic residues and root channels when they die.
- The action of soil animals which move material, create burrows and bring mineral and organic residues into close association.
- The action of micro-organisms which break down plant and animal residues, leaving humus as an important material which binds particles together.

The formation of soil structure thus requires both physical rearrangement of particles and the stabilisation of the new arrangement. Stability is particularly associated with organic materials linking mineral particles together and with clay minerals and sesquioxides (an oxide containing three atoms of oxygen with two atoms of another element).

2.2.2.4 Porosity

Soil porosity is of vital importance in the ability of soils to support plant, animal and microbial life. The spaces hold water, allow for drainage, allow entry of oxygen and removal of CO₂ from the soil, allow for root penetration into the soil and are indirectly responsible for modifying the mechanical properties of soils.

Soil porosity depends on the structure of the soil. It varies depending on:

- Texture and organic matter content,
- Depth in the soil profile,
- Management, as this causes changes in organic matter content over time and applies forces to soils which may either loosen or compact them.

Organic matter and the associated biological activity in soils are of major importance in maintaining soil porosity.

2.2.3 Slopes

The erosion of soil from a slope increases as the slope increases and lengthens (Senior, et.al, 2003). Table 2.2 shows a clear relationship between slope and sediment loading. An important conclusion of the study is that the erosion rate triples as slope doubles. This makes the clear statement that steeper slopes contribute a disproportionate level of sediment for the same disturbed area.

### Table 2.2 The effect of slope on sediment erosion rate in the Mangemangeroa Catchment

<table>
<thead>
<tr>
<th>Slope class (ave degree)</th>
<th>100% earthworks (tonnes/ km²/year)</th>
<th>Pasture (tonnes/ km²/year)</th>
<th>Increase fold over pasture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low</td>
<td>median</td>
<td>high</td>
</tr>
<tr>
<td>B (5.5°)</td>
<td>57,300</td>
<td>122,000</td>
<td>264,000</td>
</tr>
<tr>
<td>C (11.5°)</td>
<td>183,000</td>
<td>363,000</td>
<td>718,000</td>
</tr>
<tr>
<td>D (18°)</td>
<td>311,000</td>
<td>641,000</td>
<td>&gt;1,000,000</td>
</tr>
<tr>
<td>E (23°)</td>
<td>422,000</td>
<td>816,000</td>
<td>&gt;1,000,000</td>
</tr>
</tbody>
</table>
In addition, other work has been done which also demonstrates the linkage between slope and sediment yield. Figure 2-2 is another illustration of that linkage (Barfield, 1986). In addition to showing sediment yield increases for increasing slopes, the figure also shows the effects that vegetation has on sediment yield. Notice that the scale of the figure is logarithmic.

Slope length and steepness are critical factors in erosion potential, since they determine to a large extent the velocity of surface runoff. The energy and erosion potential of flowing water increases as the square of the velocity.

2.2.4 Size of disturbance

The size of disturbance also impacts on sediment yield. Greater areas of site disturbance increase erosion potential. Removal of vegetative cover, including vegetation and topsoil, increases surface runoff and erosion potential. Vegetation enhances evapotranspiration, which tends to dry soils out between storm events. Vegetation also has a roughness associated with it which tends to accelerate or retard the flow of water across it. Table 2-3 (ARC, 2000) shows the increased time that water takes to travel across various surfaces. Longer travel times reduce the potential for erosion of land surfaces.

Table 2.3 Roughness coefficients for various surface covers and travel times

<table>
<thead>
<tr>
<th>Surface</th>
<th>Roughness Coefficient (unitless)</th>
<th>Travel Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare soil</td>
<td>0.011</td>
<td>0.014</td>
</tr>
<tr>
<td>Pasture</td>
<td>0.13</td>
<td>0.093</td>
</tr>
<tr>
<td>Grass (short)</td>
<td>0.15</td>
<td>0.109</td>
</tr>
<tr>
<td>Grass (taller)</td>
<td>0.24</td>
<td>0.159</td>
</tr>
<tr>
<td>Bush (light understory)</td>
<td>0.40</td>
<td>0.24</td>
</tr>
<tr>
<td>Bush (dense understory)</td>
<td>0.80</td>
<td>0.447</td>
</tr>
</tbody>
</table>

1 Assumed 50m length, 12% slope, and 83 mm of rainfall

At low levels of site disturbance (4-10% of total site area), median sediment loadings are predicted to increase approximately 4 fold over existing land use sediment loadings. However, for maximum disturbance by earthworks (100%) the predicted increases in median loads range from about 40 to over 80 fold (NIWA, 1997).
### 2.2.5 Erosion and sediment control practices

The previous items in Sections 2.2.1 – 2.2.4 relate primarily to erosion. This item accepts that there is erosion, and erosion control and sediment control practices which are implemented to reduce downstream sediment loadings. Implementation of erosion control practices reduce particle dislodgement while implementation of sediment control practices capture sediments in transport and prevent those sediments from migrating downstream. Examples of erosion control and sediment control are shown in the adjacent images.

Most effort should be put into preventing sediment generation in the first instance by the implementation of erosion control.

The effectiveness of erosion and sediment control practices will be discussed in later sections.

### 2.2.6 Pathway and receiving system

The proximity of the earthwork area to a receiving system is important when considering the possible impact that site works can cause. The sensitivity of the receiving environment is a critical factor in determining the level of control that needs to be implemented.

As discussed in the next section, a receiving environment can include the following:

- Streams and rivers,
- Estuaries,
- Harbours,
- Open coasts, and
- Lakes

Ground can also be considered a receiving environment but is not considered one in the context of site erosion and sediment control. The primary contaminant of concern is suspended solids and the impact of that on the ground is considered to be negligible. From a permanent stormwater drainage system perspective it is important as there is concern about soluble contaminants contaminating the ground and consideration of those contaminants. It is less important from the context of erosion and sediment control as the primary concern is exposure of the ground itself to erosional processes. Contamination of ground by soil is not considered a concern. As such, ground is not being considered in this Standard as a receiving system.
In addition to the receiving system, the pathway that the sediment laden runoff takes to get from the site being earthworked to the receiving system is also important. Having enclosed storm drains on site would allow for almost 100% delivery to the receiving environment. In a similar fashion, having the receiving system near to the earthworking activity means that there is little buffering between the earthworks and the receiving system. The significance of the pathway relies on its ability to provide some additional polishing of the sediment laden runoff prior to its entry into a receiving system. Some pathways provide a level of buffering while others do not.

In general, a pathway must have sheet flow to allow for the pathway itself to provide for additional sediment capture. If there is concentrated flow, the pathway is ineffective at further sediment reduction and should not be accounted for.

2.3 Types of erosion that are associated with construction activities

There are seven main types of erosion associated with earthwork activities (ARC, 1999) as shown in Figure 2-3.

- Splash,
- Sheet,
- Rill,
- Gully,
- Tunnel,
- Channel, and
- Mass movement.
2.3.1 Splash erosion

When ground vegetation is removed from an area being earthworked, the soil surface is exposed to raindrop impact. On some soils, a very heavy rainfall may splash as much as 224 tonnes/ha of soil. Some of the splashed particles may rise as high as 0.6 m above the ground and move up to 1.5 m horizontally (Goldman, Jackson, Bursztynsky, 1986).

When raindrops hit bare ground, the soil aggregates are broken up and soil structure is destroyed.

2.3.2 Sheet erosion

When rainfall intensity exceeds the soils ability to absorb the rainfall, overland flow is initiated. Initial runoff tends to be in the form of sheet flow, where the runoff is in a shallow dispersed flow where there is no concentration of flow. It can be a significant erosion process as it can cover large areas.

The shallow flow rarely moves more than a few metres before the onset of flow concentration due to surface irregularities.

2.3.3 Rill erosion

Rill erosion is the transition area where sheet flow becomes concentrated flow. At this point, the velocity of flow increases and is accompanied by increased turbulence. The energy of water is increased as the flow depth increases and this provides greater ability to detach and convey soil particles. Rills are small but well-defined channels that may be only a 10-20 mm deep.

2.3.4 Gully erosion

Gully erosion is a complex process that is not fully understood. Some gullies are formed when runoff cuts rills deeper and wider or when the flows from several rills come together and form a larger channel. Gullies can erode in both uphill and downhill directions (Goldman, Jackson, Bursztynsky, 1986).

The following are the processes which act in the formation of gullies (ARC, 1999):
- Waterfall erosion at the head of a gully,
- Channel erosion,
- Raindrop splash,
- Diffuse flow from the side of the gully or from seepage, and
- Slides or mass movement of soil within the gully.

A gully may develop and grow rapidly and their formation may generate a considerable amount of erosion.

### 2.3.5 Tunnel erosion

Compacted bare areas generate runoff which flows directly into the subsoil via surface cracks, rabbit burrows, or old root holes. Once concentrated in the subsoil the runoff causes the sodic clays (having high concentrations of sodium) to disperse and form a suspension or slurry. Provided there is sufficient gradient, the slurry is able to flow beneath the soil surface. If the subsoil is exposed through erosion or construction work, the slurry is able to rapidly flow onto the surface. Once formed, tunnels continue to enlarge during subsequent wet periods. Eventually tunnels reach a point where the roof collapses resulting in potholes and the formation of erosion gullies. Another way for tunnel erosion to occur is in limestone areas where water dissolves the limestone and creates underground flow paths.

- Tunnel erosion appears as a series of tunnels that form beneath the soil surface
- It is both a chemical and physical erosion process
- Associated with changes in catchment hydrology or uneven saturation of clay subsoils
- Usually associated with sodic soils derived from Triassic sandstone, Permian mudstones and re-deposition of these sediments in Quaternary deposits.

Tunnel erosion may form a circular hole, sometimes referred to as a ‘tomo’, which is a Maori term for an entrance to a sinkhole or cave. Tunnels may range in size from a few centimetres to several metres in diameter.

### 2.3.6 Channel erosion

The erosion of channels results from the conveyance of concentrated flows, whose velocities scour the channel boundaries. Channel erosion is a natural occurrence but accelerated erosion is caused by a change in land use that increases the volume and rate of stormwater runoff.

Channel erosion is a major source of sediment nationwide and is increased through changing land use.
2.3.7 Mass movement

Mass movement is the erosion of soil or rock by gravity-induced collapse. It is usually triggered by groundwater pressure after heavy rain, but can also have other causes, such as stream bank undercutting or earthworks undercutting the base of a slope. Movement can be either rapid or near instantaneous or slow and intermittent. Earth and soil slip movement are also often noted after the removal of vegetation from critical slopes associated with earthworks (ARC, 1999).

Mass movement can cause major problems on earthworks sites and geotechnical investigations should be undertaken where possible to avoid critical slopes from failure.

2.4 Wind erosion

There are a number of areas in New Zealand that are subject to strong winds at various times of the year. In addition, most areas of New Zealand are subject to wind erosion during droughty times. Wind erosion can occur during horticultural planting times and on earthwork sites when areas have been cleared of vegetation and soil moisture deficits allow for transport.

There are three ways that soil moves due to wind (Hawke's Bay Regional Council, 2002).

- Suspension,
- Creep, or
- Saltation.

2.4.1 Suspension

The smallest particles are picked up and suspended in the wind, causing visible dust clouds that can travel great distances. While the amount of soil moving in wind currents is fairly small, it is lost soil material that can coat objects downwind from the area they are being generated.

2.4.2 Creep

The largest, heaviest particles remain stable or creep along the soil surface. Generally they do not travel very far.

2.4.3 Saltation

Medium sized particles account for 50-80% of soil movement through a process known as saltation. Wind causes medium sized particles to vibrate, then bounce from the soil surface. They are too big to remain suspended and tend to fall and dislodge other particles that repeat the process in a snowballing effect. This can create soil avalanches, which are thick soil clouds up to two metres deep moving down wind.
Erosion control, primarily though ground cover is a key step in reducing wind erosion effects. Rapid site re-stabilisation can hold soil together, reduces wind velocity at the ground surface and traps any moving particles.

2.5 Study results

There is value to providing a context for the reasoning as to why an Erosion and Sediment Control Standard is needed and there are a number of studies that have been done in New Zealand that provide it. The discussion will be based on two elements:

- Cause, and
- Effect.

2.5.1 Cause

One of the greatest impacts of urbanisation on receiving waters can come from soils eroded during urban construction (Williamson, 1993). The degree of the erosion depends on the amount and intensity of rain that falls while the soil is exposed in addition to the other factors explained previously.

This erosion can have an enormous impact immediately downstream of new earthworks. Dumped sediment can greatly alter the stream channel morphology, smother insect life and water draining these catchments can remain very turbid even during low flows. Table 2-4 provides mean values of turbidity and suspended solids in New Zealand streams during low flow.

Table 2.4 Mean values of turbidity and suspended solids in New Zealand urban streams during low flow

<table>
<thead>
<tr>
<th>Land use</th>
<th>Turbidity (NTU)</th>
<th>Suspended Solids (g/m³)</th>
<th>Approximate visual range (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>9</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Residential, light industrial, construction</td>
<td>42</td>
<td>53</td>
<td>0.2</td>
</tr>
<tr>
<td>Construction</td>
<td>186</td>
<td>159</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Measurements of suspended sediment yields during storms in five small basins under various landuses in the Auckland region were analysed to determine the average yields of sediment from those catchments (Hicks, 1994). The average sediment yields are shown in Table 2-5.

Table 2.5 Average sediment yields for five small catchments

<table>
<thead>
<tr>
<th>Catchment identification</th>
<th>Sediment yield(t/km²/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alexandra (urbanising)</td>
<td>970 (1.2 years of record)</td>
</tr>
<tr>
<td>Wairau (mature urban)</td>
<td>107 (6 years of record)</td>
</tr>
<tr>
<td>Pakuranga (mature urban)</td>
<td>24 (4.5 years of record)</td>
</tr>
<tr>
<td>Manukau (pasture)</td>
<td>49 (17 years of record)</td>
</tr>
<tr>
<td>Whangapouri (market-gardening)</td>
<td>49 (3 years of record)</td>
</tr>
</tbody>
</table>

The high yield from the urbanising Alexandra Basin stems from the considerable portion of its ground area that was bare for construction (approximately 28% at the time of the study). The yield from the sub-catchments undergoing construction was estimated to be approximately 6,600 t/km²/year, over 100 times the yield from undisturbed or stable areas of the basin.
Another study by NIWA (Senior, 2003) provided estimates for bare soil sediment runoff of 14,400 kg/ha/year, a 32 times increase from pastoral land. The magnitude of predicted increase lies within the range (10-100 times) historically reported for sediment yields from construction sites.

Recent monitoring of sediment pond performance through two studies (Moores and Pattinson, 2008; Larcombe, 2009) provides some further information regarding total suspended solids (TSS) concentration. The median TSS concentration for the Moores’ study on an NZTA project was 1,057 g/m² for inflow to a sediment pond. The Larcombe study was on a general subdivision development and showed a much higher TSS load for average suspended sediments concentration of 11,542 g/m², which is very high and demonstrates the variability of concentrations due to site variability.

2.5.2 Effect

In a study done for the ARC, NIWA (Lohrer et al., 2004) studied terrestrially derived sediment and the impact that has on marine macrobenthic communities related to thin terrigenous deposits. Coastal marine habitats adjacent to catchments with encroaching human development are likely to experience increased sediment loadings in ensuing decades. Thus, sedimentary disturbance regimes in which coastal marine benthic communities have evolved may be shifting as depositional events exceeding critical thresholds become more frequent. Performing manipulative experiments involving layers of terrigenous sediment < 1 cm thick in a variety of intertidal habitats in the Whitford embayment, North Island results of three separate experiments performed at five sites, as little as 3mm of the terrigenous material was sufficient to significantly alter macrobenthic community structure. The direction of change was predominantly negative. The number of individuals and taxa declined as a result of sediment application, as did the densities of nearly every common species. In addition, repeated depositional events did more damage than single ones.

Another study done (Gibbs, Hewitt, 2004) provides the following information on impacts to estuarine systems.

- Thin depositions (3-7mm) in Mahurangi and Kawau Bay on macrofauna, nitrogen and oxygen fluxes in the subtidal zone caused significant adverse effects on macrofauna.
- Catastrophic depositions (>3cm) in Okura and Whangapoua on macrofauna in the intertidal zone. Within ten days nearly all the macrofauna had died.
- Thinner depositions (1.5-2cm) in Whitianga on macrofauna at the intertidal zone. Sediment deposition had an immediate effect with slow recovery (210 days).

In addition to the biological and ecological effects from accelerated erosion, sediment-laden discharges are considered unappealing from an aesthetics perspective. Clean water is something that people consider to be of value as part of the ‘Clean & Green’ image of New Zealand.

2.6 Non-sediment contaminants on construction sites

In addition to sediment and turbidity concerns on downstream receiving environments, state highway construction can contribute other contaminants to receiving systems. These contaminants, although not as well studied as sediment from construction sites, have the potential to impact on downstream receiving systems.

Construction can involve the use of a wide variety of materials with the potential to produce metal, wood, plastic and other debris that can be washed downstream if not properly managed. In addition, chemicals associated with construction materials and equipment such as creosote, chromium and arsenic treated wood, paint, adhesives, solvents and vehicle oils, fuel and grease can leach or wash from equipment and materials during storm events. Asphalt and concrete contain chemicals that can alter pH or have toxic effects to aquatic organisms. Asphalt materials contain a variety of organic compounds including polycyclic aromatic hydrocarbons (PAHs) and additives whose environmental effects have not been evaluated. In addition, commonly used landscaping materials such as fertiliser, mulch, lime and pesticides can contribute nutrients, oxygen-demanding material and toxic contaminants.

In addition to contaminants from construction equipment and materials, land disturbance can mobilise contaminants already present on site. Land previously used for horticulture can contain pesticides (DDT is the
most famous), fungicides, and herbicides; former orchards can contain copper sulphate, timber treatment sites can contain arsenic, chromium and copper, and sites with underground tanks can contain hydrocarbons. When earthworks are intended for a state highway (new or upgraded) historic and present land use should be identified and compared with the Ministry for the Environment’s Hazardous Activities and Industries List (HAIL). If the HAIL list identifies potential for contaminants to become mobilised during earthworks then steps should be taken to determine whether a problem could occur. This would initially be a desktop study that would include a site history, site visit and discussions with the local council. The results of this would address the problem or determine the need for more intrusive site testing.

Another consideration of soil disturbance is whether the soils are acidic, alkaline or saline. Acidity is associated with leached soils, whereas alkalinity occurs predominantly in drier regions. Within a given region, the extent to which soils become acidic depends on the inputs of acidity from vegetation, the microbial biomass and the atmosphere and the ability of the native minerals to resist the acidifying effects of leaching. The development of alkalinity also depends on local parent materials, vegetation and hydrology. In arid regions Na₂CO₃ (sodium carbonate) tends to accumulate in soils. It is a soluble salt. On new projects especially, a soil scientist should do sampling for soil based contaminants to determine whether additional measures need to be implemented in conjunction with site disturbance to avoid possible contaminant discharge problems from potentially contaminated soils.

Primary non-sediment construction related contaminants of concern include the following (USEPA, 2008):

- Nutrients,
- Polycyclic aromatic hydrocarbons (PAHs), and
- Metals.

Nutrient discharges are closely related to sediment discharge levels as water discharging from construction sites carries both soil and nutrients that naturally occur in the soil. Soil nutrients can include the following elements that are necessary for normal plant growth.

- Potassium, calcium and magnesium,
- Nitrogen, phosphorus and sulphur.

Generally, nitrogen has the greatest levels in soil.

PAHs, particularly from state highway construction are possible contributors to elevated PAH levels downstream. PAHs are found in the asphalt and tar used in road construction and repair and it is possible for PAHs to leach into sediment and construction site runoff during rain events. One study (Barrett et. al, 1995) found that concentrations of iron and zinc are higher on construction sites than any other metals.

Monitoring of state highway construction runoff in the State of California (Kayhanian, Murphy, Regenmorter, Haller, undated) has indicated that there is a strong correlation between TSS and particulate concentrations of copper, chromium and zinc. The correlation indicates that minimising particulate matter in runoff may reduce total metals concentrations. This would further indicate that effective implementation of erosion and sediment control practices are essential to reducing contaminant loads discharged downstream.

The control of non-sediment contaminants must also be considered on individual projects if fuel or other potential contaminating materials are stored on site. In general, the same practices that are used for controlling sediment will provide for control of non-sediment contaminants but each site should consider the range of potential contaminants that will be on a given site to ensure that there is no inappropriate discharge.
2.7 Unique aspects of state highway construction

Erosion and sediment control for state highway construction is not always as straightforward as for general construction. There are a number of aspects of state highway construction that can be considered as unique. These aspects include the following:

- State highways are linear projects that may cross a number of catchments,
- They may require significant cuts and fills that may alter existing drainage patterns,
- They are limited in the amount of space that they occupy,
- There may be a need to maintain site traffic during construction, and
- There may be numerous adjacent properties or land use activities.

State highway construction is significantly more complicated from an erosion and sediment control perspective compared to general construction projects.

2.7.1 State highways are linear projects that may cross a number of catchments

Most conventional construction is in one catchment with the entire site draining to a point where sediment control practices may be placed conveniently. State highway projects do not always have that ability to place one practice at the lowest point. The linear nature of a state highway may mean that there are a number of low areas where management has to be provided. This makes designing erosion and sediment control practices more complicated and there is a greater potential for a problem to compromise outcomes.

2.7.2 Cuts and fills that may alter existing drainage patterns

A state highway project that must traverse hilly country has issues related to alignment and grade that must be met for safety reasons. This may necessitate significant cuts and fills to meet those requirements. Grade changes may be necessary during project construction that requires phasing of practices as certain elevations are attained. Catchment areas to practices may increase, decrease or be eliminated. This results in a much more careful approach to site management than may be required on a general construction site.

2.7.3 They are limited in the amount of space that they occupy

In urban or urbanising areas obtaining the necessary land for the state highway works may be difficult and costly. This means that the amount of land that is necessary for the new state highway or for lane additions is generally kept to a minimum to minimise costs. Sediment control practices occupy space and their implementation may be difficult in a given situation.

Where possible, consideration of erosion and sediment control practices should occur prior to obtaining the designation for a particular project to seek to ensure that adequate land is available for the effective function of erosion and sediment control practices.

2.7.4 There may be a need to maintain site traffic during construction

This concern is in conjunction with the previous one related to space limitations. If lane additions are being done, it is necessary to maintain traffic during construction, which further reduces the area available for erosion and sediment control practices. There may be situations where creative thinking is needed to minimise impacts to receiving environments due to space limitations. It is essential that traffic safety be provided so careful consideration has to be given to the use of the site area for the various work elements.
2.7.5 There may be numerous adjacent properties or land use activities

Being surrounded by various properties and land uses will present a challenge to implementation of effective erosion and sediment control. Drainage from adjacent properties may enter the state highway site and that water must be considered in the design of erosion and sediment control.

In addition to drainage issues, there may be issues related to construction noise, air pollution or relationship issues with various property owners. There may also be access issues during construction, which could impact on adjacent businesses.

These issues are not normally as critical during general construction as they are on state highway construction.

2.8 Bibliography


Fox, H., Effects of Urbanization on the Patuxent River, with Special Emphasis on Sediment Transport, Storage and Migration, Degree of Doctor of Philosophy, Johns Hopkins University, Baltimore Maryland, 1974.


Hicks, Murray, Storm Sediment Yields from Basins with Various Lanuses in Auckland Area, prepared for Auckland Regional Council, NIWA, July 1994.

Kayhanian, M., Murphy, K., Regenmorter, L., Haller, R., Characteristics of Stormwater Runoff from Highway Construction Sites in California, Transportation Research Record 1743, Paper No. 01-3181, National Academy Press,


NIWA, Sediment Loadings from the Proposed Countryside Living Zone, prepared for ARC, 1997.


Senior, A., et.al, Risks to Estuarine Biota under Proposed Development in the Whitford Catchment, prepared by NIWA for Manukau City Council and Auckland Regional Council, Technical Publication #205, August 2003.


3. Receiving environments

Having an awareness of where water goes and the sensitivity of receiving environments will determine, to a large extent, requirements for erosion and sediment control for state Highway construction. For the most part, people do not think of where sediment goes once it leaves a site other than it “goes away”. It is important to recognise that receiving environments have value, are threatened and require a greater level of protection, which should improve awareness and action.

Receiving environments from an erosion and sediment control perspective include the following:

- Streams and rivers,
- Estuaries,
- Harbours,
- Open coasts, and
- Lakes

Each of these environments will be discussed individually to provide context for their value.

One aspect that is common to all receiving environments is the potential for human interaction for recreational purposes. This issue can be important in terms of receiving environment impact but will not be discussed further in the individual subsections.

3.1 Streams and rivers

Streams and rivers provide a means of conveyance of stormwater runoff from the tops of catchments to lakes, estuaries, harbours and open coast areas. While there is no cut off point for when a stream becomes a river, normal nomenclature considers a river as a large stream. In the context of this section, streams and rivers are considered similarly. Similarly the term ‘creek’ is considered identical to stream and thus the term stream includes creeks, tributaries or brooks.

Streams in upper catchments tend to be in the form of a series of ripples and pools as shown in Figure 3-1. The ripples and pools, in conjunction with woody vegetation form the primary habitat for aquatic life. Streams in the lower portion of catchments tend to be muddy bottomed or gravel bottomed (Canterbury plains as an example) due to flatter slopes.

Another key element of a stream is slope. Figure 3-2 shows a typical stream profile where the slope in the upper portion of the stream is very steep and the stream slope reduces as the stream approaches tidal areas. In this schematic the stream is the Vaughan's Stream (NSCC, 1999) and the difference in slope from headwater to coast is clearly evident.

From a descriptive standpoint, rivers tend to be in areas of shallower slope. One definition of a river is where the banks are 18 metres apart (Wikipedia Free Encyclopaedia).
The two figures, when considered in conjunction with one another demonstrate two important points related to sediment-related issues. Excess sediment loads can fill in a stream pool and make the stream bottom homogeneous with little habitat. In addition, stream and river flow carrying capacity is reduced as the stream cross-sectional area reduces due to deposition in the stream bottom. The portion of a stream or river in the lower part of a catchment, being naturally muddy bottomed or gravel, may be more of a depositional environment where bottom dwelling organisms are smothered by the sediment deposition.

The main issue with construction and site vegetation clearance is that increased sediment loads can destroy aquatic habitat by filling in pool areas in the upper portion of streams and filling in entire stream or river lengths in the lower systems that are characterised by slight slopes at the bottom of catchments.

Streams and rivers can be considered stable if the boundaries are relatively stable and the water flow and sediment load are in balance. With excessive sediment loads, water clarity is diminished, which reduces light penetration. Water plants and algae need light for photosynthesis and reduced light penetration will reduce plant growth rate.

In addition, macroinvertebrate communities are particularly vulnerable to deposited sediment as the composition of the stream or riverbed is a major factor contributing to their distribution. Typically streams subjected to increased sedimentation have a less diverse macroinvertebrate population diversity and abundance. Macroinvertebrates, such as caddisflies, stoneflies and mayflies, which like to live in clean gravel beds, become less abundant. Worms and midge larvae, which prefer finer sediment, become more abundant (Water and Rivers Commission, 2000).

Suspended sediment can be abrasive and may damage the fine gills and mouth parts of macroinvertebrates. It may also make it harder for predatory macroinvertebrates to see their food.

From a fisheries context, many fish use stream and river pools for habitat. The loss of these pools due to sediment infilling may cause local reductions in fish population. Excess sediment may also influence the availability of food for fish. Some fish species such as gobies, feed partially on algae, while others have a diet of macroinvertebrates. Increased sedimentation may adversely affect local fish populations.
Section 7 of the RMA ensures particular regard to the protection of the habitat of trout and salmon, which excess sediment can profoundly affect the productivity of a trout or salmon stream or river. In a healthy stream, young salmon and trout hide in the interstitial spaces between cobbles and boulders to avoid predators. If fine sediment is clogging interstitial spaces between streambed gravel, juvenile salmonids lose their source of cover and food. Sediment can also adversely impact on eggs through smothering them during spawning season. Studies done in the United States found that if more than 13% fine sediment being deposited in a gravel bed, almost no steelhead or coho salmon eggs survived (Platts, et.al., 1989).

Streams and rivers are sensitive to sediment deposition.

3.2 Estuaries

Estuaries are low energy, depositional zones where the sea meets streams. They tend to be semi-enclosed coastal bodies of water with one or more rivers or streams flowing into them and with a free connection to the sea. Estuaries are often associated with high rates of biological productivity. They are among the most productive ecosystems in the world and they provide rich feeding grounds for coastal fish and migratory birds and spawning areas for fish and shellfish.

Estuaries are a transition area between fresh water riverine systems and saline ocean environments and are subject to both freshwater and marine influences, including fresh water inflow and sediment entry. They tend to be shallow systems and are subject to severe degradation from land based activities. Due to very shallow gradients and significant tidal influence they tend to be depositional areas subject to rapid infill due to sediment entry. In addition to the sediment being deposited due to low transporting energy, estuaries reduce sediments through flocculation where salts combine with clay materials to enhance deposition of fine sediments.

From a New Zealand perspective, estuaries seethe with bacteria, mud worms, crabs, migrating fish, mangroves and oystercatchers. This system has evolved in the mud flats and is vulnerable to time, tide, erosion, contamination and other effects of human activity. There are about 300 estuaries distributed around New Zealand’s coast. Most are small (< 200 hectares) with the largest being the Kaipara Harbour at 15,000 hectares. All of New Zealand’s estuaries are drowned river valleys as sea level rise flooded low areas and created them.
An estuary is typically the tidal mouth of a river and they are often characterised by sedimentation from silts carried from terrestrial runoff. They are made up of brackish water. Estuaries are marine environments, whose pH, salinity, and water level are varying, depending on the tributaries that feed them and the ocean that provides the salinity. Figure 3-3 shows a schematic of the Mahurangi estuary and where deposition of various sized sediments occurs. The colour scheme relates to moisture content of the sediments that were cored. Higher moisture content relates to finer sediments while lower moisture content relates to coarser sandy sediments (Gibbs, 2006). The purpose of the representation is to show that fine sediment deposition will tend to be in the upper portions of estuaries.

A study of areas of estuarine sediment buildup (Vant et al., 1993) provided an indicative estimate of sediment build-up and consideration of the area of impact. Information on this is sparse and an estimate of depositional area was done by mimicking estuary performance to pond sedimentation. In addition to sedimentation, flocculation and absorption can occur. That report estimated that approximately 75% of incoming sediment would be deposited and concentrated in approximately 3-4% of the estuary catchment area while the remainder would spread throughout the estuary.

Due to estuaries being low energy environments and having a high salinity, they are depositional zones where construction derived sediments become deposited. Similarly to wetlands, estuaries are a temporary feature. Sediments carried by rivers and tides bringing in sand will fill an estuary so that eventually it becomes an upland. The key point is that a natural process may take hundreds of years while accelerated sedimentation can fill an estuary in several years. The physical effects of catchment soil erosion will be greatest in the tidal creeks at catchment outlets, whereas the ecological effects of increased fine sediment loads will be more critical in the main body of estuaries (Swales et al., 2002).

Estuaries are very sensitive to excessive sedimentation.

3.3 Harbours

Harbours are primarily natural landforms where a body of water is protected and deep enough to furnish anchorage for ships. They differ from estuaries in that tidal action is greater and rates of deposition of sediments are less. Sedimentation does still occur and most harbours of the world require dredging to maintain shipping channels.

From a water quality perspective, harbours are not as sensitive as estuaries and streams from a sedimentation standpoint.
Ecological monitoring of the Central Waitemata Harbour (Townsend, Lundquist, Haliday, 2008) has provided some indication of the sediment particle sizes and has found that harbour sediments are predominantly in the fine sand, medium sand category and mud ranges between 2-3%. A major study conclusion is that grain size is not a predominantly controlling factor in aquatic community composition as changes are occurring to those communities but particle size distribution has shown minimal change during the same period. Conversely, work done in Tauranga Harbour (Park, 2009) has shown much higher percentages of mud, which would indicate that the Tauranga Harbour has different flushing capabilities in comparison to the Waitemata Harbour.

Work done in the Whaingaroa Harbour (Swales et al., 2005) has indicated that resuspension of harbour sediments and transport of those sediments to off-shore areas may limit sedimentation rates in the harbour. Thus, the harbour has a fairly low trapping efficiency.

Based on studies done to date, harbours are not as sensitive as estuaries and streams to impacts from sedimentation.

3.4 Open coasts

Open coasts are the line of demarcation between the land and the ocean. They are dynamic environments and go through constant change. Natural processes, particularly sea level rise, tidal energy, waves and various weather conditions have resulted in erosion, accretion and reshaping of coasts as well as flooding and creation of continental shelves and drowned river valleys.

Coasts face many environmental challenges relating to human-induced impacts. The human influence on climate change is considered to be a major factor of the accelerated trend in sea level rise. In addition, urban development of coastal land contributes to litter problems and reduced natural coastal habitat.

While not as serious as sedimentation issues in streams, estuaries or harbours sedimentation can be an ongoing concern on coasts with sediment plumes creating visual pollution, impacting on light penetration and potential adverse impacts on coastal reef communities. A large part of the global population inhabits areas near the coast, partly to take advantage of marine resources but also to participate in activities that occur adjacent to coastal marine areas.

Consideration of sedimentation issues on off-shore areas is difficult to assess as much less is known about the various modes and mechanics of transport to be able to make an accurate assessment of potential impacts. There are issues related to littoral drift and off-shore sediment transport along, towards or away from the coast. There are few studies that have documented these effects.

The same study from the previous subsection on harbours that considered the Whaingaroa Harbour (Swales, et al.,
2005), also found the presence of clay minerals in continental-shelf sediments that were eroded from catchment mudstone and LANDSAT images showed fine-sediment plumes extending up to 20 km off-shore from the harbour mouth.

While not being as sensitive as other receiving systems to sedimentation, there are still concerns regarding sediment discharge to open coastlines.

3.5 Lakes

A lake is a body of water that is contained in a body of land and, in the context used here, contains fresh water. Most lakes have an outfall but some do not. Lakes can be manmade or natural. The variety of lakes includes the following (Te Ara Encyclopaedia discussion of New Zealand lakes):

- Glacial lakes in the higher country of the South Island,
- Volcanic lakes that are largely confined to the Taupo Volcanic Zone and the area around Auckland,
- River, dune, landslide and coastal barrier lakes that are all formed by natural processes that change the drainage and cause water to pond up, and
- Artificial lakes that are man-made.

Lakes trap sediments that enter them as the sediment drops to the lake bottom. Having very low horizontal velocities through lakes results in a high degree of sedimentation as sediment particles drop out of suspension due to gravity. Over time lakes become shallower and may eventually fill in.

The annual rate of sedimentation in New Zealand lakes varies between 1-200 mm/year. The highest are in reservoirs due to the inflow travelling through highly eroded land and the inflow carrying a high sediment load (TeAra Encyclopedia of New Zealand)

Due to lower horizontal velocities, materials that enter a lake tend to remain in the lake. They are, in effect, sinks where contaminants can accumulate. The following lake information in Figure 3-4 from the U.S. provides an indication of the causes of stressors in U.S. lakes. As can be seen, siltation is the third greatest stressor on lake health. The impact on shallow lakes would be correspondently greater as less storage in the lake could result in significant impacts.

In a similar fashion to lakes in the U.S., New Zealand lakes are primarily impacted by nutrients. Sediment can also reduce lake clarity.
and onstate highway projects, the primary cause of sediment discharges relates to erosion and sediment control during construction.

NIWA reported on lake water quality (NIWA, 2006) and summarised the current status of 121 lakes. The land use that drained to the lakes was related to four land-cover classes: alpine, native forest/scrub, exotic forest, and pasture. Urban land uses were not identified nor considered. NIWA considered phosphorus, nitrogen, clarity, suspended solids and temperature. Median values of total nitrogen, total phosphorus and chlorophyll a were four to six times higher in pasture classes than in native bush.

The broad national picture is of high water quality in deep lakes at high altitude and in unmodified catchments, and of lower water quality in modified catchments, especially in small, shallow and warm lakes. Although lake water quality was degraded in both exotic forest and pastoral catchments, pastoral use was associated with the worst water quality, most notably in the cases of extreme deterioration.

Extrapolation of the lake environment categories to the nationwide database of 3,820 lakes suggests that approximately 60% of New Zealand lakes are still likely to have excellent or very good water quality; these are lakes in cold regions with high native and low pasture cover. However, approximately 30% of lakes are likely to have very poor to extremely poor water quality. Lowland lakes are especially likely to have poor water quality.

In terms of sensitivity to sedimentation, lakes would be considered as having a potentially moderate sensitivity to impact.

### 3.6 Overall discussion of erosion and sediment control related to receiving environments

To put the previous discussion into a context for sediment laden runoff, the following Table 3-1 provides a brief snapshot of receiving environments and their susceptibility to adverse effects from sedimentation. The Table is meant as a general guide and does not substitute for regulatory requirements required by consenting authorities. Contact should be made with the appropriate council to ensure that local requirements are complied with.

#### Table 3.1 Receiving environments and sedimentation issues

<table>
<thead>
<tr>
<th>Receiving system</th>
<th>Water quality</th>
</tr>
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<tbody>
<tr>
<td>Estuaries</td>
<td>Highest potential effect</td>
</tr>
<tr>
<td>Streams and rivers</td>
<td>High potential effect</td>
</tr>
<tr>
<td>Lakes</td>
<td>Moderate potential effect</td>
</tr>
<tr>
<td>Harbours</td>
<td>Lower potential effect</td>
</tr>
<tr>
<td>Open coast</td>
<td>Lower potential effect</td>
</tr>
</tbody>
</table>

Variation in criteria will be discussed in Section 5 Selecting a Management Approach in conjunction with Section 6 Hydrological Design Approach where risk will be assessed along with appropriate storm sizing. The combination of these two sections will provide guidance on what practices are appropriate for projects that drain into the various receiving systems.

### 3.7 Bibliography


Platts, W.S. et.al., Changes in Salmon Spawning and Rearing Habitat from Increased Delivery of Fine Sediment to the South Fork Salmon River, Idaho, Transactions of the American Fisheries Society, 118; 274-283, 1989.


Te Ara Encyclopedia of New Zealand, Lakes, Lake Processes, Sediment in Lakes.


Water and Rivers Commission, Water Notes: Advisory notes for land managers on river and wetland restoration, WN17, July 2000.
4. Erosion and sediment control concepts

4.1 Key principle of erosion and sediment control

The overarching principle of erosion and sediment control on earthworks sites is to limit sediment transport and deposition. As a number of factors (e.g. rainfall intensity, soil composition) are beyond our control, it therefore falls to applying the most appropriate solution for the circumstances. As there are numerous devices at our disposal, the integration of as many concepts as possible provides the most effective erosion and sediment control on site (Georgetown County, 2006).

These concepts are typically formalised through the use of erosion and sediment control practices detailed in an Erosion and Sediment Control Plan (ESCP) prepared for the land disturbing activity.

4.2 Advantages of erosion and sediment control

With careful pre-planning, erosion and sediment controls usually result in many on-site advantages in addition to protecting the environment.

Environmental benefits include:

- Reduced risk of damage to aquatic ecosystems,
- Improved appearance of the site and downstream waters,
- Reduced water treatment costs,
- Reduced blockage of drains, and
- Less mud dropped or washed onto roads.

On-site benefits can typically include:

- Improved drainage and reduced site wetness as a result,
- Less dust problems,
- Improved working conditions,
- Reduced downtime after rain,
- Less stockpile losses,
- Reduced clean-up costs,
- Earlier works completion, and
- Less chance of public complaints.

4.3 Concepts and principles of erosion and sediment control

Implementation of erosion and sediment controls is required to avoid, remedy or mitigate the effects of earthworks on the receiving environment. To ensure that erosion and sediment controls are effective and cost efficient, an understanding of the basic principles of erosion and sediment control is required, as is ensuring that erosion and sediment control practices are considered and carefully managed throughout the project's planning, design and construction phases (Environment Canterbury, 2007).

State Highway project's construction timeframes may take longer to construct than other types of construction projects, and the resulting longer operational life of many erosion and sediment controls, requires a stronger emphasis on some management concepts (Department of Environment and Climate Change NSW, June 2008), particularly:

- The control of upper catchment water,
- Separation of clean from dirty water,
- Protecting the land surface from erosion, and
- Preventing sediment from leaving the site.
The following concepts are therefore relevant when designing an erosion and sediment control plan for a state highway project site.

### 4.3.1 Control upper catchment water

Upper catchment water is runoff from above the area of disturbance that would normally flow through the site. The key consideration in reducing the contributing catchment is to control this clean water by interception, diversion and safe disposal to a location below the area of disturbance as shown in Figure 4.1.

Reducing the area of the catchment contributing to water flowing through the site will reduce the volume of water to be treated thereby minimising the sizing of any controls.

### 4.3.2 Separate clean from dirty

Clean water is water that has not flowed through disturbed areas whilst discharges from disturbed areas are considered to be dirty water. Minimising the volume of water that is required to be treated by a sediment control device saves space and money. Furthermore clean water (upper catchment water that does not flow through the disturbed area) has not been contaminated by sediment, therefore does not require treatment. Practices to achieve this are outlined in Section 7 of this standard.

### 4.3.3 Reduce the area available for erosion

To minimise the rates of soil loss, techniques as outlined in section 8 of this standard will assist however, protecting the land surface from erosion can be as simple as:

- Project design taking into account terrain limitations,
- Project scheduling to known climatic and soil variations,
- Minimising land clearance,
- Limiting areas of disturbance, and
- Progressively stabilising disturbed areas (e.g. grassing and mulching)
4.3.4 Minimise sediment from leaving the site

Sediment laden water (dirty water), as discussed in previous sections, can have a variety of impacts if not managed in accordance with best practice. Therefore it is imperative that a suite of controls are used on state highway construction projects. Sediment controls should be selected taking into account the site constraints and receiving environment, and steps should be taken to ensure that the controls are integrated with the permanent features of the project. Refer to the practices outlined in section 8.

4.4 The role of erosion and sediment controls

Erosion and sediment controls have different roles on an earthworks site. Erosion controls seek to minimise any sediment from being mobilised whilst sediment controls attempt to remove sediment from suspension once entrained. The analogy of erosion controls (fence at the top of the cliff) whilst sediment controls (ambulance at the bottom of the cliff) is applicable in describing their roles.

Any ESCP should place initial emphasis on erosion control although in many circumstances this may not be achievable.

4.4.1 Efficiency vs effectiveness of practices

The ability of an erosion and sediment control practice to prevent sediment from being transported or to remove sediment once entrained is a measure of its efficiency. This efficiency (as a %) can be represented as the volume removed when measured against the volume of sediment that arrives at the practice. Depending on a range of factors the removal efficiency can range from 50% to 75%.

Efficiency should not be confused with effectiveness. The effectiveness of a specific practice takes into consideration other factors such as the timing, cost, sensitivity of receiving environment and placement location of the device. For example, a sediment retention pond placed in an area that receives little or no water is still an efficient practice but is not an effective measure for that particular site.

4.5 The treatment train

A treatment train comprises a series of best management practices and/or natural features, each planned to treat a different aspect of pollution prevention, that are implemented in a linear fashion to maximise pollutant removal. This approach is directly applicable to the control of sediment on state highway projects.

Erosion and sediment control measures should generally be planned to link functionally to form a “treatment train” with each measure having a
specific role within the framework of surface water management, soil protection and stabilisation, and sediment capture. This approach can be a combination of structural (e.g. sediment ponds, hydroseeding) and non-structural (e.g. earthworking season) practices.

This approach needs to be considered during the early phases of project planning, and followed through to the completion of the project. Section 5 of this document will detail how to select the appropriate tools to ensure that this approach occurs.

4.6 Principles to follow

These ten principles (best practice principles) build upon the previous concepts and provide guidance for erosion and sediment control through the planning, construction and maintenance phase of a project.

4.6.1 Minimise disturbance

Fit earthworks, construction techniques and methodologies to land sensitivity. This may be difficult from a state highway perspective where space is limited but the concept should always be considered.

Some parts of a site should never be worked and others need very careful working. Watch out for and, if practicable, avoid areas that are wet (streams, wetlands and springs), have steep or fragile soils or are conservation sites or features.

Bear in mind a minimum earthworks strategy and only clear areas required for structures or access.

Show all limits of disturbance on the ESCP. On site, clearly show the limits of disturbance using fences, signs and flags.

4.6.2 Stage construction

Carrying out bulk earthworks over the whole site maximises the time and area that soil is exposed and prone to erosion. "Construction staging", where the site has earthworks undertaken in small units over time with progressive revegetation, limits erosion.

Careful planning is needed. Temporary stockpiles, access and utility service installation all need to be planned. Construction staging differs from sequencing. Sequencing sets out the order of construction to contractors. Detail both construction staging and sequencing in the ESCP.

4.6.3 Protect Steep Slopes

Where possible avoid existing steep slopes. If clearing of steep slopes is necessary, runoff from above the site can be diverted away from the exposed slope to minimise erosion. If steep slopes are worked and need stabilisation, traditional vegetative covers like
topsoiling and seeding may not be enough - special protection is often needed. Highlight steep areas on the ESCP showing limits of disturbance and any works and areas for special protection.

### 4.6.4 Protect watercourses

Existing streams and watercourses, and proposed drainage patterns need to be mapped. Resource consent may be required for clearance works adjacent to a watercourse.

Map all watercourses and show all limits of disturbance and protection measures in the ESCP. Also, the ESCP should show all practices to be used to protect new drainage channels. Indicate crossing or disturbances and associated construction methods in the ESCP.

![Sediment Discharge as a Result of Not Protecting the Watercourse](image)

### 4.6.5 Stabilise exposed areas rapidly

An important objective is to fully stabilise disturbed soils with vegetation after each stage and at specific milestones within stages. Methods are site specific and can range from conventional sowing through to straw mulching. Mulching is the most effective instant protection.

In the ESCP clearly define time limits for grass or mulch application, outline grass rates and species and define conditions for temporary cover in the case of severe erosion or poor germination.

![Rapid Stabilisation](image)

#### 8 weeks later

### 4.6.6 Install perimeter controls

Perimeter controls above the site keep clean runoff out of the worked area - a critical factor for effective erosion control. Perimeter controls can also retain or direct sediment laden runoff within the site. Common perimeter controls are diversion drains, silt fences and earth bunds.
Detail the type and extent of perimeter controls in the ESCP along with the design parameters for those controls.

**Types of Perimeter Controls**

4.6.7 Employ detention devices

Even with the best erosion and sediment practices, earthworks will discharge sediment laden runoff during storms. Along with erosion control measures, sediment retention structures are needed to capture runoff so sediment generated can settle out. Sediment retention ponds are often not highly effective in areas with fine grained soils. In those areas it is necessary to ensure the other control measures used are appropriate for the project and adequately protect the receiving environment.

Include sediment retention structure design specifications; detailed inspection and maintenance schedules of structures and conversion plans for permanent structures, in the ESCP.

4.6.8 Experience and training

A trained and experienced contractor is an important element of an ESCP. Contractors are individuals responsible for installing, maintaining and decommissioning erosion and sediment control practices.

Critical on-site staff should go through an erosion and sediment control training programme that may be available either locally or elsewhere in New Zealand. The NZTA also has an e-learning module on erosion and sediment control in development. Better knowledge can save project time and money, by allowing for identification of threatened areas early on and putting into place correct practices.

Making arrangements for a pre-construction meeting, regular inspection visits, and final inspection is also important.
4.6.9 Make sure the plan evolves

An effective ESCP is modified as the project progresses from bulk earthworks to permanent drainage and stabilisation. Factors such as weather, changes to grade and altered drainage can all mean changes to planned erosion and sediment control practices.

Update the ESCP to suit site adjustments in time for the pre-construction meeting and initial inspection of installed erosion and sediment controls, and make sure it is regularly referred to and available on site.

4.6.10 Assess and adjust

Inspect, monitor and maintain control measures.

Assessment of controls is especially important following a storm. A large or intense storm will leave erosion and sediment controls in need of repair, reinforcement or cleaning out. Repairing without delay reduces further soil loss and environmental damage.

Assessment and adjustment is an important erosion and sediment control practice - make sure it figures prominently in the ESCP.

Assign responsibility for implementing the ESCP and monitoring control measures as the project progresses.

The ESCP should also be integrated with the Contractor’s Social and Environmental Management Plan, therefore, reducing duplication in the site specific environmental aspect management plans.

4.7 Bibliography


Department of Environment and Climate Change NSW, Managing Urban Stormwater - Soils and Construction, Volume 2D Main Road construction, June 2008

EPA Victoria, Environmental Guidelines for Major Construction Sites (480), February 2006


Environment Canterbury, Erosion and Sediment Control Guidelines, 2007


Hawke’s Bay Regional Council, Hawke’s Bay Waterway Guidelines, Erosion and Sediment Control, April 2009.