INTRODUCTION TO STORMWATER ISSUES

1 *Overview*

Stormwater is runoff generated after rainfall and snow melt. After absorption into the soil, evaporation, and plant uptake, residual runoff may give rise to stormwater discharges. Stormwater travels down gradient firstly as **overland flow**. Overland flow will naturally fill and follow hollows and depressions in the landscape as it concentrates to form **ephemeral**, intermittent, or temporary **watercourses** before flowing into a permanent **water body**. Overland flow may also be generated when reticulated stormwater systems exceed design limits and surcharge or overflow.

Flooding of the Tinui River in 1992
Source: Wairarapa Times - Age

The **quantity** of stormwater discharged from any given rainfall event can depend upon many factors such as:

- **Storm size** (duration and intensity);
- Ground cover type and the **degree of imperviousness** (whether hard surfaces that do not allow infiltration such as buildings or pavement, or softer surfaces, such as pasture or forest;
- Soil type and pre-existing ground saturation levels; and
- Topography (where steep slopes and limited areas for water to pond will cause a greater discharge in a shorter time than more level ground).

Stormwater generated from snow melt will also be affected by the intensity of preceding snow conditions, ambient temperatures, and whether previous melting episodes have occurred.

The key stormwater issues

1. Quantity

As access is improved and land development occurs, invariably the area of **impervious** and **impermeable** surfaces also increases. Rooves, sealed carriageways, footpaths, cycle paths, car-parks and drives provide surfaces do not allow rain to infiltrate the ground, and typically more runoff is generated than in the undeveloped condition (an exception may be where existing, natural soils already have little absorptive capacity). Hard, compacted, engineered fill (commonly created for building platforms, but also in **berms**, **medians**, and **batters**), and even exposed earthworks will also reduce infiltration and may contribute to increased runoff. This reduced infiltration to groundwater leads to reduced base flows within watercourses, while increasing runoff increases the potential for flooding.

Karangahake Gorge in flood, 2006
Source: New Zealand Herald

If hydraulic 'improvements' have been undertaken, watercourses straightened, or a reticulated (piped) **stormwater network** has been constructed, then stormwater will likely also be delivered to any given point along the system more quickly than previously. This affects the **time of concentration**, and can result in stormwater arriving in a way that can cause cumulative effects either resulting in, or exacerbating, **flooding**. The increase in flood duration and / or water speeds can also result in the **scour** and erosion of channels as the **channel** adjusts to a new state of equilibrium. This process mobilises sediment, which degrades water quality. Scour and changes in the runoff regime can result in the undermining of built infrastructure such as bridge piers, abutments, and **culvert** outlets.

Changes in stormwater quantity can directly affect the well being and sustainability of communities. Effects will be most pronounced where development (whether urbanisation or agricultural) has occurred within **flood prone areas**, below **critical flood levels**, or where an **overland flow path** has been blocked. Roads are vital for emergency response and can be severely disrupted by the effects of mismanagement of stormwater quantity.

Milford Road after flooding, 1979
Source: sniktaWP

Kaikoura's main street in flood, 1993
Source: Geoff Mackley

2. Quality

Almost all human activity results in the generation of waste. This waste forms **pollutants** and **contaminants** within the environment. Where these substances are **toxic**, or where they accumulate, they cause adverse environmental effects. Stormwater running off roads is particularly at risk of containing potentially harmful pollutants and contaminants. Roads, particularly during construction and maintenance, can in themselves be sources of contaminants. Vehicles generate pollutants from engine lubricants, brake and tyre wear, and exhaust emissions. Contaminants may arise directly from spills and accidents. **Litter** is also frequently dropped onto roads

Litter discharged to the coast
Source: Island Bay Marine Education Centre

This means that the range and type of contaminants encountered can vary widely and could include any goods or potential contaminant transported by road (from milk to rat poison). Contaminants can also be generated on adjacent properties and may be discharged into the road's stormwater system from direct kerbside discharges, or indirectly as overland flow (e.g. car wash water or yard run off), or as a consequence of flooding, dust, spray or overflowing sewers.

Common contaminants include:

- **Hydrocarbons**;
- **Heavy metals** (in particular copper and zinc);
- Rubber;
- Dust, **sediment**, and particulates;
- Litter; and

Foaming stream from road side spill
Source: WaiCare

- Faecal matter (e.g. from stock trucks).

Road surfaces also absorb and hold heat more readily, so that road runoff can cause sudden spikes in water **temperature** in adjacent water bodies. Other physical effects may also arise, including changes in **dissolved oxygen** levels within a receiving environment.

Contaminants accumulate on the **road** and **verges**. Frequently contaminants can cause the clogging of pavement pores, resulting in greasy or slippery surfaces, the effect of which is often highlighted during the first downpour after a long dry-spell. Unless the build-up of contaminants is regularly removed, this material and any other contaminants present are washed from the road in stormwater. The first part of a rain storm can contain proportionately higher contaminant concentrations (**first flush**) and is particularly noticeable after prolonged dry spells and in areas with high vehicle counts. Because there is no specific defined source for the pollutants in road run-off, such contamination is typically considered to be **'non-point source' pollution**.

When run-off is not treated, contaminants are delivered via stormwater systems into streams, lakes, groundwater, estuaries, harbours and coastal waters, where the contaminants can have toxic or other adverse effects on the environment and on human health. Minimising the contaminants entering the stormwater system is the necessary first step. Even when treatment does occur, 100% contaminant removal is unlikely.

➢ See also the following discussions:

- **Stormwater contaminants**
- **Fundamentals of treatment device performance**
- **What approaches have been used?**

Building wastes spilling to road and stormwater system
Source: Auckland Council

3. Receiving environment effects

Changes in hydrology, such as the timing, velocity, and quantity of storm flows, together with degraded **water quality** can cause a range of adverse effects, such as (but not limited to):

- **Smothering** of habitat, fish eggs, food (by sediment);
- Loss of **habitat** (e.g. stream erosion, increased flows / temperature, reduced oxygen, increased turbidity, altered substrate);
- Altered predator / prey relationships (e.g. increased turbidity affecting feeding patterns or changes in food type);
- Abrasion and other physical damage to fauna (such as skin or gill damage);
- Reduced or altered **biodiversity**;
- Displacement (dislodgement of fauna and flora downstream in larger events);
- **Barriers** (to movement and migration);
- Toxic effects (acute and chronic effects from the release
- and accumulation of sediment); and
- Increased plant growth (e.g. from nutrients) causing clogging or changes in light with depth, or phytotoxic effects.

Dead eels from pollution
Source: Auckland Council

Many New Zealand fish species are poor climbers and are **diadromous** (which means that they migrate between fresh and marine waters at some point during their life cycle). Often these migrations involve considerable distances (e.g. the eel migration to Tonga). Effects on New Zealand receiving environments can therefore have wider ranging effects**.** These effects are magnified when streams are lined or piped (resulting in a total loss of habitat), and such pipes are of a length or slope, or have sufficiently large drop structures to act as a barrier.

4. Life supporting capacity

In developing New Zealand, farmland was created in Many areas using **ditches** or **watertable drains** to drain existing water bodies and reduce the likelihood of surface ponding. In urban areas, stormwater has most commonly been piped and discharged directly to watercourses or the sea. In many parts of the country both practices resulted in the loss of many ephemeral and smaller scale water bodies; often further '**hydraulic improvements**' were made by the installation of concrete linings and stream straightening.

Lined section of the River Leith, Dunedin, 2005
Source: Otago Regional Council Leith Lindsay Flood Protection Plan (2005).

The creation of roading networks often exacerbated this approach, with the creation of watertable drains or **kerb** andchannelling parallel to the **alignment** and the installation of **culverts** at water crossings. This approach resulted in not just the modification or loss of **habitat**, but often the loss of the functional relationship of the watercourse to its context.

The loss of life supporting capacity is different from the other issues described previously. Merely considering stormwater quality from the perspective of a receiving environment or any one of the other key issues may not be enough. For example a silo approach may result in high quality stormwater being conveyed down lifeless concrete culverts or channels, or treatment occurring immediately prior to a significant waterbody (e.g. a major lake or the coast) without regard to the intermediate stream. As stormwater quality improvements are fundamentally about maintaining the life supporting capacity of water ways, consideration of this broader context is necessary, and especially in **greenfield** developments.

Issues for an RCA

A **road controlling authority** (RCA) is defined within the **Land Transport Management Act** (LTMA), 2003, as:

> *"the Minister, Department of State, Crown entity, State enterprise, or territorial authority that controls the road."*

As part of its obligations under the **LTMA**, an RCA must prepare a land transport programme that:

- Assists economic development;
- Assists safety and personal security;
- Improves access and mobility;
- Protects and promotes public health; and
- Ensures environmental sustainability.

The LTMA framework requires an RCA to assess how it will deliver against each of these objectives. The framework is not conditional, nor does it discuss the level of effects necessitating action. Rather there is a basic underlying premise that some action will be taken, more so if it is practicable. Whilst stormwater management (inclusive of all four of the identified issues discussed in **Section 1.2**) lends itself to the LTMA framework, lack of quantifiable effects has sometimes been cited as a rationale for the 'do nothing' option. This argument is bolstered by the effects of past practices of piping stormwater away from roads, removing small and intermediate receiving environments and leaving discharge points that are remote from observation.

Whanganui river in flood
Source: Whanganui District Council.

The Resource Management Act 1991 (**RMA**) also requires an RCA to at least consider all four of the key stormwater issues.

In the context of a need to address issues of sustainable transport within the LTMA and the 2008 LTMA Amendment, and the RMA, the focus of road assetmanagers must shift to the **quality** of road runoff.

Stormwater may give rise to **flooding** and other quantity related effects, which may either impede traffic or affect road infrastructure, and therefore be of interest to road asset managers. Visible stormwater **quality** (e.g. **litter)**, can also directly impact on road operations; however, quality related effects tend to be less immediately visible and can occur remote from the road itself. Consequently, in the past stormwater quantity has been the primary focus of road asset managers, but now quality effects must also be provided for.

Greymouth floods in 1906
Source: Alexander Turnbull Library