Runoff: rules plus reason

Why attenuate, retain or detain?

When it comes to mitigating stormwater runoff, the real purpose risks being lost in rules and their application, says Angela Pratt, senior environmental engineer at Beca.

Urban development typically increases imperviousness, resulting in hydrological and environmental effects, particularly increased volumes and rates of runoff. Governments and local authorities nationally and internationally recognise this and have for some time addressed these effects by requiring stormwater attenuation, detention or retention, usually specified through development rules and technical guidelines. The standards vary across these authorities, as do the specific effects that they need to address, and sometimes the real purpose gets lost in the rules and their application.

This article briefly describes "attenuation" and the various types of council standards, as well as suggesting how we can better address the full range of effects of urban development.

- An increase in stormwater volume and flow rate as a result of development can have a range of effects including:
- Increases in flood risk to downstream infrastructure due to increased peak flow rate or volume in larger storms;
- Increased stream erosion as a result of more frequent storms and increased discharge volumes;
- Effects on stream ecology eg, increased sediment discharges, reductions in base flows, as well as changes to habitat resulting from erosion or flow increases;
- Reduced groundwater recharge.

Achieving hydrological neutrality

To manage some of these effects, authorities often require new developments to achieve "hydrological neutrality", although their guidelines often then apply a narrower interpretation than true neutrality, which would require no change in discharge volume or peak flow rate in all events, of all durations.

Hydrological neutrality is generally achieved by providing some form of stormwater storage (attenuation/detention/retention) and by controlling the discharge rate from that storage system by way of an orifice or weir, or by the discharging of some runoff to ground. The following are examples of council standards that have a narrower interpretation:

- Whangarei District Council – "… attenuation of the developed peak flow from the developed portion of the site to be limited to 80 percent of the pre-developed flow for the design events." (80 percent required as there are often existing flooding issues and potential cumulative effects) (WDC, 2010).
- Tauranga City (Papamoa East) – "Development … shall provide storage equal to the difference in runoff volume between the undeveloped and developed state for a 100-year ARI 48-hour rainfall event." (Consent 63636)
- Porirua and Upper Hutt City Councils – For any new development "Retention or attenuation/detention facilites … shall be designed to limit the design peak discharge from the development (post-construction) to no greater than the existing peak discharge (pre-development) already entering the public network, for a 1-in-10 year, 20-minute duration storm." (CISL, 2012)
- Christchurch City Council – "All detention facilities upstream of the Cashmere Stream/Heathcote River confluence should be sized for the 36-hour, two percent AEP design storm event." (CCC, 2003)

Broken run detention infiltration.

- Dunedin City Council – "Stormwater systems shall be provided so that any new development results in an insignificant increase in runoff into the receiving body up to the 1-in-10 year event wherever possible, or, if not possible, results in a minimal increase for which adverse effects are no more than minor." (DCC, 2010)

The above standards only seek to mitigate peak flow increases, not volume increases (although the Papamoa requirement is volume-related) and are aimed at managing primary system capacity and flood risk.

None robustly address more frequent nuisance flooding, and none address ecological, base flow or groundwater effects.

The Auckland Region started to address stream erosion with TP10 (ARC, 2003), which introduced extended detention for runoff from 34.5mm of rainfall. Extended detention (with runoff discharged slowly over 24 hours or more) is a significantly different form of attenuation/detention to the traditional methods for flood peak flow management.

More recently, Auckland City Council's new Land and Water Regional Plan goes further, requiring that in certain parts of the city Stormwater Management Areas (SMAF), new developments must provide detention (temporary storage) with a volume equal to the runoff volume from the 90th (SMAF1) or 95th (SMAF2) percentile, 24-hour rainfall event, as well as provide retention (volume reduction) of a 10mm (SMAF1) or 8mm (SMAF2), 24-hour rainfall event.

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This more modern standard recognises volume increases in addition to peak flow increases, and also the return of some of the rainfall on impervious surfaces to the ground (retention / soakage). This potentially assists in maintaining stream base flow.

When designing stormwater attenuation, there is a strong tendency to design strictly in accordance with the rules in order to obtain a discharge consent or council approval, without necessarily considering the real effects of development on the hydrological cycle and the receiving environment.

However, in working to the rules, understanding of the basis behind the rules and what they are there for can be missed, compromising the environmental outcomes.

Wider implications

The following are some matters to consider when designing a development, or when writing rules for stormwater management:

- Will increased runoff volume coupled with flow peak attenuation cause increased coincidence of peaks from different subcatchments? It may be that the post-development peak from a subcatchment needs to be set lower than the pre-development peak.
- Will increased frequency and volume of runoff result in increased energy expended on the downstream waterways, increasing erosion? This might need retention/soakage

and extended detention, plus peak-flow attenuation throughout the full range of storm events. Channel form downstream (eg, a small permanent channel with a wide floodplain) can also assist in addressing erosion risk.

- Will increased impervious area and reduced discharge to ground result in reduced stream base flow, affecting stream ecology? Some form of retention and discharge to ground is likely needed.
- Understanding these implications is an important aspect of effects mitigation that is sometimes not explicitly or easily addressed by following council guidelines. So how do we make sure that the full range of potential effects is mitigated?

The best way to understand and mitigate the effects would be a wider catchment analysis involving the following:

- Understanding the full hydrological cycle for the catchment, from base flows through frequent storms to major floods. Identify (perhaps through continuous times series modelling) how development would change flows in each part of that cycle.
- When looking at flood effects, don't forget to consider cumulative effects of multiple developments, and also more frequent nuisance flooding as well as the more extreme events.
- Understand shallow groundwater and how this might be affected by increased imperviousness, or conversely by localised retention and soakage (which might affect land stability in steeper areas).
- Understand the stream environment, including instream and riparian ecology, and also erosion potential at a range of locations in the catchment (downstream of the development).

This helps to define what mitigation measures are needed, whether that be peak flow attenuation, extended detention, retention and soakage, or a combination of these. **WNZ**

References

Auckland Regional Council (ARC) (2003) Technical Publication 10 (TP10) Design Guideline Manual Stormwater Treatment Devices.

Christchurch City Council (CCC) (2003) Waterways, Wetlands and Drainage Guide, Part B, amended May 2012.

Dunedin City Council (DCC) (2010), Dunedin Code of Subdivision and Development, August 2010.

Whangarei District Council (2010), Environmental Engineering Standards, July 2010.

Capacity Infrastructure Services Ltd (CISL) (2012), Regional Standards for Water Services, November 2012.