Stormwater Management Strategy: Achieving Hydraulic Neutrality Using A Modular Stormwater Storage Attenuation Solution.

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ABSTRACT

Stormwater attenuation is the mitigation of the adverse effects of urban development on flooding. Capturing post-development peak runoff so that it does not exceed the pre-development peak flow-rate is crucial to ensuring hydraulic neutrality. Hydraulic neutrality is achieved by providing a temporary storage for stormwater using different tank storage methodologies. Some of the traditional responses to collecting and detaining stormwater are fast becoming unfit due to the reduction of the size of residential sections. For instance, putting a big tank in an increasingly small backyard, if in fact there was a backyard at all, left no recreational space. Burying a large tank in the same spaces threw up the issues of when to excavate, with what machinery, and whether the tank would fit without displacing foundations. This paper provides a brief overview of stormwater attenuation regulations in New Zealand, and the growing limitations of traditional stormwater storage solutions. As a proffered solution for stormwater detention/retention, a fully engineered stormwater system consisting of interconnecting lightweight modular pods made from polyethylene is discussed. The applicability of this modular solution on a case by case bases for new developments in New Zealand are also highlighted.

KEYWORDS - STORMWATER, DETENTION, RETENTION, ATTENUATION

1. Introduction

The effects of urban developments on the hydrological and hydraulic processes within the catchment, and consequently the natural and built environment are many. The effects may include; flooding, loss of habitat quality and quantity, accelerated erosion and land instability, alteration in natural water balance, and changes to existing stormwater infrastructure. Policies and regulations have been put in place by regional governments across New Zealand to control these aforementioned effects.

Stormwater attenuation is commonly used to mitigate the adverse effects produced by urban developments. In principle, peak flows specific for new developments are reduced via onsite attenuation. The conventional method of achieving onsite attenuation involves the use of underground or aboveground tanks to provide temporary storage for stormwater. The stored stormwater produced during rainfall is then gradually released into the local stormwater infrastructure at a predetermined flow rate using an orifice sized specifically designed to achieve hydraulic neutrality.

2. Stormwater Management Goals and Regulations in New Zealand

To manage the increase in impervious areas created by urban development, the additional runoff created by the impervious area need to be captured temporarily so that the maximum peak flow off the development is no greater than what it was pre-development (known as hydraulic neutrality). Figure 1 below show a hypothetical example of this.

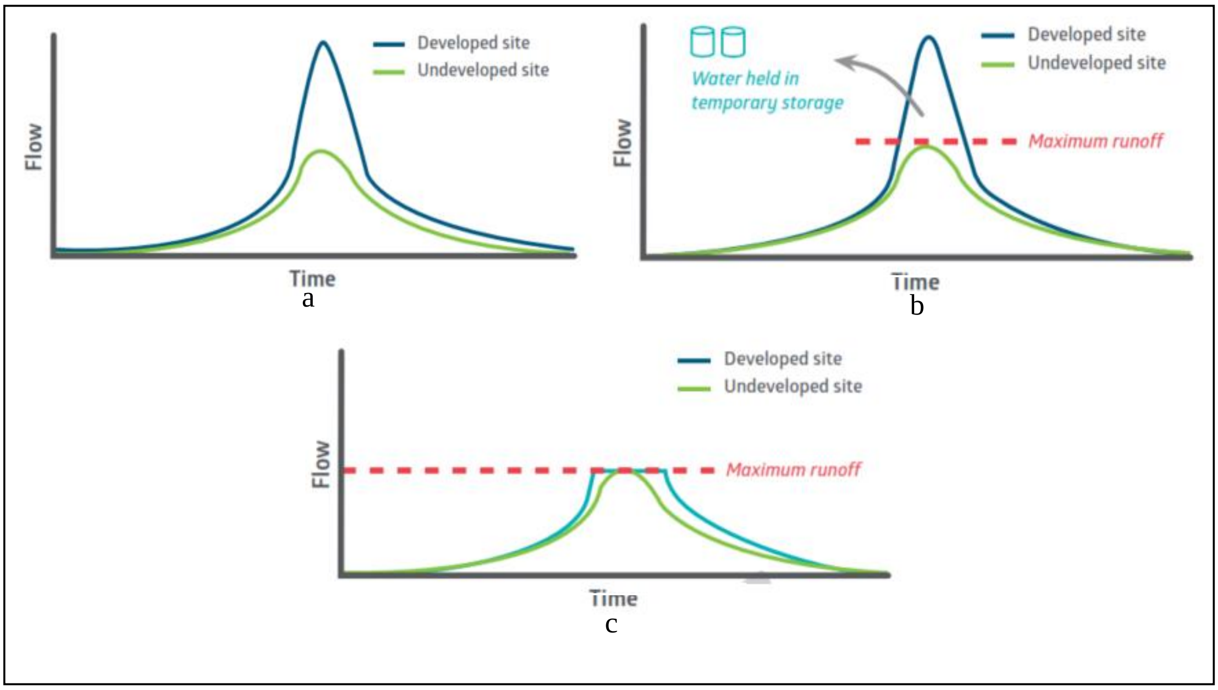

Figure 1*: Flow rate curves showing how hydraulic neutrality is achieved* (Wellington Water, 2018).

As can be seen in figure 1a above, increased sealed surfaces because of the development implies that water is unable to infiltrate into the soil or drain slowly overland. This obstruction to soil infiltration results in a higher peak flow and greater volume of runoff. From figure 1b, the difference in the peak-flow between pre and post development can is captured and held in a temporary storage vessel to be used in other applications (stormwater retention) or slowly released back into the local stormwater network (stormwater detention). Stormwater detention and/or retention methods can meaningfully attenuate peak flow rates during significant rainfall events to a threshold much closer to that of undeveloped sites (figure 1c). The goal here is to cap peak runoff from developed sites at the undeveloped flowrate.

The Auckland Unitary Plan has recently introduced new stormwater management regulations to the Auckland region including new Retention and Detention flow controls for sites located in a SMAF (Stormwater Management Areas: Flow) area. These controls seek to protect and enhance Auckland's river, streams and aquatic biodiversity in urban areas by managing the small frequent stormwater flows of up to the 1 in 1 to 2-year ARI event. The SMAF areas are mapped catchment areas (figure 2) that drain to streams that have been identified as being particularly sensitive to changes in stormwater flows, have high natural values, and are at potential risk from an increase in impervious area associated with future development. Two separate SMAF areas have been identified;

- Stormwater Management Area control – Flow 1 (SMAF1) are those catchments which discharge to sensitive or high value streams that have relatively low levels of existing impervious area.
- Stormwater Management Area control – Flow 2 (SMAF2) areas typically discharge to streams with moderate to high values and sensitive to stormwater, but generally with higher levels of existing impervious area within the catchment.

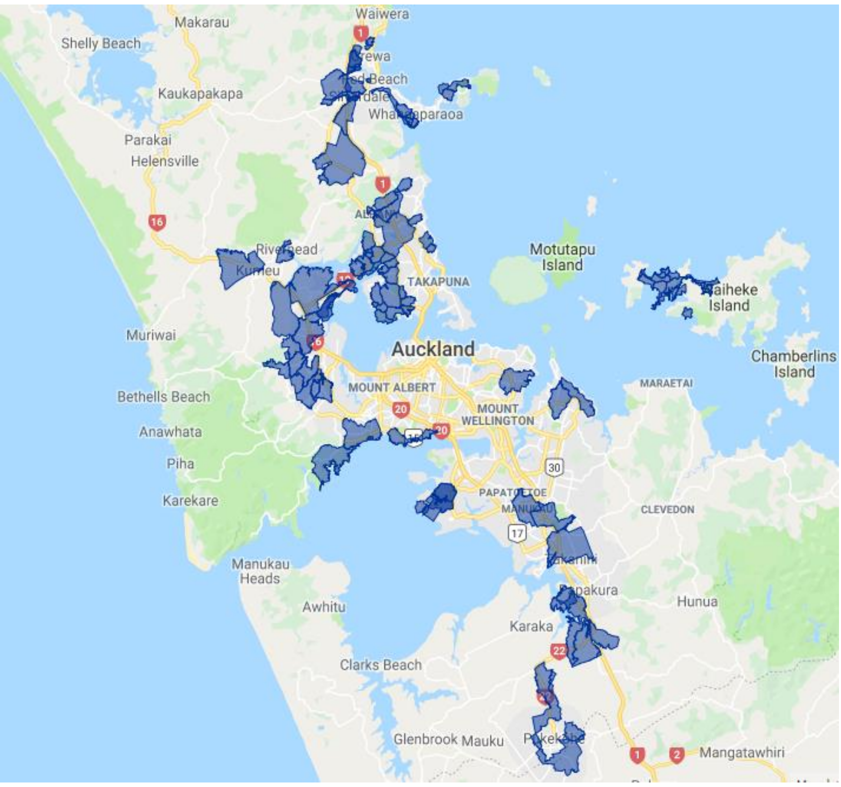

Figure 2: *Auckland Stormwater Management Area: Flow 1 & 2*

With the new regulations surrounding this, there is now a mandatory requirement for sites within these SMAF areas to provide;

- Retention (volume reduction) of at least 5mm runoff depth for the impervious area for which hydrology mitigation is required; and
- Detention (temporary storage) and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from the 90-95th percentile, 24-hour rainfall event minus the 5 mm retention volume or any greater retention volume that is achieved over the impervious area for which hydrology mitigation is required.

It is hoped that by retaining the first 5mm of runoff and allowing it to infiltrate at a rate of 1mm/hr, a 30% volume reduction could be achieved which will maintain base flow in nearby streams. Further by infiltrating the first 5 mm, a high percentage of the dissolved containments will be removed from the runoff.

The Wellington Region are finalising an across the board policy based on the average stormwater produced for different house sizes. For a house size ≤ 200 m^2 and ≥ 200 m^2 is about 3000 liters and 5000 liters respectively for an Annual Exceedance Probability (AEP) storm of 10% (a storm which has a 10 in 100 chance of occurring in a year or 1 in 100 chance of occurring in 10 years) (Wellington Water, 2018).

The Kāpiti Coast Rainwater and Greywater Code of Practice Guidelines provides solutions to meet the water demand management provisions of the Kāpiti Coast District Plan, the Greater Wellington's Regional Plan for Discharges to Land and the New Zealand Building Code (Kāpiti Coast Rainwater and Greywater Code of Practice Guidelines, 2012). In 2008, the Council made a change to the District Plan that all new residential dwellings connected to the town water supply system must reduce peak reticulated water used by households, by 30%, while;

- protecting reticulated water supply and households from cross contamination; and
- preventing unacceptable risk to the receiving environment (including human health).

The Council has two minimum acceptable solutions to comply, either installing:

- 10,000 litres rainwater storage solution, connecting to all toilets and outdoor taps; or:
- 4,000 litres rainwater storage, connecting to toilets and outdoor taps and a greywater diversion device.

3. Conventional Stormwater Attenuation Approach.

Traditional water storage solutions have hidden cost or obvious limitations. An above ground water tank will steal anywhere from 3 to 16m^2 of usable land space before piping is added. As with all stormwater practices, rainwater tanks have some limitations in some situations. Their primary limitations relate to their effectiveness for water quantity management in addition to being susceptible to damage and having unpleasant visual impact. Figure 3 below shows the advantages and disadvantages of different types of stormwater storage system.

Type of storage system	Advantages	Disadvantages
Open systems (e.g. ponds)	• Low capital costs • Low maintenance costs • Provide stormwater treatment • Can utilize existing stormwater ponds	• Public safety concerns if not fenced • Habitat for mosquito breeding • Loss to evaporation
Below-ground, closed systems	• Concealed from view • Do not consume above-ground space • Can be freeze protected	• Greater capital costs • Higher maintenance costs • Require stronger structure in traffic areas • Require pumping • Access can be difficult
Above-ground, closed systems	• Moderate capital costs • Moderate maintenance costs • Can be gravity fed	• Aesthetic concerns • More susceptible to weather conditions than below-ground systems (UV, freezing)

Figure 3: *Advantages and disadvantages of above- or below-ground tanks and stormwater ponds*

4. Modular Pods as a Prefered Solution for Stormwater Attenuation.

Aquacomb© is an innovative stormwater Detention or Re-use system that collects and holds rainwater for houses. Unlike other water tanks this unique water harvesting system comprises a series of interconnected water storage pods which are housed wholly within a concrete slab or under any hard ground surface. Its modular design allows installation of the system to be tailored to suit the needs of new builds, whether it’s to capture 3,000 or 50,000 litres. By putting water storage into the foundation of a newly built or renovated home, eliminates the need for a large ugly water tank above ground. It is the only invisible stormwater solution that does not require significant excavation or transportation costs. The lightweight tanks eliminate the need for any heavy machinery and are easy to transport and install by hand, while still being super tough and long lasting (figure 4).

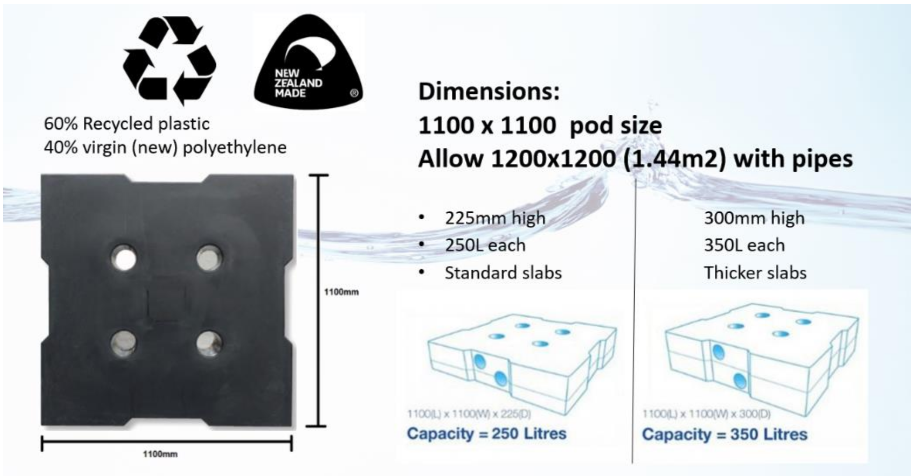

Figure 4: *The Aquacomb modular Pods Specifications*

a) Onsite Detention

Aquacomb© on site detention (OSD) is New Zealand's first in-slab stormwater system to come in a pre-packaged kit form, for simple and quick installation. The system saves days in construction time and significantly reduces building costs. In addition, the system can be used in any standalone, terrace or apartment construction requiring on-site stormwater management. It can be designed into any type of slab construction and is especially suited to waffle pod slabs used in housing. The Aquacomb© can be installed in the buildings slab or under any hard ground surface like driveways or under decks, or behind retaining walls or even stacked on their edge behind retaining walls or under soffits. Unlike traditional solutions the entire Aquacomb© system is hidden from view meaning no over ground pipes and no big water tanks taking up space on a new build (figure 5).

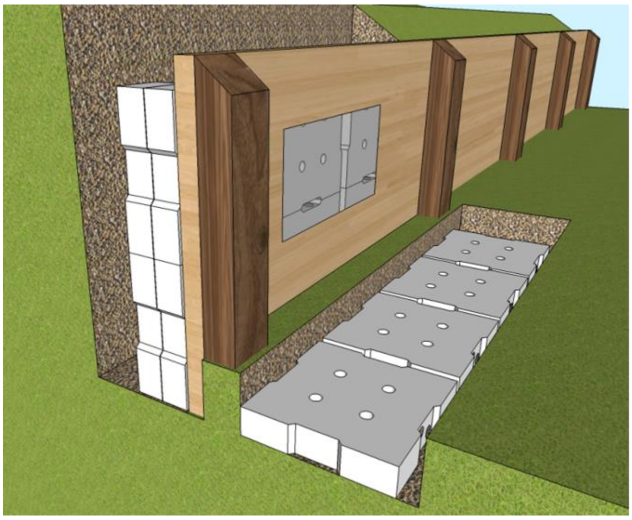

Figure 5: *Left: The Aquacomb modular pods installed behind retaining wall. Right: Under the stairs in steep site.*

The Aquacomb© pods are installed by an approved plumber or drainlayer to ensure it conforms with council's stormwater regulations. Preliminary assessment can be performed in conjunction with the architect or engineer responsible for the project to design as many pods into the concrete slab as necessary to meet the required or desired water storage capacity. Aquacomb© OSD is an established and accepted fully modular system, which has over 10,000 trouble free residential construction installations over the past 10 years throughout Australia and now for 18 months in multiple locations across New Zealand.

b) Onsite Retention

Aquacomb© is an efficient way of creating a water retention system on any new build.

Using the same pods as for a detention system, and often in conjunction with, Aquacomb pods ensure that both systems can be placed out of sight and harms way. With the attendant "Plug & Play" pump system connected into the homes toilet, laundry & outdoor taps the retention volume can provide the re-use requirements as specified.

5. Project Specific Applications of Modular Pods for Stormwater Attenuation

5.1 The implication of residential densification

Small residential sites, especially terraced or medium density developments often don't have room for above ground tanks or conventional buried tanks, or the cost of burying tanks with surcharge issues on foundations and boundaries is prohibitive (figure 6). Aquacomb is laid at grade and under existing infrastructure such as within the floor slab, or under a driveway, patio, deck or even within and under a lawn area leaving what little available space there is for the home owner to utilise.

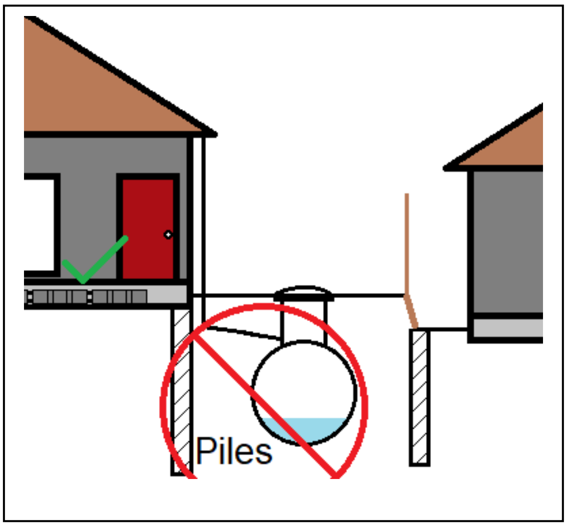

Figure 6: *Left: Aquacomb pod used to address the challenges of limited space for aboveground and underground tank. Right: An above ground tank occupying space at a small backyard.*

Constrained Commercial sites often have the same problem, there is not enough space, or the costs of existing solutions is too high. Where large volumes are required (e.g. 30,000 litres for a childcare centre or 100,000 litres for a large factory) Aquacomb pods can be laid in-slab or under the hard stand or carpark

5.2 High Invert Level Constraints

Where territorial authority infrastructure is too close to the surface to allow usual falls with the use of conventional buried tanks (figure 7), Aquacomb, being laid at grade ensures that minimum falls can be catered for.

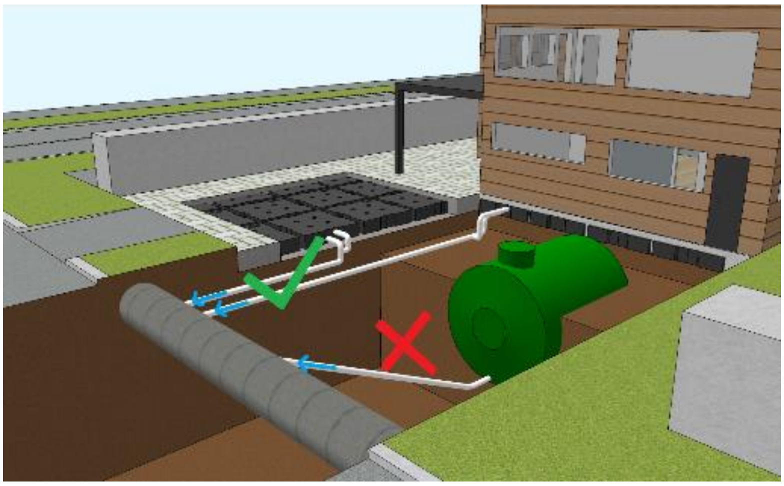

Figure 7: *Aquacomb application for High Invert Level Connections*

An example is an apartment building where large buried tanks were initially specified that required extra bridging and surcharge at great cost along with a multiple redundancy pump system, Aquacomb was able to be suspended from the ceiling of the underground carpark and achieve the fall to the invert required, at much lower cost (Figure 8).

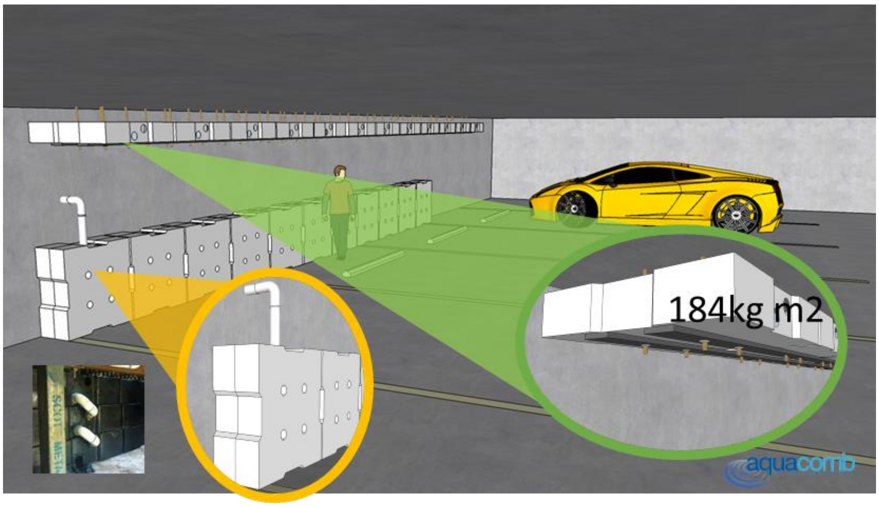

Figure 8: *Aquacomb pods suspended from the ceiling of an underground carpark*

6. Product Overview

Aquacomb™ requires no additional excavation, earthwork, haulage or disposal costs, let alone surcharge or bridging & engineering costs, like a conventional buried tank. It is completely hidden from sight meaning no unsightly above ground water tanks or pipe work. Some of the key benefits of the Aquacomb™ pods are;

- Lightweight and flexible plastic pods means Aquacomb™ is easy to install, can withstand earthquakes, & while designed as void former, can hold 2 tonnes.
- Aquacomb™ can be used for both retention and detention at once; potable water storage is also possible.
- Easy access to the system means any future maintenance is straight forward.

- Aquacomb™ is suitable for large projects such as whole residential subdivisions to apartments or commercial buildings, as well as individual dwellings.
- Simple system means no large engineering costs.
- Proven & safe solution: over 10,000 installs in 10 years, BRANZ Appraised [991: 2017] and Auckland Council Compliance Approved. (Currently undergoing Wellington Water assessment as an acceptable solution)

7. Conclusion

With increased intensification of our suburbs and the resultant increase in impervious surfaces, councils across NZ have identified the need to attenuate the difference between pre & post development stormwater flows to protect environments, waterways and infrastructure.

Depending on local factors such as volume & frequency of rainfall, ability of existing infrastructure to cope with increased load, perceived need for emergency water use, as well as specific sensitive environmental considerations, each council has, or is taking, a slightly different approach to achieving the solution, but the objective is the same – ensuring post development flows are no greater than pre development.

This intensification combined with increasingly smaller individual lots, means that the ability to achieve stormwater neutrality is increasingly difficult with traditional attenuation methods.

Above ground tanks take up valuable land and are an eyesore to many and buried tanks can be expensive to install and can have serious cost implications where size of sites require foundations and boundaries to be engineered to account for surcharge.

The Aquacomb modular stormwater storage solution answers many of the issues created by these smaller sites as well as issues around infrastructure such as high invert levels. In short, this modular, scalable, versatile pod system saves time – in installation, space – being laid under existing coverage areas, and money - by freeing up land and being cheaper to install.

8. References

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Auckland Unitary Plan E10 Stormwater management area - Flow 1 and Flow 2.pdf