Rainwater harvesting in non-residential buildings

A large amount of the water needs of non-residential buildings could be met with rainwater harvested from rooftops. This would take pressure off the water supply and stormwater infrastructures.

HARVESTING RAINWATER could also reduce building running costs, but this is financially feasible only where water and wastewater charges are based on volume.

A significant proportion of mains water is supplied to commercial and industrial buildings – in the Auckland region, it is around 25% of total water usage. Many end uses in these buildings don't need drinking-quality water but can use harvested rainwater. Non-potable uses (such as toilet flushing) have been calculated at around 23% of water use in these buildings.

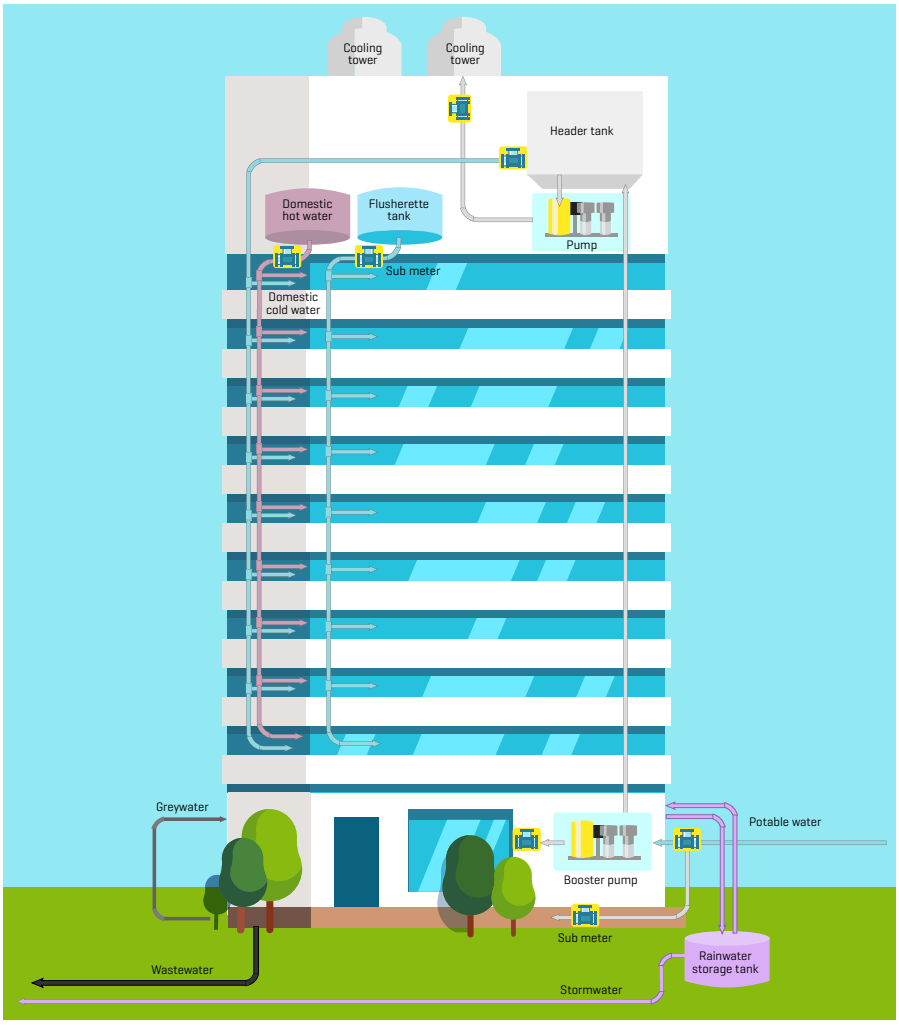
> Rainwater harvesting systems are not the same as greywater reuse systems. Rainwater systems catch rainwater on rooftops, while greywater is the wastewater taken from baths, showers and hand basins and, in some cases, from laundries.

The potential in New Zealand is almost untapped. Out of more than 41,000 non-residential buildings, just 370 are thought to have a rainwater harvesting system. Most are rural educational buildings relying solely on rainwater for their needs.

Design

Rainwater is typically collected at roof level and transported to basement/groundfloor storage tanks to keep the weight of the stored water at lower levels of the building. It is then pumped back to smaller tanks for distribution through the building.

Whether for a new build or a major renovation, a rainwater harvesting system needs to be considered in the early stages of design work. This will allow integration of the system throughout the building – for example, designing piping to the bathrooms and the smaller tanks.



A simple schematic diagram of a rainwater harvesting system in a commercial building.

Intended uses must be decided early. Where a water mains connection is available, the Ministry of Health recommends that potable uses are supplied from mains water.

A key part of design should be ensuring water efficiency throughout the building. This means specifying low-flush toilets, low-flush or waterless urinals and water-efficient tapware for basins. This can allow for smaller collection tanks, lowering overall system costs.

Collecting the water

Rainwater is mostly harvested from rooftops. Other possible catchments include car park surfaces or footpaths, but these are likely to carry a higher level of pollutants.

When specifying the roofing material, ask the manufacturer to confirm that their product is suitable for harvesting rainwater. In general, suitable materials include:

- steel (factory-painted, zinc/aluminium alloy-coated, stainless steel)
- factory-coated tiles
- glass.

Some composite asphalt roof systems or concrete tiles can leach chemicals and particles into the water. Butyl can be used, but black butyl rubber will oxidise as it weathers.

Materials that should not be used include any with lead in fixings, flashings or paint or bituminous materials.

The common materials used for guttering and pipes – uPVC, HDPE, seamless extruded aluminium and zinc/aluminium alloy-coated steel, stainless steel – are all suitable for rainwater collection.

Gutters and downpipes need to have the capacity to handle storm flows. Huge volumes of water can be collected in a short period of time on very large roofs. Siphonic systems, which exclude air from the water flow to create a siphon effect, can drain the roof quickly as they allow downpipes to function at full capacity. Turbulence and entrained air within the water can reduce potential flow rates through a downpipe.

Treatment

Systems should be designed to remove leaves, bird droppings and other debris before the water gets to the tank and include the following:

- Leaf screens – the wire mesh in these devices sieves out larger pieces of debris.
- First-flush diverters – these mechanically direct the first amount of rainfall (which washes debris off the roof) away from the tank. For large roof areas, this could be a significant volume – perhaps 500 litres. An alternative is a rain sensor that directs the first 5 mm of rainfall away from storage.

There are many options for treatment, sterilisation, filtration and ultrafiltration. Installing two different types of filter is common. Reverse osmosis systems can be used where a higher level of water cleanliness is required. Other treatment options include UV treatment and chlorination.

To cope with shortages of rainwater, the system should allow for a switch to mains water. Ideally, the change should be automated. Systems that offer remote monitoring are available.

To prevent the possibility of rainwater contaminating the mains water supply, a backflow prevention measure must be built in. This could be an air gap that prevents the water sources ever mixing or a specific valve in the piping.

The system should allow the supply pipes to be temporarily disconnected from the tank to allow for different parts of the system to be cleaned. It should also provide for overflow when rainfall is extreme, most likely through connection to the stormwater system, but potentially also using a rain garden to handle excess water.

Storage tanks

Tanks can be bought ready-made (plastic tanks storing up to 30,000 litres are available) or constructed on site. Plastic, fibreglass, concrete (ferro-cement) and steel are the main material options. Structural requirements from the water load mean they need to be in basements, building/car park foundations or underground. Local authorities typically have rules and conditions for buried tanks. Surface water must not be able to enter the tank, and it should not be subject to vehicle loads. Tanks should be lightproof to prevent algae growth and secured against unauthorised entry.

The calculation of the appropriate size tank depends on:

- water catchment area
- building size and occupant numbers (water demand)
- intended end uses (and potential future uses)
- required reliability – demand does not always coincide with rainfall
- rainfall volumes in the area.

As an example, consider a commercial building with a 1,500 m^2 roof catchment in Auckland (which gets 1,240 mm of rain annually). Assume 100 employees, 300 days' occupancy each year, with the water used for toilet flushing.

Annual rainfall (mm/year) for selected New Zealand locations.

LOCATION	Rainfall/year (mm)
NEW PLYMOUTH	1432
ROTORUA	1401
WELLINGTON	1249
AUCKLAND	1240
TAURANGA	1198
HAMILTON	1190
INVERCARGILL	1112
TAUPO	1102
GISBORNE	1050
PALMERSTON NORTH	966
QUEENSTOWN	913
DUNEDIN	812
NAPIER	803
CHRISTCHURCH	648

Calculate potential rainwater supply

Use a collection efficiency of 80% – some water is lost through first-flush diversion, spillage and evaporation.

0.8 x rainfall (mm) x collection area (m^2) = potential litres per year harvested

0.8 x 1,240 mm x 1,500 m^2 = 1,488,000 litres (1,488 m^3) potential water harvest per year

Calculate demand

Assume each employee flushes a toilet five times per day, and each flush averages 4.5 litres.

100 employees x 5 flushes x 4.5 litres x 300 days = 675,000 litres (675 m^3 per year)

Measure supply against demand

If large enough tanks are specified, rainfall collected is more than enough to meet toilet flushing needs in this example.

This is a very simplistic calculation. There are models such as PURRS (Probabilistic Urban Rainwater and wastewater Reuse Simulation) that allow a more precise assessment.

Regulatory requirements

A rainwater collection system must meet the requirements of the New Zealand Building Code including clauses E1 *Surface water* and G12 *Water supplies*. Lilac piping is adopted in AS/NZS 3500 *Plumbing and drainage* series to indicate a non-potable water supply.

Local authority requirements vary considerably around the country.

A building consent will almost certainly be required – it is required for all sanitary plumbing.

Maintenance

Treatment systems require regular maintenance. The manufacturer's manuals should be followed. A rainwater system should be

included in regular mechanical and hydronic maintenance check regimes. Filters should be checked monthly and changed annually if no other fault is identified. Filtration is one of the largest areas of system failure through lack of maintenance.

Rainwater collection in existing New Zealand buildings

BRANZ carried out a 3-year study into rainwater harvesting and greywater reuse in eight commercial buildings. The buildings all used rainwater for toilet and urinal flushing. Installation costs ranged from $7,000 to over $80,000, with tank size ranging from 7,000 litres to 185,000 litres, but most were 25,000–40,000 litres.

The volumes of rainwater used ranged from 45,000–1,147,000 litres in summer to 22,000–1,039,000 litres in winter. Annual water use was 309,000–23,525,000 litres.

Water testing by the Institute of Environmental Science and Research (ESR) on five of the buildings in the study found very little risk of infection from the flushing toilets and urinals.

Financial payback and feasibility

Discussions at the Facilities Management Association of New Zealand (FMANZ) Summit 2015 suggested there needs to be a maximum payback period of 3–5 years for management to approve inclusion in building design.

The systems studied in Auckland had a payback period less than 5 years and a benefit-cost ratio greater than 1. This is mostly due to Auckland's volumetric water and wastewater tariffs – the more water used, the higher the cost. (Outgoing wastewater is charged as a percentage of the metered amount of ingoing water.)

The systems outside Auckland had poor financial payback periods (over 20 years in three cases) because wastewater charges are not connected to water use, providing no incentive for water efficiency. When an Auckland tariff structure was applied, some became financially feasible. Economic feasibility is almost entirely dependent on the presence of volumetric wastewater tariffs.

More information

Fact sheet 4 *Water quality in New Zealand rainwater harvesting systems*

Fact sheet 6 *What is holding back rainwater and greywater systems in New Zealand?*

Fact sheet 7 *Potential network savings from rainwater and greywater systems in New Zealand*

BRANZ Bulletin 503 *Rainwater harvesting in commercial and industrial buildings*, October 2008. Judgeford, New Zealand: BRANZ Ltd.

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