Challenges of installing and maintaining 200-litre emergency rainwater tanks in the Wellington region

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ABSTRACT

In July 2013, the Wellington Regional Emergency Management Office (WREMO) partnered with a provider of water tanks to make 200-litre emergency rainwater tanks available at various council locations throughout the Wellington region. These tanks can be connected to downpipes and are designed to assist households with their emergency water needs, particularly following a disaster like a large local earthquake. While the rainwater tanks are being promoted as a viable emergency water supply, very little research exists in the Wellington context which explores the effectiveness and practicality of these systems.

This report explores the challenges associated with the installation of these tanks and the associated maintenance issues that arose, based on issues encountered with installation and maintenance of six rainwater tanks at properties in Wellington and Lower Hutt. The results identified a number of challenges associated with the installation of the tanks and their on-going maintenance, which can be broadly categorised as follows:

- Challenges associated with the property size and layout;
- Challenges associated with the design of the downpipes that the tanks are being connected to;
- The skill level of the installer; and
- Features of the tank design (for example the taps and issues associated with diverter leaking).

Generally, the majority of the challenges identified are not insurmountable. The greatest challenge identified related to property size. Properties that have space limitations are unlikely to be able to accommodate a rainwater tank. Thus, uptake of the rainwater tanks is likely to be greater among suburban property owners (where average section sizes are larger) than inner city property owners.

The main outstanding matter identified in this study is the adequacy of the retaining straps in preventing the rainwater tanks from toppling during a large earthquake. Further research on this issue is planned.

KEYWORDS

Rainwater tanks, emergency management, water quality, Wellington, Post Earthquake Functioning of Cities (PEC), urban resilience

1.0 INTRODUCTION

In July 2013, the Wellington Regional Emergency Management Office (WREMO) partnered with a provider of water tanks to make 200-litre emergency rainwater tanks available at various council locations throughout the Wellington region. These tanks are primarily designed to be connected to a suitable downpipe of a dwelling and to assist households with their emergency water needs. However, an alternative use for these tanks is for them to be filled with town supply water, thus serving as 200-litre storage tanks. The rainwater tanks are available for purchase for $105.00 including GST (WREMO, 2015). While they are being promoted as a viable option for emergency water supply, very little research exists in the Wellington context which explores the effectiveness and practicality of these systems in the aftermath of a disaster such as a large earthquake. GNS Science in conjunction with Massey University, and as part of the Post Earthquake Functioning of Cities (PEC) Research Program, has undertaken a study that investigates the following:

- The challenges associated with the installation of the tanks and any on-going maintenance issues; and
- The potability of the tank water and the implications for the provision of emergency drinking water.

The study involved the installation of five rainwater tanks attached to residential dwellings in the suburbs of Brooklyn (two tanks), Karori, Normandale and Moera, with the collected water being tested over the course of a year. A sixth rainwater tank was filled with potable water from the mains water supply and was not connected to a dwelling – this acted as a control against which the other five tanks were assessed.

The current report describes the challenges encountered during the installation of the tanks and their on-going maintenance over a one-year period. We also provide recommendations for overcoming some of these challenges (Section 2.4). A second report is in preparation and will cover findings from a year-long water sampling program including the following aspects:

- Chemical and microbiological water quality parameters;
- Observations on conditions in the tanks such as water level and biofilm build-up over time; and
- Appropriate management recommendations to ensure that the tank water is safe to drink.

1.1 RAINWATER TANKS

A rainwater tank is a water tank used to collect and store rainwater runoff, typically from rooftops via downpipes and guttering. Rainwater tanks can come in a variety of sizes from 200 litres up to 30,000 litres (The Tank Guy, 2015a). The smaller capacity tanks are typically used for gardening, rainwater retention and emergency water situations. The larger tanks are used to supply domestic water and are typically used in rural situations where reticulated town-supplied water is not available. Approximately 10% of the population of New Zealand depends on roof-collected rainwater for drinking water. Rainwater tanks and pipes leading from them are generally able to be fitted with a variety of filters to remove organic material and potentially other contaminants from the water. These can range from simple coarse filters (similar to what is found on the diverters of the 200-litre rainwater tanks installed for this project) where larger organic material such as floating leaf litter is removed from the water, to considerably finer designs which remove very small particulates and are more likely to be incorporated as part of a domestic water supply. Household filters also extend to chemically-active adsorption systems (e.g. activated carbon, cation-exchange resins) which remove specific classes of chemicals from the water, but require periodic replacement.

1.2 WELLINGTON SEISMIC ENVIRONMENT

The Wellington region lies within the deforming boundary zone between the Pacific and Australian plates (Figure 1.1), within one of the most seismically active areas of the country. The region is cut by earthquake-producing active faults, both on- and offshore. It is underlain by the subduction interface between the Australian and Pacific plates, and has been violently shaken by earthquakes in 1848, 1855 and 1942 (Downes 1995; Downes et al., 2001; Grapes & Downes, 1997; Grapes et al., 1998). In 2013, an earthquake doublet (M6.5 on 21 July and M6.6 on 16 August) centred in northern Marlborough was widely felt across New Zealand and caused damage to some buildings across the Wellington region (Holden et al., 2013).

Wellington City is bisected by the active Wellington Fault, and many engineering lifelines (*e.g.* bulk water supply pipelines, electricity, roads, telecommunications) cross this fault. Surface fault rupture and a large earthquake (approximately magnitude 7.5) is regarded as New Zealand's probable maximum earthquake loss event (Cousins et al., 2009, 2014). The likelihood of such an event occurring within the next 100 years is approximately 10% (Rhoades et al. 2011).

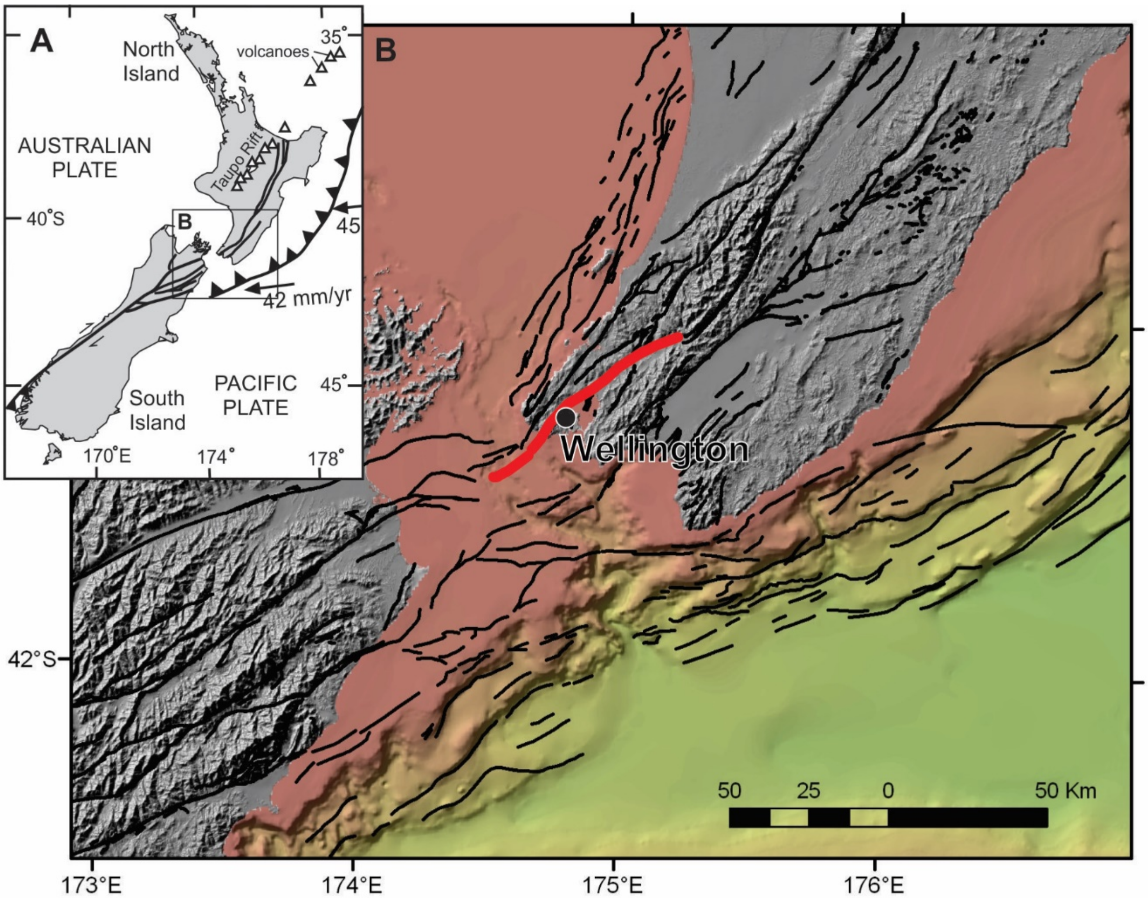

Figure 1.1 A) Tectonic setting of New Zealand. B) Known active faults of central New Zealand, with the Wellington-Hutt Valley segment of the Wellington Fault (Berryman, 1990), which bisects Wellington city, highlighted in bold red. Onshore faults from GNS Science's Active Faults Database (http://data.gns.cri.nz/af/) and offshore faults closest to Wellington from Pondard & Barnes (2010).

1.3 WELLINGTON EMERGENCY WATER CHALLENGES

Given the seismic environment of Wellington Region a number of studies have considered the potential implications for bulk water supply to the region's residents following a Wellington Fault earthquake. The purpose of these studies has been to consider whether the region's residents would have continued access to adequate water, or whether further alternative measures are required to provide access to emergency water.

Cousins et al. (2010) predicted pipeline damage to bulk water supply mains from a rupture of the Wellington Fault, and estimated times for restoration of the bulk supply to the main delivery points throughout the region. Wellington City was identified as being particularly vulnerable due to its physical isolation east of the Wellington Fault, concentration of population, and lack of access to alternative supplies. The shortest time to restore even a limited bulk water supply to Wellington City was estimated to be in the range of 35 to 55 days. This study also considered the reduction in restoration times that would result from the construction of a new dam at Whakatikei, located 35 km northeast of Wellington but on the western side of the Wellington Fault. This new source would require only one crossing of the Wellington Fault to deliver bulk water to central Wellington, compared to three crossings for the existing source at Kaitoke, north of Upper Hutt. The study concluded that the construction of a dam at Whakatikei would lead to a 15-20 day reduction in the time needed to restore water supply to central Wellington. Later this study was extended to cover restoration of bulk supply to all suburbs of Wellington, for several large earthquakes impacting the city (Cousins, 2013). A Wellington Fault earthquake was clearly the worst-case event and, in the absence of mitigation measures, could lead to tens of thousands of people being without water for weeks at a time. Such a situation was clearly untenable.

Brown (2010 & 2011) carried out cost-benefit analyses of using relatively large (5000 and 10,000-litre) rainwater tanks to replace part of the mains supply of water for normal household consumption of water. While there were clearly no economic benefits (in fact there would be large net costs) such large tanks would undoubtedly enable households to be completely independent of mains water following a disaster, assuming that water consumption rates were lowered from the normal levels of about 220 litres per person per day (GWRC 2014).

Hutchinson and O'Meara (2012) investigated the planning for emergency water services in the context of the Wellington Region. The paper undertook an evaluation of a variety of emergency water options in the Wellington region, including rain-water harvesting, surface water, groundwater, reservoirs, desalination and stored water. The report considered that rainwater harvesting could supply over double the 600 litres per person per month required to supply a family of four with 20 litres per person per day. The authors concluded that rainwater harvesting could provide a valuable emergency water resource, especially for non-potable uses such as washing.

Beban et al. (2013a, b) explored the potential roles of rainwater tanks as an alternative source of water to households in Wellington City. This study found that rainwater tanks are a viable option as an emergency water supply to households. However, rainwater tanks, particularly larger ones, can be expensive and difficult to install in established urban areas. Furthermore, roof-collected rainwater systems were thought to be vulnerable to both microbiological and chemical contamination, particularly in urban areas.

Cousins (2015) investigated the potential benefits from rainwater harvesting in addressing the gap in water supply following a magnitude 7.5 earthquake on the Wellington Fault. The gap arises because restoration of bulk supply to reservoirs, or other emergency supply points, could take weeks to months, whereas water stored in reservoirs and at people's homes is likely to be depleted within a few weeks. This study found that, on average, Wellington receives more than enough rainfall to meet the post-disaster emergency water demand of 15–20 litres per person per day. Variability in the daily rate of precipitation, however, could lead to water deficits lasting from days to weeks. In particular, long dry spells in summer were found to be a problem, with the length and distribution of the dry spells being a key determinant of the effectiveness of rainwater harvesting in terms of supplying emergency water.

Cousins (2015) also undertook large scale modelling involving 75,000 Wellington people living more than 1 km from their nearest reservoirs. This modelling demonstrated that having 300 litres per person of rainwater storage would give acceptable security of emergency supply for most of the people most of the time, assuming total dependence on rainwater. There were relatively large reductions in the numbers of days without water as the tank size was increased from 100 litres to 200 litres and then to 300 litres, but relatively small improvements thereafter. A single 200-litre tank on its own was not large enough, but in combination with other improvised storage (e.g. bathtubs), a reduced consumption rate (to 10 litres per person per day), and occasional access to water stored in council reservoirs, could make a worthwhile difference.

Beban et al (2014) considered the potential for groundwater bores to meet the emergency water needs of Lower Hutt City following a large earthquake. This study found that the restoration times for a survival level of supply (to main reservoirs) would be 20 – 25 days, with 25 – 40 days being the time to return reticulated water to houses. However, due to the location of the reservoirs within the Hutt Valley, large portions of the population would need to walk further than 1 km daily to access their emergency water needs, which presents a barrier to accessing emergency water. To ensure that the majority of the population was within 1 km walking distance of emergency water, 16 new emergency groundwater bores were recommended. These bores would largely be able to be located within public parks, which could also provide temporary accommodation if needed following a Wellington Fault earthquake.

These previous studies have identified that, following a large earthquake that would disrupt the bulk water supply in the Wellington region, there would be a need for people to have adequate storage of emergency water within their households. Several of the studies identified that rainwater tanks could have some potential in meeting private water needs. However, no studies have investigated in detail the potential challenges and barriers associated with the installation of these tanks in a Wellington context. Similarly, these studies have also not considered the quality of the water within rainwater tanks in a Wellington context, and whether the water quality would constitute a barrier to their use. As such, there is a current gap in our understanding on how effective rainwater tanks could be in the Wellington context.

2.0 PROJECT DESCRIPTION

2.1 RAINWATER TANKS

The rainwater tanks installed for this project were 200-litre barrel-shaped tanks (Figure 2.1a). The barrels themselves are tapered in shape, with a narrower base and a wider top. The barrels have a removable lid which rotates and locks into place. The rainwater tank is connected to an adjacent downpipe through a simple diverter (Figure 2.1b) which contains a coarse screen to restrict large debris from entering the tank. The rainwater tank fills through a horizontal inlet pipe installed near the top, with the inflow automatically ceasing once the water level in the tank reaches level of the diverter. There are two options at the base of the tank to install a tap, one option at the very base of the tank (Figure 2.1a, lower right, sealed) and another approximately one third the way up the tank (Figure 2.1a, showing tap installed).

Figure 2.1a The rainwater tanks that were installed (Photo source http://www.thetankguy.co.nz/.

When purchased, the rainwater tanks include one each of the following parts:

- 200 litre rainwater tank (Figure 2.1a);
- Rainwater diverter (Figure 2.1b);
- Flexible hose that connects the diverter to the rainwater tank;
- Brass tap;
- Plug; and
- Restraining strap with associated connection hooks.

The rainwater tanks are marketed as containing all the parts needed to connect onto a residential downpipe.

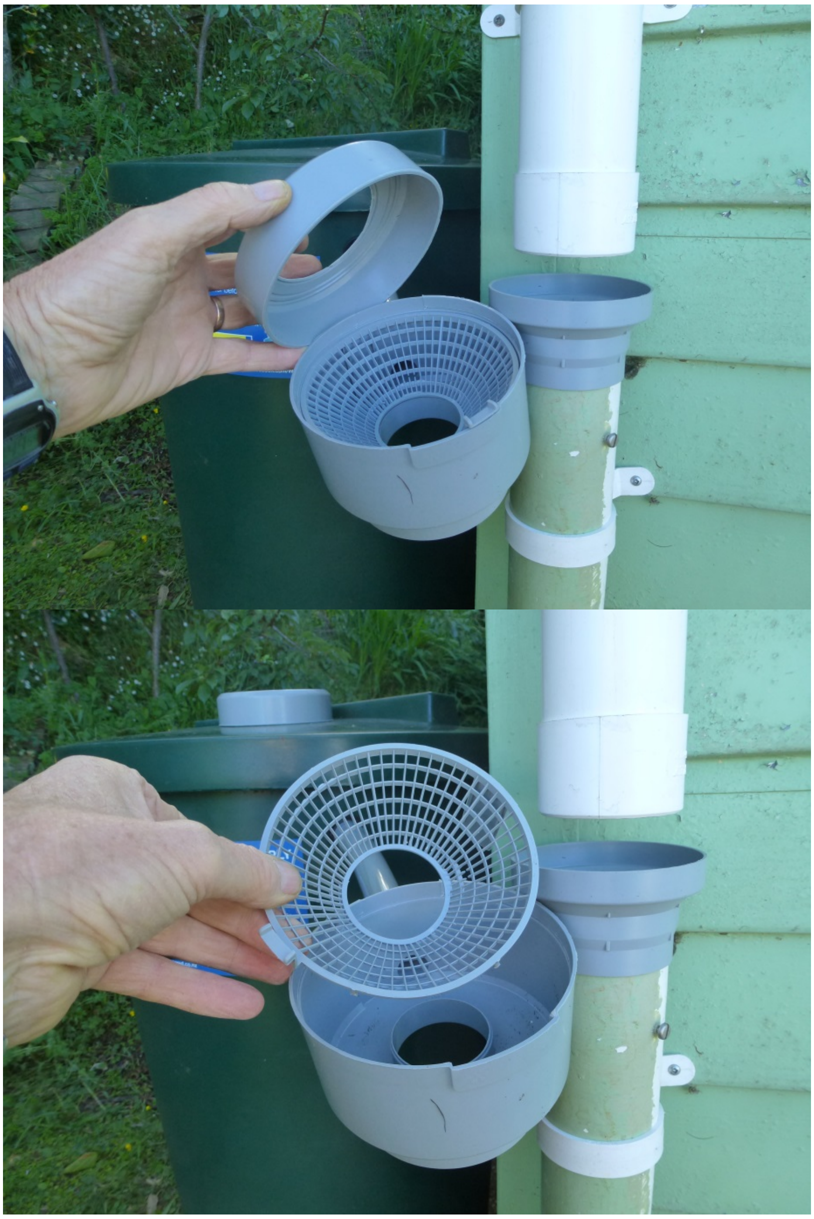

Figure 2.1b Interior of the diverter, with coarse screen in place (upper) and removed (lower).

2.2 INSTALLATION SITES

The rainwater tanks were placed at six sites in Wellington and Lower Hutt (Figure 2.2).

Figure 2.2 The locations of the six rainwater tanks.

For tanks 1, 2, 4, 5 and 6 the collection catchment comprised a specific area of the roof surface with rainwater runoff being directed to horizontal PVC guttering leading to the vertical downpipe to which the tank was connected. Tank 3 was not connected to the downpipe but was filled with tap water from the reticulation system and left as a static control. A detailed description of the buildings and their associated roof materials can be found in Appendix 3. A summarised version of the buildings and their associated roof materials is provided below:

Rainwater tank 1 – Pekanga Road, Normandale, Lower Hutt. This tank was adjacent to a garage, connected to a downpipe servicing half of the roof. The collection area was about 30 m^2. The lower half of the building was concrete wall dating from the early 1950s but the upper half was 'Skyline' style added in the early 1980s. The roof cladding was part unpainted corrugated galvanised (i.e. zinc-coated) iron and part 'Clearlight' corrugated sheeting. The ridge capping was galvanised iron with lead flashing.

Rainwater tank 2 – Mason Street, Moera, Lower Hutt. This tank was attached to a 1920s dwelling that had been extensively renovated in the 1980s. This property was located on the Hutt Valley floor, in southern Lower Hutt. The tank was connected to a downpipe on the eastern side of the dwelling. The collection area of the roof was relatively large, and was original painted long-run corrugated galvanised iron with zinc flashings. The roof materials were showing early signs of corrosion and some of the fixings were loose or corroded.

Rainwater tank 3 – Huntleigh Park Way, Ngaio, Wellington. This tank was the control tank and was not connected to a downpipe. It was filled with tap water from the reticulation system and left as a static control for the duration of the project.

Rainwater tank 4 – Homewood Crescent, Karori, Wellington. This tank was connected to a 1930s dwelling. The roofing material was original corrugated painted long-run galvanised iron. The ridge caps were galvanised iron with lead flashing. The roof materials were showing early signs of corrosion and some of the fixings were loose or corroded.

Rainwater tank 5 – Charlotte Avenue, Brooklyn, Wellington. This tank was connected to a c. 1905 dwelling. The roof catchment to the rainwater tank was made up of two distinct areas. The main area was clad with original corrugated painted galvanised iron in poor condition and had lead-head nails and flashings. The original cladding was in the process of being replaced by the owner, with the new areas clad with unpainted galvanised iron with galvanised coated iron fixings and zinc flashings. This rainwater tank was sited under a first floor timber deck.

Rainwater tank 6 – Harland Street, Brooklyn, Wellington. This tank was connected to a 1907 dwelling that had a new roof installed during the project. The new roof cladding was corrugated galvanised iron in very good condition, with soft zinc-tipped flashings. Where the chimney abutted the roof cladding there was a stepped lead flashing. The tank was located on an area of wooden decking at ground level.

2.3 RAINWATER TANK INSTALLATION

The rainwater tanks were purchased in November 2013 and were installed at the six sites during December 2013. The rainwater tanks were installed in accordance with the instructions provided, with the exception of minor variations to ensure that the section of downpipe below the diverter connection remained in place (discussed in more detail in Section 2.4 and Appendix 1). Four of the six tanks were installed by the owners of the homes. One tank (Tank 4) had to be installed by a registered plumber as the dwelling had 63 mm diameter metal downpipes which were incompatible with the diverter; these were replaced by a section of PVC downpipe for the purposes of this study. Tank 3 was not connected because there was insufficient clearance between the metal downpipe and the building to install the diverter and a decision was made to leave it unconnected as a static control. However, a registered plumber would have been required to connect this tank as this dwelling also had 63 mm diameter metal downpipes.

By early January all of the connected rainwater tanks were filled to capacity. It was observed that the five tanks connected to the downpipes filled with rainwater quickly and that the water remained at a high level for the duration of the project. Filling and recharge of tanks did not require heavy rainfall.

It was intended that no alterations be undertaken to the rainwater tanks following their installation. However the following changes had to be made during the 1-year study period:

- All of the taps were replaced with new spindle taps in April 2014 due to an issue associated with spreading washers in the original taps that were supplied with the rainwater tanks. These washers adhered to the tank side of the tap valve and prevented water flowing from the tanks when they turned on. The installation of the new taps resulted in the rainwater tanks losing approximately 10 to 20 litres per tap change.
- In October and November 2014, Tank 2 had to be disconnected from the roof supply for 6 weeks due to the need to undertake emergency stormwater repairs. During this 6 week period, the rainwater tank was transported and stored under the carport and remained disconnected from the stormwater systems. The rainwater tank was reconnected to the original downpipe once the works were completed. Approximately 60 litres (30% of the tank volume) was lost during the transportation of this rainwater tank (Figure 2.3).
- Tank 3 was topped up with new tap-water at approximate 2-monthly intervals to replace water that had been lost by sampling, the tap change, and evaporation. Volumes involved were minor (10-20 litres) compared with the tank volume.
- For Tank 6, the tap was replaced by a stainless steel ball valve tap on 22 November 2014, due to continuing problems with the April replacement tap malfunctioning. Approximately 20 litres of water was lost during this exercise. For Tank 1, the tap was replaced by a gate valve in October 2014 (Figure 2.4 and Figure 2.5).

Figure 2.3 Tank 2 disconnected from the stormwater system.

Figure 2.4 Tank 1 replacement tap.

Figure 2.5 Tank 6 replacement tap.

2.4 ISSUES ASSOCIATED WITH INSTALLATION OF RAINWATER TANKS

The rainwater tanks are available for purchase at a number of locations within the Wellington Region. Many of these locations have a display example of an installed tank set up for customers to observe. The rainwater tanks installed for the project were purchased from the Hutt City Council Visitor Information Centre. At time of purchasing, no questions are asked of the purchaser by the retailer regarding the downpipe connections that the rainwater tanks will be connected to and there is an underlying assumption that the tanks will fit all dwellings. As part of the study design, the participants decided that they would attempt to install their own rainwater tanks and document their own first hand experiences. For the purposes of this section of the report, the issues associated with the installation of the rainwater tanks will be explored separately from the issues encountered during the operation of the tanks. The issues have been subjectively classified as being high, medium or low risk in terms of their importance to the installation and operation of the rainwater tanks. Where possible, potential solutions that would address the identified issue have been suggested (Table 2.1; Section 2.4.1).

2.4.1 Installation Issues

Issues identified during the installation phase of this project are shown in Table 2.1, together with a subjective ranking of their importance and suggestions for solutions. We stress that these issues did not occur at all properties and arose as a result of constraints imposed either by the property or by the design of the dwelling.

Table 2.1 Challenges to successful installation.

Challenge	Details	Potential Solutions	Ranking
Lack of space to install a tank	Many properties in the Wellington region are either small and/or located on steep slopes. These properties may lack suitable locations to install a tank on a flat compacted base adjacent to a downpipe, while not blocking any access ways	Provide advice at the point of sale on the space requirements to install a rainwater tank; or Use tank for storage of tap-water	High
Insufficient clearance between building façade and downpipe to install diverter	For two of the dwellings in this study the downpipes were located close to the façade of the dwelling with an insufficient gap to allow the diverter to be fitted. This prevented the rainwater tank being installed by the homeowner and specialist advice was sought. For Tank 6, the diverter was incorrectly installed due to the proximity of the downpipe to the dwelling façade. This resulted in the diverter leaking.	Provide advice at the point of sale on the need to have a certain clearance distance between the downpipe and the façade of the dwelling. Provide an alternative diverter for dwellings whose downpipes are located close to the façade. Provide information or instructions on how to install the rainwater tank when the downpipe is located close to the façade. This may include the recommendation to contact a qualified plumber to assist with installation. Use tank for storage of tap-water.	High

Challenge	Details	Potential Solutions	Ranking
Lack of DIY skills	The installation of the rainwater tanks require a basic level of DIY skills	While it is difficult to determine people's DIY skills at the time of purchase, the information packs could include a list of preferred installers that people could contact if they have difficulty installing the rainwater tanks.	Medium
Unwillingness to modify downpipes	People may be unwilling or unable to make modifications to downpipes. The reasons for this may include that: • They rent the property; or • The downpipe is constructed from metal and therefore is more difficult/expensive to modify or replace.	Have educational material available for landlords so that they can understand the benefits of installing rainwater tanks; or Provide alternative advice on how the rainwater tanks could be used, without the need to modify downpipes. This could include how following a large earthquake, the tanks could then be connected to the downpipe system to provide an emergency water supply (it is assumed that people may be more willing to modify their downpipes following a large earthquake).	Medium
Diverters provided may not fit downpipes smaller than 80 mm diameter	The diverters supplied with the tanks are designed to fit standard 80 mm diameter PVC downpipes, with the capacity for the inlets to be trimmed to fit larger downpipes. However, older-style metal downpipes are generally smaller (63 mm diameter).	Providing an alternative diverter for dwellings with older-style narrow downpipes. Advice at point of sale on how to overcome problem; or Use tank to store tap-water.	Medium
Diverter separating from the downpipe connected to the guttering	Many older downpipes are suspended above the stormwater inlet which they discharge into. If there was no stormwater pipe bracket below the connection to the rainwater tank, then the stormwater downpipe below the diverter was not able to be supported. This resulted in the downpipe not being connected to the stormwater system.	Provide a downpipe bracket within the parts provided to allow the lower portion of the downpipe to be fixed to the wall.	Medium
Problems installing the restraining strap, with the consequence that the tank will not be secured in the event of a large earthquake	The restraining straps provided assume that the dwelling façade is timber. However, if the dwelling façade is brick, or if the rainwater tank is located alongside a concrete wall the restraining strap provided is unlikely to be able to be installed by a home owner. Some people were unwilling to drill into their weatherboards to install the restraining strap due to water tightness concerns. The restraining strap provided was not long enough.	Provide advice within the instructions regarding the need to seek professional advice for the installation of the restraining strap into walls made of concrete or brick. An alternative tank design or restraining method could be considered where the need for a restraining strap is either reduced or removed. Such a design may involve a tank with a flared base for increased stability. Provide a longer strap.	Very low as it does not prevent the installation of the tanks. However, there are implications for the stability of the tanks during an earthquake.

2.4.2 Operational Issues

Several issues were identified by the researchers relating to the operation of the rainwater tanks over the course of the year that they were installed (Table 2.2). The issues identified were generally experienced by more than one tank owner and therefore appear to be a function of the system design rather than being associated with limitations presented by individual properties. As with the installation table, we have provided a subjective ranking of their importance in terms of the use of the tanks, and their long-term installation. As with Table 2.1 we have suggested solutions for the issues we identified.

Table 2.2 Challenges identified during normal operation of the tanks.

Problem	Details	Potential Solutions	Ranking
Diverter leaking in high intensity rainfall events	In high intensity rainfall events water fountains out of the downpipe/diverter which results in surface flooding issues. The potential for surface flooding beside foundations goes against the purpose of downpipes and against the requirements of the building code to keep floors/timber/foundations dry and to avoid under-house water flow.	Provide a small tube of waterproof sealant (or instructions on the need to use sealant). This sealant would need to be applied at the downpipe/diverter interface. Provide clearer advice on the need for the diverter to be installed so that it is level. In this study, non-level diverters leaked during rainfall events.	High
Leaky taps	Taps installed at two of the six properties were persistently leaky, reducing the water level and potentially leading to dampness problems underneath (as per leaky diverter).	Provide thread tape to stop taps leaking.	Medium
Restraining straps causing damage to the buildings they were attached to	For tank 6, the restraining strap has resulted in the batten being pulled away from the dwelling. This has resulted from the incorrect installation of the retaining strap into non-structural elements of the dwelling.	Provide clear instructions on the need for the restraining strap to be installed into structural aspects of the building.	Medium
Taps not working	The washers in the taps provided with the rainwater tanks were too soft and spread, and then adhered to the tank side of the valve, which prevented water from flowing from the tap when it was turned on.	Provide taps with washers that do not spread and adhere.	Low
The lower section of downpipe repeatedly separated from the diverter	To install the diverter the downpipe needs to be cut. Due to the design of the diverter the lower section of downpipe regularly separated from the diverter. This meant that rainwater did not enter the stormwater system and instead discharged across the ground.	This issue was addressed in a variety of ways by the parties who installed their tank, including through the use of tape and brackets. The easiest and most practicable solution would be for the kit to provide an additional downpipe bracket that could be used to secure the downpipe below the diverter to the house.	Low
Clarity of the instructions provided	Generally the instructions were easy to follow, although the diagrams did not have captions.	Provide a caption for each diagram.	Low

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3.0 DISCUSSION

As identified under Sections 2.4.1 and 2.4.2 of this report, a variety of issues were identified with the installation of the rainwater tanks and their on-going maintenance. These issues can be broadly categorised as follows:

- Challenges associated with the property size and layout;
- Challenges associated with the age and design of the dwelling that the tanks are being attached to;
- The skill level of the installer; and
- The design aspects of the tank system (for example the taps and issues associated with diverter leakage).

(Potential solutions to specific issues under each category are identified in Table 2.1 and Table 2.2.)

It needs to be recognised that the majority of the issues identified in this report do not present such a challenge that they prevented the installation of a rainwater tank. Four out of six participants in this study were able to overcome minor problems and successfully install tanks at their properties. One property (Tank 4) required a plumber to replace the downpipe and install the rainwater tank. At the sixth property, installing the tank would have required replacing the existing metal downpipes with standard plastic ones. We did not pursue this option as we decided to use that tank as a static tap-water control.

The main issue that we identified that could prevent the installation of a rainwater tank for some properties was the lack of space around some dwellings. This issue is particularly relevant for older established residential areas and for new higher density housing areas (for example townhouses or apartments). In both of these instances, the outdoor space surrounding the dwellings is often at a premium and the installation of the rainwater tank could end up impeding access around the dwelling. This issue means that it will be less likely that owners of small properties will purchase rainwater tanks, than will owners of large properties. Hence rainwater tanks are likely to have the higher uptake in suburban properties where section sizes are more generous. Beban et al. (2013a) considered water shortfall within the Wellington Region following a Wellington Fault earthquake. Their findings showed that the suburbs with small land areas are some of the areas where the emergency water is most needed following a Wellington Fault earthquake. It has previously been assumed that rainwater tanks would be able to provide significant assistance to meeting this shortfall. However, the findings of the current study suggest that given the space issues associated with small properties, the assistance that rainwater tanks could provide in meeting this shortfall might be limited. As such, further consideration should be given as to how emergency water could be provided to land-constrained suburbs.

We suggest that many of the issues identified in this report could be overcome through the further development of a ‘Frequently Asked Questions’ (FAQ) information sheet that could be on display at the place of purchase and on a Council or other relevant website. We acknowledge that the FAQ have been updated as a result of this project, to include clearer guidance on the use of the rainwater tank for static water storage. However, this information sheet could be updated further to provide clearer guidance on a number of the other issues identified by this project. This would ensure that purchasers are better informed on the factors they need to take into account when installing the tanks. Similarly, a demonstration

'YouTube' video could be prepared which supports the information sheet and practically shows how to troubleshoot any issues that arise. This video could operate alongside an existing video (The Tank Guy, 2015b) that has been prepared, which was viewed by at least one of the installers who found it very useful.

The results of this project were also presented to representatives of the Wellington Regional Emergency Management Office and the tank suppliers at a research update session in May 2015. We acknowledge that many of the challenges identified in this report were known to these parties and they were actively exploring options to address a number of the issues that were raised. These measures included fixing the washer of the tap to the spool (with adhesive), and exploring alternative diverter designs. These measures would assist with rectifying several of the more significant issues associated with the installation and operation of the tanks.

One issue that is not easily addressed by the supplier of the tanks is the level of DIY skills of the people purchasing the rainwater tanks. A balance needs to be struck between providing a tank that can be installed by most people, and not making the tank so difficult to install that it prevents people from purchasing the tanks, or results in a type of installation that may not comply with some aspects of the building code. However, regardless of how easy a tank is to install, there will always be a proportion of the population who are unable to install the tanks due either to their skill level or their physical ability. To assist these citizens with the installation of the rainwater tanks, the supplier (WREMO) could contact a local charity provider (for example Rotary), and the charity provider could then install the tanks for a nominal fee and use it as a fund raiser.

An important issue identified by the participants during this study was the stability of the rainwater tanks during a large earthquake, particularly in view of the difficulties experienced in installing the restraining straps provided with the tanks (Table 2.1). Further work on this issue is planned.

Overall, the project team acknowledges that the 200-litre rainwater tanks have the potential to make a positive contribution to post-earthquake household emergency water supplies. While our study did identify a number of challenges with their installation and on-going use, the majority of these are easily overcome. The researchers are also mindful that initiatives that improve the private emergency water supplies are likely to have barriers and challenges that would prevent some people from adopting the option. Another advantage of the rainwater tanks is that even if people are unable to install them, they can still be filled with tap water and used as a static storage container for 200 litres of emergency water. Furthermore, the tanks could also be distributed on a large scale following an earthquake, and would be expected to fill quickly thus providing a valuable additional source of emergency water.

4.0 CONCLUSIONS

This report is the first of two and considers the challenges and barriers associated with the installation of six rainwater tanks throughout the Wellington Region. The second report will consider chemical and microbiological water quality as well as a time series of data reflecting changes throughout the sampling period. The rainwater tanks that were installed were 200 litres in volume and were available for purchase from local councils as an emergency water supply. The results identified a number of challenges associated with the installation of the tanks and their on-going maintenance, which can be broadly categorised as follows:

- Challenges associated with the property size and layout;
- Challenges associated with the downpipe design that the tanks are being attached to;
- The skill level of the installer; and
- The design aspects of the tank system (for example the taps and issues associated with diverter leaking).

The greatest challenge identified related to property size. Properties that have space limitations are unlikely to be able to accommodate a rainwater tank. Thus, uptake of the rainwater tanks is likely to be greater among suburban property owners (where average section sizes are larger) than among inner city property owners.

The other challenges to installation could be addressed easily through the provision of some additional supplies as well as the provision of more information at the time of purchase.

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5.0 ACKNOWLEDGEMENTS

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APPENDICES

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A1.0 APPENDIX 1: INSTALLATION EXPERIENCES

A1.1 TANK 1 – PEKANGA ROAD, NORMANDALE, LOWER HUTT

The longest part of the process was deciding where to locate the tank, with options being adjacent to a house with roof collection area of about 120 m^2, or adjacent to a garage with collection area of about 30 m^2. As well as being larger than that of the garage, the house roof was also very clean, being well away from trees, and lead-free, whereas the garage roof was moderately overhung by foliage and had a lead flashing along the ridgeline. Despite its deficiencies, the garage site was chosen because installation of the tank there was easy, compared with difficult at the house site.

Installation was mostly straightforward. There were two minor problems to be dealt with, (a) the inlet spigot on the tank had to be moved to the opposite side of the tank to allow easy user access to the tap, and (b) two additional clips were needed to support the lower part of the downpipe.

The installer had plenty of DIY experience, and owned the necessary tools (hacksaw, sharp knife, drill and bits, screwdriver, and duct tape for sealing the original inlet hole).

Figure A1.1 Installation at Pekanga Road, Normandale, Lower Hutt.

A1.2 TANK 2 – MASON STREET, MOERA, LOWER HUTT

It was easy to select a downpipe for the dwelling on this property. This dwelling had a number of suitable downpipes. The downpipe that was selected was due to aesthetic purposes as it meant that the tank was screened from the street.

The owner of the property installed the tank in less than 15 minutes. The installation was relatively straightforward with the only issue being identified was the need for a clip to hold the lower portion of the downpipe. As part of the installation, the owner also glued the diverter so that it became a single unit. This modification was made to ensure that the risk of leaks from the diverter during high rainfall events was reduced.

Not long after the tank was installed, it was noted that there was a small leak around the tank. To rectify this issue, the owner removed the tap, and placed an old tap in to block the outlet. The owner then placed thread tape over the tap that was removed and reinstalled this tap. This action stopped the leak.

The installer had plenty of DIY experience, and owned the necessary tools (hacksaw, sharp knife, drill and bits, screwdriver, and thread tape for sealing the tap).

Figure A1.2 Installation at Mason Street, Moera, Lower Hutt

A1.3 TANK 3 – HUNTLEIGH PARK WAY, NGAIO, WELLINGTON

The dwelling on this site has metal downpipes, which would have needed replacing with PVC piping to enable the installation of the rainwater tank. It was decided that instead of replacing the downpipe, it would be filled with tap water from the reticulation system and left as a static control for the duration of the project.

Figure A1.3 Installation at Huntleigh Park Way, Ngaio, Wellington.

A1.4 TANK 4 – HOMEWOOD CRESCENT, KARORI, WELLINGTON

Due to the proximity of the downpipe to the dwelling façade, this rainwater tank was installed by a professional plumber. The plumber had to replace the downpipe as part of the installation to ensure there was sufficient clearance between the diverter and the dwelling's façade.

Figure A1.4 Installation at Homewood Crescent, Kaori, Wellington.

A1.5 TANK 5 – CHARLOTTE AVENUE, BROOKLYN, WELLINGTON

The owners of the property installed the tank themselves. The installation was relatively straightforward with the only known issue identified as being if the restraining strap was installed, there would be a need to use a concrete drill to ensure that the strap was appropriately fixed.

The installer had extensive DIY and construction experience, and owned the necessary tools (hacksaw, sharp knife, drill and bits, and screwdriver).

Figure A1.5 Installation at Charlotte Avenue, Brooklyn, Wellington.

A1.6 TANK 6 – HARLAND STREET, BROOKLYN, WELLINGTON.

Due to its small size, this property offered very few options to enable the installation of the rainwater tank. The downpipe that was selected was on the deck, next to the main entrance to the dwelling.

The owners installed the tank, even though they had limited DIY experience. The owners used duct tape to assist with connecting the diverter to the downpipes. The owners secured the restraining straps to non-structural elements of the dwelling. After one year, these non-structural elements started to pull away from the dwelling's façade.

This rainwater tank has persistent issues with a leaking tap. The owner replaced the original tap with a stainless steel ball valve tap on 22 November 2014. This appeared to fix the leaking issue.

The owner of this property did not install the diverter flush with the rainwater tank. This resulted in the diverter leaking in high intensity rainfall events.

Figure A1.6 Installation at Harland Street, Brooklyn, Wellington.

A2.0 APPENDIX 2: FIELD LOG

Urban rainwater geochemistry and microbiology sampling program 2014

FIELD LOG

Date: ....

People: ....

TANK 1: Pekanga Rd, Normandale Go through garden gate off driveway and tank is at back corner of garage. **Observations**	**TANK 2: Mason St, Moera** Tank on right side of house looking from street. **Observations** ....
TANK 3: Huntleigh Park Way, Ngaio Access through left hand gate and up garden path to deck at rear of house. Barky dog. **Observations**	**TANK 4: Homewood Crescent, Karori** Tank on right hand side of house. Keep front gate shut to contain rabbit. **Observations** ....
TANK 5: Charlotte Ave, Brooklyn Tank is under deck at front of house, on left hand side. **Observations**	**TANK 6: Harland St, Brooklyn** Up steep driveway, take steps up to house, tank is on deck at back of house. **Observations** ....

Observations to include: water level, presence of sediment on bottom, oily film, floaters etc.

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A3.0 APPENDIX 3: ROOF CATCHMENT MATERIALS AND SURVEY

Brief provided by: Carol Stewart, Joint Centre for Disaster Research, Massey University/GNS Science:

Provide good descriptions of each of the systems in this study, in terms of:

- *roofing material type and condition*
- *type of nails used and condition*
- *gutter material type and condition.*

A3.1 METHODS

Site visits were carried out on 2 April 2015. Five houses were visited and the roof areas which formed the rain water collection areas were inspected and photographed.

All five roof claddings were corrugated galvanised iron (mild steel).

A3.2 BACKGROUND

A3.2.1 Metal corrugated roofing

Corrugated, galvanised (zinc-coated) mild steel roofing, already with a long history of use in New Zealand, was not commonly used on state constructed dwellings during the 1940s and into the 1950s, but it was used more on privately built houses.

The typical thickness was 26 (Birmingham) gauge, i.e. 0.018” (0.45 mm), although 24 gauge, 0.024” (0.609 mm), was also available. Standard sheets were eight corrugations, 25½ ” (648 mm) wide and in lengths between 5-12’ (1.5-3.6 m) until longrun roofing became available during the 1960s. Longrun meant that roofs could be made from cut-to-length sheets without laps which are susceptible to corrosion. Prior to the 1960s, laps were painted.

The sheets were installed over building underlay and wire netting that was laid over the purlins. They were laid with a 1½ lap cover or, in exposed situations or when the roof pitch was particularly low, with a 2 lap cover. Fixings were with 2½” or 3” (63 or 76 mm) long, lead-head, galvanised nails, fixed through the tops of the corrugations. The exposed edge of the sheet would be laid facing away from the prevailing wind.

During the 1960s the range of metal roofing products increased with the introduction of metal tiles and tray section clip fixed roofing designed for use at much lower roof slopes.

A3.2.2 Flashings

Flashings for metal roofs consisted of 26 gauge, galvanised flat sheet steel, cut and folded to create the required shape to flash ridges, hips, barges, valley gutters, roof penetrations and changes in roof pitch where they occurred. Ridge and hip flashings to corrugated profile roofing had a lead soft edge for dressing to the profile.

At complex junctions of metal roofs, such as around pipe penetrations and chimneys, flashings were generally in lead and dressed over the corrugations. The vast majority nowadays are soft zinc attached to the parent roofing material and dressed over the corrugations.

A3.2.3 Fixings

Fixing bases were originally made up of lead headed nails. The lead head cap was malleable and formed a weather tight seal with the roofing iron (63 or 76 mm lead-head nails or later, spiral shank galvanised nails with a metal/neoprene sealing washer fixed through the tops of the corrugations).

Lead head nail on the left

Early “TEK” screw roofing fixings

The sites visited are described in the order visited.

A3.3 SITE 5 (BROOKLYN) CIRCA 1905

The roof structure is that of a “hip” roof with valleys. The collection area of roof cladding is made up of two distinct areas. The main area is corrugated painted galvanised iron (steel) with the other area being a newish (2-3 years old) bull-nosed galvanised steel veranda roof cladding. The condition of the roof cladding to the main area is poor and badly corroded, in need of replacement.

Fixings to the bull nosed veranda are probably type 17 BUILDEX screw fasteners. Galvanised coated steel.

Flashings to this area would be soft zinc. Guttering being Marley “OG” profile and plastic. Condition: good.

Fixings to the main catchment roof area were lead head. Flashings appear to be lead based.

Guttering being Marley “OG” profile and plastic. Condition: good.


New bull-nosed verandah in tank catchment area


Older part of roof

A3.4 Site 6 (Brooklyn) circa 1907

The roof structure is that of a "hip" roof with valleys. The collection area of roof cladding is relatively small. The catchment area is fairly new corrugated galvanised iron (steel) with soft zinc tipped flashings. Where the chimney abuts the roof cladding there is a lead stepped flashing.

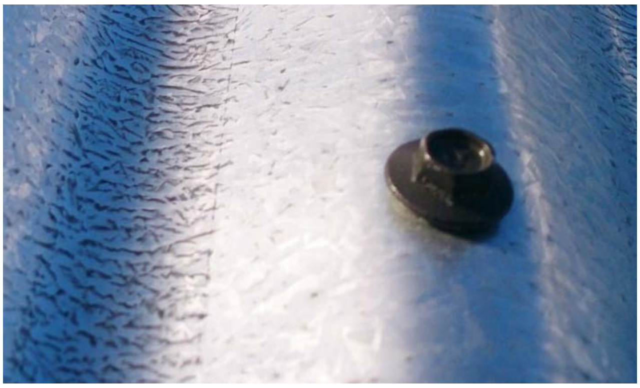
Roof cladding condition is very good.

Fixings: galvanised "TEK" screws.

The guttering is Marley "OG" profile and in good condition.

Change in pitch, fixings and end flashings

Hip rafter ridge capping



Fixings; "TEK" screws with washers

Lead flashing to chimney stack abutting roof cladding

Stress on batten caused by tank restraint strap

A3.5 SITE 4 (KARORI) CIRCA 1935

The roof structure is that of a “gable” roof. The collection area of roof cladding is relatively large. The catchment area is original corrugated painted long run galvanised iron (steel) with soft zinc tipped flashings. The condition of the roof cladding is showing signs of early corrosion and some fixings are in need of being renewed/re-fixed.

Fixings: a mixture but mostly lead head with a few “TEK” screws.

The guttering is Marley “OG” profile and in good condition, with some organic matter.

Flashings: lead tipped galvanised steel.

Marley OG profile gutter, roof and fixings

Ridge is lead-tipped galvanised steel painted

Expansion pipe flashing (galvanised steel painted)

Loose ridge fixing

Missing corroded fixing

A3.6 SITE 2 (MOERA) CIRCA 1927

The roof structure is that of a "gable" roof. The collection area of roof cladding is relatively large. The catchment area is original painted long run corrugated galvanised iron (steel) with soft zinc tipped flashings. The condition of the roof cladding is showing signs of early corrosion and some fixings are in need of being renewed. The roof has probably been re-clad in the past.

Fixings; galvanised "TEK" screws. Early type with neoprene caps which have suffered UV damage. Many of the fixings are loose and/or corroded.

The guttering is Marley "OG" profile and in good condition, but heavily laden with organic matter.

Gutter clogged with leaf litter

Ridge cap with soft zinc tipped flashing

State of fixings

A3.7 SITE 1 (NORMANDALE) CIRCA 1953

The water collection is from a garage roof. The concrete portion of the garage dates from the early 1950s but the upper ‘Skyline’ part was added in the early 1980s. The roof cladding is part unpainted galvanised corrugated steel and part ‘Clearlight’ corrugated sheeting.

Fixings: a range of galvanised fixings used.

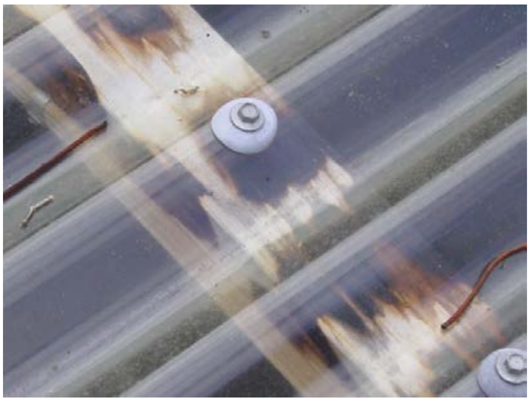
Flashings: soft lead ridge.

Guttering: Marley “OG” profile. Gutters are clogged with leaf litter which is retaining standing water.

General view of garage roof

Gutter clogged with leaf litter

Soft lead edging to ridge cap



Clearlight corrugated sheeting

Different galvanised fixings

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