The Rotorua NOW Home case study

Beacon

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The Rotorua NOW Home: A second case study

The Rotorua NOW Home is Beacon's second live research project and our first collaboration with Housing New Zealand Corporation (now Kāinga Ora: Homes and Communities).

The Waitakere NOW Home established that it is possible to build and design a home that performs well using basic principles and materials available today. The principles were developed by a team of experts in sustainable building and the house built to those specifications. The Rotorua NOW Home project took the next step.

The house was designed with the advice of our building experts to meet the requirements of Housing New Zealand.

The performance and comfort of the home was remotely monitored for one year while a family lived in it. Data was collected on energy use, water use, rainwater collection, temperature, indoor air quality, humidity and moisture levels.

Working closely with a social housing provider and monitoring the resulting home's performance have taught us much about the extent to which we can adapt or compromise the principles developed in the Waitakere NOW Home.

The path to the Rotorua NOW Home

Inspired by the Waitakere NOW Home

The idea of building a sustainable house for Housing New Zealand was sparked by the opening of Waitakere NOW Home opening. Several Housing New Zealand representatives attended and were impressed with the idea of giving the same benefits to their tenants.

Housing New Zealand Corporation had already made a substantial commitment to energy efficiency and community renewal. In 2005, Housing New Zealand invested about $80 million on improvements to its homes through its Healthy Housing, Community Renewal, Energy Efficiency, modernisation and reconfiguration programmes.

Discussions followed, and out of it came an agreement to work together on building a similar house in Rotorua.

Part of Community Renewal in Rotorua

Housing New Zealand Corporation provided the site for the Rotorua NOW Home. They chose a section in Fordlands, Rotorua, one of Housing New Zealand Corporation's Community Renewal areas. Fordlands was created in the late 1950s as a state housing area, with a fringe of private ownership. During the 1990s, much of the state housing in Fordlands was sold - mainly to private investors as rentals. It was one of the most deprived suburbs in the Rotorua District.

Community Renewal is a partnership programme between Housing New Zealand and people living and working in renewal areas to promote safe, healthy communities. The main goals are to address social exclusion, foster strong and sustainable communities, and improve the physical assets and appearance of neighbourhoods.

Designing the Rotorua NOW Home

The home was designed by local architecture firm, APR Consultants, to meet Housing New Zealand Corporation criteria for their housing stock and with advice from Beacon on how to build for best performance.

It was constructed by Warren Monk Builders. In the spirit of Community Renewal, students from the Tumahaurangi Trust's Construction Trade Training Unit helped out with the project, gaining valuable practical work experience.

Once design decisions were made, some of the specified materials and products were donated by building material manufacturers and suppliers.

The Rotorua NOW Home was opened on 28 September 2006 by Steve Chadwick, MP for Rotorua.

The Rotorua NOW Home at a glance

Its simple features include:

- A design which faces the north with lots of windows on the northern side
- Wide eaves to let the winter sun in but keep the summer sun out
- A concrete floor which absorbs heat from the sun and releases it when the air is cold
- High levels of ceiling, wall and floor insulation, much higher than in the Building Code
- Double glazed windows to keep the heat in and the noise out
- A low emission pellet burner for efficient space heating
- Solar water heating
- Water efficient taps, toilet and appliances
- A rainwater tank to collect and reuse rain
- Ventilation of moisture in the kitchen and bathrooms
- Passive ventilation to keep down moisture and avoid overheating
- Good natural light in all rooms combined with efficient light fittings and bulbs

The statistics

- The Rotorua NOW Home is a 3 bedroom, 2 bathroom, single storey dwelling, with attached garage
- It has a floor area of 141.2 m^2 (including garage) and including a concrete deck of 24.8m^2

Layout and design

Outside the square

The designers of the Rotorua NOW Home, APR Consultants, deliberately went away from a box-shaped design to a very different looking house. They wanted to show that Housing New Zealand stock need not be a 1950s style weatherboard-and-concrete-tile house. It can be cleverly designed, warm, water-efficient, comfortable and appealing.

However, the butterfly-style roof design finally selected, while visually attractive, has proved problematic with weathertightness and access to roof space the key issues. Our experience with the design has led us to discourage complex roof designs

Reflecting Māori values

The Fordlands community is predominantly Māori and the Rotorua NOW Home was designed to reflect Māori values:

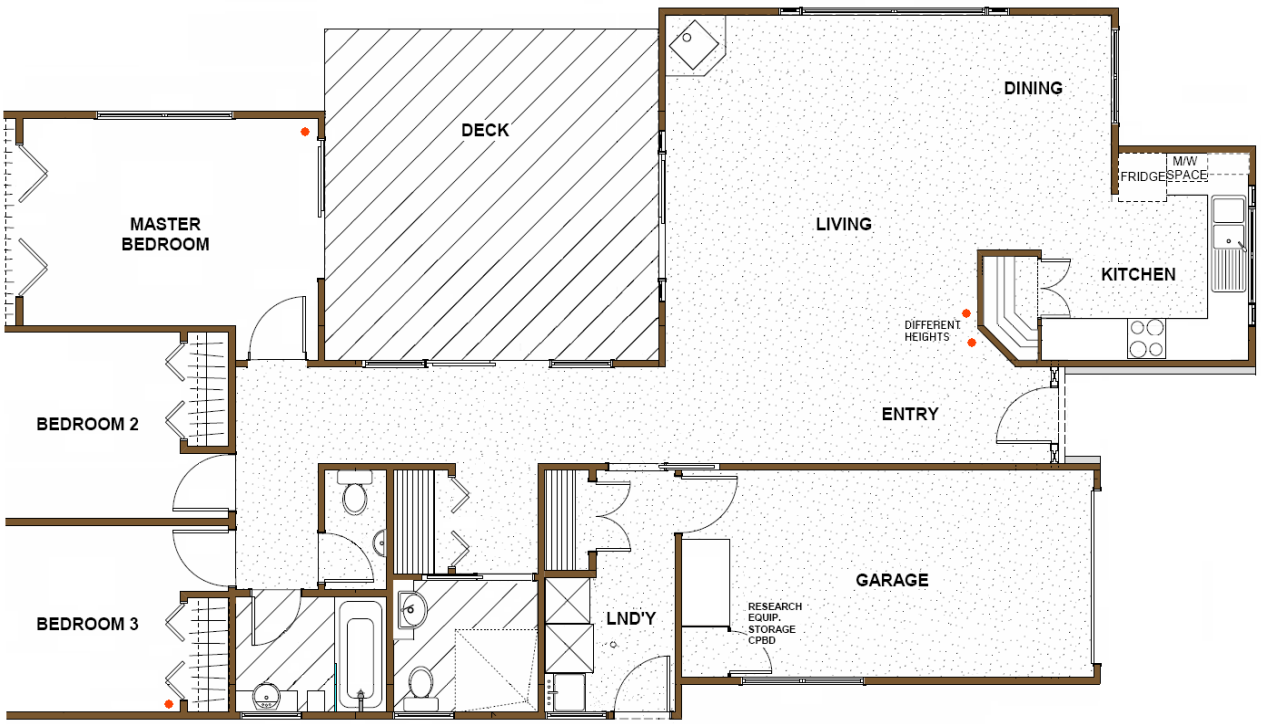
- In Māori tikanga, all food-related facilities must be separate from laundry, bathroom and toilet facilities.
- The living area is the heart of the house and is large, flexible and open plan to accommodate a whānau (family) gathering
- A large and open kitchen for catering for whānau, large sink and bench space
- A second stand-alone bathroom to cater for extended family
- A large outdoor sink to allow cleaning of kaimoana (seafood), pots and fishing gear
- A large deck area for whānau to congregate on. Decks, verandahs, patios and porches are key elements of papakainga houses as they provide a connection to Papatūānuku (Earth Mother) and an essential transition between indoor and outdoor.
- A large well-equipped garage which could accommodate extra people during a tangi - tangi activity must be closed off from the kitchen.

Flexible use of space

Flexibility of living spaces was important to cater for extended family visiting and staying. The main living area is open plan incorporating kitchen, dining and living area. A wide entry-way between the kitchen and dining areas allows several people to be involved in meal preparation at one time, and the work space in the kitchen is generous.

The garage is accessed internally from the house and can be used for extra living space when guests arrive.

The indoor living space is complemented by a large sheltered and private deck area.



Barrier free

The Rotorua NOW Home has been designed to be barrier-free with the assistance and input of CCS Disability Action, and to meet Housing New Zealand specifications for a modified home, enabling it to be used for disabled tenants. This drove decisions such as:

- No steps and easy entry with a minimum 20mm threshold
- Wider doorways and halls (810mm)
- Lever door handles
- Placing powerpoints 400mm on the walls
- A fully wheelchair-accessible bathroom with a level access shower to meet Code requirements for accessibility.

Tenants were chosen from the Housing New Zealand waiting list for modified homes.

Healthy living indoors

Passive solar heating

Making the most of the sun's warmth, and retaining the heat is important in the colder climate of Rotorua. The Rotorua NOW Home is oriented north, with both living areas, the dining area and one bedroom on the northern face of the house. Large windows and doors on the northern side admit the maximum amount of sunlight during winter while 900mm overhanging eaves provide summer shade.

Thermal mass

The Rotorua NOW Home sits on a 100mm thick concrete slab and footings. This acts as a heat store, absorbing warmth from the sun and releasing it gradually overnight. It is insulated with expanded polystyrene insulation panels both underneath and around the edges to prevent heat loss into the ground.

The concrete floor, coloured with black oxide and sealed with water-based polyurethane, is exposed through the house, except in the bedrooms which are carpeted for greater comfort.

Insulation

The Rotorua NOW Home is in a cooler Climate Zone and BRANZ Ltd scientists calculate that it would take four times as much energy to heat the Rotorua house as the Waitakere house.

The Rotorua NOW Home has higher levels of insulation than recommended in the New Zealand Building Code. The ceiling insulation has an R value (a measure of its effectiveness) of R 3.6, considerably more than the Code minimum in 2006 of R1.9. The wall insulation has an R value of R2.6, more than the R1.5 Code minimum in 2006. These insulation values are also higher than the new minimum standards introduced in 2008.

Preventing heat loss through windows

Thermal modelling by BRANZ scientists showed that double glazing was critical, and that as much heat could be retained by installing double glazing as by adding insulation to walls, floor and ceiling.

The choice for the Rotorua NOW Home windows and ranch sliders was sealed unit, clear double glazing in aluminium frames. The double glazing has an R value of 0.26, which saves 35% of energy compared to the then Building Code minimums. Later changes to the Building Code mean that this standard is now required in Rotorua and other cooler parts of the country.

At night, heat loss through windows is prevented by using curtains with thermal linings. The curtain rail is mounted close to the wall to minimise heat loss.

Getting rid of damp

The Rotorua NOW Home has high insulation levels and passive solar design to create a warmer indoor environment, less prone to condensation. Cold air holds far less moisture than warm air. In cold temperatures, the moisture naturally in the air settles on cold surfaces such as un-insulated walls, ceilings and windows as condensation. Double glazing keeps the inside glass surface warmer, so fogging and condensation (which can damage woodwork, furniture or upholstery) is much less of a problem.

A rangehood extracts moist air from the kitchen, and extractor fans are used in both bathrooms. A clothes-line behind the house encouraged the tenants to dry their clothes out in the sun.

Passive ventilation

Passive ventilation is provided by cedar louvres to the sides of windows, which can be left open without compromising security. To be doubly sure, the windows closest to the louvres have security locks fitted.

When closed, the louvres are airtight, but even partly open, they allow the continuous exchange of fresh for stale air. This helps to keep Relative Humidity levels inside the house lower so mould, mildew, bacteria and dust mites are less likely to thrive.

Weathertightness

The Rotorua NOW Home has a butterfly-style roof with an internal gutter, chosen by Housing New Zealand to give the house a more modern look. Recognising that the risk of leaks associated with internal guttering, the dimensions of the gutter and downpipes significantly exceed Code requirements. The roof is sloped to shed water into the gutter which provides a single collection point for rainwater harvesting.

The internal gutter is a wide central roof area, wide enough to walk down to clean with a broom to prevent blockages. The gutter is lined with a double layer waterproof membrane system

Flashings have been installed wherever disparate materials meet. Joins in materials, and around windows, are often prime sites for moisture penetration into the linings of a home.

Flashings are used:

- around all windows and doors, and entry roof
- around the concrete slab and insulation
- wall cladding junctions
- fascias (total fascia system)
- barge flashings.

Drains have been installed around the edge of the concrete deck area, to prevent rainwater entering the house or the building structure.

Kiln-dried, boric-treated, H1.2 Radiata pine was used for wall and roof framing. This meets the new requirement for treated radiata to be used in external walls and moisture risk situations.

How the house performed

Humidity

Relative humidity affects the comfort and health of the occupants of the house. Humidity levels within a house vary depending on the temperature – levels between 20–70% relative humidity are generally classed as acceptable.

The average daily humidity level was generally below 70%. However, the master bedroom has tended to have a high relative humidity in the early mornings of above 70%. Relative humidity is directly linked to temperature – the cold temperatures in the bedrooms overnight will have led to higher humidity levels.

Temperatures

The World Health Organisation recommends a minimum temperature of 16°C in bedrooms and 18°C in living areas for good health. In the family living areas, the Rotorua NOW Home had acceptable temperatures in daytimes and evenings but dropped below 16°C for a small proportion of the time. The bedrooms, however, were below healthy temperatures over half the time, and have been particularly cold during winter nights.

The recommended range for comfortable living is between 20°C and 25°C. This comfort range was only achieved for a small proportion of the time.

A number of factors contributed to these lower-than-expected temperatures:

- The pellet fire was changed to a less optimal position than recommended
- The heat transfer system was recommended but not installed
- The family covered the concrete floor with rugs, preventing full heat absorption. This was because of concern of their elderly relative falling and hurting themselves on the floor.
- The family did not know how to use the pellet fire to its best advantage.

What the family noticed

The family enjoyed living in the home over summer, when the cedar louvres and sliding doors opening onto the deck gave the house a fresh/airy feel. With the louvres, it was easy to get a good air flow and that kept the home cool in the heat of summer.

They also noticed how much drier the house was, with little condensation or mould.

Surprisingly, given the temperatures recorded by our monitoring equipment, the family did not complain about the cold overnight temperatures. This may reflect their previous experience of houses and expectations of living conditions.

Energy efficiency

Using free energy

A solar water heating system was used in the Rotorua NOW Home to use the free energy from the sun and significantly reduce energy costs.

The solar water heater has a single piece solar collector panel and storage tank on the roof. An electric booster unit provides supplementary heat to the water held in the storage tank when there is not enough sun and/or heavy hot water demand.

Using less energy

Space heating

Although still designed to maximise and retain solar warmth, the Rotorua NOW Home is situated in a cooler climate zone, and supplementary space heating was needed.

A pellet fire was installed in the living area. Burning pellets made from wood waste, pellet fires are very efficient and have low emissions. They produce a very clean-burning fire, with no dust or debris to irritate asthma or allergy sufferers.

A planned heat transfer system was missed during construction and, consequently, bedroom temperatures have been lower than expected. A heat transfer system with appropriate size ducting and fan is a good way to spread heat from a central heat source to outlying bedrooms.

Appliances

Housing New Zealand does not provide a fridge, washing machine or dryer for tenants. A revolving clothes-line has been installed at the rear of the house. Drying clothes outside saves power and is a healthy option as bacteria are killed by UV light. On wet days, laundry can be dried on a rack directly in the garage.

Lighting

With extensive windows and sliding doors to trap sun, the Rotorua house has plenty of natural light, especially on its north face.

Halogen lights have been used for task lighting in the kitchen and bathrooms of the Rotorua NOW Home. Although not energy efficient, they are not likely to be on as long as general room lighting.

Instead of recessed downlights which create gaps in the ceiling insulation in a home, batten light fittings compatible with energy efficient bulbs were used.

How the house performed

Overall energy savings

The Rotorua NOW Home family used 6800 kWh per year, comparing well to the 7400 kWh used in the first year in the Waitakere NOW Home.

As Housing New Zealand tenants, the household was in a low income bracket and had to provide their own whiteware. While they had fewer appliances and electronic equipment than the Waitakere NOW Home family, the appliances tended to be older and less efficient. The house was using less energy despite this.

Free energy

The solar water heater chosen for the Rotorua NOW Home has not performed to expectations. It has needed much more electrical boosting than the unit installed in the Waitakere NOW Home, making up 41% of the total electricity use.

A contributing factor to the solar panel's poor performance is that, despite advice from BRANZ building scientists, the system was not installed to make the most of winter sun. BRANZ advice is that solar panels should be inclined at an angle at least equal to the latitude of the site, rather than matching the angle of the roof.

Since the expansion of EECA's subsidy scheme for solar hot water installations, there has been a greater emphasis on correct installation and performance. Both products and their installers now need to comply with a range of eligibility requirements, including providing some performance data, in order to be eligible for a subsidy. This will help with guidance in choosing a system and installer that perform well.

Keeping the house warm

In the family living areas, the Rotorua NOW Home has had acceptable temperatures in daytimes and evenings, but sometimes dropped below the 16°C recommended by the World Health Organisation for good health overnight. It is concerning, though, that the comfort range of between 20°C and 25°C was only achieved for a small proportion of the time.

The bedrooms, however, have been below healthy temperatures over half the time, and have been particularly cold during winter nights. A heat transfer system, recommended on the plans, was not installed during construction, and the pellet burner was moved from an optimal position to a suboptimal one to meet concerns about health and safety.

Heat transfer systems can effectively heat all the bedrooms where they are separated from living areas.

In addition to getting the design right, occupants need to understand how the 'new' features of their home work. There is an element of education in ensuring a home performs its best. For example:

- For a concrete floor to absorb the most possible sun, it must be left exposed. Unfortunately, there were quality issues with the coating applied to the concrete floor and the family were concerned for the safety of their elderly family member, so the family covered much of the floor with rugs and mats. The floor absorbed less heat and consequently, not only reflected less heat at night, but also took longer to dry out. A concrete floor can take up to a year to dry out fully and work at optimal levels.
- Pellet burners put out a convective heat (they blow the heat out) rather than the radiant heat of a wood burner (which will feel hot if you sit by it). However, as heat rises, they heat from the top of the room down and it may take some time for the heat to reach occupant level. Fans can increase the rate of air movement and using the timer and thermostat allows a base temperature to be maintained through the day and overnight. The profile of use of the pellet burner indicated it was not being used optimally to effectively heat the house. Training in how to operate the pellet burner effectively wasn't provided and would be an important step in future live research homes.

Energy surprises

Twelve percent of energy use in the Rotorua NOW Home went toward lighting, considerably more than the 6% used in the Waitakere NOW Home. This is thought to be due to a combination of factors:

- The much larger number of light fittings
- The use of halogen lights in some fittings
- An insufficient number of switching circuits – meaning that one switch turned on lights in several locations, leading to overlighting of the home.

Running the pellet burner over winter time was also a surprising energy user. Testing has shown that the pellet burner requires a minimum of 250W to power the control panel, the fan and the auger. In addition, approximately twice this amount of power is required for ignition.

What the family noticed

The Rotorua NOW Home family have appreciated the warmth of the house during the day. The sun floods into the living areas, onto the wide passageway connecting to the bathrooms and bedrooms, and onto the sheltered deck.

With lots of windows and sunlight coming through the whole house, they have remarked on the good natural lighting.

The family covered the concrete floor with rugs, partly because poor finishing made it unsightly, and partly because the family feared their grandmother, an elderly lady, would fall and injure herself. Alternatives to a full concrete slab floor would be leaving only part of the floor exposed or using thermal walls.

The family, however, have found the house to be over-lit and difficult to control with a large number of lights on one switch. Lighting is an important factor in improving energy efficiency and comfortable use within a home.

Water conservation

Using less water

The Rotorua NOW Home uses 6 litre/3 litre dual flush toilets and low flow tap and shower fittings. The low flow shower mixers restrict water flow to 9 litres per minute, compared to standard showerheads which can use up to 20 litres per minute.

Tenants supply their own washing machine in the Rotorua NOW Home. No dishwasher is provided.

Using free water

Rainwater is collected from the butterfly roof using a single wide gutter and 150mm downpipes to cope with the greater volume of water being collected at a single point.

Rainwater is harvested into an underground tank to save space, resolve any issues with requirements for setbacks from boundaries, and for aesthetics.

The system includes a 4000 litre underground tank, submersible pump and a Rainbank Controller with automatic changeover and backflow prevention. The Rainbank automatically reverts to mains supply when the water in the tank is low.

Water from the rainwater tank feeds the garden taps, toilets and laundry. Unlike the Waitakere NOW Home, it does not feed the solar hot water system, and so a smaller tank has been used.

Reducing the effects of stormwater

Collecting rainwater from the roof into the tank reduces the chance of flooding stormwater drains.

Additionally the landscaping maximised permeable surfaces, with grass, garden and chip.

Concreted areas were as small as possible, reducing run-off to a minimum.

How the house performed

Problems with the monitoring

The water system and pump have been the cause of significant issues in the Rotorua NOW Home.

An electrical fault in the pump, which took 12 months to diagnose, affected the electrical systems in the house. This severely interrupted water monitoring and resulted in little useable data.

Flow rates in the system were excessively low at 1.6-1.8 litres/minute in the showers – a very poor shower for the tenants. As the water system is a manifold system and is a relative newcomer to the market, it is not clear whether the system itself or the installation is the issue.

Overall water use

The Rotorua NOW Home family used a total of 199 litres of water per person per day. This compares to the Waitakere NOW Home where the family used 189 litres per person per day in the first year, dropping to 172 litres per person per day in the second year.

Of this water, 26% (51 litres) was supplied from mains water and 74% (148 litres) from the tank water. This compares to the tank in the Waitakere NOW Home which supplied only 47%-52% of the home's water needs.

Our analysis suggests that, although the Waitakere NOW Home had a much larger tank, it did not have an automatic switch between tank and council supply, and relied on the family to manually operate a bypass valve to between mains water and tank water. Switching back to the tank water was often delayed until there was a large quantity of water in the rain tank and the family had confidence that the tank water was not going to run out again.

What the family noticed

With such low flow rates, it is not surprising that the family noticed the pressure dropping when a tap was turned on at the same time as the shower. They were also frustrated at the slow flow rates when filling the jug or running a bath.

These flow rates are unusual and are not a good example of modern low flow, water-efficient taps and shower heads. Efficient low flow showers are expected to have flow rates in the region of 6- 9 litres/minute compared to the 1.6–1.8 litres/minute.

Reducing waste

Construction waste

Good on-site waste practices were used during construction. Records of the waste generated were kept, by visual inspection, weight and photograph. Where possible, wastes were separated for landfill diversion (i.e. either for recycling, reusing or fuel purposes).

Material wastes diverted from the landfill included:

- Some treated and untreated timber, to be used on future sites
- #1 and #2 plastics and glass, recycled using the wheelie bin pickup
- Ferrous metals (almost all cladding material)
- Cardboard, through the local cardboard recycler.

Generating less waste from daily living

Recycling: Rotorua District Council offers free recycling from recycling centres and transfer stations. Two 15 litre, under-bench recycling/rubbish bins, provided in the kitchen, encourage sorting of household waste. Easy access to the garage and adequate space for non-organic recycling bins makes recycling an easy option in both houses.

Composting: There is no in-sink waste disposal system as these not only consume a great deal of water but discourage composting and overload the sewerage system.

The Rotorua NOW Home has a larger section with plentiful room for a vegetable garden and adjacent compost bins at the rear of the house. Two 400 litre compost bins will be provided to encourage composting.

Results

Construction waste generated

Of approximately 2223 kg of wastes generated by the construction of the Rotorua NOW Home, only 167 kg were diverted from the landfill. This represents approximately 8% of the waste generated. Expressed in terms of the overall floor area (141m^2), 15.8 kg/m^2 of waste was generated. According to larger US studies, typically for domestic construction, anywhere between 14.7 to 25.4 kg of waste is generated per square metre.

Waste from framing timbers is not included as the frames were made up off-site, generally regarded as being more resource efficient than onsite framing. More timber waste was generated in the Rotorua NOW Home than in the Waitakere NOW Home, reflecting the considerably more complex roof/supporting (high) wall structure and the amount of extra timber needed to act as internal gutter support.

Plasterboard is the single largest (by weight) waste type by a considerable margin – accounting for 776 kg of waste in total.

What the family noticed

The family were positive about changing their household waste habits and taking up composting and recycling.

The neighbourhood

The Rotorua NOW Home is in the Fordlands area of Rotorua. Fordlands was created in the late 1950s as a state housing area, with a fringe of private ownership. During the 1990s, much of the state housing in Fordlands was sold - mainly to private investors as rentals. It was one of the most deprived suburbs in the Rotorua District.

With Housing New Zealand's commitment to community renewal of Fordlands, it made sense to locate the Rotorua NOW Home within this community. The tenants enjoyed the easy walking access to many community features including:

- Supermarket and shops (5 minutes walk)
- An extensive park system, dating back to the original Ford homestead.
- Four kohanga reo, several Pacific Island preschools, a public kindergarten and a daycare centre
- Three primary schools (10-15 minutes walk)
- A junior high school, intermediate school, and high school
- A Te Wānanga O Aotearoa campus.

For trips further afield, the house is on a main bus route which goes into Rotorua central business district.

The Rotorua NOW Home family expressed concerns about security. They felt that the main road boundary fence was too low, making it too easy for people to walk over it. They also felt it did not give them enough privacy from neighbours and people on the street.

Find out more about Beacon

Our website includes all the research undertaken in Beacon's original government research contract, and information on current research and projects.
www.beaconpathway.co.nz

Check out our Facebook page:
www.facebook.com/beaconpathway

Check out the Beacon Blog
www.beaconpathway.blogspot.co.nz

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About this Report

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