NO101/2

WAITAKERE NOW HOME CONSTRUCTION MONITORING REPORT

A REPORT PREPARED
FOR BEACON PATHWAY LIMITED

17 November 2005

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WAITAKERE NOW HOME CONSTRUCTION MONITORING REPORT

AUTHORS

Kane, C. D.[1], Allison, R.[2], Jaques, R. A.[1] and Pollard, A. R.[1]

1. BRANZ, Private Bag 50908, Porirua, **WELLINGTON**

2. Cohousing New Zealand Ltd, P.O. Box 70001, Ranui, **AUCKLAND**.

REFERENCE

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1. EXECUTIVE SUMMARY

As part of the process of creating the design brief for the NOW Home constructed at Olympic Place in Waitakere City, a number of critical elements were identified which contribute to the success of the home in practice. It is by measuring the performance of the building and the process of creating it that we are able to establish the key minima which must be met to ensure that sustainability of the residential built environment increases.

1.1 Sustainability rating of the final home

The final design of the NOW Home was assessed according to the BRANZ Green Home Scheme environmental rating tool.

The NOW Home achieves a 'Good' Environmental Performance rating, gaining 63 credits from a potential 115, and placing at the top end of the broad 'good' category . This compares extremely well with the "Reference" Houses typical of those currently being built in the Auckland Region, which usually achieve around the 10 - 15 credit mark.

To achieve a higher rating would have been achievable within the fabric of the NOW Home as it currently exists, but this would have required additional expenditure which would have taken the project above its notional budget limit.

- Installation of a composting (dry) toilet
- Further integration of sustainability into the house design (such as earth-covered houses)
- Placing the house at a transport hub

1.2 Budget

The original budget for the NOW Home was arrived at in January 2003 by consideration of the cost of a 'typical' 3 bedroom detached family home situated in close proximity in New Lynn. Quotable Value NZ provided an assessment of the value of the buildings on land blocks similar in size to the proposed reserve land in Olympic Place. This placed a value on the house itself of $150,000.

In the intervening time, the base values upon which this original price was fixed had moved, and a recast was carried out by BRANZ economist Ian Page and resulted in a cost increase for the building of the order of 9%.

Hence, the final agreed 'budget' for the NOW Home was $179,850. To this figure covering 'building works' was added expected variations totalling $27,015 giving a total budgeted cost of $$185,233+ GST, totalling $208,387 expected to be paid by the homeowner

The final actual cost for the house was $277,965, treating donations as real costs.

1.3 Consenting Process

The consenting process appeared to proceed relatively smoothly, but only by comparison with the reported 'norm' at the time. The Beacon-specific parts of the process (mainly arising from building the house on the reserve) did not unduly delay the consenting process, with the apparent exception being the 10 day delay in receiving the Development waiver, and consequent knock-on delay in being able to uplift the Building Consent.

The biggest cause of delay was the realisation at the start of September that the site as laid out would be changed by the construction of a carpark, which caused reworking of the drainage and landscaping plans, and a two month delay. This was not due to deficiencies in the consents process.

The main observable delay in the entire Resource and Building Consent process is a cumulative one, whereby individual delays of one or two days added to a total end of project delay of between two and four weeks, depending on whether the delay was caused internally by the consenting Authority, or externally by the builder (or owner/owner's agent) not acting immediately once each step in the process was completed. This is credible given the linear and iterative nature of the consenting process.

1.4 Construction Process

Construction of the NOW Home in Olympic Place, New Lynn, commenced on 17 March 2005. The construction period was 21 weeks instead of the 12 weeks envisaged, due to a number of factors including tree stumps under the foundations, some supply delays, wet weather, theft and damage, and the need for a large number of remedial items at the end.

Close attention was paid to the progress of construction and the issues that arose through the process. The NOW Home presented a unique opportunity to observe the reality of current construction practises, and the on-site implications of incorporating details and systems that are not 'mainstream'. The construction phase of NOW Home 1 was also complicated by a number of factors not normally found in standard house construction. In summary, the recommendations arising are as follows

- Choose an architect who has experience in, and commitment to, passive solar design, sustainable materials and services, affordability and accessibility, and ensure that that architect is personally involved from the early design stages right through to producing working drawings and supervising construction.
- Ensure a high level of detailing and specification before commencing construction to minimise surprises and rework.
- The landscape design should be developed at the same time as the house design to ensure integration of all elements.
- Choose builders of an appropriate scale who are committed to doing a good job, thinking through the details, and putting in the extra effort required to trial new systems. Involve them early in the design process, so that details are realistic and achievable on-site.
- Plan a construction waste management system that goes beyond monitoring and recycling to minimising waste through careful planning.
- A log should be kept of issues that arise and how they are dealt with to assist in future projects.

1.5 Construction Waste

The waste study provides a good reflection of where single-residential recycling/waste diversion currently stands, even in a sizable city with well established recycling networks. The problems encountered at this particular site were, for the most part, typical for any New Zealand building site, and included:

- the difficulty in getting the recycling message across to all the individual site workers, for simple logistical reasons, and the material resorting (a time consuming and dirty job) necessary as a result
- the difficulty in providing easy, practical landfill diversion solutions for many waste products, which are feasible on a domestic level. Examples of this are plasterboard and concrete.

Specific to the NOW Home were additional considerations:

- the very high amount of rework needed, due to the large amount of materials damaged by vandals and construction mistakes made
- the higher amount of rework due to the expectation of a good quality product, resulting from a building professional being on-site for larger amounts of the construction time.

These points indicate that the current building practices and perhaps the level of expectation by the public/clients are likely to be lower than 'good' practice. This raises questions about education and expectations for both the building industry and the public.

1.6 Additional Research

A common theme here is that a number of delays and additional actions occurred, even outside of the fact that this is a sustainable home – to what extent would the process of creating a home benefit from fundamental scrutiny of the contributing factors?

- Time delays and the effect of these on the cost of the job (opportunity and finance costs, for example)
- Value-reduction due to the adversarial contractor/subcontractor relationship
- Teamwork and common vision between site 'specialists'
- Communication between site contractors

2. INTRODUCTION

The NOW Home constructed at Olympic Place in Waitakere City has been described in detail elsewhere and so is not covered here. As part of the process of creating the design brief for the house, a number of critical elements were identified which contribute to the success of the home in practice, and it is by measuring the performance of the building and the process of creating it that we are able to establish the key minima which must be met to ensure that sustainability of the residential built environment increases.

A table relating each of Beacon's key performance elements to the monitoring activities undertaken is presented in Table 3 on Page 22.

This report presents the key steps from the process of building the NOW Home, including:

- Sustainability rating of the final home
- Budgetary considerations
- The construction process
- The waste generated during the construction process
- Installation of the monitoring systems

Recommendations are provided for future NOW Homes, especially in regard to the construction process.

Beacon

BRANZ
BUILDING ON KNOWLEDGE

Green Home Scheme

Certificate

This certificate is in recognition that this design, as originally assessed, considers environmental, health and safety issues. The main issues considered within this design are:

Major issues examined	Specifics achieved
Energy consumption	• Good level of thermal insulation • Renewable energy-assisted hot water • Energy efficient lighting in the main areas • Designed-in overheating controls
More sustainable materials	• Use of more sustainable paint • Use of more sustainable thermal insulation
Water economy	• Provision of locally harvested water • Water reducing plumbing
Safety	• Universal design applied throughout • Hard wired smoke detection and alarms

Address:	Olympic Place, New Lynn, Waitakere City
Architect/Designer:	Greg Burn + Now House Design Team
Assessor:	Roman Jaques
Date:	1 November 2005
ID Number:	00205

For more information please contact:
Built Environment Section, BRANZ, Private Bag 50908, Porirua City, New Zealand. Ph: (04) 237 1170

GREEN HOME SCHEME
BRANZ
2005

The Environmental Rating for this Home is

Good

63 credits

3. GREEN HOMES SCHEME RATING

The final design of the NOW Home was assessed according to the BRANZ Green Home Scheme environmental rating tool.

The NOW Home achieves a 'Good' Environmental Performance rating, gaining 63 credits from a potential 115, and placing at the top end of the broad 'good' category . This compares extremely well with the 'Reference' Houses typical of those currently being built in the Auckland Region, which usually achieve around the 10 - 15 credit mark.

The NOW Home's special attributes which contribute to achieving this rating include (but are not limited to):

- having a significantly **better insulated thermal envelope** than that required by NZBC (only 247 W/m^2 versus the maximum allowable 428 W/m^2 under the calculation method).
- its **aspect**, in locating the living spaces on the northern aspect of the building
- its use of **thermal mass**, in having a fully insulated concrete floor slab which can be used as a heat sink
- the way it **mitigates overheating**, in having correctly sized overhangs and small East facing windows
- the way it **uses renewables** for the home's hot water needs
- the way it **reduces the energy use**, by incorporating energy efficient lighting into high use areas
- using paints which have a **lower environmental impact** for the majority of the painted surfaces
- the use of insulation materials which have a **lower environmental impact**
- the provision of water from a local source, **reducing reliance on mains water** supply
- its **water caring features**, for providing good storm-water control methods and water efficient shower roses
- its **indoor air quality enhancing features**, such as in the provision of a hooded extract fan directly above the cooker
- its **safety aspects**, for installing mains-operated smoke alarms
- for having an **integrated approach to sustainability** in not only its design (incorporating economic, environmental and social), but also the media generated and the tools that derive from it, making sustainable building more achievable to the public.

To achieve a higher rating would have been achievable within the fabric of the NOW Home as it currently exists, but this would have required additional expenditure which would have taken the project above its notional budget limit.

- Installation of a composting (dry) toilet
- Further integration of sustainability into the house design (such as earth-covered houses)
- Placing the house at a transport hub

4. BUDGET.

The original budget for the NOW Home was arrived at in January 2003 by consideration of the cost of a 'typical' 3 bedroom detached family home situated in close proximity in New Lynn. Quotable Value NZ provided an assessment of the value of the buildings on land blocks similar in size to the proposed reserve land in Olympic Place. This placed a value on the house itself of $150,000.

Because of the nature of the project, an additional 10% was allocated to cover special features such as the solar water heating unit and coloured floors. Similarly, owing to the need to monitor the house in service, an additional 10% was allocated to cover the cost of any 'non-standard' features required to monitor the house, although this was not subsequently drawn upon as the monitoring exercise was carried out separately.

In the intervening time, the base values upon which this original price was fixed had moved, and a recast was carried out by BRANZ economist Ian Page as follows:

- There has been a 10.9% increase in the value of new houses across the country, although this also takes into account land value, which we are not. In Auckland, this will be higher due to land prices.

- In Auckland, due to material supply and labour market pressures, it is believed that the cost of the built house will have increased approx 2% further than the rest of the country.

- Because of the weathertightness problems experienced around the country, and subsequent revisions to NZS 3602, 3640, and NZBC clauses E2 and B2, it has been assessed that the cost of construction has increased by approximately 2.5%

It was believed therefore that an acceptable cost increase for the building since January 2003 was of the order of 9%.

Hence, the final agreed 'budget' for the NOW Home was $179,850. To this figure covering 'building works' was added variations totalling $27,015 giving a total budgeted cost of $186,875 + GST.

Major cost variations against the original budget occurred ,with those above $1000 shown below

- $11.5K – floor, due to stumps in ground, extra concrete, concrete pump hire, concrete colour, price increases
- $3K – plumbing. Additional work required to accommodate monitoring system
- $2K - kitchen cabinets. Design team rejected originals, requiring cost increase
- $1.8K – electrical. Additional work required to accommodate monitoring system
- $1.5K – drainlaying. Distance to drains greater than standard 10m budget allowance.

Additionally, specific unbudgeted items were needed, with those above $1000 shown below

- $2.3K - Geotechnical inspection
- $2.3K - Slab edge insulation
- $2K - House plan draughting

Table 1 – Cost/Budget Summary

		ACTUAL		
		Net	**GST**	**Total Actual**
Base House Costs (after Donations):				
Base Materials and Labour Expenditure	G.J.Gardner	$115,644.23	$14,455.53	$130,099.76
Management Fee	G.J.Gardner	$31,000.00	$3,875.00	$34,875.00
Donation "Rebate"	Laminex	-$1,800.00	-$225.00	-$2,025.00
Donation "Rebate" (estimate)	Placemakers	-$5,000.00	-$625.00	-$5,625.00
Other House Items or Expenses	Beacon	$15,075.02	$1,884.38	$16,959.40
		$154,919.25	$19,364.91	$174,284.16
Resource and Building Consent Fees (after Donations)	Beacon	-$1,588.76	-$198.59	-$1,787.35
Unbudgeted Items (specifically cost-identifiable)	G.J.Gardner	$11,777.01	$1,472.13	$13,249.14
Theft/vandalism (in dispute)		$4,430.24	$553.78	$4,984.02
Beacon Outlay for House		$169,537.75	$21,192.22	$190,729.97
Donations (at Comparable Value)	Various	$48,746.72	$6,093.34	$54,840.06
Total "Cost" of House		$218,284.47	$27,285.56	$245,570.03
Landscaping	G.J.Gardner	$19,176.28	$2,397.04	$21,573.32
	Beacon	$9,619.60	$1,202.45	$10,822.05
Total for Site		$247,080.35	$30,885.04	$277,965.39
Against Original Budget (House Only)		$185,233.42	$23,154.18	$208,387.60

A greater degree of foresight would have enabled the inclusion of a number of the unbudgeted items into the budget, as these were reactive during the job – specifically the geotech inspections, edge insulation and draughting of the plans. Some of these variations were not identifiable at the beginning of the job – the site fencing and scaffolding, for instance at about $800 apiece. These costs would be typical of the allowances made on any site, but which were not identified in the quote from G J Gardner.

By far the largest variation against budget was $11,491 for the floor, which was largely unforeseeable due to hidden tree stumps, and a price increase in the cost of the concrete between pricing and placing. The nature of the site, and an unidentified slope in the southern corner required the builder to place extra concrete, and necessitated the hiring of a concrete pump.

The additional costs identified in table 1 (under “Beacon”) comprise curtains and some of the appliances.

5. CONSENTING PROCESS

5.1 Resource Consent

The NOW Home was a unique project, involving many 'interested' parties and with Waitakere City Council being in the difficult position of being the client, the land owner and the agency responsible for issuing both the Resource Consent and Building Consent – while at the same time trying to ensure that the interests of a lot of their departments and associated groups were being considered. Because the NOW Home was to be built on reserve land, the first hurdle was to ensure that this land was available, via council processes.

The first resolution was made in June 2003: "The City Development Committee approves the NOW Home project on the condition that EcoMatters Trust leases the land from council, with a view to purchasing the House from Forest Research Institute in two year's time. If EcoMatters Trust is unable to purchase the building in two years' time, it will sub-lease or assign the lease of the land to Forest Research Institute, which will have the right to either remove the building or sell it to another organisation, subject to the Council's approval that its use is consistent with the Park's Management Plan"

The next meeting with Waitakere to discuss this was on 26th July 2004. The Lease was to be resolved by the community board at the September committee meeting. Bronwyn Allerby was the overall charge in the consents team, and she agreed to maintain an overview of the process, without interfering. Around this time a suggestion was made that given the environmentally sensitive nature of the NOW Home, a waiver of Waitakere's $2900 development fee may be appropriate.

Because the ownership of the NOW Home had changed, with the creation of Beacon, the August 30th New Lynn community board meeting agreed the amended resolution "That the CEO be delegated authority to negotiate and execute under seal a lease under section 61(2A) of the Reserves Act 1977, to Beacon Pathway Ltd for a part of Olympic Park (part Allotment 5 of section 1, Whau Town North, situated in Block III, Titirangi Survey District, S.O. Plan 20070)."

The Olympic Park manager called on 1st or 2nd of September to tell the NOW Home Project Manager that her plans didn't match his, and that a carpark upgrade was happening to Olympic Place. All of our planning was based on an earlier utilities drawing which showed the original bowl-shaped carpark – this was out of date when Beacon was given it, as the correct drawing was dated before we received the incorrect one. The contract had been let and work was starting the following week – hence the NOW Home project had to change.

A meeting was held on Sept 3rd to discuss the carpark issue. The NOW Home architect's (Greg Burn) concern was that the carpark cut off the corner of the property. There were also stormwater issues – the drains all had to be relaid. This affected the landscaping, which had to be supplied in draft to obtain a resource consent.

By the 22nd of September, Kimball and Greg were chasing up what had happened. URS were supposed to have laid the matter to rest (new stormwater line) the previous week. This eventually happened early in October, and was rejected by the Olympic Park manager, as it didn't match with her dimensions. URS then had to rework it, and on 17th Greg Burn was still chasing up URS, and Boffa-Miskell. On the 18th Oct, the revised landscape plan arrived, along with URS's revised stormwater plans. 11 days later, version 7c of the plans were sent out, these essentially being the final versions.

The resource consent was actually lodged on November 5th and at the same time, The NOW Home Project Manager (acting as a nominated agent of Beacon) lodged an application for a waiver of the building and development contribution. On the 9th WCC emailed an acknowledgement of the waiver letter. A letter arrived from WCC on 11th suggesting that some rework be done on the application to add new Beacon contact details, and adjust the application with respect to setback from the boundary – which influences the type of resource consent required. On Feb 3rd 2005, the NOW Home Project Manager chased up the development contribution issue, (which had erroneously been invoiced), and it was eventually resolved by February 10th. According to Waitakere's rules, the building consent could not be issued as this was an outstanding fee which first had to be resolved.

Greg Burn reported that the major frustration in the process was not the actual WCC Resource Consent process – and points out that, given the circumstances with respect to the development being very unique and that we were building on a reserve, the processing was very straight forward and timely (with little request for extra information) – far better that what is often involved in a typical residential RC process. By comparison, he has been involved in quite standard RC applications with other Auckland TAs that have taken up to 4 months to issue. Apart from the issues related to the transfer of information within WCC that required amended RC documentation, the RC process itself was really quite easy

"The major frustration was that it was discovered very late in the day that the design of the proposed car park and associated drainage had changed dramatically from the initial design and documentation that we had been given (and upon which our 'site' and house location had been based). Somehow WCC had failed to make the designer of the drainage and car park aware of the location / existence of the proposed NOW Home and the dimensions of its virtual 'site' within the greater reserve site. Consequently the new car park impacted on the NOW Home site size/shape, house location and site landscaping design. The contract for the car park / drainage had been let so there was no way this could be changed. What followed was a reasonably frustrating process of minor drainage amendments which resulted in amendments to the NOW Home site and location and amendments to the landscape design."

Although the amendments were relatively small, the Resource Consent Application (and hence Building Consent Application) was delayed by two months due to the lack of knowledge within Beacon of the carpark construction.

5.2 Building Consent

Building consent plans were started by G J Gardner on Nov 2nd, and they lodged the building consent on December 21st. On Jan 10th 2005 – WCC emailed Greg Burn advising that the Building Consent had been received, and had been suspended pending the supply of further information. This was roof truss & rafter layout, engineer's design of the beam over the computer nook, and NZS 4218 details for walls and floors. Details were also required on purlin sizes and ceiling lining thickness, head, jamb and sill flashings around doors and windows, and notice had to be supplied of consent from Watercare for work within 10 m of sewer (received with no conditions by GJ Gardner on 3rd February, after Watercare sat on it).

GJ Gardner prepared the documents based on the revised RC documentation, the consent was lodged and WCC requested extra information – this is reasonably common and possibly was as a result of the GJ Gardner division involved not being familiar with the requirements of WCC (and also as a result of increased documentation requirements coming into play due to the weathertightness issues that all TA's were being confronted with at that time).

Greg Burn observed that "The only real hold-ups in this process seemed to be as a result of confusion over fees and these were subsequently resolved.

"The BC was issued in reasonably good time, compared to the time that this process was taking at other Auckland TA's. (BC processing was taking up to 30 weeks at some TA's during this period!!)"

6. CONSTRUCTION PROCESS

Construction of the NOW Home in Olympic Place, New Lynn, commenced on 17 March 2005 after a protracted period of contract negotiation. The construction period was 21 weeks instead of the 12 weeks envisaged, due to a number of factors including tree stumps under the foundations, some supply delays, wet weather, theft and damage, and the need for a large number of remedial items at the end.

Close attention was paid to the progress of construction and the issues that arose through the process. The NOW Home presented a unique opportunity to observe the reality of current construction practises, and the on-site implications of incorporating details and systems that are not "mainstream". The construction phase of NOW Home 1 was also complicated by a number of factors not normally found in standard house construction. These construction issues and other factors are summarised below, and together with the Appendix and construction photos previously sent through, form a record of construction.

6.1 Timeline:

30.11.04	Resource Consent issued
9.12.04	Turf Turning Ceremony
15.02.05	Building Consent issued.
17.3.05	Site scrape
18.4.05	Slab pour
26.4.05	Wall frames up
6.5.05	Roof on
20?.5.05	Contract signed
31.5.05	Closed in
7.6.05	Internal linings
19.7.05	Plumbing and electrical fit-out.
30.7.05	Landscaping complete
11.8.05	Handover
12.8.05	Official Opening

6.2 Continuity of Personnel:

There were a large number of people involved in this project from the design phase through to the construction. The architect, Greg Burn, was commissioned to design the house (with considerable input from the NOW Home design team) to developed design stage and was involved in early discussions with the builder. He had no formal involvement after that, although he very generously

gave his input when asked. Building Consent drawings were drawn up by the builder's in-house draftsperson without supervision by the architect, and despite several requests Greg didn't sight a copy of the Building Consent drawings until well into construction. Robin Allison (having been involved in the earlier design phase) became involved again after the Building Consent was granted as Beacon's on-site construction manager. This lack of continuity and minimal level of design documentation and specification resulted in key details not being thought through from the beginning and causing problems later e.g. slab edge insulation and pergola design – see below.

6.3 Site Choice:

The choice of site, while apparently expedient for other reasons, added extra layers of complexity to the project. Built on a reserve, the ownership issues and future use of the building took some time to sort through. An ongoing challenge of the design because of this location was the requirement for the house to be relocatable, which was at odds with providing thermal mass for passive solar gain. In the end the concrete slab was seen as more important and few 'relocatable' design features were retained.

The location on the reserve also caused major security issues during construction, with several occasions of vandalism, theft and break-in.

6.4 Structure of the Building Company:

G.J. Gardner were chosen during the design process as being a mainstream building company "experienced in non-standard procedures". Discussions were held with the principal, Bob Greenbury, about the specialised and high-profile nature of this project and expectations regarding quality, code compliance, and future benefits to the company by positioning itself as a builder of eco-homes. Delays in obtaining Building Consent, firming up the quote and signing the contract meant that by the time construction was due to start, Bob Greenbury was on extended leave and had passed this project to one of his construction managers, without apparently passing on the expectation that there would be a high level of scrutiny of the construction.

In effect G.J. Gardner did not make the most of the opportunity to learn from the NOW Home and capitalise on the experience to meet an expanding consumer demand for more eco-friendly houses. Most importantly this lack of continuity resulted in the builder's deciding that they would comply only with the existing E2/AS1 requirements of the Building Code, as officially the new E2/AS1 requirements only came into effect from June 2005. This is despite the fact that earlier discussions between Greg Burn and Bob Greenbury had made clear that the house was to be constructed to best practice code requirements.

G.J. Gardner is essentially a building management company without in-house carpenters. All work is done on a sub-contract basis, answering to a site manager who looks after several building projects at once i.e. there is no one person on-site throughout construction, but rather a site manager who visits when needed and a succession of sub-contractors, each of whom is on-site to do their specific job with little overlap between trades. This reduced the understanding of, and commitment to, the specific needs of this project by the subcontractors, and made it more difficult to enrol them to do things in a different way to their standard practice.

6.5 Construction Methods:

Standard construction practise, especially in the 'affordable' end of the market, has developed to minimise material and labour costs by using a limited and readily available range of materials, able to be erected fast and often not requiring high levels of skill. In some instances, the care and skill previously required to fit components together has been substituted with adhesives, jointers, beads and fillers, bringing amounts of metals, plastics and other petrochemicals into the construction process. Avoiding these materials (because they are non-renewable, have high embodied energy, and can be toxic) requires more time and skill in design and building. Natural materials are often more variable than manufactured materials and require more knowledge and experience of the properties of that material, and can require more awareness and care in use. In some cases decisions were made to use standard, less sustainable materials for these reasons, an example being the standard melamine and Formica kitchen bench and cabinets, rather than solid timber which requires more ongoing care.

Designing a house with systems and materials that are not standard practice requires good detailing at the design stage, and careful thinking through of all the steps by the builder before commencing.

Examples from NOW Home 1:

- Foundation insulation to the concrete slab: The plans called for underslab and slab-edge polystyrene insulation, protected by an unspecified "selected material", and flashed under the weatherboards. Polystyrene is a difficult material on-site, being bulky, lightweight (blows around in wind), and fragile (necessitating the pumping of the slab concrete, as wheelbarrows would break the polystyrene). In the NOW Home, the foundation and slab bulged along one edge during the pour. The slab wall was trimmed back at the top prior to placing the polystyrene against the outside face of the slab down to the bottom of the foundation, but it was difficult to get a tight fit against the foundation because of the bulge below ground.

  Discussions were held to find the appropriate material to use to protect the polystyrene from spade damage. Fibre-cement board was used as being inert and untreated, and although the manufacturer does not recommend its use below ground, it is in a non-structural role and will continue to function even when substantially degraded. The method of jointing or flashing the corners and sheet joins was not truly considered by the builder until the board had been fitted, and in the end relied largely on adhesive.

  The slab and foundation edges need to be very straight to allow a minimal flashing over the top of the slab-edge polystyrene and board. The metal flashing in practice had to be wide enough to accommodate the insulation and board as the bulging foundation pushed it out from the wall. More thought and care given to the whole system before commencing could have resulted in a much neater finish.

- Exposed concrete slab: This requires different treatment to a concrete slab covered by carpeting or tiles. More care is required in laying the slab to get a flat surface especially at the walls to avoid uneven gaps under skirtings. The slab needs to be kept flooded during curing to avoid cracks, and saw cuts in appropriate places (visually, and following good construction practice) should be cut within 24 hours of pouring the slab. Polishing the slab produces a large quantity of slurry which should be captured and disposed of appropriately.

- Pergola: The detailed design of the pergola (including timber sizes and spacings) was not done until it was about to be built. At this point it was realised that the eaves construction would not allow easy support of pergola members at the house, and that the depth of timber purlins needed to span the wide area outside the main living room would cut around half of the available sunlight in winter. The decision was made to delete the pergola outside the main living room for this reason, and rely on the eaves overhang to shade the hottest summer sun. If this issue had been detailed at design stage, appropriate timber sizes, spans, and connections to the house would have been resolved.

- Double-Glazed Windows: The actual builder on site was (as indicated above) on a labour-only agreement, and was less than happy with the installation of the double-glazed windows, as they were significantly heavier than single panes. This impacted on his cost structure since he needed additional help to fit the windows and this had not been appreciated at the costing stage.

6.6 Construction Quality:

Throughout the design and construction phases there has been a tension between building a replicable house using standard materials and systems to a limited budget, and building a best-practice more sustainable house that will have a high level of scrutiny. Some of the many visitors during construction certainly commented on aspects that would be considered standard current practice for this end of the market, as when less serious items were tidied up with sealant before painting.

Serious deficiencies in building quality certainly showed up in many areas, from lack of attention to waterproofing at junctions to inaccurate cutting of scribers and untidy finishing work, and these all required remedial action. While not acceptable, it begs the question of what standard of work is generally delivered in the building industry in houses without architect supervision.

6.7 Monitoring Requirements:

The installation of meters for water and electricity monitoring added to the work of these two trades; however this aspect generally went quite smoothly.

Construction waste monitoring was an aspect that required cooperation from all the trades in separating their waste into different categories. The subcontractors generally separated their waste when asked, but this required the site manager to brief each subcontractor as they came on site and this did not always occur. Separation therefore only happened to a limited extent, and the waste required quite extensive re-sorting prior to measuring. In practice sorting, weighing and measuring the construction waste was a time consuming, heavy, and very dirty job.

The construction waste included some materials damaged by vandals, and materials damaged by removal necessitated by the need for remedial work. While any job will have some waste generated by mistakes and damage, the level of waste of some materials was much higher than is theoretically achievable, indicating much room for improvement in practice.

6.8 Donated Materials:

This aspect of the project, while reducing costs for those items, also added to the complexity and number of people involved in the supply chain and caused some delays in supply.

7. MATERIAL WASTE MONITORING

7.1 Objective

The objective of the material waste monitoring project was to determine the waste quantities (by volume and weight) of all the wastes generated on the NOW Home site in New Lynn and to identify the amount of material which could be either reused on-site or which can be otherwise be diverted from the landfill.

7.2 Method

The site project manager was charged with the setting up of the waste receptacles in sensible areas, any necessary on-site re-sorting as well as the classification, measuring and cataloguing of the wastes. The site project manager was also responsible for briefing the different contractors as they arrived of the importance of waste separation, where possible.

Good onsite waste practices were achieved wherever possible and practicable. Examples of these included:

- The use of properly labelled waste receptacles using clearly displayed Recycling Organisation of NZ (RONZ) standard signage.
- The use of lids on the waste receptacles, and a fence around them, to minimise the possibility of 'drive by' contamination from pedestrians.
- The encouragement of the reuse of timber off-cuts for noggins, blocking, jack studs etc, where practical
- Maintaining a tidy construction site

The site was visited at least weekly by the site project manager. Recycling agencies were contacted for materials which had an established market, and pick-ups were coordinated. The site project manager kept two types of records. An ongoing tabular record of the waste types, when generated, volumetric record (using a visual inspection) and a weight record (using a 100kg scale) and an occasional photographic record were also kept.

The number of waste categories (and therefore waste receptacles) was kept to a practical minimum, due to site space constraints. The focus was on the easy separation of wastes for landfill diversion (i.e. either for recycling, reusing or fuel purposes). The seven waste categories used were:

1. Timber (both treated and untreated, including engineering board)
2. Plasterboard (all landfilled)
3. Cardboard (both recyclable and contaminated)
4. Masonry (concrete, mortar, and larger sweepings)
5. Metals (ferrous and non-ferrous)
6. Hazardous (fillers, solvents, paint, adhesives, sealants)
7. Other (food scrap and wrappings, sweepings, soil etc).

7.3 Results

The material waste quantities generated by the construction of the NOW Home are shown in the following Table , along with the results from two other large house-based studies conducted in North America. No comparative New Zealand studies can be used, since no large studies have been conducted nationally which separate domestic and commercial construction.

Table 2: Material waste comparison

Material Waste Quantities Generated			
	Percentages (by weight)		
Material	**NOW**	**US[1]**	**US[2]**
Timber-based products	18.7	42	38
Plasterboard	28.8	26	25
Cardboard	2.8	4	8
Masonry	16.9	11	13
Metals	2.8	2	2
Hazardous	0.2	0	1
Other	29.8	15	15
TOTAL	**100**	**100**	**100**

In all, of the 2448 kg of material wastes that were generated by the construction of the NOW Home in New Lynn, only 189 kg of waste materials were diverted from the landfill. This represents approximately 8% of the waste generated. Expressed in terms of the overall floor area (146m^2), 16.8 kg/m^2 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[3].

It should be noted that there is a fair degree of correspondence between the NZ results and the US results, with the exception of 'timber based products' and the 'other' category. This can be explained to a large extent due to the utilisation of framing timbers made up off-site for the NOW Home, so that its waste is not accounted for at all. Despite this, it is recognised that this method is considerably more resource efficient than on-site framing.

Although a diversion rate of 8% seems a small amount, it is in part reflective of the difficulty of addressing construction waste on a 'typical' construction site which has:

- few practical recycling options for some bulky wastes, such as plasterboard and concrete[i]

[i] Note that concrete recycling is available in the Auckland region, but larger amounts are needed for pickup.

- many specialist fields often working separately
- contamination problems, with not all on-site participating as fully

The material wastes that were diverted from the landfill were:

- untreated timber, used as fuel-wood
- polystyrene insulation, delivered to a recycling company
- #1 and #2 plastics, and aluminium cans, recycled using the local kerbside recycling scheme
- clear plastic wrap, recycled also.

Ferrous metals were sorted for recycling, but due to a late collection, were disposed of instead.

7.4 Discussion And Conclusions

This study is a good reflection of the state of single-residential recycling/waste, even in a sizable city with well established recycling networks. The problems encountered at this particular site were, for the most part, typical for any New Zealand building site, and included:

- the difficulty in getting the recycling message across to all the individual site workers, for simple logistical reasons, and the material resorting (a time consuming and dirty job) necessary as a result
- the difficulty in providing easy, practical landfill diversion solutions for many waste products, which are feasible on a domestic level. Examples of this are plasterboard and concrete.

Some aspects of the NOW Home building project were unique, however, and had specific implications for the waste aspects. This included:

- the very high amount of rework needed, due to the large amount of materials damaged by vandals and construction mistakes made
- the higher amount of rework due to the expectation of a good quality product, resulting from a building professional being on-site for larger amounts of the construction time.

These points indicate that the current building practices and perhaps the level of expectation by the public/clients are likely to be lower than ‘good’ practice. This raises questions about education and expectations for both the building industry and the public.

It should recognised be that the research figures presented in Table 2 are always only indicative of real world practices, even though they may be based on many studies, due to the difficulty in getting precise figures for construction waste. The difficulties (or confounding factors) include:

- the slightly different ways in which wastes may be categorised (e.g. most auditors will categorise a steel paint tin as a hazardous material, but some may classify it as a ferrous metal)
- the (rather high) likelihood of ‘drive-by contamination’, given the high exposure of a building site and easy access by the public
- accounting for waste materials (especially untreated timber, which may make its way off site before the auditor has the chance to catalogue it)
- the ill defined boundaries as to when the ‘building’ actually stops – does it, for example, include interior fit-out of the major appliances, which will significantly add to the cardboard and plastics?
- the regional specificity of some domestic building practices.

8. MONITORING SYSTEMS INSTALLATION

8.1 Summary

The monitoring plan for the NOW Home provides a mixture of critical tried and true measurements with cutting edge indicators of home performance and will provide very useful insight to understanding the performance characteristics of the NOW Home.

Because the NOW Home is designed as a real-world home, the intrusion of visible monitoring systems or people was unacceptable as these would undermine the occupant's enjoyment of the NOW Home.

The solutions chosen have come from BRANZ's 30 years of learning how to collect data in real-world situations, outside of the laboratory. The challenge of gathering the data remotely has brought new learning to Beacon.

8.2 Monitoring Technology

The NOW Home monitoring system provides remotely accessible data, removing the need for regular data collection visits. This is a priority for the research team, as it is well recognised that non-intrusive data gathering provides the most reliable information on occupant behaviour.

The technology employed is cutting-edge, which has needed new ways of thinking to provide a reliable and unobtrusive monitoring installation.

The NOW Home monitoring system uses a Pentium IV-based desktop computer wired to an Agilent® 34980A Data Logger, running two data capture cards – one analogue and one digital. The digital card is used for the collection of water and electricity use data, fed by wired-in pulsed sensors. The analogue card is collecting information on water temperatures, water tank level, conductivities of the framing timber, and solar radiation.

Point 6® wireless sensors recording room temperatures, humidities, room CO_2 and portable heater use are fed directly into the computer. A LabView® programme is used to retrieve the data from the Agilent® and wireless radio receiver and compile it into a form which is accessible from BRANZ Ltd in Wellington via an ADSL internet connection.

The following table provides the specific information we wish to obtain, to understand how the NOW Home performs compared to it's design goals. For simplicity's sake, it is presented as a discrete list, however many of the 'categories' will overlap when we are analysing the data we have obtained.

Table 3 – NOW Monitoring Summary

ELEMENT	DESIGN CONSIDERATIONS	Monitoring Measure to account for issue
	Warmth	Internal Temperatures and Humidity
	Privacy and Security	Initial assessment
	Ventilation	Measured Via Blower Door test
	Noise reduction	Internal and External SPL measures
	Air quality	Quarterly POE, and directly via CO_2 sensor
	Quality of life	Quarterly POE
	No behavioural compromises	Quarterly POE
	Aesthetically pleasing décor	Quarterly POE
	Mass market appeal	Not measured
	Fits mainstream budget for capital costs	Initial Cost
	Location specific	Measured indirectly
	First Cost	Measured
	Reduced operating costs	Ongoing service costs
	Low maintenance costs	Not measured
	Reduction in purchased energy	Utility bills, total energy used vs expectation
	Low embodied energy materials, and renewable materials	Life Cycle Costing (cladding only)
	Reduced purchased water supply	Measured usage, rainwater collection as a proportion of total water use, outdoor water use. Proportion of hot water from solar, standing losses from storage.
	Storm water utilised	Estimated based on impermeable surfaces
	Reduction in waste materials to landfill (construction and use)	Materials used and wastes generated*
	Impact on neighbourhood	Not measured
	Road noise and emissions	Measured and Quarterly POE
	Aesthetics – fits into surrounding environment	Quarterly POE
	Distance to amenities	Measured as the crow flies and Quarterly POE
	Distance to recreational facilities	Measured as the crow flies and Quarterly POE
	Links with public transport networks	Measured as the crow flies and Quarterly POE.
	Water harvesting	Measured (see Resource use)
	Surface runoff	Estimated from permeable surfaces (see Resource Use)
	Aesthetics	Not measured
	Privacy	Quarterly POE
	Convenient access	Not measured
	Proven technologically	Not measured
	Reliable utilities	Quarterly POE

	Favourable climatic exposure	Measured directly via Pyranometer
	Layout and space provision in design	Quarterly POE
	Prepared for what homeowners will face in the future	Not measured
	Telecommunication -enabled	Not measured
	Anticipates future societal requirements	Not measured
	Imaginative	Not measured
	Improved building envelope	Measured directly through thermal performance of envelope and indirectly through LCC
	Improved sound insulation	Quarterly POE, and initial acoustic testing
	Lower operating costs	Measured through utility bills
	Appliances and lighting	Measured through utility bills and efficiency of appliances. Social aspects measured thru POE.
	Drying space	Not measured
	Durability and weathertightness	Measured indirectly through life cycle costing

9. SUMMARY AND CONCLUSIONS

9.1 Recommendations for Future Projects:

- Choose an architect who has experience in, and commitment to, passive solar design, sustainable materials and services, affordability and accessibility, and ensure that that architect is personally involved from the early design stages right through to producing working drawings and supervising construction.
- Ensure a high level of detailing and specification before commencing construction to minimise surprises and rework.
- The landscape design should be developed at the same time as the house design to ensure integration of all elements.
- Choose builders of an appropriate scale who are committed to doing a good job, thinking through the details, and putting in the extra effort required to trial new systems. Involve them early in the design process, so that details are realistic and achievable on-site.
- Plan a construction waste management system that goes beyond monitoring and recycling to minimising waste through careful planning.
- A log should be kept of issues that arise and how they are dealt with to assist in future projects.
- Ensure that the occupiers are aware of the operation of the monitoring system, and provided with appropriate empowerment to act should issues such as power outages and telecommunication difficulties arise.

10. FURTHER WORK ARISING

10.1 Time delays

As mentioned, the NOW Home completion was delayed by nine weeks, from 12 -21 weeks. From a finance perspective, this would place considerable stress on the purchaser of the land, whose money may well have been better tied up in something else, especially considering that their finance costs would have nearly doubled in that time. There are also quality implications influencing the delays –

part of the extra time needed to complete is related to the amount of rework needed to achieve an acceptable level of quality, and this is by no means unique to the NOW Home.

10.2 Adversarial Relationship of Contractor / Subcontractor

As evidenced by recent reviews of the regulations surrounding the building industry, and brought to some degree of order by the Construction Contracts Act, the fundamental relationship between most parties present on a construction site is an adversarial one. To what extent does the lack of co-ordination (and subsequent additional work) increase the cost of the project to the owner?

10.3 Teamwork (or lack of it), lack of vision

Most of the trades present on a site have now become specialised ie we have a roofer, focused on and paid for installing a roof / flashings… rather than a member of a team creating a house. Is it possible that we have the very worst of the industrial revolution… the specialisation without the supporting processes, quality control, common vision etc? Is there a benchmark bespoke undertaking to which we should be comparing housing in order to gain perspective on this – boatbuilding, for example?

10.4 Site communication

To what extent would the quality of the final product, and the time taken to create it, improve by better communication amongst the parties on the site?

REFERENCES

1 *Construction waste Management – A builders Field Guide*. 1997. NAHB Research Centre. Upper Malboro. United Sates of America.

2 From the Smart Growth web site www.smartgrowth.org/library/resident_const_waste.html. Based on a "typical" 186m^2 house. Accessed 10th November 2005.

3 *Construction waste Management – A builders Field Guide*. 1997. NAHB Research Centre. Upper Malboro. United States of America.