AUTHOR: **Kerry Griffiths** (MA, MBA, MSc),

Presenter: **Kerry Griffiths**

Title of Paper: **Getting Down and Dirty**

Contact Information:
Principal Sustainability Consultant
URS New Zealand
PO Box 3367, Wellington,6140.
DDI: +64 4 496 3861; Cell: +64 29 496 3861; Email:
Kerry_griffiths@urscorp.com

Abstract

In the last five years we have seen the emergence of sustainability issues within the engineering design and the construction industry in New Zealand. These issues have been reflected in industry relevant legislation and guidance at a central and local government level, and in the establishment of organisations such as the New Zealand Green Building Council, and in Australia the Green Infrastructure Council. Many existing industry organisations have run conferences related to sustainability and climate change and are developing industry guidance and training to increase capacity within their target groups. In parallel green products and design approaches are coming onto the market. Questions of sustainability are no longer confined to the realms of academia, advocacy groups and policy think tanks. These are moving into the marketplace.

The case studies in this paper share examples of how learning is taking place and in particular how tools and frameworks along with appropriate support are starting to raise the level of engagement around more sustainable solutions by the construction industry. The two case study examples considered are the use of carbon foot-printing as a tool for emissions reduction in the construction process – both for designers and for contractors - and the use of the REBRI guidelines and related waste minimization initiatives to reduce construction waste. The paper will share the methodologies and outcomes as well as the processes used to engage the workforce at a practical level. The case studies demonstrate that when the transition is made from concepts and principles to tangible outcomes and practical action, engagement occurs and thinking shifts.

Biographical Note

Kerry Griffiths is a Principal with URS New Zealand Ltd and has worked in the Corporate Responsibility and Sustainability Management field in New Zealand for over ten years. Kerry's work includes sustainability management, sustainability assessment, carbon management, implementing Corporate Responsibility programmes, training and research, performance management and reporting, and the integration of sustainability considerations into strategy.

INTENDED CATEGORY: Delivering Sustainable Infrastructure

GETTING DOWN AND DIRTY

URS WASTES NOT

A construction site is no place to wax lyrical about carbon footprints and melting ice caps. So when engineering consultancy URS New Zealand tries to reduce the carbon emissions on large infrastructure projects, it gets down and dirty. Take the new Meridian headquarters in downtown Wellington. "Some 50 per cent of all waste heading for landfills comes from construction and demolition, so reducing waste at the source is a good place to start," says Kerry Griffiths, Principal Sustainability Consultant with URS. Working with the construction teams URS found ways to reduce recycle and reuse waste. The result: a staggering 60 per cent reduction in landfill waste.

For Transit's Northern Gateway project near Auckland, URS provided the baseline carbon footprint and practical advice, allowing the construction team to set (and start achieving) a 3 per cent emissions reduction by minimising diesel and electricity use and again by focusing on waste.

"It's a combination of simple things like the idling of vehicles and bigger ticket items like minimising rework and in some cases redesign. In addition to the actual carbon reduction, these kind of practical actions get everyone thinking about what a carbon footprint means. That in turn is driving carbon reduction targets into the design phase of major projects. It's having a network effect."

Good Cause, Good Magazine Supplement, June 2008

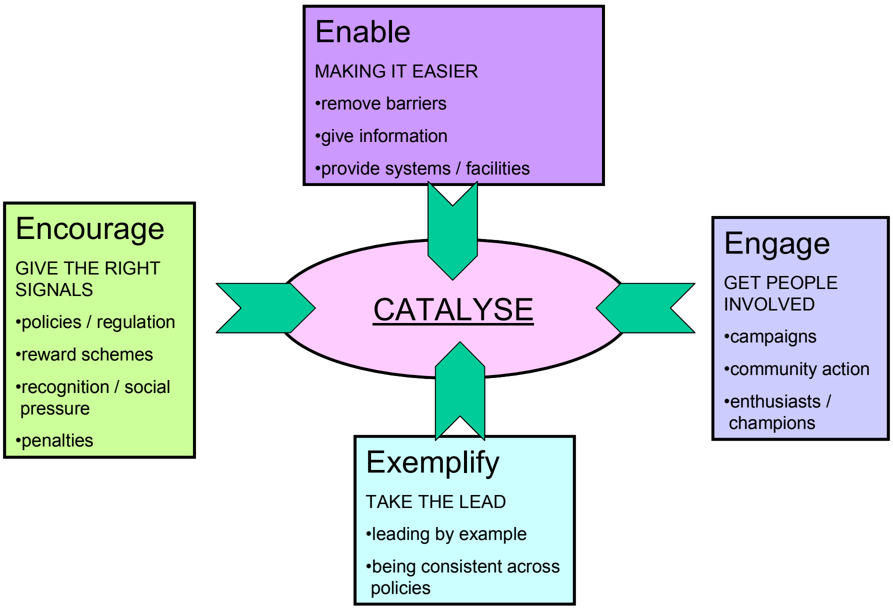
Introduction

In the last five years we have seen the emergence of sustainability issues within the engineering design and the construction industry in New Zealand. These issues have been reflected in industry relevant legislation and guidance at a central and local government level, and in the establishment of organisations such as the New Zealand Green Building Council, and in Australia the Green Infrastructure Council. Many existing industry organisations such as IPENZ, Master Builders and Roading New Zealand have run conferences related to sustainability and climate change and are developing industry guidance and training to increase capacity within their target groups. In parallel green products and design approaches are coming onto the market. Questions of sustainability are no longer confined to the realms of academia, advocacy groups and policy think tanks. These are moving into the marketplace.

The case studies in this paper share examples of how learning is taking place and in particular how tools and frameworks along with appropriate support are starting to raise the level of engagement around more sustainable solutions by the construction industry. The case studies demonstrate that when the transition is made from concepts and principles to tangible outcomes and practical action, engagement occurs and thinking shifts.

The case studies illustrate that to move the sustainability agenda forward on a project by project basis new knowledge and skills are needed. But these alone are not enough – project teams need to become engaged around the issues that sustainability presents and to be encouraged to build these issues into project systems and practices, as it illustrated in the Defra model in Figure 1 below.

Figure 1: Defra Behaviour Change Model



This model is expanded on further in the Appendix in the form of an accompanying checklist for use in process design. In "The Dance of Change" Peter Senge and his colleagues identify 10 challenges of change (see Appendix). These challenges cover three phases - initiating change, sustaining momentum, and system-wide redesign and rethinking. An awareness of these challenges and an understanding of what might be needed to address them can be as critical to incorporating sustainability into infrastructure projects as is new knowledge and skills.

Tangible Tool Generates Interest and Learning (Carbon Footprinting Case Study)

In 2007, a carbon footprint exercise was undertaken for the design and construction phases of the SH1: Northern Motorway Extension project. The exercise resulted in immediate action by the project team in setting a reduction target and exploring reduction opportunities for the remainder of the project. More importantly however the exercise provided a learning opportunity for the project engineers and management team to gain an understanding of the issues and opportunities related to carbon emissions on roading and other infrastructure projects. Following this initial project, further footprints have been completed on other road construction projects and some of the organisations involved have used the carbon footprinting tool to better understand their organisational emissions and the carbon intensity of the products and services they offer. This case study covers definitions related to carbon footprinting, the process of completing a carbon footprint including project outcomes plus some international experience

Key Definitions

Greenhouse gases (GHG)

Increasing levels of greenhouse gases in the atmosphere are leading to the phenomenon of climate change, leading to adverse effects on the world's environment, and subsequently social and economic impacts. The Kyoto Protocol addresses six greenhouse gases: carbon dioxide (CO2), methane (CH_4), nitrous oxide (N_2O), hydroflourocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

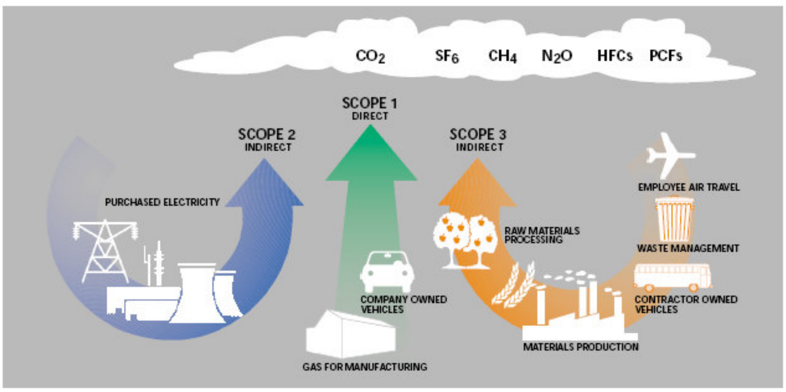
Carbon Footprint
A carbon footprint is an assessment of the greenhouse gases emitted by a particular organisation or project, typically expressed for a 12 month period or for a defined stage of a project. It includes assessment of the six greenhouse gases addressed under the Kyoto Protocol, and can include other greenhouse gases if desired. A carbon footprint describes greenhouse gas emissions as carbon dioxide equivalents (CO_2e); that is, the global warming potential of the gas relative to CO_2.

Emission Factor
An emission factor converts a specific quantity (e.g. a litre of diesel) to a measure of the greenhouse gases (e.g. CO_2) that would be emitted by the emission source (e.g. combustion of diesel in vehicles) in kg or tonnes. When the greenhouse gas is not CO_2, the emission factor also includes a conversion of the greenhouse gas to a carbon dioxide equivalent.

Embodied Emission
An ‘embodied’ emission refers to any emissions of greenhouse gases that result from the production and transportation of a product and are therefore embodied in the product. For example, embodied emissions in aggregate result from the fuel use required to excavate, crush and transport the material to site.

GHG Protocol
The Greenhouse Gas Protocol: Corporate Accounting and Reporting Standard is an internationally accepted GHG accounting and reporting standard. In accordance with the protocol the principles of relevance, completeness, consistency, transparency and accuracy are applied to the footprint assessments and subsequent reporting.

Figure 2: Source of Emissions



The Protocol classifies emission sources as either Scope 1, 2 or 3 (see Figure 2):

- Scope 1 emissions include all direct GHG emissions from sources that are owned or controlled by the company (e.g. fleet vehicles, waste oil used to power plant).
- Scope 2 emissions include all GHG emissions from the generation of purchased electricity consumed by the company and physically emitted at the facility where the electricity is generated.

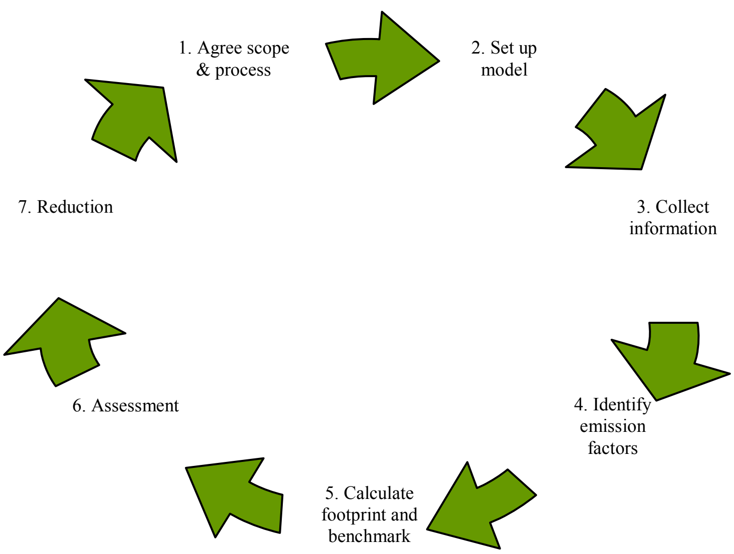
- Scope 3 includes all other indirect GHG emission sources that occur as a consequence of the company's activities but are not owned or controlled by the company (e.g. embodied emissions of purchased aggregate).

Carbon Footprint Boundary - Organisational & Operational
The organisational boundary defines the parts of the operation that will be included within the boundary of the carbon footprint. The operational boundary defines the emission sources that will be included within the carbon footprint.

Completing the carbon footprint

The process of completing the carbon footprint is outlined in Figure 3 below. The process is described not only in terms of what was involved at each stage but also how it was implemented in the case study to maximize engagement and learning.

Figure 3: Carbon Footprinting Process



1. Agree on the scope and process of the project

This phase of the project is as much about education as it is about setting the boundaries and scope of the project. In both the initial and subsequent road projects, the design and construction engineers were keen to learn how they could contribute to better outcomes for the project in terms of environmental sustainability (an underlying project principle). They realised that knowing more about the carbon impacts of design and construction activities would help to identify opportunities for emissions reduction associated with their current project and also inform their design and supply choices in the future.

We agreed the boundary would be limited to the construction phase of the project and that we would look at Scope 1, 2 and 3 emissions. Scope 3 emissions particularly related to materials use on the project were predicted to be the most significant source of emissions.

In addition to identifying the carbon footprint, one project team was keen to understand the potential carbon reduction impacts of planned inititatives envisaged on the project – a high level of recycling of demolition materials and the implementation of a project travel plan.

2. Identify the activities likely to create GHG emissions and decide which emissions sources to include.

The development of a process diagram / schematic which described the key activities of the project allowed the carbon footprinting specialists to understand the nature of the work which would be undertaken throughout the construction phase. Mapping out the activities allowed for easy identification of potential emission sources and facilitated the discussion on likely significance of various activities.

The GHG Protocol highlights the need to select Scope 3 emissions based on a number of criteria:

- Significance particularly in relation to Scope 1 & 2 emissions;
- Level of stakeholder concern related to the emission source;
- Ability of the organisation to control or influence the emissions; and
- The ability to collect reliable data.

Inclusion of sub-contractor activity and transportation of supplies in the carbon footprint exercise raised issues and opportunities around supply chain management and contracting relationships. In a similar way that health and safety performance has permeated the supply chain of construction projects, the project engineers started to explore their ability to influence sustainability issues along the supply chain.

The need to consider stakeholder concerns encouraged the team to think more widely about the carbon footprint and what project related emissions may be of interest to key stakeholders. While the focus of the project was on the construction phase the wider context of the maintenance and 'road in use' related emissions were also discussed. From a whole of life perspective, aspects of road design have an impact on future maintenance requirements (e.g. pavement quality), vehicle fuel efficiency (e.g. gradient) and modal choice by road users (e.g. inclusion of cycle-ways). Hence the wider discussion and deeper understanding may have been more influential in terms of sustainable solutions over the longer term.

Once the activities and the emission sources are finalised the carbon model can be customised to reflect the project. The model used for the case study is an Excel spreadsheet consisting of worksheets for each of the main emission sources and then an overall summary sheet which pulled the data together into a comprehensive carbon footprint for the project.

3. Collect data / information

To complete the footprint process quantities are required for each of the emission sources. In the case of a construction project the data requirements are likely to include;

- fuel use (plant, heavy vehicles, light vehicles);
- electricity (offices and project/plant);
- quantities and source of significant materials (concrete, cement, steel, aggregate, lime, wood);

- details on material delivery (likely fuel use of sub contractors);
- waste volumes including any organic waste generated; and
- other project travel (e.g. staff air travel; taxis).

The data used will vary depending on the stage of the project when the baseline footprint is being completed – actual volumes if the footprint is measured at the end of the project, predicted volumes if in pre-construction or a mix of the two if the footprint is being carried out during the project. The greatest opportunity is presented if the footprint can be established early in the project and then used to inform design choices and materials selection and as a baseline to track improvements.

During the data collection phase the project engineers need to be heavily involved as they have the knowledge of the project data systems and are best able to estimate volumes and the source of supplies.

If the baseline is carried out at the start of the project and is to be used to identify and then monitor carbon reductions, the identification of data collection and reporting requirements throughout the project will emerge. URS's experience is that current project management and reporting systems do not always track the information required to monitor and track emissions in an easy to use format. While the data exists in the systems somewhere (supplier invoices; fuel card systems; travel agent reports) if the project team understand the data needs early they will be better able to produce reliable information with which to estimate and then track reductions. Involving the team in the process, meant they have a better understanding of the data needs for carbon management and could adjust project systems to close the data gaps.

4. Identify emission factors

As highlighted above, developed emission factors exist for construction projects and for office-based activities and are plugged into the carbon model. The case study used emission factors provided by Alcorn (2003) and the Ministry for the Environment (2008).

As the team began to understand the emissions related to certain products and what was likely to influence the emissions value then they started to seek more information on the likely impact of certain product choices e.g. imported steel versus local steel; use of recycled versus virgin aggregate. As better information on emission factors associated with specific products becomes available designers and construction engineers will be better able to factor carbon intensity of products into their decision making process for options assessment and construction methodology choices.

5. Calculate the carbon footprint and benchmark

Once the data collection phase is completed the carbon model is run and the results calculated. The report back of the results to the design and construction team proved to be a great opportunity for discussion and learning. The tangible nature of the carbon footprint seemed to provide something that the engineers can get their heads around and get excited about. In a recent project feedback session a number of the engineers involved expressed their enjoyment of and interest in the footprinting exercise.

Also useful at this stage was information on the relativity or significance of the footprint. Comparisons with other projects of a similar nature and normalising of data helped to provide a sense of the relative carbon intensity of the project and the opportunities for identifying lower carbon options. Understanding the construction phase impacts as a percentage of the whole of life of road construction ensured that the designers in particular recognised the opportunities related to maintenance and road in use. Also useful was information which placed the results in context with the non-project world, for example the average annual emissions of a family car, or on a wider scale of the transport sector, or indeed for New Zealand as a whole.

6. Assessment and then reductions

For the projects involved in the case study, the two larger ones have key performance indicators to reduce project related emissions. The completion of the carbon footprint provided the project team with robust information from which to create a carbon reduction plan and to set realistic targets for focussed areas – one project has set a 3% reduction target for the final years of construction and the other is using the predicted baseline to develop a target for the construction phase.

Having carbon footprinting specialists working closely with project team members ensured a high level of engagement and ownership and increased capability and understanding of the opportunities available to decrease emissions associated with road construction projects.

Some International Experience

The examples below illustrate the increasing attention given to measuring and mitigating greenhouse gas emissions from road construction projects internationally. The implementation of these schemes will further enhance benchmarking opportunities and knowledge sharing.

VicRoads – Carbon Neutral & Options Assessment

VicRoads have constructed an emissions calculator for use on construction projects, similar to that used by URS for the projects included in this paper. Other features include the ability to calculate the reductions created by using alternative materials. To date, VicRoads have used the calculator to assess the footprint of one of their major construction projects and plan to offset the resulting emissions to create a carbon neutral road. Further research is being undertaken to explore the carbon footprint of key project inputs, to look at optimisation opportunities through use of low carbon materials, to explore reduction opportunities through smart design and to consider how to build carbon accounting into project estimating models.
http://www.vicroads.vic.gov.au/Home/PublicTransportAndEnvironment/Environment/EnvironmentalProtection/Greenhouse.htm

Highways Agency – Portfolio Management

The Highways Agency (HA) Sustainable Development Action Plan 2008 includes the development of a Carbon Accounting framework and methodology for Highways Agency activities. The Carbon Accounting tool under development is intended to assist the HA with producing an annual organisation wide carbon footprint, broken down into specific elements based on the key delivery arms of its business -

construction, maintenance, operational and business activities. **http://www.highways.gov.uk/aboutus/documents/SDAP_Jun_07.pdf**

Guidelines Not Enough (REBRI Case Study)

Construction and demolition waste contributes up to 50 percent of New Zealand's waste stream. C&D waste consists of materials such as plasterboard, timber, concrete and steel. Much of this waste can be easily recovered and there have been a number of initiatives that could be put in place to assist in reducing the amount of construction and demolition waste. One such initiative was the development of The Resource Efficiency Building Related Industries (REBRI).

To support the objective of minimising construction waste on the Kumutoto building on Wellington Waterfront and to build capacity within the construction industry the Ministry for the Environment (MfE) contracted URS to work with Fletcher Construction to achieve its waste minimisation objectives for the project. The focus of the work was to provide advice and support to Fletcher Construction regarding the development and implementation of a waste minimisation plan during the construction using the REBRI Guidelines and existing expertise in waste reduction and recovery.

The specific steps taken in delivering the project objective were:

- Audit of the existing site waste management plan and provide advice on how the plan can be improved to maximise waste reduction and recovery and to ensure adequate data collection and monitoring for performance measurement and reporting.
- Work closely with the site manager to make sure the waste management plan is being implemented most effectively on the building site.
- Work with the project manager to consider practical and cost effective options for waste reduction and recovery.
- Monitor the different stages of development for appropriate waste reduction practices.
- Work with Fletcher Construction site personnel to build their capacity in reducing waste during construction, fit-out and demolition with an aim that project management and workers are able to carry out waste reduction and recovery exercises on future projects.

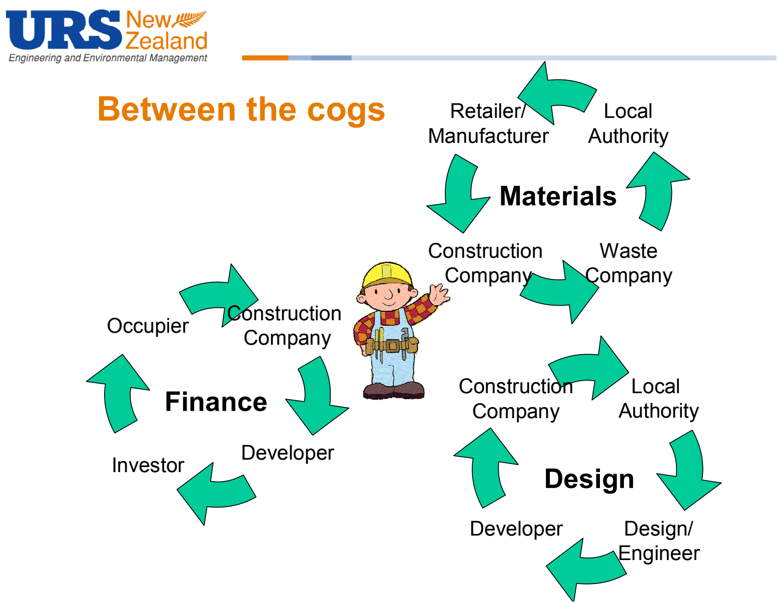
The result was 60% of generated waste diverted from landfill. In addition, the overall amount of waste generated on site was considered very low compared to other typical sites in Wellington, due to attention given to waste minimisation during the design stages and materials reuse where possible. What makes the result even more impressive is that for the majority of people involved, this was the first construction project where any waste at all was recycled.

The use of a REBRI-knowledgeable consultant to interpret the guidelines for the construction project and to maintain momentum and encouragement for the waste minimisation proved very valuable. The consultant met with the site manager and waste minimisation champions once a month to discuss on-going challenges and brainstorm solutions. Instead of referring to generic guidelines the construction staff were able to discuss specific issues and look for local solutions.

The URS team brought together a unique set of skills able to deal with the technical aspects of waste management planning and waste minimisation, to work with a wide variety of stakeholders, to design processes and training to support a significant culture change and to provide knowledge of the wider sustainability context.

One of the key lessons was that waste minimisation is a collaborative project (see Figure 4) and none of the parties would be able to achieve high reduction rates in isolation. A lot of effort had to be applied to changing people's habits and creating awareness of benefits. While management was often motivated by the financial business case and customer demand, staff on the ground responded well to a more personal call to look after the environment. Presentations on how the recycling on site would help the environment at large encouraged people to go the extra mille to use the recycling system and suggest improvements. Again the Defra model provided a useful framework.

Figure 4: Considering the whole system



One of the key benefits of the project was generating awareness and development of know-how among various parties involved in the project.

- Fletcher Construction – processes developed on the site are now being replicated on other sites. Kumutoto is used as a best practice example and training on waste minimisation was provided for all site management staff.

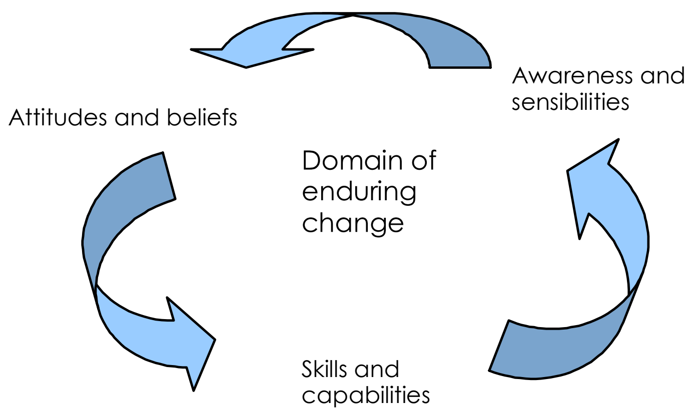
- Subcontractors and suppliers – it is expected that other organisations that came in contact with the project increased their awareness and understanding of waste minimisation issues. In some cases suppliers for the first time needed to assess their packaging and acquired additional cost related to the disposal of their packaging that was not recyclable.

Observations and Conclusions

These projects demonstrated the value of providing information and practical tools for better understanding of new issues related to achieving sustainable outcomes within the construction industry. Information about the carbon intensity of construction materials and the relative carbon profiles of construction activities has helped to inform discussion and decision-making within the design and construction teams – for these projects and for further projects. Consideration of issues such as imported versus locally produced material and the use of recycled materials will be better informed as a result. The REBRI case study also points to the value of specialist support to provide expertise, encouragement and to maintain momentum – especially as understanding grows and systems become established.

Achieving sustainable outcomes in infrastructure and construction projects is more than just about waste minimisation and carbon emission reduction. In some ways these case studies only scratch the surface of what strong sustainability is all about. But to see these case studies as superficial is to miss the point. Their intent is more about illustrating the importance of recognising the change process than it is about describing outstanding sustainability outcomes.

Figure 5: Senge's learning cycle



As represented in Senge's learning cycle, these case studies shows that the transformational benefits of sustainability initiatives as a result of new knowledge, heightened awareness, external inputs and deeper questioning are not to be underestimated. In both cases what was observed over time were changes in mindsets and attitudes which are indicative of deep learning at work. When the transition is made from concepts and principles to tangible outcomes and practical action, engagement occurs and thinking shifts.

References

Alcorn, Andrew (2003) on behalf of the Centre for Building Performance Research, *Embodied Energy and CO2 Coefficients for NZ Building Materials*, 2003.

Department of the Environment, Food and Rural Affairs, UK (Defra, 2006), *Behaviour Change: A Series of Practical Guides for Policy-Makers and Practitioners*, Summer 2006

Highways Agency (2008), http://www.highways.gov.uk/aboutus/documents/SDAP_Jun_07.pdf

Ministry for the Environment (2008), *Guidance for voluntary, corporate greenhouse gas reporting, data and methods for the 2006 calendar year,* January 2008.

Peter Senge et al, *The Fifth Discipline Fieldbook,* Nicholas Brealey Publications, 1994.

Peter Senge et al, *The Dance of Change: The Challenges to Sustaining Momentum in Learning Organisations*, Doubleday / Currency, 1999.

Transurban (2008), *Towards Carbon Neutral Toll Roads: Submission to the Garnaut Climate Change Review*, Transurban group, April 2008.

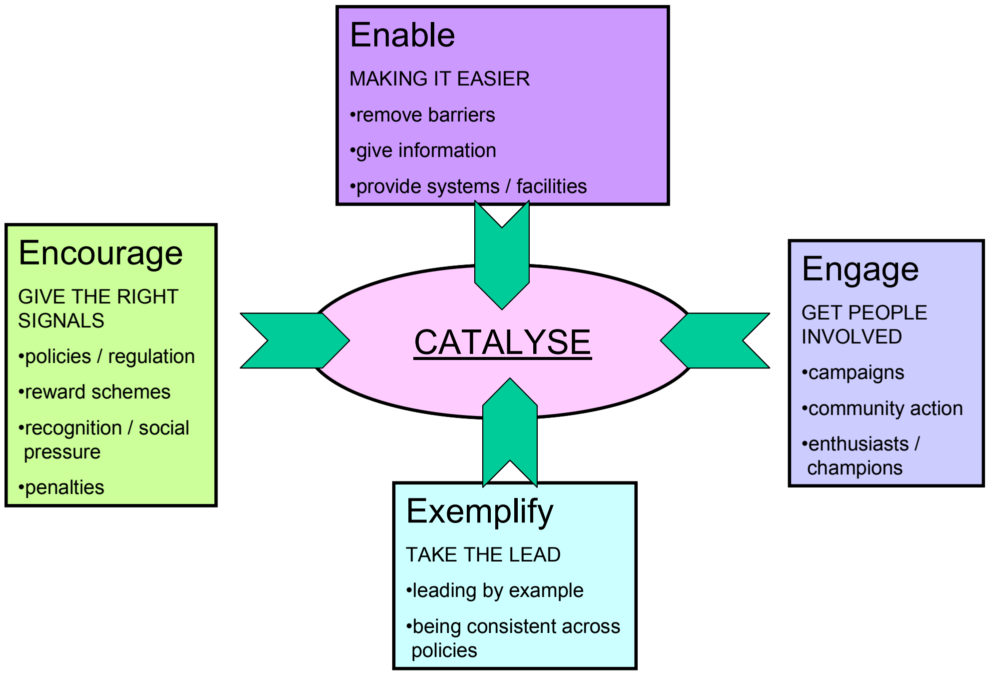
URS Wastes Not; Good Cause, June/July 2008 (Good Cause is a cause-related supplement from Good Magazine).

VicRoads (2008), http://www.vicroads.vic.gov.au/Home/PublicTransportAndEnvironment/Environment/EnvironmentalProtection/Greenhouse.htm

World Resources Institute and World Business Council for Sustainable Development (2004) *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*, Printed in USA.

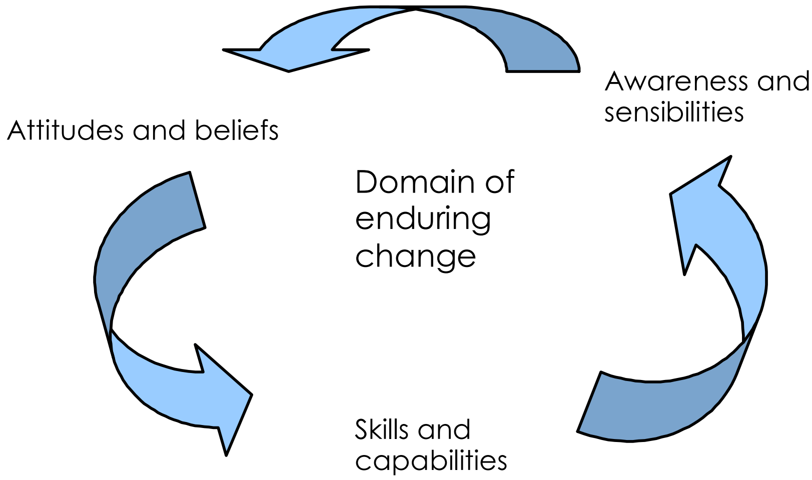
APPENDIX – Change Models

Four E Framework (Defra, 2006)



What might you do to catalyse change for sustainability in your organisation or on a specific project:	
Encourage	
Enable	
Engage	
Exemplify	
What reflections or other possible actions related to bringing about change have become clear to you?	

Achieving Enduring Change (Senge, 1994)



Skills & capabilities	
What skills and capabilities do we need related to sustainability?	
What are the gaps in this project team? In the industry?	
Awareness & sensibilities	
What do we need to be more aware of and sensitive to with relation to sustainability?	
Attitudes & beliefs	
What attitudes and beliefs support action on sustainability?	
What attitudes and beliefs prevent or delay action?	

Challenges to Change (Senge, 1999)

In "The Dance of Change" Peter Senge and his colleagues identify 10 challenges of change. Grouped into three categories -- challenges of initiating change, challenges of sustaining momentum, and challenges of system-wide redesign and rethinking -- these items amount to what the authors call "the conditions of the environment that regulate growth."

Challenges of Initiating Change

"We don't have time for this stuff!"	People who are involved in a pilot group to initiate a change effort need enough control over their schedules to give their work the time that it needs.
"We have no help!"	Members of a pilot group need enough support, coaching, and resources to be able to learn and to do their work effectively.
"This stuff isn't relevant."	There need to be people who can make the case for change -- who can connect the development of new skills to the real work of the business.
"They're not walking the talk!"	A critical test for any change effort: the correlation between espoused values and actual behaviour.

Challenges of Sustaining Momentum

"This stuff is . . ."	Personal fear and anxiety -- concerns about vulnerability and inadequacy -- lead members of a pilot group to question a change effort.
"This stuff isn't working!"	Change efforts run into measurement problems: Early results don't meet expectations, or traditional metrics don't calibrate to a pilot group's efforts.
"They're acting like a cult!"	A pilot group falls prey to arrogance, dividing the company into "believers" and "non-believers."

Challenges of System-wide Redesign and Rethinking

"They . . . never let us do this stuff."	The pilot group wants more autonomy; "the powers that be" don't want to lose control.
"We keep reinventing the wheel."	Instead of building on previous successes, each group finds that it has to start from scratch.
“Where are we going?"	The larger strategy and purpose of a change effort may be obscured by day-to-day activity. Big question: Can the organisation achieve a new definition of success?