Downer

Mā te whanaungatanga ka angitū
Relationships creating success

Estimating Embodied Carbon

Contents

Introduction

In response to global and local sustainability targets, including our commitments under the Paris Agreement, the infrastructure sector in New Zealand is focusing increasingly on reducing lifecycle carbon emissions of infrastructure.

This whitepaper explores the challenges and complexities associated with carbon estimation taking a Life Cycle Assessment (LCA) approach. It draws on interviews with procuring agencies across the country and case studies of projects such asthe City Rail Link in Auckland.

We recognise that carbon estimation is just one topic that forms part of a wider conversation around the actions we need to take to meet our sustainability obligations and invite ongoing, open discussion with the industry.

Decarbonising – Net Zero by 2050
New Zealand has signed on to the Paris agreement which is a global effort to reduce global warming to less than 2 degrees above pre-industrial level. New Zealand has committed to Net Zero by 2050. It is anticipated that statutory and regulatory requirements regarding tracking and reducing embodied carbon will significantly increase across the infrastructure value chain.

Challenges facing our sector

New Zealand's construction industry faces the substantial challenge of aligning infrastructure development with international climate change mitigation efforts. Understanding and addressing embodied carbon remains a complex challenge. A considerable proportion of a project's total embodied carbon is determined before construction begins, yet the industry often struggles with early and informed decision-making regarding the sustainability of our infrastructure (MBIE, 2020).

Collaboration and procurement practices
A lack of alignment and collaboration among clients, contractors, and designers is a critical barrier. The emphasis needs to be on procurement practices that enable positive change.

Consistent engagement with stakeholders to understand material issues is frequently missing. Despite current efforts, widespread adoption of low-carbon materials and optimised construction methods remains low.

Local authority challenges and the need for standardisation
Local authorities often face difficulties in updating current procurement practices to align with climate emergency declarations. The industry struggles with the need to address carbon emissions in infrastructure and implement sustainable practices throughout delivery. The absence of standardised guidelines for carbon calculations hampers stakeholders in making sustainable procurement choices using consistent data and methodologies.

Culture and mindset change
The challenge of culture and mindset change within New Zealand's infrastructure sector is not a matter of misalignment with broader values, but rather the pace at which change is occurring. The gradual shift towards strengthening carbon literacy and the integration of responsible decision-making has not kept pace with the growing aspirations of stakeholders. This lag in cultural transformation represents a significant challenge, reflecting a disconnect between industry practices and the expectations of a new generation that places high value on sustainability and environmental responsibility.

Though efforts are being made to foster a culture that recognises the role of stakeholders in contributing to a sustainable future, these initiatives often fall short of the rapid transformation sought. The challenge lies in accelerating this change, integrating carbon literacy into core organisational values, and aligning with national goals.

Strategies for embodied carbon reduction

1. **Revised evaluation methods:** Re-evaluating and adjusting current valuation methods in tenders, such as the Price Quality Method (PQM), can promote innovation. By emphasising non-priced evaluations over cost, there is potential to encourage creativity and the adoption of low-carbon solutions.
2. **Alignment and collaboration:** Aligning clients, contractors, and designers can help to drive meaningful change. Collaboration amongst these parties can pull together joint capabilities leading to better, more sustainable decisions. Contract models that inspire collaboration, such as early contractor involvement and alliances, allow for early-stage discussions on carbon value engineering leading to better material choices and sustainable construction methods.
3. **Challenging the status quo and risk aversion:** Striking a balance between established, conventional practices and new, sustainable technologies is vital. The industry must be open to incorporating alternative, sustainable materials and methods while maintaining cost efficiency and proven quality.
4. **Carbon estimation and decision-making:** To make meaningful decisions at the tender stage, clients need to have confidence in the numbers to enable comparison and true sustainability value. The ability to estimate a project's embodied carbon accurately requires access to comprehensive data on materials, components, and construction processes. Initiatives like open-source national databases, similar to the EC3 in the US, can facilitate consistent and reliable carbon estimations.
5. **Strengthening carbon literacy:** To facilitate carbon reductions, there is a need to boost carbon literacy across the industry. This involves enhancing the understanding of emissions sources and mitigation methods, which will subsequently lead to more effective innovations for carbon reduction

1. Revised evaluation methods

One major challenge is the evaluation of sustainability solutions under the Price Quality Method (PQM), where we see low weightings for sustainability attributes and narrow banding of non-price attributes. Low sustainability weightings can discourage innovation due to the tension between price and non-price attributes. Innovative approaches often involve new technologies, materials, and processes that may have a higher capital cost compared to conventional or established practices due to economies of scale. Evaluation methods need to be refined to encourage this innovation and adoption of low carbon solutions, with greater emphasis on non-price attributes

2. Alignment and collaboration

In New Zealand, early contractor involvement has proven invaluable in reducing embodied carbon as it allows designers and procurers to gain insights into practical, real-world solutions tailored to project needs. Proactive carbon management maximises potential reduction before project progression limits opportunities.

Collaborative contract models, such as Early Contractor Involvement and Alliances, enable discussions between clients, designers, and contractors on carbon value engineering initiatives during design development. Active engagement with suppliers, contractors, and subcontractors, allows the client to benefit from their collective expertise and contribution. This improves material selections, supply chains, construction methods, and explore alternative solutions.

An example is City Rail Link (CRL) in Auckland where open dialogue during design development led to design changes that reduced embodied carbon, such as the carbon footprint optioneering for a decision on the tunnel walkway design. It also enabled process improvements and the selection of materials and construction methods. This collaborative approach allows sustainability thinking to be embedded from day one, leading to more effective and efficient outcomes. Further detail is provided in a case study on page 8.

3. Challenging the status quo and risk aversion

Design standards and specifications at "Issued for Construction" (IFC) design stage will restrict the ability of a project to incorporate alternative materials and methods that may offer more sustainable performance. The status quo provides a sense of assurance as they are tried-and-tested practices and often create a comfort zone for all stakeholders involved. Balancing and supporting new technologies with proven practices and accommodating new technologies is essential to foster sustainable growth and advancement in the construction sector.

The illustration below depicts how the opportunity to make meaningful decisions on carbon diminishes the further the project progresses along its lifecycle.

Work stages of infrastructure delivery – amended from PAS2080:2023

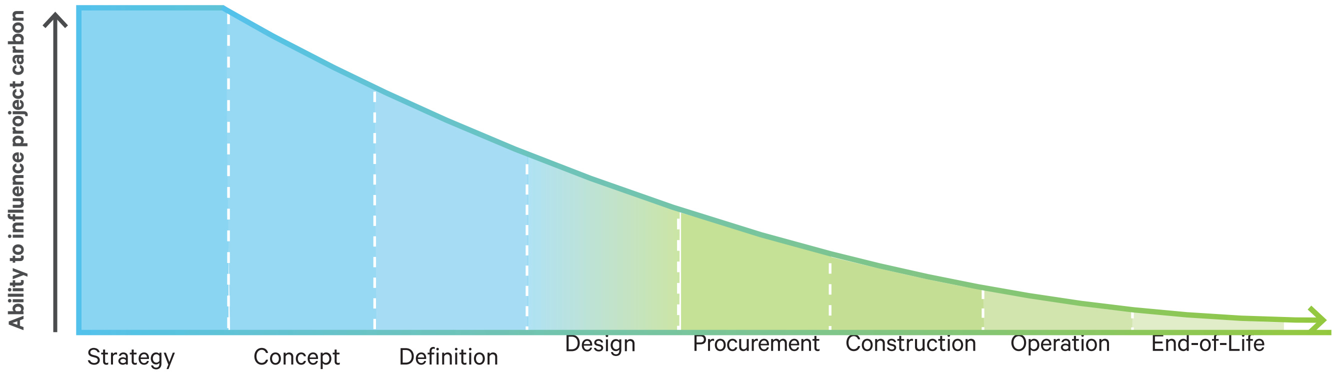

Fig 1: Work stages of infrastructure delivery

4. Carbon estimation and decision-making

Estimation of embodied carbon has numerous benefits. It enables the benchmarking of embodied carbon and establishment of realistic and measurable carbon reduction targets and supports informed value engineering to improve resource efficiency and reduce carbon intense elements. The outcomes from being able to estimate carbon volumes in tenders can serve as valuable baselines, informing future projects, and promoting continuous improvement. The ability to accurately estimate the embodied carbon of an asset requires comprehensive data for the various materials, components, and construction processes used throughout an asset's lifecycle. However, the availability and quality of data is currently limited and varied. Data must reflect the manufacturing processes and supply chains of the materials used as these can significantly impact embodied carbon.

Access to a national open-source calculators and databases, managed by clients, contractors, and suppliers would aid quantification, collaboration, and alignment. An example is the data set produced in the US, EC3 . EC3 is a cloud-based, open-access embodied carbon calculator and database formed through the joint effort of construction leaders, IT giants, and public sector agencies. The EC3 is designed to create a "single source of truth" for material carbon emissions data, including data limitations, allowing carbon smart choices by enhancing access and enabling comparison of Environmental Product Declarations (EPDs), designs, and products based on embodied carbon. In New Zealand, a range of carbon measurement tools are available including the GreenStar methodology, Moata carbon portal, Infrastructure Sustainability Council (ISC) IS Materials calculator, and Waka Kotahi's Project Emissions Estimation Tool (PEET). Along with accessible databases, consistent LCA methodologies and tools is critical.

Integrating carbon calculators into estimating software enables a rapid comparison of carbon reduction initiatives to aid decision-making during the preconstruction phase when we are faced with tight tender timeframes. This integration offers real-time carbon analysis, equipping project teams with immediate insights into the environmental impact of their choices. It also empowers data-driven decision-making by enabling comparisons of carbon emissions associated with various materials and methods. This integration facilitates dual cost and carbon reduction benefit realisation.

By providing a platform for comprehensive lifecycle analysis, these calculators enable projects to minimise emissions across all phases. This integration resonates with global sustainability objectives, propelling the construction industry towards a more environmentally responsible future.

Evolution of carbon estimation models

Carbon estimation generally occurs through three non-iterative models. Over time, we expect the industry will align towards a fully collaborative, consistent model that is government-led.

1. Non integrated estimation

Currently, the industry relies on multiple and independent processes to estimate carbon. This approach makes it challenging to achieve consistency in outputs, is time consuming, and difficult for clients to evaluate. Consequently, it does not provide incentive for clients, contractors, and suppliers to maximise the potential of carbon estimation.

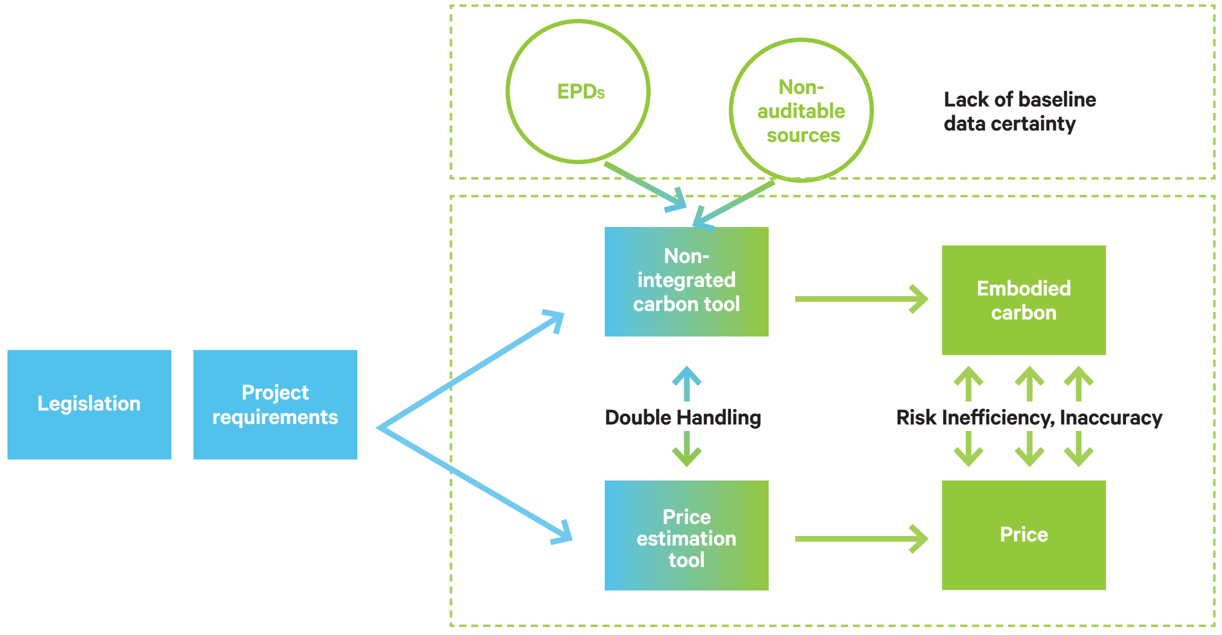

Fig 2: Non-integrated estimation model

2. Integrated estimation

This model represents an increasing level of maturity whereby organisations have integrated carbon estimation with existing estimating software. The tools and databases use variable baseline inputs and methods that do not enable a direct comparison - a requisite for accurate assessment of options and carbon reduction.

Although this is an evolution in maturity of estimating carbon, it still does not provide the client with comparable and seamless carbon estimates, as it lacks a standardised, integrated estimating tool, so that results between different entities are equitable.

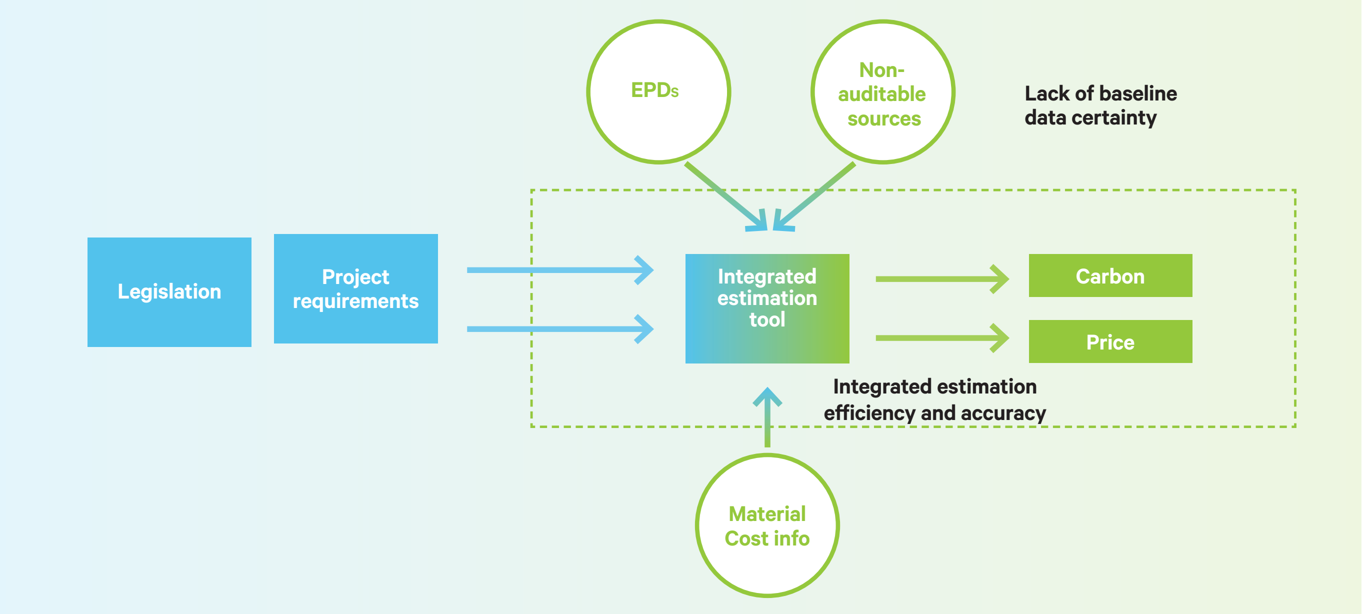

Fig 3: Integrated estimation model

3. Fully collaborative, consistent model

The ideal solution to address the constraints of earlier models is a fully collaborative system with provision for carbon calculation and EPD storage for use by the whole industry. Integration with existing estimating software is possible and encouraged to eliminate double handing and negate the need for proprietary tools. This model would enable direct comparison and knowledge sharing. This is the approach taken by the Carbon Leadership Forum in North America, where they incubated the creation of the EC3 calculator, bringing together contractors, suppliers, clients, and IT specialists with the common goal of accurately accounting for carbon, enabling effective reduction strategies.

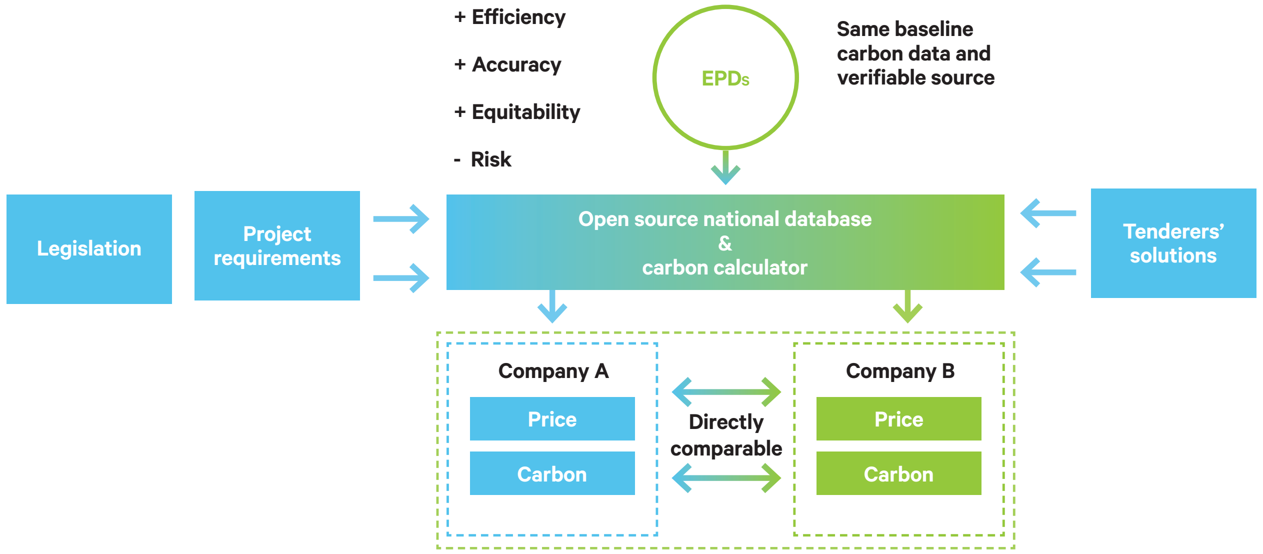

Fig 4: Fully collaborative, consistent estimation model

5. Strengthening carbon literacy

Carbon literacy extends beyond understanding what carbon is and how to calculate it - it encompasses the 'why' of carbon reduction. We are all at various stages of the carbon maturity journey. Building our collective carbon maturity is critical to enabling informed decision making at each stage of a project.

Early decisions around construction materials, lighting solutions, or sourcing local products can significantly impact both the embodied carbon and cost of a project. For these reasons, we need a collective level of literacy to make substantive, systemic changes and solutions to improve our carbon reduction outcomes. For instance, using a locally produced timber can reduce transportation emissions, support local industry, and potentially reduce costs. Another example includes choosing sustainable concrete with recycled content, which can reduce carbon emissions and material cost.

Climate literacy in New Zealand's infrastructure sector must increase, with a corresponding increase in public scrutiny, regulations, and expectations from our employees, government, and shareholders. Construction firms may need to integrate carbon literacy into their core training, reflecting an authentic commitment to sustainability.

By promoting an understanding of carbon's impact across all stages of a project's lifecycle and connecting this with their overall purpose and mission, organisations can create a culture that reflects societal values and the communities we serve. Educational initiatives, regular training, and transparent alignment with national sustainability goals will further strengthen this cultural shift. Such an approach positions the industry positively as a leader in informed, responsible decision-making and will allow us to respond to climate science. Based on scientific data, we know that if we don't collectively act now, climate change will have a significant impact on global ecosystems and economies.

Downer's role in decarbonisation

Climate change is this generation's greatest challenge. It poses a threat to the economy, as well as our health, our communities and our future. At Downer, we recognise that this challenge also brings opportunity. An opportunity to help our customers on their decarbonisation journeys, and an opportunity to contribute to a brighter future. In the coming years – and decades – Downer is well placed to play a pivotal role in Australia and New Zealand's transition to a net zero economy. Downer holds strong positions in most of the major sectors critical to the transition and has identified significant opportunities to contribute further, while also supporting the net zero commitments of our government and private sector customers. Some of the progress we have made is outlined in the following pages.

City Rail Link leading the way

City Rail Link (CRL) is a prime example of the adoption of collaborative contract mechanism facilitating early carbon quantification and identify opportunities and maximise reductions.

The scope of works includes the design and construction of two new underground stations as well as mined and cut and cover tunnels and associated rail systems.

Sustainability and project decarbonisation is a major factor throughout the delivery of the CRL Project. To facilitate reductions, the project team quantified the whole-of-life carbon of the project at an initial, reference design to baseline the quantity of embodied carbon. Carbon reduction initiatives were then identified during the detailed design and construction planning. To maximise the potential reductions, a dynamic virtual copy (or 'digital twin') of the works was created, enabling the continual quantification and comparison of carbon as design progressed.

This allowed proactive sustainability decisions to be made and adjustment of the design to minimise the carbon footprint as well as the ability to accurately measure sustainable improvement to the base design.

This integration of decarbonisation initiatives has yielded a projected 60,500 tCO_2-e reduction in total carbon footprint over the CRL's 100-year design lifespan - a 19% reduction which reduces the expected carbon payback time once the CRL is operational to under six years.

Electrification of our bitumen tanks

Downer is a leading manufacturer and supplier of bitumen-based products and an innovator in the sustainable asphalt industry.

In June 2022, Downer's Road Science business in New Zealand officially opened a new large bitumen tank at the port of Lyttelton in Canterbury. The new tank not only bolsters the region's onshore storage capacity, enabling a secure supply for customers, it also sets an industry-leading sustainability benchmark.

It was made from a repurposed oil tank, which has reduced waste to landfill through repurposing existing facilities and reducing construction emissions. Importantly, the tank is also the first of its size in Australasia to be fully electrified, instead of being process-heated by fossil fuels.

The tank has been assessed by Energy New Zealand and the results highlight a significant carbon emission saving of 240 tCO_2-e per year. The emissions reduction achieved at the Lyttelton plant provided us with a successful model for the business, including our Bluff furnace electrification project. The site is one of the companies smallest yet most carbon intensive process sites, and the conversion to electricity will see the first MW scale thermal oil heater used in New Zealand.

Wiri to Quay Park (W2QP) Value Engineering

Downer's technical design team has undertaken value engineering analysis across the W2QP programme Relevant proposals are investigated where changes may bring benefits in terms of reduced emissions, reduced embodied carbon, better programme outcomes, and lower cost.

For example, following a constructability review of the specified concrete piled wall in Westfield, we advocated the change to a soil nail wall which saved cost and programme. We used the Infrastructure Sustainability Council (ISC) IS Materials Calculator to support the design change. This change reduced emissions from 1,050 tCO_2-e to 251 tCO_2-e, or an 82% reduction from the wall-type base design.

On Package 2, KiwiRail acquired land behind a proposed retaining wall for use as a laydown and staging area during the project. Because of this, the initial design of the retaining structure was no longer optimised based on the available land and had design redundancies that could be altered for a more cost efficient, low-carbon design. The design was changed from bored pile retaining wall to gravity block and earth batter.

The base design for the wall had an estimated embodied carbon price tag of 228 tCO_2-e versus the improved design and reduction which has 110 tCO_2-e, inclusive of material, energy and waste. This is a reduction of 51% from the base design.

Our ambition

Developing capability within the infrastructure sector to provide accurate, transparent, and aligned estimates of embodied carbon is a critical step in New Zealand's journey towards net-zero emissions. Alignment on best practice for embodied carbon evaluation and quantification is not merely a technical concern; it is central to consistent and reliable estimation, seamlessly integrating cost considerations. Collaboration with clients and supply chain partners is essential for uplifting carbon literacy and maturity across the industry.

Sector transformation requires a holistic and coordinated approach, with systemic solutions to address the complex challenge of sustainable infrastructure development. We hope to stimulate thinking, encourage conversation, and create change by sharing our perspective on this important topic.

Author bios

André Araújo

André is a Bid Lead within Downer's New Business team. He has worked on major anchor infrastructure projects across the country, including Auckland Transport's Downtown Programme and the SCIRT Rebuild. He is currently finishing a Master of Engineering from the University of Auckland, bringing a practical lens to the challenge of carbon estimation in the New Zealand context.

Josh Appleton

Part of the Downer graduate programme and Young Professionals Sustainability Committee, Josh recently spent six months with our Estimating team where he was a key contributor to Downer's carbon estimation database. He is now based in Tauranga at Road Science. Previously, he was part of our Engineering team at Papakura to Pukekohe train station and Wiri to Quay Park.

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