FROM CONCEPT TO REALITY: THE CENTRAL INTERCEPTOR SUSTAINABILITY JOURNEY

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ABSTRACT

Sustainability is a mindset that is often perceived to solely drive long term benefits into society, but can actually achieve positive outcomes in the short and medium term. There are considerable opportunities in the water industry to maximise benefits across all areas of sustainability – environmental, economic, social, and cultural. These opportunities not only improve environmental outcomes, which are often the only sustainable benefit considered, but also generate efficiencies, reduce cost, stimulate innovation, and strengthen relationships with local communities. Sustainable practices, when applied correctly, have the potential to significantly impact the way in which the water industry constructs and operates its assets.

The Watercare Central Interceptor (CI) programme is the largest water project ever undertaken in Aotearoa. For its design, it was awarded the highest possible Infrastructure Sustainability (IS) rating of 'leading'. This was achieved through embedding sustainability into all areas of the project, including those not often associated with sustainability. In this paper, innovations and successes of the leading rating will be shared as well as lessons learnt for weaving sustainability into future projects. These innovations include:

- A single-pass segmental lining construction methodology, reducing our construction footprint;
- Utilising wastewater re-use for construction water, reducing our demand of potable water supplies;
- A Foundation Partnership with Mates in Construction to support mental wellbeing;
- Deconstruction of houses with a focus on diversion from landfill;
- Immersive training focused on experimental learning.

This case study demonstrates the application of sustainable practices including whole-of-life analysis of measurable resources (energy, materials, water, waste). It explores ways to embed sustainable principles into the identity of projects or organisations of any scale. Furthermore, it will discuss ways to integrate sustainable thinking into every team members' role, as a true marker of successfully implemented sustainability. The Central Interceptor examples of this include decision making and risk analysis, sustainable procurement, leaving a

legacy for the industry, adapting to future climate scenarios, net ecological enhancement, and improving community values in addition to construction outcomes. Alongside this, direct project savings include whole-of-life resource reductions of 41.4% energy, 15.3% materials lifecycle impact (measured as Greenhouse Gases), and a reduction of 40.2% in water consumed.

The paper will offer an insight into an organisational mindset shift required for the evolving water industry, with the intention of empowering the adoption of sustainable thinking within water organisations and projects.

KEYWORDS

Sustainability, Infrastructure Sustainability (IS), Whole-of-life Analysis, Central Interceptor

PRESENTER PROFILE

Olivia Philpott is responsible for driving sustainable change on the Central Interceptor Project. She managed the delivery of the 'Leading' Infrastructure Sustainability rating, exceeding the targeted 'Excellent' rating. She now oversees the implementation of sustainability initiatives through the project's construction phase.

1 INTRODUCTION

Integrating sustainable thinking into a project or organisation drives outcome-focused behaviour that adds both financial and intangible value. Sustainability is often described as the balancing of environmental, economic, social, and cultural factors (the quadruple bottom line), but it goes beyond that to tap into innovation and create efficiencies to reduce impacts on ecosystems, and support sustainably functioning societies. There are significant opportunities in the water industry to reduce negative impacts and maximise benefits.

The future of both the water and construction industries is inextricably linked with a sustainability mindset. Continuing with a traditional approach will not be enabled legislatively, reputationally, or financially. As sustainability is becoming more prevalent and mainstream, there is more motivation and resources for success in this space. It is no longer a nice to have and is fast becoming the new business as usual (BAU).

The construction industry is responsible for 40% of Tāmaki Makaurau's landfill waste and is a major contributor to the countries second and third largest GHG emissions sources, energy and industrial processes and product use (IPPU) (Auckland Council, 2018; MfE, 2021). As the water industry provides essential services and will continually require significant amounts of infrastructure (and have high operational demands), there are significant opportunities to improve how we approach this infrastructure and have meaningful impact.

The Central Interceptor Project has woven sustainability into its project identity enabling a series of outcomes across economic, environmental, social, and cultural sustainability. These outcomes are reflected in resource savings and innovations that are highlighted in sections 4 and 5 respectively.

2 CENTRAL INTERCEPTOR

The Central Interceptor Project (CI) is Aotearoa's largest wastewater tunnel project at 14.7 km long and 4.5 m in diameter. It will be located in Auckland, running underground from Grey Lynn to Watercare's Māngere Wastewater Treatment Plant. The CI scheme will reduce combined wastewater and stormwater overflows that currently flow into urban waterways and beaches by 80%. It will also duplicate a critical section of the wastewater network under the Manukau Harbour that is ageing, provide storage and capacity for growth, and improve network efficiency.

Major infrastructure projects have the opportunity to innovate and take risks that don't occur in everyday business. It is important to the CI that those opportunities are not missed. Creating a lasting impact on our team members, our industries, and our communities has always been a core part of CIs values.

Having sustainability engrained in the identity of the project encourages a different way of thinking. Where value engineering is often considered a mechanism for achieving cost savings, it does not encourage people to consider the embodied Greenhouse Gas (GHG) content of materials, the operational carbon footprint of the asset being built, and a myriad of other elements. Challenging team members, particularly engineers, to integrate sustainable thinking into their BAU roles and cast a sustainability lens over their decision making, creates an environment where people are comfortable, enabled, and empowered to innovate in this space.

From the start of the CI construction phase in 2018, an Infrastructure Sustainability rating was adopted to independently verify sustainability performance and drive best-practice behaviour. This built on the design team's approach to sustainability and benchmarks the projects performance against other projects in Aotearoa and internationally. This decision aligned with Watercare's 'Fully Sustainable' strategic priority.

3 EMBEDDING SUSTAINABLE PRINCIPLES

CI has achieved significant sustainable outcomes, and sharing these initiatives and innovations is a core part of developing the industries uptake of sustainability.

The intent of this paper is not to simply detail the successes of a major infrastructure project, but to share sustainable principles that are transferrable and relevant to a project or organisation of any scale. The following elements outlined in sections 3.1-3.6 are integral to the success of embedding sustainability into the identity of a project or organisation, leading to sustainable outcomes.

3.1 LEADERSHIP AND PRIORITISATION

A key part of being able to drive sustainable outcomes is having the buy-in from leaders in a project or organisation. This could be internally or from shareholders/stakeholders.

Once sustainability has been mandated, it is essential to determine what elements will be focused on first. Sustainability can be addressed at a broad, shallow view or a few select elements considered more thoroughly. The latter methodology is very common in current times as companies are giving urgent attention to the topic of climate change and the various surrounding factors: GHG emission calculation and reduction, adaptation of assets and adaptive planning, and climate risk assessment and disclosure.

Getting sustainability prioritised can be supported with the following discussion points:

- Legislative signals/transitional risks in the policy and legal space

    - Governments being sued for climate inaction (NY Times, 2019)
    - Corporates being sued for climate inaction (Earley, 2020)
    - Mandating Sustainability ratings in various Australian agencies (QLD, 2019; VIC, 2017; NSW, 2017)
    - Waste levy increases (MfE, 2020)
    - Zero-carbon act (NZ Govt, 2019)
- Reputational benefits with the industry and from stakeholders, including community and prospective customers or clients
- Improving staff retention and morale working for an organisation that does the right thing, and making the organisation attractive to potential new staff
- Providing the opportunity to be seen as a leader in a growing industry that will become mainstream in the next decade
- Leaving a project legacy
- Promoting efficiency – doing things once, right.

The commitment to achieving an IS rating, and the requirement being written into the construction contract with Ghella Abergeldie Joint Venture (GAJV), was a key tool to drive sustainable outcomes. A materiality assessment for the project indicated ecology, energy, materials, and water would be areas with significant opportunities. Additionally, enhancement of social and cultural outcomes were considered the way the project could leave a legacy to those who would use and inherit the tunnel, and give back to the communities who would be our site neighbours throughout the five year construction period.

3.2 INTEGRATION OF SUSTAINABILITY IN EVERY ROLE

The key to successfully implemented sustainability is for the responsibility to not sit exclusively with the sustainability or environment teams. Sustainability is a way of thinking that needs to sit across every team within a project or organisation, from strategic planning to procurement to operations. It needs to be present in every decision made, every risk assessed, and every dollar spent. To do this, every team member should integrate a sustainability lens across their BAU role to ensure widespread action rather than it being a conceptual idea that sits with a handful of individuals.

The wider objective is to weave sustainability into everyone’s roles over time, starting with the areas of biggest influence; decision makers & governance groups, strategic planning & design, and procurement. This can be done by giving specific tasks that relate to the individual roles:

Commercial & Procurement teams

- Write the quadruple bottom line into the procurement policy
- Include sustainability in the weighted section of tender evaluation
- Loop in the Sustainability team members when major change proposals or business cases are progressing

- Investigate supply chain ethics of all procured goods and services to ensure they exclude exploitation or modern slavery

Design Engineers

- Consider the impact on materials and construction fuel and water when making design changes
- Consider the options of building less or re-purposing existing infrastructure and networks
- Calculate the whole-of-life impacts of the infrastructure (construction and operational energy, materials, water)
- Investigate the options for materials with low capital carbon in designs (e.g.low-carbon concrete mix design)

Site Engineers

- Prioritise electric equipment over fuel run equipment wherever possible
- Encourage on-site waste separation
- Advocate for efficient use of water and energy on-site
- Set-up materials sharing platforms between sites

The above approach distributes responsibility for areas of sustainability through demonstrating that sustainability isn’t necessarily additional work, but rather an enhanced way of approaching the day-to-day.

Additionally, with support from leaders, including sustainable measures in a team members KPIs is another approach to drive action.

3.3 EARLY CONSIDERATION OF SUSTAINABLE IMPACT

When embedding sustainability on a project, the earlier it is considered, the more successful the implementation, as it maximises the ability to influence change (Figure 1).

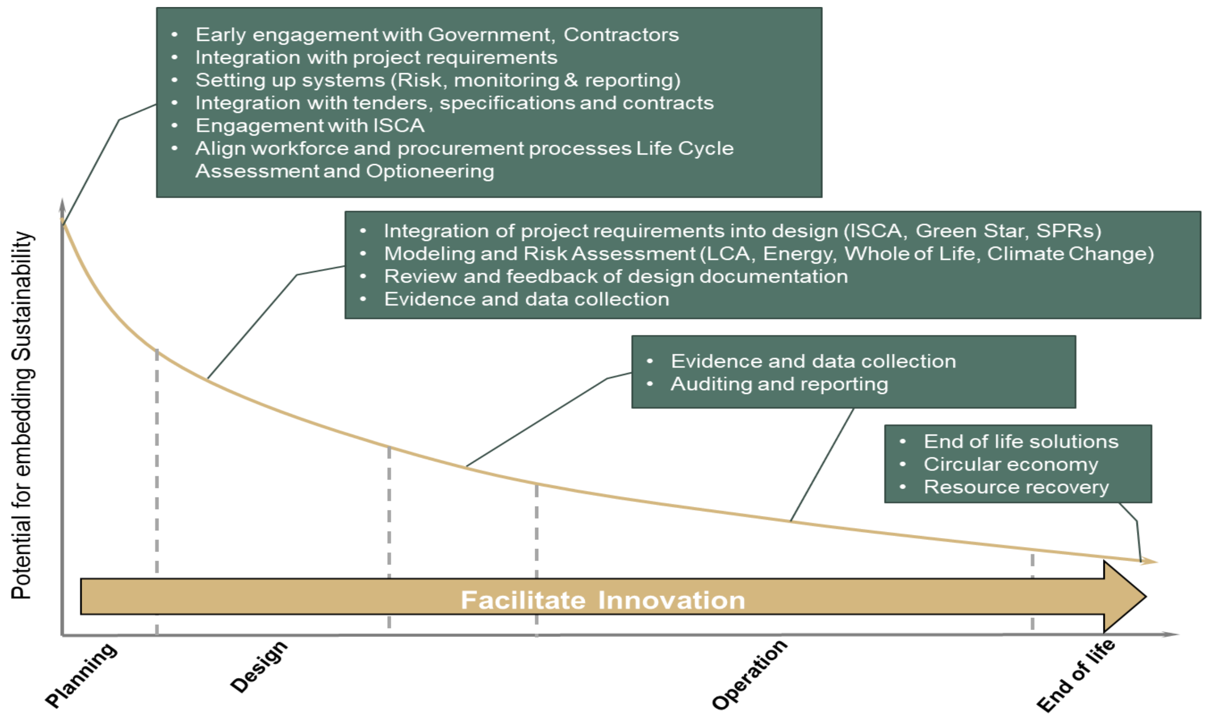

Figure 1: Embedding Sustainability on a typical project (Source: Edge Environment)

Alterations to design and construction methodologies have the opportunity to reduce resource use more much than on-site changes when design is locked in and savings are on a much smaller scale. Early contractor involvement is another way to lead to more efficient outcomes.

Early inclusion also means sustainability needs to have a weighted presence in the non-financial attributes of tender awards. Sustainability requirements should be written into project contracts (targets around waste diversion, reduction in GHG). Project planning should allocate resources (time, budget, and people) to the baselining of resources, setting up procurement, and implementation of ideas.

3.4 INFLUENCE AS A SIGNAL OF CHANGE

Projects or organisations who are achieving sustainable outcomes, act as market signals to the industry of the rising bar of BAU.

Beyond simply signaling change to the industry by publicly prioritizing sustainability, CI considers its influence to include:

- Supporting sub-contractors and suppliers to improve their performance, whether that means developing processes to track GHG, establishing sustainability policies for when future clients are evaluating tenders, or getting Environmental Product Declaration (EPDs) for specific materials that could give them a market edge.
- Investing in our industry:

    - Elevating Health, Safety and Wellness training to include practicing real processes in controlled environments
    - Improving the literacy and numeracy of team members
- Measuring success with sustainability metrics. In many cases this might be using carbon savings rather than liters of fuel, kWh electricity, or dollars saved. This not only signals what is important to the project but encourages teams to engage with these units, which to many, are not well understood.
- Trialing new technologies and processes that have the potential to be a step-change in the industry but include a degree of risk to implement.
- Sharing learnings and successes to 'close the loop'. Taking risks and embracing opportunities would not be complete without sharing these with the industry and community, to ensure the learnings can inform future projects and the successes can benefit other organisations. For CI this includes feeding back into a number of stakeholders:
    - Watercare and the Auckland Council family,
    - Major infrastructure projects in the industry,
    - Water, sustainability, and construction industry groups, and
    - Community stakeholders.

3.5 AN INFRASTRUCTURE SUSTAINABILITY FRAMEWORK

The Central Interceptor used the Infrastructure Sustainability (IS) rating tool to guide and drive sustainable outcomes and measure sustainability performance. The IS tool is an independent verification framework created and governed by the Infrastructure Sustainability Council of Australia (ISCA). They define 'Infrastructure Sustainability' as 'infrastructure that is designed, constructed, and operated to optimize environmental, social, and economic outcomes of the long term'.

ISCA has multiple benefits including:

- Providing a common international language for best practice sustainability in infrastructure
- Providing a framework for consistent application and evaluation of sustainability performance
- Help in scoping whole-of-life considerations, enabling smarter solutions that reduce risks and costs
- Building an organisations credentials and reputation in its approach to sustainable outcomes.

To date, over 170 projects have undertaken an IS rating. Of these, there are 10 in the water industry. CI is the only pipeline project in the IS scheme and the only water project registered with ISCA in Aotearoa.

While still emerging in Aotearoa, ISCA has become widespread and commonly accepted in Australia. There is the potential that a mandate to achieve IS ratings could come from New Zealand government in future. Many public entities are signaling their commitment to sustainable infrastructure, with Waka Kotahi committing all projects >$100 million to do an ISCA rating (NZTA, 2020).

The CI decided to undertake an as-built only rating in 2018 as a pilot project for Watercare. In 2019, the project decided to additionally seek a retrospective design rating. Ideally, projects would use ISCA throughout the concept and detailed design phases, but ISCA did not have a presence in New Zealand when CIs detailed design commenced (2014), thus the decision to add it retrospectively to the original commitment of an as-built only rating. The retrospective design rating was sought for a number of reasons:

- To act as a 'stock-take' of where the project was sitting and give an indication of what could be achievable for the as-built rating
- To provide independent verification of the baselining of resource data (energy, materials, water)
- To motivate the project team by being recognized for their commitment to sustainable outcomes and solidify the identity of the project.

The target was set for an 'Excellent' rating which was the contracted goal for the already committed to, as-built rating. After an extensive process of evidence gathering, resource quantifying, and verification, the project was awarded a 'Leading' rating which is the highest possible rating under Version 1.2 of the tool.

An ISCA rating drives projects to embed sustainable thinking into all areas of a project. The categories covered are shown in Table 1.

Table 1: IS V1.2 Categories

Themes	Categories
Management & Governance	Management Systems
	Procurement & Purchasing
	Climate Change Adaptation
Using Resources	Energy & Carbon
	Water
	Materials
Emissions, Pollution & Waste	Discharges to Air, Land & Water
	Land
	Waste
Ecology	Ecology
People & Place	Community Health, Wellbeing & Safety
	Heritage
	Stakeholder Participation
	Urban & Landscape Design
Innovation	Innovation

For organisations or projects at any scale in the water industry, using the ISCA framework to guide sustainable performance offers a specific and applicable framework. Guidance such as the United Nations Sustainable Development Goals, while excellent for framing up directions toward global sustainable outcomes, are very broad and designed to be applied to all activities. Using the IS rating allowed CI to retrospectively measure and realise the outcomes that had been achieved between the concept and detailed design phase.

3.6 EMBRACING BOLDNESS

Innovations are born not only from solving challenges but also from challenging business as usual processes.

Often when considering sustainability, it is easy for people to focus on recycling bins, turning off computer screens, or re-usable tote bags. While these things undoubtedly have their place in a sustainable society, if we are to achieve the objectives set out in the United Nations Sustainable Development Goals, the Zero-Carbon Act, or become 'Fully Sustainable', radical and systemic change needs to be made to our approach to the development and operations of the water industry and our society.

Gathering ideas on how to improve sustainability performance needs to empower teams to challenge traditional thinking and push the boundaries. This means encouraging teams to look past the limitations of budget, time constraints, or existing approaches and consider solutions with blue-sky thinking. This can encourage innovative and opportunity-focused mindsets. CIs ambitious leadership has enabled this kind of thinking. Innovations with significant impact have been implemented due to the projects prioritisation of sustainable values and thirst to improve our environment, industry, and community. Many of these go beyond resource efficiency or cost reduction to the intangible social and cultural value enhancement and step-changes they provide to the industry.

4 WHOLE OF LIFE ANALYSIS

One of the key principles of the application of sustainable design is measuring whole-of-life impact, as you can't manage what you don't measure. Where an initiative might look to save resources when looked at in isolation, or in the short term, it may not be the most efficient solution when looking at the long-term footprint. It was critical to consider the whole design life, in CIs case - 100 years, to determine the most efficient use of resources. In some cases, this can lead to additional resources up front but will ensure the asset will be fit for purpose for its entire design life (i.e does not deteriorate to the point of failing in that time and requiring early replacement).

Resources such as energy, materials, and water are some of the most critical elements of sustainability management and are therefore a key focus in CIs sustainability programme. Resource savings made in the detailed design phase of the project, through value engineering and a focus on reducing excessive designed infrastructure are detailed in this section. Initiatives that are in the process of being implemented in the construction phase since the detailed design or major design changes that have been made recently are not yet included in these totals.

The whole-of-life resource reductions are summarised in Table 2.

Table 2: Summary of resource reductions for CI

Category	Concept design	Detailed design	Units	% reduction
Energy	190,812	111,619	t CO_2-e	41.5%
Water	3,480,428	2,080,948	kL	40.2%
Materials	83,516	70,771	t CO_2-e	15.3%

4.1 ENERGY

Energy, measured in CO_2-e or carbon dioxide equivalent, is a major contributor to GHG emissions and consequent climate change. It is an increasingly major focus of boards and shareholders as the importance of climate related risk disclosure and understanding of the impacts of these risks is becoming well understood. While Aotearoa's electricity grid is on average >80% renewable, the sheer scale of electricity needed for the operation of the CI means the footprint remains significant (MBIE, 2020). This is exacerbated in years such as 2021 where water shortages have meant that hydro-power contribution toward the electricity grid is reduced and the non-renewable sources (coal, oil, gas) make up >20% of the grid (MBIE, 2021).

Operational energy demand for the CI is primarily associated with pumping wastewater from the tunnel to the surface. Construction energy is calculated as the combined electricity and fuel use during the 5-year design period and 6-year construction period (Primarily to run large plant such as the Tunnel Boring Machines (TBM), trucks, excavators, cranes, and other equipment). Between concept design which acts as our base case and detailed design, the project reduced 41.5% overall energy. The bulk of this saving came from the operational space from pump efficiency which was amplified over the 100-year life of the asset.

Table 3: Summary of energy related emissions for CI's detailed design

Phase	Category	Concept Design Emissions (t CO_2-e)	Detailed Design Emissions (t CO_2-e)	Reduction (t CO_2-e)	% reduction of footprint
Operations	Fuel use	-	-		
	Electricity use	160,949	90,958	69, 991	
Total Operations		160,949	90,958	69, 991	36.7%
Construction	Fuel use		19,582		
	Electricity use		1,075		

	Land clearing	3.86	3.86		
Total Construction		29,725	20,661	9,071	4.8%
Total Project		190,674	790,623	79,062	**41.5%**

Since the design rating, a number of additional initiatives have been implemented including an electric locomotive inside the tunnel (400 t CO_2-e), and a commitment to purchasing 3 electric spoil haul trucks (>300 t CO_2-e). The pursuit and analysis of such initiatives continues as the project progresses.

4.2 MATERIALS

The projects main materials used during the construction period are precast concrete, ready-mix concrete, steel, polyethylene (PE), glass/fibre reinforced plastic (GRP/FRP), and aggregates.

The primary unit for measuring materials is, like energy, t CO_2-e. Measuring materials in this one unit (rather than tonnes of steel or m^3 of concrete) equalizes all materials, and means comparisons can be made for initiatives that might reduce one material but consequently increase another.

Materials lifecycle impact can be reduced through either the reduction in overall quantity of materials or the reduction in the GHGs associated with that particular type of material. This could mean using fly-ash or other supplementary cementitious materials (SCMs) to reduce the quantity of cement (a raw material with a high GHG footprint) which lowers the overall GHGs of that concrete mix. Low-carbon concrete mix designs are becoming a prevalent part of infrastructure sustainability on projects.

The greatest emissions reduction opportunities involve two major materials for the project; concrete and steel. These result in 8.87% and 7.32% reduction in emissions respectively. However, some of CIs initiatives resulted in a ~1.25% increase of emissions due to increased plastics and composites.

This occurred when two shafts were designed to be made from FRP rather than the original concrete and steel design. This was done to improve the constructability and in particular, reduce health and safety risks. If it were to be built with concrete, in order to ensure safe construction, the shaft would be required to be <4.5 m in diameter when the flows only required a shaft of 3 m diameter. While FRP has a higher GHG footprint than concrete or steel by weight, the overall impact of the shafts was reduced as much less quantity of FRP was required than concrete. This initiative saved 881 tCO_2-e by using FRP rather than concrete and steel.

Another initiative that reduced materials was modifying certain sites from twin vortex and de-aeration shafts, having a combined diameter of 12 m, to a single cascade shaft with a diameter of just 3 m saving 5738 t $Co0_2$-e. The impact on the respective sites (many of which are public parks) is significantly reduced due to the smaller footprint as well as the quantities of materials, energy, and water required to build the shaft. Furthermore, the cascade drop shafts are specifically designed to have no operational or maintenance requirements for their lifetime; resulting in a reduction in energy, materials, and waste during the operating life of the asset.

Where operational energy dwarfed construction energy, the materials used in constructing the tunnel are far more impactful than the relatively small amount of materials used to operate the tunnel.

Overall, the opportunities for materials reduction, result in 15.3% emissions reduction in the detailed design scenario compared to the concept design.

4.3 WATER

The impact of water can be minimized through two approaches; using less water, and maximizing the use of fit-for-purpose water (which in construction is non-potable water) the latter of which can come at an additional operational cost.

The operation of the CI requires significant water to be used in the air treatment process at the two Air Treatment Facilities (ATF). This is once again a much larger footprint than the construction phase, however Tāmaki Makaurau's water shortage in 2020/2021 has driven the project to prioritise the use of non-potable water for construction purposes (TBM water, dust suppression, wheel wash, general construction water). Initiatives have resulted in a significant reduction in CIs water footprint (Table 4) and use of potable water (Table 5).

Table 4: Water reductions between concept and detailed design

CI Project Phase	Reductions compared to concept design	
	Water usage (kL)	%
Total Operations	1,336,409	38.4%
Total Construction	63,311	1.82%
Total water usage reduction	1,399,720	40.22%

Table 5: Non-potable water footprint of the project

Water Usage	Total m^3
Construction Use	
Southern TBM Drive to be replaced with Non-potable	120000
Total Construction	243740
% of Water Saved During Construction	49%
Operational Use	

Mangere ATF (Non-potable operational water)	1464000
Total Operations	1837208
% of Water Saved During Operations	79.69%
TOTALS	
Total Project Water Use	2080948
Total Water to be Replaced with Non-potable	1581000
% of Potable Water Saved Across Total Life of Project	76%

The process of measuring water highlighted that it is much easier to swap potable water to non-potable than to reduce the demand for water on construction projects. Additionally, the prioritisation of non-potable water can result in using water tankers to deliver water from alternate sources (bores). This can have an adverse result on the energy footprint which would prefer the reduction of using internal combustion engine (ICE) vehicles which produce additional GHG that must be accounted for.

4.4 SUMMARY OF RESOURCE REDUCTIONS

The study modelled the life cycle energy, water, and materials use of the project over its construction period and 100-year asset life.

- Initiatives for energy use result in a 41.5% reduction in GHG emissions and 42.3% reduction in energy use in detailed design compared to the concept design. Initiatives for operations phase are responsible for the bulk of emissions reduction (36.7%).
- Initiatives for water usage result in a 39.4% reduction in water used, and replacement of 76% of the projects water footprint for non-potable water.
- The initiatives for reducing materials lifecycle impacts result in 15.3% emissions reduction for the detailed design scenario compared to the concept design.

5 CENTRAL INTERCEPTORS SUSTAINABILITY INNOVATIONS AND SUCCESSES

The following initiatives have occurred as a result of CIs commitment the quadruple bottom line of sustainability and innovative thinking.

5.1 WASTEWATER REUSE FOR CONSTRUCTION WATER

The Central Interceptor project will use >200,000 m3 of water throughout the construction of the project. Construction water will largely be comprised of the washdown of trucks, dust suppression, cooling the TBM, and conditioning the earth at the TBM face.

As well as the intent to minimise the use of potable water for construction use, the Central Interceptor project is working with Watercare to look beyond the project scope, and ensure long-term resilience in light of climate projections for longer periods of dry days and increased demand on the potable water system as the population increases. This means looking into alternative water sources. A wastewater re-use pilot plant is being built at CIs Mangere construction site which is adjacent to the Wastewater Treatment Plant. It will act as a pilot study to look at the potential for wastewater re-use to be considered, as the future of Auckland’s potable supply.

Sustainable use of recycled water is based on three main principles:

- Protection of public and environmental health is of paramount importance and should never be compromised
- Protection of public and environmental health depends on implementing a preventive risk management approach
- Application of preventive measures and requirements for water quality should be commensurate with the source of recycled water and the intended uses.

Wastewater reuse is not uncommon internationally, whether it be direct or indirect. New Zealand does not have any regulation around wastewater re-use due to our historic abundance of water, however with growing populations and climate projections, additional water sources will be required.

5.2 SINGLE PASS SEGMENTAL LINING METHODOLOGY

Construction methodology of the CI tunnel will comprise of a single pass pre-cast concrete, with an embedded polyethylene (PE) lining. The use of single-pass linings has occurred in New Zealand before on the Hobson and Rosedale tunnels which are smaller diameter wastewater tunnels. The key difference is that these tunnels did not require additional corrosion protection and the segments were pre-cast concrete only. The flows the CI will collect are known to be highly corrosive, which is clear through the condition of the conveyance pipes and tunnels either side of the Manukau siphon (an asset the CI is duplicating due to its degraded condition). To construct the CI tunnel without the embedded PE lining of the segments would reduce the design life by at least half or provide substantially more sacrificial concrete into the thickness of the segments, to a point they would become impractical to install..

The benefits associated with single-pass lining are as follows:

- Safety: The alternative construction of a cast-in-place secondary lining is a labour-intensive operation carried out in a harsh environment. The single-pass solution adopted will significantly improve the safety and working conditions of the workers by eliminating this entire 'cast in place' confined space operation, changing to an industrial process in a controlled factory environment.
- Quality: Incorporation of the corrosion protection liner (CPL) at the segment factory is a controlled industrial process which is easy to monitor and verify, thus reducing the risk of poor quality associated with in-situ concreting (secondary lining often results in cold jointing, which requires the concrete jointing to be broken out and replaced, wasting materials, money, and time).
- Cost: The single-pass segmental lining and CPL achieve a significant reduction in the thickness of the tunnel (28%) along with an associated decrease in the excavation diameter. Pre-casting the CPL allows for this optimisation as its thickness is no longer driven by the in-situ placement of the concrete. This reduction in lining thickness and a 15% decrease in spoil to handle generates significant cost savings.
- Programme: Installing the combined structural lining and the CPL in one single operation, allows for a significant programme reduction versus a two-pass solution. The installation rate for the project will be approximately half the estimated time for the two-pass system.

The resource benefits associated with this innovation have significant savings:

- Materials: The ability to ensure quality at the segment factory ensures that there will be less wasted materials due to not meeting standards. The cold jointing process required in secondary linings also results in a lot of wasted concrete that must be cut out and re-joined
- Energy: The decrease in lining thickness results in a reduction in spoil excavation and haul resulting in energy savings due to less diesel and fuel use. The significant decrease in the construction programme ensures there will be a decrease in energy used for construction.
- Water: Water associated with concrete production and excavation are reduced relative to reductions in concrete quantities and excavation.

5.3 CONSTRUCTION TRAINING CENTER

The Central Interceptor project has developed a purpose built training center, at which all on-site staff are required to undertake a 2-day construction specific induction before they start on site. The training center allows them to experience common construction site mishaps in a safe and controlled environment. The aim is for workers to be able to identify risks and hazards, and be confident to respond on-site while ensuring environmental, archaeological, and cultural sustainability values are embedded on-site. Staff will learn a range of skills including spill response practices, correct processes to pour concrete, what to do if they dig up an archaeological site, and how to set up sediment traps.

The training center is an investment in our people to ensure they have a quicker time to autonomy on-site, and are prepared to look after their health and safety as well as watching out for their team members. The motivation behind this innovation is to reduce the common mistakes that are made early in the life of the project and the need to re-do things on-site, wasting resources and creating waste, and reduce the risks to site staff as the information received can be applied to real-life situations. The skills learnt and practices undertaken at the training center will result in the project having less delays, reduced costs, and reduced risks from errors due to undertrained staff. The training has been reviewed by a literacy coach to ensure it is accessible to everyone.

The concept for the training center has been based on ERGT – Australia's Safety Training Specialists. The training center has aimed to meet ERGTs understanding that immersive, experiential learning results in greater competency and capability in safety training. Construction Health and Safety New Zealand (CHASNZ) is interested in using this model as an example to the broader industry, and suggesting it for use on other sites in the country.

5.4 MATES IN CONSTRUCTION FOUNDATION PARTNERSHIP

The New Zealand construction industry has over 47 suicides each year, accounting for 6.9% of male suicides in New Zealand. Māori suicide rates are nearly twice as high as non-Māori. Statistics show that construction workers are six times more likely to die from suicide than by an accident at work. With over 600 construction workers (30% to be of Māori descent), expected to work on the CI over the next 6 years, mental health on-site will be an important focus.

The Central Interceptor project is a New Zealand foundation partner of the 'Mates in Construction' programme: a charity established to reduce the high levels of suicide rates in the construction industry in Australia and New Zealand. This partnership will allow Mates in Construction to appoint a field officer dedicated to looking after the wellbeing of each person on-site. The project has an advanced health and safety culture and a commitment to the wellbeing of our team members, however the commitment also goes beyond the project to benefit similar projects throughout New Zealand, as the field officer will look after a portfolio of assets.

The adoption of Mates in Construction on the Central Interceptor project will have a significant impact on the construction industry. As the project is the first civil project to adopt the programme in New Zealand, it provides the opportunity to set a new standard of health and wellbeing on construction sites. The learnings that employees take away from the different trainings will be applicable to their lives inside and outside of work.

5.5 DIG DEEP EDUCATION SCHEME

As part of wellbeing initiatives, CI is looking to improve the long-term employment prospects and personal situations of members of our workforce. Testing of all attendees at the project induction confirmed that literacy and comprehension levels of some of our workforce were low.

This data led Central Interceptor's Contractors, Ghella Abergeldie Joint Venture, to structure a practical and realistic 20-week Literacy Programme.

The aim is to direct employees onto a career pathway with greater responsibilities, more qualifications and better pay. It is also to help build their confidence and self-esteem, enabling them to contribute more to their communities. Construction today involves considerable information flow, particularly around work practices and health and safety. Low literacy levels in the workforce can lead to accidents if employees do not understand what they need to do around site.

5.6 DECONSTRUCTION OF EXISTING STRUCTURES

Watercare purchased 2 properties to use the land for the Grey Lynn shaft site of the CI Project. The houses on each of these properties needed to be removed so that the sites were clear ahead of construction. The project wanted to move away from traditional demolition toward a deconstruction methodology. The favoured approach was to have the houses taken apart more carefully to salvage materials, and use the materials for other purposes rather than ending up in landfill. Because this was a small contract, the project was able to take the risk and open the contract for tender rather than going with a traditional demolition contractor. The contract was awarded to Clear Site, who specialise in deconstruction and recycling of houses and buildings. They work to a business model of salvaging as much of the building material as possible, then on-selling on the materials for a profit. This means they can tender at a low price for the client, whilst also realising some profit from recycling and re-use of materials. The deconstruction bid was roughly half the price of some of the other tenders, which were a mix of traditional demolition and deconstruction.

The deconstruction took 2 weeks to remove the 2 houses and clear the sites completely. They salvaged 91% of the material and divert it from landfill. Highlights of the project include carpet underlay going to Mangere to make gymnastics mats, doors sent to Tonga, and Matai floorboards under the carpets that were sold for re-use.

The process of deconstruction requires more care with removing the structures and materials, which means minimized disturbance to neighbours in residential areas compared to the 'smash and bash' style of traditional demolition.

6 CONCLUSION

Sustainable construction and operation of water and wastewater assets is an ongoing and developing space. Our industry is far from functioning in a fully sustainable space, however the frameworks, tools, and knowledge are all readily available to organisations and projects who wish to lead in this space.

The Central Interceptor Project has a drive to create long-term value in our industries and communities. It is leaving a lasting legacy for an industry where much of what we do is hidden underground. The initiatives that have the potential to create step-changes in the industry and the long-term benefits of these initiatives far outweigh any short-term costs.

Attitudes toward sustainability are often likened to that of health and safety 20 years ago, or environmental compliance 10 years ago. With the increasing uptake of frameworks such as ISCA's, and awareness of and attention to quadruple bottom line thinking, the integration of sustainability will become an integral part of the evolving water industry.

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