STAYING AHEAD OF THE CURVE – COST-EFFECTIVE AND ENVIRONMENTALLY CONSCIOUS INNOVATION.

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ABSTRACT (500 WORDS MAXIMUM)

With increased focus on environmental and social outcomes in the construction industry, finding a solution that safeguards our waterways and brings value to the client, ratepayers, and local community is a story worth sharing.

The Waipa District Council (WDC) sought to strengthen an aging pipe bridge across the Waikato River which had minimum fall gravity pipework, fluctuating flows from multiple pump stations, and the potential for hundreds of litres of sewage per second to enter a sensitive and public waterway. Councils' original plan was to refurbish and extend the life of the existing structure while upgrading the size of the pipes. The question was, how could Fulton Hogan provide a solution that kept people and our environment front of mind?

Through an extensive Value Engineering period, Fulton Hogan worked with Waipa District Council to offer an alternative design, taking a "build only" refurbishment contract and replacing it with a modern design and build. After gaining the client's trust through sound design offerings, we set about constructing an economically viable, aesthetically pleasing and structurally improved bridge which is seismically resilient, of a higher quality, and will require less maintenance over its life cycle than its aging counterpart.

The design of the new pipe bridge eliminated piling and concrete works along the unstable banks of the environmentally and culturally significant Waikato River, reduced vegetation clearing, prevented the need to access high-risk erosion zones, and lowered the output of dust from sandblasting and piling works and eliminated vibration to surrounding buildings. This change in scope also resulted in a reduction of construction safety risk, as there was less requirement to work at height, over water and on steep riverbanks. A community waterway rehabilitation project was also implemented to bring the locals together in service of their environment.

Through careful construction and considered design, the Cambridge Pipe Bridge project improved public perception and engagement, protected its people and environment from construction related harm, and saved the client a significant amount of money while adding value over all. We hope to provide evidence that innovation and collaboration hold the key to future improvements in the water and construction industries.

KEYWORDS

Pipe Bridge, Value Engineering, Collaboration, Innovation, Sustainable Outcomes.

PRESENTER PROFILE

Courtney has been working in construction for 14 years in New Zealand and Australia. She is currently based in New Plymouth as the Area Manager leading a civil engineering business unit for Fulton Hogan. Her experience includes management of projects from concept to delivery from major highways, structures and more recently water and wastewater infrastructure. She thrives on realising economic solutions and tackling problems in the "too hard" basket.

INTRODUCTION

In 2018 Waipa District Council (WDC) were faced with an aging pipe bridge over the Waikato River carrying a gravity sewer pipe running at capacity and nearing the end of its service life and potentially restricting further housing development within Cambridge. The bridge was in need of repair and the pipe needed to be urgently upgraded to meet the future needs of the Waipa District in alignment with the Waipa 2050 growth strategy.

This presented a considerable environmental and infrastructure resilience risk to WDC. The delivery timeframe was a key success factor for WDC due to these pressures.

The project was awarded to Fulton Hogan who worked with their subcontractor Eastbridge and WDC to offer an alternative design. This resulted in a cost saving to the customer and an estimated $1M of value added. The outcome was to move from the original plan of strengthening the existing services bridge, to offering a completely new network arch bridge. The project team committed to designing and building a new bridge and commissioning the new sewer line in the same time period as the original contract.

The alternative design was offered at a reduced cost to Waipa District Council. This alternative design was an example of innovative value engineering and also resulted in improved environmental, social and safety outcomes.

Photograph 1: Photo of the Original Services Truss Bridge prior to upgrade (01/08/2017)

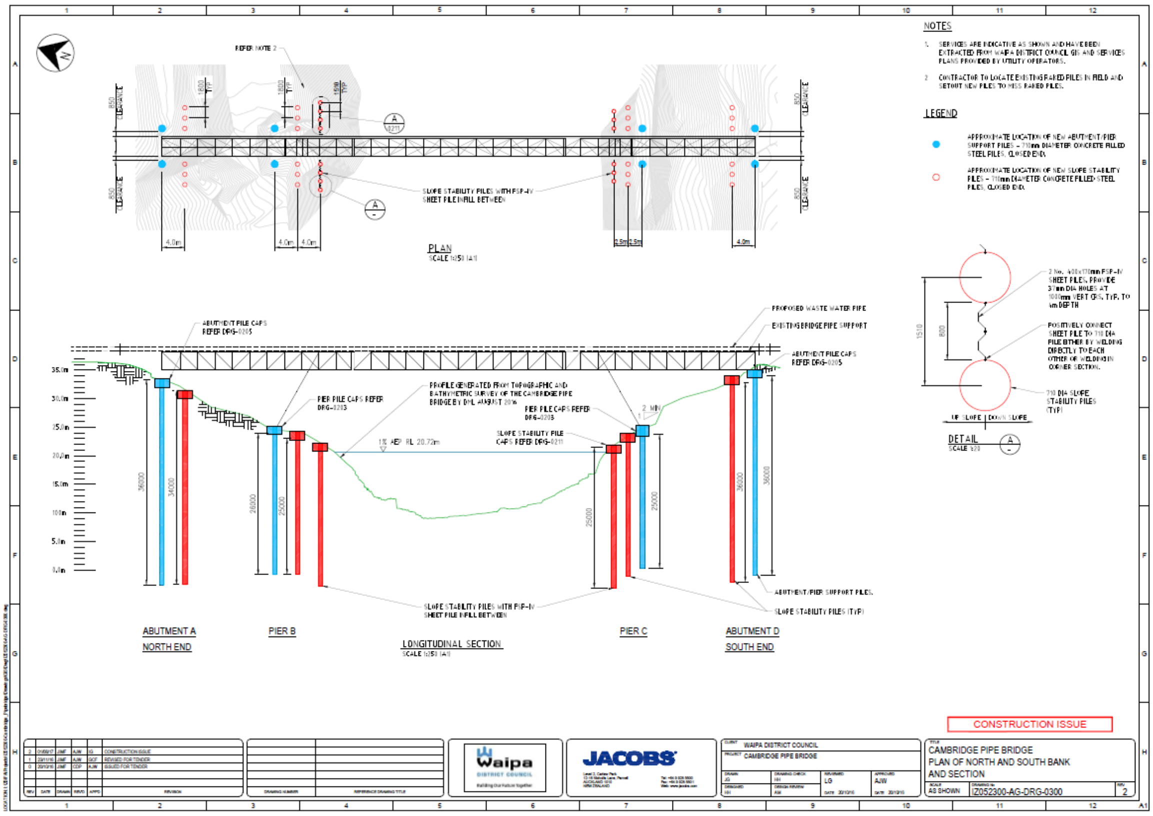

Figure 2: Original Piling Arrangement (Tender Documents)

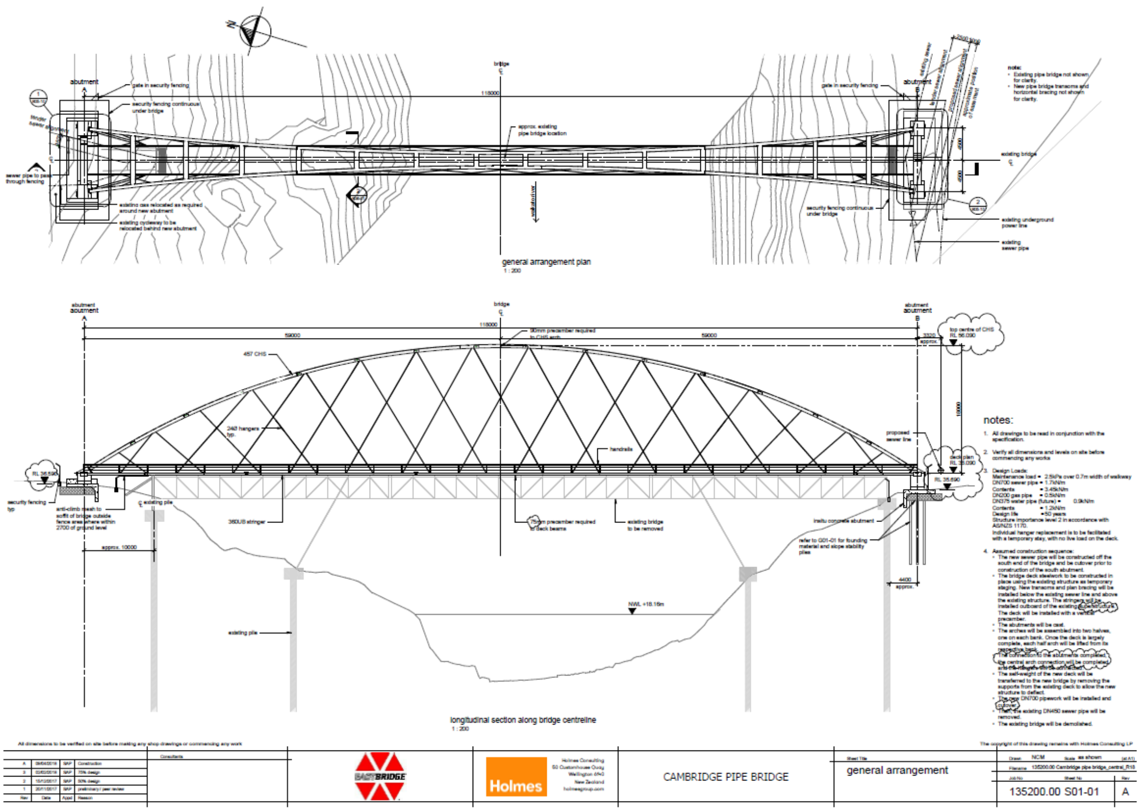

Figure 3: General Arrangement of the New Network Arch Bridge (IFC Drawing Set)

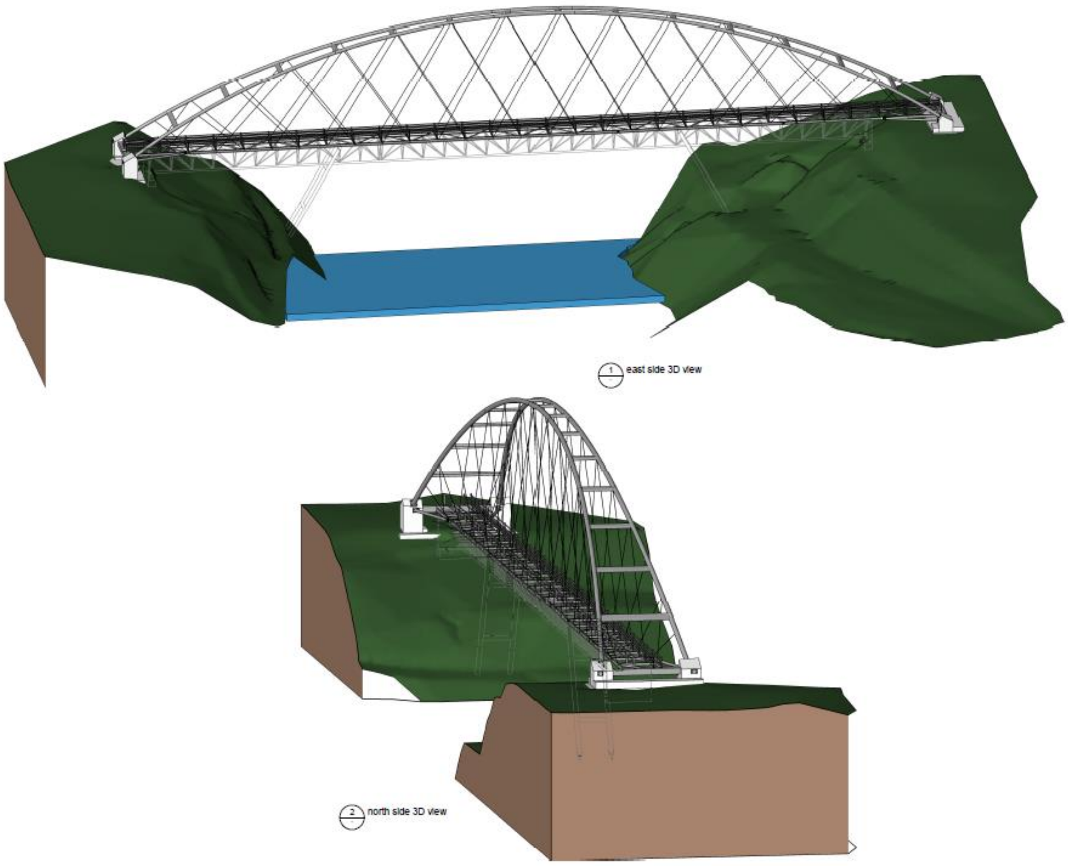

Figure 4: 3D Visualisation of the New Network Arch Bridge (IFC Drawing Set)

LOCATION

The project crossed the Waikato River between Cambridge town centre and the suburb of Leamington. Access to the northern abutment of the bridge is off Alpha Street via the entry to the Gaslight Theatre, Cycleway and Riding for the Disabled. Access on the Southern abutment is via private property on Matos Segedin Drive, Leamington.

Construction and design challenges specific to this location included contaminated land, a close proximity heritage listed building, steep river slopes, critical live services including a local water intake and treatment plant, 110kV power (above and below ground), medium pressure gas, public cycleway and parkland. Changing the design dealt with some of these challenges by reducing the risks of working on steep river slopes and accessing high erosion zones, avoiding piling within 50m of a heritage building, and less earthworks and disruption of contaminated land.

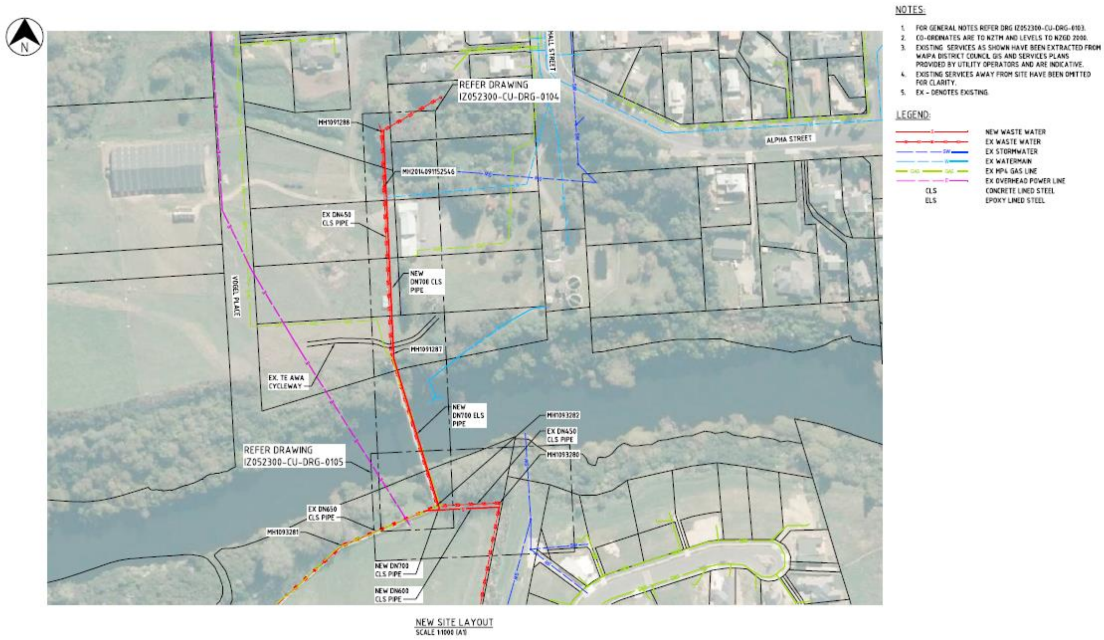

Figure 5: Location Plan

DESCRIPTION OF SCOPE OF WORKS

The project involved the replacement of a services' bridge over the Waikato River and the elements included;

- Construction of 320Lm 700mm diameter concrete lined steel sewer pipe above and below ground
- Construction of 20 concrete foundation structures to support bridge and sewer
- Removal of 320Lm 450mm diameter sewer pipe
- Design and construction of a new 118m network arch bridge with a 50 year design life to withstand an IL2 seismic event
- Minimisation of pipe displacement to eliminate risk of failure during seismic and other loading conditions such as wind
- Demolition and removal of the existing 102Lm truss bridge
- Relocation of 11kV underground power
- Relocating the existing DN 200mm medium pressure gas main onto the new bridge
- Relocation of cycleway on northern bank

The new network arch bridge was installed on the same footprint as the existing bridge with new DN 700mm sewer pipe and a gas pipeline. The existing DN 450mm sewer pipe was replaced with a new DN 700mm sewer pipe over the bridge, connecting to an existing manhole on the northern side of Moon Creek. An existing length of above ground sewer on the southern side of the bridge was replaced with a DN600mm pipeline. 20 significant concrete foundation structures were required to upgrade the above-ground pipe supports to meet modern seismic standards suit the larger pipeline.

Once commissioned, the aboveground elements of the existing bridge were demolished and removed with the exception of the pile caps which remained in place for bank stability.

Significant bankside management was required to navigate two major pipe cutovers to transfer flows from the existing to the new sewer pipes. Associated ancillary works such as detouring and relocation of the Te Awa Cycleway, construction of laydown areas, vegetation clearing and rehabilitation, construction of access off Matos Segedin Drive and fencing were also required as part of the works.

INNOVATION

VALUE ENGINEERING PROCESS

WDC had been working on bringing this project to market since as early as 2015, when they commissioned the first of the site investigations. Council engineers had spent at least three years investing in the project and bringing the solution to market. The original Contract Summary in the RFT described the works as *"Physical works associated with upgrade of the Cambridge sewer bridge (Bankside strengthening, foundations and bridge structure), plus replacement of the main sewers on the bridge and on either bankside." (Podrumac, 2017)*

The Council identified early that *"there is a possibility to reduce overall construction cost especially associated with bridge foundation and bankside works associated with these contract works."* They believed that the market and ultimate construction partner may have a range of solutions that they had not explored and could be in the interest of all parties. WDC structured the contract to include a four week Value Engineering period as well as an incentive payment structure for any savings that were made by "Design and Construction Methodology Optimisation". The details of this incentive are provided below in an excerpt from the RFT.

> *"On contract award the Contractor is to work over a four week period with Council and Council's designer (Jacobs) to determine and quantify any significant construction cost savings and associated risk mitigation to the project by optimisation of design and / or construction methodology. NB Jacobs costs will be paid directly by Council.*
>
> *At the end of this period any design changes acceptable to Council and Jacobs (as the designer) will be priced by the Contractor and the suggested changes to the Schedule of prices indicated.*
>
> *To incentivise this piece of work Council would be willing to share any cost savings with the Contractor on a 70:30 basis, i.e. 70% of savings to Council and 30% to the Contractor. Such a payment would be related only to any savings indicated to the Schedule of prices on completion of this work item and will not carry forward to any subsequent work items or variations. The incentive payment would be paid on successful completion of the associated physical works to which the suggested scope change and savings apply.*

Council at its discretion at the end of this work item may choose not to proceed with any design or scope changes and if so will revert back to the original tendered schedule of prices and work scope." (Podrumac, 2017)

Waipa DC had set up the contract to encourage innovation with a 4 week embedded value engineering period, and a cost saving share scheme. This incentivised the selected construction partner to seek added value.

The value engineering period was then extended from an initial 4 weeks to 6 weeks to fully explore the alternatives offered by Fulton Hogan.

Due to WDC's belief in the opportunities of the proposal, they were willing to revisit their own decision making and effectively let go of the project they had bought to market, invested in and envisioned delivery of over the previous three years. This collaboration resulted in an opportunity for an innovative solution to be achieved.

CONTRACT MODEL

The shift in scope from bridge upgrade to a bridge replacement resulted in a change to approximately 60% of the project scope by value. To manage this shift, a hybrid contract model was developed. This retained 40% of the original project scope as a NZS 3910 measure and value, construct only portion, and 60% became a Lump Sum, design and build portion under NZS 3916. The design and build part of the contract was managed via a major variation and was broken into a small number of schedule items payable on a progress basis.

Taking this route was not an easy road for either Fulton Hogan or WDC. It took significant effort, trust and belief by all parties. The team faced some challenges in moving from a measure and value, construct-only contract model to a design and build hybrid contract. WDC effectively handed over the reins of a significant portion of the project. In doing so, they threw their initial expectations of what they were delivering out the window, along with several years of preparation for the delivery phase. This is a prime example of how collaboration, though not always easy, can result in best-for-project outcomes and pave the way for innovation.

A summary of the overall contract is provided in Table 1 and 2 below.

Table 1: Contract Programme Summary

	Tender	**Actual**
Award Date	11/05/17 + 3 months	18th July 2017
Contractual Start Date	10 days from award	1st August 2017
Original Completion Date:	52 weeks plus 4 weeks contract optimisation 29th August 2018	52 weeks plus 6 weeks contract optimisation 29th August 2018

Actual Start Date on Site	10 days from Letter of Acceptance	12th December 2018
Weather Extensions of time		0
Paid Extensions of time:		42 days
Un Paid Extensions of Time		17 days
Final Approved Contract Completion:		21 December 2018
Actual Contract Completion:		21 December 2018

Table 2: Project Financial Summary

	Original Tender Scope	Value Engineered Scope
Project Value	$6.130M	
Revised Contract Value (V01) – change in scope post-award	$6.689M	$6.295M
Approved Variations		$593k
Final Project Value		$6.887M

COLLABORATION

Waipa District Council had to make a major decision early in the project. They were faced with evaluating the alternative solution risks and opportunities within the first weeks of the contract. This was a high-risk high-reward decision, particularly in terms of design and consenting time delay that may have resulted in changing the project scope so dramatically. At this stage the project team was still forming, with low levels of trust, and roles and relationships still developing.

The Value Engineering phase was made up of a series of workshops. The project team was made up of approximately 14 people during the early stages and were geographically distributed (Client side 4 WDC, 2 WSP, 2 Jacobs. Contractor side - 2 FH, 2 EB, 2 Holmes). Everyone came together in person for four full day workshops spaced approximately fortnightly. Success factors for the workshops included;

- Agenda and objectives clearly outlined
- All information tabled and circulated in advance
- Chaired with discipline
- Clear decision points to achieve during the workshops
- Actions tracked to keep all team members on task and united between the workshops
- Minutes taken and circulated

The team culture developed in the crucible of these early weeks. The collaborative, productive workshops were a tool that became engrained in the project delivery. These were reframed as High Risk Task Workshops and held for all major project activity planning. This level of collaboration resulted in smooth delivery, removal of barriers and maximised the collective experience of the project team really giving everyone an opportunity to contribute.

A key risk in the early decision making was the impact on changes to the existing construction and operational resource consents. A new resource consent was required for the new bridge structure. All the approved project resource consents had to go through an amendment process which was risky in terms of time and potential for rejection by the various approval parties.

Long term operation and access easements also required revision for the pipeline on the southern abutment. As the bridge abutment was located further south than the existing abutment, the new pipeline also had to be relocated slightly further south than originally planned. This change required considerable negotiation to reach agreement with the landowner.

KEY CHALLENGES

RESOURCE CONSENTS

WDC had already secured the necessary consents for the original project scope of works. These consents needed to be revised and re-submitted for approval by the relevant authorities. There were cost, time and preparation inputs required, as well as the additional risk that the amendments may not gain approval. Ultimately, this process went smoothly and all the necessary consents were approved parallel to the design process and did not result in any delays.

EASEMENTS / LANDOWNER SETTLEMENT

Easements for the existing bridge, sewer pipework and other services (gas and power) were a constraint in the development of the new bridge alternative. The new bridge abutments needed to be located behind the existing bridge abutments but retain all elements within the existing easements and not encroach unnecessarily into the adjoining private land. The pipework and new bridge abutments did result in the loss of some of the useful grazing area on the Southern Abutment and which required the easements to be renegotiated with the landowner. Negotiations are ongoing.

A further challenge was the need to secure a larger construction lay down area for the assembly and launch of the network arch. This required construction leases to be revised and extended to account for extensions of time in design and consenting phases.

BURIED HV CABLE RELOCATION

One challenge which was not anticipated during the design process was the need to relocate an underground 110kV cable. The as-built position of this cable was not shown in its true position in the design documents. When this cable was positively identified it was found to clash with the revised pipe alignment and footings. A further complication was that this cable was buried in an area with suspected asbestos contamination and was required to be treated as contaminated throughout the relocation process. Furthermore, a new easement was required to be negotiated for the revised position of the HV cable once it was relocated.

PROJECT BENEFITS

This project offered significantly more value to WDC while also reducing the construction risk profile for Fulton Hogan. This was especially true regarding construction safety and environmental risks. Fulton Hogan valued these benefits at ~$860k. A cash back was also able to be provided to WDC of $180k.

The new bridge offered the following benefits over strengthening the old structure:

ENVIRONMENTAL

The original project scope involved significant piling on the banks adjacent the Waikato River. This would have required 46 No. 710mm diameter permanent piles to an approximate depth of 25m to 36m. The piles were planned to be bottom driven using a closed 710 diameter steel casing to the required depth, and then filing the casing with reinforced concrete.

The network arch option was instead supported by two large raft foundations. These foundations were set further back on the river banks behind the abutments of the original truss bridge. This avoided the need for much of the works on the steep vegetated riverbank slopes.

The piling would have required vegetation clearing and trimming of up to 3000m^2 including the access tracks and piling platforms required. The actual vegetation clearing required was less than 600m^2 with the majority of vegetation able to be trimmed rather than felled entirely. Erosion, slope instability and sediment control associated with vegetation clearing of embankments for slope stabilisation works was significantly minimised.

Piling vibration, welding, heavy lifting and concrete works on the steep banks in close proximity to the Waikato River were also eliminated. Ultimately, no construction access was required along the river banks which are high risk erosion zones and all heavy plant was able to be located on the flat areas behind the existing bridge abutments. Dust, noise and vibration generation associated with piling works was also eliminated. Pumping concrete adjacent any waterway is an environmentally high risk activity and was entirely avoided with all concrete works able to be completed 30m+ from the river.

The bridge replacement option eliminated the need to sandblast and paint in-situ over the river. The sandblasting and painting would have required a significant scaffolding structure, encased to contain the dust and debris generated in this process.

Figure 6: Proposed Scaffolding Visualisation for Original Tender Scope showing the extent of the works required on the river banks.

Lastly, a small tributary called Moon Creek ran through the project footprint. The area was overgrown with invasive weeds and had been littered by illegal dumping and was an area that attracted anti-social behavior. A project initiative was to clean up this stream and involve local community stakeholders, project team members and subcontractors to plant native trees, collect litter, spread mulch and tidy up this area. Volunteers were also able to assist with maintaining the Riding for the Disabled carpark and fencing.

HERITAGE

Directly adjacent the project, the closest building structure is the heritage listed Gaslight Theatre building. This building had been earthquake strengthened and was regularly used by community groups. Significant disruptive piling scope within 50m of this building was avoided.

GEOTECHNICAL

Geotechnical risk in construction was reduced due to elimination of bank disturbance, reduction of vegetation clearing and elimination of piling vibration.

WDC were able to install a new structure built to new seismic design standards (IL2) and using modern materials which will have improved and more certain service life and maintenance costs.

CONTAMINATED LAND

Contaminated ground also presented a significant health risk. A benefit of eliminating the large piling scope and access tracks was to significantly reduce the volume of earthworks and soil disturbance required for the project. This resulted in reducing worker exposure to these potentially harmful contaminated soils.

The northern abutment is a designated HAIL site with known contaminants from a historic gas works. A Detailed Site Investigation Report prepared by Jacobs (Smith et al, 2017) identified the following contaminants in the northern abutment area; Coal Tar, phenols, BTEX, ammonium-N, sulphate and cyanide, dissolved copper, lead and zinc.

The southern abutment was formerly a piggery which was demolished and buried on the site. The site was highly suspected to have friable white Class A Asbestos in the soil from the buried buildings. This was confirmed in subsequent site investigations.

A specific Contaminated Land Management Plan was developed and followed strictly throughout. PPE and Hygiene protocols were required for all soil disturbing activities. A daily log was kept detailing all material movements on and off site. All soils were retained on site within the original land parcels with minimal disturbance with the exception of confirmed areas of asbestos contamination. These areas were removed by licensed professionals and disposed of in registered landfill to decontaminate the site prior to commencing works.

SAFETY

The construction safety management and complexity was significantly improved by moving from the original bridge upgrade to the replacement option. Limited access and works were required along the steep embankments of the Waikato River. The only time the areas on the riverside of the original bridge abutments were required was for minor vegetation clearing to enable demolition of the original structure and for disconnection of the original bridge pier supports. Access was by personnel on foot with small tools only; no plant was required to access these areas. Further, the exposure of personnel to these steep areas was reduced to less than one week of works during the entire programme.

The new network arch was prefabricated and coated off site. This resulted in a large reduction in exposing workers to work at height risk when compared to retrofitting the existing structure. The network arch was assembled in 12 weeks on site using a 400T and 250T crawler crane. During the main arch installation and the truss bridge demolition the project peaked with five cranes on site. Furthermore, the majority of works were able to be completed on level ground with good access and well away from the river. This included on site welding, assembly and launching of the sewer pipework across the new bridge using a temporary jacking and support system.

PUBLIC IMPACTS

Riding for the Disabled have a covered arena that was used regularly within 100m of the project and shared an access throughout. The stakeholders were concerned about the sensitivity of both animals and their riders with the disruptive vibration and noise. This was able to be avoided; regular consultation was maintained with RDA, as well as Gaslight Theatre and other local residents for the small number of noisy, high vibration or disruptive operations. These included completing repairs to the access, night shift works for bypass pumping and cut-in operations, detouring of the Te Awa Cycle way, utility disruptions (gas, power, water) and heavy lifting operations.

The reduction in piling and soil disturbance allowed dust, noise and vibration impacts on neighboring residents to be minimised. Public perception throughout the project was overwhelmingly positive with very few reported complaints.

A drinking water intake and treatment plant are located below the bridge. This infrastructure also would have been an added constraint to the original piling scope from an access and sediment control perspective. This risk was eliminated in moving to a bridge replacement.

It was identified early in the project that the existing bridge was being used unlawfully by a small number of young adults to cross from Leamington to Cambridge. The original truss bridge had a small maintenance walkway with a basic handrail. It was fitted with features to restrict access including fencing, locked gates and clear warning signage. Previously, Council had removed swings that had been attached to the bottom of the bridge and had to regularly repair the fencing where it had been vandalised. Additional temporary fencing and signage was installed and local schools were contacted throughout the project to inform them of progress and warning of the rapidly changing nature of the site. After taking this action no children were observed or reported crossing the bridge and there were no reports of unauthorised access or vandalism throughout the project.

Further, the council and public now have a leading edge bridge design with modern aesthetics. This is expected to have lower lifetime maintenance costs than continuing to maintain the old structure. The new arch bridge meets modern seismic design standards offering improved reliability and resilience in the event of an earthquake.

Photo 2: Network Arch Bridge Lift (October 2018)

Photo 3: Launching sewer pipework across new bridge structure, original truss bridge below prior to its demolition (November 2018)

Photo 4: Completed Network Arch Bridge (December 2018)

CONCLUSIONS

This paper details one successful example of how innovation and collaboration can be intentionally fostered in project delivery to generate environmental, social, safety and cost benefits. A critical factor to the success of this project was the Council's openness to working with Fulton Hogan to refine project scope from the outset. WDC had a willingness to revisit their design solution and a belief there was still opportunity to add value.

A further benefit of a well-designed value engineering process was that this forged a spirit of collaboration with the project team that endured the length of the project.

The new solution achieved the same design criteria and provided the same or greater benefits than the original scope.

Overall, through a trust-based partnership between Fulton Hogan and WDC that endorsed innovation, the project was able to offer considerable benefits over and above the original design solution. The alternative design solution cost less, reduced the short and long term environmental impacts and delivered more long term infrastructure value.

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