GatewayWA
Perth Airport and Freight Access Project

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BG&E

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2. Abstract

The Gateway WA Perth Airport and Freight Access Project is a major road improvement project providing access to Perth Airport and relieving traffic congestion by providing grade separated interchanges. The $1 billion road construction project, jointly funded by the Australian Government and State Government is due for full completion, having commenced on site in 2013, in early 2016, some nine months early.

The project also provides free-flow traffic access between Perth Airport and the major arterial roads of Tonkin Highway and Leach Highway, easing freight traffic flow between Kewdale and the major freight routes and removing congestion around the airport network. The upgrade to the main Tonkin Highway section forms the spine of the project.

The Gateway WA project has resulted in a number of firsts for Western Australia. The first Single Point Urban Interchange (SPUI) to be constructed, the first use of Continuously Reinforced Concrete Pavement (CRCP) within a road project, the first use of bath structures associated with an infrastructure project, as well as standardisation of precast planks to other Australian states. It includes 11 road bridges, eight underpasses, one footbridge, three bath structures, extensive use of mechanically stabilised earth (MSE) walls and approximately seven kilometres of noise/screen walls. All of the structural elements were integrated into the project with a high level of urban design.

The project was delivered under an Alliance involving Main Roads Western Australia (Main Roads), CPB Contractors*, Georgiou, AECOM, BG&E and GHD with a high level of cooperation among Alliance participants achieved by working in project-oriented teams.

The Gateway WA project has not simply created a utilitarian functional solution with 'architectural window dressing' but has resulted in full integration of urban design across the whole project and set a benchmark for future infrastructure projects that act as the entry point to cities and countries alike.

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(*CPB Contractors, formerly Leighton Contractors, is the CIMIC Group's construction company.)

3. Key Words

Gateway WA, Alliance, Main Roads, SPUI, top down, urban design, Grand Gateway, Sky Ribbon, Earth Ribbon, bath structures, bridges, underpasses, aviation constraints.

4. Type of Contract

Gateway WA is being delivered using an Alliance contract where five industry leaders, CPB Contractors, Georgiou, AECOM, BG&E and GHD are working in partnership with the state's road authority, Main Roads, to deliver the infrastructure.

The project was jointly funded by the Australian and State governments, with Main Roads awarding the Alliance contract by competitive tender in November 2012.

An Alliance of industry leaders coming together to deliver the work fostered an environment of innovation and fresh thinking about all aspects of the project.

The Alliance partners prepared the Direct Cost Target and detailed design for the project prior to commencing the major construction of the road network. The Alliance's systems for environment, quality and safety were certified by SAI Global.

The project was divided into separate zones that each had its own project manager and associated team. For procurement purposes, the commercial team supported the different zones by looking for opportunities to achieve economies of scale where possible. By contracting competitive and efficient suppliers to carry out work across all zones, this coordinated approach saved money for the project overall.

5. Design Process

The detailed design of Gateway WA was undertaken by AECOM, BG&E and GHD with overall design management undertaken by CPB Contractors.

An in-house design management team was assembled to oversee all designs, plans and drawings issued by the individual design teams. Before a drawing was issued for construction (IFC) it passed through an inter-disciplinary squad check review and comment process, at 15% and 85% stages, as well as the external review and verification process.

This involved distributing plans to approximately 11 internal disciplines, from environmental, community and stakeholder engagement to construction. Once these comments had been addressed and closed out, the drawings could be issued for final certification and ultimate IFC.

As part of the review process separate Safety in Design (SiD) reviews were undertaken at 15% and 85% stages. The process included a workshop based on qualitative risk assessment of each distinct work package at the two stages, with the SiD assessment covering construction, operation, maintenance and decommissioning where applicable. Attendance at the workshops involved key members of the design team, construction team and the future asset manager and facility maintainer. The reviews were arranged so that similar design types (e.g. underpasses and/or design areas) were reviewed at the same time. Specialist reviews were undertaken to cover disciplines such as the Intelligent Transport System (ITS) and pump station, where there would be a strong focus on mechanical, electrical and water interaction, and which would require specialist advice, particularly for the operation and maintenance requirements post construction.

Where risks were classified as moderate or above, mitigation measures were discussed and agreed. Risks were then re-assessed with these mitigation measures included. The aim of the process was to reduce residual risks to a severity of 'low' or 'negligible'. In some cases, the risks could not be reduced to the targeted residual risk level, and the resultant risk(s) were documented to be managed by the construction team or asset owner.

The project had seven distinct areas, later expanded to 11 (three of which fell outside of the main project scope), with the design broken up into disciplinary elements primarily covering civil, structural, landscaping and ITS. The InCite document tracking system used by the Alliance proved invaluable for handling the 7,890 drawings and associated reports, specifications and correspondence.

Designers will remain on the project until final completion, with a dedicated Construction Support Team to assist with ongoing design and construction challenges and value engineering.

6. Introduction

The Gateway WA Perth Airport and Freight Access Project is a major road improvement project providing access to Perth Airport and relieving traffic congestion by providing grade separated interchanges.

The project is the largest in monetary value ever undertaken by Main Roads at approximately $1 billion. A schematic map of its context is shown in Figure 1 with a more detailed map of the project shown in Figure 2. Tonkin Highway is a major north-south connector route in the Perth metropolitan area, and the project includes the upgrade of seven kilometres of this to free-flow from Great Eastern Highway to beyond Roe Highway, part of the major ring road for freight traffic around the southern metropolitan corridor. This upgrade section forms the spine of the project, while the project also provides free-flow traffic access between Perth Airport and the major arterial roads of Tonkin Highway and Leach Highway, as well as the easing of freight traffic flow between Kewdale and the major freight routes.

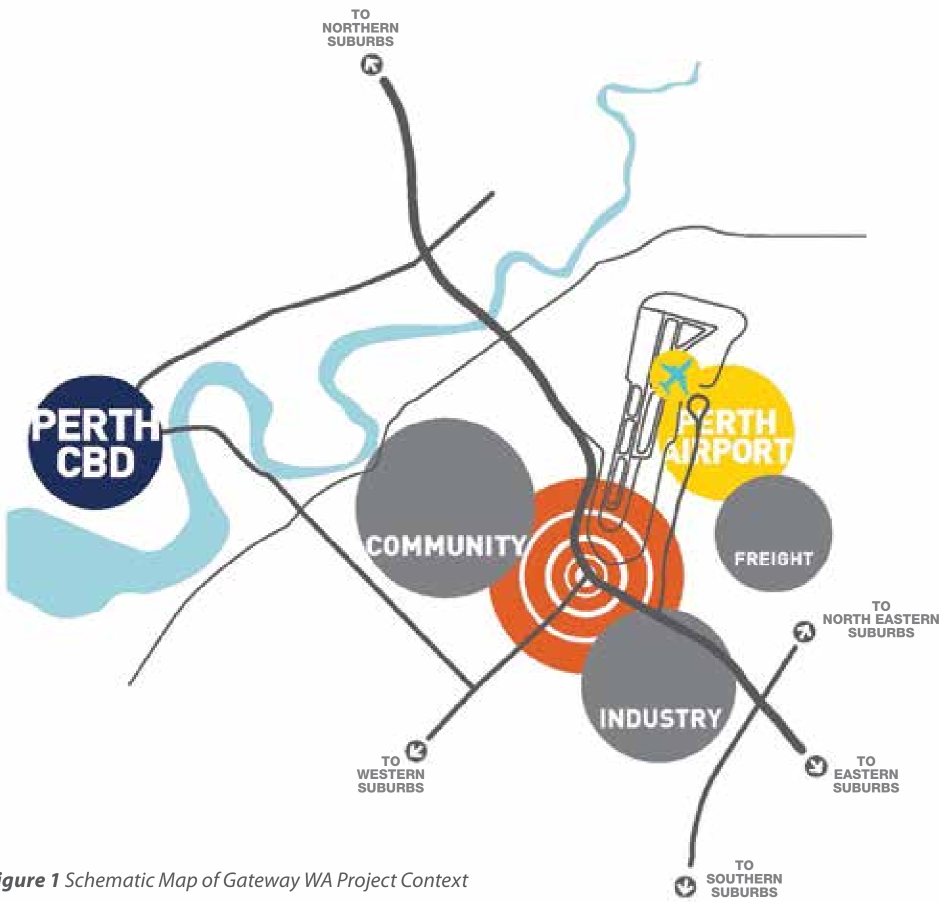

***Figure 1** Schematic Map of Gateway WA Project Context*

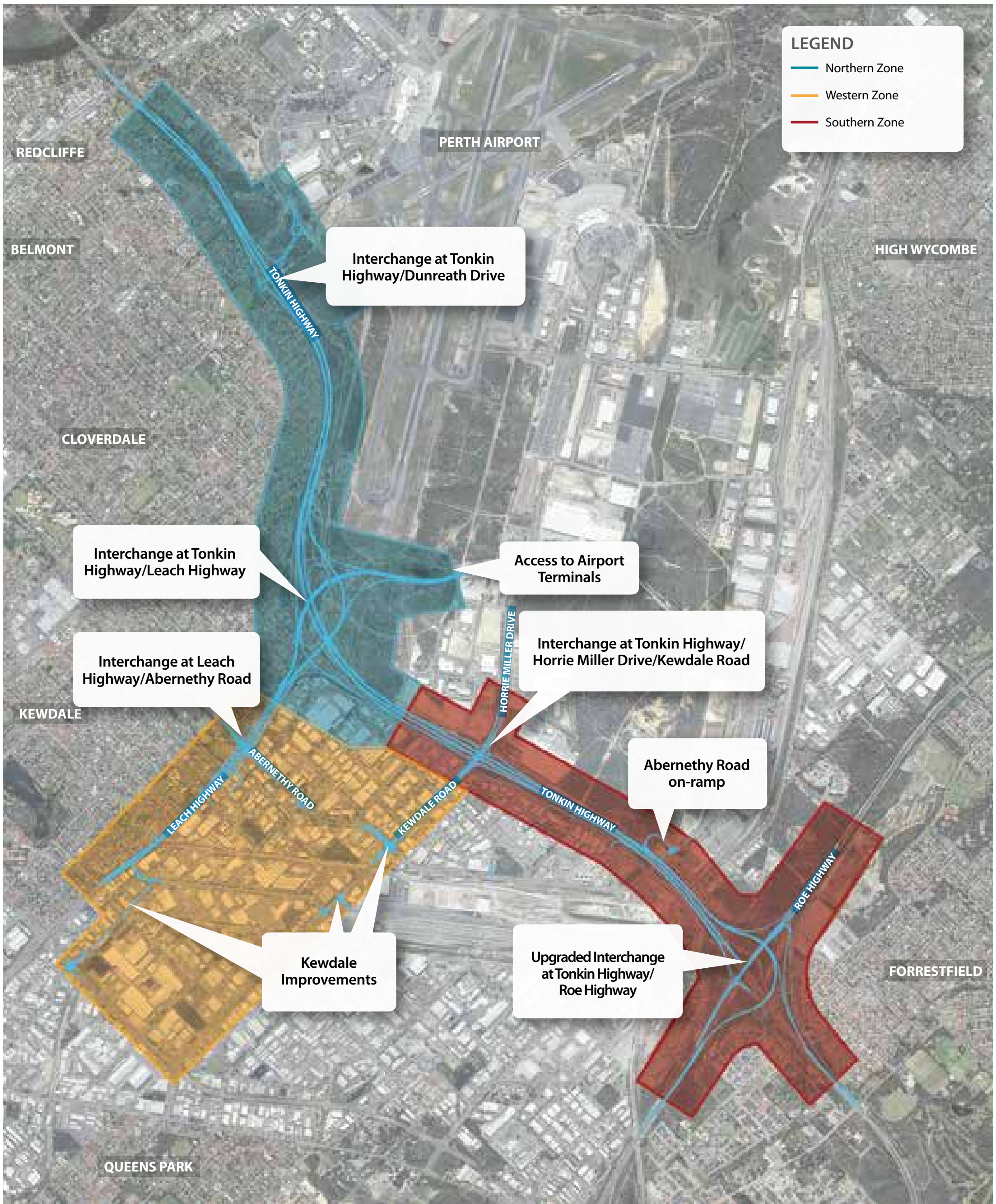

Figure 2 *Map of the Gateway WA Project*

The project provided an opportunity to form a 'gateway' to the city of Perth that expresses the dynamic, creative and rapidly evolving character of Western Australia.

The project used innovative and integrated urban design concepts to create a themed journey for both local users and national and international visitors alike, which includes coloured way-finding cues to the major landmarks of Perth City (city theme), the Swan River (river theme) and surrounding Darling Range (range theme).

Additionally as part of the central Grand Gateway, the main Tonkin Highway/ Leach Highway interchange providing access to the airport, the urban design features a 'Ribbons through the landscape' theme. This draws from the natural Perth landscape setting and represents earth, sky and vegetation through public art features Earth Ribbon, Sky Ribbon and Land Art. Functional elements including noise/screen walls, retaining walls, bridges and abutments, highway lighting and landscaping are incorporated into the urban design.

The Grand Gateway will provide a first impression for residents and visitors to Western Australia for years to come.

7. Project Scope

The Gateway WA Perth Airport and Freight Access Project is a $1 billion road construction project, being jointly funded, with the Australian Government contributing up to $676 million and the State Government contributing $310 million. The project is designed to improve the safety and efficiency of one of the state's most important transport hubs and create an entry statement to the state of Western Australia.

The project road upgrades cater for the expected doubling of passenger air travel to and from Perth Airport, prior to its planned consolidation of the airport terminals.

The upgrades also cater for an anticipated doubling of freight and container transport within the Kewdale Industrial Precinct by 2030.

The project comprises:

- Approximately 5.9 million tonnes of bulk earthworks materials (embankment and granular pavement 'aggregates');
  - Over four million tonnes of this was imported; the balance (1.8 million tonnes) was cut-to-fill site earthworks;
  - Over 1.2 million tonnes (29%) of imported material was recycled or waste product rather than virgin material;
  - 10% of recycled/waste material was produced from construction and demolition waste (C&DW), constrained by supply chain limitations and quality issues;
- Widening seven kilometres of one of Perth's main arterial roads, Tonkin Highway, to six lanes;
- Upgrading three kilometres of another of Perth's main arterial roads, Leach Highway, to expressway standard;
- Constructing four new grade separated interchanges, including the first freeway to freeway standard full movement free flowing interchange in Western Australia;
- Upgrading a fifth grade separated interchange (as part of a variation);
- Local road improvements in the Kewdale Industrial Precinct;
- Constructing around 21 kilometres of shared path and local connections for pedestrians and cyclists;
- Construction of 11 road bridges, eight underpasses and one footbridge;
- Construction of approximately 7.3 kilometres of noise/screen walls;
- Installation of approximately 26,520 square metres of MSE wall panels, all of which were painted to reflect the urban design themes;
- A landscaping program that involves the establishment of more than one million plants; and
- Innovative urban design and the installation of ITS technology also formed the main scope of the project.

All of the above were undertaken while keeping access and the level of service to road users no worse than what was experienced prior to commencement on site.

8. The Grand Gateway at the Tonkin Highway/Leach Highway Interchange

As previously highlighted, the major interchange between the new airport link with Tonkin Highway and Leach Highway, shown in Figure 3, is a focal point of the project and is referred to as the Grand Gateway.

Figure 3 *Aerial photo of Tonkin Highway/Leach Highway interchange looking from south-west towards the airport showing the interchange's four bridges and landscaping of the Grand Gateway*

The Grand Gateway at the Tonkin Highway/Leach Highway interchange provides a new main access point to Perth Airport. The interchange replaced an existing signalised T-junction at Leach Highway and Tonkin Highway which did not provide direct connectivity to the airport. Maintaining the existing flow of traffic through this interchange without causing any additional delay was critical to the phasing of the interchange construction. As the interchange occupies land that had been unused due to airport proximity, it was possible to deviate public traffic around this part of the site for the construction period. This assisted in efficiency and safety during bulk excavations for the structures.

As previously stated, an unusual feature of this interchange results from its location at the end of the main runway of Perth Airport, where there are severe height restrictions for air traffic navigation and landing systems. The height of permanent structures, road traffic, construction cranes and even the heights of the light poles are affected by these restrictions to varying extents, depending on their proximity to the flight path and tracking systems. Although the interchange loops are deviated to the left of the flight path to mitigate the magnitude of these restrictions (as seen in Figure 3), the road grade separation was principally achieved by lowering the roads under bridges rather than simply building approach embankments to bridges at higher levels.

In addition to the lowering of the road profiles, the use of slender bridge designs was adopted to reduce the overall construction depth. For the main multi-span bridge in the interchange, Bridge 1716, this was achieved by making the beams fully integral across the piers, by the use of an insitu diaphragm. To increase the openness of the structure, the diaphragm was also transversely post-tensioned, so that a pair of slender columns could be provided. By using this innovative solution, reducing the overall depth of the bridge structures assisted in reducing the overall construction depth of the interchange, thus allowing slight adjustments to be made in the lower road alignment and reducing the impact depth into the groundwater table.

The lower road design levels intercept natural groundwater levels and, as environmental constraints prevented the permanent lowering of groundwater, bath structures were required to prevent saturation of the pavement. As the groundwater falls to the north-west, the aforementioned deviation of the interchange mitigated the depth of penetration into the groundwater. Extensive hydrogeology studies were undertaken to determine the design groundwater levels for the bath structures and to ensure that normal groundwater levels were not adversely affected by the works. It also determined an acceptable system of temporary dewatering for the construction of baths and associated works by pumping into a detention pond that maintained normal groundwater levels in the nearby nature reserve and adjacent properties.

The resultant three-level interchange system constructed predominately at the end of the main airport runway was a unique challenge overcome through innovative design and construction solutions to contend with the aforementioned aviation restrictions and high groundwater levels.

The interchange had to be as slender as possible but required three separate concrete bath structures to provide a waterproof running surface where the road was constructed below groundwater level, and four curved road bridges to provide free-flow to traffic accessing Perth Airport and Tonkin Highway alike.

Figure 4 *Demonstration of close proximity of works to airport runway*

Bath Structures

To allow the road to be constructed below the permanent water table, structural elements termed bath structures were designed, which are effectively watertight structures that aim to keep the groundwater out of the road, and to independently contain the water that collects within the structure to be managed and treated before discharging into the drainage network.

The bath structures in this project comprise a concrete base slab with integral concrete retaining walls, all reinforced and cast insitu in pour lengths limited to about 30 metres. Construction joints are fully reinforced and no expansion joints are included. A bonded waterproofing membrane lines the outside of the concrete with construction joints and protrusions containing various back-up seals including hydrophilic seals.

In addition, the base slab reinforcement is designed to comply with the code for liquid retaining structures, AS 3735, with crack control in the walls designed for adverse exposure conditions, in accordance with AS 5100 (notwithstanding the waterproofing provided).

The project contains three bath structures, each for one-way ramp traffic and all near the end of the airport runway. One of these is directly under the aircraft landing path and near a natural swamp. It is relatively shallow and narrow, and is designed with sufficient weight of concrete to resist flotation.

The other two bath structures are deeper and are up to 20 metres wide to provide for three traffic lanes, plus shoulders and added width for sight distance (see Figure 5).

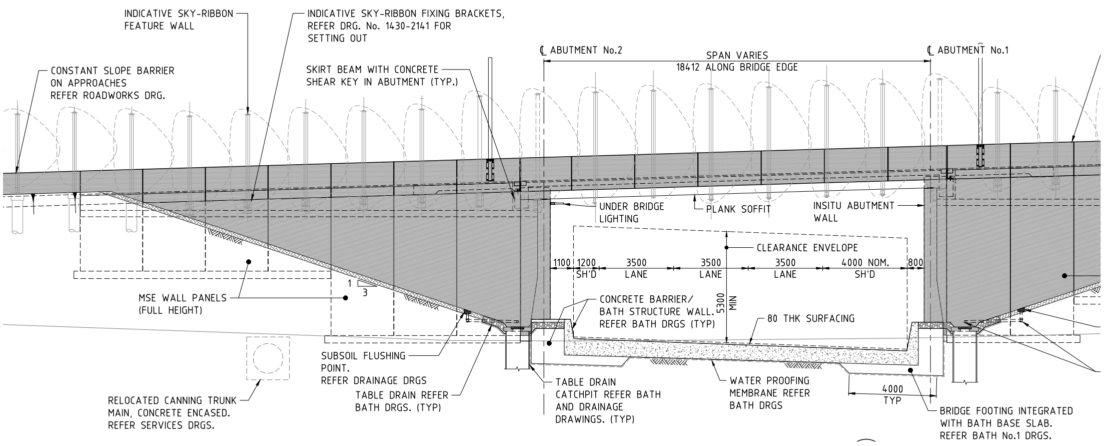

Figure 5 *Elevation of Bridge 1717 over Bath 1*

These two baths each have a bridge over them, assisting in the global buoyancy resistance by having bridge footings integral with the bath. For the ultimate limit state design, screwpiles hold down the bath walls beyond the effective influence of the weight of the bridge. Screwpiles are at the edge walls only where they can be accessed in the future for cathodic protection, or replacement if eventually necessary. A reference pile of identical construction and installation method has been provided in close proximity to the bath structures to enable extraction if required as part of the durability monitoring process. The screwpile design includes 4.2 millimetres of sacrificial steel thickness on all exposed faces to allow for corrosion over the 100 year design life. All of the bath slabs and walls are proportioned such that there is no reliance on the screwpiles at the serviceability limit state.

Drainage of the bath structures (to dispose of rainwater or overtopping water) requires a deep pump. In this case, as the three baths are in the same vicinity, a single pump station is provided. This pumps the water into retention basins set at higher levels than the baths in order to maintain normal groundwater levels for the environment. The effect of this is that seepage pressures had to be calculated and added to the ultimate limit state buoyancy forces.

Alternative types of construction and means of resisting buoyancy were rejected for the following reasons:

- Extending the base slab to pick up weight of soil would not only increase the excavation and temporary dewatering footprint, but add to the bending moments in the slab resulting in a much greater materials cost.
- Diaphragm walls or secant pile walls were likely to be ineffective as cut-off walls due to the presence of porous limestone, notwithstanding the relative impracticality of waterproofing these types of structures.

To reduce the extent of the bath structures, at each end, where there would be issues associated with water permeability into a conventional asphalt construction, a CRCP with asphalt wearing course was provided. These sections were essentially outside of the permanent water table but would be subjected to pavement capillary rise if granular sub-base was used. The use of CRCP was a first for Western Australia.

Road Bridges

The four bridges visible in Figure 3 (Bridges 1716 to 1719) are all on curved road alignments and needed to be of slender profile to mitigate the depth of baths in the groundwater. The largest of these (Bridge 1716) is a four-span curved bridge with a high degree of skew (ranging from 34° to 48°). Tee-Roff girders are designed to be built into full-depth post-tensioned pier diaphragms to provide full structural continuity and to allow for widely spaced columns (as shown in Figure 6). Small variations in edge cantilever widths were used to accommodate the straight girders within the curves.

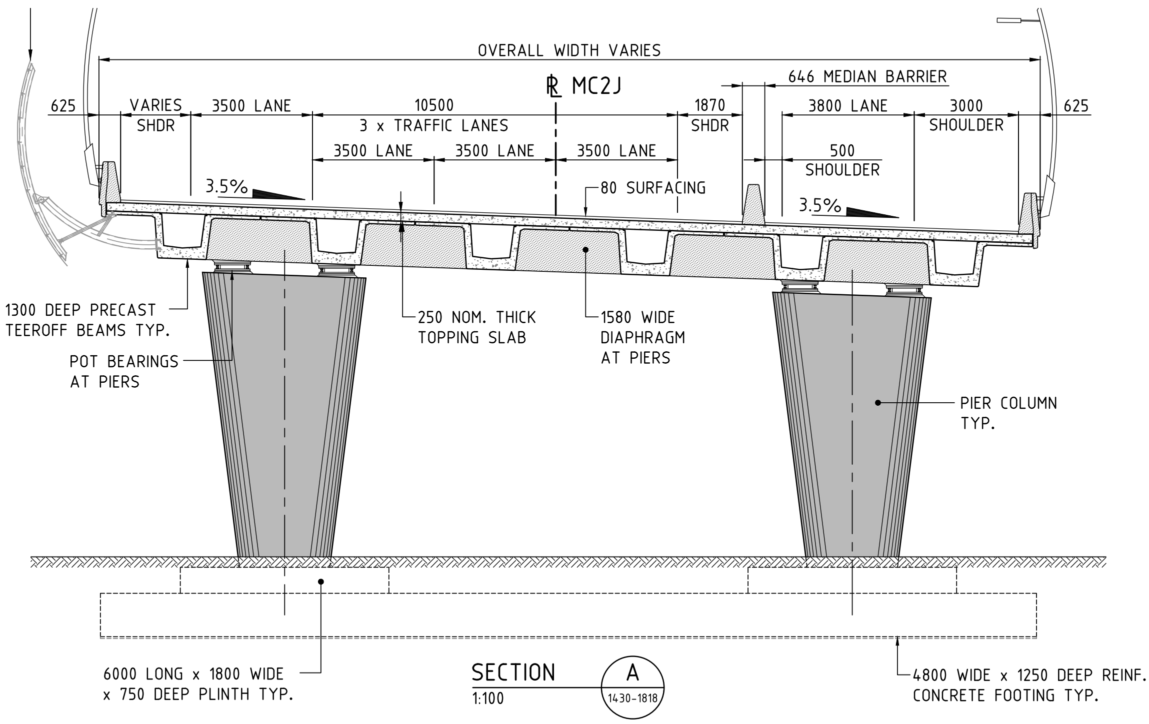

Figure 6 *Bridge 1716 cross section showing Tee-Roff girders and pier diaphragm*

The other three bridges within the interchange were designed with precast concrete planks. Two of these were single span bridges over baths as mentioned earlier. These bridges are simply supported to allow for thermal movements of the deck independently of the bath structures. Varying skews due to curvature of both of the associated road alignments are accommodated by varying the lengths and spacings of the planks in groups. All planks are nominally 600 millimetres wide and contain a 300 millimetre void as is common in other states, but not common to Western Australia. The number of planks involved made it economical to introduce this type of plank to Western Australia.

Most planks were 600 millimetres deep, but the span of Bridge 1718 exceeds 22 metres to accommodate merging traffic from the airport, so the depth of the 65 planks required was increased to 800 millimetres.

Bridge 1719, in the foreground of Figure 3, is the third of this family of plank bridges providing consistency of appearance to road users passing under from Tonkin Highway southbound to Leach Highway. It has a Principal Shared Path (PSP) of different cross-fall to the road (as can be seen in Figure 7) and a path underneath a second span as described later.

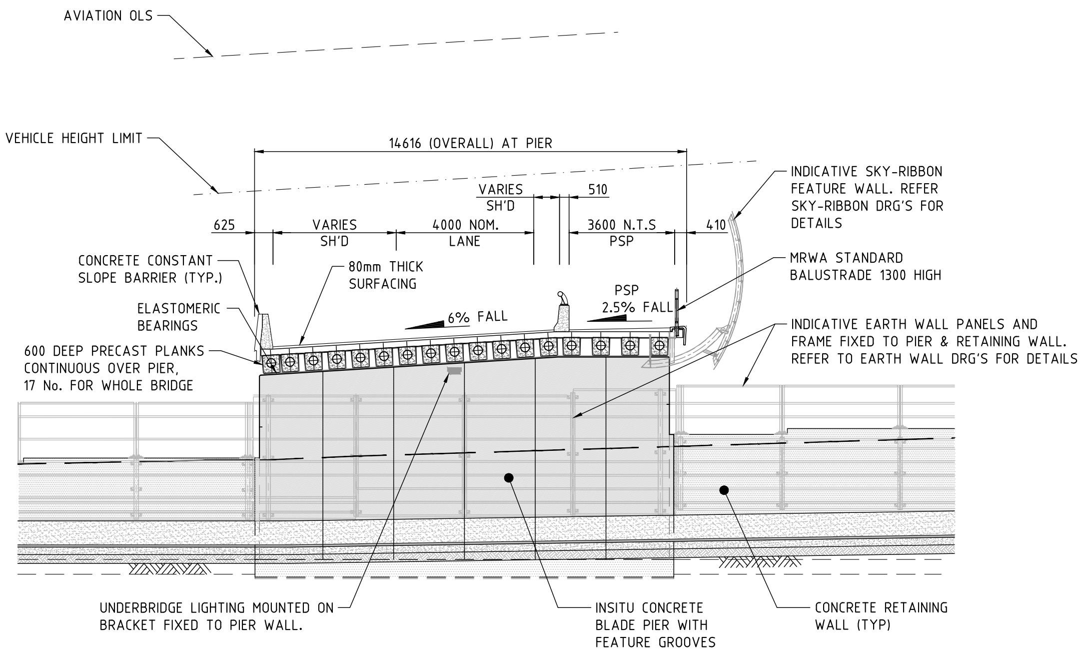

Figure 7 *Typical use of precast concrete plank in a section of Bridge 1719*

9. The Leach Highway/Abernethy Road and Tonkin Highway/Horrie Miller Drive/Kewdale Road Interchanges

As part of the Gateway WA Perth Airport and Freight Access Project, the Leach Highway/Abernethy Road intersection and Tonkin Highway/Horrie Miller Drive/Kewdale Road intersection have been upgraded from at grade signal controlled interchanges to grade separated interchanges.

The type of interchange constructed at both locations is a SPUI. This type of interchange allows all through movements on the side road of each interchange, (i.e. Abernethy Road and Horrie Miller Drive/Kewdale Road) as well as the traffic entering and exiting the main arterial roads of Leach Highway and Tonkin Highway respectively, to be controlled by a single set of traffic signals.

This type of interchange is commonly used throughout Australia, however, this is the first of its kind in Western Australia.

The curved edges of the two SPUI bridges form portals to major traffic flows and have been given special urban design consideration involving precast concrete parapets and lighting. Both of these bridges are two-span and required pier insitu concrete diaphragms designed to withstand torsion from the eccentrically loaded edge beams. The pier diaphragms allow columns to be spaced apart within the pier line to achieve an open appearance, while allowing for deck continuity, thus reducing the structural depth required of the main girders and allowing piers to be marginally more slender in elevation than in the common alternative of simply supporting precast girders on individual bearings.

Leach Highway/Abernethy Road Interchange

The initial interchange was proposed as a conventional diamond interchange with Leach Highway going over Abernethy Road. However, early on in the design, alternative solutions were explored to reverse the configuration to have Abernethy Road over Leach Highway. The benefits of this configuration were reduced noise and visual intrusion on the surrounding residential properties.

As part of the value engineering into the revised configuration, an alternative to a simple reversed diamond interchange was the use of a SPUI. The following benefits were recognised:

- More efficient operation than traditional interchange layouts as only a single set of traffic signals is required allowing traffic to clear the intersection more quickly. Many traditional interchanges, such as the diamond interchange, incorporate two separate sets of traffic signals.
- More compact than traditional interchange layouts, allowing the interchange to be constructed in locations with land/space constraints.
- Easier movement for large and oversized vehicles through the interchange due to the increased radius available for road users turning right.

A single two-span bridge, Bridge 1721, was proposed for the interchange. With relatively short spans of 15.5 metres, the use of prestressed planks integral with a central pier diaphragm for the central support was adopted. The complete deck includes insitu curved wings on each of the four corners to give the structure the shape suitable to accommodate the compact SPUI.

As the construction of the revised interchange was to be undertaken with the uninterrupted use of the existing interchange, the construction of the bridge had to be undertaken in several phases. To assist in the construction phasing, top-down construction utilising continuous flight auger (CFA) piling was adopted. The CFA piling and planks enabled very discrete portions of the bridge to be constructed in isolation as determined by the traffic phasing. The CFA abutment piles have adopted alternate soft piles and reinforced hard piles, with the piers comprising three reinforced hard piles per pier.

The adoption approval of CFA piling was not without its challenges, as the previous installation of CFA piles in sandy soils had included absorption of moisture from cover concrete and loss of concrete cover to the reinforcing cage.

Accordingly, and working collaboratively with Main Roads, extra cover to reinforcement was included in the design to allow for realistic deviations and the spacing limits and size of reinforcement pile skids were specified to minimise risk of the larger cover tolerances being encroached. A test pile was excavated to verify that the measures adopted were adequate. Following excavation under the bridge, the central piers were surrounded with insitu concrete and the abutments were clad in precast concrete panels. The resultant structure thus has a similar appearance to the other structure types on the project, while having employed a totally different substructure construction method.

Figure 8 *Excavation under Bridge 1721 complete, revealing approximately six metres of exposed CFA piles*

Tonkin Highway/Horrie Miller Drive/Kewdale Road Interchange

The Tonkin Highway/Horrie Miller Drive/Kewdale Road (Bridge 1720) interchange was always designed to be a SPUI interchange on top of the bridge, with a much larger footprint due to the span configuration.

Bridge 1720 utilises 13 Tee-Roff girders for each of the two spans, forming the major part of its width. For each of the four flared corners, a post-tensioned U-shaped trough beam spans diagonally between the abutment and the edge Tee-Roff beam. The Tee-Roff and U-shaped trough beams were made integral with post tensioned macalloy bars. The triangular infill used precast planks, and the final outer curved portion was constructed with an insitu slab. With the exception of beam/plank installation during a single weekend 56 hour closure, the rest of the construction was undertaken with Tonkin Highway beneath open to traffic.

Figure 9 *Elevation of the partially complete Bridge 1720*

10. Pedestrian Structures

Underpasses

All of the underpasses utilised precast concrete. Each of the eight standalone underpasses is trapezoidal in section utilising a non-proprietary project standardised modular shape, as shown in Figure 10, plus precast spandrel walls and wing walls. Heights and details of spandrel walls and wing walls were custom-designed to suit the geometric arrangement for each underpass in relation to road levels.

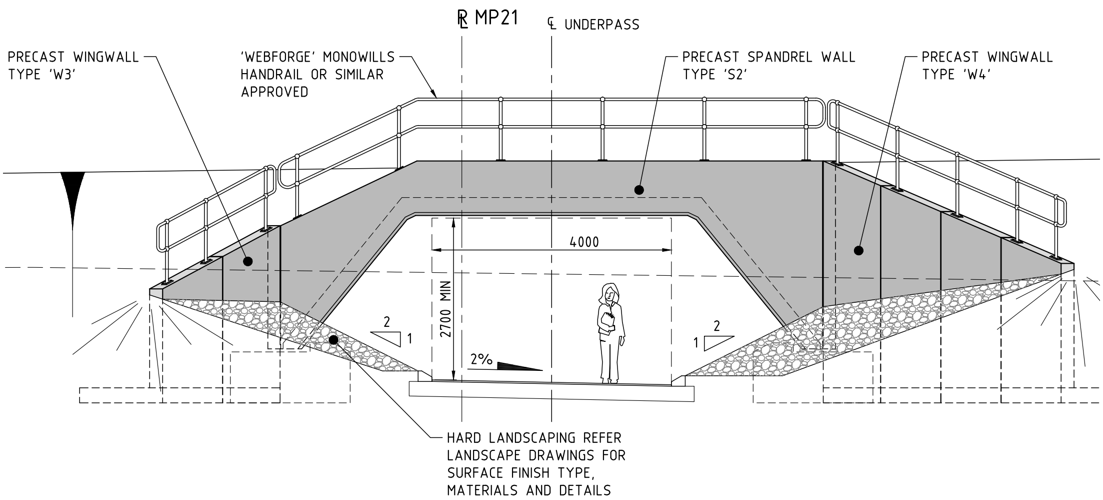

Figure 10 *Typical underpass elevation*

As a result of the modular system of the main elements, consideration was given to the installation of an additional underpass, that was scheduled for part of the ultimate Roe Highway/Tonkin Highway interchange configuration. Accordingly, the modular system was developed further to include precast underpass foundations, with the aim of constructing the complete underpass during the 2015 Easter long weekend.

Figure 11 *Underpass 9412 nearing completion at just past the midway point of the 82 hour closure*

During the four day weekend closure, the existing road embankment was excavated, foundations prepared, the full 44 metre long underpass was installed (with spandrel walls and initial wing wall section, waterproofed, electrical installations), backfilled and carriageway reinstated, opening to traffic 82 hours after the closure.

Bridge 1719

Bridge 1719 is primarily a traffic bridge utilising planks as described earlier. However, it also caters for pedestrians on top on a path to one side of the traffic, and also underneath. A short end span of the planks accommodates pedestrians at the lower level (as shown in Figure 12).

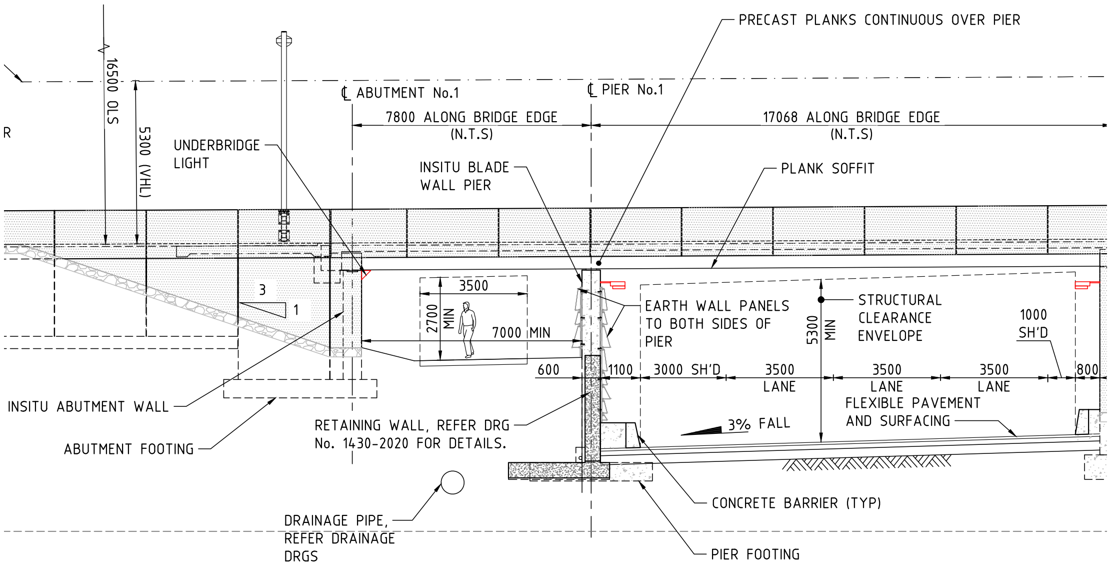

Figure 12 *Underpass as back-span of Bridge 1719*

The blade pier between this end span and the main span over traffic provides a screen between the traffic and pedestrians. Both sides of the blade pier are clad with Earth Ribbon panels. This treatment seamlessly transitions from the feature wall depicted later in the paper (Figure 16).

The planks are designed to span the full length of the bridge under self weight, and the pier bearings are grouted in place under the planks without taking any initial load, so that the bridge behaves as a two-span bridge for the subsequent concrete topping, live load (through composite action) thermal gradient and subsequent long-term effects including differential settlement, creep and shrinkage.

Footbridge 9394

A single footbridge was included in the project. This is for a PSP (Principal Shared Path) to pass over an existing well-used off-ramp, where the construction of an underpass would have been unduly disruptive. The footbridge has a main span of 19.3 metres which was achieved by partly skewing the path to reduce the skew, and balancing end spans of 13.5 metres to form a three-span continuous structure. The abutments are on MSE walls which follow the approach paths. Although extra spans were preferred aesthetically, the chosen solution shown in Figure 13 was adopted on the basis of minimising cost.

For minimal traffic disruption, the footbridge has been designed as a composite steel box in which the end steel box units are erected in the outer spans first. The main span, complete with deck and balustrade, is then lifted and bolted into position between the end units. The remainder of the deck is then cast insitu where it is not over traffic.

The foundations include screwpiles to resist collision loading at piers and to provide the minimum lateral restraint of 500 kilonewtons at each support as specified in AS 5100.2.

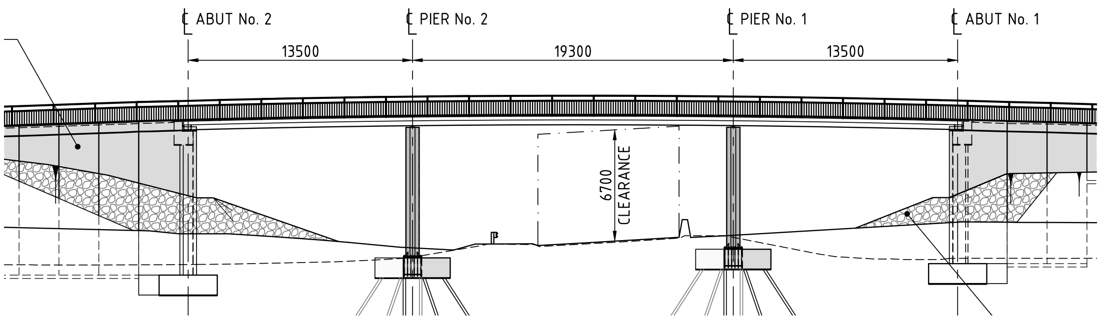

Figure 13 *PSP Footbridge 9394 over curved off-ramp – elevation from Tonkin Highway*

11. Urban Design

Overview

Description

The iconic nature of the Gateway WA project demanded a visionary approach in order to create a lasting impression for road users, residents and visitors to Western Australia. Using innovative urban design and public art, Gateway WA commissioned a number of projects within its scope to realise its vision.

Functional elements including noise/screen walls, retaining walls, bridges and abutments, highway lighting and landscaping are incorporated into the design.

Consultation

The Urban Design Strategy is founded on the concept of a journey from river to range, referencing the city through a continuous ribbon of vegetation.

There is an uninterrupted corridor approach to the improved infrastructure of existing highways based on the concept of ribbons, each of which has a direction specific landscape theme:

- River Landscape Ribbon – Tonkin Highway north
- Range Landscape Ribbon – Tonkin Highway south
- City Landscape Ribbon – Leach Highway west

The theme of each ribbon is expressed through a designated colour palette for noise/screen walls, relief patterns and bridge abutments.

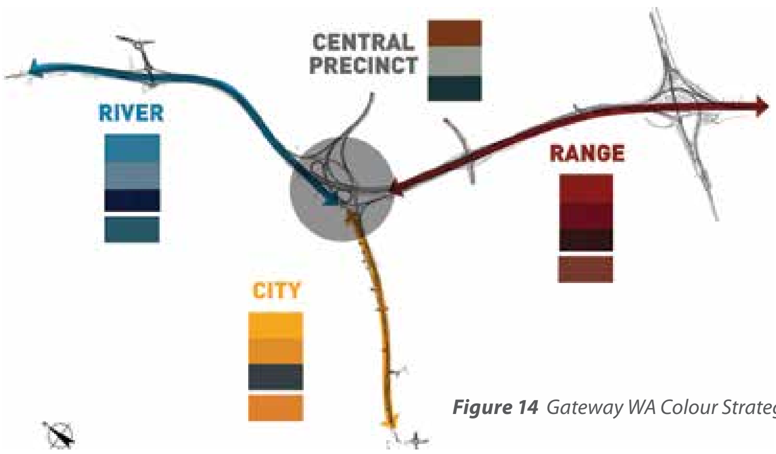

Figure 14 *Gateway WA Colour Strategy Vision*

The public art incorporation has been integrated to be complementary to the urban design and has been applied and integrated as value additions to the built infrastructure and landscape.

SKY RIBBON

Description

Sky Ribbon is a dramatic, elevated urban design structure of more than 220 panels that connect three bridge structures with the Grand Gateway, Tonkin Highway/ Leach Highway interchange, being Bridges 1716, 1717 and 1719. The panels are made out of aluminum and line the access to and from Perth Airport.

Although they may look deceptively simple, the manufacture of the shield sculptures was a technical challenge. Each shield is engraved to a one millimetre depth with a reflected textured pattern on both sides that is laser cut and etched into the panels. Other sections are cut through with hexagonal shapes, with no two shapes the same. Each of the individual panels is on a slightly different vertical and horizontal alignment to its neighbour, thus conveying a fluid effect rather than just a static representation. Sky Ribbon forms an integral part of the Grand Gateway, and represents the contemporary age and future of the state. It is designed as a counterpoint to another art piece in the Grand Gateway, Earth Ribbon (described later in the paper), which represents the ancient history and culture of the state.

Figure 15 *Sky Ribbon attached to Bridge 1716*

Artist

Artist Rick Vermey designed a striking, fluid graphic to be laser cut and etched into the panels. To do this he had to work in close collaboration with the Gateway WA design and structural engineering teams. The structural intricacy of the project compelled Rick to learn new and complex programs.

Inspiration

Given the proximity of Sky Ribbon to the airport, Rick's initial approach was to develop a design in response to themes of flight, lightness, flow and a sense of movement. He looked at the shapes, rhythms and patterns of nature.

It was apparent to Rick early in the design process that an abstract patterned design was best suited to the experience of travelling under or alongside the Sky Ribbon rather than something more pictorial or narrative.

Sky Ribbon is designed as an experience where variable moments of changing atmosphere, light and shadow are reflected along the road journey.

From the initial concept to the final manufacture, the artwork became more responsive to the technical fabrication requirements of the shields and Rick became more engaged with production, quality control and lighting.

Meeting the team that produces the panels provided Rick with crucial insight into their production methods, which allowed him to respond creatively to shifting engineering solutions.

The design process of Sky Ribbon was collaborative and responsive from the initial urban design concept to the production.

EARTH RIBBON

Description

Earth Ribbon is a layered, double-faced wall that curves around the Grand Gateway at the ground level of the Tonkin Highway/Leach Highway interchange. The wall is made from Corten weathering steel and separates the road from the PSP, acting as a cladding on bridge abutments and also on several retaining walls.

The deep red colour of the steel and the stratified design represent the topography and geology of the ancient land of Western Australia and is a counterpoint to Sky Ribbon in the Grand Gateway.

Artist

With the base design in place, Jonathan Jones, a Sydney-based Wiradjuri/Kamilaroi artist was commissioned, with the approval of the Shane Pickett Estate, to integrate artwork based on the painting practice of the late Meeyakba Shane Pickett (1957–2010).

Jonathan Jones developed the artwork in dialogue with Shane's family, including his wife, Violet, children, Roger and Trevor, and his father, Fred Pickett, along with the Estate's representative gallery, Mossenson Galleries.

Inspiration

> *"I am privileged to have been taught the traditions and cultural values of my father's Jdewat people and my mother's Balladong people. These include hunting skills, reading of weather patterns and signs that teach me to respect the seasons and understand their movements, changes and moods. I have learnt to read the songlines that journey through all living things across the entire landscape. I have sat down and watched the dusk infusion (the changing of day into night) and seen the colours of the sky and shadows move or merge into dreams of soft calming rhythms. I will always respect my cultural values, for the dreams do flow strongly through the views of my life."*
>
> MEEYAKBA SHANE PICKETT

Respected as one of the most important and influential Nyoongar artists of his generation, Pickett was born in 1957 in the wheat-belt town of Quairading in his mother's Balladong Country in south-west Western Australia.

Balancing innovation with tradition, modernity with ancient spirituality, his paintings are infused with the steadfastness of Nyoongar culture. Pickett's unique painting style speaks directly to Nyoongar country and its people with highly saturated colours and textures.

Figure 16 *Earth Ribbon, with Corten steel starting to weather and adopt the desired colour. The full weathering process will take an additional 12 to 18 months*

Pickett's status as a key local Nyoongar artist, along with his knowledge and sensitivity of country, was integral to the creation of the artwork. Through his practice, Pickett fought to maintain Nyoongar identity and territories within the contested history and space of Perth. As such, his work operates appropriately as an introduction to the city.

With its layered construction, the artwork speaks to the region's layered history and guides people through Nyoongar country. The artwork is a celebration of Pickett's work, reinforcing the enduring strength of Nyoongar country and its beauty.

LIGHTING

The use of lighting to enhance the various urban design elements has been applied across the Grand Gateway, to encompass Sky Ribbon and Earth Ribbon. The three bridges under which the main traffic passes to enter and exit the airport via the main Tonkin Highway/Leach Highway interchange, form architectural portals (structurally only one of these is an integral portal – Bridge 1721). The feature-curved edges are concave in plan and convex in section and the columns of the central pier in each case are set in from the edge to accentuate the horizontal lines of the curved edges.

Figure 17 *Sky Ribbon on Bridge 1716 with variable lighting effects*

Figure 18 *Bridge 1729 showing the lighting effects on the parapet panels and enhancement of river colours on the approach MSE walls*

12. Conclusion

The project has provided some technical and approval challenges constructing so close to the airport, as well as maintaining uninterrupted access to the airport. The resultant project has not only provided the required improvements to the infrastructure, but has provided important enhancements to the user's experience of the road network to gain access to the airport.

When construction works began in early 2013, the publicly announced date for overall project completion was early 2017. As the project continued to meet milestones ahead of plan, the overall completion date was brought forward to the end of March 2016. The project will be delivered under budget, demonstrating the project's robust financial and accounting systems, and commitment to prudent expenditure, as adopted by all of the Alliance partners.

During the project, significant savings were made and transferred back to the client to invest in other road projects. Main Roads subsequently awarded Gateway WA an additional $45 million package of works to upgrade an intersection at Roe Highway and Berkshire Road into a grade separated interchange.

The Gateway WA project has resulted in a number of firsts for Western Australia. The first SPUI to be constructed, the first use of CRCP within a road project, the first use of bath type structures associated with an infrastructure project, as well as standardisation of precast planks to other Australian states.

Arguably the most significant achievement of the Gateway WA project is the creation of the Grand Gateway for visitors from both interstate and international visitors. The first impression on arrival at Perth has been significantly enhanced, not only by the improvements to the road network, but the visual experience of using the network. Rather than simply creating a utilitarian functional solution with 'architectural window dressing', the full integration of urban design across the whole project has no doubt set a benchmark for future infrastructure projects that act as the entry point to cities and countries alike.

13. Acknowledgments

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14. References

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