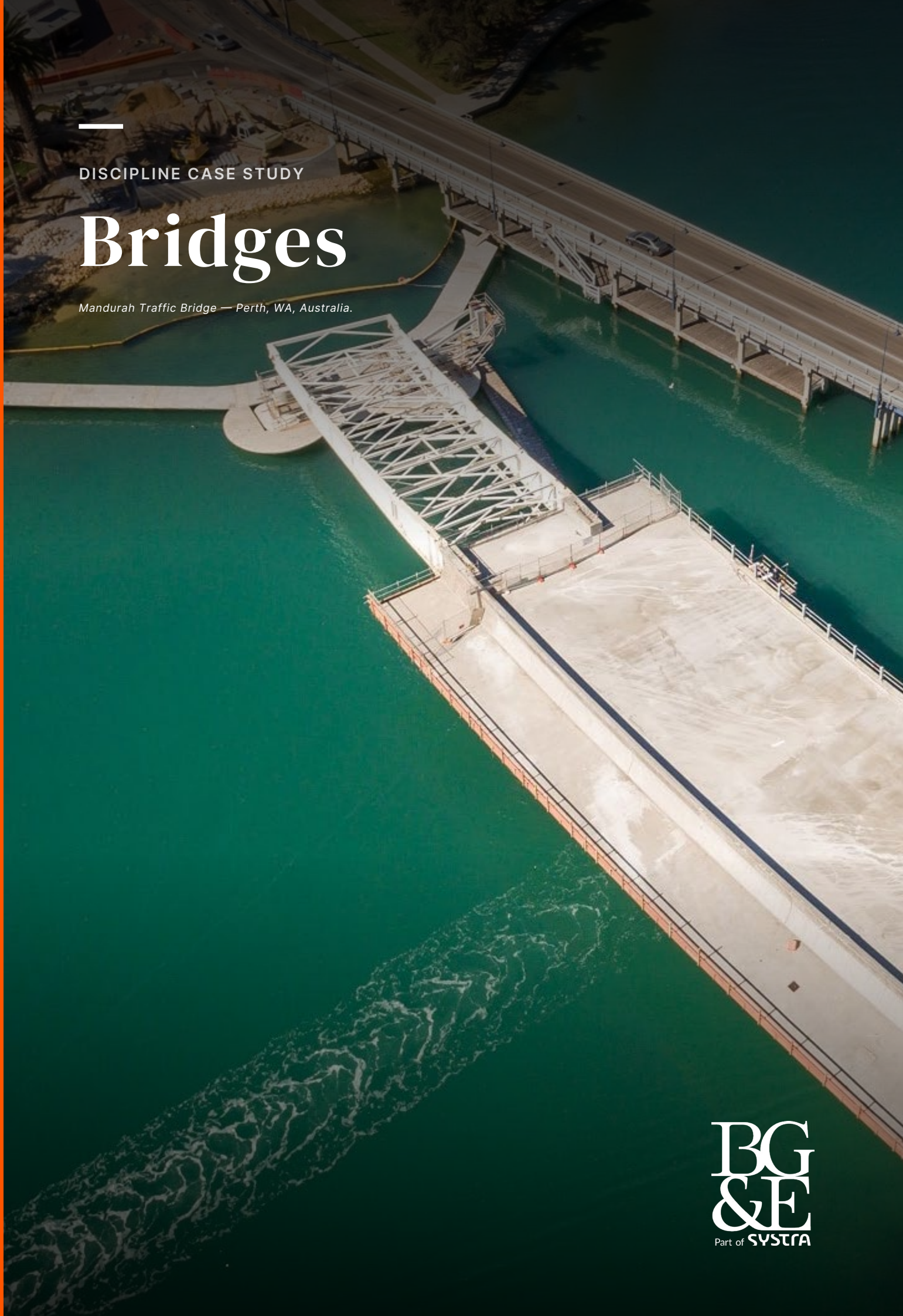
DISCIPLINE CASE STUDY

Bridges

Mandurah Traffic Bridge — Perth, WA, Australia.



BG&E
Part of SYSTRA

Sydney Gateway

CONCEPT TO DETAILED DESIGN | CONSTRUCTION METHODOLOGY | LAUNCHING DESIGN & CONSTRUCTION SUPPORT

SYDNEY, NSW, AUSTRALIA
CLIENT: JOHN HOLLAND SEYMOUR WHYTE JV

Our award-winning Bridge team delivered the detailed design for 19 bridges and viaducts as part of the $2.6 billion Sydney Gateway project on a heavily constrained brownfield site.

BG&E was engaged by the John Holland Seymour Whyte JV (JHSW JV) to deliver this transformational project.

This critical infrastructure includes a new above-ground, toll-free connection from St Peters interchange to Sydney's international and domestic airports, considerably improving connectivity for surrounding precincts and reducing commuting times.

The scope of our work included a 545 metre long viaduct, bridges with spans up to 100 metres that comprise network arches, steel composite box girders, and continuous Super-T bridges.

Airport Drive, a crucial roadway running circumferentially around Sydney International Airport, links the Domestic and International Terminals. BG&E's selection of a network arch bridge resulted in a minimised and shallow abutment footprint which prevented disruptions of Airport Drive during construction. This Australian-first network arch bridge maximised sustainability targets for the project as the efficient network-hanger geometry resulted in significantly reduced steel tonnage compared to other steel bridge structures.

BG&E further optimised the design by eliminating the transverse bracing, traditionally used to connect the tops of longitudinal arches or trusses, by adopting advanced finite element buckling analysis to Eurocodes. The removal of overhead bracing simplified the construction of the 45 degree skewed bridge deck — providing unlimited overhead clearance for trucks, and resulting in a pleasing signature structure to be enjoyed by visitors and Sydney siders alike.

In addition to the primary structural services, BG&E undertook design services for the structural temporary works and durability across the entire project.

Construction of the Sydney Gateway commenced in 2021 and reached completion in 2024.

Sydney Gateway — Sydney, NSW, Australia.

Yandhai Nepean Crossing

CONCEPT TO DETAILED DESIGN | CONSTRUCTION METHODOLOGY | LAUNCHING DESIGN & CONSTRUCTION SUPPORT

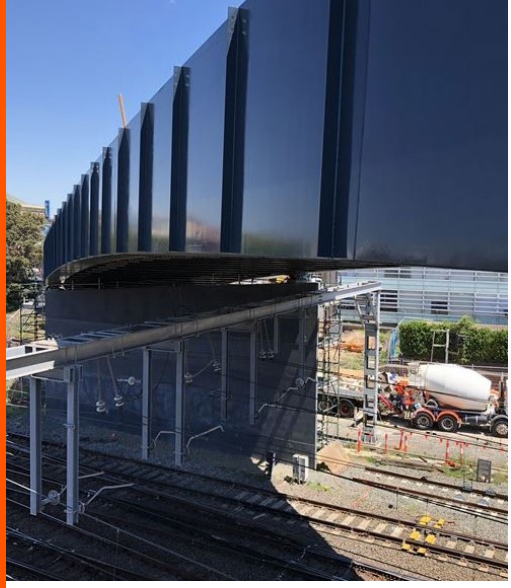
SYDNEY, NSW, AUSTRALIA
CLIENT: ABIGROUP

This architecturally designed, award-winning $50 million project is part of the great river walk which provides the community with a safe, dedicated footbridge and cycle path, as well as panoramic views of the Nepean River and surrounding areas.

BG&E with Seymour Whyte provided the detailed design of the bridge that spans 200 metres over the Nepean River and featured a 10 metre deep steel Warren truss with plan geometry that included two reverse curves.

In Australia, our technical experts were the first engineers to use the incremental launch construction method many years ago and today, it remains one of the most effective.

This challenging geometry required a complex construction approach on land. BG&E was engaged to deliver the project, and we achieved this by developing a unique and novel construction technique called 'node-by-node' launching, which articulates supporting and shifting the truss at each node using jacks and rolling skates to ensure precise execution throughout the launch.



Sydney Yard Access Bridge

CONCEPT TO DETAILED DESIGN | CONSTRUCTION SUPPORT

SYDNEY, NSW, AUSTRALIA
CLIENT: LAING O'ROURKE

The Sydney Yard Access Bridge was one of the early and enabling package of works for the Sydney Metro City and Southwest projects — it runs over the New South Wales (NSW) country rail lines and has allowed for construction of the new Central Station.

The bridge crosses five inter-city rail lines that had never been closed under a single possession. During full closure, the main girders and cross girders were installed within the 54 hour possession window.

BG&E provided the detailed design of the Sydney Yard Access Bridge and the associated civil works and drainage design. The access bridge stretches across Regent Street in Surry Hills and is 140 metres long and eight metres wide with complex vertical and horizontal geometry.

Due to the fixed start and end points of the structure and the need to clear the overhead wires while maintaining a maximum grade, our team developed a box girder solution which enabled the grade to be achieved and the structural design to be carried by a two metre deep steel box through-girder solution.

The tracks below meant the location of the piers was highly constrained. Minimum offsets from rail centre lines further restricted their physical location. The final position resulted in skews of 66 degrees to the deck. BG&E recommended a ladder deck system to ensure the cross members of the deck could remain perpendicular to the main girders, which mitigated any issues commonly associated with high skews.

Hunter Expressway Flyover

DETAILED DESIGN | LAUNCHING DESIGN & CONSTRUCTION SUPPORT

BRANXTON, NSW, AUSTRALIA
CLIENT: HUNTER EXPRESSWAY ALLIANCE

BG&E provided design and documentation for the 156 metre long, five metre wide Hunter Expressway Flyover, which forms the Branxton to Sydney ramp. The flyover was delivered as part of the Hunter Expressway project, which runs 13 kilometres from Newcastle interchange on the Pacific Motorway to the New England Highway, west of Branxton.

Constructed using the incrementally launched method, BG&E developed a design for the Hunter Expressway Flyover that utilised the contractor's existing launch equipment throughout, with only minimal modifications required to the launch nose, to account for the bridge curvature.

The geometry of the bridge was such that it had to be launched on a tight combined horizontal and vertical curve. Using 3D modelling, our team ensured the set out of the cast bed and supports were compatible with the road alignment.

The location of the bridge was subject to significant vertical and horizontal ground movements due to potential mine subsidence. While the vertical movements were reduced through a mine void filling programme, the horizontal movements required unique articulation of the bridge structure and the use of sleeved piles at piers one and two, to isolate the structure from the ground movement.

The sleeving of the piles was required in consideration of the mine subsidence, which included generating 23 metre long cantilevered pile sections, that deflected significantly during launching. BG&E developed a temporary solution of tiebacks and props to control this movement and to ensure a safe launch.

A prestressing scheme was also developed by BG&E which enabled the removal of traditional second stage prestressing and provided a 25% reduction in prestress quantities, compared to concentric stress only box.

Delivered by the Hunter Expressway Alliance which included NSW Roads and Maritime Services (RMS), Thiess, WSP, and Hyder Consulting, this infrastructure project provides critical connectivity across the state's road network.

Hunter Expressway Flyover — Branxton, NSW, Australia.

Cronulla Line Duplication & Upgrade

DETAILED DESIGN | CONSTRUCTION SUPPORT

CRONULLA, NSW, AUSTRALIA
CLIENT: TRANSPORT INFRASTRUCTURE DEVELOPMENT CORPORATION

BG&E designed four concrete through-girder rail bridges and four rail overbridges for the Cronulla Rail Line. All bridges were constructed alongside existing rail tunnels and the utilisation of a staged construction approach allowed uninterrupted traffic flow throughout the project.

As part of the Rail Clearways Program, the two remaining single track sections on the Cronulla Rail Line were duplicated. The project included the upgrade and duplication of 14 kilometres of track, upgrade of two stations, reconfiguration of Cronulla yard, and resignalling of the branch line.

BG&E designed four concrete through-girder rail bridges. Each bridge consisted of a pair of precast post-tensioned I-girders with pre-tensioned deck formwork and an insitu deck slab to tie the precast units together and provide U-frame restraint to the I-girders — including bridges on significant skew.

We also designed four rail overbridges (tunnels) consisting of contiguous pile wall abutments with deck planks and an insitu deck slab to provide moment connection and full frame action — including tunnels on significant skew to the road above.

The project also involved:

- Construction of an eight-lane stabling facility.
- Upgrade to the State Heritage Listed Cronulla Railway Station.
- Vegetation clearing to enable works.
- Installation of drainage structures.
- Installation of bridges and associated road and footpath pavement work.
- Pedestrian management and implementation.
- Protection and subsequent biodiversity offsets of Sydney Turpentine Ironbark Forest and River Flat Eucalypt Forest remnants.

Cronulla Line Duplication & Upgrade — Cronulla, NSW, Australia.

Malcolm Fraser Bridge

DETAILED DESIGN | CONSTRUCTION METHODOLOGY | LAUNCHING DESIGN & CONSTRUCTION SUPPORT

MAJURA PARKWAY, ACT, AUSTRALIA
CLIENT: FULTON HOGAN

BG&E was engaged by Fulton Hogan as a structural design partner for the Design and Construction (D&C) of the Molonglo River Bridge (subsequently named the Malcolm Fraser Bridge), which formed part of the Majura Parkway project in ACT.

Majura Road, once the main artery through the valley, was a single-carriageway rural road that handled around 18,000 vehicles daily but could not accommodate future traffic increases. The new Majura Parkway has replaced this link, improving connectivity in the region.

Following the successful tender submission, BG&E completed the design and documentation of a pair of four span, 202 metre long incrementally launched concrete box girder bridges across the Molonglo River and Morshead Drive.

BG&E's approach responded to the key design challenges:

- Road alignment — the bridges were designed to accommodate differences in alignment between the two carriageways within the bridge deck while maintaining the same launch geometry for both. This enabled the two bridges to be launched from the same cast bed and formwork.
- Skewed supports — the bridge design required launching over skewed supports, including a skewed launch nose and end diaphragms. BG&E developed a scheme to remove the second-stage pier diaphragm beams, greatly simplifying the reinforcement layout at these locations.
- 3D modelling — the two bridges were fully modelled using 3D CAD to facilitate the setout of all elements including precast barriers, railings, expansion joints, drainage, deck end clearances and structure geometry. This model was also used by our CAD team to assist with the reinforcement detailing of complex diaphragm zones to reduce the risk of clashes and delays during the construction phase.

Malcolm Fraser Bridge — Majura Parkway, ACT, Australia.

Pacific Highway Upgrade — Karuah Bypass

CONCEPT TO DETAILED DESIGN | CONSTRUCTION METHODOLOGY | LAUNCHING DESIGN & CONSTRUCTION SUPPORT

PORT STEPHENS, NSW, AUSTRALIA
CLIENT: ROADS & TRAFFIC AUTHORITY — NSW & THEISS

BG&E provided structural, civil and façade engineering services for the Karuah Bypass — a vital part of the Pacific Motorway as it connects regional New South Wales (NSW), improving safety and reducing the travel time for road users.

Specifically, we provided a design solution for the two bridges on the new freeway alignment. The western bridge, the Wetlands Bridge, is 218 metres long, and the eastern bridge, the Karuah River Bridge, is 594 metres long. The two bridges are separated by the Horse Island crossing, which is 276 metres long. Each structure comprises twin concrete box girders of uniform depth and an innovative prestressing system that provided simplifications to the cross section with time and cost benefits.

One significant feature of this project was the incremental launching of both bridges from the same casting bed at the western end of the Wetlands Bridge. When the Wetlands Bridge reached its final position, the bridges were separated — the Karuah River Bridge was pushed over Horse Island into its final position. This method minimised environmental impact compared to other construction methods. The superstructure is supported on concrete piers founded on piles and pile caps. Abutments are generally spill-through, with one being a reinforced soil wall.

At the time of delivery, these were the longest bridges incrementally launched in Australia.

Pacific Highway Upgrade — Woolgoolga to Ballina, Portion A

DETAILED DESIGN | CONSTRUCTION SUPPORT

NORTHERN RIVERS REGION, NSW, AUSTRALIA
CLIENT: PACIFIC COMPLETE

Woolgoolga-to-Ballina, Portion A was the largest of the four design packages in the Pacific Highway Upgrade, awarded to GHD with BG&E as the sub-consultant. Our team provided bridge design, structural and civil engineering, flooding and drainage, and materials testing and durability services.

This 155 kilometre stretch, spanning from north of Coffs Harbour at Woolgoolga to south of the Queensland border, marked the final link in the Pacific Highway upgrade.

It included over 100 bridges, 10 grade-separated interchanges, five town bypasses, underpasses and overpasses for local traffic, fauna crossings and driver rest areas.

The bridge over Shark Creek was the longest on the project, spanning 820 metres. We implemented a novel construction methodology for the bridge, comprising nine girders for a single deck twin carriageway superstructure.

Key contributions from BG&E for Portion A included:

- 49 kilometres of dual carriageway and local roads, with 35 kilometres of early works road design completed within four months.
- 33 kilometres of enabling works.
- 73 bridges, featuring PCS plank and Super-T girders on conventional in-situ and precast concrete substructures.
- 116 design lots (four stages for each lot), with designs delivered before or on schedule.
- Optimised road alignment of the reference design.
- Optimised bridge deck designs, reducing the number of 1,500 super tee bridge girders by 88 compared with reference designs — providing a saving of $2.8 million.
- Optimised bridge span configurations and substructure design — which reduced construction costs by $4.8 million).
- Refined the design of standard Roads and Maritime Services (RMS) prestressed planks and super tee beams.

Pacific Highway Upgrade — Woolgoolga to Ballina, Portion A — Northern Rivers Region, NSW, Australia.

Pacific Highway Upgrade — Yelgun to Chinderah

DETAILED DESIGN | CONSTRUCTION SUPPORT

NORTHERN RIVERS REGION, NSW, AUSTRALIA
CLIENT: LAING O'ROURKE

BG&E designed all overpass bridges for a 28 kilometre deviation of the Pacific Highway, south of Tweed Heads in Northern NSW.

Our involvement included:

- Seven Super-T bridges with spans up to 38.5 metres.
- The Eviron Road Overpass, that forms a gateway at the northern end of the upgrade. Twin arches span over 50 metres, supporting precast portal frames and concrete planks.
- The Old Pacific Highway Overpass, a post-tensioned Twin-T bridge that spans 40 and 50 metres on a 55-degree skew.
- Four fauna arch tunnels, allowing wildlife to safely cross over the new roadway, with precast concrete arches resting on cast-in-situ concrete walls.

Pakenham Roads Upgrade

DETAILED DESIGN | CONSTRUCTION SUPPORT

PAKENHAM, VIC, AUSTRALIA
CLIENT: SYMAL INFRASTRUCTURE & MRPV

The bridge over the Princes Freeway was the first detailed design of a road bridge undertaken by BG&E's Melbourne office, representing a significant milestone in BG&E's expansion in Australia.

BG&E was engaged for two of the three stages of the Packenham Roads Upgrades: Stage One — Princes Freeway Interchanges Upgrade and Stage Three — Racecourse Road Upgrade.

The bridge over the Princes Freeway is a two span Super-T structure with a total length of 62 metres. The bridge is fully integral at each abutment and is structurally continuous over the central pier. The deck provides for two lanes of traffic and a shared user path for pedestrians and cyclists.

The abutments consist of driven precast concrete piles that were sleeved prior to the construction of spill-through embankments to provide flexibility for the integral abutments. The central median pier is a blade-type structure, protected from collision by 75 metre pier protection 'battleships'.

BG&E, in collaboration with Symal and the Road Authority, evaluated various structural forms before choosing an integral design that minimises long-term inspection and maintenance, providing significant long-term benefits. This approach, featuring a leading-edge pavement interface, ensures a safe and smooth ride for motorists.

We also provided civil services encompassing road, earthworks, geotechnical and pavement design, traffic systems, lighting, signage, urban and active transport planning, and hydrology and flood modelling.

Avon River Bridge

DETAILED DESIGN

STRATFORD, VIC, AUSTRALIA
CLIENT: RAIL PROJECTS VICTORIA (RRV) & CPB CONTRACTORS

BG&E challenged the reference design for the Avon River Bridge upgrade, successfully reducing the superstructure depth, optimising the foundation layout, shortening the approach length, and minimising tie-in footprints. These improvements offer significant benefits in cost, constructability, and environmental impact on local fauna.

The existing rail bridge over the Avon River was constructed in 1988. Located north of the existing rail bridge and south of the Princes Highway Bridge in Stratford, the bridge underwent several lengthening works over the years due to river thalweg, which caused changes to the riverbed.

The bridge's geometry and declining condition (because of age) resulted in onerous speed restrictions of 10 kilometres per hour and limited load-carrying capacity. To improve service operation, Rail Projects Victoria (RPV) committed to building a new Avon River bridge.

BG&E delivered the detailed bridge design for CPB Contractors, who were engaged by Rail Projects Victoria under a design and construct model.

The works included:

- Track and track formation design.
- New 500 metre long bridge over Avon River.
- New flood relief bridge on the western embankment.
- New retaining walls on the eastern embankment to preserve the Native Title.
- Upgrade to McAllister Street Level Crossing.
- Preserving existing heritage-listed timber trestles on the western embankment.
- Detailed hydrology study.

The bridge comprises 18 spans of twin 1500 millimetre deep, 28 metre long Super-T girders, with driven precast-concrete pile piers through the floodplain, and driven concrete-filled steel tube piles through the river. The alignment is a single horizontal radius throughout the bridge length, with the superstructure faceted for simplified construction, while ensuring the required kinematic envelopes are provided.

BG&E conducted detailed rail-structure interaction modelling to optimise the loading on the slender piers for the upgraded bridge. Given the bridge is in a marine environment, we engaged our industry-leading Materials and Durability experts to provide specific guidance on concrete mix design and treatment of exposed surfaces.

Our design allowed for significantly less disturbance by removing the need for pile cap construction within the riverbed, alternately providing driven concrete-filled steel-tube piles to headstock level. This had profound benefits to local fauna.

Ultimately, the new bridge has improved train reliability, allows trains to operate up to 90 kilometres per hour, and caters to future freight train movements.

Avon River Bridge — Stratford, VIC, Australia.

Exford & Greigs Road Bridges

BRIDGE INSPECTION | MODIFICATIONS & STRENGTHENING DESIGN

MELTON, VIC, AUSTRALIA
CLIENT: MELTON CITY COUNCIL

BG&E was engaged by Melton City Council to inspect and load rate two road bridges over watercourses flowing into the Melton Weir.

Exford Road bridge (over the Werribee River) is a five-span structure approximately 64 metres in length. The superstructure consists of steel beams and a concrete deck for the approach spans and prestressed concrete beams with a concrete deck for the central span. The substructure (piers and abutments) is reinforced concrete. The bridge was constructed in the 1960s.

Also constructed in the 1960s, Greigs Road bridge is a three-span structure — approximately 38 metres in length — consisting of precast prestressed concrete beams, concrete deck, and concrete substructure (piers and abutments).

The load rating assessment indicated that the bridges were both under-capacity for the required design loads (even allowing for a reduction in the contemporary design loading (AS5100) to account for the age of the structures).

As such, BG&E was commissioned to undertake a strengthening design for both bridges.

The strengthening design consisted of a concrete deck overlay on both bridges to increase the structural depth of the girders. The change in level (~200 millimetres) required a regrading of the approach roads and new vertical alignment.

Additionally, the pier crossheads and abutment sill beams were strengthening with external post-tensioning and the bridge barriers are upgraded with new steel post-and-rail to meet the requirements of current codes.

The design work undertaken by BG&E provides assurance for Melton City Council that its bridges are capable of carrying the design loads which are expected and required in today's environment.

Exford & Greigs Road Bridges — Melton, VIC, Australia.

M80 Upgrade: Sydney Road to Edgars Road

PROOF ENGINEERING BRIDGES & CIVIL STRUCTURES

MELBOURNE, VIC, AUSTRALIA
CLIENT: CPB CONTRACTORS

BG&E played a crucial role as the proof engineer for the cable-stayed bridge over the M80 Freeway in Thomastown, ensuring its extension accommodated additional lanes. By collaborating closely with AECOM throughout the design process, we provided key insights that aligned with the design intent, embodying our philosophy of proactive, stage-by-stage proof engineering.

The M80 Upgrade between Sydney Road and Edgars Road created a system interchange with connections in all directions to the M31 Hume Freeway.

This included the expansion of four kilometres of the freeway to three lanes in each direction and improved interchanges at Sydney Road and Edgard Road.

BG&E was engaged by CPB Contractors to undertake structural proof engineering for the project. The detailed design was completed by AECOM.

BG&E undertook the proof engineering of the following structure types:

- Major retaining walls.
- Soil-nail walls.
- Prestressed concrete Super-T bridges.
- Carbon fibre bridge strengthening.
- Cable-stayed bridge.
- Major sign gantries.

Notably, the proof engineering for the cable-stayed bridge over the M80 Freeway in Thomastown involved a comprehensive review of the as-built structure to assess locked-in forces and allow for its extension to accommodate new lanes on the freeway.

Subsequently, BG&E worked closely with AECOM at all stages of the design to understand its design intent and design philosophy and, where appropriate, provide proof engineering input to 'steer' the design.

This staged proof engineering approach — 'going on the journey' with the designer and contractor — is central to BG&E's proof engineering philosophy. It is not intended to augment the detailed designer's role (in this case AECOM), but to ensure that proof engineering input and expertise is 'heard' at the crucial stages where the cost of change to the design is lowest.

M80 Upgrade: Sydney Road to Edgars Road — Melbourne, VIC, Australia.

Mallee Bridges Engineering Investigations

BRIDGE INSPECTION | MODIFICATIONS & STRENGTHENING DESIGN

MALLEE REGION, VIC, AUSTRALIA
CLIENT: DEPARTMENT OF ENERGY, ENVIRONMENT & CLIMATE ACTION

BG&E was engaged by the Department of Energy, Environment and Climate Action (DEECA) to assess seven deteriorated bridges crossing structures in the Mallee district that were constructed in circa 2012.

These seven structures are situated in saline environments and were found to have experienced accelerated corrosion to steelwork during previous investigations, thereby raising concerns about adverse impacts on the original intended design life of 100 years.

BG&E undertook detailed site inspections and condition assessments, as well as load rating analysis of the bridge superstructures.

Following this, we developed various options for remediating the bridges. These remedial works are expected to prolong the life of the bridge structures, enhancing the resilience of the road network in the region.

Coomera Connector (Stage One North — Shipper Drive to Helensvale Road)

DETAILED DESIGN | CONSTRUCTION SUPPORT

GOLD COAST, QLD, AUSTRALIA
CLIENT: DEPARTMENT OF TRANSPORT & MAIN ROADS

The Coomera Connector is a 45 kilometre north-south transport corridor connecting the Logan Motorway and Pacific Motorway interchange at Loganholme and Nerang-Broadbeach Road in Nerang.

The Department of Transport and Main Roads (DTMR) identified the 16 kilometre section between Coomera and Nerang (referred to as Stage One Coomera to Nerang) as having the highest demand for providing additional capacity between Loganholme and Nerang.

The preferred arrangement has been identified as a new urban high-speed motorway having grade-separated interchanges which will provide an alternate route to the M1 for both the Coomera and Nerang River crossings. Stage One will be delivered in three construction packages.

Stage One North includes a four kilometre section from Shipper Drive to Helensvale Road. Construction commenced in early 2023 and is slated for completion by 2025.

The BG&E and WSP JV (WBJV) was engaged by Acciona Georgiou (AGJV) to carry out the successful tender design and subsequent detailed design for the Coomera Connector Stage One North.

BG&E's QLD Bridge team were the lead designers for bridges and structures on this project and delivered the following design:

- Three dual carriageway road bridges Coomera Overflow Bridge, Coomera River Bridge and Helensvale Road Bridge.
- All bridges are future-proofed to six lanes to minimise construction impacts for nearby residents during future upgrades.
- One pedestrian bridge over Helensvale Road.
- Major sign and shade structures.
- RC cantilever and contiguous pile retaining walls.
- Noise walls (freestanding, mounted on barriers and on bridges).
- Existing bridge abutment modification.
- Construction support.

The bridges on this project all utilise precast Super-T girders ranging from 1225 millimetres deep to 1825 millimetres deep with over 600 precast girders required for the project. The construction corridor is only 2.5 metres wider than the total carriageway width at most locations along the Coomera River Bridge, which also runs parallel to the south coast QR railway line. Due to the tight construction corridor, Coomera River, adjacent residents, QR railway and deep soft ground — the design and construction methodology posed significant design challenges.

Coomera Connector (Stage One North — Shipper Drive to Helensvale Road) — Gold Coast, QLD, Australia.

Coomera Connector (Stage One North — Shipper Drive to Helensvale Road) — Gold Coast, QLD, Australia.

The main bridge over the Coomera River and Saltwater Creek consisted of 30 spans with a total bridge length of 885.5 metres, comprising spans ranging from 25 metres to 37 metres. The bridge comprised 1225, 1525 and 1825 deep Super-T girders with two spans being made continuous for live load to avoid major PUP services. The bridge is approximately 30 — 35 metres wide, carrying three design lanes in each direction while the southbound carriageway also carries a four metre wide shared path which includes a connection to the new Hope Island Railway Station. Due to the large width of the bridge and narrow corridor, a longitudinal joint separates the two carriageways by a 20 millimetre gap.

The Coomera Overflow Bridge and Coomera River Bridge sites consist of up to 20 metres of soft ground — which presented major challenges for the bridge design. The key challenges were designing for up to 10 metres of liquefaction, five to seven metres of scour during flooding, railway collision loads and lateral pile movements due to soft soil settlements at the abutments.

Geotechnical ground improvements were included at the bridge abutments on the north abutment of the Coomera River Bridge and both abutments of the Coomera Overflow Bridge, which consisted of rigid inclusions. Long term abutment movements and locked in additional movements and stresses on the bridge foundations had to be assessed and included in the design which was carried out by the Structural and Geotechnical design teams collaboratively during the design. Similar design checks during construction have also been undertaken by the WBJV to assist the construction team and to ensure no adverse load conditions are imparted onto the design during crane operations for girder installations.

Ipswich Motorway — Stage One Upgrade: Rocklea to Darra

DETAILED DESIGN | CONSTRUCTION SUPPORT | TEMPORARY TRAFFIC STAGING

BRISBANE, QLD, AUSTRALIA
CLIENT: BIELBY, HULL & ALBEM JV

The BG&E and Cardno design JV piloted the use of BIM for the Department of Transport and Main Roads (TMR) on the Rocklea to Darra project — the first Queensland transport infrastructure project mandated to use BIM. For BG&E, this marked our first use of BIM, employing 12d software for all civil design work — including alignment, pavement, guardrails, in-ground services, and drainage.

The BG&E and Cardno design JV along with the construction partners — Bielby, Hull and Albem JV, undertook the successful tender and detailed design and construction of this project. The detailed design was completed in approximately nine months thereafter.

Due to savings that were achieved as part of the design and construction process, a vital $40 million service road upgrade was added to the scope of works and was delivered within the overall project budget.

Located approximately 15 kilometres west of Brisbane's city centre, The Ipswich Motorway — Rocklea to Darra Stage One Upgrade is a three kilometre upgrade of the Ipswich Motorway and surrounding service roads.

A major challenge of this project was raising the existing motorway by 2.5 metres and widening it from two lanes to three lanes in each direction, without interrupting the 85,000 vehicles that travelled daily. This required complex staged construction methods and temporary traffic arrangements, developed in close collaboration with stakeholders and contractors.

Given the motorway's location through a low lying floodplain, the upgrade included improvements to the existing asset and adjacent service roads, significantly enhancing flood immunity for a section of the motorway prone to frequent flooding, without creating impacts for adjacent landowners.

Geotechnical design solutions were implemented to address settlement issues through a floodplain with very soft ground. Innovative deck unit and pile design solutions were employed, including using non-standard wing plank deck units and developing a bespoke precast concrete driving shoe for steel-driven piles, eliminating the requirement to remove dirt from within the steel tubes during construction.

This project received an excellence rating from Australia's Infrastructure Sustainability Council.

Ipswich Motorway — Stage One Upgrade: Rocklea to Darra — Brisbane, QLD, Australia.

Yamma Bridge, Cross River Rail

PROOF ENGINEERING BRIDGES & CIVIL STRUCTURES

BRISBANE, QLD, AUSTRALIA
CLIENT: CBGU JV (CPB, BAM, GHELLA & UGL)

BG&E developed a structural model of the bridge using Midas bridge analysis software and included the complex construction stages that were required to build the bridge over the live QR railway corridor.

The proof engineering process for this complex bridge involved a high level of collaboration between the designers and the construction CBGU JV to understand the construction staging as this had a direct impact on the design of the bridge. BG&E was able to engage with the design team and the CBGU JV to successfully close out all design comments on the bridge design.

The Yamma Bridge is slated to become a landmark for Brisbane's inner south — stretching 480 metres over passenger and freight rail lines to connect the Boggo Road health and science precinct, the Princess Alexandra (PA) Hospital precinct, a new high school, and the University of Queensland (UQ). This bridge is being delivered as part of the Cross River Rail Project in SE QLD.

BG&E was engaged by the CBGU JV to be the Proof Engineer for all structural designs associated with the Cross River Rail project which included a new cable stay pedestrian bridge and approach ramps.

The new bridge spans the Queensland Rail (QR) corridor and includes lifts on both sides, dedicated cycle and pedestrian paths, seating, shade and rest stops and is designed to meet disability access requirements.

The 480 metre long bridge is divided into a western approach, cable stayed bridge, and an eastern approach. The western and eastern approach ramps span up to 38 metres long and are 4.65 metres wide and the cable stayed section over the QR corridor consists of two spans (35.6 metres and 73.9 metres) and is 6.25 metres wide.

The bridge deck for the approaches and main cable stayed spans comprised of a steel box section with a cast in-situ reinforced concrete composite deck slab. The approach spans are supported on reinforced concrete piers consisting of a single pile and column extending into a pile cap. The cabled stayed spans are supported on a 45 metre high steel H Pylon supported by a reinforced concrete pile cap on bored piles.

Yamma Bridge —
Brisbane, QLD, Australia.

Exmouth Marina Footbridge

CONCEPT TO DETAILED DESIGN | CONSTRUCTION ENGINEERING AND SUPPORT

EXMOUTH, WA, AUSTRALIA
CLIENT: BENCHMARK PROJECTS (FOR LANDCORP)

Exmouth is one of the State's premier tourism destinations, and is also subject to cyclonic wind conditions — requiring the footbridge to be designed to both a very high aesthetic standard, and to withstand extreme wind. The BG&E design delivered an outstanding bridge that meets both of these criteria.

As part of a marina development to complement the boat harbour at Exmouth near the North-West Cape of Western Australia, Landcorp commissioned the design of a 92 metre long landmark footbridge over the main canal.

The footbridge provides a pedestrian link between the resort and harbour facilities and surrounding residential and commercial developments nearby the main marina precinct.

BG&E provided the structural design concept for the footbridge, with input from Jones Coulter Young Architecture, as well as provided a practical solution for fabrication and erection.

In addressing the design issues for the high steel arch, the design was proportioned with curved surfaces, slender arch members and shallow deck. Slenderness was achieved by triangulating the hangers. BG&E worked with the architectural team to determine the best aesthetic arrangement of arch height, deck height above water and cable inclination. The resulting cable arrangement is both highly aesthetic and also contributes to the stiffness of the structure.

Our team also provided construction support and management for the stability of the arch during temporary staging of the erection, and during lifting and transferring of the precast deck units into position.

The scope of works included construction support and planning — such as assessing the positioning of the crane outriggers close to abutment walls for the major lifts of the steel arch, construction staging and details for installation of the precast deck units and adjustment of the inclined cable lengths at rigging screws to allow adjustment of the deck to the design profile.

Exmouth Marina Footbridge — Exmouth, WA, Australia.

Mandurah Traffic Bridge

CONCEPT TO DETAILED DESIGN | LAUNCHING DESIGN & CONSTRUCTION SUPPORT

PERTH, WA, AUSTRALIA
CLIENT: GEORGIOU GROUP (FOR MAIN ROADS WA & CITY OF MANDURAH)

The $51.8 million replacement of Mandurah Bridge was part of a scope of works that included the decommissioning of the existing bridge and the design and construction of a new bridge over the Mandurah estuary, including associated roadworks, public amenities and infrastructure.

The innovative curved box cross section impressed the prestigious IStructE (The Institution of Structural Engineers, UK) Award Panel to shortlist Mandurah Bridge in Structural Award 2018 for category "Vehicle Bridges", with the following extract quoted from the judges:

'The judges were delighted by the simple elegance of this attractive but unusual concrete box girder design. The curvature of the plan form and soffit cross section has been well conceived and detailed to create a very pleasing solution. The engineers have turned what could have been an ordinary, mediocre and dull bridge into something delightful, and have thereby created a popular new landmark for the City of Mandurah.'

The existing structure was deteriorating and required an upgrade to expand capacity to two traffic lanes in each direction and improve safety for pedestrians and cyclists via separate and wider facilities over the bridge.

BG&E provided bridge design, civil and structural engineering, and flood modelling and hydrology services for the replacement bridge, which runs over the Mandurah estuary and into the surrounding marina precinct.

Our solution included adopting a unique curved soffit cross section constant along the full length of the 243 metre long bridge, comprising six spans with 42 metre long internal spans and 37.6 metre long end spans.

The alignment is a single curve throughout the bridge length in both plan and profile, facilitating incremental launching of the superstructure. The alignment is also dictated by proximity of properties and heritage listed land on the eastern foreshore.

The post-tensioned superstructure is supported on visually simple but elegant columns, constructed on piled foundations. A particular feature of the design is five metre wide shared path at a level lower than the road, further separated from the road by a concrete traffic barrier, isolating pedestrians from the road traffic to enjoy the crossing comfortably and safely.

Mandurah Traffic Bridge ––– Mandurah, WA, Australia.

Efficiencies in the design and the adopted construction techniques allowed several enhancements to be included in the project works within the fixed budget, including an additional span at the western foreshore to provide an open area for future development, architecturally improved balustrade and light poles, fishing platforms, feature lighting, public art, and landscaping.

On the eastern foreshore a section of the old bridge has been rehabilitated and converted to a fishing platform.This, in conjunction with two rows of existing piles retained at the western foreshore as part of the landscaping, which also includes sections of timber stringers from the demolished bridge, provides visual connections to the remains of the Old Mandurah Traffic Bridge.

The Mandurah Bridge project enhances traffic capacity and serves as an iconic structure, offering improved amenities for the Mandurah community.

AUSTROADS BRIDGE AWARDS: ***Winner*** — Best Structure Over 35 Metres.

CONCRETE INSTITUTE OF AUSTRALIA: ***Winner*** — National Award for Excellence in Concrete — Infrastructure Projects.

MASTER BUILDERS AUSTRALIA EXCELLENCE IN CONSTRUCTION AWARD (WA): ***Winner*** — Best Project / ***Winner*** — Best Civil Engineering Works $20 — $50 million.

AUSTRALIAN INSTITUTE OF BUILDING PROFESSIONAL EXCELLENCE IN BUILDING AWARD (WA): ***Winner*** — Infrastructure Category.

WORLD DEMOLITION AWARDS (INTERNATIONAL): ***Winner*** — Civils Demolition Category.

CIVIL CONTRACTOR FEDERATION EARTH AWARDS (WA): ***Winner*** — Category Five ($30 — $75 million) Earth Award.

ENGINEERS AUSTRALIA: ***Winner*** — WA Engineering Excellence Award.

THE INSTITUTION OF STRUCTURAL ENGINEERS: ***Shortlisted*** — Vehicle Bridge Category.

New Fitzroy River Bridge

CONCEPT TO DETAILED DESIGN | LAUNCHING DESIGN & CONSTRUCTION SUPPORT

KIMBERLEY, WA, AUSTRALIA
CLIENT: MAIN ROADS WA

In December 2023 the New Fitzroy River Bridge, delivered by the Fitzroy Bridge Alliance — consisting of Main Roads WA, Georgiou, BMD, and BG&E, officially opened to traffic more than six months ahead of schedule, marking the official reconnection of East and West Kimberley.

Flooding generated by ex-tropical Cyclone Ellie in December 2022 and January 2023 caused significant damage to the sections of Great Northern Highway at Willare Crossing and Fitzroy Crossing in the Kimberley.

At Fitzroy Crossing, the Fitzroy River Bridge was significantly damaged along with 500 metres of road — cutting access to Indigenous communities east of the Fitzroy River as well as the East Kimberley and Northern Territory. Main Roads WA (MRWA) determined that a new bridge was required at the same location, with repairs to the existing bridge not considered feasible.

Given the critical importance of this bridge to the State and National Road network, MRWA was looking to have a new bridge structure and access roads completed within the shortest practical timeframe and its elements that could be impacted by water flow completed before the next wet season.

BG&E provided bridge, civil, waterways, and sustainability design services for the Fitzroy River Bridge replacement project, which included:

- A new two-lane traffic bridge over the Fitzroy River.
- Integrating a pedestrian pathway on the bridge.
- Reconstructing bridge approaches.
- Implementing flood and scour protection.
- Managing the protection and relocation of utility services.
- Flood modelling and hydrology.
- Temporary causeway and access road.

The new bridge is 100 metres longer than its predecessor at 270 metres long and twice as wide at 12.4 metres wide. The bridge is an eight-span continuous bridge with weathering steel-concrete composite deck construction, consisting of six welded steel beams made composite with concrete insitu deck.

The bridge superstructure was incrementally launched from the western abutment and completed in 32 days.

Blade wall piers with pile caps were installed and supported by 1200 millimetre diameter cased piles with concrete infill. The supporting piles of the bridge substructure were placed significantly deeper than the old piles to cater for scour in the riverbed during extreme flood events, reaching a maximum depth of 40 metres into the riverbed.

BG&E also had a Senior Bridge engineer on site for the duration of the construction works to ensure that any issues could be expediently addressed and suitably resolved.

New Fitzroy River Bridge —— Kimberley, WA, Australia.

Tonkin Gap Project

CONCEPT TO DETAILED DESIGN | CONSTRUCTION SUPPORT

PERTH, WA, AUSTRALIA
CLIENT: MAIN ROADS WA

The completion of the Tonkin Gap Project marked a significant achievement in improving Perth's metropolitan road network. Delivered on time and within budget, this project overcame several challenges, including a constrained site, variable ground conditions, high groundwater, and managing traffic through a busy corridor—all during the peak of the COVID-19 pandemic.

The Tonkin Gap Alliance included Main Roads Western Australia, Public Transport Authority, Georgiou, BMD, WA Limestone, GHD, and BG&E.

The $400 million Tonkin Gap and Associated Works Project was part of an infrastructure package announced in 2019. The project is located approximately eight kilometres east of Perth, along Tonkin Highway between Collier Road, Bayswater and Dunreath Drive, Redcliffe.

Connecting the previous major upgrades of Gateway WA and NorthLink WA, this section of Tonkin Highway forms part of a vital freight and commuter access route known as the Perth to Darwin National Highway.

The Alliance delivered the Tonkin Gap Project to relieve the bottleneck where the Great Eastern Highway reduced from three lanes to two in Bayswater and Redcliffe, significantly reducing travel time and improving safety.

A package of 'Associated Works' to construct rail-enabling works for the METRONET Morley-Ellenbrook Line (MEL) was included in the project. The package included the construction of road and rail bridges and dive structures to enable trains to enter the median strip of Tonkin Highway at Bayswater and then exit in Malaga, approximately eight kilometres to the north.

The scope of works encompassed:

- Additional traffic lanes in each direction between Collier Road and Dunreath Drive.
- New bridges over the Swan River, Guildford Road, Railway Parade, the Midland Line railway, and Dunstone Road on the Tonkin Gap section.
- New bridge at Broun Avenue, integrating Morley Station bus interchange, rail bridges at Morley Drive and rail underpass dive structures with integral bridges, at Bayswater and Malaga — on the Associated Works section.
- Upgrades to the Guildford Road and Great Eastern Highway interchanges.
- A principal shared path with bridges, underpasses and local connections for cyclists and pedestrians.
- Pier collision protection and deflection walls to protect seven existing bridges in the Tonkin Highway median.
- Miscellaneous noise walls, retaining walls, lighting, and amenity improvements.

BG&E provided structural and civil engineering, and flood modelling and hydrology services for the project which was completed in late 2023.

Tonkin Gap Project — Perth, WA, Australia.

Hay Street Bridge

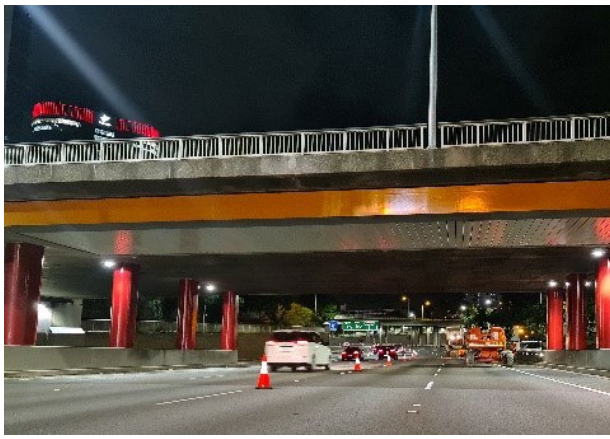
STRUCTURAL ASSESSMENT | MODIFICATIONS & STRENGTHENING DESIGN | CONSTRUCTION SUPPORT

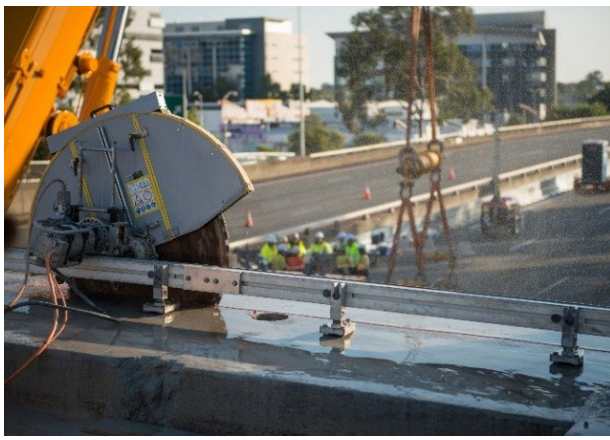
PERTH, WA, AUSTRALIA
CLIENT: MAIN ROADS WA

BG&E's innovative design modifications to the existing Hay Street Bridge provided additional clearance to reduce the likelihood of collision. Upon completion of this multi-million-dollar project, the bridge now meets the current clearance standards of the transport authority and improves safety for road-users.

BG&E was engaged by Main Roads Western Australia to undertake optioneering work and concept designs that led to detailed design and documentation for the modifications to Bridge No. 0923 on Hay Street over the north and southbound carriageways of the Mitchell Freeway and the southbound entry ramp onto the Freeway.

The superstructure of Bridge No. 0923 consists of 11-cell reinforced concrete box girders. The bridge is nominally 58 metres long with three continuous spans. The superstructure is supported on four reinforced concrete pier columns and walled abutments.





Our highly experienced team designed an out-of-the box solution to raise the height of the bridge by removing three-cells of a 21 metre middle span of the continuous bridge and adding a bridge protection beam.

BG&E designed the removal of the section of the middle span of the continuous bridge to work with the grade of the Freeway below and achieve an increased vertical clearance with minimal impact to the Freeway below and road above.

The removal of the three northern cells from Span Two of the existing bridge resulted in compatibility effects within the other spans from changing a continuous bridge to simply supported for this section of the superstructure. These issues were addressed with detailed design of post-tensioned strengthening inside the cells.

The detailed design of a bridge protection beam at the northern edge of Span Two made use of the existing pier columns and pier diaphragms, with reuse of the stone feature edge parapet also incorporated.

Hay Street Bridge — Perth, WA, Australia.

Roy Hill Mine Railway Bridges

CONCEPT TO DETAILED DESIGN | CONSTRUCTION SUPPORT

PILBARA REGION, WA, AUSTRALIA
CLIENT: CALIBRE GLOBAL (FOR ROY HILL)

BG&E supported the major greenfield Roy Hill Railway Bridges project from early stages through to detailed design and delivery.

Located in the East Pilbara Region, the Roy Hill Mine is designed to produce 55 million tonnes of iron ore annually, featuring one of the world's largest iron ore mines, a port facility at Boodarie Industrial Estate, and a 350 kilometre heavy haul rail line connecting the mine to the port.

BG&E provided bridge design, civil and structural engineering services, and hydrological analyses for the Roy Hill Mine and associated infrastructure to the port.

The scope of works included the following key elements:

- Waterways analysis, including hydrological analysis, hydraulic analysis, scour estimation, and design of scour protection for major river crossings in the Pilbara Region.
- Detailed design of eight rail-over-water bridges (steel-concrete composite), with bridges of up to 10 spans.
- Detailed design of three rail-over-rail overpass bridges (steel through-girder), with spans of up to 45 metres.
- Stakeholder liaison to agree designs for grade separated rail-over-rail crossings, where the Roy Hill crossed over FMG, BHPBIO and BC Iron assets.
- Detailed design of one road-over-rail bridge over the port rail loop.
- Civil roadworks design of Great Northern Highway intersection, level crossing, port access road and intersection, and rail construction yard — including the earthworks.
- Management of geotechnical investigation, including fieldwork, testing, interpretive reporting, and design for bridges.
- Design of pavement and surfacing for access roads and Great Northern Highway.
- Safety and constructability reviews and workshops.
- Liaison with stakeholders.
- Technical specifications to comply with Roy Hill and Main Roads WA requirements.
- Construction support.

Roy Hill Railway Bridges — Pilbara Region, WA, Australia.

Leach-Welshpool Alliance

CONCEPT TO DETAILED DESIGN | MODIFICATIONS & STRENGTHENING DESIGN | STRUCTURAL ASSESSMENT | CONSTRUCTION SUPPORT

PERTH, WA, AUSTRALIA
CLIENT: MAIN ROADS WA

Leach Highway is a strategic freight and regional link in Western Australia connecting Fremantle and the Inner Harbour with the industrial areas, including the Kewdale Intermodal Rail Freight Terminal and Perth Airport. The at-grade intersection of Leach Highway and Welshpool Road was one of Perth's most congested and dangerous intersections, with at least 50,000 vehicles travelling through the intersection each weekday.

A high percentage of heavy vehicles travel on this route. Given the critical location of this road link in relation to major industrial areas, intermodal freight facilities and the Perth Airport, transport inefficiencies directly impact economic activity in Western Australia through loss of productivity and increased freight costs.

The interchange upgrade improved the most dangerous and second most congested intersection in Western Australia, with 224 crashes recorded between 2015 and 2019, of which 204 were rear-end collisions.

BG&E was the sole civil and structural designer for the project, which included:

- A new grade separated interchange consisting of a roundabout with road bridge carrying Leach Highway over Welshpool Road.
- A new duplicate road bridge on Leach Highway adjacent to the existing bridge spanning over Armadale-Perth railway line, Sevenoaks Street and Railway Parade.
- Upgrade of barriers and installation of anti-throw/electrification screens on the existing bridge.
- Strengthening of the existing bridge to accommodate a higher performance level barrier.
- Installation of deflection walls and pier protection walls to bridge piers in the rail reserve.

The bespoke Bridge #1882 is a new duplicate road bridge carrying Leach Highway southbound traffic over Armadale-Perth railway lines, Sevenoaks Street and Railway Parade. It was constructed adjacent to the existing 50-year bridge that now carries the northbound Leach Highway traffic.

The superstructure is a complex, haunched, continuous bridge comprising eight precast post-tensioned (PT) T-beams to match the profile of the existing adjacent bridge.

The superstructure type and complexity adopted for the bridge originated from the project scope of works and technical requirements with constraints on the overall depth to fit within the restrictive vertical clearances over the railway and under the high voltage cables, and to be of weight that could be safely lifted, particularly for the central 37 metre span beams over rail. Each beam was precast in three straight post-tensioned lengths with a slight angular change at the construction joints to accommodate the road geometry that is curved in plan and profile.

The central beam was lifted in and temporarily supported by the haunched cantilevered portions of the outer beams. Following coupling of continuity PT ducts, the connections were then made rigid and then the full length of each beam was finally post-tensioned.

Leach-Welshpool Alliance —— Perth, WA, Australia.

METRONET Thornlie — Cockburn Link & Yanchep Rail Extension

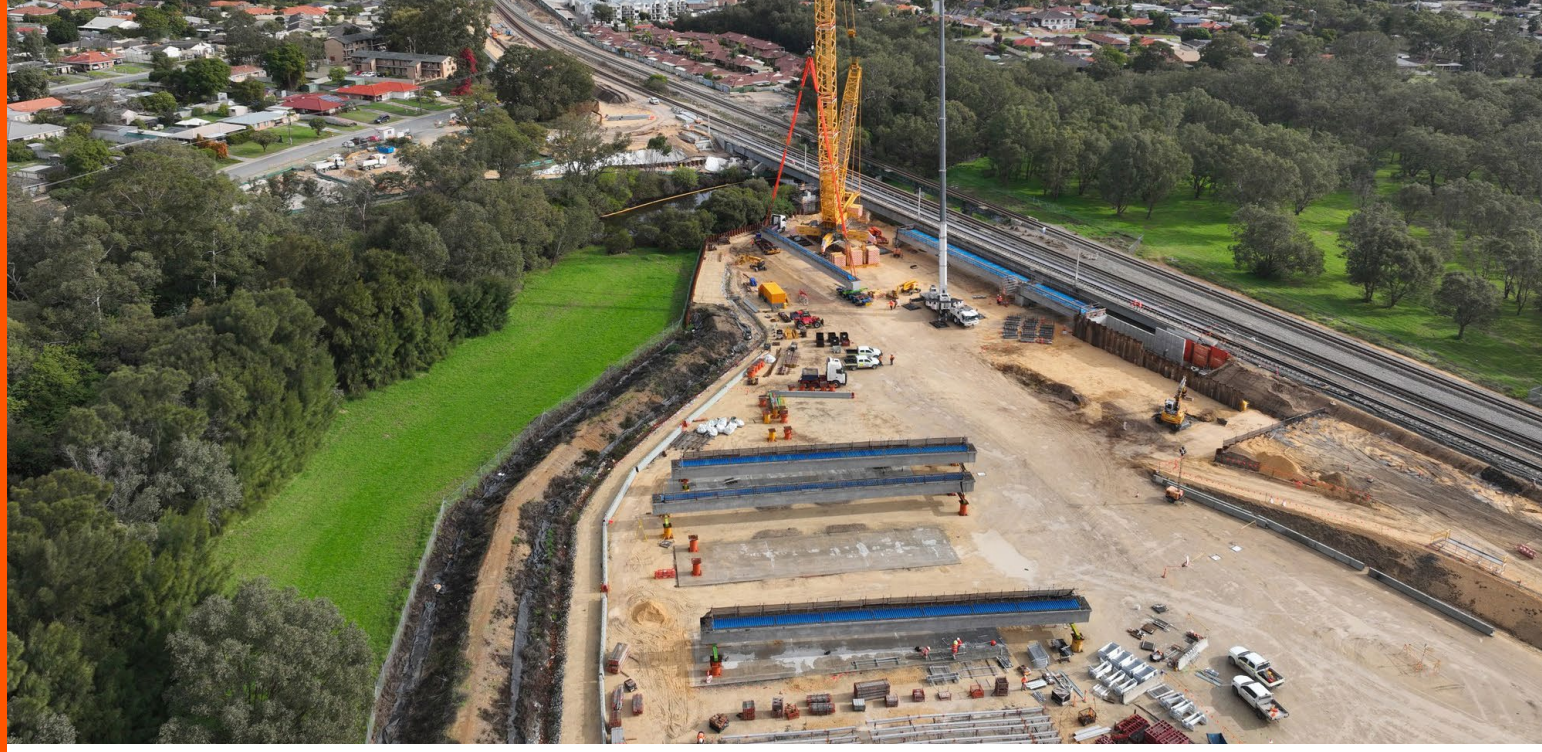
STRUCTURAL ASSESSMENT | MODIFICATIONS & STRENGTHENING DESIGN | CONCEPT TO DETAILED DESIGN | CONSTRUCTION SUPPORT

PERTH, WA, AUSTRALIA
CLIENT: NEWEST — NEWEST ALLIANCE

METRONET is the Government's long-term plan to merge transportation and land use planning in Western Australia, facilitating sustainable growth in greater metropolitan Perth over the next 50 to 100 years. It extends beyond rail infrastructure to influence the development of walkable communities around station areas.

The Yanchep Rail Extension and Thornlie-Cockburn Link are two in a series of METRONET projects aiming to expand Perth's public transport network. METRONET plans to add around 72 kilometres of new passenger rail and up to 18 stations, marking the largest investment in history into Perth's public transport.

BG&E provided detailed design and delivery services for the Yanchep Rail Extension (YRE) and Thornlie Cockburn Link (TCL) projects as part of the Design JV in support of the NEWest Alliance.



METRONET Thornlie-Cockburn Link & Yanchep Rail Extension, Canning River Rail Bridge — Perth, WA, Australia.

THORNLIE-COCKBURN LINK

Scope of works include:

- Approximately three kilometres of duplication of railway between Beckenham and Thornlie stations.
- Relocation of 11 kilometres of dual-gauge twin freight lines to create space for the electrified passenger railway.
- Approximately 14.5 kilometres of electrified passenger rail extension to connect Thornlie and Cockburn Central stations.
- Significant modifications at Thornlie Station to convert it into a through-station that accommodates six-car trains.
- Modifications to Cockburn Central Station to independently service the extension without impacting existing Mandurah Line services.
- New grade separation bridge at Ranford Road including major road upgrade works.
- Road network upgrades adjacent to Nicholson Station.
- New passenger railway bridge over Canning River.
- Modifications to the existing structures: Kenwick Tunnel, Glen Iris Tunnel and Berrigan Drive bridge.
- Stations, bus interchanges and parking facilities at Nicholson Road and Ranford Road Stations.
- Rail track, civil, drainage, main cable route to both freight rail and passenger rail.
- Replacement and upgrade of the BP KWOL underground pipeline.
- Services relocation and protection, including major gas, gravity water, and pressure water assets.
- Noise and vibration modelling and mitigation measures.
- Construction support and design of staged works packages for track, civil, drainage, rail systems, and main cable routes.
- Interface with adjacent road and rail projects.
- BIM modelling of all elements to LOD300.

BG&E carefully considered various factors such as rail freight operations, existing services, stakeholder and other project interfaces, staging of works, and environmental and heritage factors — including obtaining necessary environmental approvals. Additionally, we took into account specific elements like the Beckenham to Thornlie Station operational rail line, crossing the Canning River, the Glen Iris Tunnel and freeway interface, and the Ranford Road bridge.

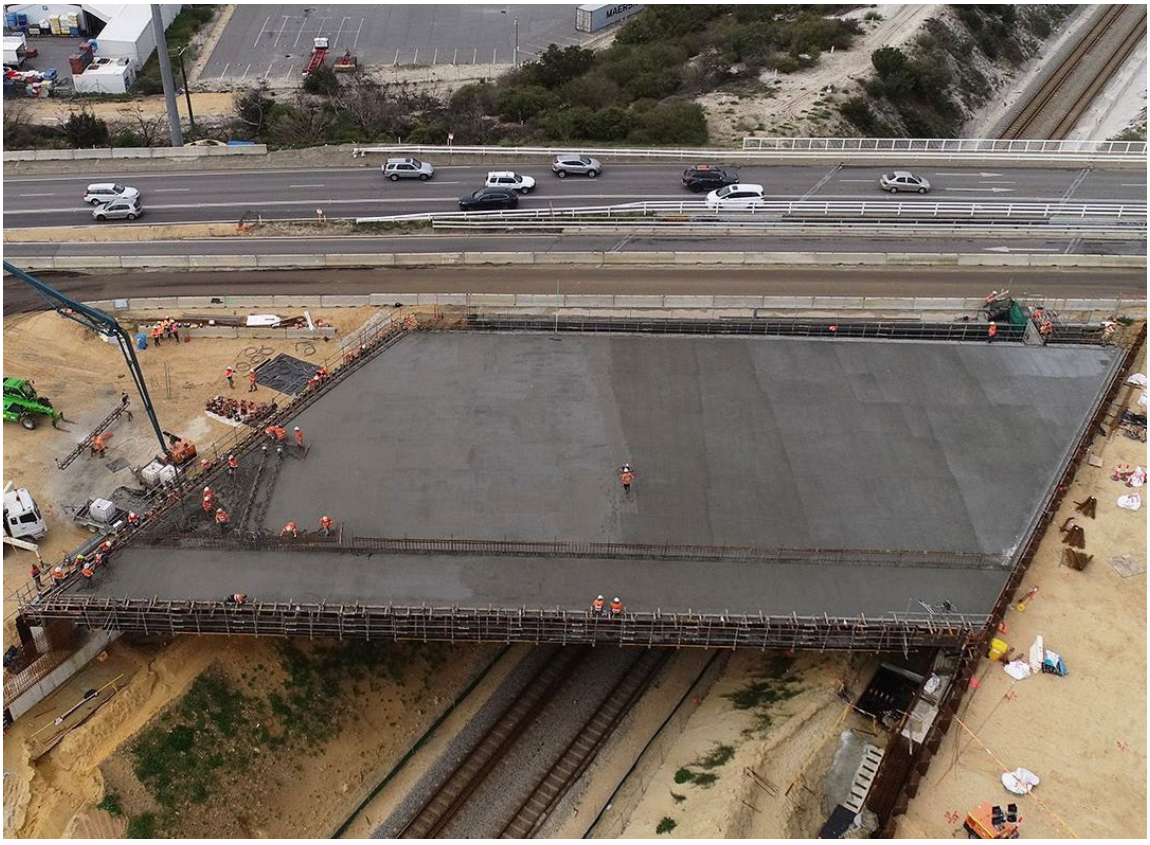
YANCHEP RAIL EXTENSION

Scope of works include:

- 15 kilometre extension to the existing Joondalup Line electrified passenger rail line, from existing Butler Station to Yanchep Station.
- 13 grade separation bridges at key road crossings.
- Retaining walls for cut alignment within rail reserve.
- Stations, bus interchanges and parking facilities for new stations at Alkimos, Eglinton and Yanchep.
- Expansion of Butler Station's bus facilities. Conversion of Butler Station from terminus to through-station.
- Noise and vibration modelling and mitigation measures.
- Significant stakeholder engagement.
- Alignment through nature reserve and three 'green bridge' fauna crossings over the railway.
- Significant earthworks along the rail alignment.
- Relocation of existing services, including major water services.
- Road access to the new rail alignment.

BG&E took into consideration various aspects, including adjacent developer interface and construction traffic, stakeholder and other project interfaces, earthworks and haulage, integration of principal shared paths, staging of works, locality, and environmental and heritage factors — including obtaining necessary environmental approvals.

METRONET Thornlie-Cockburn Link & Yanchep Rail Extension, Ramford Road Bridge — Perth, WA, Australia.



Eliwana Mine Bridges

DETAILED DESIGN | CONSTRUCTION SUPPORT

PILBARA REGION, WA, AUSTRALIA
CLIENT: FORTESCUE METALS GROUP

Fortescue Metals Group's (FMG's) Eliwana mine is located 140 kilometres west of Solomon in Western Australia's Pilbara region.

The operation included 143 kilometres of new heavy haul rail linking to the existing FMG Hamersley rail line and a 30 megatonnes per annum processing facility.

BG&E provided structural, civil and construction engineering services for Fortescue, including the detailed structural design of two railway overpass bridges, a railway arch overpass structure, and culvert structures associated with the Eliwana project. BG&E provided construction support services — leveraging our experience in the construction of steel bridges in the Pilbara region.

The unique railway bridge designs consisted of separate rail and road bridge superstructures supported by a shared substructure.

Both bridge superstructures comprised modularised steel through-girders, with the first featuring two twin 31.5 metre spans and the second consisting of six spans totalling 228 metres.

The bridges solved difficult detailing challenges associated with skewed piers supporting through-girder bridges with square slab joints. The bridges were constructed over and around third party assets including heavy haul rail, access roads and a mine services corridor (access, services, and haul road).

The structure carries the FMG rail over the future Main Roads WA project to complete the final stages of the Karratha Tom Price Road.

North South Corridor (NSC) 112, 113 & 115 Road Viaduct

ENHANCED ACCREDITED CHECKING ROLE

SINGAPORE
CLIENT: LAND TRANSPORT AUTHORITY

The North South Corridor (NSC) will be Singapore's first integrated transport corridor — connecting the East Coast Parkway expressway in the South to Admiralty Road West in the North.

The 21.5 kilometre expressway will feature continuous express bus routes and at-grade cycling trunk routes and will comprise 16 entrances and 17 exits to connect towns along the corridor.

The Land Transport Authority (LTA) tendered the works in 14 design and build packages. In collaboration with our local partner, BG&E has been awarded the enhanced Accredited Checking Role for the NSC for the following design and build packages: N112, N113, and N115 for a total construction value of about one billion SGD.

The critical components of BG&E's role include:

- Acting as consultant to the Authority.
- Structural checks with independent calculations of over 60 bridge units with evaluation of the structural capacity and serviceability performances.
- Review of design basis documentation to ensure compliance to Norms and Authority's requirements.
- Review of construction method and sequence of the balanced cantilever operations with respect to work and public safety.
- Check of pre-cambering of box girder for balanced cantilever segmental construction.

Jurong Regional Line (JRL) 105 & 106 Rail Viaduct

ENHANCED ACCREDITED CHECKING ROLE

SINGAPORE, SOUTH EAST ASIA
CLIENT: LAND TRANSPORT AUTHORITY

The Jurong Regional Line (JRL) is an elevated future Mass Rapid Transit (MRT) line that will serve the Jurong area and the western part of Singapore.

The JRL will serve 24 stations, reaching North to Choa Chu Kang, South to Jurong Pier, West to Peng Kang Hill and East to Pandan Reservoir. This is the seventh MRT line in Singapore and will feature fully automated CJ151 trains and a moving block signalling system for the line.

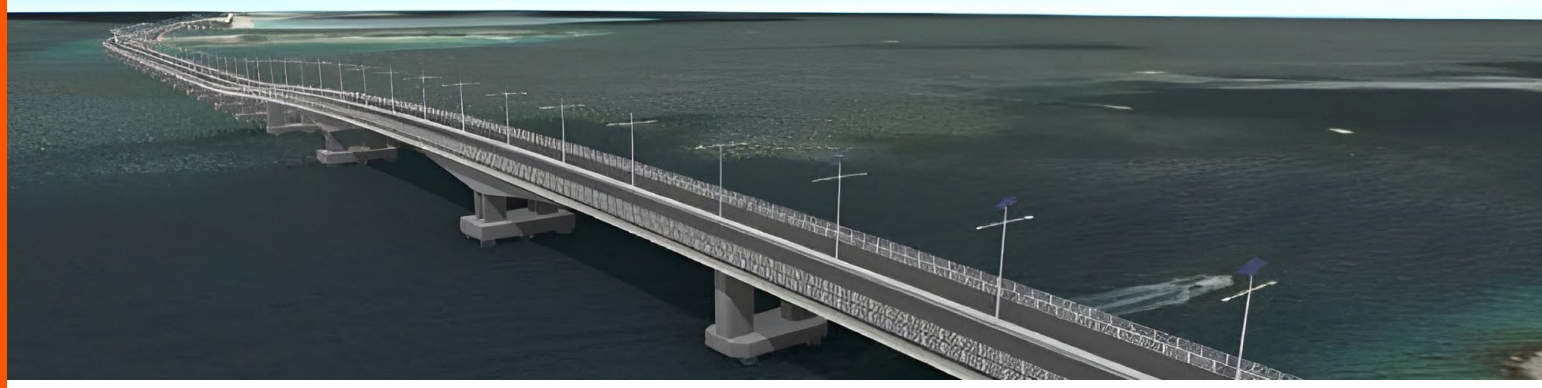
BG&E is working with a partner to fulfil the Enhanced Accredited Checking Role for the JRL. This includes viaduct packages and working collectively with the LTA and the design and construct teams.

The LTA tendered the works in 13 design and build packages. The scope of works include providing accredited checking services of the two (J105 and J106) design and build civil contracts. This includes being fully conversant about the civil works, specifically, the viaducts, stabilising structures, retaining walls, buildings and other associated permanent structures, as well as undertaking a detailed review and providing a report.

The key features of this important package are set out below.

- Performing analysis and design reviews with independent calculations on the structural and geotechnical works including but not limited to major and minor structures and elements, connections, deck furniture, all fixings, parapets, railings, permanent noise barriers, claddings and fascia, to confirm the adequacy, stability and integrity of the structural system under various construction sequence and loading conditions, meet the serviceability requirements and comply with the LTA' specifications.
- Performing a review with independent calculations on the proposed demolition sequence at existing structures or stations, checking the adequacy of the existing structures and the proposed protective and strengthening design works to the existing structures.
- Conducting analysis with independent calculations on the rail viaduct bearing articulation, design loading and movement ranges at movement joints.
- Undertaking serviceability checks, including but not limited to deformation analysis, vibration, with independent calculations for the rail viaduct, retaining walls, buildings and other associated permanent structures where appropriate.
- Reviewing the design on structural detailing, connection details including detailing of reinforcement bars and strengthening details.
- Conduct design review on drainage design, durability performance of the structures including fire protection, waterproofing, accessibility and maintainability, ease of future structural inspections and ease of future bearing maintenance and replacement works.
- Reviewing the method and construction sequence particularly in the aspect of impact to public safety, check the effects of construction load on the permanent structures and construction safety risks, and checking pre-cambering of box girder for balanced cantilever segmental construction.

JRL 105 & 106 Rail Viaduct — Singapore, South East Asia.



Male-Thilafushi Link

TEMPORARY WORKS CHECKER

MALDIVES
CLIENT: AFCONS INFRASTRUCTURE LTD

The Greater Male Connectivity Project (GMCP) is the largest infrastructure project in the Maldives, consisting of a 6.7 kilometre bridge and causeway network to connect the islands of Male, Villingili, Gulhifalhu, and Thilafushi in the Maldives using renewable energy.

The new bridge includes:

- Three navigation bridges of 140 metre main span across the deep channel between each island.
- 41 kilometres of marine viaduct in deep water.
- 32 kilometre marine viaduct in shallow water land.
- 96 kilometres of at-grade roads.

The project will use solar power for road lighting, navigation lighting, deck cell lighting, CCTV and lighting on sign gantry and architectural lighting. There will be bus terminals on all islands near mainline junctions.

BG&E is the Temporary Works Checker. The scope of service includes checking all temporary works, including temporary steel bridges and platforms for the piling operations, steel liners for temporary and permanent piles, pile cap cofferdams and shuttering, load-out jetties, erection gantries, lifting frames and spreader beams for the balanced cantilever erection, casting yard equipment, floating stability, and the lashing system for bridge segment transportation on barges.

The GMCP is set to serve as a vital economic and transport link for the Maldives, connecting four crucial islands, which represent nearly half of the country's population, with the proposed Gulhifalhu Port and Thilafushi Industrial Zone, as well as South Asia and other regions beyond.

Tees Transporter Bridge

STRUCTURAL ASSESSMENT

MIDDLESBROUGH, UK
CLIENT: ATKINSREALIS UK

The Tees Transporter Bridge, located in Middlesbrough in Northern England, opened in 1911. It is the longest cantilever bridge and longest working transporter bridge in the world. When functional, it uses a travelling gondola suspended from the bridge to carry 200 people or nine cars across the river in 90 seconds.

In 2019, the bridge was closed due to safety concerns. Urgent repair works were carried out, including the replacement of missing or damaged sections of steel on the upper spans and the drilling and bolting of other areas following the failure of some welded sections. Further assessments indicated that in addition to the defects identified, strengthening works were also required on the upper spans of the bridge.

In 2022, Atkins was awarded the full structural inspection and assessment of the Tee Transporter Bridge. BG&E was engaged by Atkins to conduct an independent Category Three Check — Structural and Mechanical Assessment.

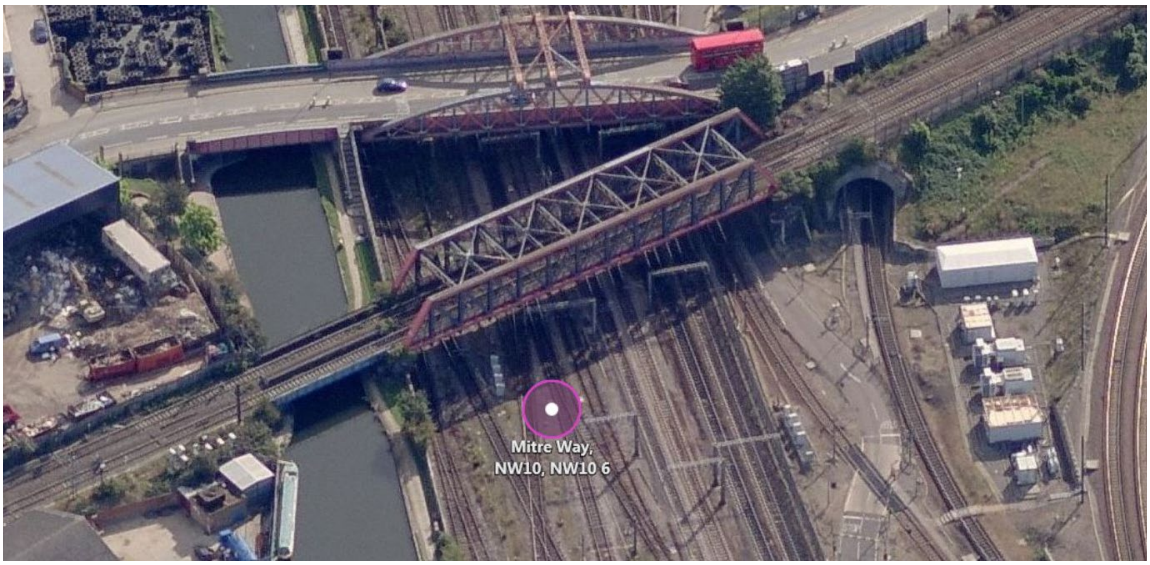
The scope of services includes the assessment of the bridge and mechanical components for the main bridge (including the winch systems, gondola and cables), and the access span.

The outcome of the structural inspection and assessment will inform what further works are required for the bridge and whether it is feasible to bring the bridge back to full operational capacity.

High Speed Two (HS2) Asset Protection Framework

STRUCTURAL ASSESSMENT | MODIFICATIONS & STRENGTHENING DESIGN | CONSTRUCTION SUPPORT

LONDON, UK
CLIENT: OTB ENGINEERING



The Skanska Costain STRABAG (SCS) JV is building 13 miles of twin-bore tunnels on the HS2 route, connecting London to the Midlands, North and Scotland. Valued at four billion pounds, this new high-speed railway will have its southern terminus at Euston. Given that 95% of the journey is underground, the project involves six Tunnel Boring Machines (TBMs), with five operating simultaneously.

The preliminary studies carried out as part of the HS2 Euston Tunnels planning phase concluded that various bridges along the HS2 tunnels route could be potentially affected by tunnelling-induced ground movements.

BG&E was appointed by OTB Engineering (working for SCS JV) to provide bridge engineering services, including site inspection, surveys and detailed structural analysis to review the results of the initial studies completed by the permanent works designers.

The approach followed by BG&E to maximise value for the client was to:

- Refine the structural analysis and incorporate soil-structure interaction considerations to maximise the opportunities to demonstrate that the existing bridges could accommodate the predicted ground movements without mitigation measures.
- Propose and develop the most efficient mitigation schemes only when strictly necessary.

Working in partnership with OTB Engineering (tunnelling specialist), BG&E analysed a large number of bridge structures, providing recommendations on the predicted level of damage.

A summary of BG&E's scope of work is highlighted below.

MITIGATION DESIGN

- Three bridge mitigation design schemes to TfL, NR and HS2 standards.

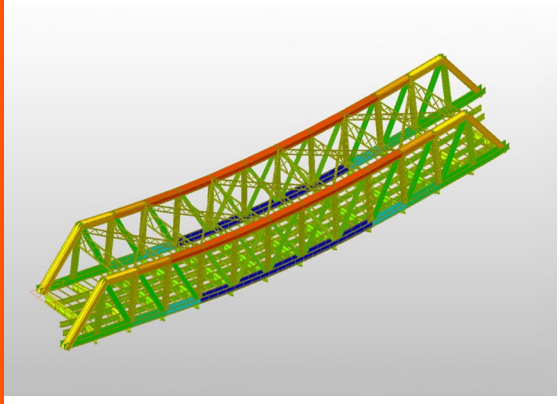
PHASE THREE GROUND MOVEMENT ASSESSMENTS (GMAS)

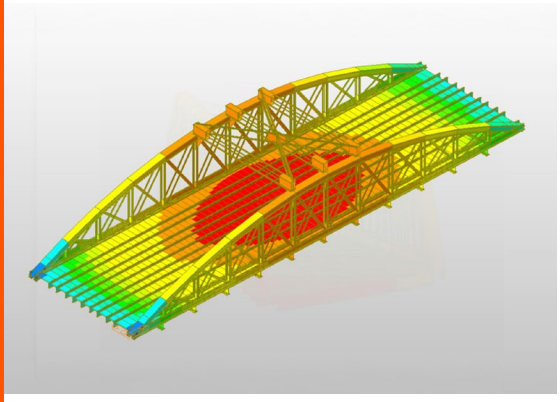
- Site surveys and inspections.
- 27 refined GMA Reports (bridge assessments).
- For eight Transport for London (TfL) assets, BG&E also provided the additional deliverables to TfL and HS2 standards — Bridge Approval in Principle (AiP) for Assessment and structural assessment reports.
- For four Network Rail (NR) assets, BG&E also provided additional deliverables to NR and standards — Forms A, B, C, AA and BA, and CRE Civils.

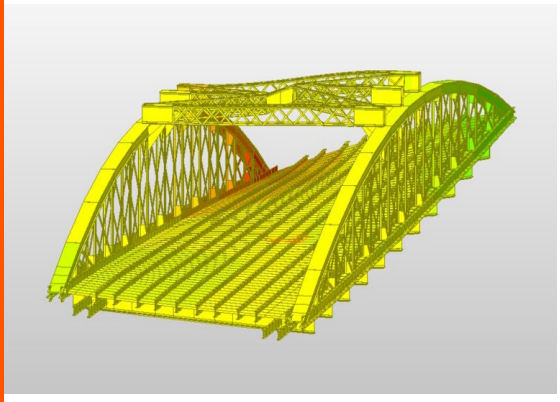
PHASE THREE GMA INDEPENDENT CAT THREE CHECKS

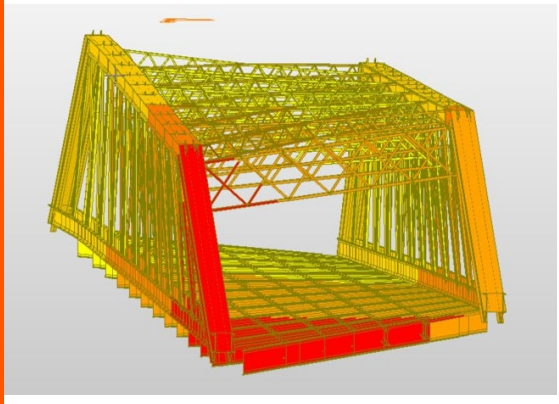
- Seven bridge GMA Reports Cat Three Checks.
- Two bridge mitigation scheme design Cat Three Checks to TfL and NR standards.

HS2 — SCS JV Asset Protection Framework — London, UK.









HS2 — SCS JV Asset Protection Framework — London, UK.

As part of the 27 bridge Phase Three refined GMA reports, full structural assessments to the asset owner's standards were carried out to determine the load capacity of all key structural components with and without the ground movement effects.

The typologies of the rail and road bridges and footbridges assessed included:

- Reinforced and restressed concrete decks.
- Composite decks.
- Steel trusses.
- Half-trough steel decks.
- Masonry arches.
- Highly skewed decks.
- Reinforced concrete portal frames.
- Multi-span continuous decks.

As a result of the refined analysis, the mitigation works required ahead of the TBM crossing were significantly reduced from the initial 27 bridges to only three.

The significant positive contribution made to the overall project can be summarised as follows:

- 90% reduction in the number of structures requiring mitigation (from 27 to only three).
- Reduction of the mitigation scheme scope.
- Significant construction programme risks removal or reduction.
- Reduction in the carbon footprint by eliminating almost entirely the initial mitigation schemes identified.
- Minimal disruption to third parties, asset owners and asset users for some of the key traffic and rail networks in the London area.

BG&E's team had demonstrated, throughout the duration of the Asset Protection Framework, the ability to undertake complex analysis, apply sound engineering and risk management principles, understand the key and most essential project requirements and expectations and provide a whole range of services to maximise the additional value delivered to the client, stakeholders and the community.

White City South Campus Infrastructure Delivery Plan

STRUCTURAL ASSESSMENT | PARTIAL DEMOLITION | MODIFICATIONS & STRENGTHENING DESIGN | CONSTRUCTION SUPPORT

LONDON, UK
CLIENT: CAREYS

Careys was awarded the contract to deliver the White City South Campus Infrastructure Delivery Plan (IDP Area A) for Imperial College. The scope of the project is to build the site-wide infrastructure at an early stage, enabling future buildings to be constructed on a serviced plot basis.

Key to the success of the masterplan and the project is a new vehicular and pedestrian access bridge adjacent to the Depot Road entrance, which will span over the central line.

It will provide a more direct link with Wood Lane and will replace the existing Depot Road bridge that will be partially demolished.

BG&E has been appointed by Careys as a Specialist Bridge Consultant to provide asset protection and temporary works design services for the existing Depot Road bridge in its current and final configuration provide the temporary works design and construction support for the construction of the new overbridge.

The full scope of the services provided on this project include:

BRIDGE ENGINEERING

- Depot Road Bridge demolition scheme feasibility, optioneering, design and checks.
- Beams temporary lifting systems.
- Beams temporary stability, longitudinal and transversal restrains and bracing systems.
- Supplier's proprietary temporary systems checks.

RAIL ENGINEERING

- Design assurance to LuL standards.

GEOTECHNICAL ENGINEERING

- Lifting crane and piling platforms.
- Temporary excavation support systems.
- Slope stability analysis.
- Groundwater management support.

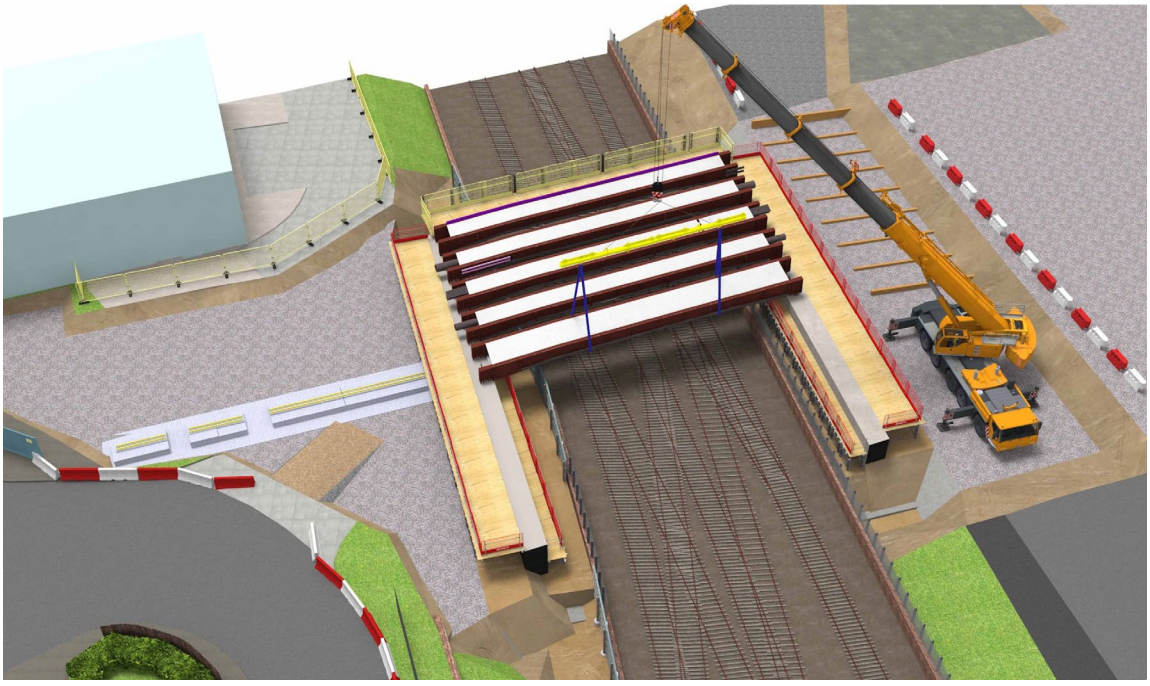
ASSET PROTECTION

- Site inspections.
- Condition survey report.
- Depot Road Bridge and existing rail infrastructure assessment and protection.
- Utility damage assessment and protection.
- Monitoring plan and response plan.

CONSTRUCTION ENGINEERING

- Construction sequencing and methodology for installation of new bridge and demolition of the existing bridge.
- Construction site support.
- TWC support (temporary works identification and design brief preparation).

White City Depot Road Bridge — London, UK.



Flyover for the Saar Interchange

DETAILED DESIGN | CONSTRUCTION SUPPORT

MANAMA & HAMAD, KINGDOM OF BAHRAIN
CLIENT: ALGHANIM INTERNATIONAL (FOR MINISTRY OF WORKS, KINGDOM OF BAHRAIN)

Out of 300 projects from across the Middle East and North African region, the work on the design and delivery of the Sheikh Khalifa Bin Salman Highway (SKBSH) and Sheikh Isa Bin Salman Highway (SIBSH) upgrade was recognised by MEED as "a true benchmark for quality and excellence," winning the MEED National Award 2021.

The SKBSH is a crucial roadway in the Kingdom, linking Manama, Hamad Town and the southern governorate. Widening and improving the SKBSH and SIBSH were essential to boost capacity, ease congestion, improve accessibility, and meet traffic demands through to 2030.

BG&E was engaged for the detailed design and construction of the new left turn flyover at the SAAR Interchange.

The flyover bridge, built using the incremental launching method, represents Bahrain's first application of this technique — a significant engineering feat for the project.

The bridge used pre-stressed concrete and advanced mechanisation and was launched from one abutment on a tight combined horizontal and vertical curve. Spanning approximately 515 metres in length and 13.45 metres in width, it accommodates two 3.75 metre lanes, with an outer shoulder of three metres and an inner shoulder of 1.96 metres.

BG&E's use of the incrementally launched construction method provided optimal advantages compared to conventional construction, including:

- Detailed design and delivery occurred without traffic closures, minimising disturbance to the community and surroundings.
- A more concentrated work area for superstructure assembly.
- Increased worker safety given the improved erection environment.
- Social and environmental benefits, including preserving cultural heritage through enhanced community connectivity, and protecting the natural environment via integrated planning regulations and reduced pollution, leading to improved safety.

Following the project's completion, vehicle capacity surged from 900 to 3,600 vehicles per hour, significantly alleviating congestion at bottlenecks, while daily traffic volume soared to 173,000 vehicles in both directions.

Saar Interchange —
Manama & Hamad, Kingdom of Bahrain.

Etihad Rail Network Viaducts, Stage Two

DETAILED DESIGN

ABU DHABI, UNITED ARAB EMIRATES
CLIENT: WSP (FOR ETIHAD RAIL)

Etihad Rail's 1,200 kilometre network will extend across the United Arab Emirates (UAE), from the border of Saudi Arabia to the border of Oman.

Engaged as a subconsultant to WSP, BG&E provided structural engineering services for Stage Two C of Etihad Rail's major national railway project, which links the Saudi Arabian and Gulf Cooperation Council (GCC) rail networks in the West to the Oman border and GCC rail network in the East.

The new infrastructure promotes growth in the UAE's industrial and services sectors and enables increased mobility of freight and passengers between cities in the UAE, ports and manufacturing hubs.

BG&E provided the detailed design for approximately 1.8 kilometres of railway bridges for the Desert Main Line C (DMC) and Jebel Ali Branch Line (JBL) line. The bridges mainly consist of post-tensioned cast-in-place box girders supported on concrete piers and piled foundations, and steel through or semi-through materials were deployed where the bridges crossed roads.

The JBL railway bridge is approximately 1.3 kilometres long, and includes 36 supported spans, ranging between 17 metres and 72 metres. The DMC railway bridge is around 550 metres long and includes 15 spans, either with a simply supported or continuous deck.

In addition to enhancing sustainable economic development, the Etihad Rail Stage Two construction project supports the wellbeing and quality of life of residents and tourists. This project is viewed by government as integral to supporting the UAE's Centennial 2071 as well as strategically enhancing the region's leadership.

Etihad Rail Network Viaducts, Stage Two — Abu Dhabi, United Arab Emirates.

At BG&E, we are united by a common purpose — we believe that truly great engineering takes curiosity, bravery and trust, and is the key to creating extraordinary built environments.

Our team of more than 800 highly skilled people, in offices across Australia, New Zealand, Singapore, the United Kingdom and Middle East, design and deliver engineering solutions for clients in the Property, Transport, Ports and Marine, Water, Defence, Energy and Resources sectors.

BRI_DIS_CS_R1_P0126

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