

# **A Tale of Two Bridges**

## **A Comparison of Tyrone and Runnyford Bridge Constructions**

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### **ABSTRACT**

As part of Eurobodalla's ongoing bridge replacement program, Council committed to the renewal of Runnyford Bridge over the Buckenbowra River at Runnyford. Simultaneously, grant funding was obtained from both NSW and Australian Governments for the replacement of Tyrone Bridge over the Tuross River at Eurobodalla. This paper looks at the two projects, the methods, costs and outcomes and compares the two.

Runnyford Bridge is a 130m long timber structure that was replaced like-for-like within the existing footprint whilst Tyrone was the replacement of a 60m long low-level timber bridge with a 90m long concrete structure at a higher level on an adjacent alignment. Runnyford was Council funded, undertaken in-house to no predetermined design rather replicating what was existing. Tyrone was grant funded and delivered by a Design & Construct Contract under external supervision by NSW Public Works, with Council undertaking the tie-in roadworks.

Whilst both projects have delivered the desired outcomes, they raised a number of significant issues in methodology, project management and skills. Lessons have been learnt from both projects and applied to Council's systems and methodologies.

### **1 INTRODUCTION**

As part of Eurobodalla's ongoing bridge replacement program that has seen the replacement of 15 timber bridges since the early 2000's, Council committed to the renewal of Runnyford Bridge over the Buckenbowra River at Runnyford. Simultaneously, grant funding was obtained from both the NSW and Australian Governments for the replacement of Tyrone Bridge over the Tuross River at Eurobodalla. This paper looks at the two projects, the methods, costs and outcomes and compares the two new structures as examples of bridge renewal methodologies.

### **2 BACKGROUND**

Council has been undertaking a bridge replacement program for over 15 years. The program has been developed and refined based on the methodology outlined in the NSW Roads Directorate Bridge Management Guide. This program has seen the successful replacement or renewal of a number of poor assets that were unable to perform their function.

In recent years the program has been able to be accelerated as a result of investment by both the NSW and Federal Government through a series of programs including the NSW Government's Fixing Country Roads Programme and the Australian Government's Bridges Renewal Programme.

During 2016-2018 four bridges were replaced. Two of these are the subject of this review - Runnyford Bridge over the Buckenbowra River at Runnyford and Tyrone Bridge over the Tuross River at Eurobodalla.

### 3 THE PROJECTS

#### 3.1 Runnyford

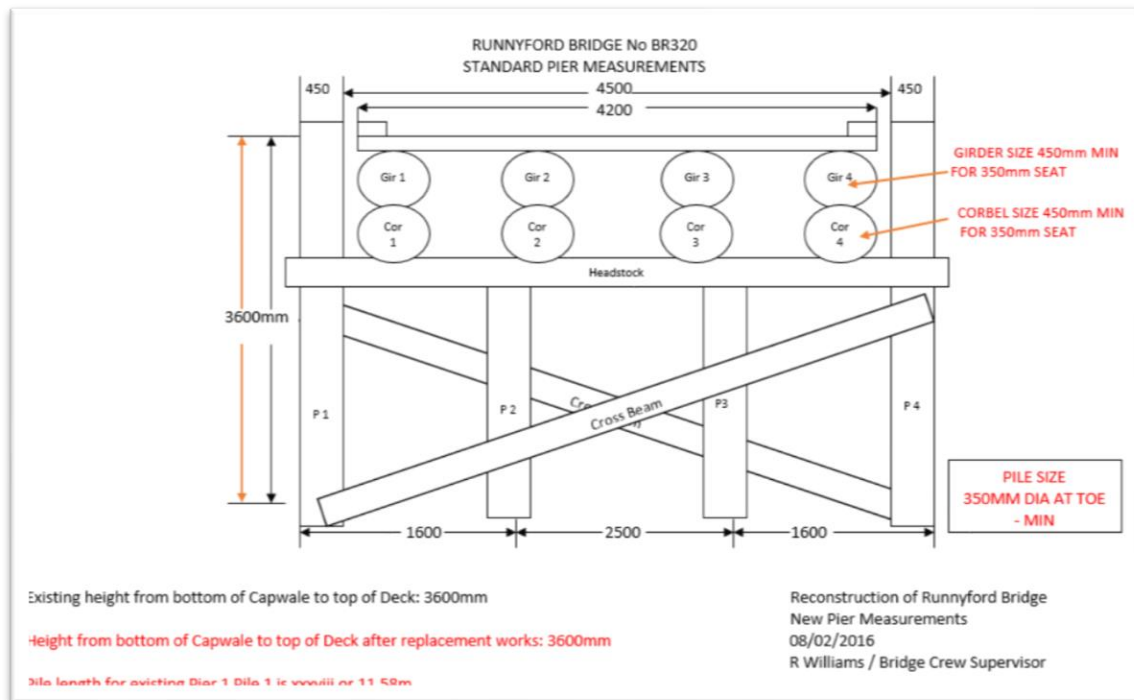
A high level, 130m long, timber bridge, it is located west of Batemans Bay, approx. 10km north-west of the Princes Hwy, where Runnyford Road crosses over the Buckenbowra River. It is composed of 13 x 10m long spans, each span constructed from timber girders and supported on piers constructed from timber piles. Some piers at the time of reconstruction were rotten through and supported by steel piles driven adjacent.



Figure 1- Runnyford Bridge



Figure 2- Location Plan - Runnyford Bridge



**Figure 3- Runnyford Bridge proposed pier layout**

The bridge was constructed in about 1953 to a (then) DMR design with subsequent alterations in the intervening years.

An assessment prior to 2004 instigated the placement of a 12 tonne limit on the bridge. Damage caused by heavy vehicles using the road when the Batemans Bay Bridge was unable to be used in November that year, necessitated repairs which lifted the limit to 15 tonnes. In September 2015, the limit was reduced to 5tonne due to further failings.

This limit was not sustainable as it restricted movement of local fire-fighting appliances and investigations were begun into the replacement of the bridge.

During the investigation period, further deterioration occurred, particularly one busy weekend when the lifting mechanism on the Batemans Bay Bridge again failed and Runnyford Road was used as an unauthorized alternate route. In recent times, piles have been observed to be sinking and the bridge twisting.

After geo-technical investigations and hydraulic assessments were undertaken, the potential options were reviewed by Council staff.

Due to it being located within a sanctuary zone of the Batemans Marine Park, significant requirements were placed upon Council, restricting the method of replacement. In particular these excluded the construction of a new bridge on a different alignment, not allowing piles to be bored and driven, and the protection of sea grasses in the adjacent river bed.

After a review of the potential options, it was determined that the bridge would be replaced like-for-like within the existing footprint.

The northern abutment had been previously replaced in 2015 and so was not included in the project.



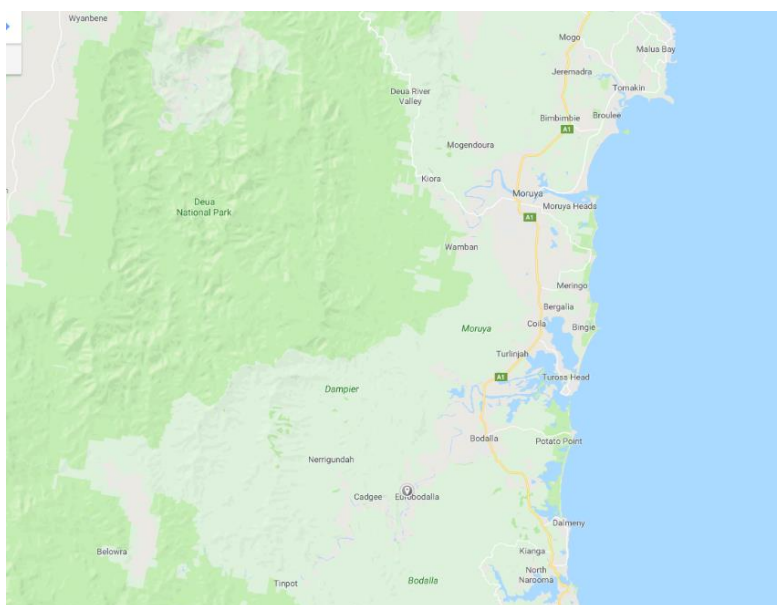
### 3.2 Tyrone Bridge

Tyrone Bridge was a low-level timber bridge over the Tuross River at Eurobodalla, approx. 9km south-west of Bodalla.

The bridge posed a number of issues for both the local community and Council, including being regularly overtopped as the deck was at a level equivalent to the 200% AEP flood event for the river. These operational issues had significant impacts on regional industries, including steep drop-down and rise from surrounding roads to the bridge deck resulting in significant strain on heavy vehicles using the bridge, routing closure due to flooding, and a high risk factor due to difficulty in assessing the impact of a flood event on the bridge before allowing re-opening.



**Figure 4- Existing Tyrone Bridge**



**Figure 5- Location Plan: Tyrone Bridge**

As part of a separate NSW Fixing Country Roads grant, the condition and structural capacity of a number of concrete and timber structures across Eurobodalla were determined. Council engaged Sterling Consultants in 2015 to undertake this as limited technical capacity existed with Council to undertake this type of investigation. Included in this review was an assessment of Tyrone Bridge.

The structural assessment indicated a 5t limit was required for T44 vehicles and 10 tonne for SM1600 vehicles due to its extremely poor state.

Consideration determined that a new bridge should be provided with corrective actions to be undertaken in the interim. Application was then sought for the funding of a new bridge.

Repairs were done that improved the load capacity of the bridge to a level that allowed the continuing use of the bridge by the milk tankers, gravel trucks with trailers (dogs), timber jinkers serving logging operations in the adjacent state forests as well as farm vehicles, school buses and residents of outlying communities that utilized the bridge on a daily basis until funding could be allocated for the construction of a replacement structure.

Concept planning was begun on a replacement. To limit the impact on transport movements and local traffic (alternative was a 17km detour from Cadgee or a 23km round trip for those close to the bridge), it was determined that the existing bridge needed to be kept operational during any construction so a new alignment chosen downstream (actually the site of the first bridge over river) to allow construction to occur without impacting traffic.



**Figure 6- Proposal for Replacement of Tyrone Bridge**

Funding became available from the NSW and Federal Governments through a number of programs and so the project was accelerated.

As the project was fully funded by external bodies, it was determined that a Design & Construct Tender would be sought. The tender was for a new concrete bridge at a raised level (approx. 100% AEP) with direct project management being undertaken on behalf of Council by Public Works Advisory.

The chosen level was dictated by the level of the bridges on Eurobodalla Rd downstream of Tyrone Bridge. These would not be replaced in the foreseeable future and therefore a level relative to the lowest of these was chosen as that bridge would limit access into the valley during flood events and therefore no additional access to properties across the Tuross River would be gained.

The successful tenderers proposed an alternate design that allowed a 90m concrete bridge rather than the concept 80m bridge. This was accepted.

## 4 COMPARISONS

### 4.1 Anticipated Outcomes

The outcome for both projects was the replacement of a failing asset (bridge) with a new bridge capable of carrying both T44 and SM1600 vehicles, whilst minimizing disruption to the local community.

### 4.2 Project Planning

#### 4.2.1 Expectation/Aims

##### *Runnyford*

The aim of the project was to rebuild the bridge like-for-like within the footprint of the existing bridge so as to lift the imposed load limit and allow the passage of emergency service vehicles such as fire tankers and large plant used in fire-fighting operations (dozers, etc)

##### *Tyrone*

The aim of the project was to improve access for important local and regional industries and reduce impacts through regular closure of the bridge due to flooding.

#### 4.2.2 Objectives

##### *Runnyford*

- Renewed bridge
- Minimal impact on the river
- Increased load limit on river crossing

##### *Tyrone*

- New bridge
- Increased productivity for businesses and community using the bridge
- Minimal impact on river

#### 4.2.3 Scope of work

##### *Runnyford*

The scope of the project was the:

- Provision of a safe work environment
- Demolition and replacement of Runnyford Bridge within its existing footprint
- Reconstruction of the south-eastern abutment in front of the existing abutment
- New road approaches to match the new deck
- Sealing of the road approaches
- Installation and maintenance of traffic control for duration of project

##### *Tyrone*

The scope of the project was the:

- Provision of a safe work environment
- Construction of new concrete bridge at a higher level on a new alignment
- Re-alignment of road approaches (vertical) and construction of a new intersection with the adjacent Eurobodalla Rd
- Demolition and removal of the existing bridge

#### 4.2.4 Key Issues

A number of key issues were identified in the project planning for both projects.

##### *Runnyford*

- Safety of workers
- Limit impact on the Marine Park that the bridge is located within
- Use and development of in-house skills that have been developed over many years and need to be preserved
- Work needing to be done within advertised time frame to limit the impact on the community
- A restored load capacity capable of carrying anticipated traffic

##### *Tyrone*

- Decrease the number of days that access and use are lost due to flooding
- Maintenance of access and use of the existing bridge during construction
- Maintenance of access to river for recreational use

### 4.3 Construction

#### 4.3.1 Timeline

##### **4.3.1.1**      *Runnyford*

The project commenced in 2016 though, due to a number of changes and alterations, the actual construction did not commence till March 2017. At the time of commencement, it was anticipated to be completed by October 2017.

- June 2016    -   Timber procurement commenced based on initial estimate
- Nov 2016    -   Significant staff changes occurred within the bridges area with the appointment of a new bridge carpenter (Work Supervisor) and Engineer responsible for Bridge and Marine assets (myself).
- Dec 2016    -   Hydraulic report received
- Jan 2017    -   Deck level chosen
- Feb 2017    -   Revised timber procurement and sourcing of plant
- Mar 2017    -   Site establishment
- April 2017    -   Abutment B constructed
- Change in type of pile used – from H5 (double treated) to H5 with additional protection
- Pile driving for first pier commenced
- May 2017    -   advice on capability of piles to handle design loads – changed to 22m piles.
- Modified to 3 piles per span due to difficulty in sourcing piles
- System for anchoring of support wires required for tethering of piles during driving operations developed
- Feb 2018    -   Deck completed. Installation of handrail commenced.
- March 2018 – Works complete and left site
- June 2018    -   Road approaches built and sealed

#### **4.3.1.2 Tyrone**

The project commenced in 2016 with the preparation of a concept design prepared in-house for alignment and height.

- April 2016 – PWA engaged to prepare tender documentation, manage project
- Aug 2016 – Tender awarded for Design review and assessment
- Sept 2016 – Tenders called for Design and Construction of bridge
- Jan 2017 – Contract for design and construction of replacement bridge awarded
- June 2017 – Design drawings submitted
- Aug 2017 – Site established and construction commenced
- Nov 2017 – Road construction undertaken by Council
- March 2018 – Existing bridge demolished
- June 2018 – Official opening

### **4.3.2 Activities**

#### **4.3.2.1 Runnyford**

After establishment of the site, including the construction of a works compound on adjacent property, works commenced on the demolition and building of the eastern abutment. Removing the first span (Span 13 by Council's numbering system), piles were then driven by an excavator before the timber abutment was constructed.

Going forward, a standard process was developed for the reconstruction of each span:

- Install anchors for stays
- Drive piles in riverbed through bridge deck using drop hammer on crane positioned on bridge in front of existing pile – monitor pile set
- Move barges supporting scaffolding into place
- Demolish span
- Build pier
- Install corbels, girders then deck

This sequence was then repeated for each subsequent span and pile.

As well, mattresses for the deck and the splicing of piles occurred within the construction compound as resources were available.

Upon completion of the deck, the handrail was installed along both sides of the bridge.

#### **4.3.2.2 Tyrone**

For Tyrone Bridge, the project was supervised by Public Works Authority (PWA) under a GC21 contract.

The submitted design was subjected to 3rd party review and acceptance. Upon approval, construction commenced.

The bridge is supported on steel piles which were driven to refusal, located outside of the river flow. Upon these piles were constructed concrete pile caps with abutments, piers and headstocks being formed on them and poured on-site.

After stipulated curing, pre-cast girders were delivered to site and installed using a crane. These were 18m long girders between the piers and 18.125m between the abutments and the adjacent piers.

After installation of the girders, the deck was formed and poured, with a power screed being used to finish the deck, prior to the installation of steel railings.



During the curing period for the deck, the abutment slabs were constructed to allow the roadworks to proceed. This involved the undertaking of bulk earthworks to suit the new alignments, construction of road pavement and sealing of the road approaches.

Upon completion of the road approaches, the old bridge was removed.

### 4.3.3 Problems Encountered

As with any project, a number of issues arose that required management.

#### 4.3.3.1 *Runnyford*

##### 1. Increased pile length

Due to the restrictions imposed by the Permit issued under the Marine Parks Act, alternate methods to boring and driving piles from a barge, as had previously been undertaken. A number of methods were investigated. The method adopted was the driving of piles from a crane located on the bridge.

Once committed to this methodology, it was found that the only available machinery with the required reach and capacity was a 50t crane. The loading placed on the bridge by such equipment meant that piles were required to be driven to an average depth of 18-22m, much more than the 9.5m indicated on the bridge drawings.

Piles of this length were not readily available and therefore were constructed on-site by splicing available 18m and 12m piles. This had not been done by staff previously.

##### 2. Support for piles

Due to the height of the piles, stays were required during driving. These were anchored to concrete blocks placed on the riverbed in locations clear of seagrass wherever possible. Some were located where the impact would be minimal with the approval of the Marine Park Authority upon the requirement that they would be moved at the end of driving that pile, so as to minimize the impact.

##### 3. Access across water

Seagrass within sections of the river meant that scaffolding could not be placed directly upon the river bed for extended periods. It was determined to utilize floating barges to support the scaffolding required for constructing the piers and installing the superstructure.

##### 4. Increased girder length

Due to having to be clear of existing piles (needed to support the existing span ahead), creep meant that the last span would have to be longer than 10m (the length of the rest of the girders) or an additional pier constructed. It was chosen to utilize a longer span for Span 2 (2nd last span constructed) but this restricts allowable load to about 95% of other spans and will require a load limit to be installed but not as restrictive as previously. Alternative girders were then needed to be sourced at short notice.

##### 5. Borer treatment

Due to the location of the bridge in tidal waters that could be prone to borer, it was initially proposed to use double-treated piles. With the change in piles, these were not available and so alternative measures were investigated. The chosen solution was wrapping the of critical sections with a denso-type tape and installation of mesh protection to the tape to protect it from waterborne material that could puncture the tape, therefore exposing the pile to borer attack

##### 6. Delays

Due to the extended construction period, the works extended from 3 months to 12 months, into winter and summer.

The extended construction period meant that time was lost due to high winds and rain during an unfavorable season. At these times, days were lost due to being unable to work with power tools, as a good grip on tools could not be guaranteed and therefore worker safety compromised. As well piles could not be moved or supported in periods of high winds, and working times reduced during winter due to the location (within a valley).

The extension of time into other seasons meant that micro-bats ( a protected species of fauna) were discovered living within some of the rotten girders, whereas the original program was outside the roosting season.

Initially it was determined to use double treated piles to restrict impact by borer. Safety and health concerns were raised about the use of handling creosote treated piles and therefore it was agreed that alternatives would be found. The chosen method was the wrapping of the piles for a depth of 1-2m below the river bed in Denso Tape with a mesh overlay. Due to the unknown final depth. This meant that often 4m of pile was required to be wrapped.

#### **4.3.3.2 Tyrone**

Despite geo-technical investigations profiling the anticipated rock profile, when the steel piles were driven they were required to be driven to deeper depths than the contractor anticipated. This meant that the piles were needed to be spliced as the machine on-site could not fully support the steel sections.

### **4.4 Outcomes**

The projects brought success as well as problems.

#### **4.4.1 Successes**

##### **4.4.1.1 Runnyford**

The result of the project was a timber bridge that looks the same as the previous bridge.

As well, Council staff learnt new techniques such as splicing of piles and use of wrapping that they will be able to apply in future projects.

##### **4.4.1.2 Tyrone**

The project was constructed within program and on-budget.

#### **4.4.2 Failures**

Both projects resulted in a number of issues that could be considered failures or opportunities to learn and develop.

##### **4.4.2.1 Runnyford**

The cost of the project was considerably greater than originally budgeted. Initial estimated at \$900,00 (albeit based on previous methods and expectations), the final cost of the project was approx.. \$2.4M.

As well as cost increases due to additional material costs, the increased workload meant the project increased from an anticipated 6 months to a 12 month period.

##### **4.4.2.2 Tyrone**

The project overall ran well. The one notable exception was the deck finish. This was considered not a suitable standard, most likely from a change in methodology that the contractor had used.

Whilst the contractor used a power screed to finish the deck, this was found to be the first time that they had done so. This was due to deck imperfections occurring on another recently finished bridge project for Council and the requirement that all future projects for Council will require the use of a power screed. The result was undulations that exceeded the specification and the resolution of this is still a matter of dispute.

## 4.5 Life-Cycle Costs

An analysis of the costs of both bridges on a metre and square metre basis has been undertaken. As the bridges are of a similar trafficable width, only the lineal metre rate is considered for comparison purposes.

The analysis has indicated the cost of constructing Runnyford Bridge as being around \$18,240/lin.m whilst Tyrone Bridge has cost \$27,800/lin.m. On a life-cycle basis, this is \$350 per lin.m per year for Tyrone Bridge whilst Runnyford is \$480 per lin. m. per year.

## 5 DISCUSSION

The opportunity to compare the concurrent construction of two different types of bridges by two project methods does not often arise.

Both methods are considered appropriate for a regional Council that has a range of resources but a limited pool of specialties to call upon. The use of different methods of project delivery enabled Council to deliver two projects simultaneously when resources usually only allow for a single project to be delivered at one time. Both projects were delivered to an acceptable level, meeting the project objectives and required outcomes,

Whilst the life cycle-cost of Runnyford Bridge, based purely on construction costs, is significantly higher than the contract construction of a concrete bridge, this is considered to be mis-leading due to the extraneous circumstances involved. The knowledge and additional costs of the problems to arise could not be allowed for even with contingencies. Once a flow was established it was found that progress was accelerated and therefore labour costs during the latter part of the project was reduced. It is held that the replacement of components in the future will be at a lesser rate than the actual construction costs.

For comparison, a similar project was undertaken simultaneously on another bridge, known as Silo Farm Bridge. This involved the replacement of 50m of an 80m bridge. Whilst no abutment was replaced, a temporary crossing of the Tuross River was required to be constructed for the full 80m. A review of costs gave a lineal rate of \$15,000 per metre (including temporary crossing of river), significantly less than Runnyford Bridge with a life-cycle cost of \$376 per annum, which is comparable with the life-cycle cost of Tyrone Bridge.

The cost to the community may have been significant but the outcome was a bridge of significantly higher capacity than the previous structure, valuable skills and expertise gained and greater knowledge of the conditions and capabilities that can be applied in the future.

## 6 LESSONS LEARNED

Plan, Plan, Plan.

The Runnyford project was hampered by a significant number of unknowns that increased costs, timeframes and impacts on the community. A number of assumptions were made based on past experiences and the project was commenced on that basis.

In reflection, the pre-planning undertaken was not sufficient and the subsequent lessons learned have been incorporated in to Council's systems and procedures to ensure that a similar situation does not arise again.

## 7 CONCLUSION

Though Runnyford Bridge cost significantly more than originally budgeted, it has a pleasing look that the residents are complimentary of. Whilst the community is happy with the new concrete Tyrone Bridge, given the non-commercial use of Runnyford Bridge, the retention of an aesthetically pleasing timber structure carries many positives.

Whilst the Life-cycle cost of the new Runnyford Bridge is significantly higher than new concrete Tyrone Bridge, it can be assumed that as components can be replaced within the life-span of the bridge, that supporting piles can be driven if rot occurs, and that complete reconstruction in the

foreseeable future will be not required if maintenance is undertaken regularly, the life-cycle cost of any future renewal will be lower due to lessons learned and implemented.

It is concluded that both bridges are fit for purpose – Tyrone Bridge requiring less intervention and having a longer anticipated time between significant intervention to cater for less impact on the road industry and users whilst the lower trafficked Runnyford Bridge can be renewed and suffer more inter-replacement deterioration by being constructed in renewable and replaceable components.

Two bridges – different requirements, different outcomes but both delivering a project that is of benefit to the community.

## 8 AUTHOR BIOGRAPHY

**Royce Toohey** is the Support Services Engineer with Eurobodalla Shire Council. Having 40 years' experience in local government, Royce has gained significant experience across the range of local government responsibilities.

Currently he is responsible for Eurobodalla's bridges and marine structures as well sundry operations such as their gravel pits and workshop. Previously he was the Asset Engineer for Eurobodalla and so is long-term focused in all projects.

Having commenced as an Engineering Assistant in 1982 after starting a degree in Surveying, he went back to university in 1991 where he was awarded a Bachelor of Engineering (Civil) after 9 years of external studies combined with working full-time in local government. In recent times he gained a Master of Engineering Management (by coursework) from the University of Technology Sydney.

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