1. Introduction

The south-west area of Sydney is planned as a key residential growth area for the city. Over the next 30 years, the population in this area is expected to increase by some 300,000 with about 110,000 new homes. To accommodate this population increase and to improve reliability on the metropolitan rail network, the NSW Government is constructing the South West Rail Link (SWRL).

The SWRL includes a major upgrade of Glenfield Station and bus/rail interchange and a new twin track passenger rail line from Glenfield to Leppington via Edmondson Park. Construction of the South West Rail Link commenced at Glenfield in August 2009. With an overall program budget of $2.1B the complete scope of works for the South West Rail Link (shown in Figure 1) comprises three separate project packages:

- **Glenfield Transport Interchange (GTI):** an upgrade of the existing railway station at Glenfield, with significant track and rail system works across the 2.4km Glenfield Rail Junction including two new grade separated junctions, new car parks and a high voltage substation. The upgrades will increase the operational capacity of the junction from 12 to 24 trains per hour.

- **Glenfield to Leppington Rail Line (GLRL):** a new 11km twin track railway line and two new stations located within the south west growth centre, at Edmondson Park and Leppington with car parking, and a stabling facility for 20 eight-car train sets.

- **Ancillary Projects:** works to support the project including a new 11 eight-car train set stabling facility in the operational train sector at Auburn and power infrastructure upgrades to facilitate future train operations.

Figure 1: Overview of the South West Rail Link
2. Delivering the job

The project is expansive in many aspects but most importantly with over 450 individual companies, subcontractors and consultants involved in delivering the South West Rail Link, the project truly personifies this year’s theme of ‘the melting pot’.

To manage the broad range of risks presented by the scope, the project utilises a range of contracting methodologies in delivery. Alliance contracts were utilised in the complex and reliability critical aspects of Glenfield Junction whilst less complex packages outside the rail corridor were packaged as design and construct or construct only packages. Both the Glenfield to Leppington Rail Line and Auburn Stabling projects had risk profiles suitable for delivery as large design and construct contracts.

Whilst the contracting methods may vary, importantly a collaborative approach is at the centre of all work across the program. To date over 5 million hours have been completed across the program, with an LTIFR of 0.6 and zero on-time running incidents, a testament to the single minded approach to safety and rail operations from every individual working in the SWRL melting pot.

Construction works commenced on the Glenfield Transport Interchange project in December 2009 and since that time substantial progress has been made across all projects. In summary of progress to date of the project is provided below as an overview:

- Glenfield Station upgrade completed and opened to public September 2012. The station includes a modern aerial concourse, additional fourth platform and level access.
- The grade separated flyover civil structures to the north and south of the station were completed June 2013 and January 2013 respectively. Trackwork commenced with the installation of the first turnout in the junction in May 2011. Since that time 19 turnouts and 4.35km of plain track have been laid.
- Glenfield South Substation construction complete for staged commissioning February 2012.
- Construction commenced on the GLRL in January 2012.
- The Hume Highway Underpass excavation was completed in January 2013.
- At time of writing both Edmondson Park and Leppington stations are approximately 40 percent complete.
- Rossmore stabling yard civil and track works are complete with overhead wiring currently being run throughout the yard.
- Thirteen of the 14 bridges across the project are practically complete.
- Glenfield to Leppington rail line track laying commenced in May 2013 with over 15km of plain line track laid on the main line and 5km at the stabling yard. The first of the two turnouts has also been installed.
- Auburn stabling construction commenced in June 2012 and is in preparation to commence commissioning activities later this year. Track and overhead wiring are in the final stages of completion.

Some of the key components of both the GTI and GLRL projects are presented in detail in the following sections of this paper.

3. Glenfield Transport Interchange

The Glenfield Transport Interchange (GTI) project utilised the Glenfield Junction Alliance (GJA) and Novo Rail Alliance to respectively deliver the civil and rail systems work across Glenfield Junction. A total of 33 possessions were available during the construction period, with a high level of coordination between all parties to ensure safe and efficient delivery to prevent delays to schedule. Including works outside of possession a total of 112 stages were planned to complete all civil and rail systems works.

Northern and Southern flyovers

While any work in the live rail corridor will inevitably present its difficulties, the design and construction of the northern flyover (NFO) provided a unique set of challenges to GJA. The northern flyover spans the Main South line with the new Up East Hills line in between the Down East Hills and the Southern Sydney Freight Line (SSFL). The flyover is
comprised of a concrete box structure, an approach ramp and connecting span, a viaduct off ramp and the connection to the East Hills Line.

Major constraints in the design and delivery of the northern flyover included:

- a 219 mm diameter high pressure Ethane Gas Pipeline (EGP) crossing under the Main South Line and East Hills Line.
- restricted vertical clearance passing under the existing Cambridge Avenue Overbridge
- restricted horizontal alignment adjacent to the Glenfield Waste Services waste management centre
- construction between the Main South Lines and the ARTC SSFL further restricting alignment options.

Value Engineering by GJA changed the original earth embankment exit ramp design to a viaduct with piled foundations located five metres from the pipeline. The viaduct consists of 14 prestressed precast concrete spans ranging from 19-21 metres in length and a trapezoidal connecting span to the NFO structure of 12 metres length. The total length of the NFO Off-ramp Viaduct is about 295 metres.

The track alignment was altered during detail design to keep it closer to the existing Up East Hills Line, avoiding any impact on the waste facility. The restricted horizontal clearances necessitated an acute crossing angle for the NFO which required some design ingenuity with the connections to the approach and off-ramps with innovative cantilever sections at the corners.

Construction of the abutments for the main NFO structure over the Main South Lines required the installation of 35 cast-in-situ concrete piles, of 1200 and 900 millimetre diameter. In order to minimise the span of the NFO, the abutment walls had to be located as close as possible to the tracks. Increasing the span would have increased the depth of the girders over the tracks and hence increased rail level of the Up East Hills Line, further exacerbating the gradient problems on the approach ramp.

Minimising the use of track possessions was achieved with detailed construction programming and the utilisation of an innovative methods team who developed all the construction methodology during the design phase. The site area was secured from passing trains using concrete barriers and protection screens which were installed during possession weekends. This reduced the risk of any equipment or personnel from infringing or accessing the track danger zone.

One of the key risks associated with piling adjacent to live tracks and 1500V overhead wiring is the handling of the long reinforcement cages. A separate methodology was developed for this and confirmed with RailCorp prior to works commencing.
The southern flyover (SFO) takes the two tracks of the Leppington Line over the Main South Line, the new Up East Hills Line and ARTC’s Southern Sydney Freight Line. The southern flyover is a major structure, comprising approach ramps adjacent to the current Main South Lines, the main structure over the current and future lines, and the off ramp viaducts and embankments. In total, the southern flyover is over 1km long.

The location of the flyover constrained the design with the start of the approach ramps dictated by the turnouts forming the junction south of Glenfield Station, while the structure itself could not be located any further south due to the proximity of Bunbury Curran Creek and the alignment of the new line to Leppington.

Construction constraints were similar to the northern flyover with live operations and limited possession availability, although timing of the construction allowed lessons learned from the northern flyover to be incorporated.

One of the more difficult issues faced by the GJA team was the design and construction of the short connecting span between the SFO Down Viaduct and the main SFO structure over the Main South Lines. This span, about 17m long, was roughly trapezoidal in shape and cantilevered progressively out over the operating Down Main South Line.

Standard construction techniques would have involved temporary supports for this span. However, due to the proximity of the Down Main South Line, the Safe Access Distance to the overhead wiring (OHW) would have been infringed, necessitating programming the construction around the three-monthly track possessions.
In order not to delay the construction programme, GJA developed an alternative solution of using six pre-cast concrete shells for the span. These shells were supported on a blade pier which was constructed clear of the running lines and OHW. With this approach, the only work to be carried out under track possession arrangements was the erection of the six shell units.

The six shell units were then successfully erected and secured in a track possession on 7 January 2012. The work was completed in a single shift. The following in-situ pour for the structural concrete element over the blade pier and the in-situ concrete pour to stitch the shell units together and form the track bed proceeded in normal working hours.

Glenfield Station and precinct

The upgrade of Glenfield Station involved the remodelling of the station to provide an aerial concourse, level platform and lift access and parking and road upgrades to the surrounding precinct. The project delivered:

- a new 750 space multi-storey car park and 120 space at grade car park
- a signalised intersection allowing safer pedestrian access to the station
- new undercover bus stops and taxi ranks, with kiss-and-ride spaces
- a new 300 m covered walkway connecting the station to the entrance to the Hurlstone Agricultural High School and the Glenfield commuter car park.

The station was operational during construction with approximately 10,000 passengers each week day with over 360 daily passenger and freight movements.
Glenfield Junction rail upgrades


The complete scope of works has seen the installation or upgrade of 19 turnouts to facilitate the required train paths and 4.35km of new plain track, 160 overhead wire structures and 12.8km of overhead wire. Platforms 1, 2 and 3 have been extended to accommodate eight car suburban trains. Platform 3 has been expanded as an island platform to provide Platform 4 for the new section of the Down East Hills.

The existing signalling interlocking consists of a SSI computer based interlocking and is being replaced with a new duplicated hot standby Microlok II upgrading 11 signalling location cases and associated equipment.

Rail systems delivery at GTI has been undertaken by the Novo Rail alliance. Turnout installation has been performed utilising PEM-LEMs.
4. Glenfield to Leppington Rail Line

The route from Glenfield south junction through Edmondson Park and Leppington stations utilises a typical 40 metre wide corridor increasing to 60 metre wide corridors at the stations. Beyond Leppington station the alignment terminates at a stabling facility with capacity for 20 x eight car sets. The works are isolated from the live operating rail network and a design and construct contract was awarded to John Holland Group in December 2010.

Some of the key features of the project include the Hume Highway Underpass, the 13 bridges, the Cowpasture Road viaduct and the stabling yard. An overview of each of these items and the rail systems are discussed in more detail. Design has allowed for maximum axle loads 22 t and maximum design speed of 115 km/h with future provision of 125 km/h.

Hume Highway Underpass

The Hume Highway is the first major infrastructure asset intersecting with the Glenfield to Leppington Rail Line and runs in a North-South direction approximately 1km west of the southern flyover at Glenfield junction.

The highway itself at this location has a design speed of 130km/h and consists of four lanes in each direction, with provision for future widening to six lanes in each direction. The highway had to remain operational at all times during the construction of the underpass, except for minor planned traffic interruptions outside of peak travel times.

The underpass allows the rail lines to pass under the northbound and southbound carriageways of the Hume Highway and comprises an approximate 80m long portal to portal single opening containing both the Up and Down
rail tracks. The design was such that it did not preclude the future widening of the Hume Highway or any future rail quadruplication. The opening was designed with vertical sides and an arch crown and is best described as a ‘muffin top’ opening as it resembles a muffin in cross section. Prior to excavation of the opening commencing, two box cuts were excavated at each end and nine by 450mm diameter grout filled canopy tubes were installed following the crown profile in section, between each end, for the full length of the proposed opening. The canopy tubes supported the overlying rock and highway pavement during the excavation works.

The underpass construction then followed a sequence of excavate, install steel sets, spray shotcrete lining, install waterproof lining and erect cast in-situ concrete lining. Work commenced in November 2012 and took less than 5 months to complete. Real time monitoring was employed with data uploaded onto a website every 15 minutes.

Bridges and viaduct

To many, discovering that the GLRL project has a total of 14 bridges within its scope; seven overbridges, six underbridges and one viaduct, comes as a surprise since the topography of the land does not suggest the need for such extensive infrastructure. The bridges cross over roads, creeks, rail and canals, so co-ordinating the construction and now handover with the affected parties and stakeholders has been key to the progress made.

Since construction began in March 2012, three road bridges are open to the public, ten are structurally complete and one is still in construction due for completion in October 2013.

Three bridge design types are evident on GLRL; in-situ box girder (post tensioned), precast Super-T’s girders and precast planks, the reduction of design types has also assisted in the great progress that has been made.

Certainly the most eye catching bridge on the project is the Cowpasture Road viaduct which is an 18 span bridge totalling 485m in length.

The first four spans of the viaduct cross over the Sydney Catchment Authority Upper Canal and Cowpasture Road on a skew. The remaining spans cross over pastoral land and Bonds Creek with the piers located with a radial arrangement.

The superstructure comprises 1500mm deep precast prestressed standard Super-T girders with a 200mm thick in-situ concrete deck. The bridge deck is continuous between expansion joints, with link slabs used to connect the girders at pier locations. The girders are supported on laminated elastomeric bearings.

Stabling yard

The new train stabling facility is located 1.5km west (country side) of the proposed Leppington station and includes sidings, administration and staff amenities building, storage facilities and cleaning facilities.

The yard has been designed for 10 sidings which hold 20 eight-car trains and two unwired 150m long machine sidings.
The overall design of the facility will allow for future expansion of the rail corridor to the west.

The co-ordination when in design and then throughout construction of the in-ground services has been critical to the successful delivery of these works with a large number of under line crossings. A stringent quality process was agreed and implemented to minimise the risk of localised subsidence.

**Permanent Way**

Permanent way construction commenced in April and at the end of August was around 80 percent complete.

The scope of works for the permanent way is summarised below:

- Approximately 20 kilometers of main line electrified track
- Two 1 kilometre long loop lines at Leppington
- A stabling Yard consisting of 10 train stabling lines and two non-electrified machine sidings
- 22 turnouts
- five catch points

The permanent way has been constructed using continuously welded AS 60kg rail laid on concrete sleepers fastened with a standard Pandrol E-clip.

The platelaying methodology can be classified as non-mechanised. Bottom ballast was laid using a ballast box and smooth drum roller and sleepers laid using an octopus and/or a bobcat with forks. Rail was placed using a L120 loader and installed on the sleepers using an excavator with an attachment.

Pandrol E-clips were applied using push along applicators. Ballast trains were used to install the top ballast and track alignment was gained using a 08 Plasser tamper liner in the stabling yard and a Plasser 09-32-2X Continuous Action Tamper (CAT) for the main line.

Rain events during the month of June slowed progress due to issues with access to the formation. This delay has not impacted the completion date for the permanent way works with rail grinding still planned to be completed by mid November.

**Overhead Wiring and Signalling**

The installation of the overhead wiring system commenced in July with the stabling yard approximately 90 percent complete at the end of August. Main Line over head wiring works will commence in mid September with the completion of track tamping on the down side of Camden Valley Way.

The works to be delivered for the new corridor include:

- 58km of contact wire
- 52km of Catenary
5. Conclusion

Progress on the SWRL is advancing rapidly from the commencement of construction in late 2009. The project is on track for commissioning of GTI in mid 2014 and the GLRL in 2015 with operational readiness activities to follow to allow for integration of the line into service.

The collaborative approach forged in the melting pot on the South West Rail Link program is allowing this new rail line to rapidly take shape. As development in the south west growth centre steadily increases, I imagine a new melting pot taking shape in the master planned town centres and the broader community in this area, proudly aided by the construction of the South West Rail Link.

ACKNOWLEDGEMENTS

The author wishes to thank Transport Projects Division of Transport for NSW for the opportunity to present this paper.

I also wish to thank all who have worked on the SWRL for their part in the project, in particular our major delivery partners;

- Glenfield Junction Alliance; TfNSW, Bouygues Travaux Public, Parsons Brinckerhoff and John Holland
- Novo Rail Alliance; Laing O’Rourke, O’Donnell Griffin and Aurecon
- John Holland Group
- Sydney Trains
- Tenix
- St. Hilliers