

## **Submission by (Mr) Kym Norley on aspects of the North West Rail Link Major Civil Construction Works (Application Number SSI-5100)**

### **Attachment 2**

This attachment provides a copy of the paper referred to in Attachment 1

The paper was developed for research purposes in a slightly different context and at a different time than specifically as a submission to the Environmental Assessment; however it shows clearly that existing underutilised infrastructure should be considered to provide a solution to the problem of increasing capacity into the Central Business District of Sydney. The original plans for the City Railway envisaged a much more intensively used network than is presently the case, and were informed by then contemporary international examples. This paper shows that existing infrastructure in the vicinity of the Harbour Bridge can offer significantly greater capacity than is currently used, and suggests how this may be utilised to take the growth in the medium term. It draws on the early documentation, operational analysis and international examples for this purpose.

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# Central city railway capacity – making better use of existing infrastructure

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## Abstract

Australia's east coast capital cities have emerging issues with the capacity of the central city component of their urban railway networks. In each case major investment has been proposed but deferred as a result of other funding priorities. In Sydney's case there are no current commitments, even though existing capacity is considered insufficient for growth. This is a particularly important issue, with work now starting on the North West Rail Link and partial funding available for the Epping-Parramatta line. However, there may be much less costly options than the rail tunnel options that were proposed in the 2005 and 2010 Sydney plans. These other options draw on simple operational principles and legacy infrastructure. The original plans for the City Railway envisaged a much more intensively used network than is presently the case, and drew on contemporary international examples. This paper shows that existing infrastructure in the vicinity of the Harbour Bridge can offer significantly greater capacity than is currently used, and suggests how this may be utilised to take the growth in the medium term. It draws on the early documentation, operational analysis and international examples for this purpose.

## 1. Introduction

Australia's east coast capital cities have each identified issues with the capacity of the central city component of their urban railway networks. In each case major investment has been proposed. The Victorian government has commenced preconstruction work on a new Regional Rail Link intended to separate regional services from suburban service (Mulder 2011). It is also planning a new cross city Metro tunnel to provide additional capacity for the northern and western suburban lines between North Melbourne and the Domain. The Queensland government is planning to construct an 18 kilometre link between Yeerongpilly and Bowen Hills in Brisbane (Cross River Rail 2011). Delays are evident in each of these projects, essentially as a consequence of funding pressures; however at this stage they are being progressed. Brisbane's Cross River project has been delayed two years by flood reconstruction. The second stage of Melbourne's Metro project to link in to the Dandenong group of lines that was referred to in the Victorian Transport Plan (Department of Transport Victoria 2008) no longer appears in the Department's list of projects. These delays are minor compared with Sydney, however, which has no current public plan to either increase the central capacity of its rail network, nor increase cross-harbour infrastructure capacity by any mode.

As recently as 2007, a plan existed for a new rail line through the Central Business district of Sydney to connect the lines on either side of the Harbour. The transport centrepiece of the 2005 Metropolitan Development Plan *City of Cities* (NSW Department of Planning, 2005a) had been the Metropolitan Rail Expansion Program (MREP), comprising three projects:

- The North West Rail Link from Epping/Beecroft to Rouse Hill;
- The South West Rail Link from Glenfield to Leppington; and
- The Harbour Rail Link (also referred to as the CBD Rail Link) between St Leonards in the north, through the CBD to Central Station and the western lines.

It was reported in 2007 (SMH 2007) that the Harbour Rail Link was not likely to be built. The circumstances surrounding transport decisions at the time are the subject of a parallel paper (Norley 2011), but there can be no doubt that the cost of a tunnel under the Harbour was a factor. The current Metropolitan Plans (NSW Department of Planning, 2010, NSW Transport and Infrastructure, 2010) make no provision for additional capacity across the Harbour and into the Central Business District (CBD).

As established elsewhere, Sydney has an extended record of equivocation on transport projects (Norley and Peters 2010, Norley 2011). The 2010 Plan produced for the former State government included a scheme to improve capacity from the west in the form of a Western Express / Central Relief line that would bring trains into Wynyard from that side. It was reported that planning for the Western Express had provided for an unfunded harbour tunnel at an indefinite time in the future (SMH 2011). There is no commitment to the Western Express by the present government (Berejiklian 2011).

The purpose of this paper is to examine another option for providing additional capacity into Sydney's CBD from the north. It specifically examines options that draw on latent capacity in existing infrastructure. The principles discussed are more generally applicable than just to Sydney. This paper seeks to show that Sydney's City Railway can offer significantly greater capacity than is currently evident, and how this may be utilised to take the growth in the medium term at least with only modest investment.

## **2. Background**

Sydney's Harbour naturally divides the metropolis, and limits what is possible with regard to transport links. Much of Sydney's high end employment is in what is described in *City of Cities* as the *Global Economic Arc* from Alexandria in the inner South East through the CBD and North Sydney to Macquarie Park in the Inner North. The central part of the Arc comprises the 'Harbour Cities' of Sydney and North Sydney on either side of the Harbour Bridge. A large part of the Arc is on the north side of the harbour – offering 600,000 jobs by 2036. The population of the North West and Inner North subregions, which includes these jobs and extends further, is growing – it will reach 1.2 million by 2036, the size of Adelaide (Transport Data Centre 2010a).

### **2.1 Cross-harbour passenger transport**

There are only two crossings of Sydney Harbour leading to the CBD from the north that are east of the middle distance suburbs of Meadowbank and Rhodes (about 12 kilometres west of the CBD). The more significant of these in terms of access to the CBD is the Harbour Bridge, with eight road lanes (one of which is a bus lane) and two railway tracks. The Bridge is supplemented by the Harbour Tunnel, but the Tunnel is configured for traffic to by-pass the CBD. With the closure last century of the North Sydney tram system, two (of four) railway tracks over the Harbour Bridge were replaced by road lanes for the Cahill Expressway. This single decision reduced the passenger carrying capacity of the Bridge by 40%, from 180,000 passengers per hour to little more than 100,000. Proposals to provide additional cross-harbour rail capacity since have involved an expensive deep tunnel or a second Bridge deck, neither of which is now represented in the Metropolitan Transport Plan (NSW Transport and Infrastructure 2010) or current government commitments.

The Metropolitan Rail Expansion Program *Harbour Rail Link* referred to above was to comprise a 10 kilometre long deep tunnel from west of Redfern (about one kilometre South West of Sydney's Central Station away from the CBD) to St Leonards (about four kilometres North West of the Bridge). That part of the Harbour is close to the deepest point just west of the Bridge (Geoscience Australia 2011). While no costs have been officially stated, based on similar projects (Waldock et al., 2008, Premier of NSW 2010) such a line would cost at least five billion dollars.

A key factor is that the capacity of the line through Central and North Sydney that uses the Bridge tracks is considered insufficient to take additional trains during the peak, and 18 of the nominal 20 trains per hour (3 minute headway) per direction capacity is now used following the opening of the Epping-Chatswood line. Most of these trains are at 100% capacity (a full seated load) or more (RailCorp 2010). It should be noted, however, that the capacity limitation is not the Bridge itself, but the major stations. This point will be discussed in more detail later in this paper.

CityRail peak patronage and that of the predominant radial component of the bus network is driven by CBD journeys to work (Norley 2010). Underlying growth for the rail network overall has averaged 2% per annum (Bureau of Infrastructure, Transport and Regional Economics 2009) for the last 30 years, a figure regarded as conservative for cross-harbour movements against the background of densification of the Inner North and growth of the Northwest. An increase of 2% per annum translates to a 35% increase in capacity in 15 years. RailCorp (2008) has observed the potential for much faster growth, of the order of 4.4% pa. At the latter rate double the capacity will be needed. This suggests that up to 24-30 paths across the Harbour will be needed within 15 years even with increases in load factor.

The three minute rail headway and buses queuing to access the city during the morning peak (Hidas et al. 2009) effectively puts the northern CBD approach near capacity. Given the importance of the Harbour Cities to Sydney's economy and employment, this is a significant issue. Some additional buses have been purchased and the new government committed to three new train services from the Central Coast via Macquarie Park, but this is very limited. This is before contemplating a Hills District rail line (the North West Rail Link) to the Sydney CBD, for which preconstruction tenders have now been called. Were the Epping-Parramatta line that was promised by Federal Labour at the 2010 election be progressed this would further add to the pressure for paths to the city. In some circles the latter line is seen purely as providing access to the Macquarie Park corridor from the west; however this line also serves major new residential developments in the Rosehill-Telopea-Carlingford corridor and may also have a CBD market.

## **2.2 Other proposals**

More cost-effective alternatives to the proposed tunnel have been proposed from time to time, including the use of more frequent single-deck trains with higher standing loads. The Western Express line envisaged use of longer trains than the present eight car sets (NSW Transport and Infrastructure, 2010). Other proposals have included an additional deck on the Bridge or reclamation of the two tracks ceded for the Cahill Expressway (Glazebrook, 2009). The Sydney Morning Herald's Independent Public Inquiry (Christie et.al. 2010, page 155ff) details the additional deck option in a 'Thought Provoker'. Its proposal, based on a submission by Australian Infrastructure Solutions, was to construct a new lower deck for up to four rail tracks, of which two were to be used initially. Two new platforms would be constructed at Wynyard below the present station and a new underground line built from there to existing unused platforms at Central station. A new station would be constructed under Castlereagh Street. Other variations have been suggested from time to time, such as a new road deck or a new road tunnel to return the ceded Bridge rail lines.

Mees has pointed out on more than one occasion (2000, 2007a, 2007b) that Australian cities, and Sydney and Melbourne in particular, appear unable to offer the capacity on their rail systems that is achieved internationally. He ascribes this in part to poor service planning and notes that higher capacities (and speeds) were once achieved in these cities. The original City Railway plans (Bradfield 1916) allowed 25 trains per hour on double track suburban lines. The Sydney Area Transportation study (Nielsen, 1974) allowed 24. Glazebrook (2009) has suggested changed service patterns that go some way to making better use of existing infrastructure. These for example took trains from one or more suburban routes into Sydney Terminal to make use of capacity on the express lines on the



Main West, without occupying paths across the Bridge. In part the Western Express adopted the same philosophy with its new line avoiding existing congestion in the CBD.

Three minute headways, as currently apply across the Sydney Harbour Bridge, are typical of urban railways of the S-Bahn (German and Swiss) or Réseau Express Régional (RER - French and Belgian) configuration. These are essentially suburban railways that are through-routed to serve the central business districts of the cities in which they have been built. London is presently building such a line in its CrossLink project. However, closer headways are possible. The Paris RER network has several lines that are operated during the peak at two minute headways. Line A, which carries very large volumes of people, for the most part has just two tracks in each direction in its central section. The extra capacity is gained from automatic moving block train operation and three doors (rather than two) per car, thus reducing station dwell time (source: RER timetables and map). A key feature of the RER, however, is the number of stations with multiple platform faces. This is achieved by bifurcating tracks, or branching, to two platform faces. The bifurcated platform configuration, which is similar to some of the examples that influenced the planning for the City Railway (Bradfield 1916), suggest that it should be possible to make more effective use of the remaining two tracks over the Bridge by removing the dwell time issue.

## **2.3 Application of the rail mode**

Sydney's CityRail heavy rail system demonstrates its history as a state-wide passenger and freight railway, within which a Metro-like central piece (Bradfield's City Railway) was grafted, and which latterly attempted to accommodate its commuter role with very un-Metro double-deck cars (Moss 2009). The underlying issue is very simple: Sydney's trains load and unload very slowly at key stations. Congestion at the train doorways – a product of limited door openings, crowded platforms and the double-deck carriages – are the primary factors. It is the dwell time at major stations that leads to the three minute headway. Were the long dwell time to be taken out of the equation, closer (2 minute) headways would be feasible. The means to do this is the underlying thesis of this paper.

It is essential to recognise that modes such as heavy rail, metro and such merely represent applications of a technology and are not technologies in their own right; therefore the details are transferable and boundaries blurred. In Gray and Hoel's text *Public Transportation* (1992), Vuchic suggests that a transit mode is defined by three characteristics, viz:

- Right-of-Way (ROW) category.
- Technology.
- Type of service.

He describes right-of-way as mixed, longitudinally separated and fully controlled (exclusive); technology as support, guidance, propulsion and control; and service as trips served, schedule and time. Vuchic notes that "contrary to the common belief that technologies mostly determine modal characteristics, the ROW category has the strongest influence on both performance and costs of modes. Beyond that, the technological characteristics are details that may be applied to more than one mode to suit the application. As pointed out by Bartlett (2008), attributes are determined by a range of factors that are largely independent of the notional type of rail mode in use; for example, capacity is determined by:

- the number of tracks in the corridor (and at platforms);
- the type of signalling;
- junctions; and
- the capacity of the trains

Bartlett's analysis draws attention to a number of fundamentals that are overlooked by writers that simply look at the generic characteristics of a mode. White (2009) overcomes the

problem of describing 'modes' as having specific characteristics associated with only that mode by describing basic system characteristics for (rail) systems collectively, recognising the overlap that occurs.

### 3. Distribution of CBD demand

Figure 1 overleaf selectively shows the catchments for the Harbour City stations serviced by the North Shore/Western and Northern lines. Within the capacity constraints of these lines, these represent the stations that would potentially serve the Hills District, North Shore and Macquarie lines in the absence of new construction across the Harbour or through Town Hall. 500 metre catchments are shown hatched for each station North Sydney to Central. Travel Zones in the wider 800 metre catchments surrounding Central, Wynyard and the north-side stations are picked out in yellow and the extent of the 800 metre Town Hall catchment is shown in red. The 500 and 800 metre catchments represent catchments based on station spacing and on the commonly accepted walk-in station catchment radius. From the author's observation passengers may choose to transfer between trains to access a station closer to their destination beyond a 500m radius. This is typified by Wynyard exits who may chose to transfer to the City Circle to access Circular Quay and environs.

It can be seen that the 500m catchments abut one another, suggesting that this was a factor in the station spacing adopted. However there is considerable overlap in the 800m catchments, such that most of the Sydney City CBD and North Sydney are captured, with overlap, by the existing cross harbour stations. The other two city lines – the City Circle and Eastern Suburbs lines – only add the North Eastern corner of the CBD to the City Railway catchment.

Town Hall, Redfern and Central are the major stations on the CityRail network, and each of these to have similar loadings as shown in Table 1 below. Town Hall is the most intensively used station in the City Railway, at least in part because it is served by all three CBD lines. Wynyard has nearly the same total patronage from the two lines that serve it.

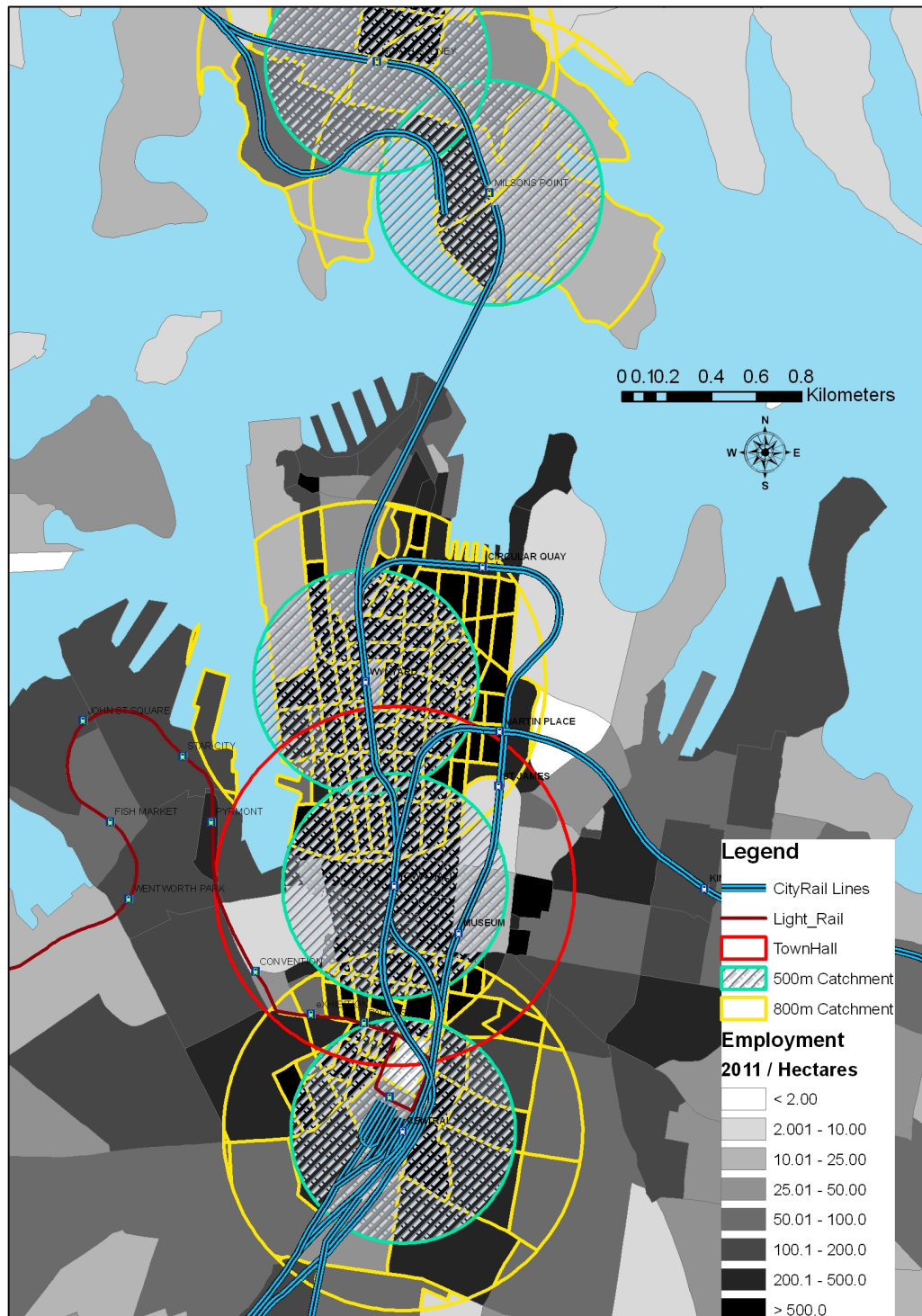
**Table 1: Ranking of main CityRail stations – AM peak counts through barriers**

<i>Rank</i>		
1	Town Hall	44,790
2	Central	44,550
3	Wynyard	41,880
4	North Sydney	18,670
5	Parramatta	15,440
6	Martin Place	14,530
7	Bondi Junction	12,270
8	Redfern	11,140
9	Strathfield	10,730
10	Chatswood	10,200

Weekday 06:00 to 09:30

Source: RailCorp 2008

**Figure 1: City station catchments**



Source: Map, Author; Employment data, TDC 2009

Most plans increasing rail capacity in the CBD have sought to serve the retail precinct at Town Hall, arguing that the Pitt Street corridor should be used to supplement the existing Town Hall station (Christie 2010). Nevertheless the importance of Wynyard (and Central) is evident from these loadings, particularly taking into account the proposed Barangaroo development.

The catchment data are shown in tabular form in Table 2.

**Table 2: Employment catchments for city stations**

Sector	Area (Hectares)	2,006	2,011	2,016	2,021	2,026	2,031
Wynyard only	289	227,681	235,318	238,278	244,158	246,895	247,733
North Sydney area	446	60,720	60,633	59,715	58,257	55,152	53,160
<b>Subtotal North Sydney to Wynyard</b>	<b>735</b>	<b>288,401</b>	<b>295,951</b>	<b>297,993</b>	<b>302,415</b>	<b>302,046</b>	<b>300,893</b>
Additional Town Hall	147	37,747	38,779	39,068	39,477	39,541	39,769
<b>Total</b>	<b>882</b>	<b>326,148</b>	<b>334,730</b>	<b>337,062</b>	<b>341,892</b>	<b>341,587</b>	<b>340,662</b>
Wynyard only	32.8%	69.8%	70.3%	70.7%	71.4%	72.3%	72.7%
North Sydney area	50.6%	18.6%	18.1%	17.7%	17.0%	16.1%	15.6%
<b>Subtotal North Sydney to Wynyard</b>	<b>83.4%</b>	<b>88.4%</b>	<b>88.4%</b>	<b>88.4%</b>	<b>88.5%</b>	<b>88.4%</b>	<b>88.3%</b>
Additional Town Hall	16.6%	11.6%	11.6%	11.6%	11.5%	11.6%	11.7%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>

The table is presented in this form to suggest that, were it possible to increase the capacity of the Harbour crossing as far as Wynyard but not necessarily any further, a large part of the CBD catchment would be covered. How this might be achieved is discussed in later sections of this paper. The table separates Town Hall catchment that is not served by the other stations between Central and North Sydney inclusive; i.e. it recognises the overlap between the station catchments. It shows that services that might terminate and turn back at Wynyard from the North or Central from the West would serve nearly 90% of the employment that is served by through services. This assumes that Central/Sydney Terminal can be reached from the West, which is the case with Central Coast and possible for other services by transfer at Epping. In this context it should also be noted that, with the existing (2011) timetables, transferring to a Central Coast express at Epping (the future junction of the Hills District Line) can save 14 minutes to Central compared with remaining on a train via Macquarie Park. Even transferring to the current Northern Line stopping service via Strathfield, the travel time to Central is the same as the time via Macquarie Park. This

suggests that in generalised cost terms the disutility of some trains not serving Town Hall is limited to the transfer penalty of changing trains once.

The table shows that the exclusion of Town Hall from the catchments reduces the employment served directly by the cross harbour stations by only 12%. It should be noted that the capacity problem only occurs in the peaks and turning back services is unnecessary at other times. Moreover up to twenty trains per hour throughout the day would not be affected were this pattern to be adopted.

The following section demonstrates that increased north-side capacity to Wynyard, using such a turn-back, is achievable without major new construction.

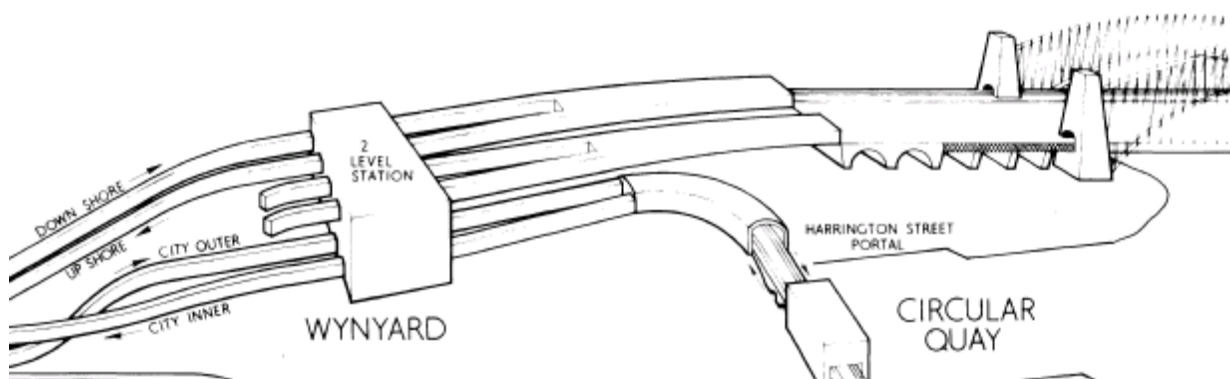
#### 4. Potential capacity

It was noted previously that the limitation to a minimum headway of 3 minutes is a result of slow loading at the major stations. It follows that, if the loading times could be accommodated in some way, the headway between trains might be reduced to a nominal 2 minutes. This is typical of high intensity urban railways popularly described as metro systems.

In order to examine the potential capacity of the northern approach to the CBD, future peak North Shore and Macquarie Park timetables were modelled on the basis that additional services would operate to a turn-back facility at Wynyard. The turn-back concept is common in railway operations world-wide and a key tenet in the CityRail 'Clearways' program to simplify its network. In order to address the loading time problem at heavily used stations, additional platforms are needed. Two stations are of particular importance, as (a) they are heavily loaded and (b) they have underutilised or unused platform roads. North Sydney has four platforms; however two (the centre roads) are normally only used for terminating trains. This role is much diminished now that trains work to and from the Epping Chatswood Rail Link, and for much of the day they are empty. Wynyard has six platforms; however two of the upper level platforms (platforms 1 and 2) are out of use and walled off. They were built as heavy rail lines, once used for the North Sydney tram system, and are now principally occupied by a car park (Oakes 2003). Two extra platforms were built at Central as part of the Eastern Suburbs Railway (Oakes 2003). The only major station in this corridor without unused platforms is Town Hall.

A later section ('Reclaiming the Bradfield legacy') provides more detail this and potential other infrastructure that may be more effectively used. The Wynyard configuration is illustrated in Figure 2 below.

**Figure 2: Configuration of Wynyard station**



Source: RailCorp; also published in full in Oakes (2003)

The timetables were modelled on the basis of the performance characteristics of the Waratah (current order) trains (Reliance Rail 2010) and the line characteristics of the sections between Town Hall and St Leonards. This section of the North Shore line is heavily speed-restricted due to the sharp curves on through Waverton and Wollstonecraft (50 km/hour) and limitations in the City Railway tunnels. Modelling was undertaken based on these speeds and 70% of the potential acceleration of the trains (specified at of 1 metre/sec<sup>2</sup>). Dwell times were back-calculated from the current timetables and confirmed by observation. It should be noted that the current CityRail timetables include significant float or catch-up time; hence some of the dwell times are not solely attributable passenger loading and unloading. The modelling shows that North Sydney dwells include between one and two minutes of float. On the new Epping Chatswood link further amounts are included at Chatswood and Epping, a significant factor in slow timings over this line.

The peak train pattern modelled is based on use of all six station boxes at Wynyard (with new track) and full use of North Sydney's four platforms for through services. Wynyard is treated as a turn-back location in the absence of new infrastructure through Town Hall and Central, which are the major pinch points other than Wynyard. It is assumed that the planned quadruplication of the St Leonards to Chatswood section would be completed, as most of the infrastructure for this, other than at Artarmon station, has been completed.

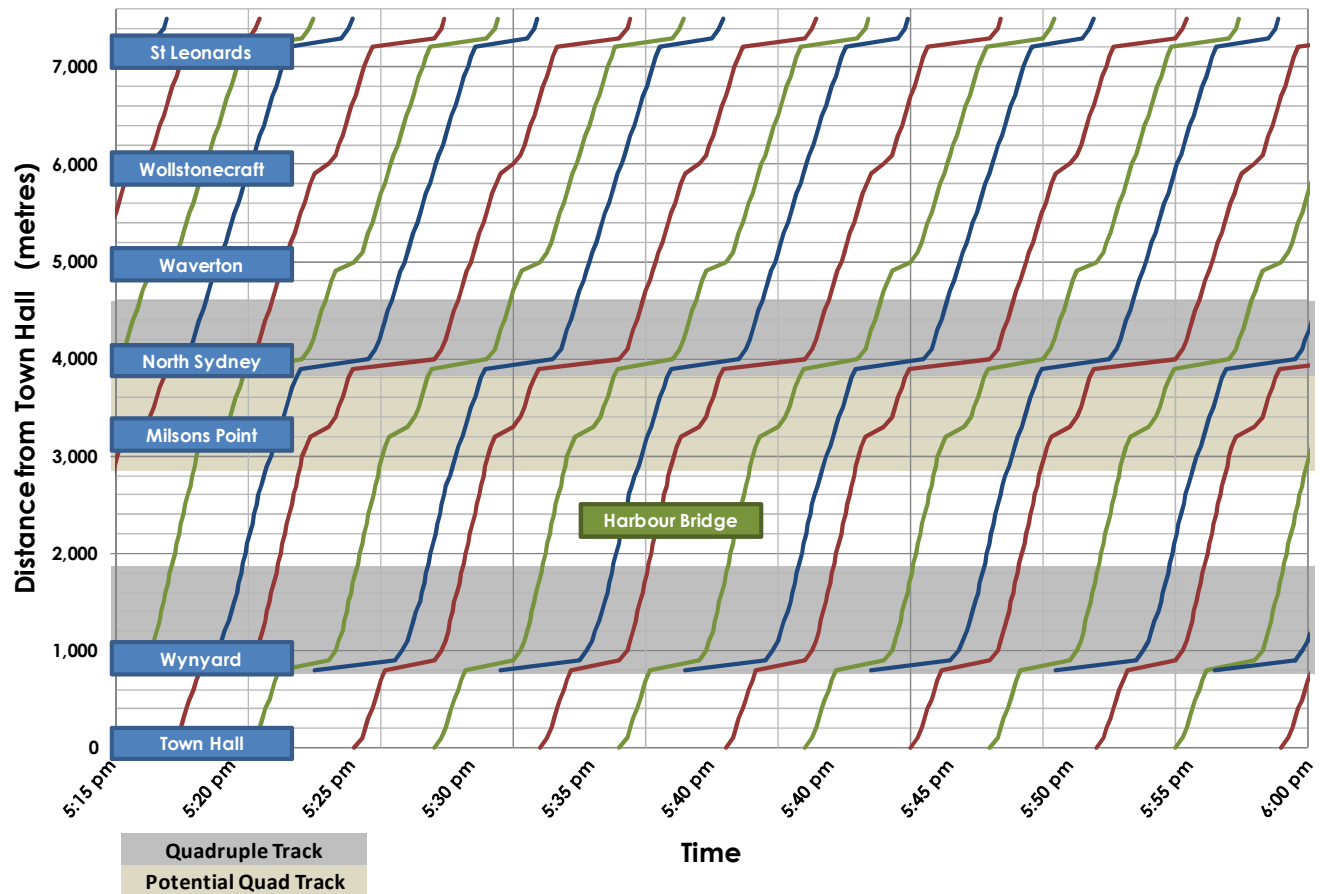
The essential features of the operating pattern are:

- Though trains are scheduled at 3 and 4 minute headways, or 17 trains per hour. This is two more trains than the present evening peak, but one short of the maximum existing morning number.
- In addition, Wynyard terminators or starters are scheduled at 7 minute headways, to give total of 26 trains to or from the north side, an increase over present maximum capacity of 44%.
- Wynyard, North Sydney and St Leonards would have a resultant service frequency of less than 2.5 minutes.
- Skip-stop techniques are used at the smaller stations; however this is not a major factor in the performance of the timetable. Direct journeys between Waverton and Wollstonecraft would not be possible under the assumptions used.
- Milsons Point would have a 3.5 minute service, and Waverton and Wollstonecraft 7 minutes.
- The timetable has been diagrammed on a minimum 1.5 minute operating margin across the Harbour Bridge span itself. A minimum of 2 minutes is maintained at smaller stations.

Testing of this timetable has suggested a slight increase up to 28 trains per hour, including 18 through, may be feasible by tightening the operating margins. It should be noted that at points in the CityRail network operating margins of 1 minute occur. There is some risk in reducing operating margins, and in relying on intensive use of the two tracks over the bridge span. Strathfield, for example, has bifurcated platforms on its up express tracks and trains regularly depart one minute after the previous service.

The resultant pattern is shown in Figure 3 on the following page.

**Figure 3: Train graph, evening peak down shore**



This shows clearly that there is capacity available, created by the use of dual platform faces at Wynyard and North Sydney, with the track bifurcated on the approaches.

The pattern works as follows:

- Every third train from the north takes the Wynyard turn-back facility (platforms 2 or 3), reverses and loads. Two tracks are available for this purpose, allowing a 10 minute window to turn the train around by using them alternately.
- Departure of the Wynyard starters has been diagrammed to precede the next through train by 1.5 minutes, which allows a 30 second buffer in the operating margin. The Wynyard starters run express to North Sydney.
- The second and third trains in the sequence are programmed to stop at Milsons Point. This widens the margin for the approach to North Sydney.
- After North Sydney, every third train (nominally the Wynyard starters) runs express to St Leonards. The following trains stop alternately at Wollstonecraft and Waverton. This has the effect of spreading the operating margin so that regular arrivals occur at St Leonards.

The frequency of trains is such that it is preferable not to hold trains at North Sydney as is done now. Dwell time in the timetable is reduced typically from 2.6 minutes to 1.6 minutes. As a consequence of this and the skip stop pattern, running times are reduced by up to two minutes from existing timings. Part of the resulting public timetable is shown in Figure 4.



Figure 4: Public Timetable (part evening peak only)

<b>Existing 2011 PM Peak</b>											
<b>Town Hall</b>	5.15	5.18	5.21	5.24			5.31	5.34	5.38		
<b>Wynyard</b>	5.18	5.21	5.24	5.27			5.34	5.37	5.41		
<b>Milsons Point</b>	5.21	5.24	5.27	5.31			5.37	5.40	5.44		
<b>North Sydney</b>	5.25	5.28	5.31	5.34			5.41	5.44	5.47		
<b>Waverton</b>	----	5.30	5.33	----			5.43	5.46	----		
<b>Wollstonecraft</b>	----	5.32	5.35	----			5.45	5.48	----		
<b>St Leonards</b>	5.31	5.35	5.38	5.41			5.48	5.51	----		
		Shore	North	Coast	Shore			Shore		North	TERM
<b>Indicative PM Peak with Wynyard Turnaround</b>											
<b>Town Hall</b>	5.13		5.17	5.20		5.24	5.27		5.31	5.34	
<b>Wynyard Platforms 2 &amp; 3</b>		5.18	----	----	5.25	----	----	5.32	----	----	5.39
<b>Wynyard Platforms 1 &amp; 4</b>	5.16	----	5.20	5.23	----	5.27	5.30	----	5.34	5.37	----
<b>Milsons Point</b>	5.19	----	5.23	5.26	----	5.30	5.33	----	5.37	5.40	----
<b>North Sydney</b>	5.22	5.24	5.27	5.29	5.31	5.34	5.36	5.38	5.41	5.43	5.45
<b>Waverton</b>	5.24	----	----	5.31	----		5.38	----	----	5.45	----
<b>Wollstonecraft</b>	----	----	5.30	----	----	5.37	----	----	5.44	----	----
<b>St Leonards</b>	5.29	5.30	5.34	5.36	5.37	5.41	5.43	5.44	5.48	5.50	5.51
<b>Line</b>	Shore	Hills	North	Shore	P'matta	Coast	Shore	Hills	North	Shore	Hills

The timetable suggests the destination to which trains are to proceed. The increased capacity allows 4 train paths per hour (as now) for the upper Northern Line, 6 per hour for The Hills (NWRL), 3 for Parramatta (PRL) and 13 for the Shore Local, Berowra and Central Coast services. This of course may be adjusted to balance demand. It has been assumed that the Wynyard starters would form the Parramatta and Hills services, with the remainder formed by the through trains. This has been assumed only to allow departures from St Leonards to be alternated between the Shore and the Macquarie Park lines and a consistent pattern to be maintained. It is arbitrary. There are alternatives to this, both in the detail of the pattern and in other changes to CityRail's services. It could be improved were the Hills services to run through and the Coast services to be formed by the Wynyard starters on the basis that this would allocate the non-through paths to services that are largely designed to serve north-side employment. Such a pattern would also allow an increase in the number of services for The Hills, traded off against reductions elsewhere.

Some of the pressure may be taken off north-side services by running the upper Northern Line services to Sydney Terminal, as suggested by Glazebrook (2009). If these trains were operated as limited express from Eastwood, as a number of the Central Coast peak trains presently operate, they would save about 14 minutes Epping to Central over existing services. Operating patterns whereby some trains are terminated at Chatswood or St Leonards, as was mooted in the 2010 Transport Plan, may still be required if growth is greater than anticipated.

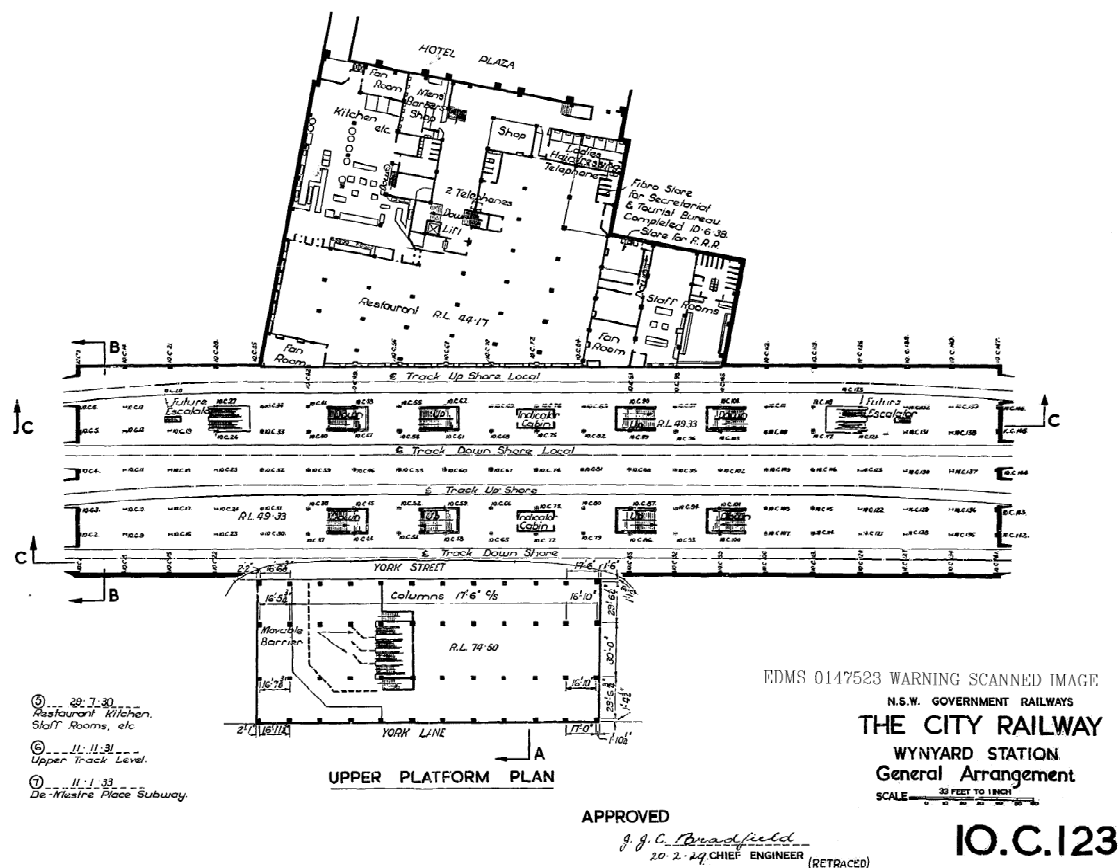
One of the major outstanding issues is dealing with the growth on the Western and Southern lines, which was the genesis of the Western Express concept. While not tested, similar principles could be applied by reversing the turn-back at Wynyard with a new pair of tracks leading to it from the West, and construction of a new station near Town Hall. The operating pattern would entail 40 trains at 3 minute headways from the West as far as Wynyard, and (say) 30 trains continuing through to the North. This presents a viable upgrade scenario provided that access into the existing and empty Wynyard platforms is feasible from the South/West as noted in the following section. In this case each platform would need to accommodate up to 20 trains per hour, which would require the turn-back to be external to the station under the approach roads to the Bridge



## 5. Reclaiming the Bradfield legacy

As described earlier, the rail infrastructure provided in Bradfield's construction of the Bridge and City railway comprised a six track station at Wynyard, four tracks over the Bridge, four track stations at Milson's Point and North Sydney, and a four track approach tunnel into North Sydney from the North. The North Sydney approach includes a fifth tunnel that was to form a flying junction for a Warringah line. Figure 5 shows the platform arrangement at Wynyard, as designed and originally built.

Figure 5: General arrangement drawing of Wynyard upper level

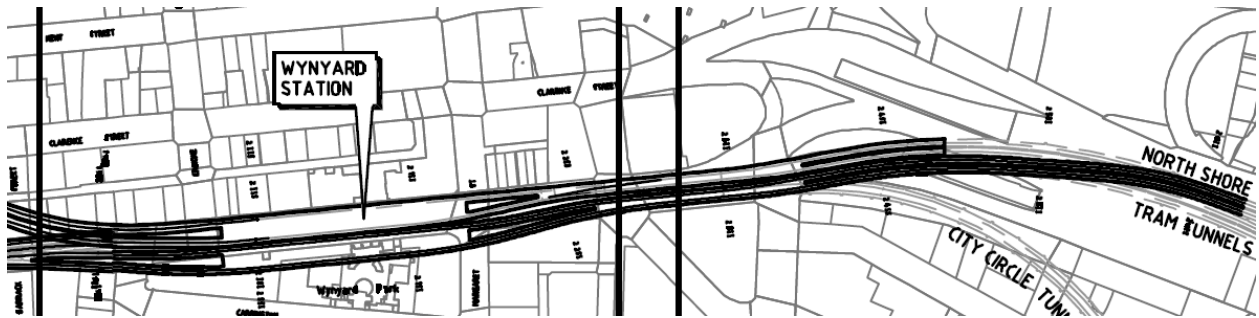


Source: RailCorp, Bradfield 1929

Work that was undertaken for the 1990 'MetroWest' proposal to construct a new line from Redfern to Wynyard under Sussex Street established that the parallel Wynyard tunnels can be linked, as shown in Figure 6. The MetroWest corridor, along with the so-called 'MetroPitt' corridor, was protected in 2005 following the MREP plan. While it is beyond the scope of this paper to confirm that none of the MetroWest corridor was built into during the intervening years, the MetroWest work suggests that it is feasible to tunnel towards Central from the existing Wynyard boxes to complete a line through the CBD. In the event that it is no longer feasible it would be necessary to rebuild Wynyard as envisaged in Christie et al (2010). That would not, however, be necessary to create the turn-back on which the present analysis is based. Under this scheme the two centre roads would become the turn-back, and the layout

south of the station modified to allow the restored easterly track (up Shore local) to cross to join the existing up track. North of the station the four tracks would converge to two within the tunnel, as suggested by the MetroWest plan. A similar plan was presented in the Sydney Area Transportation Study (1974), primarily designed to increase platform availability.

**Figure 6: MetroWest use of Wynyard station**



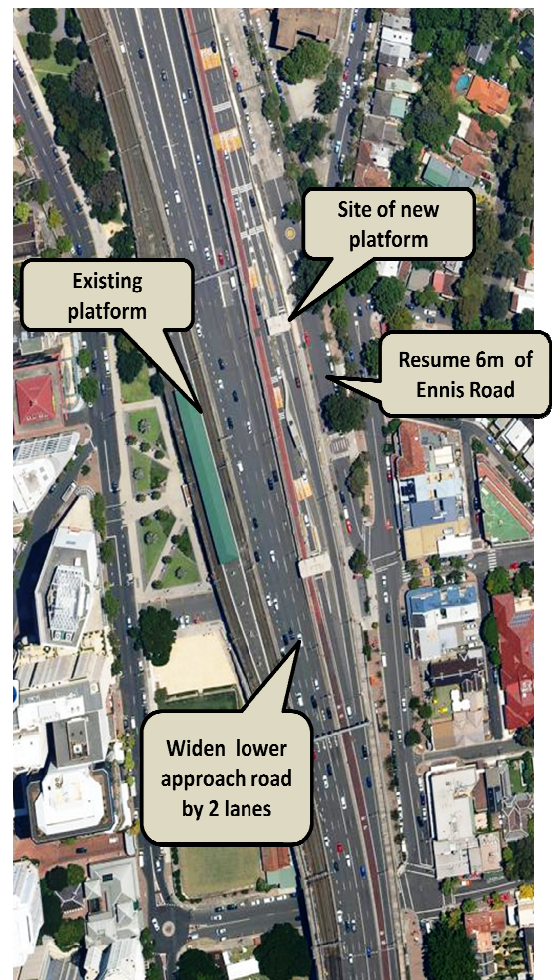
Source: RailCorp

The timetable modelling described in the previous section has established that no changes are necessary across the bridge and through Milsons Point with the operating pattern described. However there are several feasible options to restore Milsons point to a four track layout should that be desired. Most simplistically, the station could be slewed westward to allow an extra track (without platform) either side of the platform tracks. This would intrude into the park alongside the station and is unlikely to be accepted for environmental reasons.

A more acceptable, historically appropriate and elegant option would be to restore the eastern station structure. To do this without reducing the road lanes on the bridge it would be necessary to construct the station platform approximately 6-8m to the east of its original position, encroaching on the little-used Ennis Road car park. This would also require the up direction railway track to be moved to the eastern side of the bridge, such that it occupied the easternmost lane. The present up track would be vacated to maintain the number of road lanes. A new double track rail bridge over the road lanes would be required to connect the up tracks to North Sydney station, effectively restoring the structure that was there prior to the Cahill Expressway. Moving the railway to the east has the advantage that the four track approach to Wynyard station can be extended further onto the Bridge (i.e. beyond the tunnel mouth) using the existing railway right of way below the road lanes.

Other initiatives may complement the track changes. Most notably new signalling technology, presently being trialled by RailCorp (Rail Express 2011), would enhance the operation. As a minimum, Automatic Train Protection (ATP) would be appropriate for the intensive operation contemplated. This

**Figure 7: Milsons Point Reconstruction**



Map source: Nearmap

might be taken further to Automatic Train Operation (ATO) with moving block signalling (as applies in the Paris RER and various metro systems) to further tighten the operating margin and potentially increase the capacity. It is emphasised, however, that none of this is essential to achieve the results estimated.

## 6. Conclusions

The purpose of this paper has been to demonstrate the significant unused capacity that exists in the City Railway in Sydney which can be realised by simple changes to track and road layouts and use of the Bradfield legacy infrastructure. The proposal is simply to realise that the primary capacity constraint into the CBD is not the Bridge but the stations, and to use the existing station infrastructure at Wynyard and North Sydney to better effect. The principles are simple and can be applied within the existing mode of operation of the CityRail (and other urban rail) systems. Ultimately it will be highly desirable that four tracks link the north-side through the Sydney CBD. Nevertheless a solution that brings most trains off the north-side lines into the CBD represents a great improvement on options that would require services to be turned around at Chatswood and St Leonards. Running into Wynyard, together with services from the west to Sydney Terminal, would service 88% of the employment in the Central Business Districts of Sydney and North Sydney, and all of it with no more than one transfer. The Wynyard turn-back would only be required during the peak. Otherwise there is capacity for all trains to work through.

The changes at Wynyard would double platform space there, assisting to overcome the pressure on the movement of people that is emerging there and will continue to do so as a result of the Barangaroo development and others. Wynyard has the advantage of interchange with the City Circle, buses and the proposed George Street light rail line. Growth pressure on Town Hall may be relieved a little by the termination of trains at Wynyard. The principles could also allow increased capacity from the West to be added with a new station near Town Hall. Most importantly the need for a new CityRail Harbour Crossing would be deferred.

It would be very timely to provide this capacity to coincide with the opening of the North West and Epping Parramatta Rail Links. This may not be a perfect solution, nor is it a complete answer for the long term. It is not intended to be so. It is designed to buy time and to allow the new rail links planned by the present State government to be effectively used from the date at which they come into service.

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