2017

Shorter south coast train transit times

Max Michell
SAMROM Pty Ltd

Philip G. Laird
University of Wollongong, plaird@uow.edu.au

Publication Details

Michell, M. & Laird, P. G. (2017). Shorter south coast train transit times. AusRail PLUS (pp. 1-9). Canberra: Australasian Railway Association.

Shorter south coast train transit times

Abstract
The paper outlines the development of the South Coast railway linking Sydney through Wollongong to Bomaderry that was completed in 1893 as single track for most of its length. During the 1914-1920 period, duplication and grade easing between Waterfall and Coacliff was completed at the expense of 4.96 km of additional distance and with continuous tight radius curves. This paper starts from the premise that a 60 minute journey time between Sydney and Wollongong is seen as a 21st Century commuting expectation. The authors look at the achievable gains for train operations arising from realignment through the most difficult section south of Waterfall, following which they comment on other strategies that would reduce commuting times. The paper identifies that this realignment would be a necessary but incomplete solution, although addition of some other infrastructure and operational improvements would provide the foundation for reduction of existing 90 minute timings between Sydney and Wollongong to the desired 60 minutes. The authors also comment on the partly completed 35 kilometre Maldon to Dombarton freight rail link as a means of relieving pressure on passenger train running on the South Coast line as a result of reducing mixed train types over the existing difficult route.

Disciplines
Engineering | Science and Technology Studies

Publication Details
Michell, M. & Laird, P. G. (2017). Shorter south coast train transit times. AusRail PLUS (pp. 1-9). Canberra: Australasian Railway Association.

SHORTER SOUTH COAST TRAIN TRANSIT TIMES

Philip Laird[1], Max Michell[2]

(1) MSc (VUW) MSc (ANU) PhD (Calgary), FCILT, Comp IE Aust
University of Wollongong , Australia
(2) B Bus (Tpt Econ-RMIT), FCILT

Corresponding Author: **plaird@uow.edu.au**

Summary

The paper outlines the development of the South Coast railway linking Sydney through Wollongong to Bomaderry that was completed in 1893 as single track for most of its length. During the 1914-1920 period, duplication and grade easing between Waterfall and Coacliff was completed at the expense of 4.96 km of additional distance and with continuous tight radius curves. This paper starts from the premise that a 60 minute journey time between Sydney and Wollongong is seen as a 21st Century commuting expectation. The authors look at the achievable gains for train operations arising from realignment through the most difficult section south of Waterfall, following which they comment on other strategies that would reduce commuting times. The paper identifies that this realignment would be a necessary but incomplete solution, although addition of some other infrastructure and operational improvements would provide the foundation for reduction of existing 90 minute timings between Sydney and Wollongong to the desired 60 minutes.

The authors also comment on the partly completed 35 kilometre Maldon to Dombarton freight rail link as a means of relieving pressure on passenger train running on the South Coast line as a result of reducing mixed train types over the existing difficult route.

.

1.. INTRODUCTION

The South Coast railway between Sydney and Bomaderry near Nowra was completed in stages by 1893. With duplication, two major deviations were completed in 1915 and 1920 between Waterfall and Coalcliff to ease gradients for steam locomotives hauling heavier trains at the expense of additional length and curvature. The line serves both freight and passenger trains but has capacity constraints along with speed limitations where the average speed for express passenger trains over the 83 km section from Sydney to Wollongong is just 57 km/h ([1] indicates 56 km/h but subsequent timetable changes have lifted this marginally).

Sections 3.3 and 4 explore options for improvements of the track. Section 5 of the paper also outlines the long proposed Maldon to Dombarton link, which if completed, would allow for increased passenger capacity between Sydney and Wollongong.

2. NOTATION

km/h kiilometres per hour
mtpa million tonne per annum
PKCT Port Kembla Coal Terminal
SMEC Snowy Mountains Engineering Corp.

3..BACKGROUND

As noted by Oakes [2] and Singleton [3], an initial survey for a railway from Redfern to Wollongong was completed in 1874, but the estimated cost precluded a privately financed railway. The line was built by the NSW Government under the supervision by John Whitton, crossing the Georges River at Como rather than Tom Ugly's Point (due to a land owners unreasonable demands) with a single rather than double tracked bridge, which was only replaced with a double track bridge in 1972. The line was opened in sections, including Redfern to Hurstville (double track opened for traffic in October 1884), to Sutherland (single track December 1885) and Waterfall (March 1886).

A section between Clifton and Wollongong was opened in June 1887 and from Wollongong to North Kiama (now Bombo) opened in July 1888. This required the shipping of both locomotives and rolling stock by sea to Wollongong, which by then had a number of private coal railways.

The most difficult section of line to construct was from Waterfall to Clifton (now Scarborough). Over some 22.7 kilometres in length, which required no fewer than eight tunnels along with brick arch culverts and numerous deep rock cuttings. This section of line, with single track, was opened in October 1888.

As part of a policy prevailing in the early 20th Century to reduce the ruling grade to 1 in 75 for up trains on all mainline track to Sydney, two deviations were built on the South Coast line: “Helensburgh” (in sections, completed 1915); and, Stanwell Park (completed 1920).

As noted [3] “the route selected for the Helensburgh deviation, starting a mile south of Waterfall, was 5 miles 65 chains in length, increasing the distance to Wollongong by 2 miles 27 chains”, using curves as sharp as 10 chains radius in common with the line it replaced. Instead of cutting through ridges, it had "three 'U' shaped loops with five semi-circles, involving three tunnels", to rejoin the original line near Lilyvale. A new branch had to be built to serve the Metropolitan Colliery. In metric terms, the additional length of the Helensburgh deviation was 3.762 kilometres.

A 1550 metre tunnel on the old line between Otford and Stanwell Park had a grade for up (northbound) trains of 1 in 40, and rapidly became the most dis-reputable tunnel on the system for both train crew and long suffering passengers. To quote Singleton [3, p16] “Railwaymen and passengers alike were delighted when the tunnel was superseded by the Stanwell Park Deviation of 1920.”

This deviation [3, p26] “achieved the desired 1 in 80 grade against north-bound trains but involved the use of 12 chain radius curves, its length being 4 miles 4 ¾ chains, 53 ¼ chains longer than the original line.”

Part of the original line near Stanwell Park was later used for a new South Coast road. Duplication of sections including Scarborough to Wollongong followed in 1923. The only single track remaining between Sydney and Coniston is the 1002 metre long Scarborough Tunnel and adjacent sections of track.

In 1932, the Moss Vale to Unanderra line was completed as a single line with a long continuous 1 in 30 grade. The lower section from Unanderra to Dombarton was duplicated more recently in anticipation of the yet to be completed Maldon to Dombarton railway.

Electrification was extended from Sutherland to Waterfall by 1980, and onward to Wollongong and Port Kembla by December 1985, with the official opening being delayed to February 1986 due to remedial work being required on the Stanwell Park Viaduct. This work was required as a result of coal mining subsidence close to this viaduct.

In 1983, the NSW Government commenced construction of a 35 km link from Maldon to Dombarton. More information on this link, which is yet to be completed, follows in Section 5.

3.1 Capacity constraints

The South Coast line is used by passenger trains and freight trains, including about 4 million tonnes of coal to the Port Kembla Coal Terminal (PKCT) in 2015-16 [4], grain to Port Kembla, grain and export product to/from the Manildra plant at Bomaderry, steel products from Port Kembla and stone for concrete batching and ballast.

The 2007 AusLink Sydney Wollongong Corridor Strategy [5] is helpful in identifying many issues relating to present and projected demands in moving people and freight between Sydney and Wollongong. The strategy notes that the demands on the existing road and rail network will be compounded by the further development of Port Kembla and an expected growth in the number of people commuting between Wollongong and Sydney and also between Wollongong and Campbelltown/Western Sydney. The projected *“rapid growth in corridor freight”* will also pose additional challenges.

In respect of passengers, the 2007 report [5 p 13] noted that *"Commuter journeys along the Illawarra rail line are already operating at close to peak capacity. When population growth is taken into account, the Illawarra rail line will reach critical levels before 2016 during the morning peak (between 7.30 am and 9.00 am at Central). More services may need to be provided during the off-peak periods in the longer term as well. This would necessitate either lengthening of existing South Coast trains or the provision of additional services, which will lessen the availability of freight paths in non-peak times."*

The corridor strategy identified [5] that the Mount Ousley Road is already at capacity in the morning peak (AADT 34 500 in 2003 including about 5500 heavy vehicles), there is congestion at times between Heathcote and Jannali, and the rail line through Sydney cannot be used by freight trains for at least seven hours per day.

These constraints have become more severe over time, with environmental and social impacts having accelerated since 2008 when imported cars have been landed at Port Kembla.

During 2008-09 the NSW Department of Planning [6] processed and subsequently approved a Major Projects application by the Port Kembla Coal Terminal (PKCT) to lift a long standing curfew on road deliveries by coal trucks to the PKCT and to lift already high levels of road haulage of coal of some 5 million tonne per annum (mtpa) of coal to the PKCT to a maximum of 10 mtpa.

In 2010, the then Port Kembla Port Corporation was seeking approval from the NSW Department of Planning for a three stage development of the Outer Harbour of Port Kembla. This included projections for rail servicing much of the growth. However, a Submissions Report was released by the Department of Planning that included comment by the NSW Roads and Traffic Authority that after consideration of the impact of Stage 1 Port Kemba Outer Harbour traffic volumes (bulk, general and limited containers) if the predicted rail mode share could not be achieved, there would be likely *"…unacceptable impacts to road safety and traffic efficiency as well as environmental issues such as amenity, noise and air quality.*
"
In granting approval for the expansion of Port Kembla, the NSW Government appeared to take the line that the existing road and rail infrastructure would be adequate.

This view was questioned by a NSW Parliamentary State Development Committee examining NSW ports in 2004-05 [7] that made two related recommendations:

Recommendation 12. *That following the anticipated transfer of general cargo stevedoring to Port Kembla in 2006, the NSW Government re-examine the freight task out of Port Kembla to ensure that the anticipated increase in freight traffic is supported by the necessary improvements in road and rail infrastructure.*

Recommendation 13. *That the NSW Government consider the feasibility of expanding rail infrastructure into Port Kembla, including consideration of the Maldon to Dombarton line, in conjunction with the AusLink program.*

Further consents granted by the NSW Department of Planning for bulk traffic on Mt Ousley include that in 2014 for Boral to increase road haulage of quarry products from its Dunmore quarry. Here it was stated that *"Boral is unable to increase the amount of product supplied by rail …as it is unable to gain access to additional rail paths or utilise longer trains;…"*

The present situation is that South Coast line linking Sydney to Wollongong and Port Kembla is now operating at near full capacity during the day and for much of the night.

The Moss Vale Unanderra line, whilst useful for the movement of grain and coal from Southern NSW to Port Kembla, has significant operational constraints which with extra distance for freight moving between Port Kembla and Western Sydney militates against use of this route as an alternative for freight.

3.2 A need for speed

As noted above, the current average speed for semi fast passenger trains between Sydney to Wollongong (there are no express trains) is just 57 kilometres per hour ([1] indicates 56 km/h but subsequent timetable revisions have lifted this to 57 km/h) for an 83 km journey taking at best 87 minutes with modern electric trains (OSCARS).

On 8 January 1901, one week after Federation celebrations were held in Sydney, 1200 people travelled as part of an official South Coast picnic by trains. Their trains took a few minutes more than three hours to get from Sydney to Bomaderry and were hauled by steam locomotives [8]. Current best times are around two and three quarter hours.

Incredibly, in the 1930s, an express train service was on offer that took 90 minutes from Sydney to Wollongong with a steam locomotive (see Figure 1).

Figure 1. A 1930s poster of the NSW Railways advertising a fast express service [9].

The current average speed of about 57 km/h between Sydney and Wollongong compares poorly with the 72 km Perth to Mandurah suburban line with an average speed of about 85 km per hour.

It has been noted by the Illawarra Business Chamber [10] that Illawarra's rail connectivity compares poorly with that of Geelong to Melbourne, the Gold Coast to Brisbane and the Central Coast to Sydney. The report [10] estimates that the deficiencies on road and rail connectivity impose costs of about $150 million per annum on the Illawarra Region.

As a matter of interest, the line Melbourne to Geelong, now 81 km, has a train every 20 minutes on weekdays taking under 60 minutes with stops at most stations.

It is of note that a transit time for an electric multiple unit (V Set) between Wollongong and Central of 78 minutes was achieved by some trains in 1987. Indeed, the 1987 timetable had a train on a Saturday morning taking just 74 minutes. This included a time of 25 minutes from Sutherland to Central Station; today the minimum time on this section for all but a few express trains is 32 minutes.

Faster trains between Sydney and Wollongong were promised [11] in 1998 in an official NSW *Action for Transport* Statement, to be delivered by 2010. This envisaged a new Waterfall-Thirroul Route (see below) to reduce train transit times by 15 minutes.

Train transit times were extended to 90 minutes in a then new May 2006 timetable. The longer passenger train transit times appeared to be due to reasons of rail congestion and improving on time running statistics rather than rail safety. Here, Justice McInerney who conducted in 2003 a Royal Commission into the Waterfall train derailment later said that he never recommended slowing trains down. By way of partial compensation, all South Coast passenger trains now stop at North Wollongong (to service a growing University of Wollongong), Wolli Creek (a station opened in the year 2000 near Sydney Airport) and Redfern.

The 2012 State Infrastructure Strategy of NSW [12] noted, inter alia, that "As Newcastle and Wollongong grow in size and importance to the NSW economy, they need faster and more efficient links to Sydney"

This report [12, p107] also notes "An incremental program to accelerate the intercity routes is proposed, with a target of one hour journey times to Sydney from both Gosford and Wollongong, and a two hour journey time from Newcastle. The focus of the program will be operational improvements supported by targeted capital works to reduce journey times."

Infrastructure Australia's October 2016 list of priorities and proposals lists, inter alia, a NSW Government proposed initiative for Newcastle-Sydney and Wollongong - Sydney rail line upgrades, to include new deviations to eliminate curvature and flatten grades .

3.3 Previous upgrading options

In addition to Post World War proposals for rail electrification, in 1950 [13], the then NSW Minister for Transport stated that a new one and a half mile (about two km) double track Clifton tunnel was expected to be completed by 1956 at a cost of about three million pounds.

In 1990, SMEC was retained to conduct a study into a 11 km Thirroul Tunnel, from a new Helensburgh Station, located adjacent to the Princes Highway, to Coledale. More details are given in a report [14] by Connell Wagner who was commissioned by the Rail Infrastructure Corporation to undertake a rail improvement study for the South Coast Railway Line between Sutherland and Wollongong. Their report considered the 11 km tunnel option along with retaining the existing alignment, and two "Incremental Upgrade options. These were significant improvements to the alignment that followed the existing corridor, one with "best travel time" savings and the other "best value".

The Coledale Tunnel combined with new above ground track from Waterfall to a new Helensburgh Station was estimated to have a cost of $1.4 billion (±30% and excluding land / property costs based on 2003 costs) and offer travel time savings of 15 minutes in the northbound direction and 19 minutes in the southbound direction. Figure 2 shows the likely alignment of the tunnel in red, along with the winding existing track between Waterfall and Coaldale.

The "Best Value" incremental option was costed in the report [14] at $600 million with travel time savings of 13.5 minutes in the northbound direction and 16 minutes in the southbound direction, whilst the "best travel time" was two minutes faster in each direction at a cost of $770 million.

4. SPEEDING UP TRAINS

As noted above quoting Infrastructure NSW [12, p107] in aiming for one hour journey times to Sydney from Wollongong, the preferred way of proceeding is by "operational improvements supported by targeted capital works to reduce journey times."

The fact that electric multiple unit V Sets in the late 1980s could do a Sydney Wollongong journey in 75 minutes gives some support to the view that the current 90 minutes is too slow. Given increasing numbers of suburban and inter-city passenger trains and the addition of a steady flow of freight trains, without compensating infrastructure improvement it is inevitable that conflicts and congestion become a factor in train running, even with higher powered OSCAR electric trains, or the new trains due to enter service in 2019.

Figure 2 Waterfall Wollongong track [15].

Sixty minute type timings will require more a holistic approach to the problem to achieve.

Data for the current Illawarra line alignment is held as part of the suite of data files for SimTrain (a proprietary Train Performance Model exclusive to one of the authors). Copies of track plans for the original alignment between Waterfall and Otford [16] were suitably coded and linked to the modern-day alignment at locations where the alignment has remained intact from the beginning. Some difficulties arose in matching the two plans but in the end a reasonable approximation was achieved.

As noted above, the original line, somewhat untypically for NSW, followed a reasonably direct route between Waterfall and Otford, and on to Scarborough via Stanwell Park village, involving a no less than eight tunnels aggregating 4200 metres in length within a route distance of around 19 kilometers.

The subsequent deviations to get a better ruling grade toward Sydney added a significant distance to line the by looping around the various east – west ridges that lay across the path of the railway. Between Waterfall and Otford an additional distance of just under 4 km was added to the route (i.e 10.14 km became 13.90km), with further additional distance between there and Coal Cliff further extending the route length by around one km.

The existing line in the Waterfall – Otford section is dominated by sharp curves down to 200 metres radius. As a consequence, train speeds are, of necessity, slow.

The original line was not much better with 200 metre curves also being conspicuous, but of course the line length was significantly shorter, thus limiting the pain. The 'new' (now 100 years old) deviation between Waterfall and Otford was opened in sections between 1914 and 1915, easing the Sydney bound ruling grade from 1 in 40 to 1 in 80

To analyse the alternative of the original route between Waterfall and Otford as well as a curve eased version of the same route a typical existing passenger train was used for simulation runs – a four car OSCAR electric set. Simulations were run in each direction over the existing alignment as well as the original 1888 version, recognizing that the latter, with its numerous single line tunnels would not be a practical restoration proposition.

In order to overcome this and identify what a 21st century alignment might achieve, a line the same length as the original but with curvature that would allow a minimum of 100 km/h running (i.e. curves better than 600 -700 metres radius) was postulated and simulated.

Interestingly the average grade from the original line between Waterfall and the site of Lilyvale (more or less where the old 1 in 40 grades ended) is around 1 in 62 which suggests that a well aligned shorter (than now) line with reasonable ruling grades could be achieved with careful planning.

All simulation runs were assumed to start through Waterfall at 40 km/h or Otford at 50 km/h (current line speeds) and run express through the section under review.

TABLE 1 OSCAR SIMULATIONS

ROUTE	**SOUTHBOUND**		**NORTHBOUND**	
	Time	Power	Time	Power
	h:m.	kWh	h:m.	kWh
Existing	14:41	12.8	14:28	116.4
Original	10:13	11.8	10:04	110.9
Original Improved	07:24	7.9	7:47	106.9

This technique eliminates the effects of train operations other than those to do with track alignment. All simulation runs were recorded with section times and the power required for traction purposes (ignoring parasitic loads such as air-conditioning which are unrelated to the track alignment) to allow effective comparisons. Table 1 summarises the outcomes in both directions.

It will be noted that running via the original alignment, with its shorter length but sharp curves, would save around 4 minutes compared to today, but with the same alignment rejigged to have wider radius curvature the current times would be almost halved. Power consumption over this relatively short section would be reduced by as much as 9% which in the scheme of things is not particularly significant.

As a cross check on the value of the old route a pair of freight trains were simulated over both existing and original alignments. The trains were a 45 wagon coal train (loaded in the southbound direction, empty northbound) and a 1280 metre long steel train (loaded northbound, partly loaded southbound). Table 2 sets out the results of these simulations in a comparable format to Table 1.

TABLE 2 FREIGHT TRAIN SIMULATIONS

ROUTE	**SOUTHBOUND**		**NORTHBOUND**	
	Time	Power	Time	Power
	h:m.	kWh	h:m.	kWh
Coal / Existing	15:39	115.1	16:36	879.1
Coal / Original	11:26	90.7	13:53	735.8
Steel / Existing	17:02	55.2	18:08	2640
Steel / Original	12:46	38.4	15:34	2260

The coal and steel trains have grade issues elsewhere on their journeys so have adequate power for the 1 in 40 grades of the original alignment.

It will be noted that the differential between existing and original alignments is similar to the passenger train southbound, but with uphill running north the differential is reduced to under three minutes – a demonstration of the effect that elevation has on train running (in this case the elevation gain is the same but over routes of differing length).

From Otford to Scarborough (current distance 9.9km) there are several possibilities, all involving long tunnels and possibly bridging in difficult unstable country laced with worked out coal diggings. The complexities of this section are beyond the scope of this paper.

From Scarborough to Austinmer (current distance 5.1km) any curve easing would entail acquisition of lineside dwellings as well as rebuilding three existing stations on better aligned track. Given that the time saving over this section, if it was better aligned, would only be a matter of two or three minutes, it would seem prudent to invest in better performing alternatives elsewhere on the line.

Current timetables have best elapsed times of 1h 27 minutes (87 minutes) for semi fast electric inter-city trains between Sydney and Wollongong (there are no expresses scheduled in the current timetable) which represents an average speed of 57 km/h. The stated objective, as noted above [12], is for a timing of 60 minutes or close to that figure. The alignment of the existing line, along with suburban train conflicts are the major inhibitors to achieving this goal.

The conflict between Cronulla / Waterfall suburban trains and inter-city Wollongong trains from Erskineville to Sutherland is a major issue for faster running. Part of the problem is the lack of a local line platform at Wolli Creek, along with poor turnout configuration and non-existent overtaking facilities (for passenger trains) south of Hurstville. Waterfall itself has a ‘wrong way’ configuration with the down refuge (route for southbound semi fast trains) being the de facto main line but with poor turnout configuration and a 50 km/h speed limit for its not inconsiderable length. Something similar applies in the up direction.

The difficult existing alignment from Waterfall to Otford has been highlighted in earlier discussion, while that beyond is also potentially a candidate for some sort of replacement, if only to avoid the frequent geotechnical and weather-related issues on this section. Ideally this would include replacement of the Scarborough Tunnel with a well aligned double track alternative. From near Coledale through to Wollongong it should be possible to get at least 100 km/h track speeds throughout with limited curve flattening and alignment tweaking.

The net effect of all these actions would be to provide a railway that should be able to achieve a 60 minute timing for fast trains between Sydney and Wollongong. Savings are estimated at around 20 minutes for the suite of infrastructure improvements which with better pathing and more precise scheduling should enable achievement of the target time. After all, for a period following electrification, a timing as short as 74 minutes was scheduled (and achieved) over the existing route until the general slowing of trains in the face of political pressure for ‘on time’ results some years later.

The Australian Government’s 2017 budget commitments to rail [1] gives incentive for the NSW Government to prepare a business case for an upgrade of the Sydney and Wollongong. railway to reduce passenger train transit times towards the stated goal [12} of 60 minutes.

5. MALDON DOMBARTON

The Maldon-Dombarton rail link is a 35 kilometre partly completed freight line. It was started in 1983, with enabling legislation, by the Wran (NSW) Government to improve rail access to Port Kembla. More information is given in [17].

During the 1980s, the work done included construction and ballasting of over 25 kilometres of right of way from west portal of the Avon Tunnel to the boundary of Water Catchment near Wilton, construction of approaches to the Nepean River Rail Bridge and a start of tunneling at Avon tunnel on east portal and construction of west face of portal. The Avon tunnel contract was cancelled by the Greiner Government in mid 1988 (with $4.5 million compensation paid to the contractors and contrary to pre-election promises to complete the line by 1991).

In addition, the 15 km Dombarton - Port Kembla section was upgraded and duplicated, with erection of masts from Port Kembla to Dombarton for electrification for the entire Maldon Port Kembla project.

The sunk cost (dollars of the day) for the work done on the Maldon - Dombarton section was noted by Freight Rail in 1993 [17] as $42 million, and the work done on upgrading and duplication of the Dombarton - Port Kembla section as $57 million (the latter as part of upgrading Moss Vale - Unanderra line to support export grain and other bulk traffic.

The following work to complete the Maldon Dombarton rail link remains: - boring of the 4 km Avon tunnel, completion of the main span of the bridge over the Nepean River, a new bridge over the Cordeaux River and four road overbridges near Wilton; creation of some 9 km of right of way from near Wilton to near Maldon; laying of sleepers and track with crossing loops at Avon, Cordeaux, Wilton and at the Maldon Triangle; and, signalling and communications.

Support for consideration of completion of the Maldon Dombarton link was given in 2007 by a federal Parliamentary Committee [18] which noted the potential to tie in with the “Wentworth” deviation between Menangle and Mittagong (with a map on p45 with the proposed new link and deviation)

Although electrification was initially proposed at 1500 volts DC and later at 25,000 volts AC, a review in 2009 [19] considered that the use of modern diesel electric locomotives would work, at a considerably lower first cost.

A full feasibility study was conducted in 2011, and in a public consultation phase, support for completion of the Maldon Dombarton link was given by the NSW Roads and Traffic Authority.

In 2014, the NSW Government called for expressions of interest from the private sector to complete the railway. Two bids were received, however, the NSW Government declined to accept either.

Completion of the Maldon Dombarton rail link was rated by Infrastructure Australia as a priority measure until February 2017. The removal of this priority received an adverse community reaction [20].

Support for completion of this line has been based on the following issues:

A. Between Sydney and Wollongong increasing demand for more passenger capacity leaving less paths for freight trains on the Illawarra Line.

At the Permanent Way Institution Annual convention on 30 October 2015 in Sydney, in response to a question, the Chief Executive of Sydney Trains, Mr Howard Collins, said to the effect that the sooner the Maldon Dombarton railway line is built "*with freight trains gracefully gliding over it*", the better, so it could free up "his" tracks for more passenger trains.

B. Congestion and freight curfews in Sydney, adding to the cost burden for hauling coal from the western fields to Port Kembla, coupled with the need for additional motive power (4 locomotives) compared to half that number for trains operating via Maldon

C. Work was completed in late 1996 near Granville to give a direct connection for coal and freight trains between the Western Line and Maldon.

D. Considerable available freight capacity on the Southern route from Sydney (to Maldon) with relatively easy grades and room for enhancement of line capacity as and when needed.

6. CONCLUSIONS

In this paper the authors have looked at strategies that could be adopted to improve parts of the Waterfall to Otford section of the South Coast railway that have substandard alignments.

A stategy of restoration of the original steeply graded alignment between Waterfall and Otford but with double track tunnels and much easier curvature would be a key feature of any substantive line improvement, Additional time benefits would come from better pathing, additional new alignment between Otford and Coledale and selective curve easing south of Coledale, sufficient to achieve a 60 minute express train timing for Wollongong trains (and trains to all points south of Wollongong)

There would also be some benefit in completing the 35 kilometre Maldon Dombarton rail link for freight trains as a means of enhancing capacity for passenger

trains between Hurstville and Wollongong as well as enhancing reliability of passenger running.

ACKNOWLEDGMENTS

Both authors thank the Australian Railway Historical Society Railway Resource Centre for help in locating 1880s track diagrams [16]. The authors also thank the AusRail Plus conference organisers for the opportunity to prepare and present the paper, which complements an earlier paper for speeding up Sydney Newcastle trains [21]. However, the views expressed in this paper remain those of the authors and are not necessarily shared by any of the above organisations.

REFERENCES

1 Department of Infrastructure and Regional Development, 2017, The National Rail Program: Investing in rail networks for our cities and regions

2 Oakes CJ, 2003, Sydney's forgotten Illawarra Railways, Australian Railway Historical Society (NSW)

3 Singleton, CC,1984, Railway History in the Illawarra, Illawarra Historical Society, Wollongong

4 Port Kembla Coal Terminal, 2016, Annual Environmental Management Report 2015-16

5 Department of Transport and Regional Services, 2007, Sydney Wollongong corridor strategy

6 NSW Department of Planning, 2009, Director-Generals Report re Port Kembla Coal Terminal Project via http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=2238

7 NSW Parliamentary State Development Committee, 2005, Inquiry report into Port Infrastructure in New South Wales

8 Laird, P, 2015, Why are train journeys as long as a century ago? NSW hasn't lived up to Henry Parkes' dream http://www.smh.com.au/comment/why-are-train-journeys-as-long-as-a-century-ago-nsw-hasnt-lived-up-to-henry-parkes-dream-

9 Appeared in the Illawarra Mercury for 17 June 2017

10 Illawarra Business Chamber, 2014, "Linking the Illawarra", report by PwC

11 NSW Department of Transport 1998, Action for Transport 2010: an integrated transport plan for NSW

12 Infrastructure NSW, 2012, http://www.infrastructure.nsw.gov.au/expert-advice/state-infrastructure-strategy-2012.aspx

13 Illawarra Mercury 1950 "Early start on new … tunnel expected" , 22 July

14 Connell Wagner 2003 South Coast Corridor - Rail Improvement - Thirroul Tunnel Study Final Study Report

1. Christie report, 2001 Long-Term Strategic Plan for Rail, http://www.catalyst.com.au/

16 Australian Railway Historical Society Railway Resource Centre, maps of 1888 track for South Coast railway construction

17 Laird, PG 2010, An Illawarra Macarthur rail link, Australasian Transport Research Forum available at atrf.info

18 House of Representatives Standing Committee on Transport and Regional Services (Neville Committee), 2007, The Great Freight Task: Is Australia's transport network up to the challenge?

19 Connell Hatch and SdD, 2009, Maldon-Dombarton Rail Line Pre-Feasibility Study for Port Kembla Port Corporation (and the Australian Government)

20 Wollongong Transport Coalition, 2017, https://www.facebook.com/maldon.dombarton.appeal

21 Michell M and Laird P, 2016, 'Thinking outside the fence line – Sydney to Brisbane' Conference on Railway Excellence available at http://railknowledgebank.com