Achieving and Evaluating the Benefits of Urban Consolidation through Rail Transport Improvements

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Abstract:

Australian and New Zealand cities are characterised by low density housing enabled by car transport Population increases have been accommodated through peripheral urban expansion Continued expansion of cities is inefficient in energy and resource consumption however Rail transport can focus development tightly around stations to achieve cost savings in physical, social and transport infrastructure This contrasts to road solutions which lead to linear development and low residential density

Evaluating the merit of transport schemes has tended to be done in isolation of land use A more integrated approach is needed which plans transport and landuse together This paper looks at (i) the savings urban consolidation can achieve (ii) the relationship between density and rail use and (iii) how Cost Benefit Appraisal can take the package effect of landuse and transport into account Case examples from Wellington and Sydney are used to look at these aspects

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1. Introduction

Australian and New Zealand cities are characterised by low density housing enabled by car-based transportation Population increases have been accommodated through peripheral urban expansion rather than infill housing Continued expansion of cities will be increasingly inefficient in energy and resource consumption particularly if based on linear low density car orientated settlement patterns, Newman and Kenworthy (1989) and E S.D (1991) Rail transport offers an alternative:- one which emphases tighter, denser landuse around stations Cost savings in physical, social as well as transport infrastructure can be achieved through consolidation

In the past, planning has been all to frequently departmentalised; landuse and transport have been divorced from each other. The resultant strategies have unfortunately been far from optimum: transport planners have planned for low density settlements viewing the car as the most appropriate method of transport; land use planners have seen car ownership levels rising and insisted garages are provided, road reserves are provided and section sizes are large. The result has been that public transport has been disadvantaged and higher densities discouraged Accessibility has decreased with the migration from established centres Public transport service levels have been reduced accordingly and the process repeated

The circle needs to be broken: density needs to be raised and public transport promoted Both objectives can be achieved more easily if they are tackled simultaneously and the inter-linking of landuse and transport recognised

This paper continues by looking at the savings urban consolidation can achieve Section 3 then looks at some of the restrictions on density and efficient transport/landuse patterns which are inherent in current town planning rules Section 4 looks at the example of the Johnsonville line in Wellington to see how rail can benefit from denser housing Section 5 uses an example from Sydney to look at how the advantages of rail based urban consolidation can be evaluated Section 6 draws together some conclusions

2. Integrated Transport Planning

Economic savings in physical, social and transport infrastructure can be achieved by consolidating development in inner city areas and established suburban areas (urban villages) rather than on greenfield sites on the outer fringe

It is also reasonably well accepted that rail transport can focus landuse development tightly around stations in contrast to the linear and sprawling developments which often result from road construction

Conventionally, the merit of a transport scheme has been evaluated relative to other transport schemes using cost-benefit or financial appraisal as the evaluation tool. The analysis enables either (i) a sifting of different alternatives to determine the relative accessibility each affords in relation to the cost expended (a road may be compared against a railway for example) or (ii) the ranking of different transport schemes relative to one other or relative to non transport schemes

This is a restrictive approach and one which often extends back right into the demand forecasting exercise. Few studies have attempted to examine the "true" benefits of transport ie the benefit to the "end" usage of the transport

Apart from leisure travel, transport is not demanded for its own sake Rather it is demanded to satisfy end uses; to live in a certain area but participate in activities such as work or leisure in other areas. Transport is therefore a requirement for the development of an area and it is this benefit which transport improvements allow and which should therefore be evaluated

But in most demand studies and evaluations, this linkage is excluded Instead, the landuse and trip requirements (generation) are forecast seemingly independent of the transport infrastructure needed to facilitate the development As a result, the transport project is assessed in effective isolation from the development itself.

Usually, a base demand is projected on a current or future land use pattern, trips distributed according to the land use pattern and mode shares estimated according to the relative attractiveness of the modes proposed In effect, the transport scheme is assessed under an assumption of a fixed demand matrix based on an *assumed* landuse pattern

Residential, office and industrial land activity are determined and trip rates forecast The benefit of the transport scheme is then assessed assuming that this demand remains fixed. The implicit assumption is that the landuse development remains *"unaffected"* by the level of accessibility afforded by the transport scheme Consequently, none of the landuse benefits are explicitly attributed to the transport scheme itself Any that are attributed, are done so indirectly via a benefit measure usually limited to an assessment of travel time, travel cost and accident rate change

If in reality, the necessary proviso for the development is a new transport link, this measure probably understates the true benefit

In urban areas the problem is unfortunately much more complicated than in rural areas (eg the extraction of forestry products through new road construction) Accessibility helps determine the desirability for living and working. It also affects the "costs" of supplying the area with ancillary services, (sewerage, electrical, hospital, educational etc).

Transport accessibility therefore plays a crucial role in determining the spatial attractiveness and costs of developing different areas In selecting areas for development, transport importance is recognised However, in assessing the merit of the transport scheme it is conveniently forgotten

Transport accessibility is becoming more important as a result of increasing concerns over the sustainability of modern urban living. These concerns emerge from both an input perspective - the depletion of finite fossil fuels and minerals and from an output perspective - the environmental costs of land take-up Newman and Kenworthy *(op cit)* have written extensively on the inefficient use of transport energy in low density cities

Broadening the conventional evaluative measure to include the benefits of urban consolidation is not straightforward however Few studies have been done which have: (i) monetised the full costs and benefits of developing different geographic areas; and, (ii) attributed them to transport schemes

Nevertheless, some studies have been undertaken in Australia which provide a basis for estimating the benefits of urban consolidation

A potential but erroneous criticism of including the benefits of Urban Consolidation in rail projects is that such practice is not done in Road Appraisals The reported benefit measures will therefore be non comparable with those of road projects

This criticism is erroneous on two counts:

- Firstly, if urban consolidation benefits are significant and attributable they should be included in all relevant schemes whether they be road or rail;

- Secondly, road projects are less likely to be catalysts to urban consolidation by their very nature; indeed they are more likely to promote fringe development and they therefore should have the costs of fringe development entered against them

3. Restrictions on Density

Local government in most, or all, Australasian cities has indirectly helped promote inefficient landuse and transport through rates; land-use regulations; and, car orientation

- **Rates**

Local Authority services in residential areas are paid either: (i) directly through residential rates, and (ii) indirectly through commercial rates (which tend to be surcharged but ultimately pass on the extra charge to the consumer) Residents therefore do not *directly* pay the true costs for their residential services As a consequence, more services are consumed than would otherwise be the case, and residents cannot assess the true costs of their location decisions

- **Housing Type and Land use Regulations**

Modern town planning has its roots in the 19thC English "Garden City Movement" Terraced housing on small plots of land, it was argued, led to unhygienic slums. Moreover, the Garden City Movement recommended the separation of workplace and residence through zoning - an appropriate recommendation when factories were foul. Instead, the Garden City Movement advocated lower density housing on greenfield peripheral areas well away from factories and other places of work

With the benefit of hindsight, it is now considered that it was neither the type nor the density of housing which led to slums but rather a shortage of housing in areas accessible to employment Consequently, an excess demand for central city housing caused high rents, overcrowding, and inadequate maintenance But tenants could always be found no matter the housing condition, Sherlock (1991)

Since WWI and increasingly since WWII, low density trends have been particularly evident in the affluent "new English speaking world": North America, Australia and New Zealand. Low density cities have become the norm. A spacious, single floor, detached house with two car garage out in the suburbs is regarded as the "aspiration" for many prospective house owners.

Current District Schemes in New Zealand still penalise against the terraced house. Yet on its own plot, with outdoor living at ground level (and sometimes above ground level), the terraced house contains some of the best features of detached and semi-detached housing. Terraced housing should be permissible in any settlement.

The standard argument against terrace housing is that two to four storey houses built against boundaries will block some sunlight. The meridian of the sun in Australia and New Zealand is sufficient however to guarantee at least one sunroom in all dwellings, except perhaps in the middle of winter. If allowed to make the choice, some people would choose accessibility, cost, and/or other factors, ahead of winter sunlight. These choices should be allowed to be made *as of right* as they can be in Northern Europe (where zero winter sunlight is permitted).

Minimum plot sizes also limit density. Despite the steady decline in household size and lifestyle changes, minimum plot size regulations are still enforced. Front, side, and rear yards remain mandatory planning rules yet they take up space and reduce density. Owners should be allowed to have no side windows, to make their walls fire and sound resistant and to build up to their section perimeter.

Building height restrictions also limit residential density. Apart from sunlight, height restrictions are often justified on the basis of protecting views for existing residents. Undemocratically, existing residents are permitted to break the rules.

- **Car Orientation**

Garage doors are increasingly becoming the unattractive ground floor appearance of many houses. In the interests of sustainability, car usage should be discouraged. In Australia and New Zealand, planning regulations impose subtle pressures to encourage car ownership. Enforced off-street car parking is perhaps the strongest encouragement in many district schemes to own a car.

There is no valid reason why off-street car parking should be mandatory - it simply provides the reason to own a car to put in the garage. The garage also requires space which reduces housing density and increases construction costs. In contrast, existing residents are permitted to have no off-street parking which is undemocratic.

Market forces should be allowed to determine the quantity and location of car parking. Within residential areas, the kerb opposite a person's property frontage is often sufficient to meet parking requirements; for exclusive use of that kerbside, a fee should be paid.

4. The Effects of Consolidation for a Wellington Rail Corridor

- **Description of the Johnsonville Line**

Three rail lines radiate out of Wellington, the capital city of New Zealand The Johnsonville line is the oldest (opened 1885) and shortest (running 10.5 kilometres from Wellington Railway Station to Johnsonville); there are seven intermediate stations

The line runs independently from the other two rail lines It is single track with three passing loops and seven tunnels to cope with steep topography (the line rises over 150 metres over its length with maximum gradients of 2 8%) Track layout restricts speeds to 50 kph (40 kph in tunnels) and service frequency Rolling stock is very aged - English Electric multiple units first introduced in the mid 1930s and 1940s

Several studies have been commissioned over the last decade by the Wellington Regional Council (WRC) and New Zealand Rail (NZR) to determine the future of the line Closure, refurbishment, conversion to Light Rail Transit and conversion to Busway have all been appraised At the time of writing, the line is being appraised again by the WRC As part of its submission to Council, NZR commissioned a study to identify how patronage may be increased None of the previous studies have looked at the corridor as an *integrated landuse - transport issue* to determine the virtue of simultaneously increasing residential density and upgrading rail based public transport

- **Line Ridership**

Ridership of the Johnsonville line has been falling Over the five year period 1986-91 patronage declined significantly as a combined result of the recession, reduced car costs (in particular lower parking costs and increased availability) and transport deregulation Reversing the trend will be difficult; increasing the potential market through population increase is one source

In the long term, the size of the total market could be increased by targeting or allowing residential development in the immediate catchment area of the rail line Policies which redevelop, rather than decentralise Wellington city centre would also be advantageous to rail

Transport is a derived demand; the separation of residence, employment and other activities gives rise to travel demand At the moment, 41% of trips made on the Johnsonville line are to/from work; 39% to/from education; 8% personal business; 6% shopping and 6% other

Most users of the line (93%) live north of Wellington Station whilst 80% of trips involve Wellington station; The northern suburbs therefore generate trips and Wellington city attracts trips made on the Johnsonville line

Increasing the market size may be best achieved by increasing the population of the northern suburbs and/or increasing employment/shopping activities in central Wellington

In 1991, the population of the Johnsonville line was 36 thousand Over the period 1981-1991, population increased at 0 57% pa (zones weighted according to current rail usage) which was less than for the Wellington Region as a whole (0 8% pa)

Average household size has been declining in the Wellington Region As a consequence, the population of the Johnsonville line corridor can only increase if there is a more than compensating increase in the number of households Infill housing could provide the extra dwellings required. For this to happen, some relaxation of the District Plan rules as outlined earlier in section 3 would be required

Currently, gross densities (including streets, open spaces, shops, service premises, schools etc) in the Johnsonville corridor range between 14 persons per hectare to 28 Over the period 1981-91 there has been little change in density Net density (a measure which excludes open space and parks) range from between 19 persons per hectare to 28 Much higher net densities are attainable: Mount Victoria, an inner Wellington suburb has a net density of 83 persons per hectare

Three scenarios were developed to look at the potential for increasing population in the rail corridor: (1) Ten Percent Increase; (2) Maximum Probable and (3) Medium. All three scenarios assumed (i) that it would take thirty years to achieve the increase in dwellings and (ii) that the same number of houses would be built each year

Ten Percent Increase
This scenario assumed that town planning rules would not be changed significantly and that the number of dwellings would increase by 10% over the thirty year period.

Maximum Probable Scenario
This scenario was based on studies of sample residential areas along the railway to determine the capacity for realistic density increases Four study areas (deliberately unnamed) are shown in Figures 1.1 to 1.4 Many residential sites were sufficiently large to accommodate relocating the existing dwelling to the rear of the site - a not too difficult engineering process This allows extra housing in the front yard

The dwellings shown in the front yards are based upon a modern equivalent of the most successful house type built within the area bounded by the Inner Wellington Green Belt before WWI These houses were usually one room wide (5m) and three rooms deep (12m), have two storeys high, a five metre rear yard and a minimum front yard; they are still very popular today The five metre width permits one kerbside car park

Figure 1.1 shows a plan to infill six new dwellings, a percentage increase of 50% on the existing twelve houses. Five of the new dwellings are allowed by utilising road reserve and one by relocating an existing dwelling to the rear Figure 1.2 shows a plan to infill 19 new houses on an area with 11 existing houses; a percentage increase of 73% Eighteen of the new dwellings are allowed by relocating the existing house to the rear of the site and placing two semi-detached houses at the front Figure 1.3 shows nine new houses on nine existing houses (a 100% percentage increase) Site size limits five of the new dwellings to detached houses. Figure 1.4 shows a 200% increase in houses All 16 new houses are semi detached of which eight are enabled by relocating the existing house to the rear; the other eight can be accommodated at the front of the sites without relocating the existing houses.

Medium Scenario
This scenario took the average of the ten percent and maximum probable scenarios

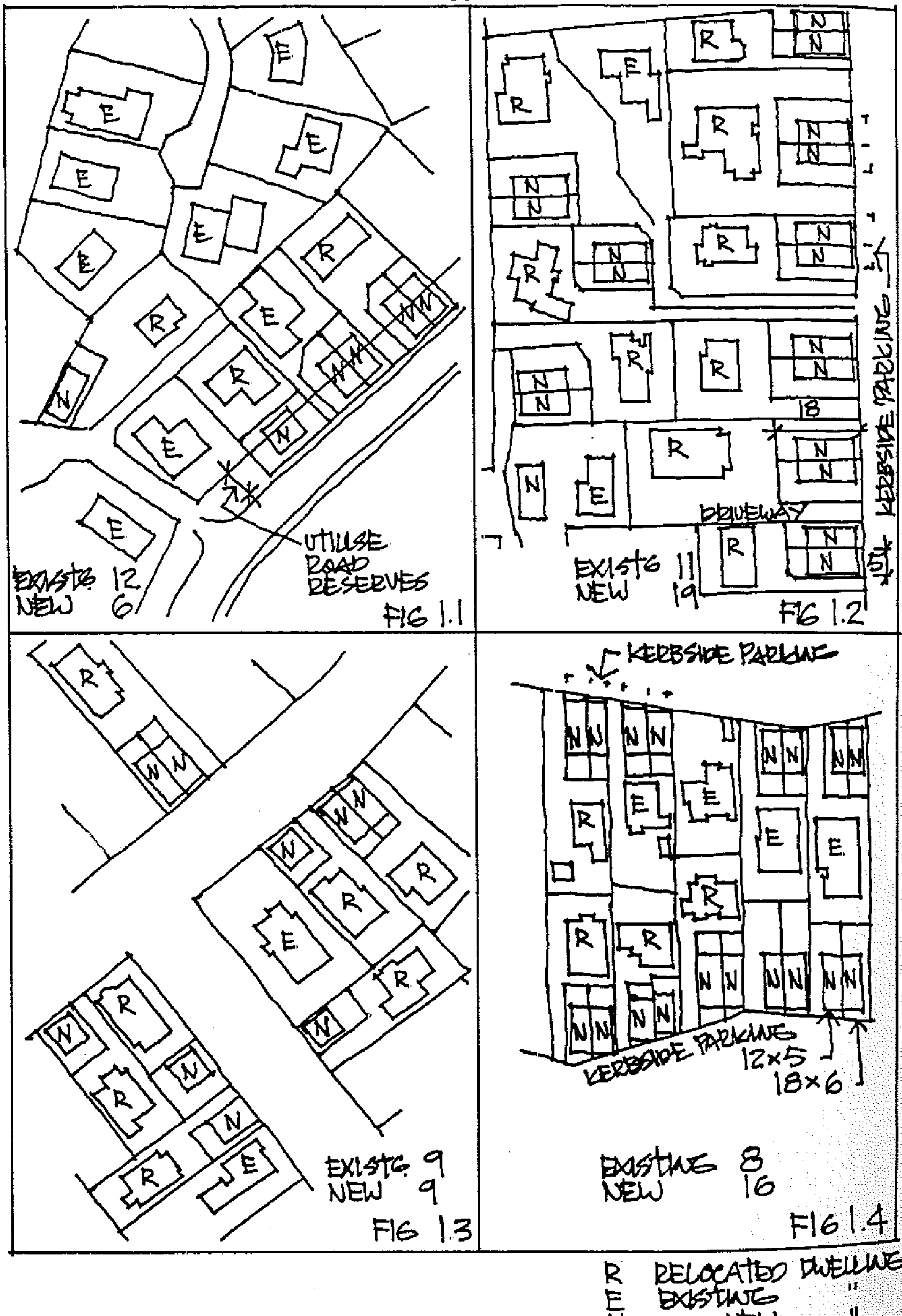

Figure 1
Increasing Housing Density: Four Case Examples

- **Scenario Forecasts**

Table 1 presents the population and resultant density forecasts In 2011, the maximum probable scenario projects an increase of 15.3 thousand people, a percentage increase of 42% (a annual increase of 1 8%) The medium scenario projects an increase of 7.7 thousand people whilst the "10% (households) scenario " projects negligible change in population

Table 1
Johnsonville Corridor Population & Density Forecasts

Year & Scenario	Households	Population	Density(1)	% Increase in Rail Trips(2)
1981	-	35031	16.8	
1986	14149	-	-	
1991	-	36214	17.4	
10% 2001	14855	35442	17.0	-1%
10% 2011	15325	36335	17.7	2%
10% 2021	15560	36782	17.7	3%
Med 2001	17167	40016	19.2	12%
Med 2011	19179	43958	21.1	24%
Med 2021	20185	45928	22.1	30%
MPrb 2001	19479	44589	21.4	25%
MPrb 2011	23033	51580	24.8	46%
MPrb 2021	24810	55075	26.5	56%

Notes: (1) Gross density in persons per hectare
(2) % increase on 1993 Average Annual Daily Rail Trips

In 1991, the population of the Johnsonville corridor accounted for about one quarter of the population of Wellington City and 10% of the Wellington Region In 2011, the maximum probable scenario projects the Johnsonville corridor population shares to rise to 31% and 12% respectively

Population demographics and location will influence the effect on rail ridership

In terms of population, the WRC projects: (i) a relatively higher growth in the 5-19 age group (who have a higher propensity to use rail) of 1% pa; (ii) a higher growth rate in the 60+ age group (who have a lower than average rail trip rate) of 1 8% pa; and, a lower than average growth rate for the remainder of the population of 0 63% pa WRC (1992) Overall the effect of the change in age profile is predicted to be slightly negative causing a -0 15% pa change in rail trips per year

In terms of location, the closer to rail stations, the greater the impact population change has on rail patronage A plot of the observed and predicted relationship between access time and residential trip rate for the Johnsonville corridor is presented in the Appendix together with the predicted functions

The predicted functions suggested a unitary access elasticity; residential trip rate is predicted to decline proportionately with access time (a ten percent increase in access time reduces the trip rate by 10%)

The predicted effect on rail ridership of the consolidation scenarios adjusted for age profile and location is shown in the last column of Table 1 The 10% scenario has negligible effect on rail patronage. The medium and maximum probable scenarios by 2011 are predicted to increase rail trips by 24% and 46% respectively on 1991 levels *(ceteris paribus)*.

The important assumption is *ceteris paribus* - it is unlikely to hold however Currently, the Johnsonville corridor has a 20% mode share of trips With consolidation this is likely to rise as a result of: (i) rail service frequency increases making rail more attractive and (ii) increasing road congestion disadvantaging the car Consequently, residential trip rates are likely to rise with consolidation

5 Evaluating the Benefits of Consolidation for Central Sydney

In the Sydney Region, population growth and urban sprawl are on the big scale. Population is forecast to reach 4.5 million by 2011 (from 3.6 million in 1990) at an annual growth rate of 1.06% pa and at an absolute increase of 48,000 pa

Sydney's outer suburbs are growing rapidly for several reasons: available detached single houses on large blocks; smaller households; and, population decline in many middle and inner suburbs Land is being used up faster than planned. Five new release areas have been identified by the Department of Planning; they are all located far away from the employment centres of central Sydney and will tend to exacerbate the transport and general problems associated with urban sprawl.

To reduce land take-up and avoid the problems of urban sprawl, the New South Wales Government is advocating Urban Consolidation in both inner-Sydney and decentralised country areas like Newcastle

The Central Industrial Area (CIA) of Sydney provides one of the best opportunities for large scale urban consolidation in Australia. Close to Sydney International Airport and the CBD, the CIA has large parcels of land ready for redevelopment.

The public and private sectors are jointly looking at a scheme to link the CIA with the CBD via a new eight kilometre underground railway line costing upwards of $A 500 million as shown in Figure 2. The underground heavy rail Airport Link is seen as being able to focus residential and commercial development tightly within walking distance of the proposed stations whilst avoiding the negative environmental disbenefits of a surface railway. The project has been evaluated as a whole Housing, infrastructure and transport have been evaluated as a package

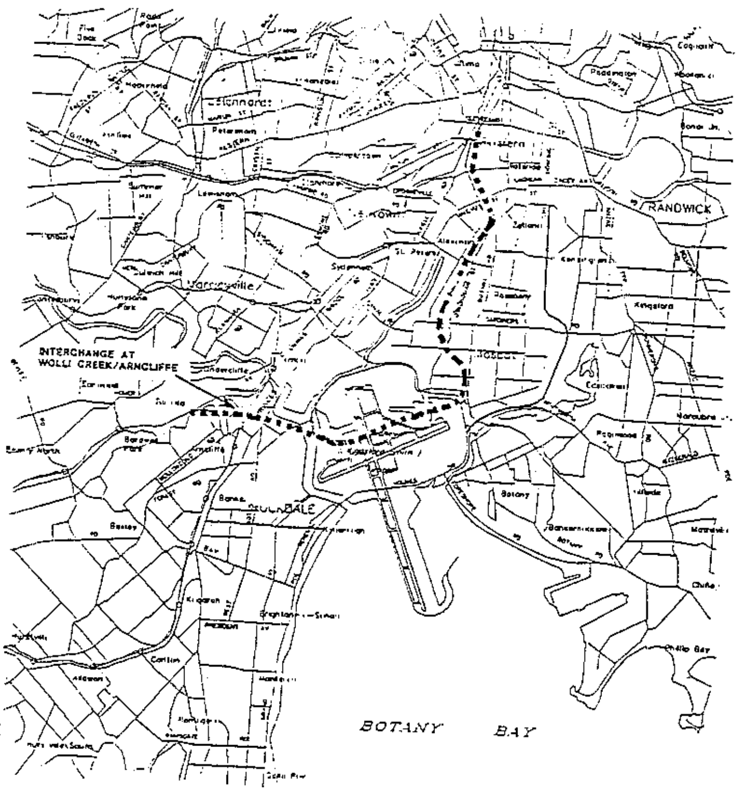

Figure 2
Possible Route of Proposed Airport Link

Three types of urban consolidation were evaluated:

- **Physical Infrastructure Savings**

Indicative estimates prepared by Hughes Trueman Ludlow/Dwyer Leslie Pty Ltd for the Department of Planning were used. Two areas on the fringe (Erskine Park/St. Clair and Rouse Hill) were compared to two consolidation areas (Bankstown and Hurstville). The range of benefits from urban consolidation are shown in Table 2:

There are substantial potential savings achievable through urban consolidation in areas where services are already in place and spare capacity is available (a result of falling population and dispersal of industry). The range of benefits are between $A 30,700 and $A 18,900 per lot (840 square metre). Sewers, water and stormwater account for approaching two-thirds of total physical infrastructure cost savings

Table 2
Total Cost Difference in Physical Infrastructure
Between Consolidation and Fringe Development
$ Per Dwelling 1989/90 Prices (840 square metre lot size)

	Maximum Difference (A$)		Minimum Difference (A$)	
Component:	50 dw/ha	18 dw/ha	50 dw/ha	18 dw/ha
Sewer	8422	7752	4551	3881
Water	4171	3601	3411	2841
Stormwater	7276	7276	3898	3898
Gas	1753	1492	1369	1108
Power	2248	2152	1885	1789
Telecom	1031	795	659	423
Local Roads	4635	4635	2483	2483
Misc.	1148	1148	615	615
Total	30684	28851	18871	17038

Source: Hughes Trueman Ludlow/Dwyer Leslie (1991)

- **Social Infrastructure Savings**

Savings were based on accommodating the predicted residence of the CIA compared to a peripheral green field site. Savings were either costed on a dwelling or population basis and were attributed to funding source: private, state or other Table 3 presents the main elements:

Table 3
Social Infrastructure Savings

Service	Costing Unit	Funding Source
Community Services	Dwelling	Private
Open Space Provision & Embellishment	Dwelling	Private
Primary School	Resident	State, Commonwealth, Private
Secondary Schooling	Resident	State, Commonwealth, Private
Tertiary Education	Included in Transport Consolidation Benefits	
Hospitals	Resident	State Commonwealth
Emergency Services	Resident	State
Shopping	Resident	Private
Churches & Charities	Resident	Private
Social Amenities	Resident	Various

Source: DJA *et al* (1992)

- **Transport Infrastructure Savings**

Savings were assumed to accrue only to residents relocating to the CIA and using rail to travel to work. Without the Airport Link, these residents were assumed to live on the urban periphery, to use rail and to work in central Sydney The justification for these assumptions was fourfold: firstly, rail obtains a 75-85% share of long distance commuting trips to the CBD; secondly, rail users are more likely to be attracted to the CIA development than car users as the development is "stimulated" by the improvement in rail service level; thirdly, inner city consolidation ultimately replaces urban fringe development; fourthly, the destination of non peak trips is far less certain

Three sources of transport infrastructure saving were considered:

- reduced travel time;
- reduced rail operating costs from transporting passengers a shorter distance;
- shorter access journeys from denser housing in the inner city than the periphery.

Transport infrastructure savings will recur increasing with the build-up in residence of the CIA. Travel time savings account for most of the savings and access savings were the smallest element.

Comparatively, physical infrastructure savings accounted for the largest share of total consolidation benefits. At 7% and assuming physical infrastructure savings of (i) A$17,000 per house and (ii) A$31,000 per house, the shares were:

	(i)	(ii)
Physical	36%	51%
Social	32%	25%
Transport	32%	24%

The overall evaluation adopted a two stage approach. The first stage followed conventional Cost Benefit Analysis for transport projects. Capital and operating costs were compared against travel time savings, accident cost savings and vehicle operating cost savings. A fixed transport demand matrix was used and the new rail link was evaluated against existing methods of transport.

The second stage introduced infrastructure savings and savings from air pollution, noise, reduced road maintenance and increased international tourism and took account of an additional disbenefit to existing rail travellers on one line who will face a longer journey time.

In the second stage, consolidation benefits were the most significant. When included, the project moved from being marginally beneficial to being clearly beneficial on an NPV basis.

6. Conclusions

Town planning and transport need to be planned together and projects evaluated as a whole Low density housing is a legacy of the Garden City movement It should not be the vision of town planners today: it was never the best prognosis and will never produce sustainable urban living

Low density housing has been enabled by car transport Transport planners have taken their objective as facilitating car mobility; getting people from home to work as quickly as possible by car The extra road capacity provided has allowed car commuters to live further out and consume move resources travelling in

Rail based public transport and dense settlements go hand in hand Rail needs density around stations to be effective Dense settlements are best served by rail to avoid road congestion Then, along dense corridors, rail can provide cost effective and environmentally benign transportation By increasing density and adopting rail solutions simultaneously, urban form and transport will become more efficient

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Appendix

Predicted Relationships Between Residential Trip Rate and Access Time

	Access Time β_1	Access Time $\lvert t\rvert$	Constant β_0	Constant $\lvert t\rvert$	R^2
J'ville Peak	-1.22	3.0	6.79	8.03	.19
J'ville Off Peak	-0.72	1.6	5.71	6.20	.04
J'ville Saturday	-0.72	1.6	5.77	6.27	.04
J'ville AADT	-1.02	1.59	3.56	1.97	.14
W'ton Peak	-1.01	1.57	3.71	2.05	.08
W'ton Off Peak	-0.86	1.56	3.13	2.02	.08
W'ton Saturday	-0.87	1.56	3.20	2.06	.14
W'ton AADT	-1.02	1.59	3.56	1.98	.14

Notes: W'ton refers to residence zones accessing Wellington station; J'ville to residence zones accessing other stations.

Estimation Equation:

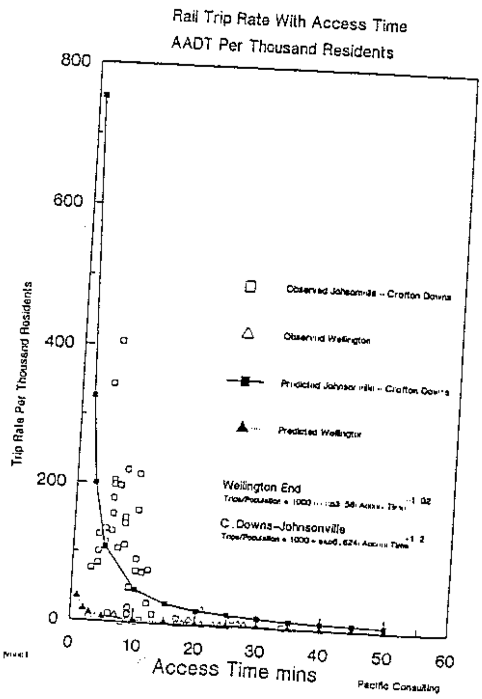
$Q/P = \exp \beta_0 . A^{\beta_1}$

Q/P = Rail trips (Q) per thousand population (P)

β_0 = Constant

A = Access time in minutes

β_1 = Access time parameter



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