Comparative costs of urban development: a literature review

Final report

Infrastructure Victoria

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SGS Economics & Planning

1991–2016 25 years of Independent insight.

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EXECUTIVE SUMMARY

In preparing the 30-year Infrastructure Strategy, Infrastructure Victoria (IV) is undertaking an options assessment of policy reforms and infrastructure projects that would support the core objective of improving social, economic and environmental outcomes for Victoria.

In this context IV has identified a need to understand the cost to retrofit, improve, upgrade and build new infrastructure in different locations currently or potentially designated for growth across the metropolitan area and the State generally.

SGS was briefed to investigate *what the existing literature tell us about the comparative costs of infrastructure to accommodate population growth 'modules' of 25,000 across the following development* settings in Victoria:

- *Large scale brownfield*
- *Established National Employment Cluster / Established Metropolitan Activity Centre*
- *Dispersed infill*
- *Greyfield*
- *Greenfield*
- *Regional centre*

SGS' review of authoritative literature on comparative infrastructure costs focused on Australian studies but included limited selected studies from New Zealand and the United States. Key findings from this review include:

1. Most authors rely on their own reviews of existing literature about infrastructure costs; very few produce their own original costings.
2. The literature review cautions against unqualified promulgation of infrastructure cost 'benchmarks' for different development settings; costs are heavily dependent on area-specific factors.
3. There are significant gaps in the literature in regard to research into infrastructure costs specific to National Employment Clusters, Activity Centres and greyfield development settings.
4. Notwithstanding the likelihood of local, case specific, variations, there is strong and consistent evidence that infrastructure can be provided at comparatively lower costs at infill locations.
5. From the costs that could be compared within the texts, infrastructure provision to greenfield lots was found to cost approximately 2-4 times more than infill, depending on the capacity of existing infrastructure to support additional people.

Based on this review of previous studies, SGS recommends that IV applies a scenario based research method whereby the costs and benefits of 'diverting' 25,000 people from a business as usual development pattern to each one of the nominated development settings is calculated in turn. This proposed approach would situate the research in 'real world' conditions and take into account actual infrastructure constraints and opportunities in the 'receptor' locations around metropolitan Melbourne and Victoria. At the same time, it will generate robust evidence on which to generate broad brush per unit infrastructure costs for different development settings.

1 INTRODUCTION

1.1 Project background

In preparing a 30-year Infrastructure Strategy for the State, Infrastructure Victoria (IV) is undertaking an options assessment of policy reforms and infrastructure projects that would support the core objective of improving social, economic and environmental outcomes for Victoria.

In developing the Strategy, integration of land use and infrastructure investment is a crucial consideration. IV has identified a need to understand the cost to retrofit, improve, upgrade and build new infrastructure in different locations designated for growth and commissioned this project to inform recommendations about grouping and sequencing infrastructure options in the *Draft Infrastructure Strategy*.

1.2 Project brief

IV engaged SGS Economics and Planning Pty Ltd (SGS) to:

- review key literature to understand the costs to provide infrastructure (new/retrofit/upgrade) in different locations identified for population growth across Victoria
- focus research on the relative capital costs of providing infrastructure for an additional 25,000 people to be added to a settlement system similar to Victoria's in five different settings, including large scale brownfield, established National Employment Cluster /Metropolitan Activity Centre, dispersed infill, greyfield, greenfield and regional centre
- note of the relative benefits attaching to adding the abovementioned number of people in the various development settings, relating to such matters as travel, productivity, human capital development, sustainability and residential amenity, amongst others, and
- outline a methodology for a possible future comprehensive investigation into the costs of infrastructure provision in different locations identified for growth in Victoria.

This project will be one input into a series of broader considerations of environmental, social and economic outcomes of managing population growth and infrastructure investment across Victoria.

1.3 Project methodology

SGS undertook the literature review in four phases as explained below.

Phase One – Research question

Upon engagement SGS sought to further define the research question and seek agreement with IV regarding appropriate operational definitions of the key terms: 'infrastructure', 'costs' and the various 'development settings', so that the literature search remained focussed.

Phase Two – Literature review

SGS carried out a systematic, desk-top based, search of literature relevant to the research question in a Victorian context, generated by scholars, industry groups, think tanks and government agencies.

Each piece of relevant research was summarised using a consistent format geared to the agreed questions (refer Appendix 1).

Phase Three – Key findings

SGS synthesised the findings of all relevant literature in respect of the research question. On the basis of the evidence gathered, it has only been possible to make qualified conclusions about the costs of providing infrastructure to service a population of 25,000 in the different development settings.

Phase Four – Design of further research

Based on the lessons from the literature, SGS has proposed an evidence gathering method and process by which the research question may be definitively resolved.

2 RESEARCH QUESTION & PARAMETERS

2.1 Research focus

The question that this paper seeks to address is:

What does the existing literature tell us about the comparative costs of infrastructure to accommodate a population 'module' of 25,000 across the following development settings in Victoria:

- *Large scale brownfield*
- *Established National Employment Cluster / Established Metropolitan Activity Centre*
- *Dispersed infill*
- *Greyfield*
- *Greenfield*
- *Regional centre.*

2.2 Definitions

Development contexts

Following is our understanding of the specific development settings of interest in this research.

It is important to note that whilst the current residential density of occupied sites varies between development settings and locations, all of these development settings present an opportunity to provide development outcomes at higher densities than the status quo. Density is a key consideration across the development contexts as it relates to access to and demands on infrastructure, land and jobs.

Figure 1 below shows the indicative location of these development settings in the Melbourne context.

Large scale brownfield

Brownfields are sites that were previously used for industrial or commercial activities which have resulted in actual or perceived environmental contamination and which have the potential to be redeveloped for residential uses (amongst others).

The major brownfield sites in Melbourne (including Fisherman's Bend and Arden Macaulay) are shown on Figure 1 below.

Established National Employment Cluster / Established Metropolitan Activity Centre

National Employment Clusters (NECs) and Metropolitan Activity Centres (MACs) are terms set out in Plan Melbourne 2014. Plan Melbourne identifies these as either already established or envisages that they will be in future. MACs are "higher order centres with diverse employment options, services and housing stock, supported by good transport connections". They are a focus of public transport networks and attract investment in education, health and other services.

NECs are ''designated geographic concentrations of interconnected businesses and institutions that make a major contribution to the national economy and Melbourne's positioning as a global city". They

play a major part in supporting population and employment growth. Plan Melbourne has identified three existing clusters at Parkville, Monash and Dandenong South, as well as three emerging clusters.

The locations of the established NECs and MACs are shown in Figure 1 below.

Dispersed infill

Dispersed infill is where land in the established urban areas is redeveloped and subdivided to create additional (up to 10) residential lots or dwellings. Figure 1 below indicates large parcels of residential land upon which permits for residential redevelopment have been issued but where construction of new dwellings has not commenced.

Greyfield

Professor Peter Newton, who coined the term 'greyfields', defines it in in his 2013 paper (p. 578) as being "concentrations of underutilised (but occupied) land parcels in inner and middle suburban locations where building stock is failing (physically, technologically and environmentally) and energy, water and communications infrastructure is in need of upgrading".

In the map below greyfield land is proxied by dwellings developed in the 1950s and 1960s. However, not all of this land would meet the definition of greyfield set out above.

Greenfield

Greenfield development involves creation of planned communities on previously undeveloped land. In Figure 1 below, greenfield land comprises unserviced areas within the urban growth boundary that are planned to be developed for residential use. Melbourne's declared growth areas are the municipalities of Cardinia, Casey, Hume, Melton, Mitchell, Whittlesea and Wyndham.

Regional centre

A regional centre is a serviced area in Regional Victoria (as distinct from an extension of a regional town centre into greenfields). Effectively, this development context represents infill in a regional setting.

The Metropolitan Planning Authority is working with local government to develop Regional Growth Plans to unlock the growth potential of regional centres. These will provide a 20-30 year land use strategy and develop integrated infrastructure planning and delivery models in centres such as Ballan, Bacchus Marsh, Kilmore, Broadford, Warragul-Drouin and Wonthaggi.

Due to the scale required to show the other development settings in the Melbourne Context, regional centres are not indicated in Figure 1.

Other key definitions

Benchmarks

A standard or a reference point (i.e. a cost of a particular thing) against which other things may be compared.

Infrastructure trigger points

A trigger point is a single event requiring a change to an infrastructure item / network in order to ensure the healthy / safe functioning of the uses it is servicing (i.e. a specific population increase in a catchment that places a level of pressure on the existing infrastructure that generates the requirement for additional infrastructure / augmentation to increase capacity).

Infrastructure thresholds

An infrastructure threshold is the level at which an infrastructure item / network reaches capacity.

Headworks

Headworks (or trunk infrastructure) is the higher order or shared infrastructure required to ensure the healthy / safe functioning of the uses it is servicing. It supports large catchments with a number of users or developments.

Contiguous development

Contiguous development means development that is adjacent to existing development (and therefore infrastructure).

Non-contiguous development

Non-contiguous development is defined as development which takes place at a distance from existing development. Consequently, it is less able to utilise existing infrastructure and services, requiring new investment.

2.3 Size of population

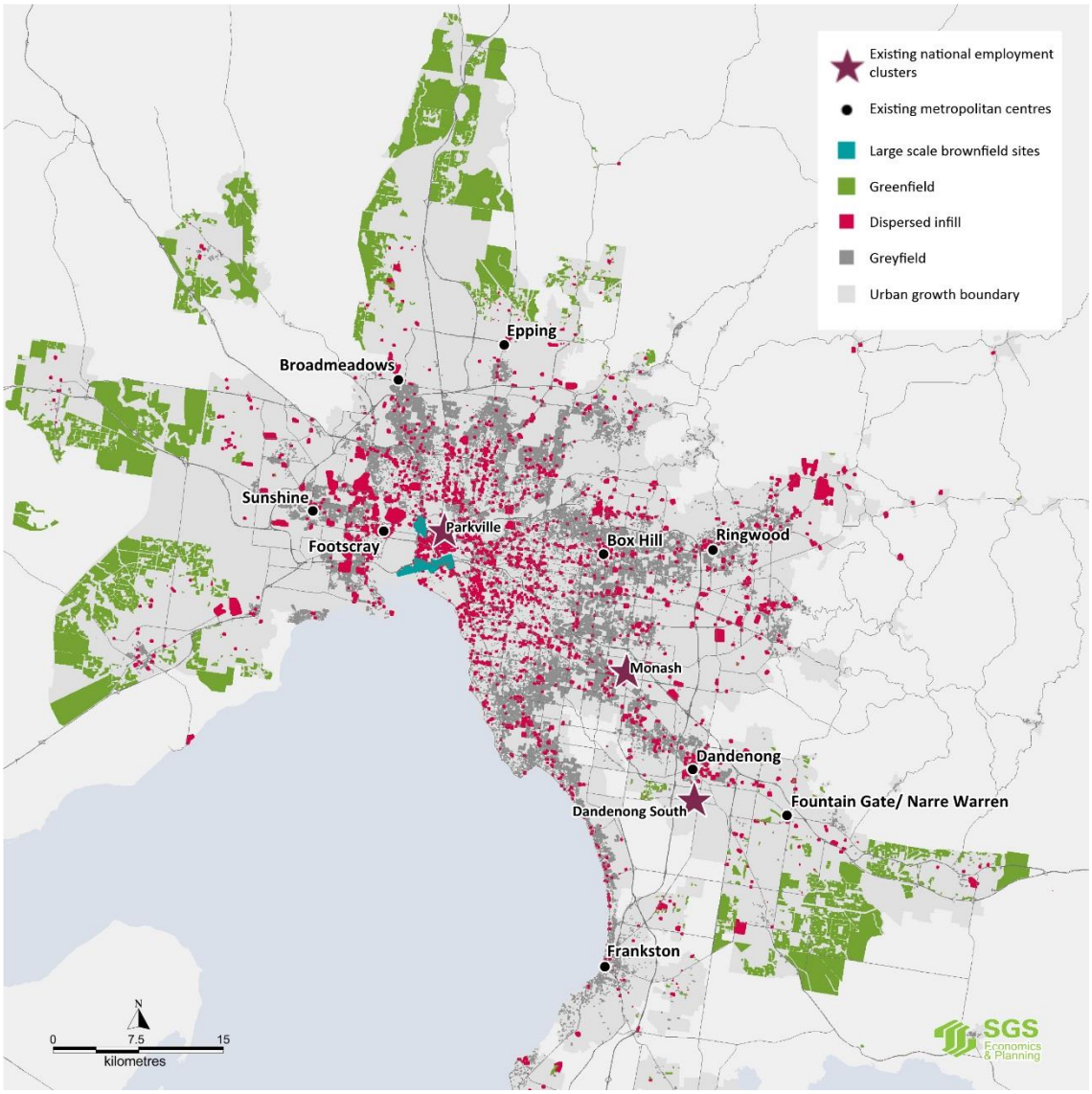
In order to make comparisons across the different development settings there is a need to use a consistent number of people or dwellings. A population size of 25,000 has been selected by IV due to its function as a trigger for key items of higher order infrastructure including arterial roads and schools. That is, if a community of 25,000 people were added to a development context with existing infrastructure, the resultant additional demand on infrastructure would be unlikely to be met without that infrastructure being upgraded or supplemented.

2.4 Costs of infrastructure

The research is seeking to compare infrastructure costs including physical infrastructure (i.e. new suburban roads, sewer lines, power substations) and social infrastructure (i.e. schools, recreation reserves, public transport).

While it was determined that comparing upfront costs was appropriate for the literature review, Infrastructure Victoria and SGS consider that it might be appropriate to consider some of the broader costs of infrastructure delivery in future quantitative investigations, informed by the findings of the literature review.

FIGURE 1. INDICATIVE DEVELOPMENT SETTINGS IN THE MELBOURNE CONTEXT



Source: SGS, 2016

3 LITERATURE REVIEW

3.1 Sources

Following is a list of the literature selected to be reviewed by SGS:

- Biddle, T. et al (2006), *The Costs of Infill versus Greenfield Development – A Review of Recent Literature*, Institute of Transport & Logistics Studies, The University of Sydney, NSW, Australia
- Centre for International Economics (2015) *Cost of Residential Servicing*, Prepared for Auckland Council.
- City of Sydney (2006) *Green Square Town Centre Infrastructure Strategy.*
- Evans Paull (June 2012), "Infrastructure Costs, Brownfields vs Greenfield", *Redevelopment Economics*, Massachusetts, USA.
- Hamilton, C. and Kellett, J. (2015) *Exploring infrastructure provision issues in greenfield and urban infill residential developments*, State of Australian Cities Conference 2015, Adelaide.
- Infraplan (December 2013) Urban Infill vs Greenfield Development: A review of economic benefits and costs for Adelaide, [Discussion Paper].
- Kinhill Engineers (April 1995), *Smart planning not sprawl: the costs and benefits of alternative fringe planning*, The Australian Urban and Regional Development Review, Canberra.
- Newton, P.W., Newman, P., Glackin, S., Stephen & Trubka, R. (2012) *Greening the Greyfields: Unlocking the Redevelopment Potential of the Middle Suburbs in Australian Cities*, World Academy of Science, Engineering and Technology: Proceedings of the 33rd International Conference on Urban Planning and Regional Development (ICUPRD 2012), Venice, Italy, Vol. 71 (2012), pp. 658-677.
- Newton, P. (2013) *Regenerating cities: technological and design innovation for Australian suburbs, Building Research & Information*, Vol. 41, No. 5, 575-588.
- Newton, P. & Glackin, S. (2014) *Understanding Infill: Towards New Policy and Practice for Urban Regeneration in the Established Suburbs of Australia's Cities*, Urban Policy and Research, 32:2, 121-143,
- Property Council of Australia et al (June 2016) *Design Perth: a joint vision for a connected, liveable and sustainable Perth*, Australia.
- SGS Economics and Planning (June 2013) *Financial costs of settlement patterns in rural Victoria: Final Report,* Australia.
- SGS Economics and Planning (January 2012), *Where and how should we grow? Final Report,* Prepared for Rural Councils Victoria
- Trubka, R., Newman, P., & Bilsborough, D. (2009) *Assessing the Costs of Alternative Development Paths in Australian Cities*, Curtin University Sustainability Policy Institute Fremantle, Parsons Brinckerhoff Australia/Curtin University.
- Trubka, R., Newman, P. & Bilsborough, D. (2010) *The Cost of Urban Sprawl – Infrastructure and Transportation,* Environment Design Guide.
- Environmental Resources Management Australia Pty Ltd (ERM) (2001), *Future Perth: Costs of Urban Form, Working Paper No. 2*, Western Australian Planning Commission, Perth.

The reviews of individual texts were summarised using a consistent template geared to the research question defined by IV. The completed templates are shown in the Appendix.

3.2 Key findings

Methodologies utilised

Most authors undertake a review of existing literature about infrastructure cost comparisons with a focus on infill versus greenfield development.

Very few authors produce their own original costings and those that do have had direct input from civil engineers. The latter studies included SGS (2013) which featured input from Aurecon, Kinhill Engineers et al (1995) and Trubka, Newman and Bilsborough (2009) where Bilsborough and Trubka were engineers at Parsons Brinckerhoff.

Much of the reviewed literature relies on costs presented in Trubka et al (2009). These were intended by the authors to be replicated and tested by others. They were deliberately produced in a simple way that breaks down the costs of inner city and fringe development by infrastructure type for 1,000 dwellings. It is important to note that these costs, which are so widely re-used, are themselves informed by a study commissioned by the Western Australian Planning Commission, titled 'Future Perth' (ERM, 2001), which drew on 22 Australian, US and Canadian studies undertaken between 1972 and 2000.

The Future Perth (ERM, 2001) study seeks to answer a question that is the most similar to the question that this literature review is seeking to solve and shares a similar purpose (in informing State Government strategy). Its main points of difference are in the way that it measures direct, indirect and external costs and provides lower and upper cost estimates (representing the degrees to which development is either contiguous or non-contiguous to existing infrastructure).

Some authors compare theoretical scenarios and/or real case studies. For instance, Infraplan (2013) compares two scenarios in which the ratio of infill to greenfield development is altered (and subsequent density) over time. Infraplan (2013) also undertakes a comparison of case studies that measure the capital and recurrent costs of physical and social infrastructure in greenfield and infill locations around the periphery of, and within, metropolitan Adelaide.

Kinhill Engineers (1995) compare greenfield scenarios which investigate the cost implications of 12 combinations of density, neighbourhood design, structure planning and development sequencing, based on a theoretical plans in a real geographical location (the Brisbane-Gold Coast corridor).

Hamilton and Kellett (2015) examine three different residential developments in Adelaide: a greenfield case on the urban fringe, an infill (large scale brownfield) case and an infill (greyfield) urban renewal case involving the redevelopment of social housing.

SGS (2013) applied an approach that involved the collection of data through council consultation, expert input from Aurecon, and GIS analysis and lead to the creation of a tool that can be used to estimate development costs for new residential developments in rural Victoria.

Numerous authors calculate the infrastructure savings achievable in diverting a portion of the population from the business as usual style of development into infill.

In the scenarios compared within the texts, density is the most commonly tested variable.

Some of the texts, i.e. those that discuss greyfield development, were reviewed to provide insight into a specific development context but did not compare or quantify costs.

Quantitative costs

Set out in the following table is a comparison of the infrastructure costs put forward by the authors reviewed, according to development setting used by the authors.

TABLE 1 COMPARATIVE DEVELOPMENT COSTS

Literature	Development setting presented in the literature:	Potential to inform development setting defined in research question	Key assumptions specific to the development setting	Cost per unit (as the research presents):
CIE (2015)	Low density	Any setting, depending on the density outcome	Factors transport infrastructure into costs	Range approx. $NZD36,000 – $50,000 per dwelling
	Medium density	Any setting, depending on the density outcome	Factors transport infrastructure into costs	Range approx. $NZD25,000 – $44,000 per dwelling
	High density	Any setting, depending on the density outcome	Factors transport infrastructure into costs	Range approx. $NZD26,000 – $34,000 per dwelling
ERM (2001)	Contiguous (some existing infrastructure)	Large scale brownfield, Established NECs/MACs, Dispersed infill, Greyfield, Regional Centre	Direct costs – initial capital	$100,000 - $257,500 per dwelling
			Operating, maintenance and replacement costs sought but insufficient info. on replacement costs	$17,200 - $19,250 per dwelling
			Indirect - capital	$4,550 per dwelling
	Non-contiguous (no existing infrastructure)	Greenfield	Direct costs – initial capital	$101,500 to $234,000 per dwelling
			Operating, maintenance and replacement costs sought but insufficient info. on replacement costs	$23,700 - $25,750 per dwelling
			Indirect - capital	$25,550 - $40,550 per dwelling
Hamilton & Kellett (2015)	Greenfield	Greenfield	Public transport upgrade	Developer costs: $53,580, Government costs: $29,044-$34,044 For 4,000 new dwellings
	Infill	Large scale brownfield	No public transport upgrade	Developer costs: $26,655 Government costs: $2,451 For 2,400 new apartments
	Infill	Greyfield	No public transport upgrade	Developer costs: $49,663 Government costs: $36,566 For 1,800 new dwellings
Infraplan (2013)	Greenfield– metropolitan periphery	Greenfield	Over 30 years, discount rate 4%, excludes some recently identified transport projects	Median of $80,500 per lot $62-89million per 1,000 dwellings
	Greenfield – minor township extension	Greenfield	Some existing capacity & infrastructure assumed Over 30 years, discount rate 4%, excludes some recently identified transport projects, includes construction costs	$45,000 per lot
	Greenfield – new broadacre sites	Greenfield	Over 30 years, discount rate 4%, excludes some recently identified transport projects, includes construction costs	$100,000 per lot (approximately, derived from graph)
	Infill Major Projects Infill / Townships Re-subdivision	Large scale brownfield	Over 30 years, discount rate 4%, excludes some recently identified transport projects, includes construction costs	Median of $20,000 net dwelling $25-45million per 1,000 dwellings $15-25million per 1,000 dwellings
Kinhill Engineers (1995)	Least expensive of 12 greenfield scenarios tested: Conventional form, preferred sequence, 15 dwellings/ha	Greenfield	20 year development, discount rate of 6%, assumes improvement to rail stations and town centre bus interchange	Total discounted infrastructure cost of $1,572 million for 100,000 people

	Most expensive of 12 greenfield scenarios tested: Inter-connective form, no development sequence, 15 dwellings/ha	Greenfield	20 year development, discount rate of 6%, assumes improvement to rail stations and town centre bus interchange	Total discounted infrastructure cost of $1,655 million for 100,000 people
PCA (2016)	Infill	Large scale brownfield	Government upfront costs only	$55,828 per lot
	Greenfield	Greenfield	Government upfront costs only	$150,389 per lot
SGS (2013)	Greenfield (rural setting)	Greenfield	Settlement of 10 dwellings, over 30 years	Costs to Council of $58,233 per dwelling
	Infill (rural setting)	Regional centre	Settlement of 10 dwellings, over 30 years	Costs to Council of $38,738 per dwelling
Trubka et al (2009)	Inner-city	Large scale brownfield	Upfront infrastructure, 2007 prices	$50.5 million per 1,000 dwellings
	Fringe	Greenfield	Upfront infrastructure, 2007 prices	$136 million per 1,000 dwellings
Trubka et al (2010)	Inner-city	Large scale brownfield	15 year present value, ongoing transport costs only (not other infrastructure), discount rate of 7% applied to some items	$169 million per 1,000 dwellings
	Fringe	Greenfield	15 year present value, includin ongoing transport costs only (not other infrastructure), discount rate of 7% applied to some items	$334,783,257 per 1,000 dwellings

Table 1 shows that where the costs of infrastructure provision are compared within texts, infrastructure provision to greenfield lots costs approximately 2-4 times more than infill. The large variation is contingent on the capacity of existing infrastructure to support additional people.

There is also considerable variation in length of time over which comparative developments are costed, and variations in the discount rate applied. Most infrastructure is costed over 15-30 years and has discount rates of 4-7% applied.

There is also variation in the treatment of capital value versus ongoing costs. Most of the studies only calculate capital value. However, it is acknowledged in numerous texts that this narrow focus is fraught. The SGS (2012) report finds that upfront capital costs for greenfield development represent around 20% of the infrastructure assets' lifetime cost. Similarly, the 2015 CIE Report cautions against making decisions on the basis of upfront capital costs alone.

Significant amongst the ongoing costs are those associated with transport. For instance, the Trubka (2008) costs are referred to in Newton et al (2012) as calculating that each new greenfield block incurs an additional $250,000 in transport over 50 years.

The 'Future Perth' (ERM, 2001) study found that the main driver of external costs was travel time, which accounted for more than 95% of external costs and was dependent on the proximity of residents to their place of work.

In the studies reviewed, district transport infrastructure was sometimes costed separately due to the high upfront costs involved in its establishment (especially rail and major roads) and recognition that the benefits are accrued over an area much wider than the development location. Accordingly, the literature is divided between those that include and those that exclude transport costs.

The divergent approaches of the authors to costing types of infrastructure are shown in Table 2, below.

TABLE 2 TYPES OF INFRASTRUCTURE COSTED

Literature	Upfront		Ongoing		Transport Infrastructure	
	Physical	Social	Maintenance	Replacement	Included in physical costs	Separately priced
CIE (2015)	✓	✓	✓	✓	X	✓
ERM (2001)	✓	✓	✓	✓	X	✓
Hamilton & Kellett (2015)	✓	✓	✓	✓	✓	X
Infraplan (2013)	✓	✓	✓	✓	✓	X
Kinhill Engineers (1995)	✓	✓	✓	✓	X	✓
PCA (2016)	✓	✓	✓	✓	X	✓
SGS (2013)	✓	✓	✓	✓	X	✓
Trubka et al (2009)	✓	✓	✓	✓	X	✓
Trubka et al (2010)	✓	✓	✓	✓	X	✓

There is also a degree of inconsistency over the exclusion of housing related construction costs, with several papers examining the broader cost of development, not just the infrastructure component of development. This reinforces a broader perspective for evaluating the relative costs and benefits of different development settings and that construction, land and remediation costs are important factors in this equation.

Another difference is that some authors split the infrastructure costs by private / non-private requirement to pay. This approach is useful in a retrospective analysis of case studies but not necessarily of use in benchmarking future development, given that infrastructure agreements between developers and approval authorities vary from project to project and according to different policy settings.

Limitations in comparing development costs

The literature sends a clear message that making comparisons between case studies is difficult. In addition to the different assumptions made in calculating infrastructure costs regarding population size, type of infrastructure, upfront vs ongoing costs and time period for assessment (as discussed above), geographical differences between locations and variation in the capacity of adjoining infrastructure systems (especially in infill locations) can have a significant impact on cost.

The key findings of Future Perth inform thinking on the relationship between density and development in outer locations on infrastructure costs and, whilst it provides a range of cost estimates (representing the degrees to which development is contiguous to existing infrastructure based on retrospective studies), it concludes that the overall picture of costs is incomplete and that it is unrealistic to provide a single estimate on how much more expensive development in outer areas can be compared with inner and middle areas due to the many location-specific factors which substantially affect the cost.

Therefore, the distance of the development to the nearest systems can have a significant impact on the cost of service delivery. The other main location-specific factor affecting costs (and the capacity to compare locations) is the infrastructure that is already in place, its catchment and the level of augmentation required. (For instance, Infraplan identifies the need for major arterial roads and connections as being an area specific factor that makes applying benchmarks challenging).

Differences between case studies are not limited to locational factors but can relate to the way that different organisations record infrastructure expenditure.

Numerous papers caution that the theoretical cost ranges presented could be higher or lower in reality and are subject to a thorough assessment on a case by case basis.

Variation in the size of the populations of the development scenarios and real case studies for which infrastructure costs are calculated adds to the difficulty in comparing the costs between the texts. The majority of the infrastructure costs provided in the literature reviewed are provided on a per dwelling basis and some are calculated per 1,000 dwellings.

Many studies scale up to the constant population number they are seeking to compare across different development settings (i.e. cost per 1,000 dwellings) from micro-level case studies that break infrastructure costs down to a per dwelling / per lot figure. This method does not account for infrastructure requirements triggered by various population sizes and initial capital requirements.

Specific population sizes or trigger points for different infrastructure requirements are not quantified in the reviewed literature. Trigger points and thresholds are identified as being a factor which makes comparison between locations difficult by Infraplan (2013) and Kinhill et al (1995) is the only study which breaks down the infrastructure requirements by indicative development size (small, medium and large). The scenario modelling undertaken by Kinhill is based on neighbourhood modules for 5,000 residents because this conforms to school and social infrastructure planning requirements.

Using benchmarks per capita / per dwelling 'benchmarks' based on previous case studies, does not factor location-specific constraints and development settings into the calculation of infrastructure costs. It is not possible to accurately ascertain how much or how little to discount the per capita / per dwelling cost according to the physical geography of the site and the capacity of existing infrastructure. This is particularly problematic with infill, where the surrounding infrastructure is so varied from one place to the next. The costs of servicing infrastructure in greenfield areas are comparatively straightforward to measure.

Broader recognition of costs and benefits

At least five of the studies acknowledge that just looking at the capital costs of infrastructure ignores broader social and environmental costs which can be crucial to judging the merits of different forms of development.

Trubka et al (2009 and 2010) factor inactivity-related health costs and greenhouse gas emissions into their infrastructure costs and consider the implications of a scenario where national emissions reductions targets become mandatory. They also compare the performance of urban and fringe developments using evaluation criteria such as distance to the CBD, transit accessibility and activity intensity (population and jobs per hectare).

Biddle et al (2006) apply a social welfare methodology for calculating social costs and benefits. Biddle et al (2006) argue that the economic, social and environmental benefits of brownfield development far outweigh its higher costs (which generally arise due to the need for decontamination).

The SGS (2012) report argued that triple bottom line benefits of infill were also superior, including improved social interaction and access to existing services, reduced reliance on private transportation and longer term land savings.

In addition to listing the most significant categories of social and environmental cost and benefit not included in their study, Kinhill et al (1995) state that it would be necessary to investigate the perceived personal benefits and costs of the different lifestyles offered by the different environments before any firm conclusion is attached to the infrastructure savings involved.

Several of the papers reviewed take a wider view of the economic costs of development, factoring in land costs and remediation costs. These are integral considerations in deciding where to target development investment (for government and developers alike).

Investigation of development contexts

The literature contained a predominance of comparisons between greenfield and infill development. Infill is often not further defined but in some instances was described as being 'precinct scale' or 'major'.

In most of the literature, the development typology that this paper defines as 'large-scale brownfield' is regarded as infill though it is sometimes distinguished as being of major / precinct scale, as distinct from minor / dispersed / piecemeal. Two of the papers reviewed make specific reference to brownfield in the context of infrastructure costs.

There are significant gaps in the literature in regard to research into infrastructure costs specific to National Employment Clusters and Activity Centres as well as greyfield.

Literature which explores the specific concept of 'greyfield' does not investigate the costs of infrastructure provision. The only text found that studied the costs of servicing greyfield was the article by Kellett and Hamilton (2015). This referred to a case study of "infill (urban renewal)" of previous social housing in outer suburban locations. SGS has inferred that this case study might qualify as 'greyfield', according to Newton's (2013, p. 578) definition.

Dispersed infill is generally recognised as having low infrastructure costs due to the capacity for developers to tap into existing infrastructure networks.

The only literature that addressed infrastructure costs in regional centres was prepared by SGS. This however did not compare regional development settings to urban development settings. Rather, this report looked at variations in settlement type within regional areas.

3.3 Summary of key findings

There appears to be consistent and strong evidence that infrastructure can be provided at comparatively lower costs at infill locations because of the (varying degrees of) spare capacity within existing infrastructure systems. Conversely, infrastructure service provision to the greenfield case studies is more expensive because of the need for new physical 'headworks' and community services.

From the costs that could be compared within the texts (presented in Table 1), infrastructure provision to greenfield lots was found to cost approximately 2-4 times more than infill, depending on the capacity of existing infrastructure to support additional people.

The literature found greenfield development costs to be reasonably consistent between Australian cities but that the cost of infrastructure at infill locations is much more difficult to ascertain due to the varying capacity of the existing systems.

In comparing different greenfield settings, the literature demonstrates a very clear inverse relationship between density and infrastructure costs.

Social infrastructure costs were found to vary less than those associated with other forms of infrastructure – in particular, transport infrastructure. In fact, the degree of variation in district transport infrastructure between case studies was found to be so great that in much of the literature it was excluded from comparative cost analyses.

Kellett and Hamilton (2015) found that the cost factors for their greenfield and urban renewal / greyfield case studies were surprisingly similar. But they acknowledge that local factors impacting on cost needed to be better understood, namely a lack of capacity in some infrastructure or the requirement to upgrade standards of infrastructure in the renewal area. In this particular case study funding for extra school capacity was required.

Few texts compared large scale infill to greenfield, let alone distinguishing brownfield. However, Biddle et al (2006, p. 12), makes the following important observation:

> *"Relatively inexpensive infill development in Sydney has tended to be situated close to existing infrastructure and services, in particular rail infrastructure. Where the relatively expensive infill development has been on brownfield land, such as in a number of harbour side locations, the capital costs are higher due to the need to build new suburban roads and provide utilities. Because these capital items are merely laterals, their costs are lower than the costs that might occur in greenfield locations. However, decontamination costs of infill developments have been cited by a number of reports as being the most significant cost holding back development."*

Evans (2012) also distinguishes brownfield from generalised 'compact' development in comparing cost savings to greenfield developments. Compact development requires less land per capita and fewer roads to connect trip origin and destination points but brownfield development settings offer additional savings due to their pre-existing infrastructure connections. Whilst Evans's point does not acknowledge decontamination costs of brownfield development it emphasises the importance of considering infill opportunities in the context of the existing infrastructure capacity, given that this can vary greatly from location to location.

Evans' observation about land costs and decontamination costs highlights the importance of considering the wider costs and benefits of development in different settings, which includes these broader economic factors as well as considering impacts on peoples' quality of life and the long term sustainability of the environment.

The texts reviewed did not explore comparisons between regional centres and other development settings. SGS' (2013) investigations looked at the financial costs of different types of settlement patterns in rural Victoria. This paper did not produce definitive cost comparisons but identified that "maintenance and operational costs over time vary significantly between [rural] settlement patterns" (p. 34). This report identified that dispersed isolated development (as distinct from regional centre development– which is serviced – a development context that this literature review seeks to compare) tends to be the most expensive to councils, in terms of servicing with community infrastructure and environmental management due to the distance that needs to be covered for council services to be provided. This development context, however, is different to the regional centre development context (which is serviced) that this question seeks to compare. We can infer from this study that a key challenge in providing infrastructure in regional centres is considering maintenance and operational costs of infrastructure.

While the literature reviewed does not directly compare the costs of servicing development in regional centres to other development contexts, we can infer that consolidation of development in regional centres – with spare infrastructure capacity – would deliver cost efficiencies relative to dispersed isolated regional development. These regional scenarios can be compared to the metropolitan development context where shifting growth from greenfield areas of Melbourne to established development settings – with existing transport and services – would reduce infrastructure costs.

4 DESIGN OF FURTHER RESEARCH

4.1 Gap analysis and confirmation of research question

The literature reviewed contains substantial gaps in relation to costing of infrastructure in established NECs, MACs, greyfield, regional centres and less so for brownfield.

The appropriateness of the adopted population size of 25,000 for investigation purposes could not be confirmed through the information distilled from the research reviewed. However, in our view, this remains a reasonable benchmark as this quantum of population is large enough to test most infrastructure thresholds across the various development settings.

Having reviewed the existing literature the research question can be reframed as follows:

What are the urban infrastructure costs involved in accommodating 'modules' of 25,000 people in different development settings in Victoria?

In the following section we set out a research methodology that might best answer this question.

4.2 Issues to be addressed in the research design

Any research method that fully addresses IV's requirements will need to resolve a number of design issues which have become apparent through our review of previous studies. These issues can be grouped into four themes dealing respectively with scoping of relevant infrastructure costs, capacity constraints in infrastructure, life-cycle costing and the benefits of alternative development patterns.

Scoping of infrastructure costs

The different studies reviewed implicitly or explicitly deal with varying ranges of infrastructure assets, making direct comparisons of costs across development settings problematic. Any research commissioned by IV should be very clear about the items of infrastructure which are included and excluded from the analysis. Moreover, it would be important for the costs under different development settings to be itemised so that the role of any particular infrastructure category in determining comparative cost performance can be reliably isolated.

Decisions also need to be made about the nature of the infrastructure items to be factored into the analysis. Most studies reviewed confine themselves to infrastructure services which are anchored by fixed assets. If this is to be the case in any research commissioned by IV, it should be made explicit. Focussing on fixed assets would mean that some services, for example, bus public transport and policing, where recurrent operational expenses are the principal costs faced by funding agencies, may be set aside.

On the face of things, very high order infrastructure assets, such as dams or power stations, would be out of scope in researching comparative costs in different development settings, because such infrastructure items are likely to be required to service a region regardless of how development is distributed within that region. Having said this, moves towards more distributed forms of infrastructure

provision, especially with respect to water cycle management, make this question in research design less relevant.

A preferred scope of infrastructure items for incorporation in a comparative costs study is set out in Table 3.

TABLE 3 RELEVANT INFRASTRUCTURE SCOPE FOR COMPARATIVE COST STUDIES

Typical geographic catchment	Capital (fixed) asset infrastructure
1 Neighbourhood/suburb	Local streets, sewers and drains
1 Neighbourhood/suburb	Local parks
1 Neighbourhood/suburb	Libraries
1 Neighbourhood/suburb	Child care centres
1 Neighbourhood/suburb	Neighbourhood centres
2 Town / muncipality	Collector and sub-arterial roads
2 Town / muncipality	District main sewers and drains
2 Town / muncipality	Pre-schools
2 Town / muncipality	Primary schools
2 Town / muncipality	Secondary schools
2 Town / muncipality	District parks
3 Town / muncipality	Aquatic centres
3 metropolitan / regional	Inter-regional arterials
3 metropolitan / regional	Dams and other high level water harvesting infrastructure
3 metropolitan / regional	Waste water treatment plants - regional
3 metropolitan / regional	Waste water treatment plants - local and sub-regional
3 metropolitan / regional	Inter-regional and inter-urban highways and freeways
3 metropolitan / regional	Tramways
3 metropolitan / regional	Metro rail systems
3 metropolitan / regional	Line haul (commuter) rail
3 metropolitan / regional	Flagship arts and cultural institutions
3 metropolitan / regional	Household waste recyclying centres
3 metropolitan / regional	Industrial waste processing centres
3 metropolitan / regional	Electricity transmission
3 metropolitan / regional	Electricity distribution
3 metropolitan / regional	Hospitals - regional and metropolitan
3 metropolitan / regional	Hospitals - sub-regional
3 metropolitan / regional	Regional stadia
3 metropolitan / regional	Universities
3 metropolitan / regional	Technical and trade training institutions
4 state	Electricity generation
4 state	Airports - regional
4 state	Courts
4 state	Social housing
4 state	Aged care - hostels
4 state	Aged care - nursing homes
5 national	Airports - international

Source: SGS Economics and Planning Pty Ltd

Capacity constraints

We noted from the review that:

- many studies scale up from micro-level case studies without taking into account different constraints and development settings
- measurement of infill infrastructure costs do not always take into account the quality and capacity of the surrounding / existing infrastructure, and, similarly
- thresholds / triggers for major infrastructure provision, for example, public transport set-up costs, may not be properly factored into the analysis.

The question of capacity constraints is possibly the most critical conceptual issue to be dealt with in the research design. In principle, if there were to be *zero* spare capacity in any of the infrastructure assets noted in Table 3, one would expect that the marginal cost of extending infrastructure to support growth would be *lowest* in greenfield areas, simply because infrastructure providers would not need to contend with higher land costs and the complexities of intervening in established urban areas. But, as shown by the literature review, most previous studies point to substantial cost savings in urban infill. This signifies

the overriding influence of leveraged spare capacity in the comparative cost outcomes. The problem is that nature of spare capacity, and the avoidance or otherwise of triggers for capacity enhancement, are generally not well described or accounted for in previous studies.

This suggests to us that any future IV study should factor in an *incremental accounting framework*. Instead of simply comparing the costs of accommodating 25,000 people in different development settings 'en bloc', a step-wise procedure would be applied where the costs of accommodating successive 'tranches' of 5,000 people (or 2,000 dwellings) would be tracked.

This approach would reveal whether and when major capacity constraints are encountered in the build-up of population within the development setting in question.

Life-cycle accounting

The literature review generally counsels that a lifecycle approach to estimating infrastructure costs is preferable to a sole focus on up-front capital costs. This is likely to be particularly relevant in infill and brownfield situations where overall infrastructure capacity may be adequate to accommodate growth but the design and specifications of that infrastructure mean that recurrent costs increase relatively quickly with an increasing use load. For example, heavier use of road pavements designed to outdated standards may accelerate the need for re-sheeting or reconstruction.

Conceptually, accounting for recurrent costs is not difficult, though it would add some computational complexity.

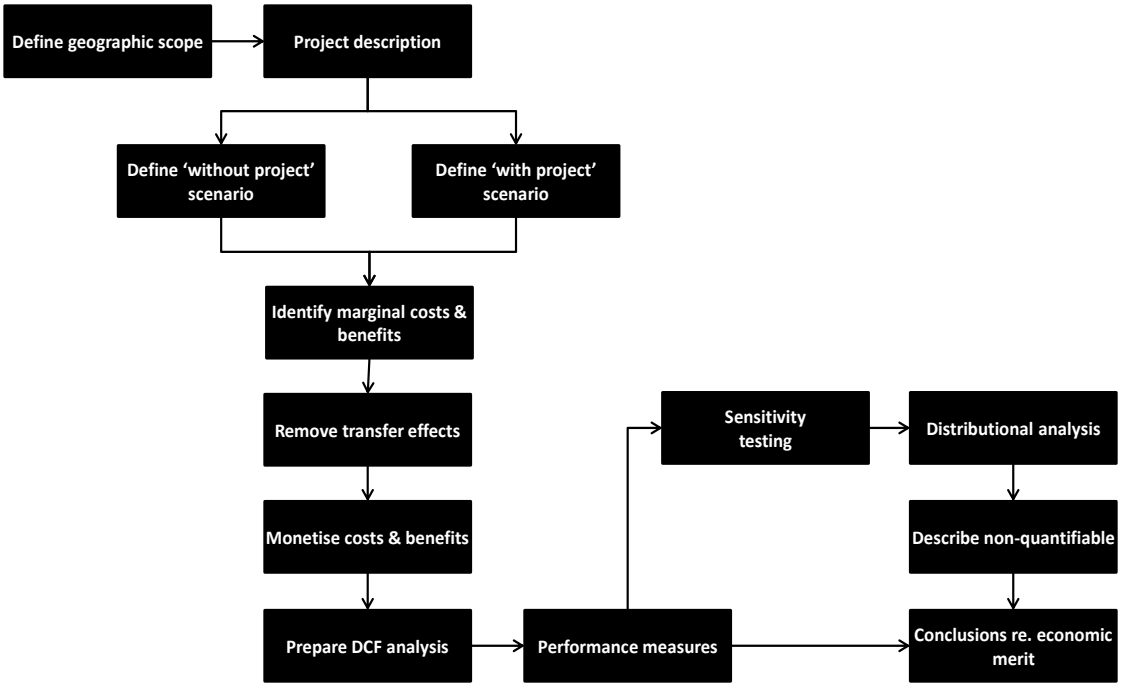
Offsetting benefits

Of the studies reviewed, only the Kinhill et al (1995) research emphasised that comparative infrastructure costs should be kept in due perspective when judging the relative merits of different forms of urban growth. It pointed out that savings in infrastructure costs cannot be regarded as 'efficient' in a welfare sense if they are won at the expense of undue frustration of housing preferences. In other words, households should be allowed to give full expression to their preferences in their housing choices so long as they are properly confronted with all the resource costs involved in meeting these preferences, including externalities. In this situation, households may choose higher infrastructure cost 'solutions' because the associated benefits (in their eyes) outweigh these costs.

Conceivably, higher infrastructure cost patterns of urban development may also be favoured in public policy because there is a net community benefit after accounting for positive externalities. For example, accommodating households in (potentially) more expensive development in, say, NECs may be preferred because of the collateral boost to human capital development.

These considerations imply that any future IV research should take a cost benefit analysis approach to appraising the advantages and disadvantages of different development settings for growth. If such an approach is taken, it should comply with the generally applied methodology for this type of economic analysis, as shown in Figure 2 below.

FIGURE 2 GENERIC COST BENEFIT ANALYSIS METHOD



Source: SGS

4.3 Proposed research method

Overview

This sub-section draws together SGS's recommendations for a preferred research method to answer the adopted question in a way that deals effectively the constraints and shortcomings of previous studies.

The binding logic of the proposed method revolves around the issues of spare infrastructure capacity and density. As we have noted, if there is no spare infrastructure capacity within the array of development settings under consideration, and if their housing densities are of the same order, the marginal cost of accommodating a household within the existing urban footprint should be higher than in a greenfield setting. This is because extension of infrastructure in greenfield areas avoids the additional costs of disruption and adaptation which inevitably arise in an infill or brownfield situation.

The logic continues that if density proves to be the key factor driving infrastructure cost efficiencies, these savings could, presumably, be captured regardless of development setting. Thus, for example, those savings generated in infill areas as a function of higher densities could be replicated in greenfield areas simply by lifting housing densities to commensurate levels.

Accordingly, the proposed method focusses on specific case study districts rather than hypothetical locations. It is only in 'real' case study locations that questions of infrastructure capacity and threshold/triggers for capacity expansion can be rigorously explored.

The proposed method relies on comparing the incremental cost of switching a given quantum of housing from a representative greenfield development area to each one of 5 alternative settings for that growth, being the areas nominated in the research design - large scale brownfield, established National Employment Cluster / established Metropolitan Activity Centre, dispersed infill, greyfield and regional centre.

Mapping infrastructure capacity and selecting case study locations

Given the overriding importance of infrastructure capacity and housing density in determining marginal per household costs of urban growth in different settings, it would be prudent to undertake infrastructure capacity mapping across the metropolitan area and future growth areas in Melbourne and regional centres. This will enable judicious selection of case study locations so that the results are not unduly distorted by unusually high (or low) capacity endowments. Moreover, understanding the geography of spare capacity across the various infrastructure systems will facilitate more reliable extrapolation of case study findings to the broader parts of the State which nominally fit the same 'development setting' category.

For the most part, it can be expected that this mapping analysis will focus on capacity within the hard infrastructure categories, in particular:

- Local streets, sewers and drains
- Local parks
- Collector and sub-arterial roads
- District main sewers and drains
- District parks
- Inter-regional arterials
- Waste water treatment plants - local and sub-regional
- Tramways, and
- Metro rail systems.

Recurrent expenses (e.g. staff) are likely to figure more prominently in the total cost of supplying social infrastructure such as schools and health services. Spare capacity in built assets is therefore less likely to influence the cost of providing social infrastructure in different locations.

Once 'representative' case study locations across the 6 development settings have been selected based on this mapping of spare capacity, the analytical approach would move to an assessment of marginal costs and benefits which we now describe.

Analytical approach in case study locations

This analytical approach is illustrated in Table 4, nominating 'greyfield' as the example development setting.

The greyfield area in question (nominally a suburb or district in Maroondah) will have a trend based trajectory for additional housing development. This will entail a certain amount of infrastructure investment in and of itself. The key question for the research is what ***additional*** cost would attend acceleration of development in the Maroondah district to accommodate a further 10,000 dwellings over a 5 year period (designed to capture infrastructure capacity constraints), translating to an additional 25,000 people versus trend growth.

Costs (and benefits) are measured for each year on year tranche of 2000 additional dwellings. This is intended to reveal whether and when any threshold for infrastructure expansion is encountered to enable ongoing growth at the accelerated rate.

The mock up table also illustrates that the costs incurred in accommodating the additional 10,000 dwellings in Maroondah will be offset by cost savings in providing for the same number of dwellings in the representative greenfield district. This approach allows direct comparison of marginal infrastructure costs (and benefits) between the greyfield development model and greenfield. This method can be further enhanced by providing for different versions of greenfield, that is, urban expansion at different densities.

Completion of such tabulated analyses for each alternative development setting in turn will enable definitive comparison of costs between the case studies in question. Because of the depth of detail and

the modular nature of the comparisons (ie taking annual tranches of growth rather than end-state outcomes), SGS is of the view that the tabulations will also support extraction of general principles and benchmarks governing costs in different development settings.

TABLE 4 INFRASTRUCTURE COSTS AND BENEFITS ANALYSIS – CASE STUDY MOCK UP

Greyfield development setting (Maroondah)	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
	2016	2017	2018	2019	2020	2021
Trend annual increment in housing units (Base Case)		**450**	**500**	**550**	**500**	**500**
Additional housing units with intervention*		2000	2000	2000	2000	2000
Total housing units (Base Case)	**3,000**	**3,450**	**3,950**	**4,500**	**5,000**	**5,500**
Total housing units (Project Case)	**3,000**	**5,450**	**7,950**	**10,500**	**13,000**	**15,500**
Marginal costs Project Case versus Base Case						
Capital cost - Local streets, sewers and drains		$	$	$	$	$
Capital cost - Local parks		$	$	$	$	$
Capital cost - Libraries		$	$	$	$	$
Capital cost - Child care centres		$	$	$	$	$
Capital cost - Neighbourhood centres		$	$	$	$	$
Capital cost - Collector and sub-arterial roads		$	$	$	$	$
Capital cost - District main sewers and drains		$	$	$	$	$
Capital cost - Pre-schools		$	$	$	$	$
Capital cost - Primary schools		$	$	$	$	$
Capital cost - Secondary schools		$	$	$	$	$
Capital cost - District parks		$	$	$	$	$
Capital cost - Aquatic centres		$	$	$	$	$
Capital cost - Inter-regional arterials		$	$	$	$	$
Capital cost - Waste water treatment plants		$	$	$	$	$
Capital cost - Tramways		$	$	$	$	$
Capitalised future maintenance - Local streets, sewers and drains		$	$	$	$	$
Capitalised future maintenance - Local parks		$	$	$	$	$
Capitalised future maintenance - Libraries		$	$	$	$	$
Capitalised future maintenance - Child care centres		$	$	$	$	$
Capitalised future maintenance - Neighbourhood centres		$	$	$	$	$
Capitalised future maintenance - Collector and sub-arterial roads		$	$	$	$	$
Capitalised future maintenance - District main sewers and drains		$	$	$	$	$
Capitalised future maintenance - Pre-schools		$	$	$	$	$
Capitalised future maintenance - Primary schools		$	$	$	$	$
Capitalised future maintenance - Secondary schools		$	$	$	$	$
Capitalised future maintenance - District parks		$	$	$	$	$
Capitalised future maintenance - Aquatic centres		$	$	$	$	$
Capitalised future maintenance - Inter-regional arterials		$	$	$	$	$
Capitalised future maintenance - Waste water treatment plants		$	$	$	$	$
Capitalised future maintenance - Tramways		$	$	$	$	$
Marginal benefits Project Case versus Base Case						
Savings in greenfield capital costs - Local streets, sewers and drains		$	$	$	$	$
Savings in greenfield capital costs - Local parks		$	$	$	$	$
Savings in greenfield capital costs - Libraries		$	$	$	$	$
Savings in greenfield capital costs - Child care centres		$	$	$	$	$
Savings in greenfield capital costs - Neighbourhood centres		$	$	$	$	$
Savings in greenfield capital costs - Collector and sub-arterial roads		$	$	$	$	$
Savings in greenfield capital costs - District main sewers and drains		$	$	$	$	$
Savings in greenfield capital costs - Pre-schools		$	$	$	$	$
Savings in greenfield capital costs - Primary schools		$	$	$	$	$
Savings in greenfield capital costs - Secondary schools		$	$	$	$	$
Savings in greenfield capital costs - District parks		$	$	$	$	$
Savings in greenfield capital costs - Aquatic centres		$	$	$	$	$
Savings in greenfield capital costs - Inter-regional arterials		$	$	$	$	$
Savings in greenfield capital costs - Waste water treatment plants		$	$	$	$	$
Savings in greenfield capital costs - Tramways		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Local streets, sewers and drains		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Local parks		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Libraries		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Child care centres		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Neighbourhood centres		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Collector and sub-arterial roads		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - District main sewers and drains		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Pre-schools		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Primary schools		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Secondary schools		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - District parks		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Aquatic centres		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Inter-regional arterials		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Waste water treatment plants		$	$	$	$	$
Savings in capitalised future maintenance costs in greenfield areas - Tramways		$	$	$	$	$
Reduction in VKT - externalities		$	$	$	$	$
Health cost savings		$	$	$	$	$
Human capital enhancement		$	$	$	$	$

NPV costs versus Base Case per diverted dwelling	$
NPV benefits versus Base Case per diverted dwelling	$
NPV of net benefit versus Base Case per diverted dwelling	$

** diverted from greenfield*

Source: SGS Economics & Planning Pty Ltd

A phased methodology

This research method can be implemented via a three phase approach as follows.

Phase 1 – Establish governance arrangements and development assumptions

Phase 1 would involve agreement on project partners. In order to facilitate the best outcome, which we see as achieving strategic alignment with other key policy documents and buy-in to the directions recommended by IV, we would recommend developing a project steering group that comprises of key personnel from IV, Metropolitan Planning Authority, Department of Environment, Land, Water and Planning and Places Victoria. Including representatives from these State Government departments would also help to ensure that the researchers would have access to information pertinent to modelling costs of infrastructure to government owned sites that may be selected as project cases.

Phase 1 would reconfirm key research parameters as canvassed in this report, including,

- real project cases representative of the following development settings:
  - Project case 1: Large scale brownfield
  - Project case 2: Established national employment cluster / Established activity centre
  - Project case 3: Dispersed infill
  - Project case 4: Greyfield
  - Project case 5: Greenfield
  - Project case 6: Regional Centre
- the types of infrastructure to be costed in the project cases;
- the lifecycle costs to be covered, and
- constant factors (length of time – between 5 and 10 years, size of population to be accommodated – 25,000).

Phase 2 – Detailed infrastructure costs for each project case

Phase 2 would require detailing the independent variables which relate to each development setting. These include:

- types of dwellings
- household size
- rate of development
- density of dwellings
- specific infrastructure costs which would be influenced by the geographical location of the project case.

Phase 2 would also undertake the infrastructure capacity mapping to support selection of appropriate case study locations.

Finally, Phase 2 would see the cost and benefit data gathering proceed in accordance with the format we explained above.

Phase 3 – Cost / benefit comparison to base case

In order to give these costs a practical meaning (enabling the comparison of cost savings and additions) a marginal cost / benefit for each project case would be calculated in Phase 3, also using the method outlined.

As discussed, Phase 3 will compare all settlement scenarios to a 'business as usual' population distribution scenario (or base case). This would utilise the projected additional Victorian population to (say) 2026 and in each instance of comparison, 'divert' 25,000 people out of Greenfield settlement into the different settlement scenarios / project cases.

We further suggest that this study could consider the broader social, environmental and economic costs and benefits of the different development settings and provide an opinion on what the best scenario is for distributing 25,000 people in Victoria.

General discussion about the proposed methodology

The proposed approach is most similar to the methodologies applied by Infraplan (2013) and Kinhill et al (1995). Infraplan (2013) compares a base case scenario with one that has an increased ratio of infill (and therefore an increased average overall population density). Meanwhile, Kinhill et al (1995) estimates costs with variations in settlement pattern (lot size, dwelling type, household size and dwelling density) to accommodate 100,000 people in the Gold Coast corridor.

In order to enhance the practical application of this study to inform strategic infrastructure and land use planning, civil engineers should be engaged to measure the costs of delivering infrastructure to *specific* places which exhibit the development characteristics of the respective project cases.

On the one hand, using examples of real places has the drawback that they are less useful as a generalised costing benchmarks because they are location specific. However, in utilising engineers to undertake the site-specific work, their knowledge of 'rules of thumb' and general infrastructure thresholds, as well as their capacity to identify factors specific to each location (that influence the costs) can be tapped to produce the generalised benchmarks IV may require for its high level strategic investigations.

APPENDIX – LITERATURE REVIEWS

What research is being appraised?	**Infraplan (December 2013) Urban Infill vs Greenfield Development: A review of economic benefits and costs for Adelaide, [Discussion Paper].**		
Which cities does the research examine?	Australia wide with a focus on Adelaide		
What is the purpose of the research	To stimulate discussion through examining the main assumptions that sit behind statements / policies relating to affordability and land supply, infrastructure costs, population growth and the impacts of infill and greenfield development on the building industry and the local economy.		
What methodology is used?	• Review of previous studies • Compares 2 scenarios that redirect 20,000 net dwellings from greenfield to infill locations over the next 30 years: Scenario 1) Assumes a lower dwelling density of 10 dwellings per hectare over a ratio of 80:20 by 2032 Scenario 2) Assumes a higher dwelling density of 15 dwellings per hectare but a lower infill result given that the ratio (70:30) stays constant • 2 approaches used: 1) Current <u>case studies</u> that measure the capital and recurrent costs of physical and social infrastructure relating to development in greenfield locations on the periphery of Adelaide and infill development - Similar housing types are used (apartment development is not included given the complexities of separating out construction costs from overall development costs) 2) <u>Bench marking</u> against other Australian cities (given there is a reasonable consistency in the style of development and infrastructure costs, notwithstanding local difference that add to these costs)		
Key findings, concepts and assumptions	• The benefits, costs and impacts of these two types of development can vary widely depending on where they are applied: city, inner and middle ring metropolitan areas, on the metropolitan periphery, as an extension to townships and peri-urban areas • There is a view that greenfield development comes at a substantially higher infrastructure cost because of the need for new physical 'head works' (i.e. new trunk water and sewer lines and suburban roads, power and communication systems) as well as basic community services (i.e. town centres, health care, schools, public transport, recreation reserves and emergency services). • In contrast, this infrastructure partly/wholly exist within infill locations and may support spare capacity. • Evidence suggests that these infrastructure items can be provided at a comparatively lower infrastructure cost at infill locations because it is more cost effective to augment existing systems, compared to greenfield developments. • Cost assumptions per lot used to compare the costs of 124,000 dwellings over 30 years (discount rate 4%), excludes some recently identified transport projects (given that many of the transport benefits accrue over a wider area). • Study also discusses the social and environmental impacts of these development scenarios • Greenfield development costs are reasonably consistent between locations on the fringe of Adelaide as well as between cities • The cost of infrastructure at infill locations has been far more difficult to ascertain and is presented as a range from $15,000-25,000 (with an average cost of $20,000 per net dwelling • The costs provided by this study could be lower or higher than the ranges presented and subject to a more thorough assessment on a case by cases basis • Defines greenfield development to generally encompass land on the urban periphery (fringe development) or near townships (also referred to as 'broad acre' land development • Defines infill development to be the more intensive use of land for residential development in urban areas • Separates infill into major (more than 10 lots) and minor (created from the demolition and replacement of existing dwelling stock)		
Quantitative infrastructure costs	Development setting	Assumptions	Cost per unit (as presented in the research)
	Greenfield Greenfield – metropolitan periphery		Median of $80,500 per lot $62-89million per 1,000 dwellings

	Greenfield – minor township extension	Some existing capacity & infrastructure assumed	$45,000 per lot
	Greenfield – new broadacre sites		$100,000 per lot (approximately, derived from graph)
	Infill Infill – Major Projects / Townships Re-subdivision		Median of $20,000 net dwelling $25-45million per 1,000 dwellings $15-25million per 1,000 dwellings
Infrastructure thresholds and population trigger points	• Trigger points and thresholds could make a significant difference to the final infrastructure cost outcome i.e. without further expansion to the north of Gawler, small extensions to the metropolitan area such as Playford may not trigger the augmentation of Bolivar (sewerage treatment plant)		
Limitations in comparing development costs	• In practice the level of infrastructure capacity at infill locations varies widely as does the density of development in greenfield locations (creating economies of scale and lowering the infrastructure cost per lot). • Challenge in applying benchmarks is that infrastructure costs are heavily dependent on area-specific factors. I.e. differing road costs based on necessity for major arterial roads and connections • Comparisons are complex and need to be location and development specific, and considerate of infrastructure that is already in place and its catchment		

Source: SGS, 2016

What research is being appraised?	**Kinhill Engineers (April 1995), *Smart planning not sprawl: the costs and benefits of alternative fringe planning*, The Australian Urban and Regional Development Review, Canberra.**
Which cities does the research examine?	• The Coomera greenfield area in the Brisbane-Gold Coast Corridor of SE Queensland
What is the purpose of the research	• To examine the relative costs of supplying urban infrastructure when the urban fringe is developed according to different development patterns. • Commissioned by Australian Urban and Regional Development Review, prepared by Kinhill Engineers, managed by Qld Department of Housing, Local Government and Planning
What methodology is used?	• Review of previous studies • Study constructs a conceptual and operational model that can be expanded to include total development costs and benefits. • Compare costs of supplying residential infrastructure at different densities with different urban forms, with and without structure planning and development sequencing • Sprawl scenario assumes ad hoc sequencing and development forms and 10 dwellings/hectare • Better designed suburban environments assume 15 dwellings/hectare, structure planning and neighbourhood design philosophies i.e. greater connectivity with other residents & improved access to local facilities and services and optimal sequencing (incremental growth at the urban fringe to permit efficient extension or private benefit and social infrastructure) • Like-for-like comparisons based on case studies involving a 100,000 person, 20 year development in the Coomera Brisbane-Gold Coast Corridor of SE Queensland (greenfield) • 8 patterns of development are tested for an eventual population of 100,000 people with the following variations: • 10, 15 and 20 dwellings per hectare • 3 forms: conventional, inter-connective and PTSD (public transport sensitive development) • 3 options: market sensitive, sequencing on 2 development fronts, physical infrastructure determined sequencing and random sequencing

<table>
<tr><td>Key findings, concepts and assumptions</td><td colspan="3">A better designed suburban environment would deliver 6% saving in the [1995] cost of infrastructure compared to a ‘sprawl’ scenario
Overall comparison of urban infrastructure costs, based on preferential sequencing, confirms that conventional development at 10 dwellings per hectare is significantly more expensive than at higher densities (i.e. more than 3% more expensive than development at 15 dwellings per hectare, based on inter-connective design principles)
The least costly form of development is conventional development at 15 dwellings per hectare
This study shows infrastructure costs are likely to be inversely related to density and that these cost savings would be made in the private benefit / user pays component of infrastructure
Social infrastructure costs are largely invariant with density, within the environments examined in this study
Cost of infrastructure is sensitive to geographical sequencing of development and rate of development
It would be necessary to investigate the perceived personal benefits and costs of the different lifestyles offered by the different environments before any firm conclusion is attached to the infrastructure savings involved
The wider costs and benefits of alternative growth scenarios need exploring from the point of view of both households and of the environment (report lists the most significant categories of cost and benefit not included in the present study)
Cost data (obtained via review of previous studies, published annual reports, communication with Councils and other public agencies and other documents from public authorities) showed a significant range of variation in the capital and recurrent cost of social infrastructure services
Report provides detailed capital costs of social and physical infrastructure for each scenario
Report provides detailed design assumptions re housing mix, lot size and density
Assumptions of the scenarios tested:
- a constant total population and a constant population profile
- a timeframe of 20 years
- all infrastructure costs, both capital (including land) and recurrent have been estimated
- costs include social and community infrastructure, physical infrastructure and public transport facilities (assumes improvement to rail stations, town centre bus interchange in all scenarios but light rail only included in the PTSD scenario)
- rate of discount 6%</td></tr>
<tr><td rowspan="4">Quantitative infrastructure costs</td><td>Development setting</td><td>Assumptions</td><td>Cost per unit (as presented in the research)</td></tr>
<tr><td>For each of the 12 scenarios</td><td></td><td>Total discounted infrastructure cost</td></tr>
<tr><td>e.g. least expensive infrastructure cost

conventional form, preferred sequence, 15 dwellings/ha</td><td></td><td>$1,572 million for 100,000 people</td></tr>
<tr><td>e.g. most expensive infrastructure cost

inter-connective form, no development sequence, 15 dwellings/ha</td><td></td><td>$1,655 million for 100,000 people</td></tr>
<tr><td>Infrastructure thresholds and population trigger points</td><td colspan="3">The underlying urban design for each of the scenarios tested has been developed on a modular basis, with a basic neighbourhood module for 5,000 residents adopted for the study (which conformed to the requirement for school and social infrastructure planning.
Incremental categories of infrastructure listed</td></tr>
</table>

Source: SGS, 2016

What research is being appraised?	**Trubka, R., Newman, P., & Bilsborough, D. (2009) *Assessing the Costs of Alternative Development Paths in Australian Cities*, Curtin University Sustainability Policy Institute Fremantle, Parsons Brinckerhoff Australia/Curtin University.**
Which cities does the research examine?	Australia-wide
What is the purpose of the research	"The purpose of this research is to develop a tool to assess the economic costs in urban development decisions in Australia by comparing inner-city redevelopment and conventional fringe development. The associated costs taken into consideration for the assessment include infrastructure provision, transportation costs, greenhouse gas emissions, and inactivity-related health costs and are estimated for a development of 1,000 dwellings. The proposed approach can be used to assess these costs in any development or in any infrastructure decision that would lead to different development patterns." Page 2
What methodology is used?	• Costs of infrastructure provision were mostly replication of that found in 'Future Perth,' a study that was commissioned by the Western Australian Planning Commission and that has been used extensively as a basis for methodologies since. • To inform this report they reviewed 22 studies on infrastructure costs associated with inner, middle, and outer city developments from the United States, Canada, and Australia. • For the purpose of this report, the consumer price index and labour price index were consulted to inflate the 1999 prices contained within Future Perth to 2007 Prices. The resulting cost of upfront infrastructure provision for an inner city and fringe development in 2007 prices were $50.5 million and $136.0 million respectively. • Another study used that is also widely relied upon is the transport study by Newman and Kenworthy (1992) that reports on annual costs associated with private vehicle depreciation and operating costs, annual road infrastructure costs, transit costs, time costs, and externalities. These costs were adjusted 2007 prices and then capitalized over a 50-year period (p. 2) • The annual costs of transportation an inner city development was $256.8M and fringe development was $507.1M (p. 2) • For the purpose of calculating the economic impact of greenhouse gas production as a function of urban form, deciding upon a cost for emissions production is fairly subjective due to a lack of commitment to carbon pricing. The greenhouse gas emissions cost were predicted with 73.4% of the variance explained by using the following equation: y = (365 days/yr)(Price/kg CO2-e)(# of Dwellings)(Ppl/Dwelling)(.073x - .25z + 4.35) = (365)(0.170)(1000)(2.5)(.073x - .25z + 4.35) = 155,125(.073x - .25z + 4.35) where y = annual cost, x = distance to CBD, and z = transit accessibility (pp. 12 – 16) • The embodied costs of urban redevelopment and fringe development are broken down into the categories of infrastructure provision, transportation costs, greenhouse gas emissions and health costs • In terms of health-related costs, a capitalisation period of 50 years was chosen under the **assumption** that 50 of a residential development is considered a reasonable average life expectancy (p. 18)
Key findings, concepts and assumptions	• There are large cost savings associated with urban redevelopment • This is especially pertinent to infrastructure and transportation • While still performing better for infill rather than greenfield, GHG emissions and health make up a lesser portions of total costs • If national emissions reductions targets become mandatory, the GHG portion of the costs increases significantly as infill would save 4,400 tonne of GHG per year per every 1,000 dwellings • Also, in regards to health and wellbeing, infill encourages active transport modeshare, and Australia is now one of the most obese populations in the world Active forms of travel that are only realisable if areas are provided with high levels of amenity, servicing and of transit access; the savings over 50 years of an urban lifetime are $19.32 million and $4.23 million for 1000 dwellings, However, "if these more walkable, low emission developments are pursued then the savings in transport and infrastructure for 1000 dwellings are in the order of $86 million up-front for infrastructure and $250 million for annualized transportation costs over 50 years." (pg 2)
Comments	**It is argued that this study can be replicated as it is a simple model** that can be used to "predict urban development costs associated with any proposed development in Australian cities or with the associated urban development from any major infrastructure decisions." (p. 1)

Infrastructure performance?

Page 3

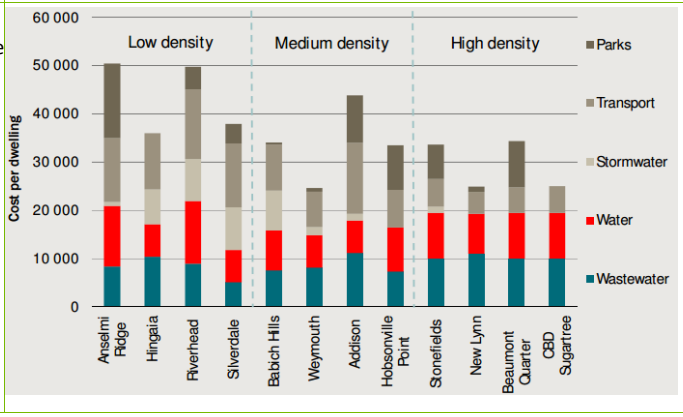
	Urban redevelopments	Fringe developments
Daily per capita GHG emissions (kg CO2-e)	0–4	8–10 and up
Distance to CBD (Km)	<10	>40
Activity Intensity (pop. + jobs per ha)	>35	<20
Transit Accessibility (% with >15min service)	>80%	<20%

Infrastructure cost?

Page 5

Infrastructure Item	Inner	Outer
Roads	$5,086,562	$30,378,881
Water and Sewerage	$14,747,616	$22,377,459
Telecommunications	$2,576,106	$3,711,851
Electricity	$4,082,117	$9,696,505
Gas	$0	$3,690,843
Fire and Ambulance	$0	$302,509
Police	$0	$388,416
Municipal Services	Not Reported	Not Reported
Education	$3,895,458	$33,147,274
Health	$20,114,867	$32,347,327
Total	$50,502,726	$136,041,065

Source: http://www.reconnectingamerica.org/assets/Uploads/pb_cusp_urban_v_fringe_research.pdf

What research is being appraised?	**Centre for International Economics (2015) Cost of Residential Servicing, the Centre for International Economics, Prepared for Auckland Council.**
Which cities does the research examine?	Auckland (New Zealand)
What is the purpose of the research	• This study, undertaken by the CIE and ARUP, builds evidence to inform the Council's future land use planning decisions. • Will be used to benchmark costs for future developments • Will allow for asset management planning and, • Will create a better understanding of appropriate charges to users/developers
What methodology is used? pp. 40-50	• A case study approach using actual costs and estimates of costs based on projects across Auckland to allow a direct comparison between developments characterised as low, medium and high densities. • The following were investigated; - water, wastewater and stormwater services - transport infrastructure - community services and parklands.
Key findings **Page 9**	• Infrastructure service provision to the greenfield case studies was more expensive than for infill developments. • However, there due to the considerable variation in costs between case studies of similar location and density, generalised estimations are difficult and as such, each specific proposal should be analysed in detail to order understand any site-specific characteristics • Replacing and upgrading the established networks (eg- wastewater services to meet greater demand) have added substantially to the costs new development infrastructure • Once in place, the costs of any further developments in the area are expected to be very small, and therefore initial decisions should not be made on the basis of high upfront capital costs
Quantitative infrastructure costs: **Page 7**	
No dwelling/population number was listed as a trigger	
Challenges, limitation and assumptions (p. 10)	**Challenges** arose due to the fact that, prior to the amalgamation of Auckland Council, local infrastructure provision and operation was provided by the former territorial authorities and their financing and recording varied considerably between organisations; - detailed expenditure breakdowns for assets were not always available so there was a lack of uniformity - as such, the lack of historical data is likely to underestimate the true cost of servicing developments This led to **Limitations with the** case study approach as some estimates on operating costs for specific assets were unavailable where private providers may elect for a trade-off between capital expenditure and operating expenditure costs over the life of an asset. As a result **Assumptions** were required to overcome these limitations, meaning relative cost estimates of servicing the different case study developments are indicative only and the costs per dwelling is not a precise estimate

What research is being appraised?	**Property Council of Australia et al (June 2016) Design Perth: a joint vision for a connected, liveable and sustainable Perth, Australia.**
Which cities does the research examine?	Perth
What is the purpose of the research	The study summarises key challenges of Perth's urban development and growth pattern, including demographic changes, environmental limits, economic productivity, urban form, and climate change. Chapter 8 specifically addresses understanding the benefits of infill and urban regeneration.
What methodology is used?	The cost estimates for 2007 used by Trubka, Newman and Bilsborough were adapted for this study, though prices were adjusted to 2015 values. Focus is solely gov. infrastructure costs, no account of private developer contributions were included. All costs are per lot, and unless otherwise stated, per year costs. It is acknowledged that additional costs would also exist in as we as what is tabled within the report. (pp. 50-51)
Key findings, concepts and assumptions	Findings • Potential gov. saving of $23 billion to 2050 in infrastructure costs by increasing infill target from 47% to 60% (pp. 52-53) • Costs three times greater for greenfields than infill to provide main roads, headworks, sewerage, communications, education and health services (p. 51) • This is equal to up to $94,561 more per lot in greenfield developments than infill. • This is equivalent to a substantial subsidy provided by government that could be better spent with emphasis on infill instead of greenfield • Additional private transport cost impact of $6,600 per lot per year in greenfield V infill on average over 50 years, + $1400 per lot per year of economic costs to environment, health and productivity. Concepts – Three models/scenarios (pp.9/52); • Dispersed City; (business as usual scenario) lowest density option which has 30% infill of the required net new 800,000 dwellings being delivered • Connected City; (the WAPC's preferred future growth option) 47% of the additional dwellings being delivered through infill. Originally developed in the Commission's Directions 2031 report. • Contained City – (used as a comparator for price modelling) 100% of additional dwellings infill

Government upfront infrastructure costs: (p. 50)

Infrastructure Type	INFILL per lot	GREENFIELD per lot	COMPARISON per lot
Roads	$5,623	$33,583	$27,960
Water and Sewerage	$16,303	$24,738	$8,435
Telecommunications	$2,847	$4,103	$1,256
Electricity	$4,512	$10,719	$6,207
Gas	$0	$4,080	$4,080
Fire and Ambulance	$0	$334	$334
Police	$0	$429	$429
Education	$4,306	$36,644	$32,338
Health (Hospitals, etc)	$22,237	$35,759	$13,522
TOTAL COST PER LOT	$55,828	$150,389	$94,561

Does the research discuss thresholds / population size trigger points and the specific infrastructure required?	Most figures are calculations per lot, where this is not the case, eg "This translates to a saving of up to $94.5 million for every 1000 lots developed in infill sites," this figure is a multiple of the per lot saving (as seen in infrastructure costs above). No trigger points are addressed
General statements re limitations in comparing development costs:	It appears to recycle the quant data from Roman Trubka, Peter Newman, and Darren Bilsborough which is used in the 2001 'Future Perth: Costs of Urban Form Working Paper No.2,' and is itself an incarnation of data from previous decades. This keystone data seems to be used/adapted by most reports across the board

<table>
<tr><td>What research is being appraised?</td><td colspan="3">Trubka, R., Newman, P. & Bilsborough, D. (2010) The Cost of Urban Sprawl – Infrastructure and Transportation, Environment Design Guide.</td></tr>
<tr><td>Which cities does the research examine?</td><td colspan="3">Australia-wide, with focus on Melbourne (although using West Australian data [see methodology])</td></tr>
<tr><td>What is the purpose of the research</td><td colspan="3">An assessment of the comparative costs of urban redevelopment with the costs of greenfield development. Shows that substantial costs could be saved from infill V. greenfield development</td></tr>
<tr><td>What methodology is used? (p. 2)</td><td colspan="3">Relies on quantitative data generated most recently from Environmental Resources Management (ERM), 2001, Future Perth: Costs of Urban Form Working Paper No. 2, (unpublished), report prepared for the Western Australian Planning Commission by ERM Australia Pty. Ltd., Perth.

However, the ‘Future Perth’ report drew on studies that ranged between the years of 1972 to 2000 but adjusted the reported costs to 1999 prices while this study takes account of 2002 prices of materials and labour in construction having increased further than consumer price index and labour price indices as a result of the mining boom on the labour market. As a result infrastructure costs were inflated according the Australian Bureau of Statistics’ reported price indices for the years 1999 to 2007

This data was first found by the researcher here: Newman, P, et al., 1992, 'An Economic Impact Statement Comparing Fringe and Inner Developments, in Housing, Transport and Urban Form', The National Housing Strategy, Australian Government, Canberra</td></tr>
<tr><td>Key findings

(p. 5)</td><td colspan="3">• Australian urban development has been car-dependant for the past 50 years, resulting in sprawl
• This is very costly; every new block on the urban fringe cost around $85,000 compared to redevelopment – equivalent to an infrastructure subsidy from various levels of government
• State Treasury officials are unaware of the extent of this ‘subsidy,’ and greenfield infrastructure is automatic response currently taken
• This could be because inner urban redevelopment projects often need upfront costs and are seen as a burden
• Once established, both urban typologies have ongoing costs, though the most significant of these are associated with transport:- the cost of private and public transport operations for greenfield is around $18,000 per household per year more than that for urban redevelopment.
• Over a 50-year period this adds up to an additional cost of $251 million for 1000 dwellings, or $251,000 per household.</td></tr>
<tr><td rowspan="15">Transportation Costs for 1000 Inner-City and Fringe Dwellings Prices shown are calculated for 2007. (p. 4)</td><td>Cost For 1000 Dwellings</td><td>Inner-City Development</td><td>Fringe Development</td></tr>
<tr><td>Capital cost of car ownership</td><td>$2,990,802</td><td>$8,628,654</td></tr>
<tr><td>Fuel costs</td><td>$1,203,925</td><td>$3,255,349</td></tr>
<tr><td>Other operating car costs</td><td>$1,476,392</td><td>$4,259,675</td></tr>
<tr><td>Time costs (total)</td><td>$6,158,348</td><td>$8,210,448</td></tr>
<tr><td>Private transport</td><td>$3,116,810</td><td>$8,210,448</td></tr>
<tr><td>Public transport</td><td>$3,041,538</td><td>$0</td></tr>
<tr><td>Walking and cycling</td><td>$0</td><td>$0</td></tr>
<tr><td>Road costs</td><td>$1,216,597</td><td>$3,508,806</td></tr>
<tr><td>Parking costs</td><td>$2,184,489</td><td>$7,709,869</td></tr>
<tr><td>Externalities (total)</td><td>$243,731</td><td>$703,250</td></tr>
<tr><td>Fatalities</td><td>$73,368</td><td>$211,693</td></tr>
<tr><td>Injuries</td><td>$23,627</td><td>$68,172</td></tr>
<tr><td>Property damage</td><td>$38,549</td><td>$111,228</td></tr>
<tr><td>Air pollution</td><td>$90,777</td><td>$261,925</td></tr>
<tr><td>Noise pollution</td><td>$17,409</td><td>$50,232</td></tr>
<tr><td>Transit costs(capital, and operating</td><td>$3,136,540</td><td>$470,481</td></tr>
<tr><td colspan="3">Public transport travel time costs are not allotted a value for fringe developments because like in the outermost suburbs of Sydney and Melbourne, the level of public transport service is low to non-existent. Travel time costs are not allotted to walking and cycling because the act may also be discretionary, or done for enjoyment, and little empirical evidence exists to quantify the disutility of active commuting modes.</td></tr>
<tr><td rowspan="5">15-Year Present Value.

(p. 5)</td><td>Item with discount rate (7%)</td><td>Inner</td><td>Fringe</td></tr>
<tr><td>Transport</td><td>$136,309,097</td><td>$226,100,382</td></tr>
<tr><td>Roads and Parking</td><td>$30,976,806</td><td>$102,178,732</td></tr>
<tr><td>Externalities</td><td>$2,219,884</td><td>$6,504,143</td></tr>
<tr><td>Total</td><td>$169,505,787</td><td>$334,783,257</td></tr>
</table>

What research is being appraised?	**Newton, P. & Glackin, S. (2014) *Understanding Infill: Towards New Policy and Practice for Urban Regeneration in the Established Suburbs of Australia's Cities*, Urban Policy and Research, 32:2, 121-143.**
City examined?	Melbourne
What is the purpose of the research?	This document examines current infill development pattern in Melbourne. It investigates both brownfields and greyfields to better understand if urban regeneration is to figure significantly in delivering more liveable and sustainable cities. To describe the background of the negative externalities associated with sprawl and challenges and opportunities for redeveloping the middle ring suburbs in Melbourne and other Australian cities. To establish the economic and sustainability case for compact city strategies of redirecting more population and residential investment towards the established middle suburbs. Infrastructure costs are one element of this.
What methodology is used?	Lifts calculation entirely from R. Trubka, P. Newman, and D. Bilsborough, Assessing the Costs of Alternative Development Paths in Australian Cities. Perth: Curtin University Sustainability Policy Institute, 2008
Key findings, concepts and assumptions	While greyfield environments comprise over half of a city's geography they are not focussed on as potential housing supply areas by government urban policy or strategy apart from the general reference to an infill target. (p. 140) Green urbanism (sustainable medium density infill) is proposed in grey and brownfield area where they are not performing well.
Comments	This document does not investigate infrastructure costs
Infrastructure Charges as a	N/A

What research is being appraised?	**Newton, P.W., Newman, P., Glackin, S., Stephen & Trubka, R. (2012) *Greening the Greyfields: Unlocking the Redevelopment Potential of the Middle Suburbs in Australian Cities*, World Academy of Science, Engineering and Technology: Proceedings of the 33rd International Conference on Urban Planning and Regional Development (ICUPRD 2012), Venice, Italy, Vol. 71 (2012), pp. 658-677.**
Cities examined?	Australia-wide but Melbourne focused
What is the purpose of the research?	To describe the background of the negative externalities associated with sprawl and challenges and opportunities for redeveloping the middle ring suburbs in Melbourne and other Australian cities. To establish the economic and sustainability case for compact city strategies of redirecting more population and residential investment towards the established middle suburbs. Infrastructure costs are one element of this.
What methodology is used?	Lifts calculation entirely from R. Trubka, P. Newman, and D. Bilsborough, Assessing the Costs of Alternative Development Paths in Australian Cities. Perth: Curtin University Sustainability Policy Institute, 2008
Key findings, concepts and assumptions	• There is a culture of low density greenfield development in Melbourne, originally following the train lines then post-1950s far more laisse-faire approach of automobile reliant transport. • These finds are all based on development types and there are no new findings in relation to infrastructure costs. • Of potential interest is the level of public transport access findings found in the table below
Comments	In regards to infrastructure this document relies solely on data generated from other reports
Infrastructure Charges as a	As stated above, the Trubka et al (2008) study calculates that each new greenfield fringe block incurs an extra $85,000 in infrastructure costs compared to urban redevelopment, and $250,000 extra in transport costs over 50 years

	Metro Melbourne	Brownfield		Greyfield		Total infill	
Public Transport Access Level	Total residential properties	Net increase	Net increase as % of total dwellings in PTAL zone	Net increase	Net increase as % of total dwellings in PTAL zone	Net increase	Net increase as % of total infill
High (7-10)	219,613	16,040	7.3%	4,939	2.2%	20,979	32.8%
Medium (3-6)	573,340	8,410	1.5%	14,199	2.5%	22,609	35.4%
Low (0-2)	778,903	5,240	0.7%	15,057	1.9%	20,297	31.8%
Total	1,571,856	29,690	1.9%	34,195	2.2%	63,885	100.0%

What research is being appraised?	**City of Sydney (2006) *Green Square Town Centre - Infrastructure Strategy*.**	
Cities examined?	Sydney, Activity Centre	
What is the purpose of the research?	• To calculate the costs of infrastructure provision and divide a portion of this by percentage calculated for developers by correlating costs to equivalent floorspace of sites. • The report is assessing the different demands of a new town centre development. They are the following; road network, open spaces, and service infrastructure including sewerage, stormwater, water supply and electricity	
What methodology is used? **pp. 17 - 21**	Method of calculation of construction costs were done in accordance with usual project delivery, which are; • Costs associated with the design, approval/tender processes, legal/financial advice relating to the realisation of the infrastructure, project management costs/ insurance costs, remediation costs (including the costs of geotechnical investigation, development of remediation action plans, any EPA approvals and licences, and site auditors), costs associated with subdivision to create public land or rights of public access (including surveyors' costs, registration fees, and legal costs), costs associated with and resulting from the "forward funding" of works and alsof costs associated with latent contingencies. (p. 17) Payment Method advocated would be to measure the contribution on a site by site basis for the infrastructure based on the following; • Floorspace by site which was considered an appropriate measure of intensity of usage and therefore correlated to an equivalent (percentage) contribution to infrastructure. • A figure for commercial, retail and residential contributions is calculated per square metre using a 'Development Rights Model.' This is seen as transparent, easily calculable, providing financial certainty to both the Council and to landowners. • Late participants who benefit from newly built infrastructure carry the adjustment to the cost of the acquisition of the Development Rights	
Key findings, concepts and assumptions	Having identified the total anticipated cost of the essential infrastructure, and that there is a shortfall in the funding sources the key concept is that this gap can be appropriately met with the model of developer floorspace percentage used to calculate infrastructure charges	
	COST OF INFRASTRUCTURE (AT 2005 $)	
Infrastructure cost?	**Subdivision works:**	**$000**
	Water Feature	7,900
	Public Plaza	19,100
	Merton Street Park	200
	Bouevarde Park and Heritage Park	1,600
	Internal roads (including through site links on sites 14 and 15)	4,600
	Internal pavements	1,800
	External roads and pavements	3,100
	Site works to attain RL levels	900
	Cross site box culvert	2,600
	Remediation – extra over	2,900
	Design and DA and CC fees	4,000
	Construction contingency	2,600
	Public services	5,000
	Temporary services and capital works	-
	Other Costs:	
	Upstream stormwater management	2,000
	Remediation contingency	10,000
	Professional costs	3,500
	Cost recovery	3,000
	Management costs	6,600
	Project contingency	4,600
	Cost of capital	17,200
	TOTAL	**103,214**
Optional reviewer comments	This evaluation is probably more detailed and specific than other infrastructure costings, due to the purpose, which was to calculate any shortfall in funding and establish a way for the developers to meet this.	

What research is being appraised?	**Biddle, T. et al (2006), *The Costs of Infill versus Greenfield Development – A Review of Recent Literature*, Institute of Transport & Logistics Studies, The University of Sydney, NSW, Australia**	
Which cities does the research examine?	Sydney, with other examples from around Australia and the world.	
What is the purpose of the research?	This paper reviews and summarises selected literature that is applicable to, but not necessarily restricted to, the Sydney growth scenario. The component issues researched are as follows: • The capital costs of greenfield development and related infrastructure; • The capital costs of infill redevelopment; • The development of a good model for this comparison; and • The social costs and implications of either course of development.	
What methodology is used?	Literature review	
Key findings	• The evidence reviewed points to a conclusion that "the costs of infill are less than the cost of greenfield development in terms of infrastructure costs and externalities such as air pollution and water supply, and the rehabilitation of contaminated industrial sites." (Biddle, et al. 2006, p13) • While costing the land development portion of brownfields versus greenfields, a study by Regional Analytics (2002) (in Canada) established that brownfield development was of greater cost (than greenfields), but that the economic, social, and environmental benefits of brownfield development far outweighed the cost difference. These benefits included a reduction in urban sprawl and associated cost, such as traffic congestion and pollution (Biddle, et al. 2006, p11). The Regional Analytics paper concluded that for every CAN$1 spent on brownfield redevelopment, between CAN$3.50 and CAN$3.80 additional output would be generated by the Canadian economy. • Social welfare economic cost and benefit analysis of development can include: – Economic infrastructure, including water, sewerage, power and communications – Social infrastructure, such as education, recreation, health and welfare – Developers' net benefit (producer surplus) – Transport costs and benefits, both public and private – Amenity/congestion effects – Environmental effects, including CO2 emissions, and pollution from wastewater run-off – Congestion and the economic value lost – Mental health costs, related in some cases to inner city living and also to outer areas that are lacking in social services and amenities – Health costs from polluted air in inner city locations – The benefit (cost) of (not) rehabilitating contaminated and abandoned potential infill locations.	
Which development settings does the research explore and how does it define them?	**Development setting:**	**Definition:**
	Large scale brownfield	• According to the US Environmental Protection Agency (1997), a brownfield is "an abandoned, idled, or underused industrial or commercial facility where expansion or redevelopment is complicated by real or perceived environmental contamination." (Biddle, et al. 2006, p2) • The definition adopted by the National Round Table on the Environment and the Economy is as follows: "brownfields are abandoned, vacant, derelict or under-utilised commercial and industrial properties where past actions have resulted in actual or perceived contamination; brownfields differ from other contaminated sites in that they hold active potential for redevelopment" (NRTEE, 2003). (Biddle, et al. 2006, p2)
	Infill	• Infill can also be referred to as 'urban consolidation', 'medium density housing', 'redevelopment' or 'high rise development'. Infill has been defined as a more intensive use of land for residential development in urban areas. Such development can be in the form of medium to high density residential flats, town houses (row housing) and villa units. Urban consolidation is generally deemed to refer to redevelopment of existing urban areas and infill development of vacant or under-utilised urban areas (TM & AE, 1991, p.5). (Biddle, et al. 2006, p2) • There are possibilities that "infill development can be provided at comparatively little infrastructure expense in infill areas, compared to greenfield developments, although infill areas are at times subject to decontamination and landscaping costs. • Additionally, because the infrastructure and community support systems are already in place, they are quite frequently the reason for infill development to occur, for example development in suburbs such as Hurstville, Chatswood and Bondi, which are located close to Sydney's public transport hubs, shopping centres and main roads. (Biddle, et al. 2006, p5)
	Greyfield	• The term "greyfield" was recently defined in a study by PricewaterhouseCoopers and the Congress for the New Urbanism as "old,

		obsolete, and unprofitable retail and commercial sites" (PricewaterhouseCoopers, 2001). Clearly, one major difference between a greyfield and a brownfield is the lack of perceived contamination of the site (Biddle, et al. 2006, p2).	
	Greenfield	• Greenfield is also described as "suburbanisation", "urban growth" or "suburban fringe development". • Biddle et al. found that a universal definition of "greenfield" was difficult to find in the literature. This was probably due to simplistic associations with the terms "green" and "field", which signify farmland and/or forests. • Biddle et al. articulate that the majority of articles define "greenfield" as, for example, "unused land parcels or farmlands outside urban borders" (Amekudzi et al., 2003, p.28). De Sousa (2000) defines greenfield more specifically as "a clean agricultural or open land site located in the periphery" (De Sousa 2000, p.833). The definition of 'greenfield' thus appears to encompass wildlife habitats and productive farmland on the urban periphery. (Biddle, et al. 2006, p3) • "Greenfield development requires substantial infrastructure costs for local councils to build suburban roads; government owned utility authorities to lay water and sewer lines, power supply and telephone cables; and government to provide basic community services such as town centres, schools, emergency services, police, public transport and efficient road systems. • By contrast, these services and infrastructure generally already exist and may have spare capacity in infill areas." (Biddle, et al. 2006, p5)	
	Sprawl	• The concept of sprawl has been difficult to define empirically argues Biddle et al. However can be described as "low-density, leapfrog development that is characterized by unlimited outward extension. In other words, sprawl is significant residential or non-residential development in a relatively pristine setting. • In nearly every instance, this development is low density, it has leapt over other development to become established in an outlying area, and its very location indicates that it is unbounded." (Burchell et al., 2002, p.3).	
What assumptions does the research make about the following terms across the different development settings	Costs	The cost comparisons include: • essential infrastructure such as roads, transport, water and sewerage; • other infrastructure such as new schools versus under-utilised schools; • community services, such as police and health; • public transport; and • social costs such as comparisons of environmental conditions and air quality. (Biddle, et al. 2006, p1)	
Quantitative infrastructure costs: From: Study by Travers Morgan and Applied Economics (1991)	**Development setting:**	**Assumptions specific to the development setting**	**Cost per unit (as the research presents):**
	Greenfield	Costs include physical and social infrastructure, including 'piped' services such as water, sewerage, drainage, gas, electricity, and telephone; suburban roads and a share of the arterial roads; and health, education, and community service costs.	$20,000 to $60,000 per greenfield block (1991$)
From: Stud by De Sousa (2002)	Brownfield vs Greenfield	In terms of travel related costs including external costs The significant net benefits of residential brownfield development to the citizens of Toronto were deemed to be related to the avoidance of high transport costs, but came with externality costs from living with higher levels of air pollution. (Biddle, et al. 2006, p10)	A benefit of CAN$74,124 per hectare when developing brownfield land over greenfield land for residential use.
	Travers Morgan and Applied Economics (1991) undertook a housing costs study which included developing a **social welfare** methodology for calculating social costs and benefits which Biddle et al. reviewed. The results are below.		

FIGURE 3 NET SOCIAL BENEFIT ($M) FROM URBAN STRATEGIES IN SYDNEY, MELBOURNE, AND ADELAIDE (1991$)

Scenario	Sydney	Melbourne	Adelaide
	Urban Consolidation Middle Ring Suburbs		
	Hornsby, Parramatta and Ryde LGAs	Brunswick, Melbourne, Northcote and Preston LGAs	Enfield, Port Adelaide and Woodville LGAs
Dispersed fringe (8 dwellings/ha)	-26.88	-240.61	47.5
Concentrated fringe (10 dwellings/ha)	-40.6	-197.76	59.36
A ⅔ dispersed fringe @ 8 dwellings per hectare and ⅓ infill @ four units per existing block.	126.73	-61.16	46.44
Dispersed fringe @8 dwellings per hectare plus an additional population equal to ⅓ infill @ four units per existing block.	143.72	-133.61	62.2

- The results given were principally determined by the underlying house prices in each of the cities.
  - In Sydney, housing costs on the fringe were close in cash terms to the 'resource cost' of providing the housing and the entire associated infrastructure. There were, however, holding costs of developing the infrastructure, especially roads, water, sewerage, and stormwater, in advance.
  - In Melbourne, the dwelling price was well short of the resource cost.
  - In Adelaide, a consumer surplus may arise from fringe development because consumers are willing to pay more for such dwellings than the full resource cost. This is a result of medium density housing being considered less desirable and infrastructure and land prices being much lower on the fringes of Adelaide. (Biddle, et al. 2006, p7)

- "The housing costs study report concluded that areas with excess infrastructure capacity should be identified, that developers should not pay the capital contributions for the use of this infrastructure, and that there be greater scrutiny of fringe development and full charging of costs, including all infrastructure costs, to the developer or purchaser." (Biddle, et al. 2006, p7)
- Biddle, et al. also calculated indicative cost saving for Sydney if development was controlled (infill) as opposed to allowed to sprawl (greenfield) using date found in their literature review. See below:

FIGURE 4 SAVINGS ACHIEVABLE THROUGH CONTROLLED GROWTH IN SYDNEY REGION FOR A POPULATION INCREASE OF 2,000,000 BETWEEN THE YEARS 2006 AND 2051

Projected Savings	Amount	Units
- Land use	53,333	Hectares
- Road kms built	10,100	Kilometres
- Road building cost	$5,500,000,000	
- Water quantity	18,800,000	Litres/Day
- Water infrastructure costs	$650,000,000	
- Fiscal impacts of lower service provision	$210,250,000	
- Property development savings	$21,000,000,000	

General statements re limitations in comparing development costs:

- The study found that "while there are many comparisons of specific costs such as transport infrastructure, there are few studies that have attempted to quantify all the costs in a structured and comparable manner. The selection of reviewed studies offered different approaches to quantifying the comparative costs in part, and, in one case, in total." (Biddle, et al. 2006, p1)

Any other interesting observations this paper makes:

- The literature reviewed conducted by Biddle et al. found the literature "tends to favour infill redevelopment over greenfield development, because of lower costs, demand for housing close to the CBD, and reduced contribution to greenhouse gas emissions" (Biddle, et al. 2006, p1).
- However, on the other hand, "there is some literature that recognises the need for urban growth, or at least fringe development, because it recognises other market forces, provides low cost housing, economic development, and areas of clean air for families to live in, rather than in polluted, congested, and crowded inner suburbs where apartment living may provide the only low cost choice for many." (Biddle, et al. 2006, p1).
- "Relatively inexpensive infill development in Sydney has tended to be situated close to existing infrastructure and services, in particular rail infrastructure. Where the relatively expensive infill development has been on brownfield land, such as in a number of harbour side locations, the capital costs are higher due to the need to build new suburban roads and provide utilities. Because these capital items are merely laterals, their costs are lower than the costs that might occur in greenfield locations. However, decontamination costs of infill developments have been cited by a number of reports as being the most significant cost holding back development." (Biddle, et al. 2006, p12)

What research is being appraised?	**Evans Paull (2012), "Infrastructure Costs, Brownfields vs Greenfield", *Redevelopment Economics*, Massachusetts, USA.**		
Which cities does the research examine?	Cities across the US		
What is the purpose of the research?	The following analysis examines previous research, compares that to the information for the Massachusetts Brownfields Tax Credit (BTC) projects, and then develops a quantitative "order of magnitude" estimate of the infrastructure savings attributable to the BTC (brownfield) projects. (Paull, 2012, p1)		
What methodology is used?	• An impact analysis of infrastructure costs based on 55 brownfield tax credit projects. • The analysis examines previous research, compares that to the information for the Massachusetts Brownfields Tax Credit (BTC) projects, and then develops a quantitative "order of magnitude" estimate of the infrastructure savings attributable to the BTC projects. (Paull, 2012, p2)		
Key findings	• There have been a series of studies that compare infrastructure costs for compact development vs. sprawl development. These studies have quantified the infrastructure savings due to compact development at between 10 and 65 percent, with most studies estimating the differential at 20 – 30 percent. (Paull, 2012, p2 – citing the EPA) • However Puall argues these estimations are not taking the full difference between the two settlement types into account. Brownfield development is often the site for compact development, and as theses brownfield sites already have pre-existing infrastructure connections the costs are even cheaper than sprawl development, and therefore the savings greater. • The conclusion is that Massachusetts BTC projects (which are brownfield development settings) save infrastructure costs, relative to alternative greenfields development, by 50 to 80 percent. (Paull, 2012, p6)		
Which development settings does the research explore and how does it define them?	**Development setting:**	**Definition:**	
	Large scale brownfield	• Brownfields redevelopment is generally assumed to save infrastructure costs relative to alternative greenfield development. • "Infrastructure, such as roads and utilities, to support brownfield redevelopment generally requires less land per capita and results in less stormwater runoff than infrastructure needed to support a similar amount and type of conventional development. Generally, the lower the population density, the more roads and highways are called for to connect trip origin and destination points." (Paull, 2012, p1 – citing the EPA)	
Quantitative infrastructure costs: From: *James Frank, "The Costs of Alternative Development Patterns: A Review of Literature. Washington, DC. Urban Land Institute. 1989.* From: *Scott Bernstein, "Using the Hidden Assets of America's Communities and Regions to Ensure Sustainable Communities." Center for Neighborhood Technology, 2003*	**Development setting:**	**Assumptions specific to the development setting**	**Cost per unit (as the research presents):**
	Infill	Density of 15.6 Dwelling Units per acre	US$ 37,000 per unit (2012$)
	Spread development	Density of 3-5 Dwelling Units per acre	US$ 65,000 – $74,000 per unit (2012$)
	Infill/greyfield	Assumption measured was infrastructure investment required	$US 12,500 per unit (2012$)
	Greenfield	Assumption measured was infrastructure investment required	$US 62,000 per unit (2012$)

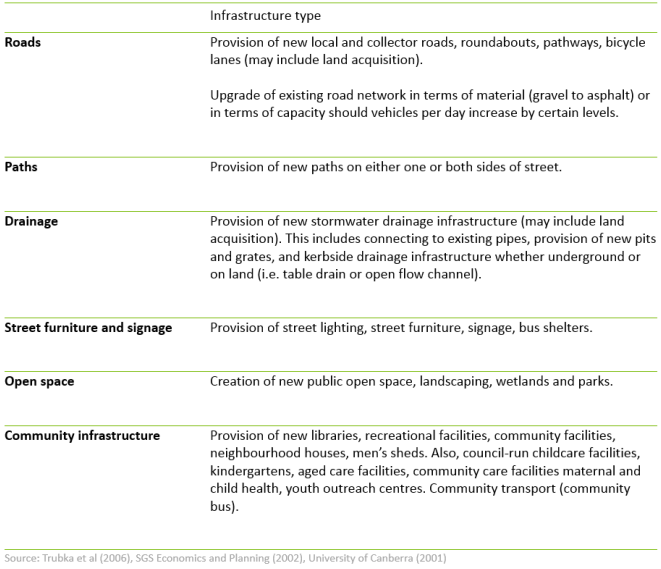
What research is being appraised?	**Hamilton, C. & Kellett, J. (2015) *Exploring infrastructure provision issues in greenfield and urban infill residential developments*, State of Australian Cities Conference 2015.**		
Which cities does the research examine?	Adelaide		
What is the purpose of the research?	This paper is a literature review of previous work and a study of three developments in Adelaide to answer three questions (Hamilton and Kellet, 2015, p2): 1. Are there real differences in infrastructure cost factors in greenfield (non-serviced) and infill (serviced) residential developments? 2. Can the costs be identified for these cost factors? 3. What are the implications for planning new development?		
What methodology is used?	• Firstly a literature review was undertaken by Hamilton and Kellet to understand previous work. • Then a case study was undertaken to compare development costs for three different housing developments in Adelaide, and compare them to previous findings.		
Key findings, concepts and assumptions	• From the literature review Hamilton and Kellet found that "it is clear that few studies have been undertaken and findings are mixed." (Hamilton and Kellet, 2015, p4) • The paper considers three different residential developments in Adelaide as case studies; – A greenfield case on the urban fringe – An infill (urban renewal) case where previous social housing is demolished and/or upgraded (possible greyfield case) – A second infill development case which except this one is a transit oriented development (TOD) focussing on the construction of apartments on land once used by industry. (Brownfield case) • The infrastructure cost factors for both the greenfield and urban renewal areas are "surprisingly similar" which may reflect a lack of capacity in some infrastructure or the need to upgrade standards of infrastructure in the renewal area. (Hamilton and Kellet, 2015, p10) • In general the evidence suggests that "it is less costly in infrastructure terms for government to develop on infill sites rather than greenfield sites" (Hamilton and Kellet, 2015, p10). However this may not always be the case for developers and the costs they face. • The findings of this study align well with previous studies that have assessed the costs of providing infrastructure for infill and greenfield development. (Hamilton and Kellet, 2015, p10).		
Quantitative infrastructure costs: Hamilton and Kennet case studies (Hamilton and Kellet, 2015, p5)	**Development setting:**	**Assumptions specific to the development setting**	**Cost per unit (as the research presents):**
	Greenfield 4,000 new dwellings	**Costs to developers only** – infrastructure design and approval, roads, water and sewerage, telecommunications, electricity, gas, and open space.	Total developer costs per dwelling - $53,580
	Urban renewal 1,800 new dwellings	**Costs to developers only** – infrastructure design and approval, roads, water and sewerage, telecommunications, electricity, gas, and open space.	Total developer costs per dwelling - $49,663
	Infill TOD 2,400 new apartments	**Costs to developers only** – infrastructure design and approval, roads, water and sewerage, telecommunications, electricity, gas, and open space.	Total developer costs per dwelling - $26,655
	Greenfield 4,000 new dwellings, a new school needed constructing due to supply constraints in the area	**Costs to government only** include roads, public transport upgrade, open space, municipal services, education and health. Fire, Police and Ambulance costs were not available.	Total government costs - $29,044 to $34,044 per dwelling
	Urban renewal 1,800 new dwellings. Funding for extra school capacity required.	**Costs to government only** include roads, open space, municipal services, and education. Fire, Police and Ambulance costs were not available. No public transport system upgrade costs or health costs.	Total government costs - $36,566 per dwelling
	Infill TOD 2,400 new apartments No need for new school required due to target market of residents (young professionals)	**Costs to government only** include open space, municipal services, and education. Fire, Police and Ambulance costs were not available. No road, public transport system upgrade or health costs.	Total government costs - $2,451 per dwelling

What research is being appraised?	**Newton P., (2013) *Regenerating cities: technological and design innovation for Australian suburbs*, Swinburne Institute for Social Research, Melbourne, Australia. Published in Building Research & Information, 2013, Vol. 41, No. 5, p575–588.**	
Which cities does the research examine?	Australia wide	
What is the purpose of the research?	"This paper seeks to chart a trajectory for urban regeneration that will enable the evolution of more resilient and sustainable cities. In developed as well as developing societies, this involves an ability to plan effectively for and implement socio-technical transitions across key urban sectors – transport, housing, energy, water, waste – as well as urban regeneration more broadly within the context of a long-term metropolitan strategic plan." (Newton, 2013, p575)	
Key findings	• Basic argument of the article is that the current development path in Australia, on greenfield, brownfield and sporadic greyfield sites, will not lead to resilient and sustainable cities. A new model is needed. • Greenfields, brownfields and greyfields constitute the three arenas of contemporary urban development, each progressively more challenging to plan and implement. • Sustainable cities will be realized only when brownfield and greyfield regeneration constitute the prime focus of urban policy and plan-making. (Newton, 2013, p575) • Two principal areas for housing regeneration, apart from alterations to existing property and piecemeal infill are precinct scale redevelopment, which focuses on brownfield sites, and greyfield precinct redevelopment. These developments should be focussed in designated activity centres, transport corridors and prospective residential neighbourhoods with high redevelopment potential. (Newton, 2013, p575)	
Which development settings does the research explore and how does it define them?	**Development setting:**	**Definition:**
	Large scale brownfield	• "Brownfield redevelopment has emerged as a process for reimagining and transitioning those urban areas which have 'outlived' their original industrial era functions. Principal among these are the abandoned or underutilized docklands which now occupy prime waterfront sites in all coastal cities, as well as the thousands of industrial sites to be found in all large metropolitan areas: the factories, scrap yards, railroad corridors and vacant petrol stations which catalogue the nation's industrial past." (Newton, 2013, p579) • Brownfields are "typically owned by a single party, usually government or industry; at a scale which is closer to that provided by greenfield sites for development; contaminated to some degree (depending upon the nature of prior use); and unoccupied (obviating the need for community engagement at a level required of greyfields)." (Newton, 2013, p579) • Also in scope for this class of regeneration are the abandoned or under-performing retailing centres. In the inner and middle suburbs of Australian cities, strip shopping centres on major transport routes have tended to retain their utility over time, but are also targets for revitalization at a scale beyond the individual property in the context of transport corridor redevelopment (Adams et al., 2009). (Newton, 2013, p579)
	Greyfield	• "Unlike brownfields, greyfields usually have no need for site remediation. Furthermore, they predominantly lie between Australia's more vibrant inner-city housing market and recently developed greenfield suburbs, providing greater access to employment, public transport and services than the latter zone." (Newton, 2013, p579) • Greyfields have become a key target for more intensive redevelopment by state government planning agencies in their future capital city development strategies." • There are three arenas for greyfield precinct-scale redevelopment; Transit-orientated developments, public transport corridors, and greyfield residential precincts. • "Greyfields are concentrations of underutilized (but occupied) land parcels in inner and middle suburban locations where building stock is failing (physically, technologically and environmentally) and energy, water and communications infrastructure is in need of upgrading." (Newton, 2013, p578) • Currently there is no development model appropriate for medium-density housing precinct regeneration in the greyfields in Australia.
	Greenfield	• Greenfields are the most straightforward urban development with well-established development models.
	Pressures facing/limiting development in cities and	• **Climate change** - A recognition that cities are responsible for more than 80% of the world's anthropogenic greenhouse gas emissions (Zoellick, 2011)

	that can influence infrastructure costs	and the impact that increased temperature, rising sea levels and rainfall variability will have on human settlements. (Newton, 2013, p576) • **Population change** - For fast-growing cities, the problem is that the planning and delivery of housing and urban infrastructure increasingly lags behind demand. For shrinking cities, the challenge is distressed neighbourhoods and how to (re)direct investment in infrastructure and services to these areas (Solman, 2011). (Newton, 2013, p576) • **Ageing infrastructure** -Significant parts of the physical infrastructure of cities in developed societies are nearing the end of their design life performance and, with increasing demand, pressure is mounting on the standard of service they are meant to provide (Mirza, 2007; Regan, 2008). The low ratings now being reflected in 'infrastructure scorecard' studies testify to their decline (Engineers Australia, 2010). (Newton, 2013, p576) • **Socio-demographic change** - This encompasses a raft of issues related to population demographics such as new demands on housing and services, and the extent to which housing and locational preferences of the cohorts that follow will favour different living environments to their predecessors. Advances in medical science have contributed to the emergence of an ageing population in high-income societies that will pose unprecedented challenges to the property and health sectors in coming decades (Newton & Doherty, 2013). (Newton, 2013, p576) • **Urban economic base** - The green economy has been advanced as the sixth major socio-technical transition to emerge with a capacity for major urban transformation to the eco-city (Hargroves & Smith, 2005; Newton & Bai, 2008; OECD, 2011c). For a major sectoral and spatial transformation to occur (e.g. to a green economy and eco-cities), there needs to be an associated critical mass of new enabling technologies – many related to urban infrastructure and future city functioning. (Newton, 2013, p576) • **Volatility in financial markets** - The volatility in financial markets that has characterized the years since the onset of the global financial crisis in 2007 is likely to be sustained in the short- to medium-term and influence both supply and demand-side investment decisions in cities. (Newton, 2013, p576)
Does the research discuss thresholds / population size trigger points and the specific infrastructure required?	• There is discussion about needing sustainable infrastructure such as renewable energy, bike infrastructure, and electric cars and so on, but not any population trigger points.	
Any other interesting observations this paper makes:	• "Conventional methods of domestic construction and housing delivery have limited capacity to provide the quantity, diversity and quality of medium-density housing needed for the effective regeneration of established suburban areas." (Newton, 2013, p582) • "Commercial construction techniques are difficult to deliver on a lot-by-lot basis and at a price point attractive to the current market." (Newton, 2013, p582)	

What research is being appraised?	**SGS Economics and Planning (2013) *Financial costs of settlement patterns in rural Victoria: Final Report,* prepared for Rural Councils Victoria**	
Which cities does the research examine?	Rural Victoria	
What is the purpose of the research?	SGS Economics and Planning (SGS) explored the relationship between infrastructure costs and settlement patterns. (SGS, 2013, p1) The project aimed to (SGS, 2013, p1): • Improve the understanding of the costs of capital, maintenance and service provision of different rural settlement typologies and the cumulative effect of development decisions over time • Create a modelling tool that can be easily used and adapted by councils • Ensure key metrics can be easily updated for tailoring to local circumstances • Make more obvious the financial (and other) benefits of development in areas with under-utilised infrastructure and latent service capacity.	
What methodology is used?	• SGS applied an approach that focused on information and data collection through council consultation, expert input from Aurecon, and GIS analysis. • This data collection lead to the creation of a tool that can be used to estimate development costs for new residential developments in rural Victoria.	
Key findings	• Whilst this study did not produce definitive cost comparisons between settlement types, it did identify that rural councils acknowledge different settlement types can drive varying cost patterns over time. • The study's key finding were (SGS, 2013, p1): – A significant *information gap* exists around the cost of different settlement types – That non-contiguous development is more expensive to service – Ongoing costs were higher than the initial capital overlay over the life of the asset. • The key conclusion is that "settlement patterns do indeed generate different costs over time. Even if councils are not providing new infrastructure to service growth, maintenance and operational costs over time vary significantly between settlement patterns." (SGS, 2013, p34) • "The vast infrastructure network required for dispersed development (despite its more basic standard) generates considerable cost to local government. In contrast, infill development, that is development which takes place on vacant parcels of land within existing infrastructure networks, generates considerably less cost to local government." (SGS, 2013, p34) • "Most interestingly, greenfield development and its high level of infrastructure provisioning (typically paid for by developers) lumps councils with exorbitant ongoing costs. This is significant given the growing emergence of greenfield development in rural locations." (SGS, 2013, p34) • In a rural setting – "Comparing the costs at a high level over time indicates that over varying time periods, dispersed development tends to be the most expensive to councils." (SGS, 2013, p34)	
Which development settings does the research explore and how does it define them?	**Development setting:**	**Definition:**
	Greenfield	• Greenfield development is defined as "development of multiple dwellings which takes place on undeveloped land and is typically of a low to average density. It can be defined as the development of planned communities on previously undeveloped (green) land." (SGS, 2013, p8) • In rural locations, greenfield development often occurs on the outskirts of towns or as satellite suburbs along highways and coastal regions. (SGS, 2013, p8) • Greenfield development usually requires completely new infrastructure networks to be constructed and the volume of development places additional 'at once' pressure on service provision. • Greenfield development is seen as a cost effective settlement type, although ongoing maintenance costs for the local council of the new infrastructure can be significant (SGS, 2013, p9).
	Dispersed development (similar to dispersed infill but in a rural setting)	• Dispersed development is usually "incremental and takes place gradually as large rural lots are subdivided, often at some distance from existing development." (SGS, 2013, p9) • For a single development, "dispersed development is usually inexpensive to service as it can utilise nearby infrastructure, and any works to connect the development to existing infrastructure networks are usually provided for by the property owner." As there is typically less infrastructure provided in rural locations, costs are also reduced. (SGS, 2013, p9) • However, over time, "dispersed development can result in significant costs to councils. High levels of dispersed development can be difficult to efficiently service with community infrastructure and environmental management (for example, rubbish collection), due to distance." (SGS, 2013, p9)

	Costs	• A key driver in the cost of providing new infrastructure is the size of a new development. A larger development area or site is more likely to have a formal developer contributions plan associated with it. • Typically greenfield subdivisions are the largest type of development and are the easiest to apply a developer contributions plan to. In greenfield developments, the capital outlay is usually covered, in full or in part, by the developer. • However local government will typically pay the ongoing maintenance costs of these new assets. There is a risk to councils that new development will lead to ongoing maintenance costs (detailed below) that are higher than the increase in rates received. • Ribbon-type, infill and dispersed development usually occurs on an incremental basis, and relies on existing infrastructure and services where possible. "Incremental development is more difficult to charge development contributions for, as smaller developers are often involved, and it is difficult to establish new infrastructure requirements or expansions in an established area." (SGS, 2013, p12) • Dispersed, isolated development will create higher costs due to the distance that needs to be covered for council services to be provided. Locations with limited access to existing capacity may necessitate new investments in social infrastructure (schools etc.) and services at a cost to council. FIGURE 5 ONGOING MAINTAINANCE AND OPERATIONAL RESPONSIBILITIES FOR LOCAL GOVERNMENT **Ongoing costs** **Roads** — Maintenance of local road network, including resealing, gravel re-sheeting, routine maintenance and rehabilitation. **Paths** — Maintenance of paths, including resealing, gravel re-sheeting, routine maintenance and rehabilitation. **Drainage** — Maintenance of drainage infrastructure from legal point of discharge to network. Stormwater which is captured within a private property must be directed from/to a legal point of discharge which is typically either an underground council drain, or at a kerb and channel or open earth drain. Councils are responsible for maintaining from this point forward, which for open drains can include clearing blockages, excavating debris and removing or maintaining vegetation. For underground drains, councils are responsible for the barrel drain and associated pits. **Street furniture and signage** — Maintenance of street lighting, street furniture, signage, bus shelters. **Open space** — Ongoing maintenance of open space, including landscaping, mowing, weeding, etc. **Community infrastructure** — Maintenance of building assets as well as operating council-run facilities. **Environmental management** — Rubbish collection (labour, truck hire), operation of landfill and transfer stations. Source: Trubka et al (2006), SGS Economics and Planning (2002), University of Canberra (2001) (SGS, 2013, p11)

<table>
<tr><td rowspan="2">What assumptions does the research make about the following terms across the different development settings</td><td>Infrastructure</td><td colspan="2">FIGURE 6 COUNCIL PROVIDED INFASTRUCTURE FOR RESIDENTIAL DEVELOPMENT
 
<table>
<tr><th></th><th>Infrastructure type</th></tr>
<tr><td>Roads</td><td>Provision of new local and collector roads, roundabouts, pathways, bicycle lanes (may include land acquisition).

Upgrade of existing road network in terms of material (gravel to asphalt) or in terms of capacity should vehicles per day increase by certain levels.</td></tr>
<tr><td>Paths</td><td>Provision of new paths on either one or both sides of street.</td></tr>
<tr><td>Drainage</td><td>Provision of new stormwater drainage infrastructure (may include land acquisition). This includes connecting to existing pipes, provision of new pits and grates, and kerbside drainage infrastructure whether underground or on land (i.e. table drain or open flow channel).</td></tr>
<tr><td>Street furniture and signage</td><td>Provision of street lighting, street furniture, signage, bus shelters.</td></tr>
<tr><td>Open space</td><td>Creation of new public open space, landscaping, wetlands and parks.</td></tr>
<tr><td>Community infrastructure</td><td>Provision of new libraries, recreational facilities, community facilities, neighbourhood houses, men's sheds. Also, council-run childcare facilities, kindergartens, aged care facilities, community care facilities maternal and child health, youth outreach centres. Community transport (community bus).</td></tr>
</table>
Source: Trubka et al (2006), SGS Economics and Planning (2002), University of Canberra (2001)
(SGS, 2013, p10)</td></tr>
<tr><td>Density</td><td colspan="2">• SGS outline a study carried out in Canada by Halifax regional municipality (2005) which found (SGS, 2013, p13):
– Clear trends between density and costs
– There was an influence of density on service costs, with per unit costs decreasing as neighbourhoods increased in density
• The rural low density settlement pattern was found to be nearly three times more expensive than the urban settlement pattern.</td></tr>
<tr><td rowspan="5">Quantitative infrastructure costs:</td><td>Development setting:</td><td>Assumptions specific to the development setting</td><td>Cost per unit (as the research presents):</td></tr>
<tr><td>Dispersed (rural setting)
10 dwellings built</td><td>Council provides: Road maintenance, road replacement every 30 years, drainage maintenance, and waste collection.
Council does not provide: roads, footpaths, drainage, open space.</td><td>$233,564 per dwelling, over 30 years</td></tr>
<tr><td>Greenfield (rural setting)
10 dwellings built</td><td>Council provides: Road maintenance, road replacement every 30 years, drainage maintenance, and waste collection.
Council does not provide: roads, footpaths, drainage, and open space.</td><td>$58,233 per dwelling, over 30 years</td></tr>
<tr><td>Infill (rural setting)
10 dwellings built</td><td>Council provides: Road maintenance, road replacement every 30 years, drainage maintenance, and waste collection.
Council does not provide: roads, footpaths, drainage, and open space.</td><td>$38,738 per dwelling, over 30 years</td></tr>
<tr><td colspan="3">• A second scenario is calculated in the report where 20 houses are constructed over 50 years</td></tr>
<tr><td>Does the research discuss thresholds / population size trigger points and the specific infrastructure required?</td><td colspan="3">• "The cost of providing social services, such as education, health and community facilities, is largely driven by demographic characteristics rather than settlement patterns." (SGS, 2013, p13)</td></tr>
<tr><td>General statements re limitations in comparing development costs:</td><td colspan="3">• The cost of providing, maintaining and operating infrastructure and services can vary substantially between local governments in rural locations.</td></tr>
<tr><td>Any other interesting observations this paper makes:</td><td colspan="3">• A review of 'Assessing the Costs of Alternative Development Paths in Australian Cities' was done by SGS with the key finding from Trubka's research is that non-contiguous development can attract higher costs. "Non-contiguous development is defined as development which takes place at a distance from existing development (such as 'leapfrog' development). Consequently, it is less able to utilise</td></tr>
</table>

	existing infrastructure and services, requiring new investment. Non-contiguous development is typically of a dispersed, ad-hoc nature; however greenfield subdivisions that are not located near existing development may also be thought of as non-contiguous." (SGS, 2013, p12)

What research is being appraised?	Environmental Resources Management Australia Pty Ltd (ERM) (2001), Future Perth: Costs of Urban Form, Working Paper No. 2, Western Australian Planning Commission, Perth.		
Which cities does the research examine?	• Concentrated on Australia but some studies in USA and Canada (chosen because they shared similar socioeconomic and political structures to Australia as well as sharing concern over costs of urban form)		
What is the purpose of the research	• Commissioned by WA Planning Commission to inform the Perth Metropolitan Region component of a new strategic plan for Perth • Designed to inform government's assessment of development options and help infrastructure providers, urban developers and state providers		
What methodology is used?	• Review of 22 previous studies that have attempted to define the economic costs of urban development, particularly from the viewpoint of the impact of location on costs • Review examined direct costs of urban development (paid for directly through the market), indirect costs (incurred directly and paid for through the market / private insurance / taxation) and external costs (incurred directly but not transacted through the market) • The extent to which costs changed relative to urban form was examined by mapping the costs in inner, middle and outer areas (with assumptions about density and availability of existing infrastructure)		
Key findings, concepts and assumptions	• One broad conclusion is that inner and middle suburbs generate lower costs than outer areas • Overall picture on costs is incomplete • Concluded it is unrealistic to provide a single estimate on how much more expensive development in outer areas can be compared with inner and middle areas because there are many location-specific factors which substantially affect the cost of development across outer areas. • Review identified minimal research had been undertaken on how external costs change with urban form • A weakness of the direct cost estimates was that they mainly covered initial capital costs and excluded operating, maintaining and replacement costs of infrastructure (favouring inner areas where initial capital expenditure was not required) • Another weakness of direct cost estimates did not always include the same cost factors, thus making comparison across studies difficult • Indirect costs varied to a lesser extent than direct costs, with urban form (especially where they were more a function of demographic characteristics than development location i.e. service provision) • Main driver of external costs is travel time, accounting for >95% of external costs and depending on the proximity of residents to their place of work (with value of non-contiguous development possibly 1.4-3.4 times the value of external costs under contiguous development scenarios) • Other external costs were measured at a more aggregate level due to availability of data therefore difficult to draw conclusions on the effect of urban form • Where sufficient information was available from the studies reviewed, lower and upper cost estimates were recommended for the range of costs examined (representing contiguous and non-contiguous development respectively) • Density and location are major determinants of cost • Excluding land and construction costs, initial capital costs of a non-contiguous development with no existing infrastructure can be 3.2-4.2 times higher than a contiguous development with existing infrastructure • Identifies an important classification of study type: retrospective vs forward-looking studies		
Quantitative infrastructure costs	Development setting	Assumptions	Cost per unit (as presented in the research)
Direct costs	Contiguous (some existing infrastructure)	Initial capital cost Land construction costs account for 90% of initial capital costs	$100,000 - $257,500 per dwelling

	Non-contiguous (no existing infrastructure)	Initial capital cost Land construction costs account for 70% of initial capital costs	$101,500 to $234,000 per dwelling
	Contiguous (some existing infrastructure)	Operating, maintenance and replacement costs but insufficient info. On replacement costs	Not possible to derive a complete list but based on those reported: $17,200 - $19,250 per dwelling
	Non-contiguous (no existing infrastructure)	Operating, maintenance and replacement costs sought but insufficient info. On replacement costs	Not possible to derive a complete list but based on those reported: $23,700 - $25,750 per dwelling
Indirect costs	Contiguous	Capital Examined two thirds of initial capital cost categories reported for ambulance, police, education & health	$4,550 per dwelling
	Non-contiguous	Capital Examined two thirds of initial capital cost categories reported for ambulance, police, education & health	$25,550 - $40,550 per dwelling
	Contiguous	operating and maintenance and replacement costs Examined fire, ambulance, police, education & health Insufficient info. On replacement costs	Not possible to derive a complete list but based on those reported: $2,700-3,300 per dwelling
	Contiguous	As above	Comparable

Source: SGS, 2016

What research is being appraised?	**SGS Economics and Planning (2012) *Where and how should we grow? Final Report,* Prepared for Rural Councils Victoria**	
Which cities does the research examine?	Rural Victoria	
What is the purpose of the research?	The Municipal Association of Victoria (MAV) commissioned SGS Economics and Planning (SGS) to understand the impacts of different settlement patterns from a 'triple bottom line' perspective and a 'local government fiscal' perspective over the short, medium and longer term.	
What methodology is used?	The study included a review of current literature and three case studies that aimed to collect costs experienced by councils for residential development in the Golden Plains Shire, City of Greater Shepparton and Shire of Strathbogie.	
Key findings	• "How settlements grow and where urban development occurs affects infrastructure provision and service delivery costs for councils. Different settlement patterns have different infrastructure requirements." (SGS, 2012, pi) • The report found that infill development is least costly development setting when close to existing infrastructure and services with sufficient capacity. Triple bottom line benefits of infill were also superior, including improved social interaction and access to existing services, reduced reliance on private transportation and longer term land savings. (SGS, 2012, pi) • It was also found that in rural Victoria greenfield development can present lower upfront capital costs to council, due to development contributions plans or Section 173 Agreements. However, the report finds that upfront costs are often lower than the operating and renewal cost of assets, with construction accounting for approximately 20 per cent of an asset's lifetime cost, therefore maintaining these assets can be expensive for councils. (SGS, 2012, pi)	
Which development settings does the research explore and how does it define them?	**Development setting:**	**Definition:**
	Dispersed infill	• Where development is vaguely centralised, but significant development in non-serviced areas exists. • Dispersed rural development "does not present many upfront costs to council. Despite a lack of substantial infrastructure (such as sealed roads, underground drainage or sewerage), new residents generally accept this and it is reflected through the lower price of land in these locations. Costs may be incurred by local government where dispersed development reaches a threshold to necessitate infrastructure upgrades, such as sealing of gravel roads." (SGS, 2012, p36) • "Some of the major costs associated with dispersed development include ongoing maintenance costs for unsealed roads, which are higher than the costs associated with sealed roads. Road upgrades were also recognised as a significant cost to council." (SGS, 2012, p36)
	Greenfield	• New development in areas with little existing infrastructure. Development tends to be predominantly suburban and reliant on existing town centres and/or activity centres for jobs and services. • "The upfront costs to local government for greenfield development are generally quite low if a developer contributions plan is in place, which ensures that most upfront costs are picked up by the developer. Therefore, greenfield development involves less upfront costs and financial risk to councils." (SGS, 2012, p35) • "Local government incurs higher operating and maintenance costs for greenfield development compared to ad-hoc development due to the greater stock of infrastructure that must be kept. Ongoing costs to local government include maintaining drainage and open space, footpaths, street lights, cleaning drains and garbage collection." (SGS, 2012, p35) • "Greenfield developments often lack sufficient social infrastructure, meaning that residents will travel to nearby established town centres for services. This can place pressure on existing surrounding services and can also contribute to increased traffic congestion and heighten other negative impacts associated with car use." (SGS, 2012, p36)
	Consolidated infi settlement patter	• Where infill opportunities are recognised and maximised. • Broadly, "infill development is less costly as it is located near existing infrastructure and services, and local government is therefore not required to contribute capital costs, assuming additional capacity requirements do not trigger an upgrade or extension of existing infrastructure and services. Should additional or upgraded infrastructure be required however, then costs may be significant for local government." (SGS, 2012, p35) • "As it is difficult to determine usage proportions in existing urban areas, it is harder to obtain funding from developer contributions for development in infill locations. Therefore, the upfront cost to local council for infill development is often higher as it must cover the costs for upgrading existing infrastructure, such as drainage, to accommodate increased population and densities." (SGS, 2012, p35)

	Ribbon development	• Where development extends along coastal frontages or transport links. • "Ribbon development usually occurs next to/alongside existing residential areas, meaning there are few, if any capital costs to council arising from incremental development. The case study highlighted the need for a major piece of infrastructure to be upgraded due to increased traffic in an area, however, as with infill development, ribbon development can utilise existing infrastructure and so there are less upfront costs to council, compared to greenfield development." (SGS, 2012, p36) • "As well as local servicing costs such as street sweeping and garbage collection, ongoing costs identified with ribbon development include road maintenance costs, as well as traffic management and road upgrade costs associated with increased traffic." (SGS, 2012, p36)

What assumptions does the research make about the following terms across the different development settings

Infrastructure Costs

Infrastructure Item	Greenfield	Dispersed	Ribbon	Infill
New local roads, required upgrades, intersections and roundabouts within the development site	Developer pays proportion or entire cost	Not often required unless traffic reaches a certain threshold. Council will pay.	Not often required unless traffic reaches a certain threshold. Council will pay.	Larger sites will usually be paid for by developer. Smaller sites may not need new road infrastructure.
Required road upgrades, intersections and roundabouts around the development site	Council usually pays entire cost	As above	As above	As above.
New/upgraded drainage	Developer pays proportion or entire cost	Developer/resident pays for upgrades on site	Developer/resident pays for upgrades on site	Council usually pays
New footpaths, cycle paths and shared paths	Developer pays proportion or entire cost	If required, council pays.	If required, council pays.	Council pays
Street signage, furniture and lighting	Developer pays proportion or entire cost	If required, council pays.	If required, council pays.	Council pays
Gross pollutant traps (in water sensitive area)			$645,000	
Open space, recreation, reserves, playgrounds	Developer pays a proportion via open space levy or DCP	Council pays, open space levy may apply	Council pays, open space levy may apply	Council pays, open space levy may apply
Community facilities, libraries, youth centres	Council usually pays cost	Residents usually rely on existing facilities. Council pay for new required facilities.	Residents usually rely on existing facilities. Council pay for new required facilities	Residents usually rely on existing facilities. Council pay for new required facilities
Maternal and child health facilities, child care facilities, aged care facilities	Council usually pays cost	Residents usually rely on existing facilities. Council pay for new required facilities	Residents usually rely on existing facilities. Council pay for new required facilities	Residents usually rely on existing facilities. Council pay for new required facilities

		Council planning costs (surveying, consultants, expert witnesses, VCAT)	Council pays.	Council pays if this is required.	Council pays if this is required.	Council pays if this is required.
	Infrastructure maintenance cost	**Infrastructure Item**	**Greenfield**	**Dispersed**	**Ribbon**	**Infill**
		Road maintenance (potholes, line marking, gravel re-sheeting)	Local government with potential State/Fed. Funding for major upgrades	Local government with potential State/Fed. Funding for major upgrades	Local government with potential State/Fed. Funding for major upgrades	Local government with potential State/Fed. Funding for major upgrades
		Drainage maintenance	Local government.	Local government.	Local government.	Local government.
		Maintenance of open space, playgrounds, reserves	Local government. Potential for developer to pay costs within site for first 12-24 months.	Local government.	Local government.	Local government.
		Garbage collection and clearing of illegally dumped rubbish.	Local government.	Local government.	Local government.	Local government.
		Operation of community facilities	Local government.	Local government.	Local government.	Local government.
		Maintenance of community facilities	Local government.	Local government.	Local government.	Local government.
Does the research discuss thresholds / population size trigger points and the specific infrastructure required?	• Councils may incur costs from development for extending or upgrading infrastructure and community facilities, as a result of an increased local population and usage. • New social infrastructure would need to be provided when population thresholds for certain facilities are reached. "These population thresholds vary across locations and are generally not publicly available. This would be the case for dispersed and greenfield development locations where assets may not currently exists and residents rely on nearby services in other towns." (SGS, 2012, p37)					
General statements re limitations in comparing development costs:	• Consultation by SGS found that cost data was not readily collected by councils and that there is limited evidence available on the actual cost of upfront infrastructure requirements. "This may be a reflection of the variance in cost for different developments in municipalities, and the wide range of factors that may influence costs (i.e. terrain, existing infrastructure provision and distance, density of development and so forth)." (SGS, 2012, p31)					
Any other interesting observations this paper makes:	• The case studies and literature in the report show that "utilising existing infrastructure will reduce upfront costs to councils, and will lead to a number of broader economic, social and environmental benefits for the community." (SGS, 2012, p39). However, it is also noted that "there can be increased difficulty with local government obtaining developer contributions for infill development. Further to this, ongoing maintenance and operation costs will still apply." (SGS, 2012, p39)					

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