FINAL REPORT

Western Sydney Place Based Infrastructure Compact

PIC 1

Prepared for
The Greater Sydney Commission

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Summary

A Place Infrastructure Compact is a mechanism to understand the choices for development of an area and the infrastructure requirements, costs and benefits associated with different choices. This project is one part of the PIC. It aims to:

- compare different scenarios for development in Western Sydney to examine the costs and benefits of different development patterns
- compare difference staging and sequencing scenarios across and within precincts to understand the choices facing Government in the timing and location of when land is released, and infrastructure that is required.

Three land use scenarios, plus a base case, have been developed which reflect differences in zoning controls, enabling infrastructure and demand:

- The **base case** assumes current zoning controls, and committed and approved infrastructure
- **Scenario 1** has assumed no further zoning changes, beyond what is already approved.[1]This scenario allows for some infrastructure developments above which has been already approved or committed, which enables development to occur in excess of the base case. This sees
  - housing growth is limited to existing metropolitan clusters such as Penrith, Liverpool and Campbelltown-Macarthur with the exception of the Aerotropolis
  - limited employment growth focused on the Western Sydney Airport and already developed or rezoned areas in Western Sydney.
- **Scenario 2** has focused on the realisation of the Western Parkland City vision with the Western Sydney Aerotropolis as the focus of growth. This sees:
  - housing growth focused on renewal in existing communities with new infill opportunities provided by the initial precincts of the Aerotropolis and developing around newly provided metro stations, between St Marys and the Aerotropolis with other new transport links provided as per Future Transport 2056
  - strong jobs growth around the Aerotropolis supported by steady growth with existing metropolitan centres and employment areas.
- **Scenario 3** has focused on a different growth pattern for Western City where there is greater development and more jobs focus within existing metropolitan and strategic centres, and a more dispersed settlement pattern into the greenfield areas. This sees:
  - housing growth is focused on the development of existing greenfield communities such as the South West and North West Growth Areas, with other new transport links assumed in Future Transport 2056

1 Scenario 1 was the original base case in this analysis. See appendix A for a further discussion of this scenario and how the base case was constructed.

– jobs growth in the Western City overall under this scenario is reduced compared to Scenario 1 as the impetus for a shift in jobs to the west is smaller with a less attractive Aerotropolis.

The development outcomes across scenarios in total are shown in table 1.

1 Development outcomes for scenarios for PIC 1

Measure	Scenario	2016	2036	2056
Population ('000s of people)	BC	25	40	40
	Sc1		81	136
	Sc2		111	219
	Sc3		121	199
Dwellings ('000s of dwellings)	BC	8	13	13
	Sc1		28	46
	Sc2		38	74
	Sc3		41	67
Jobs ('000s of jobs)	BC	8	24	38
	Sc1		32	59
	Sc2		69	180
	Sc3		54	111
Jobs per person	BC	0.32	0.60	0.96
	Sc1		0.39	0.43
	Sc2		0.62	0.82
	Sc3		0.44	0.56

Source: GSC, CIE.

Benchmarks of the 'economic' cost per person and job to 2056 are shown for each scenario in table 2. The economic costs of infrastructure are the discounted capital and operating costs of infrastructure required to meet development under the scenarios. These are divided by the present value of additional people and jobs in each scenario since 2016. The cost per person and job is highest in the base case, and lowest in the high growth scenarios. The incremental cost per person and job is measured relative to the base case for Scenario 1, and relative to Scenario 1 for Scenarios 2 and 3. This is because Scenarios 2 and 3 involve very similar amounts of infrastructure costs albeit for different growth levels.

2 Economic costs per person and job to 2056 (inside, discounted)

Scenario	Discounted inside capital and operating costs	Discounted popn growth (2016 to 2056)	Discounted job growth (2016 to 2056)	Cost per person and job	Incremental [a] cost per person and job
	$b PV	'000 PV	'000 PV	$000/ person + job	$000/ person + job
Base case	8.5	11	11	378	378
Scenario 1	12.6	37	17	236	133
Scenario 2	18.1	58	46	174	109
Scenario 3	17.3	58	32	193	130

[a] Incremental costs are costs that are additional to the prior growth scenario, but with Scenarios 2 and 3 both compared to Scenario 1 due to having very similar infrastructure spend.

Note: Costs are discounted and are in Dec-2019 dollars. Excludes land acquisition costs.

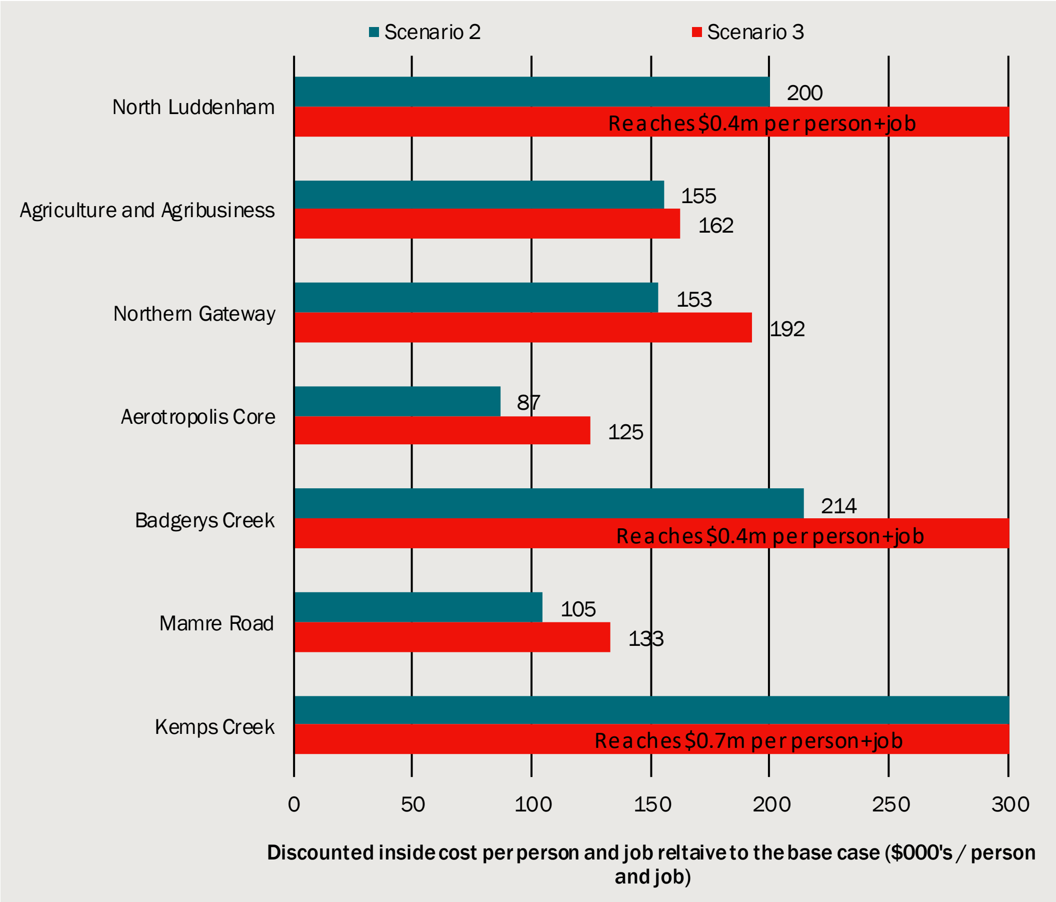
Source: CIE based on information provided by GSC and agencies.

Charts 3 and 4 of cost-effectiveness by precinct are split into two groups of precincts:

- Job-focussed precincts, which are those which GSC seeks to provide mainly employment-related benefits, and
- Population-focussed precincts, which are those which GSC seeks to provide mainly population-related benefits

The most cost-effective job-focussed precincts for development are the Aerotropolis Core and Mamre Road. The cost per person and job is significantly lower for population-focussed precincts, which may suggest that the costs of providing infrastructure to meet the demand for infrastructure from of jobs are higher than for population.

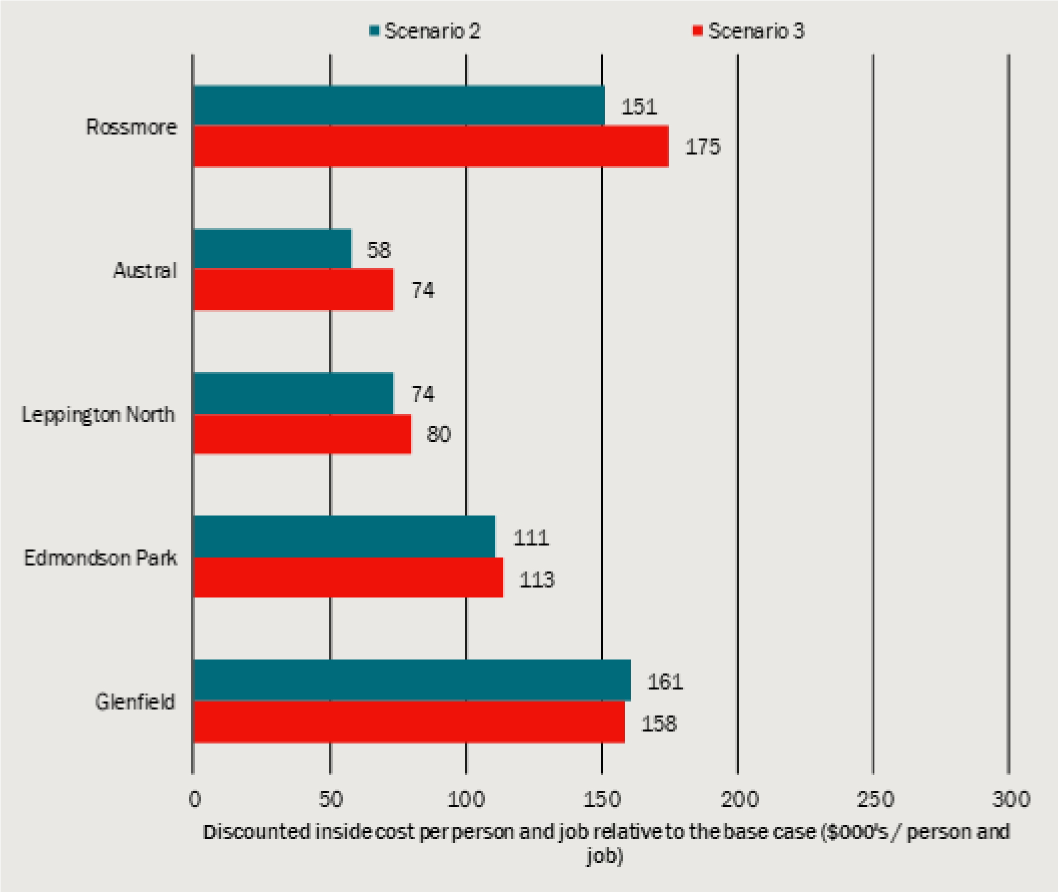
3 Cost effectiveness for job-focussed precincts



Note: The Western Sydney Airport precinct has been excluded because it has very little population and job growth.

Data source: CIE.

4 Cost effectiveness for residential-focussed precincts



Data source: CIE.

The monetised results are shown in table 5. The discounted costs relative to the base case, range from $4.1 billion for Scenario 1 up to $9.6 billion for Scenario 2. The costs of Scenario 3 are somewhat lower than Scenario 2, at $8.8 billion.

The benefits are measured for:

- liveability – willingness to pay for housing in each precinct, given the current attributes of the place, and the changes that each scenario leads to, less the cost of development
- productivity – willingness to pay for commercial and industrial development in each precinct, given the current attributes of the place, and the changes that each scenario leads to, less the cost of development
- sustainability – a range of environmental impacts, impacts outside of the PIC area and impacts not captured elsewhere.

Liveability benefits are the largest component of benefits. The liveability benefit in Scenario 2 and 3 is around $2.5-3.0 billion more than Scenario 1, which has a liveability benefit of $4.3 billion relative to the base case. The benefits associated with liveability are mostly associated with the value of development at current attributes, with a small contribution from improved accessibility to jobs by public transport.

Productivity benefits are the second largest component of benefits, and are highest in the highest job growth scenario (Scenario 2). There is a moderate private benefit from more development in the Aerotropolis at projected rents without any improvement in characteristics of the place (such as accessibility improvements). This is captured in the productivity benefit using current attributes. Additional productivity benefits are associated with the businesses to be located in the PIC area being more accessible to labour supply by public transport. These benefits increase from $0.2 billion in Scenario 1 to $0.4 billion in Scenario 3 and $0.6 billion in Scenario 2. These benefits are highest in Scenario 2 because there are more jobs and businesses in the PIC area to benefit from increased accessibility to labour supply driven by population growth and transport infrastructure projects.

Sustainability benefits are $0.6 billion in Scenarios 2 and 3 relative to the base case. This is mainly associated with water quality improvements, but tree canopy and native vegetation improvements also lead to benefits.

Spillover impacts from the scenarios relative to the base case are negative. This is mainly due to the magnitude of congestion and pollution caused by vehicle usage in the PIC area, which is higher in the scenarios than the base case. Once benchmarks are accounted for around private vehicle use in scenarios relative to Sydney averages, the net costs of pollution and congestion are somewhat lower. Higher growth scenarios lead to moderate increases in private vehicle kilometres travelled per person, due to car kilometres travelled in the PIC area being significantly higher than Sydney-wide averages.

For overall metrics we report:

- net benefits — this is the benefits measured for the scenarios less the costs
- net benefits adjusted for benchmarks. This is net benefits, plus the benchmark of population driven costs
  - we use a conservative estimate of typical population driven costs that only includes congestion and environmental impacts from private vehicle use
  - there are potentially substantially more population driven costs regardless of whether new housing is built, such as higher demand for schooling, health facilities and green infrastructure. There are also potentially benefits from locating people and jobs in other places, as this would improve labour market access for businesses and job accessibility for people. Neither of these has been quantified in this evaluation, given information available

The most appropriate metric in our view is the net benefit adjusted for benchmark costs of population growth. The scenario that performs most strongly on this metric is Scenario 3. With a less conservative view of benchmark costs for population growth this result would be stronger. Given that few PIC evaluations have been conducted, the benchmarks are not particularly strong for comparing costs and benefits relative to other areas.

Scenario 1 and Scenario 2 have a similar net benefit of $0.6 billion and $0.5 billion in present value terms respectively.

5 Overall costs and benefits

	Scenario 1	Scenario 2	Scenario 3
	$b, pv	$b, pv	$b, pv
Costs			
Capital costs identified by agencies	-4.1	-9.6	-8.8
Total capital costs	**-4.1**	**-9.6**	**-8.8**
Benefits			
Liveability benefits			
Current attributes	4.1	6.0	6.0
Change in job accessibility	0.3	1.4	0.9
Change in open space	0.0	0.1	0.1
Change in access to strategic centres	0.0	0.0	-0.1
Total liveability benefits	**4.3**	**7.5**	**6.9**
Productivity benefits			
Attributes of comparator areas	0.5	1.6	1.2
Change in business accessibility	-0.1	0.0	-0.1
Change in labour market access	0.2	0.6	0.4
Lost value of agricultural land	-0.1	-0.8	-0.7
Digital benefits	0.0	1.1	1.3
Total productivity benefits	**0.4**	**2.5**	**2.0**
Sustainability benefits			
Tree canopy (air quality, GHG and flood mitigation/water quality)	0.0	0.0	0.0
Tree canopy health benefits	0.0	0.1	0.1
Native vegetation	0.0	0.1	0.1
Water quality	0.2	0.4	0.4
Building energy consumption	0.0	0.0	0.0
Social housing	0.0	0.0	0.0
Total sustainability benefits	**0.2**	**0.6**	**0.6**
Spillovers			
Congestion spillovers outside of the PIC area	-0.6	-1.6	-1.4
Vehicle pollution	-0.2	-0.7	-0.6
Total spillovers	**-0.8**	**-2.2**	**-1.9**
Total benefit	**4.2**	**8.3**	**7.5**
Benchmarks of costs of population growth			
Congestion imposed on others	0.4	1.2	1.0
Vehicle pollution from car congestion	0.2	0.5	0.4
Population driven infrastructure costs	Na	Na	Na
Population driven accessibility benefits	Na	Na	Na
Total benchmark	**0.6**	**1.8**	**1.4**

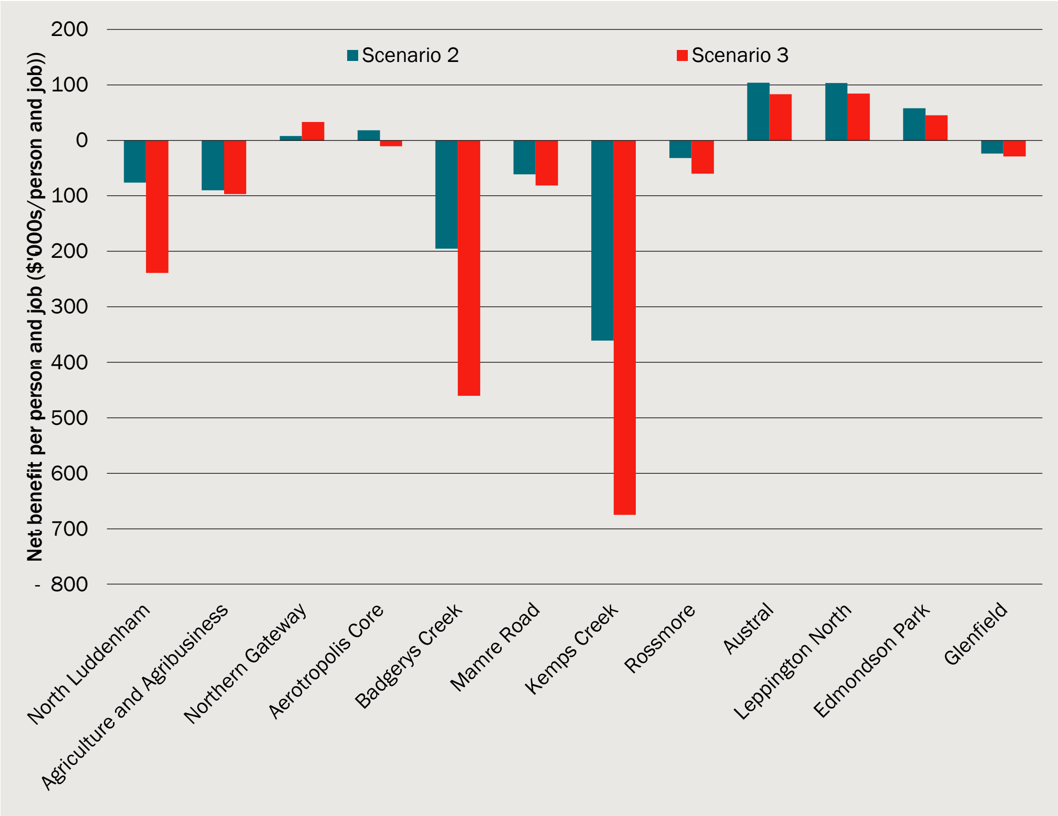
	Scenario 1	Scenario 2	Scenario 3
	$b, pv	$b, pv	$b, pv
Overall metrics			
Net benefit without benchmarking	-0.1	-1.3	-1.3
Net benefit with benchmarking	0.6	0.5	0.1

Note: Using a 7 per cent discount rate. 'Current attributes' refers to current levels of accessibility, open space and other physical characteristics that would affect willingness to pay. Note that we do not present the benefit-cost ratio of each scenario since some benefits are measured net of costs, and thus capital and operating costs are not 'all-inclusive' of costs. For example liveability benefits are measured net of construction costs. Additionally, sustainability benefits are net changes, some of which are negative.

Source: CIE.

Net benefits per person and job are positive for Leppington North and Austral, but are strongly negative for Badgery's Creek and Kemps Creek. The net benefits associated with Aerotropolis Core are very close to $0 per person and job in both scenarios, yet are slightly positive for Scenario 2.

6 Net benefits per person and job by scenario



Note: South Creek Sth has been excluded since the net benefit per person and job is not defined for a precinct with zero population and job growth.

Data source: CIE.

Combined results across both PICs

The monetised results for both PIC areas combined are shown in table 7. The discounted costs relative to the base case, range from $5.9 billion for Scenario 1 up to $15.6 billion for Scenario 2. The costs of Scenario 3 are somewhat lower than Scenario 2, at $15.4 billion.

Liveability benefits are the largest component of benefits. The liveability benefit in Scenario 2 and 3 is around $8 billion more than Scenario 1, which has a liveability benefit of $4.2 billion relative to the base case. The benefits associated with liveability are mostly associated with the value of development at current attributes, with a small contribution from improved accessibility to jobs by public transport.

Productivity benefits are the second largest component of benefits, and are highest in the GPEC-focussed growth scenario (Scenario 3).

Sustainability benefits are $2.5 billion in Scenarios 2 and 3 relative to the base case. This is mainly associated with tree canopy and water quality improvements, but native vegetation improvements also lead to benefits.

Spillover impacts from the scenarios relative to the base case are negative. This is mainly due to the magnitude of congestion and pollution caused by vehicle usage in the PIC areas, which is higher in the scenarios than the base case. Once benchmarks are accounted for around private vehicle use in scenarios relative to Sydney averages, the net costs of pollution and congestion are somewhat lower.

The most appropriate metric in our view is the net benefit adjusted for benchmark costs of population growth. The scenario that performs most strongly on this metric is Scenario 3. With a less conservative view of benchmark costs for population growth this result would be stronger. Given that few PIC evaluations have been conducted, the benchmarks are not particularly strong for comparing costs and benefits relative to other areas.

The scenario with the highest net benefit is Scenario 3.

7 Overall costs and benefits

	Scenario 1	Scenario 2	Scenario 3
	$b, pv	$b, pv	$b, pv
Costs			
Capital costs identified by agencies	-5.9	-15.6	-15.4
Total capital costs	**-5.9**	**-15.6**	**-15.4**
Benefits			
Liveability benefits			
Current attributes	4.3	10.3	10.9
Change in job accessibility	-0.1	1.7	0.9
Change in open space	0.0	0.1	0.2
Change in access to strategic centres	0.0	0.0	-0.1

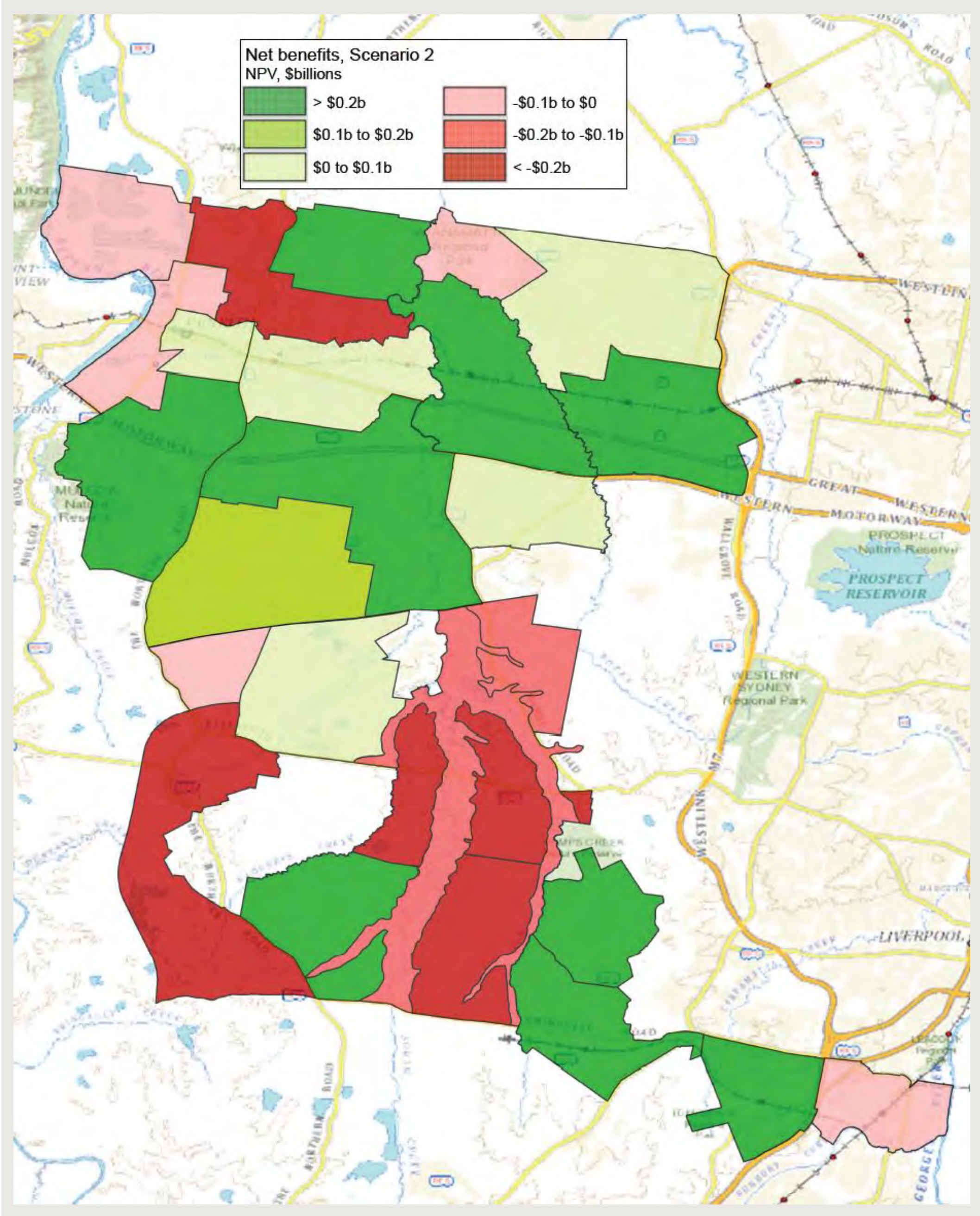
	Scenario 1	Scenario 2	Scenario 3
	$b, pv	$b, pv	$b, pv
Total liveability benefits	**4.2**	**12.1**	**11.9**
Productivity benefits			
Attributes of comparator areas	0.6	2.3	2.5
Change in business accessibility	-0.3	-0.4	-0.5
Change in labour market access	0.3	1.3	1.3
Lost value of agricultural land	-0.1	-0.9	-0.8
Digital benefits	0.0	3.0	3.5
Total productivity benefits	**0.5**	**5.3**	**6.0**
Sustainability benefits			
Tree canopy (air quality, GHG and flood mitigation/water quality)	0.0	0.2	0.2
Tree canopy health benefits	0.1	1.2	1.2
Native vegetation	0.0	0.4	0.4
Water quality	0.2	0.7	0.7
Building energy consumption	0.0	0.0	0.0
Social housing	0.0	0.0	0.0
Total sustainability benefits	**0.3**	**2.5**	**2.5**
Spillovers			
Congestion spillovers outside of the PIC area	-0.8	-3.1	-3.2
Vehicle pollution	-0.4	-1.3	-1.3
Total spillovers	**-1.2**	**-4.5**	**-4.5**
Total benefit	**3.9**	**15.5**	**15.9**
Benchmarks of costs of population growth			
Congestion imposed on others	0.6	2.5	2.5
Vehicle pollution from car congestion	0.3	1.1	1.1
Population driven infrastructure costs	Na	Na	Na
Population driven accessibility benefits	Na	Na	Na
Total benchmark	**0.8**	**3.6**	**3.6**
Overall metrics			
Net benefit without benchmarking	**-2.0**	**-0.2**	**0.5**
Net benefit with benchmarking	**-1.1**	**3.5**	**4.0**

Note: Using a 7 per cent discount rate. 'Current attributes' refers to current levels of accessibility, open space and other physical characteristics that would affect willingness to pay. Note that we do not present the benefit-cost ratio of each scenario since some benefits are measured net of costs, and thus capital and operating costs are not 'all-inclusive' of costs. For example liveability benefits are measured net of construction costs. Additionally, sustainability benefits are net changes, some of which are negative.

Source: CIE.

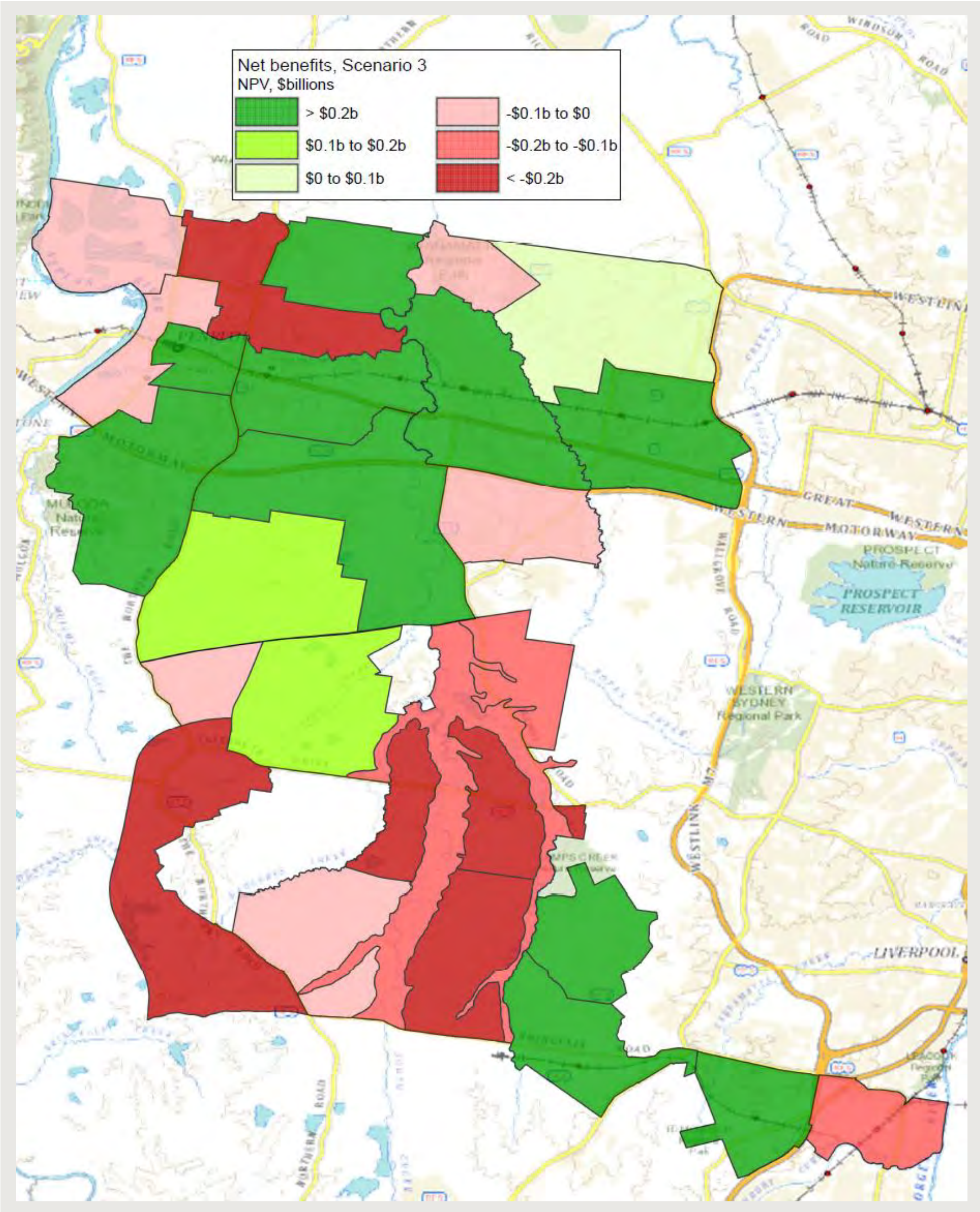
Spatially, the precincts which deliver most net benefits are those along the existing rail corridor in GPEC, Orchard Hills, the eastern precincts in PIC 1 (excluding Glenfield). The Aerotropolis Core only delivers net benefits in Scenario 2, where there is higher development in and around the Aerotropolis, however this scenario results in lower benefits for PIC 2 and overall.

8 Net benefits across both PIC areas — Scenario 2



Data source: CIE.

9 Net benefits across both PIC areas — Scenario 3



Data source: CIE.

Sensitivity analysis

We measure the sensitivity of net benefits for a range of alternative assumptions, including alternative discount rates and property value assumptions.

Net benefits vary significantly under these sensitivities, with the preferred scenario being either Scenario 1 or Scenario 2 depending on the case (table 10). For example, low discount rates or higher property benefits (due to rental growth) support Scenario 2 as the preferred scenario, while Scenario 1 is preferred under higher discount rates and lower population outcomes.

10 Sensitivity analysis of net benefits

Sensitivity test	Scenario 1	Scenario 2	Scenario 3
	$b, PV	$b, PV	$b, PV
Central case (discount rate 7 per cent)	0.6	0.5	0.1
Low discount rate (3 per cent) and residential IRR	2.1	6.1	2.7
High discount rate (10 per cent) and residential IRR	-2.2	-4.4	-4.0
Low stormwater costs	0.6	2.4	1.4
Lower population and jobs due to COVID	1.4	-0.2	-0.4
2019 DPIE population and job projections	1.4	0.4	0.1
Lower residential density	1.7	1.2	0.7
50% commercial/industrial rental premium from 2026	1.1	1.9	1.1
10 per cent increase in supply causes 1 per cent fall in prices	-0.6	-0.5	-0.9
1 per cent annual real growth in rents	2.2	6.1	4.5

Note: Net benefits are discounted and relative to the base case.

Source: CIE.

Higher population and jobs growth in Glenfield

Glenfield is a precinct in PIC 1 that is expected to have significant residential development. Scenario 3 has significantly greater growth than Scenario 2 in Glenfield. However both scenarios may understate the level of growth given recent take-up of development.

Campbelltown Council have provided a set of alternative population, dwelling and job growth assumptions that are intended to be more reflective of recent information about development.[2] We test the sensitivity of net benefits per person and job to higher growth in Glenfield. We have assumed that liveability, productivity, and sustainability benefits per person and job are the same in this alternate case for Glenfield's growth. Changes to Glenfield's growth will impact the cost per person and job relative to the base case, but the extent of this impact is uncertain.

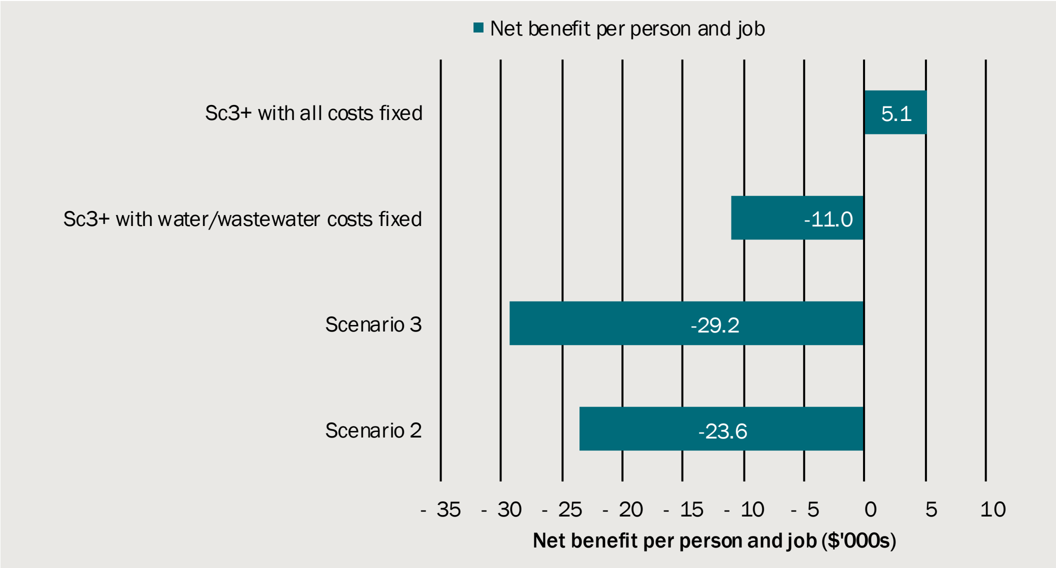
The costing of an alternative scenario for Glenfield would ideally be performed by agencies. Given time constraints, we have sought to model cost per person and job under Scenario 3+ using high-level assumptions about spare infrastructure capacity. Spare capacity in the wastewater infrastructure for Glenfield suggests that there will not be additional water/wastewater costs to accommodate Scenario 3+. We have not been able to assess the extent of additional costs for infrastructure other than water/wastewater under Scenario 3+.

The net benefit per person and job for Glenfield under these cases and Scenarios 2 and 3 is shown in table 11. There is a slight net benefit per additional person and job relative to

2 These have been supplied to CIE via GSC in a document named 'Glenfield PIC Assumptions Review.docx'.

the base case in Glenfield if all infrastructure costs are the same between Scenario 3 and Scenario 3+. If there were no additional water/wastewater costs only from Scenario 3+, there would still be a net cost from Glenfield under Scenario 3+.

11 Net benefit per person and job in Glenfield under Scenario 3+



Data source: CIE.

Staging and sequencing

The scale of developable land, the level of demand for jobs and housing and the cost of delivering infrastructure and services within the two initial PIC areas, necessitates a considered approach to sequencing growth with infrastructure over time.
Feedback received from some stakeholders during consultation on the PIC Pilot for Greater Parramatta and the Olympic Peninsula (GPOP), emphasised the need to consider sequencing options prior to determining a preferred option.

GSC have developed three staging and sequencing options in terms of the total amount of land serviced, location of development within the precincts and timing of land servicing. The staging and sequencing options are:

- Option 1: A maximum approach which allows for growth and development on multiple fronts, providing full flexibility on the location and quantum of land for development
- Option 2: A moderate approach that strategically locates land to be serviced and developed, and provides enough quantum for the market to flexibly determine optimal areas for development
- Option 3: A minimum approach where land enabled to serviced and developed is planned and provided as required to progressively meet the forecast growth and demand in few locations

GSC have conducted an evaluation of the staging and sequencing options they developed. The preliminary results from this evaluation, presented in the *Western Sydney PIC Preliminary Staging and Sequencing Scoping Paper*[3], are as follows:

- A maximum approach focussing on growth within most precincts, requires significant additional infrastructure and services to support growth and development, resulting in additional capital and operating costs and does not maximise the use of land around catalytic infrastructure such as the existing east west rail corridor and Wester Sydney Airport metro
- Both the moderate and minimum options strongly align with existing government policy and prioritise growth within key strategic centres and precincts, including around Penrith Centre, Kingswood and Werrington health and education precinct and St Marys

The moderate and minimum options were identified by GSC as having the strongest alignment with the GSC Staging and Sequencing principles.

Within-precinct staging and sequencing

The PIC scenarios which we have evaluated have been developed at the level of precincts. Within each precinct, there are a range of factors affecting the pattern of development that will be preferred, such as how accessibility changes and the costs to government of development within parts of a precinct.

CityPlan have undertaken an opportunities and constraints analysis to identify areas within precincts best-suited to support the anticipated growth. This approach and their findings are documented in their report *Precinct Analysis – Western Sydney PIC Development Sequencing*, which is an attachment to this report.

CityPlan's analysis found that greenfield land was more constrained than existing urban areas due to factors such as flood risk. Opportunities for beneficial development are highest in land within walking distance to existing or future infrastructure such as train/metro stations.

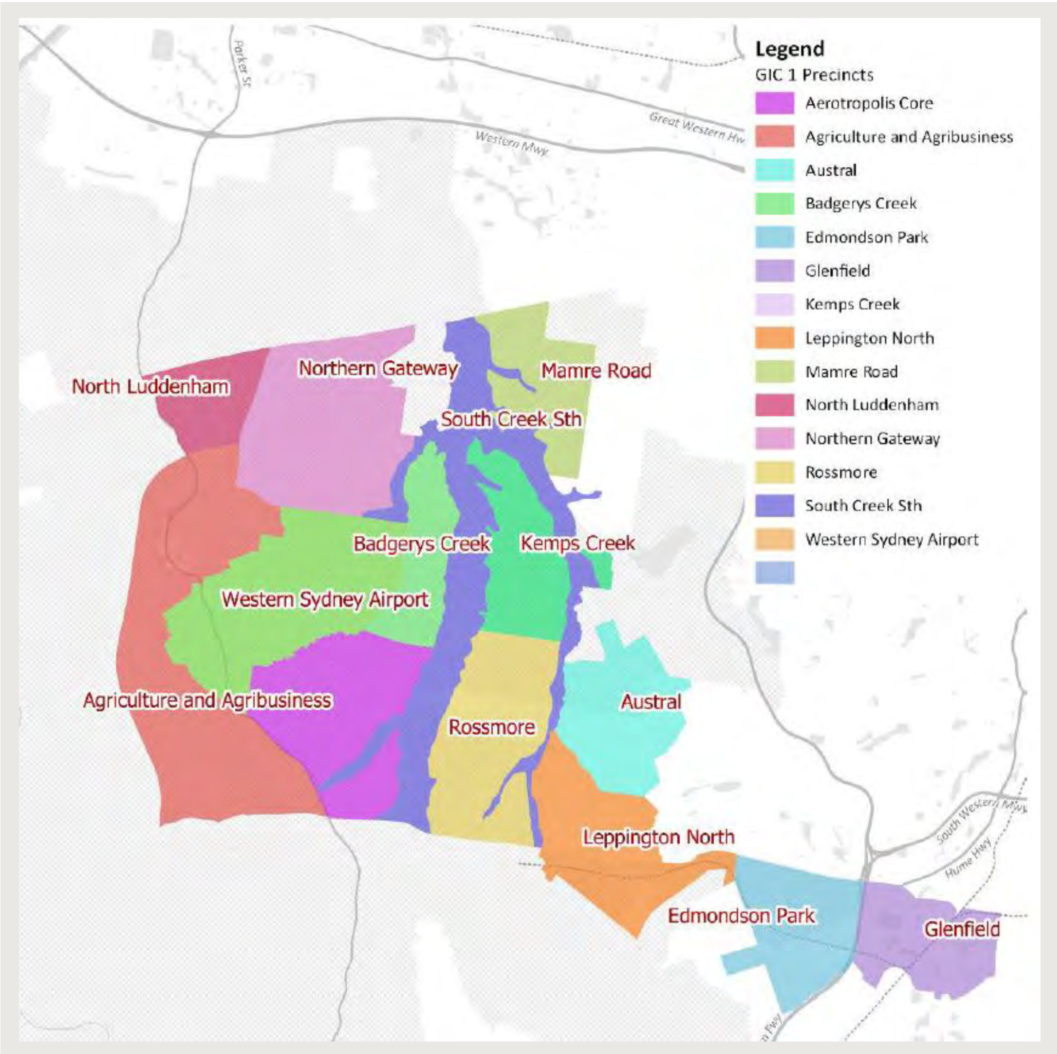
3 GSC, 2020, *Western Sydney PIC Preliminary Staging and Sequencing Scoping Paper v.0.06*, provided to CIE directly, unpublished.

1 Introduction

PIC 1 area

The area covered by this evaluation is Place-based Infrastructure Compact 1 (PIC 1) area (chart 1.1). The study area is primarily in rural land use with some urban development in the south east of the study area. Austral, Leppington North, Edmondson Park and Glenfield have already been rezoned for urban development.

1.1 Map of PIC 1 area



Data source: Greater Sydney Commission.

The PIC 1 area housed an estimated 25 000 people in 8 000 dwellings in 2016, with around 8 000 jobs. A detailed stocktake of the area is set out in the next chapter.

This project

The project aims to:

- compare different scenarios for development in Western Sydney to examine the costs and benefits of different development patterns
- compare difference staging and sequencing scenarios across and within precincts to understand the choices facing Government in the timing and location of when land is released, and infrastructure that is required. This will be used to inform the preferred staging and sequencing plan to be taken forward for further review in a strategic business case.

The project is part of a broader program to undertake Place Based Infrastructure Compacts to inform infrastructure and land use change across Sydney. The project will support this broader work plan by bringing out lessons for how this process can operate in the future. The lessons have been collated into the evaluation framework report and are not included in this report.

Methodology

The methodology for the project is based on the Evaluation Framework developed by the CIE for the Greater Sydney Commission (GSC). This framework seeks to build a logical system to understand what the impacts are for different land use scenarios and what values can be placed on these impacts. The Framework was updated to incorporate lessons learnt from the GPOP PIC and SBC.

The framework sits within a Cost Benefit Analysis (CBA) framework. CBA is the typical method currently used in NSW for assessment of alternative policy options and infrastructure choices across all areas of Government.[4] It generally focuses on direct effects of policies and infrastructure, such as time savings and cost savings and is undertaken on a project-by-project basis. The referent group for this CBA is the community of NSW.[5]

CBA is used as the basis for evaluating the merits of alternative decisions regarding ‘places’ and could include, for example, which region to develop first, the timing of the development, the ‘optimal’ level of density for the area and the infrastructure needed to support the development. The analysis needs to consider implications of decisions within the PIC 1 area on areas outside of the project area.

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4 NSW Treasury has issued CBA Guidelines (March 2017) which are required to be utilised by agencies in their deliberations. https://arp.nsw.gov.au/sites/default/files/TPP17-03_NSW_Government_Guide_to_Cost-Benefit_Analysis_0.pdf

5 Construction and development costs are ultimately borne by residents and businesses locating in the PIC area.

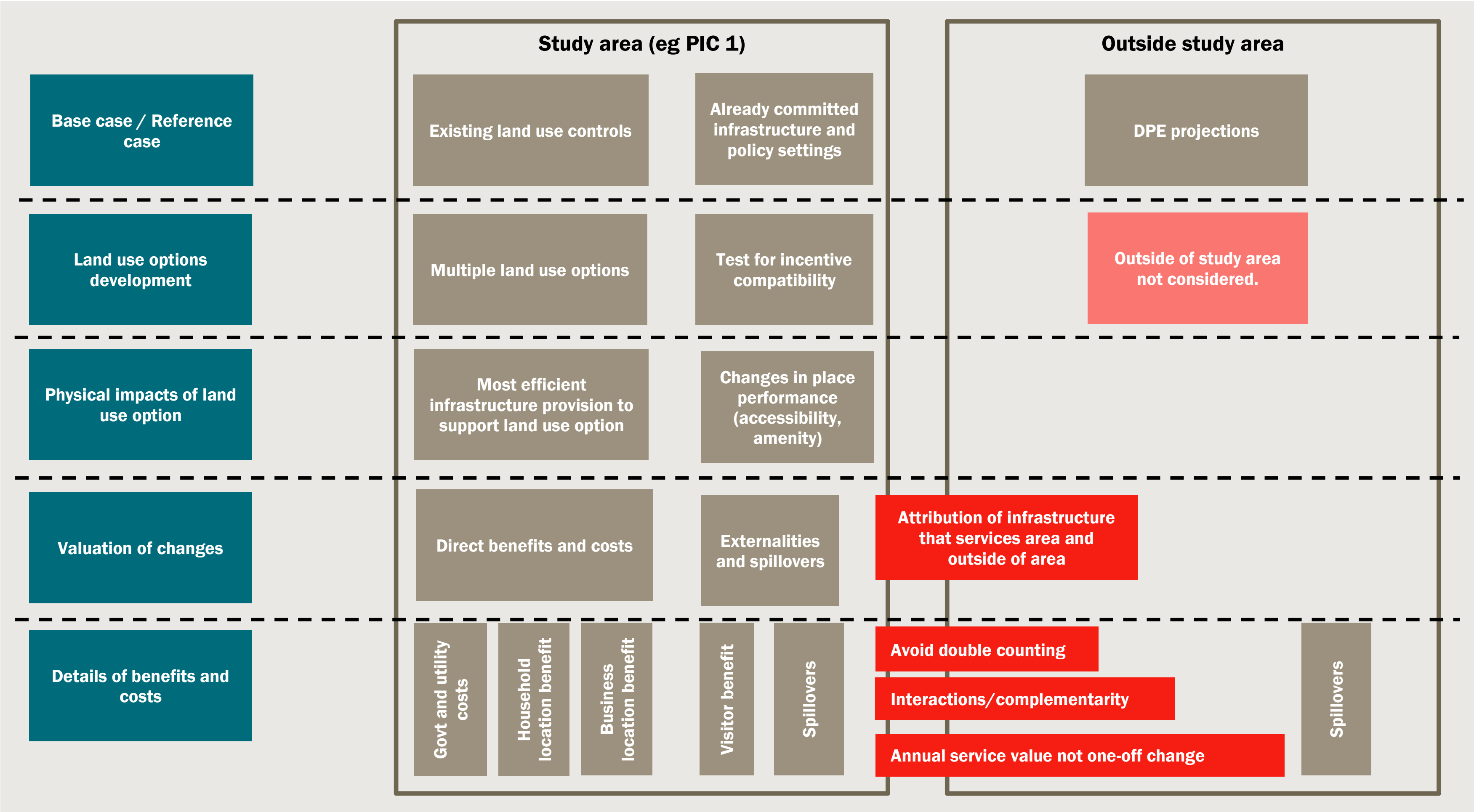
The key steps for CBA are set out in box 1.2.

1.2 Key steps in a CBA

- **Articulating the decision that the CBA is seeking to evaluate**. For example, in relation to options considered by the GSC, the decision relates to the amount and timing of development and infrastructure provision. The way in which the CBA is framed and the information requirements will differ depending on the decision being evaluated.
- **Establishing the base case** against which to assess the potential economic, social and environmental impacts of changes. It will need to consider the strategic context, the constraints within existing infrastructure/services and the preferences of people and businesses as to where they want to locate and what drives their location decisions. The base case encapsulates the outcomes that would occur in the absence of changes in land use regulations and additional infrastructure investment.
- **Quantifying the changes** from the base case resulting from the possible scenarios being considered. Each scenario will comprise a set of land use outcomes over time (e.g. dwelling and employment typologies and take-up rates) and a set of Government infrastructure requirements to support the scenario. The changes may be known with certainty or could also be defined in probabilistic terms. The quantification should focus on key changes that will be utilised in the valuation stage.
- **Placing values on the changes** and aggregating these values in a consistent manner to assess the outcomes.
- **Generating the Net Present Value (NPV) of the future net benefits stream**, using an appropriate discount rate, and deciding on the Decision Rule on which to assess the different options. The best decision rule is to choose the scenario that has the highest net benefits.
- **Undertaking sensitivity analysis** on a key range of variables, given the uncertainties related to specific benefits and costs, especially willingness to pay.
- **Review and Monitoring** of impacts, benefits and costs to ensure transparency and accountability, and comparison against expectations.

The overall components of the evaluation framework are illustrated in chart 9.7. The framework is set out in detail in a separate report *Framework for place-based evaluation.*

1.3 Overall components of the evaluation framework to be applied at each decision stage for a place



Source: CIE.

2 Stocktake of the PIC 1 area

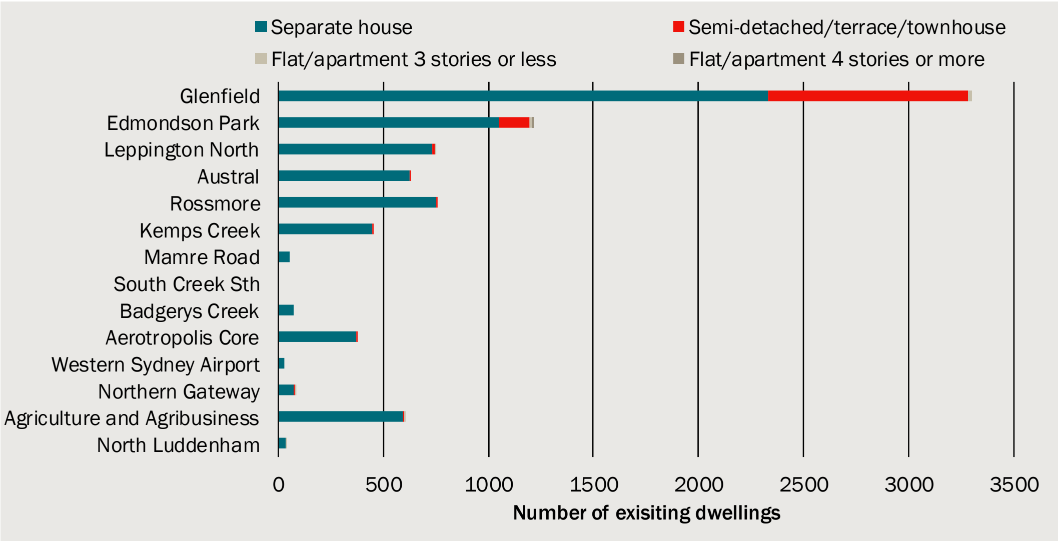
- **The PIC 1 area is currently dominate by rural and agricultural land use. Existing development is concentrated in precincts in the east of the study area.**

Dwelling structures

The extent of existing housing in the PIC 1 area is limited by the existing rural and agricultural land uses, which do not enable urban housing patterns. In 2016, there were approximately 8 300 dwelling in the PIC 1 area, of which just more than half are located in the partially developed precincts of Glenfield and Edmondson Park (Chart 2.1).

Most dwellings in the PIC 1 area are detached houses, which is as expected given the predominantly rural and agricultural land use. Around 13 per cent of dwellings are semi-detached dwellings which are almost all located in Glenfield and Edmondson Park. Currently there are a negligible number of apartments in the PIC 1 area.

2.1 Number of dwellings by precinct and dwelling typology



Note: Dwelling types are based on dwelling typology shares from the 2016 census for SA2 geographies. These are converted to precinct level dwelling shares by mapping SA2 geographies to precincts based on area. This assumes that dwellings are uniformly distributed across precincts.

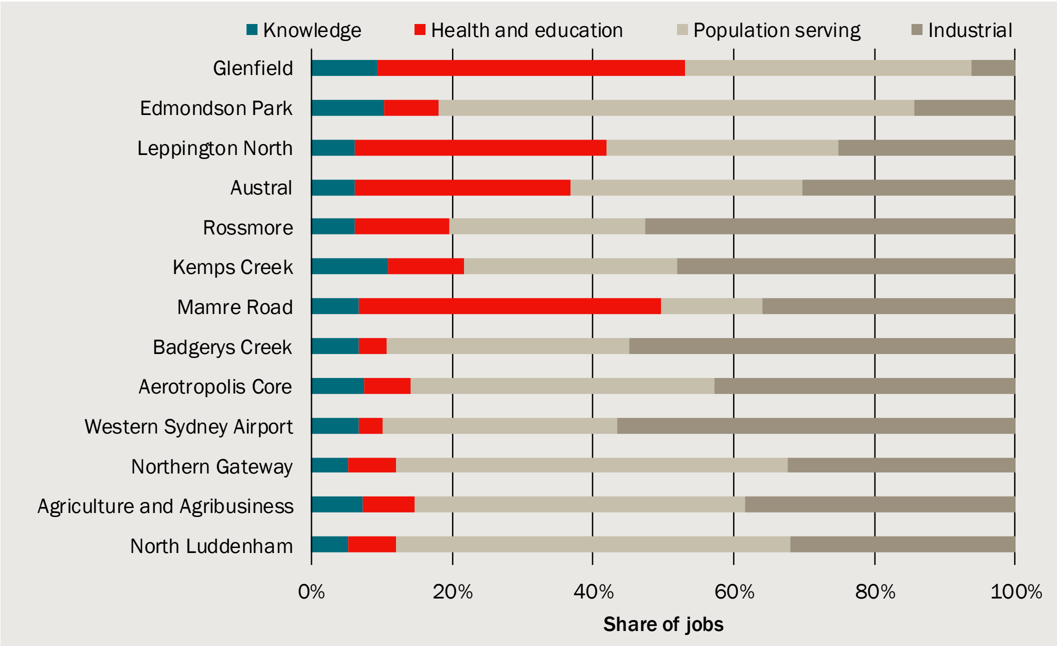
Data source: ABS TableBuilder, Australian Census 2016, SGS.

Industry structures

Across the PIC 1 areas the share of knowledge jobs is low, around or below 10 per cent of total employment (chart 2.2). Employment across the other industry categories is generally evenly distributed with around 28 per cent of jobs accounting belonging to the population servicing and industrial industries respectively and 37 per cent belonging to education and health industries.

Across precincts there is a large amount of variation. For instance, Glenfield, Austral, Leppington North and Mamre road have relatively large shares of health and education employment, which appears to be due to these precincts being located nearby to the urban fringe. Similarly, other precincts, such as Rossmore and Badgerys Creek have a high share of industrial jobs, which appears to be related to the agricultural activities in these precincts.

2.2 Industry structure by precinct, 2016



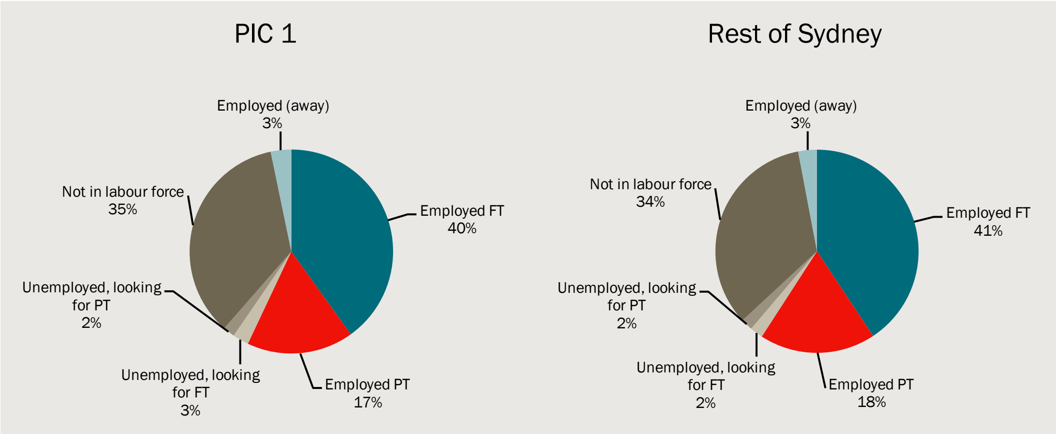
Note: South Creek is excluded from this chart as there are no jobs located in the precinct.

Data source: SGS, CIE.

Jobs and wages

In 2016, labour force outcomes were similar across the PIC 1 area, and was also broadly in line with the rest of Sydney (chart 2.3).

2.3 Comparing PIC 1 labour force characteristics to the rest of Sydney (2016)



Note: analysis excludes 'not applicable' and 'not stated' categories; PT=Part time; FT= Full time.

Data source: ABS TableBuilder, Australian Census 2016, place of usual residence, by SA2,

In 2016, the largest sectors in the PIC 1 were industrial sectors, of which around half were machinery operators and drivers and labourers (chart 2.4). In contrast around 70 percent of health and education employers were professionals or clerical and administrative workers. Occupations were generally evenly distributed for the remaining population and serving and knowledge industries.

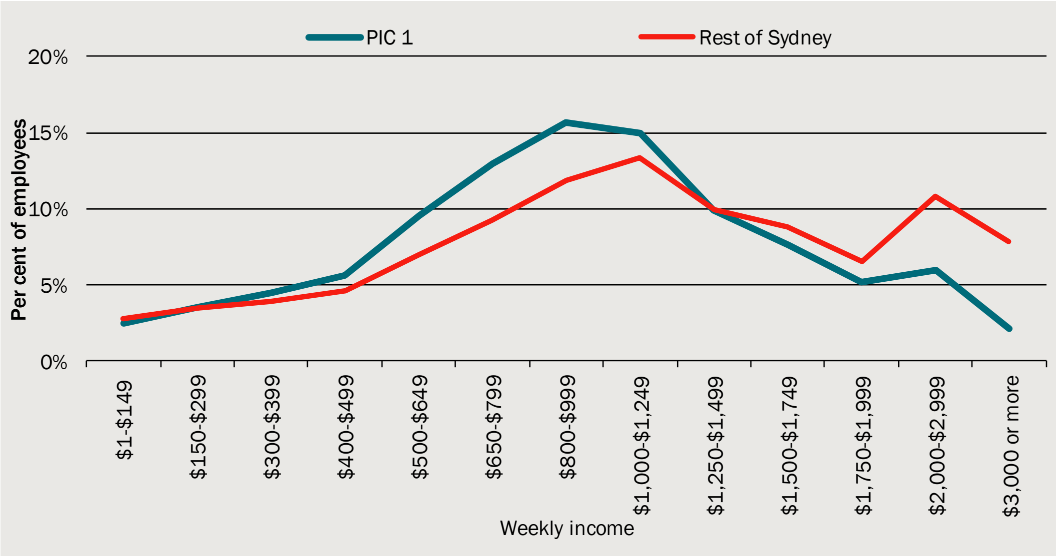
2.4 Occupation type by industry in PIC 1, 2016

Note: Industrial includes: Agriculture, Forestry and Fishing, Mining, Manufacturing, Electricity, Gas, Water and water services, Transport, postal and warehousing and Wholesale trade; Population serving includes: Construction, accommodation and food services, retail trade, arts and recreation services and Other services; Health and education includes: Education and training and Healthcare and social assistance; Knowledge intensive includes: Information, media and telecommunications, financial and insurance services, rental, hiring and real estate services, professional scientific and technical services, administrative and support services and Public administration and safety; Unknown includes: Inadequately described, not stated and not applicable.

Data source: TableBuilder, Australian Census 2016, by 2016 place of work.

In 2016, income distribution for the PIC 1 area was slightly skewed to the left compared to all of Sydney. This suggests lower income in the PIC 1 on average for existing PIC 1 residents compared to Sydney as a while.

2.5 Probability distribution function by weekly income



Data source: TableBuilder, Australian Census 2016.

Amenities

As presented in table 2.6, there are limited amenities currently in the PIC 1 area. This reflects the current land use in the area – urbanisation and development of the PIC 1 will need to be enabled by the provision of amenities the costs of which are considered in the PIC analysis.

2.6 Amenities in PIC 1

Health	Education	Entertainment and culture	Recreation	Retail
No hospitals within the precinct – serviced by Liverpool, Campbelltown, Fairfield and Nepean Hospitals, as well as those which serve metropolitan Sydney (e.g. Children's Hospital at Westmead)	5 primary schools within in the PIC 1 area and a further 2 which service parts of the area	Aboriginal Cultural Heritage sites and objects located throughout the PIC 1 area	Range of sports facilities including: ▪ Ovals ▪ Multisport facilities ▪ Lawn bowls ▪ Netball and tennis courts Athletics tracks	Limited retail locations in the PIC 1 area
Bringelly Early Childhood Health Centre and Community Nursing Service	TAFE NSW Glenfield campus services the PIC 1 area	Some local level facilities, including: community centres and licensed venues.	There is little formalised passive and active public open space	
		No libraries or regionally significant infrastructure		

Source: GSC.

3 Scenarios for PIC 1

- **Three land use scenarios, plus a base case, have been developed which reflect differences in zoning controls, enabling infrastructure and demand:**
  - **The base case assumes current zoning controls, and committed and approved infrastructure**
  - **Scenario 1 assumes current zoning controls, base case infrastructure plus additional uncommitted infrastructure**
  - **Scenarios 2 and 3 assume new zoning controls, base case infrastructure plus additional uncommitted infrastructure. The two scenarios reflect different demand outcomes.**

Three land use scenarios have been developed for the Western Sydney PIC 1. Each scenario comprises:

- a set of land use outcomes over time, such as dwelling and employment typologies and take up, and
- a set of Government infrastructure requirements to support the scenario.

For this PIC the process of scenario development has consisted of first identifying land use scenarios and second identifying the infrastructure which is necessary and sufficient to support the scenario.

Scenario 1 has been developed based on the current zoning controls, but with some infrastructure investments to enable development in excess of the base case. Scenarios 2 and 3 assume changes in zoning controls, which allow additional development compare to both the base case and scenario 1. These two scenarios were developed based on the same zoning controls but with different demand outcomes affecting the timing and location of uptake. The land use, together with the infrastructure requirements in scenarios 2 and 3 reflect two possible states of the world in terms of demand, which is exogenous and uncertain in the future. In addition to these scenarios, a base case scenario was developed which is the no policy change scenario with no further rezoning other than what is already approved and committed.

For this analysis, additional staging and sequencing scenarios have been developed which are used to assess within precinct staging and sequencing across the precincts.

This chapter assesses the constraints and drivers of development in the Western Sydney PIC 1 area, summarises the land use and infrastructure scenarios, and assesses whether there is a nexus between land use and infrastructure.

Development driver of the PIC 1 area

The PIC 1 area is being considered as a location for development. The path of development in partially dependent on the extent to which development is constrained and how infrastructure can alleviate constraints.

The key factor constraining growth in the PIC 1 area is the absence of the fundamental infrastructure required to enable urban development. Most of the study area is greenfield and with current land use characterised by rural uses. Enabling growth in the PIC 1 area will mean providing enabling infrastructure in the PIC 1 area, as well as addressing constraints in existing infrastructure that serve the region.

3.1 Constraints on PIC 1's growth

Sector	Contraints
Transport	▪ Current transport network not suitable for urban development, with limited road and public transport infrastructure
Education	▪ Education facilities do not have enough capacity to support urban development
TAFE	▪ No constraints
Health	▪ Provision of community health facilities and ambulance stations required for growth
Water and energy	▪ Little existing water and energy infrastructure due to rural land use
Open space	▪ Lack of passive and active open space, tree canopy and native vegetation
Emergency Services	▪ New fire stations required
Social Housing	▪ No constraint
Arts and culture	▪ Little arts and culture infrastructure in the PIC 1 area given rural land use
Justice	▪ Some additional courtrooms required. Correction facility capacity is not a constraint.
Waste	▪ Little constraint – constraints are emerging across Sydney

Source: GSC, CIE.

Constraints are sometimes relatively easily addressed by additional infrastructure and at other times are difficult to address due to physical limitations. For example, road network capacity is very expensive to increase when the urban form has already developed around existing roads. That is, widening roads in areas where there are existing buildings involves loss of value of dwellings that have to be demolished.

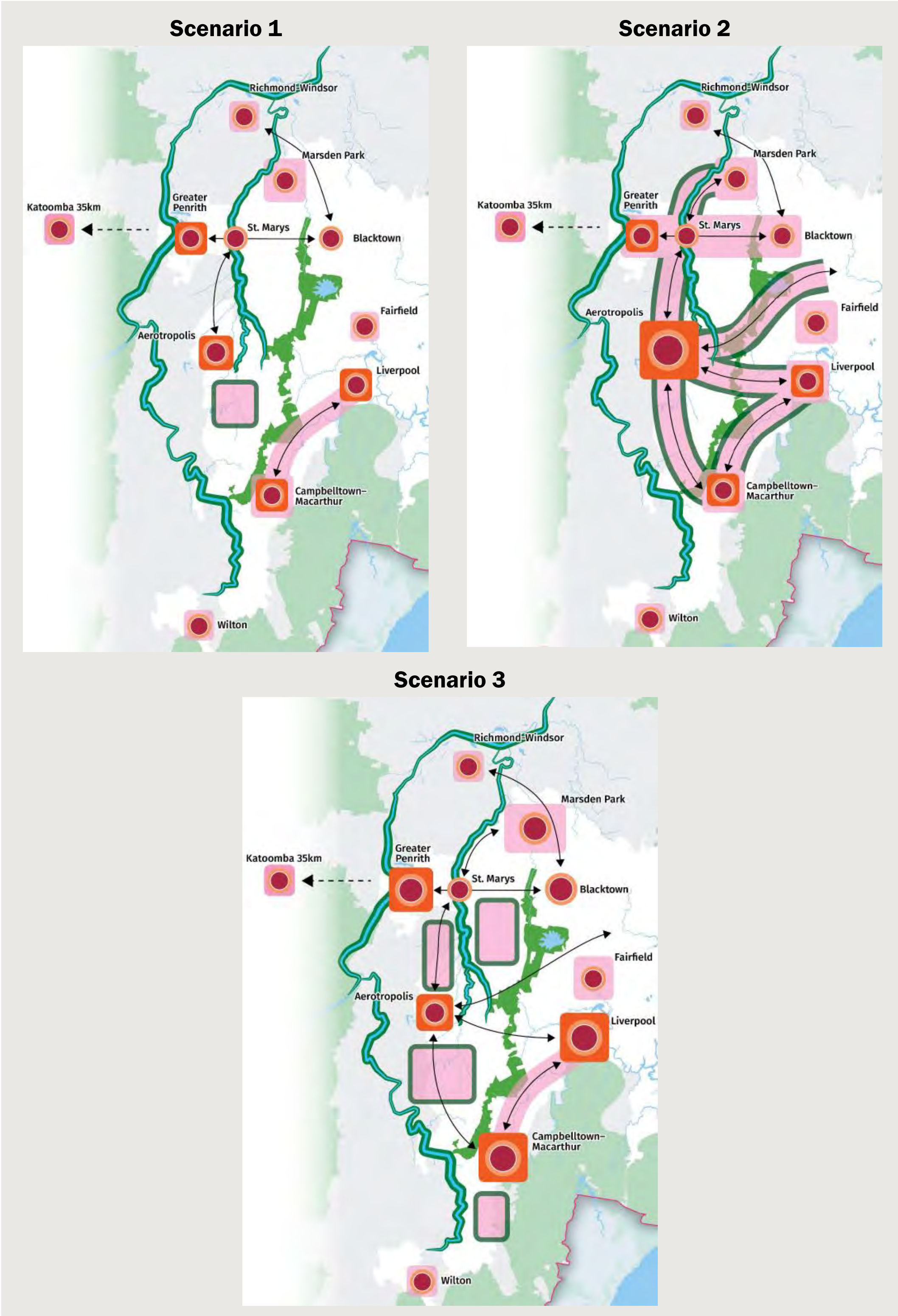
Land use scenarios

The three land use scenarios developed by the GSC have the same zoning controls; differences in land use outcomes (population, dwellings and jobs) across the scenarios appear to be mostly driven by assumed differences in demand (chart 3.2). These are compared to a base case scenario.These have been generated by the GSC based on possible take-up of land across precincts.

- **Scenario 1** has assumed no further zoning changes, beyond what is already approved.[6]This scenario allows for some infrastructure developments above which has been already approved or committed, which enables development to occur in excess of the base case. This sees
  – housing growth is limited to existing metropolitan clusters such as Penrith, Liverpool and Campbelltown-Macarthur with the exception of the Aerotropolis
  – limited employment growth focused on the Western Sydney Airport and already developed or rezoned areas in Western Sydney.
- **Scenario 2** has focused on the realisation of the Western Parkland City vision with the Western Sydney Aerotropolis as the focus of growth. This sees:
  – housing growth focused on renewal in existing communities with new infill opportunities provided by the initial precincts of the Aerotropolis and developing around newly provided metro stations, between St Marys and the Aerotropolis with other new transport links assumed in Future Transport 2056
  – strong jobs growth around the Aerotropolis supported by steady growth with existing metropolitan centres and employment areas.
- **Scenario 3** has focused on a different growth pattern for Western City where there is greater development and more jobs focus within existing metropolitan and strategic centres, and a more dispersed settlement pattern into the greenfield areas. This sees:
  – housing growth is focused on the development of existing greenfield communities such as the South West and North West Growth Areas, with other new transport links provided as per Future Transport 2056
  – jobs growth in the Western City overall under this scenario is reduced compared to Scenario 1 as the impetus for a shift in jobs to the west is smaller with a less attractive Aerotropolis.

6 Scenario 1 was the original base case in this analysis. See appendix A for a further discussion of this scenario and how the base case was constructed.

3.2 Land use scenarios



Data source: GSC.

These scenarios were provided to infrastructure providers to inform cost workbook submissions.

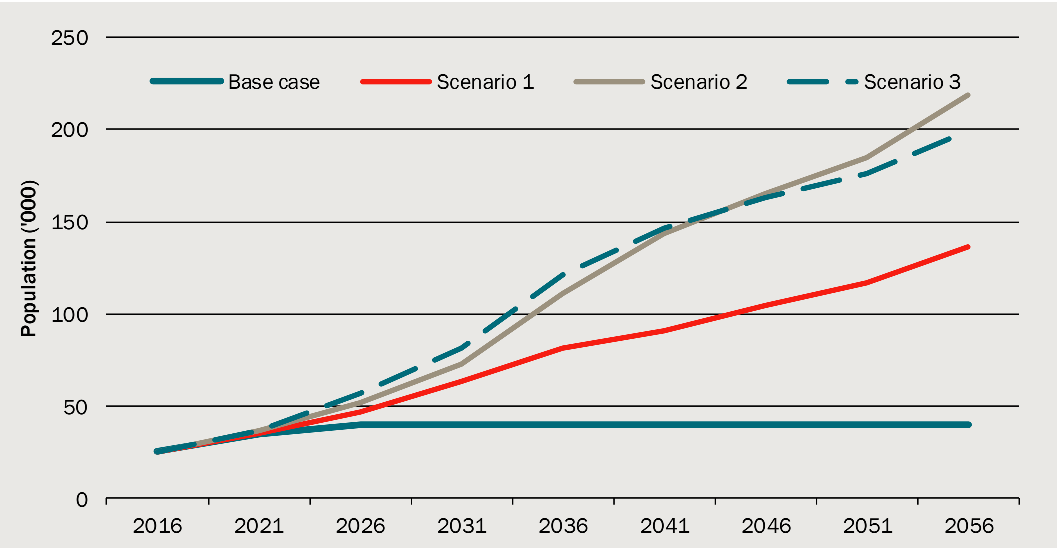
Total population growth varies little between scenarios 2 and 3, which allow for rezoning of land in PIC 1, but is significantly higher than scenario 1 and base case (chart 3.3). This is because the base case and scenario 1 assume land zoning remains at current controls. The difference between scenario 1 and the base case is due to capacity constraints on the existing zoning being alleviated.

PIC 1 populations are expected to increase from 25 000 in 2016 to:

- 39 700 in the base case by 2056 (an increase of 14 400 people)
- 136 000 in scenario 1 by 2056 (an increase of 111 000 people)
- 219 000 in scenario 2 by 2056 (an increase of 193 000 people)
- 199 000 in scenario 3 by 2056 (an increase of 174 000 people)

Also, while population growth is very similar across scenarios 1 and 2 across the entire PIC 1 area, there is considerable variation in the distribution of growth across precincts.

3.3 Population residing in PIC 1 by scenario



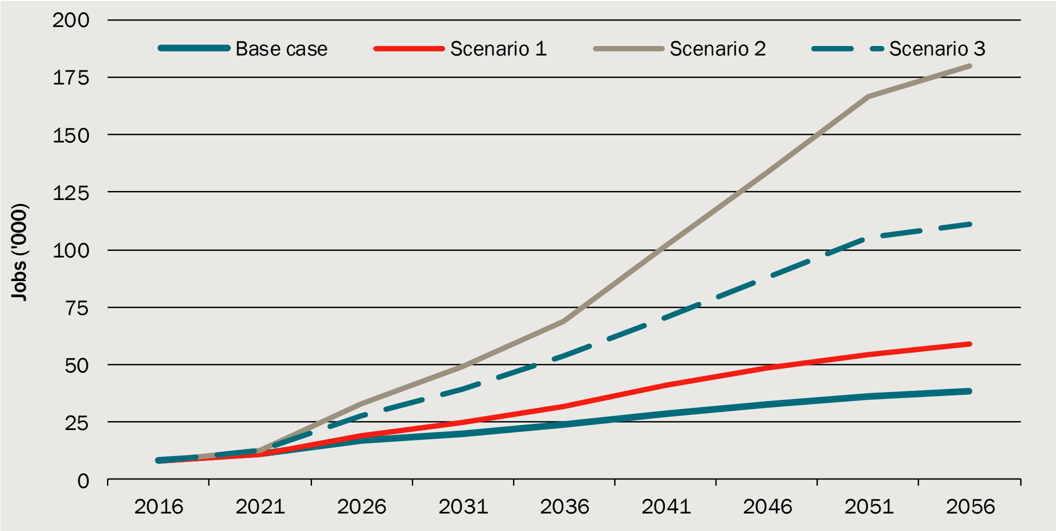
Data source: GSC.

Total employment growth across PIC 1 is more variable between scenarios (chart 4. By 2056, forecast employment in scenario 1 is 3 times larger than the base case and around 60 per cent greater than scenario 2. Scenario 1 is assumed to result in greater job growth, as businesses located at the Aerotropolis an around infrastructure.

PIC 1 jobs are expected to increase from 8 000 in 2016 to:

- 59 000 in the base case by 2056 (an increase of 51 000 jobs)
- 59 000 in scenario 1 by 2056 (an increase of 51 000 jobs)
- 180 000 in scenario 2 by 2056 (an increase of 172 000 jobs)
- 111 000 in scenario 3 by 2056 (an increase of 103 000 jobs)

3.4 Jobs in PIC1 by scenario



Data source: GSC.

The level and growth in land use measures between 2016-2056 are summarised in table 3.5.

Population increases from 25 000 in 2016 to 136 000 under scenario 1 and 219 000 under Scenario 2. Growth is occurring off a low base and implies a 439 per cent increase in population under scenario 1 and a 765 per cent increase under Scenario 2.

Dwellings growth is very similar to population growth, with the differences between growth under the base case, Scenario 1 and Scenario 2 being significantly larger than the differences between Scenario 1 and 2. The difference between dwelling growth and population growth is driven by assumed changes in occupancy rates which are expected to fall from 3.03 persons per dwelling to 2.96 in 2056.[7]

The increase in the number of jobs in PIC 1 is larger than the increase in population, with jobs increasing from 8 000 in 2016 to 59 000 in 2056 under the base case and 180 000 in scenario 1. Scenario 2 also has a rapid increase in jobs. As the number of jobs in PIC 1 are expected to increase by more than the increase in population, job per person (grow faster than population,

Across dwellings, population and jobs the base case expects significantly lower growth than any of the scenarios, as growth is constrained by the limited infrastructure in the PIC 1 area. Jobs per person is higher in the base case, which appears due to jobs related development associated with the Western Sydney Airport and Aerotropolis proceeding to some extent, while residential development is limited. The increase in jobs per population is small for the other options due to there being more housing growth in these scenarios.

7 Note average household size is assumed to increase from 2016 to 2021 before falling to 2056.

3.5 Land use scenarios for PIC 1

Measure	Scenario	Level					Difference relative to 2016			
		2016	2026	2036	2046	2056	2026	2036	2046	2056
							%	%	%	%
Population ('000s of people)	BC	25	40	40	40	40	57	57	57	57
	Sc1		47	81	104	136	85	222	312	439
	Sc2		52	111	165	219	105	340	552	765
	Sc3		57	121	163	199	124	378	544	688
Dwellings ('000s of dwellings)	BC	8	13	13	13	13	56	57	57	57
	Sc1		15	28	36	46	85	231	326	452
	Sc2		17	38	56	74	105	360	575	788
	Sc3		19	41	55	67	122	393	562	708
Jobs ('000s of jobs)	BC	8	17	24	33	38	110	197	307	376
	Sc1		19	32	48	59	141	298	503	636
	Sc2		33	69	134	180	311	758	1569	2145
	Sc3		28	54	88	111	245	568	993	1288
Jobs per person	BC	0.32	0.42	0.60	0.82	0.96	34	89	159	203
	Sc1		0.41	0.39	0.46	0.43	30	24	46	37
	Sc2		0.63	0.62	0.81	0.82	100	95	156	160
	Sc3		0.49	0.44	0.54	0.56	54	40	70	76

Source: GSC, CIE.

Transport and accessibility

Current levels of transport accessibility across the PIC area are shown spatially in chapter 5.

Spatial distribution of growth

The land use scenarios developed vary considerably in the distribution of growth across precincts. The main difference between the scenarios is the strength of growth in precincts, as opposed to the distribution of growth across precincts. The growth rates across the precinct are relatively high as growth occurs from a very low base; across the PIC 1 area there were around 25 000 residents in 2016.

Table 3.6 shows the average annual population growth and the share of total growth across PIC 1 area. Population growth across all scenarios is expected to be strongest in Northern Gateway, Austral, Leppington North and Edmondson Park. Population growth in the Aerotropolis Core, Rossmore and North Luddenham is significantly higher under scenario 2 and 3 than in scenario 1 and the base case. Without the rezoning, population growth in these precincts would be very subdued.

The share of growth across the precincts reflects the change in focus across the scenarios:

- Scenario 1, compared to the base case, has a smaller proportion of total growth across the PIC area in the already rezoned precincts of Austral, Leppington North, Edmondson Park and Glenfield. Despite this, the majority of growth is expected to occur in these precincts in scenario 1.
- Scenario 2, compared to scenario 1, has a larger share of total growth in the Aerotropolis Core and Rossmore.
- Scenario 3, compared scenario 2, has less development around the Aerotropolis Core, and more growth in the already rezoned precincts. Compared to the base case however scenario 2 has a greater share of development around the Aerotropolis Core and the other areas rezoned in the scenarios.

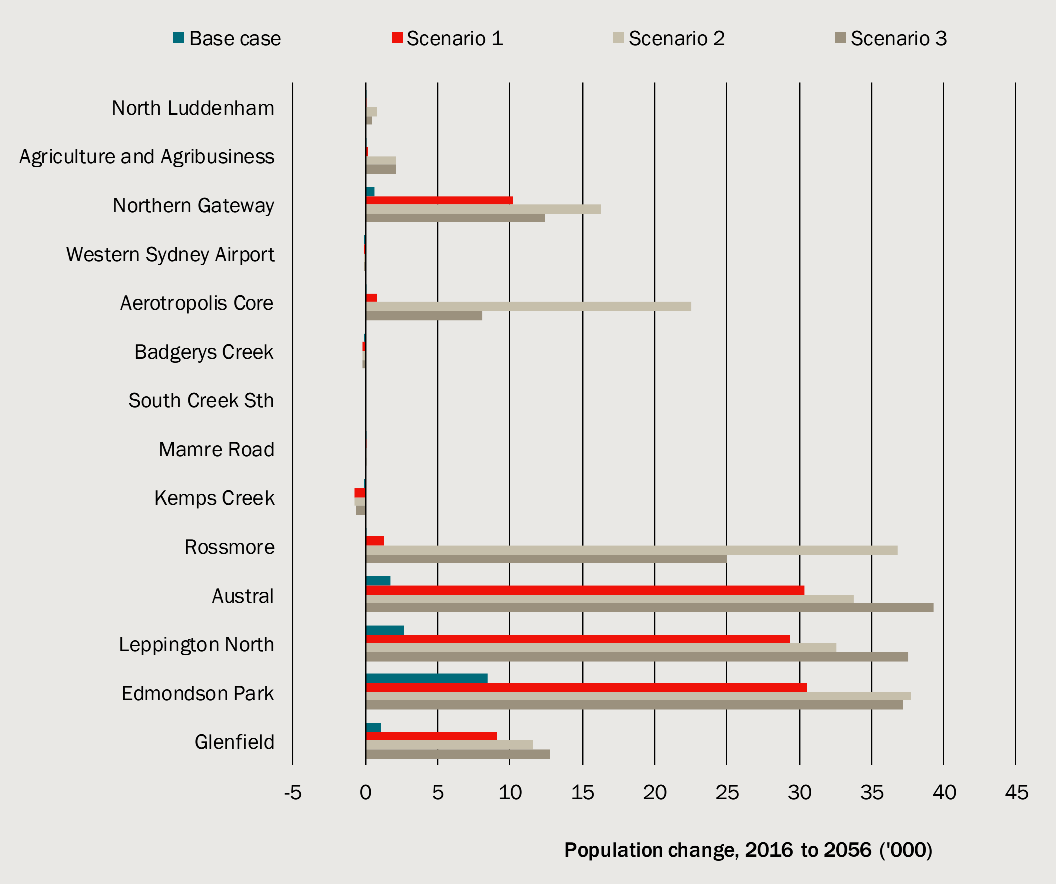
3.6 Population by precinct

	Average annual growth (2016-2056)				Share of total growth			
	BC	Sc1	Sc2	Sc3	BC	Sc1	Sc2	Sc3
		Per cent	Per cent	Per cent		No.	No.	No.
North Luddenham	0.0	0.9	5.7	4.2	0.0	0.0	0.4	0.2
Agriculture and Agribusiness	0.0	0.3	2.0	2.0	0.1	0.2	1.1	1.2
Northern Gateway	3.1	9.8	11.1	10.4	4.1	9.2	8.4	7.1
Western Sydney Airport	-0.6	-6.3	-6.3	-5.9	-0.1	0.0	0.0	0.0
Aerotropolis Core	0.1	1.2	7.6	5.1	0.2	0.7	11.7	4.7
Badgerys Creek	-0.3	-6.1	-5.0	-5.0	-0.2	-0.2	-0.1	-0.1
South Creek Sth	NA	NA	NA	NA	0.0	0.0	0.0	0.0
Mamre Road	0.0	0.1	0.7	0.6	0.0	0.0	0.0	0.0
Kemps Creek	-0.1	-2.0	-1.9	-1.6	-0.3	-0.7	-0.4	-0.4
Rossmore	0.0	1.1	7.2	6.3	0.1	1.2	19.0	14.4
Austral	1.8	7.7	7.9	8.3	12.1	27.4	17.5	22.6
Leppington North	2.1	7.1	7.3	7.7	18.1	26.4	16.9	21.6
Edmondson Park	2.9	5.5	6.0	6.0	58.5	27.5	19.5	21.4
Glenfield	0.3	1.6	2.0	2.1	7.3	8.2	6.0	7.3
Total	1.1	4.3	5.5	5.3				

Source: GSC, CIE.

Chart 3.7 shows the change in population between 2016 and 2056 under the scenarios and the base case. The majority of increase in population will occur in the already zoned precincts of Austral, Leppington North and Edmondson Park under all scenarios. The main difference between the scenarios is the amount of development in Rossmore and the Aerotropolis Core.

3.7 Population change, 2016 to 2056



Note: Calculated as the contribution to PIC area growth between from 2016 to 2056 divided by total growth from 2016 to 2056.
Data source: GSC, CIE.

Table 3.8 shows the average annual jobs growth and the share of total growth across PIC 1 area. Across all scenarios, jobs growth is expected to be strongest in the Western Sydney Airport precinct, which includes development of the airport in the base case. Scenarios 2 and 3 both assumed significantly stronger jobs growth across precincts compared to the base case, with particularly large differences for Aerotropolis Core.

The share of growth across the precincts reflects the change in focus across the scenarios:

- Scenario 1, compared to the base case, has a smaller share of jobs going into the already rezoned precincts of Austral, Leppington North and Edmondson Park and a larger proportion in the Aerotropolis Core.
- Scenario 2, compared to scenario 1, has a lower share of total jobs in the Western Sydney Airport precinct as the increase in jobs in this precinct in scenario 2 is proportionally smaller than the total increase in jobs across the PIC 1 area.
- Scenario 3, compared scenario 2, has less development around the Aerotropolis Core, and more growth in the already rezoned precincts and the Western Sydney Airport. This pattern is broadly in line with the population changes. Compared to the base case however scenario 3 has a greater share of development around the Aerotropolis Core and the other areas rezoned in the scenarios.

3.8 Job growth by precinct

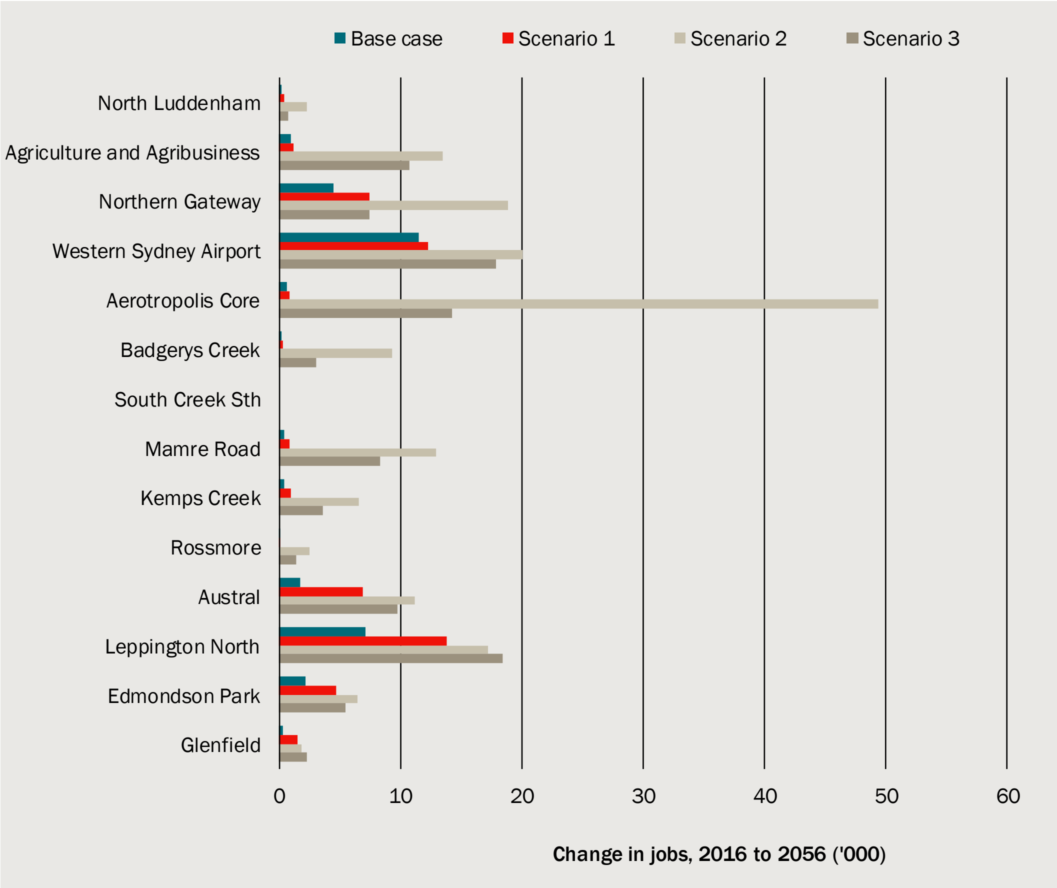
	Average annual growth (2016-2056)				Share of total growth			
	BC	Sc1	Sc2	Sc3	BC	Sc1	Sc2	Sc3
	Per cent	Per cent	Per cent	Per cent		Per cent	Per cent	Per cent
North Luddenham	3.6	4.6	9.1	6.2	0.8	0.7	1.3	0.7
Agriculture and Agribusiness	3.4	3.8	9.8	9.2	3.0	2.2	7.9	10.4
Northern Gateway	8.0	9.3	11.8	9.3	15.0	14.5	11.0	7.2
Western Sydney Airport	19.9	20.1	21.6	21.3	38.0	24.0	11.7	17.3
Aerotropolis Core	1.7	2.2	11.7	8.3	2.0	1.7	28.7	13.8
Badgerys Creek	2.3	2.6	10.8	7.9	0.8	0.5	5.4	3.0
South Creek Sth	NA	NA	NA	NA	0.0	0.0	0.0	0.0
Mamre Road	1.5	2.4	8.4	7.3	1.4	1.6	7.5	8.0
Kemps Creek	1.1	1.9	5.6	4.2	1.5	1.9	3.8	3.5
Rossmore	0.1	0.4	3.5	2.5	0.1	0.3	1.5	1.3
Austral	4.2	7.4	8.6	8.3	5.8	13.4	6.5	9.4
Leppington North	4.9	6.5	7.0	7.2	23.4	27.0	10.0	17.8
Edmondson Park	4.9	6.8	7.5	7.1	7.3	9.3	3.8	5.3
Glenfield	0.3	1.2	1.5	1.7	0.9	2.9	1.1	2.2
Total	**4.0**	**5.1**	**8.1**	**6.8**				

Source: GSC, CIE.

Chart 3.9 shows the change in jobs between 2016 and 2056 under the scenarios and the base case. Where growth occurs depends largely on the scenario.

- The base case and scenario 1 expects to see very modest jobs growth across all precincts.
- Scenario 2 sees jobs increases across all precincts, compared to the base case, but the largest increase occurs in Aerotropolis Core Precinct with 49 000 additional jobs by 2056.
- Scenario 3 sees significantly lower jobs around Aerotropolis Core compared to scenario 2; this accounts for around half of the difference in jobs between scenario 2 and 3.

3.9 Change in jobs by precinct, 2016 to 2056



Note: Calculated as the contribution to PIC area growth between from 2016 to 2056 divided by total growth from 2016 to 2056.
Data source: GSC, CIE.

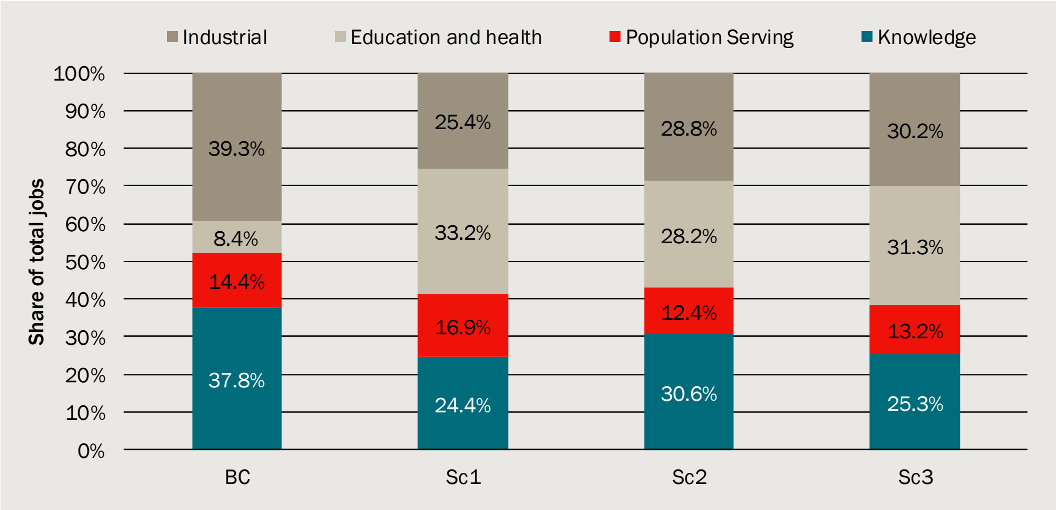
Changes in industry composition

Jobs projections have been divided into the following industry categories. :

- Knowledge
- Population Serving
- Education and health
- Industrial

Industry shares remain relatively consistent across scenarios, with the exception of the base case which has a small proportion of education and health and population serving jobs (chart 3.10). This is because the base case does not assume much population growth in the PIC 1 area, resulting in limited increase these population related industries. The main difference between the scenarios is the total number of jobs as opposed to the composition of jobs.

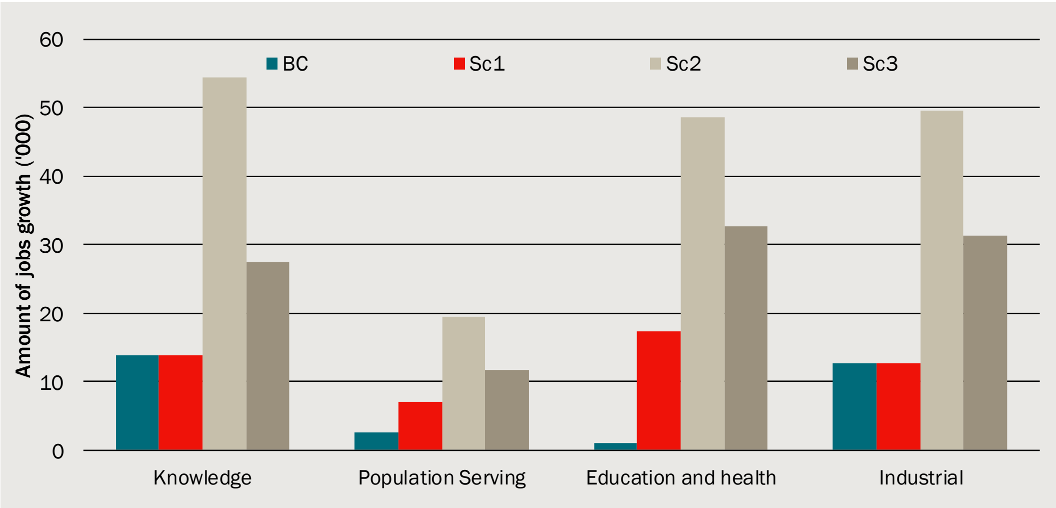
3.10 Share of jobs by industry (2056)



Data source: CIE.

While industry shares of employment remain similar across the scenarios, the amount of growth in each industry is clearly different (chart 3.11). In scenarios 2, sees considerably stronger growth across all sectors compared to the other scenarios, led by knowledge jobs.

3.11 Jobs growth by industry (2016 to 2056)



Data source: CIE.

Infrastructure and services

Agencies provided an assessment of the infrastructure projects that would be required over a 20 or 40-year timeframe to meet the forecast land use under each scenario.

Consideration of scenarios

To establish a nexus, the infrastructure should be that necessary and sufficient to enable the land use outcome to occur (see box 3.12).

3.12 Necessary and sufficient

Infrastructure and land use are linked if:

- **Necessary condition**: the infrastructure is necessary for the land use outcome to occur – if the infrastructure was not put in place, then the land use outcome could not occur
- **Sufficiency condition**: the infrastructure allowed for (or other Government activities modelled) is sufficient that the land use outcome would occur. That is, there are not other constraints that would stop the land use outcome occurring regardless of whether or not the infrastructure was put in place.

What does necessary and sufficient mean in practice?

- The infrastructure must lead to an **'acceptable' standard of service** for each government service type in the land use scenario – defining acceptable and unacceptable outcomes may be subjective for some services. For example, most urban transport systems are subject to crowding and congestion at some times.
- The absence of the infrastructure must lead to an **'unacceptable' standard of service** for each government service type in the land use scenario.
- The scenario outcome must be **compatible with private incentives**. That is, developers, households and businesses would make choices consistent with the scenario, given the government infrastructure and services provided.
- The infrastructure should be the **most efficient set of infrastructure** that leads to an acceptable standard of service and is compatible with private incentives. If an efficient set of infrastructure is developed for one scenario, but an inefficient set of infrastructure is developed for another, then this could lead to bias between scenarios in the evaluation.

Is infrastructure required and of net benefit?

The nexus between land use and infrastructure is relatively strong for certain sectors. Education have developed the infrastructure requirements under each scenario by considering growth under the scenarios and determining the infrastructure investment to maintain service standards roughly constant. This is relatively more straightforward for a sector such as education, where service standards are roughly measured in terms of the number of students compared to the amount of infrastructure. The number of students per teaching space is held constant at 23 students. This establishes a strong nexus between land use and infrastructure.

Other sectors are somewhat more complex. For example, the amount of open space per person is only a rough approximation of service standards. As land use density changes, resident and employee preferences around the amount and type of open space can change, where denser communities may require more pocket parks but not necessarily more bushland.

The most complex sector in terms of the nexus is transport. A range of factors that combine to make the relationship between growth and infrastructure less clear.

- Transport infrastructure investments are 'lumpy' as opposed to 'smooth' in terms of how the amount of people/jobs in an area relates to the infrastructure required. For example, an existing piece of infrastructure may have a volume-to-capacity ratio of below 50 per cent, meaning that the surrounding area may not require additional large major project investments except for very large changes in land use. However, if land use crosses a threshold where service standards begin to fall, then the infrastructure required could be very expensive.
- Travel patterns can change significantly in response to congestion. Travellers can shift between modes, change the location of employment, or change their time of travel to interpeak or offpeak times in response to poor transport system performance. As a result, the extent to which development results in congestion will depend on how travel behaviour adjusts.

Infrastructure that is not necessary or sufficient to enable land use but improves service standards

Another issue associated with the nexus is the justification for additional spending to improve service standards. In general, improvement to service standards beyond that experienced currently should only occur as a by-product of infrastructure that is required to support land use. For example, if the PIC 1 area would experience unacceptably high road congestion in one of the scenarios, then additonal road investment is required, although this might improve service standards for transport accessibility beyond those experienced in the other scenarios. However, in the case of investments such as recycled water infrastructure, these are not required, but only included in a Scenario with the motivation to increase service standards. In general, these investments are not required for growth. For these types of investments, a project specific CBA may be a more appropriate tool to assess the feasibility of the project, without interfering with the place-based evaluation. These findings could then feedback into the place-based evaluation where the investment is considered as part of an infrastructure package, as is the case with recycled water infrastructure.

Incentive compatibility of land use scenarios

Incentive compatibility in this context refers to the scenarios assuming private decisions that are made consistent with the incentives faced by those decision-makers. For example, a scenario would not be incentive compatible if it involved a level of development that would not be profit-making for developers, since they would choose to develop less if they were not making a profit. The level of development specified under the land use scenarios should be assessed for incompatibility with the incentives of developers, landowners, communities and local government.

The land use scenarios may specify a level of development above that which is incentive compatible. This can arise for reasons such as the following:

- **Insufficient demand:** There may be insufficient demand for additional residential or commercial property, and rents for new property may fall if the supply of property is increased to the level specified under the scenarios. This would mean the development is not commercially feasible.
- **Opportunity cost:** Existing buildings have significant value, meaning that the additional rents from demolishing and building something new may be insufficient to make it profitable for developers.
  – For example, demolishing a 3-storey apartment block to build a 4-storey apartment block of a similar quality would not be commercially feasible if the rents from the existing building (the opportunity cost) are high. The additional rents from the larger apartment block would likely be insufficient to outweigh construction costs
- **Lack of support from local community:** Local communities (potentially through local government) may oppose development, and planning processes or resistance by existing landholders to sell to developers may make development unachievable.
- **Physical constraints:** Unforeseen physical constraints could mitigate the amount of feasible development, since extra development would lead to disamenity for residents.

In developing the land use scenarios, we understand development feasibility has been considered. The process for developing land use scenarios involved establishing the capacity of the PIC 1 area to accommodate development, and then assessing the amount of development that would be feasible. This process seeks to avoid assuming development that is inconsistent with private incentives.

Incentive compatibility of infrastructure scenarios

Government is the decision-maker in terms of public investment in infrastructure. From the perspective of the PIC, there is no incentive compatibility problem on the part of government.

However, the expected usage of infrastructure under the scenarios is subject to the private decisions of individual travellers, people seeking medical treatment and parents/students choosing their school or university. In developing the infrastructure scenarios, requirements should be determined assuming behaviour by these users of infrastructure that is consistent with their incentives. For example, if a scenario specifies the construction of a public transport link that does not result in private travel time savings or other benefits to individuals, it should be assumed that patronage of the infrastructure would reflect their incentive to improve their travel time/conditions.

Risks to scenarios

Viability of development

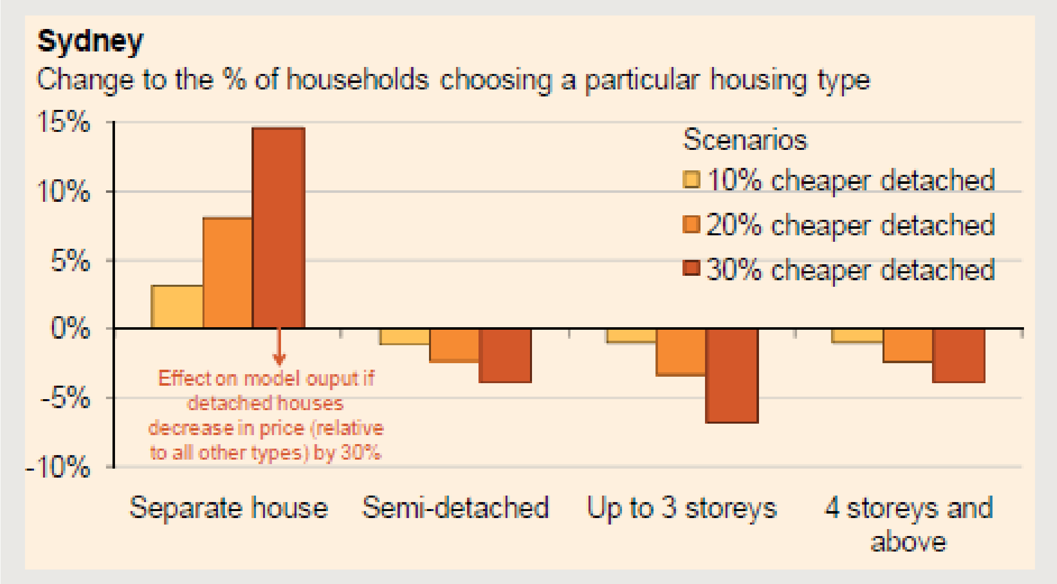
There is some uncertainty around the types of dwellings which will be delivered in the PIC 1 area. The land use scenarios predict development in the PIC 1 area will predominantly consist of apartments and semi-detached terrace houses, with little of no detached dwellings. This is different to current green field developments of which the majority of dwellings are detached. There is a risk that the high-density development may no eventuate.

The housing mix will ultimately depend on the commercial feasibility of developing different housing types. This in turn depends on development related costs and the demand from buyers. Without enough demand, development of a specific dwelling type will not be feasible.

The demand for apartments will reflect the extent to which people will trade-off space and affordability/location. For example, for 50 per cent of people to want to live in apartments might require that apartment prices are half of the price of detached houses in the same area. This is a standard demand curve — as the price of apartments falls, the number of people willing to prefer it over other housing options will rise. Similarly, as the price of detached dwellings increases, there will be a larger market for apartments and semi-detached dwellings and fewer people will live in detached dwellings.

Work undertaken by the Grattan Institute considering housing preferences in 2011 suggests that a reasonable share of people will change their housing choice in response to price. They found that if detached housing became cheaper, say by 30 per cent, then the share of households choosing it would increase substantially, by 15 per cent (chart 3.13). These households switched from apartments up to 3 storeys high (about half of households), semi-detached (about one quarter) and apartments larger than four storeys (one quarter).

3.13 Depth of housing preferences by type in Sydney

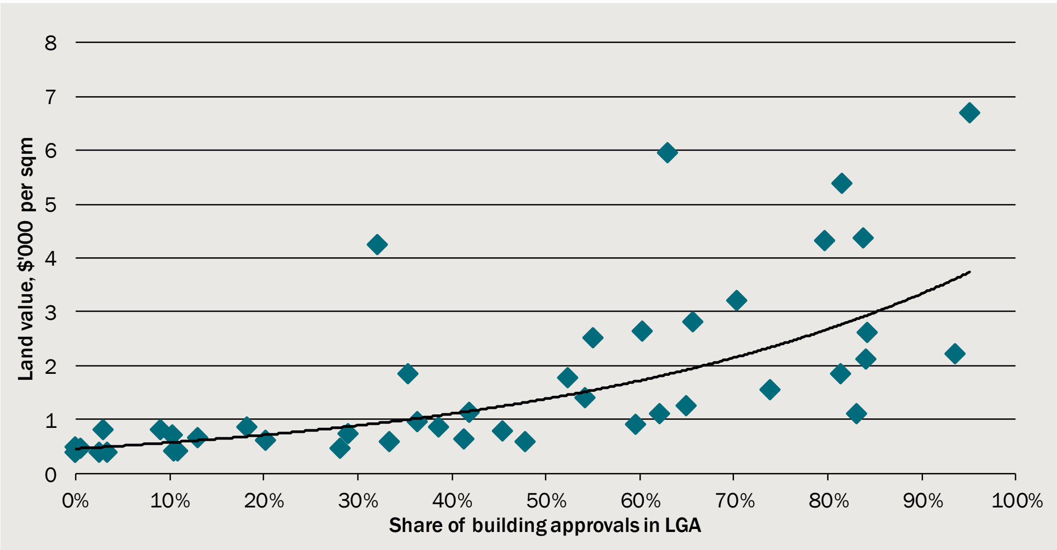


Note: The change in price is the change in the price of detached housing.
Data source: Grattan Institute, *The housing we'd choose.*

This results in the observation that the viability of higher density development is related to land values. Land values account for large proportion of the value of detached house compared to higher density dwellings.

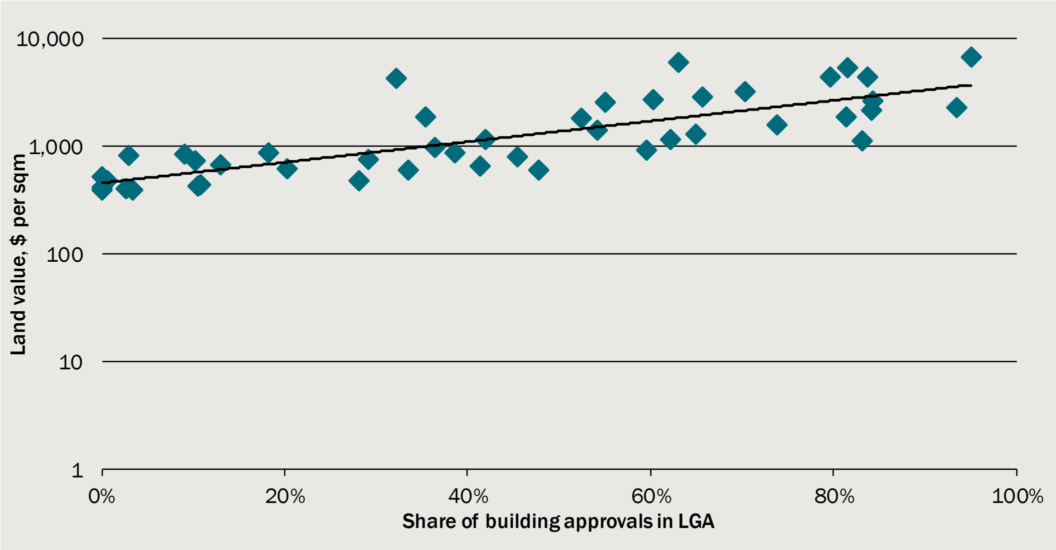
Across LGAs in Greater Sydney, there is a clear exponential relationship between land values and the share of apartments in the LGA (chart 3.14). As land values in on the fringe of Sydney may tend to be lower than other locations in Sydney, there is some risk around the realisation of the dwelling typologies.

3.14 Median land value per sqm compared to apartment share of total building approvals, 2017-2019



Note: The trend line is an exponential trend.
Data source: DPIE land value database, ABS, CIE.

3.15 Median land value per sqm compared to apartment share of total dwellings, log scale



Note: The trend line is an exponential trend.

Data source: DPIE land value database, ABS, CIE.

4 Infrastructure costs of supporting each scenario

- **The discounted capital and operating costs for the PIC area are $8.5b for the base case, $12.6b for Scenario 1, $18.1b for Scenario 2 and $17.3b for Scenario 3.**
- **The precincts which have the lowest cost per additional person and job are the eastern precincts such as Austral, Leppington North and Edmondson Park. Among the precincts with a greater focus on employment growth than population growth, the Aerotropolis Core and Mamre Road are relatively more cost-effective.**

Growth scenarios for the Aerotropolis require additional infrastructure and government services, as well as private investment such as for dwellings, retail space and commercial space. This chapter considers only the costs for infrastructure and government services. In particular, these costs cover:

- transport infrastructure costs (road upgrades, new public transport infrastructure)
- health infrastructure costs
- green infrastructure costs (such as sports fields and parks), some of which will be local infrastructure costs
- blue infrastructure costs (such as floodway vegetation and channel stabilisation)
- water and wastewater infrastructure costs
- stormwater infrastructure costs
- education infrastructure costs
- electricity and gas infrastructure costs
- arts and culture infrastructure costs
- fire services infrastructure costs
- justice infrastructure costs

They do not include any other types of local infrastructure costs.

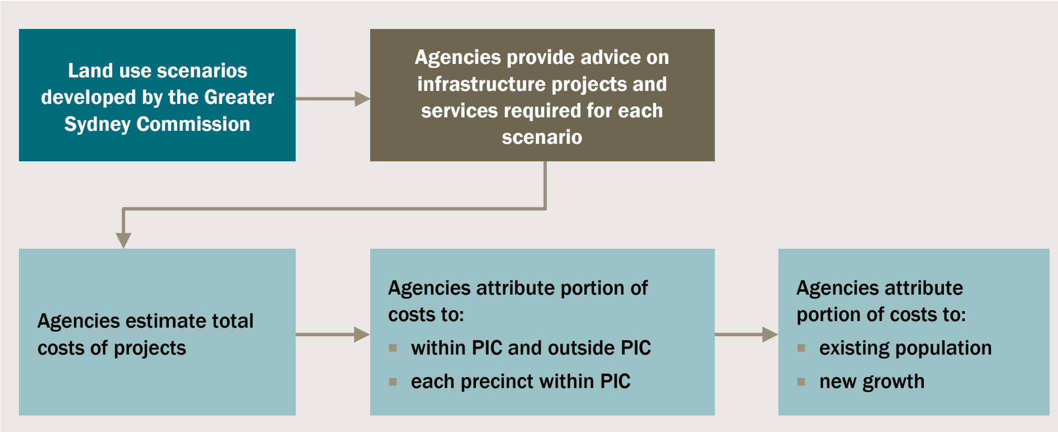
Coverage of costs and process for estimating costs

There are a wide range of costs borne by Government and utilities, but not all of these are or need to be included in the evaluation. As a general principle, if the costs would differ depending on where people lived, then the costs should be measured, and if they would not, then they do not need to be measured.

For this evaluation, we have considered both capital and operating costs. There will be some operating costs that differ depending on where people live, such as operating costs for public transport systems and open space. Other operating costs are likely to be very similar regardless of where people live (such as staffing costs for teachers, nurses and doctors). This illustrates the comparing the costs and benefits of an evaluation for a PIC to evaluations of other PICs, to understand how capital and operating costs compare between areas.

The process for arriving at costs is shown in chart 3.11. This process involves attributing costs to within the PIC and outside the PIC and to each of the precincts within the PIC.[8] It also involves attributing costs to growth or to serving existing activity.

4.1 Process for estimating costs



Data source: CIE.

For the purposes of the evaluation of scenarios, we focus on all costs that are allocated to the PIC area. There may be circumstances where some of the costs allocated to the PIC area are for renewal of existing assets that serve existing residents. This is less of an issue for greenfield areas where there is only a small existing population. These will wash out in the comparison between scenarios and hence we focus on all costs allocated to the PIC area rather than only costs allocated to growth.

The estimates of costs do not distinguish by who will have to bear the costs. Costs could be funded through:

- NSW Government
- local councils
- developers through state and local developer contributions
- users through user charges, such as for water and electricity.

It is not important for the evaluation as to how costs are funded, only that all costs are included and are included only once.

The final conceptual issue is the treatment of land acquisition costs, particularly for open space. The amount of land in the PIC area is constant, and scenarios are allocating this land to different purposes and with different levels of density of activity on land. The opportunity cost of pursuing a scenario is what no longer occurs. For example, in pursuing a high density residential development of a precinct, the opportunity cost may

8 Costs are attributed to the PIC area or outside the PIC area on the basis of the share of patronage, incremental costs, or population/jobs served which is within the PIC area.

be the loss of detached housing. The lost services are directly measured through comparing the scenarios. There is no need to separately include land acquisition costs for open space, roads or other activities within the cost estimates. These costs are not included in cost estimates except where explicitly indicated.

Estimates of cost for scenarios

The capital costs for each scenario are shown in table 4.2. This includes costs for all projects selected by agencies, costs allocated to PIC 1 area and costs allocated to growth.[9] The share of land costs assumed to be inside costs is equal to the share of capital costs allocated to the PIC area for each project. Operating costs are costs to 2056 for the 'all years' costs and costs to 2036 for the 0-20 years costs. Land acquisition costs in the first 20 years are identified based on the share of capital expenditure occurring in the first 20 years as a share of total capital expenditure. This means that land acquisition costs are assumed to remain in the same proportion to capital expenditure for each project in the first and second 20 years of the PIC development period.

4.2 Capital, operating and land acquisition costs by scenario

Scenario	Capital costs			Operating costs			Land acquisition costs		
	Total	Inside	New growth	Total	Inside	New growth	Total	Inside	New growth
	$b	$b	$b	$b	$b	$b	$b	$b	$b
All years									
Base case	20.2	11.5	10.8	11.1	8.3	8.1	4.3	3.5	3.4
Scenario 1	36.5	18.4	17.3	30.1	14.7	14.1	5.8	4.4	4.2
Scenario 2	82.6	32.0	30.6	43.7	21.0	20.3	18.6	15.5	12.3
Scenario 3	82.1	30.7	29.0	43.4	20.7	19.9	18.1	15.0	11.7
0-20 years									
Base case	17.6	8.9	8.2	3.4	2.5	2.4	4.3	3.5	3.4
Scenario 1	28.7	13.4	12.5	9.8	4.5	4.3	5.6	4.3	4.1
Scenario 2	45.0	21.4	20.2	12.6	6.1	5.8	17.5	14.9	11.8
Scenario 3	44.1	20.2	18.8	12.4	5.8	5.5	16.9	14.3	11.1

Note: Costs are undiscounted and are in Dec-2019 dollars.
Source: CIE based on information provided by GSC and agencies.

Economic costs per person and job

Benchmarks of the 'economic' cost per person and job to 2056 are shown for each scenario in table 4.3. The economic costs of infrastructure are the discounted capital and

9 Costs allocated to growth are costs inside the PIC area minus a share of costs allocated to the existing population in the PIC area in 2016. That is, it excludes costs associated with improvement of service standards for existing residents of GPOP. The allocation of costs to growth and to existing population/jobs has been performed by agencies with advice from GSC.

operating costs of infrastructure required to meet development under the scenarios. These are divided by the present value of additional people and jobs in each scenario since 2016. The cost per person and job is highest in the base case, and lowest in the high growth scenarios. The incremental cost per person and job is measured relative to the base case for Scenario 1, and relative to Scenario 1 for Scenarios 2 and 3. This is because Scenarios 2 and 3 involve very similar amounts of infrastructure costs albeit for different growth levels.

4.3 Economic costs per person and job to 2056 (inside, discounted)

Scenario	Discounted inside capital and operating costs	Discounted popn growth (2016 to 2056)	Discounted job growth (2016 to 2056)	Cost per person and job	Incremental [a] cost per person and job
	$b PV	'000 PV	'000 PV	$000/ person + job	$000/ person + job
Base case	8.5	11	11	378	378
Scenario 1	12.6	37	17	236	133
Scenario 2	18.1	58	46	174	109
Scenario 3	17.3	58	32	193	130

[a] Incremental costs are costs that are additional to the prior growth scenario, but with Scenarios 2 and 3 both compared to Scenario 1 due to having very similar infrastructure spend.

Note: Costs are discounted and are in Dec-2019 dollars. Excludes land acquisition costs.

Source: CIE based on information provided by GSC and agencies.

4.4 Incremental economic costs per person and job to 2056 (inside, discounted)

Scenario	Incremental capital, and operating costs	Incremental popn growth (2016 to 2056)	Incremental job growth (2016 to 2056)	Incremental cost per person and job
	$b	'000	'000	$000/ person + job
Scenario 3 vs Scenario 1	4.7	21.3	15.0	130
Scenario 2 vs Scenario 3	0.8	-0.7	14.7	56

Source: CIE.

Financial cost per person and job

Benchmarks of the financial cost to government per person and job to 2036 are shown for each scenario in table 4.5. The financial costs to government of infrastructure are the undiscounted capital and land acquisition costs of infrastructure required to meet development under the scenarios. These are divided by the number of additional people and jobs in each scenario between 2016 and 2036. The cost per person and job is highest in the base case, and similar between all scenarios. The incremental cost per person and job is measured relative to the base case for Scenario 1, and relative to Scenario 1 for Scenarios 2 and 3. The incremental cost per person and job in Scenarios 2 and 3 is higher than the incremental cost of growth between the base case to Scenario 1. That means that going from the base case growth level to Scenario 1 is more cost effect than going from Scenario 1 to either the higher growth scenario.

4.5 Government (financial) costs per person and job to 2036 (new growth, undiscounted)

Scenario	New growth capital and land acquisition costs	Popn growth (2016 to 2036)	Job growth (2016 to 2036)	Cost per person and job	Incremental [a] cost per person and job
	$b	'000	'000	$000/ person + job	$000/ person + job
Base case	14.1	14	16	468	468
Scenario 1	21.6	56	24	269	149
Scenario 2	42.9	86	61	292	320
Scenario 3	40.7	96	45	288	313

[a] Incremental costs are costs that are additional to the prior growth scenario, but with Scenarios 2 and 3 both compared to Scenario 1 due to having very similar infrastructure spend.

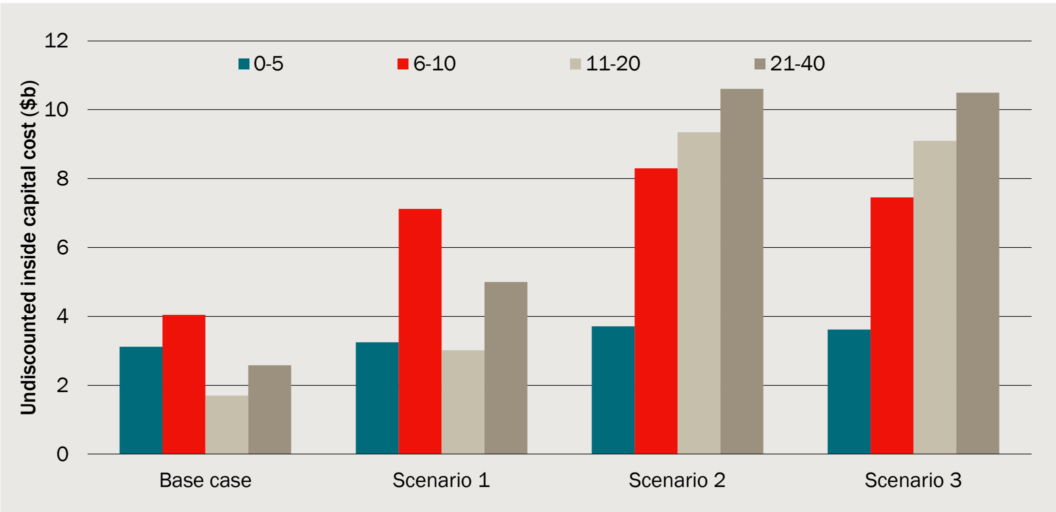
Note: Costs are undiscounted and are in Dec-2019 dollars. Includes capital, operating and land acquisition costs. Population and job growth is not discounted.

Source: CIE based on information provided by GSC and agencies.

Timing of costs

The timing of costs makes a substantial difference to the evaluation of scenarios. The effect of discounting is to increase the relative importance of costs and benefits that occur in the near-term. The scenarios have population and jobs growth mostly occurring in the later years (chart 4.7), while costs are distributed somewhat more evenly over all years. Scenario 2 in particular has significantly higher growth in the 21-40 year period, with only slightly increased costs (chart 4.6).

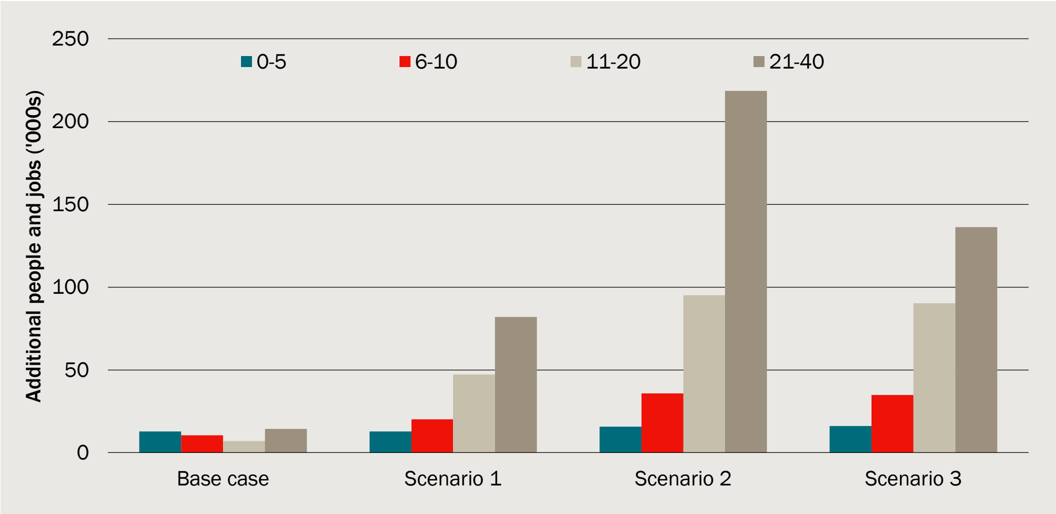
4.6 Costs over time



Note: Costs are undiscounted and are in Dec-2019 dollars. Excludes land acquisition costs.

Source: CIE based on information provided by GSC and agencies.

4.7 Additional population and jobs over time



Source: CIE based on information provided by GSC.

Estimates of costs for precincts

Total inside costs for each precinct and benchmarks per person and job are shown in table 4.8. Costs tend to be focused on where the extra growth occurs such as in the Aerotropolis Core and the eastern precincts which have significant residential development. The Aerotropolis Core has the highest population and jobs growth of any precinct in Scenario 2, but costs are low in per person and job terms (see chart 4.9 and table 4.10).

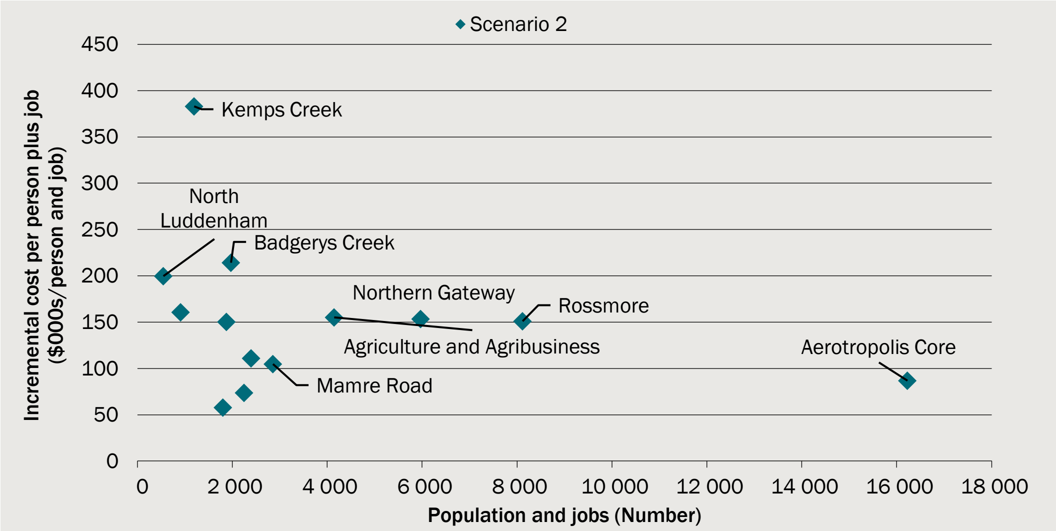
4.8 Economic costs by precinct for each scenario

Precinct	Base case	Scenario 1	Scenario 2	Scenario 3
	$m PV	$m PV	$m PV	$m PV
North Luddenham	138	221	262	218
Agriculture and Agribusiness	477	630	1 140	1 113
Northern Gateway	688	1 178	2 275	1 740
Western Sydney Airport	1 514	1 827	1 813	1 726
Aerotropolis Core	418	605	1 851	1 166
Badgerys Creek	33	144	446	358
South Creek Sth	100	183	282	258
Mamre Road	56	169	366	331
Kemps Creek	84	206	511	464
Rossmore	271	426	1 542	1 305
Austral	1 214	1 654	1 787	2 139
Leppington North	1 280	1 905	2 131	2 366
Edmondson Park	1 306	2 048	2 208	2 464
Glenfield	911	1 407	1 481	1 665
Total	**8 491**	**12 602**	**18 095**	**17 311**

Note: This excludes land acquisition costs. All costs are in Dec-2019 dollars and discounted.

Source: CIE based on information provided by the GSC and infrastructure agencies.

4.9 Relationship between cost-effectiveness and land use growth for Scenario 2



Note: Costs are incremental (i.e. relative to Scenario 1) and discounted.

Source: CIE based on information provided by the GSC and infrastructure agencies.

4.10 Economic costs per person and job by precinct for each scenario

Precinct	Base case	Scenario 1	Scenario 2a	Scenario 3
	$000/person and job	$000/person and job	$000/person and job	$000/person and job
North Luddenham	1 246	1 175	358	713
Agriculture and Agribusiness	1 551	1 478	249	264
Northern Gateway	262	168	175	215
Western Sydney Airport	569	660	390	430
Aerotropolis Core	1 910	1 250	111	188
Badgerys Creek	679	37 685	225	460
South Creek Sth	0	0	0	0
Mamre Road	494	803	119	152
Kemps Creek	857	10 700	421	704
Rossmore	8 910	1 244	182	219
Austral	572	161	148	146
Leppington North	270	136	131	129
Edmondson Park	154	144	133	132
Glenfield	980	394	331	292
Total	**378**	**236**	**174**	**193**

Note: This excludes land acquisition costs. Inside costs are in Dec-2019 dollars and discounted.

Source: CIE based on information provided by the GSC and infrastructure agencies.

When considering only costs within the 0-20 year period (table 4.11), the pattern of costs is relatively similar across precincts, with the Aerotropolis Core and eastern precincts accounting for the most costs.

4.11 Financial costs by precinct for each scenario

Precinct	BC	Scenario 1	Scenario 2	Scenario 3
	$m	$m	$m	$m
North Luddenham	208	283	424	344
Agriculture and Agribusiness	496	682	2 635	2 543
Northern Gateway	883	1 612	3 672	2 672
Western Sydney Airport	2 303	2 755	2 651	2 486
Aerotropolis Core	520	682	3 125	1 984
Badgerys Creek	35	136	984	756
South Creek Sth	561	634	1 585	1 543
Mamre Road	39	167	728	674
Kemps Creek	113	239	1 282	1 097
Rossmore	232	406	2 753	2 358
Austral	1 167	1 733	2 718	3 377
Leppington North	1 306	2 051	3 281	3 577
Edmondson Park	1 656	2 564	3 071	3 350
Glenfield	2 025	2 662	2 985	3 236
Total	**11 546**	**16 606**	**31 894**	**29 998**

Note: This includes land acquisition costs. New growth costs are undiscounted and are in Dec-2019 dollars.

Source: CIE based on information provided by the GSC and infrastructure agencies.

The financial cost per person and job is significantly higher than the economic cost, because it includes more costs (i.e. land acquisition costs) and only includes growth until 2036. Growth in the first 20 years is disproportionately low compared to costs incurred in that period, with most growth occurring in the latter years.

4.12 Financial costs per person and job by precinct for each scenario

Precinct	BC	Scenario 1	Scenario 2	Scenario 3
	$'000s/ person + job	$'000s/ person + job	$'000s/ person + job	$'000s/ person + job
North Luddenham	1 085	877	518	965
Agriculture and Agribusiness	1 156	1 024	395	380
Northern Gateway	199	125	153	174
Western Sydney Airport	730	873	483	556
Aerotropolis Core	1 729	962	151	232
Badgerys Creek	611	- 2 324	580	966
South Creek Sth	0	0	0	0
Mamre Road	248	568	183	214
Kemps Creek	982	- 4 978	1 057	1 539
Rossmore	5 419	816	251	283
Austral	416	116	158	138
Leppington North	187	87	119	112
Edmondson Park	161	149	158	128
Glenfield	1 634	459	416	315
Total	**382**	**208**	**217**	**213**

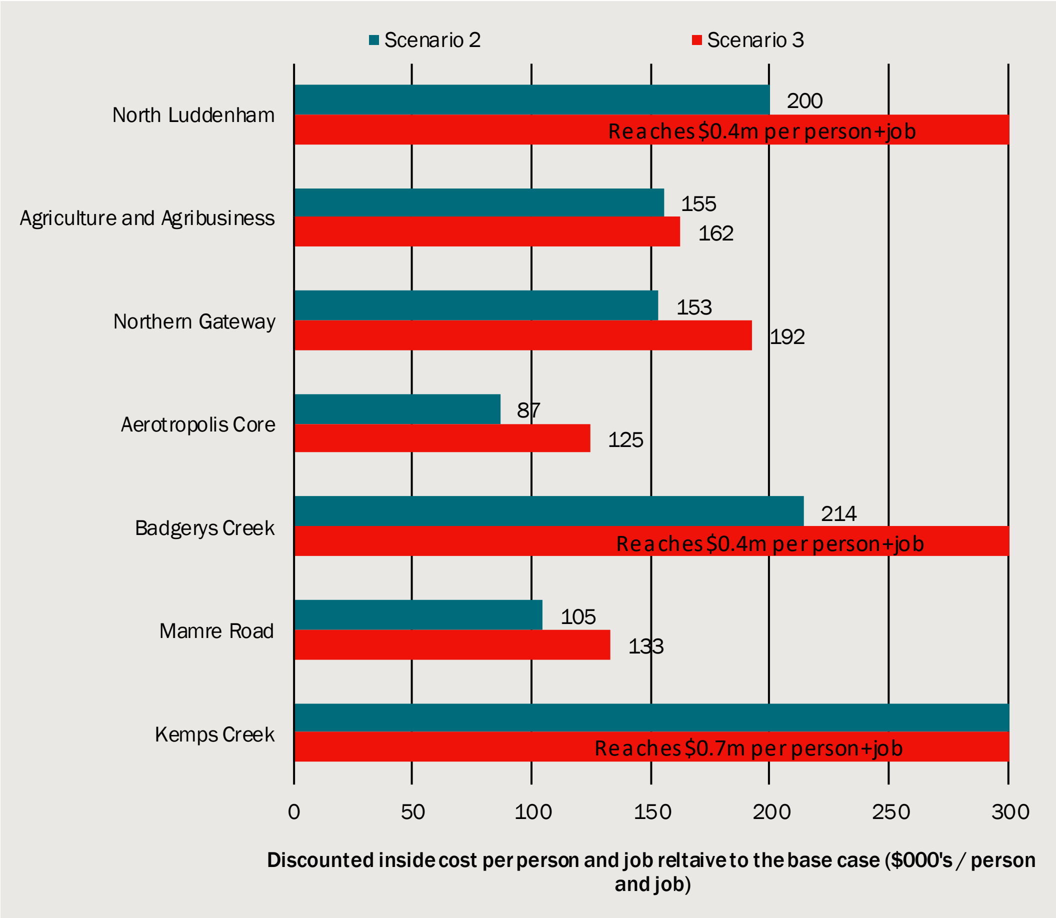
Note: This includes land acquisition costs. New growth costs are undiscounted and are in Dec-2019 dollars.
Source: CIE based on information provided by the GSC and infrastructure agencies.

Charts 4.13 and chart 4.14 of cost-effectiveness by precinct (relative to the base case) are split into two groups of precincts:

- Job-focussed precincts, which are those which GSC seeks to provide mainly employment-related benefits, and
- Population-focussed precincts, which are those which GSC seeks to provide mainly population-related benefits

The most cost-effective job-focussed precincts for development are the Aerotropolis Core and Mamre Road. The cost per person and job is significantly lower for population-focussed precincts, which may suggest that the costs of providing infrastructure to meet the demand for infrastructure from of jobs are higher than for population.

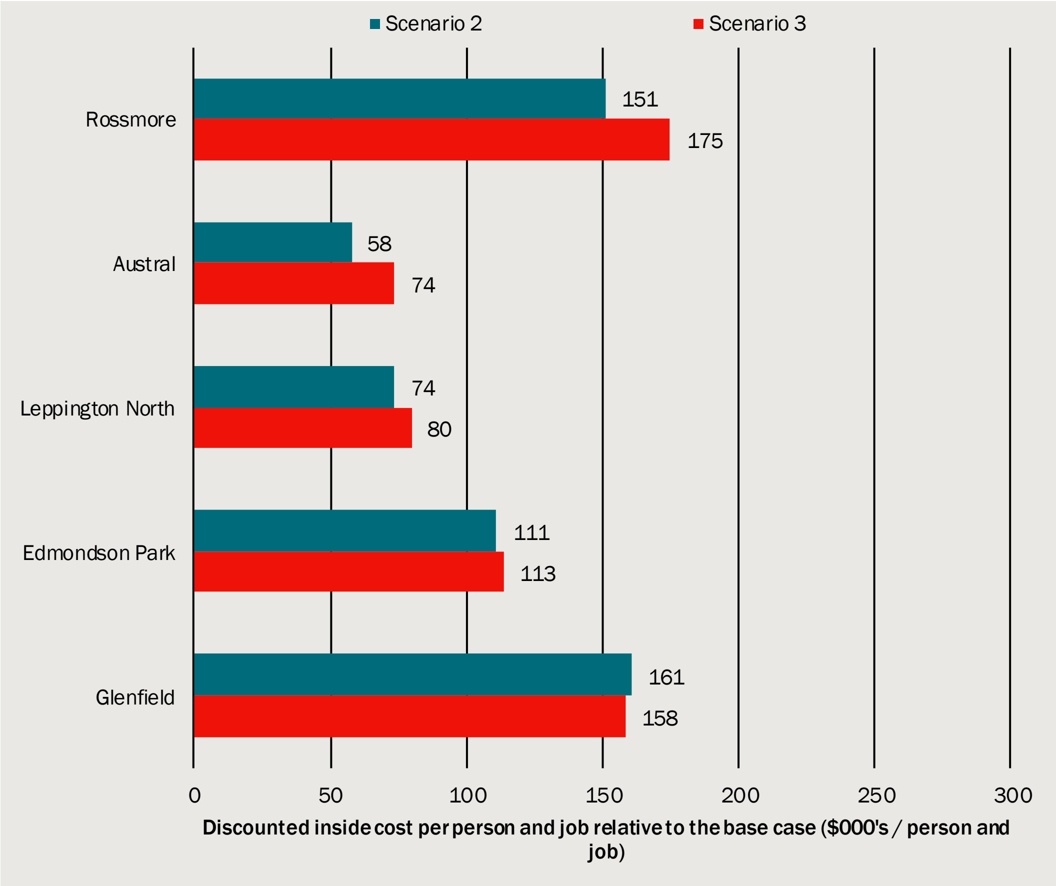
4.13 Economic cost effectiveness for job-focussed precincts



Note: The Western Sydney Airport precinct has been excluded because it has very little population and job growth.

Data source: CIE.

4.14 Economic cost-effectiveness for residential-focussed precincts



Data source: CIE.

5 Physical outcomes of scenarios

Measuring benefits from the perspective of a place means measuring the benefits for those that live, work and interact with a place. There are two steps to measuring and communicating benefits:

1 Measure the physical attributes of the place that vary across scenarios. This could include the number of people living there, the accessibility to jobs and the amount of open space, for example

2 Value the attributes of the place. This involves understanding the willingness to pay for different characteristics of a place.

This chapter sets out the first of these steps.

Summary of physical outcomes

The changes in physical attributes of the PIC area across the scenarios include:

- measures of the number of dwellings/people and jobs locating in the study area
- measures of accessibility from the perspective of people living in the area and businesses locating in the area

There are clearly many other factors that matter for people as to where they live that will be difficult to measure or should not be included. For example, personal safety and crime are amongst the most important drivers of where people want to live. Who else lives in the area is a major driver of where people want to live. This can include friends/family, as well as broader socioeconomic and cultural differences. This will respond to scenarios but is not a decision by a scenario and hence should not be included.

The physical changes resulting from land use and infrastructure scenarios are summarised in table 5.1.

- Job accessibility increases the most under scenario 1, with around 100 000 jobs accessible to the PIC area by 2056, compared to under 40 000 in 2016 (chart 5.2). Overall accessibility varies across the PIC area, however.
- Job accessibility by public transport increases the most under scenario 1, with over 5 000 jobs accessible to the PIC area by 2056, compared to around 600 in 2016. Overall accessibility varies across the PIC areas and to a larger degree than for the car-based accessibility.

The share of people accessible to the nearest strategic centre (Badgerys's Creek) decreases across the scenarios, as congestion increases. Importantly, however, is the fact that these accessibility metrics utilise generalised time (meaning in vehicle time plus a range of other components such as boarding and access time for public transport). Many of the precincts travel time to strategic centres are close to the threshold of 45 minutes (e.g. generalised time to Badgerys's creek from Leppington is around 46 minutes).

5.1 Summary of physical impacts of scenarios 2056

Metrics	Metrics in 2016	Metrics in 2056			Difference to reference case in 2056		
	Base case	Base case	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Number of people (‘000)	8.45	48.45	11.71	80.71	68.68	-36.7	32.3	20.2
Number of jobs (‘000)	2.35	22.43	12.68	105.42	50.56	-9.7	83.0	28.1
Accessibility metrics								
Job density index (PT) 2016=100	100.0	85.9	102.6	99.2	94.8	16.7	13.3	8.9
Job density index (Car) 2016=100	100.0	245.8	209.2	296.6	285.5	-36.6	50.8	39.7
Share of people within 45 minutes (by PT) of a metropolitan centre (per cent)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Share of people within 30 minutes (by car) of a metropolitan centre (per cent)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Share of people within 45 minutes (any mode) of a metropolitan centre (per cent)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Share of people within 45 minutes (by PT) of a strategic centre (per cent)	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0
Share of people within 30 minutes (by car) of a strategic centre (per cent)	23.1	36.2	18.3	0.3	0.3	-18.0	-35.9	-35.9
Share of people within 45 minutes (any mode) of a strategic centre (per cent)	69.1	62.0	46.0	49.3	45.5	-16.0	-12.7	-16.4
Average jobs accessible within 45 minutes by public transport (‘000)	0.6	2.9	1.6	5.1	3.4	-1.3	2.2	0.5
Average jobs accessible within 30 minutes by car (‘000)	31.9	48.3	50.1	100.5	77.5	1.8	52.2	29.2
Average jobs accessible within 45 minutes by any mode (‘000)	90.1	111.7	116.4	235.5	190.5	4.7	123.7	78.8
Population accessible by PT within 45 minutes (‘000)	1	4.3	1.0	2.9	3.2	-3.4	-1.5	-1.1
Population accessible by car within 30 minutes (‘000)	75	83.1	49.6	111.2	116.2	-33.5	28.1	33.1
Population accessible by all modes within 45 minutes (‘000)	500	276.7	190.8	357.3	401.7	-85.9	80.6	124.9

Source: CIE

Transport outcomes

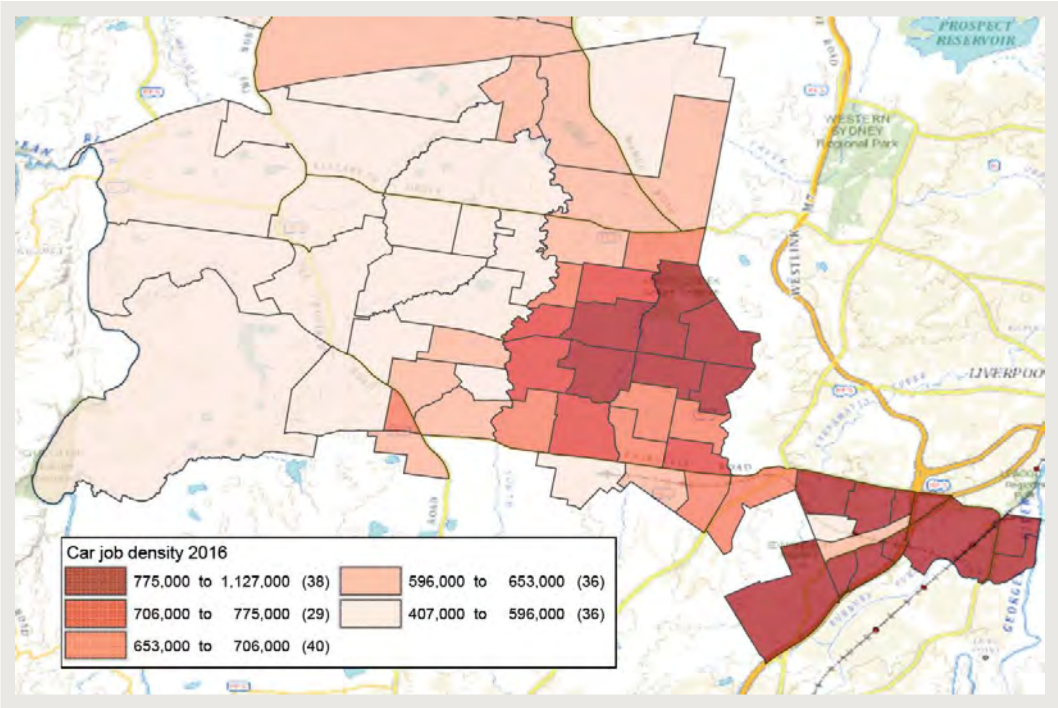
The transport outcomes under the scenarios have been determined using transport modelling outputs supplied by TfNSW. These are the result of modelling using PTPM, a travel model used by TfNSW. Outputs were provided for 2019 and for each scenario in 2026, 2036, and 2056. The 2019 model run has been used as a proxy for outcomes in 2016, and travel times from that model run are used to calculate accessibility metrics in 2016 without any adjustment. The 2019 model run may have differences to transport outcomes in 2016, but we have chosen to use this run because it is the most recent current run available and reflects the most accurate starting point from which the scenarios diverge..

Accessibility across the PIC area

Accessibility to jobs via car

Job accessibility by car in 2016 is highest in the eastern parts of the PIC area near Kemps Creek and the existing residential areas of Glenfield and Edmondson Park (chart 5.2). Accessibility by car varies dramatically across precincts, with the highest accessibility precincts have more than double the accessibility level than the western precincts, as measured by the job access density measure.

5.2 Accessibility to jobs by car at 2016

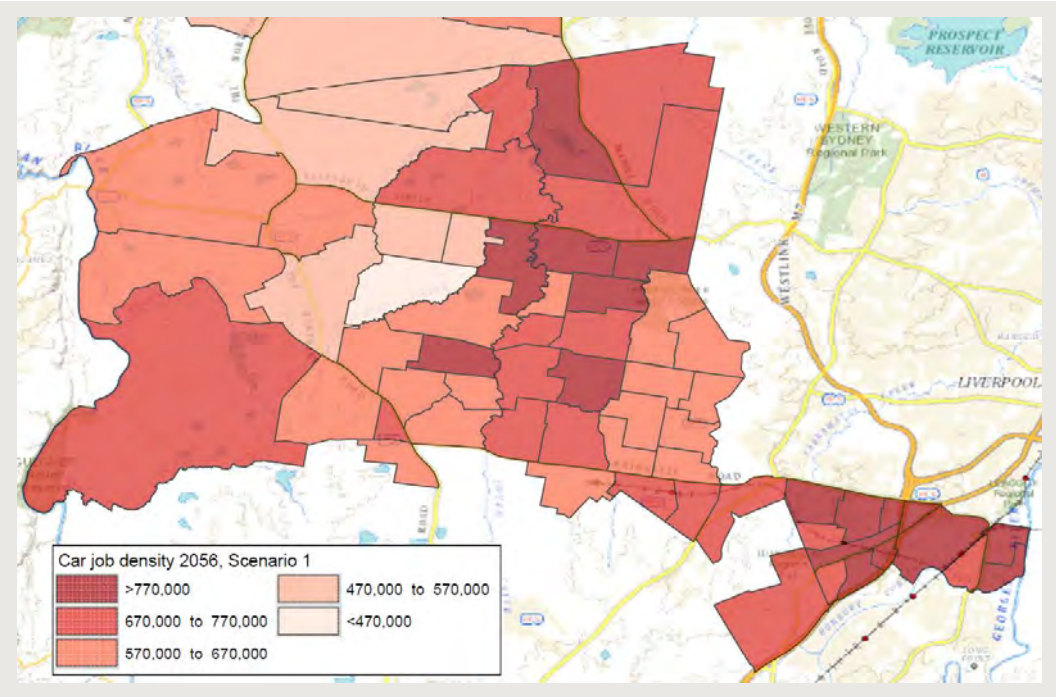


Note: Job accessibility is measured using the job density metric.

Data source: CIE.

Accessibility to jobs by car becomes more equal across the PIC area by 2056 under Scenario 1, with deterioration in access around Kemps Creek and an improvement around Mamre Road (chart 5.3). This is likely driven by infrastructure such as the M12 and a deterioration of accessibility between Liverpool and the PIC area due to increased congestion towards Liverpool. Volume-to-capacity ratios around Glenfield and on the M7 are very high by 2056 under Scenario 1.

5.3 Accessibility to jobs by car at 2056, Scenario 1



Note: Job accessibility is measured using the job density metric.

Data source: CIE.

5.4 Volume-to-capacity on the road network at 2056, Scenario 1

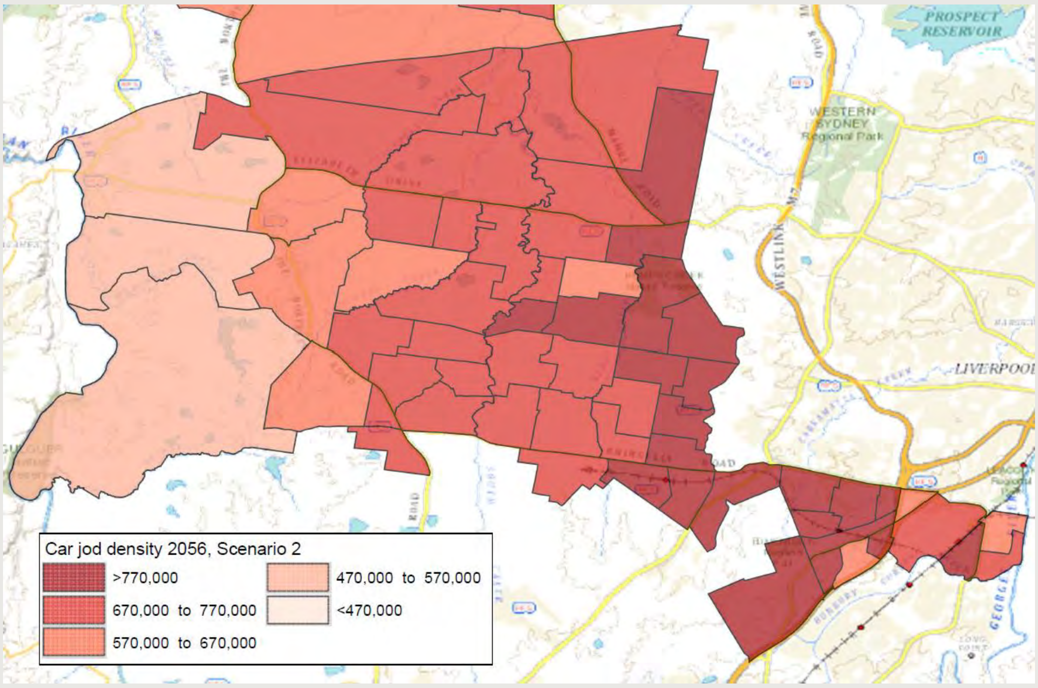
Note: The volume-to-capacity ratio of a each road is shown by the colour, with light roads having a lower ratio and dark coloured roads having a higher ratio. The thickness of each road indicates the volume in the AM peak of that road in one direction.

Data source: TfNSW.

Job accessibility by car in Scenario 2 is less variable than job accessibility in Scenario 1. This is associated with two competing influences:

- Less congestion on the M7 and the M5 extension improve accessibility for areas around the Aerotropolis and Mamre Road/Kemps Creek, which is also boosted by jobs growth in that area. Congestion in Scenario 2 on the M7 (see chart 5.6) is significantly lower than congestion in Scenario 1 (chart 5.4).
- Greater congestion in the vicinity of Kemps Creek and the areas around Glenfield result in some decrease in accessibility in those areas. Infrastructure significantly mitigates the impact of additional congestion, as can be seen in the higher volume-to-capacity ratios throughout the PIC in chart 5.7 compared to chart 5.6.

5.5 Accessibility to jobs by car at 2056, Scenario 2



Note: Job accessibility is measured using the job density metric.

Data source: CIE.

5.6 Volume-to-capacity on the road network at 2056, Scenario 2

Note: The volume-to-capacity ratio of a each road is shown by the colour, with light roads having a lower ratio and dark coloured roads having a higher ratio. The thickness of each road indicates the volume in the AM peak of that road in one direction.

Data source: TfNSW.

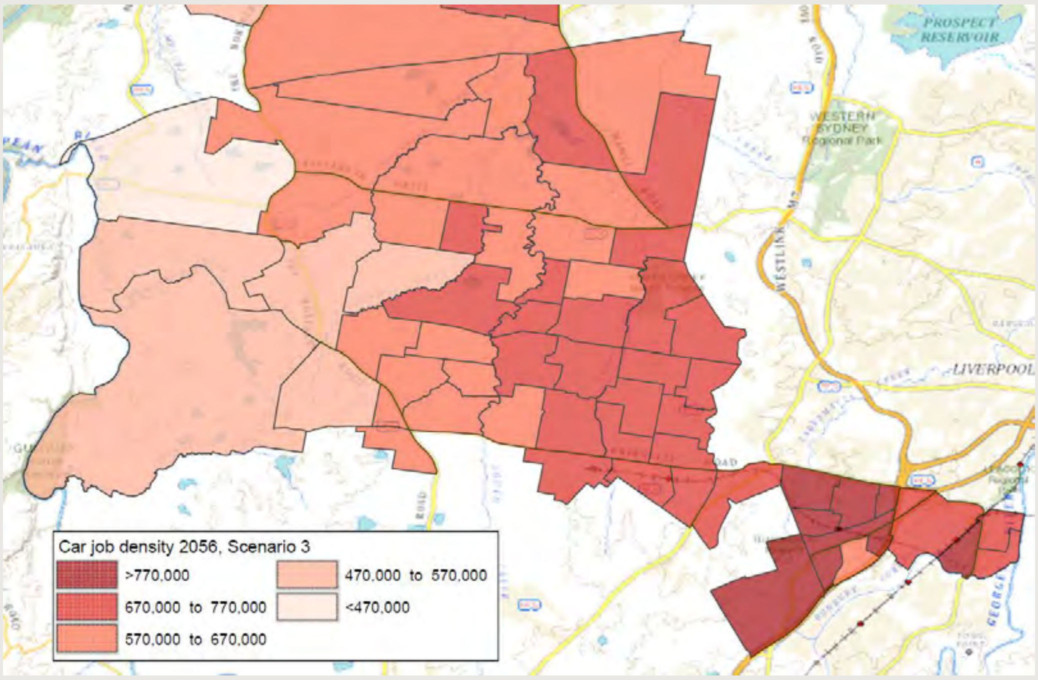
5.7 Volume-to-capacity on the road network at 2056, Scenario 2 with Scenario 1 infrastructure

Note: The volume-to-capacity ratio of a each road is shown by the colour, with light roads having a lower ratio and dark coloured roads having a higher ratio. The thickness of each road indicates the volume in the AM peak of that road in one direction.

Data source: TfNSW.

In Scenario 3 relative to Scenario 2, accessibility is slightly improved in the areas where more population growth occurs (around Glenfield, Austral and Leppington North) while it is worse for the areas around the Aerotropolis and near the M7 (chart 5.8). This suggests the impact of jobs growth in the Aerotropolis is having a significant impact on accessibility to jobs throughout the PIC, but that job accessibility for the eastern precincts (e.g. Glenfield) is more dependent on access to areas outside the PIC. Congestion in these eastern precincts is worse in Scenario 3, and particularly around the intersection of the M5 and M7 (chart 5.9).

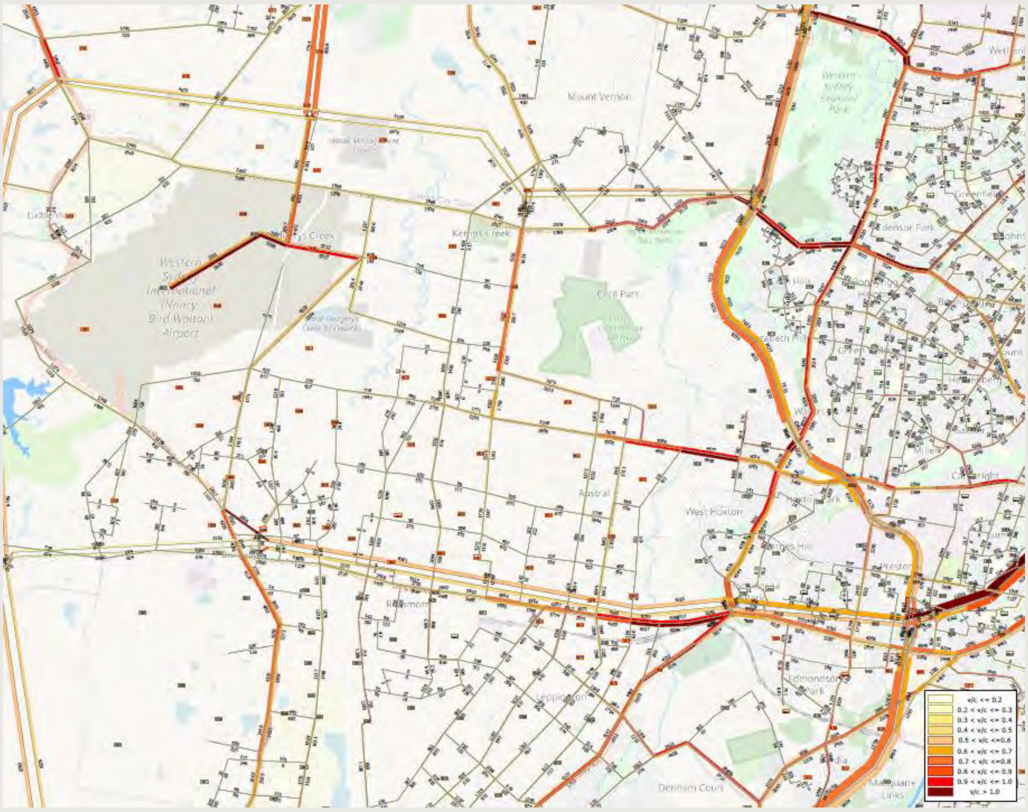
5.8 Accessibility to jobs by car at 2056, Scenario 3



Note: Job accessibility is measured using the job density metric.

Data source: CIE.

5.9 Volume-to-capacity on the road network at 2056, Scenario 3

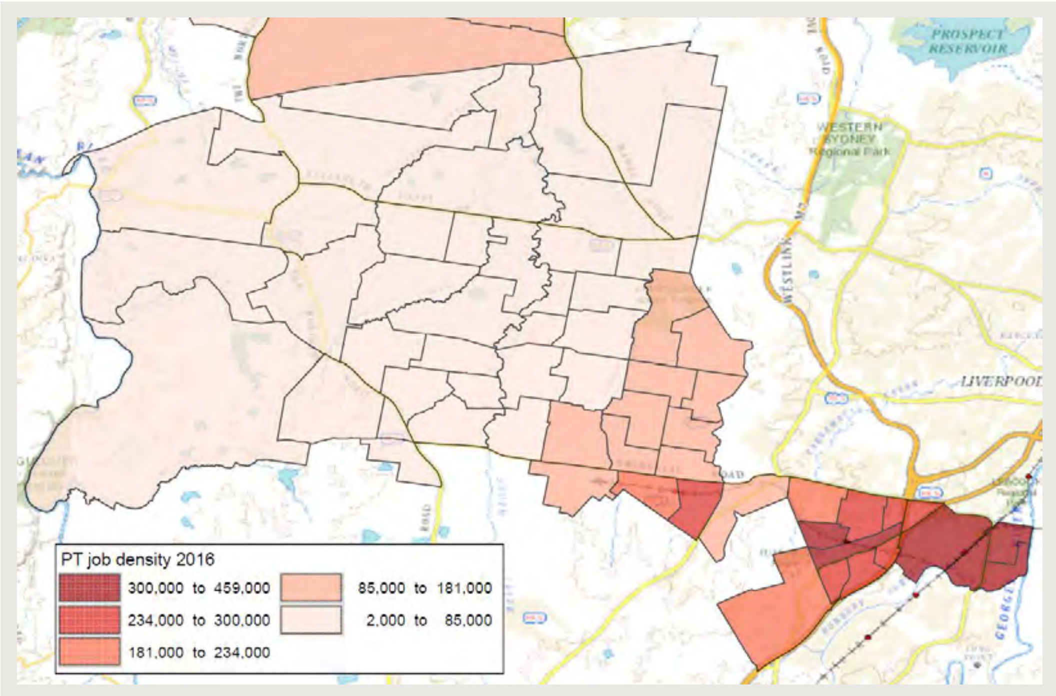


Note: The volume-to-capacity ratio of a each road is shown by the colour, with light roads having a lower ratio and dark coloured roads having a higher ratio. The thickness of each road indicates the volume in the AM peak of that road in one direction.
Data source: TfNSW.

Accessibility to jobs via public transport

Accessibility to jobs by public transport is more starkly different across the PIC than car accessibility. Accessibility to jobs via public transport being extremely low in the western part of the PIC area. The areas with existing residential development, particularly those with access to the stations on the South line (i.e. Glenfield) or adjoining stations, have much better accessibility via public transport.

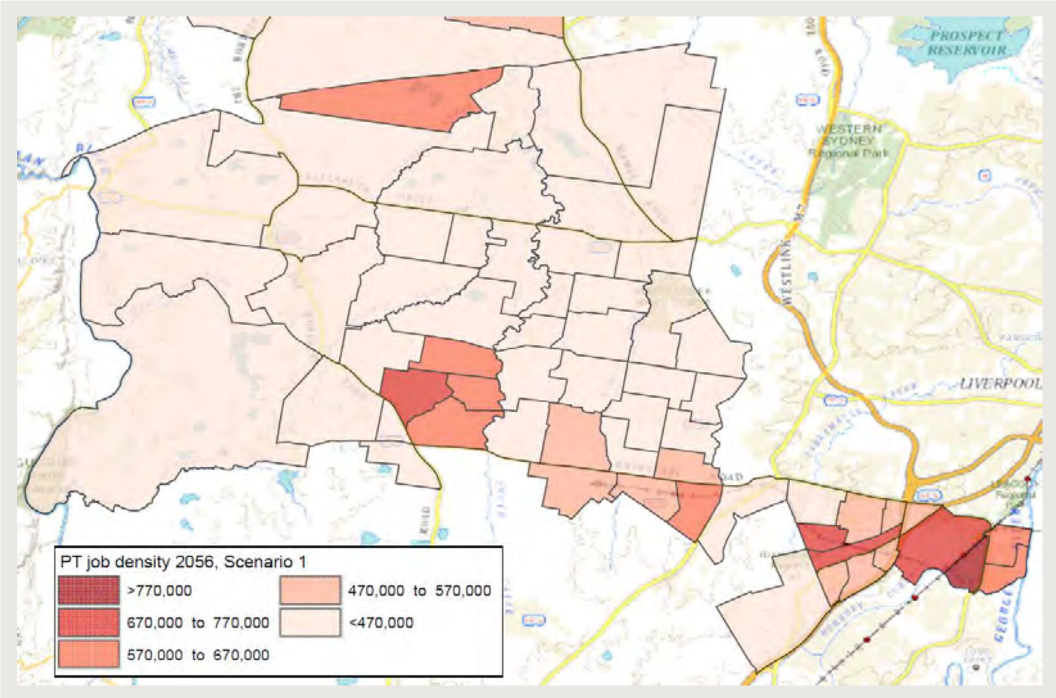
5.10 Accessibility to jobs by public transport at 2016



Note: Job accessibility is measured using the job density metric.
Data source: CIE.

By 2056 under Scenario 1, accessibility improves around the Aerotropolis and particularly along the South West Rail Link and Sydney Metro Western Sydney Airport line (chart 5.11). Overall accessibility levels are significantly higher as well due to growth in jobs outside the PIC area.

5.11 Accessibility to jobs by public transport at 2056, Scenario 1

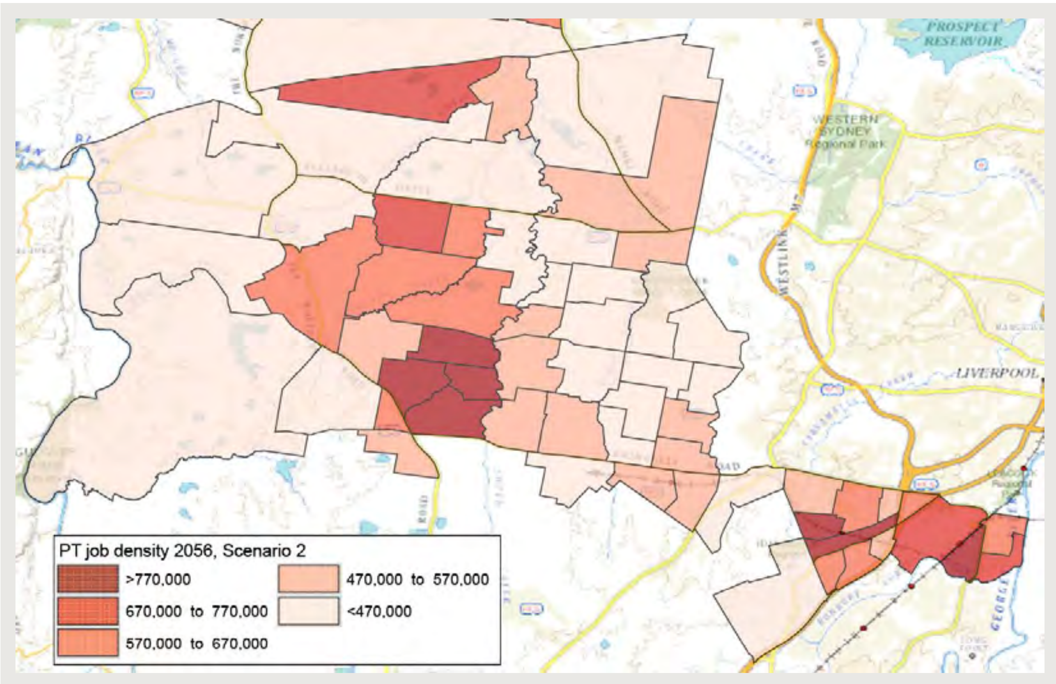


Note: Job accessibility is measured using the job density metric.

Data source: CIE.

Accessibility in Scenario 2 is moderately higher than in Scenario 1 (chart 5.12), mainly driven by improvements around the Aerotropolis, Northern Gateway and WSA.

5.12 Accessibility to jobs by public transport at 2056, Scenario 2

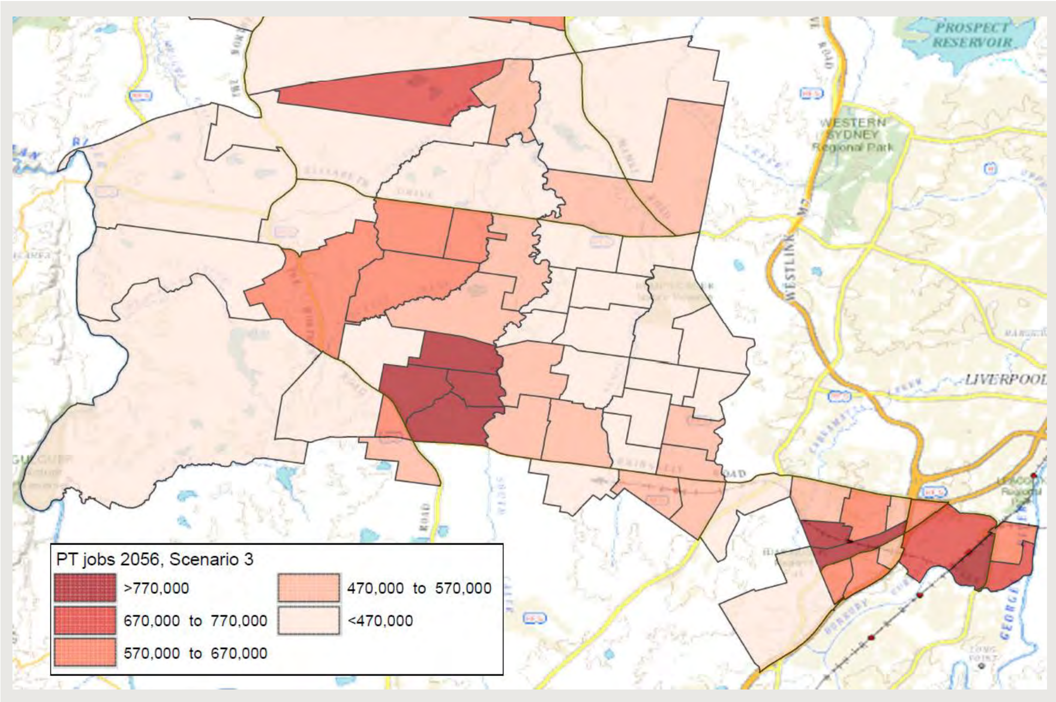


Note: Job accessibility is measured using the job density metric.

Data source: CIE.

The spatial pattern of improved accessibility by public transport is relatively similar in Scenario 3 (chart 5.13). There is a somewhat smaller increase around WSA than under Scenario 2, but overall the differences are minor.

5.13 Accessibility to jobs by public transport at 2056, Scenario 3



Note: Job accessibility is measured using the job density metric.

Data source: CIE.

Walkability

We haven't estimated walkability of the PIC area because the smallest geography for which we have land use estimates is travel zone, and travel zones in the PIC area are very large. As a result, it is not possible to extrapolate the walkability development in the PIC area over time and across scenarios.

6 Staging and sequencing

- **GSC have developed three staging and sequencing options for the PIC area, corresponding to a maximum, moderate and minimum level of land servicing for the PIC area to meet the same scenario growth by 2036.**
- **GSC have conducted a preliminary evaluation of these options, and the moderate option has the best alignment to the Staging and Sequencing Principles.**

Staging and sequencing between precincts

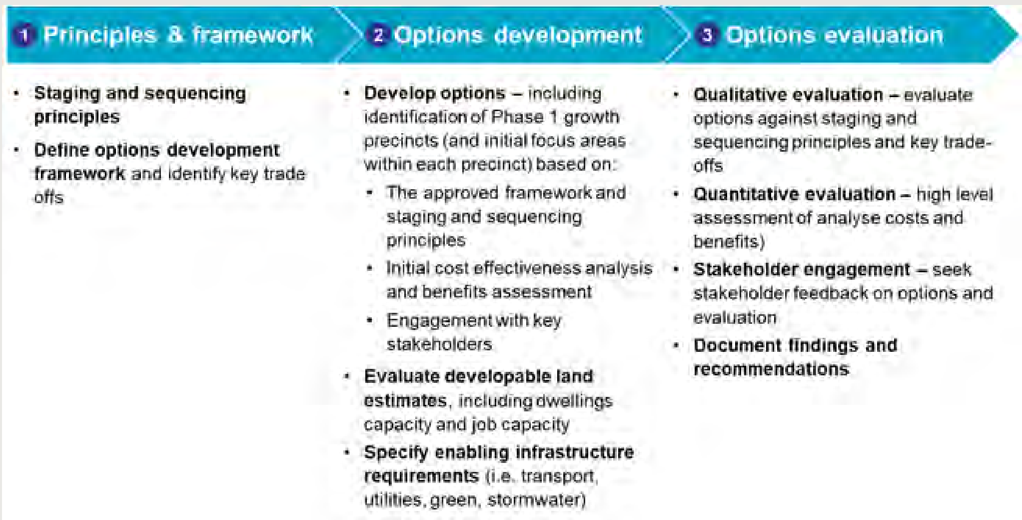
The scale of developable land, the level of demand for jobs and housing and the cost of delivering infrastructure and services within the two initial PIC areas, necessitates a considered approach to sequencing growth with infrastructure over time.

By way of example, preliminary analysis suggests that only around 10 to 15 per cent of the total land area within PIC #1 would be needed to spatially accommodate the forecast jobs and dwelling growth under the PIC scenarios, over the next 20 years, based on conservative benchmarked densities.

Feedback received from some stakeholders during consultation on the PIC Pilot for Greater Parramatta and the Olympic Peninsula (GPOP), emphasised the need to consider sequencing options prior to determining a preferred option. Most of these stakeholders were either landowners or development industry groups seeking early development opportunities.

An overview of the staging options development and evaluation approach is illustrated in Chart 6.1, with more detailed information provided below.

6.1 Staging and sequencing evaluation approach



Data source: GSC *Western Sydney PIC Preliminary Staging and Sequencing Scoping Paper*.

Principles and framework

In December 2019, the Infrastructure Delivery Committee (IDC) approved staging and sequencing principles for the Western Sydney PIC Program (table 6.2). As a complement to these principles, a framework for developing staging options (including respective trade-offs), has also been developed, as illustrated in chart 6.2. The framework was approved by IDC in May 2020.

6.2 GSC Planning principles

Category	Planning principles
Tri-level Government Policies and Directions	1 Strategic alignment with government policy, including the Western Sydney City Deal Commitments, Regional and District Plans and subsequent strategic planning directions, which reinforce the need to sustainably plan for existing and new communities and the metropolitan cluster of Liverpool, Penrith, Campbelltown and the Aerotropolis.
Job creation, skills and industry	1 Leverages investment in city shaping (or catalytic) infrastructure in the Western Parkland City, namely the Western Sydney (Nancy Bird Walton) International Airport, Sydney Metro Greater West, TAFE and universities by maximising the use of land around these investments to support job creation, skills development and new industry. 2 Prioritises early strategic employment creation and agglomeration in high vale and knowledge intensive jobs, new industries, learning and skills development to rebalance opportunities across Greater Sydney.
Property and Land Ownership Drivers	3 Leverages consolidated land holdings in Government and private ownership where new employment lands, mixed use and residential communities can be master planned. 4 Supports new solutions for constrained lands (e.g. fragmentation, flood affected) to create new opportunities for viable, productive and sustainable uses as part of the fabric of the Western Parkland City. 5 Supports a diversity of new highly urban housing (and not suburban housing) that can be affordably delivered by industry, governments and utility providers, consistent with local strategic planning and in line with market demand. 6 Leverages opportunities early to improve the social sustainability of communities in the Western City, including through the transformation of concentrated areas of social housing.

Category	Planning principles
Enabling and Supporting Infrastructure and Service Drivers	7 Precincts are viably supported by existing, planned or cost effectively provided enabling infrastructure including water, electricity, gas, digital (5G), green, blue and transport networks and systems 8 Precincts are viably supported by existing, planned or cost effectively provided supporting social infrastructure and by the public, private and not-for-profit sector 9 Supports opportunities to co-locate activities and services in precincts, such as at the Aerotropolis and in health and education precincts; and for multiutility/multifunctional corridors through upfront and early strategic alignment

Source: GSC.

6.3 Options development framework

	Amount of land serviced	Infrastructure and service costs	Control over urban outcomes	Land prices	Likelihood of realising growth projections
1 Maximum land enabled for growth and development on multiple fronts		$$$	✓	$	✓✓✓
2 Moderate level of land enabled and serviced by targeted stimulus growth opportunities in strategic locations and industries		$$	✓✓	$$	✓✓
3 Minimum land enabled and serviced that is planned to progressively meet demands of growth		$	✓✓✓	$$$	✓

Data source: GSC *Western Sydney PIC Preliminary Staging and Sequencing Scoping Paper*.

Each option developed by GSC using this framework varies in terms of the total amount of land serviced, location of development within the precincts and timing of land servicing. The staging and sequencing options are:

- Option 1: A maximum approach which allows for growth and development on multiple fronts, providing full flexibility on the location and quantum of land for development
- Option 2: A moderate approach that strategically locates land to be serviced and developed, and provides enough quantum for the market to flexibly determine optimal areas for development
- Option 3: A minimum approach where land enabled to serviced and developed is planned and provided as required to progressively meet the forecast growth and demand in few locations

Options development

For both PIC areas, each of the staging and sequencing options were spatially defined by GSC, taking a range of factors into consideration. For PIC 1 (Aerotropolis), the key considerations included:

- Analysis of constraints and opportunities undertaken by CIE and CityPlan

- The Western City Aerotropolis Authority (WCAA) Western Sydney Aerotropolis Plan
- Current and known rezoning and gateway determinations (including Sydney Science Park in the Northern Gateway, Mamre Road, Leppington North and Glenfield Hurlstone Agricultural Site)
- Stakeholder engagement, including consultation with WCAA, Planning Partnerships Office (PPO), DPIE, Campbelltown Council, Camden Council and Liverpool Council

Options evaluation

The evaluation of the staging and sequencing options consists of two key elements, including:

- A qualitative assessment of alignment with the staging and sequencing principles
- A quantitative analysis of key trade-offs as per the framework (i.e. land requirements, land acquisition costs, high level assessment of infrastructure costs)

GSC have conducted an evaluation of the staging and sequencing options they developed. The preliminary results from this evaluation, presented in the *Western Sydney PIC Preliminary Staging and Sequencing Scoping Paper*[10], are as follows:

- A maximum approach, which assumes all precincts are serviced for growth creates significant additional capacity for dwellings and jobs, more than three times greater than what is required to meet forecast demand at 2036
- A more sequenced approach to growth allows for the staged delivery of infrastructure and services and deferral of capital expenditure
- A moderate approach, focussing on key areas within the initial precincts identified within the Western Sydney Aerotropolis Plan (WSAP) and aligned with committed catalytic infrastructure (including Western Sydney Airport Metro), and other known growth and renewal areas (i.e. Leppington Town Centre, Glenfield), provides strong alignment with existing government policy and prioritises investing limited capital to support the creation of high value and knowledge intensive job within key strategic employment areas around the Nancy Bird Walton Airport
- A minimum approach best aligns the supply of land (and provision of infrastructure and services) with forecast growth in demand, however, doesn't align with the full extent of growth and development of the initial precincts identified within the WSAP and has less ability to facilitate strategic employment outcomes and may overly constrain the market to deliver intended outcomes

Charts 6.4, 6.5 and 6.6 illustrate the maximum, moderate and minimum options, respectively. Further detail is provided in table 6.7 about the specification of these options, including the infrastructure that can be deferred in the moderate and minimum land servicing options. Table 6.8 presents the qualitative evaluation GSC have conducted

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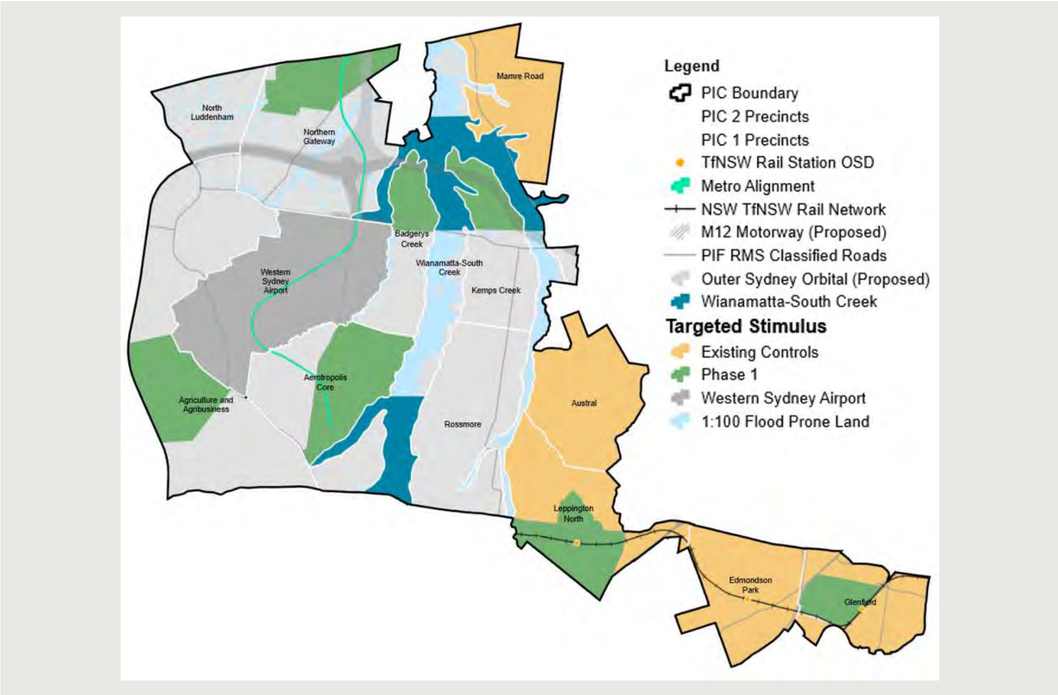
10 GSC, 2020, *Western Sydney PIC Preliminary Staging and Sequencing Scoping Paper v.0.06*, provided to CIE directly, unpublished.

against the 10 Staging and Sequencing Principles. Teal cells of the table correspond to a positive outcome for that principle, grey cells correspond to a neutral outcome, and red to a negative outcome. The moderate option was identified by GSC as having the strongest alignment with existing policy, prioritising growth in strategic employment areas, but requiring additional investment in enabling infrastructure and services.

6.4 Maximum option map

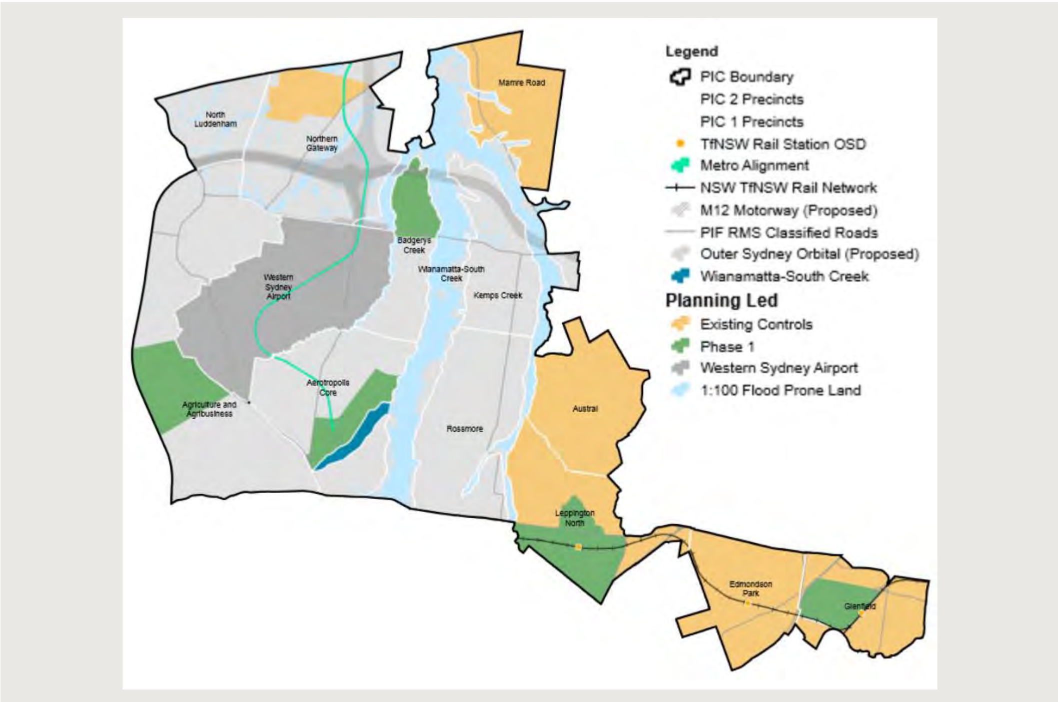
Data source: GSC *Western Sydney PIC Preliminary Staging and Sequencing Scoping Paper*.

6.5 Moderate option map



Data source: GSC *Western Sydney PIC Preliminary Staging and Sequencing Scoping Paper*.

6.6 Minimum option map



Data source: GSC Western Sydney PIC Preliminary Staging and Sequencing Scoping Paper

6.7 PIC 1 – staging options development

	Maximum – maximum land enabled for growth on multiple fronts	Moderate – moderate level of land enabled and serviced for growth coordinated in strategic locations	Minimum – minimum land enabled and serviced to progressively meet demands of growth
Growth Description	▪ Allows majority of precincts to be enabled and serviced in full over time ▪ Gives full flexibility for the market to determine optimal areas for development and contribute to infrastructure delivery ▪ Assumes current (dispersed) land use forecast (as per the Common Planning Assumptions) and identified infrastructure and services needs in the PIC process	▪ Prioritises jobs growth around the proposed major centres and station catchments of the Western Sydney Airport Metro and proximity to the Airport ▪ Provides a moderate level of serviced land within all five initial precincts identified in the Aerotropolis Plan, and at Kemps Creek ▪ Enables review of some already rezoned lands (or identified for rezoning) at Sydney Science Park, Leppington Town Centre and Glenfield Hurlstone Agricultural site). ▪ Enables continued servicing in the remaining rezoned precincts in line with long held landowner and market expectations ▪ Provides market flexibility within a more coordinated and affordable infrastructure program	▪ Focus growth and development around selected major centres and station catchments along the Western Sydney Airport Metro within some of the identified initial precincts ▪ Restricts the level of servicing and development in the remaining precincts (including already rezoned precincts), until needed to meet demand ▪ Optimises infrastructure investment by constraining market options to develop potentially impacting on housing supply and affordability
Assumed demand, 2036 Scenario 2	▪ Population: 110,000 ▪ Jobs: 69,000 ▪ Dwellings: 38,000	▪ Population: 110,000 ▪ Jobs: 69,000 ▪ Dwellings: 38,000	▪ Population: 110,000 ▪ Jobs: 69,000 ▪ Dwellings: 38,000
Estimated capacity and land requirements	▪ Dwellings capacity: 132,000 ▪ Jobs capacity: 230,000 ▪ Developable land requirements: 4,000 ha	▪ Dwellings capacity: 88,000 ▪ Jobs capacity: 125,000 ▪ Developable land requirements: 1,400 ha	▪ Dwellings capacity: 67,000 ▪ Jobs capacity: 89,000 ▪ Developable land requirements: 1,000ha
Phase 1 rationale	▪ Market and opportunity led development to accelerate the supply of new housing and to attract businesses and industries in any areas the market finds most cost effective to acquire, assemble and development land ▪ Reflects the Western Sydney Aerotropolis Plan (WSAP) ▪ Allows flexibility for the market to accommodate any higher than forecasted uptake in demand	▪ Badgerys Creek, Mamre Rd, Aerotropolis Core, Northern Gateway and Agribusiness are all initial precincts identified within the Western Sydney Aerotropolis Plan (WSAP) ▪ Alignment with existing government commitment and zoning for growth and development for the Science Park in the Northern Gateway, Mamre Road, Austral, Edmondson Park, and with further rezoning at the Leppington Town Centre and the school site in Glenfield. The latter is aligned with current planning by Camden Council for the Town Centre, and the planned release of part of the school site for development	▪ Alignment with existing government commitment and zoning for growth and development for the Science Park in the Northern Gateway, Mamre Road, Austral, Edmondson Park, and with further rezoning at the Leppington Town Centre and the school site in Glenfield. The latter is aligned with current planning by Camden Council for the Town Centre, and the planned release of part of the school site for development ▪ Targeted areas in the immediate metro station precinct within the Aerotropolis and the Northern Gateway

	Maximum – maximum land enabled for growth on multiple fronts	Moderate – moderate level of land enabled and serviced for growth coordinated in strategic locations	Minimum – minimum land enabled and serviced to progressively meet demands of growth
	▪ A broader sharing of infrastructure investment capital across the Western Sydney Aerotropolis Growth Area within capital and contribution limits	▪ Kemps Creek between South Creek and Elizabeth Drive is included to provide land for State and utility infrastructure, to take advantage of access to utility services along the Elizabeth Dr corridor, and this area's proximity to the M12, M7, Mamre Rd ▪ Kemps Creek also takes advantage of work in South Creek and associated development in Badgerys Creek (north) and Mamre Road enabling the initiation of a Circular Economy with the planned Wastewater and Resource Recovery Centre in the mid-2020s	▪ Badgerys Creek (north) proximity to airport entry, supports job creation and key urban services land uses ▪ Agribusiness (part) immediately opposite to airport freight landside access point ▪ Mamre road supports job creation
Rationale for sequencing later phases	N/A	▪ Rossmore - lack of alignment within existing strategic plans (i.e. not identified as an initial precinct within the WSAP), relatively high costs and adjacency to already rezoned precincts that have capacity for growth ▪ Remainder of Northern Gateway - no committed upgrades to Luddenham Road and significant land requirements for infrastructure in the remainder of the Northern Gateway, with exact boundaries subject to refinement. ▪ Valuable existing uses expected to continue operation in the remaining areas of Badgerys Creek, Kemps and Aerotropolis Core e.g. ANL, quarry, Inghams ▪ Valuable rural industries expected to continue operation in the remaining areas e.g. market gardeners, nurseries, poultry farmers ▪ Remainder of Agribusiness around Dwyer Road/Bringelly Village and Luddenham Village – fragmented ownership, assumes these areas retain rural character in short term ▪ Remainder of Agribusiness, Aerotropolis Core, Northern Gateway not required to meet likely demand for some time and sufficient market flexibility in Phase 1	▪ Kemps Creek, Rossmore and North Luddenham – not identified as initial precincts within the WSAP and relative high cost precincts compared to the remaining precincts within the Aerotropolis ▪ Remainder of Agribusiness, Aerotropolis Core, Northern Gateway not required to meet forecast demand for some time
Summary of Deferred Infrastructure (to 2036)	*As per agency and utility provider advice received in Infrastructure and Service Assessments (October 2019-April 2020)*	**Transport** ▪ Slight reduction in priority bus infrastructure required to support rapid bus services	**Transport** ▪ Slight reduction in priority bus infrastructure required to support rapid bus services

	Maximum – maximum land enabled for growth on multiple fronts	Moderate – moderate level of land enabled and serviced for growth coordinated in strategic locations	Minimum – minimum land enabled and serviced to progressively meet demands of growth
(focussing on enabling major transport, utilities, green, stormwater infrastructure)		▪ Fewer new local bus routes required with opportunity for further network and service optimisation to reduce fleet and operational cost ▪ Up to 37% fewer lane kilometres of State and regional roads required, with the potential to defer 7 of the 34 projects and to stage the delivery of 14 other projects ▪ Principal Bicycle Network infrastructure to be delivered as part of new road projects or upgrades, and within the Green Grid aligned with green infrastructure improvements **Water, wastewater and recycled water** ▪ Costs are reduced as some new trunk main sections and pumping stations for water, wastewater and recycled water services can be deferred due to the more concentrated urban form to meet 2036 forecast growth ▪ There is no change in the scope and cost to increase the capacity of existing and build new water reservoirs and water recycling facilities including the proposed Upper South Creek advanced water recycling centre as these continue to support the same population (maximum) **Electricity** ▪ Lower distribution length works than developer-led ▪ Potentially three fewer zone substations **Gas** ▪ Rossmore SRS would not be required ▪ Reduced secondary gas main length **Green Infrastructure** ▪ Reduced costs due to staged delivery of Wianamatta Park and Gateway Park ▪ Reduced costs due to staged approach to waterway management and biodiversity conservation projects ▪ Reduced costs due to reductions in the need for local open space that is accessible within 400m due to more concentrated development and tree canopy which is now targeted around precincts/areas that come first	▪ Fewer new local bus routes required with opportunity for further network and service optimisation to reduce fleet and operational cost ▪ Up to 40% fewer lane kilometres of State and regional roads required, with the potential to defer 9 of the 34 projects and to stage the delivery of 12 other projects ▪ Principal Bicycle Network infrastructure to be delivered as part of new road projects or upgrades, and within the Green Grid aligned with green infrastructure improvements **Water, wastewater and recycled water** ▪ Costs are further reduced as a greater number of trunk mains and pumping stations for water, wastewater and recycled water services can be deferred due to the higher concentrated urban form ▪ There is no change in the scope and cost to increase the capacity of existing and build new water reservoirs and water recycling facilities including the proposed Upper South Creek advanced water recycling centre as these continue to support the same population (maximum) **Electricity** ▪ Shortest distribution length and some not required in precincts at all ▪ Potentially three to four fewer zone substations **Gas** ▪ As per moderate option (i.e. Rossmore SRS would not be required and reduced secondary gas main length) **Green Infrastructure** ▪ Reduced costs due to staged delivery of Wianamatta Park and the exclusion of the Gateway park. ▪ Reduced costs due to staged approach to waterway management and biodiversity conservation projects

	Maximum – maximum land enabled for growth on multiple fronts	Moderate – moderate level of land enabled and serviced for growth coordinated in strategic locations	Minimum – minimum land enabled and serviced to progressively meet demands of growth
		Stormwater ▪ Reduction in costs due to more focused urban form limiting number of stormwater catchments affected by 2036	▪ Reduced costs due to reductions in the need for local open space that is accessible within 400m due to more concentrated development tree canopy which is now targeted around precincts/areas that come first Stormwater ▪ Further reduction in costs due to fewer areas of new urban development limiting number of stormwater catchments affected by 2036

Source: GSC *Western Sydney PIC Preliminary Staging and Sequencing Scoping Paper*.

6.8 PIC 1 – evaluation against staging and Sequencing Principles

Principle	Maximum – maximum land enabled for growth on multiple fronts	Moderate – moderate level of land enabled and serviced for growth coordinated in strategic locations	Minimum – minimum land enabled and serviced to progressively meet demands of growth
1. Strategic alignment with government policy	▪ Meets the Western Sydney City Deal commitments and allows realisation of initial precincts as outlined within the Western Sydney Aerotropolis Plan (WSAP) ▪ Does not reinforce the existing clusters of Liverpool, Penrith, Campbelltown ▪ Does not facilitate a sustainable sequenced approach to precinct planning	▪ Allows for a sustainable and sequenced approach to precinct planning ▪ Strongly aligned with the WSAP, including the identified initial precincts ▪ Strong alignment with already rezoned precincts (Northern Gateway, Mamre Road, Leppington North, Austral, Edmondson Park and Glenfield) and current active rezoning projects (i.e. Leppington Town Centre and Glenfield school site)	▪ Allows for a sustainable and sequenced approach to precinct planning ▪ Alignment with already rezoned precincts (Northern Gateway, Mamre Road, Leppington North, Austral, Edmondson Park and Glenfield) and current active rezoning projects (i.e. Leppington Town Centre and Glenfield school site) ▪ Allows for some growth and development within each of the initial precincts identified within the WSAP but to a lesser extent
2. Leverages investment in catalytic infrastructure	▪ Does not maximise the use of land around catalytic infrastructure ▪ Allows for growth in precincts (i.e. North Luddenham, Rossmore) that do not leverage key catalytic infrastructure such as the Western Sydney Airport Metro stations	▪ Supports growth and development around Western Sydney Airport Metro Stations ▪ Strong alignment with Western Sydney Airport Metro, City Deal rapid bus services, the M12 and projects under the Western Sydney Infrastructure Plan	▪ Supports growth and development around Western Sydney Airport Metro Stations ▪ Strong alignment with Western Sydney Airport Metro, City Deal rapid bus services, the M12 and projects under the Western Sydney Infrastructure Plan

Principle	Maximum – maximum land enabled for growth on multiple fronts	Moderate – moderate level of land enabled and serviced for growth coordinated in strategic locations	Minimum – minimum land enabled and serviced to progressively meet demands of growth
3. Prioritises early strategic employment	▪ Supports employment, but does not prioritise strategic employment locations or support business or industry agglomeration to a few key locations ▪ Includes additional residential and mixed-use precincts	▪ Supports agglomeration of high value and knowledge intensive jobs around the Nancy Bird Walton Airport (i.e. Aerotropolis Core, Agribusiness, Northern Gateway, Badgerys Creek (north) ▪ Supports freight and distribution (Greater Sydney, NSW and international) around Mamre Road and Kemps Creek (north) with the planned intermodal terminal and Western Sydney Freight Line (WSFL)	▪ Concentrates employment opportunities within fewer areas and locations which may not suit all employment industry categories
4. Leverages consolidated land holdings **(assumes 100ha is the benchmark for consolidated land holdings)**	▪ High levels of supply are likely to impact the need and ability to leverage large consolidated land holdings ▪ Includes highly fragmented precincts (i.e. Rossmore, Kemps Creek)	▪ Focuses on precincts and areas within precincts with a high number of large land holdings in Government and private ownership ▪ Includes precincts with Government controlled or owned sites, including holdings of residual land acquired for infrastructure projects	▪ Focuses on key precincts (Northern Gateway, Aerotropolis Core) and areas within precincts with a high number of large land holdings in Government and private ownership
5. Supports new solutions for constrained lands **(i.e. flood affected and highly fragmented)**	▪ May provide greater opportunity for innovation from the market to address constrained land to enable development to occur	▪ Provides the ability to target and leverage constrained lands (i.e. flood affected lands around Wianamatta-South Creek, aviation noise exposure) to facilitate urban outcomes (such as environment and recreation) and/or key services ▪ Retains a focus on solving the problem of fragmented lands around Leppington Station before opening more residential fronts	▪ Narrow focus on precincts and areas within precincts that are less constrained, which limits the ability and need to create and support new opportunities for constrained lands (i.e. fragmentation, flood affected)
6. Supports a diversity of new urban housing	▪ High levels of supply are likely to result in less need for highly urban housing and less ability to control urban design ▪ Likely to result in business as usual low-density housing development	▪ Provides the flexibility to support a mix of urban housing typologies and diversity in density	▪ Limitations on supply will impact the ability to facilitate a mix of urban housing ▪ More likely to result in primarily higher density developments
7. Leverages opportunities to improve social sustainability	▪ Provides some opportunity to pursue social outcomes, however this is less likely to driven by the private sector	▪ Provides the opportunity to pursue social outcomes (i.e. social and affordable housing) via leveraging government owned land (particularly within Aerotropolis Core)	▪ Provides the opportunity to pursue social outcomes (i.e. social and affordable housing) via leveraging government owned land (particularly within Aerotropolis Core)

Principle	Maximum – maximum land enabled for growth on multiple fronts	Moderate – moderate level of land enabled and serviced for growth coordinated in strategic locations	Minimum – minimum land enabled and serviced to progressively meet demands of growth
8. Precincts are viably supported by enabling infrastructure	▪ Significant additional infrastructure and services required to support growth and development across all precincts	▪ Allows for some reduction in additional infrastructure and services required to support growth and development ▪ Better aligned with investment already committed for enabling infrastructure such as the Western Sydney City Deal rapid bus services, the M12 and projects under the Western Sydney Infrastructure Plan ▪ Better leverages precincts along Elizabeth Dr and Mamre Road which may need to be upgraded regardless to support background traffic growth and access to other targeted precincts and the Airport	▪ Requires the least amount of additional infrastructure and services to support growth and development ▪ Aligns with investment already committed for enabling infrastructure such as the Western Sydney City Deal rapid bus services, the M12 and projects under the Western Sydney Infrastructure Plan
9. Precincts are viably supported by supporting social infrastructure	▪ Requires the provision of social infrastructure across all precincts in line with dispersed development	▪ Provides greater ability to concentrate social infrastructure in key precincts and around key catchments such as Western Sydney Airport Metro stations ▪ Provides for more complete places and communities and better utilisation of investment in social infrastructure	▪ Provides greater ability to concentrate social infrastructure in key precincts and around key catchments such as Western Sydney Airport Metro stations ▪ Provides for more complete places and communities and better utilisation of investment in social infrastructure
10. Supports co-locations opportunities	▪ Limited incentives for developers to support co-location opportunities ▪ Likely to result in a piecemeal approach to development, infrastructure and service delivery	▪ Provides some opportunities to co-locate activities and services particularly around Western Sydney Airport Metro stations catchments within the Aerotropolis Core and Northern Gateway ▪ Provides the ability to co-locate urban services and freight and distribution activities particularly around Badgerys Creek, Kemps Creek, Wianamatta-South Creek and Mamre Road	▪ Provides some opportunities to co-locate activities and services particularly around Western Sydney Airport Metro stations catchments within the Aerotropolis Core and Northern Gateway ▪ However, reduced land supply may result in limited flexibility to partner with landowners and developers
Summary evaluation and rationale	▪ Limited ability to ensure alignment with existing government policy (particularly the WSAP and existing catalytic infrastructure such as the Western Sydney Airport Metro) ▪ Significant additional infrastructure and services required to support growth and development, resulting in additional capital and operating costs	▪ Strongest alignment with existing government policy, strategic planning material and catalytic infrastructure (i.e. Western Sydney City Deal, WSPA, Western Sydney Airport Metro) ▪ Prioritises growth within key strategic employment areas around the Nancy Bird Walton Airport, focussing on high value and knowledge intensive jobs ▪ Does require additional investment in enabling infrastructure and services to support growth and development, but likely to create additional benefits, particularly related to job creation	▪ Some alignment with existing government policy, however, doesn't align with the full extent of growth and development of the initial precincts identified within the WSAP ▪ Leverages major catalytic infrastructure investments (i.e. Western Sydney Airport Metro) ▪ Least cost option, however, still requires additional investment in enabling infrastructure and services to support growth and development

Principle	Maximum – maximum land enabled for growth on multiple fronts	Moderate – moderate level of land enabled and serviced for growth coordinated in strategic locations	Minimum – minimum land enabled and serviced to progressively meet demands of growth
	▪ Does not prioritise strategic high value employment and does not support business and industry agglomeration		▪ Less ability to facilitate strategic employment outcomes as employment opportunities are concentrated at locations which may not suit all employment industry categories

Note: Outcomes for the evaluation of the options against each principle receive one of three ratings, with teal corresponding to positive, grey to neutral and red to negative. ,

Source: GSC Western Sydney PIC Preliminary Staging and Sequencing Scoping Paper

Within-precinct staging and sequencing

The PIC scenarios which we have evaluated have been developed at the level of precincts. Within each precinct, there are a range of factors affecting the pattern of development that will be preferred, such as how accessibility changes and the costs to government of development within parts of a precinct.

The tools used elsewhere in this evaluation are not able to be used to evaluate options for development within precincts. The main reason is that the PIC scenarios do not define land use outcomes within a precinct, with only the total population, jobs and dwellings for each precinct defined in the scenarios. Similarly, costs are allocated to each precinct, but not to areas within precincts.

Accordingly, a different approach to assess staging and sequencing within precincts has been adopted by CityPlan, who are partners with The CIE on this project. CityPlan have undertaken an opportunities and constraints analysis to identify greenfield and infill locations to support the anticipated growth. This approach and their findings are documented in their report *Precinct Analysis – Western Sydney PIC Development Sequencing*, which is an attachment to this report.

CityPlan's analysis found that greenfield land was more constrained than existing urban areas due to factors such as flood risk. Opportunities for beneficial development are highest in land within walking distance to existing or future infrastructure such as train/metro stations.

7 Valuing the outcomes as a place to live

- **Liveability benefits are slightly higher for Scenario 2 compared to Scenario 3, with a difference around $0.6 billion in present value terms.**
- **Scenarios 2 and 3 have a net liveability benefit relative to Scenario 1, which itself has a benefit relative to the base case. Liveability benefits are largely associated with the value of residential development at current attributes of the area.**
- **Improved public transport accessibility to jobs is somewhat offset by reduced accessibility to jobs by car, with a small net benefit associated with improved accessibility to jobs overall.**

Approach to measuring liveability benefits

Liveability benefits of the scenarios are measured using the standard approach of willingness to pay and opportunity cost. The value is equal to:

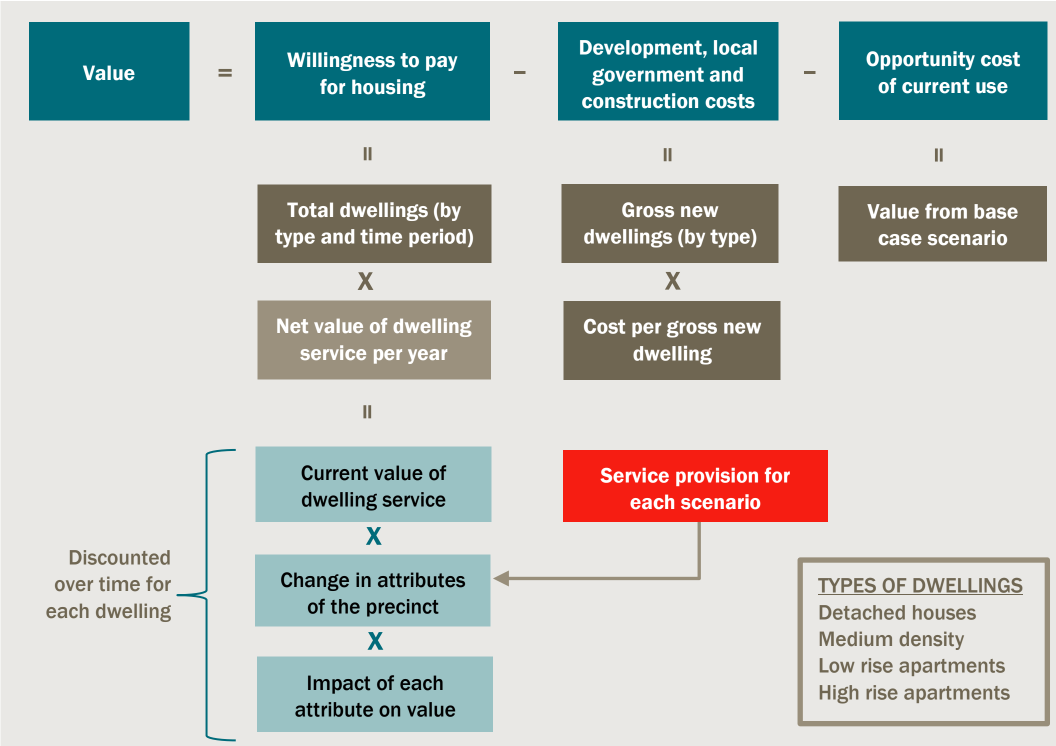
- the willingness to pay of people for living in an area, which is reflected in the willingness to pay for housing
- less the development, local council and construction costs, and the opportunity cost of using the site for an alternative purpose.

The value of living in an area over time changes because of the outcomes for the scenario. For example, if the scenario leads to greater accessibility to jobs in the future than now, then the value of living in the place will increase.

The approach is set out illustratively in chart 7.1.[11]

11 This approach measures development feasibility in that development will be feasible if willingness to pay is greater than the sum of costs borne by developers and the opportunity cost of the current use. However, we have not included some non-economic costs of development, such as Special Infrastructure Contributions (SIC). These are not the focus of the model, which is aimed at estimating economic value rather than financial returns.

7.1 Approach to valuing liveability



Data source: CIE.

The calculations of value are undertaken at a precinct level.

Differentiators across scenarios

Across the scenarios a range of benefits have been quantified; these are summarised in table 7.2.

7.2 Changes in place that are valued in evaluation

Attribute	Approach used for valuation
Number of dwellings of each type	Measure of willingness to pay for each dwelling, reflecting characteristics at a precinct level
Accessibility to jobs via private vehicle	Hedonic regression for impact and transport modelling for change in accessibility
Accessibility to jobs via public transport	Hedonic regression for impact and transport modelling for change in accessibility
Amount of open space (share of precinct that is open space)	Benefit transfer from a hedonic model of the willingness to pay for open space in the UK for impact
All time travel time to metro centre	Hedonic regression for impact of willingness to pay for change in travel time
All mode travel time to strategic centres	Hedonic regression for impact of willingness to pay for change in travel time

Attribute	Approach used for valuation
Dwelling construction and local infrastructure costs	Construction, development and local infrastructure costs per dwelling of each type

Source: CIE.

Benefits are measured by mapping outcomes to consumer willingness to pay for different levels of liveability. Willingness to pay is measured by market rents and dwelling prices in different locations and for different levels of local amenity. Changes in local amenity are related to changes in willingness to pay using parameters estimated from a hedonic model or using a benefit transfer approach, taking a parameter from an existing study. The hedonic and benefit transfer approaches and the hedonic model estimated for this paper are discussed in further detail in Appendix B.

For each scenario, benefits are measured by taking the marginal change in rents associated with a change in characteristics and multiplying it by the number of dwellings in that scenario. A description of the variables used to measure the physical changes and the parameters used to quantify the benefits are shown in table 7.3.

7.3 Changes in place that are valued in evaluation

Attribute	Valuation approach	Parameter and assumptions
Value of additional dwellings	The total number of dwellings under each scenario (summarised in chapter 3) are split into typologies. The benefit of additional dwellings is estimated as the number of new dwellings in a given year times the dwelling rent, before accounting for the change in other attributes (i.e. without improvements in accessibility or open space)	Dwellings growth is assigned to one of four building typologies (houses, medium density, flats (1-3) and flats (4+)) based on the expected zoning in 2056. The share of new dwellings, by typology is summarised in chart 7.5. Rents by typology and precinct are summarised in table 7.8. Real rents are assumed to stay constant in real terms. These assumptions are discussed further in the following section
Accessibility to jobs via private vehicle	Measured using job access density by car, which measures how accessible jobs are depending on car travel time and job location. See Appendix D for further information on how these are calculated and chapter 5 for a discussion of these metrics.	The valuation parameters are taken from the estimated hedonic model. The parameters used are as follows: ▪ Detached houses: 0.308 ▪ Semi-detached houses: 0.150 ▪ Flats (1-3 storeys): 0.064 ▪ Flats (4+ storeys): 0.069 These parameters are from a log-log specification and can be interpreted as the per cent change in dwelling rents for a per cent change in job density. Parameters are differentiated by dwelling type on the basis of the land share of value, which is equal to 49 per cent for houses, 24 per cent for medium density, 10 per cent for 1-3 storey flats and 11 per cent for flats with more than 4 storeys.

Attribute	Valuation approach	Parameter and assumptions
Accessibility to jobs via public transport	Measured using job access density by public transport, which measures how accessible jobs are depending on public transport travel time and job location. See Appendix D for further information on how these are calculated and chapter 5 for a discussion of these metrics.	The valuation parameters are taken from the estimated hedonic model. The parameters used are as follows: ▪ Detached houses: 0.089 ▪ Semi-detached houses: 0.044 ▪ Flats (1-3 storeys): 0.019 ▪ Flats (4+ storeys): 0.020 These parameters are from a log-log specification and can be interpreted as the per cent change in dwelling rents for a per cent change in job density.
Amount of open space (share of precinct that is open space)	Open space is measured as the open space share of total land area of a precinct. This is then multiplied by a parameter taken from GLA Economics (2003).	We use a parameter of 0.03, such that a 1 percentage point increase in open space, results in a 0.3 per cent increase in dwelling prices or rents. This is the lower range estimate, as the GLA report indicates the likely impacts is between 0.3 and 0.5 per cent.
All mode travel time to strategic centres (e.g. St Marys or Badgerys Creek North)	This measures the all mode travel time from a precinct to the closest strategic centre. As travel times increase, the valuation of dwellings decreases.	The valuation parameter is taken from the estimated hedonic model. The parameters used are as follows: ▪ Detached houses: -0.053 ▪ Semi-detached houses: -0.026 ▪ Flats (1-3 storeys): -0.011 ▪ Flats (4+ storeys): -0.012 These parameters are from a log-log specification and can be interpreted as the per cent change in dwelling rents for a per cent change in travel time
Dwelling construction costs	Construction costs are measured for each new dwelling constructed post 2016. Construction costs vary for houses, semi-detached houses and flats, but are constant across precincts. Construction costs are per m^2, assumptions around floor space are taken from JLL.	▪ Detached house: $1 862 per m^2, average floor space of 150 m^2 ▪ Semi-detached house: $2 492 per m^2, average floor space of 150 m^2 ▪ Flat: $2 755 per m^2, average floor space of 129 m^2 These estimates do not include any demolition or removal of existing property costs, which are only relevant for brownfield areas. The churn rate is assumed to be 1.0 for all new dwellings. This is the number of buildings constructed per net new dwelling. This reflects the low number of existing dwellings in the precinct. The loss of existing dwellings on land used for agriculture is reflected in our estimate of the loss of agricultural land, which includes some dwellings in the capital associated with that land. This is discussed further in Chapter 8.
Development costs	Development costs are added to unit construction costs and measured for all dwellings constructed post 2016. These costs vary for houses, semi-detached houses and flats of 1-3 storeys and flats over 4 storeys, but are constant across precincts. Development costs are per dwelling.	▪ Detached house: $59 475 per dwelling ▪ Semi-detached house: $50 946 per dwelling ▪ Flats (1-3 storeys): $36 409 per dwelling ▪ Flats (4+ storeys): $33 444 per dwelling

Attribute	Valuation approach	Parameter and assumptions
Local infrastructure costs	Local infrastructure costs are added to unit construction costs and measured for all dwellings constructed post 2016. These costs vary for houses, semi-detached houses and flats of 1-3 storeys and flats over 4 storeys, but are constant across precincts. Local infrastructure costs are per dwelling.	■ Detached house: $5 524 per dwelling ■ Semi-detached house: $4 735 per dwelling ■ Flats (1-3 storeys): $3 390 per dwelling ■ Flats (4+ storeys): $3 115 per dwelling
Residual value	Residual value is measured for dwellings constructed post 2016. This applies a straight-line depreciation to the dwelling structure only.	All dwelling types are assumed to have a 50 year economic life. Given the evaluation period ends in 2056, this means the dwellings are in service to 2056 and then a residual value of the cost of construction is applied at the end point.

Notes: The BASIX data set provides data on the floor size of dwellings, which is collected as part of the certification of dwellings under the BASIX program which seeks to reduce energy and water consumption in dwellings across NSW. The data includes internal area by detached house, semi-detached dwellings and flats.

Source: CIE.

Dwelling typologies and rents

The number of dwellings under each scenario, which was provided as an input to this analysis, have been assigned to one of four housing typologies: houses, medium density, flats in buildings between 1 and 3 storeys and flats of 4 or more storey. This is necessary to estimate value of precincts as a place to live, as benefits and construction costs vary across typologies; different dwelling shares would result in different liability estimates for otherwise identical areas.

Dwelling type by precinct in 2016 is calculated by combining mesh block level data, from the 2016 census, into precincts and calculating dwelling shares by types. This is multiplied by the total number of dwellings in precinct in 2016. The share of dwellings by type varies by precinct.

Two approaches were used to determine share of dwellings by type in 2056:

- for the already rezoned precincts (Austral, Leppington North, Edmondson Park, and Glenfield) the dwelling typology shares are based on the stated land zonings
- for the remaining precincts detailed zoning, or dwelling typologies, were not produced as part of the land use forecasts. This analysis was however, completed for the PIC 2 area, and GSC has advised that development in the PIC 1 area is expected to be similar to the PIC 2 area consisting primary of semi-detached dwellings and apartments. Accordingly, for the remaining precincts we have used the average dwelling typology share implied by the PIC 2 rezoning. The mapping from zoning to dwelling type is shown table 8.12.

7.4 Zone code to dwelling typology mapping

Dwelling typology	Zoning code
House	▪ RL ▪ LL ▪ LD
Med Dens	▪ MM
Flats 1-3	▪ R1
Flats 4+	▪ R1.4, R1.9, R2.2 R2.8 and R3.6 ▪ MX1, MX1.5, MX2.1, MX3, MX4 and MX6 ▪ CBD8

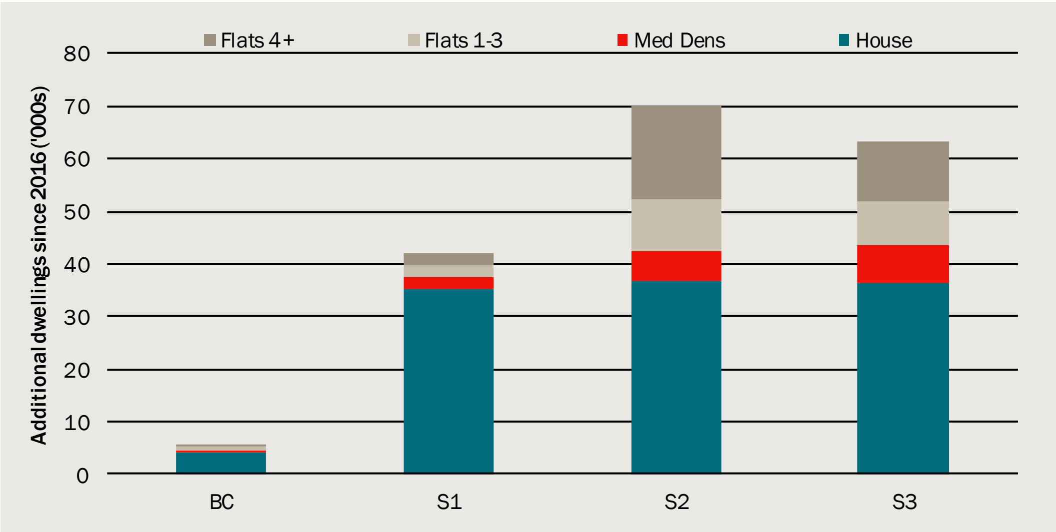
Source: COX and JLL 2019, Greater Penrith to Eastern Creek Land Use Scenarios, prepared for GSC; CIE.

The share of new dwellings attributed to each dwelling type is shown in chart 7.5. The same share is used for each period (i.e. if 10 per cent of dwelling growth is attributed to medium density from 2016 to 2026, 10 per cent of dwelling growth is attributed to medium density between 2026, 2036 and 2056 as well). Most of the development in Scenario 1 additional to the base case is associated with houses.

On the other hand, most of the development in Scenarios 2 and 3 additional to Scenario 1 is associated with flats (chart 7.6). This is a departure from recent building activity with detached dwellings accounting for around half of the new dwellings in Liverpool and Penrith LGAs over the past few years, and over 80 per cent of dwellings in Camden LGA (table 7.7).

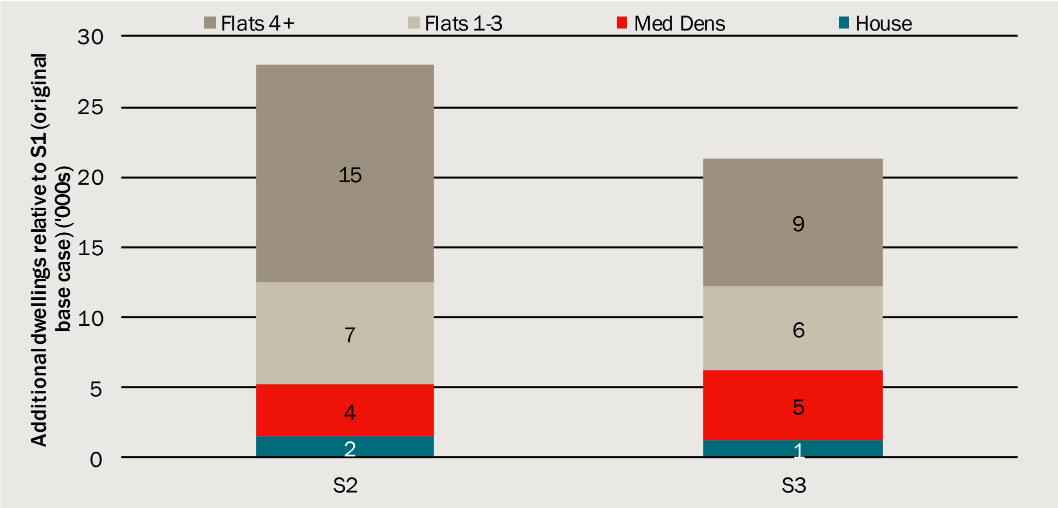
The share of dwellings by typology varies across precincts.

7.5 New dwellings constructed between 2016 and 2056 by scenario



Data source: GSC, CIE.

7.6 Additional dwellings at 2056 in scenarios relative to original base case



Data source: CIE.

7.7 Building approvals 2017-2019, by LGA

	House	Med Dens	Flats 1-3	Flats 4+
	Per cent	Per cent	Per cent	Per cent
Camden	81.9	15.2	2.9	0.0
Liverpool	48.8	12.6	0.0	38.5
Penrith	47.6	19.0	1.0	32.5

Source: ABS, CIE.

Other assumptions

Annual dwelling rents at current characteristics of the PIC area (i.e. without physical changes such as improved accessibility) have been estimated by JLL (table 7.8). These estimates have been developed by JLL based on rents in the emerging residential centres of Leppington, Edmondson Park and Glenfield. To achieve a greater understanding of rents at higher densities, which do not currently arise in those emerging centres, JLL used residential sales and leasing evidence from a number of existing and emerging residential centres outside of the PIC area. These centres include:

- Liverpool
- Schofields
- Rouse Hill
- Marsden Park
- Penrith
- Blacktown
- Campbelltown

Rents are not assumed to be different across precincts without changes to the physical attributes of the PIC area. The challenge with differentiating rents across the PIC area is a lack of information around proposed uses within each precinct.

7.8 Annual dwelling rent

Precinct	Detached house	Semi-detached house	Flat
	Annual rent ($2020)	Annual rent ($2020)	Annual rent ($2020)
All precincts	28 125	24 438	21 375

Source: JLL.

Benefits relating to increased development (value of additional dwellings, construction costs and residual value) are only measured for dwellings constructed post 2016. Benefits relating to changes in liveability resulting from development under each scenario are assumed while benefits relating to liability are measured for both the new and existing dwelling stock.

Benefits are measured for 2026, 2036 and 2056. Intervening benefits have been linearly interpolated.

We have discounted benefits as follows:

- Housing benefits are discounted at their internal rate of return (IRR), which makes the flow of housing benefits the same as dwelling prices. The IRR is assumed to be 3 per cent; further work will seek to refine and test this assumption. When a dwelling is constructed in 2020, the lump sum benefit occurs in 2020 and then needs to subsequently be discounted back to 2016. For existing dwellings, the lump sum benefit occurs in 2016 and does not need to be subsequently discounted.
- To discount the value of the future stream of benefits from the point at which a new dwelling is constructed to total, we discount the lumpsum of benefits by 7 per cent.

This approach ensures that at the time of construction the discounted dwelling services are broadly in line with house prices; this lump sum benefit is then discounted to present values, using the standard 7 per cent discount rate.

Benefits for social and affordable housing are included in the aggregate liveability valuations, insofar as these developments are incorporated into the projected land use assumptions for each scenario. They are treating the same way as private dwellings assuming, that affordable housing delivers the same level of benefits. This may overstate benefits as the marginal willingness to pay of individuals in social or affordable housing will be lower than private renters or owners. Benefits may be understated where construction costs are lower for affordable or social housing due to the use of lower cost finishes or social housing results in externalities which have not been valued. These other benefits are not likely to be material in the context of this study.

Estimates of value as a place to live

Table 7.9 shows the NPV of housing services under each scenario. Scenario 2 and Scenario 3 have very similar total benefits, which appears to be largely due to a higher level of development compared to the base case and Scenario 1. The increase in liveability, which relates to job accessibility, open space and accessibility to strategic centres also increase in line with the value of new dwellings at current attributes, but are smaller in magnitude.

7.9 Value of housing services for each scenario

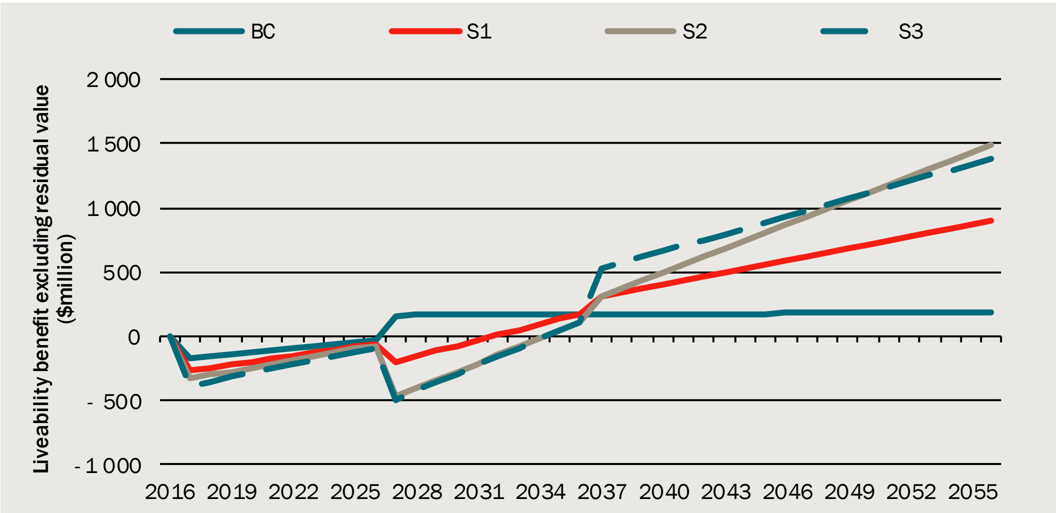
Scenario	Net value of new dwellings at current attributes of PIC area	Increase in liveability	Total
	$b, NPV	$b, NPV	$b, NPV
Base case	1.2	0.4	1.6
Scenario 1	5.3	0.7	6.0
Scenario 2	7.2	1.9	9.1
Scenario 3	7.2	1.3	8.5

Note: Net value is value less construction costs.

Source: CIE.

The time profiles of benefits vary significantly across scenarios (chart 4.14). The base case (constrained) involves negligible benefits beyond 2026, which can be seen to be the result of almost no housing development beyond this point (chart 7.11). The base case has the highest liveability benefits until 2036, after which Scenarios 2 and 3 increase to have around $500 million in additional benefits relative to Scenario 1 by 2056. This is partially due to greater development prior to 2036 requiring more years before benefits accrue to outweigh the costs of construction (which are borne earlier than the benefits accrue). Scenario 3 catches up to Scenario 2 between 2036 and 2056, as a result of more dwelling growth over that period.

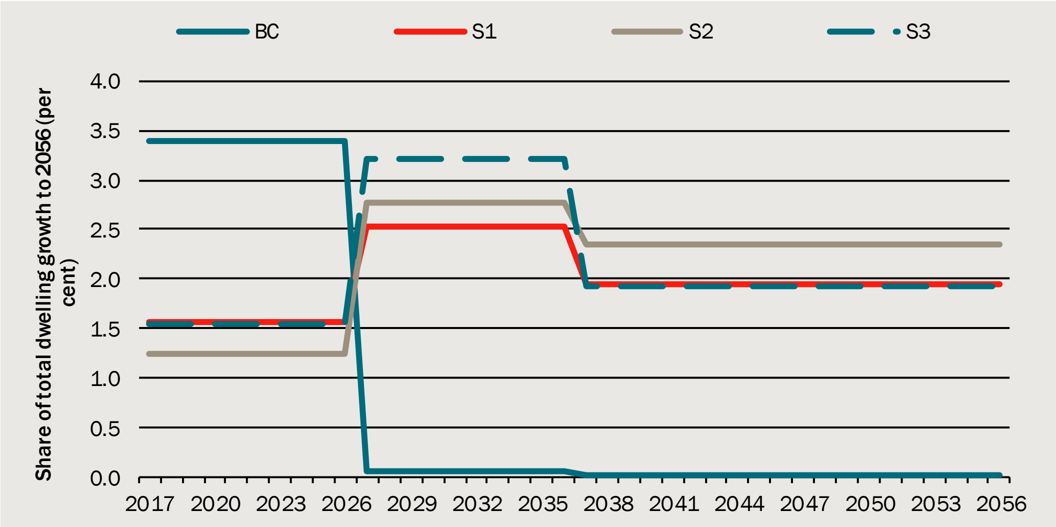
7.10 Annual liveability benefits by scenario



Note: Excludes residual value. Liveability benefits are net of construction costs.

Data source: CIE.

7.11 Annual housing development, share of total from 2016 to 2056



Data source: CIE.

Value of housing compared to the base case under each scenario

The value of housing compared to the base case, under each scenario, is shown in table 7.12. All development scenarios have net benefits compared to the base case. Scenario 2 has the largest net benefit, driven by higher levels of development. While job accessibility by car is lower in the scenarios compared to the base case, it is more than offset by benefits associated with improved accessibility by public transport. Across the scenarios there is little variation in the value of increased open space and access to strategic centres.

7.12 Value of housing services for each scenario relative to base case

Benefit	Scenario 1	Scenario 2	Scenario 3
	$ billion, NPV	$ billion, NPV	$ billion, NPV
Additional housing	6.8	10.9	11.2
Increased job density – car	-0.5	-0.4	-0.6
Increased job density – public transport	0.7	1.8	1.5
Increased open space	0.0	0.1	0.1
Access to strategic centres	0.0	0.0	-0.1
Residual value of housing	0.6	1.1	0.9
Total benefit	**7.7**	**13.5**	**13.1**
Dwelling Construction cost	3.4	6.0	6.1
Net benefit	**4.3**	**7.5**	**6.9**

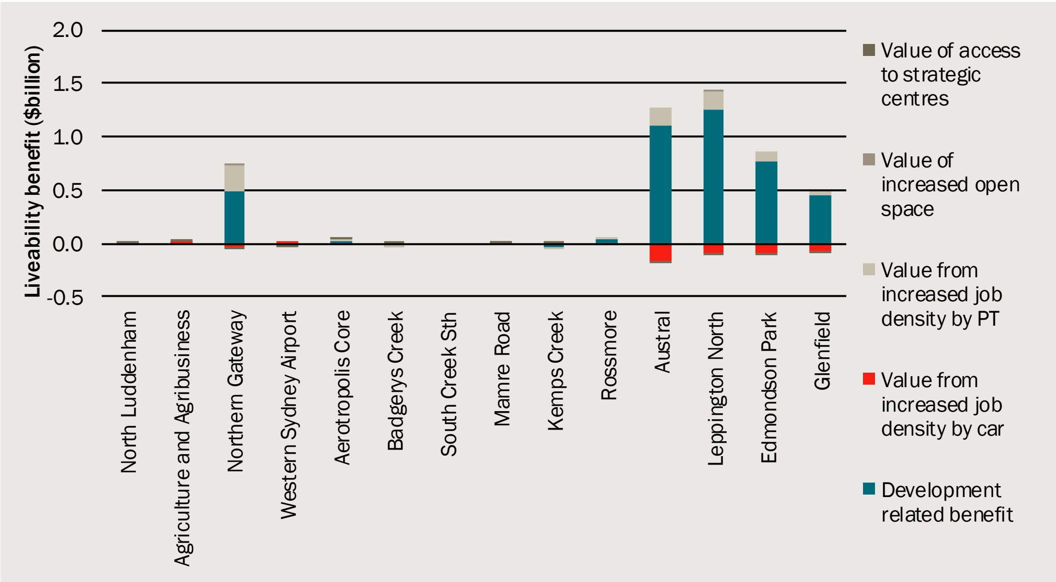
Source: CIE.

Estimates as a place to live by precinct relative to the base case

Total benefits and category specific benefits vary considerably across precincts (charts 2 – 7.15). Development related benefits tend to be largest in precincts which are expected to experience large increases in dwelling numbers under the respective scenarios, while the other benefits are more closely related to existing population and the physical changes outlined in each scenario.

Across scenarios, the distribution of benefits across precincts tends to be strongly correlated. The precincts with existing residential development of Austral, Leppington North, Edmondson Park and Glenfield, plus Northern Gateway have significant liveability benefits in all scenarios. The Aerotropolis also has significant liveability benefits in Scenario 2, and less so in Scenario. Rossmore has comparable liveability benefits to the established residential areas around Austral, except in Scenario 1 where there is little development in the precinct.

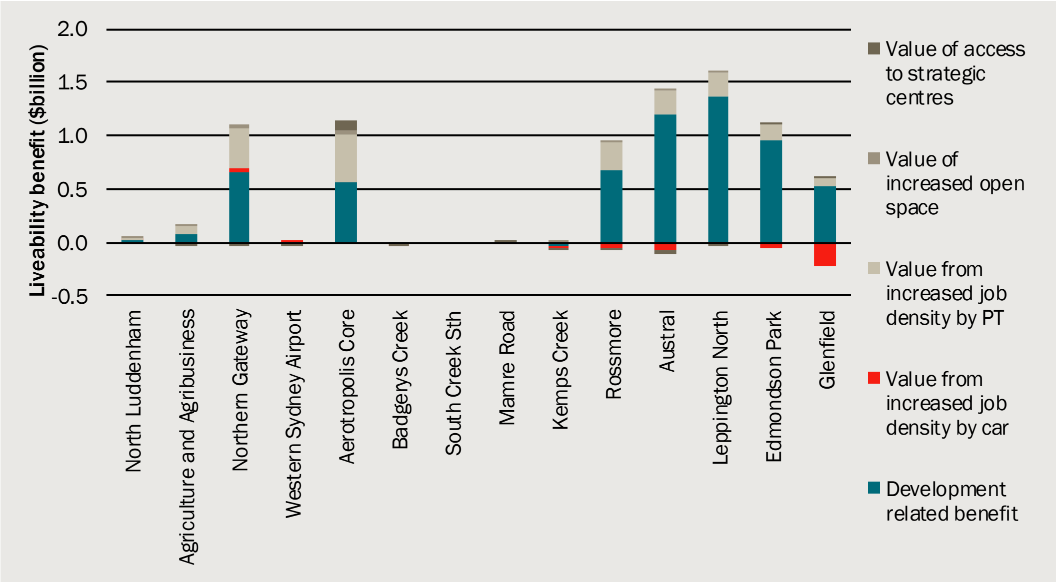
7.13 Liveability benefits relative to the base case — Scenario 1



Note: Development related benefits are net of dwelling construction costs.

Data source: CIE.

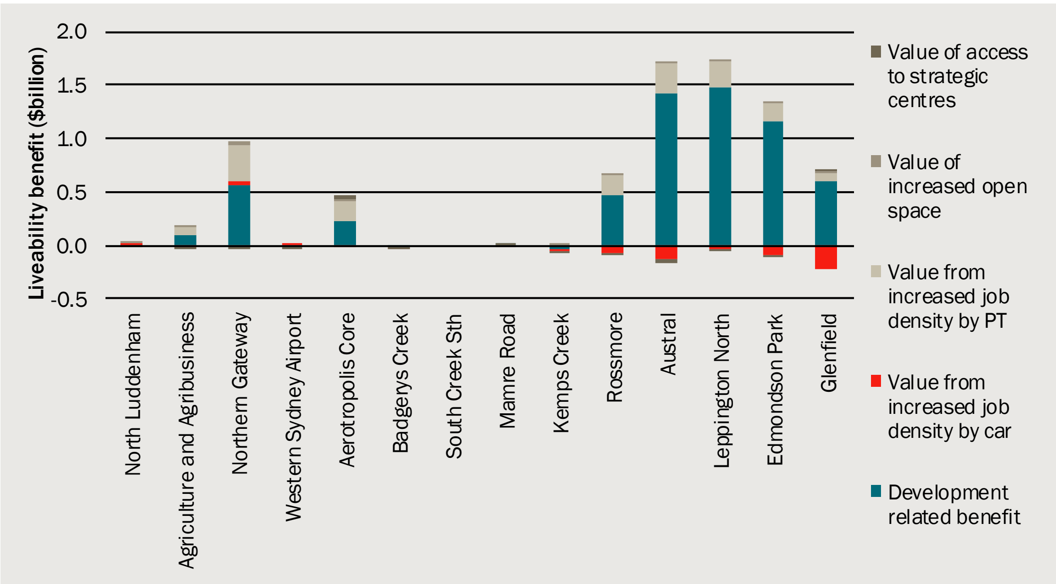
7.14 Liveability benefits relative to the base case — Scenario 2



Note: Development related benefits are net of dwelling construction costs.

Data source: CIE.

7.15 Liveability benefits relative to the base case — Scenario 3



Note: Development related benefits are net of dwelling construction costs.

Data source: CIE.

Accessibility to universities, TAFEs and cultural infrastructure

It is difficult to capture in simple metrics the amount and quality of universities and cultural infrastructure that people are accessible. A key reason for this is that many of the characteristics of these facilities are not yet identified or rely on private sector decisions that are highly uncertain. Additionally, the value of accessibility to universities and cultural infrastructure will already be included to some extent in changed accessibility to metropolitan and strategic centres, which tend to contain such infrastructure. Given this difficulty in measurement and potential for double-counting, we do not measure benefits associated with changes in accessibility to universities or cultural infrastructure.

Benefits of social housing

Social housing is rental housing subsidised by government and provided to assist people who are unable to access suitable accommodation in the private market. This includes (see table 7.16):[12]

- Public housing, which is owned and managed by the NSW Government
- Community housing, which is owned and/or managed by non-government organisations
- Aboriginal housing, specifically for Aboriginal people, owned by the Aboriginal Housing Office and managed by the Government or owned and/or managed by Aboriginal Community Housing Providers managed by either by Aboriginal community housing providers.

7.16 Number of social housing dwellings

Type of social housing	Social housing dwellings
	No.
Public housing	100 623
Community housing	41 629
Aboriginal housing	9 576
Total	**151 828**

Source: https://public.tableau.com/profile/facs.statistics#!/vizhome/Social_Housing_Residential_Dwellings/Dashboard.

No social housing benefits have measured as LAHC has indicated that no social housing dwellings are expected to be provided in the PIC 1 area.

Impacts not quantified

We have not measured the increase in the number of permanent teaching spaces as a benefit. Previous work has found no significant impact on teacher perception, morale, job satisfaction, student achievement and behaviour with the use of portable or demountable classrooms.[13] This has led to the conclusion that the impact of a teaching space on educational outcomes, the quality of the space is more important than the permanent and

12 IPART 2017, *Review of rent models for social and affordable housing*, p.1.

13 Chan, T. 2009, *Do portable classrooms impact teaching and learning?*, Journal of Educational Administration, vol. 47, no. 3, pp. 290-304.

the presence of demountable are more likely to impact on community perceptions than student learning.[14]

We have not measured impacts for other potential design related impacts, such as environment (i.e. temperature, noise airflow etc.) or how the design process has accounted for pedagogy, assuming the new educational spaces are consistent with current guidelines.

Open space health benefit externality

Open space can encourages additional physical activity. Increased physical activity has been shown to have a positive impact on health and wellbeing, reducing the risks of non-communicable disease such as coronary heart disease, stroke, type 2 diabetes, breast cancer and colon cancer.[15]

Increased physical activity may improve how individuals feel (which would be reflected in the use value of green infrastructure), but also results in an externality for the broader activity as a result of reduced health expenditure, productivity savings from reduced absenteeism and reduced mortality.

Attributing health benefits to green infrastructure is problematic, as it is difficult to observe whether increasing the provision of open space increases physical activity or results in a diversion from other locations. In order to estimate this benefit, a number of assumptions are required around the change in activity (i.e. the number of time individuals visit parks and for what reason) and user substitution patterns.[16]

Improved interconnectedness of open space and availability

Some types of green infrastructure, such as bicycle paths and footpaths may result in improved accessibility and provided opportunities for active transport. The value in using this infrastructure depends on connectivity to other parts of the green network and other activities. Connected routes may result in increased active transport and reduced generalised travel costs (either due to faster travel times, a more pleasant journey and other saved costs), but also gains for the broader transport network (i.e. if individuals switch from road transport to active transport there may a reduction in congestion for other road users).

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14 Blackmore, J., Bateman, D., Loughlin, J., O'Mara, J. and Aranda, G. 2011, *Research into the connection between built learning spaces and student outcomes*, prepared for the Victorian Department of Education and Early Childhood Development, p. 14.

15 Ding, Lawson, Kolbe-Alexander, Finkelstein, Katzmarzyk, van Mechelen, Pratt 2016, The economic burden of physical inactivity: a global analysis of major non-communicable diseases, The Lancet.

16 Varcoe, T., Betts O’Shea, H. and Contreras, Z. 2015, Valuing Victoria’s Parks Accounting for ecosystems and valuing their benefits: Report of first phase findings, accessed on 13 September 2016 at <http://www.delwp.vic.gov.au/parks-forests-and-crown-land/managing-land>.

Without specific transport information, it is difficult to measure the current transport benefit, which is generated by existing bike networks and footpaths in Sydney. In evaluating the benefits of specific initiatives, this benefit would be able to quantified by expected usage for walking and cycling.

Benefits of affordable housing

Affordable housing is rental housing delivered with some form of government support or intervention and is provided by the private or not-for-profit sector to assist people on very low to moderate incomes.[17] Affordable housing is not the same as the broader issue of “housing affordability”.[18]

Affordable housing is delivery using some form of government support or intervention, such as:[19]

- Providing subsidies for landlords to rent properties to eligible households at below market rents. An example of this was the National Rental Affordability Scheme and the current NSW Government Social and Affordable Housing Fund
- Planning invectives, where developers are allowed greater densities in return for constructing affordable dwellings
- Philanthropic investment

Rents for affordable housing are generally set in one of two ways:[20]

- at a discount relative to current market rents for similar properties in the same area. Generally, this is 20 to 25 per cent below market rents.
- as a proportion of a household’s before tax income. Where rent is set this way, households may be charged between 25% and 30% of before tax income for rent.

Affordable housing is open to households earning higher levels of income, than social housing, which generally means this group will not experience the same barriers to education, health care and employment. As a result, the benefit associated with affordable housing will be much smaller than for social housing.

The main value of affordable housing will be the value of providing additional dwellings, which is measured separately. We have not measured any other benefit for affordable housing, as there a lack of evidence to link affordable housing to changes in education, health, employment or safety outcomes.

Costs of affordable housing

The impacts of affordable housing on producer and consumer surplus is illustrated in chart 7.17. Affordable housing recipients pay a subsidised rent () which is lower than the

17 IPART 2017, *Review of rent models for social and affordable housing*, p. 1.

18 IPART concludes that affordable housing is not a solution to “housing affordability” more generally.

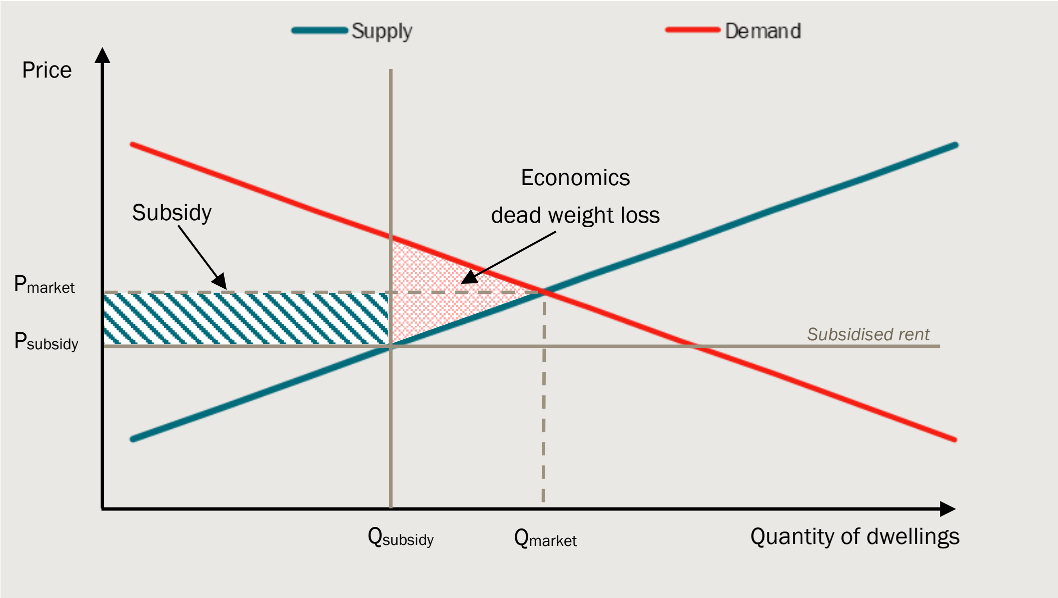
19 IPART 2017, *Review of rent models for social and affordable housing*, p. 90.

20 https://www.facs.nsw.gov.au/housing/help/ways/renting-affordable-housing

market rent (). The difference between these is the subsidy which is paid by affordable housing providers and Government to affordable housing tenants. In economic terms this subsidy is not a cost, but a transfer from affordable housing owners to households. In financial terms, however, this will be the main financial cost of affordable housing.

The main economic costs of affordable housing will be associated with the impacts on housing markets.

7.17 Market impacts of affordable housing



Data source: CIE.

Where developers are required to pay for affordable housing, the main economic costs will be:

- The economic dead weight loss of providing subsided rental accommodation. This is the economic cost of setting a price ceiling below the market price for rent, that is the foregone value of higher value land use for social housing sites. This has two main impacts
  - A reduction in producer surplus. Requiring developers to provide affordable housing increases the cost of development, which means that fewer developer can make an economic profit (given the lower rents for affordable dwellings). This results in less development occurring resulting in some developer profits from development being foregone.
  - A reduction in consumer surplus. The reduction in development means that some individuals can no longer find homes despite having a willingness to pay greater than the equilibrium housing price (). The benefit that these households would have received from housing is forgone.
- Indirect costs associated with affordable housing. The costs of administering affordable housing may be greater than that of administering private rental accommodation. This would be an additional cost of providing affordable housing. Market distortionary impacts on the housing market.

- The cost associated with raising government funds to finance construction or the ongoing subsidy (i.e. the dead weight loss of taxation).

We have not measured the cost of providing affordable housing in this analysis.

Feasibility of affordable housing analysis by JLL

JLL were commissioned by the GSC to conduct an assessment of the feasibility of affordable housing. JLL found that the provision of affordable housing has variable levels of viability across specific sites and precincts within the Western Economic Corridor and surrounds.

Applying the DPIE Affordable Housing Viability Tool, several representative sites across the Western Economic Corridor and surrounds were evaluated to assess the viability of 5 per cent and 10 per cent (of total GFA) affordable housing targets. Based on a range of inputs including land prices, dwellings sale prices, constructions costs and developer contributions, JLL analysed the 'residual land value once up zoned', which is the difference between revenue and costs after excluding the developers margin. If the residual land value greater than the base land value, development, including affordable housing allowances, at that site is viable.

The key findings include:

- Under the 5 per cent affordable housing contribution, testing showed a mix of viability results from marginal/viable to unviable, depending largely on the 'as is' value (both site dependant and level of premium) and the proposed controls.
- In the existing urban areas of Penrith and St Marys there are examples where the uplift in controls is sufficient to provide viable development with a 5 per cent affordable housing levy, assuming immediate change in controls. This is despite the existing 'in use' values in these precincts being comparatively higher than some of the other precincts.
- Greenfield areas, such as Aerotropolis Core and Northern Gateway, currently typically have development values that are lower than the urban precincts mentioned above, as well as disproportionality lower 'in use' values (due to their rural nature). These greenfield areas are likely to have increased affordable housing viability over the medium to longer term as the residual land value grows commensurately higher.
- Generally, across the precincts, the 10 per cent affordable housing contribution had more challenges with viability.

There are a range of factors that play a key role in the feasibility of affordable housing, many of which will likely improve feasibility over the medium to long-term. For example:

- **Land value growth vs improved value growth**: Land value grows at a faster rate than improved value. Therefore, over time, with all else being equal – land values (reflected in development values) will grow at a faster rate than improved values (reflected in 'as is' values).
- **Improved amenity resulting from infrastructure investment**: There is a significant amount of infrastructure committed and proposed within the Western Economic

Corridor and surrounds. This infrastructure will significantly improve the amenity and accessibility of the precincts and catalyse a change in their character. Infrastructure investment is likely to improve the viability of affordable housing provision over the short, medium and longer term.

- **Potential for staging of affordable housing contribution rates**: The current assessment explores the viability of affordable housing provisions of 5 per cent and 10 per cent. However, a staged implementation of affordable housing contributions could improve the viability of affordable housing over the short to medium term. A staged approach would provide greater visibility to the private sector on the market rates to be imposed along with the staging of those rates over time. This will enable both improvement in development values associated with infrastructure investment (as discussed above), as well as, the opportunity for the market to adjust development value assumptions.
- **Whole of government support for affordable housing**: the need for affordable housing is being considered across all levels of government. There are a number of policy choices which could improve the viability of development. For example, the current feasibility assessment assumes affordable housing dwellings are provided as an in-kind contribution from the developer. This could be replaced with some form of alternative option (e.g. affordable housing provided at a set discount to market value) which would improve the viability associated with the affordable housing contributions.

Congestion costs imposed outside of the PIC area

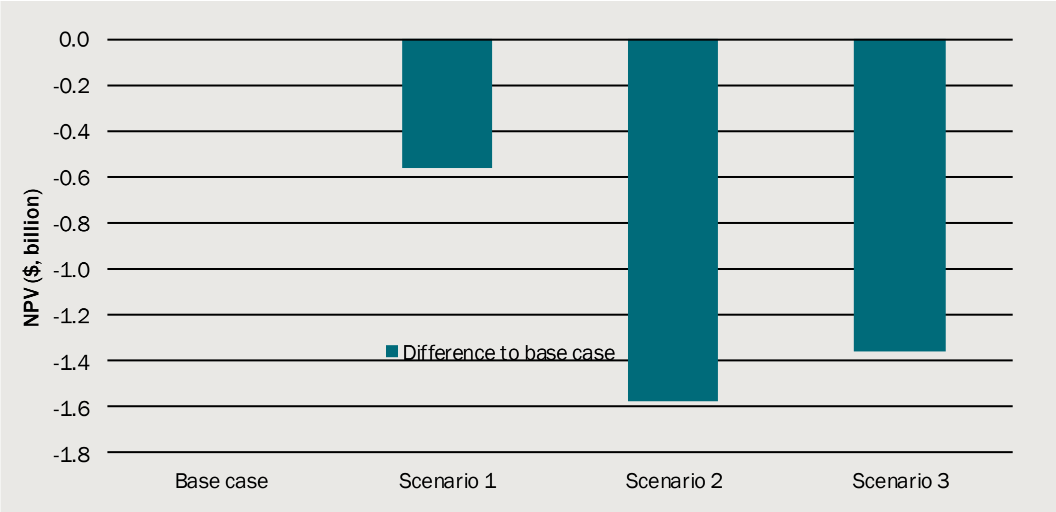
Additional people and jobs in the Aerotropolis will impose congestion costs outside of the PIC area, because additional vehicle kilometres are generated (see chart 3.2 above). We use a marginal cost of congestion of 44 cents per vehicle kilometre from TfNSW *Economic Parameter Values*.[21] This is inflated to Dec-2020 dollars using the consumer price index. We allow for half of the additional vehicle kilometres to impact as spillovers — a substantial part of the impact is absorbed by people living in and working in the PIC 1 area and already picked up in accessibility changes for car travel. We cannot precisely estimate how much of the congestion impacts will be felt by those with destinations or origins in PIC 1 versus those outside of PIC 1 with the transport modelling available.[22]

The estimated congestion spillovers outside of PIC 1 are shown in chart 7.18. Congestion spillovers impose a $1.6 billion cost on people outside of PIC 1 for Scenario 2, relative to the base case. This falls for Scenario 3, because of lower growth in population and jobs.

21 It is not possible to identify the specific impact of changes in trips from, to and within PIC 1 on congestion in the transport modelling because there are also changes in what happens outside of PIC 1.

22 The transport modelling has changes in activity outside of the PIC area which makes it difficult to identify changes only from what is happening within PIC area.

7.18 Congestion spillovers outside of PIC 1



Data source: CIE.

Note that in relative terms, the additional private vehicle demand created by population and job growth in PIC 1 is higher than Sydney-wide averages. The per capita private vehicle demand falls sharply with higher growth scenarios, because of extra public transport provision. This means that congestion spillovers would likely be much higher than those associated with accommodating people and jobs in other locations. This is discussed further in chapter 9.

These benefits are associated with liveability and productivity in that they affect the ability of residents and workers to travel. However, they are impacts outside the PIC area. Therefore, for the purpose of summaries of overall results from the PIC evaluation, they are considered together with sustainability benefits and other spillovers.

8 Valuing the outcomes as a place to work

- **Benefits associated with enhanced productivity of the PIC area are mainly associated with the value of commercial and industrial development at current attributes of the PIC area. There is a larger benefit associated with Scenario 2 that Scenario 3.**
- **Accessibility of businesses to other businesses by car worsens in higher development scenarios relative to the base, while accessibility to labour supply by public transport improves. This drives a small net benefit in the scenarios associated with superior accessibility outcomes.**

Approach to measuring productivity benefits

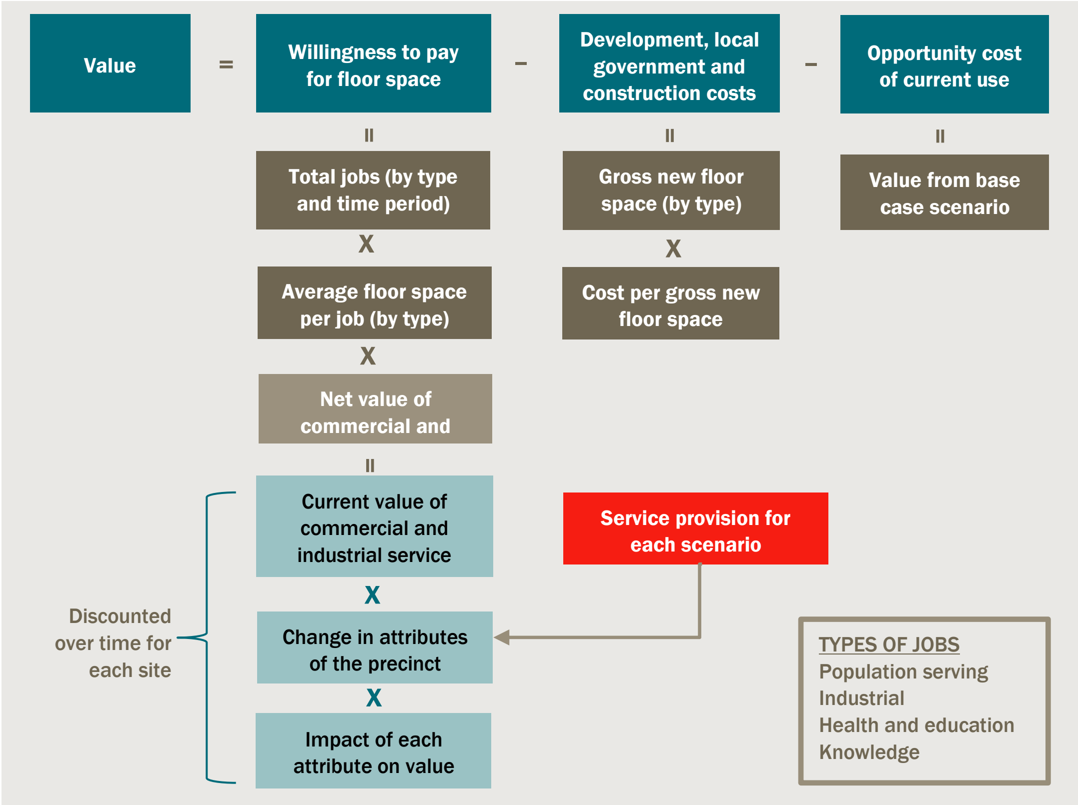
The productivity benefits of the scenarios are measured using the standard approach of willingness to pay and opportunity cost. The value is equal to:

- the willingness to pay of businesses for locating in a precinct, which is reflected in the willingness to pay for commercial and industrial floor space
- less the development and construction costs, and the opportunity cost of using the site for an alternative purpose.

The value of a business locating in an area over time changes because of the outcomes for the scenario. For example, if the scenario leads to greater accessibility to the labour market than now, then the value of locating in the place will increase.

The approach is set out illustratively in chart 8.1.

8.1 Approach to valuing productivity



Data source: CIE.

Differentiators across scenarios

Across the scenarios, a range of benefits have been estimated. The changes in place that are valued in the evaluation are summarised in table 8.2.

8.2 Changes in place that are valued in evaluation

Attribute	Approach used for valuation
Amount of floor space	Measure of willingness to pay for each property, reflecting characteristics at a precinct level
Accessibility of businesses to jobs via private vehicle	Hedonic regression for impact and transport modelling for change in accessibility
Accessibility of businesses to the labour force via public transport	Hedonic regression for impact and transport modelling for change in accessibility

Source: CIE.

Benefits are measured by mapping outcomes to consumer willingness to pay for different levels of productivity. Willingness to pay is measured by market rents and commercial property prices in different locations and for different levels of local amenity, with the change in local amenity related to changes in willingness to pay using parameters estimated from a hedonic model. The hedonic approaches and benefit transfer approaches are discussed in further detail in appendix C.

For each scenario, benefits are measured by taking the marginal change in rents associated with a change in characteristics and multiplying it by the amount of commercial floor space in that scenario. The change in rents is estimated by using parameters from the hedonic model. Descriptions of the variables used to measure the physical changes and parameters used to quantify benefits are shown in table 8.3.

8.3 Changes in place that are valued in evaluation

Attribute	Valuation approach	Parameter and assumptions
Value of additional commercial property	The total Floor Space (FS) of commercial property under each scenario are split among four industry sectors (summarised in chapter 3): ▪ Knowledge-intensive ▪ Population servicing ▪ Health and education ▪ Industrial The benefit of additional commercial property in each sector is estimated as the amount of FS in a given year multiplied by the rent per square-metre of FS, before accounting for the change in other attributes (i.e. without improvements in accessibility)	Rents by sector are summarised in table 8.4. Real rents are assumed to remain constant in real terms.
Accessibility of businesses to jobs via private vehicle	Measured using job access density by car, which measures how accessible jobs are depending on car travel time and job location (see chapter 5 and Appendix D for a discussion of these metrics).	The valuation parameters are taken from the estimated hedonic model. The parameters used are as follows: ▪ Knowledge intensive, population servicing and health and education sectors: 0.266 ▪ Industrial sector: 0.1148 These parameters are from a log-log specification and can be interpreted as the per cent change in dwelling rents for a per cent change in job density. They have been calculated by multiplying the coefficients estimated in hedonic models (which have the natural log of land value as the dependent variable) by the land-share of commercial property value. This has been assumed to be 30 per cent.
Accessibility to population via public transport	Measured using population access density by public transport, which measures how accessible people are to businesses depending on public transport travel time and population/job locations (see chapter 5 and appendix D for a discussion of these metrics).	The valuation parameters are taken from the estimated hedonic model. The parameters used are as follows: ▪ Knowledge intensive, population servicing and health and education sectors: 0.134 ▪ Industrial sector: 0.131 These parameters are from a log-log specification and can be interpreted as the per cent change in dwelling rents for a per cent change in population density. They have been calculated by multiplying the coefficients estimated in hedonic models (which have the natural log of land value as the dependent variable) by the land-share of commercial property value. This has been assumed to be 30 per cent.

Attribute	Valuation approach	Parameter and assumptions
Dwelling construction costs	Construction costs are measured for each new commercial building constructed post 2016. Construction costs vary for buildings related to each industry sector, and are constant across all precincts. Construction costs are per m^2, and the Floor Space (FS) requirement under each scenario is determined by multiplying the number of jobs by a FS per job requirement. The amount of FS that is constructed in each scenario and each 10-year period is the difference between the floor space requirement in the previous period and the floor space requirement in the subsequent period. If there is a decrease in floor space, then no construction costs are incurred and we do not include demolition costs. We do not make an adjustment for commercial property churn because the area does not have significant existing commercial development.	Commercial construction cost assumptions are contained in table 4.12. Assumed FS per job by industry sector is shown in 8.6. There is no churn rate for all precincts.
Development costs	Development costs are added to unit construction costs and measured for all commercial and industrial property constructed post 2016. Development costs are per m^2 of floor space.	▪ All sectors: $270 per m^2
Local infrastructure costs	Local infrastructure costs are added to unit construction costs and measured for all commercial and industrial property constructed post 2016. Local infrastructure costs are per m^2 of floor space.	▪ All sectors: $25 per m^2
Residual value	Residual value is measured for commercial constructed post-2016. This applies a straight-line depreciation to the commercial building (structure) only.	All commercial building types are assumed to have a 50-year economic life.

Source: CIE.

Benefits relating to increased development (value of additional commercial floor space, construction costs and residual value) are only measured for commercial floor space constructed post 2016. Benefits relating to changes in productivity resulting from development under each scenario are measured for both the new and existing dwelling stock.

Benefits are measured for 2026, 2036 and 2056. Intervening benefits have been linearly interpolated.

Commercial rent estimates for the PIC 1 area at current characteristics have been supplied by JLL. Given the lack of existing commercial land use within the PIC 1 area, JLL sourced office, retail and industrial sales and leasing evidence from a number of existing commercial centres within the Western Park City and nearby. Some of these comparators fall within precincts in the Greater Penrith to Eastern Creek (GPEC) area of PIC 2. Some of the comparator areas used include:

- Liverpool

- Penrith
- Blacktown
- Campbelltown
- St Marys
- Mount Druitt
- Erskine Park
- Moorebank
- Eastern Creek
- Wetherill Park
- Ingleburn

Based on the comparators used by JLL, these rents will represent the commercial and industrial rents achievable for the PIC area with attributes (e.g. accessibility levels) similar to those currently in the comparator locations. Accordingly, to estimate the value of improved accessibility levels, we constrain accessibility benefits in the PIC area to be equal to the benefits of improving from current levels of accessibility at Penrith Centre, St Marys or Mount Druitt to the future levels of accessibility in each precinct of the PIC.

8.4 Commercial rents in PIC 1

Precinct	Knowledge intensive	Population serving	Health and Education	Industrial
	$/m²	$/m²	$/m²	$/m²
All precincts	325	400	475	115

Source: JLL, CIE.

8.5 Construction costs of new commercial floor space in PIC 1

Precinct	Knowledge intensive	Population serving	Health and Education	Industrial
	$/m²	$/m²	$/m²	$/m²
All precincts	4 495	3 416	4 459	1 400

Source: JLL, CIE.

8.6 Floor space per job

Sector	Floor space requirement per job
	m²/job
Health & Education	40
Industrial	100
Knowledge Intensive	30
Population Servicing	55

Source: DPE, CIE.

We apply the standard 7 per cent social discount rate. We estimate an IRR to make the flow of commercial property services the same as property prices. For commercial property, there is not strong evidence that using a rate other than 7 per cent is appropriate. Therefore, we have assumed the IRR for commercial property is 7 per cent.

Lost value of agricultural land in greenfield areas

For greenfield areas such as the Aerotropolis PIC area, residential and commercial development will come at the expense of land being used for agricultural and environmental living uses. Infrastructure also requires land, and this results in loss of agricultural land. We measure the value of lost agricultural land by assuming that lost value per hectare is equal to the current value of agricultural lots across the entire Western City.

We use property sales data for lots zoned rural (e.g. RU1) or for environmental living €, which is available in the NSW Land and Property sales dataset. We estimate that for the LGAs within the Western City the average sales price per hectare was $399 988 per hectare in 2018. Assuming a rental yield of 3 per cent, and no escalation in prices between 2018 and Dec-2019, this implies an annual rent of $12 000 per hectare.

We further assume that only 70% of land is developable, and therefore that the ratio of land taken by residential and commercial property to the reduction in land available for agricultural uses is 143 per cent.[23] No ratio is applied to infrastructure land, on the basis that infrastructure land take can include uses of undevelopable land (e.g. within the flood extent).

Benefit of accessibility to an airport

No benefit associated with decreased distance to the nearest airport has been separately measured in our analysis. The commercial and industrial rent estimates provided by JLL are based on the appropriate comparator area for the PIC area *once it has been developed*. Accordingly, it would be expected to already account for the presence of WSA, which will be constructed by the time that jobs growth is realised.

However, WSA will be a and potential cause of higher rents (and therefore greater benefits from development) and further investigation on what commercial and industrial land uses will benefit from its presence is warranted.

Estimates of value as a place to work

Table 8.7 shows the NPV of commercial property services under each scenario. Total benefits (net of construction costs) are increasing with respect to development, with Scenario 2 having the greatest net benefits.

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23 That is, the reciprocal of 70 per cent.

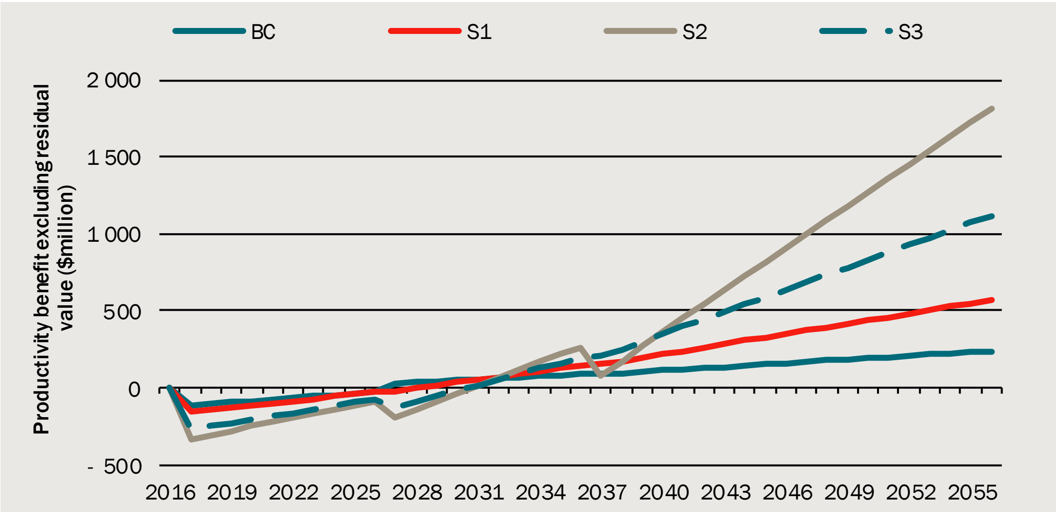
8.7 Value of commercial property services for each scenario

Scenario	Increase in the amount of commercial floor space	Increase in productivity	Total
	$b, NPV	$b, NPV	$b, NPV
Base case	0.4	0.1	0.4
Scenario 1	0.8	0.2	1.0
Scenario 2	2.0	0.7	2.6
Scenario 3	1.5	0.4	1.9

Source: CIE.

Most of the benefits of Scenarios 2 and 3 relative to the base case accrue in later years (chart **Error! Reference source not found.**). Kinks in net benefits are associated with changes in the trajectory of development between the 0-10, 10-20, 20-40 periods of the scenarios. The rate of development under each scenario is shown in chart **Error! Reference source not found.**).

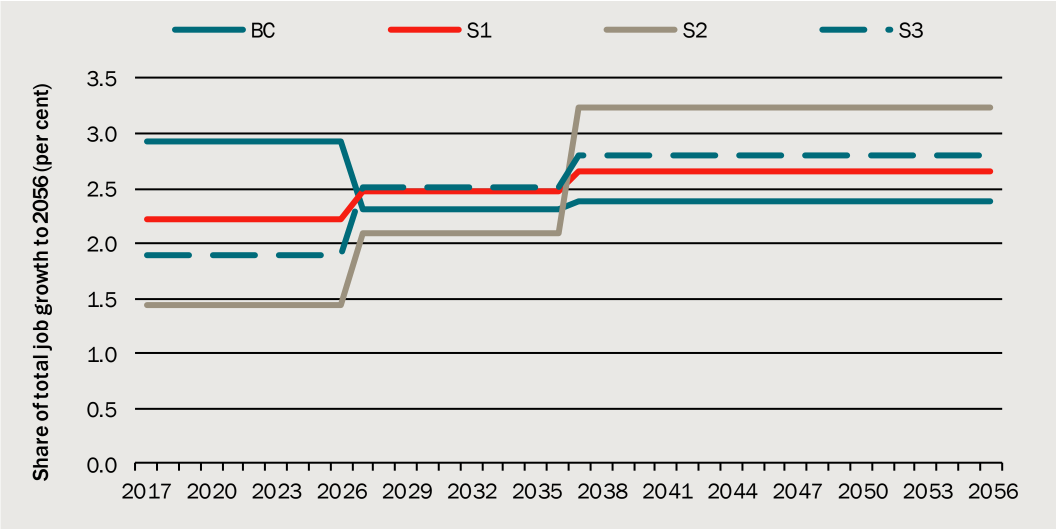
8.8 Annual commercial property benefits by scenario



Note: Excludes residual value. Benefits are undiscounted.

Data source: CIE.

8.9 Annual commercial property development, share of total from 2016 to 2056



Data source: CIE.

Value of commercial property compared to the base case under each scenario

The total value of commercial property services is higher in Scenario 2 and Scenario 3, with $1.4 billion and $0.7 billion of net benefits relative to the base case (table **Error! Reference source not found.**). This is mostly driven by the value of development at current attributes. Improved accessibility of businesses to population by public transport is a larger driver of benefits that job density by car, which decreases slightly in higher growth scenarios due to worsening congestion.

8.10 Value of commercial property services for each scenario relative to the base case

Benefit	Scenario 1	Scenario 2	Scenario 3
	$ billion, NPV	$ billion, NPV	$ billion, NPV
Value from increased commercial space	1.3	5.8	3.8
Value from increased job density (by car)	-0.1	0.0	-0.1
Value of increased population density (by PT)	0.2	0.6	0.4
Residual value of commercial property	0.2	1.0	0.5
Gross benefit	**1.6**	**7.3**	**4.6**
Construction costs	1.0	5.1	3.2
Lost value of agricultural land	0.1	0.8	0.7
Net benefit (gross benefit – construction costs – lost value of agricultural land)	**0.4**	**1.4**	**0.7**

Source: CIE.

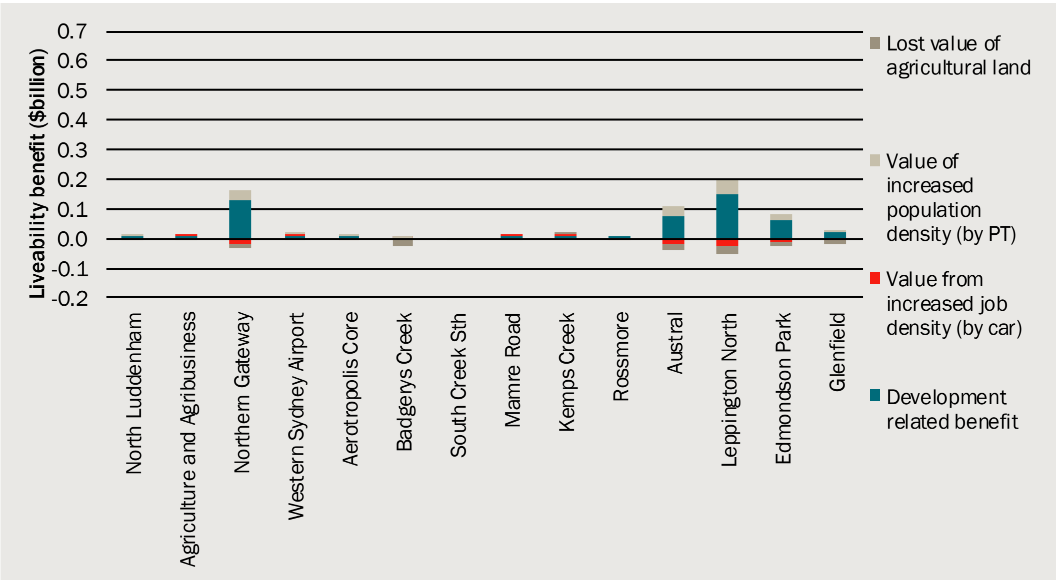
Estimates of value as a place to work by precinct relative to the base case

Charts 8.11-8.13 present our estimates of net benefit from commercial property services at the precinct-level. 'Development related benefit' refers to the benefits of additional commercial property assuming that attributes of commercial property (such as accessibility) remain unchanged. Accessibility benefits are the additional benefits resulting from increases in accessibility reflected in increased willingness to pay for commercial property.

Some noteworthy results at the precinct-level are as follows:

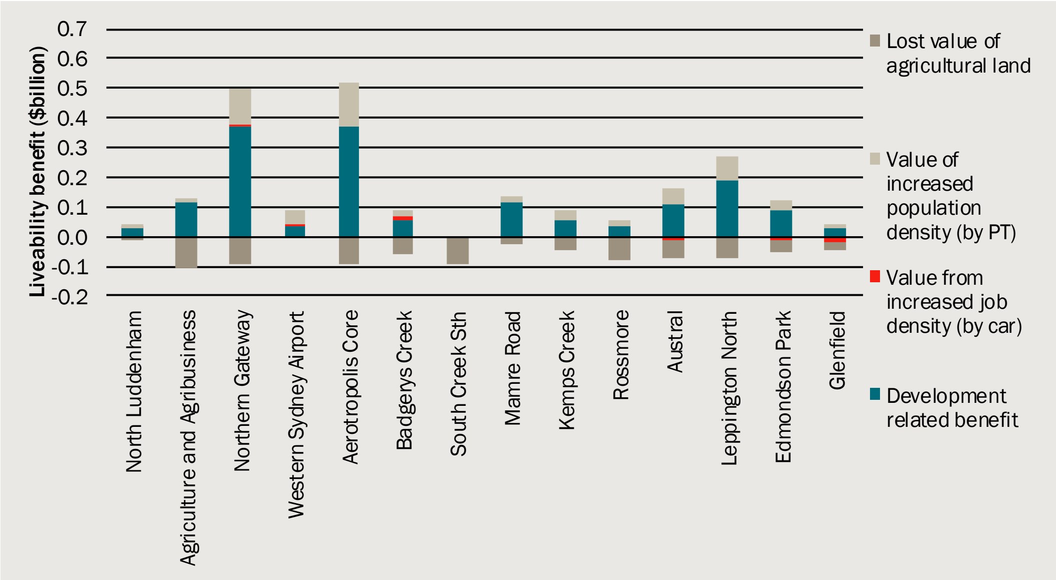
- Scenario 2 has the highest net productivity benefit by a considerable margin. This is mainly comprised of the value of development and improved accessibility in Northern Gateway and the Aerotropolis Core. However, other precincts such as Leppington North and Agriculture and Agribusiness also comprise a moderate share of benefits.
- South Creek South has lower productivity in Scenarios 2 and 3 relative to the base case, associated with infrastructure land take resulting in lost value of agricultural land.
- Commercial development has net productivity benefits in all precincts, due to the value of development exceeding construction, development and local government costs which tend to be faced by developers.

8.11 Value of commercial property services relative to the base case – Scenario 1



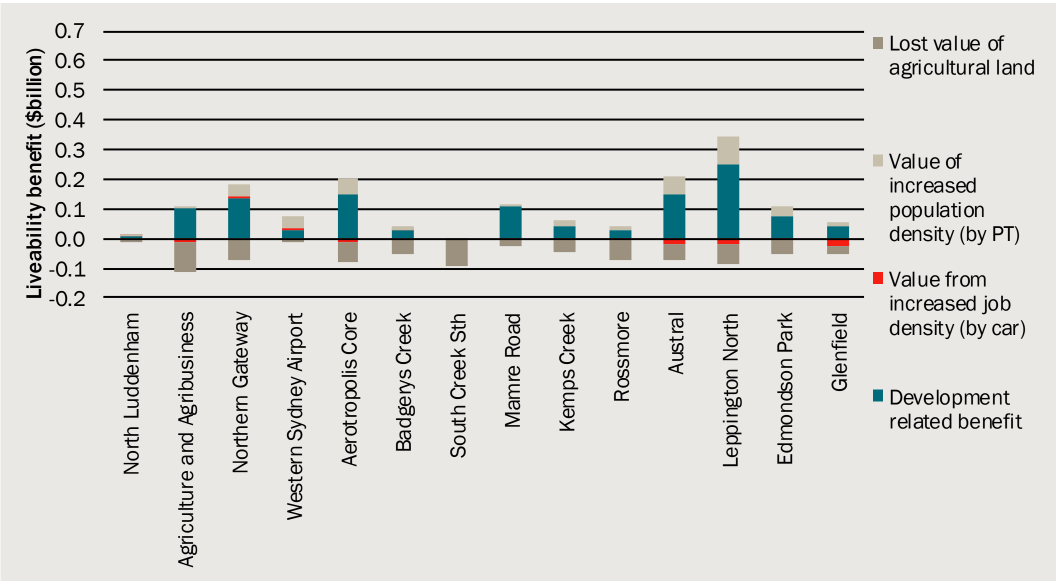
Data source: CIE.

8.12 Value of commercial property services relative to the base case – Scenario 2



Data source: CIE.

8.13 Value of commercial property services relative to the base case – Scenario 3



Data source: CIE.

Digital benefits

Costs associated with investments in digital infrastructure have been included in the base case and scenarios for the PIC. These costs are associated with a range of benefits that are spread across the liveability, productivity and sustainability categories. For example:

- Reductions in travel times due to Smart Transport make people more accessible to their jobs, which is a liveability benefit because it relates to making the PIC area a better place to live.

- However, reduced travel times also improve business' accessibility to labour supply, which makes the PIC area a higher value place for businesses to locate, and therefore a productivity benefit.
- The digital infrastructure investments also lead to reduced environmental impacts from electric vehicle uptake, reduced carbon emissions from office buildings, and a range of other sustainability benefits.

We have estimated the benefits of digital infrastructure using the estimated benefit-cost ratios (BCRs) from the *Smart Western City Program – Strategic Program Business Case* (table 8.14). We have made the following assumptions to use the BCRs from the *Business case*:

- We have allocated the BCR from Technology Package A in the *Business case* to the base case and Scenario 1, since these PIC scenarios only include the internet connectivity, data sharing, Smart Monitoring and Digital Twin investments as per Package A. We also assume that the geographic area covered in the Base case and Scenario 1 is the 'Aerotropolis plus town centres' coverage referred to in the *Business case*.
- We have allocated the BCR from package C to PIC Scenarios 2 and 3. We also assume that the geographic coverage of the infrastructure is 'The Whole Western Parkland City' as defined in the *Business case*. The geographic extent of the option determines the BCR used, but note that it is only applied to the inside costs (not total costs) of the infrastructure included in the PIC. Therefore, using this approach will only estimate the inside benefits of the infrastructure, on the assumption that the ratio of costs and benefits is equal between the PIC area and the rest of the Parkland City.

These benefits are all allocated as productivity benefits, because we cannot split out the liveability, productivity and sustainability components from the *Business case*.

8.14 Benefit-cost ratio for digital infrastructure

Scenario	Benefit-cost ratio		
	7 per cent discount rate	3 per cent discount rate	10 per cent discount rate
Base case	0.5	1.3	0.6
Scenario 1	0.5	1.3	0.6
Scenario 2	4.6	5.8	3.8
Scenario 3	4.6	5.8	3.8

Source: Deloitte, 2019, *Smart Western City Program – Strategic Program Business Case*, prepared for the Department of Planning, Industry and Environment.

9 Valuing outcomes from spillovers – sustainability

- **Sustainability benefits are measured for:**
  - **Protection and improvement of native vegetation**
  - **Improvements in water quality**
  - **Dwelling related greenhouse gas emissions**
  - **Tree canopy benefits**
  - **Environmental impact of transport**
- **Green and blue infrastructure benefits are significantly larger for scenarios 2 and 3 due to large investments in these scenarios compared to the base case and scenario 1.**
- **Comment on transport externality and congestion**

The primary benefit of providing infrastructure in the PICS are the dwellings and commercial space which is enabled by infrastructure. For instance, the primary rationale for providing stormwater infrastructure is to prevent local flooding, which is necessary for urban development to occur. The multifaceted nature of infrastructure requirements to enable development is one of the main rationales for undertaking PIC analysis, which compare the benefits of urban development against all necessary infrastructure cost.

However, some of the blue and green infrastructure provided in the PIC are expected to generate benefits in addition to those associated with people living and working in the area. We have called these sustainability benefits, but we recognise that sustainability could equally apply as a label across benefits designated as liveability and productivity. Further, there are spillovers associated with changed travel patterns across the scenarios. Benefits measured in this analysis consist of:

- Protection and improvement of native vegetation. This results in benefits associated with preserving native flora and associated fauna
- Improvements in water quality due to native vegetation protection and rehabilitation along riparian corridors, and changes in water flows associated with water recycling and the associated changes in waste water and stormwater releases
- Trees provided for canopy cover. This results in benefits associated with urban cooling.
- The emissions associated with different dwelling typologies. Environmental benefits associated with the dwelling typologies envisioned under the scenarios, reflecting the difference GHG emissions between, for instance, detached dwellings and apartments.
- Changes to pollution and congestion spillovers from transport, which depend on car usage in the PIC area relative to the Sydney-wide average usage.

Note the benefits of the following infrastructure are not considered in this section:

- Open space amenity benefits (including passive and active recreation). The amenity benefits associated with open space are measured as an outcome of a place to live through the property service model developed for this analysis.
- Open space urban cooling benefits (in addition to tree canopy). The provision of green space may result in urban cooling benefits in addition to canopy cover. We have not measured this benefit separately to avoid double counting, as we have included the benefit associated with providing canopy cover in open space.
- The amenity value of tree canopy, as distinct from the environmental benefits. Amenity benefits are measured as an outcome of a place to live through the property service model developed for this analysis.
- Channel stabilisation works. The benefit of these works is captured by benefits related to vegetation along riparian corridors. These works are required as hydrological modelling has shown that development in the South Creek catchment will result in in an increase in the duration and frequency of erosive flows. Stabilisation works prevent waterways from eroding and undercutting high ecological value areas within the waterway and floodplain. These benefits will already be measured for the provision of vegetation along riparian corridors and biodiversity; channel stabilisation in interpreted as an enabling investment for the projection of vegetation in riparian areas.

Protection and improvement of native vegetation

The scope of works allows for a significant investment in native vegetation in scenario 2 and 3, while the base case and scenario 1 does not allow for any additional native vegetation by 2056 (chart **Error! Reference source not found.**).

9.1 Additional native vegetation, 2056

Precinct	Base case and scenario 1	Scenario 2 and 3
	ha	ha
North Luddenham	0	33
Agriculture and Agribusiness	0	398
Northern Gateway	0	132
Western Sydney Airport	0	0
Aerotropolis Core	0	23
Badgerys Creek	0	41
South Creek South	0	85
Mamre Road	0	79
Kemps Creek	0	173
Rossmore	0	212
Austral	0	159
Leppington North	0	253
Edmondson Park	0	417
Glenfield	0	209
Total	**0**	**2 214**

Source: GSC.

Note this does not include native vegetation provided along vegetated riparian zones to avoid double counting, as the impact of these investments is measured separately as a water quality benefit.

Valuing native vegetation benefits

The benefit associated with protecting and improving native vegetation is measured using the willingness-to-pay (WTP) of the community for native vegetation and the associated native animals. This may include use value (i.e. the value households derive visiting areas of native vegetation) as well as non-use values (i.e. the option value of having the choice to visit native vegetation, or the value of knowing areas of native vegetation exists etc.).

We quantify this benefit by transferring benefit measurements from other primary studies which undertake surveys to elicit Sydney household WTP for native vegetation (table 7.10). There is a wide range of estimates for the WTP, however we have chosen to use the parameter from Mazur and Bennett (2009) to be consistent with the approach used in the South Creek Business Case.[24] This measures the WTP today for an improvement in amenity in 20 years.

9.2 Valuations of native vegetation

Study	Study scope	Benefit in study year per ha per household	Benefit per ha per household	Adjusted for scope
	ha	$2009	$2019	$2019
Mazur and Bennett 2009, Location differences in communities' preferences for environmental improvements in selected NSW catchments: A Choice Modelling approach.	1 050 000	0.0006	0.0008	0.06
Gillespie Economics 2009, Bulli Seam Operations Socio-Economic Assessment, prepared for Illawarra Coal Holdings.	90 000	0.90	1.1	7.65
Gillespie Economics 2009, Mount Thorley Warkworth Operations Choice Modelling Study of Environmental and Social Impacts, prepared for Coal & Allied Pty Ltd.	90 000	0.41	0.5	3.43

Note: Scope relates the to amenity over which the improvement in the WTP study was offered. Valuations are based the number of households in Greater Sydney.

Source: See sources in table.

We have adjusted the WTP for inflation, but also to account for the scope of the original study. Previous work has found that "scope" and "scale" effects in WTP studies can have a large impact on WTP parameters, where:[25]

24 Frontier Economics 2018, Western Parkland City (South Creek Catchment) – Land and water use Strategic Options Business Case, prepared for INSW.

25 Rolfe J., Windle J., Bennett J. and Mazur, K. 2013, Calibration of values in benefit transfer to account for variations in geographic scale and scope: Comparing two choice modelling experiments, contributed paper presented at the 57th Australian Agricultural and Resource Economics (AARES) 2013 Annual conference.

- Scope relates to the geographic scope over which an amenity improvement was offered. For instance, Mazur and Bennett (2009) elicit household preferences for a change in native vegetation, given the context of there already been 1 million hectares of native vegetation
- Scale refers to the quantity of the amenity being considered (i.e. the change in amenity offered in the WTP survey

These effects are both related to the diminishing marginal utility of a good. To account for scope impacts Rolfe et al. (2013) propose the following scope adjustment:

Where quality relates to the scope and small and large refer to the size of the scope. To be consistent with the South Creek Business Case, we have applied this transformation. We have used the scope of native vegetation in the South Creek catchment (13 347 hectares) to ensure that our parameter value is consistent with the previous work.

The benefit is estimated by multiplying the benefit parameter by the amount of native vegetation provided in 20 years (the final amount of native vegetation provided as part of the project); multiplying this by the number of households in Sydney adjusting for non-response. The adjustment for non-response accounts for the fact that individuals who partake in WTP surveys may have higher WTP than the general population. We use the approach outlined in Morrison, which recommends applying WTP values for one third of non-respondents.[26] Given the survey the primary WTP study had a response rate of 45 per cent, we apply the WTP parameter to 63 per cent of households.[27]

The results are shown in table 9.3, indicating a benefit related to native vegetation of $145 million for scenario 2 and scenario 3.

9.3 Total native vegetation benefit

Scenario	Benefit
	NPV ($ million)
Base case	0.0
Scenario 1	0.0
Scenario 2	144.7
Scenario 3	144.7

Note: discount rate of 7 per cent

Source: CIE.

26 Morrison, M. 2000, Aggregation biases in stated preference studies, Australian Economic Papers, 39(2).

27 $\left(45\% + \left(\frac{45\%}{3}\right)\right)$.

Improvements in water quality

The PIC program of works has identified infrastructure works which are expected to improve water quality along South Creek and other waterways in the study area. These works include:

- Protection and improvement of vegetation in the vegetated riparian zone
- Protection and improvement of other water dependent vegetation
- Water channel stabilisation

In addition to these investments which are likely to directly impact water quality, the land use and arrangements for stormwater and wastewater are likely to impact on health of water ways within the precinct as well as outside.

For this study, information was available on the length of waterways with native vegetation on both banks as a result of the project (table 7.12). A previous study used vegetated stream length as an indicator of native plant native plant and animal diversity, including birds dependent on the river[28]

9.4 Vegetated stream length

Stream order	Improve	Protect	Total
	km	km	km
1st	57.6	22.8	80.4
2nd	32.9	13.4	46.3
3rd	18.3	13.0	31.2
4th	7.9	25.1	33.0
5th	2.8	3.4	6.1
6th	6.5	9.3	15.8
Total	**125.9**	**86.9**	**212.9**

Note: Stream order is based on the Strahler system. A first order stream has not other streams flowing into it and when two streams of the same order join, the resulting stream has the next highest order. The higher the stream order a second order stream is downstream of at least

Source: GSC.

Using this information we have determined the length of vegetated streams under the base case and each scenario:

- "protect" vegetation represents vegetated stream length in 2016. We have then assumed, based on advice from DPIE, that 1st and 2nd order streams are lost under the base case (i.e. become degraded). Only "protect" waterways, or those which are currently of ecological value, are included in the base case.
- scenario 1 allows for some costs associated with vegetation along riparian zones, but not to the same extent as scenarios 2 and 3. Stream length in this scenario is determined by scaling length in scenario 2 and 3, by the ratio of investments in scenario 1 compared to scenario 2 and 3.

28 Bennett J., Cheesman J., Blamey R. and Kragt M., 2015, *Estimating the non-market benefits of environmental flows in the Hawkesbury-Nepean River*, Journal of Environmental Economics and Policy, p. 4.

- vegetated stream length in 2056 for scenario 2 and 3 is assumed to be equal to the "protect" and "improve" waterway length.

The vegetated stream lengths are shown in table 2.4.

9.5 Vegetated stream length by scenario, 2056

Precinct	2016	Base case, 2056	Scenario 1, 2056	Scenario 2 and 3, 2056
	km	km	km	Km
North Luddenham	0.7	0.1	4.1	7.1
Agriculture and Agribusiness	16.4	5.0	24.9	24.9
Northern Gateway	9.6	5.5	17.6	22.5
Western Sydney Airport	2.2	1.9	2.9	2.9
Aerotropolis Core	8.2	4.6	13.8	26.4
Badgerys Creek	5.5	3.2	4.8	8.5
South Creek South	35.1	25.2	36.1	67.5
Mamre Road	1.3	0.6	1.0	2.6
Kemps Creek	0.7	0.1	0.8	6.1
Rossmore	0.9	0.1	6.8	14.8
Austral	4.8	3.5	5.7	13.7
Leppington North	1.5	1.0	6.8	15.8
Edmondson Park	0.0	0.0	0.0	0.0
Glenfield	0.0	0.0	0.0	0.0
Total	**86.9**	**50.7**	**125.3**	**212.9**

Source: GSC, CIE.

We also have information on the area of vegetation provided in the riparian buffer, but have not used this to measure benefits, in order to avoid doubling counting – the benefit of additional vegetation is likely to already be measured in the WTP for waterways with vegetated riverbanks.

Note we have only measured benefits based on the length of watercourses which are expected to have vegetation protected or improved. Native vegetation is only one dimension of water quality. Previous studies considering the water quality of Hawksbury-Nepean river have also considered:[29]

- suitability for swimming – length of the river (km) which has water quality meeting minimum quality standards for direct contact recreation such as swimming.
- time taken to catch a Bass fish – this is an indicator of how many Bass are in the river, which is a good indicator of the total number of native fish in the river.
- clear of non-native water weeds – length of the river (km) that is not infested with invasive water weeds. Weeds can be unsightly from the bank and a nuisance to people

29 Bennett J., Cheesman J., Blamey R. and Kragt M., 2015, *Estimating the non-market benefits of environmental flows in the Hawkesbury-Nepean River*, Journal of Environmental Economics and Policy, p. 4.

swimming and boating. They are also one of the reasons for reduced native plant and animal life in the river.

We have not included these benefits, information on the impact of the project on these outcomes were not available.

Valuing improvements in water quality

Improvements in water quality are valued based on information from a WTP study for the Hawksbury-Nepean River (table **Error! Reference source not found.**).[30] These parameters were also used in the South Creek Business Case.

The study assessed providing additional riverside vegetation at different levels, allowing for diminishing marginal utility. We have capped benefits where there is more than 100km of vegetated streams, as the study indicates there is no additional benefit at this point.

9.6 Riverside vegetation, value per additional km per year for 10 years

	WTP per km	WTP per km
	$2012	$2019
50-85km	0.67	0.78
85-100km	2.28	2.66
100-120km	0.00	0.00

Note: WTP per Sydney household.

Source: Bennett J., Cheesman J., Blamey R. and Kragt M., 2015, Estimating the non-market benefits of environmental flows in the Hawkesbury-Nepean River, Journal of Environmental Economics and Policy.

We have applied this benefit to 50 per cent of Sydney households, as the source study did not indicate the survey response rate.

The results are shown in table 5.1. This indicates a benefit of $356 million for Scenario 2 and 3 relative to the base case.

9.7 Total water quality benefit

Scenario	Benefit relative to current	Benefit relative to base case
	NPV ($ million)	NPV ($ million)
Base case	-128.9	0.0
Scenario 1	96.0	224.9
Scenario 2	227.5	356.4
Scenario 3	227.5	356.4

Note: discount rate of 7 per cent

Source: CIE.

30 Bennett J., Cheesman J., Blamey R. and Kragt M., 2015, *Estimating the non-market benefits of environmental flows in the Hawkesbury-Nepean River*, Journal of Environmental Economics and Policy, p. 4.

Dwelling-related GHG emissions and dwelling typologies

Households in detached dwellings tends to have higher greenhouse gas (GHG) emissions associated with electricity and gas consumption. This is due to a range of factors including:

- floor area, detached dwellings tend to be larger than semi-detached properties and flats resulting in reduced energy consumption for temperature regulation and lighting
- thermal properties of different dwelling typologies due to differences in construction techniques, materials and physical characteristics of buildings. For instance, shared walls in semi-detached and flats tend to provide better insulation
- average household size. Detached houses tend to have higher average household size than other dwelling typologies, which increases energy consumption which for a given dwelling is generally related to the number of residents.

This means that compared to the base case, the scenarios may result in GHG emissions savings over the life of new residential dwellings.

To account for this, we have considered data on emissions by dwelling typology form two sources. An IPART study in 2010 conducted a survey of existing households to determine the average electricity and gas consumption for different dwelling typologies.[31] We have converted average annual electric and gas consumption into CO_2 emissions using conversion factors from the Commonwealth Department of Environment and Energy.[32]

This indicates that detached dwellings GHG emissions are 52 and 86 per cent higher than semi-detached dwellings and flats respectively. However, this measure is likely to overstate the difference in emissions for new dwellings, as the survey results are for established dwellings. Old dwellings are likely to have higher energy consumption compared to new dwellings, due to improvements in building technology and policies, such as Building Sustainability Index (BASIX) regulations which drive energy efficiencies.

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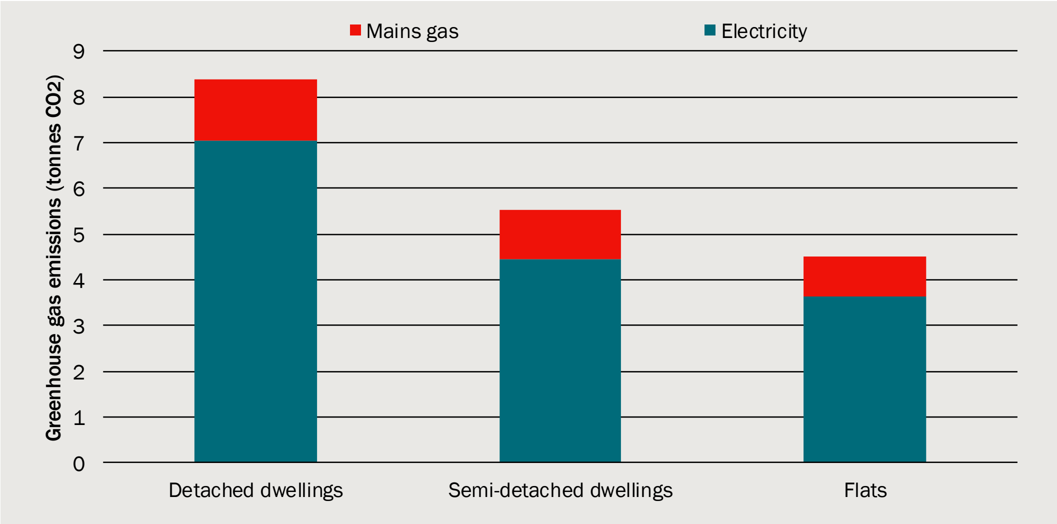
31 IPART 2010, Residential energy and water use in Sydney, the Blue Mountains and Illawarra, Results from the 2010 household survey.

32 Department of Environment and Energy 2019, National Greenhouse Accounts Factors, August.

9.8 Average annual GHG emissions



Data source: IPART.

To account for the potential difference between established and new dwellings we have also estimated emissions across different dwelling typologies using published data on BASIX certificates.[33]

This database reports the expected energy consumption for each BASIX certificate issued between 2011/12 and 2017/18. This uses data imputed by BASIX applicants regarding the characteristic of their dwelling, such as dwelling type, floor space and appliances, to calculate the expected energy consumption and associated CO_2 release per resident. In the data set this is reported as the percentage deviation from the benchmark of 3292 kg of CO_2 per resident. From this data, we are able to identify detached dwelling, semi-detached dwellings, flats in building of up to 3 storeys and flats in buildings of 4 or more storeys. Total energy consumption for a dwelling type is determined by multiplying emissions per resident by average household size estimates.

Results are shown in table 9.9. BASIX emissions per detached dwelling and semi-detached dwellings are lower than those reported by IPART, which is consistent with expectations that new dwellings are likely to have lower annual operating emissions compared to established dwellings. Emissions for flats are similar across the studies.

Across dwelling typologies in the BASIX data, emissions per person tend to be higher in flats compared to detached and semi-detached dwellings, which is consistent with previous analysis of BASIX data.[34] This pattern is revered for emissions per dwelling due to average household size.

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33 Accessible here: https://www.planningportal.nsw.gov.au/opendata/dataset/basix-certificate-data-2011-12-to-2017-18

34 Analysis of BASIX data indicates that emissions savings compared to the baseline are smaller for higher density dwellings, indicating higher consumption per person in flats compared to detached houses. For example see NSW DPIE 2011, 2006-09 Multi-Dwelling Outcomes BASIX Ongoing Monitoring Program, p. 7.

9.9 Emissions by dwelling typology

	Annual emissions per resident	Average household size	Annual emissions per dwelling
	Tonnes CO2	No.	Tonnes CO2
House	1.8	3.1	5.8
Med Dens	1.8	2.6	4.7
Flats 1-3	2.1	2.1	4.5
Flats 4+	2.3	2.2	5.0

Note: Emissions data and average household size is calculated for metropolitan Sydney. Emissions data is based on BASIX certificates issued between 2011/12 and 2017/18 and is estimated based on median.

Source: DPIE, ABS 2016 Census.

Flats of four or more storeys appear to have higher emissions than flats in buildings of up to 3 storeys and medium density dwellings. This is due to the average household size being relatively high for this dwelling type, together with the high emissions per resident.

The cost of GHG has been valued using consistent with carbon price estimated by Commonwealth Treasury for the Clean Energy Future Policy Scenario.[35] Note that the value changes overtime.

There is considerable uncertainty around the appropriate parameters to use to measure the cost of carbon emissions. A previous review of the NSW Energy Savings Scheme recommended:

> In the absence of a locally appropriate study of the whole of economy cost of climate change impacts, the NSW Government preference is for market data to be used where it exists.[36]

The Review of the NSW Energy Savings Scheme determined the appropriate carbon price is the forecast European Union Emission Allowance Units price based on futures derivatives published by the European Energy Exchange.[37] However, the review noted this price forecast is considered to be a conservative value for the cost of carbon, with a very large difference in the values estimate by the Commonwealth Treasury and forecast European prices (chart 1.3).

Both projected carbon prices rely on assumptions that are not completely transferable to the current NSW context. Using the alternative European forecast prices would result in smaller economic benefits.

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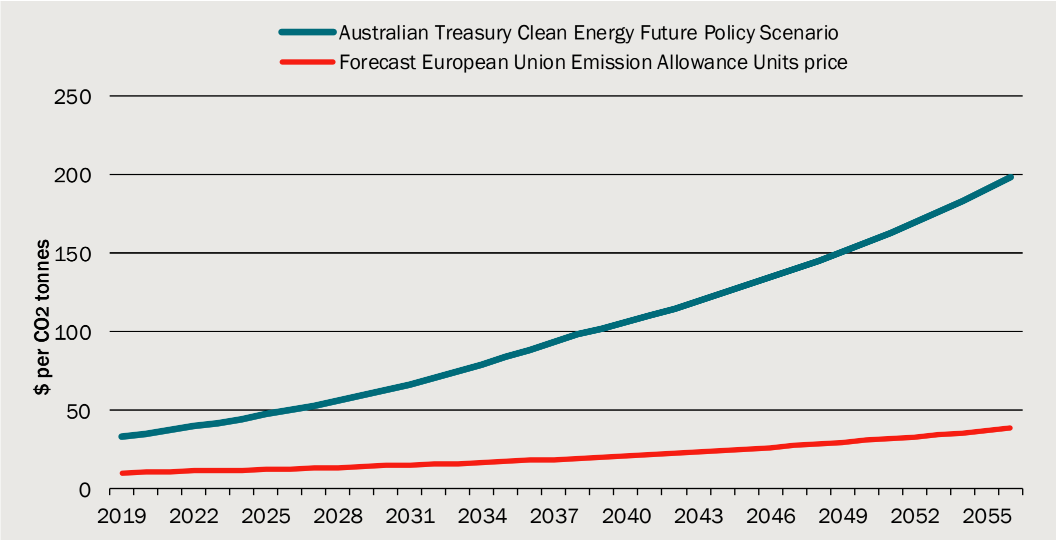
35 Core (household modelling) scenario reported in 2015 dollars sourced from Commonwealth Treasury, 2011, *Strong growth, low pollution: modelling a carbon price*. http://cache.treasury.gov.au/treasury/carbonpricemodelling/content/report/downloads/Modelling_Report_Consolidated.pdf.

36 NSW, 2015, *Review of the NSW Energy Savings Scheme: Part 2: Options Paper,* Page 128.

37 Based on European Union Emission A price trajectory from Independent Economics and Frontier Economics, 2014, *Economic and Energy Market Forecasts,* prepared for the Australian Energy Market Operator, accessed at www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report/~/media/Files/Other/planning/NEFR/2014/2014%20Supplementary/IE_Economic_Forecast_2014_FINAL.ashx

9.10 Estimated external cost of greenhouse gas emissions



Note: Escalated to 2019 values using CPI.

Data source: Commonwealth Treasury, 2011, Strong growth, low pollution: modelling a carbon price, Independent Economics and Frontier Economics, 2014, Economic and Energy Market Forecasts, prepared for the AEMO.

In addition to differences in GHG emissions associated with operations of dwellings, there may also be difference in emissions related to the construction process and the materials required to build a given dwelling type. This is the GHG associated with embodied energy of dwellings, which is the sum of all energy required to build a dwelling. We have not quantified this benefit due to a lack of information. Future evaluation of this project could consider this benefit in additional to the annual greenhouse gas emission from the operation of dwellings.

Results are shown in table 9.11. Because each of the scenarios allow for a different number of dwellings to be constructed, we have only measured benefits for the number of dwellings developed in scenario 1, consistent with the evaluation frameworks approach to treat displacement.

9.11 Total value GHG emission benefits

	Total benefit
	NPV ($ million)
Base case	0.0
Scenario 1	0.0
Scenario 2	1.0
Scenario 3	0.8

Source: CIE.

Tree canopy

Under the base case and scenario 1 there will be no additional tree cover (i.e. no additional trees planted), while canopy cover increases in scenarios 2 and 3 (table **Error!**

Reference source not found.). The difference in additional canopy coverage between scenarios 2 and 3 is predominantly due to extra arterial road and street plantings.

These estimates have been developed based on the following assumptions:

- the number of large and medium trees provided under each scenario are taken from the cost workbooks provided developed by the agencies and the GSC
- large trees are assumed to have a canopy diameter of 8 metres at maturity, as specified in the cost workbooks, which corresponds to a canopy area of around 201 square metres. Large trees are generally use for open space and some street plantings
- medium trees are assumed to have a canopy area at maturity of 62.5 square metres, as specified in DPIE's submission.
- trees table around 10 to 15 years to reach maturity and the sizes noted above. We have assumed that the canopy size of each tree increases linearly from the time of planting till reaching maturity.

9.12 Canopy cover as a share of precinct

Precinct	Base case, 2016	Scenario 2, 2056	Scenario 3, 2056
	Per cent	Per cent	Per cent
North Luddenham	7%	15%	15%
Agriculture and Agribusiness	19%	29%	29%
Northern Gateway	10%	43%	41%
Western Sydney Airport	20%	19%	19%
Aerotropolis Core	15%	49%	57%
Badgerys Creek	16%	32%	32%
South Creek South	18%	72%	62%
Mamre Road	12%	30%	30%
Kemps Creek	24%	60%	60%
Rossmore	19%	44%	44%
Austral	22%	59%	59%
Leppington North	19%	37%	40%
Edmondson Park	23%	50%	50%
Glenfield	20%	25%	25%
Total	**18%**	**43%**	**42%**

Note: Base case canopy cover is calculated from DPIE data

Source: DPIE 2020, 2020, Greater Sydney Region Urban Vegetation Cover to Modified Mesh Block 2016; CIE.

The benefits of tree canopies

Benefits associated with tree canopies include:

- urban heat islands — Trees and vegetation provide a cooling effect through evapotranspiration and shading on hard surfaces that would otherwise absorb heat from direct sunlight.
- greenhouse gases — The US EPA report that the process of evapotranspiration and shading effects from trees can reduce local air summer temperatures by 1 to 5 degrees

Celsius.[38] It is estimated that every one-degree Celsius reduction in temperature reduces household energy usage by 5 per cent.[39] It is likely that this benefit may be experienced by commercial buildings that receive a cooling benefit from nearby greenspace.

- air quality — Trees directly influence air quality by capturing pollutants on the plant surface, absorbing gaseous pollutants (e.g. ozone and nitrogen dioxide) into the leaf, resuspending particles into the atmosphere, emitting particles (e.g. pollen) and disrupting the dispersion of pollution as a result of wind systems. A Sydney based study found that higher concentrations of urban forestry in Sydney is associated with decreasing particulate matter.[40]
- flood mitigation — Vegetation may help regulate the flow of water and provide protection against flooding, with planted tree or plant beds reducing the volume and velocity of stormwater reaching waterways.[41] In 2011, Brisbane City Council estimated that street side trees contributed $1.67 million to the city of Brisbane, by improving air quality, capturing rain and storing carbon.
- amenity benefits associated with canopy cover and tree plantings. This benefit is considered in chapter 6 as part of the property service model which includes a measure of the amenity value of canopy cover, reflected in land prices.

Literature on the cooling effects of canopy cover and greenspace include the following estimates:

- The GSC has previously reported that a 10 per cent increase in green space can reduce temperatures by 1.13°C[42]
- US EPA report that the process of evapotranspiration and shading effects from trees can reduce local air temperatures by 1 to 5 Degrees Celsius.[43]
- The surface temperature within a greenspace may be 15-20 degrees Celsius lower than that of the surrounding urban area, giving rise to 2-8 degrees Celsius cooler air

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38 US Environmental Protection Agency, 2016, *Using Trees and Vegetation to Reduce Heat Islands*, https://www.epa.gov/heat-islands/using-trees-and-vegetation-reduce-heat-islands Website last updated August 12, 2016.

39 Lehmann, S. 2014, ‘Green spaces can combat urban heat stress’, The Adelaide Review.

40 Irga, P.J., Burchett, M.D., Torpy, F.R, 2007, Does urban forestry have a quantitative effect on ambient air quality in an urban environment?, Atmospheric Environment, 120 (2015) 173-181.

41 Parks Victoria and Department of Environment, Land, Water and Planning. 2015, ‘Valuing Victoria’s Parks Accounting for ecosystems and valuing their benefits: Report of first phase findings’, p 79, available at: https://www.forestsandreserves.vic.gov.au/__data/assets/pdf_file/0027/57177/Valuing-Victorias-Parks-Report-Accounting-for-ecosystems-and-valuing-their-benefits.pdf.

42 GSC 2018, Our Greater Sydney 2056 Western City District Plan – connecting communities, March, p. 119.

43 US Environmental Protection Agency, *Using Trees and Vegetation to Reduce Heat Islands*, https://www.epa.gov/heat-islands/using-trees-and-vegetation-reduce-heat-islands Website last updated August 12, 2016.

temperatures and a cooling effect that extends out in to the surrounding area (Taha, Akbari and Rosenfield, 1988; Saito, 1990-91).[44]

Valuing benefits of tree canopies

Health cooling benefits of canopy cover

Trees and vegetation provide a cooling effect through evapotranspiration and shading on hard surfaces that would otherwise absorb heat from direct sunlight. The degree of cooling differs across tree species, with greater leaf cover and water content in the soil and vegetation providing the greatest cooling impact. For example, Yu and Hien (2006) reported that the ambient temperature in a park was strongly correlated to the density of plants.[45]

Heat-related illnesses include rash, cramps, dizziness, heat exhaustion and heatstroke, Extreme heat is stated to kill more Australians than any natural disaster with heatstroke fatal in up to 80 per cent of cases.[46]

For this analysis we have used incidence rates for different health impacts caused by excessive heat estimated by AECOM (table 3.10). This shows how temperatures above 30°C impact on ambulance attendance, transport to hospital, ED presentations and mortality rates. We can then related this to the amount of canopy cover created by the project, assuming that a 10 per cent in the area of canopy cover results in the a 1.13°C to show the impact of the project on the health outcomes shown in table 5.10.[47]

9.13 Health impact parameters for urban heat impacts per degree above 30°C

Health impact parameters	Incidence rate
Ambulance Attendance – heat[a]	0.09
Transported to hospital	80%
ED Presentations, aged 64-74yrs[a]	0.52
ED Presentations, aged 74+ yrs[a]	3.82
Mortality[a]	0.08

44 Taha, H.G., Akbari, H. and Rosenfield, A., (1988). *Vegetation canopy micro-climate: A field project in Davis, California.* Lawrence Berkeley Laboratory Report No. 24593. Lawrence Berkeley, Davis, California, USA.
Saito, I. (1990-91), *Study of the effect of green areas on the thermal environment in an urban area,* Energy and Buildings 15, 493-8.
Both sourced in Doick, K. and Hutchings, J., 2013, *Air temperature regulation by urban trees and green infrastructure*, Forestry Commission Research Note (FCRN012).

45 Doick, K. and Hutchings, J., 2013, *Air temperature regulation by urban trees and green infrastructure*, Forestry Commission Research Note (FCRN012).

46 Better Health Victoria, *Heat stress and heat-related illness,* https://www.betterhealth.vic.gov.au/health/healthyliving/heat-stress-and-heat-related-illness. Accessed 23 September 2016.

47 GSC 2018, Our Greater Sydney 2056 Western City District Plan – connecting communities, March, p. 119.

[a] Incidence rate per 100 000 persons per 1 degree above 30°C

Source: AECOM, 2012, *Economic Assessment of the Urban Heat Island Effect,* Prepared for the City of Melbourne.

Cost parameters used to quantify benefits are shown in table 9.23. The value of statistical life (VSL) is taken from the Office Best Practice Regulation (OBPR) and is applied to persons below the age of 65. For those aged 65 or above, we have calculated the VSL using the value of statistical life year advised by the OBPR ($213 000 per year)[48] and the expected life expectancy for this age group in NSW (14 years).[49] The total cost per death is estimated using these two vales assuming that the over 65 year old cohort account for 75 per cent of heat related deaths.[50] The cost of admitted emergency department presentations is based on average cost for NSW reported by the ; Independent Hospital Pricing Authority, while ambulance costs are based on current NSW Ambulance fees.

9.14 Health benefit and cost parameters

Health impact parameters	Incidence rate
Value of statistical life <65 years of age ($ million)	$4.9 million
Value of statistical life >65 years of age ($ million) [a]	$2.9 million
Cost of admitted emergency department presentation	$982
Ambulance cost	$433

[a] Calculated based on a life expectancy of 14 years and value of statistical year of $213 000.

Note: The cost of ED presentations are escalated from $2017/18 to $2019 using CPI.

Source: Department of the Prime Minister and Cabinet Office of Best Practice Regulation; Independent Hospital Pricing Authority National Hospital Cost Data Collection round 22; NSW Ambulance fees and charges (https://www.ambulance.nsw.gov.au/our-services/accounts-and-fees); CIE.

The number of days where temperature exceeds 30°C is based on information from the Bureau of Meteorology (chart 4.7). These values have been used from 2016 till 2019, and for later years we have assumed the number of days above 30 increase by 1.6 per cent per annum until 2039 and by 0.9 per cent per annum from 2039 onwards based on the expected increase in hot days in Western Sydney from AdaptNSW.[51]

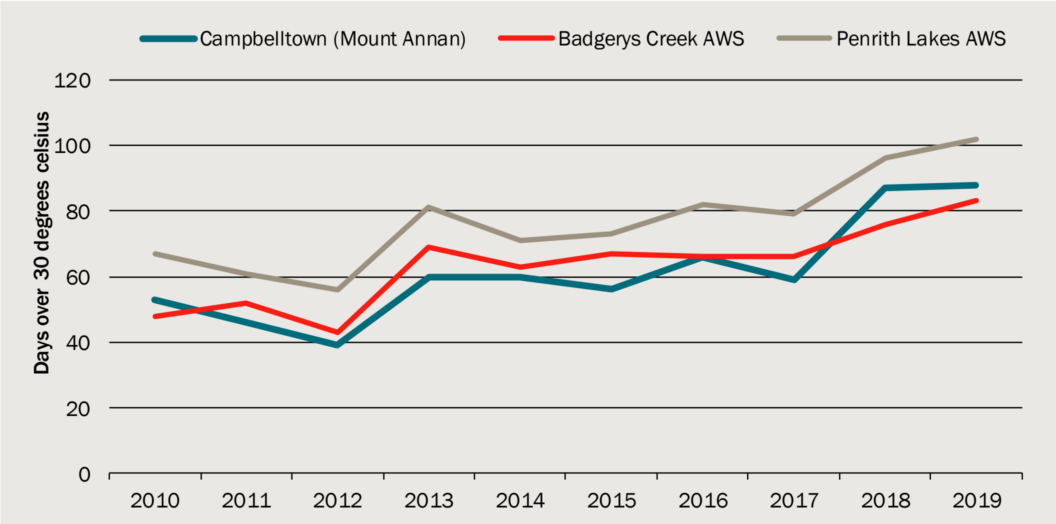
48 Office of Best Practice Regulation 2019, Best Practice Regulation Guidance Note Value of statistical life, August.

49 Estimated based on ABS life expectancy by year (3302.0.55.001 - Life Tables, States, Territories and Australia, 2016-2018) and population by year (3101.0 - Australian Demographic Statistics, Jun 2019).

50 Consistent with AECOM assumptions, based on information that between 65% and 90% of mortalities during 2009 Melbourne heatwave were people aged 65 and over. AECOM, 2012, Economic Assessment of the Urban Heat Island Effect, Prepared for the City of Melbourne, p. 28.

51 The growth rates are based on the number of days above 35°C reported in AdaptNSW 2014 and 2015 Metropolitan Sydney Climate Change Snapshot. This indicated that in 2014 Western Sydney had 10 to 20 days above 35°C, and expected to have an additional 5 to 10 days between 2020 and 2029 compared to 2014, and additional 10 to 29 days above 35°C by 2070. Our approach assumes the number of days above 30°C grows at the same rate as the number of days above 35°C.

9.15 Number of days greater than 30°C



Note: The following weather stations were used: Penrith Lakes AWS (67113), Badgerys Creek AWS (67108) and Campbell Town (Mount Annan 68257).

Data source: Bureau of Meteorology

Health benefits are shown in table 9.16. There are no benefits measured for the base case or scenario 1, as no additional canopy cover is provided in these scenarios. The benefits for scenarios 2 and 3 are similar, just under $60 million in present value terms, with differences due to changes in the level and distribution of population across scenarios as the benefit is measured for residents in each precinct. The benefits for PIC 1 scenarios are significantly lower than PIC 2, due to the large difference in population between the tow areas early in the evaluation period.

Almost all the benefits are due to the reduction in mortality, given the VSL is $4.9 million.

9.16 Value of health impacts due to cooling effect of greenspace

Health impact	Base case	Scenario 1	Scenario 2	Scenario 3
	NPV ($ million)	NPV ($ million)	NPV ($ million)	NPV ($ million)
Value of avoided mortality	0	0	54.3	57.2
Value of avoided emergency department costs	0	0	0.8	0.9
Value of avoided ambulance costs	0	0	0.0	0.0
Total health benefit	**0**	**0**	**55.1**	**58.1**

Source: CIE.

Other benefits of canopy cover

Findings from Endreny et al (2012) have been used to estimate the non-user benefits of tree canopy coverage across the scenarios.[52] This study estimated the contribution of tree cover to ecosystem services in 10 megacities by measuring the impact per square km of tree canopy on:

- air quality (metric tonnes removed of carbon monoxide, ozone, nitrous dioxide sulphur dioxide and PM2.5 and PM5)
- stormwater (cubic metres of stormwater avoided)
- building energy demand (kWh of electricity avoided and Mbtu of energy avoided), and
- carbon sequestration (kg of CO_2 sequestered).

Across the ten cities included in the analysis the average and median per square metre of tree canopy was $1.04 and $0.71, respectively (table 9.17).

9.17 Benefit per m² of tree canopy per person

City	Total benefit
	Per m² of canopy
Beijing	1.09
Buenos Aires	0.23
Cairo	0.56
Istanbul	0.72
London	0.70
Los Angeles	1.59
Mexico City	1.07
Moscow	0.31
Mumbai	0.64
Tokyo	3.46
Average	**1.04**
Median	**0.71**

Note: Values have been converted from 2017 USD using a US CPI and World Bank PPP conversions.

Source: Endreny, T., Santagata, R., Perna, A., Stefano, C.D., Rallo, R.F. & Ulgiati, S. 2017, 'Implementing and managing urban forests: A much needed conservation strategy to increase ecosystem services and urban wellbeing', Ecological Modelling, vol. 360, pp. 328-335.

Benefits were estimated using the median parameter with results reported in table 1.1. Again, there were no benefits for the base case or scenario 2 as they are not expected to deliver any additional canopy cover.

52 Endreny, T., Santagata, R., Perna, A., Stefano, C.D., Rallo, R.F. & Ulgiati, S. 2017, 'Implementing and managing urban forests: A much needed conservation strategy to increase ecosystem services and urban wellbeing', *Ecological Modelling*, vol. 360, pp. 328-335.

9.18 Value of canopy cover impact on air quality, stormwater management, building energy demand and carbon sequestration

Scenario	Benefit
	NPV ($ million)
Base case	0.0
Scenario 1	0.0
Scenario 2	28.7
Scenario 3	32.4

Note: discount rate of 7 per cent

Source: CIE.

Total external benefits canopy cover

Total canopy cover benefits are reported in table (table 9.19). Health benefits account for most of the benefits.

9.19 Total canopy cover benefit

Scenario	Benefit
	NPV ($ million)
Base case	0.0
Scenario 1	0.0
Scenario 2	83.9
Scenario 3	90.5

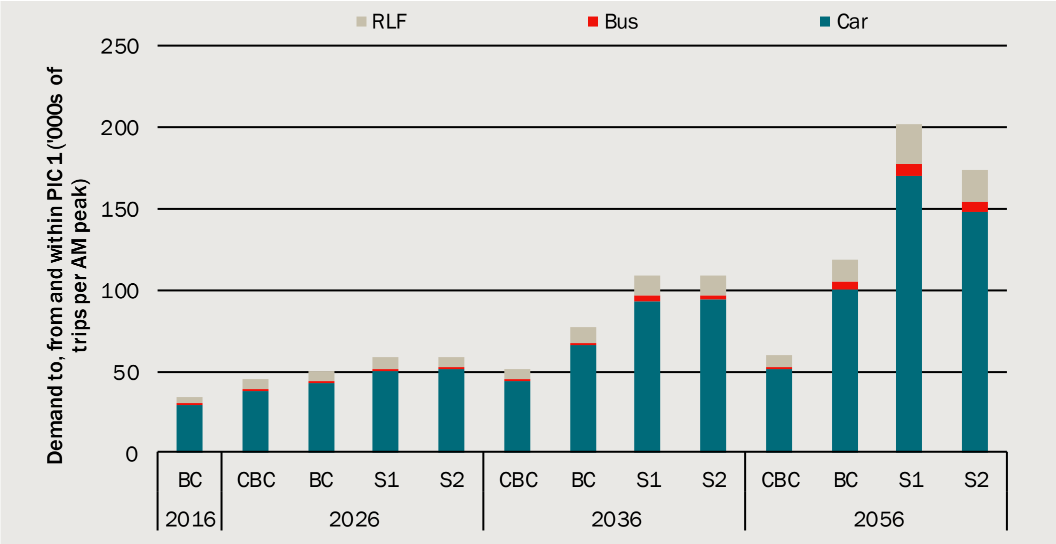
Note: discount rate of 7 per cent

Source: CIE.

Environmental impacts from transport

Across all scenarios, AM peak trip demand is expected to increase over time (chart 2.5). While cars are expected to remain the most common mode of travel, there is expected to be a shift from travel by car to rail, light rail and ferry and buses. For instance, the number of peak AM trips in 2056 is highest in Scenario 3 (at just over 600 000 for all modes), however, the proportion of trips by car is ~14 percentage points lower than in 2026.

9.20 Demand by mode, within, to and out of PIC 1 ('000s of trips per AM peak)



Note: RLF refers to 'rail, light rail and ferry'.

Data source: Transport for NSW.

Environmental impacts from transport have been estimated based on externality unit costs published by Transport for NSW (table 3.2).[53] Due to data limitations, externalities have been estimated for passenger cars only. The externalities considered in the analysis include:

- air pollution
- greenhouse gas emissions
- noise, and
- water pollution (organic waste or persistent toxicants run off from roads generated by vehicle use).

9.21 Passenger car externality costs (cents/km travelled $2020)

Externality types	Passenger car
	Cents (2020)/km travelled
Air pollution	3.4
Greenhouse gas emissions	2.7
Noise	1.1
Water pollution	0.5
Total	**8.1**

Note: values inflated from Jun-2019 to Dec-2019 using a CPI inflator of 1.01, calculated from, Australian Bureau of Statistics, CPI, All Groups, Sydney.

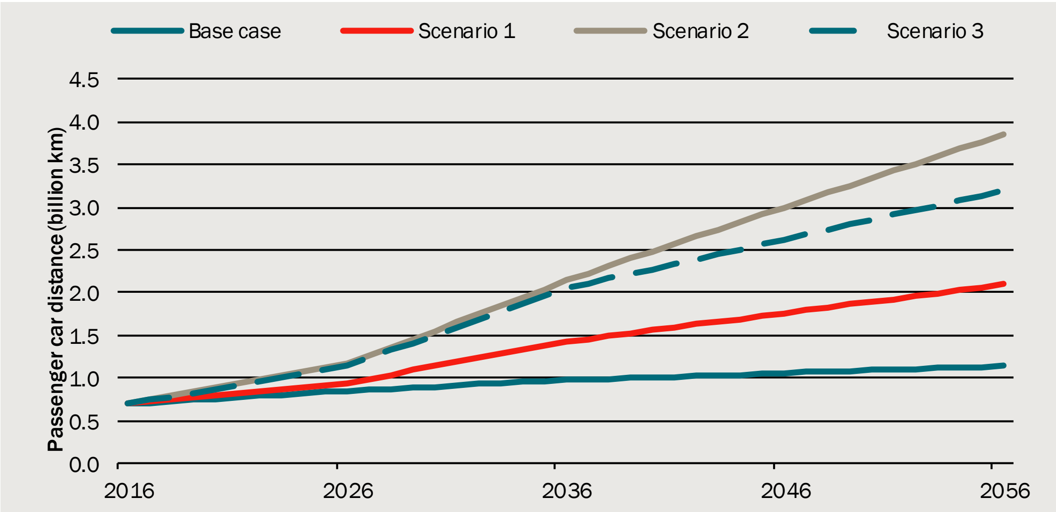
Source: Transport for NSW. 2020, *Economic Parameter Values*, p 38.

53 Transport for NSW, 2020, *Economic Parameter Values – September 2019*, available at: https://www.transport.nsw.gov.au/news-and-events/reports-and-publications/transport-for-nsw-economic-parameter-values

AM peak distance (km) for passenger cars, as provided by Transport for NSW, have been escalated by a factor of 1 385 to estimate total annual distance travelled, by scenario.[54]

Passenger car distance (km) has been extrapolated linearly between modelled years to estimate the discounted impact of transport changes across scenarios (chart 3.2). While there is an increase in car kilometres over time and generally for higher population and job scenarios, this is much less than proportional to the growth. In higher development scenarios, extra public transport capacity mitigates the increase in per person vehicle kilometres travelled but in overall vehicle kilometres travelled to, from and within PIC 1. The impacts are highest for scenario 2, which also involves the greatest population and jobs growth.

9.22 Passenger car distance (km) within, to and out of the PIC 1 area



Data source: CIE.

As presented in chart 9.23 transport impacts are greatest under Scenario 2 and smallest under the Base Case.

However, it is important to note that the impact of air pollution, greenhouse gases, noise and water pollution are expected to reduce over time with the move towards electric vehicles. For example, research commissioned by the Australian Energy Market Operator estimates that by 2036, electric vehicles will account for 37 per cent of new vehicle sales, increasing to 90 per cent by 2050.[55] Hence, the costs presented in this analysis are considered an upper bound estimate.

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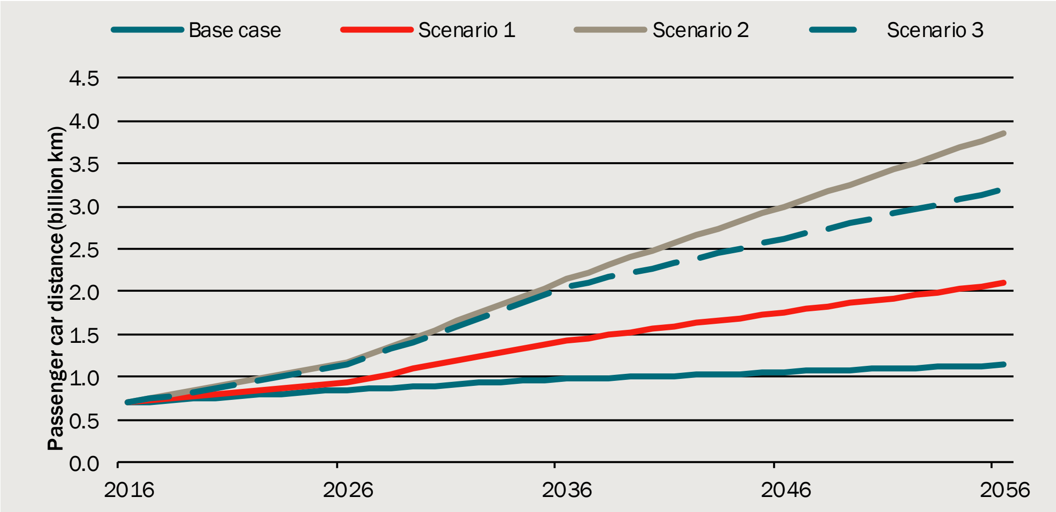
54 This is based on TfNSW *Economic Parameter Values* factors of 4.46 from 3.5 hour AM peak to weekday and 345 from weekday to annual. A 10 per cent reduction is applied to this to reflect a lower expansion for cost as opposed to volume, based on: Orthongthed et al. 2013, 'Estimating cost expansion factors in the Sydney urban and NSW rural road networks for economic evaluation of road projects', Proceedings from the Australasian Transport Research Forum, 2-4 October 2013, Brisbane Australia

55 ENERGIA. 2017, 'Electric Vehicles Insights', prepared by ENERGIA for the *Australian Energy Market Operator's 2017 Electricity Forecast Insights*, available at: http://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/EFI/2018/FINAL---AEMO-EV-Insights---September-2017.pdf

9.23 The impact of pollution from cars (NPV)



Note: Based on a linear extrapolation of Passenger car distance (km), by scenario, by year, discount rate of 7 per cent

Data source: CIE.

10 Benchmarks of costs of population growth

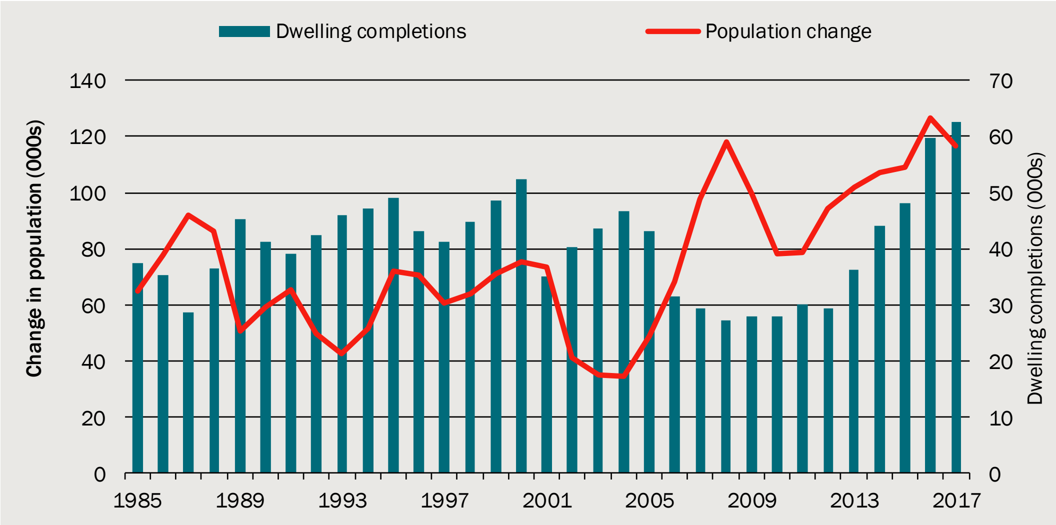
- **Costs and benefits of the PIC evaluation for the PIC have not been fully benchmarked**
- **Future work such as future PIC evaluations should continue to develop comparable benchmarks, and these should be included in future evaluations. This should be done transparently, so that the costs and benefits can be seen with and without benchmarks.**
- **Private vehicle usage in the PIC area is significantly higher than the Sydney-wide average. We estimate benchmarks for the costs of congestion and pollution associated with locating growth in other areas of Sydney.**

Most people implicitly see development as synonymous with population growth. While they are closely related, these are not the same.

- Population growth leads to a range of costs for Government such as for extra services, extra infrastructure and revenue from additional taxation receipts. These are costs and benefits imposed on the NSW Government from population growth
- Development leads to a different set of costs to connect new housing or employment areas into existing precincts, and benefits from the use of this new housing or employment land.

Historically, there have been large divergences in NSW between population growth and development levels, particularly in the mid-2000s when dwelling completions fell sharply and population growth increased sharply (chart 4.13). While at a NSW level the relationship between development and population growth is weak, at a spatial level, population growth does concentrate where new development occurs.

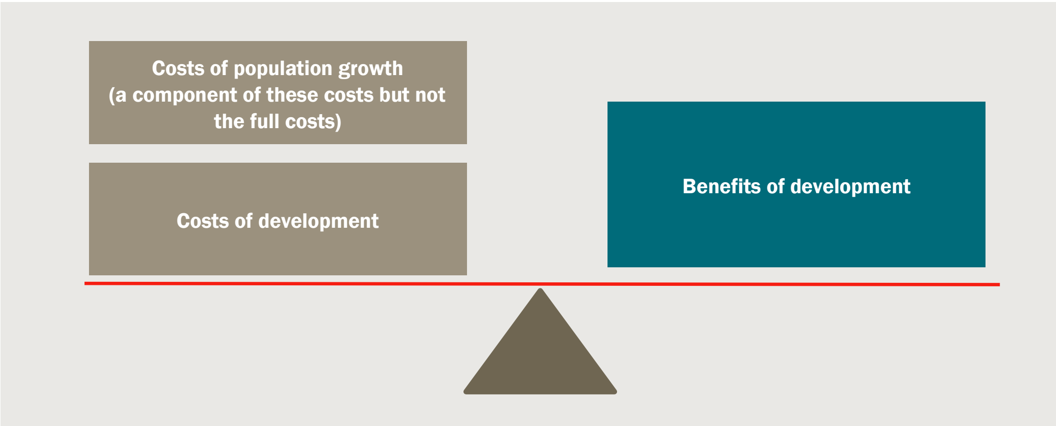
10.1 Historical population growth and new dwellings



Data source: ABS Building Activity and ABS Population data.

The evaluation approach implicitly compares the costs of development **and** a part of the costs of population growth against the benefits of development (chart 2.4). This means that it should be expected that in many cases there will be a net cost from higher growth options if this is not adjusted for.

10.2 What is actually being measured in the costs and benefits

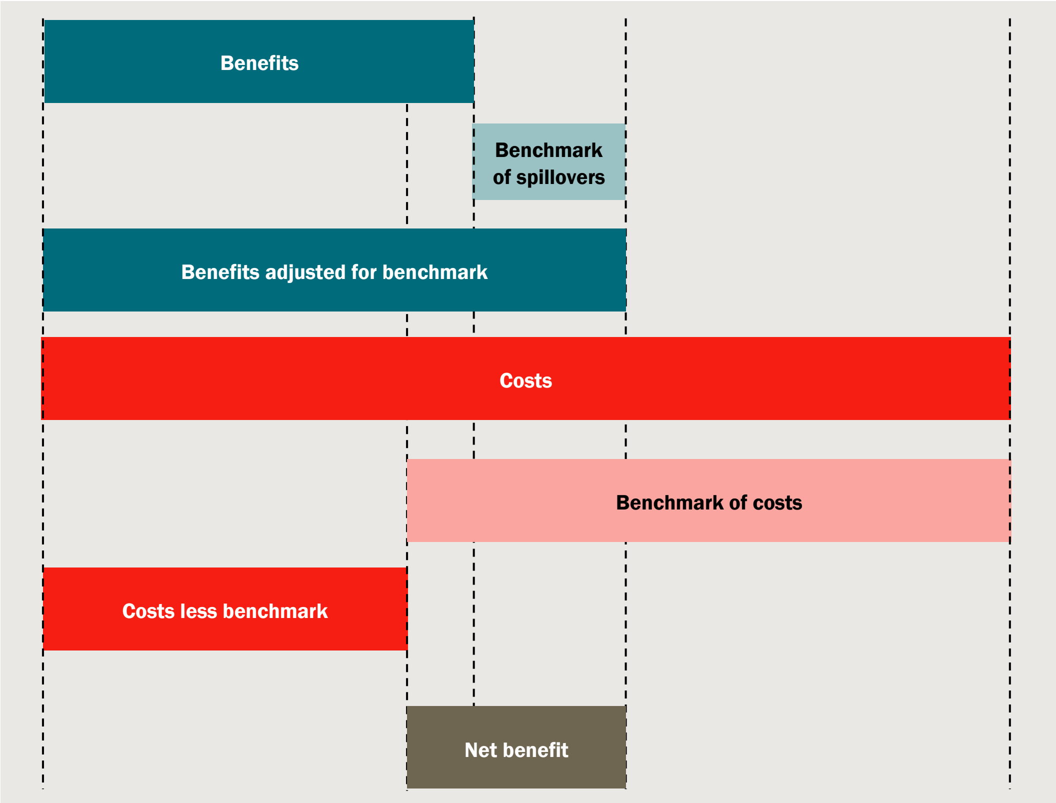


Source: CIE.

To see this more clearly, imagine that no new development was allowed across Sydney. Realistically, a large part of the population growth would occur, but the household size would increase and space per employee would fall. That is, the lack of change in land use controls would constrain development much more than it would constrain population growth. The additional population would still require capital expenditure on new schools, transport and health facilities, and would still generate additional transport congestion and crowding (depending on the transport infrastructure undertaken).

To adjust the estimates of net benefits, we have considered cost estimates from previous studies for growth of Sydney (chart 5.5) in order to calculate a meaningful net cost/benefit. The purpose of these studies was to compare different ways of accommodating growth. This means that they do not necessarily include all costs related to growth, but only costs that infrastructure and service provider thought would be different across scenarios.

10.3 Estimating the net benefit



Data source: CIE.

Costs of population growth

The most reliable estimates of the costs of population growth for Sydney are from past studies into what would be required to cater for different ways of accommodating growth. Over the past ten years, four studies have been conducted:

- In 2010, the CIE conducted a study of the costs and benefits of different amounts of Sydney's growth being accommodated in infill versus greenfield areas, for the NSW Department of Planning.
- In 2012, the CIE, assisted by ARUP, conducted a study of the costs and benefits of different types of infill development, for the NSW Department of Planning.
- In 2016, the CIE conducted a study of the implications of alternative spatial directions for Sydney, for Infrastructure NSW, Greater Sydney Commission and NSW Treasury.
- In 2018, the CIE undertook the economic evaluation for the Greater Parramatta and Olympic Peninsula (GPOP) Pilot Growth Infrastructure Compact (GIC), for the Greater Sydney Commission.

The three earlier studies had a broadly similar purpose – understanding where development has the largest benefits and the lowest costs. In each case, the total population housed across Sydney was kept unchanged. This meant that where costs were expected to be the same across scenarios, no estimates were included. For example, if the Department of Health expected costs to be similar under all scenarios, then the total costs were not measured.

For the purposes of the PIC 1, the amount of people within the PIC 1 area is not constant.

A striking finding across all of the above studies is that the overall costs for accommodating growth are very large, but the difference between doing this in different ways is much smaller.

The last study, in 2016, is most similar to the GIC evaluation in terms of using the same tools, covering the same costs and having a similar set of projects in the baseline for transport. The expected costs of additional population growth from this study were:

- $20,000 per person and job in additional transport congestion costs for growth from 2016 to 2036. This increased sharply to ~$40,000 per person for additional growth from 2036 to 2056. This does not include the cost of infrastructure that was in all scenarios, such as WestConnex, Sydney Metro North West, Sydney Metro, CBD and South East light rail, NorthConnex and the M12 motorway
- $7,000 per person and job in additional school infrastructure costs
- $5,000 per person and job in additional water and wastewater costs
- $4,000 to $5,000 per person in additional local councils costs, which are primarily paid for by developers through s94 contributions.

In total then, with only some infrastructure categories covered, costs are $38 000 per additional person and job to 2036 and $50 000 per additional person and job from 2036 to 2056. Including health infrastructure, electricity and environmental cost would add further to this.

10.4 Cost estimates from previous studies compared to this study

Study	2010 study	2012 study	2016 study	2016 study	GPOP GIC	GPOP GIC
Scenario					Scenario 2a	Scenario 3
Area covered	Sydney	Sydney	Sydney	Sydney	GPOP	GPOP
Time period	2016 to 2036	2016 to 2031	2016 to 2036	2036 to 2056	2016 to 2056	2016 to 2056
	$/person and job	$/person and job	$/person and job	$/person and job	$/person and job	$/person and job
Transport congestion/major infrastructure	13	9	20	40	33	42
Education	4	6	7	na	5	5
Health	10	na	na	na	6	6
Water and wastewater	7	na	5	5	2	3
Local council	16	2	5	4	na	na
Environmental	1	1	na	na	na	na
Open space	8	na	na	na	13	15
Electricity	2	na	na	na	2	1

Note: Na means not available. Results are shown only for the baseline scenario. All costs have been converted to 2018 dollars using ABS CPI as an inflator.

Source: CIE 2018, CIE 2016, CIE and ARUP 2012, CIE 2010.

focussed only on the cost items expected to be different across scenarios. Important differences are set out below.

- Transport congestion costs will depend on the amount of infrastructure and service improvements included in the scenarios. In the previous studies, the costs of this infrastructure are not measured because they are the same across all the scenarios considered. However, this means that the total transport costs to meet population growth are understated in the earlier studies.
- Costs for connecting development areas to existing transport networks are not included in the estimates above, as these are specifically development-related rather than being for population change.
- The 2010 and 2012 study used a net present value of costs relative to a net present value of dwellings to estimate costs per dwelling. This has been converted to per person in the above table. The 2016 study uses total costs divided by total growth in the population, without any discounting.

The GPOP GIC and Western Sydney PIC evaluations have some important differences to the earlier studies, which makes comparisons difficult and less accurate than is desirable. The most significant are

- the GIC covers a larger range of infrastructure types than the 2016 study
- the GIC has different sets of transport infrastructure for each scenario, and measures the costs of this rather than using congestion
- the GIC values changes in accessibility. Higher density scenarios increase accessibility because there are more jobs and people close together, but decrease accessibility because transport speeds decline. The speed decline is measuring something similar to the congestion impact of previous studies. However, there is no analogue for the increased accessibility. If job growth occurred elsewhere other than GPOP, it would lead to improved accessibility to jobs for other areas.

Because of these differences to earlier studies, and that only one previous GIC/PIC has been conducted (i.e. GPOP), for this evaluation, we show results for net benefits and net benefits adjusted for benchmarks.

Costs of additional vehicle use

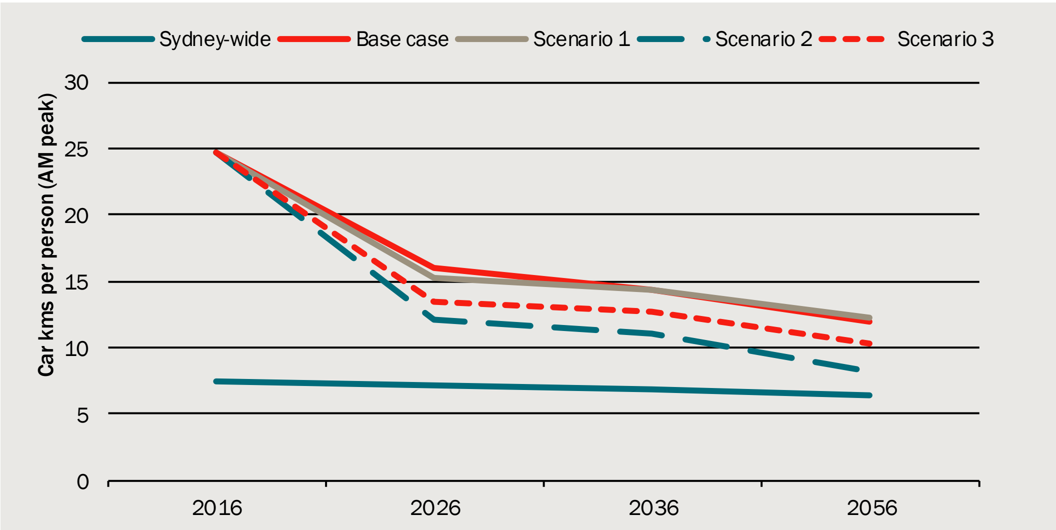
Car vehicle usage both in per person and per job terms is significantly higher in 2016 for the PIC area compared to the Sydney-wide average (chart 10.5 and chart 10.6). This is partially attributable to the large physical distances between locations within the PIC area, and the low number of people and jobs resulting in low density. However, under all scenarios, particularly those with more transport infrastructure such as Scenario 1, 2 and 3, there is a fall in vehicle kilometres per person/job.

10.5 Car vehicle kilometres per person

Note: This is vehicle kilometres from and within the PIC area.

Data source: TfNSW and CIE calculations.

10.6 Car vehicle kilometres per job



Note: This is vehicle kilometres into and within the PIC area

Data source: TfNSW and CIE calculations.

The implication of this is that scenarios with more people and jobs in PIC 1 tend to increase vehicle use, and this is likely to be at a much higher rate than would occur on average across Sydney. This means that the spillovers for environmental pollution from car use and from congestion will be much higher than if people and jobs created average vehicle use.

To estimate the benchmark for average costs associated with congestion imposed on others, we use the same approach as estimating the costs from PIC 1 (see the chapter on sustainability), except we use Sydney-wide averages. Note that this does not account for different incremental effects of a vehicle kilometre in one location versus another — all locations are assumed to have the same marginal cost of congestion.

Quantified benchmarks

The estimates for benchmarks are shown in table 10.7 and should be added to the benefits of the scenarios. These benefits are lower than the costs associated with private vehicle use, which means the net impact of private vehicle usage spillovers is negative relative to the benchmark level.

We have only shown benchmarks for congestion and environmental costs of car pollution quantitatively. This means that benchmarks are an underestimate of the costs of additional population growth in general, and likely a substantial underestimate. However, additional population and jobs growth would also bring accessibility benefits in other locations, which has not been included, and would have offsetting impacts.

10.7 Benchmarks for costs and benefits from population growth

Cost item	Base case	Scenario 1	Scenario 2	Scenario 3
	$b, pv	$b, pv	$b, pv	$b, pv
Congestion imposed on others	0.0	0.4	1.2	1.0
Vehicle pollution from car congestion	0.0	0.2	0.5	0.4
Population driven infrastructure costs	Na	Na	Na	Na
Population driven accessibility benefits	Na	Na	Na	Na
Total quantified benchmark	**0.0**	**0.6**	**1.8**	**1.4**

Source: CIE.

11 Overall evaluation of scenarios

- **Without accounting for benchmarks, none of the scenarios considered have a net benefit relative to the base case. Once benchmark costs of transport congestion and pollution are accounted for, all scenarios have a net benefit relative to the base case.**

Monetised results

The monetised results are shown in table 11.1. The discounted costs relative to the base case, range from $4.1 billion for Scenario 1 up to $9.6 billion for Scenario 2. The costs of Scenario 3 are somewhat lower than Scenario 2, at $8.8 billion.

The benefits are measured for:

- liveability – willingness to pay for housing in each precinct, given the current attributes of the place, and the changes that each scenario leads to, less the cost of development
- productivity – willingness to pay for commercial and industrial development in each precinct, given the current attributes of the place, and the changes that each scenario leads to, less the cost of development
- sustainability – a range of environmental impacts, impacts outside of the PIC area and impacts not captured elsewhere.

Liveability benefits are the largest component of benefits. The liveability benefit in Scenario 2 and 3 is around $2.5-3.0 billion more than Scenario 1, which has a liveability benefit of $4.3 billion relative to the base case. The benefits associated with liveability are mostly associated with the value of development at current attributes, with a small contribution from improved accessibility to jobs by public transport.

Productivity benefits are the second largest component of benefits, and are highest in the highest job growth scenario (Scenario 2). There is a moderate private benefit from more development in the Aerotropolis at projected rents without any improvement in characteristics of the place (such as accessibility improvements). This is captured in the productivity benefit using current attributes. Additional productivity benefits are associated with the businesses to be located in the PIC area being more accessible to labour supply by public transport. These benefits increase from $0.2 billion in Scenario 1 to $0.4 billion in Scenario 3 and $0.6 billion in Scenario 2. These benefits are highest in Scenario 2 because there are more jobs and businesses in the PIC area to benefit from increased accessibility to labour supply driven by population growth and transport infrastructure projects.

Sustainability benefits are $0.6 billion in Scenarios 2 and 3 relative to the base case. This is mainly associated with water quality improvements, but tree canopy and native vegetation improvements also lead to benefits.

Spillover impacts from the scenarios relative to the base case are negative. This is mainly due to the magnitude of congestion and pollution caused by vehicle usage in the PIC area, which is higher in the scenarios than the base case. Once benchmarks are accounted for around private vehicle use in scenarios relative to Sydney averages, the net costs of pollution and congestion are somewhat lower. Higher growth scenarios lead to moderate increases in private vehicle kilometres travelled per person, due to car kilometres travelled in the PIC area being significantly higher than Sydney-wide averages.

For overall metrics we report:

- net benefits — this is the benefits measured for the scenarios less the costs
- net benefits adjusted for benchmarks. This is net benefits, plus the benchmark of population driven costs
  - we use a conservative estimate of typical population driven costs that only includes congestion and environmental impacts from private vehicle use
  - there are potentially substantially more population driven costs regardless of whether new housing is built, such as higher demand for schooling, health facilities and green infrastructure. There are also potentially benefits from locating people and jobs in other places, as this would improve labour market access for businesses and job accessibility for people. Neither of these has been quantified in this evaluation, given information available

The most appropriate metric in our view is the net benefit adjusted for benchmark costs of population growth. The scenario that performs most strongly on this metric is Scenario 3. With a less conservative view of benchmark costs for population growth this result would be stronger. Given that few PIC evaluations have been conducted, the benchmarks are not particularly strong for comparing costs and benefits relative to other areas.

Both Scenario 1 and Scenario 2 have a similar net benefit of $0.5 billion in present value terms.

11.1 Overall costs and benefits

	Scenario 1	Scenario 2	Scenario 3
	$b, pv	$b, pv	$b, pv
Costs			
Capital costs identified by agencies	-4.1	-9.6	-8.8
Total capital costs	**-4.1**	**-9.6**	**-8.8**
Benefits			
Liveability benefits			
Current attributes	4.1	6.0	6.0
Change in job accessibility	0.3	1.4	0.9

	Scenario 1	Scenario 2	Scenario 3
	$b, pv	$b, pv	$b, pv
Change in open space	0.0	0.1	0.1
Change in access to strategic centres	0.0	0.0	-0.1
Total liveability benefits	**4.3**	**7.5**	**6.9**
Productivity benefits			
Attributes of comparator areas	0.5	1.6	1.2
Change in business accessibility	-0.1	0.0	-0.1
Change in labour market access	0.2	0.6	0.4
Lost value of agricultural land	-0.1	-0.8	-0.7
Digital benefits	0.0	1.1	1.3
Total productivity benefits	**0.4**	**2.5**	**2.0**
Sustainability benefits			
Tree canopy (air quality, GHG and flood mitigation/water quality)	0.0	0.0	0.0
Tree canopy health benefits	0.0	0.1	0.1
Native vegetation	0.0	0.1	0.1
Water quality	0.2	0.4	0.4
Building energy consumption	0.0	0.0	0.0
Social housing	0.0	0.0	0.0
Total sustainability benefits	**0.2**	**0.6**	**0.6**
Spillovers			
Congestion spillovers outside of the PIC area	-0.6	-1.6	-1.4
Vehicle pollution	-0.2	-0.7	-0.6
Total spillovers	**-0.8**	**-2.2**	**-1.9**
Total benefit	**4.2**	**8.3**	**7.5**
Benchmarks of costs of population growth			
Congestion imposed on others	0.4	1.2	1.0
Vehicle pollution from car congestion	0.2	0.5	0.4
Population driven infrastructure costs	Na	Na	Na
Population driven accessibility benefits	Na	Na	Na
Total benchmark	**0.6**	**1.8**	**1.4**
Overall metrics			
Net benefit without benchmarking	**-0.1**	**-1.3**	**-1.3**
Net benefit with benchmarking	**0.6**	**0.5**	**0.1**

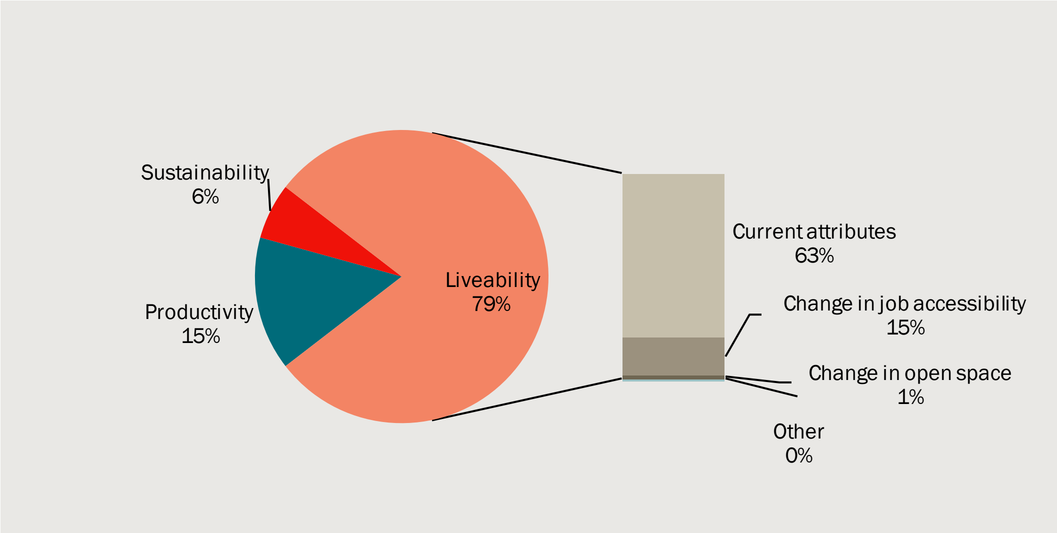
Note: Using a 7 per cent discount rate. 'Current attributes' refers to current levels of accessibility, open space and other physical characteristics that would affect willingness to pay. Note that we do not present the benefit-cost ratio of each scenario since some benefits are measured net of costs, and thus capital and operating costs are not 'all-inclusive' of costs. For example liveability benefits are measured net of construction costs. Additionally, sustainability benefits are net changes, some of which are negative.

Source: CIE.

The split of benefits for scenarios 2 and 3 are shown in charts 11.2 and 4.4 respectively. The largest component of benefits in both scenarios is associated with liveability improvements, and mainly the value of development at current attributes of the place.

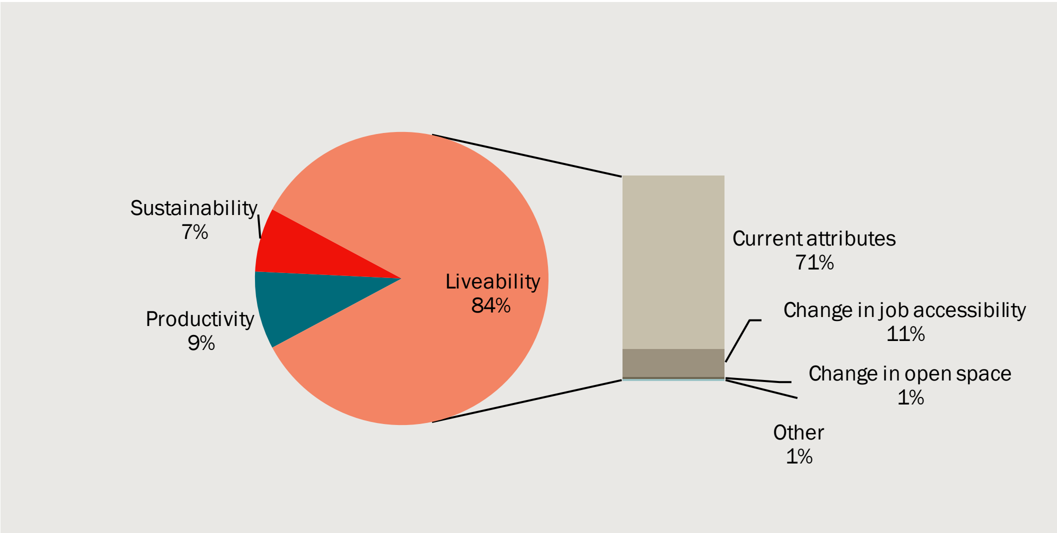
There are also benefits associated with improvements in the liveability of the PIC 1 area. Productivity and sustainability benefits of the scenarios are smaller.

11.2 Split of benefits for Scenario 2



Data source: CIE.

11.3 Split of benefits for Scenario 3



Data source: CIE.

The totals are presented per person and per job to allow for easier comparison to other GICs and benchmarks (table 11.4). The net benefit adjusted for benchmarks per additional person and job are around $15 000 per person and job for Scenario 1, while there is a net benefit of $6 000 and 2 000 for Scenarios 2 and 3 respectively (relative to the base case). This is mainly because of lower benefits per person and job, while costs per person and job are lower for the higher development scenarios.

Note that the central case does not allow for any impacts from saturating the market for housing or jobs for the PIC. For example, if there was a limited market for higher density apartments, and willingness to pay declined rapidly thereafter, then this would reduce the benefits per person and job of higher growth scenarios and particularly Scenarios 2 and 3.

11.4 Overall results per person and per job (incremental to base case)

Cost or benefit item	Scenario 1	Scenario 2	Scenario 3
	$000/person and job	$000/person and job	$000/person and job
Total capital and operating costs	-133	-118	-131
Benefits	135	102	112
Net benefits	3	-16	-19
Benefits (adjusted for benchmark)	153	124	133
Net benefits (adjusted for benchmark)	20	6	2

Source: CIE.

In table 11.5 we show the costs and benefits of the additional growth from one scenario to the next.

- Capital costs are particularly high in discounted terms for the incremental growth from the base case to Scenario 1. Incremental costs for the scenarios are around $10 000 to $30 000 lower per person and job than in the scenarios.
- The incremental net benefits of scenarios relative to the previous scenario are negative moving from Scenario 1 to either Scenario 2 or Scenario 3.

11.5 Overall results per person and per job (incremental to lower growth scenario)

Cost or benefit item	Scenario 1 vs base case	Scenario 2 vs Scenario 1	Scenario 3 vs Scenario 1
	$000/person and job	$000/person and job	$000/person and job
Total capital and operating costs	-138	-106	-125
Benefits	135	82	92
Net benefits	-3	-24	-32
Benefits (adjusted for benchmark)	153	106	116
Net benefits (adjusted for benchmark)	15	0	-9

Source: CIE.

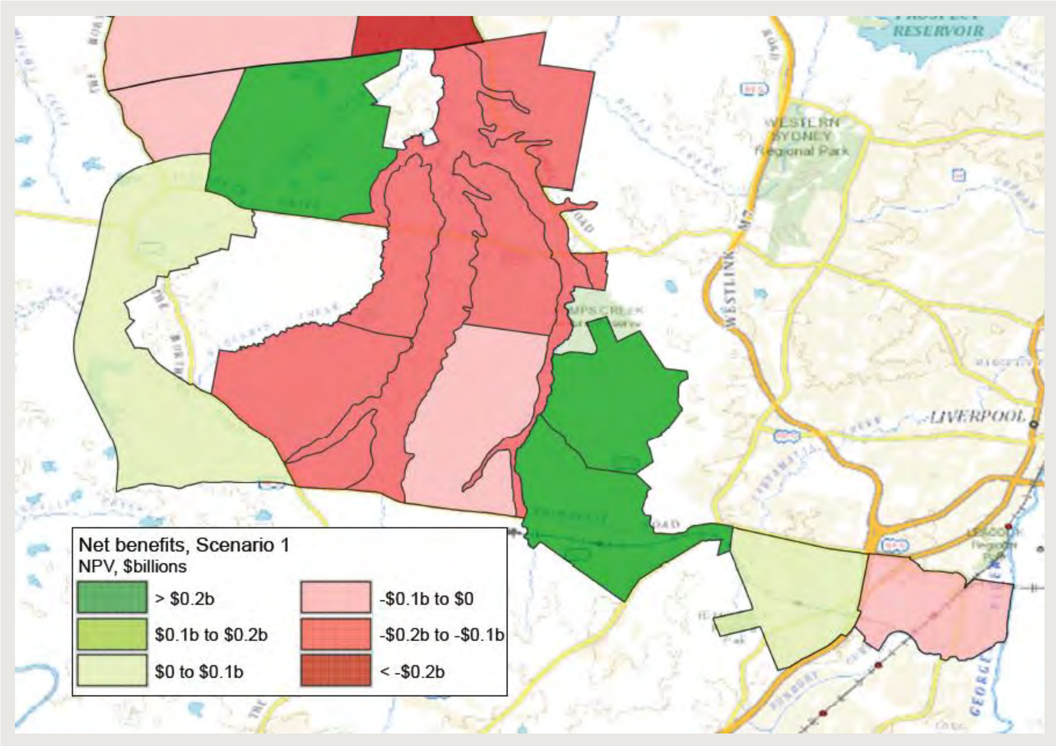
Net benefits by precinct

Net benefits by precinct are highly variable, as shown in charts 11.6 to 11.8 for Scenarios 1–3. Results tend to be quite different for the Eastern residential-focussed precincts compared to the western precincts closer to the Aerotropolis.

- The Eastern precincts of Austral, Edmondson Park, and Leppington North have net benefits in all three scenarios relative to the base case.
- In Scenario 1, Northern Gateway and the Agriculture and Agribusiness precincts have net benefits, while all other western precincts have net costs. In the higher development scenarios, the Aerotropolis Core only has a net benefit in Scenario 2. That suggests that this precinct has a net cost unless it is developed to the level of

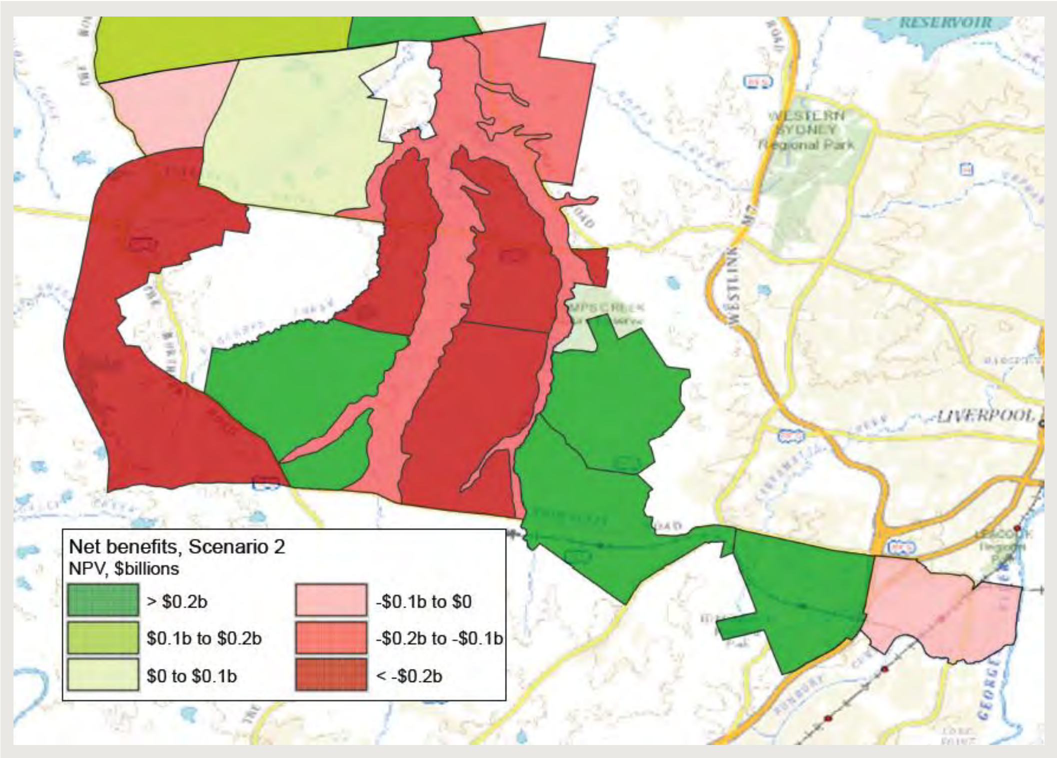
Scenario 2, which has the most population and jobs growth out of any scenario for that precinct. Northern Gateway has a net benefit in both Scenario 2 and 3.

11.6 Net benefits by precinct – Scenario 1



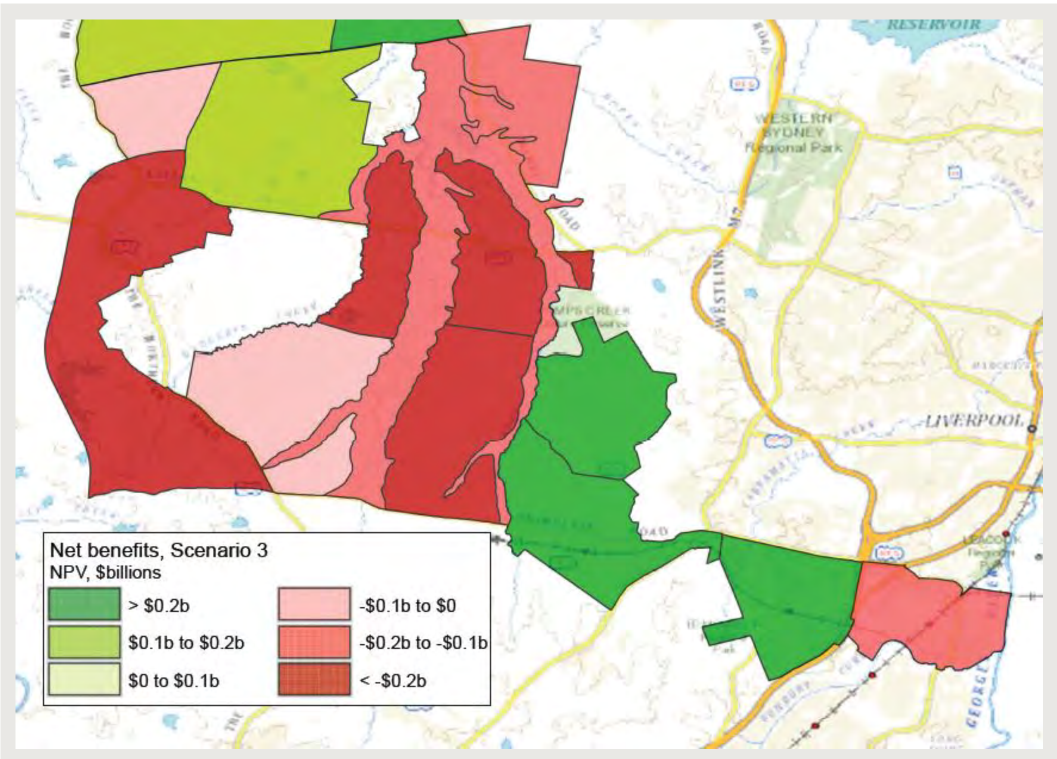
Data source: CIE.

11.7 Net benefits by precinct – Scenario 2



Data source: CIE.

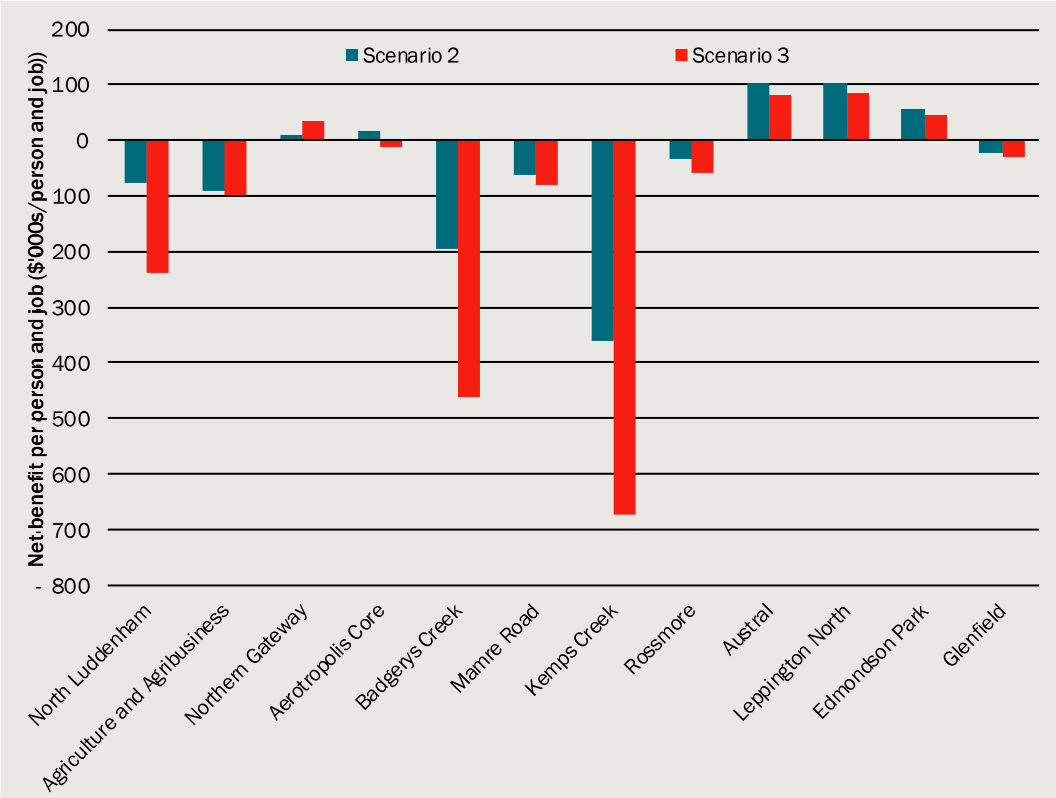
11.8 Net benefits by precinct – Scenario 3



Data source: CIE.

Net benefits per person and job are positive for Leppington North and Austral, but are strongly negative for Badgery's Creek and Kemps Creek. The net benefits associated with Aerotropolis Core are very close to $0 per person and job in both scenarios, yet are slightly positive for Scenario 2.

11.9 Net benefits per person and job by scenario

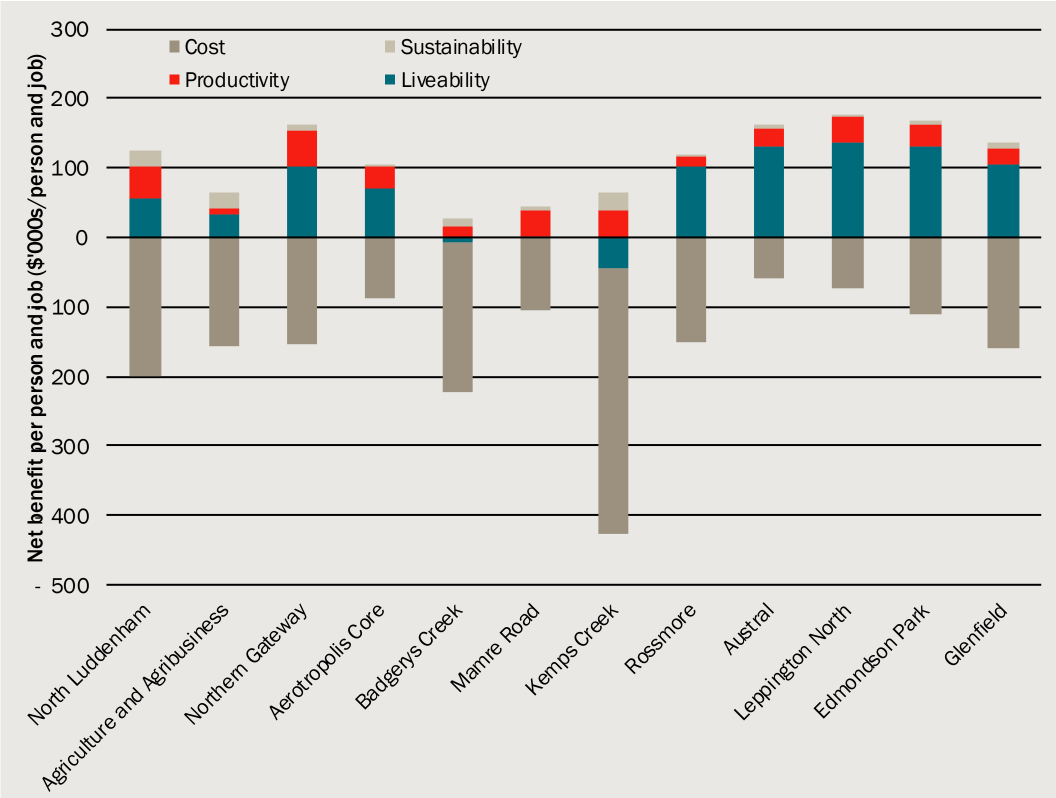


Note: South Creek Sth has been excluded since the net benefit per person and job is not defined for a precinct with zero population and job growth.

Data source: CIE.

Both the benefits and costs per person and job relative to the base case vary spatially (chart 11.10). Benefits are similar in North Luddenham, Northern Gateway and Aerotropolis Core, but higher costs in Northern Gateway and North Luddenham compared to the Aerotropolis drive the outcome of net benefits. Productivity benefits are a significantly higher share of benefits for the western precincts compared to the Eastern precincts. Glenfield has significantly higher costs than the other eastern precincts, which drives the net cost outcome for the precinct.

11.10 Split of net benefits per person and job – Scenario 2

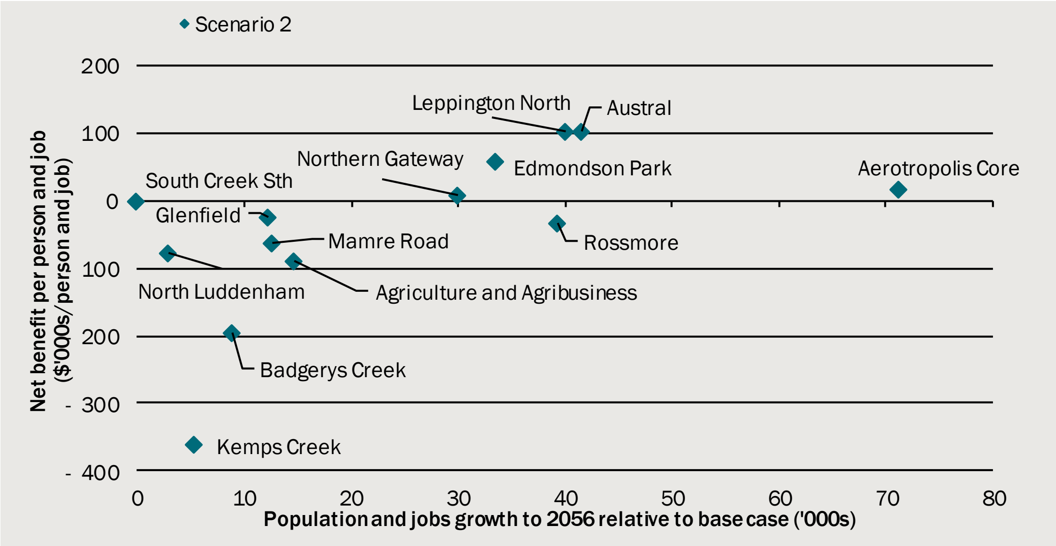


Note: South Creek Sth has been excluded since the net benefit per person and job is not defined for a precinct with zero population and job growth.

Data source: CIE.

Net benefits per person and job are generally increasing with respect to growth (chart 11.11). That is, precincts such as Austral, Leppington North and Aerotropolis Core, which have higher growth, tend to have a net benefit per person and job. In contrast, lower growth precincts such as Glenfield, Mamre Road and Badgery's Creek tend to be associated with net costs. This may reflect efficiencies from providing infrastructure for a larger number of people and jobs.

11.11 Net benefits per person and job compared to growth – Scenario 2



Data source: CIE.

Sensitivity analysis

We measure the sensitivity of net benefits for each of the following cases:

- **Central case**: assumes a discount rate of 7 per cent and an internal rate of return for housing of 3 per cent
- **Low discount rate**: assumes a discount rate of 3 per cent and an internal rate of return for housing of 1.5 per cent
- **High discount rate**: assumes a discount rate of 10 per cent and an internal rate of return for housing of 7 per cent
- **Low stormwater costs**: based on reducing street trees by 50%, removing the stormwater harvesting projects, and reducing every precinct's end of pipe stormwater basin project by 20%.
- **Lower population and jobs due to COVID**: based on a reduction in projected population from 10.6 million to 9.9 million people in 2041,[56] we uniformly apply a 93.4 per cent reduction to dwellings and jobs additional to the base case in all years. This adjustment is made to the liveability and productivity benefit calculations only, with costs, sustainability benefits remaining the same. Transport modelling outputs are also not updated.
- **2019 DPIE population and job projections**: based on the Sydney Housing Supply Forecasts for 2016, we adjust dwelling and jobs growth in the model to align to these dwelling projections for Penrith, Camden, Campbelltown and LGAs.[57] This

56 NSW Government Expert Population Advisory Group, 2020, *Report on COVID-19 population projection scenarios*, June 2020, Sensitive NSW Cabinet.

57 We multiply dwelling and jobs for precincts in Penrith LGA by 0.967, 0.767, and 0.741 for Scenarios 1, 2 and 3 respectively. For Liverpool precincts the factors are 1.183, 1.031 and 1.033 respectively. For Campbelltown the factors are 1.128, 1.104 and 1.081. For Camden the factors

adjustment is made to the liveability and productivity benefit calculations only, with costs, sustainability benefits remaining the same. Transport modelling outputs are also not updated.

- **Lower residential density**: we assume that at least 75 per cent of new dwellings in each precinct are houses or medium density by increasing the share of new dwellings that are medium density. The shares of new dwellings in each precinct that are flats of 1-3 and 4+ storeys are determined based on the ratio of dwellings of each flat type in the central case scenarios.[58]
- **50% commercial/industrial rental premium from 2026**: The impact of Western Sydney Airport on commercial and industrial rents is uncertain. While JLL estimates of rents are based on the value of properties in the area once developed, this may underestimate rents once the airport is completed. Under this sensitivity test, we assume that commercial and industrial rents in all precincts are 50 per cent higher under all scenarios and the base case from 2026 onwards. This is based on Cohen and Brown (2013),[59] which estimated that for each 10 per cent closer a commercial property is to Vancouver International Airport, sale prices are 7.6 per cent higher. We assume that from 2026 onwards, Western Sydney Airport would be associated with an increase in commercial/industrial rents in PIC 1 of 50 per cent.[60]
- **10 per cent increase in supply causes 1 per cent fall in prices**: this reflects a saturation of property market demand due to development in the PIC area.
- **1 per cent annual real growth in rents**: this is applied to rents before accessibility benefits and other changes in the place are factored in.

Net benefits vary significantly under these sensitivities, with the preferred scenario being either Scenario 1 or Scenario 2 depending on the case (table 11.12). For example, low discount rates or higher property benefits (due to rental growth) support Scenario 2 as the preferred scenario, while Scenario 1 is preferred under higher discount rates and lower population outcomes.

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are 1.358, 1.173 and 1.161. These factors are based on the ratio of dwellings in these LGAs under the Sydney Housing Supply Forecasts to the number of dwellings in these LGAs under each PIC scenario. Agriculture and Agribusiness is assumed to be split 50/50 between Liverpool and Penrith. Leppington North is assumed to be split 50/50 between Liverpool and Camden. Glenfield is in Campbelltown LGA, Northern Gateway and Mamre Road are in Penrith, and all other precincts are in Liverpool LGA.

58 For example, if in the central case new apartment dwellings in Luxford are split between 1-3 storeys and 4+ storeys in an 80/20 ratio, we likewise assume that new apartment dwellings in this sensitivity analysis are split 80/20.

59 Cohen, J. and Brown, M., 2013, *Impact of Vancouver Airport on Commercial property values*, p.12, available at: https://www.aeaweb.org/conference/2014/retrieve.php?pdfid=1225

60 We estimate there will be a reduction of approximately 80 per cent in distance from PIC 1 to the nearest airport, with Sydney Airport being approximately 40km away from an area such as Rossmore and around 10km from Western Sydney Airport. For simplicity, we have tested the same uplift in rents as for PIC 2, which is 50 per cent from 2026 onwards.

11.12 Sensitivity analysis of net benefits

Sensitivity test	Scenario 1	Scenario 2	Scenario 3
	$b, PV	$b, PV	$b, PV
Central case (discount rate 7 per cent)	0.6	0.5	0.1
Low discount rate (3 per cent) and residential IRR	2.1	6.1	2.7
High discount rate (10 per cent) and residential IRR	-2.2	-4.4	-4.0
Low stormwater costs	0.6	2.4	1.4
Lower population and jobs due to COVID	1.4	-0.2	-0.4
2019 DPIE population and job projections	1.4	0.4	0.1
Lower residential density	1.7	1.2	0.7
50% commercial/industrial rental premium from 2026	1.1	1.9	1.1
10 per cent increase in supply causes 1 per cent fall in prices	-0.6	-0.5	-0.9
1 per cent annual real growth in rents	2.2	6.1	4.5

Note: Net benefits are discounted and relative to the base case.
Source: CIE.

Higher population and jobs growth in Glenfield

Glenfield is a precinct in PIC 1 that is expected to have significant residential development. Scenario 3 has significantly greater growth than Scenario 2 in Glenfield. However both scenarios may understate the level of growth given recent take-up of development.

Campbelltown Council have provided a set of alternative population, dwelling and job growth assumptions that are intended to be more reflective of recent information about development.[61] For example, the current Hurlstone Agricultural High School site is in the process of being rezoned for residential development, and currently expected to comprise in excess of 5 400 homes upon completion.

Tables 11.13 and 11.14 show the population and jobs in 2016 and growth in each period afterwards growth respectively supplied by Campbelltown Council compared to Scenario 3. The alternate land use assumptions supplied by Campbelltown Council are referred to in this section as 'Scenario 3+', denoting that they involve higher land use growth in Glenfield.[62] The tables show that by 2056 there are 5 079 additional people and 1 106 additional jobs in Glenfield under Scenario 3+ compared to Scenario 3. This amounts to a total additional growth of 6 185 people and jobs.

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61 These have been supplied to CIE via GSC in a document named 'Glenfield PIC Assumptions Review.docx'.

62 We calculate the change in the present value of growth in people and jobs relative to Scenario 3. This is based on the additional people in Scenario 3+ and a discount rate of 7 per cent. We estimate that the present value of population growth since 2016 is 16 per cent higher in Scenario 3+ compared to Scenario 3, and the present value of jobs growth since 2016 is 113 per cent higher. Total discounted population and jobs growth relative to 2016 is 28 per cent higher.

11.13 Additional population in Glenfield under PIC Scenario 3 and Campbelltown Council estimates

Estimate	2016	2016-36	2036-56	Total
	No. of people	No. of people	No. of people	No. of people
Scenario 3+	9 926	9 132	8 740	27 798
Scenario 3	9 926	9 269	3 524	22 719
Difference (Sc3+ – Sc3)	**0**	**-137**	**5 216**	**5 079**

Source: Campbelltown Council, CIE.

11.14 Additional jobs in Glenfield under PIC Scenario 3 and Campbelltown Council estimates

Estimate	2016	2016-21	2021-26	2026-36	Total
	No. of jobs	No. of jobs	No. of jobs	No. of jobs	No. of jobs
Scenario 3+	2 387	380	770	970	4 507
Scenario 3	2 387	217	198	599	3 402
Difference (Sc3+ – Sc3)	**0**	**163**	**572**	**371**	**1 106**

Note: We assume that growth between 2036 and 2056 is the same under Scenario 3+ and Scenario 3.

Source: Campbelltown Council, CIE.

We test the sensitivity of net benefits per person and job to higher growth in Glenfield. As explained below, for this sensitivity we keep benefits per person and job constant and vary costs per person and job depending on the extent of spare capacity of Scenario 3 infrastructure.

We have assumed that liveability, productivity, and sustainability benefits per person and job are the same in this alternate case for Glenfield's growth. However, changes to Glenfield's growth may affect liveability and productivity benefits through impacts on accessibility. We have not obtained transport modelling runs under this alternative case for Glenfield growth due to time constraints for this analysis, and thus cannot estimate how benefits per person and job will change. Given that most of the liveability and productivity benefits for PIC 1 are associated with the value of development of current attributes or attributes in comparator areas, rather than the value of accessibility improvements, changes in benefits per person are expected to be small.

Changes to Glenfield's growth will impact the cost per person and job relative to the base case, but the extent of this impact is uncertain.

- At one extreme, cost per person and job in Scenario 3+ may be the same as Scenario 3. This would occur if the cost of accommodating an additional person or job in Scenario 3+ is the same as the cost of accommodating and additional person or job in Scenario 3 (relative to the base case). This would be likely if there was no spare capacity in the infrastructure provided in scenario 3.
- At the other extreme, the total cost of infrastructure in Scenario 3+ may be the same as Scenario 3. This would occur if there is no additional cost to providing infrastructure to accommodate the additional people and jobs in Scenario 3+. This would be likely if there is sufficient spare capacity in the infrastructure provided in Scenario 3.

The costing of an alternative scenario for Glenfield would ideally be performed by agencies. Given time constraints, we have sought to model cost per person and job under Scenario 3+ using high-level assumptions about spare infrastructure capacity. We construct two cases for costs in Glenfield under Scenario 3+:

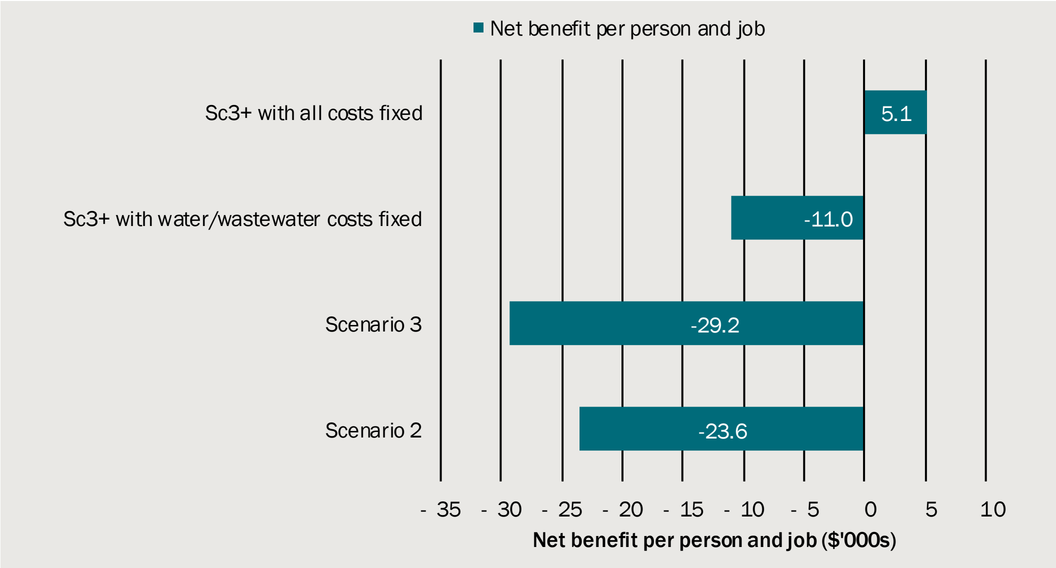
- Based on discussions with Sydney Water, there is spare capacity in the water and wastewater infrastructure provided in Scenario 3.[63] Glenfield is a particularly expensive precinct in terms of water infrastructure (see chart 4.19). However, the costs of water infrastructure are largely associated with connecting Glenfield to the Upper South Creek wastewater treatment facility. Once this connection is made, it provides significant additional capacity for Glenfield to grow further. Therefore, we assume that there would not be additional water and wastewater costs. This case is referred to as 'Sc3+ with water/wastewater costs fixed'.
- An alternative is that there is spare capacity in all infrastructure provided under scenario 3 for Glenfield (the second extreme case referred to above). This case is referred to as 'Sc3+ with all costs fixed'.

The cost of increasing growth from Scenario 2 to Scenario 3 in Glenfield is similar to the cost of Scenario 3 relative to the base case. That is, costs per person and job are similar between Scenario 2 and Scenario 3 despite significantly different growth levels. Spare capacity in the wastewater infrastructure for Glenfield suggests that there will not be additional water/wastewater costs to accommodate Scenario 3+. We have not been able to assess the extent of additional costs for infrastructure other than water/wastewater under Scenario 3+.

The net benefit per person and job for Glenfield under these cases and Scenarios 2 and 3 is shown in table 11.15. There is a slight net benefit per additional person and job relative to the base case in Glenfield if all infrastructure costs are the same between Scenario 3 and Scenario 3+. That is, if there are no extra infrastructure costs required to accommodate 6 185 additional people and jobs in Glenfield by 2056, then there would be a net benefit of $5 100 per person and job from Glenfield under Scenario 3+. If there were no additional water/wastewater costs only from Scenario 3+, there would still be a net cost from Glenfield under Scenario 3+.

63 PIC 1 proposed forecasts within Glenfield (and Edmondson Park) are significantly higher than what Sydney Water have planned for (based on DPIE forecasts). This requires changes to their servicing approach, sending wastewater to the new Upper South Creek facility as well as the Malabar system. This change adds to the cost of servicing beyond what would have been required to service the Western Sydney Aerotropolis Growth Area alone. Sydney Water have indicated to GSC that "There are short term and long term capacity issues within the Malabar wastewater system. The servicing strategy outlined in PIC 1 for Glenfield and Edmondson Park relies on Malabar System Planning at the time of assessment which does not include a solution for the very high growth. Should the high growth be adopted as a likely scenario, Sydney Water would undertake detailed optioneering around how to manage this through the Malabar System…".

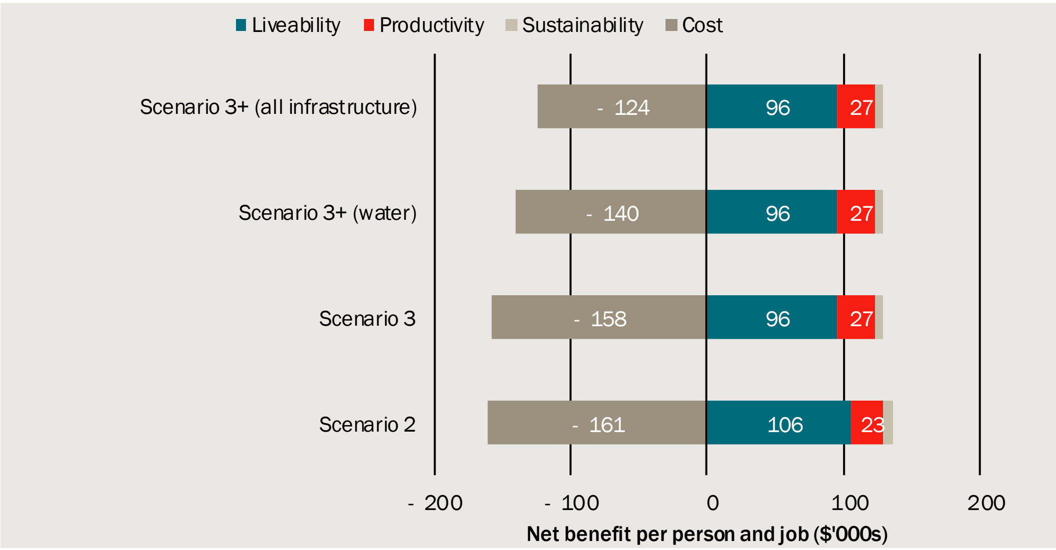
11.15 Net benefit per person and job in Glenfield under Scenario 3+



Data source: CIE.

The changes in cost per person and job can be seen in chart 11.16. While additional cost additional to the base case per person and job is around $158 000 in Scenario 3, it falls to $140 000 per person and job in Scenario 3+ if water infrastructure costs are the same. If all infrastructure costs are the same, then it falls further to $124 000 per person and job. Scenario 2 is shown for comparison, which has a higher cost per person and job than Scenario 3, but a lower benefit per person and job due to worse accessibility.

11.16 Components of net benefit per person and job in Glenfield under Scenario 3+



Data source: CIE.

Comparison of results between Aerotropolis and GPEC PICs

The monetised results for both PIC areas combined are shown in table 11.17. The discounted costs relative to the base case, range from $5.9 billion for Scenario 1 up to $15.6 billion for Scenario 2. The costs of Scenario 3 are somewhat lower than Scenario 2, at $15.4 billion.

Liveability benefits are the largest component of benefits. The liveability benefit in Scenario 2 and 3 is around $8 billion more than Scenario 1, which has a liveability benefit of $4.2 billion relative to the base case. The benefits associated with liveability are mostly associated with the value of development at current attributes, with a small contribution from improved accessibility to jobs by public transport.

Productivity benefits are the second largest component of benefits, and are highest in the GPEC-focussed growth scenario (Scenario 3).

Sustainability benefits are $2.5 billion in Scenarios 2 and 3 relative to the base case. This is mainly associated with tree canopy and water quality improvements, but native vegetation improvements also lead to benefits.

Spillover impacts from the scenarios relative to the base case are negative. This is mainly due to the magnitude of congestion and pollution caused by vehicle usage in the PIC areas, which is higher in the scenarios than the base case. Once benchmarks are accounted for around private vehicle use in scenarios relative to Sydney averages, the net costs of pollution and congestion are somewhat lower.

The most appropriate metric in our view is the net benefit adjusted for benchmark costs of population growth. The scenario that performs most strongly on this metric is Scenario 3. With a less conservative view of benchmark costs for population growth this result would be stronger. Given that few PIC evaluations have been conducted, the benchmarks are not particularly strong for comparing costs and benefits relative to other areas.

The scenario with the highest net benefit is Scenario 3.

11.17 Overall costs and benefits

	Scenario 1	Scenario 2	Scenario 3
	$b, pv	$b, pv	$b, pv
Costs			
Capital costs identified by agencies	-5.9	-15.6	-15.4
Total capital costs	**-5.9**	**-15.6**	**-15.4**
Benefits			
Liveability benefits			
Current attributes	4.3	10.3	10.9
Change in job accessibility	-0.1	1.7	0.9
Change in open space	0.0	0.1	0.2
Change in access to strategic centres	0.0	0.0	-0.1
Total liveability benefits	**4.2**	**12.1**	**11.9**

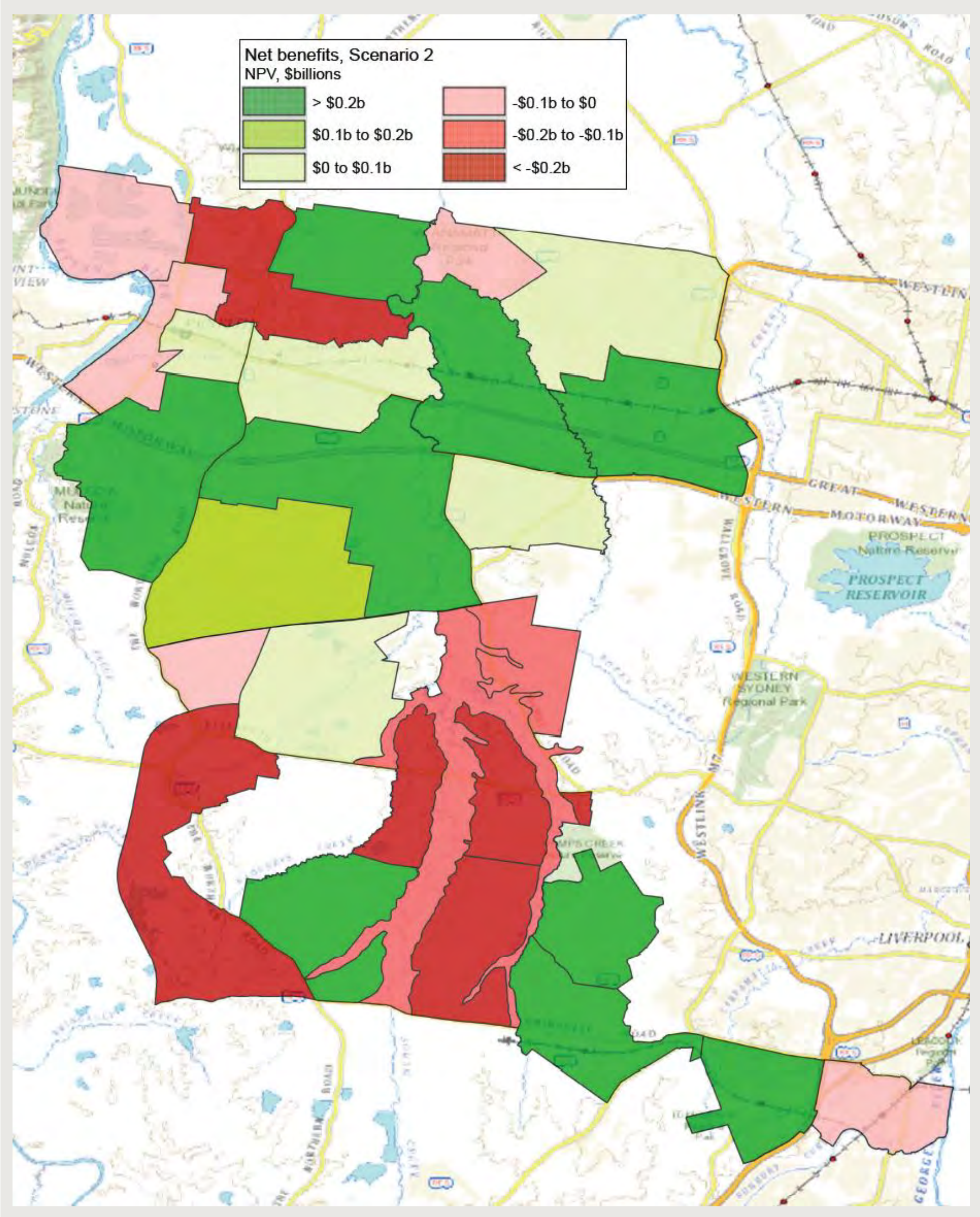
	Scenario 1	Scenario 2	Scenario 3
	$b, pv	$b, pv	$b, pv
Productivity benefits			
Attributes of comparator areas	0.6	2.3	2.5
Change in business accessibility	-0.3	-0.4	-0.5
Change in labour market access	0.3	1.3	1.3
Lost value of agricultural land	-0.1	-0.9	-0.8
Digital benefits	0.0	3.0	3.5
Total productivity benefits	**0.5**	**5.3**	**6.0**
Sustainability benefits			
Tree canopy (air quality, GHG and flood mitigation/water quality)	0.0	0.2	0.2
Tree canopy health benefits	0.1	1.2	1.2
Native vegetation	0.0	0.4	0.4
Water quality	0.2	0.7	0.7
Building energy consumption	0.0	0.0	0.0
Social housing	0.0	0.0	0.0
Total sustainability benefits	**0.3**	**2.5**	**2.5**
Spillovers			
Congestion spillovers outside of the PIC area	-0.8	-3.1	-3.2
Vehicle pollution	-0.4	-1.3	-1.3
Total spillovers	**-1.2**	**-4.5**	**-4.5**
Total benefit	**3.9**	**15.5**	**15.9**
Benchmarks of costs of population growth			
Congestion imposed on others	0.6	2.5	2.5
Vehicle pollution from car congestion	0.3	1.1	1.1
Population driven infrastructure costs	Na	Na	Na
Population driven accessibility benefits	Na	Na	Na
Total benchmark	**0.8**	**3.6**	**3.6**
Overall metrics			
Net benefit without benchmarking	**-2.0**	**-0.2**	**0.5**
Net benefit with benchmarking	**-1.1**	**3.5**	**4.0**

Note: Using a 7 per cent discount rate. 'Current attributes' refers to current levels of accessibility, open space and other physical characteristics that would affect willingness to pay. Note that we do not present the benefit-cost ratio of each scenario since some benefits are measured net of costs, and thus capital and operating costs are not 'all-inclusive' of costs. For example liveability benefits are measured net of construction costs. Additionally, sustainability benefits are net changes, some of which are negative.

Source: CIE.

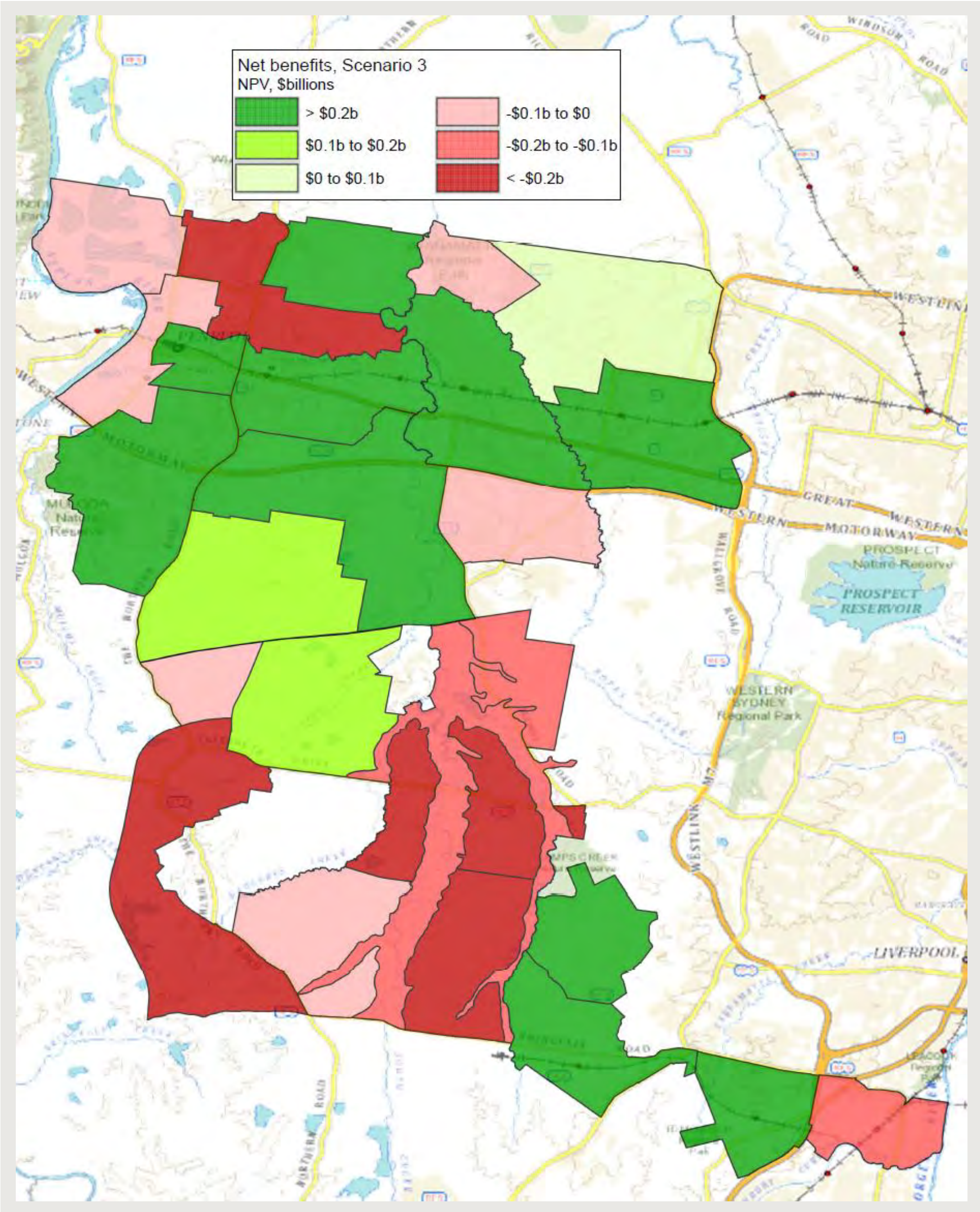
Spatially, the precincts which deliver most net benefits are those along the existing rail corridor in GPEC, Orchard Hills, the eastern precincts in PIC 1 (excluding Glenfield). The Aerotropolis Core only delivers net benefits in Scenario 2, where there is higher development in and around the Aerotropolis, however this scenario results in lower benefits for PIC 2 and overall.

11.18 Net benefits across both PIC areas – Scenario 2



Data source: CIE.

11.19 Net benefits across both PIC areas – Scenario 3



Data source: CIE.

A Valuing characteristics of a place to live

The value of characteristics of the PIC area as a place to live has been measured conducted in the three following steps:

1 The change in physical characteristics across the scenarios were identified. These changes are documented in the scenarios presented in chapter 3 of this report.
2 The change in physical characteristics were mapped to outcomes. This traces how the proposed changes are expected to affect liveability along a number of dimensions, including accessibility and general amenity of an area. These impacts are characterised in chapter 5 of this report.
3 Finally, outcomes of the different scenarios are valued where possible. This is done by mapping outcomes to consumer willingness to pay for different levels of liveability. This estimates the willingness to pay per dwelling for the change in outcomes, for both existing and new dwellings, which are enabled by the infrastructure program.

Specific outcomes have been valued using benefit transfer and hedonic price valuation. Where benefits cannot be valued, we have provided a qualitative discussion of the possible value of outcomes and possible future approaches to value these.

Benefit transfer takes applies valuations from previous studies to value the willingness to pay for the impacts in the PIC area. This approach is often used where there is limited information available with which to estimate the benefits of a specific intervention and can also provide a useful cross check of valuations estimated using alterative techniques.

Hedonic valuation uses variation in property prices to find the marginal valuation of different levels of accessibility and amenity. This assumes that benefits residents experience in a given location, such as accessibility to work or amount of green infrastructure, are capitalised into property price. Variation in both property prices and local characteristics across Sydney, allows valuations to be ascribed to different characteristics.

The model developed to measure the valuation of liveability can present results using both benefit transfer and hedonic valuation, however for some impacts only one of valuation approaches was possible. The methodology and data sources of for the valuations used are described in further detail in the following section.

Hedonic price estimate

To measure the contribution of specific characteristics of dwellings to its final prices we use hedonic regression techniques, which are used frequently in the home-price measurement literature. Hedonic regressions regress house prices on against property attributes overtime:

where is a property characteristic, and is a time dummy which takes value 1 when the property is sold in time period t and zero otherwise. Typical characteristics measured in hedonic price regressions are location, number of bedrooms and neighbourhood amenities. Variation in house prices are explained by differences in these characteristics. We can use the parameters from the regressions to infer the willingness to pay, or value that individuals place on each of the individual characteristics. For a place-based evaluation, we are interested in measuring the change in dwelling prices associated with different levels of amenity provided under the different scenarios.

Modelling results

We estimate the hedonic model using land values from the NSW Land and Property Information. These data are available to every property in NSW, but do not include the value of additions. We regress these against the variables of interest, which measure location specific characteristics which change across scenarios, as well as a number of controls, including zoning, distance to the coast housing density and whether a property is under a strata title. We estimate separate models for

- a sample including all properties in the Sydney, Wollongong and Newcastle areas[64]
- a sample including only properties in the 8 LGAs which comprise the Western City, namely: Blue Mountains; Camden; Campbelltown; Fairfield; Hawkesbury; Liverpool; Penrith; and, Wollondilly.

The parameter estimates from our preferred specification for each sample are shown in table A.1. We have used the whole-of-Sydney coefficients in our estimates of the value of dwellings (see Chapter 7), on the basis that some of the estimated coefficients for Western Sydney have wide confidence intervals/are not statistically significant.

64 This is defined according to the area included in PTPM. This model covers the same geographical area as the travel zones classification, which can be viewed here: https://www.transport.nsw.gov.au/data-and-research/forecasts-and-projections/travel-zone-explorer

B.1 Residential hedonic model

	Sydney-wide		Western City LGAs	
Explanatory variables (	Coefficient	Standard error	Coefficient	Standard error
Ln(job density by car)[a]	0.631**	0.260	0.353**	0.124
Ln(job density by public transport)	0.183*	0.098	-0.013	0.055
Local centre walkability dummy (=1 if local centre within 800m of dwelling)	0.046*	0.024	0.018	0.024
Ln(travel time to nearest strategic centre)	-0.109	0.072	0.046	0.028
Canopy cover (per cent of mesh block total land area) [b]	0.010***	0.003	-0.001	0.001
Ln(lot density; number of properties per lot) [c]	0.445***	0.040	0.361***	0.076
Number of topographical contour lines per m^2, by mesh block [d]	0.000***	0.000	0.000	0.000
Strata title dummy (=1 if under strata title)	0.499***	0.041	0.210***	0.037
Constant	-3.567	2.929	-0.010	1.644
Zone dummies				
R1	2.469***	0.252	4.159***	0.223
R2	1.851***	0.227	3.912***	0.195
R3	1.967***	0.249	3.990***	0.174
R4	1.898***	0.265	4.213***	0.137
R5	1.781***	0.192	3.448***	0.142

[a] See appendix C for an explanation of how job density is calculated.

[b] The NSW Urban Vegetation Cover to Modified Mesh Block 2016 dataset which we have used in available at: https://www.planningportal.nsw.gov.au/opendata/dataset/nsw-urban-vegetation-cover-to-modified-mesh-block-2016

[c] Lot density is the number of dwellings on a given lot in the land value data base. For a single detached house this will be 1, and for a lot with 10 apartments, this will be 0.1. This provides a proxy measure of FSR, building height and location density.

[d] This variable has been constructed using a topographical map for NSW, which has been used to identify the number of topographical lines crossing each mesh block. This count (by mesh block) is divided by the area of the meshblock to create a variable that is a proxy for how sloped each mesh block (and thus property) would be. This would be expected to affect amenity (potentially through superior views) and construction costs (sloped blocks may cost more to build homes on). The sign of the coefficient is uncertain ex ante due to those countervailing effects.

Note: *, ** and *** represent significance at the 10%, 5% and 1% levels respectively. Standard errors are cluster robust at the LGA level.

Source: CIE.

The estimates for Sydney as a whole imply that a 1 per cent increase in job density is corresponds to a in a 0.6 per cent increase in land values. Higher travel times to strategic centres are associated with lower land valuations.

The model also predicts a positive relationship between canopy cover and walkability to local centres, with land values increasing by 0.01 per cent and 4.6 per cent for a 1 percentage point increase in canopy cover and for a dwelling being within 800 metres of a local centre. Prices are also increasing in property density.

We have estimated several other specifications but rejected these where the sign of results did not have a clear economic interpretation. In particular:

- Accessibility to metropolitan centres (measured by the quickest time by any mode to the nearest metropolitan centre) was included in some model specifications tested. However, this variable had a positive coefficient, which suggested that properties with lower travel times were less expensive, which is counterintuitive. Additionally, it is difficult to define whether and at what point WSA or the Aerotropolis would become a metropolitan centre. Accordingly, this variable was excluded from modelling.

Limitations

The hedonic approach used to estimate characteristic valuations has several limitations:

- Omitted variable bias; coefficients estimates will be biased as we are unable to control for a range of unobserved factors which effect land values. Where these factors are correlated with explanatory variables included in the model, the coefficient for that characteristic will be biased upwards.
- Simultaneity bias; the causal relationship between some amenities and dwelling prices is not clearly identified. An area may have higher land values due to amenities, but amenities may also change in response to land values. For instance, wealthier individuals may be able to privately provide canopy cover or may be more effective in lobbying local government to increase provision of canopy cover. In this case, areas with high land prices would have additional canopy cover reflecting sorting process of households to neighbourhoods, and additional canopy cover would not necessarily cause property prices to increase. Here the parameter estimate in a hedonic model would not estimate a causal relationship and could overstate the willingness to pay for an additional amount of a characteristic. This is difficult to resolve, without instrumental variables (i.e. a variable which is correlated with the amenity characteristic, but not correlated with land values) or a natural experiment (i.e. a situation where a characteristic is randomly changed, independently of land prices e.g. an investment program which increases open space in some parts of Sydney) that allows the causal relationship to be identified. In undertaking ex-post evaluations of the PIC evaluations, consideration should be given to econometric strategies which can be used to identify causal relationships between amenities and land prices to provide further evidence around the actual parameter estimate.[65]
- Property price data limitations; the conclusions of this analysis are limited by the data on property prices and property types. This analysis uses land price data, which is a component of property prices, estimated by the Valuer General. The process of estimating land values may introduce some measurement error into land prices, which would bias parameter estimates. An alternative approach, often used in the literature, is to use house price transaction data with property level controls for dwelling quality (e.g. dwelling size, dwelling age, number of bedrooms etc.). This approach is preferred as it is more transparent than using land price data and may better control for variation in the housing stock across different parts of Sydney.
- Limitations in transport modelling; the conclusions of this analysis are highly dependent on the quality of the transport modelling outputs which are used to measure job density. Measurement errors in transport modelling will bias results; as

65 There may be scope in the future to use investments related to the PIC 1 as natural experiments to identify causal relationship between specific characteristics and property prices. There is an extensive literature which uses natural experiments to identify causal relationships.

transport modelling is refined for future PICs, hedonic estimation benefit valuations should be revisited.

Comparison to hedonic modelling for the GPOP GIC

In the GPOP GIC evaluation, we similarly estimated a hedonic model using land values from the NSW Land and Property Information. The parameter estimates from the preferred specification are shown in table A.2. The key differences between our model presented at table A.1 and the GPOP modelling are as follows:

- The impact of job density by car is smaller in the GPOP modelling.
- The impact of job density by public transport is positive and statistically significant.
- Standard errors are smaller relative to the magnitude of coefficients in the GPOP modelling, and more variables are statistically significant.

B.2 Residential hedonic model for GPOP GIC

Explanatory variables (	Coefficient	Standard error
Ln(job density by car)	0.309***	0.07
Ln(job density by public transport)	0.225**	0.087
Ln(lot density; number of properties per lot)[b]	0.521***	0.035
Ln(travel time to nearest metropolitan centre)	-0.074	0.073
Ln(travel time to nearest strategic centre)	-0.097**	0.044
Ln(travel time to nearest university)	-0.235***	0.047
Canopy cover (per cent of LGA total land area)	0.009**	0.004
Local centre walkability dummy (=1 if local centre within 800m of dwelling)	0.038*	0.021
Strata title dummy (=1 if under strata title)	-0.484***	0.054
Coastal dummy (=1 if less than 3km from coastline)	0.777***	0.091
Constant	3.730*	2.031
Zone dummies		
R1	1.443***	0.39
R2	1.193***	0.377
R3	1.256***	0.378
R4	1.134***	0.376
R5	1.360***	0.385

[a] Lot density is the number of dwellings on a given lot in the land value data base. For a single detached house this will be 1, and for a lot with 10 apartments, this will be 0.1. This provides a proxy measure of FSR, building height and location density.

Note: *, ** and *** represent significance at the 10%, 5% and 1% levels respectively. Standard errors are cluster robust at the LGA level.

Source: CIE.

Benefit Transfer

The benefit transfer method uses results from existing primary studies to predict welfare estimates for another. This is often used where data availability does not make directly estimating welfare possible or to benchmark estimates.

Measures of accessibility

A range of parameter accessibility parameter estimates relevant to the data available for the PIC area are summarised in tables A.3. These studies have used hedonic techniques to measure accessibility benefits in Sydney and Melbourne.

B.3 Accessibility valuations

Study	Outcome valued	Valuation
LUTI Consulting. (2016) – Greater Sydney	Distance to any CBD, ln(distance)	1 per cent increase in distance results in a 0.05 per cent decrease in price.
	Development density, ln(FSR)	1 per cent increase in density results in a 0.239 per cent increase in price
	Distance to 2nd tier centre, ln(distance)	1 per cent increase in distance results in a 0.027 per cent decrease in price.
	Distance to 3rd tier centre, ln(distance)	1 per cent increase in distance results in a 0.016 per cent decrease in price.
Densmore and Mulley (2012) – Liverpool/Parramatta transitway	Access time to motorway	a one-minute decrease in access time 4.2 per cent to house prices
	Access time to shopping centre	a one-minute decrease in access time adds 0.7 per cent to house prices, and
	Access time to employment	a one-minute decrease in access time adds 0.7 per cent to house prices
Abelson, Joyeux and Mahuteau (2012) – Greater Sydney	Distance (km) and vehicle car time (mins) to nearest centre.	1 per cent increase in the distance of the suburb from a metro centre increases house prices by an average of 0.029 per cent
	Distance (km) and vehicle car time (mins) from CBD	1 per cent increase in distance from the CBD was associated with a 0.51 per cent decrease in house prices

Source: CIE.

LUTI Consulting estimate a hedonic model to investigate the impact of investment in transport infrastructure and urban renewal projects on land values in Sydney.[66] The

66 LUTI Consulting. 2016, 'Transit and Urban Renewal Value Creation — Hedonic Price Modelling Assessment of Sydney's Key Transit and Transit-Oriented Urban Renewal

variables considered in the analysis included unimproved land value, unimproved land value per square meter, land area (square metres), floor space ratio, distance to any CBD, distance to activity centre (levels 1 to 4), distance to coast, Spatial Network Analysis for Multimodal Urban Transport Systems indicators (2011), effective job density, SEIFA (Socio-Economic Indexes for Areas) score, high school catchment Myschool Rating, and access to transport (heavy rail, light rail, bus rapid transit, ferry, main road). They use metropolitan Sydney land valuation and property sales value, as used in the hedonic modelling presented in the previous section and cannot control for individual property characteristics.

Densmore and Mulley (2012), assessed the impact of the Liverpool Parramatta transitway (a bus rapid transit system) on land value.[67] Accessibility variables in the model included time to the closest motorway, time to the nearest major centre (Liverpool or Parramatta), travel time by bus to a local shopping centre and travel time by bus to an employment centre served by the transit way. They use property level transaction data and are able to control of a range of property characteristics including, the number of bedrooms and number of parking spaces.

Abelson, Joyeux and Mahuteau (2012) estimated the impact of access, property size, public transport, urban density and crime on house prices in 626 suburbs in the Greater Sydney Region.[68] The analysis was conducted for the period October 2008 to September 2009 and was restricted to detached houses only. They include several accessibility measures in their hedonic model including:

- distance (km) and vehicle car time (mins) from CBD
- distance (km) and vehicle car time (mins) from nearest beach
- distance (km), vehicle car time (mins) and walk time (mins) to nearest railway station
- distance (km) and walk time (mins) to nearest high frequency bus stop, and
- distance (km) and vehicle car time (mins) to nearest centre.

The dominant explanatory variable in the model was proximity to the CBD. Holding all other variables constant, a 1 per cent increase in distance from the CBD was associated with a 0.51 per cent decrease in house prices. Hence, as the distance of a suburb from the CBD increases from 20km to 30km, house prices decrease by another 25 per cent. Access to a beach, was another key driver of house prices, with a 1 per cent increase in distance of suburb from the beach leading to a decrease in house prices by an average of 0.16 per cent (holding all other variables constant). In contrast, a 1 per cent increase in the distance of the suburb from a metro centre increases house prices by an average of

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Investments (2000 – 2014)', available at: http://www.luticonsulting.com.au/wp-content/uploads/2013/12/Sydney-Transit-and-Urban-Renewal-Value-Creation-Report.pdf

67 Densmore, K. & Mulley, C. 2012, 'Accessibility and residual land value uplift: Identifying spatial variations in the accessibility impacts of a bus transitway', Institute of Transport and Logistics Studies, *The Australian Key Centre in Transport and Logistics Management, The University of Sydney*, Working Paper 12-06.

68 Abelson, P., Joyeux, R. & Mahuteau, S. 2012, 'Modelling House Prices across Sydney with Estimates for Access, Property Size, Public Transport, Urban Density and Crime', *National Institute of Labour Studies, Flinders University, Adelaide Australia*, Working Paper No. 181/2012.

0.029 per cent (holding all other variables constant). The study uses suburb level price data and is not able to control for property level characteristics.

Open space valuations

A range of parameter open space parameter estimates relevant to the data available for this PIC are summarised in table A.4.

B.4 Green space valuations

Study	Description	Valuation
Hedonic		
Greater London Authority (GLA) Economics (2003) – UK	Amount of green space in London	A 1 percentage point increase in the amount of green space in a London neighbourhood increases house values by between 0.3 and 0.5 per cent
Compton (2005) – US	Abutting or fronting onto open space	20% valuation increase
Lutzenhiser and Netusil (2001) – US	Proximity to speciality and urban parks.	8.5 per cent of property value for those within 500m of a specialty park or 1.8 per cent for urban parks.
Acharya and Bennet (2001) – US	Open space within 1.6 km of dwelling	0.06 per cent increase in house price from 1 per cent increase
Ambrey and Fleming 2014 – Australia	Green space ina district	$1 238 for a 1 per cent increase (on average 143 sqm) in green space in a collection district (average of 1.85 square km)
Krekle et al. (2015) – German	$526 willingness to pay to increase open space within 1 km by 1 hectare.	$526 willingness to pay to increase open space within 1 km by 1 hectare.

Note: Values have been converted into AUD using Purchasing Price Parity conversion factors for 2015 from <http://data.worldbank.org/indicator/PA.NUS.PPP>, accessed 20 September 2009. Values have been converted to 2016$ using the CPI for all groups for Australian capital cities.

Source: CIE, GLA Economics 2003, Compton 2005, Lutzenhiser and Netusil 2000, Acharya and Bennet 2001, Lockwood and Tracy 1995, Varcoe et al. 2015, Reed et al. 1999, Ambrey and Fleming 2014, Krekle et al. 2015.

The GLA (2003)[69], Compton (2005)[70] Lutzenhiser and Netusil (2001)[71] use hedonic models to estimate the value of open space. In contrast, Ambrey and Fleming (2014) use reported life satisfaction reported in the Household, Income and Labour Dynamics in Australia survey together with information on green, in measuring the value of green space, controls for a range of demographic factors allowing for differences in willingness to pay to be identified across different groups of society.[72] Their key findings are:

69 Greater London Authority Economics 2003, 'Valuing Greenness: Green spaces, house prices and Londoner's priorities'.

70 Crompton, J. L. 2005, 'The impact of parks on property values: empirical evidence from the past two decades in the United States', Managing Leisure, 10.

71 Lutzenhiser, M. and Netusil, N. N. 2001, 'The effect of open spaces on a home's sale price', Contemporary Economic Policy, 19(3).

72 Aubrey C. and Fleming C. 2014, 'Public greenspace and life satisfaction in urban Australia', Urban Studies, 51(6).

- People living in densely populated areas derive greater value from green infrastructure
- People aged between 15 and 19, and 40 and 49 have lower levels of life satisfaction in areas with higher greenspace (i.e. they place a negative value of green space).
- Benefits of public greenspace do not appear to depend on gender, ethnicity, level of health, employment status or dwelling type.

The measures used also do not take into account differences in the quality of green infrastructure. Estimates of value based on use implicitly assume that high quality greenspaces are those which are visited repeatedly and by many visitors. This approach, however, measures quality at a very high level and does not provide an understanding of the specific characteristics of green infrastructure that individuals value. Take for instance a large regional park such as Parramatta Park or Centennial Park. Using the value estimates, we are unable to determine whether users value the continuous path around the park, park embellishments, other characteristics of the park or the amenity from the combination of these factors in the one location. Because green infrastructure comes in different configurations, the value derived is likely to differ accordingly.

Some studies estimate the value per visit to a park. Lockwood and Tracy (1995) measure the value of visits to Centennial Park in Sydney using both travel cost and contingent valuation methodologies.[73] Similarly, Read Sturgess and Associates (1999)[74] estimate the value of visits to parks in Melbourne using a travel cost methodology, the results of which have also being used in a study by Varcoe et al. (2015).[75] This report does not make use of these benefits, due to a lack of information on the number of visits to open space under different scenarios.

[73] Lockwood, M. and Tracy, K. 1995, 'Non market economic valuation of an urban recreation park', Journal of leisure research, 27(2).

[74] Read Sturgess and Associates 1999, 'Economic assessment of the recreational values of Victorian Parks', prepared for Victorian Department of Natural Resources and Environment.

[75] Varcoe, T., Betts O'Shea, H. and Contreras, Z. 2015, 'Valuing Victoria's Parks Accounting for ecosystems and valuing their benefits: Report of first phase findings'. accessed on 13 September 2016 at <http://www.delwp.vic.gov.au/parks-forests-and-crown-land/managing-land >.

B Valuing characteristics of a place to work

The value of characteristics of the PIC area as a place to work, has been measured conducted in the three following steps:

1 The change in physical characteristics across the scenarios were identified (chapter 3)
2 The change in physical characteristics were mapped to outcomes. (chapter 5)
3 Finally, outcomes of the different scenarios are valued where possible.

Specific outcomes have been valued using benefit transfer and hedonic price valuation. Where benefits cannot be valued, we have provided a qualitative discussion of the possible value of outcomes and possible future approaches to value these.

In general, the factors affecting business location decisions are less well understood compared to the factors affecting residential location decisions. There are few relevant studies available that would allow us to infer willingness to pay for characteristics of a place to work in terms of the changes in the value of property services.

The model developed to measure the valuation of productivity has the capability to present results using both benefit transfer and hedonic valuation. Only hedonic valuation estimates have been obtained in this study. The methodology and data sources for the hedonic valuations used are described in further detail in the following section.

Hedonic price estimate

To measure the contribution of specific characteristics of dwellings to its final prices we use hedonic regression techniques, as explained in Appendix B. We likewise use similar techniques to measure the contribution of specific characteristics of commercial and industrial property, as explained below.

Modelling results

We estimate the hedonic model using the using land values from the NSW Land and Property Information. These data are available to every property in NSW, but do not include the value of additions.

To model commercial land values, we model the subset of properties which are in business or industrial zones.[76] We regress commercial land values these against job densities and controls for each zoning code (e.g. B1, B2, etc.). Separate models are estimated for the commercial sector (Business zones) and the industrial sector (industrial zones). Observations in these regressions are weighted according to the number of jobs in

[76] This includes B1-B7 and IN1-IN3 zones, as well as other undefined B and IN zones.

the travel zone of each property. The parameter estimates from our preferred specifications for commercial and industrial land are shown in tables B.1 and B.2.

C.1 Commercial hedonic model

Explanatory variables (	Coefficient	Standard error
Ln(job density by car)[a]	0.992***	0.179
Ln(population density by public transport)[a]	-0.078	0.165
Constant	-5.159**	1.935
Zone dummies		
B1	0.677***	0.184
B2	1.120***	0.179
B3	1.129***	0.252
B4	1.039***	0.157
B5	0.139	0.164
B6	0.000	0.222
B7	-0.159	0.252
B8	1.974***	0.208

[a] See appendix D for an explanation of how job density is calculated.

Note: *, ** and *** represent significance at the 10%, 5% and 1% levels respectively. Standard errors are cluster robust at the LGA level.

Source: CIE.

C.2 Industrial hedonic model

Explanatory variables (	Coefficient	Standard error
Ln(job density by car)[a]	0.583***	0.137
Ln(population density by public transport)[a]	0.217**	0.100
Constant	-3.903*	2.275
Zone dummies		
IN3	-0.247	0.174

[a] See appendix D for an explanation of how job density is calculated.

Note: *, ** and *** represent significance at the 10%, 5% and 1% levels respectively. Standard errors are cluster robust at the LGA level.

Source: CIE.

According to these estimates job density by car has a large impact on land values. The model estimates a 1 per cent increase in job density by car is associated with a 0.992 per cent increase in commercial sector land values, while a 1 per cent increase is associated with a 0.583 per cent increase in smaller land values.

The estimated impacts of a 1 per cent increase in population density by public transport are smaller than the impacts of job density for industrial property, and in fact are not significant different from zero for commercial property. This may be because commercial property which is more accessible by public transport to where people live has lower value for other, unobserved characteristics. To maintain consistency between the structural form of the commercial and industrial hedonic models, we retain the population density by public transport variable in the commercial model, but the coefficient is assumed to be equal to zero for the purpose of estimating the value of commercial property (see chapter 8). The coefficient for the population density by public transport was positive in the hedonic modelling we conducted for the GPOP GIC. However, the model shown in table B.1 contains updated land and property data current as at March 2020 and a more recent transport model run corresponding to 2019. A key factor likely to drive the negative sign of this variable is multicollinearity between job density by car and population density by public transport. Highly desirable locations for commercial property are likely to be high in terms of both attributes.

Limitations

The hedonic approach used to estimate characteristic valuations has several limitations. The issues of omitted variable bias, simultaneity bias, property price data issues and transport data issues apply equally to the estimates for commercial and industrial space.

In addition to these general problems, there are significant challenges in estimating the value commercial and industrial land due to diverse land use which this covers. Commercial land use ranges from professional services through to retailing; different sectors are likely to derive different levels of amenity form locations reflecting variation in the and the labour they require. Industrial applications are similarly diverse. Additional disaggregation is not possible due to data limitations around the location of specific industries.

Similarly, within sectors there are significant in values from being in specific locations (e.g. a law firm in the CBD is likely to have different valuation for job accessibility compared to a suburban law firm).

Comparison to hedonic modelling for GPOP GIC

In the GPOP GIC, we similarly estimated hedonic models using the using land values from the NSW Land and Property Information. The parameter estimates for these models of commercial and industrial property values, which are very similar in structure to the models explained earlier in this appendix, are shown in for are shown in tables 7.4 and 5.7. These models use only property data and transport modelling available in 2018.

The key difference between these results and those shown in tables B.3 and B.4 are that the population density by public transport variable has a positive and significant coefficient in both specifications. The impact from job density by car is also smaller in the GPOP modelling.

C.3 Commercial hedonic model for GPOP GIC

Explanatory variables (	Coefficient	Standard error
Ln(job density by car)	0.379***	0.088
Ln(population density by public transport)	0.472***	0.112
Constant	-4.188***	1.401
Zone dummies		
B1	0.100	0.393
B2	0.480	0.375
B3	0.606	0.455
B4	0.590	0.365
B5	-0.246	0.444
B6	-0.437	0.421
B7	-0.531	0.397
B8	1.481***	0.471

Note: *, ** and *** represent significance at the 10%, 5% and 1% levels respectively. Standard errors are cluster robust at the LGA level.

Source: CIE.

C.4 Industrial hedonic model for GPOP GIC

Explanatory variables (	Coefficient	Standard error
Ln(job density by car)	0.169***	0.048
Ln(population density by public transport)	0.624***	0.066
Constant	-4.355***	1.169
Zone dummies		
IN3	-0.405	0.271

Note: *, ** and *** represent significance at the 10%, 5% and 1% levels respectively. Standard errors are cluster robust at the LGA level.

Source: CIE.

According to these estimates job density by car has a large impact on land values. The model estimates a 1 per cent increase in job density by car is associated with a 0.379 per cent increase in commercial sector land values, while a 1 per cent increase is associated with a 0.169 per cent increase in industrial land values. The estimated impacts of a 1 per cent increase in population density are larger than the impacts of job density.

Benefit Transfer

The benefit transfer method uses results from existing primary studies to predict welfare estimates for another. This is often used where data availability does not make directly estimating welfare possible or to benchmark estimates.

Hedonic modelling studies for commercial property generally include two main categories of explanatory variables:

- on physical characteristics of properties, which will generally not vary in predictable ways under the PIC scenarios[77]
- proximity to transport infrastructure and CBDs, rather than measures of accessibility (such as the job/population access density metrics) that incorporate more information about accessibility rather than just location.

The hedonic modelling literature for commercial land is sparse. We have not used estimates from this literature because

- there is insufficient consistency in estimates,
- sample sizes used in the literature are generally small (less than 200 properties), and
- the factors affecting business decision-making that we can measure (e.g. accessibility) are not included in the hedonic models that have been identified in the literature.

Benefit of accessibility to an airport

There is a sparse literature relating to the value of accessibility/proximity to an airport. We have identified three studies of the relationship between commercial property values and proximity or accessibility to an airport:

- Cohen and Brown (2017)[78]
- Cohen, Brown and Blake (2015)[79]
- Cohen and Brown (2013)[80]

These studies identify the benefit for commercial property of being close or highly connected to Canadian airports such as Vancouver International Airport. This is the main international airport for Vancouver, which has under 700 000 people in comparison to Sydney's 5.23 million people. Cohen and Brown (2013) find that for every 10 per cent

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77 Some predictable changes, such as older buildings being replaced by new buildings is observed to be associated with increases in land values in the literature. See, for example, Sayer, J. and Moogan, J., 2007, 'An analysis and evaluation of hedonic price valuations in local leasehold office markets', 13th Conference of the Pacific Rim Real Estate Society, January 21 to 24, 2007, available at: http://www.prres.net/Proceedings/..%5CPapers%5CMoohan_Sayer_Hedonic_Price_Valuations.pdf

78 Cohen, J. & Brown, M., 2017, 'The Effect of International Airports on Commercial Property Values: Case Studies of Toronto, Ontario, Canada and Vancouver, BC, Canada', *The Economics of Airport Operations (Advances in Airline Economics, Vol. 6)*, Emerald Publishing Limited, pp.313-333, available at: https://www.emerald.com/insight/content/doi/10.1108/S2212-160920170000006012/full/html.

79 Cohen, J., Brown, M. & Blake, J., 2015, *Does Airport Access Affect Prices of Various Commercial Properties Differently? A Nonparametric Approach to a Natural Experiment*, Working Paper, available at: https://pdfs.semanticscholar.org/9f38/4925baa198393adf68a811c193571f594bdf.pdf

80 Cohen, J. & Brown, M., 2013, *Impact of Vancouver Airport on Commercial Property Values*, Working Paper, available at: https://www.aeaweb.org/conference/2014/retrieve.php?pdfid=1225

decrease in distance to the airport leads to a 7.6 per cent increase in commercial property prices.

By comparison, the Aerotropolis is currently around 40km from Sydney Airport, and upon completion of WSA will be approximately 7km from WSA. This suggests a reduction of 82.5 per cent in distance to the nearest airport from the Aerotropolis, which would imply an increase in rents of 62.7 per cent relative to levels without the airport. No benefit associated with decreased distance to the nearest airport has been incorporated. This is because:

- It is difficult to extrapolate impacts based on the Canadian studies, which have not been replicated for airports overseas or for secondary city airports
- The impact of WSA is already factored partially through the realisation of job projections that rely on the opportunities it offers. Therefore, the benefits associated with jobs growth are already conditional its construction.

The commercial and industrial rent estimates provided by JLL are based on the appropriate comparator area for the PIC area *once it has been developed*. Accordingly, it would be expected to already account for the presence of WSA, which will be constructed by the time that jobs growth is realised.

However, WSA will be a and potential cause of higher rents (and therefore greater benefits from development) and further investigation into its impacts on rents is warranted.

C Measuring accessibility

This appendix provides technical detail about the approach used to calculate accessibility metrics.

Box C.1 shows the specification we use for job access density and population access density.

D.1 Calculating access density metrics

Job access density can be represented using the following equation:

where

- *JA* is job access,
- *j* is the travel zone we are looking at,
- *i* is the destination travel zone,
- is the number of jobs at destination *i* and
- is the time to go from *j* to *i*.
- The function is an exponential where time is between *a* and *c*. Where time is below *a* it is 1 and where time is above *c* it is zero. We use the following parameters: *a* = 15 minutes, *b* = -0.016 and *c* = 180 minutes.[81]

Population access density can be represented using the following equation:

where

- *PA* is population access,
- *i* is the travel zone we are looking at,
- *j* is the origin travel zone,
- is the number of people at origin *j* and
- is the time to go from *j* to *i*.
- The function is an exponential where time is between *a* and *c*. We use the same parameters as those used in the job access density function.

These access metrics are not denoted in units that are easy to interpret. Therefore, we calculate them according to the functions above, and then compared them between scenarios using indexes that take value 100 in 2016.

81 See the parameters used for the decay curve for commuting trips: KPMG, 2017, *Effective Density*, Appendix A p.7, available at: https://atap.gov.au/public-consultations/files/_KPMG_Wider_Economic_Benefits_of_Transport_2017.pdf

For all accessibility metrics using catchment time thresholds (such as 30 minutes or 45 minutes), we use generalised total time from origin to destination. This weights the components of travel time according to preferences of travellers about the relative disbenefit of increases to each component. Generalised car time is calculated as the sum of in-vehicle time, vehicle operating cost and a travel time penalty dependent on the amount of tolls paid on the journey between travel zones. Generalised public transport time is the minimum generalised time across public transport modes. For public transport (including buses, rail, light rail and ferry) trips, this includes:

- **Access time** for the main mode of transport, whether by walking, car or bus,
- **Waiting time** for the transport vehicle (such as waiting at a station)
- **In-vehicle time**
- 2 minutes of **interchange time** between modes or different vehicles of the same mode
- **Egress time**, which refers to time spent walking between the end of the main mode journey and the final destination

The weightings used to calculate generalised time are shown in table C.2.

D.2 Weighting applied to travel time components to estimate generalised time

Travel time component	Car	Bus	Rail / light rail / ferry
In-vehicle time	1.0	1.0	1.0
Tolls	2.5		
Access time		1.24	1.00
Waiting time		1.4	1.40
Walking time		1.5	1.50
Number of boardings		6.4 min/ boarding	6.4 min/ boarding

Source: TfNSW, CIE.

Accessibility metrics are all calculated in terms of 3.5-hour AM-peak time, because the models used by TfNSW have only produced outputs for this time period.

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