2016 Travel Zone Projections (TZP 2016) for Population, Workforce & Employment in the Sydney Greater Metropolitan Area

Technical Guide

Version 1.0

Contents

Part 1: Model Overview and Results

1 Glossary and abbreviations

Term	Definition	Abbreviation
Average Annual Growth Rate (%)		AAGR
Australian and New Zealand Standard Industry Classifications	(ABS Cat. 1292.0)	ANZSIC (2006)
Australian Bureau of Statistics		ABS
Australian Standard Geographical Classification	The Australian Standard Geographical Classification was used from 1984 to 2011 by the ABS for the collection and dissemination of geographically classified statistics.	ASGC
Australian Statistical Geography Standard	The Australian Statistical Geography Standard is the ABS' new geographical framework and it is effective from July 2011, replacing the ASGC. The vast majority of ABS spatial data will be based on the ASGS by 2014.	ASGS
Bureau of Transport Statistics	(see Transport Performance and Analytics).	BTS
BTS Land Use Regions	Intermediate geographies which are an aggregation of travel zones and aligned to LGAs. These are a temporary requirement and will be redundant once DPE projections shift from ASGC to ASGS.	BTSLUR
Transport Performance and Analytics	Previously called Bureau of Transport Statistics (BTS).	TPA
Department of Planning and Environment		DPE
Employment	Employed persons by place of work	Emp
Estimated Resident Population	The total number of people that live within a defined area. This includes both people residing in private and non-private dwellings (i.e. college dormitories, jails, nursing homes).	ERP
Freight Movement Model		FMM

Term	Definition	Abbreviation
Greater Metropolitan Area	The Greater Metropolitan Area is the area used for TfNSW's Strategic Travel Model. The GMA includes the Sydney Greater Capital City Statistical Area (GCCSA), the Southern Highlands and Shoalhaven SA4, Illawarra SA4, Newcastle and Lake Macquarie SA4 and Lower Hunter, Port Stephens, Maitland SA3s as defined by the ABS.	GMA
Greater Sydney Commission	An independent organisation funded by the NSW Government to coordinate and align the planning that will shape the future of Greater Sydney.	GSC
Household size	The ratio of *persons in occupied private dwellings* to *occupied private dwellings* (e.g. currently the *household ratio* in Melbourne (C) is 1.91. This means on average there are 1.91 persons in each occupied private dwelling).	
Housing Supply Forecast Model	The 2016 Sydney Housing Supply Forecast Model provides estimates of future housing supply that will be built over the next 5 years. Estimates are prepared by the NSW Department of Planning & Environment to inform infrastructure planning and service delivery, as well as to inform decisions on future land use zoning. TPA has been provided additional forecasts to 2036.	HSFM
Household Travel Survey	Is the largest and most comprehensive source of personal travel data for Sydney	HTS
Intergenerational Report	2015 report by the Australian Government which assesses long-term changes including Australia's population size, age profile, economic growth and workforce	IGR
Iterative Proportional Fitting	Statistical method which aligns known totals to an estimated distribution	IPF
Workforce	For any group, persons who are employed or are unemployed but are actively seeking work.	WF
Land Use		LU
Local Government Area		LGA

Term	Definition	Abbreviation
New South Wales		NSW
Not Private Dwelling	Communal accommodation provided by institutions such as hospitals or prisons and transitory accommodation such as hotels and motels.	NPD
Occupied Private Dwellings	A private dwelling that is occupied on Census night. Also represents households.	OPD
Occupancy Rate	The ratio of occupied to unoccupied private dwellings	OR
People in Occupied Private Dwellings	Estimated resident population who reside in private dwellings	POPD
People in Non-Private Dwellings	This includes persons in communal or transitory type accommodation (i.e. prisons, boarding school, hospital, defence establishments).	PNPD
Priority Growth Area	Areas identified by DPE with strategic population and employment targets	PGA
Place of Institution	Refers to variables which are based on education locations (e.g. the number of people attending a tertiary institution within a particular zone)	PoI
Place of Usual Residence	Refers to variables which are based on the home location of population (e.g. the number of people who live in a particular zone)	PUR
Place of Work	Refers to variables which are based on employment locations (e.g. the number of 'Retail Trade' industry jobs within a particular zone)	PoW
Population Synthesiser	Model uses land use data to create 'agents' for input into STM	Pop Syth
SGS Economics and Planning		SGS
Strategic Transport Model	The STM combines travel behaviour with likely population, employment and transport networks to estimate future travel under different strategic land use and transport scenarios.	STM

Term	Definition	Abbreviation
Structural Private Dwelling	A privately owned building or structure that people live in. This may include a house, an apartment, or it may be a mobile dwelling such as a caravan.	SPD
Sydney Greater Metropolitan Area	Defined as the Sydney Statistical Division, Newcastle Statistical Subdivision and Illawarra Statistical Division.	Sydney GMA
Transport for New South Wales	Transport for NSW is the lead agency of the NSW Transport cluster. Its role is to lead the development of a safe, efficient, integrated transport system that keeps people and goods moving, connects communities and shapes the future of our cities, centres and regions.	TfNSW
Travel Zone	Travel Zones (TZs) are the smallest standard geography used for a number of transport datasets in NSW. They represent geographical areas that are used in origin-destination transport modelling. Latest version was created in 2011 and largely aligns with 2011 ABS Destination Zones. See https://opendata.transport.nsw.gov.au/dataset/travel-zones-2011 for additional information	TZ or TZ11
Trip Attractors	Variables relate to destinations. These destinations range from places of work and education to destinations such as shopping centres.	
Trip Generators	Variables relate to the origin location of travel (i.e. place of residence)	
Unemployment Rate	Number of unemployed persons expressed as a percentage of the workforce.	UR

2 Executive Summary

2.1 Background

Transport Performance and Analytics ('TPA') within Transport for NSW ('TfNSW') produces Travel Zone ('TZ') level projections (population, enrolments, workforce and employment) for Greater Sydney ('Sydney GMA' or 'GMA') as an input into the Strategic Travel Model ('STM'). The Travel Zone projections are also used for a range of other strategic and policy work across government and the private sector.

Projections are regularly updated through major and interim updates. Major updates realign to ABS Census data releases and geographies, while interim updates incorporate other updated datasets and also approach improvements.

This update (Travel Zone Projections 2016 or TZP 2016) reflects an interim update and aligns exactly with the latest 2016 release from the Department of Planning and Environment ('DPE') population projections. SGS Economics and Planning ('SGS') worked in partnership with the TPA Land Use team to refine the approach and update the projections for Travel Zone Projections 2016.

2.2 Report audience and package of outputs

This is a technical report which documents the overall approach, assumptions, data sources and summary results from Travel Zone Projections 2016. It is intended for a reader with a general understanding of the economic and projection techniques and should be read in conjunction with the model spreadsheets and results which provide additional details/results.

2.3 Cautions

It is important to remember the TZP estimates are developed to support a strategic view of Sydney and are calibrated with that city wide view in mind. Therefore, caution is advised when focusing solely on individual zones or variables as this is not the intention of the data. For a strategic transport model what is critical is that all people/workers/students are at least allocated down to the 'general area' to then create travel flows from one location to another.

Also, when modelling the possible land use, it should be understood there is no one single future. Therefore, these projections seek to represent the most likely urban future based on current data, trends and an understanding of policy/structural changes. It does not reflect a policy aspiration or project specific scenario which would need to be further developed as a separate scenario.

At a high level, the data covers three dimensions:

- **Time Period:** 5 yearly time periods from 2011 to 2056
- **Geography:** 2,949 travel zones across the Sydney GMA
- **Profiling Variables:** 60+ variables covering people, employment and students.

2.4 Travel Zone Projections 2016 Approach Overview

The following diagram highlights the key data inputs and steps used to create the TZP 2016. It also highlights the key links to the Population Synthesiser ('Pop Syth') and STM/FMM models.

Figure 1 Travel Zone Projections 2016 approach overview[1]
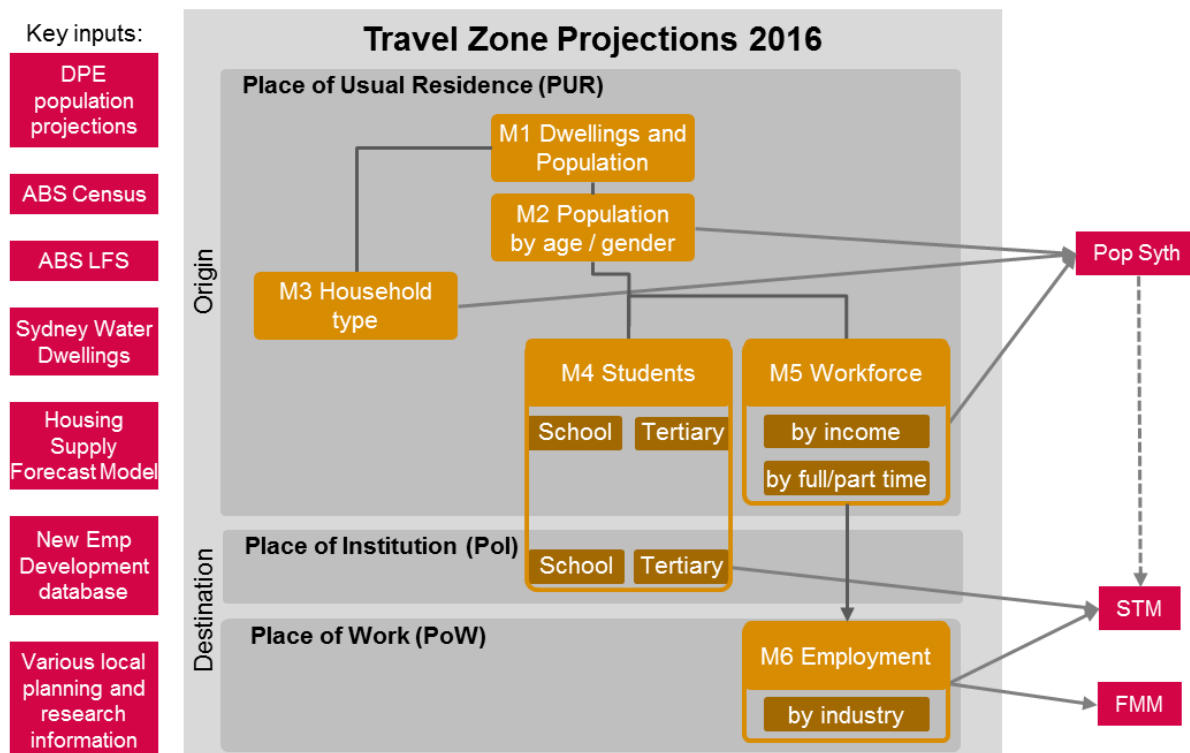
At a high level, official DPE Local Government Area population and household projections are disaggregated to travel zones using a number of small area input sources on current and future development trends. From this, population is further segmented by age/sex, household type, education and workforce status.

Given no official employment projections exist, workforce estimates are then combined with macro-economic trend analysis to project employment for the GMA. Employment by industry is then disaggregated to regions and then travel zones using a number of small area input sources on current and future employment.

The following further steps through the key aspects of the TPA TZP 2016 process which are discussed in detail through this report.

2.4.1 Step 1: Structural Private Dwellings (SPD) by Travel Zone

SPD (i.e. occupied and unoccupied dwellings) are the first variable to be estimated. All Place of Usual Residence (PUR) data is then essentially a disaggregation of this travel zone level dwelling distribution. The following components are taken into account:

- Control totals. Household data (OPD) (i.e. occupied private dwellings) from DPE is sourced by LGA from 2011 to 2041. A number of small adjustments are then made before they are used as control totals.

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[1] HSFM refers to the Housing Supply Forecast Model provided by the Department of Planning &Environment

- Base distribution (2011 and 2016). The base SPD dwelling distribution is sourced from ABS 2011 Census data by Statistical Area 1 (SA1). This is then realigned to Travel Zones. ABS Buildings Approvals and Sydney Water Connections Data are then used to bring this base dwelling distribution to 2016. It is then benchmarked to the adjusted LGA control totals to align with DPE projections.

- Projection distribution. The Housing Supply Forecast Model (HSFM) forms the primary input into the projected distribution of dwellings. A number of other localised greenfield and planned development information is also sourced. All dwelling development data is treated as 'possible capacity' with a 'preferred timing'. Adjusted LGA control totals are then distributed down to this 'possible capacity'.

2.4.2 Step 2: Population and segmentation

Dwellings are then systematically disaggregated to occupied private dwellings, population, age-sex, household types, student enrolments and workforce status. All population segments refer to persons living in private dwellings (i.e. excludes persons in non-private dwellings, nursing homes, jails, hotels, etc.).

Base 2011 disaggregation ratios (i.e. household size, age-sex splits, etc.) are largely sourced from the ABS 2011 Census. Data is then benchmarked back to control total data. Control total data is largely sourced from DPE by LGA and then adjusted similar to the SPD data.

An Iterative Proportional Fitting (IPF) approach is used to evolve the travel zone distribution over time to align to the Adjusted LGA controls totals, whilst still reflecting the variation at the travel zone level. Seed values for new residential locations are sourced from the respective local region.

2.4.3 Step 3: Workforce control totals (workers at their place of usual residences)

Participation rates by age and sex for the GMA are projected using the Productivity Commission's recommended approach and drawing on the latest ABS Labour Force Survey data. These are then applied to the DPE population by age and sex data to estimate the total workforce. A standard long term unemployment rate is also set at 5.0 per cent.

Workforce is then disaggregated to SA4s and then Travel Zones. It is also split into full/part time employment and five income bands. In this process SA4 and travel zone variances in participation rates, unemployment rates, full/part time and income bands are captured drawing on current trends from the ABS 2011 Census and projected age-sex.

2.4.4 Step 4: Employment (workers at their place of work or jobs in a location)

GMA employment by industry is projected using detailed trends analysis of employment by industry from the ABS Labour Force Survey, Census Journey to Work data, projected workforce and analysis of major-economic factors (i.e. regarding structural changes in the broader economy drawing from state and national publications). A number of indicator series are created to understand how the employment by industry projections align with both recent trends and key age segments (i.e. age cohorts).

GMA employment is first disaggregated to SA3s and then travel zones. Again, trend analysis and indicator series are used at the SA3 level to breakdown the employment by industry projections. This ensures population serving employment (i.e. retail, education, etc.) is shifted to where population growth is projected to occur while the

spatial distribution of other industries remains consistent with recent trends. A 'new developments database' forms the primary input into shifting employment projections from a base trend. Similar to the HSFM data for dwellings, this database is used as a 'possible capacity' and 'preferred timing' dataset, while there is a feedback loop to adjust broader trends where the new developments database is signalling a clear shift in policy and base trends.

2.5   Results overview

By 2056 there are projected to be more than 5 million jobs and more than 10 million people in the Sydney GMA (see Figures 2 and 3). The distribution of projected population and employment growth will have a marked impact on how the city functions.

In broad terms we will continue to see the urban footprint of Sydney expand as new growth areas establish to the North West and South West of Sydney. While at the same time infill development through both major redevelopments and small scale incremental developments will provide for significant population growth within the existing urban footprint.

The economy will continue to undergo a fundamental restructure away from traditional manufacturing based sectors to one based on services – retail, health, professional and other. This transition has fundamental implications on spatial distribution of new jobs which will congregate around major nodes and population growth areas.

The following tables provide a summary of population and employment growth by district.

Figure 2 Population projections by Greater Sydney Commission (GSC) districts: 1996-2056

GSC District	ERP 1996	ERP 2016	ERP 2036	ERP 2056	AAGR 1996-2016	AAGR 2016-2036	AAGR 2036-2056
Central	751,700	1,012,400	1,337,500	1,706,500	1.5%	1.4%	1.2%
North	726,400	885,500	1,085,600	1,383,400	1.0%	1.0%	1.2%
South	620,800	741,300	945,600	1,221,500	0.9%	1.2%	1.3%
South West	525,300	715,800	1,089,800	1,409,200	1.6%	2.1%	1.3%
West	299,600	355,000	442,600	571,500	0.9%	1.1%	1.3%
West Central	664,100	972,000	1,520,700	1,969,000	1.9%	2.3%	1.3%
Total GSC Sydney	**3,587,900**	**4,682,000**	**6,421,900**	**8,261,000**	**1.3%**	**1.6%**	**1.3%**
xGSC Newcastle	762,600	953,800	1,149,800	1,323,400	1.1%	0.9%	0.7%
xGSC Wollongong	372,100	452,100	523,200	579,900	1.0%	0.7%	0.5%
Total GMA	**4,722,600**	**6,087,900**	**8,094,900**	**10,164,300**	**1.3%**	**1.4%**	**1.1%**

Note: ERP is the estimated resident population (no. persons)

AAGR is the Annual Average Growth Rate (%)

GMA is the Greater Metropolitan Area (see Section 4.4 Spatial Geographies for additional details)

Figure 3 Employment projections by GSC districts: 1996-2056

GSC District	Emp 1996	Emp 2016	Emp 2036	Emp 2056	AAGR 1996-2016	AAGR 2016-2036	AAGR 2036-2056
Central	630,100	904,500	1,183,000	1,469,400	1.8%	1.4%	1.1%
North	353,500	483,300	599,300	737,100	1.6%	1.1%	1.0%
South	199,800	241,500	298,400	370,900	1.0%	1.1%	1.1%
South West	158,000	237,100	352,300	484,300	2.1%	2.0%	1.6%
West	89,600	133,100	196,700	251,500	2.0%	2.0%	1.2%
West Central	291,800	440,300	650,700	842,300	2.1%	2.0%	1.3%
Total GSC Sydney	**1,722,700**	**2,439,800**	**3,280,500**	**4,155,500**	**1.8%**	**1.5%**	**1.2%**
xGSC Newcastle	275,000	427,500	520,000	625,000	2.2%	1.0%	0.9%
xGSC Wollongong	132,200	184,400	220,500	259,900	1.7%	0.9%	0.8%
Total GMA	**2,129,900**	**3,051,700**	**4,020,900**	**5,040,400**	**1.8%**	**1.4%**	**1.1%**

Note: Emp refers to the jobs available.

AAGR is the Annual Average Growth Rate (%)

GMA is the Greater Metropolitan Area (see Section 4.4 Spatial Geographies for additional details)

3   Introduction

3.1   Background

The TPA produces land use TZ projections (population, workforce and employment) as an input into the STM. The data produced is also available to download from the TfNSW Open Data Hub (https://opendata.transport.nsw.gov.au/) and is used as an input into a diverse range of local planning and research work by a wide range of practitioners.

These TZPs are developed to support a strategic view of Sydney and are calibrated with that city wide view in mind. When modelling the possible land use, it should be understood there is no one single future. Therefore, these projections seek to represent the most likely urban future based on current data, trends and an understanding of policy/structural changes that may impact the future.

In 2015, SGS was engaged to undertake a review of the land use modelling undertaken by the TPA. This review was documented in the SGS report – Appraisal of BTS Land Use Projections (November 2015). In general, SGS found the approach was reasonable and rigorous based on available data and resources allocated. However, a number of ways to improve the approach were identified. In order to leverage internal resources, ensure consistency and manage risk it was recommended that the TPA land use modelling approach be further reviewed and improved in stages (or modules) with a clear plan developed for an ultimate overhauled structure leveraging best practice, data, approaches and software.

SGS was engaged to work within the TPA to further review and refine the land use Travel Zone Projection ('TZP') approach. This work was completed in stages to first focus on automation of existing processes; and then to include improvements to data, approaches and linkages between modules.

SGS then worked with the TPA team to feed the latest data into the improved model framework to create the final Travel Zone Projections 2016 presented in this report.

3.2   Audience and objective of this report

This technical report is intended to provide a technical account of the entire approach, data and method used to create TZP 2016. It is expected that the reader has some technical understanding of models and concepts and it is not intended for a general lay audience.

For readers who are familiar with the previous data set known as LU14, there is commentary that explains the differences in methodology and approach in this 2016 release.

It should be noted further detail regarding the functionality of each module is also contained with the spreadsheets. Detailed datasheets also include the final TZP 2016 results along with a number of additional summary breakdowns by Districts, LGAs and Precincts.

3.3   Report structure

The remainder of the report is structured as follows:

Section 4	Model framework and data specification
Section 5	TZP 2016 results overview
Section 6	Module 1: Population and Households

Section 7	Module 2: Age - sex
Section 8	Module 3: Household Type
Section 9	Module 4: Enrolments
Section 10	Module 5: Workforce segmentation
Section 11	Module 6: Employment by Industry

4 Model framework and data specification

This chapter is a comprehensive summary of the data generated by the Travel Zone Projection modelling team and how it links to internal and to external requirements. Understanding the overall linkages between each module of the model is critical to understand the role and function of each.

4.1 Overview

TPA creates Travel Zone Projections of population, workforce and employment using a population based statistical model, which are used as inputs in the Pop Syth, STM and FMM models for transport forecasting.

The population synthesiser is used to create 'agents'. The resulting agents, along with additional TZP inputs, are then used by STM to create travel flows. Some of the TPA small area data is also published online and used for other purposes.

At a high level, the data covers three dimensions:

- **Time Period**: 5 yearly time periods from 2011 to 2056

- **Geography**: 2,949 travel zones across Sydney Greater Metropolitan Area (GMA)[2]

- **Profiling Variables**: 60 variables covering people, households, employment and students.

These various attributes are currently created using a series of interrelated MS Excel based modules.

The remainder of this section provides additional detail around the TZP framework, time periods, geographies and variables.

4.2 TZP framework

The following diagram highlights the key data inputs and steps used to create the Travel Zone Projections 2016 data set. It also highlights the key links to the Pop Syth and STM.

Each module (presented visually as orange boxes) draws on a number of external datasets along with previous module outputs to create a specific set of data which is then used in other modules or for external purposes (presented visually as pink boxes).

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[2] Note this definition of the Sydney GMA refers to the STM model area. It does not align with the old ABS SD and SSD definition.

Figure 4 TZP modelling relationships[3]
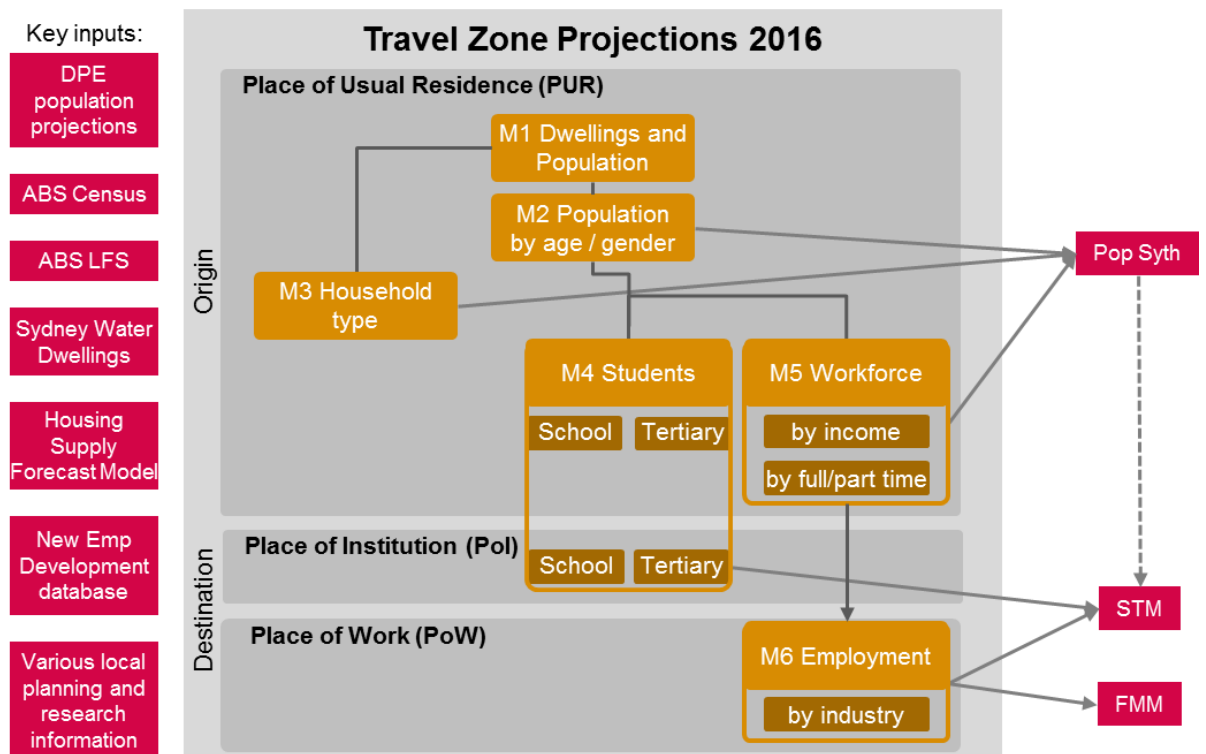
4.2.1 Modules 1/2/3: Dwellings, population and segmentation

SPD (i.e. occupied and unoccupied dwellings) are the first variable to be estimated. All Place of Usual Residence (PUR) data is then essentially a disaggregation of this travel zone level dwelling distribution.

- **Control totals**. Household data (OPD) (i.e. occupied dwellings) from DPE is sourced by LGA from 2011 to 2041. A number of small adjustments are then made before they are used as control totals.

  o The data is extended to 2056 using a trend analysis.

  o It is converted to 'Adjusted LGAs' a geography created by TPA which largely reflects 2011 LGAs with adjustments to fit Travel Zones and more closely align to Statistical Area 2 (SA2).

  o It is scaled up to an SPD estimate using a standard occupancy rate from the 2011 ABS Census

- **Base distribution (2011 and 2016)**. The base SPD dwelling distribution is sourced from ABS 2011 Census data by Statistical Area 1 (SA1). This is then realigned to Travel Zones. ABS Buildings Approvals and Sydney Water Connections Data are then used to bring this base dwelling distribution to

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[3] Note: PUR – Place of Usual Residence. Refers to variables which are based on the home location of population

   PoW - Place of Work. Refers to variables which are based on employment locations

   PoI - Place of Institution. Refers to variables which are based on education locations

2016. It is then benchmarked to the adjusted LGA control totals to align with DPE projections.

- **Projection distribution**. The HSFM forms the primary input into the forecast distribution of dwellings. A number of other localised greenfield and planned development information is also sourced. All dwelling development data is treated as 'possible capacity' with a 'preferred timing'. Adjusted LGA control totals are then distributed down to this 'possible capacity'.

  o If the control totals are too high then 'capacity' is brought forward to meet the DPE projection or eventually distributed across the dwelling stock. This effectively means demand is stronger than supply and so developments will come online sooner than planned.

  o Conversely if the control totals are too low then 'capacity' is pushed out to meet the DPE projection and in some circumstances may never be fully realised (in the modelling horizon). This effectively means demand is lower than planned supply so developments are delayed or occur slower than anticipated.

Dwellings are then systematically disaggregated to occupied private dwellings, population, age-sex, household types, enrolments and workforce status. All population segments refer to persons living in private dwellings (i.e. exclude people in non-private dwellings, nursing homes, jails, etc.).

Base 2011 disaggregation ratios (i.e. household size, age-sex splits, etc.) are largely sourced from the ABS 2011 Census for travel zones. Data is then benchmarked back to control total data by Adjusted LGAs. Control total data is largely sourced from DPE by LGA and then adjusted as per the SPD steps above (i.e. extended to 2056 and converted to 'Adjusted LGAs')

An Iterative Proportional Fitting (IPF) approach is used to evolve the travel zone distribution over time to align to the Adjusted LGA controls totals, while still reflect the variation at the travel zone level. The population profile of seed values for new residential locations (i.e. where no base distribution exists) are sourced from the respective local region.

The following primary inputs are used to project population and dwellings:
- DPE LGA forecasts (2011 – 2036)
- Sydney Water Dwellings data (2016)
- HSFM Data (2016 – 2036)
- Various local planning and research information
- ABS Census data (2011)

A process map of modules 1,2 and 3 are included in Appendix C: Travel Zone Projections 2016: Process Maps.

4.2.2   Module 4: Student enrolments

Student Enrolments by place of residences are first estimated then translated into a place of institution.

Population by age is translated into primary, secondary and tertiary enrolments using a similar process as for other population segmentation. A base distribution is sourced from 2011 ABS Census and current ACARA enrolment data. Official enrolment forecasts are then disaggregated to a SA4 and then Travel Zone level using the IPF approach.

A gravity model is then used to covert enrolments by place of residence to place of institution. High level enrolment caps for schools are then put in place to redirect students to their next closest school.

The following key inputs are used to project enrolments at the Primary, Secondary and Tertiary level:

- Current enrolment from ACARA 2011
- Australian University Enrolments
- Population projections 2011-2056 (M01a)

4.2.3   Module 5: Workforce and Income

Participation rates by age and sex for the GMA are projected using the Productivity Commission's recommended approach and drawing on the latest ABS Labour Force Survey data. This is then applied to the DPE population by age and sex data to estimate the total workforce. A standard long term unemployment rate is also set at 5.0 per cent which aligns with the 2015 Intergenerational Report long term unemployment range of 4.0 – 6.0%.

Workforce is then disaggregated to SA4s and then TZs. It is also split into full/part time employment and five income bands ($0 - $20,799, $20,800 - $31,199, $31,200 - $41,599, $41,600 - $67,599, >=$67,600) for use in the TPA Pop Syth. In this process SA4 and TZ variances in participation rates, unemployment rates, full/part time and income bands are captured drawing on current trends from the ABS 2011 Census and projected age-sex.

The following primary inputs are used to project workforce:

- ABS Labour Force Survey data
- ABS Census data
- Intergenerational Report NSW 2015

4.2.4   Module 6: Employment

GMA employment by industry is projected using detailed trends analysis of employment by industry from the ABS Labour Force Survey, Census Journey to Work, projected workforce and analysis of major-economic factors regarding structural changes in the broader economy drawing on state and national publications. A number of indicator series are created to understand how the employment by industry projections align with recent trends, and align with key age segments (i.e. age cohorts).

GMA employment is first disaggregated to SA3s and then travel zones. Again, trend analysis and indicator series are used at the SA3 level to breakdown the employment by industry projections. This ensures population serving employment (i.e. retail, education, etc.) is shifted to where population growth is projected while the spatial distributions of other industries remain consistent with recent trends. A 'new developments database' forms the primary input into shifting employment projections from a base trend. Similar to the HSFM data for dwellings, this database is used as a 'possible capacity' and 'preferred timing' dataset, while there is a feedback loop to adjust broader trends where the new developments database is signalling a clear shift in policy and base trends.

The following primary inputs are used to project employment:

- ABS Labour Force Survey data

- ABS Census data

- New Developments Database, which contains various assumed employment developments across Sydney. These employment assumptions were compiled by TPA and reviewed by DPE (see Appendix A: New development database).

4.3 Time periods

Results are generated for a base year followed by projections which run to 2056. The current base year is 2011. This will remain for the 2016 minor data release. The following future periods are also produced: 2016, 2021, 2026, 2031, 2036, 2041, 2046, 2051, and 2056.

The base year will be updated to 2016 following the release of the 2016 ABS Census and the next major TZP release. At this point the future periods will be incremented by 5 years once the base year is updated to 2016.

4.4 Spatial geographies

4.4.1 2011 Travel Zones

All land use variables are generated by **TPA 2011 Travel Zone** (TZ11) geography classification. These TZ11 align with the latest ABS Census Destination Zones and the associated ASGS (SA2, SA3, and SA4) structure. There are 3,514 TZ11 across all of NSW. However, projections are created for 2,949 TZ11 which is referred to as the 'Sydney GMA' (see Figure 5 Sydney GMA – showing SA3s. An interactive map is provided on the TfNSW website). The GMA includes the Sydney Greater Capital City Statistical Area (GCCSA), the Southern Highlands and Shoalhaven SA4, Illawarra SA4, Newcastle and Lake Macquarie SA4 and Lower Hunter, Port Stephens, Maitland SA3s as defined by the ABS. Note this Sydney GMA definition does not exactly align with the old ABS SD and SSD definition of the Sydney GMA (see Table 1 Geographies used in TPA land use modelling).

Figure 5 Sydney GMA – showing SA3s
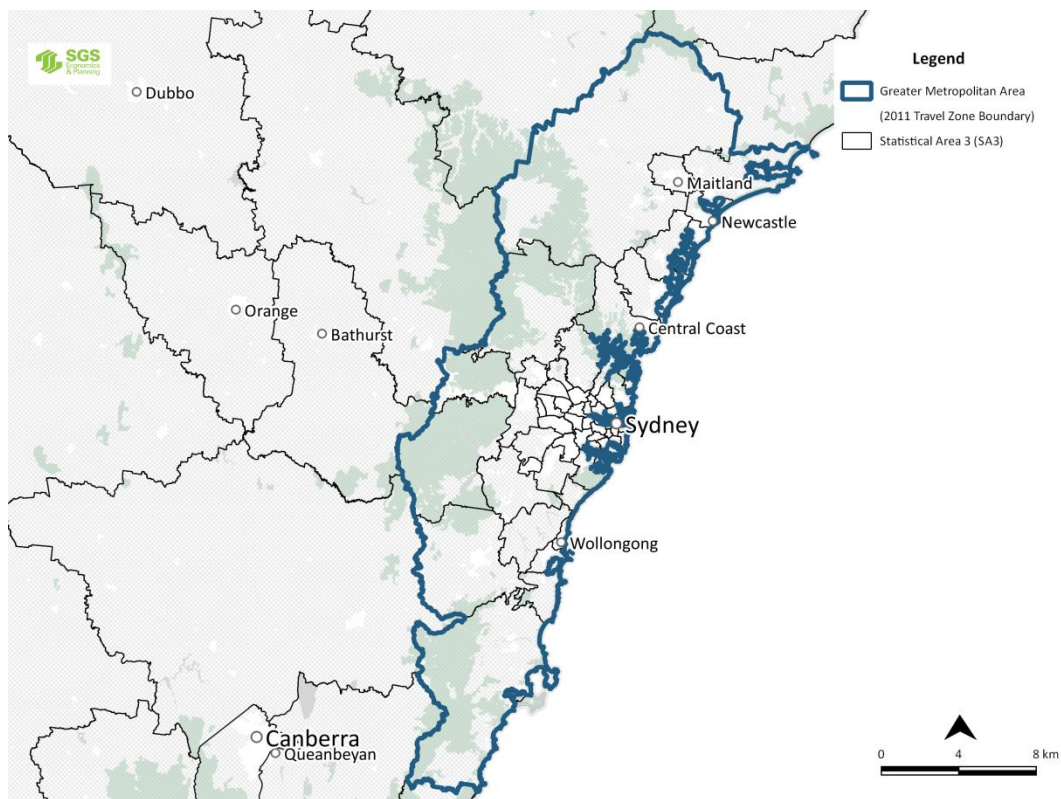
4.4.2 Other geographies

There are a number of other relevant geographies which are used in the development of the TZPs (see table below). As much as possible these are standardised and consistent across modules and with external data sources.

Table 1 Geographies used in TPA land use modelling

OLD Sydney GMA Formally defined as Sydney Statistical Division, Newcastle Statistical Subdivision and Illawarra Statistical Division. Statistical (sub) divisions ('SSD') are an old geographic structure created by the ABS and were discontinued during the 2011 Census. This old definition of the Sydney GMA should not be confused with the STM model area which is also called the Sydney GMA.	
Sydney GCCSA and Rest of NSW (RoNSW) **Part of ABS ASGS (Cat. 1270.0.55.001)** The GCCSA is the ABS latest definition of 'Greater Sydney'. It excludes Newcastle and Illawarra which are included in 'Rest of NSW'.	

Statistical Area 4 (SA4)
Part of ABS ASGS (Cat. 1270.0.55.001)

There are 30 SA4's across NSW with 19 covering the 2,949 modelled travel zones. One SA4 is only partly included in this modelled area.

They provide a sound sub-regional geographic scale for the TZP work to align with. Increasingly economic and demographic data is provided via this geography (i.e. Labour Force Survey, Census).
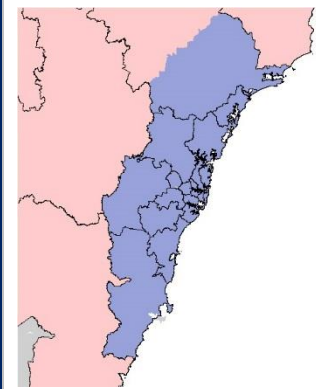
Statistical Area 2
Part of ABS ASGS (Cat. 1270.0.55.001)

This geography is approximately the same size of a suburb and can be useful for reporting and reviewing of results at a local neighbourhood level.
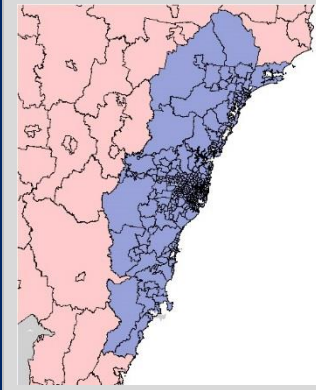
Precincts (including strategic centres)

This geography aligns to 'known places' and 'key strategic areas' based around TZs. These align with GSC defined centres while also including additional centres and other areas across the remainder of the model area (GMA).

These precincts form a key role in the review and reporting process.
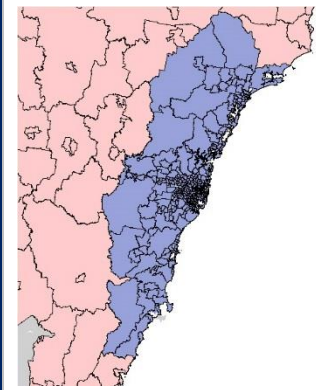
Local Government Areas (LGA)

These are political boundaries which may not always align with functional land use areas. Some LGAs have recently been redefined in the recent NSW Council amalgamations. As such, many statistical agencies have moved away from using them.

This geography should only be used for summary reporting, if at all.
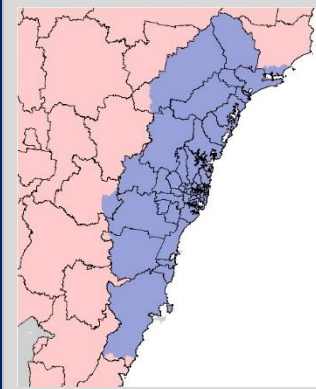
BTS Land Use Regions (BTSLUR)- or Adjusted LGAs

There are 56 regions which provide an interim geography between SA2 and LGAs.

These are being phased out with focus on shifting to the new ASGS geographic structure.
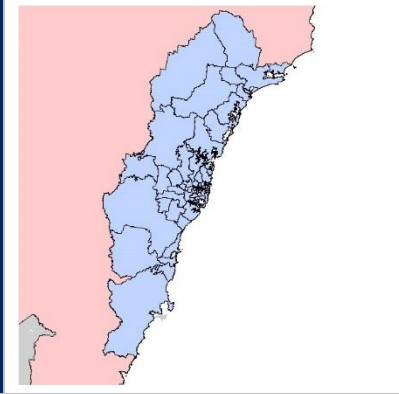
A note on TZ geographic framework going forward

Travel Zone data is the core output geography for the TZP 2016 and is created using a range of different geographies that largely 'input' into this process. These vary for different modules based on the input data source structure.

A consistent and stepped geographic framework which is used across all modules and used for both inputting data and outputting/reviewing results enables consistency, better cross module links over time and staged development.

The following presents a four stage framework for how modules should incrementally align to key geographic areas in the future. *Currently some modules still align to LGAs or Adjusted LGAs.*

Figure 6 TPA's TZ Spatial Framework
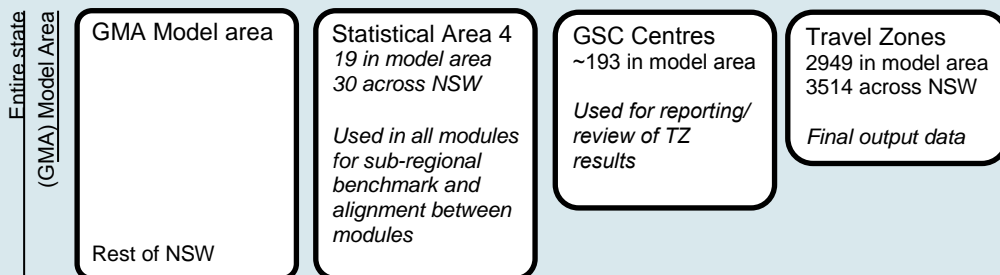
This framework provides a number of advantages:

- SA4 results provide clear regional level picture and enable easy linkages across modules (i.e. between workforce and jobs). It also allows for the modules created to be further developed to project the whole of NSW.

- Precincts: An intermediate geography that aligns to 'known places' and 'key strategic areas' that have been created. This geography can continue to evolve over time based on the government policy focus areas. As such these precincts are used for summary reporting and review. Some precincts may include just one or a small group of Travel Zones which aligns with that location.

- Centres are classified as either 'Strategic', 'District' or 'Other' to reflect there are of influence and priority.

4.5   Variable breakdowns

A number of variables are created in each module. These are used for both external requirements and as inputs into subsequent modules. Detailed breakdowns are required to create an accurate picture of trip attraction and generation. However, too many variable breakdowns may undermine the data quality and can make the process overly complicated. Understanding the exact requirements and tailoring module structure around this is critical.

4.5.1 Core Transport Model TZP variable requirements

The core purpose of the TPA TZP data is for input in the Pop Syth, STM and FMM.

The TZP variables required for these transport models fall into two primary categories.

- **Generator variables** that relate to the origin location of travel (i.e. place of usual residence (PUR))

- **Attractor variables** that relate to destinations. These destinations range from places of work (PoW) and educational institutions (PoI) to destinations such as shopping centres.

Table 2 summarises the 25 inputs required by the population synthesiser as well as additional 4 fields which need to be generated but not required.

Table 2 Population Synthesiser data input requirements

Place of count	Category	Sub category	Variable
PUR	POPD	POPD	POPD
PUR	POPD	Age-Sex	Males 0 - 19 Males 20 - 39 Males 40 - 59 Males ≥60 Females 0 - 19 Females 20 - 39 Females 40 - 59 Females ≥60
PUR	POPD (>15)	In Workforce (iWF) Not in Workforce (NiWF)	Full-time workers Part-time workers Unemployed[#] Not in Workforce[#]
PUR	POPD	POPD (<15) POPD(15+) (note includes people employed and not-employed)	Children (≤15 years old) $0 - $20,799 $20,800 - $31,199 $31,200 - $41,599 $41,600 - $67,599 ≥ $67,600
PUR	POPD	Enrolled students Not students	Primary School Student Secondary School Student Tertiary Institution Student Not a Student[#]
PUR	OPD	Household Types	Couples with Children Couples Only Single Parent Single Person Other Types

[#] *Generated variables not required by the Pop Syth.*

Table 3 lists the 19 attractor variables which are produced by the TPA Land Use Forecasting team for use by the STM as well as additional 8 variables that are generated but not required as STM inputs.

Table 3 STM data input requirements

Place of count	Category	Sub category	Variable
PUR	POPD	POPD	POPD
PoW	Total Employment	Total Employment	Total Employment
PoW	Total Employment	Employment income bands (currently 2011 dollars)	$0 - $20,799 $20,800 - $31,199 $31,200 - $41,599 $41,600 - $67,599 >=$67,600
PoW	Total Employment	Service industries	Accommodation and Food Services Financial and Insurance Services Rental, Hiring and Real Estate Services Professional, Scientific and Technical Services Administrative and Support Services Education and Training* Health Care and Social Assistance Arts and Recreation Services Other Services Retail Trade
		Other industries	Agriculture, Forestry and Fishing[#] Mining[#] Electricity, Gas, Water and Waste Services[#] Construction[#] Wholesale Trade[#] Transport, Postal and Warehousing[#] Information Media and Telecommunications[#] Manufacturing[#]
PoI	Enrolments	School enrolments	Primary School Enrolments Secondary School Enrolments
		Tertiary enrolments	Tertiary Institution Enrolments*

*Tertiary Institution Enrolments were proxies by employment in the tertiary education sector, which is a subset of the 'Education and Training' industry.

[#] *Generated variables not required by the STM*

In addition to inputs for the STM, the TPA also provides 34 attraction variables for use in the Freight Movement Model (FMM). The data segmentation required by the FMM is detailed in Table 4.

Table 4 FMM data input requirements

Place of count	Category	Sub category	Variable
PoW	Total Employment	Non-Manufacturing (1 digit ANZSIC)	Agriculture, Forestry and Fishing
			Mining
			Electricity, Gas, Water and Waste Services
			Construction
			Wholesale Trade
			Retail Trade
			Accommodation and Food Services
			Transport, Postal and Warehousing
			Information Media and Telecommunications
			Financial and Insurance Services
			Rental, Hiring and Real Estate Services
			Professional, Scientific and Technical Services
			Administrative and Support Services
			Education and Training
			Health Care and Social Assistance
			Arts and Recreation Services
			Other Services

2016 Travel Zone Projections

Place of count	Category	Sub category	Variable
PoW	Total Employment	Manufacturing (2 digit ANZSIC)	Food Product Manufacturing
			Beverage and Tobacco Product Manufacturing
			Textile, Leather, Clothing and Footwear Manufacturing
			Wood Product Manufacturing
			Pulp, Paper and Converted Paper Product Manufacturing
			Printing (including the Reproduction of Recorded Media)
			Petroleum and Coal Product Manufacturing
			Basic Chemical and Chemical Product Manufacturing
			Polymer Product and Rubber Product Manufacturing
			Non-Metallic Mineral Product Manufacturing
			Primary Metal and Metal Product Manufacturing
			Fabricated Metal Product Manufacturing
			Transport Equipment Manufacturing
			Machinery and Equipment Manufacturing
			Furniture and Other Manufacturing
			Food Product Manufacturing
			Beverage and Tobacco Product Manufacturing

4.5.2 Broader TZP variables requirements (by each module)

Beyond the core transport model requirements, the data is also available to download from the TfNSW Open Data Hub and used as an input into a diverse range of local planning and research work by a wide range of practitioners. As highlighted earlier in

this chapter, there are also interrelationships between Modules and associated variable requirements. For example, detailed age/sex breakdowns are required for the development of Workforce variables.

Figure 7 seeks to define the entire scope of variables that the Land Use Forecasting team needs to produce. This covers requirements for Transport Modelling, website publishing and Module interdependencies.

Figure 7 Model variable generation and module dependencies
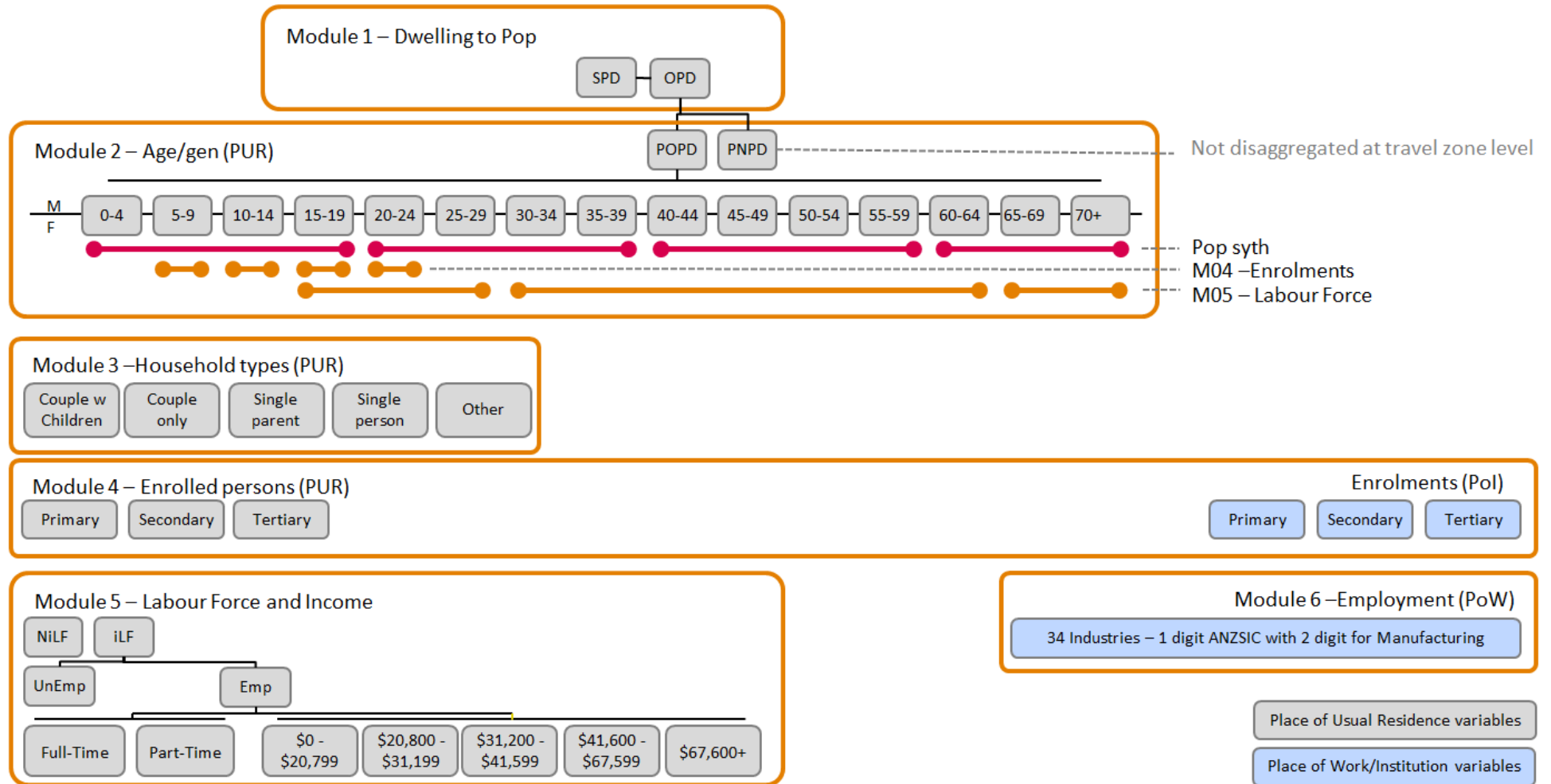
5 TZP 2016 results overview

This chapter provides a high level overview of the Travel Zone Projections 2016 results. For an additional fine grain level view of results, data is presented on a data explorer visualisation with an interactive map, accessible on the TfNSW website.

5.1 Greater Sydney Land Use Narrative

By 2056 there are projected to be more than 5 million jobs and more than 10 million people in the Sydney GMA. The distribution of projected population and employment growth will have a marked impact on how the city functions. The size and complexity of the Sydney urban system will be a significant challenge and the future distribution of growth will respond to the provision of future infrastructure, metropolitan strategic planning and evolving market and economic demands and preferences.

In broad terms we will continue to see the urban footprint of Sydney expand as new growth areas establish to the North West and South West of Sydney. While at the same time infill development through both major redevelopments and small scale incremental developments will provide for significant population growth within the existing urban footprint.

The economy will continue to undergo a fundamental restructure away from traditional manufacturing based sectors to one based on services – retail, health, professional and other. This transition has fundamental implications on spatial distribution of employment with agglomeration around major nodes and population growth areas.

Figure 8 Greater Sydney employment and population growth
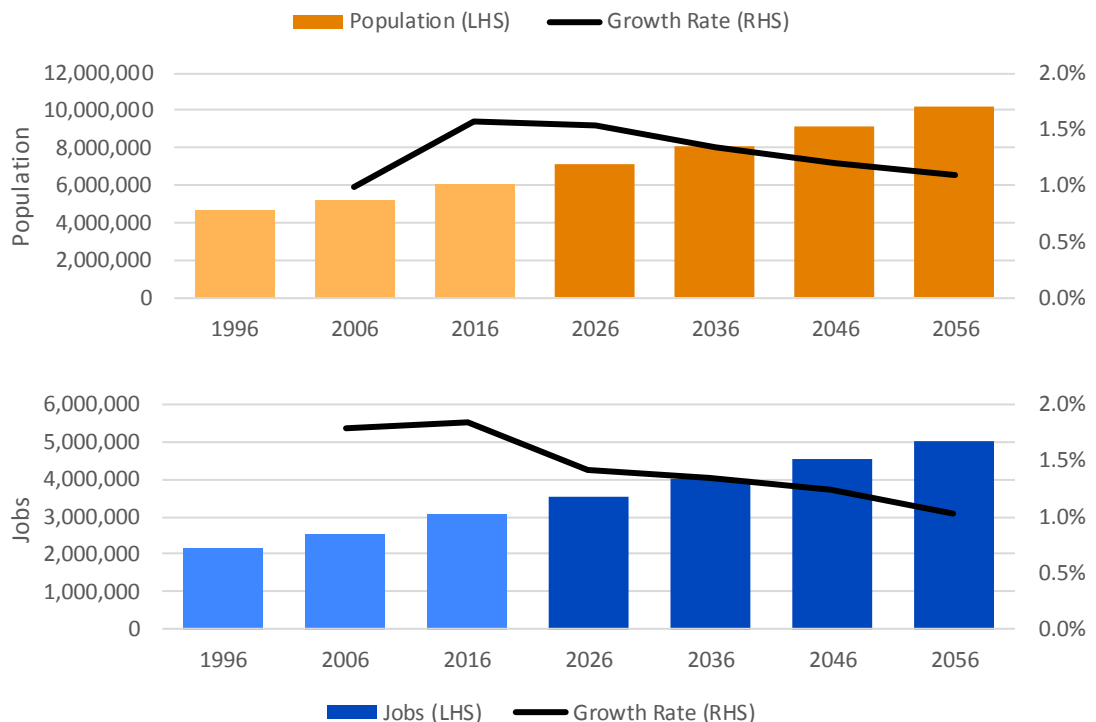
Figure 9 Distribution of Greater Sydney employment and population growth

2016 Travel Zone Projections
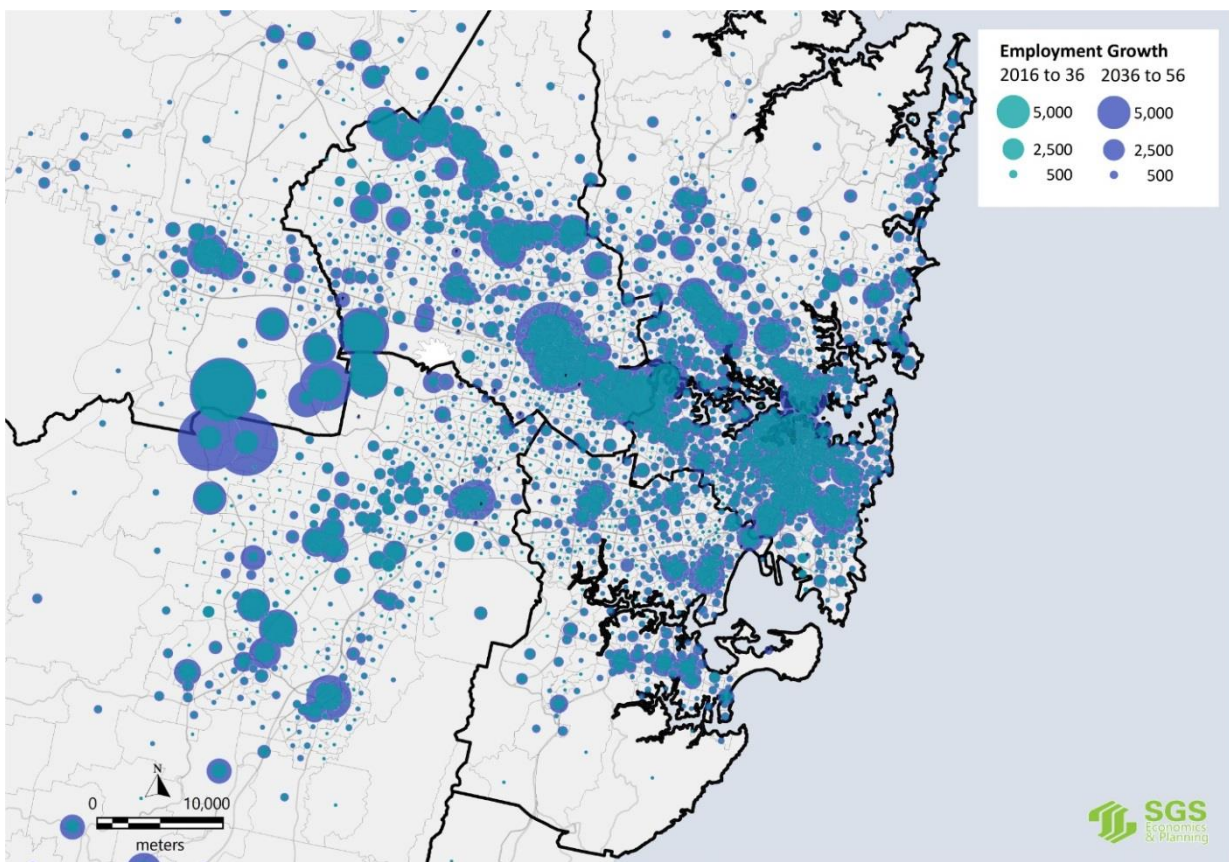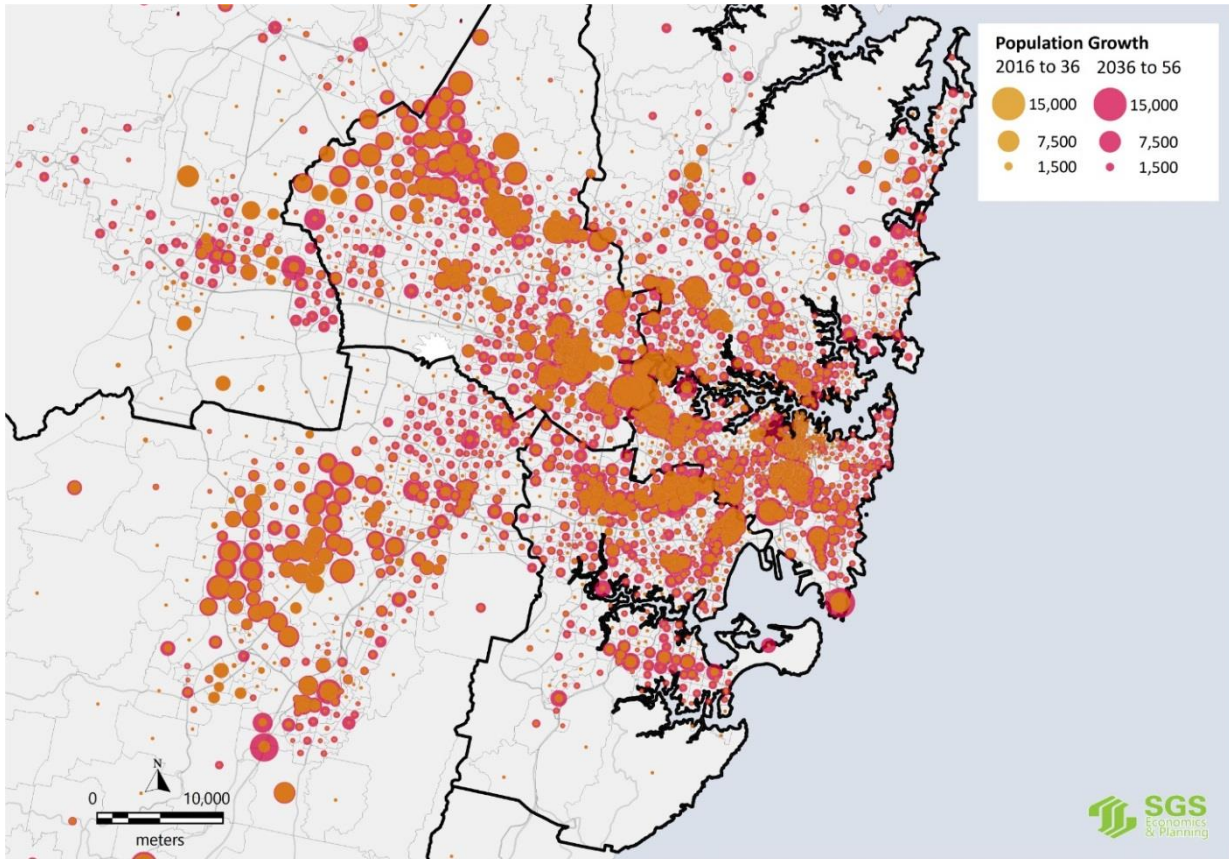
5.2   GSC District Summary

The GSC Districts represent broad economic sub-regions across Greater Sydney and form the basis of significant sub-regional planning and coordination. Two additional 'Districts' for the broader Newcastle and Wollongong regions have been added to the official GSC Districts to cover the entire Sydney GMA.

5.2.1   Population and Dwellings

Table 5 and *Note: SPD refers to Structured Private Dwellings.*
AAGR is the Annual Average Growth Rate (%)
GMA is the Greater Metropolitan Area (see Section 4.4 Spatial Geographies for additional details)

Table 6 below show the structural private dwelling and population projections by district. The results indicate a rapid growth within the GMA, which will house an additional two million residents by 2036 – which represents an annual average growth rate of 1.4 percent.

Much of this growth stems from within Greater Sydney, which is projected to reach 6.4 million residents by 2036 and then 8.2 million by 2056. When considering the sub-regional distribution, the South West and West Central (which contains Parramatta) districts exhibit the most significant growth, with annual average growth rates of 2.1 and 2.3 percent respectively. This high growth rate means that, by 2036, the population within the Central district will be eclipsed by that of West Central.

Table 5 Structural private dwelling projection by districts: 1996-2056

GSC District	SPD 1996	SPD 2016	SPD 2036	SPD 2056	AAGR 1996-2016	AAGR 2016-2036	AAGR 2036-2056
Central	348,800	469,700	627,200	814,000	1.5%	1.5%	1.3%
North	298,900	364,400	455,300	585,300	1.0%	1.1%	1.3%
South	233,600	279,800	363,200	477,000	0.9%	1.3%	1.4%
South West	177,700	249,000	392,000	518,200	1.7%	2.3%	1.4%
West	113,200	140,000	179,900	234,100	1.1%	1.3%	1.3%
West Central	239,100	348,900	557,900	742,000	1.9%	2.4%	1.4%
Total GSC	**1,411,200**	**1,851,800**	**2,575,500**	**3,370,600**	**1.4%**	**1.7%**	**1.4%**
xGSC Newcastle	338,400	433,300	536,200	625,600	1.2%	1.1%	0.8%
xGSC Wollongong	166,000	211,100	251,500	282,100	1.2%	0.9%	0.6%
Total GMA	**1,915,600**	**2,496,100**	**3,363,200**	**4,278,300**	**1.3%**	**1.5%**	**1.2%**

Note: SPD refers to Structured Private Dwellings.
AAGR is the Annual Average Growth Rate (%)
GMA is the Greater Metropolitan Area (see Section 4.4 Spatial Geographies for additional details)

Table 6 Population projection by districts: 1996-2056

GSC District	ERP 1996	ERP 2016	ERP 2036	ERP 2056	AAGR 1996-2016	AAGR 2016-2036	AAGR 2036-2056
Central	751,700	1,012,400	1,337,500	1,706,500	1.5%	1.4%	1.2%
North	726,400	885,500	1,085,600	1,383,400	1.0%	1.0%	1.2%
South	620,800	741,300	945,600	1,221,500	0.9%	1.2%	1.3%
South West	525,300	715,800	1,089,800	1,409,200	1.6%	2.1%	1.3%
West	299,600	355,000	442,600	571,500	0.9%	1.1%	1.3%
West Central	664,100	972,000	1,520,700	1,969,000	1.9%	2.3%	1.3%
Total GSC	3,587,900	4,682,000	6,421,900	8,261,000	1.3%	1.6%	1.3%
xGSC Newcastle	762,600	953,800	1,149,800	1,323,400	1.1%	0.9%	0.7%
xGSC Wollongong	372,100	452,100	523,200	579,900	1.0%	0.7%	0.5%
Total GMA	4,722,600	6,087,900	8,094,900	10,164,300	1.3%	1.4%	1.1%

Note: ERP refers to Estimated Resident Population.

AAGR is the Annual Average Growth Rate (%)

GMA is the Greater Metropolitan Area (see Section 4.4 Spatial Geographies for additional details)

5.2.2   Workforce and Employment

A summary of the workforce projections by districts are shown below in Table 7. Overall, the workforce is expected to increase by nearly 2 million persons within the GMA by 2056. Workforce growth is highly correlated with population growth so is projected to have the fastest rate of workforce growth (2.3%) in the West Central district.

Table 7 Workforce projections by districts: 2016-2056

GSC District	Workforce 2016	Workforce 2036	Workforce 2056	AAGR 2016-2036	AAGR 2036-2056
Central	559,200	728,100	931,700	1.3%	1.2%
North	481,100	587,700	761,200	1.0%	1.3%
South	362,100	458,200	599,200	1.2%	1.4%
South West	318,100	477,300	597,800	2.0%	1.1%
West	182,500	222,000	288,200	1.0%	1.3%
West Central	467,800	735,400	924,200	2.3%	1.1%
Total GSC	2,370,700	3,208,600	4,102,400	1.5%	1.2%

GSC District	Workforce 2016	Workforce 2036	Workforce 2056	AAGR 2016-2036	AAGR 2036-2056
xGSC Newcastle	450,200	537,200	617,500	0.9%	0.7%
xGSC Wollongong	199,200	229,200	253,000	0.7%	0.5%
Total GMA	**3,020,100**	**3,975,000**	**4,972,900**	**1.4%**	**1.1%**

Note:

AAGR is the Annual Average Growth Rate (%)

GMA is the Greater Metropolitan Area (see Section 4.4 Spatial Geographies for additional details)

The growth of workforce is also driven by increasing participation rates over the next 20 years due to a variety of factors such as the continuing trend of increasing female participation rates (Figure 10) and people staying in the workforce for longer (Figure 11).

Figure 10 Participation rates: Female 25-29 years
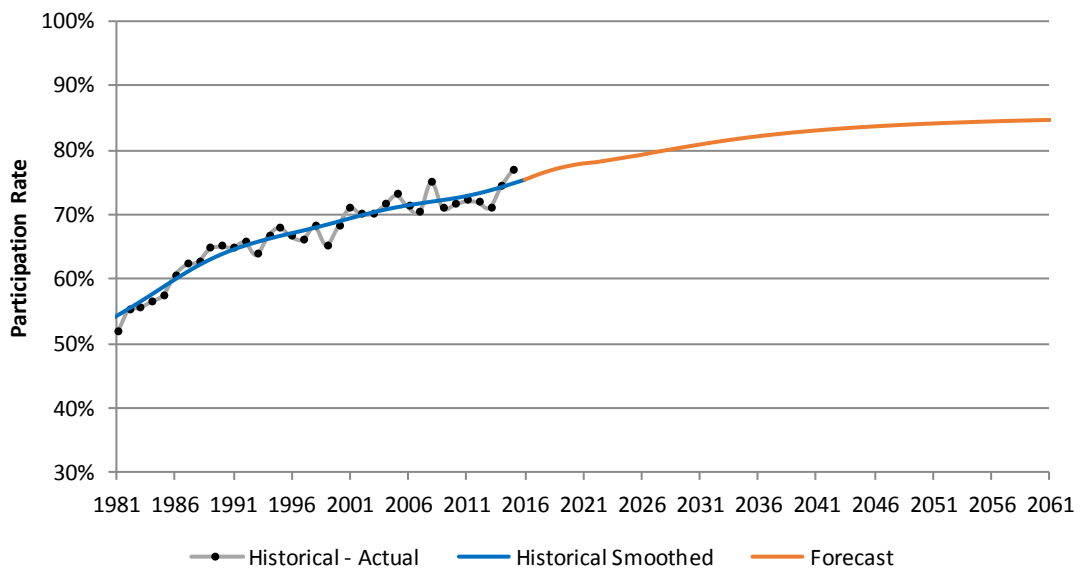
Figure 11 Participation rates: Male and female 55-59 years
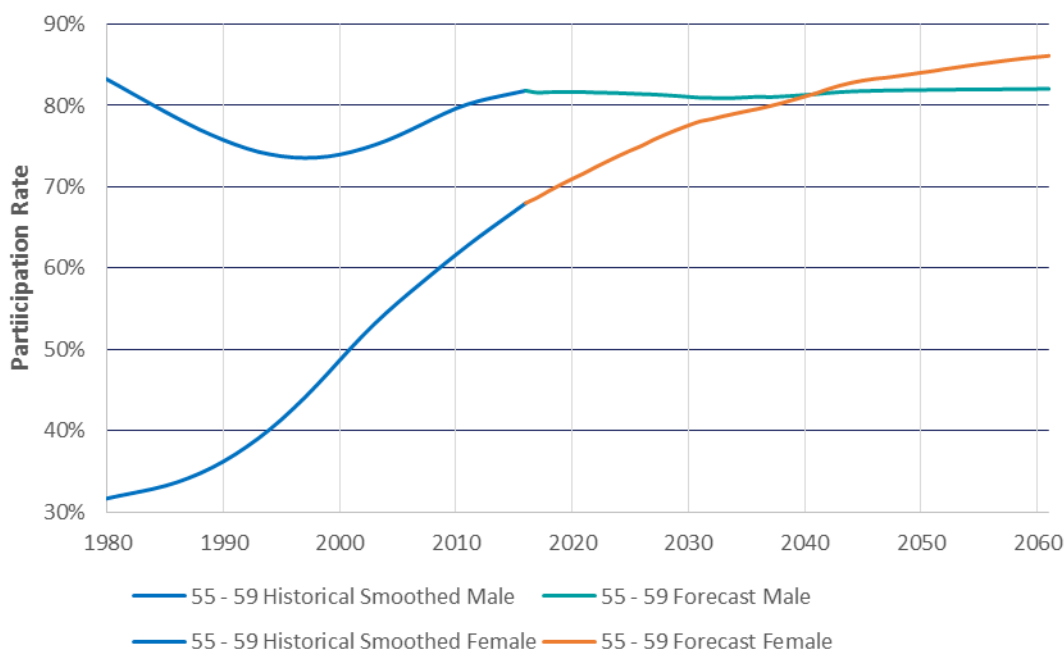
Employment projections by district are shown below in Table 8. Employment is expected to continue to grow most strongly within the West Central, South West and West districts.

Table 8 Employment projections by districts: 1996-2056

GSC District	Emp 1996	Emp 2016	Emp 2036	Emp 2056	AAGR 1996-2016	AAGR 2016-2036	AAGR 2036-2056
Central	630,100	904,500	1,183,000	1,469,400	1.8%	1.4%	1.1%
North	353,500	483,300	599,300	737,100	1.6%	1.1%	1.0%
South	199,800	241,500	298,400	370,900	1.0%	1.1%	1.1%
South West	158,000	237,100	352,300	484,300	2.1%	2.0%	1.6%
West	89,600	133,100	196,700	251,500	2.0%	2.0%	1.2%
West Central	291,800	440,300	650,700	842,300	2.1%	2.0%	1.3%
Total GSC	**1,722,700**	**2,439,800**	**3,280,500**	**4,155,500**	**1.8%**	**1.5%**	**1.2%**
xGSC Newcastle	275,000	427,500	520,000	625,000	2.2%	1.0%	0.9%
xGSC Wollongong	132,200	184,400	220,500	259,900	1.7%	0.9%	0.8%
Total GMA	**2,129,900**	**3,051,700**	**4,020,900**	**5,040,400**	**1.8%**	**1.4%**	**1.1%**

Note: Emp refers to the jobs available.

AAGR is the Annual Average Growth Rate (%)

GMA is the Greater Metropolitan Area (see Section 4.4 Spatial Geographies for additional details)

2016 Travel Zone Projections

Comparing district-wide employment to workforce, Figure 12 shows the persistence of distributional features.

The Central district will continue to have a large net inflow of workers, while districts such as South and South West have significant outflows.

Figure 12 Workforce and employment by District
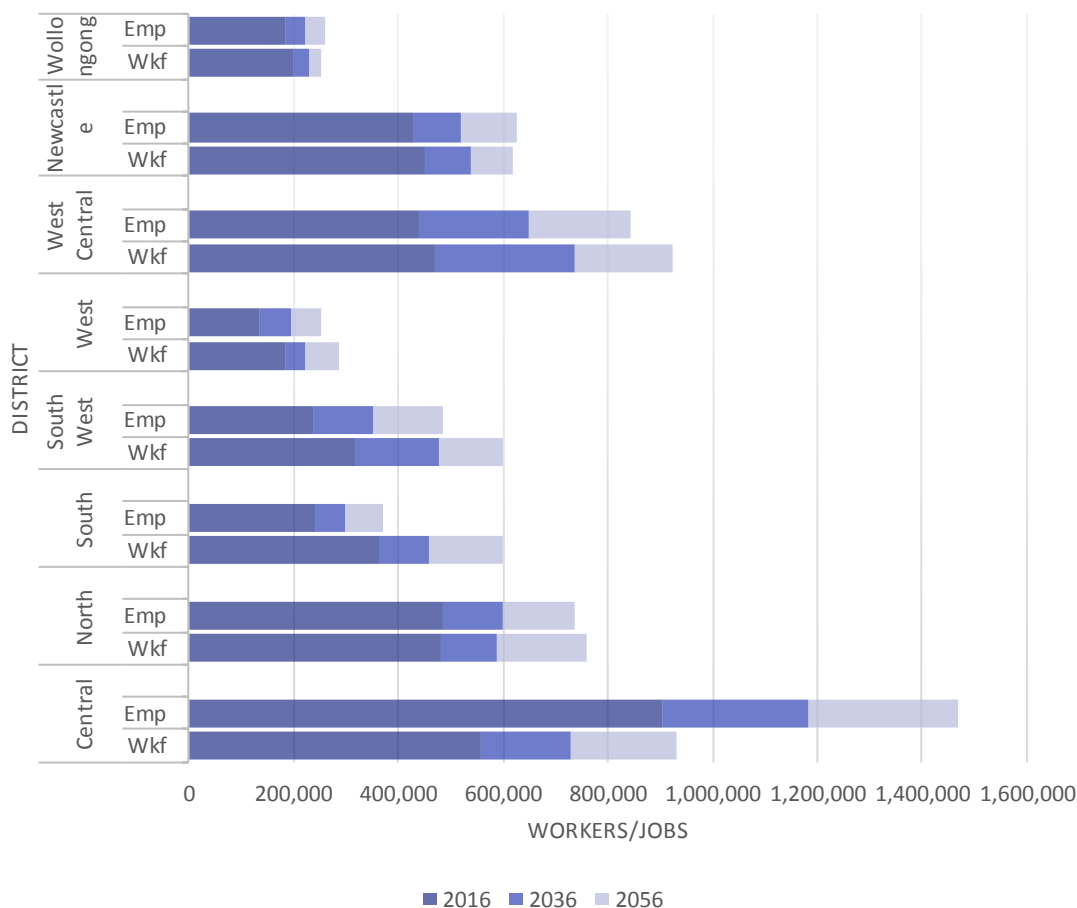
5.3 Precinct (including GSC Centres) summary

193 Precincts were defined across the GMA. These are aggregations of Travel Zones around key centres or suburbs. The following section profiles a small selection of these precincts focusing on those that will contain most of the population and employment growth or that are the focus of policy work. The boundaries of these Centres are shown in the Appendix section of this report.

5.3.1 Central Sydney and Parramatta

Significant development and policy work is occurring around the two major hubs of Greater Sydney - Central Sydney and Parramatta. By 2056 they will have 286,000 and 190,000 residents and 830,000 and 210,000 jobs respectively. These precincts have been further broken in to a number of sub-precincts to better understand the scale of growth within these areas.

Figure 13 presents population levels and gross density (based on travel zone area) within Central Sydney and Parramatta sub-precincts. Figure 14 presents the same for employment levels and gross density.

Significant dwelling and employment growth is projected in these areas. While the majority of the jobs growth will be focused in the Sydney CBD, population growth will

be spread across the surrounding precincts. By 2056, Parramatta CBD followed by Broadway will have the highest gross population density. However, Sydney CBD gross employment density will remain significantly higher than any other precinct.

Figure 13 Population by Sub-Precinct, Central Sydney and Parramatta
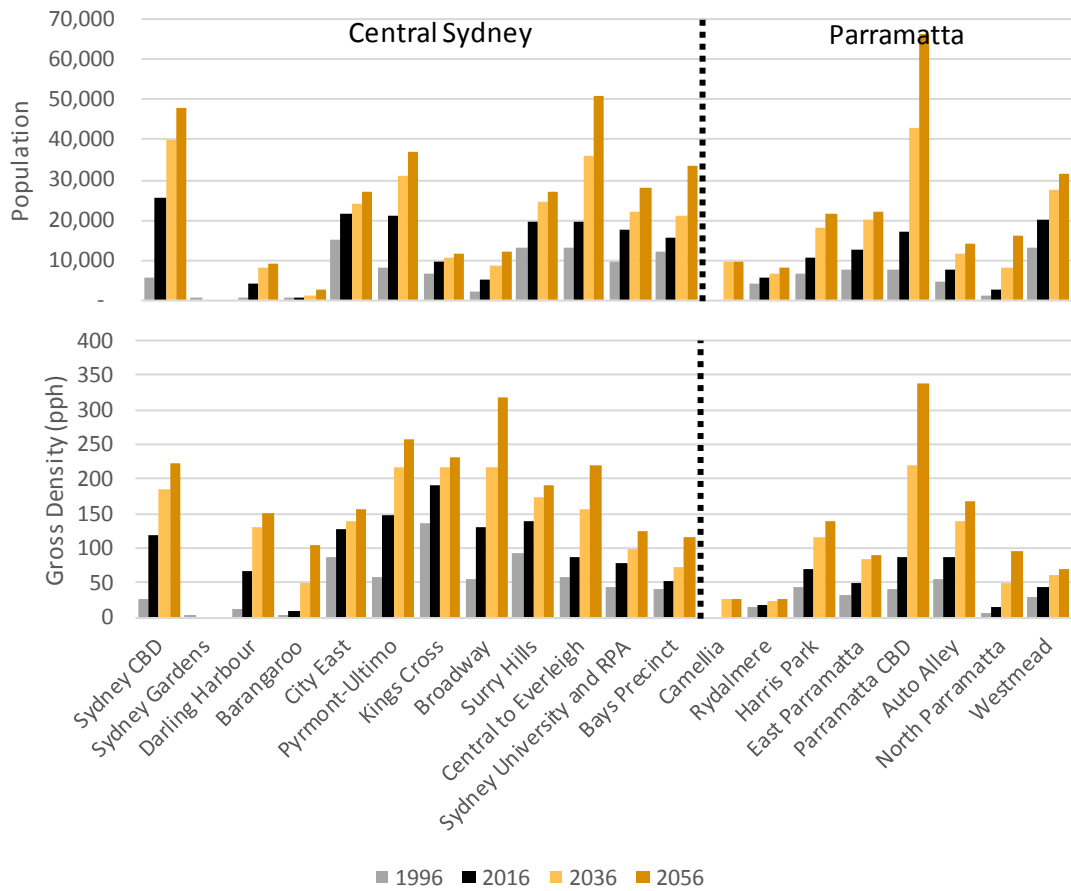
Figure 14 Employment by Sub-Precinct, Central Sydney and Parramatta

Legend: ■ 1996 ■ 2016 ■ 2036 ■ 2056
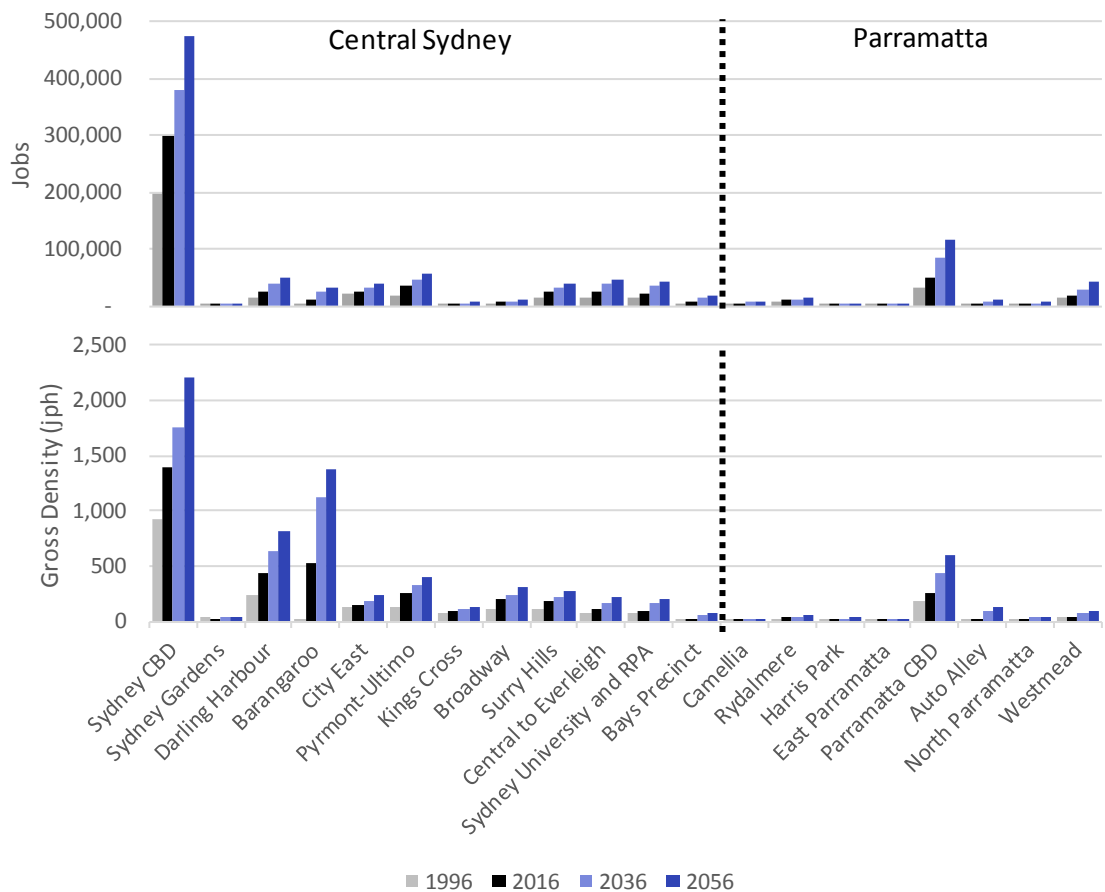
5.3.2 Strategic Centres

There are 20 Strategic Centres across Greater Sydney. Population and employment across these strategic centres (excluding Central Sydney) has been presented in Figure 15 and Figure 16. They have been sorted by distance to Central Sydney.

Figure 15 highlights the significant population and employment growth projected for Greater Parramatta given significant policy and infrastructure focus around this area. It also illustrates that significant population growth is projected for Green Square, Penrith along with a number of other key centres. In terms of employment Western Sydney Airport will see significant growth as will Macquarie Park.

Figure 15 Population by Precinct, strategic centres (ex Central Sydney)
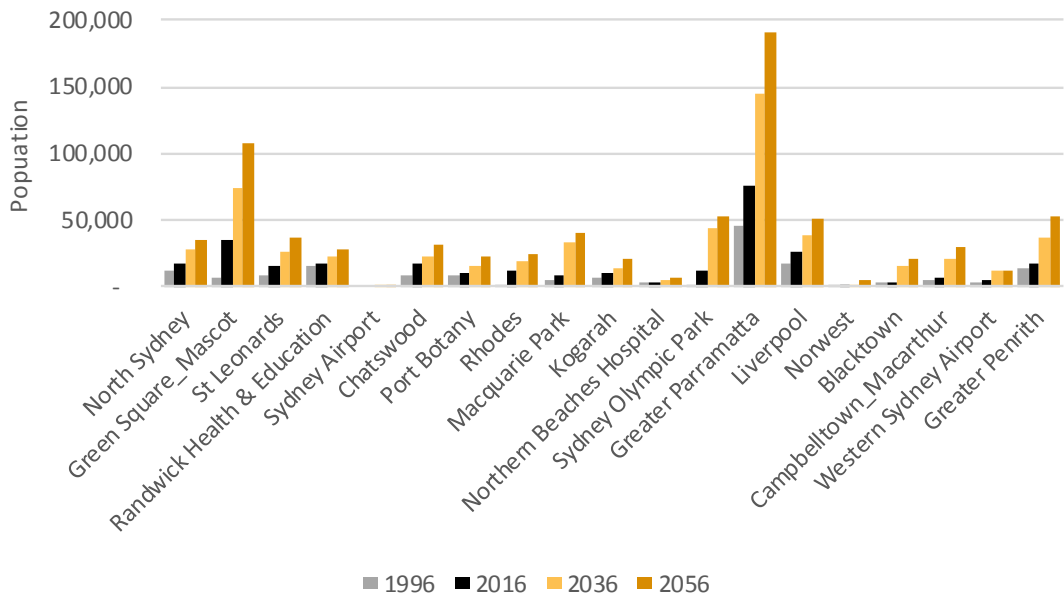
Figure 16 Employment by precinct, strategic centres (ex Central Sydney)
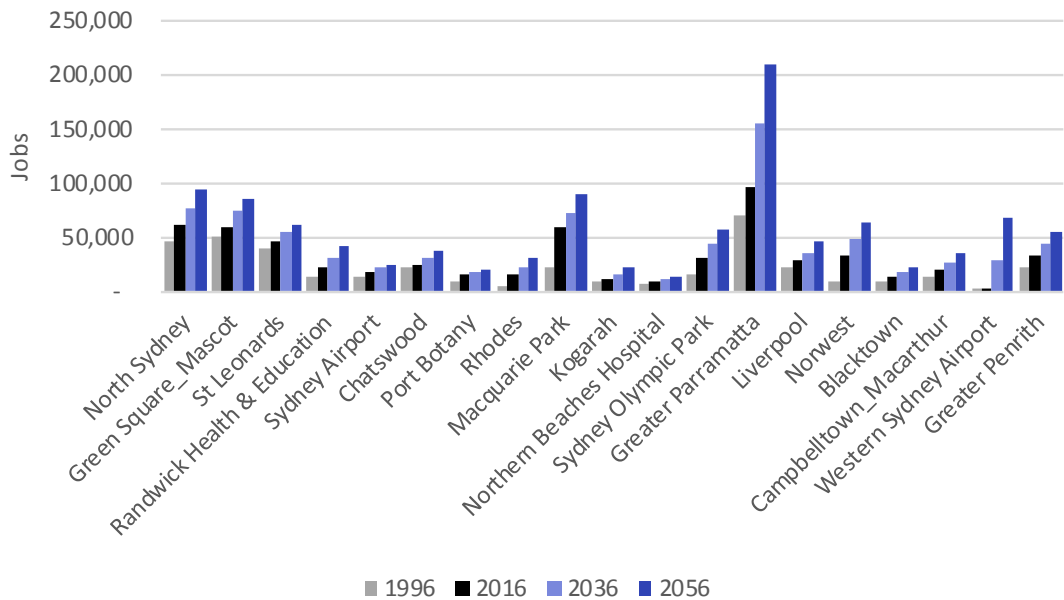
5.3.3   Summary of selected precincts

Figure 17 presents the 'top 15' precincts in terms of population and employment at 2016 and projected growth from 2016 to 2056. Greenfield release areas within South West Priority Growth Area (PGA) and West PGA are the drivers behind the high projections for population. Also urban renewal areas such as Parramatta and strategic sites in Central Sydney.

In terms of employment the top three employment growth precincts are Central Sydney, Parramatta and Western Sydney Airport.

Figure 17 Population, selected top15 Precincts

Top 15: Population at 2016

Top 15: Population Growth from 2016 to 2056
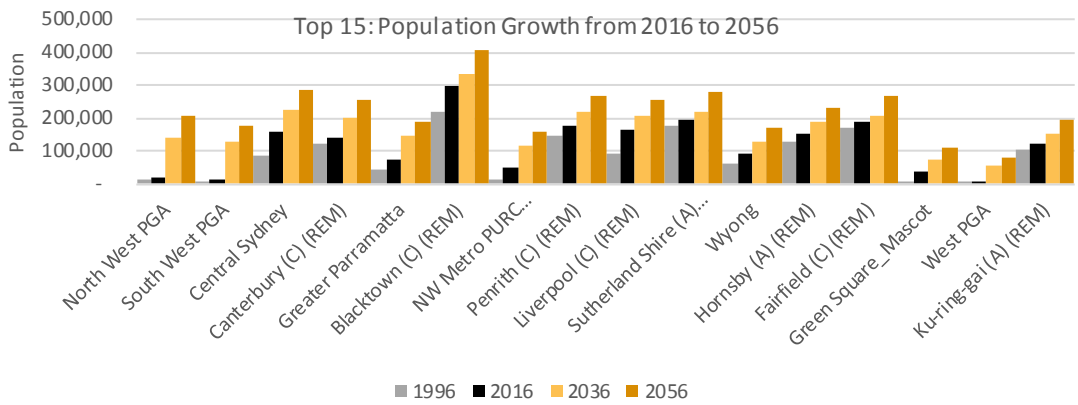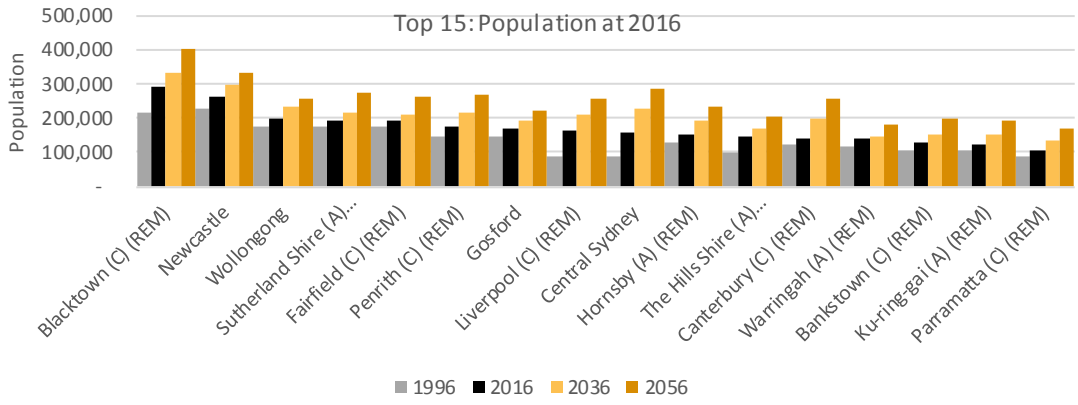
Figure 18 Employment, selected top15 Precincts

Top 15: Jobs at 2016

Top 15: Jobs Growth from 2016 to 56

2016 Travel Zone Projections
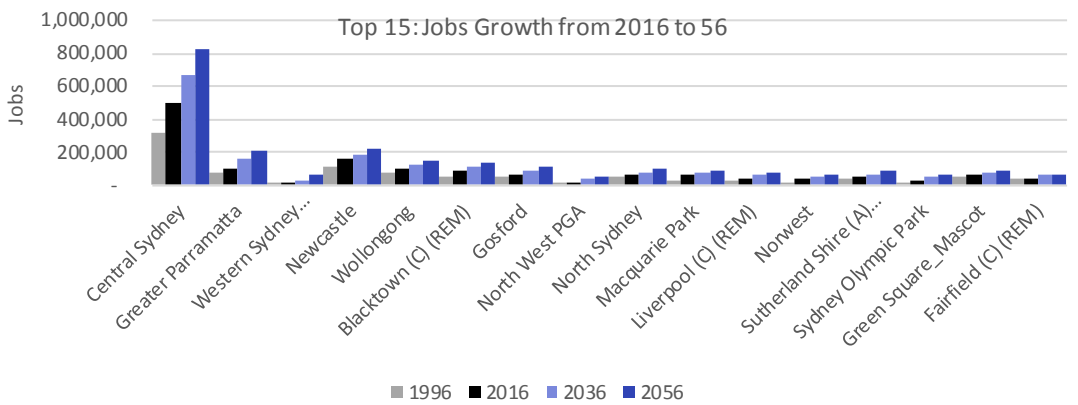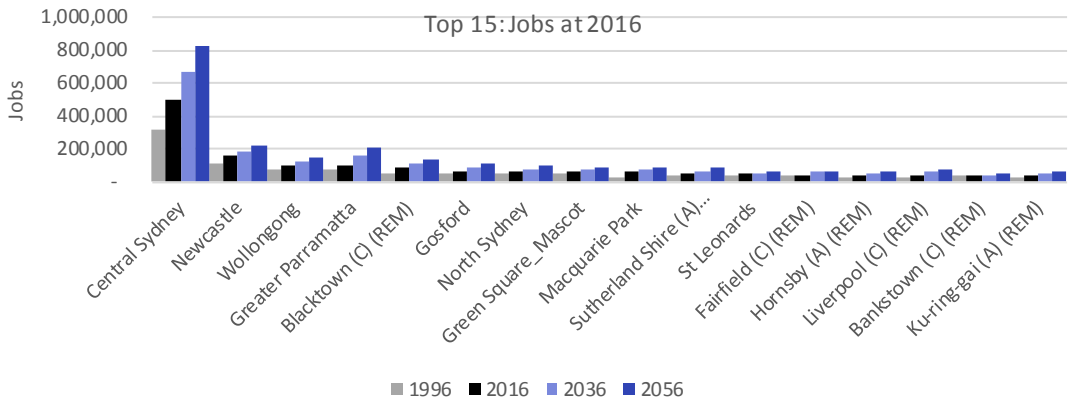
Additional TZP 2016 breakdowns and raw data.

This section provided a very small snapshot of the TZP 2016 dataset to highlight a few of the key trends within the dataset. Along with this report several data spreadsheets which contain the raw data along with a number of summary tables by Districts, Local Government Areas and all precincts have been created. This includes additional breakdowns such as dwelling, population, population by age, workforce status, employment by industry and enrolments by subsector. They also include summary growth levels, growth rates and density estimates.

The remainder of this report further details the key assumptions, data sources and approach used in each module.

Part 2: Detailed Model Methodology

6 Module 1: Population and dwellings

This chapter provides a summary of the revised dwellings and population module of TZP 2016. The chapter includes analysis of how the revised approach differs from the previous approach used during the Land Use Projections released by TPA in 2014 ('LU14').

6.1 Module 1 overview

The diagram below presents an overview of the module and the relationship to the other modules.

Figure 19 Module 1 overview
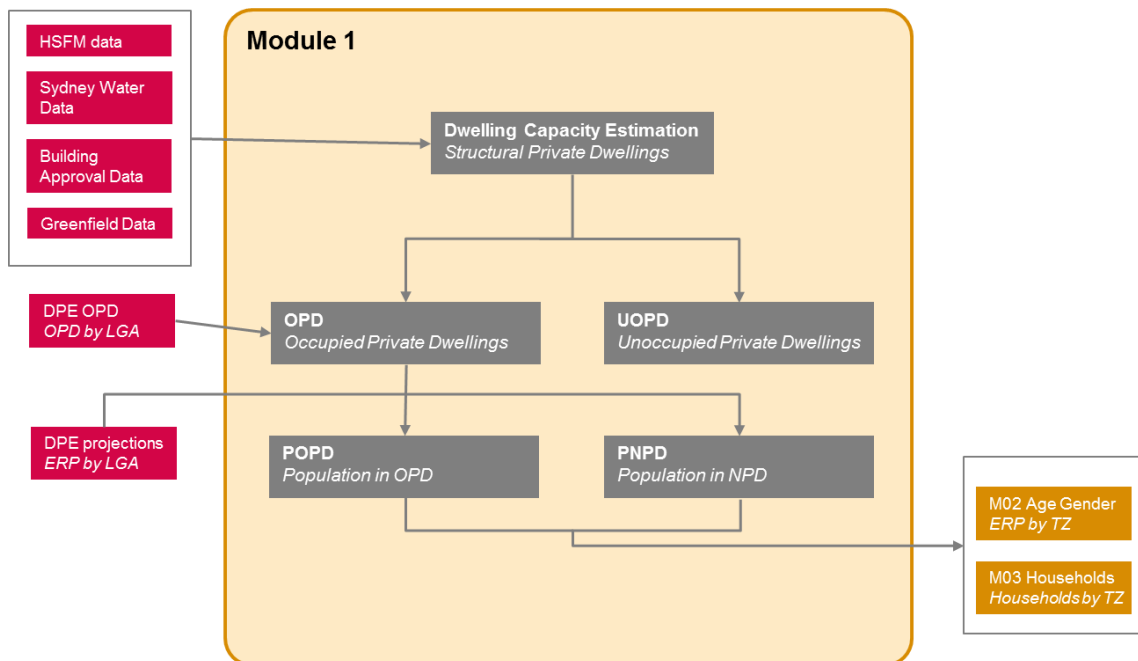
This module is made up of four components:

- **Dwelling Capacity Estimation** (Structural Private Dwellings) – Incorporating HSFM forecasts for the Metropolitan area, Sydney Water data, Building Approvals and Greenfield data, and adjusted Land Use 2014 data to determine dwelling capacity for each travel zone.

- **Dwelling Projections (Occupied and Unoccupied Private Dwellings)** – Incorporating the capacity estimation, Occupied Private dwellings and Unoccupied Private Dwellings by travel zone are projected.

- **Population in Occupied Private Dwellings** – Combining the Private Dwelling projection and average household sizes by travel zone, the DPE population projections for persons in OPD are projected at the travel zone.

- **Population in Non Private Dwellings** – Combining non private dwellings projected and historical household sizes, DPE population projections for persons in NPD are projected at the travel zone.

6.2 Module 1 technical model overview

The following sections provide a brief overview of how the model spreadsheets operate.

6.2.1 M01a – Capacity Estimation

This module determines dwelling capacity at a travel zone level drawing on a range of data sources. This first module has been built to incorporate the most up to date and available datasets available at the time. In future iterations of the model, this module will need to be restructured to incorporate updated and new data sources to inform future dwelling capacity.

This module requires inputs from the following sources:

Inputs

- HSFM forecasts for the Metropolitan area
- Sydney Water dwelling stock data aggregated at the Mesh block
- Buildings Approval Data
- Previously sourced data by TPA (2014) – Adjusted Land Use 2014
- Illawarra Greenfield and Target Data
- Lower Hunter Target Data

Functions

- HSFM forecasts, Sydney Water and Target Data inform the additional priority capacity available in each travel zone.
- The secondary additional capacity is driven by the Adjusted Land Use 2014 remaining capacity identified.

6.2.2 M01b – Dwelling Projections

This module distributes the DPE Occupied Private Dwellings projections by LGA to travel zone based on the capacity estimates from M01a.

Inputs

Key inputs:

- Occupied Private Dwellings (DPE Adjusted LGA Control Totals)
- Available Residential Land by travel zone
- Capacity Inputs from M01a
- Capacity Calibration

Functions

This module has two primary functions:

- The spreadsheet 'Control Totals' converts Occupied Private Dwellings to Structural Private Dwellings using a regional occupancy rate.
- The spreadsheet 'Capacity Calibration' allows the user to input manual calibrations to override the capacity inputs from M01a. For zones which require a manual override, enter a value of 1 in the "Capacity Override" column. Next, input the additional yearly capacity and define the fraction which should be allocated as priority capacity. Finally, entering a value of 1 in the "Lock to priority" columns will peg dwelling growth for that year to priority capacity calibration
- The spreadsheet 'Calculations' determines the final dwelling stock in each travel zone based on dwelling capacity and DPE control totals by LGA. For years 2016 to 2056, the growth of Structural Private Dwellings is distributed

based firstly on the priority capacity. In the case there is a residual of dwelling growth (i.e. there is not enough capacity); the secondary capacity is used to allocate the remainder of the growth. If the both priority and secondary priority capacities are exhausted and a residual remains – future dwelling capacity is brought forward to meet the dwelling growth.

6.2.3 M01c – Population by Travel Zone

This module distributes the DPE population forecasts for Occupied Private Dwellings and Non-Private Dwellings.

Inputs

- Population in Occupied Private Dwelling and Population within Non-Private Dwellings from DPE

- Occupied Private Dwellings projected from M01b

- SA1 distribution of Population in Occupied Private and Non-Private Dwellings and the number of Occupied Private dwellings and Non-Private dwellings.

Functions

This module has several key functions:

- The spreadsheet 'POPD Household Size' calculates household sizes based on SA1 Census data. These household sizes are assumed to remain the same throughout the projection. The user can override the Census data using the 'Override Indicator'. The user can change the indicator to '1' and add in the household size for those travel zones.

- The spreadsheet 'Final POPD Projection' distributes the DPE population projections in two steps:

- First Cut: The growth in dwellings is multiplied by the assumed household size for each travel zone

- Final Cut: Population growth (DPE) by LGA is distributed based on the first cut projection.

- The spreadsheet 'PNPD Distribution' allows the user to input additional NPD Developments that are confirmed to be developed. The household size is required as it will override the current Census distribution.

- The spreadsheet 'Final PNPD Projection' distributes the LGA projected for PNPD (DPE forecast) by NPD household size for each travel zone as determined by Census distribution and any additional new development input.

6.3 Comparison to LU14 approach

Figure 20 below shows the broad methodology of the LU14 approach including the datasets used and the outputs delivered.

Figure 20 LU14 Method approach

Key inputs:

- DoPE pop forecasts
- ABS Census/ other datasets
- MDP (2011)
- Growth area lot release
- Various local planning and research information

Core Products

Population
- Population and Households
- Population by age and gender

Population *(workforce)* Segmentation
- Household Type
- Students
- Workforce by full/part time
- Workforce by income

Employment
- *At Syd GMA level*
- Employment by industry/income

Cross checks

Additional Responsibilities
- Data preparation/ briefings
- Scenario modelling *(pop/emp only)*

In LU14, five yearly population forecasts by LGA are provided by DPE and form control totals for the whole analysis process. TPA has little feedback into this development process. These projections are aligned BTSLUR which aligns (old) LGA geography to groupings of (new) Statistical Area 2's (SA2) which the latest BTS Travel Zones and other ABS datasets are now based around.

For each BTSLUR there are essentially three modules used to project population (and households) as detailed in the technical documentation:

- Base year Module (2011)
- First Decade Projection Module (2016 – 2021)
- Post First Decade Module (2026 – 2041)

6.3.1 Base Year Module (2011)

2011 ABS Census data is aligned to BTS travel zones using and area overlap approach. Census data is scaled to account for undercounts by aligning data to ERP and DPE estimates at the BTSLUR level.

6.3.2 First Decade Projection Module (2016 – 2021)

The first decade of projections is guided by the DPE Metropolitan Development Program (MDP) for LGAs within Sydney. The MDP shows expected residential development at the lot level. This includes both major developments and incremental change. Lot level data is aggregated to the travel zone, to determine expected development in each travel zone. This is converted to population using a household size ratio.

Expected population growth is then shared among the travel zones according to expected growth. For example, if half the dwelling growth expected in an LGA in any year is centred in one travel zone, half of the projected population growth will be allocated to that travel zone.

Where LGA dwelling growth in any five-year period implies greater population growth than the DPE forecast, those additional dwellings are modelled as an oversupply that is used in the subsequent five-year period (i.e. increasing the dwelling supply in the next period).

TPA also amends estimates for major developments that are known to be in the pipeline, including urban activation precincts.

Outside Sydney, there is no MDP and so the allocation of LGA level population projections between travel zones is done by extrapolating each travel zone's initial share followed by targeted adjustments based on any local intelligence.

6.3.3 Post First Decade Module (2026 – 2041)

Beyond 2021, projections are based on extrapolation of trends established in the first ten years, amended for capacity constraints, zoning changes and other constrains. This is heavily dependent on professional judgement. Where detailed information is not available (which is often the case 30 years into the future) limited change from the current trends have been implemented. This produces a quite conservative projection which is heavily focused around existing development patterns.

6.3.4 Population In OPD/NPD and Occupied Private Dwellings (Households)

The base distribution allocation is completed for total population. This is then broken into population in occupied private dwellings and non-private dwellings. The share of population living in non-private dwellings such as motels and boarding schools is estimated based on ABS figures, new facilities is also captured.

A household size ratio is then used to estimate occupied private dwellings. Adjustments to the household size ratio are made to reflect changes in development forms and demographic trends.

Issues and Solutions

The LU14 approach is structured around allocating down total population then determining households, while most fine grain inputs and capacity limits are provided in the form of dwellings. The TZP 2016 approach focuses on distributing dwellings first (see below)
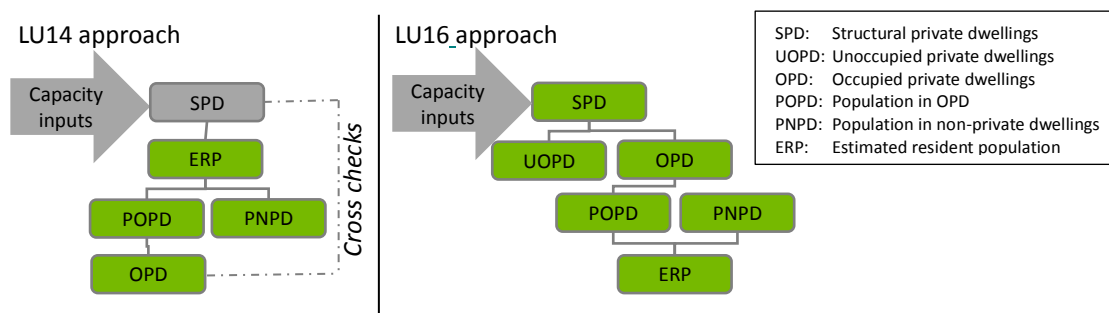
The LU14 approach also relies on the Metropolitan Development Program to inform dwelling capacity data. As this is no longer updated, other fine grain datasets such as lot level housing data from Sydney Water Connection data and the HSFM created by the DPE have been used as inputs. This enables the base year to be updated between Census periods and enable an improved base distribution.

7   Module 2: Age-Sex

This chapter provides a summary of the revised age-sex module of TZP 2016. The chapter also includes analysis of how the revised approach differs from the previous approach used during the Land Use Projections released by TPA in 2014 ('LU14').

7.1   Module 2 overview

The following diagram presents an overview of the population by age/sex module and how it interacts with the broader TZP framework. Understanding where inputs are sourced and what outputs are required are critical when operating the module.

Figure 21 Module 2: Age sex module approach overview
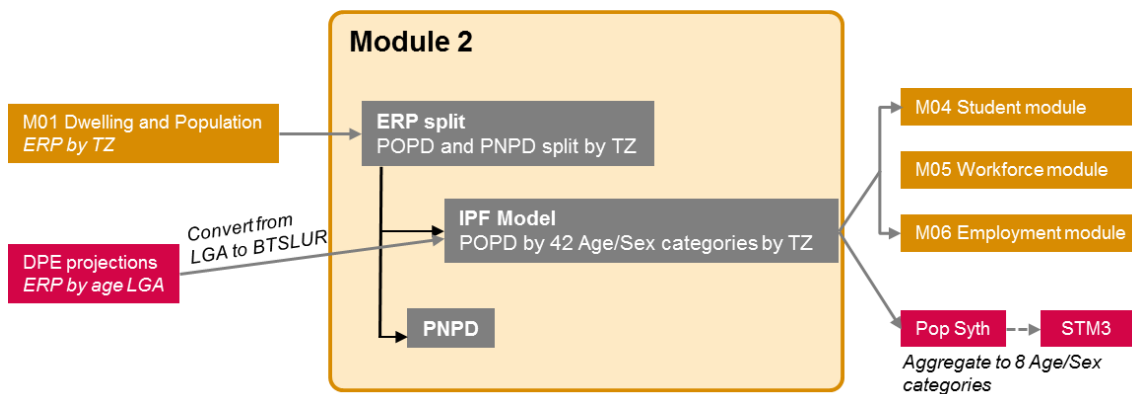
Estimated resident population (ERP) is comprised of two segments:

- People in occupied private dwellings (POPD) – Estimated resident population who reside in private dwellings. This represents approximately 98 per cent of the population.

- People in non-private dwellings (PNPD) – people who live in colleges, aged-care facilities, jails and other non-conventional dwelling forms. This segment of the population is not used for trip generation in the STM and is therefore not further disaggregated.

POPD is then disaggregated into a number of age-sex categories for each time period.

- 42 age by sex categories are created for use in subsequent modules.

- Results are aggregated to 8 age by sex categories for the population synthesiser and STM.

While the objective of the previous module was an accurate estimate of population levels in each travel zone, the age-sex module adopts these values and primarily focusses on their distribution across age-sex categories. As such, this process is almost entirely automated.

Iterative Proportional Fitting (IPF) is the approach used to disaggregate travel zone population control totals (POPD) into age-sex categories while maintaining an acknowledged age-sex distribution at the regional level.

Iterative proportional fitting (IFP) concept overview

IPF is a statistical method which aligns known totals to an estimated distribution. In the age-sex module, the total population (POPD) of each travel zone is known, having been estimated previously. Similarly, for each control region, the total for each age-sex category is known from DPE population by age-sex projections.

Using these totals, along with an approximated distribution, an iterative process is used to estimate the population in each age-sex category by travel zone. This process is run for every region in each period. For the base period (currently 2011), the IPF starting distribution is approximated using 2011 census data. Future periods align the final distribution of the preceding period as the starting distribution for the IPF procedure.

The IPF method is outlined below. The approach essentially involves a number of iterations where the distribution is aligned to row totals, then column totals and so on until a convergence criterion is achieved. This results in a final distribution which aligns with the base distribution while matching the row and column control totals.

Figure 22 IPF Procedure
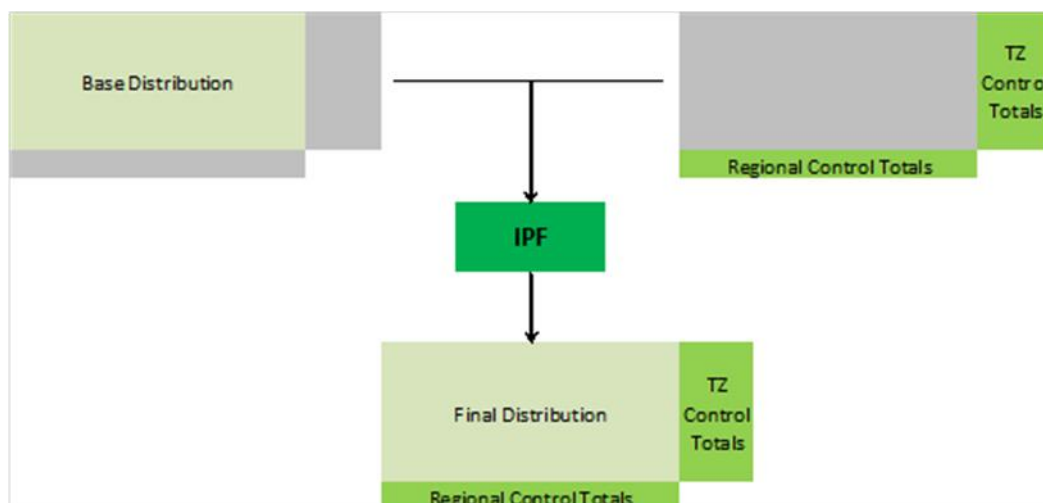
7.2   Module 2 Technical model overview

The following sections provide a brief overview of how the model spreadsheets operate.

Further documentation is included with each spreadsheet.

7.2.1   M02a – Data setup

Brings in relevant data from various sources and structures them for the IPF process.

Inputs

Key Inputs:

- Age by Sex census data by SA1 (obtained via ABS TableBuilder)
- SA1 to TZ11 concordance (obtained from GIS team)

Functions

This module performs two key functions:

- Convert SA1 level census data to TZ11
- Zones with a low total population are likely heavily influenced by ABS randomisation – these zones are adjusted to reflect the age-sex structure of the broader region.

7.2.2   M02b – Iterative Proportional Fitting

Performs IPF process to estimate age and sex breakdowns by Travel Zone over time

Key assumptions

- For future years, the IPF procedure uses the age-sex distribution of the previous period as a starting point.

  o This approach reflects that at small geographic levels, age distribution over time is more heavily influenced by migration than by cohort ageing (e.g. families locating in zones close to schools or young-adults migrating based on access to employment and housing forms)

  o Regional trends in age-sex structure are captured at a travel zone level by the IPF procedure.

- Future growth zones (which have no historical age-sex distribution) are assumed to have a starting distribution which mirrors the distribution of the broader region

Inputs

Key Inputs:

- Travel Zone control totals for ERP in OPD

- Base year ERP totals by Travel Zone

- Regional age-sex control totals

- Base year age-sex distribution by travel zone

The module requires a number of parameter inputs:

- Number of regions – set to 56 under the current BTSLUR structure

- Convergence criteria – iterative process is complete when the sum of the absolute differences (between estimated regional age-sex and regional age-sex control totals) are below this level

- Future year – module will perform IPF up to the specified year

- Base year – specify the base year (currently 2011)

- ERP_OPD Criteria – Specify the share of a Travel Zone's population that has to live in a private dwelling in order for the TZ specific age-sex distribution to be used. Travel Zones which do not satisfy this criteria will be assigned the regional age-sex distribution

- Input data structure – Defines the structure of 'TZ11 ERP' and 'Regional Age Sex Totals' sheets

  o Required for model to read input data correctly

  o Will need to be adjusted if a new regional or TZ structure is adopted

Functions

This module runs the IPF procedure to estimate the ERP in OPD within each age-sex category for the base year and all future periods.

The following is a summary of the estimation process:

- Read input parameter data

- For each region that requires estimation:

  o Read base year control total and age-sex distribution input data

  o Use IPF procedure to estimate final age-sex distribution in base year

  o For each future period:

- Read control total input data and age-sex output from previous period
- Use IPF procedure to estimate final age-sex distribution

7.2.3 M02c – Results and checking

Collates the output from M02b, performs validation checks and provides summaries by regions (currently BTSLUR), district and travel zone.

Functions

This module has four primary functions:

- The 'TZ ERP Validation' sheet checks that the final age-sex outputs sum to ERP in OPD control totals for each travel zone and year
    - All cells should equal 0 (displayed as '-')
- The 'Regional Validation' sheet checks that the sum of ERP in OPD within each age-sex category, across all constituent travel zones of each region, is equal to the corresponding regional control totals.
- All c ells should be ~0
- The 'Regional Summary' sheet aggregates the age-sex output into 5 categories and presents the results for each region and travel zone
    - Select region first then choose travel zone within that region
- The 'District Summary' sheet aggregates the age-sex output into 5 categories and presents the results for each district and travel zone
    - Select district first then choose travel zone within that district
    - District definitions can be changed using the 'District Definitions' sheet

Figure 23 M02c Output summary
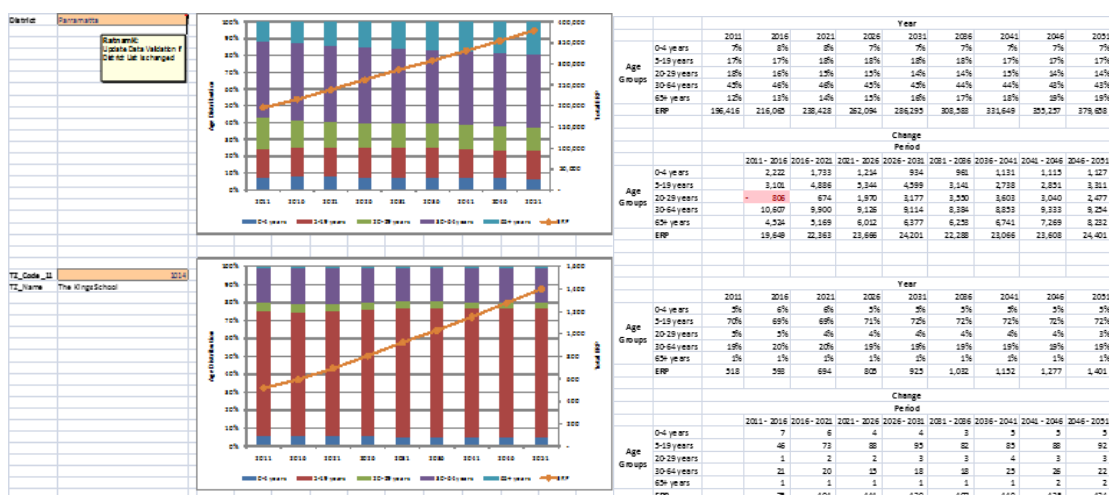
7.3   Comparison to LU14 approach

Figure 24 provides an overview of the previous approach used for September 2014 data release. The process was completed with a large number of formula based spreadsheets and post-processing adjustments were required to get the outputs in a suitable format for the Population Synthesiser (namely discounted to People in Occupied Private Dwellings).

Figure 24 Approach used during Sept 2014 data release
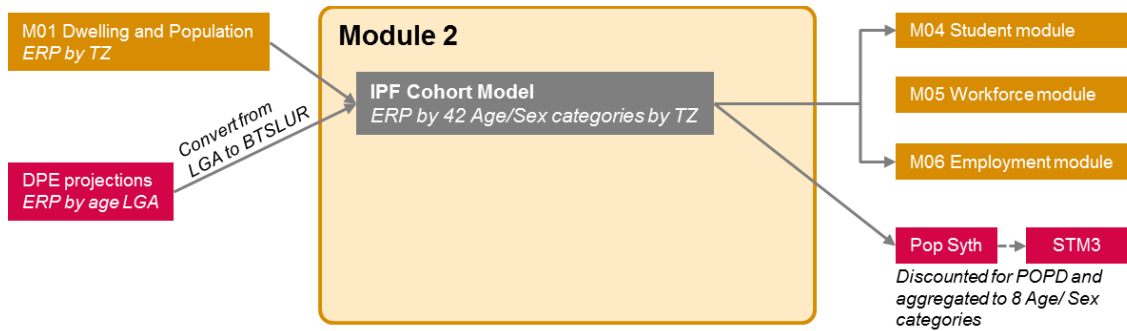
The new method entails three major methodological changes from the September 2014 approach. These methodological changes were adopted as they improve model accuracy, speed up processing time and better align outputs with the requirements of the population synthesiser.

The details of the new approach along with a brief analysis of their impact are presented below.

7.3.1 Modelling of POPD vs total ERP (POPD + PNPD)

The LU14 approach estimated the age-sex distribution of total ERP by travel zone. However, as the population synthesiser aligns with the Household Travel Survey (HTS) and therefore requires POPD only. Post-processing was required to create this during the September 2014 release.

The revised model produces age by sex projections for POPD specifically. As such, results are not directly comparable. However, they should broadly align as the vast majority of the population live in OPD. The following table illustrate how different POPD is to ERP for a number of geographies based on the LU14 release.

Table 9 Comparison of ERP and POPD

	ERP	POPD	% POPD
Greater Sydney and Surrounds	5,618,933	5,529,196	98.4%
Select SA4s			
Sydney - City and Inner South	283,784	273,716	96.5%
Sydney - Parramatta	413,886	405,555	98.0%
Illawarra	289,027	284,696	98.5%
Sydney - South West	376,582	373,845	99.3%
Selected Travel Zones (TZ11)			
236 - University of Sydney Main Camperdown Campus	984	41	4.2%
1018 - Parramatta Correctional Centre	628	50	8.0%
30 - Sydney CBD_Circular Quay Herald Square	44	35	80.5%
657 - Randwick Plaza	3,927	3715	94.6%
556 - Paddington	1,529	1,529	100.0%

7.3.2 Revised base year distribution

In the LU14 release the 2011 age-sex distribution was estimated using census data downloaded by single years. As the ABS introduces random errors to small numbers in order to protect confidentiality this level of disaggregation results in lower data quality.

Since a single year age breakdown is not required for modelling, the age-sex census data was re-extracted by 5-year age groups. This aggregated request means that the introduced random errors need to be applied to far fewer values, improving the accuracy of the distribution.

The marginal impact of this method was assessed by comparing the outputs of the original model against outputs of the new model (run using ERP, rather than POPD, for consistency). Across all zones and age-sex categories, the largest level change in population is 32. While the shift in methodology can cause large changes to the age-sex distribution in some zones, these are always areas which have an extremely small population. Across all zones and age-sex categories which experience a distribution change of greater than 5%, the maximum level change is 8 people.

7.3.3 Fixed age-sex distribution vs cohort distribution

The September 2014 release estimated the age-sex distribution of future periods based on an ageing cohort approach, whereas the revised method adopts the distribution of the previous period as the starting IPF distribution. This method has been chosen as it reflects a more realistic age-sex distribution at a travel zone level while also reducing the computational requirements of the model.

While a cohort approach is appropriate for large geographies, smaller regions are more heavily influenced by migration patterns than a locally ageing population. For example, factors such as housing form or proximity to employment and education are significant drivers at a local level. Under the revised method, individual travel zones will follow the age-sex trends of the broader region due to the IPF process (i.e. trends such as an ageing population will be captured) but will also retain their relative demographic characteristics. An example is presented on the following page

Travel Zone 2606 – Westfield Hurstville Station North
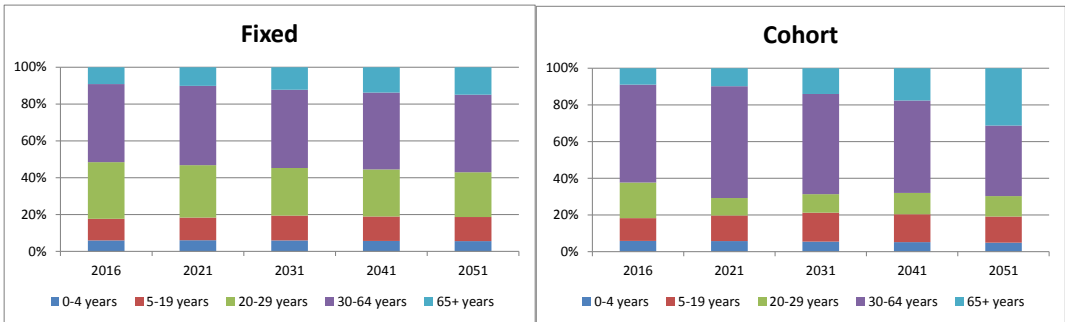
The travel zone of 'Westfield Hurstville Station North' is one which is heavily influenced by the use of a fixed age-sex starting distribution rather than a cohort approach for future periods. This particular zone, which contains both a train station and Westfield shopping centre, also has relatively high density housing forms.

Using the cohort distribution methodology, the initially high proportion of working age residents (20 – 64 years) age within the zone. This results in a 2051 age distribution which has a far higher proportion of retirement aged residents (65+). However, the relatively high accessibility and dense housing of the zone means that it is far more likely that it will remain similar to its current distribution (with changes only reflecting shifts in the regional distribution).
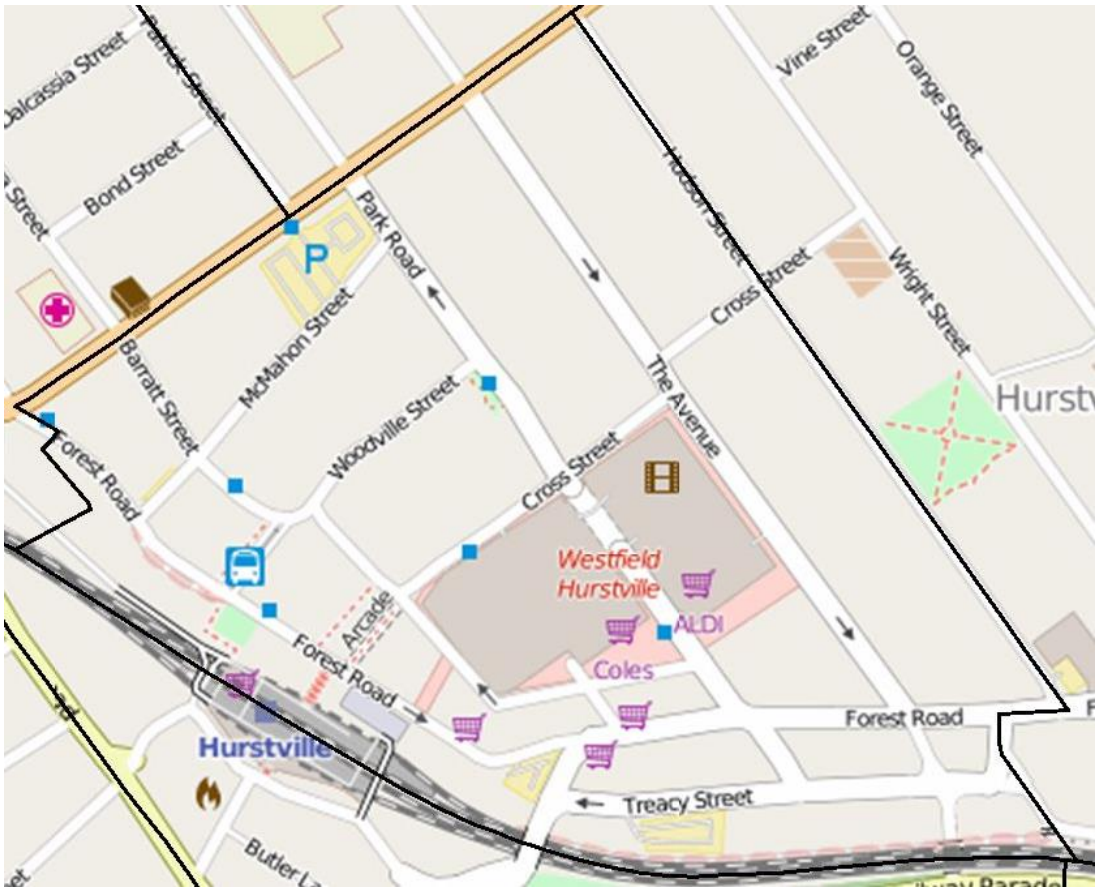
8 Module 3: Household type

8.1 Module 3 Overview

Only minor changes in the method were made to the Household by Type module which will be explained in Comparison to LU14 approach. The following diagram presents an overview of the module and how it interacts with the TZP framework.

Figure 25 Module 3: household by type overview
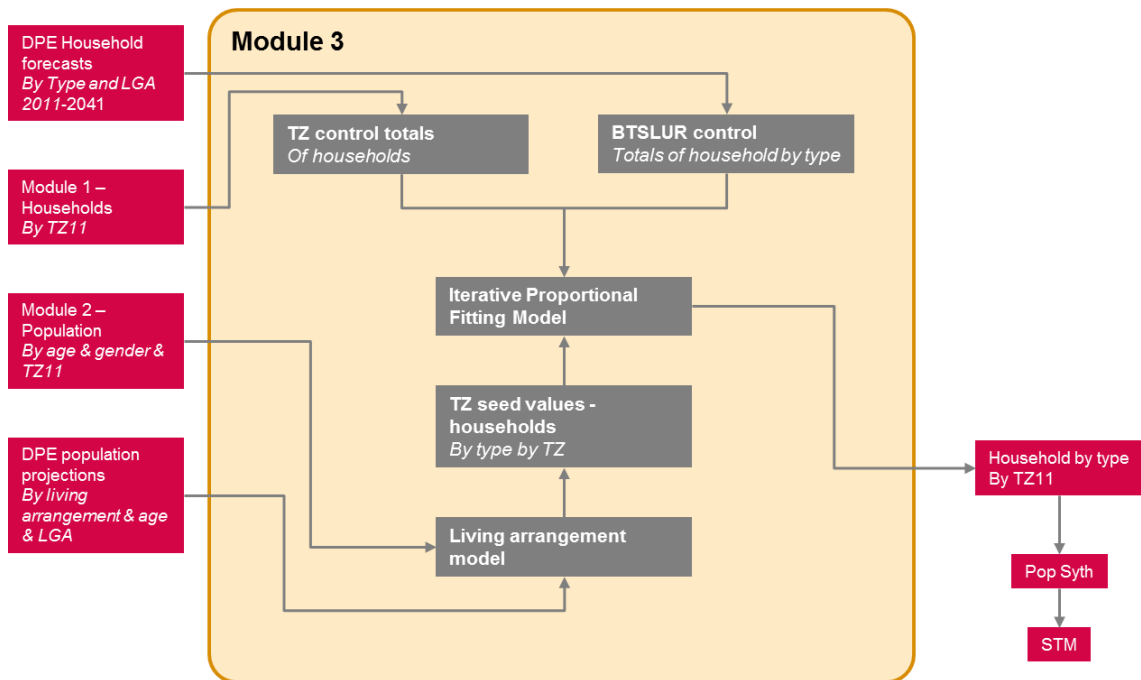
The primary function of the Household by Type module is to use the outputs of previous modules and DPE household forecasts and population projections to project household totals by type.

The household types considered are:

- Couples with Children
- Couples only
- Single parent
- Single person
- Other types (which comprises primarily group households).

The inputs into module 3 specify the household totals at the travel zone level and distribution of household types at the adjusted LGA level. Thus, the focus of module 3 is on the distribution of these household types at the travel zone level – this distribution is achieved using the Iterative Proportional Fitting (IPF) approach explained in Module 2 (Section 6).

For each time period the IPF approach requires an approximate distribution of household types at the travel zone level as a starting point, or 'seed value'. These seed values are generated and inferred from the population projections and living arrangement distributions provided by module 2 and DPE, respectively.

8.2 Module 3 technical spreadsheet overview

The following sections provide a brief overview of how the model spreadsheets operate.

Further documentation is included with each spreadsheet.

8.2.1 M03a – Adjusted LGA population

This module converts LGA level population forecasts by age and living arrangement to the Adjusted LGA level.

Inputs

Key Inputs:

- LGA population forecasts by age and living arrangement 2016-2041 (provided by DPE)
- LGA to Adjusted LGA concordance (supplied by TPA)

Functions

This module performs the following function:

- Converts LGA level population forecasts by age and living arrangement to the Adjusted LGA level

8.2.2 M03b – Living arrangement propensities

This module generates population living arrangement propensities by age and household type from the output of M03a.

Key assumptions

To convert the population in occupied private dwellings projected by age and living arrangement to population projection by age and household type the following table is used.

Table 10 Household groups definition

Population in OPDs	Couples with children	Children <15 with 2 parents Child aged 15+ living at home Partnered with children <15 Partnered with children 15+
	Couples only	Partnered with no children at all
	Single parent	Single parent with children <15 Single parent with children 15+ only Living alone
	Single person	Single in a group household
	Group	Single in a group household
Population in NPDs		

Inputs

Key Input:

- Adjusted LGA population forecasts by age and living arrangement 2016-2041 (output from M03a)

Functions

This module performs the following functions:

- Converts population projection by age and living arrangement to population projection by age and household type
- Calculates the Adjusted LGA population living arrangement propensities by age and household type for 2016-2041

8.2.3 M03c – Calculating seed values

Estimates the distribution of households by type at the travel zone level for 2016-2041.

Key assumptions

- Only persons of age 15 + are considered in the Household by Type categories
- To convert population projections by household type to household projections the following Household-Population factors are assumed for all travel zones.

Table 11 Household – Population factors

Household type	Scale factor
Couples with children	0.5
Couples only	0.5
Single parent	1.0
Single person	1.0
Group	0.449

Inputs

Key Inputs:

- Adjusted LGA population living arrangement propensities by age and household type 2016-2041 (output from M03b)
- TZ11 population projections by sex and age 2016-2041 (output from M02b)
- Group headship data 2011 (2011 Census of Population and Housing)

Functions

This module performs the following functions:

- Converts TZ11 population projections by sex and age to TZ11 population projection by age
- Generates population by age and household type projections 2016-2041

Estimates the TZ11 distribution of households by type for 2016-2041

8.2.4 M03d – Running the IPF

This module estimates the distribution of households by type for 2016-2051.

Key assumptions

- The Adjusted LGA household projections by type are extended to 2056 by
  assuming the Adjusted LGA distribution of household types remains fixed from
  2051

Inputs

Key Inputs:

- TZ11 household projections 2016-2056 (output from M01b)

- Adjusted LGA household projections by type 2016-2051 (supplied by TPA)

- Estimate of the TZ11 household distribution by type 2016-2041 (output from
  M03c)

Functions

This module performs the following functions:

- Extends the adjusted LGA household projections by type data to 2056

- Performs the IPF procedure using seed values for 2016-2041 from M03

- Performs the IPF procedure for 2046-2051 using seed values from the IPF
  output of the previous time period

8.3   Comparison to LU14 approach

Only one minor change has been made to the previous approach used for the
September 2014 data release. This revision relates to the spreadsheet M03b – Living
arrangement propensities and flows through to the final spreadsheets M03c –
Calculating seed values and M03d – Running the IPF. The revised approach assists
in streamlining the household by type module without out adversely affecting the
accuracy of projections.

The previous approach extended the output of M03b from 2041 to 2046 and 2051 by
applying the linear trend of the change between 2036 and 2041 for each age bracket
and each adjusted LGA. This extension then allowed the seed values for the years
2016-2051 to be generated from M03c in the previous approach.

The revised method does not extend the output of M03b to 2046 and 2051 and hence
does not generate seed values for the years 2041 and 2051 in M03c. Instead these
seed values are taken from the output of the IPF procedure for the previous time
period. This process and extension of projection to 2046 and 2051 is automated and
fully contained within M04d.

9 Module 4: Enrolments

This chapter provides a summary of the revised student enrolment module which has been reviewed and currently further developed by SGS. Included in this chapter is analysis of the current approach and the revised approach.

9.1 Module 4 overview

The primary function of the student enrolment module is to use some outputs from previous modules to project primary, secondary and tertiary enrolments. The outputs generated from this module will result in Primary, Secondary and Tertiary enrolments at the place of institution.

Figure 26 Module 4: Enrolment approach overview
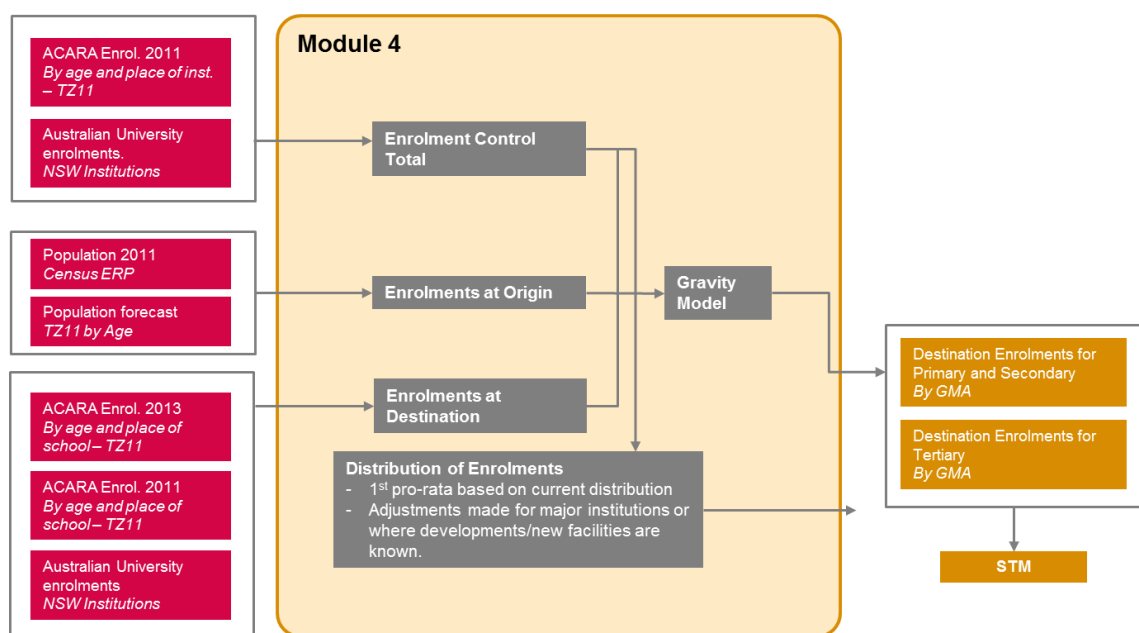
9.2 Module 4 technical model overview

9.2.1 Module 4a: Enrolment Control Total

This module produces the enrolment control totals for residents within the NSW region. These control totals are used in the Module 4b. The IPF method is used to calculate the distribution of age to education enrolment.

Input

- 2011 Census data detailing current age and education status.
- Outputs of Population by Age as produced in M02b
- NSW current school enrolments at 2011 produced by ACARA
- Tertiary enrolments data provided by Department of Education and Training and National Centre for Vocational Education Research

Functions

- The 'IPF Output' sheet draws on all other input sheets to produce the enrolment control totals. The IPF method used is the same as used to produce

outputs in Module 2. The IPF method is applied to calculate the distribution age groups by education enrolment.

9.2.2 Module 4b: Enrolled residents by travel zone

This module estimates the total number of enrolled residents by travel zone. This module utilises the IPF method to distribute age control totals by institution enrolment. The ERP by age group by travel zone totals are estimated in Module 2 are aligned with the state regional enrolled resident control totals as estimated in Module 4a. This ensures the total number of enrolled persons by school type for each travel zone is equal to the population total for that travel zone as well as being equal to the institution type.

Inputs

- Census data
- M02b age data
- M04a control totals
- IPF parameters

Functions

- **"Base data":** This sheet requires inputs from various sources. This data will provide the base data for the IPF to run. The distribution data by travel zone by age and institution is derived from Census data. Total ERP by age and travel zone is extracted from M02b. Control totals by age and institution is derived from M04a results.

- **"Macro Trends":** This is derived from share calculations dependant on the results of M04a. The propensity for each age group to enrol into a specific institution is based on Census data. These propensities are applied to 2016-2051 ERP totals to derive the control totals by age and institution.

- **"Input Control Totals":** Control totals for 2011 come from M04a. For years 2016-2051, institution control totals are trended based on the shares determined in the sheet 'Macro Trends'

- **"Input Distribution":** Reading from the sheet 'Base data'. The distribution is only needed for 2011. The IPF for years 2016-2051 is dependent on the results of the previous year's distribution. Essentially, the Census distribution is used consistently to inform all distributions. This method is similar to the method used in M02b.

- **"Input Parameters":** This sheet requires inputs to the IPF calculations. The user will need to input the number of zones to be calculated.

Key assumptions

- Macro trends are based on Census trends. This assumption is linear but currently the best estimate.

- 2011 Census distribution is the base for IPF. This distribution essentially informs the future years as the IPF calculations draw on the distribution determined in the previous year.

9.2.3 Module 4c: Destination Enrolments

This module collates the two key datasets and allocates a travel zone to each school listed to determine the base year (2011) distribution of enrolments. The current capacity of each school is currently being analysed. The forecasts given by the

Department of Education are linear. These forecasts will be used as a base for determining the capacities of each school.

The Department of Education has specific capacity parameters for schools. They are:

- Primary schools can only allow for a maximum of 1,000 students without any major work being completed to the school site.

- Secondary schools can only allow for a maximum of 2,000 students without any major work being completed to the school site.

- These capacities are further restricted to allow a minimum of 10 sqm of play space/green area per child on the school site.

Inputs

- ACARA enrolments data at 2011

- Department of Education enrolments data and forecasts for primary and secondary schools

Key assumptions

School capacities are a major assumption in this module. The Department of Education is currently reviewing their capacity forecasts. This data is not currently available. This means significant assumptions around school capacities will be made in this module as well as any development of new schools. This module will be created to allow for Department of Education forecasts to be easily fed into the model once they are available.

9.2.4 Module 4d: Enrolment Projection for Primary and Secondary Schools

This module estimates the small area destination enrolments in each future year out to 2051 using a gravity model.

Inputs

- Capacity of each school by type by travel zone into the future, assumptions are made regarding the approximate locations/size of future schools as detailed in M04c. This is only a 'capacity' input and students are only allocated to this capacity if there is sufficient demand estimated by the gravity model.

- Origin enrolled persons by school type by travel zone as detailed in M04b

- Travel time matrix for each travel zone in NSW and each school travel zone as provided by TPA. .

A gravity model essentially uses the following conceptual structure estimates the propensity for a student to attend a school. This propensity is calculated from every travel zone to every school.

$$\text{Propensity to attend a school by type} = \frac{\text{Estimated preference}}{\text{Travel time to school}}$$

A different propensity is calculated for each type of student: primary Government, primary non-government, secondary Government and secondary non-government. The estimated preference is not an input; it is calculated in the base year using actual enrolment origin/destination data. This is then used for the next year. The estimated preference adjusts each year if schools reach capacity to reduce the schools 'pull'. This approach results in students attending the closest school (within capacity constraints) adjusted by known preference behaviours (i.e. more prestigious schools will draw a wider catchment).

9.2.5 Module 4e: Tertiary Enrolments

This module estimates tertiary enrolments for the destination of students at both TAFE and University under a Full time and Part time split. First it collates the Tertiary enrolments data and allocates a travel zone(s) to each institution. The total of enrolled persons in 2011 from M04a is then compared to the total from the enrolments data to determine an upscale factor. This is then applied to the origin data for each travel zone to determine the number of enrolments by place of residence for each year from 2011 to 2051. This new total was then re-distributed to each travel zone with a tertiary institution using the base data to estimate the final destination enrolments by place of attendance. Shares for institution by type are then adjusted for future periods to reflect planned redevelopments/expansions where information is available.

9.3 Comparison with LU14 approach

Figure 27 2014 method of projecting enrolments
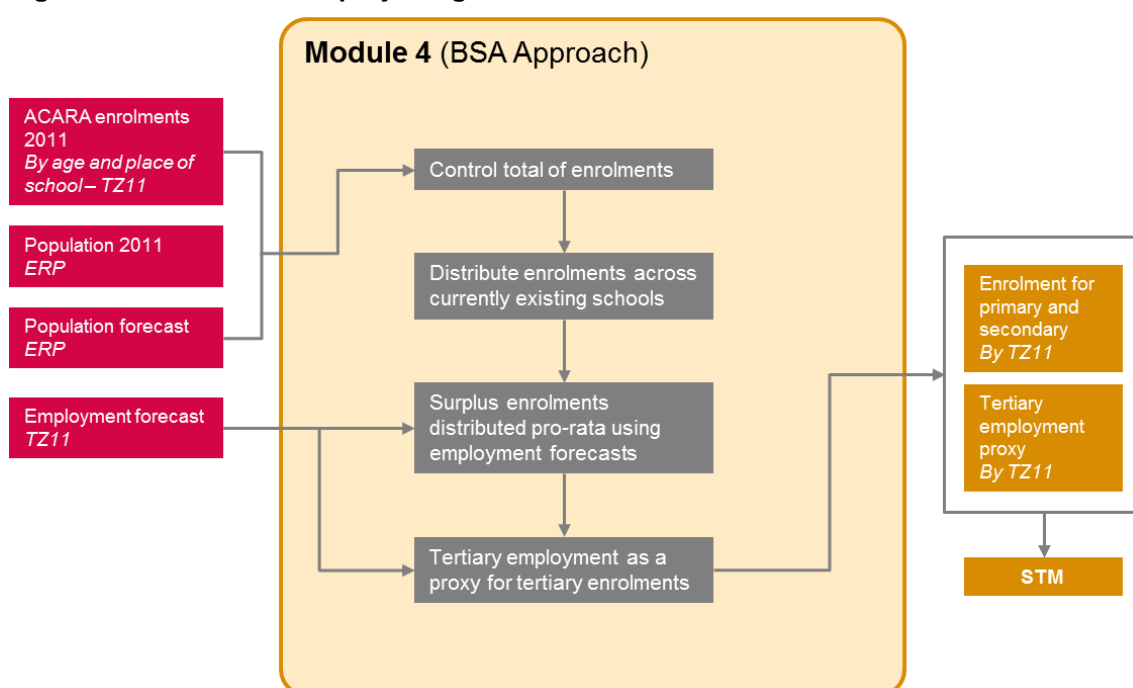
The model uses three major inputs:

- Population projections for primary and secondary school age groups. This is population at usual residence.

- 5-12 years

- 13-19 years

- JTW data used to determine employment

- 2011 enrolment data for private and non-private schools data obtained from ACARA. These enrolments have been concorded to the relevant travel zones. The data is only for current employment at 2011. This is the control total for 2011.

Unused data sources

Enrolment data obtained from the Department of Education was not used to inform the projections. Two sets of forecasts were given:

- Public school enrolment forecast – this dataset contains historic enrolments from 2006-2015. The forecast starts at 2016 and projected out to 2051. The

dataset identifies each school and the LGA it falls within. Three different scenarios were forecast in this dataset: a high, low and likely scenario(s). These forecasts are primarily based on the population forecast provided by the DP&E.

- Non-government schools – this dataset is provided at an aggregate sub-region level. 2011 is the only historical data point provided.

The dataset was not used as the enrolments data for *non-public schools* was only provided at a sub-region level. Disaggregation of this data was considered a problem.

Method

The ACARA enrolment data is used to determine the ratio of enrolment to school age population within the GMA. The ratio is produced for both primary and secondary enrolments. These ratios are then applied to the population projection for school age groups to obtain the control totals for enrolments across the GMA.

Distributing the control total of enrolments across the travel zones is done using the following steps:

- Projected known 'schools' (i.e. place of enrolment by travel zones). It is assumed existing 'schools' are at 99.9% capacity thus only growing the enrolment by 0.01% every projection year.

- The remaining enrolments that cannot be accommodated by the existing schools are then apportioned out according to the employment projections for each travel zone.

- A ratio of population to employment for each travel zone is determined. This ratio is used to allocate the remaining enrolments.

Assumptions

- Enrolments are capped at 88.3% and 79.2% – for primary and secondary schools respectively – in relation to population. This is based on the 2011 ACARA data compared to 2011 population data.

- All current schools are at 99.9% capacity and will only grow at 0.01% over the projection.

- The surplus of enrolments is distributed across the travel zones using a population to employment ratio for primary and secondary jobs. This distribution only occurs for those travel zones that have population growth but no current enrolment data.

- This ratio is based on JTW at the travel zone level. Employment by education is broken down to the four digit level. The percentage split of employment between primary and secondary schools is then attained at that level. For travel zones that do not contain enough information on jobs for specifically primary or secondary education – the split is used from the SA2.

Limitations

- Capping enrolments to population based on ACARA data may be underestimating total enrolments. Using the DP&E estimations of enrolments shows there is much higher enrolment total than attained by ACARA.

- The assumption of schools within the travel zones already at capacity is limited. It does not account for the growth in primary and secondary employment for these travel zones. This is contradictory of the second assumption used to allocate the 'surplus' enrolments for travel zones that do not have any historical enrolment data (i.e. no 'school'). Further, the Department of Education historical data provides some indication to school

capacity – some school enrolments have grown over 200% from 2006 to 2015.

- This method does not consider spatial movements. That is enrolment within a travel zone that does not have a school is not then allocated to an adjacent or close by travel zone that has a school.

10 Module 5: Workforce segmentation

10.1 Module 5 overview

The following diagram presents an overview of the revised Workforce module and how it interacts with the broader TZP framework.

Figure 28 Module 5: Workforce approach overview
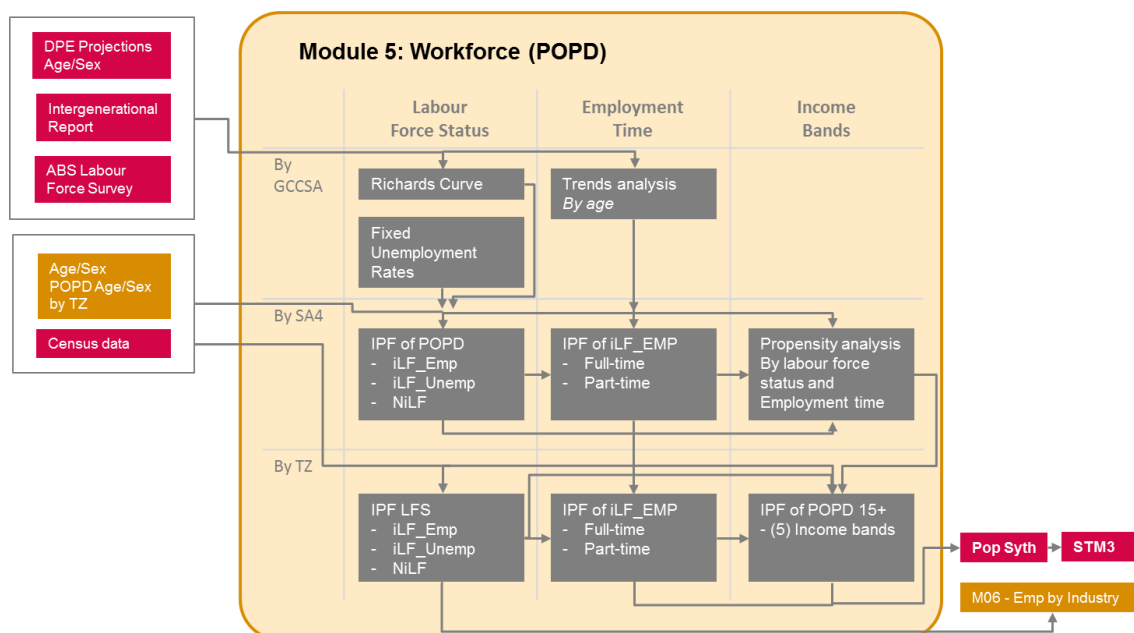
The primary function of the Workforce module is to use the outputs of prior modules to project various segmentations of the working age population in a largely automated manner. It essentially does this three times at different geographic scales: Greater Sydney; sub-regions (SA4s), and finally by TZ. The module also breaks down the data in three stages: Workforce Status, Employment status (full-time/part time) and Income Bands. Trends and external data sources are used for high geographies, while a more automated approach is used for smaller geographies.

Specifically the outputs generated by the Workforce modules include:

Segmentation of the working age population (POPD 15+) by workforce status	Segmentation of employed population by employment status (full time/part time)	Segmentation of the working age population (POPD ≥15) by income bands*
• In Workforce and Employed • In Workforce and Unemployed • Not In Workforce	• Employed full-time • Employed part-time	• $0 - $20,799 • $20,800 - $31,199 • $31,200 - $41,599 • $41,600 - $65,000 • ≥$65,000

* It should be noted that the final two income bands generated do not exactly match the bands of the HTS (which are $41,600 - $67,599 and ≥$67,600).

Before each module is described individually the following provides some broader reasoning and processes elements established in this Module:

	Workforce Status	Employment time	Income Bands
By GCCSA	Disaggregation is first undertaken at the metropolitan level for a number of reasons: • The analysis can draw on a wider range of datasets and research which is only available at a more aggregate geographic level. • More complex modelling and analysis can be completed which is not possible for 100s/1,000s of areas. • The data can be easily checked against other key indicators and form a benchmark for subsequent disaggregation. (e.g. projected participation rates can be converted to a total workforce for Sydney and checked against national and state trends and jobs growth)		
By GCCSA	Participation rates estimation focuses on projecting entry/exit rates for each of the 42 age-sex group over time. This captures both changing behaviour (i.e. females having children later) and the evolving age profile of the city. While unemployment fluctuates significantly in the short-term due to economic cycles it is relatively stable in the long term. Therefore, analysis has focused on estimating a reasonable long term (stable) rate.	A wide number of factors contribute to full/part time split. From industry structure, to economic cycles and labour market constraints. Analysis showed the propensity to work part-time is primarily driven by age (e.g. young people studying or older people reducing their hours). Therefore, it has been used to project this attribute over time.	Income distribution is not modelled by GCCSA. This is because labour force survey data at an SA4 level is equally robust for the chosen method (see below).
By SA4	The stage 1 IPF process produces regional level control totals. It is better to complete this process in two stages, rather than jumping straight down to TZ level for a number of reasons: • Additional sub-regional (SA4) data that is not available at a TZ level can be draw into the process • Additional checks and QA can be performed at an aggregate level where results are easier to interpret (i.e. the number of workers in the "Eastern Suburbs" and be checked rather than just TZ 456.)		

	Workforce Status	Employment time	Income Bands
By SA4	This captures regional (SA4) variations in both workforce characteristics and demographic structure. This intermediate step enables the incorporation of the most recent labour force survey data, which is more recent and robust than census data.	This captures regional (SA4) variations in both workforce characteristics and demographic structure. This intermediate step enables the incorporation of the most recent labour force survey data, which is more recent and robust than census data.	Income distribution is complex and similar to full/part time split is influenced by a wide range of factors. Analysis similarly showed that the workforce status and employment time are the most significant determinants (and are also influenced by age-sex structure) and hence were used to project this attribute. As real income growth will cause a shift across income bands, an appropriate rate (currently IGR forecast) is chosen to account for this.
By TZ	Robust metropolitan and sub-regional control totals should now have been established. Therefore, the final IPF process has a much less significant task and simply needs to disaggregate these control totals reasonably across the current and projected population by TZ. Census data is used to capture local variations within each SA4.		

10.2 Module 5 technical spreadsheet overview

10.2.1 Module 05a/b – Participation Rate for Greater Sydney and Rest of NSW

These sheets involve projecting participation rates (PR) by age and sex at a high geographic level (Greater Sydney and Rest of NSW). A cohort based projecting approach, which is consistent with the method which is used both internationally and by the Productivity Commission, has been utilised.

Unlike a direct projection of PR, a cohort approach captures the differing labour market behaviour across generations (caused by factors such as shifting social attitudes or changes to the aptitudes/opportunities of the population).

The cohort approach requires the rates at which cohorts enter or exit the labour market to be modelled. Ignoring net changes to the civilian population of an age cohort (migration, births and deaths), an entry rate represents the proportion of those who are currently not in the workforce that enter the workforce in the next period, while an exit rate represents the proportion of those who are currently in the workforce that will leave the workforce in the next period.

Entry Rate Example:

In the 20-24 year old age group in 1990 there are 200 people in the workforce and 100 who are not in the workforce (participation rate of 66.6%).

If in 1995 there are 250 people in the 25-29 year old age group in the workforce (and 50 not in the workforce), then the entry rate for 20-24 year olds in 1990 was equal to 50%. Alternatively, this represents a PR of 83.3% for the 25-29 year old age group in 1995.

This entry rate could represent students completing university and entering the workforce. Changing attitudes, such as students preferring to study for longer, could result in the entry rate of 20-24 year olds decreasing over time.

A detailed description of the cohort based approach can be found in Technical Paper 3 of the 2005 Productivity Commission Report 'Economic Implications of an Ageing Australia'. A discussion of Richards curves can be found in Technical Paper 2'. These can be accessed via the following link: http://www.pc.gov.au/inquiries/completed/ageing/technicalpapers

While both entry and exit rates have an upper bound of 1, a lower limit does not theoretically exist. For a given age-sex category, it is therefore appropriate to model the rate which will be positive in future years.

Once the appropriate type of rate is chosen, it is modelled using a Richards curve (generalised logistic function). A Richards curve has desired property of being bounded and, as discussed in the Productivity Commission report, has the advantage of a greater degree of flexibility (e.g. it does not have to be not symmetric).

Richards Curves

The functional form of a Richards curve is: $y = c + \dfrac{a}{(1 + b \times e^{-g \times t})^\lambda}$

The diagram below presents a Richards curve with parameters:

$$a = 25, b = 0.001, c = 20, g = -0.4, \lambda = 0.2$$
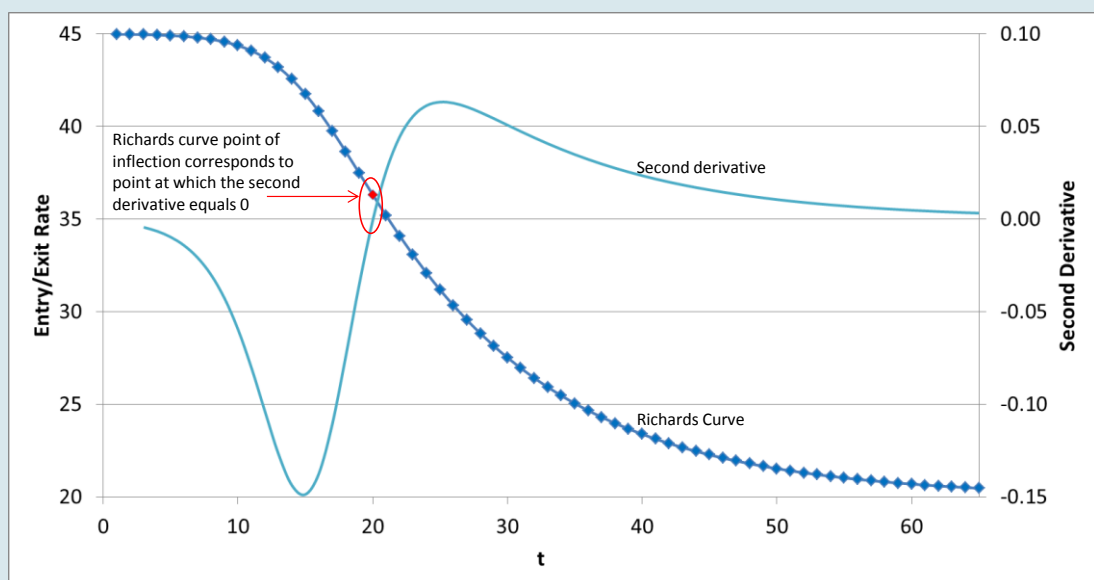
As shown above, the point of inflection of a Richards curve is defined as the point at which its second derivative is zero. This is of significance because if the point of inflection is known, one less parameter needs to be estimated.

Inputs

Key Inputs:

- Labour Force Survey participation rate data - ABS cat 6291.0.55.001 (LM2)

The module requires a number of initial parameter inputs. The 'Input Parameters' sheet will load the relevant data into the individual participation rate projection sheets:

- Number of historical entry/exit rate observations

- First and last years of entry/exit rate observations

- Number of PR observations (this will be 5 years more than the number of entry/exit rate observations, as age cohorts are in 5 yearly groups)

- First and last years of participation rate observations

- Base year – specify the base year (currently 2011)

- Choice of rate to be modelled for each age-sex category

- Choose rate to be modelled based on visual inspection of the 'Entry Rates' and 'Exit Rates' sheets.

- Choose the rate that will be positive in future years

- Maximum PR by sex

- Define participation rate upper bound for each sex (currently based on existing literature which recommends 99% for males and 95% for females)

Once the model has been initialised, a number of inputs are required to model each age-sex category:

- Estimated point of inflection year for entry/exit rate series

- For chosen start and end years, the model will interpolate (or extrapolate) to determine the point at which the second derivative of the series is equal to 0

- Professional judgement as to the most likely point of inflection is required if the second difference series intersects the horizontal axis multiple times

- Select start and end years for Richards curve fitting

- Algorithm will fit curve to only these years of historical data

- Multiple trials may be required to achieve most suitable long term curve

- Starting values for parameters a,b,c and λ must be chosen.

- Multiple trials may be required in order for algorithm to suitable fit

Functions

- The 'Smoothed PR Data' sheet adjusts the input PR data using a Hodrick-Prescott Filter

  - The HP filter is a mathematical algorithm which is used to remove the cyclical component of a time series, resulting in a series that is more sensitive to long-term shocks.

  - The parameter λ, which relates to the penalty for changes in the long-term growth rate, is currently set at 100 (suggested value for annual data)

- On each age group sheet, projected PR of each age-sex category by fitting a Richards curve to historical entry or exit rate data. The following is a summary of the process:

  - Calculate point of inflection based on user inputs

- o Based on chosen years, point of inflection and starting parameter values, use solver algorithm (inbuilt to MS Excel) to compute parameters which minimise the sum of squared errors between the estimated entry/exit rate values and historical data
- The 'Smoothed Projected PR' and 'Projected PR' sheets combine historical PR with the projected entry/exit rates in order to project participation rates by age-sex category
- The 'Summary Charts' sheet provides the means for checking the final PR projections (viewed alongside both actual and smoothed historical PR data)

10.2.2 Module 05c – Unemployment rate for Greater Sydney and Rest of NSW

Module 5c projects unemployment rates by age group for Greater Sydney and the Rest of NSW based on user-defined assumptions regarding their long term ranges for overall (non-age specific) unemployment rates.

Historical unemployment rate data is used to determine the unemployment rate of specific age groups for periods when the regional rate was within a given range.

Unemployment Rate Example:

The overall long term unemployment rate forecast of the IGR is 5%. Based on this forecast, the long term unemployment rates for Greater Sydney could be defined to vary between 4% and 6%.

Examining the period spanning from 1991 to 2015, for periods when the Greater Sydney unemployment rate fell between 4% and 6%, the average unemployment rates for 20-24 year old males and 40-44 year old females were 8% and 4% respectively.

Inputs

- Labour Force Survey data – ABS cat 6291.0.55.001 (LM2)
- Upper and lower bounds of overall unemployment rate forecasts for
  - o Greater Sydney
  - o Rest of NSW (likely higher than Sydney)

Functions

- The 'Unemployment Rate' sheet identifies the historical years for which overall unemployment was within the user-defined assumption of long term unemployment rate ranges
- Using data from only these identified years, the 'Long Term Unemployment Projection' sheet computes age-specific unemployment rate projections

10.2.3 Module 05d – Workforce Base Data

The purpose of M05d is to synthesise data from various sources and structure the outputs such that they can be used as inputs to the IPF procedures in M05e, M05g and M05h. However, this module also provides a means to review the projections of workforce status and employment time at a metropolitan level (in order to ensure that projected trends for Sydney and Rest of NSW are reasonable before further disaggregation).

Inputs

Key Inputs:

- SA1 to TZ11 concordance (obtained from GIS team)

- Labour force status by age by SA1 (obtained via TableBuilder)

- Employment time by age by SA1 (obtained via TableBuilder)

- Income band by employment time by SA1 (obtained via TableBuilder)

- Travel zone control totals for ERP in OPD by age (obtained from M02b)

- Labour force survey participation rate and unemployment rate data by age by SA4 (base year and most recent year)

- Historical and projected participation rate and unemployment rate data by age by GCCSA (obtained from M05a, M05b and M05c)

- GMA population in occupied private dwellings by age by sex by GCCSA

- GMA population in occupied private dwellings by age by sex by SA4

- GMA population in non-private dwellings by age by sex by GCCSA

- Historical and projected part-time employment shares by age by GCCSA (obtained from M05f)

- Parameter input: Base year of model

Functions

The first function of M05d is to produce GCCSA control totals and SA4 starting distributions for the stage 1 IPF processes of M05e (workforce status segmentation) and M05g (employment time segmentation). Once inputs are finalised, a macro computes the outputs via the processes described below:

- The model combines the GCCSA participation rate, unemployment rate and part-time employment rate inputs with population (in OPD) by age by sex data to produce GCCSA control totals for each workforce and employment time category

  - This process is replicated for population in non-private dwellings at a GCCSA level for workforce status only. This output is required to determine the overall size of the GMA workforce – used in employment module

- SA4 IPF starting distributions for the base year are computed using participation/unemployment/part-time employment rates from the base year labour force survey in conjunction with SA4 age-sex structures

- SA4 IPF starting distributions for projected years are computed using participation/unemployment/part-time employment rates from the most recent labour force survey in conjunction with SA4 age-sex structures of the relevant projected year

The second function of the module is to estimate the travel zone starting distributions for the stage 2 IPF processes of M05e (workforce status segmentation) and M05g (employment time segmentation). It also computes age-specific income band propensities by TZ (which are used in M05h to calculate IPF process starting distributions). This follows the process outlined below:

- Convert SA1 level census data to TZ11

- Zones with a low total population are likely heavily influenced by ABS randomisation – these zones are adjusted to reflect the structure of the broader region. This results in the following propensities:

- Workforce status propensity by age group

- Employment time propensity by age group

- Income band propensity by workforce characteristics (employed full-time, employed part-time, unemployed and not in the workforce)

- For each year, IPF starting distributions for workforce status and employment time segmentation are calculated by combining the propensities by age group with the projected age structure of each travel zone

- For each year, the IPF starting distribution for income band segmentation is calculated by combining the income band propensities by workforce characteristics with projections of workforce status (obtained from M05e) and employment-time (obtained from M05h).

Finally, results for Greater Sydney and Rest of NSW can be reviewed as shown below.

Figure 29 M05D Review of workforce segments

Greater Sydney ▼									
	iLF_emp	iLF_unemp	NiLF	Pop15+	Pop15-29	Pop30-64	Pop65+	PR	UR
2011	2,306,959	123,378	1,243,593	3,673,929	990,148	2,134,108	549,673	66.2%	5.1%
2016	2,528,884	125,506	1,333,885	3,988,275	1,009,501	2,322,567	656,207	66.6%	4.7%
2021	2,733,598	133,468	1,451,597	4,318,663	1,036,016	2,513,826	768,821	66.4%	4.7%
2026	2,939,526	142,748	1,585,433	4,667,708	1,096,775	2,673,347	897,587	66.0%	4.6%
2031	3,157,945	153,281	1,726,772	5,037,998	1,185,792	2,828,298	1,023,908	65.7%	4.6%
2036	3,396,565	164,647	1,867,310	5,428,522	1,288,513	2,994,203	1,145,806	65.6%	4.6%
2041	3,641,506	175,846	2,003,440	5,820,792	1,379,894	3,172,615	1,268,283	65.6%	4.6%
2046	3,878,955	186,334	2,135,576	6,200,865	1,452,199	3,363,624	1,385,043	65.6%	4.6%
2051	4,108,348	196,408	2,270,349	6,575,105	1,516,849	3,539,433	1,518,823	65.5%	4.6%
2056	4,332,687	206,851	2,417,174	6,956,712	1,588,293	3,713,706	1,654,714	65.3%	5%
2061	-	-	-	-	-	-	-	#DIV/0!	#DIV/0!

10.2.4   Module 05e – Workforce IPF

Performs 2 stage IPF process which first estimates workforce status segmentation by SA4 and then by travel zone over time.

Inputs

Key Inputs (from M05d):

- Greater Sydney and Rest of NSW control totals by workforce segment and year

- POPD by SA4 and year

- Starting IPF process distribution of workforce segment by SA4 and year

- POPD by travel zone and year

- Starting IPF process distribution of workforce segment by travel zone and year

The module also requires a number of parameter inputs:

- Number of SA4s within Greater Sydney and Rest of NSW (15 and 13 respectively)

- Convergence criteria – iterative process is complete when the sum of the absolute differences (between estimated regional workforce segment totals and regional workforce segment control totals) are below this level

- Future year – module will perform IPF up to the specified year

- Base year – specify the base year (currently 2011)

- Input data structure – Defines the data structure of the SA4 and travel zone level input sheets

- Required for model to read input data correctly

Functions

This module first runs the IPF procedure to estimate the ERP in OPD, by SA4, within each workforce category. Using these as regional control totals, a second IPF process then estimates the workforce segments for all constituent travel zones. The estimation process is summarised below:

- Read input parameter data

- For each year and region that requires estimation

  - Read Greater Sydney and Rest of NSW workforce segment control totals, SA4 ERP in OPD control totals and starting distribution data

- Use IPF procedure to estimate final SA4 workforce distribution

- For each year and region that underwent the first stage IPF procedure

  - Read travel zone ERP in OPD control totals and starting distribution data (see above for calculation detail)

- Use IPF procedure to estimate final travel zone workforce distribution.

10.2.5 Module 05f – Workforce Part-Time Rates

At a metropolitan level (i.e. Greater Sydney and Rest of NSW), module 05f utilises historical labour force survey data to project age-specific propensities for workers to engage in part-time employment.

The modelling approach chosen is a univariate log-log regression. While a cohort approach, similar to that used in M05a/b was considered, the log-log regression method was selected due to the fact that it achieves reasonable projections with a far greater degree of automation.

Log-log regression

The estimated regression: $\log PR = \alpha + \beta \log t$
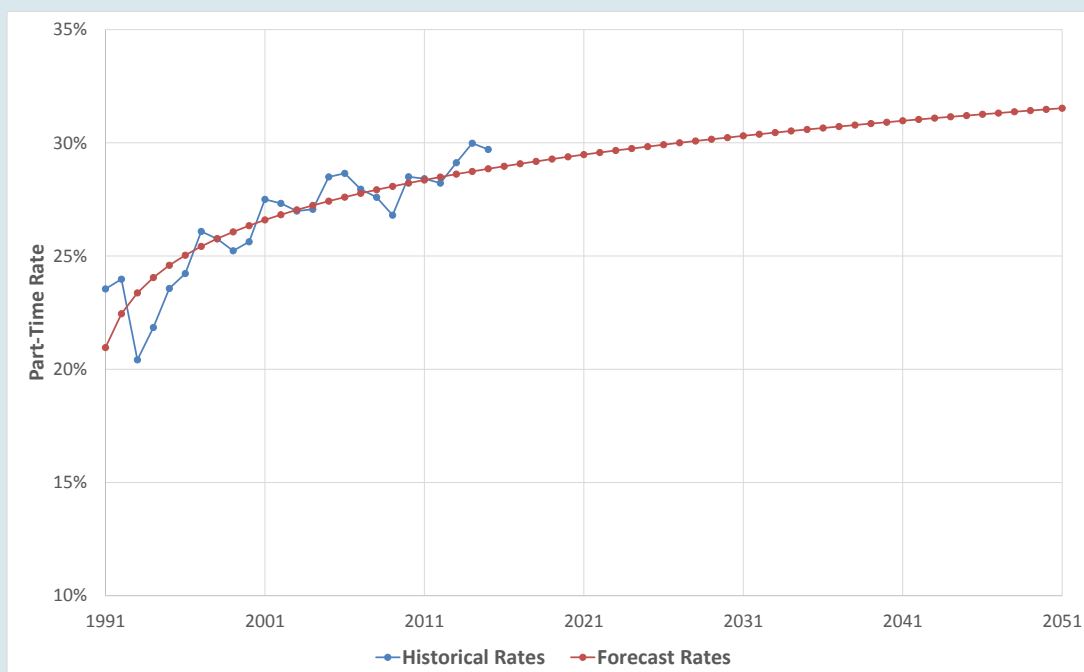
The diagram above presents the observed and projected part-time rates for 55-64 year olds in Greater Sydney where $\alpha = -0.83$ and $\beta = 0.07$.

Inputs

Key Inputs:

- Labour Force Survey data – ABS cat 6291.0.55.001 (LM1)

The module also requires a number of parameter inputs:

- Data specification inputs detailing the first and last years of historical data and the base projection year
- Part-time employment rate upper limits by age group
- User defined part-time rate upper limits by age group and metropolitan region

Functions

- The 'Parameter Estimation' sheet estimates the parameters α and β for each age group in Greater Sydney and Rest of NSW
- Once the module is run, the 'Final Part-Time Rate Series' sheet complies the historical and projected part-time rates
- The 'Summary Charts' sheet provides the means for checking the final Part-time projections (viewed alongside historical data)

10.2.6 Module 05g – Part-Time Segmentation IPF

Performs 2 stage IPF process which first estimates employment-time segmentation by SA4 and then by travel zone over time.

Inputs

Key Inputs:

- Greater Sydney and Rest of NSW control totals by employment-time segment and year

- Workforce in OPD by SA4 and year

- Starting IPF process distribution of employment-time segment by SA4 and year

- Workforce in OPD by travel zone and year

- Starting IPF process distribution of employment-time segment by travel zone and year

The module also requires a number of parameter inputs:

- Number of SA4s within Greater Sydney and Rest of NSW (15 and 13 respectively)

- Convergence criteria – iterative process is complete when the sum of the absolute differences (between estimated regional workforce segment totals and regional workforce segment control totals) are below this level

- Future year – module will perform IPF up to the specified year

- Base year – specify the base year (currently 2011)

- Input data structure – Defines the data structure of the SA4 and travel zone level input sheets

- Required for model to read input data correctly

Functions

This module first runs the IPF procedure to estimate the workforce in OPD, by SA4 employment-time category. Using these as regional control totals, as second IPF process then estimates the employment-time segments for all constituent travel zones. The estimation process is summarised below:

- Read input parameter data

- For each year and region that requires estimation

  o Read Greater Sydney and Rest of NSW employment-time segment control totals, SA4 workforce in OPD control totals and starting distribution data

- Use IPF procedure to estimate final SA4 employment-time distribution

- For each year and region that underwent the first stage IPF procedure

  o Read travel zone workforce in OPD control totals and starting distribution data (see above for calculation detail)

- Use IPF procedure to estimate final travel zone employment-time distribution

10.2.7 Module 05h – Income Segmentation

Module 05h segments POPD who are of working age (15+) into five income bands. Propensities for individuals to fall within each income band are modelled as a function of their workforce characteristics (employed full-time, employed part-time, unemployed and not in the workforce) and real income growth.

For each workforce and employment-time segment, census data is used to determine the propensity of that segment to fall within eleven census income categories. Assuming a uniform distribution within categories, the eleven bands are disaggregated to form 29 sub-bands.

Combining these propensities with projections of POPD by workforce characteristics (obtained from M05e and M05g) results in a preliminary estimate of POPD within each income band. However, this estimate is based on income levels in the census year (2011), and real wage growth over time will result in a shift across income bands. Using an assumed rate of long-term real income growth (currently set as 1.4% in line with the 2015 IGR); along with the median earnings of each income sub-band, the shifts across bands are calculated. These shifts are then applied to the preliminary estimate to derive a final income band distribution by SA4.

Real Income Growth Example:

Suppose that for a given SA4 n 2011, part-time workers had a 25% propensity to fall within income sub-band 6. In the absence of real income growth, this implies that if there were 100 part-time workers in 2021, 25 of them would fall into income sub-band 6.

However, as real income does in fact grow, these 25 part-time workers will instead shift across income sub-bands - falling within income sub-band 8 rather than sub-band 6.

Similarly, individuals from a lower sub-band may now fall within sub-band 6. Another alternative is that 10 years of real income growth for a particular sub-band (e.g. sub-band 1) is insufficient to cause a shift.

Once income band estimates by SA4 have been derived, these are used as regional control totals in a travel zone level IPF process. This ensures that regional income band characteristics are maintained while still allowing for intra-regional variation based on travel zone specific workforce characteristics and income band propensities.

Inputs

Key Inputs:

- Income by workforce characteristics census data by SA4 (obtained via ABS Tablebuilder)
- Labour force characteristics by SA4 and year
- Working age POPD by travel zone and year
- Workforce characteristics by travel zone and year

The module also requires a number of input parameters;

- Number of SA4s within Greater Sydney and Rest of NSW (15 and 13 respectively)
- Convergence criteria – iterative process is complete when the sum of the absolute differences (between estimated SA4 income band totals and SA4 income band control totals) are below this level
- Future year – module will perform IPF up to the specified year
- Base year – specify the base year (currently 2011)
- Input data structure – Defines the data structure of the SA4 and travel zone level input sheets
  - Required for model to read input data correctly
- Real Income Growth Rate
  - Defines the rate at which individuals will shift across income bands

Functions

- The 'Income Band Growth' sheet computes the median income for each of the 29 income sub-bands and applies the assumed real income growth rate to these across time. This determines the shift across income sub-bands

- The disaggregation of the eleven census income categories into the 29 sub-bands (assuming a within-category uniform distribution) is performed on the 'Adjusted SA4 Census Data' sheet

- For each year, the preliminary 29 sub-band propensities are adjusted for real income growth and summarised on the sheet 'Projected sub-band Propensities'

- These 29 sub-bands are then aggregated into the 5 income bands required by the STM and applied to workforce segment projections to derive final estimates of working age population by income band and SA4.

- Travel zone starting distribution is read from M05e (see above for calculation detail) and IPF procedure estimates final income band distribution

10.2.8 Module 05i – Workforce and Segmentation Summary

Collates the output from M05e, M05g and M05h presents them for review.

Functions

This module provides a means for reviewing the following results:

- Workforce segments (Employed, Unemployed and Not in Workforce) alongside age structure

- Employment-time segments (Full time and Part time) alongside age structure

- Income Bands

Results are reviewed at three geographic levels:

- SA4

- District
  - District definitions can be changed using the 'District Definitions' sheet

- Travel zone
  - Select SA4 or district first and then choose from constituent travel zones

Figure 30 M05I Summary output
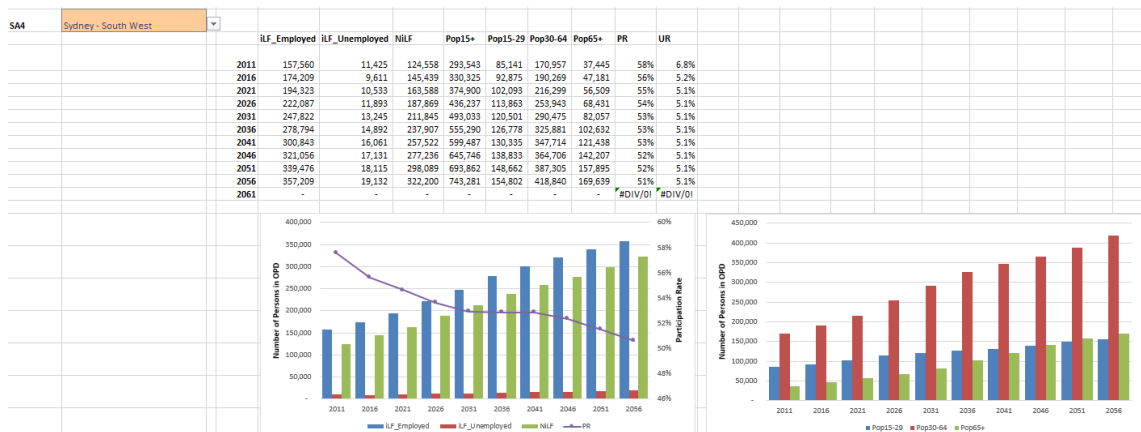
10.3 Comparison to LU14

The following provides an overview of the previous approach used for September 2014 data release.

Figure 31 Module 4 approach used to produce LU14
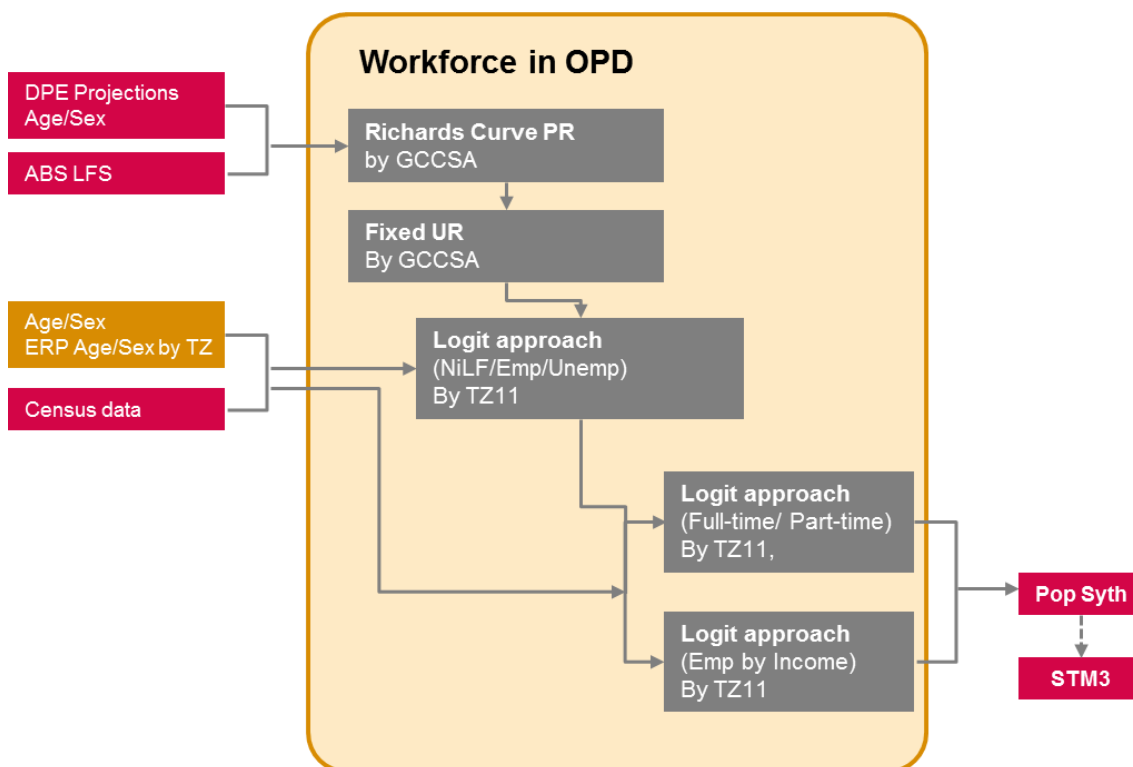
In addition to incorporating the latest available datasets and streamlining existing processes, the revised approach incorporates the following methodological changes.

10.3.1 Modelling of POPD vs ERP

The LU14 approach modelled ERP, which was then discounted using a TZ-specific factor. In contrast, the revised approach uses POPD throughout the estimation process.

10.3.2 Use of IPF procedure vs 'Logits' for all levels of segmentation

The use of an IPF approach has a number of advantages while retaining the key property of the logit method (i.e. simultaneously incorporating rates which are projected at a metropolitan level and variations in travel zone level characteristics).

- Robust control totals for Greater Sydney and Rest of NSW can be established and reviewed before allocation to smaller geographies

- Unlike the prior approach, sub-regional (SA4) variations are captured using the most recent labour force survey data. Once again, results can be reviewed at a sub-regional level once metropolitan control totals have been allocated

- Travel zone level estimates are based on more detailed census data, which incorporate TZ-specific variations, while also following both sub-regional and metropolitan trends.

A summary of the differences in workforce status segmentation in the GMA region are presented below:

Figure 32 Workforce status segmentation comparison, POPD

Original Method
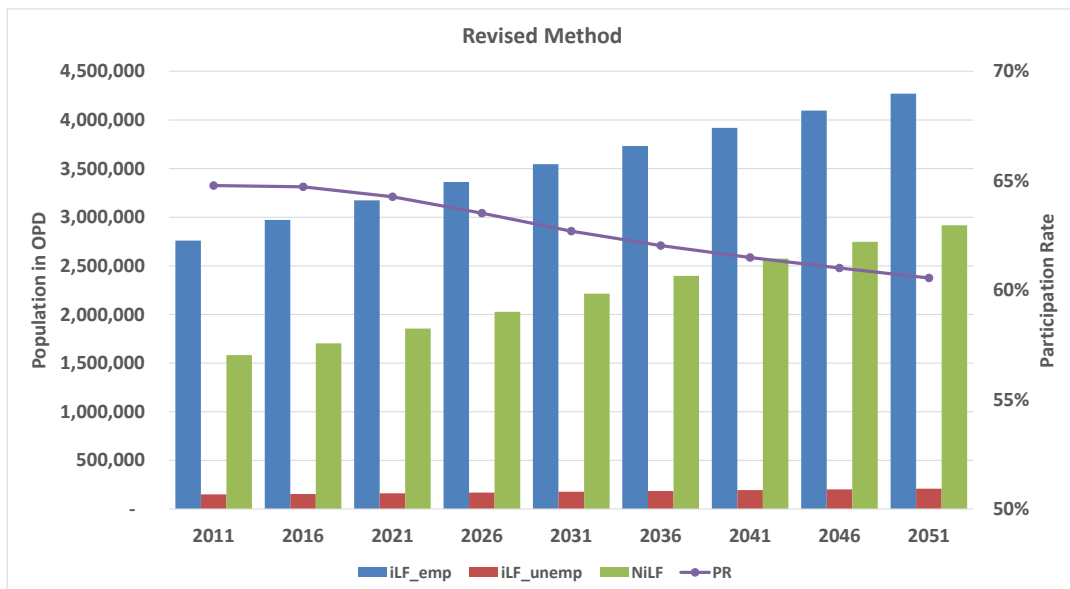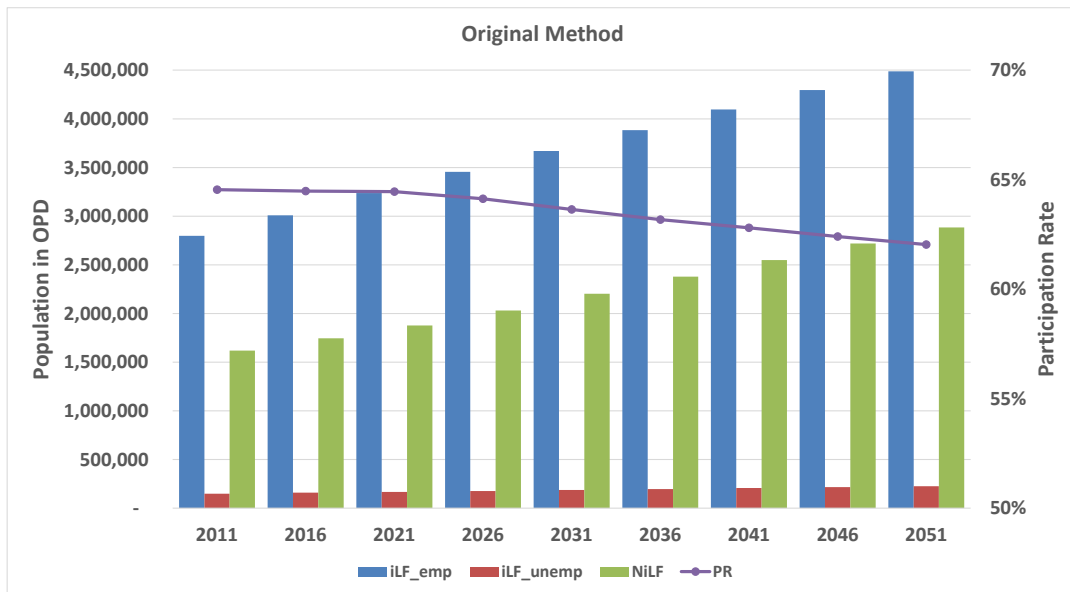
Revised Method

Error! Reference source not found. indicates that:

- The revised method projects a slightly faster decline in overall participation rate
- A direct consequence of this is that workforce (employed POPD) grows more slowly under the revised method

10.3.3 Part-time employment projection methodology

In addition to using the IPF processes instead of logits, two major changes have been made to the September 2014 methodology for part-time employment segmentation.

The previous model benchmarked the 2011 number of part-time workers in the GMA to the HTS. However, no adjustment was made to total workers. This meant that the level of full-time workers was required to offset the part-time worker adjustment, resulting in an inaccurate estimate.

The revised methodology does not benchmark part-time workers to the HTS (the estimate is in fact similar to the HTS).

Projecting part-time employment shares is also treated significantly differently under the revised model. The previous approach assumed an annual growth of 0.25% for

the share of part-time workers while the current methodology projects the share of part-time employment by age group using a log-log regression analysis of historical labour force survey data.

The resulting differences for the GMA region are summarised below:

Figure 33 Part-time employment segmentation comparison
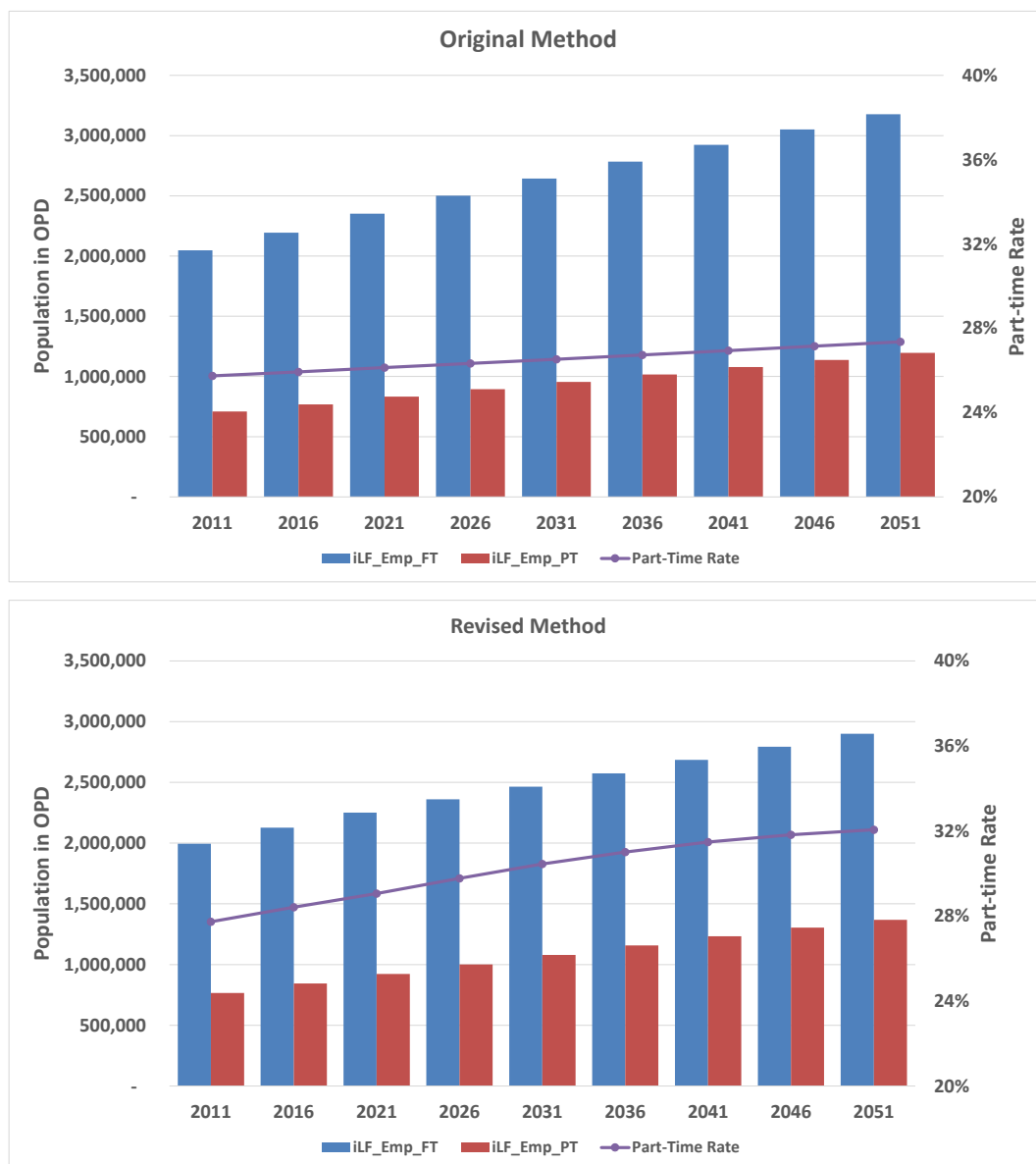
10.3.4 Updated Income Band Segmentation methodology

Two key revisions to the income band segmentation methodology have been made compared to the September 2014 method.

The previous approach (LU14) modelled the propensities of falling within each income band by age group (implying fixed propensities within each age group). While there is a relationship between income and age, it is not the sole determinant. The revised methodology instead computes income band propensities by workforce status and employment-time (e.g. a full-time worker is likely to have different propensities to a part-time worker or unemployed individual). This approach is also influenced by the age structure of the population, as age is a determinant of participation and part-time employment rates.

The second major methodological change relates to the treatment of real income growth. The September 2014 approach applies a 1% 'Raise Parameter' to income bands, which essentially shifts population across income bands each year. In contrast, the revised method applies a rate of real income growth (1.4% p.a. sourced from IGR) to income levels determined from census data. This results in the following advantages:

- Growth rate is applied to actual income levels rather than shifting a proportion of the population across bands

- This growth rate is applied to a disaggregated set of incomes (29 sub-bands), which results in a more accurate measure of income growth

A summary of the resulting changes are presented below:

Figure 34 Income band segmentation comparison
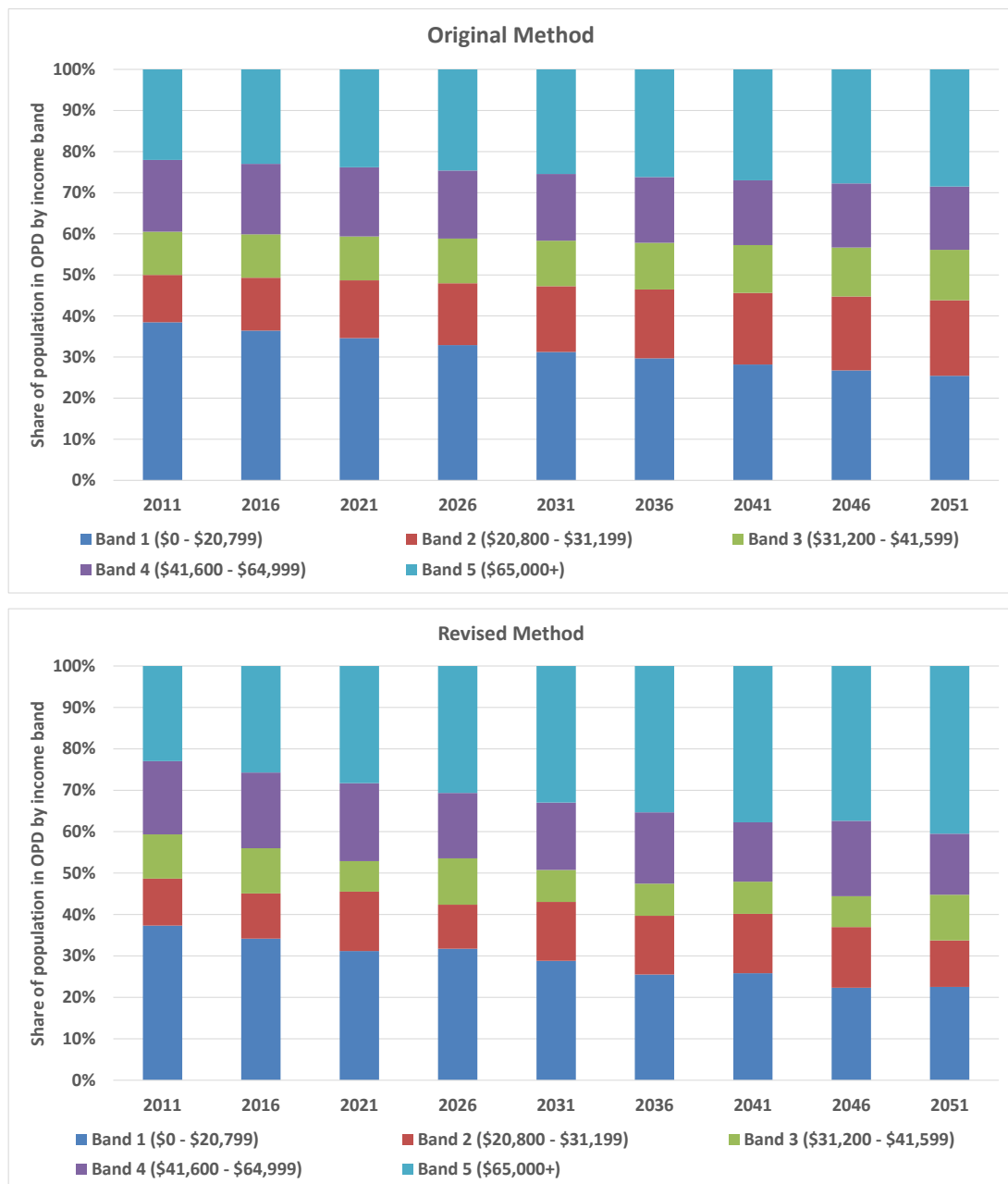
Key differences between the original and revised methods include:

- Significantly faster growth of the proportion of the population in the highest income band. This is primarily due to the improved treatment of real income growth

- This directly causes a decrease in the proportion that fall within the lower bands

11 Module 6: Employment by Industry

11.1 Module 6 Overview

The Employment by Industry module has two major functions. First, the quantum of jobs by industry is projected for the GMA region. Following this, the spatial distribution within each industry is projected based on a variety of factors. This spatial projection is itself a two-step process, being estimated first by SA3 and then by travel zone.

Unlike demographic characteristics, projecting the growth and distribution of employment by industry is more reliant on professional judgement and is influenced by both endogenous and exogenous factors. With this in mind, the design of the modules focuses on the following:

- Automated procedures to produce first-cut estimates (e.g. quantum and distribution of retail employment in GMA)

- Logical, transparent and time-efficient methods by which professional judgement can be applied

An important distinction between module 6 and previous modules is that estimates are not restricted to persons living in private dwellings. This is due to the fact that it is a 'destination' variable and is used as a relative attractor within the STM.

Table 4 lists the outputs generated by the employment module, while the figure below presents an overview of the revised employment module and how it interacts with the TZP framework.

Figure 35 Module 6: Employment projection approach overview
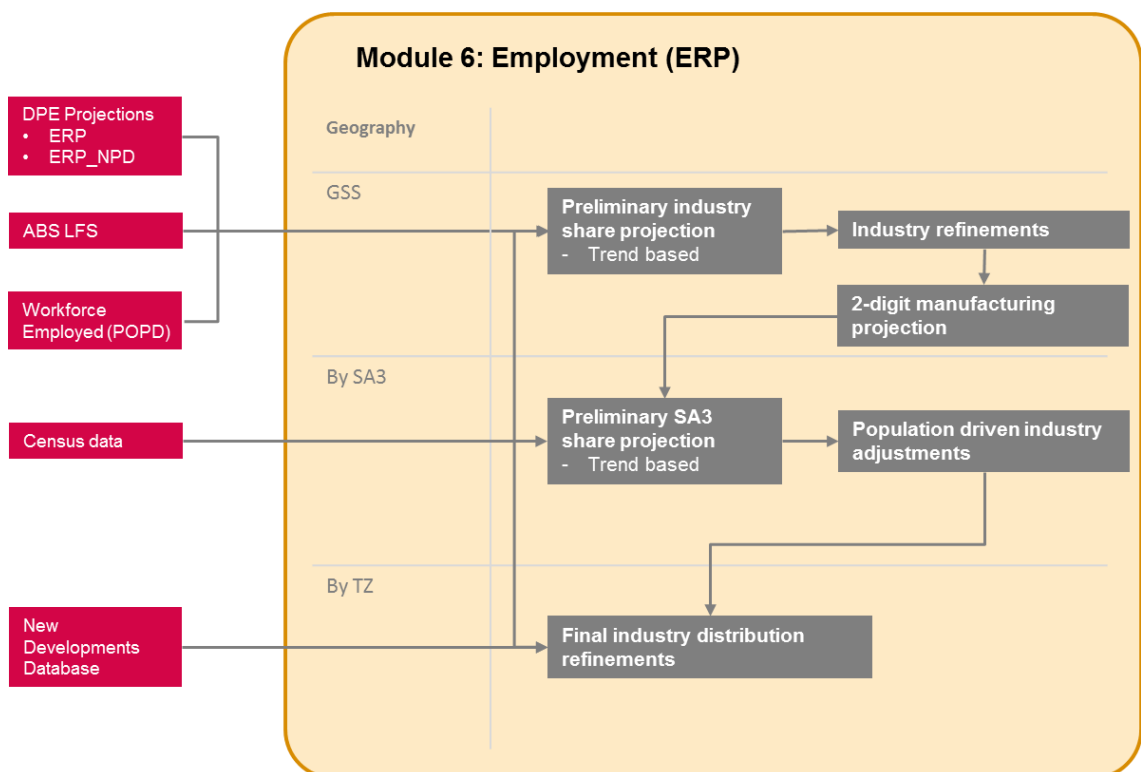
11.2　Module 6 - technical spreadsheet overview

11.2.1　Module 6a – Industry Projection for the GMA region

Module 6a combines the outputs of previous modules with historical labour force survey and census data to project the quantum of employment by industry within the GMA region. The projection process has three major components:

- Projected total employment within the GMA region for each period. This involves augmenting the outputs of M05 such that the following factors are captured:

- Flows of workers between the GMA region and the rest of NSW

- Employment of persons who reside in non-private dwellings

- Automated process which produces preliminary share projections based on historical trends

- The user can select from two univariate regression models

- Refinement of industry projections based on a variety of factors (e.g. population to employment ratio or expected growth rate)

Preliminary industry share example

The estimated regression can be of the form: $\log Share_t = \alpha + \beta \log t$ or

$$\log Share_t = \alpha + \beta t$$
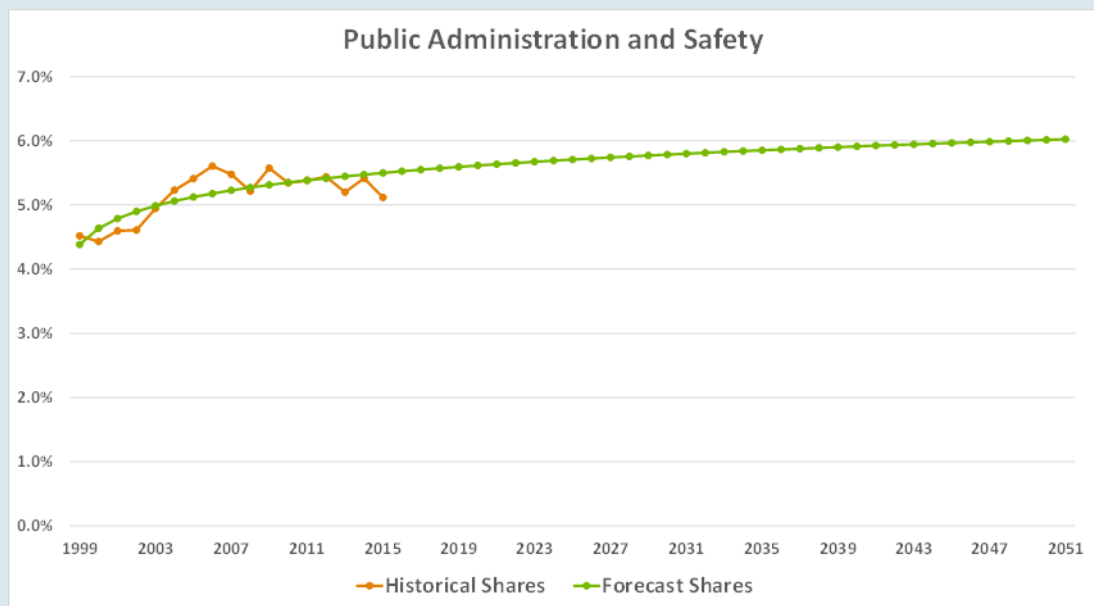
The diagram above presents the historical and projected shares (based on a Log-Log model) of the Public Administration and Safety industry.

Inputs

Key Inputs:

- SA4 Labour Force Survey data – ABS cat. 6291.0.55.001

- Historical ERP by age data – ABS cat. 3218

- Projected ERP by age data - DPE

- 2011 Census data

- GMA workforce (POPD) from M05d

- GMA Population in Non-private dwellings from M01

The model also requires a number of parameter inputs on the 'Preliminary Share Projection' sheet:

- Select preliminary method for projecting the employment share of each industry

- Define the structure of historical data and projections

- Existing adjustments on the individual industry sheets can be cleared if desired

Following this, each industry requires inputs which define how its level is projected:

- Choose measure used to estimate first-cut projection

- Input values which correspond to the chosen measure (e.g. if ERP/Emp ratio is chosen, input projected ratio for each projection year)

- These will differ across industries and are subject to professional judgement

- Select whether to lock projection to first-cut estimate

- Industries which are not locked will have final estimates which are scaled such that the sum of jobs across industries is equal to the benchmark total for the GMA region

Functions

- The 'Annualised Data' sheet annualises the historical LFS data while also using 2011 Census data to discount the employment estimate of the 'Hunter Valley excluding Newcastle' SA4 (as this falls partially outside the GMA region)

- LFS data is defined by place of usual residence. The 'GMA Industry Employment (POW)' sheet adjusts this measure by using 2011 JTW Census data to account for worker flows between the GMA region and rest of NSW. This results in a final estimate of employment by industry within the GMA region

- The 'Parameter Estimation' sheet estimates the parameters α and β for each industry based on both log-log and log-linear models

- These parameters (based on a user selection) are then used to produce initial projections on the 'Preliminary Share Projection' sheet. Clicking 'Run' will load these onto the individual industry projection sheets

- For each industry sheet, review the projections implied by the preliminary shares against the provided indicators and refine if necessary. Charts displaying both level changes and growth rates are also presented, and should be checked to ensure projections follow a smooth path

Industry refinement example

Consider the Health Care and Social industry, presented below:

Health Care and Social Assistance Year	Chosen First-Cut Forecast Measure ERP/Emp	Lock to First-cut estimate? Lock	First-Cut Estimate	Final Employment Estimate	ERP AAGR	Preliminary Share	Share	5-year AAGR	ERP/Emp	ERP_15+/ Emp	ERP_15_64/Emp	ERP_65+/ Emp	ERP_5_24 /Emp
1999	-	216,756	216,756	216,756		9.59%	9.59%						
2000	-	214,446	214,446	214,446		9.25%	9.25%						
2001	23	221,035	221,035	221,035		9.34%	9.34%		22.7	18	15	2.8	6
2002	22	234,805	234,805	234,805	0.8%	9.77%	9.77%		21.6	17	15	2.7	6
2003	22	232,152	232,152	232,152	0.7%	9.53%	9.53%		22.0	18	15	2.7	6
2004	22	235,393	235,393	235,393	0.5%	9.61%	9.61%	1.66%	21.8	18	15	2.7	6
2005	21	243,526	243,526	243,526	0.7%	9.74%	9.74%	2.58%	21.2	17	14	2.7	6
2006	21	250,705	250,705	250,705	0.8%	9.87%	9.87%	2.55%	20.8	17	14	2.6	6
2007	21	254,567	254,567	254,567	1.5%	9.88%	9.88%	1.63%	20.8	17	14	2.7	6
2008	20	273,070	273,070	273,070	1.8%	10.28%	10.28%	3.30%	19.7	16	13	2.5	5
2009	19	281,006	281,006	281,006	1.8%	10.49%	10.49%	3.61%	19.5	16	13	2.5	5
2010	18	303,307	303,307	303,307	1.4%	11.18%	11.18%	4.49%	18.3	15	12	2.4	5
2011	18	317,241	317,241	317,241	1.2%	11.43%	11.43%	4.82%	17.7	14	12	2.4	5
2012	18	321,603	321,603	321,603	1.4%	11.49%	11.49%	4.79%	17.7	14	12	2.4	5
2013	17	337,758	337,758	337,758	1.6%	11.87%	11.87%	4.34%	17.1	14	12	2.4	4
2014	16.6	354,589	354,589	354,589	1.7%	12.30%	12.30%	4.76%	16.6	13	11	2.4	4
2015	-	353,723	353,723	353,723		12.04%	12.04%	3.12%	-	-	-	-	-
2016	16.5	367,137	367,137	367,137	1.5%	12.26%	12.28%	2.96%	16.5	13	11	2.4	4
2021	16.1	404,626	404,626	404,626	1.5%	13.43%	12.67%	1.96%	16.1	13	10	2.6	4
2026	15.8	443,431	443,431	443,431	1.4%	14.71%	13.11%	1.85%	15.8	13	10	2.7	4
2031	15.4	483,182	483,182	483,182	1.3%	16.11%	13.54%	1.73%	15.4	13	10	2.9	4
2036	15.1	524,306	524,306	524,306	1.2%	17.65%	13.95%	1.65%	15.1	14	9	2.9	4
2041	14.7	567,238	567,238	567,238	1.1%	19.33%	14.36%	1.59%	14.7	12	9	3.0	4
2046	14.4	611,819	611,819	611,819	1.0%	21.17%	14.80%	1.52%	14.4	12	9	3.0	3
2051	14.0	658,651	658,651	658,651	1.0%	23.19%	15.29%	1.49%	14.0	12	9	3.0	3

(1)   (2)   (3)

The preliminary share projection results in the industry capturing an unreasonably large share of regional employment (highlighted red). As a population driven industry, the ratio of population to employment is a reasonable indicator. Setting this as the chosen first-cut measure, and selecting values which imply that employment continues to grow slightly faster than population (1), results in a projection which:

- Has a more reasonable share of total employment (2)

- Displays a strong but declining growth rate consistent with recent trend (3)

Additionally, selecting 'Lock' means that the industry will not be scaled.

Health Care and Social Assistance
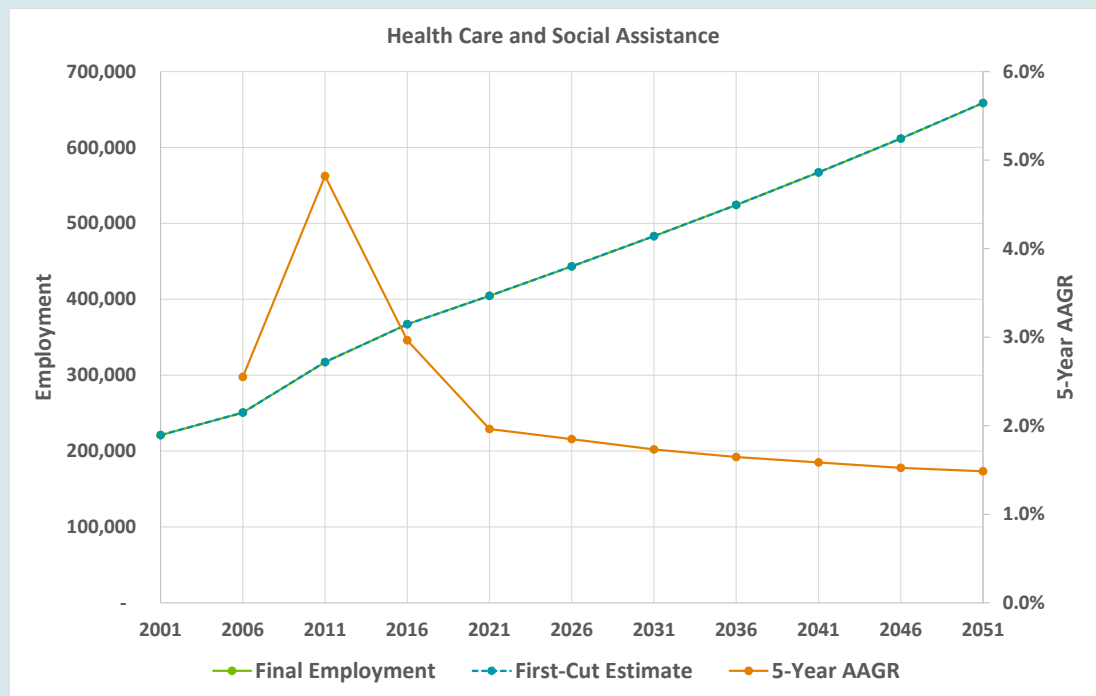
11.2.2 Module 6b – 2 digit Industry Projections

This module uses historical employment data from census to disaggregate the 1-digit industry projection produced in Module 6a to a 2-digit industry projection. The projection is broken into two steps:

- The share of employment for each 2-digit industry is calculated based on the historical employment data from 1996 to 2011.

- The shares of employment at a 2-digit level are projected using a log-log regression as in Module 6a. These shares are then applied to the 1-digit employment projections as determined in the previous module.

Inputs

Key inputs:

- Historical employment data at the 2-digit level from 1996-2011

- 1-digit industry projection at the 1-digit level produced in M06a.

Functions

- The 'Historical Employment Input' sheet requires inputs of 2-digit employment from 1996-2011

- The 'Industry Focus' sheet requires the user to pick the 1-digit industry to be disaggregated to the 2-digit level

- The '%_shares' sheet projects the share of each 2-digit industry based on a log-log regression.

- Using these projections, the 1-digit employment projection is disaggregated to produce the final 2-digit projection as seen in the 'Summary' sheet.

11.2.3 Module 6c – SA3 Industry Projections

Module 6c distributes the previously determined employment by industry projections to the SA3 level. This is achieved using historical census data in conjunction with information on planned developments and professional judgement. When assessing information on planned developments, which is sourced from the 'New Developments' database compiled by the TPA, there are two cases which should be considered:

- The 'New Developments' in some areas will represent growth that is over and above that which is predicted by projections based on historical data. This will be the case for greenfield or previously undeveloped regions

- The alternative is that these 'New Developments' are already partially captured within the original growth projections. This is because regions with sites that have undergone past urban renewal will be expected to continue exhibiting strong growth through similar renewal in the future.

The module also consists of two sub-modules (described in the next section) which synthesise inputs for M06c. These have been isolated as they are areas which could benefit from additional development.

The projection procedure of M06c is comprised of three stages:

- Preliminary SA3 shares for each industry are estimated using a log-log regression model

  - The projected shares are smoothed in order to avoid trend reversals from 2011 to future years (e.g. share decreasing from 2011 to 2016 and then increasing monotonically)

- An automated process which identifies and adjusts projections in SA3s where initial projections of employment growth are insufficient to service forecasted population growth.
    - This applies to six population serving industries
    - A threshold population to employment ratio (ERP/Emp) is computed in M06c_1. SA3s are adjusted such that this ratio (for growth) in forecasted years is not exceeded.
        - For example, consider an SA3 which is projected to have a significant increase in population but limited growth in Retail Trade. This will result in an ERP/Emp which exceeds the defined threshold, leading the module to adjust the distribution of Retail Trade employment such that the ratio falls to the threshold level
- Refinement of industry distribution (across SA3s) based on professional judgement which should be informed by various presented factors such as:
    - Known developments and growth in employment (i.e. New Developments Database)
    - Forecasted population growth
    - Regions breaking away from recent trends

Projections can then be reviewed through an examination of employment density (projected employment per hectare of employment zoned land) across SA3s. This will provide a high-level representation of how SA3s are expected to evolve relative to their quantity of employment land. This component is an area which will benefit from future development, as improved GIS zoning layers become available (there are currently zoning gaps).

Inputs

Key inputs:

- GMA employment by industry projected from M06a
- ERP projections by SA3 from M01
- ABS Census data at the SA3 level for employment from 1996-2011
- Parameters defining minimum ERP/Emp ratio (M06c_1)
- Concordance of industries to one of three categories (commercial, industrial and other)
- Known estimates of future employment by travel zone (i.e. New Developments Database)

Following this, a range of inputs which will reflect professional judgement based adjustments are required:

- Select industry to which distributional adjustments are being made
    - View 'Third Cut Summary Charts' sheet in a separate window while making adjustments
- For SA3s which require an adjustment, input a share adjustment
- Select whether to lock the projection of SA3s. This will prevent the SA3 from bearing any of changes when projections are scaled to match GMA control totals. SA3 projections could be locked if:

- o Current projections are accurate and should not vary when subsequent changes are made to other SA3s (e.g. manual adjustments have been made to align an SA3 with known developments)
- o Adjustments that are made should not affect certain other SA3s

Functions

- The 'Preliminary Share Projections' sheet estimates share of employment by industry captured by each SA3 using a log-log regression model. These are then applied to the GMA industry control totals to generate a first cut projection.

- The 'Second Cut Adjustments' sheet adjusts the first cut projection to reflect expected population growth in each SA3. For several population serving industries, if the SA3 is projected to have insufficient employment growth, employment will be allocated to that SA3 such that a minimum level of service is provided to these additional residents. To ensure industry totals are maintained, these changes are offset from regions which have a relatively high level of employment growth relative to population growth (see Figure 33).

- The 'Third Cut Adjustments' sheet (which should be used while simultaneously viewing the 'Third Cut Adjustment Charts' sheet), enables the user to make professional judgement based adjustments to the distribution of employment by industry. Key components of this are:

  - o The New_Dev_Flag column indicates SA3s that have a cumulative projection of employment growth which may not fully account for known new developments (i.e. the currently projected employment growth is below or not significantly higher than the growth implied by the 'New Developments' database).

  - o Manual share adjustments can be specified to adjust the distribution of employment across SA3s (which will propagate to future years once made).

  - o Any adjustments are offset against all SA3s in order to maintain industry control totals. The 'Level Lock' input provides the option to prevent selected SA3s from bearing any of the offset (e.g. if a certain SA3 already has a reasonable projection, it should be locked so that it does not bear any of the offset changed which stem from adjustments to other SA3s).

- A review of workforce self-containment should then be conducted on the 'Employment to Workforce Summary' sheet.

  - o For each SA4 (and constituent SA3), this sheet displays the projected employment/workforce ratio as well as the four fastest growing industries. While different regions will have different levels of self-containment, significant changes to the ratio within a region (SA4) should be examined (as this has the potential to significantly alter traffic flows within the STM).

  - o This sheet should only be reviewed after the first round of adjustments have been added to the 'Third Cut Adjustments' sheet (e.g. trend smoothing or accounting for known developments)

  - o The implied employment densities of each SA3 can then be reviewed on the 'Final SA3 Employment Densities' sheet. This provides a summary of employment by broad category (commercial, industrial and total).

Employment density review may or may not be a useful review mechanism at the SA3 level. In some cases it should provide insight regarding how a region is projected to develop compared to others (e.g. projections imply that region 'X' will be as dense in 2021 as region 'Y' was in 2011). However, the incomplete zoning layer published by DPE and differences in the proportion of employment lands across SA3s can make comparisons inappropriate in other cases (e.g. the Sydney – Inner City SA3 has far more commercially zoned land than the Eastern Suburbs – South SA3, making it appear less dense).

Examining employment density will be more useful at the TZ level, and since this dataset would have to be developed for that, we've included it in M06_c as well.

Figure 36 Module 6c: Second-cut projection approach
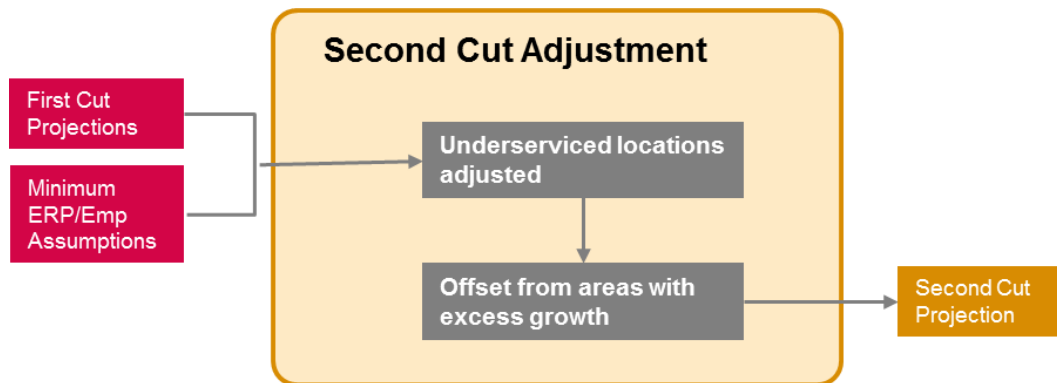
Third Cut Adjustments Examples

When making manual adjustments, the user should have both the 'Third Cut Adjustments' sheet and 'Third Cut Adjustments Charts' sheets open side by side.

Case 1 – New development indicator

Consider the Professional, Scientific and Technical Services industry in Blacktown - North.

The figures below show both the 'Third Cut Adjustments' sheet (above) and 'Third Cut Adjustments Charts' sheet (below). The red circle highlights that the expected development occurring in this SA3 will generate significantly more employment than is projected in the second cut (i.e. 650 compared to 202). This is expected in Greenfield regions; as historical data cannot predict future growth.

Final Emp Level 2011	Final Share 2011	Final Emp Level 2016	Final Cumulative Growth 2016	Final Share 2016	Adjusted Second Cut Share 2021	Emp Level 2021	New_Dev Flag 2021	Cumulative New_Dev Growth 2021	Share adjustment 2021	Level Lock 2021	Final Emp Level 2021	Final Cumulative Growth 2021	Final Share 2021
3,557	1.32%	4,331	774	1.42%	1.43%	4,949	0	-			4,949	1,392	1.43%
2,026	0.75%	2,368	342	0.78%	0.79%	2,734	0	420			2,734	708	0.79%
1,314	0.49%	1,530	216	0.50%	0.52%	1,782	0	125			1,782	468	0.52%
1,702	0.63%	1,926	224	0.63%	0.63%	2,171	0	-			2,171	470	0.63%
1,318	0.49%	1,516	198	0.50%	0.51%	1,779	0	-			1,779	461	0.51%
1,030	0.38%	1,166	136	0.38%	0.38%	1,302	1	300			1,302	271	0.38%
7	0.00%	8	1	0.00%	0.00%	9	0	-			9	2	0.00%
915	0.34%	1,097	182	0.36%	0.37%	1,272	0	-			1,272	357	0.37%
4,018	1.50%	4,311	293	1.41%	1.39%	4,820	0	-			4,820	802	1.39%
2,164	0.81%	2,449	285	0.80%	0.80%	2,761	0	-			2,761	597	0.80%
916	0.34%	1,117	201	0.37%	0.38%	1,304	0	-			1,304	388	0.38%
9,343	3.48%	10,574	1,231	3.46%	3.45%	11,923	0	1,800			11,923	2,580	3.45%
1,688	0.63%	1,976	288	0.65%	0.65%	2,251	0	-			2,251	563	0.65%
1,252	0.47%	1,417	165	0.46%	0.47%	1,613	0	-			1,613	361	0.47%
7,562	2.82%	8,843	1,281	2.90%	3.05%	10,535	1	3,670			10,535	2,973	3.05%
805	0.30%	922	117	0.30%	0.30%	1,052	0	-			1,052	247	0.30%
286	0.11%	342	56	0.11%	0.11%	393	0	-			393	107	0.11%
433	0.16%	337	(96)	0.11%	0.10%	347	1	800			347	(87)	0.10%
1,663	0.62%	1,847	184	0.60%	0.58%	2,018	0	-			2,018	354	0.58%
654	0.24%	740	86	0.24%	0.25%	856	1	650			856	202	0.25%
768	0.29%	817	50	0.27%	0.26%	916	1	600			916	148	0.26%
2,125	0.79%	2,405	280	0.79%	0.78%	2,712	0	100			2,712	587	0.79%

Blacktown - North - Professional, Scientific and Techn	2011	2016	2021	2026	2031	2036	2041	2046	2051
Final Emp Level	654	740	856	977	1,098	1,226	1,356	1,483	1,608
Final Share	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Employment AAGR		2.5%	2.9%	2.7%	2.4%	2.2%	2.0%	1.8%	1.6%
Population AAGR		5.7%	5.7%	4.4%	4.1%	3.5%	2.3%	2.1%	2.0%

Blacktown - North - Professional, Scientific and Technical Services

Blacktown - North - Professional, Scientific and Technical Services
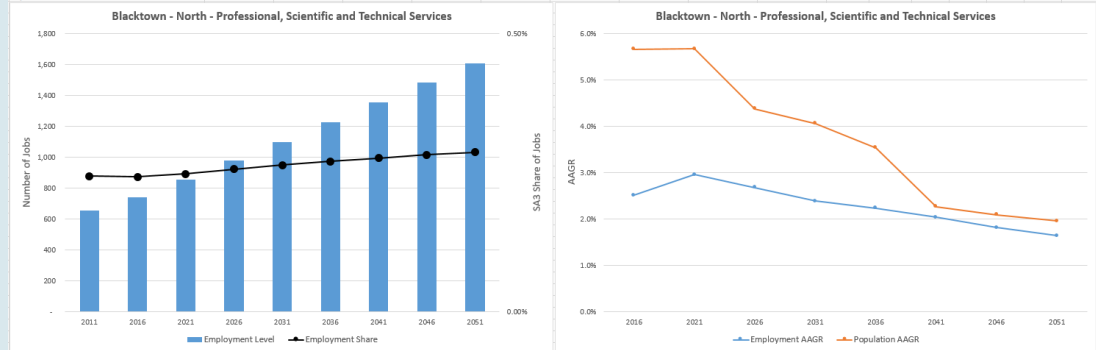
Inputting a manual adjustment (circled blue below) alters the share of industry employment that Blacktown – North captures such that it is sufficient to account for the new developments input (circled red below). Entering '1' in the 'Level Lock' column ensures that this projection will not change should changes be made to other SA3s. Comparing the 'Third Cut Adjustments Charts' sheet after the adjustment to prior the adjustment shows the employment share has now increased significantly in this SA3.

Final Emp Level 2011	Final Share 2011	Final Emp Level 2016	Final Cumulative Growth 2016	Final Share 2016	Adjusted Second Cut Share 2021	Emp Level 2021	New_Dev Flag 2021	Cumulative New_Dev Growth 2021	Share adjustment 2021	Level Lock 2021	Final Emp Level 2021	Final Cumulative Growth 2021	Final Share 2021
3,557	1.32%	4,331	774	1.42%	1.43%	4,949	0	-			4,942	1,385	1.43%
2,026	0.75%	2,368	342	0.78%	0.79%	2,734	0	420			2,730	704	0.79%
1,314	0.49%	1,530	216	0.50%	0.52%	1,782	0	125			1,779	465	0.51%
1,702	0.63%	1,926	224	0.63%	0.63%	2,171	0	-			2,168	467	0.63%
1,318	0.49%	1,516	198	0.50%	0.51%	1,779	0	-			1,776	458	0.51%
1,030	0.38%	1,166	136	0.38%	0.38%	1,302	1	300			1,300	269	0.38%
7	0.00%	8	1	0.00%	0.00%	9	0	-			9	2	0.00%
915	0.34%	1,097	182	0.36%	0.37%	1,272	0	-			1,270	355	0.37%
4,018	1.50%	4,311	293	1.41%	1.39%	4,820	0	-			4,812	795	1.39%
2,164	0.81%	2,449	285	0.80%	0.80%	2,761	0	-			2,757	593	0.80%
916	0.34%	1,117	201	0.37%	0.38%	1,304	0	-			1,302	386	0.38%
9,343	3.48%	10,574	1,231	3.46%	3.45%	11,923	0	1,800			11,905	2,562	3.44%
1,688	0.63%	1,976	288	0.65%	0.65%	2,251	0	-			2,248	560	0.65%
1,252	0.47%	1,417	165	0.46%	0.47%	1,613	0	-			1,611	359	0.47%
7,562	2.82%	8,843	1,281	2.90%	3.05%	10,535	1	3,670			10,520	2,958	3.04%
805	0.30%	922	117	0.30%	0.30%	1,052	0	-			1,050	245	0.30%
286	0.11%	342	56	0.11%	0.11%	393	0	-			392	106	0.11%
433	0.16%	337	(96)	0.11%	0.10%	347	1	800			346	(87)	0.10%
1,663	0.62%	1,847	184	0.60%	0.58%	2,018	0	-			2,014	351	0.58%
654	0.24%	740	86	0.24%	0.25%	856	0	650	0.15%	1	1,374	720	0.40%
768	0.29%	817	50	0.27%	0.26%	916	1	600			915	147	0.26%
2,125	0.79%	2,405	280	0.79%	0.78%	2,712	0	100			2,708	583	0.78%

Blacktown - North - Professional, Scientific and Techn	2011	2016	2021	2026	2031	2036	2041	2046	2051
Final Emp Level	654	740	1,374	2,117	2,966	3,934	4,771	5,405	5,787
Final Share	0.2%	0.2%	0.4%	0.6%	0.7%	0.9%	1.0%	1.0%	1.0%
Employment AAGR		2.5%	13.2%	9.0%	7.0%	5.8%	3.9%	2.5%	1.4%
Population AAGR		5.7%	5.7%	4.4%	4.1%	3.5%	2.3%	2.1%	2.0%

Blacktown - North - Professional, Scientific and Technical Services

Blacktown - North - Professional, Scientific and Technical Services
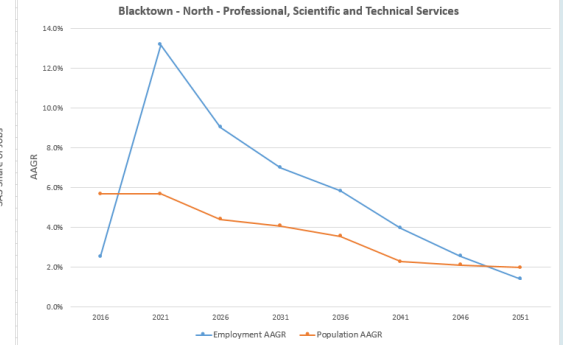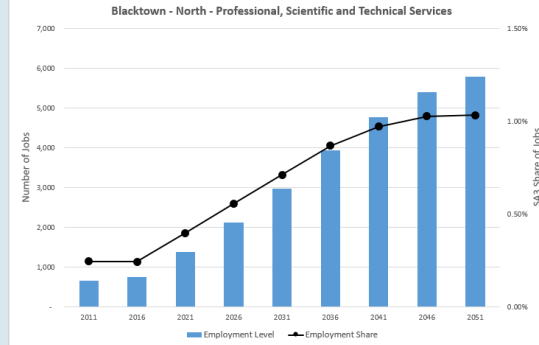
The 'Match New_Dev' function will enable the above adjustments to be made across all SA3s and years simultaneously. The 'Match New_Dev (Current row)' function applies the adjustments to all years for the selected SA3

Industry	Public Administration	Save Adjustments	Match New_Dev
New_Dev Threshold	100%	Clear Adjustments	Match new_Dev (Current row)

Case 2 – Employment share smoothing

This particular issue could occur if the preliminary share estimate for 2016 (calculated via regression) aligns poorly with the observed 2011 share. Consider the Professional Services industry in the Penrith SA3. The figure below shows a large jump in the employment share between 2011 and 2016 (1). 2016 also displays a significantly higher growth rate compared to other periods (2). An adjustment to the 2016 share of employment will nullify this issue (as the correction will propagate to future years).

Final Emp Level	Final Share	Adjusted Second Cut Share	Emp Level	New_Dev Flag	New_Dev Level	Share adjustment	Adjusted Emp Level	Level Lock	Final Emp Level	Final Share
2011	2011	2016	2016	2016	2016	2016	2016	2016	2016	2016
3,557	1.32%	1.42%	4,331	0	0		4,331		4,331	1.42%
2,026	0.75%	0.78%	2,368	0	245		2,368		2,368	0.78%
1,314	0.49%	0.50%	1,530	0	75		1,530		1,530	0.50%
1,702	0.63%	0.63%	1,926	0	0		1,926		1,926	0.63%
1,318	0.49%	0.50%	1,516	0	0		1,516		1,516	0.50%
1,030	0.38%	0.38%	1,166	0	50		1,166		1,166	0.38%
7	0.00%	0.00%	8	0	0		8		8	0.00%
915	0.34%	0.36%	1,097	0	0		1,097		1,097	0.36%
4,018	1.50%	1.41%	4,311	0	0		4,311		4,311	1.41%
2,164	0.81%	0.80%	2,449	0	0		2,449		2,449	0.80%
916	0.34%	0.37%	1,117	0	0		1,117		1,117	0.37%
9,343	3.48%	3.46%	10,574	0	850		10,574		10,574	3.46%
1,688	0.63%	0.65%	1,976	0	0		1,976		1,976	0.65%
1,252	0.47%	0.46%	1,417	0	0		1,417		1,417	0.46%
7,562	2.82%	2.90%	8,843	0	300		8,843		8,843	2.90%
805	0.30%	0.30%	922	0	0		922		922	0.30%
286	0.11%	0.11%	342	0	0		342		342	0.11%
433	0.16%	0.11%	337	1	320		337	1	337	0.11%
1,663	0.62%	0.60%	1,847	0	0		1,847		1,847	0.60%
654	0.24%	0.24%	740	0	30		740		740	0.24%
768	0.29%	0.27%	817	0	100		817		817	0.27%
2,125	0.79%	0.79%	2,405	0	0		2,405		2,405	0.79%
1,513	0.56%	0.56%	1,713	0	80		1,713		1,713	0.56%
94,931	35.35%	35.61%	108,746	0	6515		108,746		108,746	35.61%
5,381	2.00%	2.08%	6,353	0	0		6,353		6,353	2.08%
2,645	0.99%	1.01%	3,086	0	0		3,086		3,086	1.01%
2,259	0.84%	0.80%	2,442	0	0		2,442		2,442	0.80%
1,263	0.47%	0.47%	1,430	0	0		1,430		1,430	0.47%
2,037	0.76%	0.75%	2,306	0	0		2,306		2,306	0.75%
2,095	0.78%	0.78%	2,372	0	90		2,372		2,372	0.78%
3,106	1.16%	1.15%	3,515	0	0		3,515		3,515	1.15%
3,117	1.16%	1.16%	3,528	0	0		3,528		3,528	1.16%
3,709	1.38%	1.37%	4,198	0	0		4,198		4,198	1.37%
16,536	6.16%	5.92%	18,086	0	0		18,086		18,086	5.92%
2,389	0.89%	0.88%	2,691	0	0		2,691		2,691	0.88%
4,772	1.78%	1.77%	5,401	0	0		5,401		5,401	1.77%
22,686	8.45%	8.39%	25,623	0	0		25,623		25,623	8.39%
1,560	0.58%	0.58%	1,766	0	0		1,766		1,766	0.58%
2,514	0.94%	0.93%	2,845	0	0		2,845		2,845	0.93%
5,650	2.10%	2.04%	6,221	0	0		6,221		6,221	2.04%
954	0.36%	0.39%	1,182	0	0		1,182		1,182	0.39%
1,656	0.62%	0.61%	1,874	0	0		1,874		1,874	0.61%
537	0.20%	0.24%	728	0	0		728		728	0.24%
1,480	0.55%	0.58%	1,764	0	0		1,764		1,764	0.58%
-	0.00%	0.00%	6	0	0		6		6	0.00%
2,066	0.77%	0.86%	2,632	0	40		2,632		2,632	0.86%
708	0.26%	0.26%	802	0	0		802		802	0.26%

(3)

Penrith - Professional, Scientific and T	2011	2016	2021	2026	2031	2036	2041	2046	2051
Final Emp Level	2,066	2,632	3,001	3,331	3,651	3,982	4,322	4,650	4,968
Final Share	0.8%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%
Employment AAGR		5.0%	2.7%	2.1%	1.9%	1.7%	1.7%	1.5%	1.3%
Population AAGR		2.8%	2.5%	2.0%	1.9%	1.7%	1.6%	1.6%	1.5%

Penrith - Professional, Scientific and Technical Services

(1)

Penrith - Professional, Scientific and Technical Services

(2)

Inputting a share adjustment (1) to set the final share equal to the first forecasted share, smooths the projection (2) and results in a more realistic series of employment growth rates (3).

Final Emp Level	Final Share	Adjusted Second Cut Share	Emp Level	New_Dev Flag	New_Dev Level	Share adjustment	Adjusted Emp Level	Level Lock	Final Emp Level	Final Share
2011	2011	2016	2016	2016	2016	2016	2016	2016	2016	2016
3,557	1.32%	1.42%	4,331	0	0		4,331		4,335	1.42%
2,026	0.75%	0.78%	2,368	0	245		2,368		2,370	0.78%
1,314	0.49%	0.50%	1,530	0	75		1,530		1,531	0.50%
1,702	0.63%	0.63%	1,926	0	0		1,926		1,928	0.63%
1,318	0.49%	0.50%	1,516	0	0		1,516		1,517	0.50%
1,030	0.38%	0.38%	1,166	0	50		1,166		1,167	0.38%
7	0.00%	0.00%	8	0	0		8		8	0.00%
915	0.34%	0.36%	1,097	0	0		1,097		1,098	0.36%
4,018	1.50%	1.41%	4,311	0	0		4,315		4,315	1.41%
2,164	0.81%	0.80%	2,449	0	0		2,449		2,451	0.80%
916	0.34%	0.37%	1,117	0	0		1,117		1,118	0.37%
9,343	3.48%	3.46%	10,574	0	850		10,574		10,584	3.47%
1,688	0.63%	0.65%	1,976	0	0		1,976		1,978	0.65%
1,252	0.47%	0.46%	1,417	0	0		1,417		1,418	0.46%
7,562	2.82%	2.90%	8,843	0	300		8,843		8,851	2.90%
805	0.30%	0.30%	922	0	0		922		923	0.30%
286	0.11%	0.11%	342	0	0		342		342	0.11%
433	0.16%	0.11%	337	1	320		337	1	337	0.11%
1,663	0.62%	0.60%	1,847	0	0		1,847		1,849	0.61%
654	0.24%	0.24%	740	0	30		740		741	0.24%
768	0.29%	0.27%	817	0	100		817		818	0.27%
2,125	0.79%	0.79%	2,405	0	0		2,405		2,408	0.79%
1,513	0.56%	0.56%	1,713	0	80		1,713		1,714	0.56%
94,931	35.35%	35.61%	108,746	0	6515		108,746		108,848	35.64%
5,381	2.00%	2.08%	6,353	0	0		6,353		6,359	2.08%
2,645	0.99%	1.01%	3,086	0	0		3,086		3,088	1.01%
2,259	0.84%	0.80%	2,442	0	0		2,442		2,444	0.80%
1,263	0.47%	0.47%	1,430	0	0		1,430		1,431	0.47%
2,037	0.76%	0.75%	2,306	0	0		2,306		2,308	0.76%
2,095	0.78%	0.78%	2,372	0	90		2,372		2,374	0.78%
3,106	1.16%	1.15%	3,515	0	0		3,515		3,519	1.15%
3,117	1.16%	1.16%	3,528	0	0		3,528		3,531	1.16%
3,709	1.38%	1.37%	4,198	0	0		4,198		4,202	1.38%
16,536	6.16%	5.92%	18,086	0	0		18,086		18,103	5.93%
2,389	0.89%	0.88%	2,691	0	0		2,691		2,693	0.88%
4,772	1.78%	1.77%	5,401	0	0		5,401		5,406	1.77%
22,686	8.45%	8.39%	25,623	0	0		25,623		25,647	8.40%
1,560	0.58%	0.58%	1,766	0	0		1,766		1,768	0.58%
2,514	0.94%	0.93%	2,845	0	0		2,845		2,848	0.93%
5,650	2.10%	2.04%	6,221	0	0		6,221		6,227	2.04%
954	0.36%	0.39%	1,182	0	0		1,182		1,183	0.39%
1,656	0.62%	0.61%	1,874	0	0		1,874		1,876	0.61%
537	0.20%	0.24%	728	0	0		728		729	0.24%
1,480	0.55%	0.58%	1,764	0	0		1,764		1,766	0.58%
-	0.00%	0.00%	6	0	0		6		6	0.00%
2,066	0.77%	0.86%	2,632	0	40	-0.09%	2,349	1	2,349	0.77%
708	0.26%	0.26%	802	0	0		802		803	0.26%

(1)

Professional, Scientific and Technical Services
Penrith

Penrith - Professional, Scientific and T	2011	2016	2021	2026	2031	2036	2041	2046	2051
Final Emp Level	2,066	2,349	2,681	2,978	3,267	3,565	3,871	4,166	4,453
Final Share	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%
Employment AAGR		2.6%	2.7%	2.1%	1.3%	1.6%	1.7%	1.5%	1.3%
Population AAGR		2.6%	2.5%	2.0%	1.3%	1.7%	1.6%	1.6%	1.5%

Penrith - Professional, Scientific and Technical Services (2)

Penrith - Professional, Scientific and Technical Services (3)

11.2.3.1   M06c Sub-modules

The two sub-modules of M06 prepare inputs to the primary module. However, these have been identified as areas which could benefit from further development, and have therefore been created separately.

11.2.3.2   M06c_1

One input required for M06c is the minimum level of employment required to service population growth for selected industries (input defined as a maximum ERP to employment ratio). M06c_1 examines historical employment and population data to determine this ratio. This is currently achieved by making an assumption regarding the percentage of SA3s which currently provide an appropriate level of service. For example, if the assumption is that 95% of SA3s provide an adequate level of service (for population serving industries), it implies that 5% do not, and the calculated maximum ERP/employment ratio will be defined as the lowest ratio among this 5% (note, a higher ratio indicates a lower level of service).

Key inputs:

- GMA employment by industry projected from M06a
- ERP projections by SA3 from M01
- ABS Census data at the SA3 level for employment by industry

11.2.3.2.1 M06c_2

A final assessment of projections in M06c involves reviewing the employment density of SA3s. This compares employment projections to the area of currently zoned employment land. M06c_2 computes this area of employment land by both travel zone and SA3.

Key inputs:

- Area overlap of travel zones by planning zone obtained via GIS analysis

11.2.4   Module 6d – TZ Industry Projections

Module 6d completes the distribution of employment by allocating the SA3 industry control totals to a travel zone level. The base distribution is defined by census data (for the base year only). This distribution is then augmented by information on planned developments (i.e. the New Developments database) and professional judgement. The projection process has two primary components:

- Use census data and the New Developments database to compute the base distribution of employment by industry within each SA3
- The data combination of the two inputs acts as an attractor variable which is used to distribute SA3 employment across the constituent travel zones.
- Previously defined manual calibrations can be retained if changes are made to the base shares (e.g. New Developments input is updated)
- Apply manual calibrations to override projections at a travel zone level

Charts presenting the growth of employment (total and by industry) can then be used to review the projections. Additionally, the employment density of travel zones will indicate locations in which too much growth is projected (e.g. highly developed existing CBD zones).

Inputs

Key Inputs:

- ABS Census data at the travel zone level (2011)
- Estimate of available land by travel zone (M06c_2)
- SA3 employment by industry projections from M06c

- Known estimates of future employment by travel zone (i.e. New Developments Database)

Following this, a range of inputs which will reflect professional judgement based adjustments are required:

- On 'TZ Summary' sheet, select SA3 to which travel zone calibrations are to be applied
    - View 'Manual Calibrations' sheet in a separate window

- On the 'Manual Calibrations' sheet, enter a distribution override for desired industries

- Select whether to lock projections of each industry. This will prevent that travel zone from bearing any changes (caused when projections are scaled to SA3 control totals) should other zones be subsequently adjusted.
    - E.g. If industry 'A' in zone 'x' is locked, any changes to industry 'A' in zone 'y' will not result in a redistribution towards/away from zone 'x'.

- Enter a note which describes the motivation for manual changes

Functions

- The 'Base Shares' sheet combines census and New Developments data to create an attractor variable which is used to distribute employment by industry control totals across the constituent travel zones of each SA3.
    - For each period, the final shares of the previous period are used to calculate a first cut projected for each zone
    - For zones which have a base projection lower than the growth implied by 'New Developments' data, the projection is adjusted, the SA3 rebalanced to control totals and new shares computed.

- The 'TZ Summary' sheet presents the currently projected total employment for all travel zones within the selected SA3. Growth rates and density (jobs/hectare) are also shown, and should be used for review.

- The 'Manual Calibrations' sheet will display the employment projections, by industry, for the travel zone that is currently the active cell on the 'TZ Summary' sheet.

Share override adjustments, based on professional judgement, can be entered here. Once calibrations are saved, projections will balance to SA3 control totals

12 Appendix A: New development database

The New Developments Database is a major input into M06c. Figure 23 below shows the projects that are considered in the projection. The top twenty projects (based on overall number of jobs projected by 2056) were assessed by the DPE and adjusted to meet the Department's employment projected expectations for these projects.

Table 12: Summary of new developments database for employment

Project Name	Project Description	Project Area by Travel Zones
Alex Avenue	Alex Avenue Precinct was rezoned for urban development in May 2010. It will provide a Town Centre of up to 25, 000sq.m retail area (TZ 3958). A school will be located within TZ 3959. Another school will be located within TZ 3960.	3958, 3959, 3960
Area 20	This precinct was rezoned for urban development in October 2011. This precinct will include a light industrial zoned area as well as a planned station as part of the North West Rail Link.	3948
Austral / Leppington North	This project is the continued development of the Austral/Leppington North precinct.	3627
Barangaroo	This project is the development of the Barangaroo precinct including the three international towers. This project is expected to be completed by 2016.	1, 2, 3, 4, 5
Bays Precinct	This project includes the redevelopment of the foreshore to include an innovation hub.	153, 806, 828, 830, 832, 835
Box Hill/Box Hill Industrial	The Hills Council Contributions Plan No. 15 (June 2016) provides estimates for jobs within the Box Hill Precinct. The Precinct Plan provides for over 115 hectares of employment land with the potential to generate approximately 17, 800 jobs. Most of the new development will occur within the 11-20 year development timeframe (refer to the contributions plan for more detail).	4426, 4428, 4429, 4430, 4431
Broader Western Sydney Employment Area	The Western Sydney Employment Area (WSEA) is broken up into precincts A-G, with only precinct A released for development at this time. Once fully constructed, WSEA will provide around 97, 000 jobs throughout all the precincts and any additional land covered by the associated WSEA SEPP.	4045, 4961, 4964, 5002, 3626, 3477, 3479, 3482, 4059

Project Name	Project Description	Project Area by Travel Zones
Central to Eveleigh	This project is the redevelopment of the corridor between Central to Eveleigh. The project includes increased neighbourhood shops and some commercial development.	330, 132, 134, 136, 137, 140, 141, 142, 143, 144, 145, 146, 151, 152, 154, 156, 157, 158, 159, 160, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 176, 178, 179, 180, 181, 182, 183, 184, 185, 188, 189, 190, 191, 192, 193, 194, 195, 197, 196, 198, 199, 201, 202, 205, 206, 207, 208, 212, 214, 215, 217, 218, 223, 226, 227, 228, 229, 230, 231, 232, 233, 236, 238, 239, 240, 242, 243, 246, 247, 249, 255, 256, 257, 258, 260, 261, 262, 263, 264, 265, 266, 267, 270, 271, 272, 273, 274, 276, 277, 279, 281, 282, 283, 284, 285, 286, 287, 288, 559, 560, 562, 563, 565, 812
Clemton Park Village Centre/Former Sunbeam Factory Campsie	This project is the construction of a mixed use development comprising a retail component, mini-major tenancy, and supermarket with 290 residential apartments, community centre. This is stage 3 of the redevelopment of the former Sunbeam Factory site.	2517
Defence Land Moorebank - Intermodal Terminal	The defence site at Moorebank was rezoned to facilitate the development of the Moorebank Intermodal Terminal resulting in additional employment in this precinct.	3824
Edmondson Park Town Centre	This project is centred around the development of a Town Centre around the newly built train station of Edmondson.	3239

Project Name	Project Description	Project Area by Travel Zones
Enfield Intermodal Terminal	This project will be used as a storage and handling facility resulting in a small increase of employment within this travel zone.	984
Former Hoxton Park Airport - Development	This project is a result of a rezoning of the former Hoxton Park Aerodrome to a mixed use. The rezoning is expected to result in increased employment.	3712
Freight Transport Warehouse and Distribution Centre - Huntingwood	This project is expected to provide increased employment for this travel zone when complete.	4163
Glenfield to Macarthur	This project is a large development in and around the Campbelltown station. It will include large residential developments as well as commercial buildings.	3213, 3215
Greater Macarthur Investigation Area	This project is a large area release. It is planned to include approximately 33, 000 dwellings and 30, 000 local jobs within the area.	3300, 3305, 3307, 3005, 3007, 3008, 3009, 3010
Horsley Drive Business Park	This project is a development of a business park that will be including warehousing and distribution facilities.	3480
Hunter Economic Zone (HEZ)	This project is the continued development of the industrial park within the Hunter Economic Zone.	6740
Huntingwood West Precinct	This project is an industrial estate development.	4060
Huntlee Development	This project is a development of the Huntlee town centre within Cessnock. It will include an approximately 60ha of employment lands as well as residential development	6701
Liverpool CBD	This project is a rezoning of lands to mixed use. The development will include office and retail floorspace.	3843
Macquarie Centre expansion	This project is an expansion of the Macquarie Centre including the expansion of the shopping centre, four mixed use towers.	1539

Project Name	Project Description	Project Area by Travel Zones
Marrickville Metro	This project is a redevelopment of the centre to include commercial and retail.	303
Marsden Park	This project is a growth centre with an expected residential and employment precinct.	3950, 3956, 3961
Marsden Park Industrial	This precinct was rezoned to industrial and bulky goods retailing.	3962, 3968, 3970
Newcastle CBD	This project includes the rezoning and building of the light rail project along within the Newcastle CBD.	6317, 6351, 6352
Northern Beaches Hospital	This project is expected to be complete by 2018.	2140
NWRL-Kellyville	The North West Rail Link is expected to result in employment around the proposed station	4568
NWRL-Rouse Hill	The North West Rail Link is expected to result in employment around the proposed station	4436
Oran Park	This project is a business park development.	3678
Other developments	These projects are small scale redevelopments sourced from Cordells. This includes small rezoning and mixed use developments expected to provide small levels of employment	5331, 5180, 6613, 5700, 5723, 5736, 5838, 5644, 5647, 6400, 6414, 6427, 6210, 6117, 4434, 4160, 79, 97
Parramatta	This project is the continued development of the Parramatta precinct.	1018, 1019, 1021, 1023, 1024, 1025, 1026, 1052, 1053, 1054, 1055, 1056, 1057, 1058, 1059, 1062, 1064, 1065

Project Name	Project Description	Project Area by Travel Zones
Penrith Panthers development	This project is a development of a seniors housing development expected to provide an increase in health employment.	4980
Penrith Station Car park	The development is to include business, commercial and light industrial space.	4977
Port Botany Expansion	The expansion of the port will result in increased employment capacities.	401, 402
Potts Hill Redevelopment	The redevelopment is expected to include increased employment lands.	2329
Redfern-Waterloo Development	The redevelopment between Redfern and Waterloo is expected to increase employment capacity.	210, 211, 216, 222
Residential/commercial development at former BATA manufacturing site	The redevelopment of the former manufacturing site is likely to include some employment capacity for retail employment.	423
Riverstone	The Riverstone Growth Centre Precinct was rezoned for urban development in May 2010. It will include a Major Town Centre, industrial land, schools, and neighbourhood centres.	3933, 3935, 3941, 3953
Riverstone West	Riverstone West Growth Centres precinct was rezoned August 2009. It is expected that 16ha will be Business Park, 72 ha will be (IN1) Industrial and 16ha will be (IN2) Light Industrial.	3934, 3937
SICEEP Precinct	The Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP) development includes a convention centre, a theatre, a hotel complex, and 'The Haymarket' residential/ commercial development.	89, 108, 125

Project Name	Project Description	Project Area by Travel Zones
South West Growth Area	This project will include large residential and commercial development within the South West Growth Area precinct.	3243, 3615, 3616, 3621, 3624, 3629, 3630, 3632, 3633, 3634, 3651, 3653, 3654, 3655, 3656, 3657, 3658, 3659, 3660, 3662, 3663, 3664, 3668, 3669, 3671, 3672, 3674, 3679, 3681, 3683, 3685, 3689, 3691, 3692, 3724, 3478, 3483, 3864, 3865
Southern Employment Lands	This project is a large industrial development for warehousing and distribution centre.	1238
Sydney Metro - Bankstown to Sydenham	This project is the development of the corridor the Sydney Metro will run. It is expected the development of the metro will increase commercial employment capacity along the corridor.	307, 310, 313, 2301, 2305, 2307, 2308, 2311, 2504, 2509, 2510, 2511, 2512, 2514, 2515, 2533, 2541, 2542, 2545, 926, 927, 941, 943, 944, 945
Sydney Metro - Northwest	This project is the development of the corridor the Sydney Metro will run. It is expected the development of the metro will increase commercial employment capacity along the corridor.	4514, 4515, 4516, 4517, 4521, 4532, 4533, 4534, 4536, 4571, 4433, 4438, 3906, 3908, 1805, 1806, 1402, 1406, 1407

Project Name	Project Description	Project Area by Travel Zones
Sydney to Parramatta	This project is the redevelopment of Parramatta road from Sydney to Parramatta. It will include increased commercial floorspace along the corridor.	316, 317, 318, 237, 706, 707, 717, 719, 720, 735, 738, 819, 820, 821, 826, 900, 901, 903, 910, 911, 912, 939, 950, 951, 952, 958, 960, 961, 963, 969, 970, 1300, 1301, 1303, 1304, 1318, 1320, 1321, 1322, 1323, 1324, 1326, 1328, 1333, 1334, 1335, 1220, 1222, 1046, 1045, 1047, 1048, 1068, 1071
Tallawarra Lands	This project is the development of a new water and wastewater infrastructure to service the Tallawarra Lands.	5726
Town Centre and Civic Precinct of Warnervale	Development of the town centre and civic.	5186
Western Sydney Airport and surrounds	This project is the development of Badgery's airport and surrounds. This is expected to provide employment once the airport is developed.	4967, 4968, 4970, 3609
Wolli Creek redevelopment	The redevelopment of Wolli Creek is expected to increase employment capacity due to increased provision of commercial and retail floor space.	2702
Woolooware Bay Town Centre Development	This redevelopment is expected to provide a small increase to the employment capacity within the travel zone.	2914

13 Appendix B: GSC Centres

The figure below shows the centres that are defined by the GSC. These centres outlined below are the major strategic and district centres within Greater Sydney.

Figure 37 GSC Centres
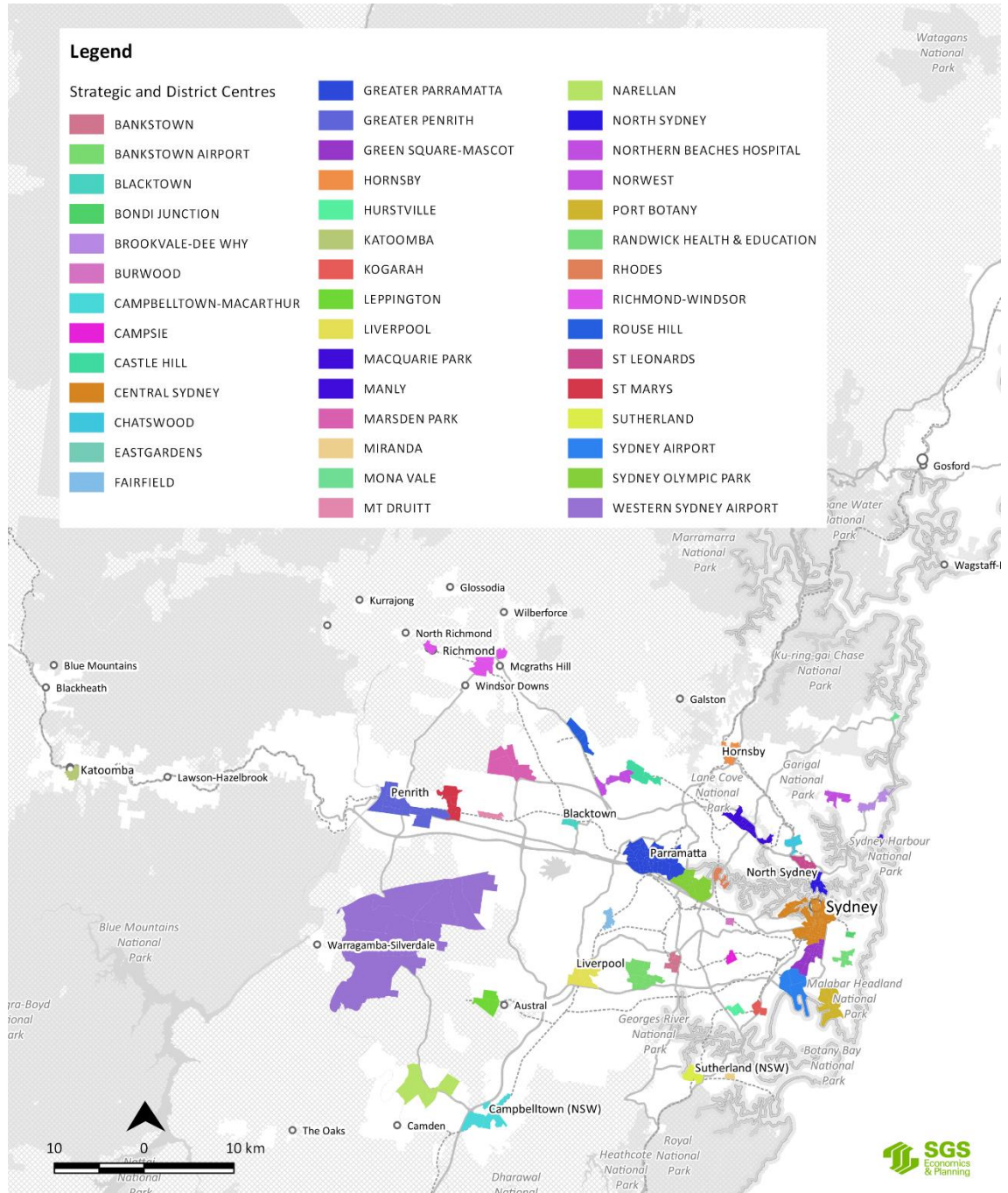
14 Appendix C: Travel Zone Projections 2016: Process Maps

Population & Dwelling Projections Model

Description: This model estimates population and dwellings, by age-sex, and by household type at the Travel Zone level to 2056. This is achieved by 1) distributing dwelling capacity and estimating the population in each Travel Zone; 2) distributing the population across age-sex categories, and 3) using outputs from 1) and 2) to distribute the population across household types at the Travel Zone level. Below are the input data sets, the modelling and process of Population & Dwelling Projections Model, output data sets, and insights that can be drawn.
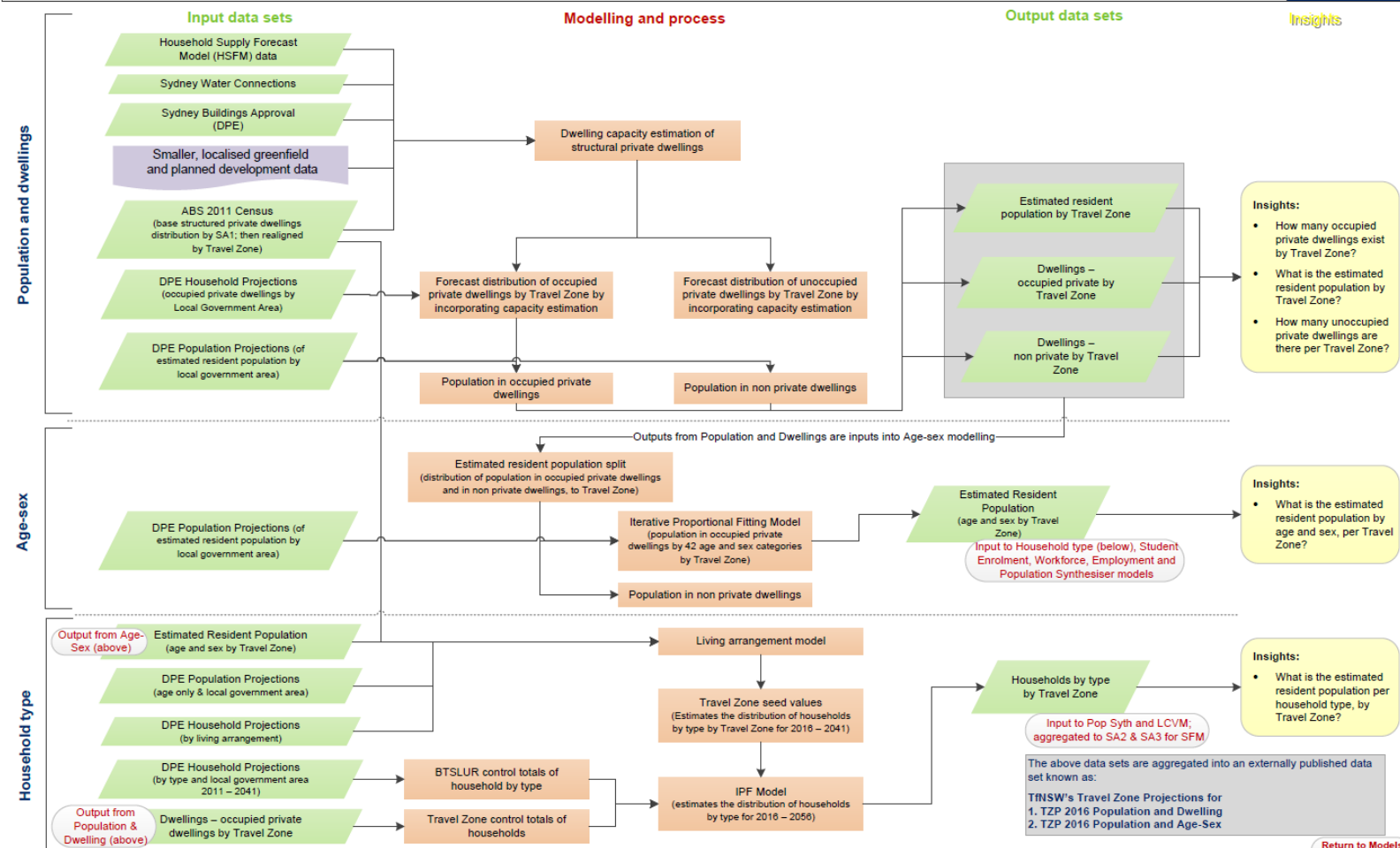
Source: TfNSW TPA, '2016 Travel Zone Projections (TZP 2016) – Part 1: Model Overview and Results'.

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Student Enrolment Projections Model

Description: This model uses outputs from the Population & Dwelling Projections model (Estimated Resident Population – age and sex), to estimate student enrolments for primary, secondary and tertiary education, by place of residence and place of institution at the Travel Zone level to 2056. Below are the input data sets, the modelling and process of the Student Enrolments Projections Model, output data sets, and insights that can be drawn.

Input data sets **Modelling and process** **Output data sets** **Insights**

Output from STM

STM Highway skims
(travel time matrix)

ABS 2011 Census
(estimated resident population with current age and education status)

Output from Population & Dwelling

Estimated Resident Population
(age only by Travel Zone)

Enrolments at origin:
- Student attendance by primary, secondary and tertiary by greater metropolitan area
- Primary and secondary ages 5-18; tertiary ages 18-84

Gravity model:
- Estimates the propensity for a student to attend a school from every Travel Zone to every school
- Results in students attending closest school (within capacity constraints) adjusted by known preference behaviours)
- Produces primary and secondary outputs (growth applies to primary and secondary, not tertiary)

Primary and secondary enrolments
(place of usual residence and destination enrolments, by place of institution in greater metropolitan area)

Input to Pop Syth and STM

Insights:
- What are the enrolments at place of usual residence, for primary and secondary students?
- What are enrolments by place of institution and destination?
- How many primary and secondary students live in this Travel Zone?
- Where do the students who attend schools in this Travel Zone reside (by Travel Zone)?

ACARA enrolments 2013 (NSW current school enrolments by age and place of school / institution at Travel Zone)

Enrolment control total:
- Using Iterative Proportional Fitting to calculate the distribution of age groups to education enrolment – primary, secondary and tertiary

Australian university enrolments
(NSW Institutions; estimates of tertiary enrolments by destination; full time and part time split)

TAFE enrolments
(estimates of tertiary enrolments by destination; full time and part time split)

DoE Forecast
(enrolment data and forecasts for primary and secondary schools, by age and place of school at Travel Zone)

Enrolments at destination:
- From ACARA data sets, forecast forward the number of students that each institution can take (capacity)
- Sydney greater metropolitan area, large and small campuses, by Travel Zone

Distribution of enrolments (tertiary only):
- Estimates tertiary enrolments for the destination of students at both TAFE and University under a full time and part time split
- First pro-rata based on current distribution
- Adjustments made for major institutions, or where developments / new facilities are known
- Employment data assists with distribution of students by campuses; then use proportional distribution

Tertiary enrolments
(place of usual residence and destination enrolments, by place of institution in greater metropolitan area)

Input to Pop Syth and STM

Insights:
- What are the enrolments at place of usual residence, for tertiary students?
- What are tertiary enrolments by place of institution and destination?

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Source: TfNSW TPA, '2016 Travel Zone Projections (TZP 2016) – Part 1: Model Overview and Results'.

Workforce Projections Model

Description: This model uses outputs from the Population & Dwelling Projections Model to estimate various segmentations of the working age population, over 3 modelling runs at 3 geographic scales: Greater Sydney, sub-regions of SA4s, at the Travel Zone level to 2056. The population is broken down by workforce status (employed or 'workforce', unemployed and not in the workforce), and employed persons are further broken down by employment status (employed full-time or part-time) and income bands. Below are the input data sets, the modelling and process of Workforce Projections Model, output data sets, and insights that can be drawn.

Input data sets   **Modelling and process**   **Output data sets**   **Insights**

Geography	workforce Status	Employment Status (full-time / part-time)	Income Bands

GMA

DPE Population Projections (of estimated resident population by local government area)

2015 Intergenerational Report (IGR)

ABS Labour Force Survey (LFS) (1978-2016 - Cat. No. 6291.0.55.001 and 6291.0.55.003)

Richard's Curve:
- Estimates the participation rate, which focuses on forecasting entry / exit rates for each of the 42 age-sex group over time
- Captures both changing behaviour (i.e. females having children later; shifting social attitudes or opportunities of the population) and the evolving age profile of the city)

Fixed unemployment rates:
- Estimates unemployment by age group for greater Sydney and rest of NSW, based on user-defined assumptions regarding long term ranges for overall unemployment rates (non-age specific)

Trend analysis by age:
- Factors influencing f/t and p/t include industry structure, economic cycles and labour market constraints
- Analysis showed propensity to work p/t is primarily driven by age (e.g. young people studying or older people reducing their hours). Therefore, it's used to forecast this attribute over time

Forecast participation rates by age and sex of working population

By SA4

Output from Population & Dwelling

Estimated Resident Population (age and sex by Travel Zone)

ABS 2011 Census (Cat. No. 6291.0.55.011 LM2, LM1, RM1 and ABS TableBuilder – labour force status and personal income (weekly) at the SA4 level)

Workforce base data:
- Synthesise data to produce GCCSA control totals and SA4 starting distributions for segmentations of 1) workforce status, and 2) employment status, using GCCSA participation, unemployment and p/t rates, by age-sex.
- Then estimate TZ starting distributions for next stage, and compute age-specific and income band propensities by TZ

Iterative proportional fitting to estimate the estimated resident population in occupied private dwellings (OPD), by SA4, within each workforce category:
- In workforce – employed
- In workforce – unemployed
- Not in the workforce

Forecasts age-specific propensities for workers to engage in full time and part time employment. Then IPF to estimate *employment* status segmentation in OPD by SA4:
- Full-time (f/t)
- Part-time (p/t)
- Not in the workforce

Propensity analysis:
- Segments the population of working age (15+) in OPD into 5 income bands. Then propensity analysis of individuals to income band based on workforce status and employment status (as they are the most significant determinants of income distribution; also influenced by age-sex structure)
- Estimates income band by SA4

Workforce, employment status and income bands forecasts at place of usual residence, by Travel Zone

Input to Pop Syth and Employment

Insights:
- What is the estimated resident population in occupied private dwellings that are in the workforce, and work full time, part time or are unemployed, by income band?

By TZ

Iterative proportional fitting to estimate the estimated resident population in occupied private dwellings, by Travel Zone, within each workforce category:
- In workforce and employed
- In workforce and unemployed
- Not in the workforce

IPF to estimate the employment status segments for all constituent Travel Zones over time:
- Full-time
- Part-time
- Not in the workforce

IPF to segment population of working age (15+) in OPD by Travel Zone:
- 5 Income bands (based on 2011 Census; uses assumed long-term real income growth rate of 1.4% aligned to 2015 IGR, and median earnings of each income sub-band, to calculate shifts across bands)

The above data sets are aggregated into an externally published data set known as:

TfNSW's Travel Zone Projections for
1. TZP 2016 Workforce Summary
2. TZP 2016 Workforce Detailed

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Source: TfNSW TPA, '2016 Travel Zone Projections (TZP 2016) – Part 1: Model Overview and Results'.

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2016 Travel Zone Projections

Employment Projections Model

Description: This model is used to produce employment projections by industry, at the Travel Zone level to 2056. It has 2 major functions: 1) the total employment (persons employed by place of work) by industry is projected for the GMA region, and 2) the spatial distribution within each industry is projected based on a variety of factors, at geographies SA3 and Travel Zone. *Note: As estimating the growth and distribution of employment by industry is reliant on professional judgement and influenced by endogenous and exogenous factors, the modules are designed to automate first-cut estimates, then apply professional judgement to obtain 2nd cut final estimates. Below are the input data sets, the modelling and process, output data sets, and insights that can be drawn.*

Input data sets	**Modelling and process**	**Output data sets**	**Insights**

Geography

GMA

Output from Population & Dwelling
Estimated Resident Population (age and sex by Travel Zone)

ABS Labour Force Survey (LFS) (1978-2016 - Cat. No. 6291.0.55.001 and 6291.0.55.003)

Output from Workforce
Workforce, employment status and income bands projections at place of usual residence, by Travel Zone

Output from Population & Dwelling
Dwellings – non private by Travel Zone

ABS Census data (historical employment at the 2 digit level from 1996 – 2011 by SA3 and Destination Zone (DZN). Also 2011 Journey to Work (inflow and outflow of workers from ABS TableBuilder) by industry at SA3 level)

Preliminary industry share forecast – Trend based:
- Forecasts the quantum of employment by industry within the GMA region by:
  - 1) forecasting total employment within GMA region for each period to capture 1.1) net inflow of workers from the rest of NSW to the GMA, and 1.2) employment of persons who reside in non-private dwellings
  - 2) Refining industry forecasts based on variety of factors, such as population to employment ratio, or expected growth rate
- Produces 1-digit ANZSIC industry forecast

Industry refinements:
- For each industry sheet, review the forecasts implied by the preliminary shares against the provided indicators and refine the level changes and growth rates if necessary
- For example if a population driven industry captures an unreasonable share of regional employment (shown in the ratio of population to employment), adjust the growth values to result in a forecast that 1) has a more reasonable share of total employment, and 2) displays a strong but declining growth rate consistent with recent trends

2-digit ANZSIC manufacturing forecasting:
- Uses historical employment data from Census (1996 to 2011) to disaggregate the 1-digit industry forecast to a 2 digit industry forecast

By SA3

Preliminary SA3 share forecast – Trend based:
- Distributes the previously determined employment by industry forecasts to SA3 level by using 1) historical census, 2) planned developments and 3) professional judgement (such as growth in employment in known developments, forecast population growth, regions breaking away from recent trends, impacts on industries)
- Forecasts then reviewed through an examination of employment density (forecast employment per hectare of employment zoned land) across SA3. This provides a high-level representation of how SA3 are expected to evolve relative to their quantity of employment land

Population driven industry adjustments:
- Checks population in SA3 areas is sufficiently serviced by employment

Final industry distribution refinements at SA3 level:
- control total to ensure SA3 is broken down to the Travel Zone level

By TZ

New developments database (known developments and growth in future employment by Travel Zone. The top 20 projects (based on overall number of jobs forecast by 2056) were assessed by DPE)

Preliminary TZ industry forecasting share – Trend based:
- Allocates the SA3 industry control totals to a TZ level by 1) using Census data and new developments database to compute the base distribution of employment by industry within each SA3, and 2) use professional judgement to apply manual calibrations to override forecasts at TZ

Population driven industry adjustments:
- Checks population in Travel Zones are sufficiently serviced by employment

Final industry distribution refinements at Travel Zone level

Employment (persons employed by place of work) projections by industry at Travel Zone level

Input to STM, LCVM, PB-SA-FMM, FMM and SFM

Insights:
- What is the employment (persons employed by place of work) by industry at the Travel Zone level?
- What is the likely future employment per Travel Zone?

The above data sets are aggregated into an externally published data set known as:

TfNSW's Travel Zone Projections for
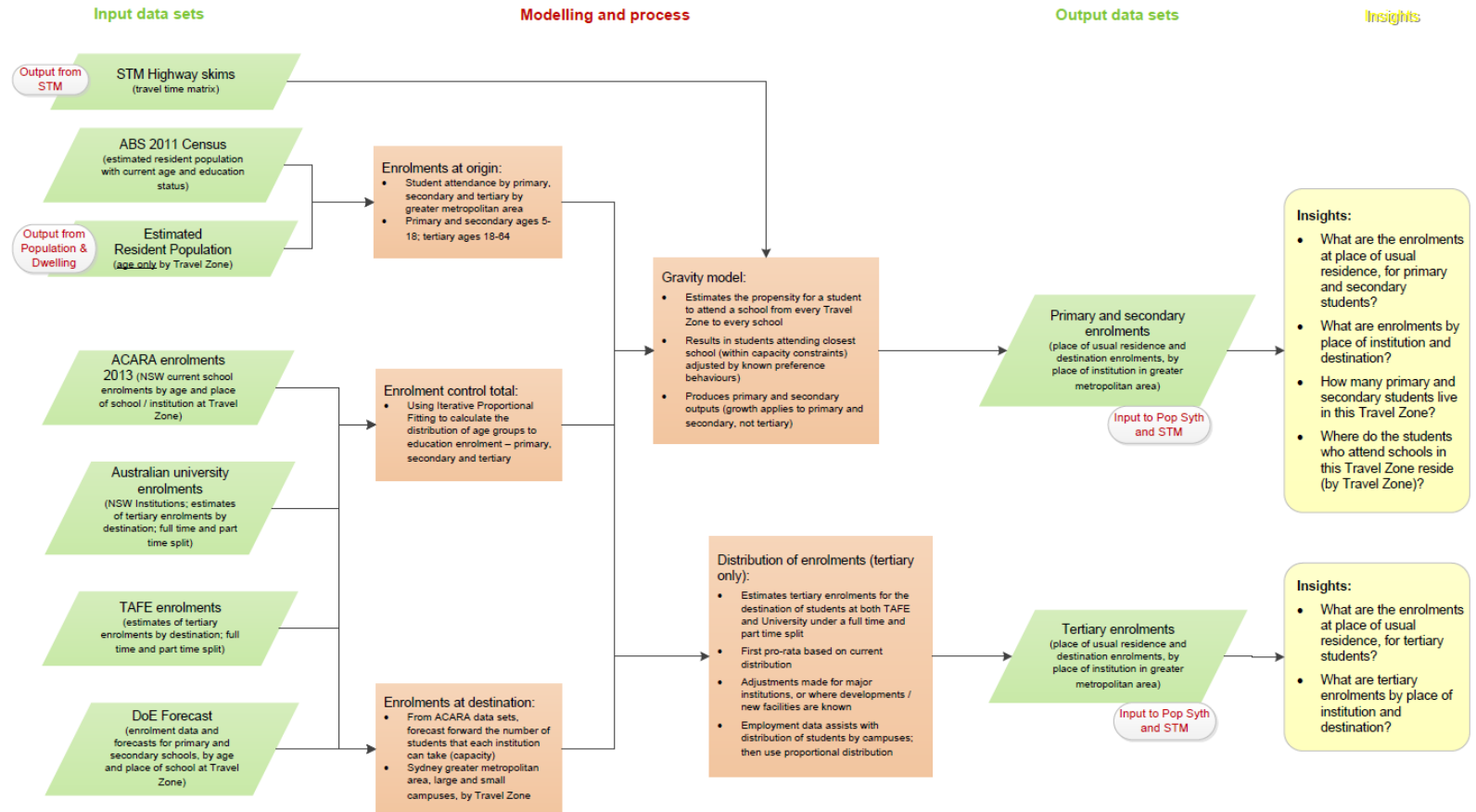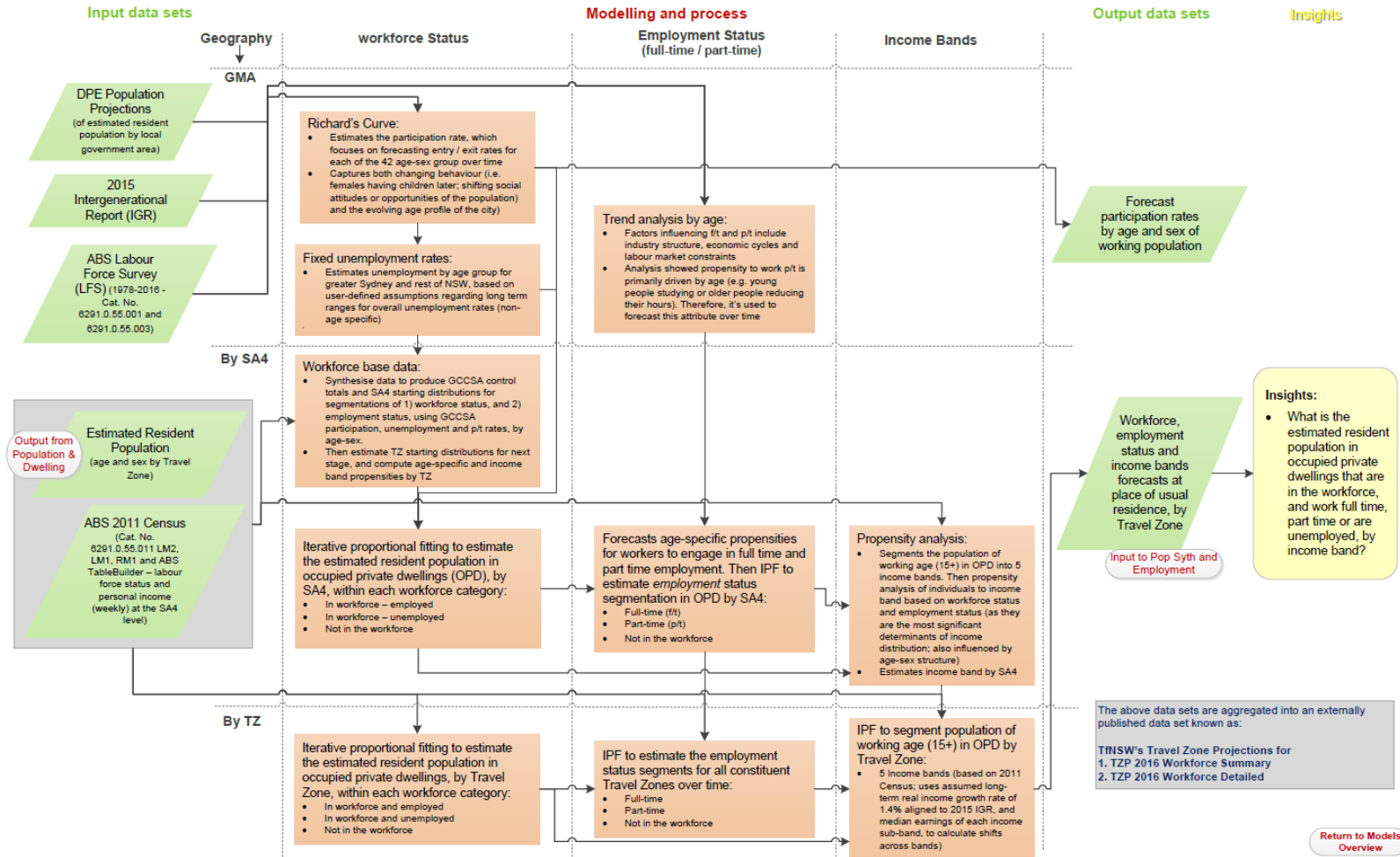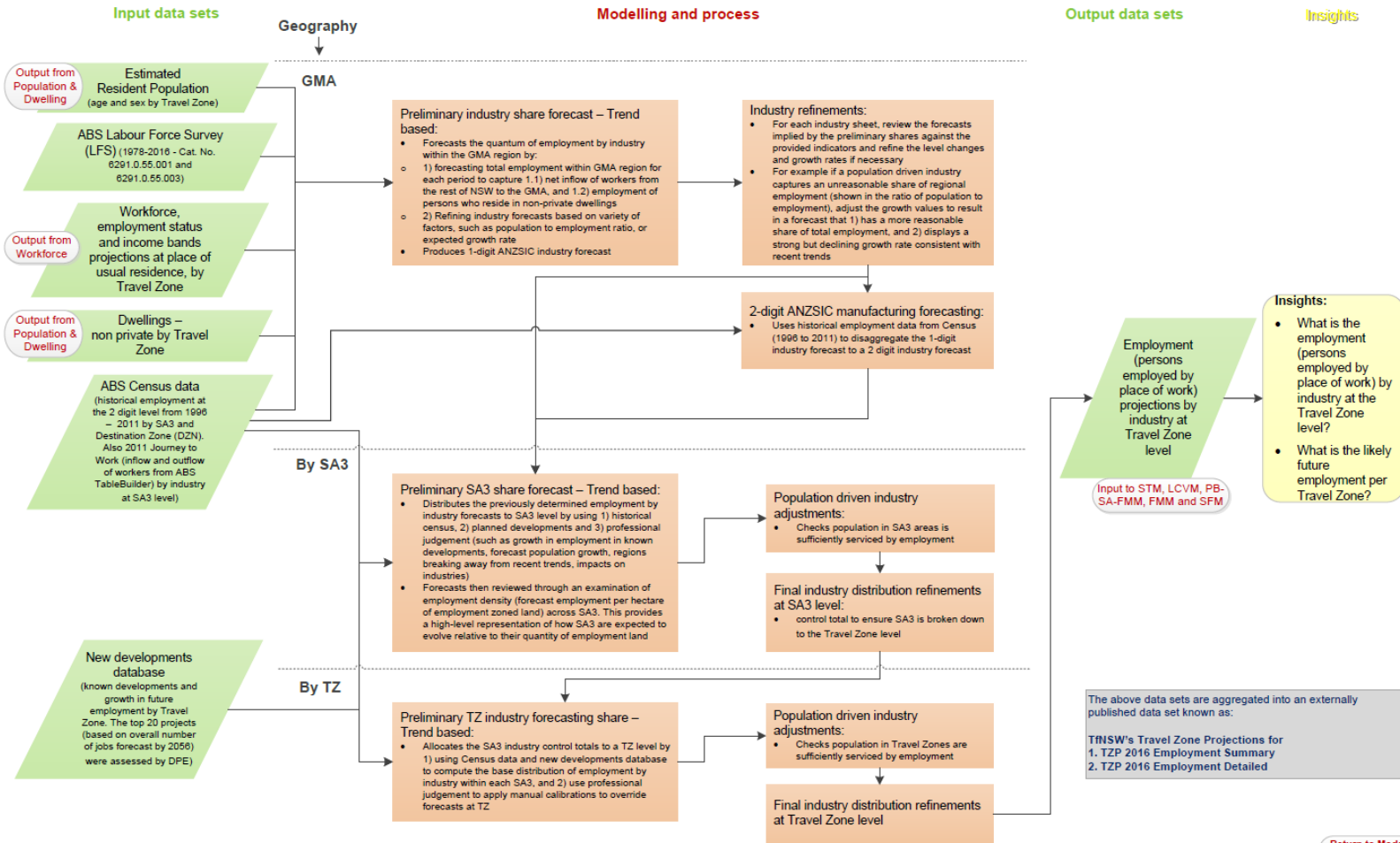1. TZP 2016 Employment Summary
2. TZP 2016 Employment Detailed

Source: TfNSW TPA, '2016 Travel Zone Projections (TZP 2016) – Part 1: Model Overview and Results'.

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