Transport
for NSW

New South Wales Travel Zone Projections (TZP22) Technical Guide

November 2022

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Acknowledgement of Country

Transport for NSW acknowledges the traditional custodians of the land on which we work and live.

We pay our respects to Elders past and present and celebrate the diversity of Aboriginal people and their ongoing cultures and connections to the lands and waters of NSW.

Many of the transport routes we use today – from rail lines, to roads, to water crossings – follow the traditional Songlines, trade routes and ceremonial paths in Country that our nation's First Peoples followed for tens of thousands of years.

Transport for NSW is committed to honouring Aboriginal peoples' cultural and spiritual connections to the lands, waters and seas and their rich contribution to society.

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Date:	10 November 2022
Version:	Final
Reference:	Transport for NSW
Division:	Customer Strategy and Technology
Review date:	2022

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Glossary and abbreviations

Term	Definition	Abbreviation
Advanced Analytics and Insights	Advanced Analytics and Insights provide objective and credible transport data, advice, and analysis within Transport for NSW.	AAI
Australian and New Zealand Standard Industry Classifications	The standard classification was jointly developed by the Australian Bureau of Statistics and Statistics New Zealand for the collection, compilation and publication of statistics by industry in Australia and New Zealand. This classification is hierarchical with four levels, namely Divisions (1 digit; the broadest level), Subdivisions (2 digit), Groups (3 digit) and Classes (4 digit; the finest level).	ANZSIC
Australian Bureau of Statistics	The ABS is Australia's national statistical agency, providing trusted official statistics on a wide range of economic, social, population and environmental matters of importance to Australia.	ABS
Australian Curriculum, Assessment and Reporting Authority	An independent statutory authority responsible for data collection and reporting to support education for students nationwide. Provides NSW enrolments to be used in TZP.	ACARA
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' geographical framework, effective from July 2011, replacing the ASGC.	ASGS
Average Annual Growth Rate (%)	The growth rate over a given period divided by the number of years in the period	AAGR
Department of Planning and Environment	New South Wales state government agency responsible for effective and sustainable planning to support the growth in the state of New South Wales	DPE
Eagle Eye	A web-based application used for analysing and developing insights from multiple data sets used for school provisional planning in NSW. The tool is developed by Service Planning at School Infrastructure NSW.	
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, and nursing homes).	ERP
Freight Movement Model	Transport for NSW in-house model associated with freight movements across New South Wales	FMM
Future Employment Development Database	A database of various assumed employment developments across NSW, which provides small area level future inputs into the employment model and is used as the primary input to shift census trend projections.	FEDD
Greater Cities Commission	An independent organisation funded by the NSW Government to coordinate and align the planning that will shape the future of Greater Sydney.	GCC
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	This was the name of the *Greater Cities Commission* before 2022.	GSC
Household size	The ratio of *persons in occupied private dwellings* to *occupied private dwellings* (e.g., if the *household ratio* in Sydney is 1.91, this implies on average there are 1.91 persons in each occupied private dwelling).	
Household Travel Survey	The largest and most comprehensive source of personal travel data for the Sydney GMA.	HTS
Intergenerational Report	2021 report by the NSW Treasury that assesses long-term changes over the next 40 years, which includes the state's population, age profile, economic growth, and workforce.	IGR
Iterative Proportional Fitting	A statistical method that aligns known totals to an estimated distribution.	IPF
Land Use	In the context of TZP, it refers to Population, Workforce, Employment and Student projection outputs at Travel Zone level.	LU
Local Government Area	Area of the third tier of government in Australia with responsibilities under the Local Government Act. LGA boundaries are defined as of 2018.	LGA

New South Wales	The State of New South Wales is the area analysed for the TZP22 projections.	NSW
Non Private Dwelling	Communal accommodation provided by institutions such as hospitals or prisons and transitory accommodation such as hotels and motels.	NPD
Occupancy Rate	The ratio of occupied to unoccupied private dwellings	OR
Occupied Private Dwellings	A private dwelling that is occupied by one or more people. When using Census data, this represents a private dwelling that is occupied by one or more people on Census night.	OPD
Place of Enumeration	Refers to variables that are based on the location at which the person is counted on Census Night (e.g., the number of people who stayed in a particular zone on Census night).	PoE
Place of Institution	Refers to variables that 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 that are based on the home location of the population (e.g., the number of people who live in a particular zone).	PUR
Place of Work	Refers to variables that are based on employment locations (e.g., the number of 'Retail Trade' industry jobs within a particular zone).	PoW
Population in Non-Private Dwellings	Estimated resident population who reside in communal or transitory type accommodation (e.g., prisons, boarding schools, hospitals, and defence establishments).	PNPD
Population in Occupied Private Dwellings	Estimated resident population who reside in private dwellings.	POPD
Population Synthesiser	A model that uses land use data to create 'agents' for input into STM.	Pop Synth
SGS Economics and Planning	An urban public policy consultancy consisting of economists, planners and spatial analysts. SGS has developed the Travel Zone projections since 2015.	SGS
Strategic Travel Model	The STM combines travel behaviour with population, employment, and transport networks to estimate future travel under different strategic land use and transport scenarios.	STM
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 Housing Supply Forecast	The Sydney Housing Supply Forecast is a spatial dataset that distributes future housing supply across Sydney for the next 20 years, prepared at a Mesh Block level by the NSW Department of Planning & Environment. It is used to guide infrastructure planning and service delivery to support new housing development and population growth; and informs long-term strategic planning.	SHSF

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
Transport Performance and Analytics	Transport Performance and Analytics within TfNSW previously produced the Travel Zone Projections prior to TZP22.	TPA
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. The latest version was created in 2016 and largely aligns with 2016 ABS Destination Zones. See https://opendata.transport.nsw.gov.au/dataset/travel-zones-2016 for additional information.	TZ or TZ16
Trip Attractors	Variables relate to destinations. These destinations range from places of work and education to destinations such as shopping centres.	
Trip Generators	Variables related to the origin location of travel (i.e., place of residence).	
Unemployment Rate	The number of unemployed persons expressed as a percentage of the workforce.	UR
Unoccupied Private Dwellings	A private dwelling that is unoccupied although was built specifically for living purposes and is habitable (such as a vacant house, holiday home, hut or cabin). When using Census data, this represents a private dwelling that is unoccupied on Census night.	UOPD
Victoria University	The Centre of Policy Studies at Victoria University created the State Victoria University Employment Projections by 1-digit ANZSIC industry group from 2016-2066.	VU
Workforce	For any group, persons who are employed or are unemployed but are actively seeking work.	WF

1 Introduction

1.1 Background

Advanced Analytics and Insights ('AAI') within Transport for NSW ('TfNSW') produces the 2022 Travel Zone ('TZ') level projections (population, students, workforce and employment) for New South Wales ('NSW') 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. Transport Performance and Analytics ('TPA') produced previous versions of the Travel Zone Projections ('TZP').

The data produced is available to download from the TfNSW Open Data Hub and is used as input into a diverse range of local planning and research work by a wide range of practitioners.

TZP is developed to support a strategic view of New South Wales and is calibrated with that State 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 and regional future based on current data, trends and an understanding of policy/structural changes that may impact the future.

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 approach improvements.

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 practices, data, approaches, and software.

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

In 2018, SGS worked with the TPA team to feed the 2016 Census into the model to create the Interim Travel Zone Projections 2016 v1.51. This update was completed in January 2019. A major update was undertaken in 2019/2020 to develop TZP19 based on 2019 NSW population projections that have been released from the Department of Planning, Industry and Environment ('DPIE') developed pre the COVID-19 pandemic.

This version (TZP 2022) reflects an interim update, based on 2022 NSW population projections that have been released from the Department of Planning and Environment ('DPE'), as well as updated employment projections released from Victoria University ('VU'). TZP22 also builds upon the improvements made to TZP19, with enhanced automation and data validation features.

The projections in TZP22 extend from 2016 to 2066. Consideration should be given to the fact that there is more detailed planning and economic data available up to 2041, with less reliance on projections post-2041.

1.2   Audience and objective of this report

This is a technical report which documents the overall approach, assumptions, and data sources for the development of the Travel Zone Projections 2022 (TZP22). It is intended for a reader with a general understanding of economic and projection techniques.

This version of the TZP22 technical guide details the high-level methodology to develop the travel zone projections. It provides an overview of the respective modules used to develop the constituent parts of the projections and the data flow of information between them.

It should be noted that further detail regarding the functionality of each module is also contained in individual model files. Detailed datasheets also include the final TZP22 results along with several additional summary breakdowns by Districts, LGAs and Precincts.

The TZP22 Insights Report provides a summary of the forecast results.

1.3   Data limitations and cautions

The TZP dataset is extremely detailed with millions of datapoints across 60+ variables, 19 time periods and around 3,758 travel zones. Further, for a strategic transport model what is critical is that **all** people/workers/students are allocated down to a zone - to then create travel flows from one location to another. This requirement means there cannot be undefined/unallocated locations or variable categories and that there must be a strong nexus between all data variables throughout the model.

This detail is required for the STM to create and allocate trips and means assumptions are required to fill data gaps/uncertainty, which may not be necessary under other circumstances where undefined categories are not problematic, and certainty of outcomes is more critical.

Therefore, similar to the STM, the TZP dataset should be seen as a strategic state-wide dataset. A high degree of caution should be exercised when using the data, particularly at more detailed levels. Users should further note that a comprehensive analysis of individual sites or precincts has not been undertaken in the development of TZP. Figures for an individual TZ should not be considered accurate, even in base or historic years, as source data is generally not available at this geographic extent; instead, estimates have been derived using rules to disaggregate source data from larger geographic areas down to this level.

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 a current understanding of policy/structural changes. It does not reflect a pure policy aspiration or project-specific scenario which would need to be further developed as a separate scenario.

Table 1 provides an indicative view of the certainty of the data at different spatial, temporal and detail levels.

Table 1 Data Certainty Summary

Location and Geographic Detail	Certainty
State	
Greater Sydney	
GSC District	
Six Cities	
Regional NSW	
Local Government Area	
Centre	
Travel Zone	

Time	Certainty
2016	
2017-2020	
2021	
2022-2025	
2026	
2031	
2036	
2041	
2046	
2051	
2056	
2061	
2056	

Area Outlook	Certainty
Established	
Renewal	
Growth Area	
Currently Undeveloped	

Forecast Variable Detail	Certainty
Total	
Minimal Categorisation (i.e., Broad Industry Category Employment/Labour Force Status (Employed vs. Unemployed)	
Detailed Breakdown (Employment by ANZSIC Industry/Population by 5-year age cohort)	

More Certain

Less Certain
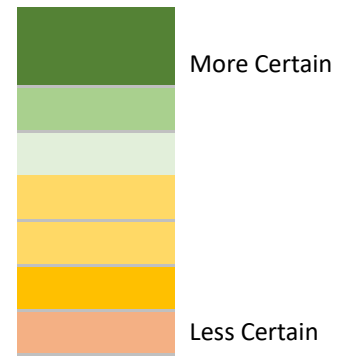
1.4   High Level Results

This chapter provides a high-level overview of the Travel Zone Projections 2022 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.[1]

In addition, a TZP22 Insights Report highlighting results in more detail is available upon request from TfNSW which will provide more detail on specific locations and trends by different components of the forecast including mapping summaries.

1.4.1   Land Use Forecasts

By 2066, there are projected to be more than 5.9 million jobs and more than 11.8 million people in New South Wales. The majority of people and jobs will be in established urban areas across the Sydney Greater Metropolitan Area which currently has approximately 79 per cent of people and 80 per cent of jobs; this will increase to 83 per cent of the total population and 84 per cent of jobs by 2066.

Figure 1 shows a summary of the NSW employment and population growth out to 2066. Growth rates for both employment and population are similar post-2036, however, there are some deviations in population growth in the prior years due to the COVID-19 pandemic and its recovery. The ratio of people to jobs across NSW was approximately 2.04 persons for every job in 2016, which will drop to approximately 1.94 persons for every job by 2026, and will increase back to approximately 1.99 persons for every job by 2066.

Figure 1 NSW employment and population growth

Source: SGS Economics and Planning, 2022

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[1] https://www.transport.nsw.gov.au/data-and-research/reference-information/travel-zone-explorer-visualisation
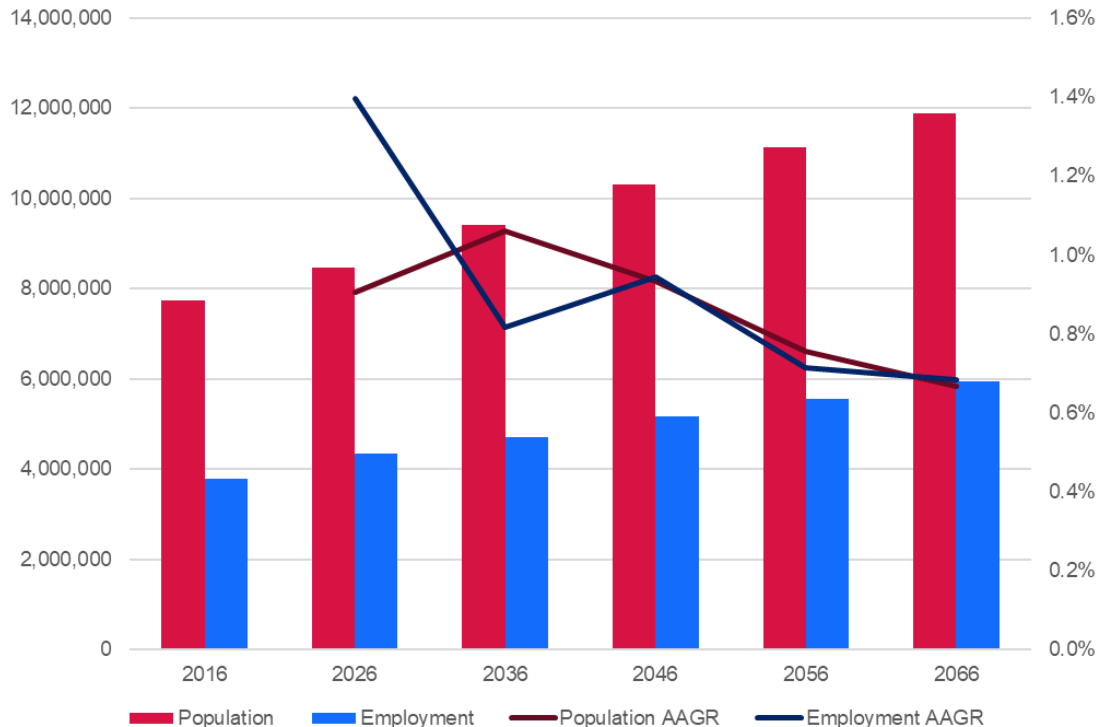
The following pages provide a summary of the forecasts by the Six Cities. The Six Cities (Eastern Harbour City, Central River City, Western Parkland City, Central Coast City, Illawarra-Shoalhaven City, and Lower Hunter and Greater Newcastle City) are used as part of the Greater Cities Commission's (GCC) plan to shape the 2023 Region Plan. The LGAs of Dungog, Singleton, and Wingecarribee plus the SA2 of Tea Gardens - Hawks Nest combined with the Six Cities together form the Sydney Greater Metropolitan Area. Anything outside of this is considered the Rest of NSW for the purposes of this reporting. Figure 2 illustrates the Six Cities definition spatially.

Figure 2 Six Cities context map
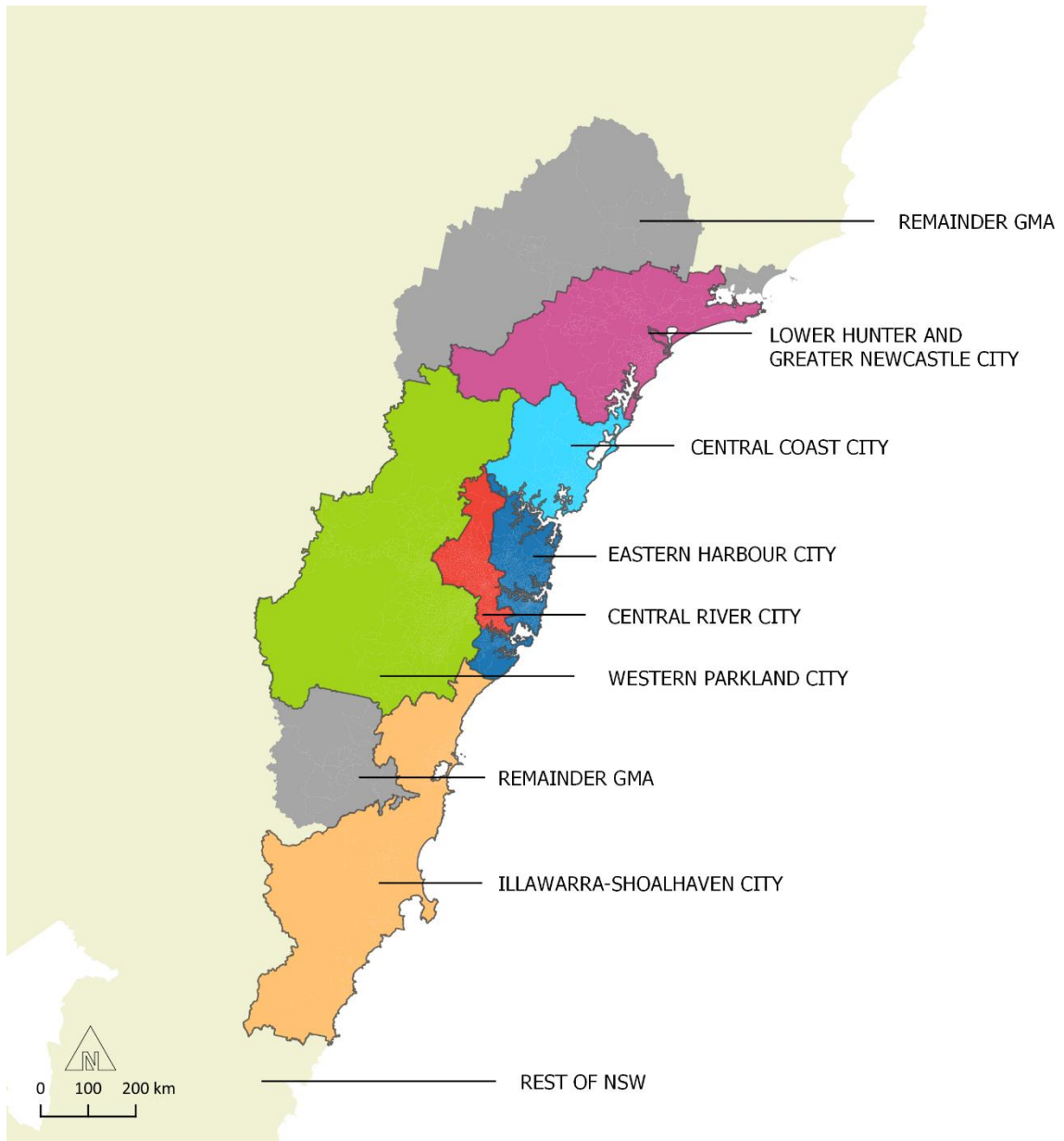
Source: SGS Economics and Planning, 2022

1.4.2 Population and Dwellings

Table 2 shows a summary of the dwelling projections by the Six Cities in Greater Sydney and NSW. This shows the existing concentration of population across the Six Cities with approximately 74% of dwellings in 2016, which increases to 77% by 2066.   The strongest growth is in the Western Parkland City and is associated with identified growth areas and land availability to support the Western Sydney Aerotropolis. This coincides with a declining proportion of dwellings in the Rest of NSW with a greater density in Greater Sydney and the Sydney GMA.

Table 2 Structural Private Dwelling Projections by City 2016-2066

City	2016	2026	2036	2066	AAGR 2016-26	AAGR 2026-36	AAGR 2036-66
Eastern Harbour City	1,001,500	1,079,800	1,151,400	1,340,300	0.8%	0.6%	0.5%
Central River City	556,000	634,600	736,700	1,032,700	1.3%	1.5%	1.1%
Western Parkland City	400,100	453,400	526,700	774,200	1.3%	1.5%	1.3%
Central Coast City	163,400	175,300	190,000	227,800	0.7%	0.8%	0.6%
Illawarra-Shoalhaven City	199,900	225,600	259,600	354,800	1.2%	1.4%	1.0%
Lower Hunter and Greater Newcastle City	269,300	303,800	344,600	455,900	1.2%	1.3%	0.9%
Total Six Cities	**2,590,100**	**2,872,500**	**3,209,000**	**4,185,800**	**1.0%**	**1.1%**	**0.9%**
Remainder GMA	44,700	50,200	56,900	75,100	1.2%	1.3%	0.9%
Total GMA	**2,634,900**	**2,922,700**	**3,265,900**	**4,260,900**	**1.0%**	**1.1%**	**0.9%**
Rest of NSW	882,500	942,800	1,007,600	1,163,300	0.7%	0.7%	0.5%
Total NSW	**3,517,400**	**3,865,400**	**4,273,500**	**5,424,200**	**0.9%**	**1.0%**	**0.8%**

AAGR is the Annual Average Growth Rate (%)
GMA is the Greater Metropolitan Area (see Section 2.4 Spatial Geographies for additional details)

Table 3 shows the same trend in population as seen in the dwelling projections, with an increasing share of population in the Sydney GMA highlighted by the growth in the Western Parkland City.

Table 3 Estimated Resident Population Projections by City 2016-2066

City	2016	2026	2036	2066	AAGR 2016-26	AAGR 2026-36	AAGR 2036-66
Eastern Harbour City	2,143,200	2,279,700	2,458,900	2,827,600	0.6%	0.8%	0.5%
Central River City	1,488,200	1,691,600	1,962,000	2,707,200	1.3%	1.5%	1.1%
Western Parkland City	1,056,900	1,197,900	1,393,700	2,048,900	1.3%	1.5%	1.3%
Central Coast City	336,600	360,300	389,900	462,000	0.7%	0.8%	0.6%
Illawarra-Shoalhaven City	404,600	454,800	523,500	716,300	1.2%	1.4%	1.1%
Lower Hunter and Greater Newcastle City	570,100	643,400	731,300	967,900	1.2%	1.3%	0.9%
Total Six Cities	**5,999,600**	**6,627,800**	**7,459,400**	**9,729,800**	**1.0%**	**1.2%**	**0.9%**
Remainder GMA	86,800	96,200	107,900	138,000	1.0%	1.2%	0.8%
Total GMA	**6,086,400**	**6,723,900**	**7,567,300**	**9,867,800**	**1.0%**	**1.2%**	**0.9%**
Rest of NSW	1,646,500	1,738,900	1,837,600	2,025,900	0.5%	0.6%	0.3%
Total NSW	**7,732,900**	**8,462,800**	**9,404,900**	**11,893,700**	**0.9%**	**1.1%**	**0.8%**

AAGR is the Annual Average Growth Rate (%)

GMA is the Greater Metropolitan Area (see Section 2.4 Spatial Geographies for additional details

Figure 3 shows the distribution of population (based on ERP) for Greater Sydney which shows a concentration of population around the inner city and distributed along key transport corridors, such as Parramatta to Sydney CBD and emerging population in the North West and South West of Sydney. High densities of population are seen to the south of Sydney CBD around Green Square.

Figure 3 Greater Sydney Population Distribution 2016
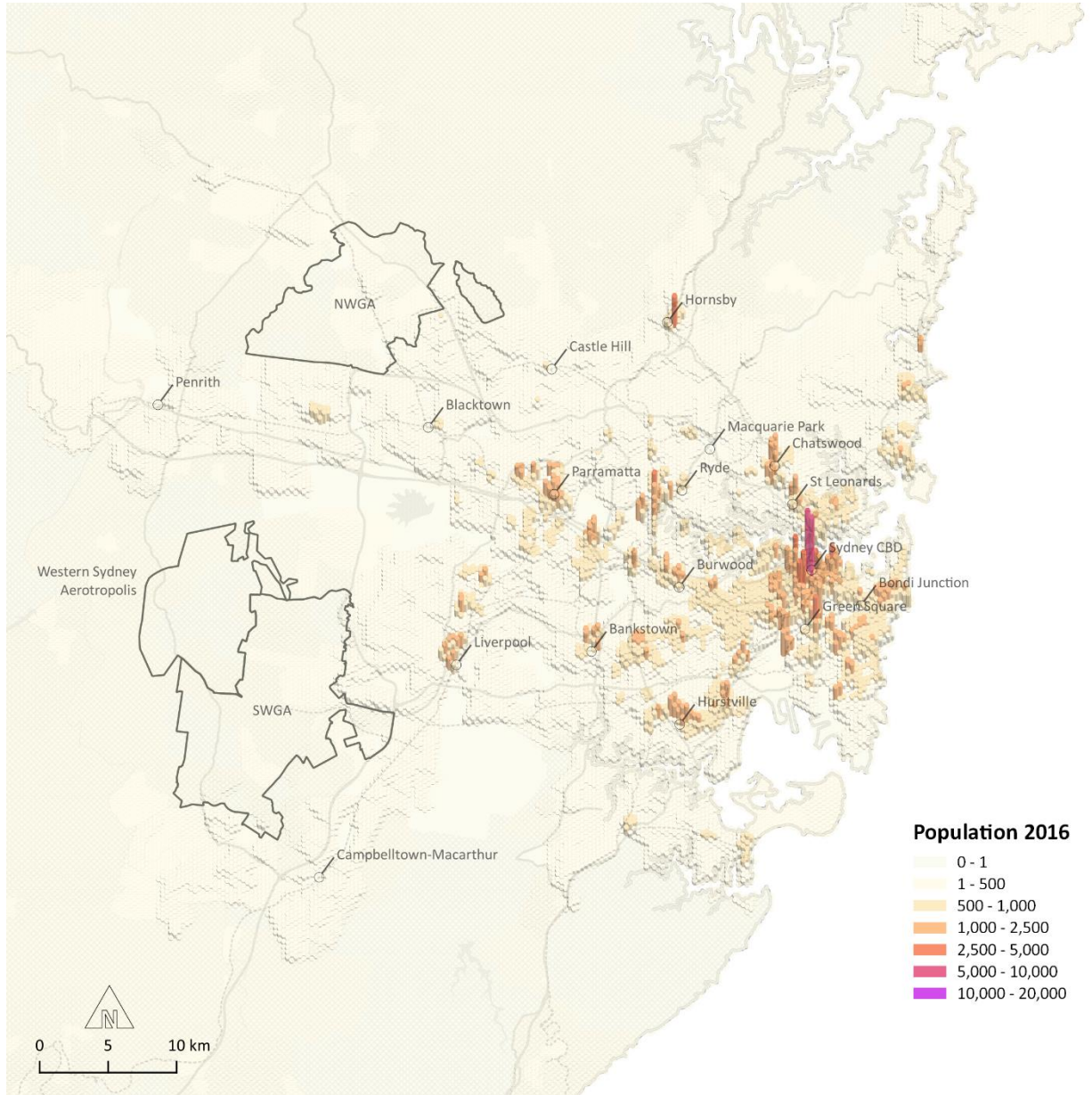
Source: SGS Economics and Planning, 2022

Growth between 2016 and 2036 as shown in Figure 4 continues along existing distributions with more focus around South Western Sydney around the South West Growth Area as well as continued growth in the North West.

Figure 4 Greater Sydney ERP Growth Distribution 2016-2036
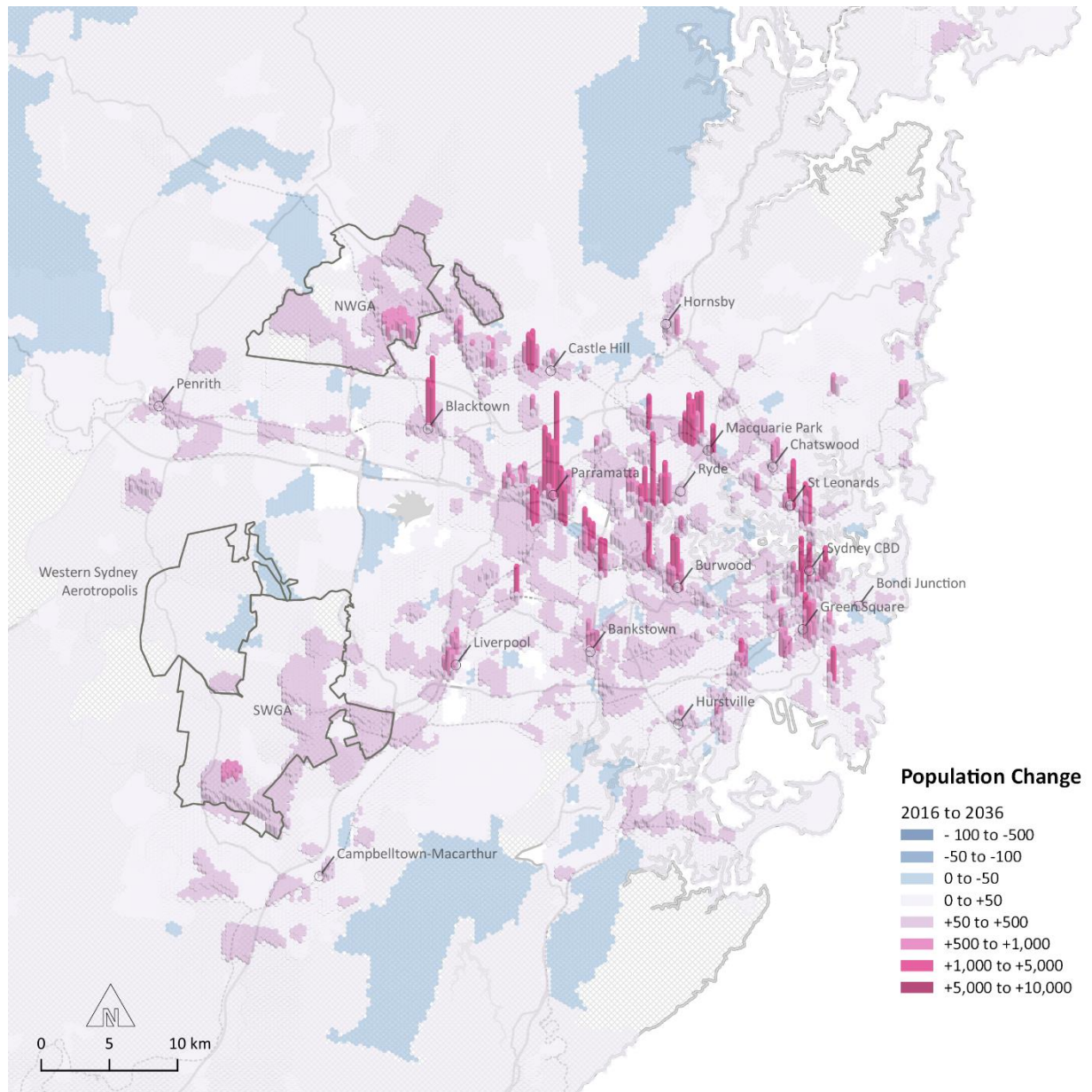
Source: SGS Economics and Planning, 2022

Growth continues westward towards 2056 as shown in Figure 5, particularly in the South West. Emerging populations are establishing around the Western Sydney Aerotropolis.

Figure 5 Greater Sydney ERP Growth Distribution 2036-2056
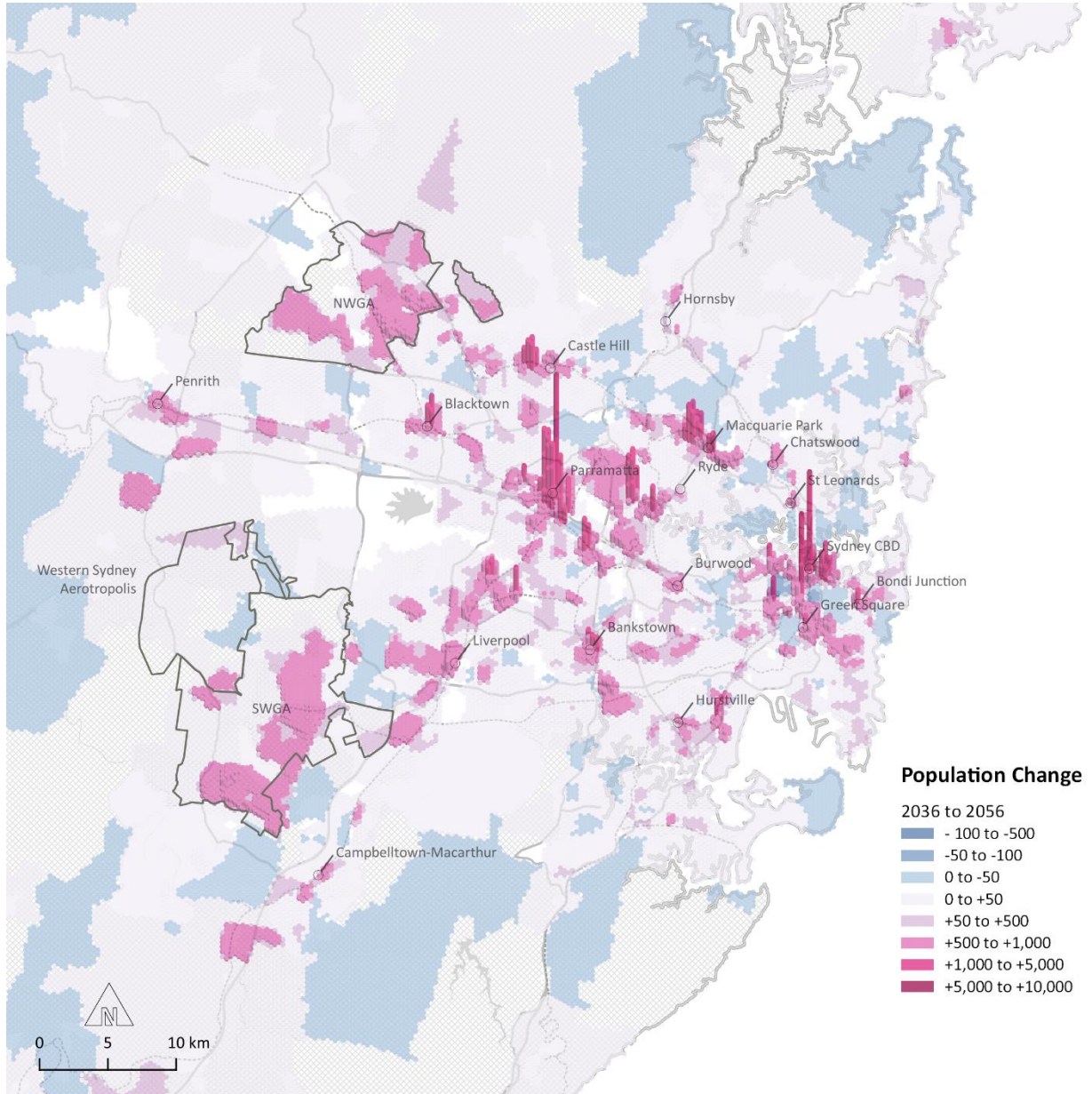
Source: SGS Economics and Planning, 2022

1.4.3 Workforce and Employment

Table 4 shows the distribution of the resident workforce across NSW forecasted to 2066. Workforce represents the available number of people, based on where they live, that is either actively employed or looking for work. Therefore, it differs from employment which is based on the number of jobs at the location of work.

This means that workforce and employment will have a different spatial distribution as people travel, sometimes large distances to work and there may be a proportion of the population that is unemployed and looking for work.

The projections of workforce show a similar spatial and growth trend to dwellings and population as it is also based on where people live, but also considers the age of the resident population and whether they are participating in the workforce.

Table 4 Workforce projections by City: 2016-2066

City	2016	2026	2036	2066	AAGR 2016-26	AAGR 2026-36	AAGR 2036-66
Eastern Harbour City	1,176,900	1,287,600	1,375,300	1,497,500	0.9%	0.7%	0.3%
Central River City	719,000	855,700	999,500	1,329,500	1.8%	1.6%	1.0%
Western Parkland City	505,300	580,100	672,100	945,100	1.4%	1.5%	1.1%
Central Coast City	162,000	171,900	185,900	215,400	0.6%	0.8%	0.5%
Illawarra-Shoalhaven City	176,900	204,000	235,100	316,900	1.4%	1.4%	1.0%
Lower Hunter and Greater Newcastle City	277,300	312,800	356,700	462,900	1.2%	1.3%	0.9%
Total Six Cities	3,017,500	3,412,100	3,824,700	4,767,300	1.2%	1.1%	0.7%
Remainder GMA	39,200	44,600	49,400	60,800	1.3%	1.0%	0.7%
Total GMA	3,056,700	3,456,700	3,874,000	4,828,100	1.2%	1.1%	0.7%
Rest of NSW	720,900	779,100	819,400	886,600	0.8%	0.5%	0.3%
Total NSW	3,777,600	4,235,800	4,693,500	5,714,700	1.2%	1.0%	0.7%

AAGR is the Annual Average Growth Rate (%)
GMA is the Greater Metropolitan Area (see Section 2.4 Spatial Geographies for additional details)

The growth of the 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 and people staying in the workforce for longer.

Employment projections by City are shown below in Table 5. Employment is expected to continue to grow most strongly within the Western Parkland City, and Lower Hunter and Greater Newcastle City.

Table 5 Employment projections by City: 2016-2066

City	2016	2026	2036	2066	AAGR 2016-26	AAGR 2026-36	AAGR 2036-66
Eastern Harbour City	1,485,800	1,702,700	1,785,900	2,138,900	1.4%	0.5%	0.6%
Central River City	608,600	713,800	800,900	1,037,900	1.6%	1.2%	0.9%
Western Parkland City	376,900	458,400	537,500	834,600	2.0%	1.6%	1.5%
Central Coast City	123,800	136,300	141,600	169,700	1.0%	0.4%	0.6%
Illawarra-Shoalhaven City	159,800	187,600	216,600	270,300	1.6%	1.4%	0.7%
Lower Hunter and Greater Newcastle City	264,400	333,700	374,500	485,100	2.4%	1.2%	0.9%
Total Six Cities	**3,019,300**	**3,532,500**	**3,857,000**	**4,936,600**	**1.6%**	**0.9%**	**0.8%**
Remainder GMA	44,800	47,600	52,700	69,300	0.6%	1.0%	0.9%
Total GMA	**3,064,100**	**3,580,100**	**3,909,700**	**5,005,900**	**1.6%**	**0.9%**	**0.8%**
Rest of NSW	720,000	766,400	805,800	949,600	0.6%	0.5%	0.5%
Total NSW	**3,784,100**	**4,346,500**	**4,715,500**	**5,955,500**	**1.4%**	**0.8%**	**0.8%**

AAGR is the Annual Average Growth Rate (%)
GMA is the Greater Metropolitan Area (see Section 4.4 Spatial Geographies for additional details)

Comparing city-wide employment to workforce, Figure 6 and Figure 7 show the persistence of distributional features.

The Eastern Harbour City will continue to have a large net inflow of workers, while the Central River City and Western Parkland City will have significant outflows. Noting that the rate of population growth and therefore workforce growth is much higher in the Central River City and Western Parkland City compared to employment growth.

These summaries are based on total employment and therefore do not consider specific employment industries and their resident workforce distribution.

Figure 6 Workforce and employment by City 2016
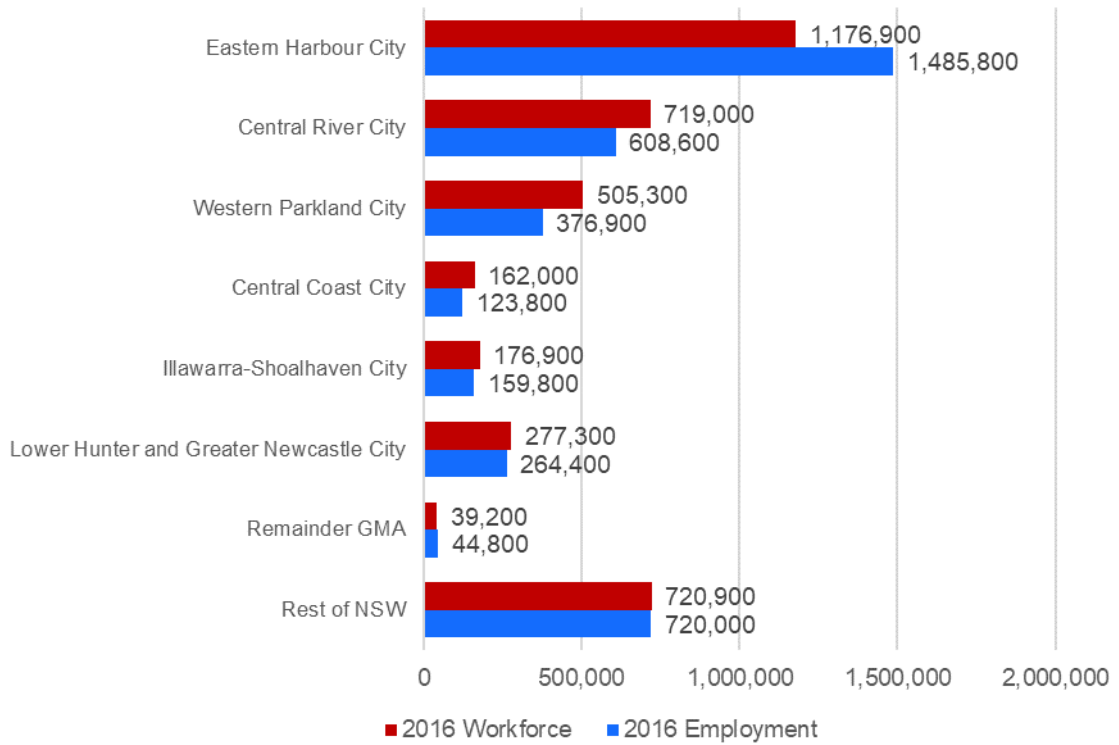
Source: SGS Economics and Planning, 2022

Figure 7 Workforce and employment by City 2066
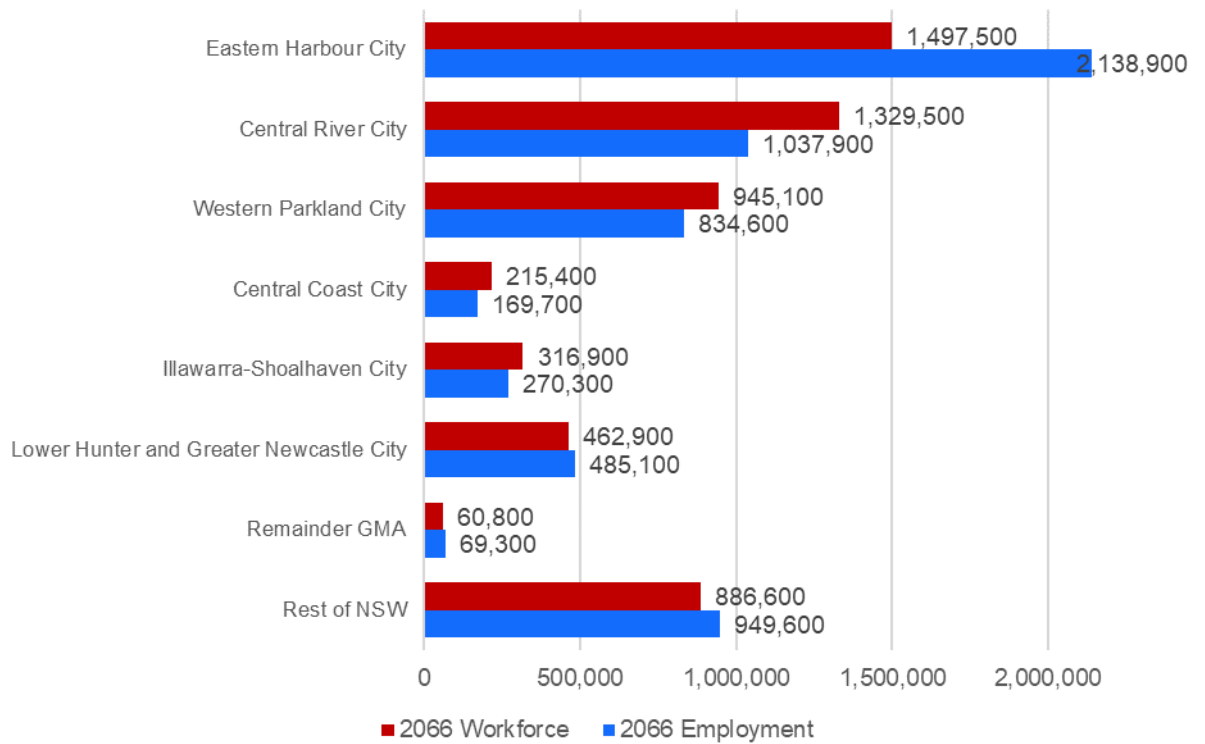
Source: SGS Economics and Planning, 2022

The existing employment distribution as shown in Figure 8 shows the high concentration of employment in the Sydney CBD and inner suburbs extending towards Macquarie Park and Parramatta with sparse employment on the western edge of the city, highlighting the gap in the workforce and employment distribution.

Figure 8 Greater Sydney Employment Distribution 2016
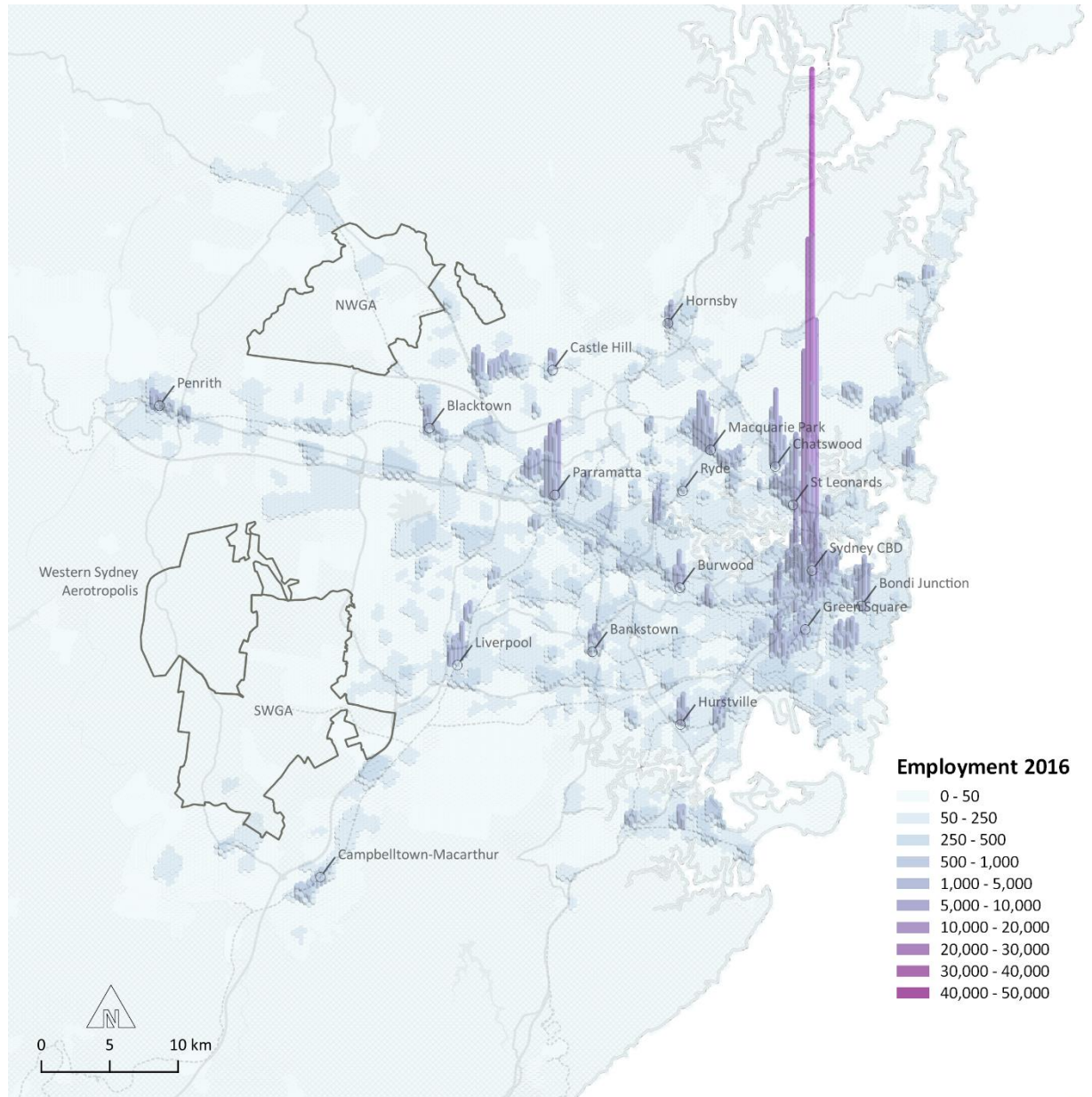
Source: SGS Economics and Planning, 2022

Growth in employment to 2036 consolidates in the eastern part of the city with emerging
employment hubs centred around the Western Sydney Aerotropolis and more employment focused
in the North West and South West Growth Areas highlighted in Figure 9.

Figure 9 Greater Sydney Employment Growth Distribution 2016-2036
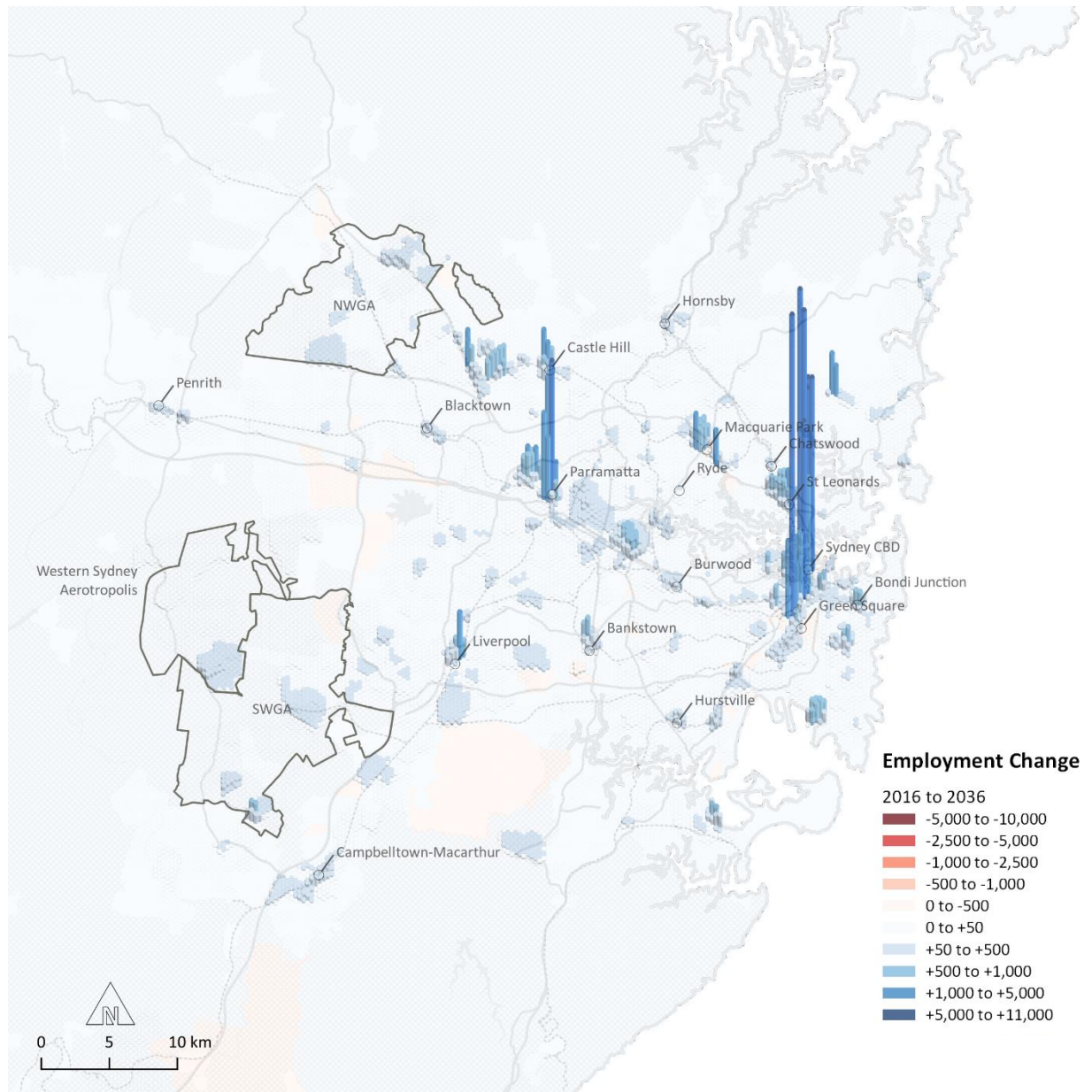
Source: SGS Economics and Planning, 2022

Figure 10 shows this continuing towards 2056 with significant employment generated by the Aerotropolis, continued growth in Liverpool and the corridor south to Campbelltown-Macarthur. Growth in the Sydney CBD continues to be strong.

Figure 10 Greater Sydney Employment Growth Distribution 2036-2056
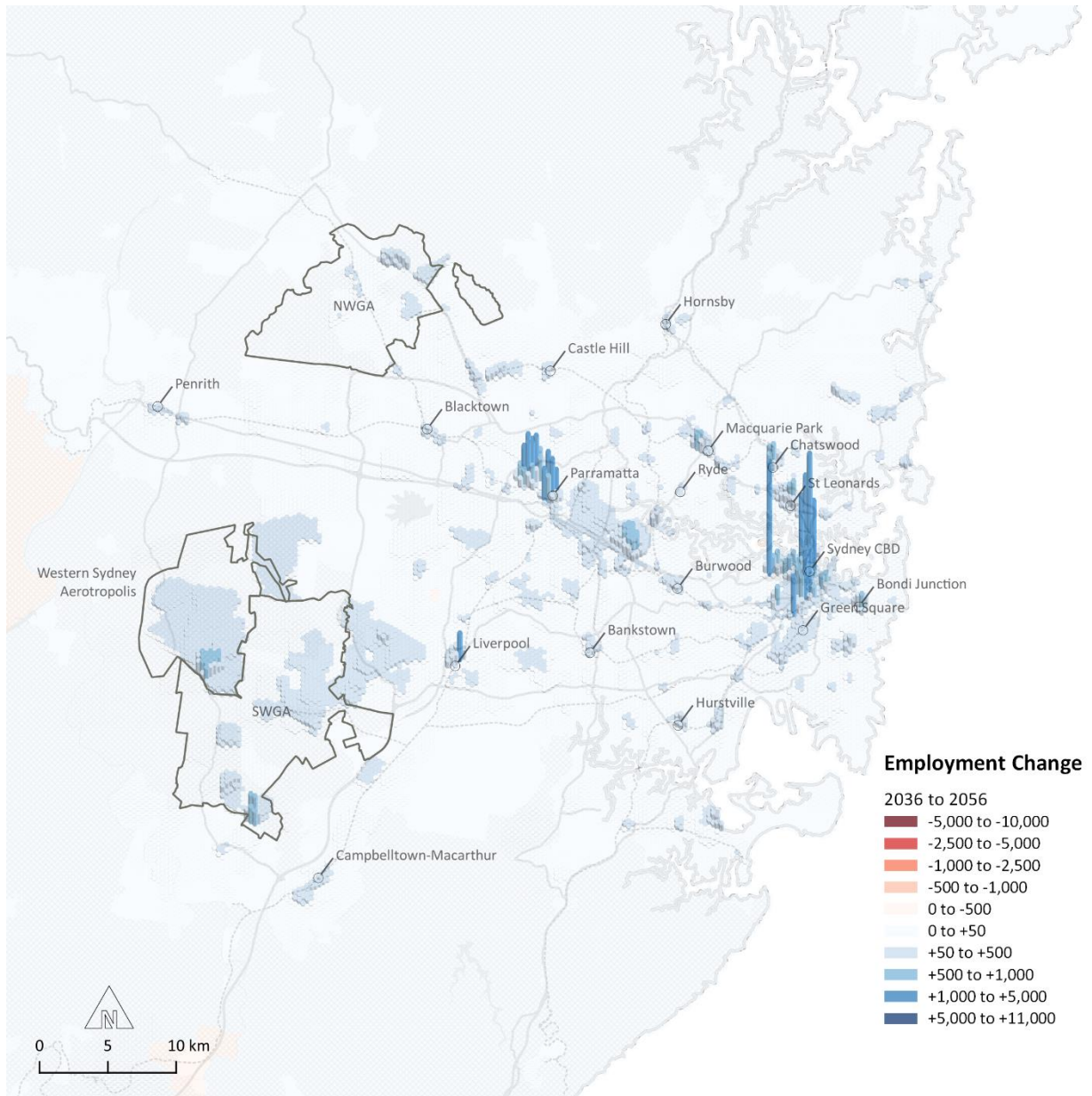
Source: SGS Economics and Planning, 2022

1.5   Report structure

The remainder of the report is structured as follows:

Section 2	Model framework and data specification
Section 3	Module 0: Concordance Module
Section 4	Module 1: Dwellings and Population
Section 5	Module 2: Age by Sex
Section 6	Module 3: Households by Household Type
Section 7	Module 4: Students
Section 8	Module 5: Workforce Segmentation
Section 9	Module 6: Employment by Industry
Section 10	Module 7: Checks and Validation

2 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 with internal and external requirements. Understanding the overall linkages between each module of the model is critical to understanding the role and function of each.

2.1 TZP dataset overview

TfNSW creates Travel Zone Projections of population, workforce, students, and employment using a model, which are used as inputs in the Population Synthesiser ('Pop Synth'), STM and the Freight Movement Model ('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 TfNSW small area data is also published online and used for other purposes.

At a high level, the data covers three dimensions:

- **Time Period**: Annual forecasts from 2016 to 2026 and 5 yearly time periods from 2026 to 2066
- **Geography**: TZP22 is available in TZ16 geography with 3,758 travel zones across New South Wales.
- **Profiling Variables**: 60 variables covering people, households, employment and students.

These various attributes are currently created using a series of interrelated Microsoft Excel, VBA, Python and R based modules.

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

2.2   TZP modelling overview

The following diagram highlights the key data inputs and steps used to create TZP22. It also highlights the key links to the Population Synthesiser and STM/FMM models.

Figure 11: Travel Zone Projections 2022 Overview
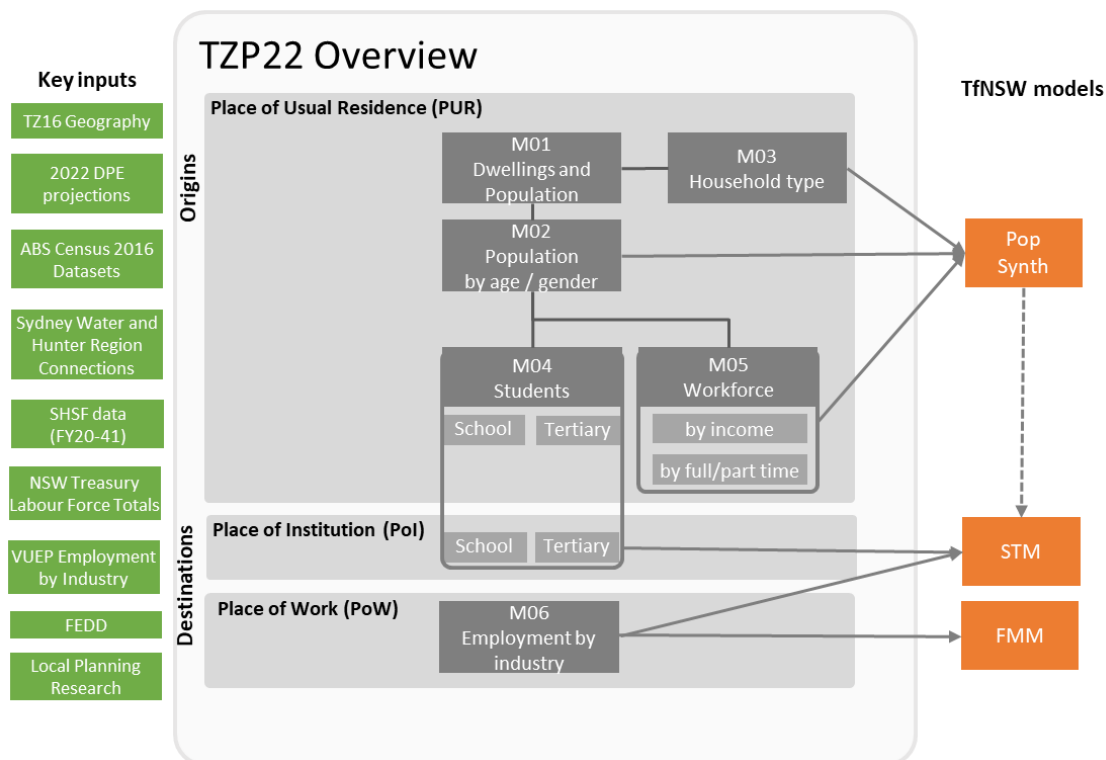
Source: SGS Economics and Planning, 2022

At a high level, official DPE SA2 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, the population is further segmented by age and sex, household type, school and tertiary enrolment type, and workforce status.

VU Employment Projections at state level by industry (at 1 digit industry) at POW are used to create employment projections by 33 ANZIC industries at Travel Zone level. Employment by industry numbers is first disaggregated from the State level to regions and finally to travel zones using a number of small area input sources on historical and future employment trends.

The following section provides a high-level summary of the TZP22 process. This summary is then discussed in further detail in forthcoming sections of the report.

2.2.1   Modules 1/2/3: Dwellings, population, and segmentation

Structural Private Dwellings (SPD) (i.e., the sum of occupied (OPD) and unoccupied private dwellings (UOPD)) 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.

Base distribution (2016)

- The base SPD dwelling distribution is sourced from ABS 2016 Census data by Statistical Area 1 (SA1), realigned to Travel Zone16 geography. ABS Buildings Approvals and Sydney Water Connections Data are then used to bring this base dwelling distribution to 2021. It is then benchmarked to the SA2 control totals to align with DPE projections for 2022.

Population Control Totals

DPE provided the following inputs:

- State-wide ERP by Sex and 5-year age group from 2016 to 2061
- Collapsed SA2 by Sex and 5-year age group from 2016 to 2041

Adjustments to this data were made as follows:

- The state totals by Sex and 5-year age group were linearly interpolated to 2066 using the trend between 2056 and 2061.
- The state ERP by Sex and 5-year age group from 2016-2066 was then used as control totals to convert DPE's Collapsed SA2 by Sex and 5-year age group from 2016 to 2041 to SA2 from 2016 to 2066.

Dwelling Control Totals

- Structural Private Dwellings are built from population forecasts from DPE and Census dwelling data by SA2 from 2016 to 2066. A number of small adjustments are then made before they are used as control totals. It is scaled up to an SPD estimate using occupancy rates from the 2016 ABS Census.
- Occupied Private Dwellings are then calculated using an occupancy rate.

Projection distribution

- The SHSF 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'. SA2 control totals are then distributed down to this 'possible capacity'.
- If the control totals are too high, '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.
- Conversely, if the control totals are too low, '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 the planned supply, so developments are delayed or occur slower than anticipated.

Dwellings are then systematically used as the basis to identify occupied private dwellings, population splits, age-sex, household types, enrolments, and workforce status. All population segments refer to persons living in private dwellings (i.e., this excludes people living in non-private dwellings such as nursing homes, jails, etc.).

Base 2016 disaggregation ratios (i.e., household size, age splits, etc.) are largely sourced from the ABS 2016 SA1 Census data for travel zones. Data is then benchmarked back to control total data by SA2. Control total data is largely sourced from DPE by SA2 and then adjusted as per the SPD steps above.

An Iterative Proportional Fitting (IPF) approach is used to evolve the travel zone distribution over time to align with the SA2 controls totals while still reflecting variation at the travel zone level. The population profile of seed values for new residential locations (i.e., where no base exists) is sourced from the respective local region.

> The following primary inputs are used to project population and dwellings:
> - DPE SA2 ERP, POPD and PNPD Forecasts (FY16-66)
> - Sydney and Hunter Water Dwellings data (FY16-21)
> - SHSF Data (FY20-41)
> - Hunter Greenfield and Infill data (FY21-66)
> - Illawarra Greenfield data (FY21-66)
> - Illawarra Infill data (FY20-34)
> - Various local planning and research information
> - ABS Census data (2016)

A process map of Modules 1,2 and 3 are included in Appendix B: Travel Zone Projections 2022: Process Maps.

2.2.2 Module 4: Student enrolments

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

Population by age is translated into primary, secondary, and tertiary students using a similar process as for other population segmentation. A base distribution is sourced from the 2016 ABS Census and 2021 Australian Curriculum, Assessment and Reporting Authority (ACARA) enrolment data. Official enrolment forecasts are then disaggregated to SA4 and then Travel Zone level using the IPF approach.

A gravity model is then used to covert students 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 levels:
> - Current enrolments from ACARA 2021
> - School capacity projections from Eagle Eye 2021-2025
> - Australian University Enrolments 2021
> - Population projections 2016-2066 (M01)

2.2.3 Module 5: Workforce and Income

State Labour Force data is provided by NSW Treasury and is utilised to break down the population into employed (workforce), unemployed and persons not in the labour force. Workforce numbers are then disaggregated into SA4s and Travel Zones. These numbers are also split into full-time/part-time employment categories and income bands, which are utilised for calibration of the TfNSW STM. SA4 and travel zone variance in participation rates, unemployment rates, full-time/part-time and income bands are captured by drawing on quarterly trends from data published as part of the ABS Labour Force Survey, along with the projected age-sex composition of the workforce identified from Module 02.

The following primary inputs are used to project workforce projections:

- NSW Treasury State Labour Force Projections
- ABS SA4 Labour Force Survey data
- ABS Census data
- NSW Intergenerational Report 2021

2.2.4 Module 6: Employment

State employment by industry projections is calculated externally by VU. These forecasts are first adjusted to be consistent with the workforce side of the model, then disaggregated to SA3s and then travel zones. Trend analysis and indicator series are used at the SA3 level to break down employment by industry projections. This ensures population-serving employment (i.e., retail, education, etc.) is shifted appropriately to where population growth is projected to occur, while the spatial distribution of other industries remains consistent with recent trends.

A future employment development database (FEDD) provides small area level future employment inputs and is used as the primary input to shift census trend projections. Similar to the SHSF data for dwellings, this database is used as a 'possible capacity' and 'preferred timing' dataset. A feedback loop exists within the model to adjust broader trends where the developments database is signalling a clear shift in policy and base trends.

The following primary inputs are used to project employment:

- Victoria University Employment Projections
- ABS Labour Force Survey data
- ABS Census data
- Future Employment Development Database, which contains various assumed employment developments across NSW. Though it is statewide, it has a heavy skew towards Greater Sydney. These employment assumptions were compiled by SGS and reviewed by TfNSW (see Appendix A: Future Employment Development Database (FEDD)).

2.3 Time periods

Projections are created in the base year of 2016 and extend out to 2066. Future periods are produced in five-yearly periods, with the first 10 years produced annually.

The resulting future periods are as follows:

Forecast Years	Notes
2016	Base Year
2017	
2018	
2019	
2020	
2021	
2022	
2023	
2024	
2025	
2026	
2031	
2036	
2041	
2046	
2051	
2056	
2061	
2066	

2.4 Spatial geographies

The Greater Metropolitan Area ('GMA') is the area used for TfNSW's Strategic Travel Model. This 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.

All land use variables are generated by the TfNSW 2016 Travel Zone (TZ16) geography classification. The TZ16 geography of 3,758 travel zones covers the entire state of NSW (including the Sydney GMA and the Rest of NSW) and aligns with the 2016 ABS Census Destination Zones and the associated ASGS (SA2, SA3 and SA4) structure.

A geographic map of key areas is shown in Figure 12.

Figure 12: NSW State, Sydney GMA, and Travel Zone Boundaries
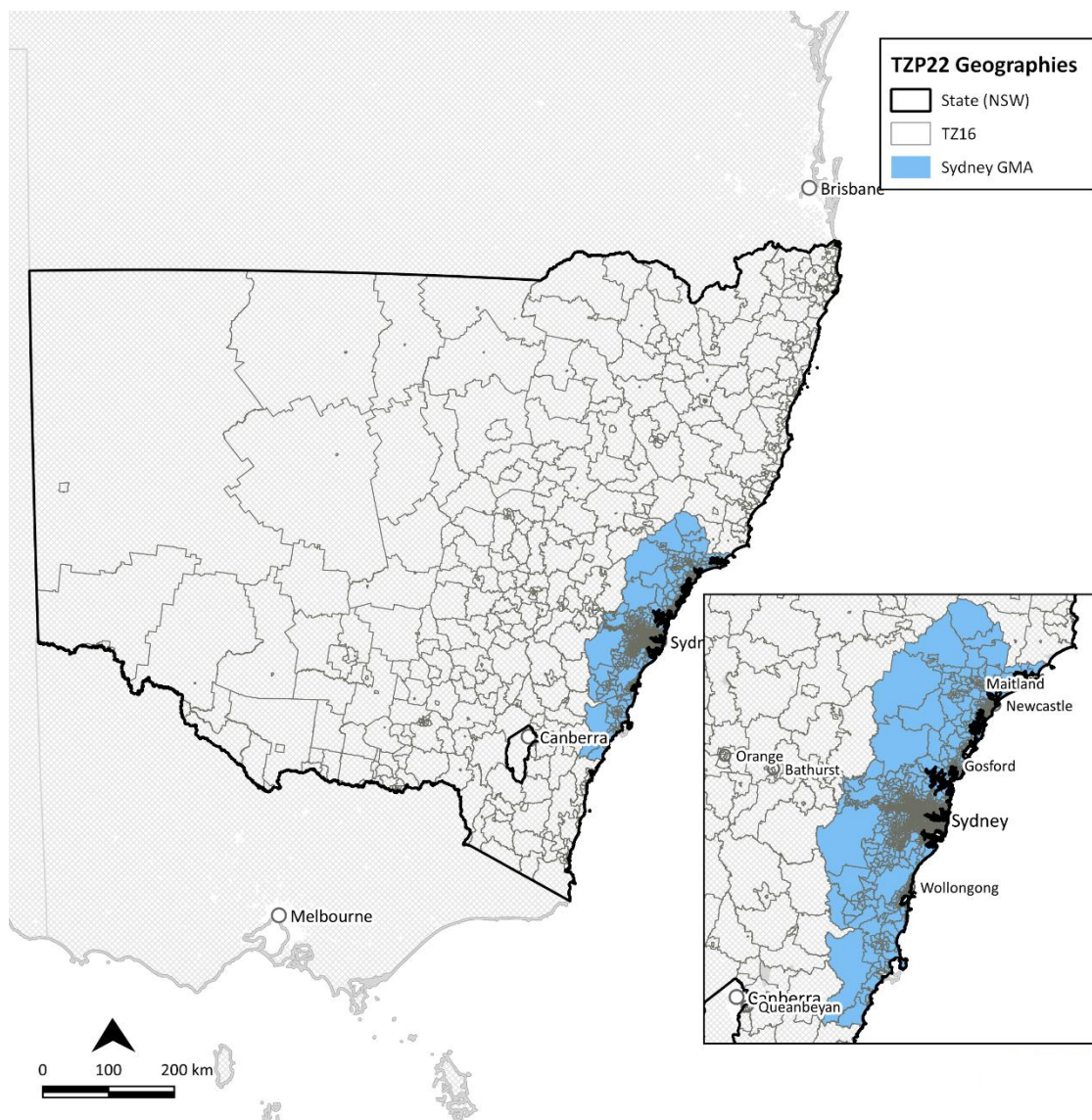
Source: SGS Economics and Planning, 2022

2.5   Variable breakdowns

Numerous variables are created in each of the six modules. Projections of these variables 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 as part of the STM. 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.

2.5.1   Core Transport Model TZP variable requirements

The core purpose of the TfNSW TZP data is for input in the Pop Synth, 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, that is, by 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 6 summarises the 25 inputs required by the population synthesiser as well as an additional 4 fields which need to be generated but are not required.

Table 6: Population Synthesiser data input requirements

Place of count	Category	Sub category	Variable
PUR	POPD	POPD	POPD
PUR	POPD	Age-Sex	Males 0 - 9
			Males 10 - 19
			Males 20 – 29
			Males 30 - 39
			Males 40 - 59
			Males 60 - 79
			Males ≥80
			Females 0 - 9
			Females 10 - 19
			Females 20 – 29
			Females 30 - 39
			Females 40 - 59
			Females 60 - 79
			Females ≥80
PUR	POPD (>15)	In the Labour Force (iLF)	Full-time workers
			Part-time workers
			Unemployed
		Not in the Labour Force (NiLF)	Not in Workforce[#]

Place of count	Category	Sub category	Variable
PUR	POPD	POPD (<15) POPD (15+) (Note, this includes people employed and not employed)	Children (≤15 years old) Negative or Nil income $1-$149 $150-$299 $300-399 $400-499 $500-649 $650-799 $800-999 $1,000-$1,249 $1,250-$1,499 $1,500-$1,749 $1,750-$1,999 $2,000-$2,999 $3,000 or more
PUR	POPD	Enrolled students Not students	Primary School Student Secondary School Student Tertiary Institution Student Not a Student[#]
PUR	POPD	Students in each tertiary type	University – Full time University – Part time Technical – Full time Technical – Part time
PUR	OPD	Household Types	Couples with Children Couples Only Single Parent Single Person Other Types

 # Generated variables not required by the Pop Synth.

Table 7 lists the 19 attractor variables which are produced by the TfNSW Place Forecasting team for use by the STM as well as an additional 8 variables that are generated but are not required as STM inputs.

Table 7: 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 – created outside the TZP22 model* *(Currently 2016 dollars)*	*Negative or Nil income* *$1-$149* *$150-$299* *$300-399* *$400-499* *$500-649* *$650-799* *$800-999* *$1,000-$1,249* *$1,250-$1,499* *$1,500-$1,749* *$1,750-$1,999* *$2,000-$2,999* *$3,000 or more*
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

Place of count	Category	Sub category	Variable
PoW	Total Employment	Other industries	Retail Trade
			Agriculture, Forestry and Fishing[#]
			Mining[#]
			Electricity, Gas, Water and Waste Services[#]
			Construction[#]
			Wholesale Trade[#]
			Transport, Postal and Warehousing[#]
			Information Media and Telecommunications[#]
			Manufacturing[#]
PoW	Total Employment	Retail	Retail Trade
PoI	Students	School students	Primary School Students
			Secondary School Students
		Tertiary students	Tertiary Institution Students

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

In addition to inputs for the STM, TZP22 also provides 34 attraction variables for use in the Freight Movement Model (FMM). The data segmentation required by the FMM is detailed in Table 8.

Table 8: 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
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

Place of count	Category	Sub category	Variable
			Transport Equipment Manufacturing
			Machinery and Equipment Manufacturing
			Furniture and Other Manufacturing
			Food Product Manufacturing
			Beverage and Tobacco Product Manufacturing

2.5.2 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 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 13 seeks to define the entire scope of variables that the Place Forecasting team needs to produce. This covers requirements for Transport Modelling, website publishing and Module interdependencies.

Figure 13: Model variable generation and module dependencies
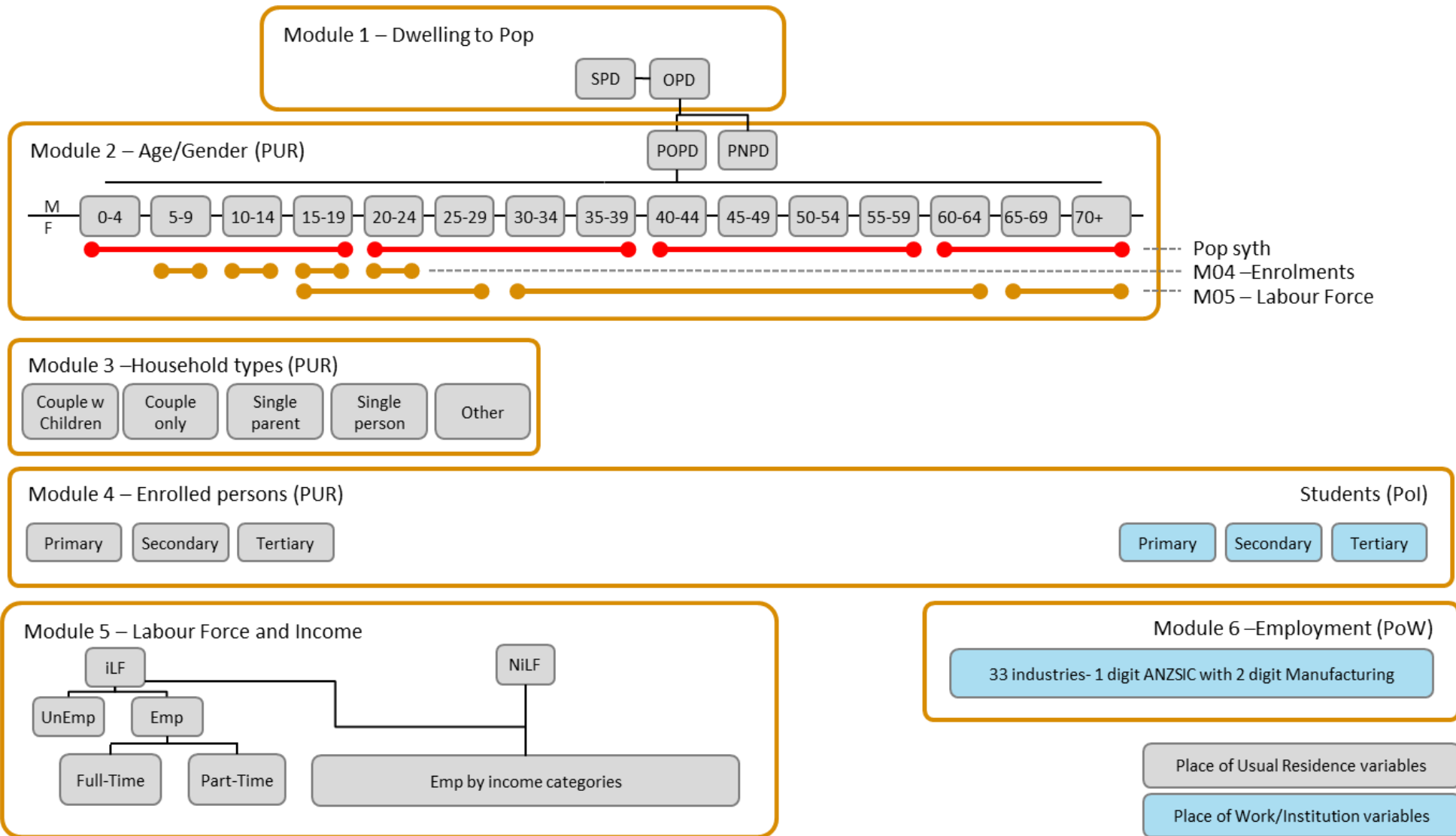
Source: SGS Economics and Planning, 2022

Detailed Module Specification

3   Module 0: Concordance Module

This chapter provides a summary of the concordance module of TZP22. This was a new module introduced in TZP19 to separate all concordance computations. TZP 2016 v1.51 and older versions performed concordance calculations separately within each module.

3.1   Module 0 Technical Model Overview

The following sections provide an overview of how the model operates.

3.1.1   M00a – Input Data

This module acts as the mechanism used to create and check the spatial distribution used in later concordance steps, primarily utilised for the split between Persons in Occupied Private Dwellings (POPD) and Persons in Non-Private Dwellings (PNPD).

Inputs

Key Inputs:

- ABS Census - POE Database
- ABS - Regional Population Growth 3218.0
- Transport for NSW TZ16 Shapefile

Functions

This module has one key function: Store and creates spatial distributions used in later concordance steps.

3.1.2   M00b – Concordance Module

This module converts data from various geographies to geographies utilized in later modules, the concordances are done via weights created from geospatial data and ABS census data to weight concordance by Area, Population, Dwellings or Employment.

Inputs

Key Inputs:

- ABS Census - PUR Database & ABS ERP
- ABS Census - POE Database
- ABS Census - Age by Sex census data by SA1
- ABS Quarterly Building Approvals, 2017-2021 (YTD, Q2 2021)
- DPE SHSF 2021, From FY22-41
- Sydney Water Corporation Dwelling Connections Data FY16-21 (obtained from DPE)
- Hunter Water Connections Data 2016-2021 (obtained from DPE)
- TZP2019 SPD
- DPE Hunter Infill Forecast FY21-66
- DPE Hunter Greenfield Forecast FY21-66
- DPE Illawarra Infill Forecast FY20-34
- DPE Illawarra Greenfield Forecast FY21-66

Functions

This module has several key functions:

- Age by Sex census data is converted from SA1 2016 to TZ16
- ABS ERP Population inputs from M00a from SA1/SA2 2016 to TZ16
- DPE SHSF 2021 from MB 2016 to TZ16
- Sydney Water Dwelling FY16-21 connections from MB 2016 to TZ16
- Hunter Water Dwelling FY16-21 connections from MB 2016 to TZ16
- Hunter Infill Forecast FY21-66 from suburb (SSC) 2016 to TZ16
- Hunter Greenfield Forecast FY21-66 from custom geography to TZ16
- Illawarra Infill Forecast FY20-34 from suburb (SSC) 2016 to TZ16
- Illawarra Greenfield Forecast FY21-66 from custom geography to TZ16
- ABS Building Approvals data is converted from SA1 2016 to TZ16
- ABS Dwelling Inputs data is converted from SA1 2016 to TZ16

3.1.3   M00x – Temporary Concordance Module

This module converts input population data supplied by DPE at the state-wide and Collapsed SA2 level to SA2, as well as conducting some data manipulation to ensure that the outputs of concordance files align with control totals for the system.

Inputs

Key Inputs:

- State-wide ERP from 2016 to 2061 (provided by DPE)
- Collapsed SA2 ERP from 2016 to 2041 (provided by DPE)
- SA2 POPD from 2016 to 2066 (developed by SGS/TfNSW, approved by DPE)
- SA2 PNPD from 2016 to 2066 (developed by SGS/TfNSW, approved by DPE)
- Travel Zone residential areas (provided by TfNSW)
- ABS Census - Dwelling data from M00a

Functions

This module has several key functions:

- ERP data used to create OPD and SPD projections at SA2
- Convert residential area data from TZ11 to TZ16

Adjustments to DPE inputs in TZP22

For TZP22, the following DPE population inputs were provided as follows:

- State-wide ERP by Sex and 5-year age group from 2016 to 2061.
- Collapsed SA2 by Sex and 5-year age group from 2016 to 2041.

Adjustments to this data were made as follows:

- The state totals by Sex and 5-year age group were linearly interpolated to 2066 using the trend between 2056 and 2061.
- The state ERP by Sex and 5-year age group from 2016-2066 was then used as control totals to convert DPE's Collapsed SA2 by Sex and 5-year age group from 2016 to 2041 to SA2 from 2016 to 2066.

The split of POPD/PNPD by SA2 was derived using the following method:

- The proportion of POPD to PNPD was calculated by SA2 by Age and then multiplied by the ERP SA2 Age data
- The 2041 POPD to PNPD split was held constant from 2041
- Once the POPD by age was created, the ERP Male Female Split was applied from DPE's Collapsed SA2 by Sex and 5-year age group
- The Male / Female split was held constant from 2041
- Total POPD was calculated by aggregating POPD by age
- Total PNPD was calculated using ERP minus POPD

Additionally, occupancy rates and household sizes at an SA2 level were set to 2016 census values as default, although these can now be overridden by manual user input.

To deal with issues related to mismatches in data sets, a "back-up" concordance now takes place when certain mathematical properties prevent a complete concordance of people or dwellings. This back-up concordance is an area-based concordance which only occurs if a dwelling-based, or person-based concordance has mis-matches in the data. An example of this is when there may be concordance data stating no existing dwelling, though water connections data indicates the presence of a dwelling.

The only exception to this method is the population control totals, which are processed using a POPD & PNPD weighted concordance module. This is to ensure the accurate allocation of population weights into each travel zone, an improvement of the person only concordance.

4   Module 1: Dwellings and Population

This chapter provides a summary of the revised dwellings and population module of TZP22.

4.1   Module 1 Overview

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

Figure 14: Module 1 Overview
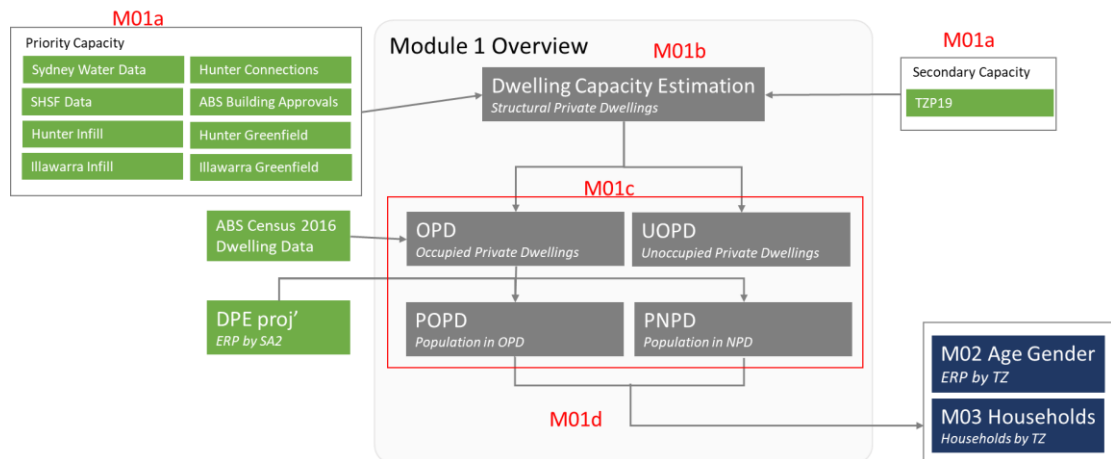
Source: SGS Economics and Planning, 2022

This module is made up of four components:

- **Dwelling Capacity Estimation** (Structural Private Dwellings) – Incorporating Sydney Housing Supply Forecasts for the Metropolitan area, Sydney & Hunter Region Water connections data, ABS Building Approvals, Hunter Infill and Greenfield capacity data, Illawarra Infill and Greenfield capacity data, and TZP19 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 by applying occupancy rates from the census to the estimated Structural Private dwellings.
- **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 travel zone level.
- **Population in Non-Private Dwellings** – Combining the non-private dwellings projected and historical household sizes, DPE population projections for persons in NPD are projected at travel zone level.

4.2   Module 1 Technical Model Overview

The following sections provide an overview of how the model operates.

4.2.1   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.

This module requires inputs from the following sources:

Inputs

- SHSF data (FY22-41)
- Sydney and Hunter Water dwelling connections stock data aggregated at the Mesh block (FY16-21)
- Hunter Greenfield and Infill data (FY21-66)
- Illawarra Greenfield data (FY21-66)
- Illawarra Infill data (FY20-34)
- ABS Buildings Approval Data (FY17-21)
- Previously sourced data from TZP19 (FY16-66)

Sydney Housing Supply Forecast

The DPE Sydney Housing Supply Forecast is a spatial dataset that distributes future housing supply across Sydney for the next 20 years and is updated annually. It is a 'point-in-time' forecast, based on current zoning and planning controls, announced and proposed State and Local strategic planning, planning proposals and gateway determinations.

It sets out where, when and how much housing is expected to be built across Sydney and is used to guide infrastructure planning and service delivery to support new housing development and population growth; and inform long-term strategic planning.

The SHSF data provided by DPE, extends to 2041 and underpins the model being the major input into the primary dwelling capacity estimation in M01a.

The data is provided at the Mesh Block level, this is then concorded to travel zone geographies before being fed into the capacity calculation model. After updating years between 2016-20 with data from Sydney Water and ABS Building approvals SHSF capacity data is the leading input from 2020-2041 the leading input is.

The SHSF covers Sydney, DPE also provided future infill and greenfield housing supply data for the Hunter and Illawarra regions. Infill areas of the Hunter and Illawarra regions were provided at the Suburb level, while Greenfield areas were provided at a custom geography. Both geographies are concorded to travel zone, before being fed into the capacity calculation model.

Secondary Capacity

Secondary capacity is a "filler" utilised when the locked and priority capacity for a given SA2 does not exceed the allocated control total.

The SHSF is available over a 20-year period, from 2020 until 2041. Given the TZP projections extend beyond this period there is a requirement to allocate the additional dwelling demand post 2041 accordingly.

The secondary capacity consists of the shortfall between the priority inputs, the secondary capacity dataset for TZP22 is based on the previous distribution of dwellings from TZP19. This provides a robust baseline for allocating additional demand without the guidance of a primary data source.

Secondary capacity is an additional supply side dataset utilised when no other primary capacity data source is available, i.e., SHSF. This allows this knowledge to remain as an input into the model, without exceeding the dwelling control totals identified in earlier stages.

The secondary capacity is only utilised when both priority capacity is lower than the control totals and the controls are not completely exhausted for that period. Beyond this if the SA2 still has not reached the control total, then the remaining control total is pro-rated across the travel zones within the SA2.

The figure below outlines the capacity allocation process.
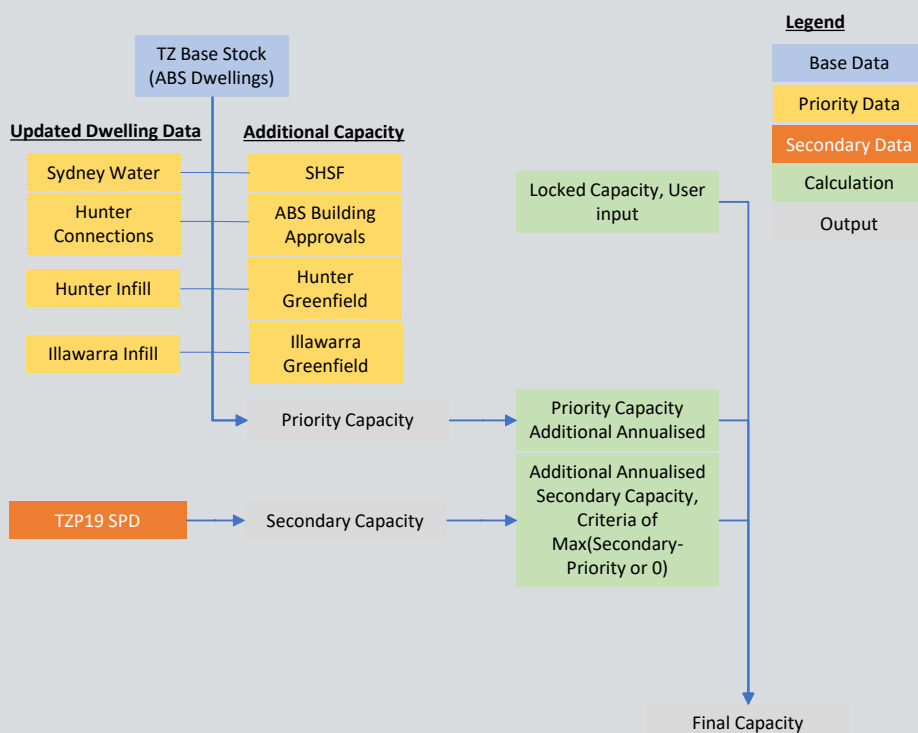
Source: SGS Economics and Planning, 2022

Functions

- SHSF forecasts, Sydney & Hunter Region Water, Hunter Infill and Greenfield, Illawarra Infill and Greenfield, and Building Approvals inform the additional priority capacity available in each travel zone.
- TZP19 data informs the secondary additional capacity in each travel zone.

4.2.2   M01b – Dwelling Projections

This module distributes the DPE projections by SA2 to travel zone based on the capacity estimates from M01a.

Inputs

Key inputs:

- Dwellings data (based on DPE SA2 Control Totals and census data)
- Available Residential Land by travel zone
- Capacity Inputs from M01a
- Capacity Calibration
- SPD Calibration

Functions

This module has two primary functions:

- Review the capacity inputs from M01a and determine if manual adjustments are required
- Calculate the final dwelling stock in each travel zone based on dwelling capacity and DPE control totals by SA2. For the years 2016 to 2066, the growth of Structural Private Dwellings is distributed based firstly on the priority capacity. In the case there is residual of dwelling growth (i.e., there is not enough capacity); the secondary capacity is used to allocate the remainder of the growth. If priority and secondary capacities are exhausted any residual capacity remaining is prorated based on shares of the control totals future dwelling capacity and is brought forward to meet the dwelling growth.

An additional function has been incorporated into M01b since TZP19:

- The final SPD output can be redistributed to follow a user input as supplied in SPD Calibration. This was implemented for travel zones in the Central Coast where an expected distribution (%) for households was supplied for a specific SA2. This means that regardless of the final SPD output for a specific SA2, the travel zones in that SA2 will follow the user input's expected distribution.

4.2.3   M01c – Population by Travel Zone

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

Inputs

- Estimated Population in Occupied Private Dwelling and Population within Non-Private Dwellings
- 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:

- Calculates base 2016 household sizes based on SA1 Census data.
- Distributes the DPE population projections in two steps:
    - First Cut: The growth in dwellings is multiplied by the assumed base household size for each travel zone
    - Final Cut: Population growth (DPE) by SA2 is distributed based on the first cut projection proportions.
- Distributes PNPD (DPE forecast) for each travel zone as determined by Census distribution and any additional new development input.

4.2.4   M01d –Travel Zone Adjustments

This module exists to deal with issues arising in the model which yield outputs out of line with likely development activity. The changes in this module entirely are contained within SA2 geographies independent of other areas and are output via intra travel zone shifts within the higher geography (SA2).

This is done by shifting target areas where validation checks have not been reached and seeks to increase the accuracy of the broader TZP framework.

The outputs from this module are structurally the same as those from M01C, only providing the user with the ability to introduce travel zone level shifts in OPD, POPD and PNPD (and therefore ERP).

5 Module 2: Age by Sex

This chapter provides a summary of the age-sex module of TZP22. This approach is the same as that was used for the TZP19 projection release.

5.1   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 is critical when operating the module.

Figure 15: Module 2 Overview
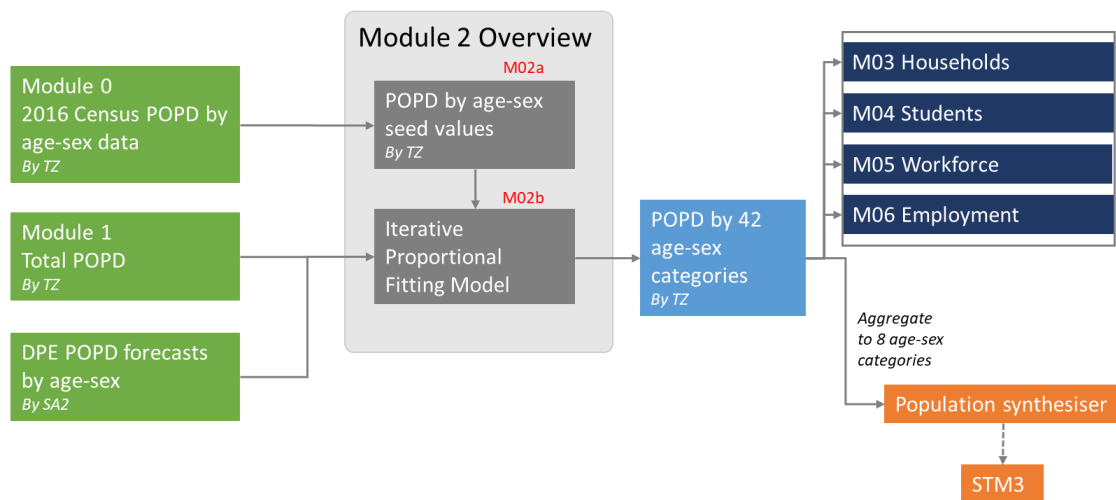
Source: SGS Economics and Planning, 2022

Estimated resident population (ERP) is comprised of two segments:

- Population in occupied private dwellings (POPD) – Estimated resident population who reside in private dwellings. This represents approximately 98 per cent of the population.
- Population 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 several age-sex categories for each time period.

- 42 age by sex categories are created for use in subsequent modules.
- Results are aggregated into 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 takes these values and primarily focuses on their distribution across age-sex categories. As such, this process is almost entirely automated.

The control totals for Module 2 are the POPD values by Travel Zone from Module 1.

The module starts with base data which uses the census age/sex distribution. For the following 5-year interval, this distribution is used as a starting value and Iterative Proportional Fitting (IPF) is

used to adjust this distribution to the age/sex control totals for that period. The resulting distribution then becomes the starting distribution for the next period, and so on.

Iterative proportional fitting (IPF) concept overview

IPF is an iterative method that 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 (SA2), the total for each age-sex category is known from the DPE POPD by age-sex projections.

Using these totals, along with an approximated distribution, an iterative process is used to estimate the POPD in each age-sex category by travel zone. This process is run for every region in each period. For the base period (currently 2016), the IPF starting distribution is approximated using 2016 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 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 that aligns with the base distribution while matching the row and column control totals.

Figure 16: IPF Procedure
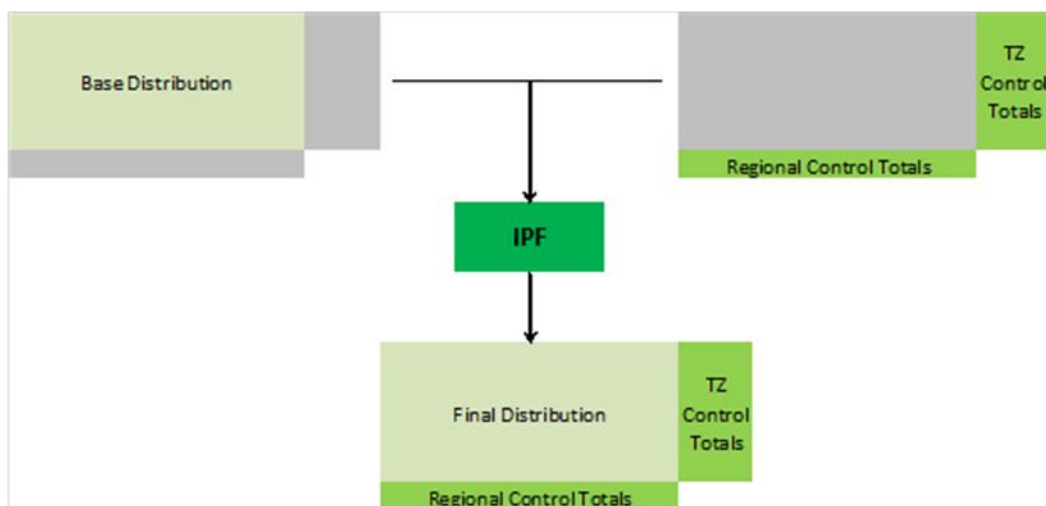
5.2　Module 2 Technical Model Overview

The following sections provide an overview of how the model operates.

5.2.1　M02a – Base Distribution

Brings in relevant data from various sources and structures them for the IPF process by smoothing inaccuracies resulting from small census data counts.

Inputs

Key Inputs:

- Age by Sex census data by TZ16 (obtained from M00b)

- SA2 to TZ16 concordance

Functions

This module performs a key function:

- Zones with a low total population are adjusted to reflect the age-sex structure of the overarching SA2 because they are influenced by ABS randomisation.

5.2.2   M02b – Iterative Proportional Fitting

Performs an IPF process to estimate age and sex breakdowns by Travel Zone over time. The IPF model uses a base distribution, along with travel zone POPD control totals, and regional age-gender control totals to calculate an age by gender distribution that is consistent with the three inputs.

Key assumptions

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

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

- Regional trends in the age-sex structure are captured at a travel zone level by the IPF procedure.
- Future growth Travel Zones (which have no historical age-sex distribution) are assumed to have a starting distribution that mirrors the distribution of the overarching SA2.

Inputs

Key Inputs:

- Base year ERP totals by Travel Zone
- POPD totals by Travel Zone
- Age-sex POPD control totals by SA2
- Base year age-sex distribution by Travel Zone

The module requires several parameter inputs:

- SA2 POPD forecasts by age from 2016 to 2066, developed by SGS/TfNSW (based on DPE ERP data), are proportionally adjusted to match the POPD control totals by Travel Zone.
- Convergence criteria – the 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 years – the module will perform the IPF procedure for every 5-year period up to 2066.
- Base year – the module will use the base year 2016.
- ERP_OPD Criterion – Specify the share of a Travel Zone's population that must live in a private dwelling for the TZ-specific age-sex distribution to be used. Travel Zones that do not satisfy this criterion will be assigned the SA2 age-sex distribution.
- This criterion is required for the model to read input data correctly.
- This criterion will need to be adjusted if a new regional or TZ structure is adopted.

Functions

This module runs the IPF procedure to estimate the POPD 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:

    - Read base year control total and age-sex distribution input data
    - Use IPF procedure to estimate final age-sex distribution in the base year

- For each future period:

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

5.2.3   M02c – Module Outputs and Summaries

Functions

This module has two primary functions:

- Converts outputs from XLSX format to CSV format.
- Aggregates data from the travel zone geography to the SA4/SA2 geography for each required output.

6 Module 3: Households by Household Type

6.1 Module 3 Overview

This chapter provides a summary of the household module of TZP22.

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

Figure 17: Module 3 Overview
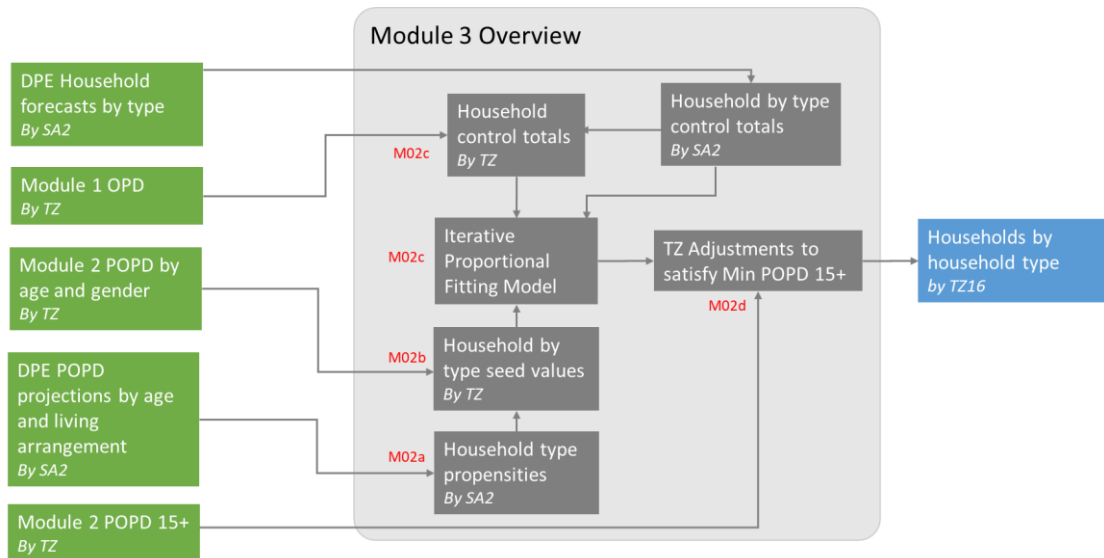
Source: SGS Economics and Planning, 2022

The primary function of the Household by Type module is to use the outputs of previous modules, along with DPE household forecasts and population projections to project household totals by type. The control totals for this module are the SA2 households by household type data supplied by DPE.

The household types considered are:

- Couples with Children
- Couples only
- Single parent
- Single person
- Other types (Group households, and multiple and other family households).

The inputs into module 3 specify the household totals at the travel zone level and the distribution of household types at the collapsed SA2 level, which is converted to the SA2 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 5).

For each time period, the IPF approach requires an approximate distribution of household types at the travel zone level as a starting point (the 'seed value').

The module also ensures the Minimum POPD 15+ criteria are met. This is explained further in the breakout box below.

6.2 Module 3 Technical Model Overview

The following sections provide an overview of how the model operates.

6.2.1 M03a – Living arrangement propensities

This module generates SA2 population living arrangement propensities by age and household type.

Key assumptions

To convert the POPD projections by age and living arrangement to POPD projections by age and household type the following table is used to aggregate living arrangement categories to household types.

Table 9: Household groups definition

Household type	TZP living arrangement	DPE 2022 living arrangement
Couples with children	Children <15 with 2 parents	Child aged under 15 * *p* *(p = proportion of parents (with children <15) who live partnered)*
	Child aged 15+ living at home	Child aged 15+ living with parents
	Partnered with children <15	Partnered with child(ren) aged under 15
	Partnered with children 15+	Partnered with child(ren) aged 15+ only
Couples only	Partnered with no children at all	Partnered with no children
Single parent	Children <15 with 1 parent	Child aged under 15 * *q* *(q = proportion of parents (with children <15) who live as a single)*
	Single parent with children <15	Single with child(ren) aged under 15 (single parent)
	Single parent with children 15+ only	Single with child(ren) aged 15+ only (single parent)
Single person	Living alone	Single and living alone
Other	Single in a group household	Single and living in a group household
	Single in family living arrangement	Single and living with a family (related or unrelated individual)
		Single and living in an 'Other Family'

Inputs

Key Input:

- SA2 population forecasts by age and living arrangement 2016-2041 (using data supplied by DPE)

Functions

This module performs the following functions:

- Converts POPD projections by age and living arrangement to POPD projections by age and household type
- Calculates the SA2 population living arrangement propensities by age and household type for 2016-2041

6.2.2 M03b – Calculating seed values

Estimates the distribution of households by type at the travel zone level for 2016-2041 to use as seed values, using the Travel Zone population projections by sex and age from Module 2.

Key assumptions

- Only persons of age 15+ are considered in the Household by Type categories. This is a simplifying assumption to remove the need for additional assumptions, such as needing to know the average number of children per household for each category.
- To convert population projections by household type to household projections the following Household-Population factors are assumed for all travel zones.

Table 10: Household – Population factors

Household type	Scale factor	Assumption
Couples with children	0.5	2 adults per house
Couples only	0.5	2 adults per house
Single parent	1.0	1 adult per house
Single person	1.0	1 adult per house
Other	0.422	Based on the average household size from the ABS Census

Inputs

Key Inputs:

- SA2 population living arrangement propensities by age and household type 2016-2041 from Module 03a
- TZ16 population projections by sex and age 2016-2041 from Module 02b

Functions

The starting distribution comes from the population by age group at the TZ level, for which shares of household type by age group from DPE SA2 level projections are applied (propensities calculated in M03a).

For instance, if 30% of an age group are single parents within an SA2, 30% of the households in all the TZ in that SA2 will be single parents. If 30% are couples (say without children), then 15% of households will contain couples without children.

This module performs the following functions:

- Converts TZ16 population projections by sex and age to TZ16 population projection by age
- Generates population by age and household type projections 2016-2041
- Estimates the TZ16 distribution of households by type for 2016-2041

Minimum POPD 15+

As part of the validation requirements for the STM, consistencies between households by household type (Module 3) and POPD 15+ (Module 2) are required. To achieve this, Minimum POPD 15+ is calculated using the distribution of households by household type for 2016-2066. Accordingly, the Minimum POPD 15+ criteria are:

- At the SA2 level, Minimum POPD 15+ must be equal to or lower than the computed POPD 15+ from Module 2.
- At the TZ16 level, Minimum POPD 15+ must be equal to or lower than the computed POPD 15+ from Module 2.

What is Minimum POPD 15+?

Minimum POPD 15+ is computed by multiplying the number of households and the minimum household size for each household type. This is then summed this across all household types.

The minimum household size (persons 15+) for each household type is assumed to be as follows:

Household type	Minimum household size
Couples with children	2.0
Couples only	2.0
Single parent	1.0
Single person	1.0
Other	2.0

How is this issue rectified?

Where Minimum POPD 15+ is higher than the computed POPD 15+ from Module 2, this implies that the number of households is too high.

To rectify the issue, the number of households in the problematic SA2/TZ needs to be downwards adjusted to meet the criteria. This will reduce the Minimum POPD 15+ for that SA2/TZ so that it becomes equal to or lower than the computed POPD 15+.

Why Minimum POPD 15+ instead of Minimum POPD?

Only persons of age 15+ are considered in the Household by Type categories for Module 3. This is a simplifying assumption to remove the need for additional assumptions, such as needing to know the average number of children per household for each category.

Because the Household outputs are computed using persons 15+ only, the Minimum POPD calculated must also only consider persons 15+. The flowchart illustrates an example of how Minimum POPD 15+ is calculated.

Example of calculation

200 POPD classified as 'Couples w children'

- 160 POPD 15+
- 40 Under 15

80 Households classified as 'Couples w children'

IPF

90 Households classified as 'Couples w children'

Minimum POPD 15+ for 'Couples w children' is 180
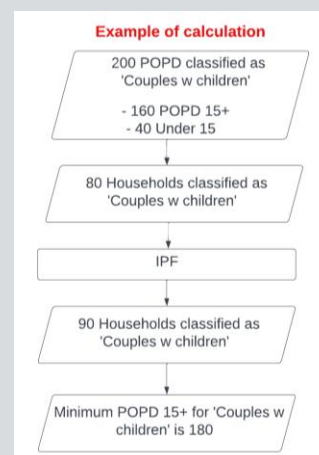
Source: SGS Economics and Planning, 2022

6.2.3 M03c – IPF

This module estimates the distribution of households by household type for 2016-2066.

Key assumptions

- The minimum household sizes used to calculate SA2 Minimum POPD 15+ are as per the table presented above in the breakout box.
- The DPE SA2 households by household type projections up to and including 2041 will satisfy the SA2 Minimum POPD 15+ criteria.
- The SA2 households by household type projections by type are extended to 2066 by assuming the SA2 distribution of household types remains fixed from 2041, with some adjustments to satisfy the SA2 Minimum POPD 15+ criteria.

- The minimal adjustment is made to satisfy the criteria. That is, POPD 15+ will equal Minimum POPD 15+ for any SA2s needing adjustment for the relevant years.

- Linear growth is assumed, first and then the IPF is run.

Inputs

Key Inputs:

- SA2 POPD 15+ 2046-2066 (output from M03c)
- SA2 households by household type projections 2016-2041 (using data supplied by DPE)
- TZ16 OPD 2016-2041 (output from M01b)
- Estimate of the TZ16 household distribution by type 2016-2041 (output from M03b)

Functions

This module performs the following functions:

- Extends the SA2 households by household type projections by type data from 2046-2066.
- Checks to ensure the SA2 Minimum POPD 15+ criteria are met for 2046-2066, and if this is not met, it adjusts households by household type downwards for the relevant SA2 in the relevant year so that the criteria are met.
- Performs the IPF procedure using seed values for 2016-2041 from M03.
- Performs the IPF procedure for 2046-2066 using seed values from the IPF output of the previous time period.

6.2.4   M03d – Travel Zone Adjustments

This module exists to deal with the Minimum POPD 15+ issue at the Travel Zone level by adjusting the TZ distribution of households by household type within each SA2. This is done iteratively until the TZ Minimum POPD 15+ criteria are satisfied.

Key assumptions

- The minimum household sizes used to calculate TZ16 Minimum POPD 15+ are as per the table presented above in the breakout box.
- The changes in this module entirely are contained within SA2 geographies (to ensure DPE SA2 control totals are met) independent of other areas and are output via intra travel zone shifts within the higher geography (SA2).

  - For any adjustments made, the smallest adjustment is used to satisfy the criteria. That is, POPD 15+ will equal Minimum POPD 15+ for any travel zones needing adjustment for the relevant years.

Inputs

Key Inputs:

- TZ16 POPD 15+ 2016-2066 (output from M02c)
- SA2 household by household type projections 2016-2066 (output from M03c)

Functions

This module performs the following functions:

- Calculates TZ Minimum POPD 15+ to 2066
- Checks to ensure the TZ Minimum POPD 15+ criteria are met for 2016-2066
- For travel zones where the TZ Minimum POPD 15+ criteria are not satisfied:

  - Households are adjusted downwards, which consequently adjusts Minimum POPD 15+ downwards.
  - This ensures that POPD 15+ from M01 is not lower than Minimum POPD 15+.
  - Households from the other travel zones in the same SA2 are adjusted upwards to compensate for this decrease.
  - This is done iteratively until all travel zones satisfy the Minimum POPD 15+ criteria within each SA2.

6.2.5   M03e – Module Outputs

Functions

This module has one primary function:

- Converts outputs from XLSX format to CSV format.

7   Module 4: Students

This chapter provides a summary of the student module.

7.1   Module 4 Overview

The primary function of the student module is to use some outputs from other modules to project primary, secondary and tertiary students. The outputs generated from this module will result in Primary, Secondary and Tertiary students at both place of usual residence and place of institution.

Figure 18: Module 4 Overview
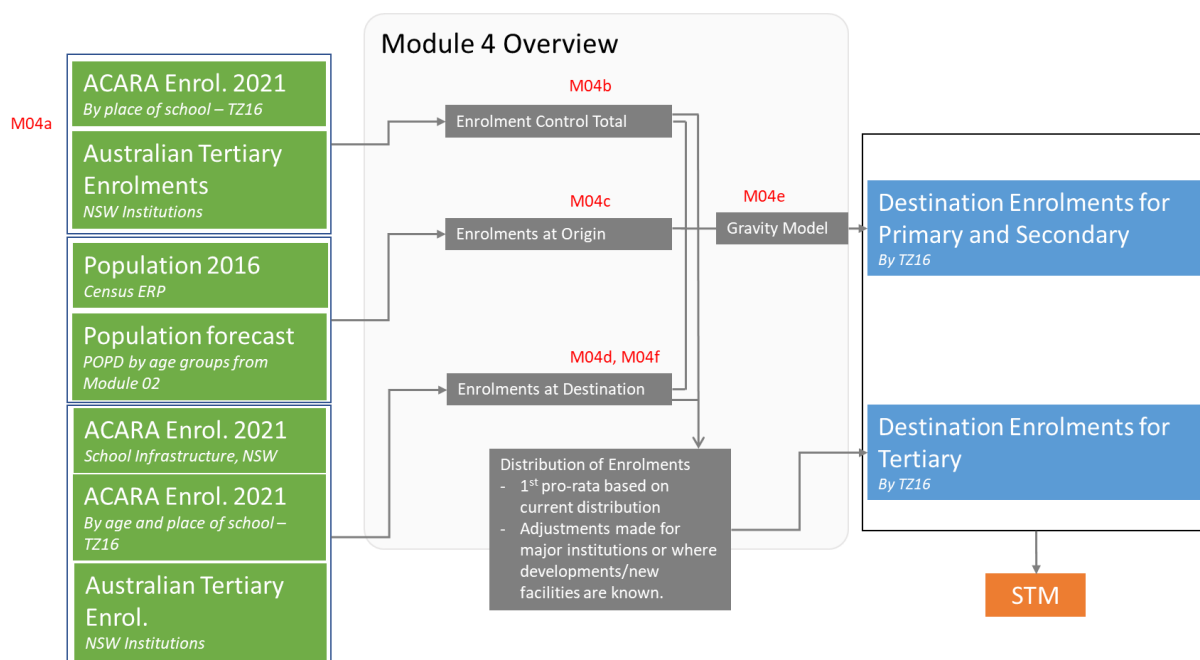
Source: SGS Economics and Planning, 2022

7.2   Module 4 Technical Model Overview

7.2.1   M04a – Age Control Totals

This module converts the population by 5-year age group outputted from module 2 to school and tertiary age groups.

Input

- Age by sex and 5-year age groups

Functions

- The 5-year age groups are first disaggregated into single-year age groups using propensities from the 2016 Census. The propensities are the proportions of single-year age groups within the broader 5-year age groups they belong.
- Population by single-year age group is then aggregated into school and tertiary age groups.

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7.2.2 M04b – Enrolments Control Totals

This module sets the state control totals for students at their place of usual residence in the base year. The 2016 state control totals for school students are aligned to enrolment data from ACARA; University students are aligned to the ABS Education and Work dataset, while the control totals for Vocational Education and Training (VET) students are derived from the 2016 Census.

Input

- 2016 Census data detailing current age and education status
- NSW school enrolments (ACARA 2021, enrolments)
- NSW University students at place of usual residence from the Australian Bureau of Statistics
- Department of Education and Training Higher Education Statistics 2016 - Enrolment Count by Type of Attendance by Institution

Functions

- The IPF method is used to align Census enrolments with the enrolment state control totals. The IPF method used is the same as that used to produce outputs in Module 2. In this module, IPF is applied to calculate the age group distributions by education enrolment.

7.2.3 M04c – Enrolments at Origin

This module estimates the total number of enrolled residents by travel zone. It utilises the IPF method to distribute age control totals by institutions. The POPD by age groups and travel zone totals estimated in Module 2 is 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 and the institution type.

This module outputs students at place of usual residence at the travel zone level.

Inputs

- 2016 Census data
- M04a – Enrolments by school and tertiary age groups, type of education institution, and attendee status
- School Infrastructure NSW Enrolments forecasts

Functions

- The 2016 Census data is first converted from SA1 to travel zones to create the seeds for the IPF.
- Propensities for education types and attendee statuses within each age group in 2016 are held constant in the forecast years for tertiary enrolments. For school enrolments, propensities in 2021 are adjusted so that the number of students attending government schools aligns with the enrolments forecast which were produced by School Infrastructure NSW for TZP19. There were no new School Infrastructure NSW projections for TZP22 to update the propensities used for 2021.
- Students at travel zone level are calculated using the IPF method, which calibrates the seeds from the 2016 Census to the age group control totals in Module 4a and state control totals in Module 4b.

7.2.4   M04d – Enrolments at Destination

This module assigns travel zones and capacities to schools in NSW to form the place of institutions in each forecast year. The current capacity of each school is analysed using the current utilised capacity from ACARA 2021 data as well as its projections to 2025. This is further adjusted to 2066 using the school enrolment forecasts prepared by School Infrastructure NSW for TZP19, which will be used as a base for determining the capacities of each school. Note, there were no new School Infrastructure NSW projections available for TZP22.

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

- Adjusted school capacity forecasts from School Infrastructure NSW
- Enrolments at origin from M04c
- Future planned schools from School Infrastructure NSW
- Potential future schools identified by SGS

Functions

- A list of existing schools across NSW is used to form the travel zone destinations in the base year.
- Planned future schools are identified by School Infrastructure NSW while unplanned schools are identified by SGS to reflect the growing demand in areas with rapid population growth.
- A final set of school capacity forecasts by sector (government or non-government) and enrolment type (primary or secondary) at the travel zone level will then flow into the next module.

7.2.5   M04e – Final School Enrolments

This module is a gravity model that estimates the small area destination enrolments in each future year, using inputs from the preceding modules. A gravity model allocates students to schools based on two factors:

- Push factor (travel time)
- Pull factor (attractiveness of a school, e.g., size and equipment)

The push and pull factors form a propensity, which is calculated from every travel zone to every school. A different propensity is calculated for each type of student: primary Government, primary non-government, secondary government, and secondary non-government. The propensities adjust 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).

Inputs

- School capacity forecasts
- Students at place of usual residence
- Travel time matrix

Function

- The gravity model 'attractiveness' factor is first calibrated to 2016 using actual POI school enrolments from ACARA.
- The 'pull' factor is adjusted for each school so that it pulls just enough students to equal their current enrolments.
- Students at place or usual residence are then allocated to schools based on the pull and push factors.
- The POI enrolments are capped at a school's capacity so that a school would not be allocated with students unreasonably beyond its capacity. Demands can then be diverted to new schools as they become available in the model.

7.2.6   M04f – Tertiary Enrolments

This module estimates tertiary enrolments at VET training institutions and Universities under a full-time and part-time split.

Total enrolments at place of institutions are aligned to total students at place of usual residence as the STM requires that total students at origins equate to destinations.

Enrolments for potential future tertiary institutions are also projected. Future University campuses and VET training facilities are assigned to travel zones along with estimated capacities, based on research and likely geographic locations.

Inputs

- Module 4c Enrolments at Origin
- VET enrolments at places of institutions from the National Centre for Vocational Education Research
- University enrolments at place of institutions from the Department of Education
- Research information regarding future University campuses and enrolments from SGS and TfNSW
- Employment by industry data from the 2016 Census

Function

- The module collates the tertiary enrolment data and allocates a travel zone(s) to each institution.
- Tertiary students at their place of usual residence are first distributed to travel zones with tertiary institutions, using propensities drawn from the actual 2016 University and VET enrolments data. Employment by higher education industries and Destination Zones are converted to the travel zone level to develop employment-to-enrolments ratios for different tertiary institutions. The ratios are then used to distribute total enrolments at tertiary institutions to the associated campuses.

8   Module 5: Workforce Segmentation

8.1   Module 5 Overview

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

Figure 19: Module 5 Overview
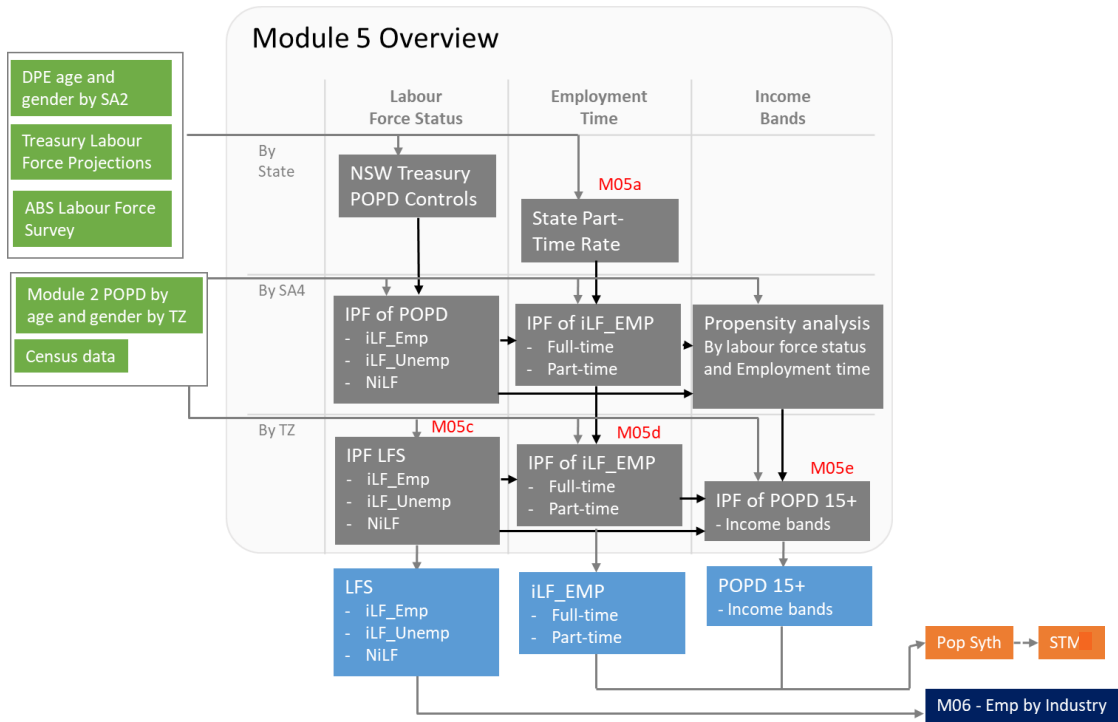
Source: SGS Economics and Planning, 2022

The primary function of the Workforce module is to use the outputs of prior modules to segment the working-age population in a largely automated manner. This is undertaken at the State level, sub-regional level (SA4) and TZ level. The module also breaks down the data into three stages: Workforce Status (Employed, Unemployed and Not in Labour Force), 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 are presented in Table 11.

Table 11 Segmented workforce output variables

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 (Emp) • In Workforce and Unemployed (Unemp) • Not In Workforce (NiLF)	• Employed full-time (Emp_FT) • Employed part-time Emp_PT)	• Negative or Nil income • $1-$149 • $150-$299 • $300-399 • $400-499 • $500-649 • $650-799 • $800-999 • $1,000-$1,249 • $1,250-$1,499 • $1,500-$1,749 • $1,750-$1,999 • $2,000-$2,999 • $3,000 or more

Before each module is described individually Table 12 provides some broader reasoning and process elements established in this Module.

Table 12 Workforce module reasoning and process

	Workforce Status	Employment time	Income Bands
By State	Disaggregation starts at the State level for a number of reasons: • The analysis can draw on a wider range of datasets only available at a more aggregate geographic level. • High-level modelling can be conducted that is not possible at a smaller area level. • The data can be easily checked against other key indicators and form a benchmark for subsequent disaggregation. (e.g., disaggregated NSW Treasury data can be aggregated to a total population for NSW and checked against national and state trends)		
By State	NSW Treasury provides State Labour Force projections, Participation Rates, Unemployment Rates and Population 15+. This data is used to create State control totals for those Employed, Unemployed and Not in Labour Force.	ABS Labour Force Survey data for NSW helps to provide part-time rates for the State and sub-regions.	Income distribution is not modelled at the State level. This is because labour force survey data is available at an SA4 level (see below).
By SA4	The stage 1 IPF process produces regional-level control totals. It is better to complete this process from State to SA4 and then SA4 to TZ, rather than jumping straight from State to TZ level:		

	Workforce Status	Employment time	Income Bands
	• Additional sub-regional (SA4) data that is not available at a TZ level can be introduced 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 TZ456).		
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 the full-time/part-time split, and this is influenced by a wide range of factors. Analysis similarly showed that 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 NSW IGR compound average growth rate in real GSP per capita) 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 TZ.		

8.2 Module 5 Technical Model Overview

8.2.1 M05a – State Part-Time Rate

Labour Force projections of Employed, Unemployed and Not in the Labour Force have already been created at a State level by NSW Treasury. The only component not provided by Treasury is a State part-time rate projection.

Module 05a utilises historical ABS Labour Force Survey data to project the propensity for workers to engage in part-time employment out to 2066. The modelling approach chosen is a univariate log-log regression, which was selected because it achieves reasonable projections with a far greater degree of automation.

Log-log regression: This diagram presents the observed and projected part-time rates for the NSW Workforce

The estimated regression: $\log_e PR = \alpha + \beta \log t$
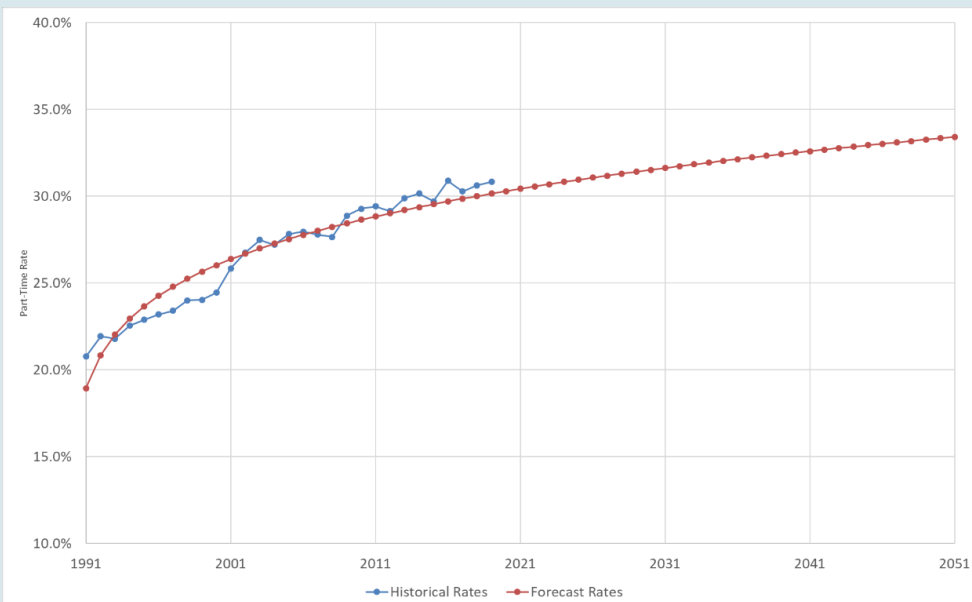
Source: SGS Economics and Planning, 2022

Inputs

Key Inputs:

- ABS - Labour Force Survey data 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
- A Part-time employment rate upper limit
- User-defined part-time rate upper limits

Functions

- Estimates the parameters α and β for the State
- Compiles the historical and projected part-time rates
- Checking the final Part-time projections (viewed alongside historical data)

8.2.2   M05b – Labour Force Starting Distribution

The purpose of M05b is to calculate starting distributions of Workforce Status (Employed, Unemployed and Not in Labour Force), Workforce Time (Full-time/Part-time) and Workforce Incomes at a State, SA4 and Travel Zone level to be used as inputs to the IPF procedures in M05c, M05d and M05e.

With all three geographies having had their starting distributions calculated through different methodologies, the purpose of the starting distribution is to ensure each geography is calibrated in preparation for the forthcoming IPF procedure. The result of the IPF procedure is that the three geographies will equal each other.

The 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 the Rest of NSW are reasonable before further disaggregation).

Inputs

Key Inputs:

- SA1 to TZ16 concordance (obtained internally from TfNSW)
- ABS Census - Labour force status by age by SA1
- ABS Census - Labour force status and hours worked (full-time/part-time) by age by SA1
- ABS Census - Income band by hours worked (full-time/part-time) by SA1
- Travel zone control totals for POPD by age (obtained from M02b)
- State Workforce Control Totals (obtained through NSW Treasury LTFP and adjusted to equal M02 POPD control totals)
- Labour force survey participation and unemployment rate data by age by SA4 (base year and most recent year)
- Population in occupied private dwellings by State
- Population in occupied private dwellings by age by sex by SA4
- Population in non-private dwellings by age by sex by State
- Historical and projected part-time employment shares by age by State (obtained from M05a)
- Parameter input: Base year of model

Functions

The first function of M05b is to produce State control totals and SA4 starting distributions for the stage 1 IPF processes of M05c (Emp, Unemp, NiLF) and M05d (Emp_FT, Emp_PT). Once these inputs are finalised, a macro computes the outputs via the processes described below:

- The model utilises NSW Treasury Labour Force that has been adjusted to align with POPD calculations from Module 02.
- SA4 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 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 It also computes age-specific income band propensities by TZ (which are used in M05e to calculate IPF process starting distributions). This follows the process outlined below:

- Convert SA1 level census data to TZ16.

- Zones with a low total population are likely to contain data that has been heavily influenced by the process the ABS has adopted to ensure confidentiality. In these cases, the values for the zones are adjusted to reflect the structure of the broader SA2 geography. 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, 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 starting distribution for income band segmentation is calculated by combining the income band propensities by workforce characteristics with projections of workforce status (obtained from M05c) and employment-time (obtained from M05d).

8.2.3   M05c – Labour Force IPF

Module 05c performs the IPF process. This process aligns totals for Workforce Status (Emp, Unemp, NiLF) for the State, SA4 and TZ. The result is that the Workforce Status at the travel zone level will equal control totals at an SA4 level and the State level.

Inputs

Key Inputs (from M05c):

- State 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:

- Determine the number of SA4s across NSW (28)
- Set a convergence criterion – the iterative process is considered complete when the sum of the absolute differences (between estimated regional workforce segment totals and regional workforce segment control totals) are below this level (i.e., differences are less than 0.1)
- Future year – module will perform IPF up to the specified year (2066)
- Base year – specify the base year (currently 2016)
- Input data structure – Defines the data structure of the SA4 and travel zone level input
- Required for the model to read input data correctly

Functions

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

- Read the input parameter data.
- For each year and region that requires estimation:

  - Read State workforce segment control totals, SA4 POPD control totals and starting distribution data.

- Use the IPF procedure to estimate the final SA4 workforce distribution.
- For each year and region that underwent the first stage IPF procedure:

- Read travel zone POPD control totals and starting distribution data (see above for calculation detail).

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

8.2.4   M05d – Part-Time Segmentation IPF

Module 05d performs an IPF process that first aligns Workforce Employment Time (Employed Full-Time, Employed Part-Time) to the State to Workforce Employment Time by SA4. The second stage is then to align Workforce Employment Time by SA4 to Workforce Employment Time by travel zone. The result is that Workforce Employment Time totals at the travel zone level add up to equal the State control total.

Inputs

Key Inputs:

- State 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:

- Determine the number of SA4s across NSW (28)
  - Set a convergence criterion – the iterative process is considered complete when the sum of the absolute differences (between estimated SA4 workforce employment time totals and travel zone workforce employment time totals) are below this level (i.e., differences are less than 0.1)

- Future year – module will perform IPF up to the specified year (2066)
- Base year – specify the base year (currently 2016)
- Input data structure – defines the data structure of the SA4 and travel zone level input
- Required for the 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:

- For each year and region that requires estimation: Read State employment-time segment control totals, SA4 workforce in OPD control totals and starting distribution data.
- Use the IPF procedure to estimate the final SA4 employment-time distribution.
- For each year and region that underwent the first stage IPF procedure: Read travel zone workforce in OPD control totals and starting distribution data (see above for calculation detail).
- Use the IPF procedure to estimate the final travel zone employment-time distribution.

8.2.5   M05e – Income Segmentation

Module 05e segments POPD who are of working age (15+) into fourteen 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 fourteen census income categories. Assuming a uniform distribution within categories, the fourteen bands are disaggregated to form 38 sub-bands.

Combining these propensities with projections of POPD by workforce characteristics (obtained from M05c and M05d) results in a preliminary estimate of POPD within each income band. However, this estimate is based on income levels in the 2016 census year, 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 1.1% in line with the compound average growth rate in real GSP per capita from the 2021 NSW 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
>
> If for a given SA4 in 2016, 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:

- Determine the number of SA4s across the State (28)
- Set a convergence criterion – the 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 2016)
- Input data structure – Defines the data structure of the SA4 and travel zone level input

    - Required for the model to read input data correctly

- Real Income Growth Rate – compound average growth rate in real GSP per capita (2021 NSW IGR)

- Defines the rate at which individuals will shift across income bands

Functions

- Computes the median income for each of the 38 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 fourteen census income categories into the 38 sub-bands (assuming a within-category uniform distribution).
- For each year, the preliminary 38 sub-band propensities are adjusted for real income growth.
- These 38 sub-bands are then 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 M05c (see above for calculation detail) and the IPF procedure estimates the final income band distribution.

9 Module 6: Employment by Industry

9.1 Module 6 Overview

The Employment by Industry module has one key function. Its role is to disaggregate the quantum of jobs by industry at the State level down to an SA3 and travel zone level. This spatial disaggregation is 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., the total and distribution of employment for individual industries (e.g., Retail) across NSW)
- 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 employment acts as a 'destination' variable and is used as a relative attractor within the STM.

The figure below presents an overview of the employment module and how it interacts with the TZP framework.

Figure 20 Module 6 Overview
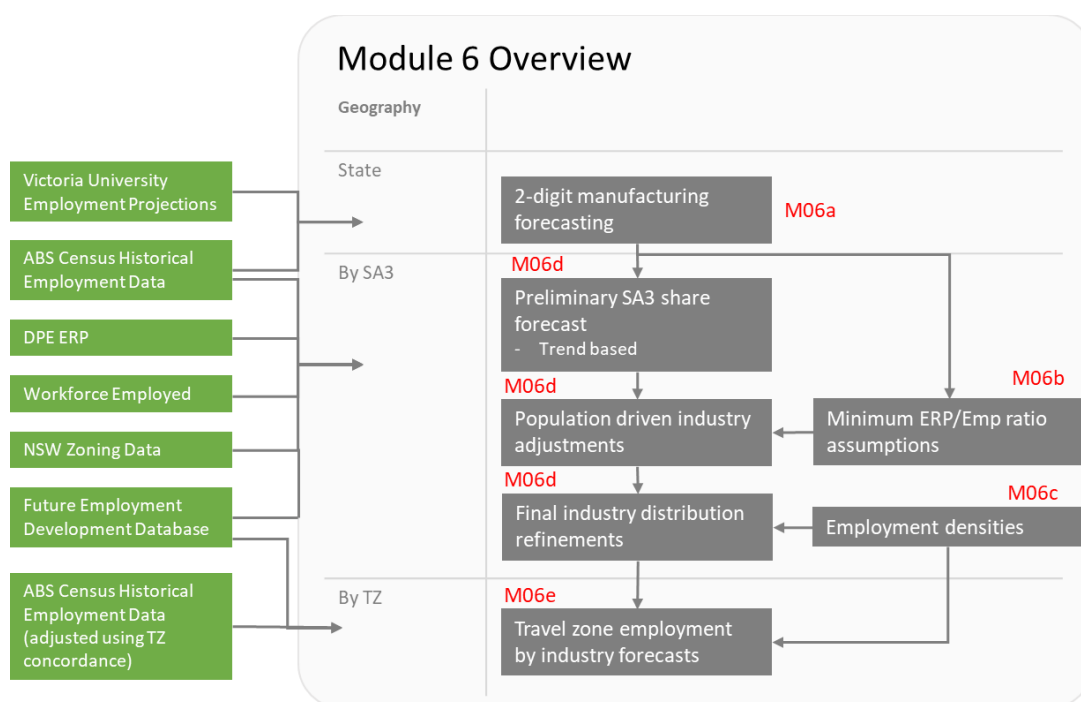
Source: SGS Economics and Planning, 2022

9.2 Module 6 - Technical Model Overview

9.2.1 M06a – 2-digit Manufacturing Forecasting

This module uses historical employment data from various Census periods to disaggregate the 1-digit State industry control totals provided by Victoria University ('VU') to a 2-digit industry projection for Manufacturing. The projection is broken into two steps:

- The share of employment for each 2-digit manufacturing industry is calculated based on historical employment data from 1996 to 2016.
- The shares of employment at a 2-digit manufacturing level are projected using a log-log regression. These shares are then applied to the 1-digit manufacturing projections as determined in the previous module.

Inputs

Key inputs:

- Historical manufacturing employment data at the 2-digit level from 1996-2016
- VU 1-digit industry projections

Functions

- Inputs of 2-digit manufacturing employment from 1996-2016
- Disaggregate 1-digit industry employment to the 2-digit level
- Projects the share of each 2-digit industry based on a log-log regression.
- Using these projected shares, the final 2-digit employment projections are produced

9.2.2 M06b – Population Serving Employment Ratios

Module 06b is utilised to establish a minimum level of employment that would be required to service population growth for population-serving industries. A minimum level of employment is defined as a maximum ERP-to-employment ratio. These ratios are then applied in M06d when disaggregating jobs from a State level to an SA3 level.

For example, consider an SA3 which is projected to have a significant increase in population, but limited growth in Retail Trade as per the first cut of disaggregation. This will result in an ERP/Emp ratio that exceeds the defined threshold. In other words, there may be a projection of insufficient retail jobs based on the population. As such, the number of Retail Trade jobs for that SA3 needs to be adjusted to ensure a more appropriate amount.

The ERP/Emp ratios are determined by examining historical employment and population data. This is currently achieved by assuming the percentage of SA3s that currently provide an appropriate level of service. For example, if the assumption is that 85% of SA3s provide an adequate level of service (for population-serving industries), it implies that 15% do not, and the calculated maximum ERP/employment ratio will be defined as the lowest ratio among this 15% (note, a higher ratio indicates a lower level of service).

Inputs

Key inputs:

- State employment by industry projected from M06a
- ABS & DPE ERP data by SA3
- ABS Census and ERP data at the SA3 level for employment by industry

9.2.3   M06c – Employment Densities

An important consideration for the forthcoming M06d SA3 industry projection is to use professional judgement to review the employment density of SA3s when allocating jobs. M06c allows the user to compare employment projections to the area of currently zoned employment land. M06c computes this area of employment land by both travel zone and SA3.

Key inputs:

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

9.2.4   M06d – SA3 Industry Projections

Module 6d distributes the VU State Industry control totals to the SA3 level. The distribution to the SA3 level is achieved using historical census data which provides a trend of each SA3's employment trajectory. M06d also introduces information on planned developments, which is used to adjust the SA3's trend.

When assessing information on planned developments, which is sourced from the 'Future Employment Development Database (FEDD) there are two cases that should be considered:

- The FEDD in some areas will likely represent growth over and above that which is predicted by projections based on historical census data. This is particularly the case for greenfield or previously undeveloped regions, where no historical employment projections exist. Additionally, planning documentation can often provide optimistic employment projections.
- The alternative is that these FEDD projections 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.

In incorporating single-year projections for 2016-2026, a few assumptions have been made regarding opening years in these periods.

- For projects with projections in 2021 with no opening dates, an assumed opening date of 2021 was applied.
- For projects with projections in 2021 or 2026 and an opening date between 2016 and 2026, employment projections were linearly ramped up from the starting date to the next available five-year figure

M06d utilises M06b and M06c to assist in synthesising inputs further. These have been isolated as they are areas that could benefit from additional development.

The projection procedure of M06d 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 2016 to future years (e.g., share decreasing from 2016 to 2021 and then increasing)
- An automated process that 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 (Construction, Retail Trade, Accommodation and Food Services, Rental Hiring and Real Estate Services, Education and Training and Health Care and Social Assistance).
- A threshold population-to-employment ratio (ERP/Emp) was computed in M06b. SA3s are adjusted such that this ratio (for growth) in forecasted years is not exceeded.
- 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., Future Employment Development 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 that will benefit from future development, as improved GIS zoning layers become available (there are currently zoning gaps).

Inputs

Key inputs:

- State employment by industry projected from M06a
- ABS & DPE ERP data by SA3
- ABS Census data at the SA3 level for employment from 2006-2016
- Parameters defining minimum ERP/Emp ratio (M06b)
- Concordance of industries to one of three categories (commercial, industrial, and other)
- Known estimates of future employment by travel zone (i.e. Future Employment Developments Database)

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

- Select the industry to which distributional adjustments are being made
- 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 changes when projections are scaled to match State control totals. SA3 projections could be locked if:
- 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)
- Adjustments that are made should not affect certain other SA3s

Functions

- Estimates share of employment by industry captured by each SA3 using a log-log regression model. These are then applied to the State industry control totals to generate the first-cut projection.
- 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 that have a relatively high level of employment growth relative to population growth (see Figure 33).

Figure 21 Module 6d: Second-cut projection approach
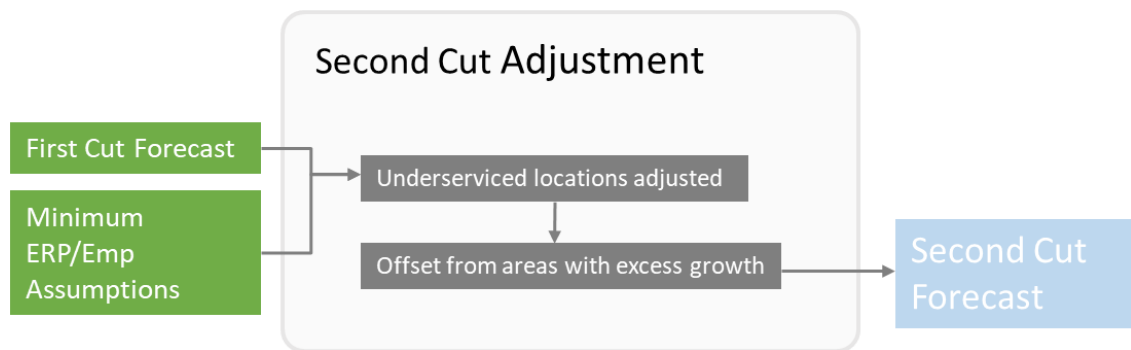
SGS Economics and Planning, 2022

Key components of this are:

- Indications of SA3s that have a cumulative projection of employment growth that 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 FEDD).
- Manual share adjustments can be specified to adjust the distribution of employment across SA3s (which will propagate to future years once made).
- 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 changes which stem from adjustments to other SA3s).

Figure 22 Module 6d: Third-cut projection approach
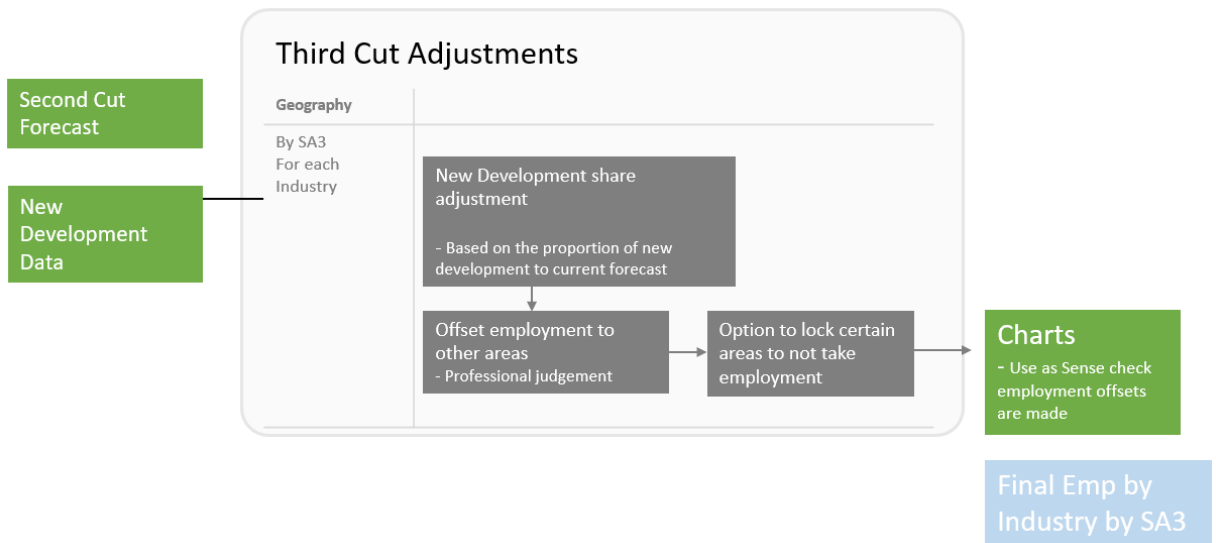
SGS Economics and Planning, 2022

9.2.5 M06e – TZ Industry Forecasting

Module 6e completes the distribution of employment by allocating the SA3-level industry control totals to a TZ 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 Future Employment Developments Database (FEDD)) and professional judgement. The projection process has two primary components:

- Use census data and the FEDD 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 its constituent travel zones.
- 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 TZs will indicate locations in which too much growth is projected (e.g., highly developed existing CBD zones). Further details on the employment disaggregation process are provided in Appendix E.

Inputs

Key Inputs:

- ABS Census Place of Work employment data at the DZN and MB level (2016)
- Estimate of available land by travel zone (M06c)
- SA3 employment by industry projections from M06d
- Estimates of future employment by travel zone (i.e., FEDD)

Functions

- Combine census and FEDD 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 projection for each zone.
- For zones that have a base projection lower than the growth implied by FEDD data, the projection is adjusted, and the SA3 is rebalanced to control totals and new shares computed.
- Review projected total employment for all travel zones within the selected SA3. Growth rates and density (jobs/hectare) are also calculated.
- Display the employment projections, by industry, for individual travel zones.

Share override adjustments, based on professional judgement, can be made balanced to SA3 control totals.

10 Module 7: Checks and Validation

10.1 Overview

The quality checks module is the last step in the model. This module is a Python Script that takes the output from previous modules and performs a number of automated calculations to evaluate quality and consistency within and between the outputs of the various modules. The checks module has three main functions – negatives checks, control totals checks and validations checks. The negatives check determines whether output files contain any negative numbers. The control totals check determines whether the DPE control totals for the State are consistent with aggregated figures in the output files. The validations check further checks for consistency between different sub-geographies.

10.2 The Overall Logic of the Order of the Checks

Step 1 — Check that there are no negative values

Step 2 — Check the sum of all small area disaggregation against high level control totals

Step 3 — Check further travel zone segmentations against initial disaggregation, e.g., workforce income segmentation against initial workforce forecast

Step 4 — Therefore, all files are checked against the control totals

Step 5 — Check each travel zone segmentation breakdown

The checks module is configured to be run from start to finish in its entirety. Each module output file along with global functions is loaded at the start of the module run and then required in each section of the script. The checks module takes an average of two minutes to run.

10.3   Control Totals

The control totals step of the module checks that figures in the module output files are consistent with the DPE control totals for the State. This validation also checks for consistency between output files of different modules. For example, the workforce for any given area (Module 5) is equivalent to the resident population aged between 15 and 65 (Module 2). This check sums all geographic areas for each file and only checks for consistency between the aggregate figures, not for different sub-areas. Each test is outlined below.

10.3.1   Module 1 Population and Dwellings

Figure 23 Graphical representation of control total check for Module 1 output files
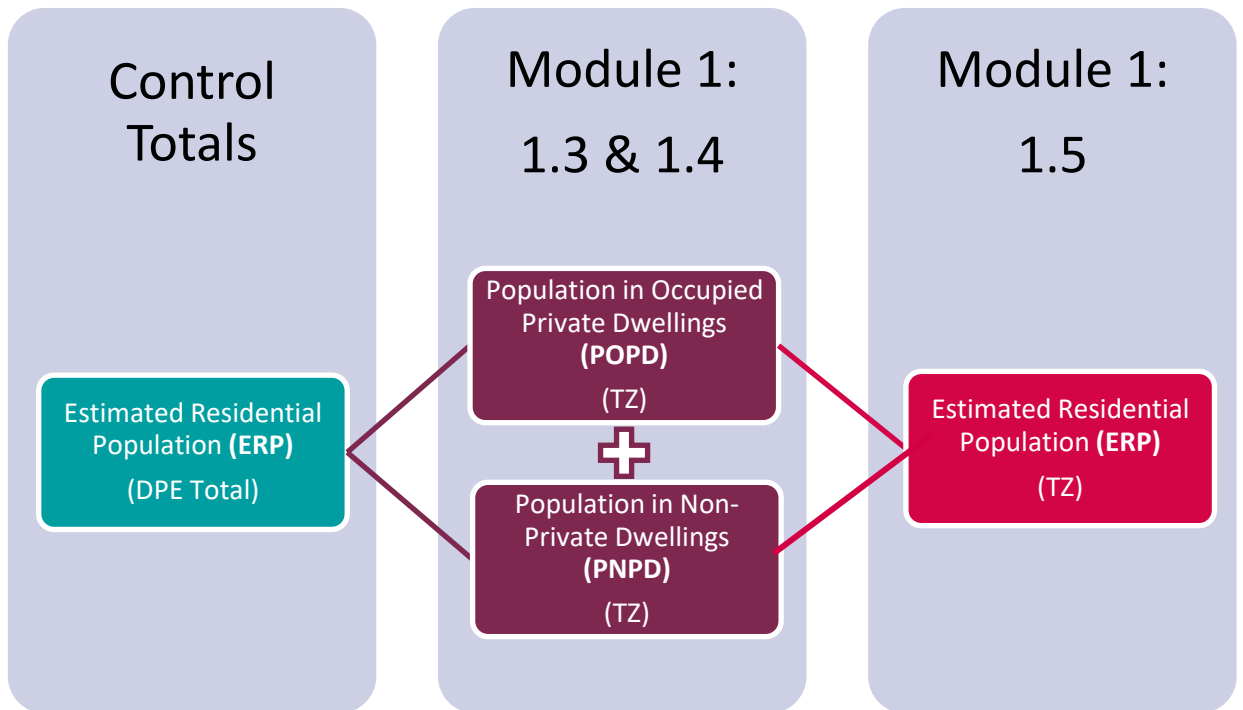
10.3.2 Module 2 Age-Sex

Figure 24 Graphical representation of control total check for Module 2 output files

Control Totals	Module 2: 2.1 & 2.2	Module 2: 5.1
Population in Occupied Private Dwellings **(POPD)** (DPE Total)	Population in Occupied Private Dwellings (15-64+) **(POPD)** (TZ)	Workforce (TZ)
	Population in Occupied Private Dwellings **(POPD)** (TZ)	
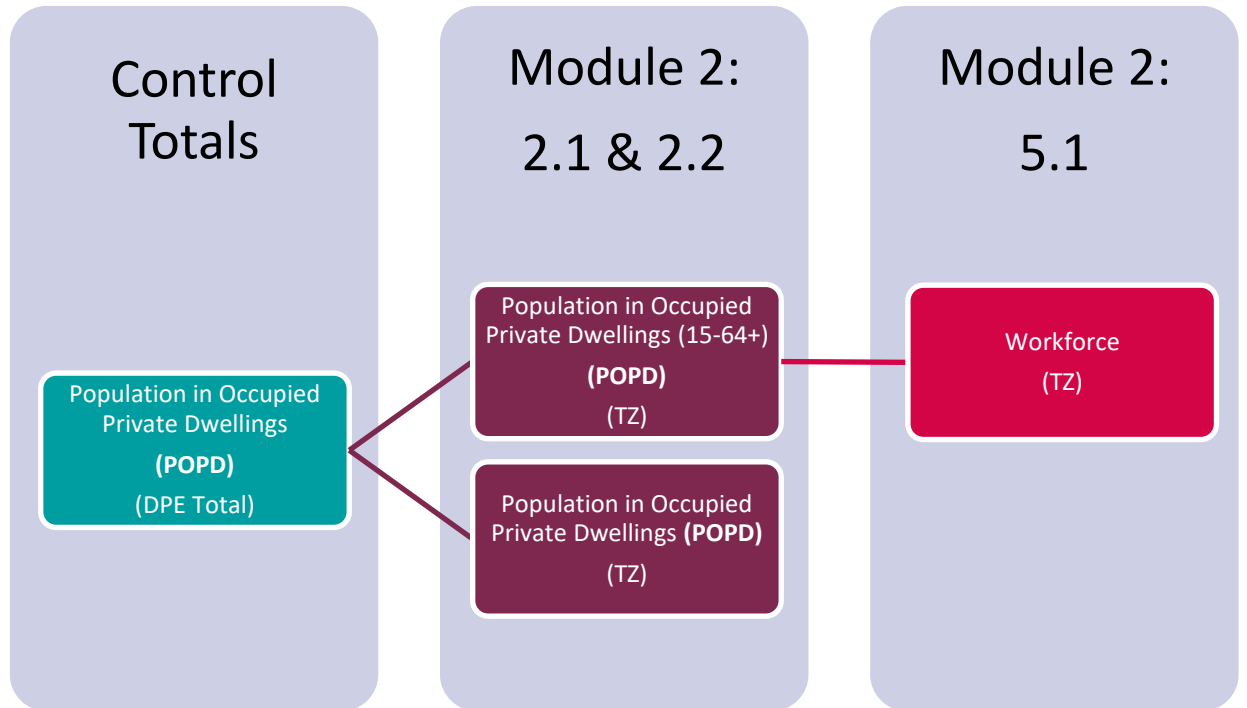
Checks are also completed between Module 2 output files, to check that the sum of the 5-year age brackets in output file 2.1 is equivalent to each of the aggregated age bracket output files 2.2 and 2.3 as outlined in Figure 25 below:

Figure 25 POPD age categories in Module 2 output files 2.1, 2.2 and 2.3

10.3.3   Module 3 Household Type

Figure 26 Graphical representation of control total check for Module 3 output file
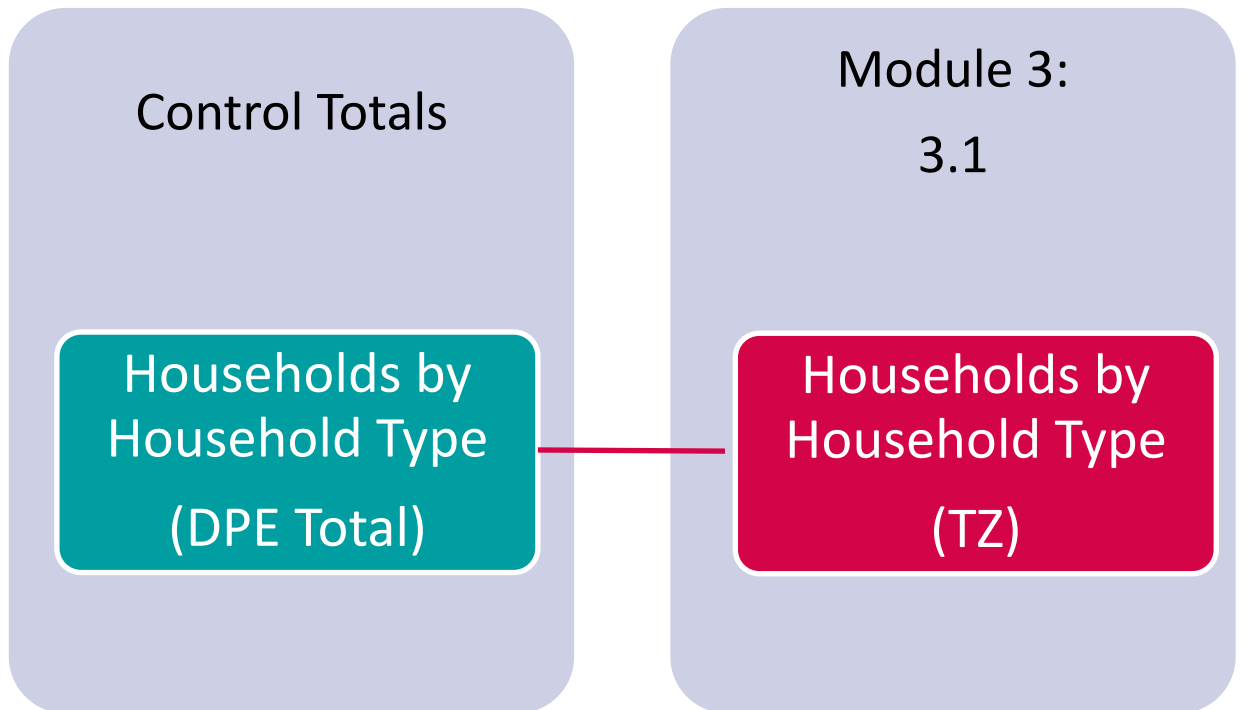
10.3.4   Module 4 Students

Module 4 is independent of any other Module. It cannot be checked against any DPE control total or population groups in the output files of any other modules. The output files of Module 4 are checked for internal consistency such that the total number of students within NSW.

4.1 Primary and secondary school students at place of usual residence (Total) = 4.2 Primary and secondary school students at place of institution (Total)

4.3 Tertiary students at place of usual residence (Total) < 4.4 Tertiary students at place of institution (Total)

10.3.5   Module 5 Workforce

Figure 27 Graphical representation of control total check for Module 5 output files
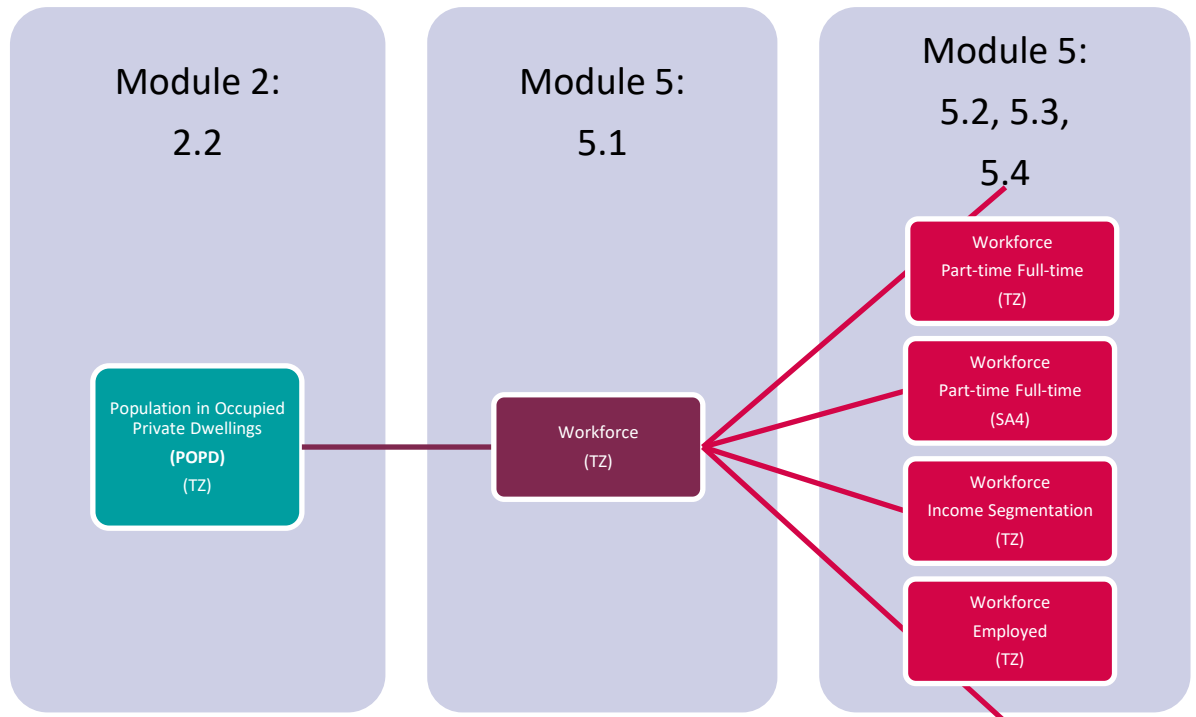
10.3.6 Module 6 Employment by Industry

Module 6 is self-contained and independent of any other module.

Figure 28 Graphical representation of control total check for Module 6 output files
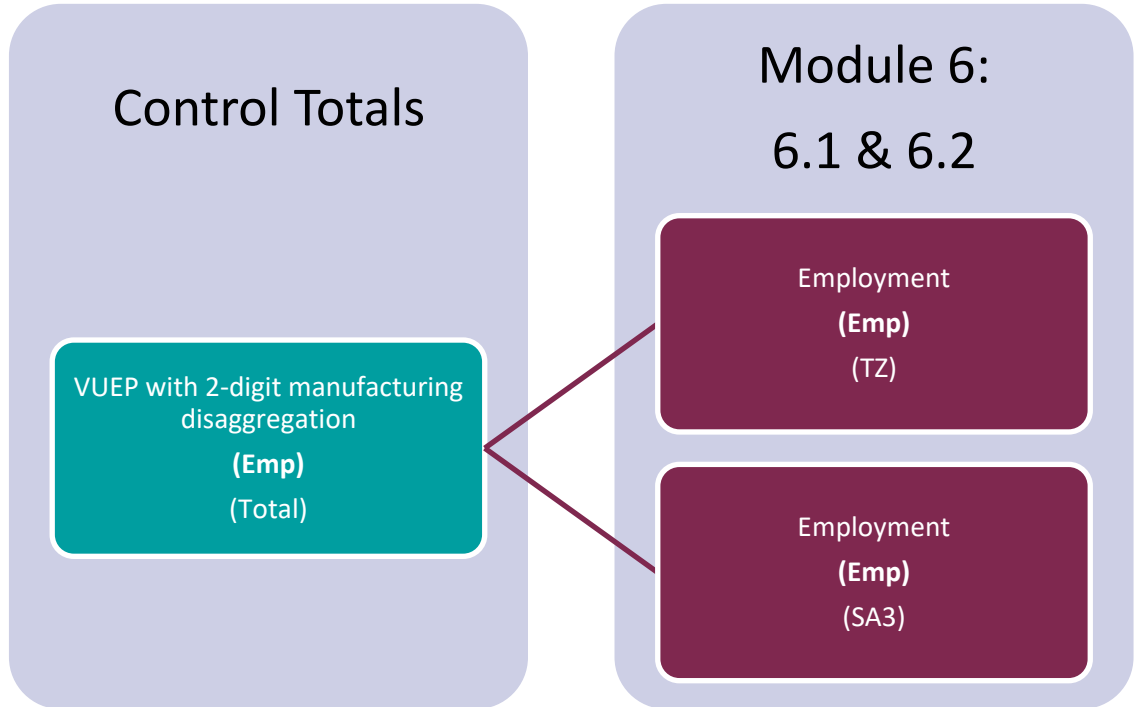
10.4   Validations

The validations step of the module conducts further consistency checks between figures in module output files, e.g., check that the number of occupied dwellings does not exceed the number of people in each travel zone. Unlike the control totals step outlined above, this step of the module checks for consistency in reported numbers between corresponding geographic sub-areas (travel zones, SA3 and SA4). The validations follow the same general order as the control totals checks.

Table 13 Description of Validation Checks

Module 1 – Population and Dwellings	
1.1 OPD (TZ) / 1.2 SPD (TZ) <= 1	Checks that the number of occupied dwellings (OPD) does not exceed the total dwelling stock (SPD) in the model for each travel zone.
1.3 POPD (TZ) / 1.2 OPD (TZ) >= 1	Checks that the number of people in occupied dwellings (POPD) exceeds the number of private occupied dwellings in the model for each travel zone.
1.3 POPD (TZ) + 1.4 PNPD (TZ) = 1.5 ERP (SA3)	Checks that the population assigned to private and non-private dwellings in travel zones is equivalent to the estimated resident population in the corresponding travel zones.
Module 2 – Age-Sex	
2.1 ERP (Sum of 15-64+) (TZ) = 2.2 ERP (15-64+) (TZ)	Checks that the aggregate of the five-year categories in output file 2.1 is equivalent to the pre-aggregated groups in output file 2.1 for each travel zone.
2.1 ERP (Sum of 15-29) (TZ) = 2.2 ERP (15-29) (TZ)	
2.1 ERP (Sum of 30-64) (TZ) = 2.2 ERP (30-64) (TZ)	
2.1 Age by Sex (Sum of 64+) (TZ) = 2.2 Age by Sex (64+) (TZ)	
2.1 ERP (15+) (TZ) = 2.3 ERP (15+) (SA4)	Checks that the 15+ population reported at the SA4 level is equivalent to the aggregate of corresponding travel zones.
Module 3 – Household Type	
3.1 Household Type (TZ) = Household Type (SA2)	Checks that the aggregate of households by household types aggregated at the travel zone level is equivalent to the DPE control totals reported at the SA2 level.
Module 4 – Enrolments	
4.1 Total Primary and Secondary enrolments (PUR) = 4.2 Total Primary and Secondary enrolments (POI)	Checks to ensure that the total student count aligns when looking at where the students are located vs. where the students are enrolled.

Module 5 – Workforce Segmentation	

5.1 Labour Force_TZ16= 2.2 Age Groups (15-64+) _TZ	Checks that workforce figures are equivalent to the POPD aged over 15 years for each travel zone.
5.1 Labour Force_TZ16= 5.4 Labour Force Income Segmentation_TZ16	Checks that the workforce figures are equivalent to the aggregate employees across all income categories for each travel zone.
5.1 Labour Force_TZ16 = 5.2 Labour Force Part Time Full Time_SA4	Checks that the workforce figures for travel zones are equivalent to the aggregate of part-time and full-time employees at the corresponding SA4 level.
5.1 Labour Force_TZ16 = Labour Force Part Time Full Time_TZ16	Checks that the workforce figures are equivalent to the aggregate of part-time and full-time employees for each travel zone.
5.1 Labour Force_TZ16 = SA3 Employment	Checks that the workforce reported at the SA3 level is equivalent to the aggregate of the workforce for the corresponding travel zones.

Module 6
No further relevant checks

11 Appendix A: Future Employment Development Database (FEDD)

The Future Employment Development Database (FEDD) is a major input into M06d. Table 14 below shows the projects that are considered in the projections.

Table 14: Summary of future developments database for employment (as of Oct 2022)

Project #	Project Name	Travel zones impacted by project
1	Blacktown ACU	[4112]
2	St George Hospital - Acute Services	[2738]
3	The Sandstone Precinct	[42, 43]
4	Angus Place Coal	[7098, 7120]
5	Russell Vale Coal 2	[5610]
6	Spur Hill Underground Coal	[7005]
7	Sunrise NickelCobalt	[7053, 7022]
8	Wallarah 2 Coal	[5144]
9	UTS Blackfriars Precinct	[207]
10	Fairfax Media Warehouse Chollura	[2328]
11	Westfield Parramatta	[1058]
12	Arthur Phillip High School	[1074]
13	Parramatta Square	[1055]
14	Circular Quay - ADPG	[30]
15	Circular Quay - Quay Quarter	[32, 33]
16	Barangaroo Casino	[2, 3]
17	Barangaroo One Sydney Harbour	[3]
18	Barangaroo South	[4]
19	Central Barangaroo	[2]
20	Blackwattle Bay	[228, 153, 836, 830, 745, 828, 812, 837]
21	Clarence Correctional Centre	[7739, 7740]
22	Darling Harbour Live and ICC Sydney	[108, 89, 88]
23	Bella Vista	[4567, 4572, 4571, 4516, 4447, 4521, 3902]
24	Castle Hill	[4533, 4537, 4536, 4526, 4527]
25	Kellyville	[4560, 4559, 4567]
26	Macquarie Park	[1547, 1545, 1539]
27	Tamworth UNE	[7585]
28	North Ryde	[1552, 1562]
29	Norwest	[4514, 4512, 4515, 4517]
30	Sydney Olympic Park	[1326, 1328, 1331]

Project #	Project Name	Travel zones impacted by project
31	Parkes	[7054, 7049]
32	Wagga Wagga	[7328, 7329, 7347, 7352]
33	Bayside West Precincts	[2763, 2713, 2707, 2705, 2699, 2711]
34	Camelia	[1068, 1071, 1091, 1092, 1209]
35	Westmead University of Sydney	[1018, 1019, 1036, 1037, 1043, 1044, 1045, 1046, 1048]
36	Wilton Growth Area	[3008, 3003, 3012, 3010, 3002]
37	Central to Eveleigh	[224, 222, 270, 268, 216, 132, 146, 208, 215, 223]
38	Enfield Intermodal	[984]
39	Glenfield to Macarthur	[3210, 3213, 3212, 3215, 3219, 3216, 3278, 3279, 3277, 3246, 3247, 3248, 3252, 3253, 3269, 3293, 3295, 3271, 3209, 3217, 3220, 3221, 3222, 3283, 3281, 3292, 3289, 3290]
40	Marsden Park	[3947, 3950, 3956, 3961, 3966, 3967]
41	Marsden Park Industrial	[3962, 3968]
42	Moorebank Intermodal Terminal	[3824]
43	Newcastle CBD	[6350, 6351, 6353, 6355, 6357, 6352, 6358, 6383, 6317, 6394, 6308, 6720, 6310, 6639, 6314, 6316, 6313, 6325, 6367, 6369, 6377, 6385, 6337, 6386, 6600, 6613, 6612, 6610, 6323, 6303, 6302, 6301, 6360, 6361, 6393, 6359, 6336, 6384, 6457, 6458, 6430, 6432, 6431, 6433, 6425, 6427, 6428, 6200]
44	Northern Beaches Hospital	[2140]
45	Martin Place	[60, 75]
46	Port Botany Expansion	[402]
47	Southern Employment Lands	[262, 264, 265, 266, 267, 287, 263, 330, 289]
48	Western Sydney Airport	[3598, 3609, 3635, 3636]
49	Woolooware Bay	[2914]
50	St Leonards and Crows Nest	[1841, 1832, 1836, 1837, 1842, 1844, 1845, 1912, 1843, 1908, 1910, 1914, 1915, 1838, 1911]
51	Telopea	[1131]
52	Cockle Bay Wharf	[90, 91]
53	Oakdale Central Business Hub	[3477]
54	Pitt Street	[97, 115]
55	One Carrington Street	[57]
56	University of Western Sydney Innovation Hub	[1057]
57	Eastern Creek Business Hub	[4055]

Project #	Project Name	Travel zones impacted by project
58	Dexus Quarry West	[4046, 1238]
59	Camden Medical Campus Precinct	[3691]
60	Westmead Hospital CASB	[1045]
61	Central Park Block 4N	[206]
62	Calibre Industrial Park Eastern Creek	[4059]
63	Victoria Cross	[1962]
64	Marrickville Metro Shopping Centre Expansion	[303]
65	Nepean Hospital	[4951]
66	Balarald Mineral Sand Mine	[7382]
67	Hawsons Iron Ore	[7449]
68	Boggabri Coal Mine	[7567]
69	Blacktown Hospital Stage 2	[4109]
70	Imax Mixed Use Redevelopment	[89]
71	Vickery Coal	[7569]
72	Concord Repatriation General Hospital	[715]
73	Watermark Coal	[7569]
74	Mandalong Coal Extension	[6222, 6216, 6219, 6223, 6224]
75	Tahmoor South Coal	[3018]
76	Gosford Hospital Redevelopment	[5331]
77	Maxwell Project	[7006]
78	Berry And Walker Street	[1953]
79	Hornsby Ku-Ring-Gai Hospital	[1626]
80	Coffs Harbour Hospital	[7767]
81	ANSTO Innovation Precinct	[2829, 2831]
82	Albury RJP	[7438]
83	Alex Avenue NWGA	[3911, 3918, 3958, 3959, 3960]
84	Austral SWGA	[3615, 3616, 3621, 3624]
85	Bankstown	[2367, 2305, 2313, 2301, 2337]
86	Bourke Abattoir	[7453]
87	Box Hill Precinct	[4428, 4430, 4423, 4429, 4431, 4424, 4426]
88	Bulli hospital	[5656]
89	Catherine Fields North SWGA	[3663, 3664, 3674, 3675]

Project #	Project Name	Travel zones impacted by project
90	Catherine Fields SWGA	[3662, 3673, 3681, 3686, 3689, 3690]
91	Coffs Harbour film studio	[7761]
92	Colebee NWGA	[3970]
93	Concord Repatriation General Hospital Redevelopment	[715]
94	Dubbo Hospital redevelopment	[7486]
95	East Leppington SWGA	[3243, 3676]
96	Frenchs Forest Precinct	[2153, 2140]
97	Gledswood Hills The Crest SWGA	[3687]
98	Goulburn Hospital	[7143]
99	Griffith Hospital	[7281]
100	Hydro Kurri Kurri	[6733]
101	Kempsey Hospital redevelopment	[7626]
102	Leppington North SWGA	[3627, 3630, 3633, 3634, 3655, 3656, 3658]
103	Leppington Stage 1-5 SWGA	[3660, 3666, 3665, 3670]
104	Lismore Hospital redevelopment	[7823]
105	Liverpool health precinct	[3841]
106	Lowes Creek Maryland SWGA	[3659, 3668]
107	Macksville Hospital redevelopment	[7637]
108	Marsden Park North NWGA	[3931, 3936, 3942, 3945, 3954]
109	Moree SAP	[7519, 7524]
110	Mount Penang	[5342]
111	Mudgee Hospital redevelopment	[7106]
112	New Shellharbour Hospital	[5834]
113	Oran Park SWGA	[3678, 3679, 3680, 3683, 3684, 3685]
114	Pondicherry SWGA	[3672]
115	Pyrmont Peninsula	[153, 154, 155, 187, 78, 151, 152, 186, 88, 89, 108, 157, 156, 228, 125, 159, 160]
116	RPA redevelopment	[238]
117	Randwick campus redevelopment	[659]
119	Riverstone East NWGA	[3938, 3948, 3971, 3939, 3943]

Project #	Project Name	Travel zones impacted by project
120	Riverstone NWGA	[3933, 3935, 3940, 3941, 3944, 3946, 3952, 3953, 3972, 3974]
121	Riverstone West NWGA	[3934, 3937]
122	Rossmore SWGA	[3653, 3654]
123	Schofields NWGA	[3925, 3957, 3963, 3969]
124	Shanes Park NWGA	[3965]
125	Shellharbour Civic Centre	[5842, 5840]
126	Shoalhaven District hospital	[6129]
127	Showground Station Precinct	[4543]
128	South Coast Correctional Facility Expansion	[6138]
129	South Creek West SWGA	[3650, 3651, 3652, 3657, 3669, 3671]
130	South Jerrabomberra RJP	[7203, 7198]
131	Sutherland hospital redevelopment	[2902]
132	Tallawong Station NWGA	[3949, 3973]
133	Tamworth Hospital redevelopment	[7585]
134	Toyota Site Caringbah	[2901]
135	Turner Road SWGA	[3691, 3692, 3693, 3694]
136	Tweed Valley hospital redevelopment	[7837]
137	University of Wollongong Innovation Campus Fairy Meadow	[5603]
138	Villawood Logistics Estate	[1205]
139	Vineyard NWGA	[4408, 4407]
140	WOW Customer Fulfilment Centre Auburn	[1333]
141	WOW Distribution & Fulfilment centre	[305]
142	WOW Wetherill Park DC	[3505]
143	WSA. 1. Aerotropolis Core	[3612, 3617, 3618, 3622, 3623, 3629]
144	WSA. 2. Agriculture and Agribusiness	[3625, 3626, 3628, 4969, 4970, 4971]
145	WSA. 3. Badgerys Creek	[3608]

Project #	Project Name	Travel zones impacted by project
146	WSA. 4. Kemps Creek	[3482, 3594, 3599, 3607, 3611]
147	WSA. 5. Mamre Road	[3479]
148	WSA. 6. Northern Gateway	[4967, 4973, 4983]
149	WSA. 7. Rossmore	[3613, 3614, 3619, 3620, 3631, 3632]
150	WSA. 8. South Creek	[3485]
151	WSA. 9. Twin Creeks	[4968]
152	Wagga Wagga hospital redevelopment	[7339]
153	West Schofields NWGA	[3951, 3955, 3964]
154	Williamtown SAP - RAAF Base	[6539, 6372, 6523, 6524, 6540]
155	Wyong Hospital redevelopment	[5192]

Source: SGS Economics and Planning, 2022

Table 15 provides a summary of the contribution that each FEDD project has had on the final employment outputs. Not all FEDD jobs end up in the final employment dataset of TZP22. This is because the TZP22 model is restricted to its total employment number for each industry across all of NSW. When disaggregating this total job number down to individual TZs, the result is that the FEDD estimate of jobs may be higher than is allowed for that TZ. If all FEDD jobs were given in such a situation, it could draw in too many jobs and negatively affect the trend in other areas. In such a situation, the cell below is marked '100%' in red.

For instance, in 36 Wilton Growth Area, the FEDD contributed up to 47.7% of total jobs in 2021. In 2031 however, there is a '100%' flag. This means that the FEDD was projecting more jobs for the Wilton Growth area in 2031, than could fit into that area (more FEDD jobs than total jobs would mean it is greater than 100%). As such, the final model could only take in as many FEDD jobs up to its total limit before it affected the employment trends of surrounding TZs.

Table 15: Contribution of FEDD projects to total jobs (as of November 2022)

Project	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066
1 Blacktown ACU	1.2%	5.5%	5.4%	5.3%	5.2%	5.0%	4.9%	4.8%	4.7%	4.5%
2 St George Hospital - Acute Services	4.4%	4.2%	4.1%	4.0%	3.8%	3.7%	3.6%	3.5%	3.3%	3.2%
3 The Sandstone Precinct	18.3%	18.5%	18.8%	18.5%	18.0%	17.5%	17.1%	16.9%	16.7%	16.5%
4 Angus Place Coal	0.0%	26.6%	27.7%	29.7%	31.3%	32.1%	32.1%	32.0%	31.3%	30.6%
5 Russell Vale Coal 2	0.0%	25.3%	24.4%	23.8%	23.4%	22.9%	22.3%	21.7%	21.0%	20.2%
6 Spur Hill Underground Coal	0.0%	0.0%	29.9%	29.0%	29.0%	28.6%	28.1%	27.5%	26.7%	25.8%
7 Sunrise NickelCobalt	27.8%	29.9%	28.6%	28.6%	28.3%	27.7%	26.8%	26.0%	25.0%	24.0%
8 Wallarah 2 Coal	0.0%	27.3%	26.9%	26.8%	26.4%	25.8%	25.3%	24.7%	23.9%	23.2%
9 UTS Blackfriars Precinct	14.8%	15.4%	15.6%	15.8%	16.0%	16.0%	16.0%	16.0%	16.0%	15.7%
10 Fairfax Media Warehouse Chollura	6.4%	6.6%	6.5%	6.3%	6.2%	6.0%	5.8%	5.7%	5.5%	5.3%
11 Westfield Parramatta	0.0%	54.3%	54.5%	52.4%	50.1%	48.3%	46.3%	44.5%	43.5%	42.2%
12 Arthur Phillip High School	4.2%	4.0%	4.0%	3.9%	3.7%	3.6%	3.5%	3.3%	3.2%	3.1%
13 Parramatta Square	61.7%	81.2%	80.1%	77.2%	74.1%	71.0%	68.5%	66.1%	64.1%	62.4%
14 Circular Quay - ADPG	0.0%	5.7%	11.4%	11.1%	10.9%	10.5%	10.2%	9.9%	9.6%	9.4%
15 Circular Quay - Quay Quarter	0.0%	16.2%	16.0%	15.6%	15.1%	14.6%	14.2%	13.8%	13.4%	13.0%
16 Barangaroo Casino	79.8%	37.4%	32.0%	31.3%	30.5%	29.4%	28.5%	27.7%	26.9%	26.2%
17 Barangaroo One Sydney Harbour	0.0%	7.6%	7.8%	7.5%	7.1%	6.8%	6.5%	6.3%	6.0%	5.8%
18 Barangaroo South	72.0%	70.9%	70.2%	68.4%	66.8%	64.7%	62.8%	61.2%	59.4%	57.8%
19 Central Barangaroo	0.0%	68.9%	76.4%	75.0%	73.2%	70.8%	68.7%	67.0%	65.1%	63.5%
20 Blackwattle Bay	0.0%	3.9%	4.5%	13.9%	48.1%	62.5%	63.7%	64.5%	64.6%	63.0%
21 Clarence Correctional Centre	48.1%	49.9%	50.3%	50.0%	50.0%	49.8%	50.2%	50.1%	49.8%	49.7%
22 Darling Harbour Live And Icc Sydney	31.4%	30.5%	29.6%	28.1%	26.7%	25.6%	24.7%	23.9%	23.1%	22.4%
23 Bella Vista	5.1%	18.6%	29.0%	37.3%	36.0%	35.6%	34.8%	34.1%	33.1%	32.2%
24 Castle Hill	38.1%	53.1%	64.6%	73.0%	70.6%	69.5%	68.1%	66.7%	64.9%	63.3%

Project	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066
25 Kellyville	63.7%	65.6%	62.5%	58.6%	56.5%	56.0%	54.9%	53.8%	52.3%	51.0%
26 Macquarie Park	6.8%	33.3%	32.8%	32.0%	31.1%	30.3%	29.6%	29.0%	28.2%	27.4%
27 Tamworth UNE	0.0%	1.2%	1.2%	1.2%	1.2%	1.1%	1.1%	1.1%	1.0%	1.0%
28 North Ryde	24.7%	41.5%	51.4%	58.5%	56.8%	55.5%	54.3%	53.3%	51.9%	50.5%
29 Norwest	20.8%	37.9%	45.3%	50.6%	48.5%	47.5%	46.4%	45.3%	44.0%	42.7%
30 Sydney Olympic Park	0.0%	28.5%	47.1%	58.8%	66.9%	73.0%	78.5%	74.0%	72.1%	70.3%
31 Parkes	46.6%	67.7%	80.8%	91.0%	98.8%	95.6%	93.3%	91.2%	87.9%	84.9%
32 Wagga Wagga	11.0%	36.7%	57.7%	67.1%	68.0%	65.9%	64.7%	63.5%	61.4%	59.4%
33 Bayside West Precincts	21.6%	36.0%	47.1%	55.6%	62.6%	60.5%	59.3%	58.0%	56.1%	54.3%
34 Camelia	0.0%	10.2%	41.7%	57.5%	66.7%	64.0%	61.6%	59.4%	57.9%	56.0%
35 Westmead University of Sydney	3.5%	6.2%	11.4%	17.8%	20.6%	31.5%	41.4%	38.0%	36.6%	35.4%
36 Wilton Growth Area	47.7%	93.7%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
37 Central to Eveleigh	61.3%	82.8%	85.9%	88.0%	88.0%	87.5%	87.1%	86.8%	85.5%	83.8%
38 Enfield Intermodal	9.6%	15.8%	15.5%	15.0%	14.6%	14.2%	13.9%	13.7%	13.2%	12.8%
39 Glenfield to Macarthur	17.5%	22.8%	27.8%	31.7%	29.6%	28.9%	28.1%	27.5%	26.8%	25.9%
40 Marsden Park	0.0%	100.0%	100.0%	100.0%	96.7%	96.0%	91.9%	91.8%	87.1%	81.8%
41 Marsden Park Industrial	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
42 Moorebank Intermodal Terminal	15.8%	74.5%	88.4%	94.4%	91.7%	89.2%	86.9%	84.9%	82.8%	80.3%
43 Newcastle CBD	3.3%	6.8%	9.7%	11.1%	10.5%	10.2%	9.9%	9.7%	9.3%	9.0%
44 Northern Beaches Hospital	100.0%	69.1%	57.4%	50.9%	45.6%	44.0%	42.9%	41.9%	40.2%	38.9%
45 Martin Place	0.0%	58.9%	58.5%	57.1%	55.7%	53.9%	52.3%	51.0%	49.5%	48.1%
46 Port Botany Expansion	0.0%	95.0%	94.5%	93.6%	91.7%	91.4%	89.9%	88.6%	87.8%	87.3%
47 Southern Employment Lands	11.2%	19.5%	26.0%	25.5%	24.7%	23.6%	22.9%	22.2%	21.4%	20.9%
48 Western Sydney Airport	16.7%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
49 Woolooware Bay	0.0%	35.9%	36.5%	36.6%	36.3%	35.0%	34.3%	33.6%	32.5%	31.7%
50 St Leonards and Crows Nest	8.0%	15.0%	21.2%	26.8%	25.9%	24.9%	24.1%	23.8%	22.9%	22.0%
51 Telopea	0.0%	16.6%	33.4%	29.9%	27.3%	27.0%	25.5%	24.7%	24.4%	23.0%
52 Cockle Bay Wharf	31.0%	48.4%	47.8%	46.7%	45.7%	44.3%	43.2%	42.2%	41.1%	40.0%
53 Oakdale Central Business Hub	37.3%	36.8%	36.6%	36.1%	35.8%	35.3%	35.0%	34.1%	32.9%	31.8%
54 Pitt Street	0.0%	17.8%	17.8%	17.4%	17.0%	16.5%	16.0%	15.6%	15.2%	14.8%
55 One Carrington Street	57.9%	57.6%	57.1%	55.7%	54.5%	52.8%	51.3%	50.1%	48.6%	47.4%
56 University of Western Sydney Innovation Hub	7.4%	19.3%	27.0%	26.2%	25.4%	24.5%	23.6%	23.0%	22.5%	22.2%
57 Eastern Creek Business Hub	74.5%	73.2%	72.6%	71.0%	69.5%	67.6%	66.4%	65.5%	63.4%	61.7%
58 Dexus Quarry West	13.7%	13.6%	13.0%	12.4%	11.9%	11.4%	11.0%	10.8%	10.4%	10.1%

Project	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066
59 Camden Medical Campus Precinct	0.0%	81.2%	65.1%	49.9%	45.8%	34.9%	25.4%	19.8%	20.0%	18.6%
60 Westmead Hospital CASB	5.1%	4.4%	4.2%	3.8%	3.4%	3.1%	2.8%	2.5%	2.4%	2.3%
61 Central Park Block 4N	51.1%	55.6%	56.2%	54.8%	53.2%	51.1%	49.6%	48.3%	46.8%	45.7%
62 Calibre Industrial Park Eastern Creek	40.6%	44.4%	43.5%	41.9%	40.8%	39.6%	38.9%	38.2%	36.9%	35.7%
63 Victoria Cross	0.0%	34.4%	34.1%	33.2%	32.2%	31.1%	30.3%	29.5%	28.7%	27.9%
64 Marrickville Metro Shopping Centre Expansion	31.5%	33.7%	34.1%	32.8%	31.5%	29.9%	29.0%	28.2%	27.2%	26.6%
65 Nepean Hospital	0.0%	12.6%	12.2%	12.0%	11.4%	11.0%	10.7%	10.4%	9.8%	9.4%
66 Balarald Mineral Sand Mine	81.4%	85.3%	80.3%	78.8%	76.7%	74.3%	72.4%	70.8%	69.0%	66.7%
67 Hawsons Iron Ore	0.0%	45.1%	50.5%	54.3%	58.8%	64.4%	72.5%	83.8%	99.5%	100.0%
68 Boggabri Coal Mine	41.2%	66.8%	70.3%	74.8%	78.3%	79.4%	78.9%	78.0%	76.0%	73.7%
69 Blacktown Hospital Stage 2	14.5%	14.5%	13.9%	13.6%	13.0%	12.5%	12.1%	11.8%	11.2%	10.8%
70 Imax Mixed Use Redevelopment	0.0%	12.5%	12.4%	11.5%	10.8%	10.3%	9.9%	9.5%	9.2%	8.9%
71 Vickery Coal	0.0%	29.6%	29.2%	29.4%	29.2%	28.6%	27.9%	27.2%	26.4%	25.4%
72 Concord Repatriation General Hospital	10.1%	16.5%	16.0%	15.5%	15.2%	14.6%	14.1%	13.8%	13.1%	12.6%
73 Watermark Coal	0.0%	35.5%	35.1%	35.3%	35.1%	34.3%	33.5%	32.7%	31.7%	30.5%
74 Mandalong Coal Extension	24.2%	19.8%	20.0%	20.5%	20.4%	20.2%	19.5%	18.9%	18.1%	17.2%
75 Tahmoor South Coal	0.0%	69.4%	65.9%	67.0%	66.6%	66.3%	64.5%	62.9%	60.8%	57.6%
76 Gosford Hospital Redevelopment	4.6%	5.2%	6.7%	6.6%	6.3%	6.1%	6.0%	5.9%	5.6%	5.4%
77 Maxwell Project	0.0%	35.8%	36.4%	35.5%	36.7%	37.0%	36.6%	36.2%	35.4%	34.3%
78 Berry And Walker Street	0.0%	32.4%	32.1%	31.2%	30.3%	29.3%	28.5%	27.7%	27.0%	26.3%
79 Hornsby Ku-Ring-Gai Hospital	7.8%	7.4%	7.1%	6.9%	6.6%	6.3%	6.1%	6.0%	5.7%	5.5%
80 Coffs Harbour Hospital	3.3%	6.5%	6.5%	6.5%	6.3%	6.1%	6.0%	5.9%	5.6%	5.5%
81 ANSTO Innovation Precinct	20.9%	39.6%	53.6%	63.2%	64.4%	62.0%	60.3%	58.6%	56.4%	54.3%
82 Albury RJP	0.0%	66.0%	93.1%	97.7%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
83 Alex Avenue NWGA	33.3%	39.4%	47.4%	52.6%	52.3%	52.9%	51.9%	54.4%	51.4%	47.9%
84 Austral SWGA	82.3%	73.6%	84.4%	97.7%	100.0%	100.0%	100.0%	95.5%	89.0%	84.9%
85 Bankstown	10.3%	16.1%	25.9%	30.2%	33.7%	36.7%	35.6%	34.9%	33.6%	32.4%
86 Bourke Abattoir	0.0%	54.8%	56.7%	59.3%	62.8%	67.7%	75.9%	87.5%	100.0%	100.0%
87 Box Hill Precinct	23.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
88 Bulli hospital	0.7%	1.3%	1.3%	1.2%	1.2%	1.1%	1.1%	1.1%	1.0%	1.0%
89 Catherine Fields North SWGA	0.0%	2.2%	6.5%	8.7%	9.0%	9.0%	9.4%	10.9%	8.6%	8.2%
90 Catherine Fields SWGA	41.6%	59.2%	72.5%	73.9%	69.0%	64.6%	59.1%	58.0%	51.5%	49.0%

Project	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066
91 Coffs Harbour film studio	0.0%	18.5%	33.9%	33.9%	33.2%	32.4%	31.8%	31.2%	30.4%	29.6%
92 Colebee NWGA	1.4%	48.2%	73.9%	80.7%	85.0%	88.9%	89.3%	90.3%	85.4%	81.2%
93 Concord Repatriation General Hospital Redevelopment	0.0%	9.1%	12.5%	15.5%	15.2%	14.6%	14.1%	13.8%	13.1%	12.6%
94 Dubbo Hospital redevelopment	0.0%	3.1%	3.0%	3.0%	2.9%	2.8%	2.7%	2.6%	2.6%	2.5%
95 East Leppington SWGA	47.2%	85.2%	92.7%	94.3%	91.2%	89.9%	89.3%	88.1%	84.5%	81.6%
96 Frenchs Forest Precinct	0.0%	26.4%	35.8%	41.4%	45.8%	44.1%	43.0%	42.0%	40.2%	38.8%
97 Gledswood Hills The Crest SWGA	26.1%	51.3%	70.3%	75.1%	68.7%	66.7%	64.9%	65.4%	60.3%	57.7%
98 Goulburn Hospital	0.0%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%	0.5%
99 Griffith Hospital	0.0%	0.8%	0.8%	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%	0.6%
100 Hydro Kurri Kurri	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
101 Kempsey Hospital redevelopment	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%	1.3%	1.3%	1.2%	1.2%
102 Leppington North SWGA	58.9%	68.6%	86.7%	96.0%	100.0%	97.7%	86.8%	83.6%	76.1%	72.6%
103 Leppington Stage 1-5 SWGA	10.2%	19.6%	25.8%	42.1%	59.5%	55.3%	47.5%	46.7%	39.8%	37.9%
104 Lismore Hospital redevelopment	1.2%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.0%	1.0%	1.0%
105 Liverpool health precinct	0.0%	0.0%	5.7%	4.5%	4.2%	4.0%	3.8%	3.7%	3.5%	3.4%
106 Lowes Creek Maryland SWGA	14.3%	24.5%	36.0%	73.8%	94.4%	100.0%	99.5%	93.2%	86.2%	82.9%
107 Macksville Hospital redevelopment	2.4%	2.4%	2.4%	2.4%	2.3%	2.2%	2.2%	2.2%	2.1%	2.0%
108 Marsden Park North NWGA	84.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	96.1%
109 Moree SAP	0.0%	14.2%	26.2%	27.7%	29.0%	30.2%	31.7%	33.1%	34.2%	33.1%
110 Mount Penang	0.0%	37.4%	54.9%	65.2%	72.1%	76.9%	80.7%	79.1%	76.4%	74.1%
111 Mudgee Hospital redevelopment	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
112 New Shellharbour Hospital	0.0%	0.0%	31.6%	22.1%	21.0%	20.3%	19.6%	18.9%	18.4%	17.6%
113 Oran Park SWGA	23.1%	60.4%	71.6%	73.2%	65.8%	59.1%	53.7%	56.1%	51.3%	49.5%
114 Pondicherry SWGA	71.3%	67.5%	76.6%	93.7%	100.0%	100.0%	100.0%	98.4%	91.9%	88.5%
115 Pyrmont Peninsula	0.7%	8.7%	16.0%	25.5%	32.0%	31.0%	30.1%	29.4%	28.6%	27.9%
116 RPA redevelopment	0.0%	0.0%	1.1%	1.1%	1.0%	1.0%	0.9%	0.9%	0.8%	0.8%
117 Randwick campus redevelopment	0.0%	4.2%	8.2%	7.9%	7.6%	7.2%	7.0%	6.8%	6.5%	6.2%
119 Riverstone East NWGA	11.2%	47.6%	59.9%	63.7%	69.0%	75.5%	76.1%	78.2%	74.0%	70.1%
120 Riverstone NWGA	23.4%	38.7%	50.9%	53.1%	56.0%	57.0%	56.1%	60.7%	57.8%	54.3%
121 Riverstone West NWGA	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
122 Rossmore SWGA	11.4%	24.6%	34.3%	42.7%	50.6%	75.0%	77.7%	71.8%	66.5%	64.0%

Project	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066
123 Schofields NWGA	16.8%	40.2%	54.3%	60.5%	62.7%	63.9%	62.7%	65.3%	61.9%	58.1%
124 Shanes Park NWGA	6.4%	20.2%	30.0%	39.7%	41.6%	41.6%	40.6%	42.8%	40.4%	38.1%
125 Shellharbour Civic Centre	1.7%	1.7%	1.7%	1.3%	1.3%	1.3%	1.2%	1.2%	1.1%	1.1%
126 Shoalhaven District hospital	0.0%	4.5%	8.4%	7.5%	7.2%	6.9%	6.7%	6.5%	6.3%	6.0%
127 Showground Station Precinct	0.0%	24.9%	38.5%	59.1%	57.1%	55.9%	54.9%	53.8%	52.5%	51.2%
128 South Coast Correctional Facility Expansion	45.4%	40.5%	41.0%	39.9%	40.2%	40.3%	40.4%	40.4%	40.0%	39.7%
129 South Creek West SWGA	6.2%	12.6%	18.4%	71.3%	92.9%	99.4%	98.3%	91.2%	84.6%	81.2%
130 South Jerrabomberra RJP	0.0%	0.0%	55.1%	76.5%	86.9%	93.8%	90.7%	87.6%	84.4%	80.8%
131 Sutherland hospital redevelopment	2.1%	5.8%	7.6%	7.6%	7.4%	7.1%	6.9%	6.7%	6.4%	6.1%
132 Tallawong Station NWGA	17.0%	44.8%	59.1%	63.5%	64.5%	65.6%	63.5%	66.3%	63.8%	59.2%
133 Tamworth Hospital redevelopment	0.2%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%
134 Toyota Site Caringbah	0.0%	31.4%	43.6%	54.3%	63.3%	61.0%	59.5%	58.1%	56.2%	55.4%
135 Turner Road SWGA	58.3%	62.1%	67.4%	68.9%	71.4%	64.8%	54.5%	51.3%	49.0%	46.6%
136 Tweed Valley hospital redevelopment	0.0%	1.9%	3.6%	3.2%	3.1%	3.0%	2.9%	2.8%	2.7%	2.6%
137 University of Wollongong Innovation Campus Fairy Meadow	0.0%	2.2%	4.2%	3.9%	3.8%	3.6%	3.5%	3.4%	3.3%	3.2%
138 Villawood Logistics Estate	3.6%	15.7%	14.6%	13.8%	13.1%	12.5%	12.1%	11.7%	11.4%	11.0%
139 Vineyard NWGA	5.8%	15.1%	21.5%	28.1%	30.1%	30.1%	30.5%	34.9%	32.4%	30.6%
140 WOW Customer Fulfilment Centre Auburn	0.0%	9.3%	9.1%	8.6%	8.0%	7.6%	7.3%	6.9%	6.8%	6.6%
141 WOW Distribution & Fulfilment centre	0.0%	11.4%	11.4%	10.8%	10.3%	9.9%	9.5%	9.2%	8.9%	8.7%
142 WOW Wetherill Park DC	0.0%	22.0%	22.1%	21.2%	20.6%	20.0%	19.6%	18.8%	18.2%	17.6%
143 WSA. 1. Aerotropolis Core	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
144 WSA. 2. Agriculture and Agribusiness	58.5%	51.9%	65.3%	69.0%	73.9%	76.1%	74.4%	71.1%	65.9%	63.3%
145 WSA. 3. Badgerys Creek	11.7%	23.4%	31.6%	35.9%	39.2%	37.0%	32.0%	31.9%	29.3%	28.0%
146 WSA. 4. Kemps Creek	9.6%	32.9%	49.9%	62.6%	73.5%	77.3%	78.7%	76.5%	71.6%	68.9%
147 WSA. 5. Mamre Road	8.3%	78.9%	95.6%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
148 WSA. 6. Northern Gateway	33.9%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
149 WSA. 7. Rossmore	0.0%	12.4%	23.9%	28.9%	30.0%	39.8%	41.4%	41.6%	35.9%	34.0%
150 WSA. 8. South Creek	0.0%	13.6%	45.6%	68.7%	90.2%	100.0%	100.0%	100.0%	100.0%	100.0%
151 WSA. 9. Twin Creeks	3.5%	8.5%	10.2%	11.4%	11.5%	12.2%	12.9%	13.7%	13.3%	12.9%

Project	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066
152 Wagga Wagga hospital redevelopment	0.7%	1.7%	2.2%	2.2%	2.1%	2.0%	2.0%	1.9%	1.8%	1.8%
153 West Schofields NWGA	9.8%	31.2%	44.4%	50.8%	52.8%	53.3%	52.1%	55.2%	52.5%	49.6%
154 Williamtown SAP - RAAF Base	36.2%	34.5%	37.9%	39.9%	40.1%	40.6%	41.2%	41.7%	39.6%	38.1%
155 Wyong Hospital redevelopment	0.0%	5.2%	9.9%	9.9%	9.4%	9.0%	8.7%	8.5%	8.1%	7.7%

Source: SGS Economics and Planning, 2022

12 Appendix B: Travel Zone Projections 2022: 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 2066. 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.

* - Data set to be recorded as a key data set in the TfNSW Data and Information Asset Register.
Source: TfNSW, '2022 Travel Zone Projections (TZP22) – Part 1: Model Overview and Results'.

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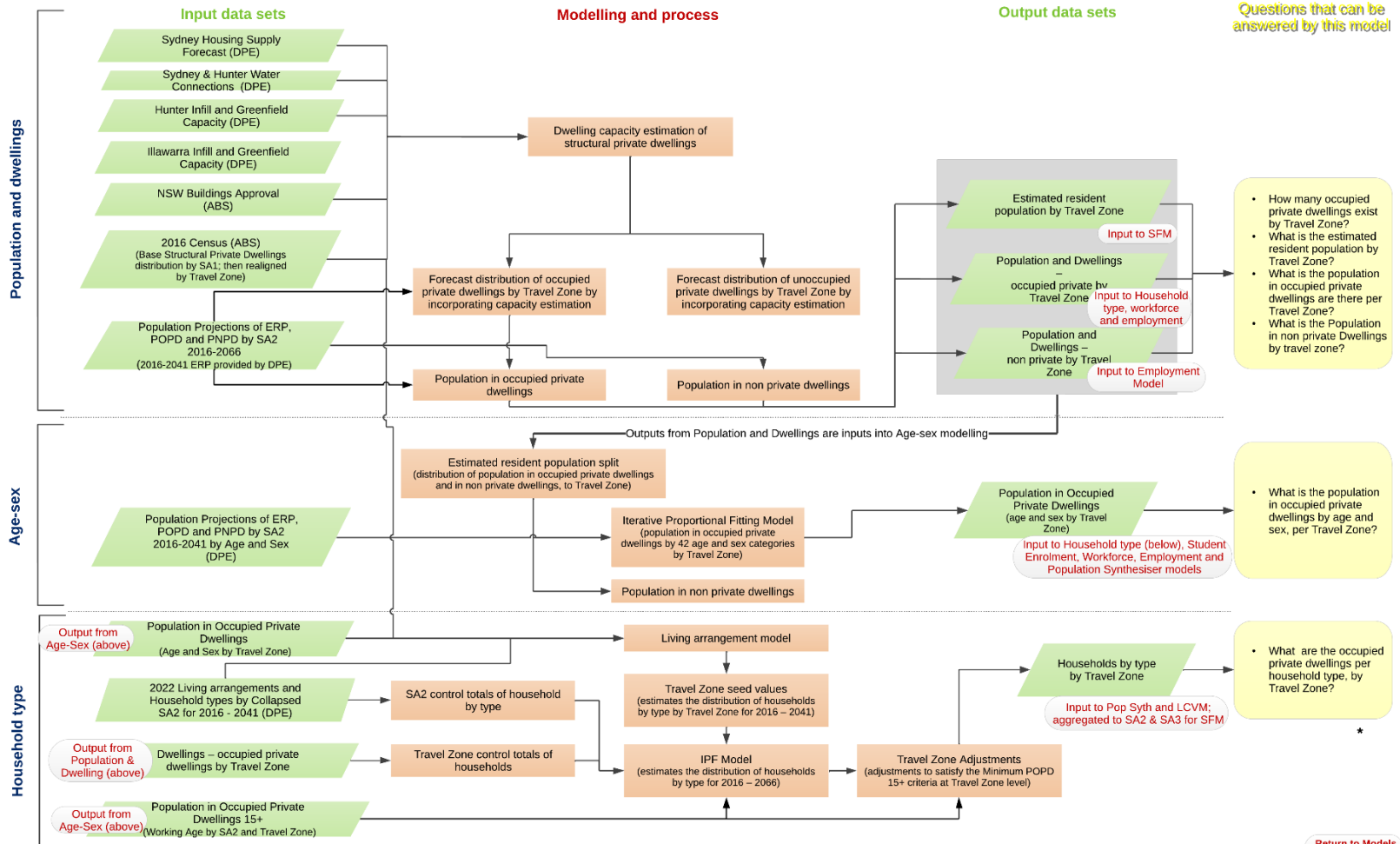
Student Enrolment Projections Model

Description: This model uses outputs from the Population & Dwelling Projections model (population in occupied private dwellings – 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 2066. 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

Questions that can be answered by this model

Output from STM
STM Highway skims
(travel time matrix)
(TPA-DAR-STM-0003)

ABS 2016 Census
(estimated resident population with current age and education status)
(TPA-DAR-ODSR-0013)

Output from Population & Dwelling
Population in occupied private dwellings
(age only by Travel Zone)
(TPA-DAR-ODSR-0011)

Enrolments at origin:
- Student attendance by primary, secondary and tertiary in NSW
- Primary and secondary ages 5-18; tertiary ages 18-64

ACARA enrolments 2021 (NSW current school enrolments by age and place of school / institution at Travel Zone)
(TPA-DAR-ODSR-0014)

Australian University enrolments 2021
(NSW Institutions; estimates of tertiary enrolments by destination; full time and part time split)
(TPA-DAR-ODSR-0015)

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

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)
(TPA-DAR-ODSR-0018)

Input to Pop Syth and STM

- 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)?

VET enrolments, TAFE and Private Training Providers 2021
(estimates of tertiary enrolments by destination; full time and part time split)
(TPA-DAR-ODSR-0016)

School Infrastructure Forecast
(NSW Student projections for Primary and Secondary Schools by place of enrollment, and new schools data.)
(TPA-DAR-ODSR-0017)

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

Distribution of enrolments (tertiary only):
- Estimates tertiary enrolments for the destination of students at both VET (TAFE and Private Training) 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)
(TPA-DAR-ODSR-0019)

Input to Pop Syth and STM

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

* - Data set to be recorded as a key data set in the TfNSW Data and Information Asset Register.
Source: TfNSW, '*2022 Travel Zone Projections (TZP22) – Part 1: Model Overview and Results*'.

Return to Models Overview

Workforce Projections Model

Description: This model uses outputs from the Population & Dwelling Projections Model to estimate various segmentations of the working age population at 3 geographic scales: NSW, SA4s and Travel Zones to 2066. The population is broken down by workforce status: Employed (a.k.a 'Workforce'), Unemployed and Not in the Labour Force (NiLF). Employed persons are disaggregated further 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** · **Questions that can be answered by this model**

Geography · **Workforce Status** · **Employment Status (full-time / part-time)** · **Income Bands**

State

NSW Treasury IGR Labour Force Projections (2016-2061)

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

Preparing the NSW Control Totals:
- Treasury Labour Force Projections are the sum of working population in occupied private dwellings (OPD) and non-private dwellings (NPD)
- The model requires State projections to equal to M02 POPD
- NPD is netted out of State LF controls
- Trend analysis undertaken for 2061 to 2066

State Part Time Rates:
- NSW Treasury provides total employment control totals, but this is not split by Full-Time and Part-Time workers
- ABS LFS for NSW is applied to employed workers, to split up the State Control totals into FT and PT

By SA4

Workforce starting distributions:
- Utilise NSW Treasury Data to produce State Workforce control totals
- Initialise model to create SA4 and TZ starting distributions (iLF_Emp, iLF_Unemp, NiLF)
- Estimate TZ starting distributions for next stage, and compute age-specific and income band propensities by TZ

Output from Population & Dwelling

Estimated Resident Population (age and sex by Travel Zone)

ABS 2016 Census (Cat. No. 6291.0.55.011 LM2, LM1, RM1 and ABS TableBuilder – labour force status and personal income (weekly) at the SA4 level)

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 14 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

(Divided into data sets below)

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

Input to Pop Syth and Employment

- What is the 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:
- 14 Income bands (based on 2016 Census; uses assumed long-term real income growth rate of 1.1% aligned to 2021 IGR, and median earnings of each income sub-band, to calculate shifts across bands)
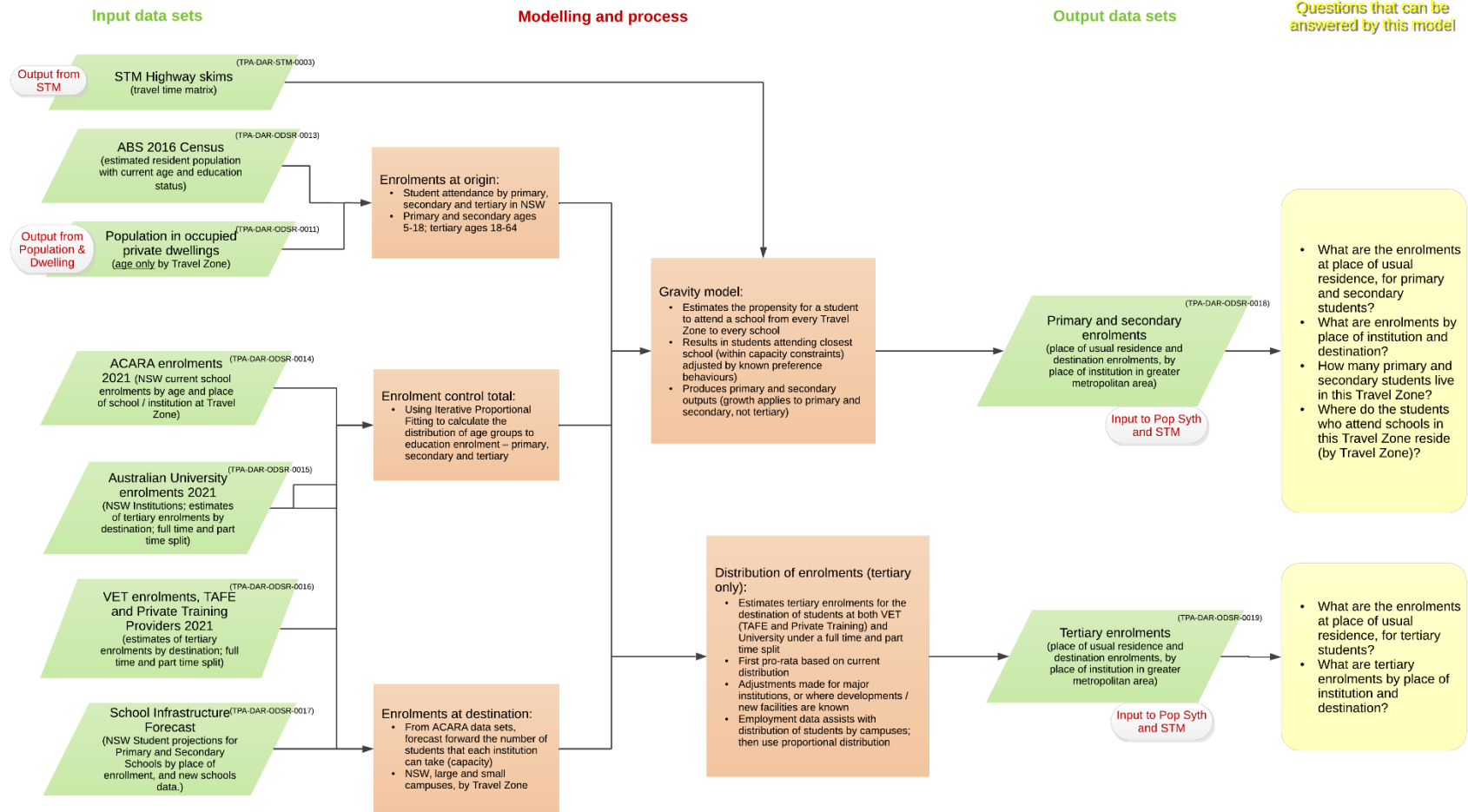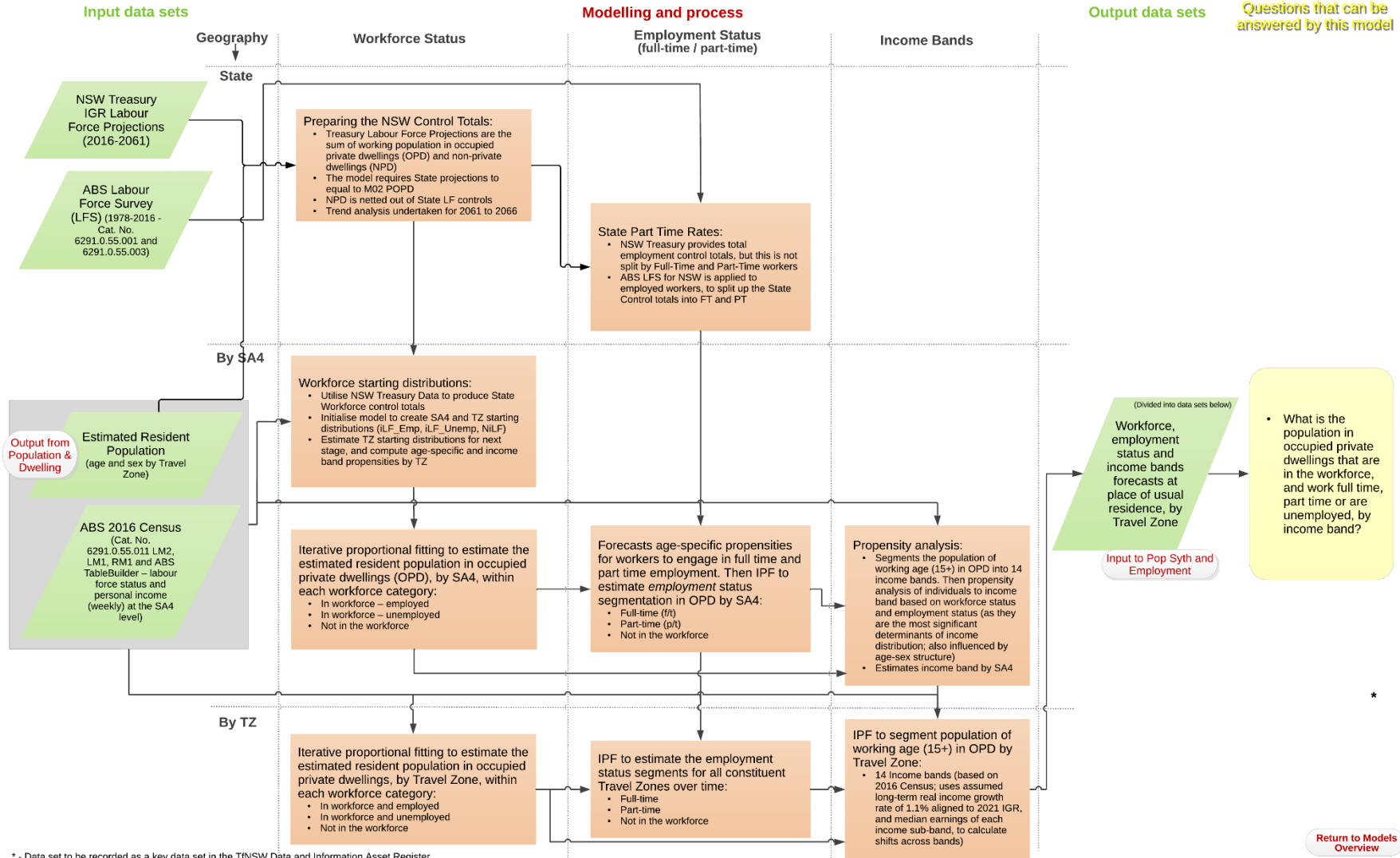
* - Data set to be recorded as a key data set in the TfNSW Data and Information Asset Register.
Source: TfNSW, '2022 Travel Zone Projections (TZP22) – Part 1: Model Overview and Results'.
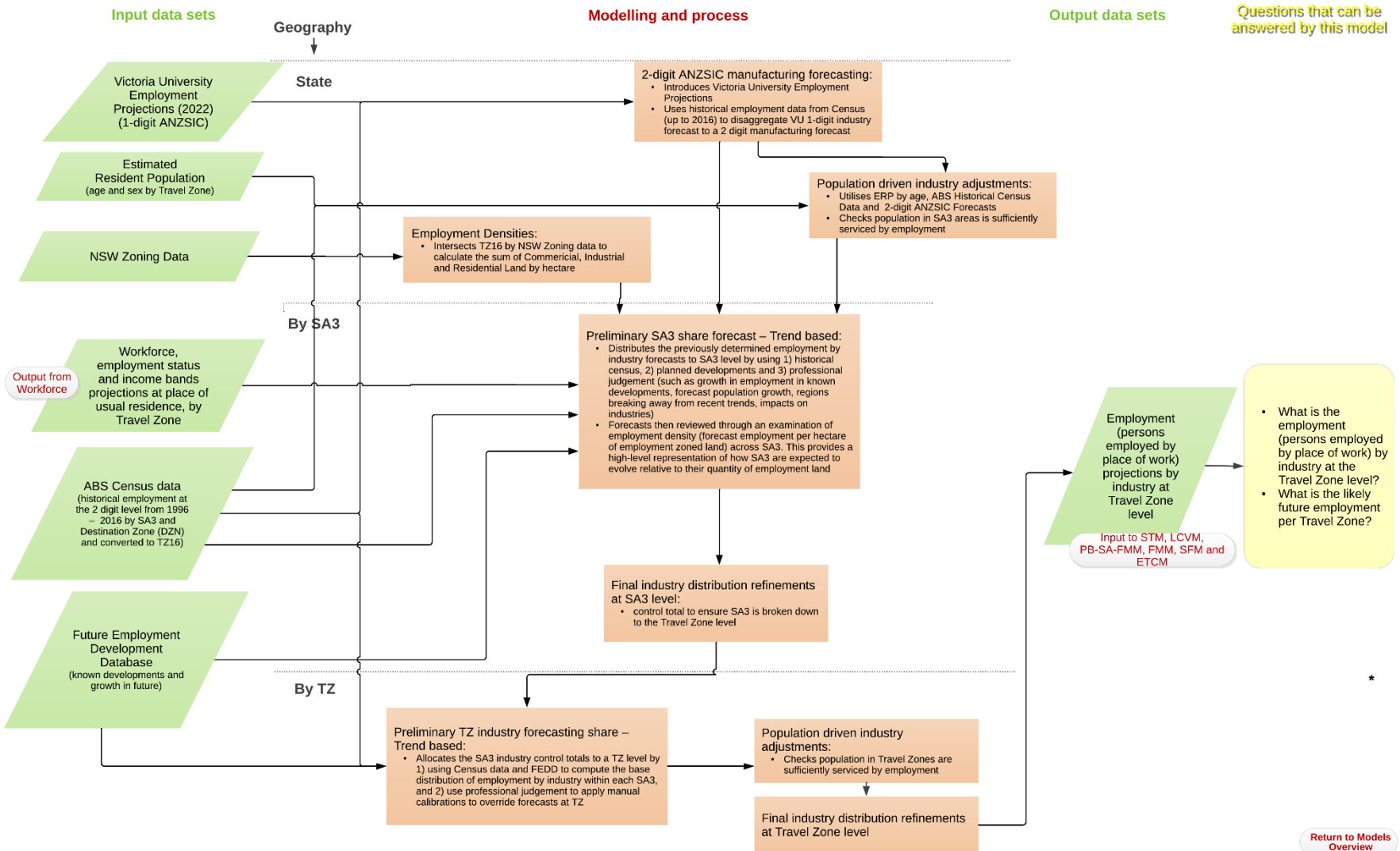
Return to Models Overview

Employment Projections Model

Description: This model is used to produce employment projections by industry, at the Travel Zone level to 2066. It has 2 major functions: 1) the total employment (persons employed by place of work) by industry is projected for the NSW, 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   Geography   **Modelling and process**   **Output data sets**   **Questions that can be answered by this model**

State

Victoria University Employment Projections (2022) (1-digit ANZSIC)

2-digit ANZSIC manufacturing forecasting:
- Introduces Victoria University Employment Projections
- Uses historical employment data from Census (up to 2016) to disaggregate VU 1-digit industry forecast to a 2 digit manufacturing forecast

Estimated Resident Population (age and sex by Travel Zone)

Population driven industry adjustments:
- Utilises ERP by age, ABS Historical Census Data and 2-digit ANZSIC Forecasts
- Checks population in SA3 areas is sufficiently serviced by employment

NSW Zoning Data

Employment Densities:
- Intersects TZ16 by NSW Zoning data to calculate the sum of Commericial, Industrial and Residential Land by hectare

By SA3

Output from Workforce

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

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 are 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

ABS Census data (historical employment at the 2 digit level from 1996 – 2016 by SA3 and Destination Zone (DZN) and converted to TZ16)

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

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

- 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?

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

Future Employment Development Database (known developments and growth in future)

By TZ

Preliminary TZ industry forecasting share – Trend based:
- Allocates the SA3 industry control totals to a TZ level by 1) using Census data and FEDD 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

*

* - Data set to be recorded as a key data set in the TfNSW Data and Information Asset Register.
Source: TfNSW, *'2022 Travel Zone Projections (TZP22) – Part 1: Model Overview and Results'*.

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13 Appendix C: Table of Assumptions

Module	Assumption
M01a - Capacity Estimation	SHSF data is assumed to have the highest degree of certainty - assigned to priority capacity
	Sydney and Hunter water connections data – assigned to priority capacity
	Hunter Infill and Greenfield capacity data – assigned to priority capacity
	Illawarra Infill and Greenfield capacity data – assigned to priority capacity
	ABS Building Approvals – assigned to priority capacity
	TZP19 is assumed to have a lower degree of certainty - assigned to secondary capacity
M01b - Dwelling Forecasting	Structural private dwellings aligned to SA2 control totals (prepared by TfNSW, using DPE data)
	Water connection data is assumed to be the latest available information on the Dwelling location.
	Occupied private dwellings aligned to SA2 control totals (prepared by TfNSW, using DPE data)
M01c - Population by Travel Zone	Persons in occupied private dwellings aligned to SA2 control totals (prepared by TfNSW, using DPE data)
	Within an LGA, relative differences in travel zone household sizes are based on SA1 geography (prepared by TfNSW, using census data)
M01d - Travel Zone Adjustments	The data in selected travel zones were smoothed to reflect local trends.
M02a - Age by Gender Base Distribution	SA1 Census data is used to inform the base distribution of POPD by age by gender at travel zone level.
	Due to the randomisation of small numbers in census data, travel zones with a base estimate below 20 POPD in any category are assigned the distribution of its encompassing SA2. This is particularly relevant for future growth zones, which have no historical data available.
M02b - Age by Gender	The base year to run the IPF is 2016.
	To ensure that PNPD does not influence the IPF results (i.e. POPD by age by gender), travel zones with an ERP/OPD ratio less than 50% are assigned a seed distribution equal to the encompassing SA2.
	For each future year, the IPF procedure uses the age-gender results of the previous period as the seed distribution.
	Future growth Travel Zones (which have no historical age-sex distribution) are assumed to have a starting distribution that mirrors the distribution of the overarching SA2.
M02c - Module Outputs and Summaries	None

M03a - Living Arrangement Propensities	To convert the POPD projections by age and living arrangement to POPD projections by age and household type, the number of persons in each household type is calculated by summing up one or more living arrangement types.
M03b - Calculating seed values	Only persons of age 15+ are considered in the Household by Type categories. This is a simplifying assumption to remove the need for additional assumptions, such as needing to know the average number of children per household for each category.
	Future growth Travel Zones (which have no historical age-sex distribution) are assumed to have a starting distribution that mirrors the distribution of the overarching SA2.
M03c - IPF	The base year to run the IPF is 2016.
	Minimum household sizes used to calculate SA2 Minimum POPD 15+ are as follows: Couples with children - 2.0, Couples only – 2.0, Single parent – 1.0, Single person – 1.0, Other – 2.0.
	The DPE SA2 households by household type projections up to and including 2041 will satisfy the SA2 Minimum POPD 15+ criteria.
	The SA2 households by household type projections by type are extended to 2066 by assuming the SA2 distribution of household types remains fixed from 2041, with some adjustments to satisfy the SA2 Minimum POPD 15+ criteria.
	The smallest adjustment possible is made to satisfy the SA2 Minimum POPD 15+ criteria. That is, POPD 15+ will equal Minimum POPD 15+ for any SA2s needing adjustment for the relevant years.
	Linear growth is assumed first, and then the IPF is run.
M03d - Travel Zone Adjustments	Minimum household sizes used to calculate TZ16 Minimum POPD 15+ are as follows: Couples with children - 2.0, Couples only – 2.0, Single parent – 1.0, Single person – 1.0, Other – 2.0.
	The changes in this module entirely are contained within SA2 geographies (to ensure DPE SA2 control totals are met) independent of other areas and are output via intra travel zone shifts within the higher geography (SA2).
	For any adjustments made, the smallest adjustment possible is used to satisfy the TZ16 Minimum POPD 15+ criteria. That is, POPD 15+ will equal Minimum POPD 15+ for any travel zones needing adjustment for the relevant years.
M03e - Module Outputs	None
M04a_1 - School Data Analysis	School Infrastructure and ACARA school enrolment forecast concorded to TZ16.
M04a_2 - Age Control Totals	The single age distribution derived from the 2016 Census data is applied to the population forecast by 5-year age groups to obtain the school age groups.
M04b - Enrolment Control Totals	The 2016 Census age by education attendance is as seed values into the IPF to obtain enrolment control totals by institution type.

M04c - Enrolments at Origin	The 2016 distribution of school attendance is applied to the age group forecast from 2016-2066.
	Where there is no base data input in the initial distribution of persons, the regional distribution is applied. This accounts for growth areas where there is no precedent of population.
	SA1 Census data is used to inform the base distribution of POPD by schooling age at travel zone level.
	The base year to run the IPF is 2016.
	For each future year, the IPF procedure uses the household results of the previous period as the seed distribution.
M04d - Enrolments at Destination	School capacity for primary schools is assumed to be 1,000 persons and secondary students are assumed to be 2,000.
M04e - Final School Enrolments	The capacity of the secondary schools adjusted in future years to assist the model run.
	2016 travel times are used for future years implying there are no improvements to school access in the future.
M04f - Tertiary Enrolments	The spatial distribution of tertiary students across the State is assumed to remain consistent across the forecast. This does not account for any future institutions.
M05a – State Part-Time Rate	NSW Treasury Labour Force Totals provide State level control totals. Consequently, only an overall part-time rate for the State was required. The upper limit for part-time rate across New South Wales is considered to be 50%.
M05b/c/d - Starting Distributions and Labour Force Status/Time IPF	NSW Treasury State Labour Force Control Totals (Emp + Unemp + NiLF) slightly proportioned to align with M02 POPD.
	SA1 Census data is used to inform base distribution for all labour force segments at travel zone level.
	Due to the randomisation of small numbers in census data, travel zones with a base estimate below 20 POPD in any category are assigned the distribution of its SA2. This is particularly relevant for future growth zones, which have no historical data available.
	For each future year, the IPF procedure uses the labour force status results of the previous period as the seed distribution.
M05e - Income Segmentation	Due to the randomisation of small numbers in census data, travel zones with a base estimate below 20 POPD in any income category are assigned the distribution of its encompassing 'SA2'. This is particularly relevant for future growth zones, which have no historical data available.
	Assumed real income growth rate of 1.1%. This is the compound average growth rate in real GSP per capita from the 2021 NSW IGR.
	For each future year, the IPF procedure uses the labour force status results of the previous period as the seed distribution.

M06a – 2-digit Industry Forecasting	ANZSIC categories were maintained at their employment shares prior to 2006 and then interpolated between Census periods between 2006 and 2016.
M06b – Population Serving Employment Ratios	For six population servicing industries, a maximum ERP/Emp ratio (growth) is specified. These are estimated in M06b, and the resulting limits are as follows: - Construction: 39.1 - Retail Trade: 32.1 - Accommodation and Food Services: 143.7 - Rental, Hiring and Real Estate Services: 535.9 - Education and Training: 39.8 - Health Care and Social Assistance: 32.8
M06d – SA3 Industry Forecasting	SA3 industry control totals are adjusted to blend together the census base projections for each industry with employment numbers estimated for the FEDD at an SA3 level. Not all FEDD jobs could be filled for each SA3 before affecting the trends of other SA3s.
	SA3 employment totals were also adjusted to ensure that they aligned with population growth trends. As such, manual adjustments were required to ensure that declines in population saw an appropriate decline in employment. This is most notable in regional SA3s.
M06e - TZ Industry Forecasting	In the absence of additional information, travel zone employment shares (of their encompassing SA3) are assumed to remain the same as the base year (i.e., 2016)
	All travel zone assumptions contained within the Future Employment Developments Database are supplied by SGS

14 Appendix D: Output Files

14.1 Data Source of Output Files

File name	Source module	Excel sheet/notes
1.1 Structural Private Dwellings_TZ.csv	M01b	SPD Forecast
1.2 Occupied Private Dwellings_TZ.csv	M01d	OPD Forecast
1.3 Population Occupied Private Dwellings_TZ.csv	M01d	POPD Forecast
1.4 Population Non Private Dwellings_TZ.csv	M01d	PNPD Forecast
1.5 Estimated Resident Population_TZ	M01d	ERP Forecast
1.6 Estimated Resident Population_SA3	M01d	ERP_SA3
1.7 Population Non Private Dwellings_SA3	M01d	PNPD_SA3
2.1 Age by Sex 5 Year Age Groups (0-100) _TZ.csv	M02c	R Automatically generated
2.2 Age Groups (15-64+) _TZ.csv	M02c	R Automatically generated
2.3 Age by Sex 5 Year Age Groups (15-64+) _SA4.csv	M02c	R Automatically generated
3.1 Household Type_TZ.csv	M03e	R Automatically generated
3.2 Adjusted SA2 Household Type.csv	M03e	R Automatically generated
4.1 Primary and Secondary School students PUR_TZ.csv	M04c	Summary_P&S_OUTPUT
4.2 Primary and Secondary School students POI_TZ.csv	M04d_2	Final Output
4.3 Tertiary Students PUR_TZ.csv	M04c	Summary_T_Output
4.4 Tertiary Students POI_TZ.csv	M04f	Output_FINAL
5.1 Labour Force_TZ16.csv	M05c	TZ16 IPF Output
5.2 Labour Force Part Time Full Time_SA4.csv	M05d	SA4 IPF Output
5.3 Labour Force Part Time Full Time_TZ16.csv	M05d	TZ16 IPF Output
5.4 Labour Force Income Segmentation_TZ16.csv	M05e	TZ16 IPF Output
6.1 Employment SA3 Forecast.csv	M06d	Employment forecast
6.2 Employment TZ Forecast.csv	M06e	Employment forecast

15 Appendix E: Employment Allocation Model

15.1 Employment Allocation Model

A Journey to Work (JTW) dataset is used to provide the basis for small area employment projections in TZP22. The dataset allocates employment data using ABS Census 2016 obtained at a Destination Zone (DZN) level to Travel Zones (TZ). It was created by SGS Economics and Planning as part of TZP16 v1.51 for Transport for NSW.

Due to issues inherent in census data such as undercount or poor self-reporting accuracy, the JTW data is recalibrated to align with the Labour Force Survey (adjusted to reflect Place of Work (POW) rather than Place of Usual Residence (PUR) at a State level).

The following information provides a brief description of the methodology used to convert DZN data to TZ data, as found in the JTW dataset.

15.2 Building the conversion tables

To obtain the estimated number of jobs within a TZ, estimates are initially prepared at the ABS mesh block level which is a smaller geography than TZ. Mesh blocks usually align with the TZ geography and are designed by the ABS to represent a small area of relative demographic homogeneity.

Where a TZ and Mesh Block boundary aligns, TZs are a summation of, of the constituent mesh blocks. Where ABS mesh blocks do not align exactly with travel zones, the spatial area within mesh blocks overlapping with travel zones is used to estimate the size of the travel zone.

The ABS publishes estimates of the count of dwellings at the mesh block level (ABS 2074.0), Employment estimates, however, are more complex, as this data is not available. To obtain these estimates of employment at a Travel Zone level, it is necessary to build a model that utilises Mesh Block land use categories, in combination with employment by ANZSIC category and occupation (i.e., DZN data).

The allocation process involves separating jobs according to ANZSIC category and Occupation (Blue Collar, White Collar – Low Skilled, White Collar – High Skilled).

These jobs are then allocated to Mesh Blocks within the DZN according to their associated land use category (i.e., Residential, Parkland, Commercial, Primary Production, Industrial, etc.).

The process involves a "50/30/20" hierarchical split, as detailed in Table 16. 50% of jobs are allocated to the first set of Mesh Block Categories, the following 30% of jobs are allocated to the second set and the final 20% are allocated to the final set.

A process is then undertaken to identify yes or no if that Category and Occupation are to be associated with the respective mesh block category (through a 1 or 0 identifier as shown in Table 16. Once this mesh block allocation is complete, a mesh block to TZ concordance then creates employment at a TZ level.

Example: 50% of Blue Collar Jobs in Example Industry #2 are allocated to Industrial Mesh Blocks. The next 30% are distributed across Industrial Mesh Blocks a second time. The final 20% is allocated evenly across Mesh Blocks with Commercial, Industrial Agricultural and Other land use categories.

Table 16: Example of employment allocation model (example industry)

	Example Industry #1			Example Industry #2		
	Blue Collar	White Collar (Low Skilled)	White Collar (High Skilled)	Blue Collar	White Collar (Low Skilled)	White Collar (High Skilled)
1st Allocation	50%	50%	50%	50%	50%	50%
Residential						
Commercial		1	1		1	1
Industrial	1	0		1	0	
Education		0			0	
Hospital/Medical		0			0	
Agricultural		0			0	
Transport		0			0	
Parkland		0			0	
Water		0			0	
Other		0			0	
2nd Allocation	30%	30%	30%	30%	30%	30%
Residential	1	1	1		0	
Commercial	1	1	1		1	1
Industrial	1	1	1	1	0	
Education	1	0			0	
Hospital/Medical	1	0			0	
Agricultural	1	0	0		0	
Transport	1	0			0	
Parkland		0			0	
Water		0			0	
Other		0			0	
3rd Allocation	20%	20%	20%	20%	20%	20%

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Category						
Residential	1	1	1		0	
Commercial	1	1	1	1	1	1
Industrial	1	1	1	1	1	1
Education	1	1	1		0	
Hospital/Medical	1	1	1		0	
Agricultural	1	1	1	1	1	1
Transport	1	0			0	
Parkland		0			0	
Water		0			0	
Other	1	1	1	1	1	1

Source: SGS Economics and Planning, 2022

16 Appendix F: Important notes for TZP22 users

16.1 TZP22 Data sets and information

TZP22 output datasets are available from the [TfNSW Open Data Hub](#). To download data, users will need to register and create an account. The data is available in CSV or MS Excel format. The MS Excel files contain additional notes and cautions.

The spatial file Travel Zone 2016 Geography are also available from the Open Data Hub.

A data visualisation is available on the [TfNSW Corporate Website](#).

An issues register is kept for TZP22 to capture issues found in the TZP dataset or to flag new information that could be used for future versions of the projections. To flag items please contact the Place Forecasting team at TfNSW using model.selection@transport.nsw.gov.au - Attention Place Forecasting.

16.2 Cautions and notes for TZP22 users

16.2.1 Considerations

TZP provide a long-term view of the future aligned with the NSW Government's Common Planning Assumptions (CPA) population and employment projections.

- The projections are developed to support a strategic view of NSW and are calibrated as an input into TfNSW travel models, including the Strategic Travel Model (STM).
- The TZP projections are not based on specific assumptions about future new transport infrastructure, but do take into account known land-use developments underway or planned, and strategic plans.
- The projections present a small area geography, long-term view of the future patterns of population, dwellings, workforce and employment across NSW.

- The projections rely on best available information from early-mid 2022. Caution is recommended as they are forward looking estimates only and not meant to be absolute forecasts of population and employment for NSW.

- The projections do not incorporate results of the National Census conducted by the ABS in 2021, as the required information was not available at the time of production of the projections.

- The projections are not government targets.

16.2.2 Limitations and cautions

Travel Zone Projections are a strategic state-wide dataset and caution should be exercised when considering results at detailed breakdowns.
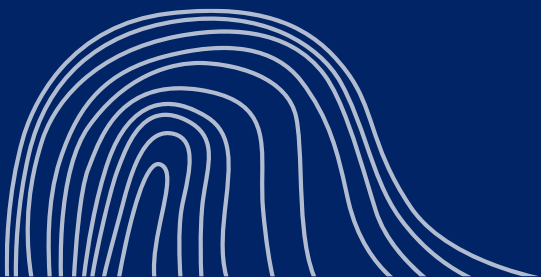
- The TZP22 outputs represent a point in time set of projections.

- Travel Zone (TZ) level outputs are projections only and should be used as a guide.

- As a general rule, TZ level projections are illustrative of a possible future only.

- A high degree of caution should be exercised when using the TZP dataset at more detailed

levels. Results for an individual TZ should not be considered accurate, even in base or historic years, as source data is generally not available at this geographic extent. Instead, estimates have been derived using rules to disaggregate source data from larger geographic areas down to this level. As with all small area data, aggregation of travel zone projections to higher geographies leads to more robust results.

- Users should further note that comprehensive analysis of individual sites or precincts has not been undertaken in the development of TZP.

- Employment estimates in the base year (2016) may not align with published ABS Census results as they are adjusted for Census undercount and in some cases to correct known issues with ABS small area employment data (e.g. misallocation of data to incorrect DZNs).

16.2.3   Alignment to the 2022 Common Planning Assumptions

- TZP22 Estimated Resident Population (ERP) outputs align with DPE's ERP control totals for the State and SA2.

- Population in Occupied Private Dwellings (POPD) and Population in Non Private Dwellings (PNPD) added together in TZP22 align with DPE's ERP at the SA2 level.

- More detailed breakdowns of the population dataset, such as by age and sex may not align perfectly due to minor differences in modelling approach and the use of spatial concordances.

- TZP22 projections for Occupied Private Dwellings vary from DPE's Implied Dwellings projections because they are different measures of dwellings.

- An assessment of the reliability of the TZP data has been completed, with a view to inform the best way to use it.