Appendix III –The Tasmanian Small Area Population Projections (ABS)

Text provided by the Australian Bureau of Statistics

Tasmania Small Area Population Projections

This appendix outlines the process used for producing population and enrolment projections for all Statistical Area 1s (SA1s) in Tasmania, from June 2015 to June 2021.

Projection Method

The method employed for projecting the population down to Statistical Area 2 (SA2) level was the cohort-component method, widely accepted as the best way of producing age/sex population projections. It involved applying annual fertility and mortality rates and internal migration and overseas migration by age and sex to the base population to produce a projected population, which then became the base population for projecting the next year and so on. This cycle was repeated until the projection horizon was reached.

The following four-tiered process was taken in projecting the resident population aged 18 years and over for all SA1s in Tasmania:

1. State Projections. The Tasmania population was projected by age and sex.
2. Capital City / Rest of State Projections. The Hobart and the Rest of Tasmania populations were projected by age and sex (and constrained to 1).
3. Statistical Area 2 Projections. The population of all Tasmania's SA2s was projected by age and sex (and constrained to 2) and a subset of those over 18 was extracted.
4. Statistical Area 1 Projections. The SA2 projected population aged 18 and over (in 3) was split into SA1s.

Finally, the SA1 projected population aged 18 and over was combined with enrolment data to produce projected enrolments.

1. State Projections

The base population for the Tasmania cohort-component projections was preliminary age/sex Estimated Resident Population (ERP) as at 30 June 2015,. Assumptions for the projections were based on both short and long-term trends for each component of population change. These fertility, mortality, overseas migration and interstate migration assumptions were based on those used in the latest *Population Projections, Australia, 2012 (base) -2101* (ABS Cat. No. 3222.0), but adjusted to reflect more recently available data. All States and Territories were independently projected, then constrained to sum to the Australian-level projection.

2. Capital City/Rest of State Projections

As per the State/Territory level, the capital city and rest of state projections used assumptions updated from the *Population Projections* publication. 30 June 2015 ERP base population was used, with assumptions reflecting historically observed region-specific patterns of fertility, mortality, overseas migration and internal migration. The Tasmania projections acted as control totals.

3. Statistical Area 2 Projections

The base population for the SA2 cohort-component projections was also 30 June 2015 SA2 age/sex ERP. The fertility, mortality and migration assumptions were based on SA2-specific levels observed during the past five years, constrained to the assumed capital city/rest of state levels and trends. SA2 age/sex migration profiles were derived from 2011 Census data on place of usual residence one year ago, with migration levels based on recent growth rate and proportion of Capital City/Balance of State migration.

The ABS regularly collects demographic information down to the SA2 level, which means that SA2 projections (in contrast to smaller areas) are firmly based on a series of known data. At each yearly cycle in this process, the resulting SA2 projections were constrained to sum to the capital city/rest of state projections, helping to produce more reliable SA2 figures. SA2s with an ERP of less than 1,000 persons were generally held constant for the projection duration as assumptions for the accompanying tiny age/sex cells are too unreliable.

From the resultant 30 June SA2 projections, the projected population aged 18 and over was derived by sub setting the total population for each SA2.

4. Statistical Area 1 Projections

SA1 projected population aged 18 and over were calculated by extrapolation using 2011-2015 SA1 ERP.

SA1 projections were formed using extrapolations from 2011-2015 SA1 ERP constrained to the SA2 projections. Projected population aged 18 at 31 March 2021 was derived by interpolation using the 30 June projections.

Following the above four-tiered process the projected enrolments (for SA1s) are calculated using the 30 September 2016 relationship between each SA1's enrolments and its ERP (see Appendix III).

The lack of demographic data collected regularly at SA1 level makes it necessary to use the conversion method as outlined above. While the process is quite complex, it should be reiterated that the basic concept of splitting SA2s to SA1 level cannot be expected to give projections as reliable as those for SA2s. However, as the goal is to support the redrawing of State Electoral Division boundaries which are aggregates of large numbers of SA1s there is a high likelihood that any random errors or inconsistencies will be statistically offset in the aggregation process.

Boundaries

Previous redistributions have used Census Collection Districts (CCDs) as the base unit, however in 2011 CCDs were superseded by the new SA1 unit.

SA1 and SA2 boundaries are from the *Australian Statistical Geography Standard (ASGS) Volume 1 – Main Structure and Greater Capital City Statistical Areas, July 2011* (ABS Cat. 1270.0.55.001) corresponding to those used for the 2011 Census.

Disclaimer

It is important to recognise that the projection results given in this report reflect the assumptions made about future fertility, mortality and migration trends. While these assumptions are formulated on the basis of an objective assessment of historical demographic trends and their likely future dynamics, there can be no certainty that they will be realised.

The ABS takes responsibility for the method employed, however in accordance with ABS policy regarding small area population projections, the assumptions used are the final responsibility of the client, and the projections are not official ABS population statistics.

The projections may be referred to as "...projections prepared by the ABS according to assumptions reflecting prevailing trends agreed to by the Tasmanian Electoral Commission...".

No liability will be accepted by the ABS for any damages arising from decisions or actions based upon this population projection consultancy service.

Appendix IV – Projection methods for the Tasmania, Capital City/Balance of State, Statistical

Text provided by the Australian Bureau of Statistics

This appendix gives a more detailed breakdown of the four-tiered process outlined in Appendix III. Apart from the births formulae all equations apply to both sexes, so sex has not been denoted. "State" and "state-level" may refer to either State or Territory.

Step 1 - State Projections

This involved projecting the Tasmania population by age and sex at 30 June 2015 out to 30 June 2021.

The cohort component method used can be summarised in the formulae below:

where:

x	->	age
max	->	highest age projected (100+ for state; 85+ for sub-state)
t	->	base year
P	->	population
F	->	fertility rate
f	->	females
B	->	births
Q	->	death probability
OM	->	net overseas migration
IM	->	net interstate (or internal) migration
NM	->	net migration (SA2 projections only)

In Step 1 the following refer to interstate migration; in step 2 they refer to internal migration; and in step 3 they refer to total (overseas + inter-SA2 migration).

DEP	->	departures
ARR	->	arrivals
DEPRATE	->	per capita departure rate (donor state *or* capital city-rest *or* SA2)
ARRRATE	->	per capita arrival rate (receiving states)

For ages 0 to maximum age - 1:

(i) $$P_{x+1}(t+1) = P_x(t) * [1-Q_x(t)] + (0.5 * OM_x(t)) * (1-(0.5 * Q_x(t))) + (0.5 * OM_{x+1}(t)) * (1-(0.5 * Q_{x+1}(t)))$$

(ii) $$P_{max}(t+1) = P_{max}(t) * [1-Q_{max}(t)] + P_{max-1}(t) * [1-Q_{max-1}(t)] + OM_{max}(t) * (1-(0.5 * Q_{max}(t))) + (0.5 * OM_{max-1}(t)) * (1-(0.5 * Q_{max-1}(t)))$$

Births were then calculated:

(iii) $$B(t) = 0.5*[\sum_{x=15}^{49} (F_x(t)*P_{f,x}(t)) + \sum_{x=15}^{49} (F_x(t+1)*P_{f,x}(t+1))]$$

After constraining to projected Australian-level births, these were then used to calculate age 0 in the projected year:

(iv) $$P_0(t+1) = B(t)*(1-Q_b(t)) + (0.5*OM_0(t)) * (1-(0.5*Q_0(t)))$$

Interstate migration was calculated by applying departure rates to the Tasmania population and arrival rates to the population of the remaining States and Territories (to obtain numbers departing other States to reside in Tasmania). These rates were based on the assumptions published in *Population Projections, Australia, 2012 (base) to 2101* (ABS Cat. No. 3222.0).

(v) $$DEP_x(t+1) = P_x(t+1) * DEPRATE_x$$

(vi) $$ARR_x(t+1) = P_x(t+1)^{\text{Non-Tas}} * ARRRATE_x$$

The resulting total arrivals and departures were then scaled to a predetermined total net interstate migration assumption. Finally, the arrivals and departures by age and sex were scaled to the new arrival and departure totals, and then combined to give net age/sex interstate migration.

(vii) $$IM_x(t+1) = ARR_x(t+1) - DEP_x(t+1)$$

Then add the interstate migration:

(viii) $$P_x(t+1) = P_x(t+1) + IM_x(t+1)$$

To achieve coherent interstate migration figures, projections are concurrently run for all States, Territories and Australia. After constraining the State age/sex population to the Australian-level (method described in Step 2), year t+1 then became the base for projecting the next year and the cycle was repeated until the final projection year was reached.

Step 2 - Hobart / Rest of Tasmania Projections

This employs the cohort component method to project the Hobart Greater Capital City Statistical Area and the Rest of Tasmania. The formulae in Step 1 generally apply to these projections, except that the upper age is 85+, fertility rates are by 5yr age of mother and migration arrival levels are used instead of rates.

For ages 0 to maximum age - 1:

(ix) $$P_{x+1}(t+1) = P_x(t) * [1-Q_x(t)] + (0.5 * OM_x(t)) * (1-(0.5 * Q_x(t))) + (0.5 * OM_{x+1}(t)) * (1-(0.5 * Q_{x+1}(t)))$$

(x) $$P_{max}(t+1) = P_{max}(t) * [1-Q_{max}(t)] + P_{max-1}(t) * [1-Q_{max-1}(t)] + OM_{max}(t) * (1-(0.5 * Q_{max}(t))) + (0.5 * OM_{max-1}(t)) * (1-(0.5 * Q_{max-1}(t)))$$

Births were then calculated:

(xi) $$B(t) = 0.5*[\sum_{x=15-19}^{45-49} (F_x(t)*P_{f,x}(t)) + \sum_{x=15-19}^{45-49} (F_x(t+1)*P_{f,x}(t+1))]$$

After constraining to projected State-level births, these were then used to calculate age 0 in the projected year:

(xii) $$P_0(t+1)= B(t)*(1-Q_b(t)) + (0.5*OM_0(t)) * (1-(0.5*Q_0(t)))$$

Capital city-Rest of state internal migration departures were calculated by applying 2011 Census-derived departure rates to the population:

(xiii) $$DEP_x(t+1) = P_x(t+1) * DEPRATE_x$$

Total capital city-Rest of state internal arrivals were then derived using the pre-set net migration assumptions:

(xiv) $$ARR(t+1) = NM(t+1) - \sum_{x=0}^{x=max} DEP_x(t+1)$$

(xv) The assumed age-specific arrival levels were derived from 2011 Census data. Together with departures from (xiii) these were simultaneously constrained (via IPF - see xvii - xix) to:

(a) Capital city-Rest of state arrival and departure totals

(b) State age-specific net migration

Then the arrivals and departures were applied to the population projected so far:

(xvi) $P_x(t+1) = P_x(t+1) + ARR_x(t+1) - DEP_x(t+1)$

Year t+1 then became the base for projecting the next year and the cycle was repeated until the final projection year was reached. However, before $P_x(t+1)$ became the new base, the projected capital city-rest of state were constrained to sum to the State projection. This involved a final 2-way iterative proportional fitting (IPF) process; the year is t+1:

where:

CC-Bal	->	Capital City or Rest of State *region*
S	->	Tasmania
a	->	first region
z	->	last region
r	->	region number

Scale the regional (capital city-rest of state) totals to the State total:

$$(xvii) \quad {}^{P}CC\text{-}Bal = {}^{P}CC\text{-}Bal * ({}^{P}S \Big/ \sum_{r=a}^{r=z} {}_{P_r}CC\text{-}Bal)$$

For each region scale ages to sum to the new region total:

$$(xviii) \quad {}_{P_x}CC\text{-}Bal = {}_{P_x}CC\text{-}Bal * ({}^{P}CC\text{-}Bal \Big/ \sum_{x=0}^{x=max} {}_{P_{xr}}CC\text{-}Bal)$$

For each age, scale both regions to sum to the State total:

$$(xix) \quad {}_{P_x}CC\text{-}Bal = {}_{P_x}CC\text{-}Bal * ({}_{P_x}S \Big/ \sum_{r=a}^{r=z} {}_{P_{xr}}CC\text{-}Bal)$$

Stages (xviii) and (xix) were then iterated several times before the resulting matrix was rounded while not changing the marginal constraints.

Step 3 – Statistical Area 2 Projections

This used the cohort component method to project all Tasmania SA2s. The formulae in Step 1 generally apply to the SA2 projections, except that the upper age is 85+, fertility rates are by 5yr age of mother, migration arrival rates were not used and Net Migration (overseas + inter-SA2) was used instead of overseas and inter-SA2 separately.

This slightly simpler approach to migration was warranted as the overseas component is negligible in most SA2s in comparison with inter-SA2 migration. Furthermore as an annual historical time-series only exists at the SA2 level for *net* migration, any overseas/inter-SA2 split can only be approximated using past Census data.

For ages 0 to maximum age - 1:

(xx) $P_{x+1}(t+1) = P_x(t) * [1-Q_x(t)]$

(xxi) $P_{max}(t+1) = P_{max}(t) * [1-Q_{max}(t)] + P_{max-1}(t) * [1-Q_{max-1}(t)]$

Births were then calculated:

(xxii) $$B(t) = 0.5*[\sum_{x=15-19}^{45-49}(F_x(t)*P_{f,x}(t)) + \sum_{x=15-19}^{45-49}(F_x(t+1) * P_{f,x}(t+1))]$$

After constraining to projected capital city/rest of state births, these were then used to calculate age 0 in the projected year:

(xxiii) $P_0(t+1) = B(t) * (1-Q_b(t))$

SA2 migration departures were calculated by applying 2011 Census-derived departure rates to the population:

(xxiv) $DEP_x(t+1) = P_x(t+1) * DEPRATE_x$

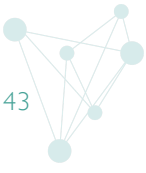
Total SA2 arrivals were then derived using the pre-set net migration assumptions:

(xxv) $$ARR(t+1) = NM(t+1) - \sum_{x=0}^{x=max} DEPx(t+1)$$

(xxvi) The assumed age-specific arrival levels were derived from 2011 Census data. Together with departures from (xxiv) these were simultaneously constrained (via IPF - see xvii - xix) to:

(a) SA2 arrival and departure totals (from the previous 2 steps)

(b) Capital city/rest of state age-specific net internal migration



Then the arrivals and departures were applied to the population projected so far:

(xxvii) $P_X(t+1) = P_X(t+1) + ARR_X(t+1) - DEP_X(t+1)$

After constraining the SA2 age/sex populations to sum to the capital city/rest of state projections using iterative proportional fitting (method described in Step 2), year t+1 then became the base for projecting the next year and the cycle was repeated until the projection horizon was reached.

Step 4 – Statistical Area 1 Projections

This involved splitting the completed SA2 population projections into SA1s.

(xxviii) Each SA1's ERP aged 18 and over was extrapolated linearly to 30 June 2021, based on 30 June 2011 – 30 June 2015 data.

(xxix) Results were then aligned so they summed to the SA2 projections. Two approaches were used for this:

(a) If extrapolated SA1s sum to less than projected SA2s (or both projection & extrapolation falling) then scale all SA1s in the SA2 pro rata.

(b) If the extrapolation was growing faster than the projection, scale down only the growth SA1s according to their share of the growing SA1s.

This dual approach improved the results for SA1s in SA2s where there was widely divergent SA1 growth.

Appendix V– Conversion of Australian Bureau of Statistics (ABS)

Text provided by the Australian Bureau of Statistics

The Australian Bureau of Statistics (ABS) have calculated projections of the population of Australian residents aged 18 years and over for each Statistical Area 1 (SA1) starting with a base at 30 June 2015 annually through to 30 June 2021. To allow baseline comparison with latest electoral roll counts, interpolation was used to derive 30 September 2016 population. The 31 March 2021 population projections were also calculated by interpolating between 30 June figures.

For most SA1s it was assumed that the proportional relationship between electoral enrolments and resident population aged 18+ will continue. Accordingly, the population projections were converted to enrolment projections as follows:

P_{2016} = ABS projection of residents aged 18 and over at 30 September 2016

P_{2021} = ABS projection of residents aged 18 and over at 31 March 2021

E_{2016} = Enrolled persons at 30 September 2016

E_{2021} = Projected enrolled persons at 31 March 2021

$E_{2021} = (E_{2016} / P_{2016}) * P_{2021}$

For example, a Statistical Area 1's figures may be:

P_{2016} = 479

P_{2021} = 493

E_{2016} = 363

E_{2021} = (363 / 479) * 493

= 374

Some SA1s with very high growth have low enrolment to population ratios due to lags in occupancy and/or change in enrolment address. These ratios were adjusted upwards as the lags work out over time, adjusting to the degree necessary to maintain the overall State enrolment ratio.

Where a SA1 crosses existing electoral boundaries, the projected enrolment has been allocated to electoral divisions in the same proportion as current enrolments.

In a minority of SA1s where enrolments were greater than the baseline population projection, it was assumed that electoral enrolments will grow by the same amount as the population of Australian residents aged 18 and over, i.e.:

E2021 = E2016 + (P2021 - P2016)

For example, a Statistical Area 1's figures may be:

P_{2016} = 1,125

P_{2021} = 1,390

E_{2016} = 1,192

E_{2021} = 1,192 + (1,390-1,125)

= 1,457

Thereafter the Redistribution Committee may amend the enrolment projections for certain SA1s based on specific local knowledge of the area.