# Appendix 2 – *Text provided by the Australian Bureau of Statistics*

## Projection methods for the Australian Capital Territory, Statistical Areas Level 2 (SA2s) and Statistical Areas Level 1 (SA1s) - more details

This appendix gives a more detailed breakdown of the three-tiered process outlined in Appendix 1. 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 Australian Capital Territory (ACT) population by age and sex from the base population at 30 June 2016 out to 30 June 2022.
The cohort component method used is described 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* 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 ACT population and arrival rates to the population of the remaining states and territories (to obtain numbers departing other states to reside in the ACT). 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) $ARR_X(t+1) = P_X(t+1)^{Non\text{-}ACT} * ARRRATE_X$

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 – Statistical Area Level 2 Projections

This used the cohort component method to project all ACT 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 total 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 total 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 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) $$ARR(t+1) = NM(t+1) - \sum_{x=0}^{x=max} DEP_X(t+1)$$

(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) ACT 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 Level 1 Projections

This involved splitting the completed SA2 population projections into SA1s.

(xxviii) SA1 populations aged 18 and over, up to 13 January 2022, were projected using linear extrapolation and based on known populations at 30 June 2012 – 30 June 2016.

(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.