



# Notice

21 August 2015

## **Mid-West and South-West Gas Distribution Systems Access Arrangement 2015 - 2019**

### **CONSULTATION ON PROPOSED AMENDMENTS TO THE FINAL DECISION**

The Economic Regulation Authority (ERA) is seeking public comment on its proposed amendments to the Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems (GDS) made on 30 June 2015 (Final Decision). The GDS is a regulated gas pipeline that is owned and operated by ATCO Gas Australia Pty Ltd (ATCO).

The ERA's Final Decision did not approve ATCO's revised access arrangement proposal. Subsequent to the publication of the Final Decision, the ERA was made aware by ATCO and other parties of issues that require corrections and points of clarification. Additionally, the ERA is proposing amendments for issues it identified in the course of making the required corrections.

Pursuant to clause 20 of schedule 2 to the *National Gas Access (Western Australia) Law* (which applies because of section 7 of the *National Gas Access (WA) Act 2009* (NGL(WA))), the ERA therefore proposes to amend its Final Decision to make some corrections and clarifications. Specifically, the ERA proposes to amend the following sections of the Final Decision:

- Operating Expenditure
- Opening Capital Base
- Projected Capital Base
- Rate of Return
- Haulage Tariffs
- Haulage Tariff Variation Mechanism
- Appendix 8 – Automatic updating formulas for the return on debt
- Appendix 9 – Modelling depreciation outcomes to 2080
- Appendix 10 – Public Reference Tariff Model

Attachment 1 to this notice lists the proposed changes to be made to the ERA's Final Decision.

A consequence of some of these proposed amendments is that the total revenue approved by the ERA will increase by \$0.84 million (nominal), which in turn will result in the year on year change in tariffs moving from -10.3 per cent to -10.0 per cent.

If the proposed amendments are made, then following publication of its amended Final Decision, the ERA will be required by rule 64 of the National Gas Rules (NGR) to itself propose and give effect to a revised access arrangement that will apply to ATCO's GDS. In revising an access arrangement for a regulated gas pipeline, the rules and processes that the ERA must follow are governed by the NGL(WA) and the NGR.

### **Invitation to Make Public Submissions**

Interested parties are invited to make submissions on the ERA's proposed amendments to the Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems by **4:00 pm (WST) on Thursday, 27 August 2015**.

Submissions should be marked to the attention of Mr Tyson Self, Assistant Director Gas.

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### **Confidentiality**

In general, all submissions from interested parties will be treated as being in the public domain and placed on the ERA's website. Where an interested party wishes to make a submission in confidence, it should clearly indicate the parts of the submission for which confidentiality is claimed, and specify in reasonable detail the basis for the claim. Any claim of confidentiality will be considered in accordance with the provisions of the *National Gas Access (WA) Act 2009*. The publication of a submission on the ERA's website shall not be taken as indicating that we have knowledge, either actual or constructive, of the contents of a particular submission and, in particular, whether the submission in whole or part contains information of a confidential nature and no duty of confidence will arise for the ERA.

For further information contact:

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# Attachment 1 - List of Proposed Amendments to the Final Decision

## Operating Expenditure

The ERA proposes to amend the erroneous wording in paragraph 380 of the Final Decision in order to clarify that the ERA has not allowed operating expenditure of \$2.1 million over 2014 and 2015 for corporate support to prepare the revised access arrangement. This remains consistent with the ERA's Draft Decision dated 14 October 2014 (Draft Decision). The ERA has allowed one-off expenditure of \$2.1 million for the preparation of the next access arrangement proposal (AA5) divided between 2018 and 2019.

This change to the wording of the Final Decision has no impact on tariffs, as the tariff model and tables within the Final Decision did not include \$2.1 million over 2014 and 2015 for corporate support to prepare the revised access arrangement.

## Opening Capital Base

The ERA proposes to amend the Final Decision to include \$0.65 million in the opening capital base in 2012/13 for IT capital expenditure. The ERA's Final Decision erroneously excluded \$0.65 million for the GIS enhancement project, which was initially approved in the ERA's Draft Decision.

This change to the opening capital base has an impact on tariffs and on the tariff model. Tables within the Final Decision will change to reflect the inclusion of \$0.65 million for the GIS enhancement project.

## Projected Capital Base

The ERA proposes to correct a typographical error in Table 67 of the Final Decision by changing the amount deducted for capitalised overheads from \$16.31 million to \$16.91 million. Table 67 should be consistent with paragraph 814 of the Final Decision, which states a figure of \$16.91 million.

This change to Table 67 has no impact on tariffs or on the tariff model.

## Rate of Return

The ERA proposes that the reference to 30 September be changed to 31 October in paragraphs 1700, 1701, 1702, 1703 and Appendix 8 paragraphs 45, 60, 61, 62, and 63, such that it aligns with the ERA's required four month window for the nominated averaging period for the debt risk premium of 1 July to 31 October.

A similar change from 'three' to 'four' months is proposed to be made in paragraph 1688.

The ERA proposes to correct footnote 591 in paragraph 1378 to reflect the ERA's concerns about the sensitivity and interpretation of estimates for the elasticity of the return on equity to the return on debt (provided by DBNGP (WA) Transmission Pty Limited in response to the ERA's Draft Decision on ATCO's access arrangement proposal). Specifically, footnote 591 is reworded to:

The Authority notes DBP's submission suggesting that the elasticity of the return on equity to the return on debt should be 6, based on Merton's model (Dampier Bunbury Pipeline, DBP Submission to ATCO Draft Decision, 7 January 2015, p. 3). The Authority is currently investigating these claims as part of its response to DBP's access arrangement proposal.

The Authority has concerns that the outcomes are very sensitive to the input parameters and to any associated interpretation of the evidence.

In particular, the Authority considers that the evidence assembled by SFG suggests that the elasticity in the Australian context should be 7 or higher, given an average term of debt for the benchmark firm of 10 years (Dampier Bunbury Pipeline, Proposed revisions DBNGP Access Arrangement 2016-2020, 31 December 2014, Supporting Submission 12, Appendix L, pp. 15 - 16).

Re-running SFG's calculations with an elasticity of 7 and the return on debt used for this Final Decision gives the following. The current spot debt risk premium for 2015 used for this decision is 1.868 per cent (Appendix 8, paragraph 57). The associated estimated cost for the benchmark firm of issuing new (10 year) debt in March 2015 was therefore 4.56 per cent (given the swap rate of 2.71 per cent for 10 year debt from the RBA's data). Applying an elasticity of 7 to that figure would give a return on equity for the benchmark firm around 10 per cent, with an implied MRP of 10.5 per cent (based on an 'adjusted spread' of 1.05, an equity risk premium of  $7 \times 1.05 = 7.35$  implied by the Merton relationship, and a resulting implied  $MRP = 7.35 / 0.7$ ).

Considering input sensitivity, if the spread rose to 2.2 per cent, the implied MRP would be 13.4 per cent. The Authority notes that more than 50 per cent of monthly observations of the spread to swap of BBB band bonds have exceeded 220 basis points since January 2010, based on the Reserve Bank Data (see Reserve Bank of Australia, Aggregate measures of Australian corporate bond spreads and yields, Statistical Table F3, accessed July 2015).

The Authority considers that these numbers are unsupportable. The implied MRP of 10.5 per cent is well outside the range for the MRP considered reasonable, and used for this Final Decision. The cross check value is also extremely sensitive to inputs such as the credit spread.

The Authority has therefore not used this cross check method in this Final Decision.

The ERA also proposes to remove unnecessary wording on capital expenditure weighting and an incorrect reference to Table 96 in paragraph 1711.

These changes to the Final Decision have no impact on the Authority's Final Decision, tariffs or the tariff model.

## **Depreciation**

The ERA proposes to include an additional three paragraphs after paragraph 2039 in the Final Decision. The paragraphs are as follows:

2040. In particular, analysis by the Authority suggests that the pure HCA approach increases the AA4 revenue requirement – and therefore average tariffs over the period – by around 13 per cent as compared to the CCA approach. While ATCO's proposed transition approach ameliorates this AA4 impact to 3 per cent, the effect of the proposed transition is simply to defer large tariff increases. The Authority estimates that under the ATCO transition approach, the revenue requirement in AA5 and AA6 is increased by around 10 per cent as compared to the CCA approach. In subsequent access arrangement periods (AA7 and beyond), the revenue requirement under the ATCO transition approach is less than the CCA approach, which reflects the resulting subsidy from current to future customers. These quantitative impacts are entirely consistent with the real revenue per GJ impacts illustrated in Figure 38 contained in Appendix 9.

2041. A further important consideration for the Authority in this context is the requirement under Part 2 of the *National Gas Access (WA) (Local Provisions) Regulations 2009*, (which are subsidiary to the *National Gas Access (WA) Act 2009*), to take into account the impact on consumers. Part 2 r.7 states:

## **7. Impact on small use customers and retailers to be taken into account**

- (1) When exercising a discretion in approving or making an access arrangement for a distribution pipeline the ERA must take into account the possible impact of the proposed reference tariffs, the method of determining the tariffs and the reference tariff variation mechanisms on —
  - (a) users to whom gas is or might be delivered by means of a small delivery service provided for in the access arrangement; and
  - (b) small use customers to whom gas is or might be delivered by those users.
- (2) In subregulation (1) a reference to the impact of something is not limited to the economic impact of that thing.
- (3) A requirement under this regulation to take a matter into account applies —
  - (a) despite anything in the National Gas Law or Rules that would otherwise prevent the matter being taken into account; and
  - (b) in addition to any requirement under the National Gas Law or Rules —
    - (i) for any other matter to be taken into account; or
    - (ii) as to the content of the access arrangement.

2042. The Authority considers that it is clear that the impact on consumers of moving to the HCA approach, even with ATCO's proposed transition, would be significant. For these reasons, the Authority cannot accept ATCO's proposed approach, as it would have a clear detrimental impact on the incomes of Western Australian consumers over the next decade or more. The Authority considers that the smoother revenue path over time in real terms – delivered by the CCA approach – is consistent with its obligations under both the NGR and the National Gas Access (WA) (Local Provisions) Regulations 2009.

### **Haulage Tariffs**

The ERA proposes to correct a typographical error in Table 122 in paragraph 2252 by deleting "million" from the top left hand corner of Table 122.

### **Haulage Tariff Variation Mechanism**

The ERA proposes to change the formulas for the haulage tariff variation mechanism for Tariff Class A1, A2 and B1 in the Final Decision as follows:

- remove the price cap formula and revise it to allow for a tariff basket;
- refer to actual quantity rather than forecast; and
- clarify that the P(N-1) is the prevailing tariff applied to the customers.

The ERA proposes to change the formulas for the haulage tariff variation mechanism for tariff class B3 in the Final Decision as follows:

- add an additional condition such that the year to year growth of usage charges P3 and P4 are identical;
- clarify the usage price per GJ for P3 at October 2015 is \$14.99 multiplied by CPI at September 2014 divided by CPI at March 2013;
- clarify the usage price per GJ for P4 at October 2015 is \$6.47 multiplied by CPI at September 2014 divided by CPI at March 2013;
- clarify that Q1 as one customer connection; and
- clarify that the P(N-1) is the prevailing tariff applied to the customers.

The ERA proposes to amend the cost pass through mechanism so that it is incorporated within the haulage tariff variation mechanism rather than as a separate calculated tariff variation process. The cost pass through amount (as with the annual debt risk premium update) would change the X-factor used in the tariff variation mechanisms. ATCO brought to the ERA's attention that it inadvertently had not sought compensation of the taxation impact of cost pass through amounts. The ERA considers that ATCO should recover the taxation component of the cost pass through and the impact of other changes on return on working capital and equity raising costs by adopting an approach whereby the cost pass through is modelled within the tariff model and not as a separate process.

As a result, the ERA's intends to replace sections of Annexure B of the GDS access arrangement in the Amended Final Decision (see Attachment 2).

These changes to the haulage tariff variation mechanism do not impact on the calculation of the forecast building block revenue during the fourth access arrangement period.

### **Appendix 8 - Automatic updating formulas for the return on debt**

The Authority proposes to amend paragraphs 18 to 45 of Appendix 8 of the Final Decision. This section is revised to provide additional notes to allow parties to replicate the bond yield approach for estimating the debt risk premium (**DRP**), which contributes to the estimated return on debt. This will ensure that the annual update to the DRP is transparent in its method and fully automatic.

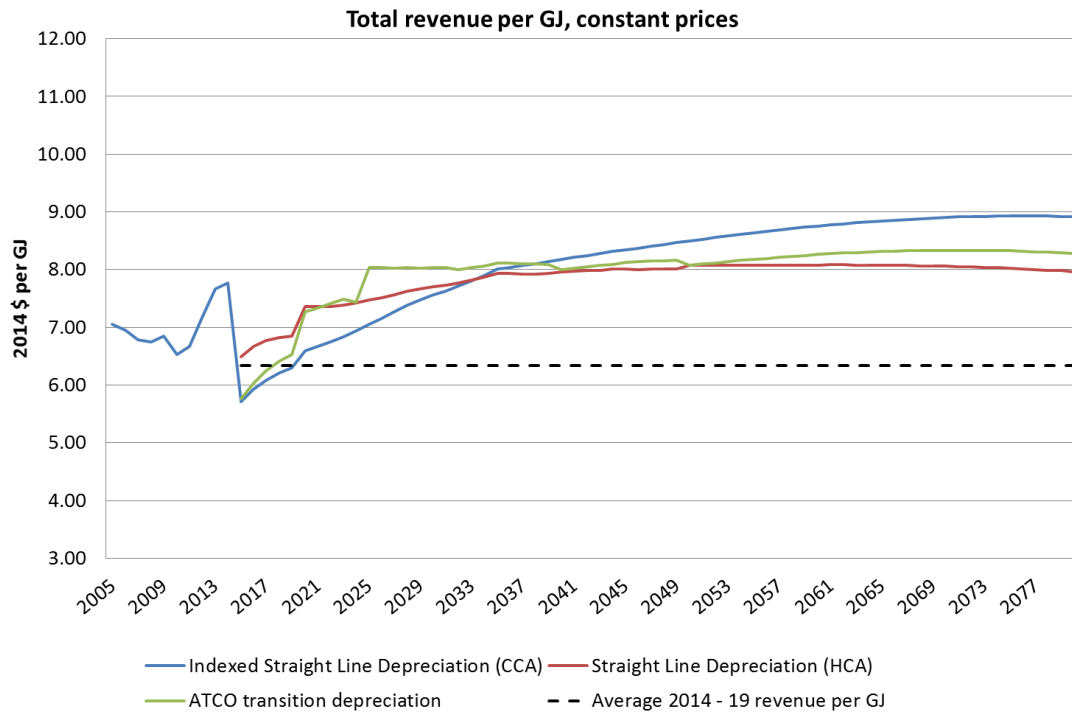
Details of the amended text are set out at Attachment 3 of this Notice.

### **Appendix 9 – Modelling depreciation outcomes to 2080**

The ERA proposes to remove an erroneous footnote 1157 in paragraph 13 in Appendix 9.

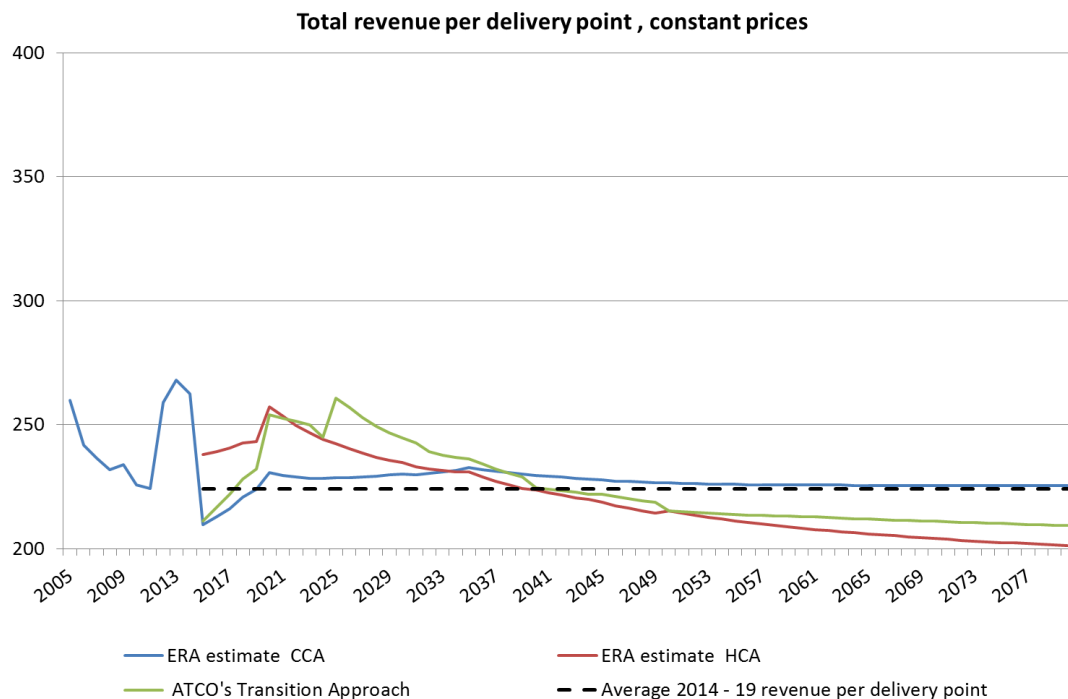
The ERA proposes to amend Figure 29 and 31 of the Final Decision in order to correct the WACC applied over the fourth access arrangement period 2014 to 2019 used in the analysis of depreciation. The revised figures are as follows:

**Figure 29 Average revenue per GJ, constant prices**



Source: ERA analysis

**Figure 31 Average revenue per delivery point, constant prices**



Source: ERA analysis

The ERA also proposes to amend Table 144 and Table 145 of the Final Decision to report the real 2014 dollars estimates of the estimated long run marginal costs used in the ERA's depreciation analysis. The revised tables are as follows:

**Table 144 Long run marginal costs per GJ for specified periods (\$ per 'incremental' GJ)**

	2006 - 2019	2020 - 2035	2036 - 2080
<b>Average incremental capacity (capital expenditure) cost per GJ</b>	21	95	22
<b>Average incremental operating cost per GJ</b>	4	87	51
<b>Average incremental capacity cost (capital expenditure) plus marginal operating cost per GJ</b>	26	182	73

*Notes:* Relevant nominal costs and volumes for each specified period were discounted back to 2014 net present terms using the long run nominal WACC (see paragraph 7).

*Source:* ERA analysis

**Table 145 Long run marginal costs per connection for specified periods (\$ per 'incremental' connection)**

	2005 - 2019	2020 - 2035	2036 - 2080
<b>Average incremental capacity (capital expenditure) cost per connection</b>	557	751	422
<b>Average incremental operating cost per connection</b>	119	692	976
<b>Average incremental capacity cost (capital expenditure) plus marginal operating cost per connection</b>	676	1443	1398

*Notes:* Relevant nominal costs and connections for each specified period were discounted back to 2014 net present terms using the long run nominal WACC.

*Source:* ERA analysis

These changes to Appendix 9 have no impact on the ERA's Final Decision, tariffs or the tariff model.

### **Appendix 10: Public Reference Tariff Model**

The ERA proposes to adjust the tariff model to:

- Express the time period 1 July 2014 to 31 December 2014 in days/365 rather than as a half year fraction when applying the rate of return in the building block.
- Remove six months of capital expenditure (1 January to 30 June 2000), which has been double counted in the initial tax asset base.
- Apply the same discount rate and inflation throughout the periods 1 January 2015 to 31 December 2015 to calculate tariff revenue; and to be consistent with the discount rate and inflation used in the building block revenue.
- Add an amount for commercial meters that was erroneously deducted from the tax asset base.

These changes to the tariff model will have an impact on tariffs and on the tables in the Final Decision.



## Attachment 2 – Proposed Revised Haulage Tariff Variation Mechanism

The Authority proposes to amend sections 1.1 to 1.3.3 and additional text to include a new section 2.2 in paragraph 2329 of the Final Decision with the following text:

The Authority has amended clauses 1 and 2 of Annexure B of the proposed revised access arrangement as follows:

### 1.1 Variation

- (a) ATCO Gas Australia may vary any Haulage Tariff by varying one or more Tariff Components of that Haulage Tariff during a Variation Period in accordance with this clause 1.
- (b) Each Haulage Tariff varied under this clause 1 applies as varied on and from the first day of the applicable Variation Period.
- (c) Each Haulage Tariff varied under this clause includes the impacts of any cost pass through as specified in clause 2.
- (d) Tariffs applicable from the commencement of the Access Arrangement at 1 July 2014 are unchanged from those applicable at 30 June 2014 under rule 92(3) of the NGR.
- (e) All tariffs commencing 1 January of the variation year in Annexure A are to be recalculated after including the cost pass through and the annual update of the trailing average debt risk premium. This will produce the X-Factor and hence the tariffs for the variation year. These tariffs, which are in 30 June 2014 dollars are adjusted to the nominal dollar value, to be charged, based on real 31 December dollars of the variation year.
- (f) Variation year is the year when the tariffs start from 1 January.
- (g) Variation period is the period when the tariffs start from dates other than 1 January of the variation year.

### 1.2 Variation Period is the period commencing 1 October 2015

#### 1.2.1 Tariff Classes A1, A2, B1, B2 and B3

All tariffs commencing 1 October 2015 in Annexure A are to be adjusted to the nominal dollar value to be charged, based on 31 December 2015 dollars. The tariffs set out in clauses 1.1(b), 1.2(b), 1.3(b), 1.4(b) and 1.5(b) of Annexure A are inflated by CPI to generate prices applicable from 1 October 2015. The adjustment of tariffs is calculated as follows:

$$P_{2015}^{i,j} \leq P_1^{i,j} \frac{CPI_{Sep2014}}{CPI_{Mar2013}}$$

Where

$P_{2015}^{i,j}$  is the value of Tariff Component  $j$  of haulage Tariff  $i$  as varied on and from the first day of the variation period which is 1 October 2015;

$P_1^{i,j}$  is the value of Tariff Component  $j$  of haulage Tariff  $i$  at 1 October 2015 in 30 June 2014 dollars as set out in Annexure A;

$i$  is the relevant reference tariff class – A1, A2, B1, B2 and B3;

$j$  is the relevant tariff component – the number of possible components, depends on the reference tariff class being considered, with  $j = 1$  to  $k$  ;

$k$  is the maximum number of possible components for each relevant tariff component being considered;

$CPI_{Sep2014}$  is the value of the CPI All Groups, Weighted Average of Eight Capital Cities for 30 September 2014 as a proxy to 31 December 2015 CPI;

$CPI_{Mar2013}$  is the value of the CPI All Groups, Weighted Average of Eight Capital Cities for 31 March 2013 as a proxy to 30 June 2014 CPI.

### 1.3 Variation Period is the Year commencing 1 January of each year 2016, 2017, 2018 and 2019

#### 1.3.1 Tariff Classes A1, A2 and B1

All tariffs commencing 1 January of the variation year are to be recalculated after including the cost pass through and the annual update of the trailing average debt risk premium. This will produce the X-Factor. The tariffs are inflated by CPI to generate prices applicable from 1 January of variation year. The tariffs must meet the following condition:

$$(1+X-Factor_N) \frac{CPI_{Sep(N-1)}}{CPI_{Sep(N-2)}} \geq \frac{\sum_{i=A1}^{B1} \sum_{j=1}^k P_N^{i,j} Q_{(N-2)}^{i,j}}{\sum_{i=A1}^{B1} \sum_{j=1}^k P_{(N-1)}^{i,j} Q_{(N-2)}^{i,j}}$$

Where

$P_N^{i,j}$  is the value of Tariff Component  $j$  of haulage Tariff  $i$  at 1 January of the variation year  $N$ ;

$P_{(N-1)}^{i,j}$  is the prevailing Tariff Component  $j$  applied to the customers of haulage Tariff  $i$  at 1 January of the variation year  $(N-1)$  for  $N = 2017$  to  $2019$ ;

$P_1^{i,j}$  is the value of Tariff Component  $j$  of haulage Tariff  $i$  at 1 October 2015 as set out in Annexure A;

$Q_{(N-2)}^{i,j}$  is the number of connections or volume sold in year  $(N-2)$  where

$Q_{(N-2)}^{i,1}$  is the number of connections;

$Q_{(N-2)}^{i,j}$  is the volume sold for  $j \geq 2$

$i$  is the relevant reference tariff class – A1, A2 or B1;

$j$  is the relevant tariff component – the number of possible components, depends on the reference tariff class being considered, with  $j = 1$  to  $k$  ;

$k$  is the maximum number of possible components for each relevant tariff component being considered;

$N$  is the variation year  $N = 2016$  to  $2019$ ;

$X-Factor_N$  is the price change from 1 January of variation year  $(N-1)$  to 1 January of variation year  $N$  after including the cost pass through and the

annual update of the trailing average debt risk premium for year  $N$  in 30 June 2014 dollars;

$X\text{-Factor}_{2016}$  is the price change from 1 October 2015 to 1 January 2016 after including the cost pass through and the annual update of the trailing average debt risk premium, in 30 June 2014 dollars;

$CPI_{Sep(N-1)}$  is the value of the CPI All Groups, Weighted Average of Eight Capital Cities for 30 September of year  $(N-1)$  as a proxy to 31 December of year  $N$  CPI;

$CPI_{Sep(N-2)}$  is the value of the CPI All Groups, Weighted Average of Eight Capital Cities for 30 September of year  $(N-2)$  as a proxy to 31 December of year  $(N-1)$  CPI.

### 1.3.2 Tariff Class B2

All tariffs commencing 1 January of the variation year are to be recalculated after including the cost pass through and the annual update of the trailing average debt risk premium. This will produce the X-Factor. The tariffs are inflated by CPI to generate prices applicable from 1 January of the variation year. The tariffs must meet the following condition:

$$P_N^j \leq P_1^j \frac{CPI_{Sep(N-1)}}{CPI_{Mar2013}} \prod_{t=2016}^N (1+X\text{-Factor}_t)$$

Where

$P_N^j$  is the value of Tariff Component  $j$  as varied from 1 January of the variation year  $N$ ;

$P_1^j$  is the value of Tariff Component  $j$  at 1 October 2015 as set out in Annexure A;

$j$  is the relevant tariff component for  $j = 1$  to  $3$ ;

$t$  is the variation years, where  $t = 2016$  to year  $N$ ;

$N$  is the variation year  $N = 2016$  to  $2019$ ;

$X\text{-Factor}_t$  is the 30 June 2014 dollar price change from 1 January of variation year  $(t-1)$  to 1 January of variation year  $(t)$  after including the cost pass through and the annual update of the trailing average debt risk premium for year  $t$ ;

$X\text{-Factor}_{2016}$  is the 30 June 2014 dollar price change from 1 October 2015 to 1 January 2016 after including the cost pass through and the annual update of the trailing average debt risk premium;

$CPI_{Sep(N-1)}$  is the value of the CPI All Groups, Weighted Average of Eight Capital Cities for 30 September of year  $(N-1)$  as a proxy to 31 December of year  $N$  CPI;

$CPI_{Mar2013}$  is the value of the CPI All Groups, Weighted Average of Eight Capital Cities for 31 March 2013 as a proxy to 30 June 2014 CPI.

### 1.3.3 Tariff Class B3

All tariffs commencing 1 January of the variation year are to be recalculated after including the cost pass through and the annual update of the trailing average debt risk premium. This will produce the X-Factor. The tariffs are inflated by CPI to generate prices applicable from 1 January of each variation year. The tariffs must meet the following condition:

$$\sum_{j=1}^4 P_N^j Q^j \leq (1 + \text{X-Factor}_N) \frac{\text{CPI}_{\text{Sep}(N-1)}}{\text{CPI}_{\text{Sep}(N-2)}} \sum_{j=1}^4 P_{(N-1)}^j Q^j ; \text{ and}$$

$$\frac{P_N^4}{P_{(N-1)}^4} = \frac{P_N^3}{P_{(N-1)}^3}$$

Where

$P_N^j$  is the value of Tariff Component  $j$  of the B3 haulage tariff, starting from 1 January of the variation year  $N = 2016$  to 2019;

$P_{(N-1)}^j$  is the prevailing Tariff Component  $j$  applied to the customers of haulage tariff at year  $(N - 1)$ ;

$P_N^1$  is a fixed standing charge per connection where:

$$P_{2015}^1 \text{ is } \$75.71 \times \frac{\text{CPI}_{\text{Sep}2014}}{\text{CPI}_{\text{Mar}2013}} \text{ per connection;}$$

$$P_{2016}^1 \text{ is } \$77.97 \times \frac{\text{CPI}_{\text{Sep}2015}}{\text{CPI}_{\text{Mar}2013}} \text{ per connection;}$$

$$P_{2017}^1 \text{ is } \$86.93 \times \frac{\text{CPI}_{\text{Sep}2016}}{\text{CPI}_{\text{Mar}2013}} \text{ per connection;}$$

$$P_{2018}^1 \text{ is } \$95.90 \times \frac{\text{CPI}_{\text{Sep}2017}}{\text{CPI}_{\text{Mar}2013}} \text{ per connection;}$$

$$P_{2019}^1 \text{ is } \$104.86 \times \frac{\text{CPI}_{\text{Sep}2018}}{\text{CPI}_{\text{Mar}2013}} \text{ per connection;}$$

$P_N^2$  is 0 for the first 2 GJ;

$$P_{2015}^3 \text{ is } \$14.99 \times \frac{\text{CPI}_{\text{Sep}2014}}{\text{CPI}_{\text{Mar}2013}} \text{ per GJ at 1 October 2015;}$$

$$P_{2015}^4 \text{ is } \$6.47 \times \frac{\text{CPI}_{\text{Sep}2014}}{\text{CPI}_{\text{Mar}2013}} \text{ per GJ at 1 October 2015;}$$

$Q^j$  is the number of connections or demand volume where:

$Q^1$  is 1 customer connection;

$Q^2$  is 2 GJ;

$Q^3$  is 8 GJ;

$Q^4$  is 5 GJ;

$j$  is the relevant tariff component, where  $j = 1$  to 4;

$N$  is the variation year, where  $N = 2016$  to 2019;

$X\text{-Factor}_N$  is the 30 June 2014 dollar price change from 1 January of variation year  $(N-1)$  to 1 January of variation year  $N$  after including the cost pass through and the annual update of the trailing average debt risk premium, for  $N = 2017$  to 2019;

$X\text{-Factor}_{2016}$  is the price change from 1 October 2015 to 1 January 2016 after including the cost pass through and the annual update of the trailing average debt risk premium;

$CPI_{Sep(N-1)}$  is the value of the CPI All Groups, Weighted Average of Eight Capital Cities for 30 September of year  $(N-1)$  as a proxy to 31 December of year  $N$  CPI;

$CPI_{Sep(N-2)}$  is the value of the CPI All Groups, Weighted Average of Eight Capital Cities for 30 September of year  $(N-2)$  as a proxy to 31 December of year  $(N-1)$  CPI.

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## **2.2 Variation of Haulage Tariffs**

If a Cost Pass Through Event occurs, ATCO Gas Australia:

- (a) must notify the ERA of the Cost Pass Through Event; and
- (b) may recover direct Conforming Operating Expenditure, depreciation and return on direct Conforming Capital Expenditure and consequential changes to the return on working capital, taxation and equity raising costs incurred or forecast to be incurred by ATCO Gas Australia (or on ATCO Gas Australia's behalf) as a direct result of the Cost Pass Through Event, provided that these costs have not already been recovered by ATCO Gas Australia.

## Attachment 3 - Amended Appendix 8 of the Final Decision: Automatic updating formulas for the return on debt

The Authority proposes to amend paragraphs 18 to 45 of Appendix 8 of the Final Decision by replacing that section with the following text. The section is revised to provide additional notes for parties seeking to replicate the bond yield approach for estimating the debt risk premium (**DRP**), which contributes to the estimated return on debt. This will ensure that the annual update to the DRP is transparent in its method and is fully automatic.

### *Post-March 2015 Estimates of the forward looking DRP for inclusion in the trailing average DRP estimate*

18. The *forward looking* estimates of the DRP for each calendar year will be estimated using the Authority's revised bond yield approach. Resulting estimates of the DRP will be included in the trailing average.
19. The first estimate is that made for the 20 day period ending 2 April 2015, which has been included in the estimate of the DRP for financial year 2014-15 and calendar year 2015 included in this Final Decision.
20. The next estimate that will be made falls in the period July to September 2015, (DRP<sub>2016</sub>), and will be incorporated in the trailing average DRP to apply in 2016 (that is, TA DRP<sub>2016</sub>).
21. The following automatic formulas will apply, and will remain unchanged for the duration of the AA4 period, and hence will apply for the estimates made for DRP<sub>2016</sub>, as well as for the estimates DRP<sub>2017</sub>, DRP<sub>2018</sub> and DRP<sub>2019</sub>.

### **Techniques to estimate the forward looking debt risk premium**

22. The Authority will utilise the following three techniques as part of the automatic formula to estimate the DRP contributing to the annual updates:
  - the Gaussian Kernel;
  - the Nelson-Siegel methodology; and
  - the Nelson-Siegel-Svensson methodology.
23. Each of these techniques is discussed in turn below.

#### ***The Gaussian Kernel***

24. This methodology was discussed in detail previously in the main body of this Final Decision under the discussion of the RBA's approach.
25. CEG submitted that bond issue amounts expressed in foreign currencies should be converted to Australian dollar amounts before being applied as weights in the Gaussian Kernel estimates.<sup>1</sup> The Authority accepts this recommendation. Consequently, where a bond is issued in a foreign currency the weighting in the

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<sup>1</sup> ATCO Gas Australia, *Response to the ERA's Draft Decision on required amendments to the Access Arrangement for the Mid-West and South-West Gas Distribution System*, 27 November 2014, Appendix 9.2, p. 72.

Gaussian Kernel estimates now uses the principal amount converted into an Australian dollar amounts. The currency conversion uses the closing exchange rate on the date of the bond's issue.

**The Nelson-Siegel methodology**

26. The Nelson-Siegel methodology assumes that the term structure of the DRP has the parametric form shown below:

$$y_t(\tau) = \beta_{0t} + \beta_{1t} \frac{1 - e^{-\lambda\tau}}{\lambda\tau} + \beta_{2t} \left( \frac{1 - e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau} \right)$$

Where

$\hat{y}(\tau)$  is the credit spread (debt risk premium) at time t for maturity  $\tau$  ; and

$\beta_{0t}, \beta_{1t}, \beta_{2t}, \lambda$  are the parameters of the model to be estimated from the data.

27. The Nelson-Siegel methodology uses observed data from the bond market to estimate the parameters  $\beta_{0t}, \beta_{1t}, \beta_{2t}, \lambda$  by using the observed debt risk premium and maturities for bonds. With the estimated parameters  $\beta_{0t}, \beta_{1t}, \beta_{2t}, \lambda$ , a yield curve is produced by substituting these estimates into the above equation and plotting the resulting *estimated* debt risk premium  $\hat{y}(\tau)$  by varying the maturity  $\tau$ .  $\hat{y}(\tau)$  has the interpretation of being the *estimated* debt risk premium for a benchmark bond with a maturity of  $\tau$  for a given credit rating.

**The Nelson-Siegel-Svensson methodology**

28. The Authority also notes CEG's submission in relation to the notation errors in the parametric form of the Nelson-Siegel-Svensson curve published in the Draft Decision. The form published in the Draft Decision was incorrect, however it was not used in the calculations used in the Authority's estimates of the cost of debt. The parametric form of the Nelson-Siegel-Svensson curve used by the Authority is that specified in the Svensson (1994) paper referenced by CEG.<sup>2</sup> The correct notation for this parametric form is shown below:

$$\hat{y}_t(\tau) = \beta_{0t} + \beta_{1t} \frac{1 - e^{-\tau/\lambda_1}}{\tau/\lambda_1} + \beta_{2t} \left[ \frac{1 - e^{-\tau/\lambda_1}}{\tau/\lambda_1} - e^{-\tau/\lambda_1} \right] + \beta_{3t} \left[ \frac{1 - e^{-\tau/\lambda_2}}{\tau/\lambda_2} - e^{-\tau/\lambda_2} \right]$$

Where

$y_t(\tau)$  is the credit spread (debt risk premium) at time t for maturity  $\tau$  ; and

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<sup>2</sup> L. Svensson, *Estimating and Interpreting Forward Interest Rates: Sweden 1992-1994*, Institute for International Economic Studies, University of Stockholm, Seminar Paper No 579, p. 6.

$\beta_{0t}, \beta_{1t}, \beta_{2t}, \beta_{3t}, \lambda_1, \lambda_2$  are the parameters of the model to be estimated from the data.

29. The Nelson-Siegel-Svensson methodology is estimated in the same way as the Nelson-Siegel method, except uses a different parametric form.

#### **Automatic method for annual updating the estimate of the debt risk premium**

30. The Authority will use the following method to implement the automatic formulas for estimating the DRP for each annual update:
- develop the benchmark sample under the revised bond yield approach: (i) including corporate bonds denominated in domestic currency (**AUD**) and foreign currencies including USD; Euros; and British pounds where the country of risk is Australia; and (ii) exclude bonds issued by the financial sector, duplicates, inflation linked, called and perpetual instruments;
  - convert the foreign currency bond yields into hedged Australian dollar equivalent yields;
  - average AUD equivalent bond yields across the averaging period for each bond (for example, where a 20 trading day averaging period applies, each bond will have a single 20 day average yield calculated for it);
  - estimate yield curves on the 20 day averages of the Australian dollar yield data applying the Gaussian Kernel, Nelson-Siegel and Nelson-Siegel-Svensson techniques;
  - use the simple average of these three yield curve's 10 year cost of debt estimate to arrive at the market estimate of the 10 year cost of debt;
  - estimate the debt risk premium.
31. The following sections outline these steps in more detail.

##### **Step 1: *Determining the benchmark sample***

32. The following automatic selection criteria will be applied to source the corporate bonds to be included in the benchmark sample from the Bloomberg terminal:
- credit rating of each bond must match that of the benchmark efficient entity, as rated by Standard & Poor's;
  - time to maturity of 2 years or longer;
  - bonds issued where the country of risk is Australia (except by the financial sector which is excluded<sup>3</sup>) and denominated in AUD; USD; Euros; and GBP;<sup>4</sup>

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<sup>3</sup> As classified by Bloomberg Industry Classification System level 1.

<sup>4</sup> Country of risk is based on Bloomberg's methodology using four factors listed in order of importance; management location, country of primary listing, country of revenue and reporting currency of issuer. This criteria allows for the largest sample of bonds that reflect an Australian risk premium.



- inclusion of both fixed bonds<sup>5</sup> and floating bonds;<sup>6</sup>
- inclusion of both bullet and callable/ puttable redemptions;<sup>7</sup>
- at least 50 per cent of observations for the averaging period is required (that is, 10 yield observations over the required averaging period of 20 trading days are required);<sup>8</sup> and
- are not called, perpetual, a duplicate or inflation linked.

33. These automatic selection criteria are set out in Table 139.

**Table 139 Revised Bond Yield Approach Selection Criteria**

Criteria	ERA's approach
Remaining term	>= 2 years
Amount at issuance	N/A
Denominated currency	AUD, USD, EUR and GBP
Industry of issuers	Non-financial corporates only
Country of Risk	Australia
Maturity Type	Bullet, Callable and Puttable
Exclude	Perpetual, inflation linked, called instruments
Consolidate	Duplicate issues

Source: ERA analysis

34. The country of risk criteria ensures that yields and credit spreads estimated on the bonds issued are reflective of risks primarily linked to economic and financial market conditions in Australia. Perpetual, inflation linked and called instruments are excluded. Duplicate issues such as those that are reported by Bloomberg as both privately placed and publically issued are excluded to avoid double counting their yields in the sample.
35. The sample of bonds as at 2 April 2015 – used for the 2015-16 estimate – includes 92 instruments which are outlined in Appendix 6.

<sup>5</sup> This is a long term bond that pays a fixed rate of interest (a coupon rate) over its life.

<sup>6</sup> This is a bond whose interest payment fluctuates in step with the market interest rates, or some other external measure. Price of floating rate bonds remains relatively stable because neither a capital gain nor capital loss occurs as market interest rates go up or down. Technically, the coupons are linked to the bank bill swap rate (it could also be linked to another index, such as LIBOR), but this is highly correlated with the RBA's cash rate. As such, as interest rates rise, the bondholders in floaters will be compensated with a higher coupon rate.

<sup>7</sup> A callable (puttable) bond includes a provision in a bond contract that give the issuer (the bondholder) the right to redeem the bonds under specified terms prior to the normal maturity date. This is in contrast to a standard bond that is not able to be redeemed prior to maturity. A callable (puttable) bond therefore has a higher (lower) yield relative to a standard bond, since there is a possibility that the bond will be redeemed by the issuer (bondholder) if market interest rates fall (rise).

<sup>8</sup> The Authority notes that there is a tendency for fewer bonds to be available on the long end of the yield curve. If circumstances arise where this criteria results in a paucity of bonds such that curve fitting is impractical the Authority may exercise judgement to determine whether exclusion of bonds based on this criteria is appropriate.

36. The Bloomberg search SRCH <GO> facility is used to conduct a search for bonds with a Standard & Poor's issue level (as opposed to issuer) rating that matches the BBB band benchmark credit rating, that match the criteria set out in Table 140.<sup>9</sup> This is carried out as soon as practicable after the date that marks the final trading day.<sup>10</sup>

**Table 140 Revised Bond Yield Approach Search Criteria – Bloomberg Search Structure**

Criteria	ERA's approach
Country of risk	Australia
S&P Rating	BBB+ to BBB-
Currency	Australian Dollar, United States Dollar, Euro Currency and British Pound
Maturity Date	>= 2 years from now
Maturity Type	Bullet or Callable or Putable but not Perpetual
Security Type	Inflation Linked Note
Sector/Industry Group	Exclude 'Financials' (based on Bloomberg Industry Classification System Level 1 Sector Name)
Was Called	No

37. A screen shot of how this would look in the Bloomberg SRCH<GO> function is presented in Figure 27. Security status will default to active. It is important to note that in the top left hand corner of this figure the 'Asset Classes' criteria has been enabled to consolidate duplicate bond issues. The consolidation option is accessed by typing 11 in the top left hand corner to the left of <HELP> and then hitting <GO> ensuring that *only* the 'Corporate' and 'Consolidate Duplicate Bonds' option is checked before clicking 'Update'. The remaining criteria are entered into the Bloomberg SRCH function as shown in Figure 27 by typing the keywords into the 'Field' column and hitting <GO> after each of the criteria are entered to add new criteria. The criteria in the Bloomberg search panel can be edited by clicking the pencil icon to the right of each criteria.<sup>11</sup>

<sup>9</sup> <GO> is the Bloomberg equivalent of hitting the enter key after entering commands in the top left hand corner of the screen to the left of <HELP>. For example, type SRCH and then hit the <GO> key.

<sup>10</sup> Note that the revised bond yield approach is based on Eastern States trading days for consistency with Commonwealth Government Security data used in risk free rate and inflation calculations.

<sup>11</sup> For the maturity date change the boundary condition to 'years from now' by selecting 'Y'.

**Figure 27 Bloomberg ‘SRCH’ Function Populated with Sample Selection Criteria.**



Source: Bloomberg

38. The results of this search are exported into Microsoft Excel.<sup>12</sup> The only information that is collected from the search result output into Excel at this stage is the 'Bloomberg ID' or 'ticker' for each bond.<sup>13</sup> Each ticker needs to be appended with " Corp" so that formulas used in the next step can recognise them as a corporate bond. This can be carried out using the structure in Microsoft Excel below.<sup>14</sup>

**Table 141 Appending Bloomberg Bond Tickers for use in Pricing Formulas– Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
Pasted value of bond ticker (example)	A2 down	EXXXXXXXXX Corp
Bond ticker appended with " Corp"	B2 down	=A2&" Corp"

39. The values in B2 down can be pasted as values into a separate worksheet for use in the formulas used in the step that follows.

<sup>12</sup> Click the 'Results' button and in the resulting screen click 'Actions' and then 'Export to Excel'.

<sup>13</sup> It is important to save a copy of this search for future reference if help is requested from Bloomberg Helpdesk.

<sup>14</sup> It is recommended that formulas presented in these Excel structure tables are copy and pasted from an electronic copy of this document.

**Step 2: Conversion of yields into AUD equivalents**

40. The Authority's approach for conversion of foreign currency yields into Australian dollar equivalents does not require estimates of a conversion factor as it utilises Bloomberg Swap Manager facilities directly. This approach is transparent and replicable – anyone with access to a Bloomberg terminal can enable the functionality will get the same hedged Australian dollar equivalent yield for any given bond, provided they use the same date, currency, payment frequency and deal type. Further details of the approach are outlined in Appendix 5.

*Automatic update additional notes – collecting data and converting yields*

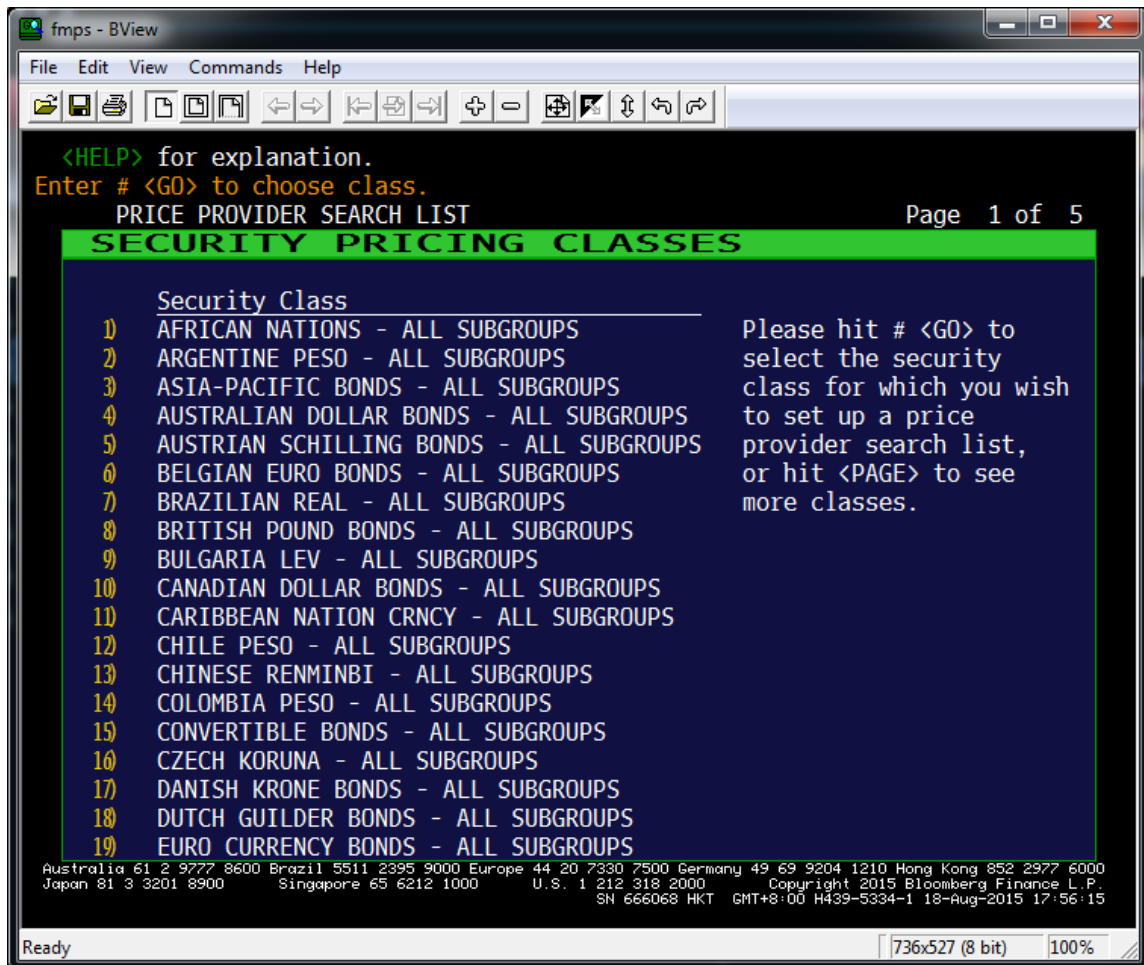
41. Before data for each of the bond identifiers in the sample (established in the previous section) is retrieved some pricing source defaults need to be set within the Bloomberg terminal itself. This determines the source that formula outlined further below use to draw bond pricing from.
42. All bonds issued in the currencies illustrated in Table 142 have been set to retrieve prices from the associated pricing sources in the Bloomberg terminal.

**Table 142 Pricing Waterfall Set in Bloomberg for Retrieving Bond Price Data**

Currency of Issuance	1st Pricing Source	2nd Pricing Source
USD	BVAL	TRAC
EUR	BVAL	BGN
GBP	BVAL	BGN
AUD	BVAL	CBBT

43. To set these as the default sources in the Bloomberg terminal for each currency use FMPS <GO> shown in Figure 28. Scroll down to reveal 'US Denominated Corporate Bonds – All Subgroups'. Select this and in the resulting window select US Denominated Corporate Bonds – All Subgroups' again.

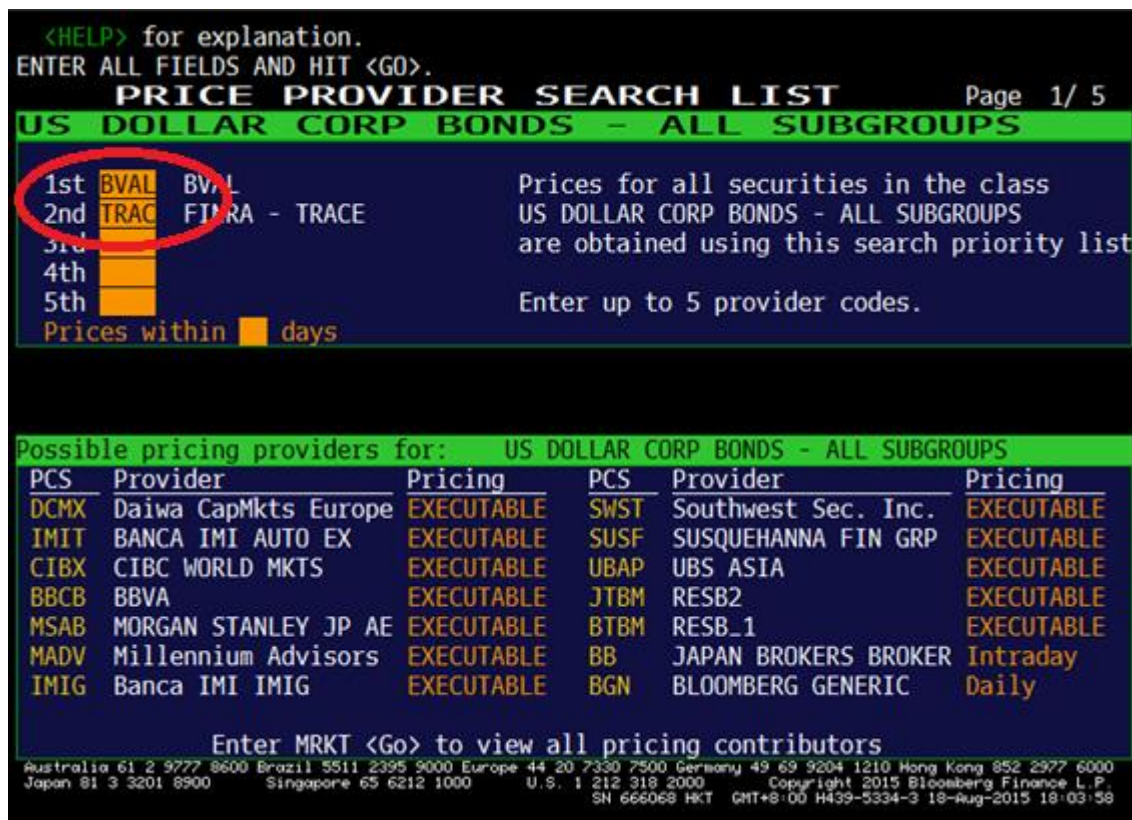
Figure 28 Security Pricing Classes List



Source: Bloomberg

44. Figure 29 shows where the pricing source settings in Table 142 should be entered in the pricing source window using the US dollar denominated bonds as an example. The first pricing source should be entered to the right of '1st' in the red circle and second pricing source to the right of '2nd'. Once this is complete hit <GO> followed by 1 <GO> to save.

Figure 29 Pricing Source Window Default Setting - US Dollar Corporate Bond Example



Source: Bloomberg

45. Repeat the steps outlined in paragraphs 43 and 44 for the remaining currencies selecting:
- 'Euro Currency Bonds – All Subgroups' > 'Original EUR Issued Bonds and Other Redenominated Bonds' > 'Euro Currency Bonds – All Subgroups' for Euro denominated bonds;
  - 'British Pound Bonds – All Subgroups' > 'British Pound Bonds – All Subgroups' for GBP denominated bonds; and
  - 'Australian Dollar Bonds – All Subgroups' > 'Australian Dollar Bonds – All Subgroups' for AUD denominated bonds.

46. Data is collected through a Microsoft Excel spreadsheet that interfaces with Bloomberg through the Bloomberg Application Programming Interface (**API**). The 'tickers' identifying each bond in the sample selection step above are the key input into this spreadsheet. The bond tickers are appended with " Corp" so that they can be read by the "Bloomberg Data Point" (**BDP**) or "Bloomberg Data History" (**BDH**) function in Excel which then retrieves various attributes for each bond in question.<sup>15</sup> The key attributes required at this stage of the process are:
- Maturity date (MATURITY);
  - Currency (CRNCY);
  - Amount issued (AMT\_ISSUED);
  - Issue date (ISSUE\_DT);
  - Bid price for the bond (px bid);
  - Ask price for the bond (px ask); and
  - Asset swap spread bid (asset swap spd bid);
  - Asset swap spread ask (asset swap spd ask);
  - Australian dollar exchange rate with each bond's native currency at date of issue (for example for the US/Australian dollar exchange rate; USDAUD Curncy).
47. The key formulas are set out in Table 143. All formulas B2 through to E2 can be filled downward in Excel to retrieve the attributes for the cross section of bonds.
48. Formulas then convert the mid asset swap spread highlighted in K2 into a hedged Australian dollar equivalent making reference to some of the cells outlined above (Table 144). All formulas P2 through to R2 can be filled downward in Excel to retrieve the converted yields for the cross section of bonds. The Bloomberg Swaps Toolkit must be enabled so that these formulas can call the swap manager tool in the Bloomberg terminal through Excel. Further information and example templates can be found in the Swaps Toolkit under DAPI <GO> in the Bloomberg terminal.
49. The date entered in cell A1 is changed to each of the trading days in the averaging period. The hedged Australian dollar yield is returned in cells R2 downward.<sup>16</sup> The hedged yields for the cross section of bonds should be saved for each date.

**Step 3:      *Averaging yields over the averaging period***

50. Under the finalised approach for conversion of yields into Australian dollar equivalents only hedged Australian dollar equivalent yields (as opposed to spreads) are reported. The averaging period (in this case 20 days) results in 20 hedged Australian dollar equivalent yields for each bond. The days are based on Australian eastern states trading days and are counted back from and include the determination date for the DRP calculation.

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<sup>15</sup> The space before " Corp" is intentional. BDP retrieves current values while BDH is used to retrieve historical data.

<sup>16</sup> Note that this process can take a few minutes to populate. It is important to ensure the yields have populated fully and without error each time the date is changed in cell A1. At times this may require restarting Excel.

51. The observations on these days are then averaged to create one 20 day average observation for each bond. The spread to an Australian dollar swap is calculated as a single estimate based on the observed cost of debt estimated using all three techniques on the entire sample of bonds.<sup>17</sup>

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<sup>17</sup> As opposed to downloading individual swap spreads.



**Table 143 Formula to Retrieve Bond Prices and Attributes– Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
Bond Ticker	FromA2 down	EXXXXXXXXXX Corp
Trading day date	A1	mm/dd/yyyy
Currency to convert to	B1	AUD
Payment frequency	C1	Q
Issue date	B2	=BDP(A2,"ISSUE_DT")
Maturity date	C2	=BDP(A2,"MATURITY")
Currency of bond issue	D2	=BDP(A2,"CRNCY")
Amount issued – currency of issuance (bond face value)	E2	=BDP(A2,"AMT_ISSUED")
Amount issued – Australian dollars (bond face value)	F2	=IF(D2="AUD",E2,E2*BDH(D2&"AUD Curncy","px_last",B2,B2))
Bid Price Label	G1	PX BID
Ask Price Label	H1	PX ASK
Bond bid price	G2	=BDH(A2, "px bid", \$A\$1, \$A\$1, "QuoteType", "P","fill","P")
Bond ask price	H2	=BDH(A2, "px ask", \$A\$1, \$A\$1, "QuoteType", "P","fill","P")
Asset swap spread bid	I2	=BDP(A2,"asset swap spd bid",\$G\$1,G2,"ASW_SWAP_CURRENCY",\$B\$1,"A SW_SWAP_PAY_RESET_FREQ",\$C\$1,"SETTLE_ DT",TEXT(\$A\$1,"YYYYMMDD"),"SW_CURVE_DT", TEXT(\$A\$1,"YYYYMMDD"))
Asset swap spread ask	J2	=BDP(A2,"asset swap spd ask",\$H\$1,H2,"ASW_SWAP_CURRENCY",\$B\$1,"A SW_SWAP_PAY_RESET_FREQ",\$C\$1,"SETTLE_ DT",TEXT(\$A\$1,"YYYYMMDD"),"SW_CURVE_DT", TEXT(\$A\$1,"YYYYMMDD"))
Asset swap spread mid	K2	=AVERAGE(I2:J2)
Remaining term to maturity from determination date (dd/mm/yyyy)	L2	=YEARFRAC(dd/mm/yyyy,C2)

Source: ERA Research, Bloomberg

**Table 144 Formula for Converting to Hedged Australian Dollar Equivalent Yields– Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
Payment frequency for fixed leg of swap (leg 1)	M1	Semiannual
Payment frequency for floating leg of swap (leg 2)	N1	Quarterly
Deal type (fixed float)	O1	FXFL
Deal Structure ID (called from Bloomberg terminal)	P2	=BSTRUCTURE(\$O\$1,"Leg[2].Currency",\$B\$1,"Leg[1].Currency",\$B\$1,"Leg[2].Spread",K2,"EffectiveDate",B2,"MaturityDate",C2,"Leg[1].PayFrequency",\$M\$1,"Leg[2].PayFrequency",\$N\$1,"Leg[2].ResetFrequency",\$N\$1)
Valuation ID (called from Bloomberg terminal)	Q2	=BPRICE(P2,"Target=Leg[1].FixedCoupon","Premium=0","Leg[2].Spread",K2,"ValuationDate",\$A\$1,"MarketDate",\$A\$1,"headers=false")
Australian dollar equivalent yield	R2	=BView(Q2,"Leg[1].FixedCoupon","headers=false")

Source: ERA Research, Bloomberg

*Automatic update additional notes – averaging yields over the averaging Period*

52. The averaging period is based on eastern states trading days with the last day of the averaging period being on the DRP determination date. Once a table of AUD equivalent bond yields has been established for every day across the average period the sample of yields for each bond across the averaging period is assessed to ensure it has a number of observations equal to at least half of the averaging period. Bonds that do not meet this requirement are deleted from the sample. The sample of yields for each bond is then averaged. This results in one averaged observation for each bond.

**Step 4: Apply curve fitting techniques**

53. Step 4 involves the estimation of the yield curves for each of the three methods.

*Automatic update additional notes – estimating yield curves*

54. As noted, the Authority will utilise the following three techniques as part of the automatic formula to estimate the 10 year cost of debt and DRP contributing to the annual updates:

- the Gaussian Kernel;
- the Nelson-Siegel methodology; and

- the Nelson-Siegel-Svensson methodology.
55. For ease of replication by third parties only Microsoft Excel is used for processing the data. Each of these techniques is discussed in turn below.<sup>18</sup>

#### Gaussian kernel method

56. The Gaussian kernel methodology is implemented in accordance with that set out in December 2013 Reserve Bank of Australia Bulletin article, 'New Measures of Australian Corporate Credit Spreads'.<sup>19</sup> The details on how the approach is replicated in Excel is set out below as follows.
57. The remaining term to maturity, bond face value in Australian dollars and Australian dollar equivalent yield for each bond observed are the inputs required for this approach. These are the outputs reported in cells L2 and F2 in Table 143 and cell R2 in Table 144 respectively. The methodology is structured in Excel using these inputs. The structure is outlined in Table 145.

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<sup>18</sup> Microsoft Excel 2013 (15.0.4745.1000) 32 bit as part of Microsoft Office Professional Plus 2013 is the version currently used for these calculations.

<sup>19</sup> Reserve Bank of Australia, 'New Measures of Australian Corporate Credit Spreads', *Bulletin*, December quarter 2013.

**Table 145 Gaussian Kernel Point Estimation Methodology – Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
Remaining term to maturity	A1 down	L2 as output in Table 143
Amount issued – Australian dollars (bond face value)	B1 down	F2 as output in Table 143
Australian dollar equivalent yield	C1 down	R2 as output in Table 144
Absolute deviation from target tenor	D1 down	=ABS(A1-\$K\$1)
Squared deviation from target tenor	E1 down	=(A1-\$K\$1)^2
Gaussian kernel	F1 down	=(EXP(-E1/(2*\$K\$4)))/\$K\$8
Joint Weighting	G1 down	=F1*B1
Sum of Joint Weighting	Last cell column G	=SUM(G1:\$G\$Second last row)
Weight	H1 down	=G1/(\$G\$Lastrow)
Weighted yield	I1 down	=C1*H1
Weighted maturity	J1 down	=A1*H1
Sum weighted maturity (effective term to maturity)	Last cell column J	=SUM(J1:\$J\$Second last row)
Target tenor	K1	Input target tenor (eg 10 for 10 years)
Smoothing parameter (sigma)	K2	1.5
Actual sigma	K3	=STDEV(A:A)
Sigma squared	K4	=K2^2
mean	K5	=AVERAGE(A:A)
pi	K6	=PI()
2 x Square root of pi	K7	=SQRT(2*K6)
2 x Square root of pi x smoothing parameter	K8	=K7*K2
Target tenor yield	K9	=SUM(I:I)

58. The approach is non-parametric and thus requires no estimation of curves. The output for any target tenor input into cell K1 is instantly reported in cell K8.
59. The target tenor yields are calculated for the 3, 5, 7 and 10 year terms. The associated effective term to maturity in the last cell of column J is also recorded for each tenor. A linear extrapolation out to an effective tenor of 10 years and interpolation to 7 years is performed using the following formula.

$$y_t(t) = y_t[et(7)] + \left( \frac{y_t[et(10)] - y_t[et(7)]}{et(10) - et(7)} \right) (t - et(7))$$

Where

$t$  is the tenor to be interpolated or extrapolated to;

$y_t(t)$  is the semi-annual yield extrapolated out to 10 years;

$\tau$  is the input target tenor (for example in cell K1 above);

$y_t[\tau]$  is target tenor yield output from the Gaussian kernel method; and

$et(\tau)$  is the effective tenor output from the Gaussian kernel method.

60. This can be implemented using the structure set out in Table 146.

**Table 146 Linear Interpolation and Extrapolation of Gaussian Kernel Estimates – Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
Tenor	A1:D1	Values 3, 5, 7 and 10.
3 year target tenor yield (semi-annual basis)	A2	From cell K9 in Table 145.
5 year target tenor yield (semi-annual basis)	B2	From cell K9 in Table 145.
7 year target tenor yield (semi-annual basis)	C2	From cell K9 in Table 145.
10 year target tenor yield (semi-annual basis)	D2	From cell K9 in Table 145.
3 year effective tenor	A3	Last row of column J in Table 145.
5 year effective tenor	B3	Last row of column J in Table 145.
7 year effective tenor	C3	Last row of column J in Table 145.
10 year effective tenor	D3	Last row of column J in Table 145.
3 year target tenor annualized yield	A4	$=((1+A2/200)^2-1)*100$
5 year target tenor annualized yield	B4	$=((1+B2/200)^2-1)*100$
7 year target tenor annualized yield	C4	$=((1+C2/200)^2-1)*100$
10 year target tenor annualized yield	D4	$=((1+D2/200)^2-1)*100$
Interpolated 7 year yield (semi-annual basis)	E2	$=C2+((D2-C2)/(D3-C3))*(7-C3)$
Extrapolated 10 year yield (semi-annual basis)	F2	$=C2+((D2-C2)/(D3-C3))*(10-C3)$
Interpolated 7 year yield annualized	E4	$=((1+E2/200)^2-1)*100$
Extrapolated 10 year yield annualized	F4	$=((1+F2/200)^2-1)*100$

61. The value in F4 is the Gaussian kernel cost of debt extrapolated to a tenor of 10 years. This value averaged with the 10 year cost of debt estimate from the other two methods is the Authority's final 10 year cost of debt estimate.

The Nelson Siegel method

62. The first step in the estimation process is to estimate a value for the decay factor  $\lambda$  which determines the tenor at which  $\beta_{2t}$  (the medium-term factor) reaches its maximum influence. Diebold and Li (2006) propose that 30 months (2.5 years) is commonly used as a medium-term tenor.<sup>20</sup> Setting  $\tau$  to 2.5 and substituting it into the weighting factor attached to  $\beta_{2t}$  in the NS specification gives:

$$\text{Max} \left( \frac{1 - e^{-2.5\lambda}}{2.5\lambda} - e^{-2.5\lambda} \right)$$

63. A value of  $\lambda$  must be found that maximises the  $\beta_{2t}$  weighting factor. This problem is set out in Excel as shown in Table 147.

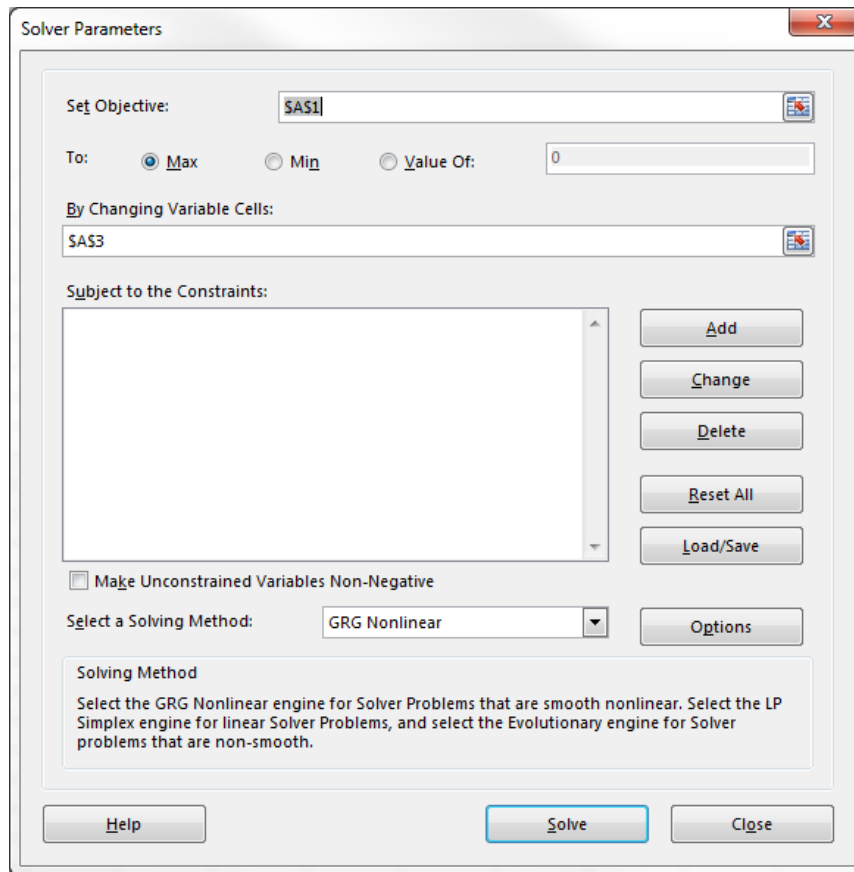
**Table 147 Nelson Siegel Decay Factor Estimation – – Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
$\beta_{2t}$ weighting factor	A1	=(((1-EXP(-\$A\$3*A2))/(\$A\$3*A2))-EXP(-\$A\$3*A2))
Tenor (maturity) $\tau$	A2	2.5
Decay factor $\lambda$ (Starting value used)	A3	0.00000000000001 (that is 1E-14)

64. The Excel solver add-in is set up as depicted in Figure 30 and Figure 31.

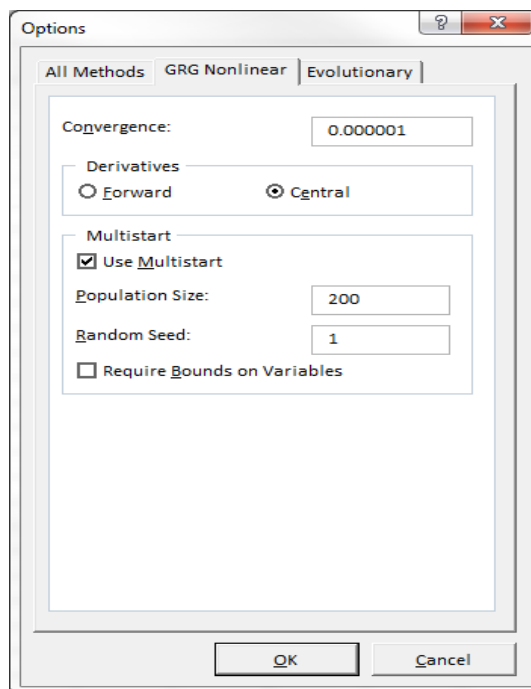
<sup>20</sup> F. Diebold and C. Li, 'Forecasting the term structure of government bond yields', *Journal of Econometrics*, vol.130, no.2, pp. 337-364.

**Figure 30 Nelson Siegel Decay Factor Estimation – Microsoft Excel Solver Settings**



65. The GRG non-linear solver is used to find the maximum point (or peak) on a non-linear function, hence the selection of 'GRG Nonlinear' and 'Max' in Figure 30.

**Figure 31 Microsoft Excel GRG Nonlinear Solver Settings**





66. The convergence of 0.000001 is considered precise enough such that the solver will stop when the solution in the last iterations change by this amount.<sup>21</sup> To ensure the peak is a global maximum (as opposed to just local) the solver carries out the optimisation from many different random starting points on the function reflected by the selection of the 'Multistart' option in Figure 31. The number of different starting points is based on the 'Population size' field and setting the 'Random seed' to 'one' ensures that the random selection process is always based on the same seed each time the solver is used. The central difference derivative method is selected for the greatest accuracy. In this case the problem is unconstrained and so no bounds are required on variables.
67. This process yields a value for  $\lambda$  of 0.71731 which will be used as a starting value in the final fitting of the NS yield curve.<sup>22</sup> Starting values are still required for  $\beta_{0t}, \beta_{1t}, \beta_{2t}$ . These are found as follows.
68. The decay factor ( $\lambda$ ) value is substituted as a constant into the terms attached to  $\beta_{1t}$ ,  $\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right)$  and  $\beta_{2t}$ ,  $\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}-e^{-\lambda\tau}\right)$ .
69. These terms are then set as a function of each bond's remaining term to maturity as shown for cell L2 in Table 143. This will result in a  $\beta_{1t}$  weight and  $\beta_{2t}$  weight for every bond in the sample.
70. An Ordinary Least Squares (**OLS**) regression is carried out using the Excel Data Analysis tools' 'Regression' function. The structure for setting out the data to which the OLS regression is applied is shown in Table 148.

**Table 148 Nelson Siegel Starting Value Regression – Microsoft Excel Template Structure**

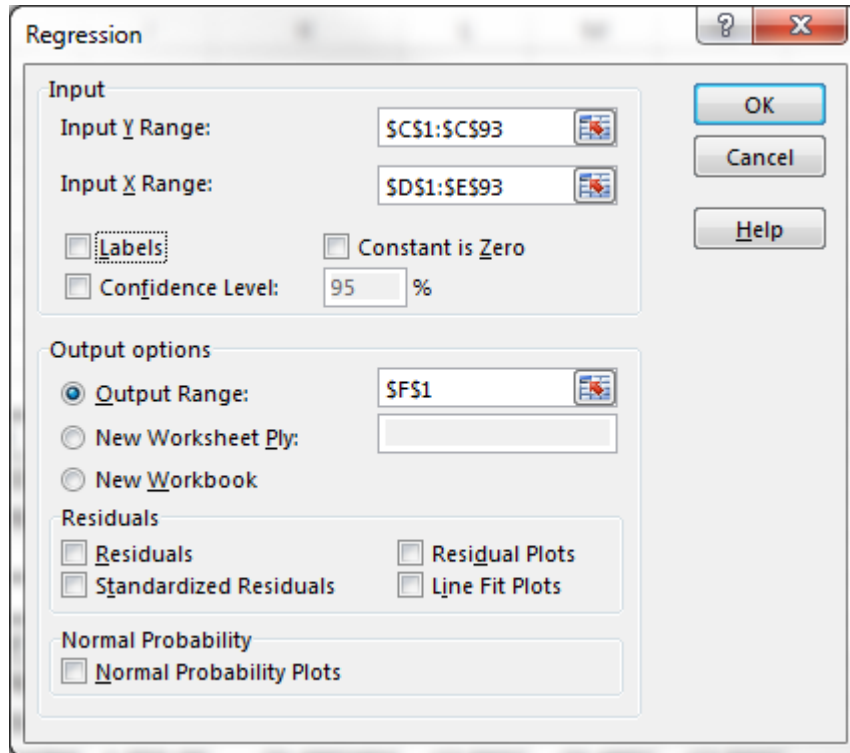
Attribute	Cell	Formula or entry
Decay factor $\lambda$	A1	Link to solution in cell A3 in Table 147.
Maturity ( $\tau$ )	B1 down	The results of from cell L2 in Table 143.
Australian dollar equivalent yield	C1 down	Values as calculated by cell R2 in Table 144.
$\beta_{1t}$ weight factor	D1 down	$=((1-EXP(-\$A\$1*B1))/(\$A\$1*B1))$
$\beta_{2t}$ weight factor	E1 down	$=(((1-EXP(-\$A\$1*B1))/(\$A\$1*B1))-EXP(-\$A\$1*B1))$

<sup>21</sup> Diebold and Li (2006) published their decay method to 4 decimal places.

<sup>22</sup> This solution is output in cell A3 in Table 147 once the solver has found a solution.

71. The Y input values are the Australian dollar yield equivalents output for each bond as shown in cell R2 in Table 144. The X input values are the entire series of  $\beta_{1t}$  and  $\beta_{2t}$  weights associated with each of the bonds. The 'Constant is zero' box shown in Figure 32 should be left unchecked so that an intercept term is included in the regression which will serve as a starting value for  $\beta_{0t}$ .

**Figure 32 Nelson Siegel Starting Value Regression – Microsoft Excel Regression Settings**



72. The intercept, X Variable 1 and X Variable 2 appear under the coefficients in the output table. These are used as the starting value estimates for  $\beta_{0t}$ ,  $\beta_{1t}$  and  $\beta_{2t}$  respectively while the value in cell A1 in Table 148 is used as the starting value for  $\lambda$ .<sup>23</sup> The values for these estimates are then used as an input into the final NS curve fitting process which is outlined below in Table 149.

<sup>23</sup> This is output into cells G17, G18 and G19 in the example set out above.

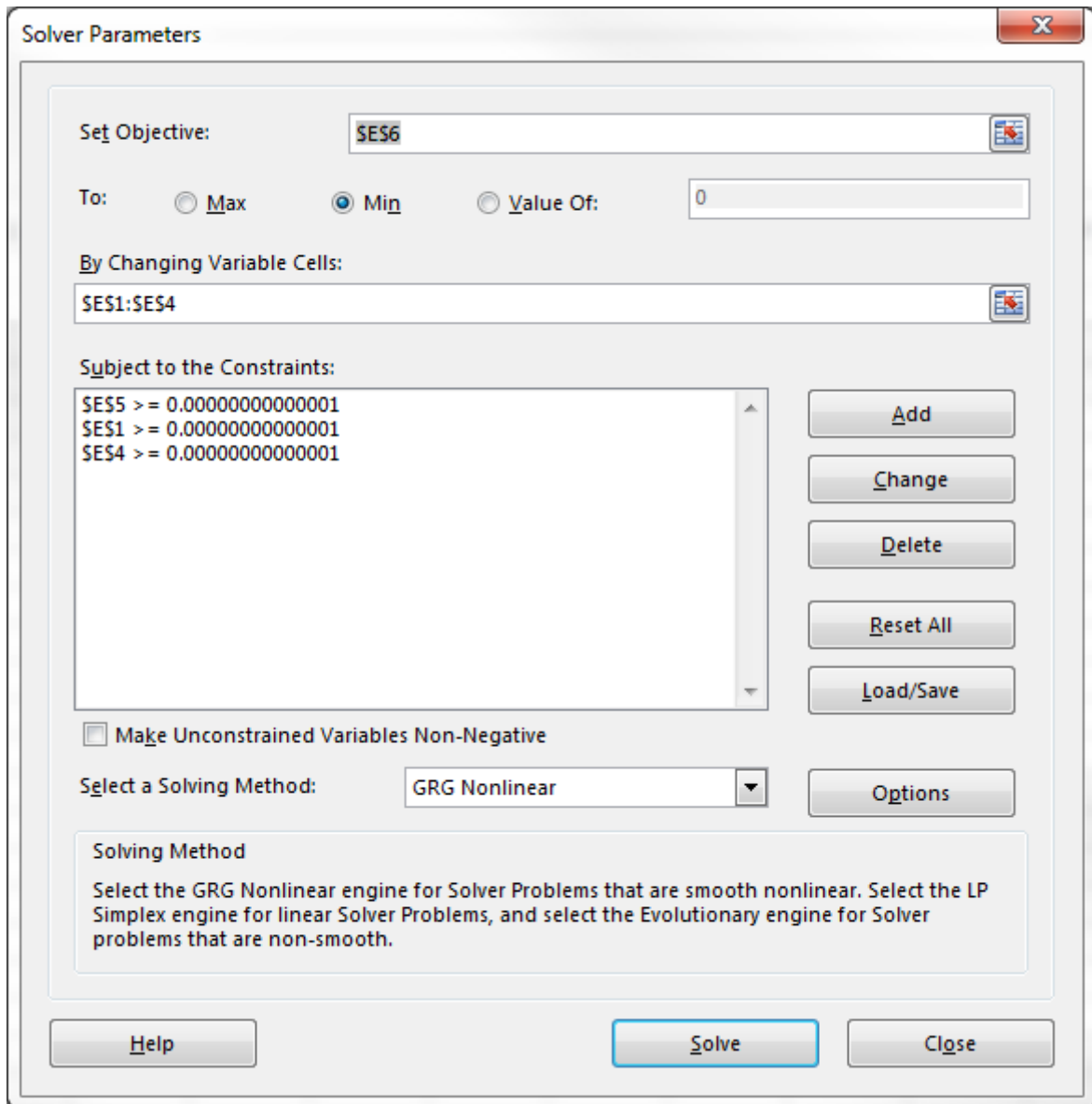
**Table 149 Nelson Siegel Curve Fitting Methodology – Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
Remaining Term to Maturity	A1	Values as calculated by cell L2 in Table 143.
Australian dollar equivalent yield	B1	Values as calculated by cell R2 in Table 144.
NS Functional Form	C1	= $\$E\$1 + \$E\$2 * ((1 - \text{EXP}(-\$E\$4 * A1)) / (\$E\$4 * A1)) + \$E\$3 * (((1 - \text{EXP}(-\$E\$4 * A1)) / (\$E\$4 * A1)) - \text{EXP}(-\$E\$4 * A1))$
Squared Residual	D1	=(B1-C1)^2
$\beta_{0t}$	E1	Starting value for $\beta_{0t}$ calculated above
$\beta_{1t}$	E2	Starting value for $\beta_{1t}$ calculated above
$\beta_{2t}$	E3	Starting value for $\beta_{2t}$ calculated above
$\lambda$	E4	Starting value for $\lambda$ calculated above <sup>24</sup>
$\beta_{0t} + \beta_{1t}$	E5	= E1+E2
Sum of Squared Residuals	E6	=SUM(D:D)

73. The solver is then set to minimize the sum of the squared residuals as shown in cell E6 by changing the values in the cells E1 through to cell E5 with the constraints set out in Figure 33. The GRG Nonlinear solver is used again and set as shown in Figure 31.

<sup>24</sup> This cell is linked to the exact solution for the decay factor in order to avoid issues associated with truncating decimal places.

Figure 33 Nelson Siegel Parameter Constraints - Excel Solver Settings



74. The solutions for  $\beta_{0t}, \beta_{1t}, \beta_{2t}$  and  $\lambda$  output in cells E1 to E4 in Table 149 are entered back into the NS functional form. The process in Excel is outlined below in Table 150 for 3, 5, 7 and 10 year tenors.

**Table 150 Nelson Siegel Yield Estimation Methodology – Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
Tenor	A1:D1	Values 3, 5, 7 and 10.
3 year AUD yield (semi-annual basis)	A2	= $\$E1+\$E2*((1-EXP(-\$E4*A1))/(\$E4*A1))+\$E3*(((1-EXP(-\$E4*A1))/(\$E4*A1))-EXP(-\$E4*A1))$
5 year AUD yield (semi-annual basis)	B2	= $\$E1+\$E2*((1-EXP(-\$E4*B1))/(\$E4*B1))+\$E3*(((1-EXP(-\$E4*B1))/(\$E4*B1))-EXP(-\$E4*B1))$
7 year AUD yield (semi-annual basis)	C2	= $\$E1+\$E2*((1-EXP(-\$E4*C1))/(\$E4*C1))+\$E3*(((1-EXP(-\$E4*C1))/(\$E4*C1))-EXP(-\$E4*C1))$
10 year AUD yield (semi-annual basis)	D2	= $\$E1+\$E2*((1-EXP(-\$E4*D1))/(\$E4*D1))+\$E3*(((1-EXP(-\$E4*D1))/(\$E4*D1))-EXP(-\$E4*D1))$
$\beta_{0t}$	E1	Solution for $\beta_{0t}$ output in cells E1 Table 149.
$\beta_{1t}$	E2	Solution for $\beta_{1t}$ output in cells E2 Table 149.
$\beta_{2t}$	E3	Solution for $\beta_{2t}$ output in cells E3 Table 149.
$\lambda$	E4	Solution for $\lambda$ output in cells E4 Table 149.

75. The yields at each tenor are output in cells A2 to D2, however are on a semi-annual basis (as if bond interest payment is made every 6 months). This needs to be annualised so that it represent an effective annual interest rate. This is done using the formulas in Table 151.

**Table 151 Annualising Semi-Annual Bond Yields - Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
3 year AUD yield (annual basis)	A3	= $((1+A2/200)^2-1)*100$
5 year AUD yield (annual basis)	B3	= $((1+B2/200)^2-1)*100$
7 year AUD yield (annual basis)	C3	= $((1+C2/200)^2-1)*100$
10 year AUD yield (annual basis)	D3	= $((1+D2/200)^2-1)*100$

76. The value in D3 is the Nelson Siegel 10 year cost of debt estimate. This value averaged with the 10 year cost of debt estimate from the other two methods is the Authority's final 10 year cost of debt estimate.

## The Nelson-Siegel Svensson method

77. The Nelson-Siegel Svensson methodology assumes that the term structure of the cost of debt has the parametric form shown below:

$$\hat{y}_t(\tau) = \beta_{0t} + \beta_{1t} \left( \frac{1 - e^{-\tau/\lambda_1}}{\tau/\lambda_1} \right) + \beta_{2t} \left( \frac{1 - e^{-\tau/\lambda_1}}{\tau/\lambda_1} - e^{-\tau/\lambda_1} \right) + \beta_{3t} \left( \frac{1 - e^{-\tau/\lambda_2}}{\tau/\lambda_2} - e^{-\tau/\lambda_2} \right)$$

Where

$y_t(\tau)$  is the yield at time  $t$  for maturity  $\tau$ ; and

$\beta_{0t}, \beta_{1t}, \beta_{2t}, \beta_{3t}, \lambda_1, \lambda_2$  are the parameters of the model to be estimated from the data.

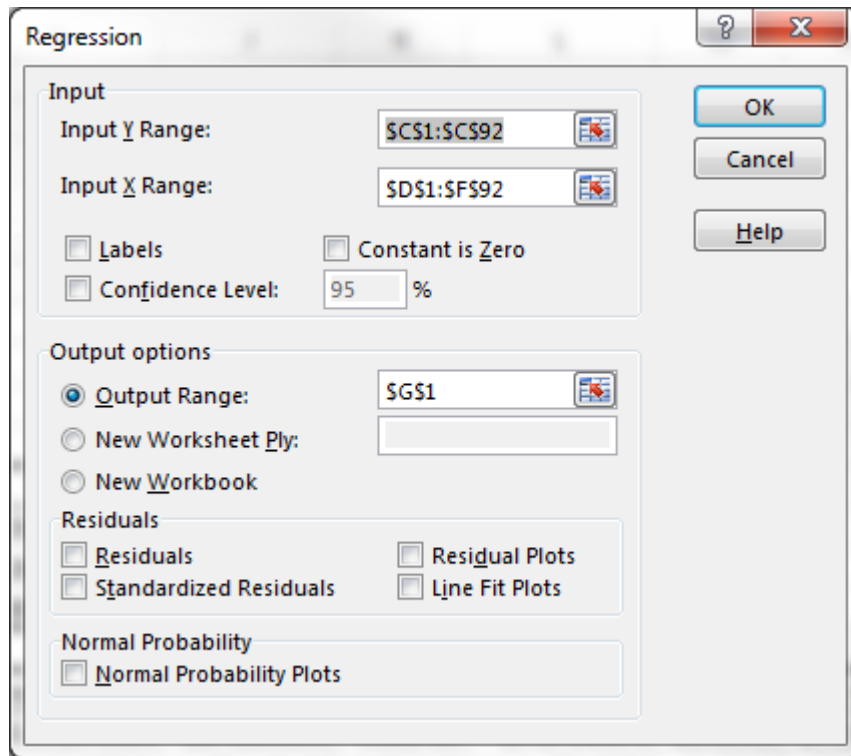
78. The Nelson-Siegel Svensson (**NSS**) methodology uses observed data from the bond market to estimate the parameters  $\beta_{0t}, \beta_{1t}, \beta_{2t}, \beta_{3t}, \lambda_1$  and  $\lambda_2$  by using the observed yields and maturities for bonds. With the estimated parameters  $\beta_{0t}, \beta_{1t}, \beta_{2t}, \beta_{3t}, \lambda_1$  and  $\lambda_2$ , a yield curve is produced by substituting these estimates into the above equation and plotting the resulting *estimated yield*  $\hat{y}(\tau)$  by varying the maturity  $\tau$ .  $\hat{y}(\tau)$  has the interpretation of being the *estimated yield* for a benchmark bond with a maturity of  $\tau$  for a given credit rating.
79. The NSS methodology uses two decay factors  $\lambda_1$  and  $\lambda_2$ . At each annual update the starting values for these parameters are based on the previous years' final estimates.
80. The decay factors are substituted as constants into the terms attached to  $\beta_{1t}$ ,  $\left( \frac{1 - e^{-\tau/\lambda_1}}{\tau/\lambda_1} \right)$ ,  $\beta_{2t} \left( \frac{1 - e^{-\tau/\lambda_1}}{\tau/\lambda_1} - e^{-\tau/\lambda_1} \right)$  and  $\beta_{3t} \left( \frac{1 - e^{-\tau/\lambda_2}}{\tau/\lambda_2} - e^{-\tau/\lambda_2} \right)$ .
81. These terms are then set as a function of each bond's remaining term to maturity as shown for cell L2 in Table 143. This will result in a  $\beta_{1t}$  weight,  $\beta_{2t}$  weight and  $\beta_{3t}$  weight for every bond in the sample.
82. An Ordinary Least Squares (**OLS**) regression is carried out using the Excel Data Analysis tools' 'Regression' function.

**Table 152 Nelson Siegel Svensson Starting Value Regression – Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
Decay factor $\lambda_1$	A1	Last years' $\lambda_1$ .
Decay factor $\lambda_2$	A2	Last years' $\lambda_2$ .
Maturity ( $\tau$ )	B1 down	The results of from cell L2 in Table 143.
Australian dollar equivalent yield	C1 down	Values as calculated by cell R2 in Table 144.
$\beta_{1t}$ weight factor	D1 down	$=((1-EXP(-B1/\$A\$1))/ (B1/\$A\$1))$
$\beta_{2t}$ weight factor	E1 down	$=((((1-EXP(-B1/\$A\$1))/ (B1/\$A\$1)))- (EXP(-B1/\$A\$1)))$
$\beta_{3t}$ weight factor	F1 down	$=((((1-EXP(-B1/\$A\$2))/ (B1/\$A\$2)))- (EXP(-B1/\$A\$2)))$

83. The Y input values are the Australian dollar yield equivalents output for each bond as shown in cell R2 in Table 144. The X input values are the entire series of  $\beta_{1t}$ ,  $\beta_{2t}$  and  $\beta_{3t}$  weight factors associated with each of the bonds. The 'Constant is zero' box shown in Figure 34 should be left unchecked so that an intercept term is included in the regression which will serve as a starting value for  $\beta_{0t}$  .

**Figure 34 Nelson Siegel Svensson Starting Value Regression – Microsoft Excel Regression Settings**



84. The intercept, X Variable 1, X Variable 2 and X Variable 3 appear under the coefficients in the output table. These are used as the starting value estimates for  $\beta_{0t}, \beta_{1t}, \beta_{2t}$  and  $\beta_{3t}$  respectively while the values in cell A1 and A2 in Table 152 are used as the starting value for  $\lambda_1$  and  $\lambda_2$ .<sup>25</sup> The values for these estimates are then used as an input into the final NSS curve fitting process which is outlined below. The structure within Excel is outlined in Table 153.

<sup>25</sup> This is output into cells H17, H18, H19 and H20 in the example set out above.

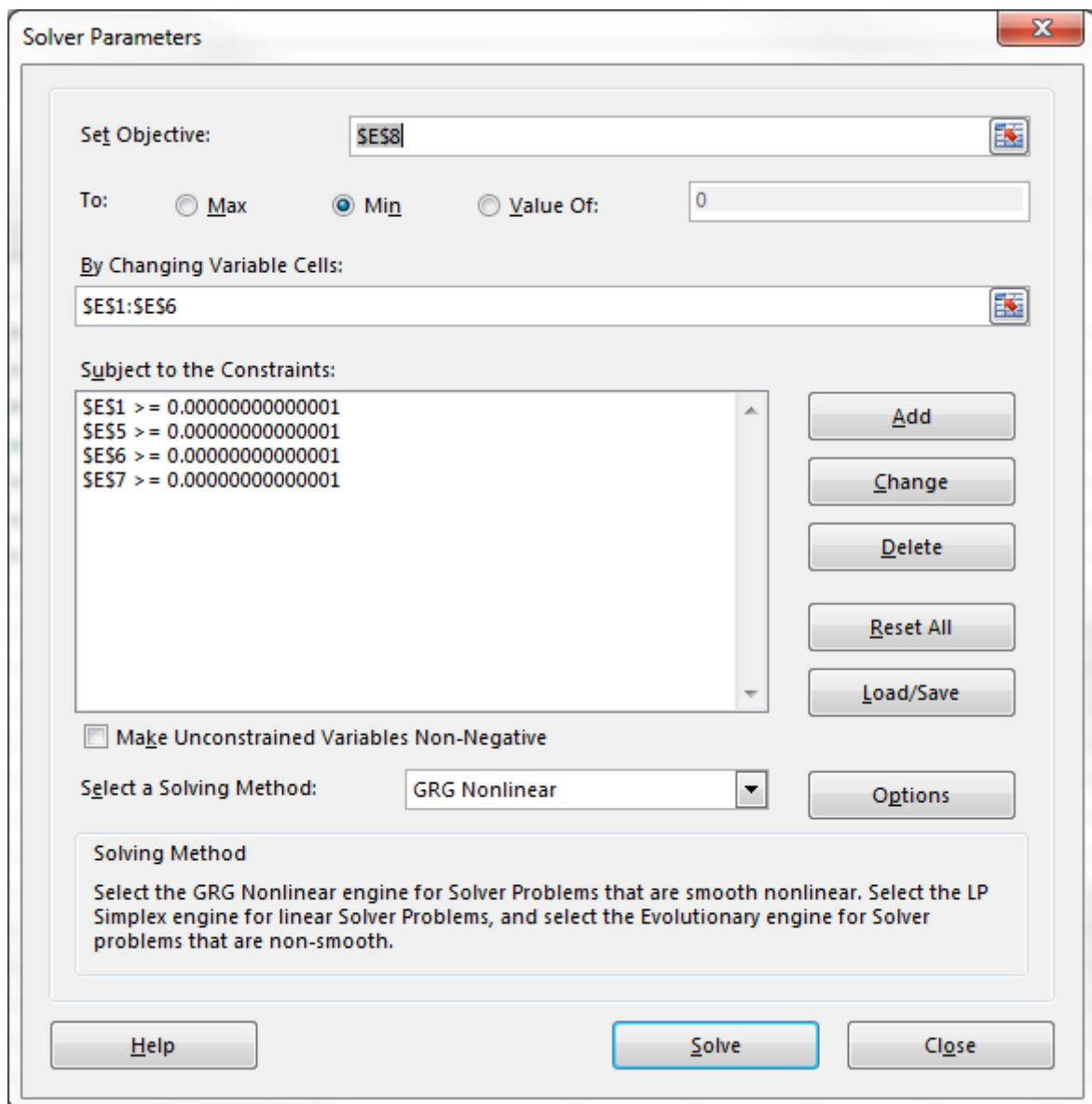


**Table 153 Nelson Siegel Svensson Yield Curve Estimation Methodology – Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
Remaining Term to Maturity	A1	Values as calculated by cell L2 in Table 143.
Australian dollar equivalent yield	B1	Values as calculated by cell R2 in Table 144.
NSS Functional Form	C1	= $\$E\$1 + \$E\$2 * ((1 - \text{EXP}(-A1/\$E\$5))/ (A1/\$E\$5)) + \$E\$3 * (((1 - \text{EXP}(-A1/\$E\$5))/ (A1/\$E\$5)) - (\text{EXP}(-A1/\$E\$5))) + \$E\$4 * (((1 - \text{EXP}(-A1/\$E\$6))/ (A1/\$E\$6)) - (\text{EXP}(-A1/\$E\$6)))$
Squared Residual	D1	= $(B1 - C1)^2$
$\beta_{0t}$	E1	Starting value for $\beta_{0t}$ calculated above
$\beta_{1t}$	E2	Starting value for $\beta_{1t}$ calculated above
$\beta_{2t}$	E3	Starting value for $\beta_{2t}$ calculated above
$\beta_{3t}$	E4	Starting value for $\beta_{3t}$ calculated above
$\lambda_1$	E5	Last years' $\lambda_1$ .
$\lambda_2$	E6	Last years' $\lambda_2$ .
$\beta_{0t} + \beta_{1t}$	E7	= E1+E2
Sum of Squared Residuals	E8	=SUM(D:D)

85. The solver is then set to minimize the sum of the squared residuals as shown in cell E8 by changing the values in the cells E1 through to cell E6 with the constraints set out in Figure 35. The GRG Nonlinear solver is used again and set as shown in Figure 31.

Figure 35 Nelson Siegel Svensson Parameter Constraints – Microsoft Excel Solver Settings



86. The solutions for  $\beta_{0t}, \beta_{1t}, \beta_{2t}, \beta_{3t}, \lambda_1$  and  $\lambda_2$  output in cells E1 to E6 in Table 153 are entered back into the NSS functional form. The process in Excel is outlined below for 3, 5, 7 and 10 year tenors (Table 154).

**Table 154 Nelson Siegel Svensson Yield Estimation Methodology – Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
Tenor	A1:D1	Values 3, 5, 7 and 10.
3 year AUD yield (semi-annual basis)	A2	= $\$E1+\$E2*((1-EXP(-A1/\$E5))/(\$E5))+\$E3*(((1-EXP(-A1/\$E5))/(\$E5))-(EXP(-A1/\$E5)))+\$E4*(((1-EXP(-A1/\$E6))/(\$E6))-(EXP(-A1/\$E6)))$
5 year AUD yield (semi-annual basis)	B2	= $\$E1+\$E2*((1-EXP(-B1/\$E5))/(\$E5))+\$E3*(((1-EXP(-B1/\$E5))/(\$E5))-(EXP(-B1/\$E5)))+\$E4*(((1-EXP(-B1/\$E6))/(\$E6))-(EXP(-B1/\$E6)))$
7 year AUD yield (semi-annual basis)	C2	= $\$E1+\$E2*((1-EXP(-C1/\$E5))/(\$E5))+\$E3*(((1-EXP(-C1/\$E5))/(\$E5))-(EXP(-C1/\$E5)))+\$E4*(((1-EXP(-C1/\$E6))/(\$E6))-(EXP(-C1/\$E6)))$
10 year AUD yield (semi-annual basis)	D2	= $\$E1+\$E2*((1-EXP(-D1/\$E5))/(\$E5))+\$E3*(((1-EXP(-D1/\$E5))/(\$E5))-(EXP(-D1/\$E5)))+\$E4*(((1-EXP(-D1/\$E6))/(\$E6))-(EXP(-D1/\$E6)))$
$\beta_{0t}$	E1	Solution for $\beta_{0t}$ output in cells E1 Table 153.
$\beta_{1t}$	E2	Solution for $\beta_{1t}$ output in cells E2 Table 153.
$\beta_{2t}$	E3	Solution for $\beta_{2t}$ output in cells E3 Table 153.
$\beta_{3t}$	E4	Solution for $\beta_{3t}$ output in cells E4Table 153.
$\lambda_1$	E5	Solution for $\lambda_1$ output in cells E5Table 153.
$\lambda_2$	E6	Solution for $\lambda_2$ output in cells E6Table 153.

87. The yields at each tenor are output in cells A2 to D2, however are on a semi-annual basis (as if bond interest payment is made every 6 months). This needs to be annualised so that it represents an effective annual interest rate. This is done using the formulas in Table 155.

**Table 155 Annualising Semi-Annual Bond Yields - Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
3 year AUD yield (annual basis)	A3	$=((1+A2/200)^2-1)*100$
5 year AUD yield (annual basis)	B3	$=((1+B2/200)^2-1)*100$
7 year AUD yield (annual basis)	C3	$=((1+C2/200)^2-1)*100$
10 year AUD yield (annual basis)	D3	$=((1+D2/200)^2-1)*100$

88. The value in D3 is the NSS 10 year cost of debt estimate. This value averaged with the 10 year cost of debt estimate from the other two methods is the Authority's final 10 year cost of debt estimate.

**Step 5: Estimate the regulatory debt risk premium**

*Automatic update additional notes – calculating the DRP*

89. The annualized 10 year cost of debt estimate from each of the three methods above is averaged to arrive at the final estimate of the 10 year cost of debt. That is, the simple average of cell F4 in Table 146, D3 in Table 151 and D3 in Table 155. The DRP is calculated as the spread between the 10 year cost of debt and the average value of the AUD 10 year IRS rate averaged over the same averaging period used for the observed AUD equivalent bond yields above. The AUD 10 year IRS rate data is downloaded from Bloomberg for each of the trading days in the averaging period. The average of these observations is then annualized assuming a semi-annual payment basis. The structure used in Excel is set out in Table 156.

**Table 156 Debt Risk Premium Calculation - Microsoft Excel Template Structure**

Attribute	Cell	Formula or entry
Trading day date	A1 down	mm/dd/yyyy
AUD 10 year IRS rate	B1 down	=BDH("ADSWAP10 Curncy","PX_LAST",A1,A1)
Average (20 day averaging period example)	B21	=AVERAGE(B1:B20)
Annualized average AUD 10 year IRS rate	B22	=((1+B21/100/2)^2-1)*100
10 year final cost of debt estimate	B23	=AVERAGE(Table 6!F4,Table 11!D3,Table 15!D3) <sup>26</sup>
10 year DRP	B24	=B23-B22

90. The value in cell B24 is the final 10 year DRP estimate which is used in calculating the return on debt.

#### Contingency approaches to data related issues

91. In the event that there are unexpected problems with the data or results of applying the automatic formulas, the Authority will adopt the following actions outlined in Table 157.

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<sup>26</sup> This formula assumes that the Excel worksheets have been named after the tables outlined above. For example, Table 6 Linear Interpolation and Extrapolation of Gaussian Kernel Estimates – Microsoft Excel Template Structure is a worksheet in Excel labelled “Table 6”. Table 6!F4 makes reference to cell F4 in Table 6.

**Table 157 Contingency approaches to data related issues**

Event	Changes to Approach
A) No bonds in the sample – resulting from the application of the bond yield approach criteria in Table 1 – have a remaining term to maturity equal to or greater than 10 years (from the last day of the nominated averaging period).	A linear extrapolation will be carried out using the formula outlined below this table and the averages of all three methods at 7 and at the effective tenor that results from target of 10 years.
B) The number of bonds in the sample result in non-robust parametric curve estimates.	Non-robust is defined as the standard deviation between yield estimates reported on a semi-annual basis using all three methods being equal to or greater than 105 basis points using the '=stdev' formula in Microsoft Excel.  Under this circumstance the averaging period will be extended by 20 trading days increments until the standard deviation between the three estimates falls under 105 basis points.
C) Bloomberg bond data becomes inaccessible.	The Reserve Bank of Australia ( <b>RBA</b> ) 'Aggregate Measures of Australian Corporate Bond Spreads and Yields' bond yield data for the BBB band credit rating will take the place of the Authority's estimates and will be extrapolated to 10 years using the equation outlined below this table.

$$y_t(10) = y_t[7] + \left( \frac{y_t[et(10)] - y_t[7]}{et(10) - 7} \right) (et(10) - 7)$$

Where:

$y_t[et(10)]$  is the average of all three methods estimated cost of debt (as per event A in Table 157) or the RBA's data (as per event C in Table 157).

$et(10)$  is the effective tenor resulting from the 10 year target reported by the Authority's Gaussian kernel approach (as per event A in Table 157) or that corresponding to the effective tenor corresponding the RBA's 10 year estimate (as per event C in Table 157).

$y_t[7]$  is the average of all three methods estimated cost of debt at a 7 year tenor (as per event A in Table 157) or the RBA's data at the target tenor of 7 years (as per event C in Table 157).<sup>27</sup>

<sup>27</sup> Event A requires the procedure outlined in paragraph 57 to interpolate the cost of debt at the 7 year tenor for the Authority's Gaussian kernel approach. This is not required for the NS and NSS curve 7 year estimates.