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RE: Impacts of the revised pole calculator

We have used data from pole inspection records provided by CitiPower & Powercor (CPP) to model the potential effects of the proposed revised pole calculator. The details of the proposed new pole calculator are included in the draft document titled “Network Asset Maintenance Policy for Serviceability Assessment of Poles” – Version D in the file name.

Before applying the new pole calculator rules, the data was cleansed as per Appendix B. The data was provided in spreadsheet form. The WoodScan data was provided separately to the regular inspection data, and was modelled in its own spreadsheet. The data relating to number of drill holes was also provided separately across four spreadsheets.

The primary areas of assessment were;

1. Impact of accuracy of diameter measurement.
2. Impact of the proposed pole calculator changes on reinforced poles
3. Impact of the new calculations for WoodScan inspections
4. Determination of appropriate limits for the number of inspection and treatment holes allowed in a pole before the pole requires remedial action.

This letter summarises the assessment that was completed.

NOTE: Any numbers that are presented are based on the assumptions that the data provided is accurate, and a current picture of the network. Other visual inspection rules, and more accurate measurement techniques may produce different actual numbers in practice. This assessment is purely looking at the potential ***relative*** impacts on replacement numbers, and numbers of poles in each serviceability category, caused by the proposed pole calculator revisions.

1 POLE CALCULATOR RESULTS

The baseline results for all poles are summarised and compared to the existing database results in Figure 1 and Table 1. The calculations assume a utilisation of 80% for all poles (design load divided by original design capacity).

Table 1: Numbers of all poles falling into each serviceability using different percentile fibre strength values, compared to current SAP records. Green highlight is recommended for the new pole calculator.

Rating	P2+ Unserviceable	P2 Unserviceable	P3 AC Serviceable	P4 Serviceable	P5 Serviceable
5th Percentile	67958	129630	58131	77959	40014
10th Percentile	21590	135688	51706	104740	59968
50th Percentile	670	5192	32404	186501	148925
SAP Records	118	4158	14093	386644	

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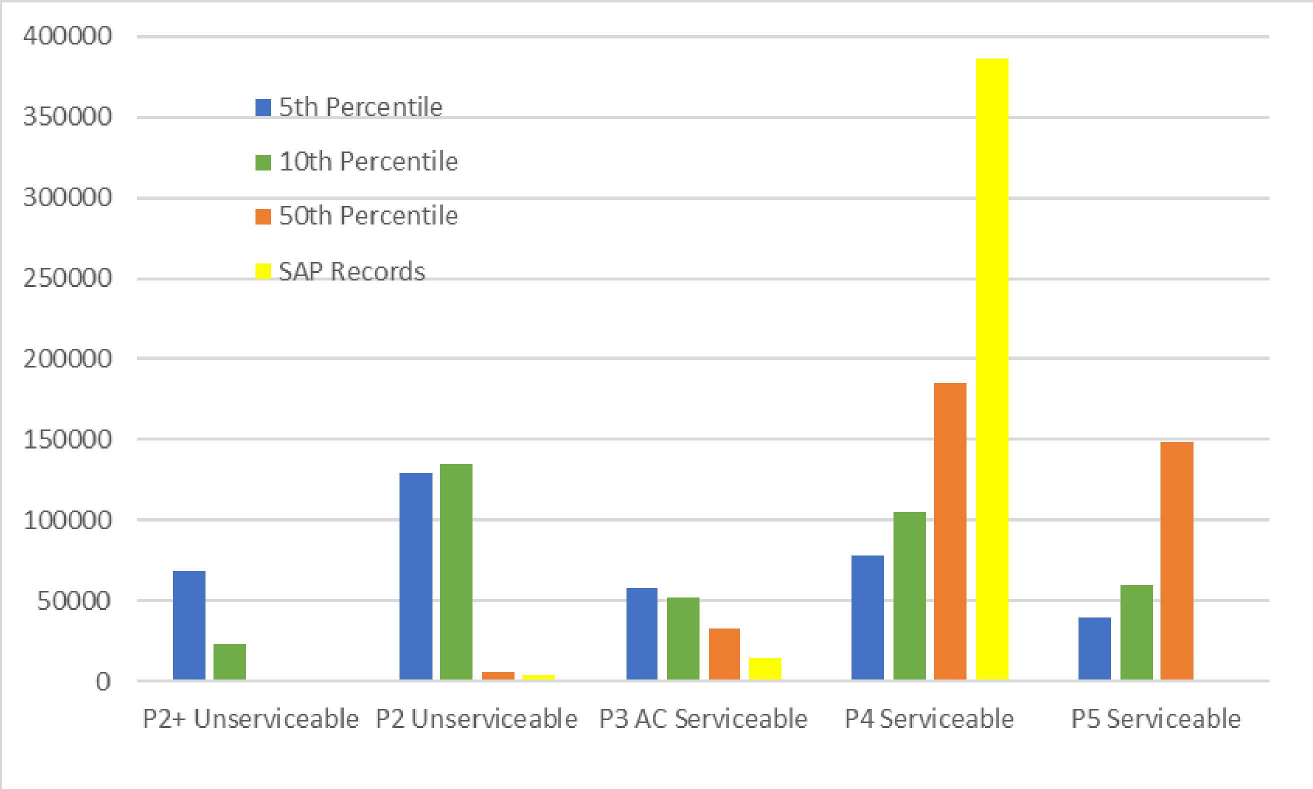

Figure 1: Distribution of serviceability ratings for all poles for a range of fibre strength percentiles, compared to the existing ratings in SAP.

2 DIAMETER SENSITIVITY

The diameter is well known to be the most critical measurement for determination of pole strength. Because the strength of a pole is a function of diameter cubed, small changes in diameter can have a significant impact on the results of an inspection.

To quantify the sensitivity of the diameter measurement, the serviceability results for the data as provided were compared to the baseline results in Section 1. The diameter used to determine the design load was left the same, but the diameter used in the strength assessment was altered by +5mm, +10mm, +20mm and -5mm, -10mm and -20mm. The results of this analysis are included in Figure 2.

Table 2: Number of poles (all poles) within each serviceability rating for different diameter adjustments.

Rating	P2+ Unserviceable	P2 Unserviceable	P3 AC Serviceable	P4 Serviceable	P5 Serviceable
+20mm	1253	2797	18852	142079	209646
+10mm	1375	3572	27112	166043	176525
+5mm	1447	4342	29327	179920	159591
Baseline	670	5192	32404	186501	148925
-5mm	1916	6300	26921	188596	150894
-10mm	2182	7995	24655	193258	146537
-20mm	3493	12642	38027	184950	135515
SAP Records	118	4158	14093	386644	

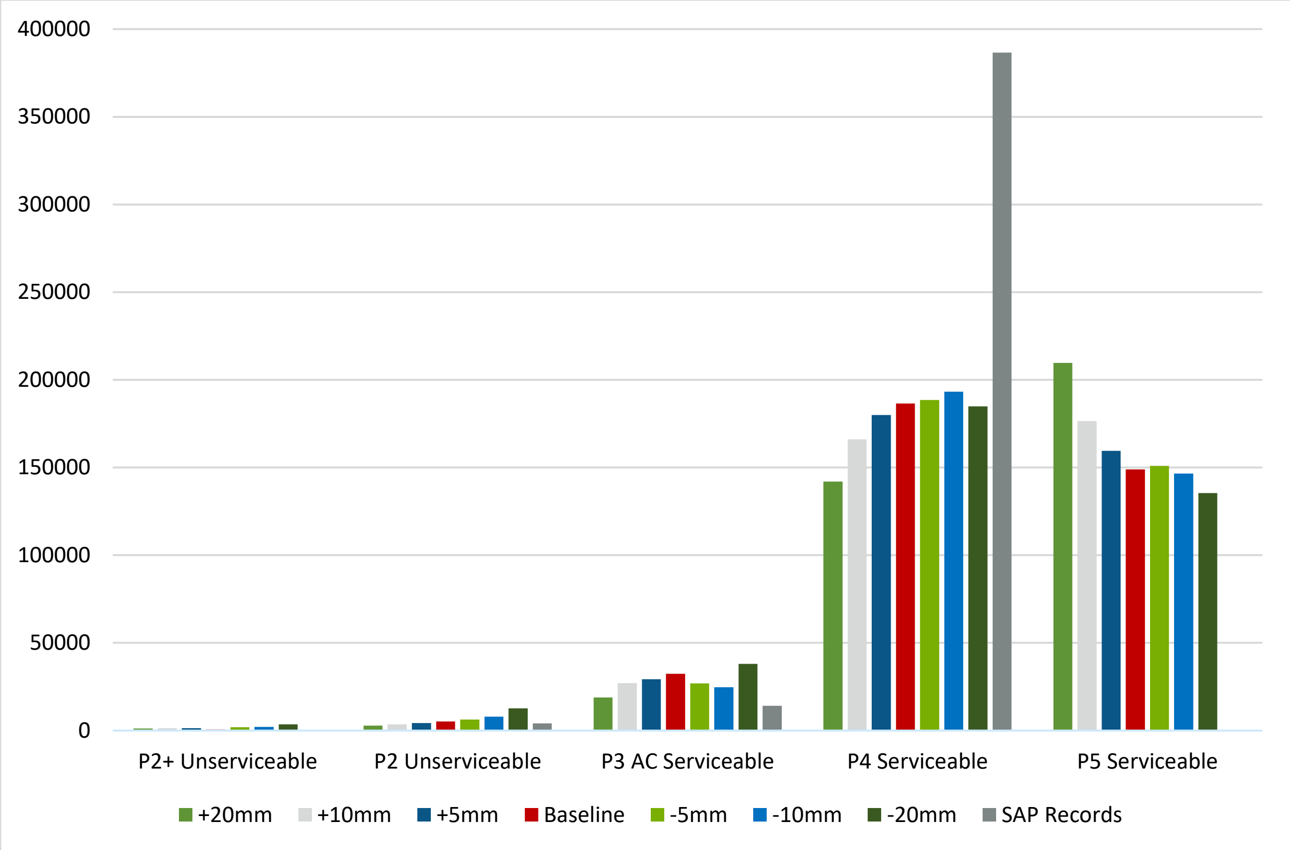

Figure 2: Serviceability assessment sensitivity to diameter measurement. SAP Serviceable poles are all in P4 serviceable.

As can be seen from the results in Figure 2, it is critical to get the diameter reading as accurate as possible, particularly within +/-10mm where possible. To avoid missing critical poles, it is especially important to ensure the original diameter/strength grade is accurate, and that the residual diameter measurement does not over-state the actual diameter.

What is interesting about the results, apart from some increases in P2+ unserviceable poles with diameter added being a data quality anomaly, is that most of the movement when the diameter is under-estimated (negative adjustment) the movement is more from P3 AC Serviceable into the Unserviceable ratings, particularly within the -5mm and -10mm adjustments.

3 REINFORCED POLES

The difference between the existing serviceability ratings of reinforced poles and those expected from the new calculator are included in Figure 3 and Table 3.

Table 3: Numbers of reinforced poles falling into each serviceability using different percentile fibre strength values, compared to current SAP records. Green highlight is recommended for the new pole calculator.

Rating	P2+ Unserviceable	P2 Unserviceable	P3 AC Serviceable	P4 Serviceable	P5 Serviceable
5th Percentile	360	3500	12424	7733	4815
10th Percentile	318	2395	2674	14773	8672
50th Percentile	298	2325	2469	8210	15530
SAP Records	31	2654	1158	26507	

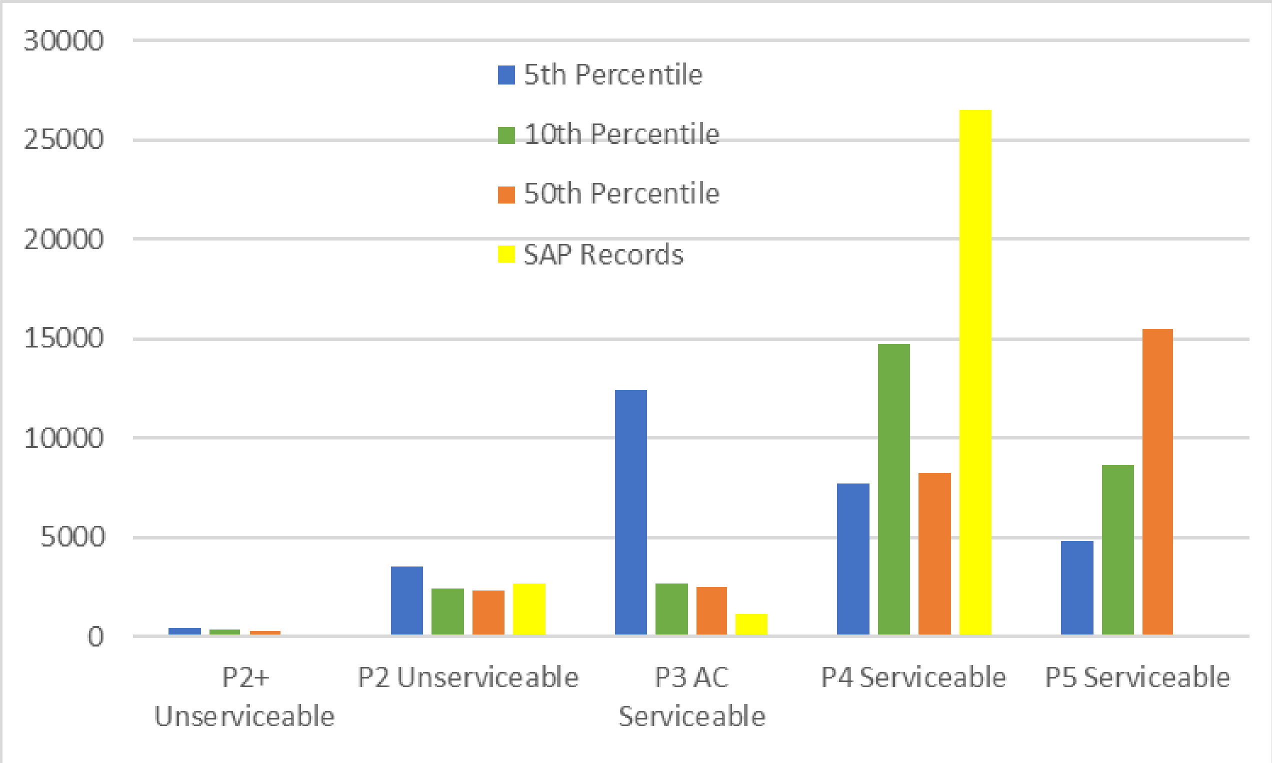

Figure 3: Reinforced pole serviceability rating comparison.

It is apparent from the results in Table 3 and Figure 3 that the new pole calculator will have a minimal effect on the serviceability classifications of reinforced poles with approximately 1,250 poles moving from serviceable into the AC Serviceable grade, or about 4%.

4 WOODSCAN IMPACTS

The WoodScan data provided by CPP was re-analysed using the proposed new Pole Calculator equations and compared to the existing database results in Table 4 and Figure 4. The calculations assume a utilisation of 80% for all poles (design load divided by original design capacity).

Table 4: Numbers of all WoodScan inspected poles falling into each serviceability rating using different percentile fibre strength values, compared to current SAP records. Green highlight is recommended for the new pole calculator.

Rating	P2+ Unserviceable	P2 Unserviceable	P3 AC Serviceable	P4 Serviceable	P5 Serviceable
5th Percentile	215	1588	1704	2401	151
10th Percentile	170	567	1050	3082	1190
50th Percentile	161	322	377	1660	3539
WoodScan Records	184	736	2111	3077	

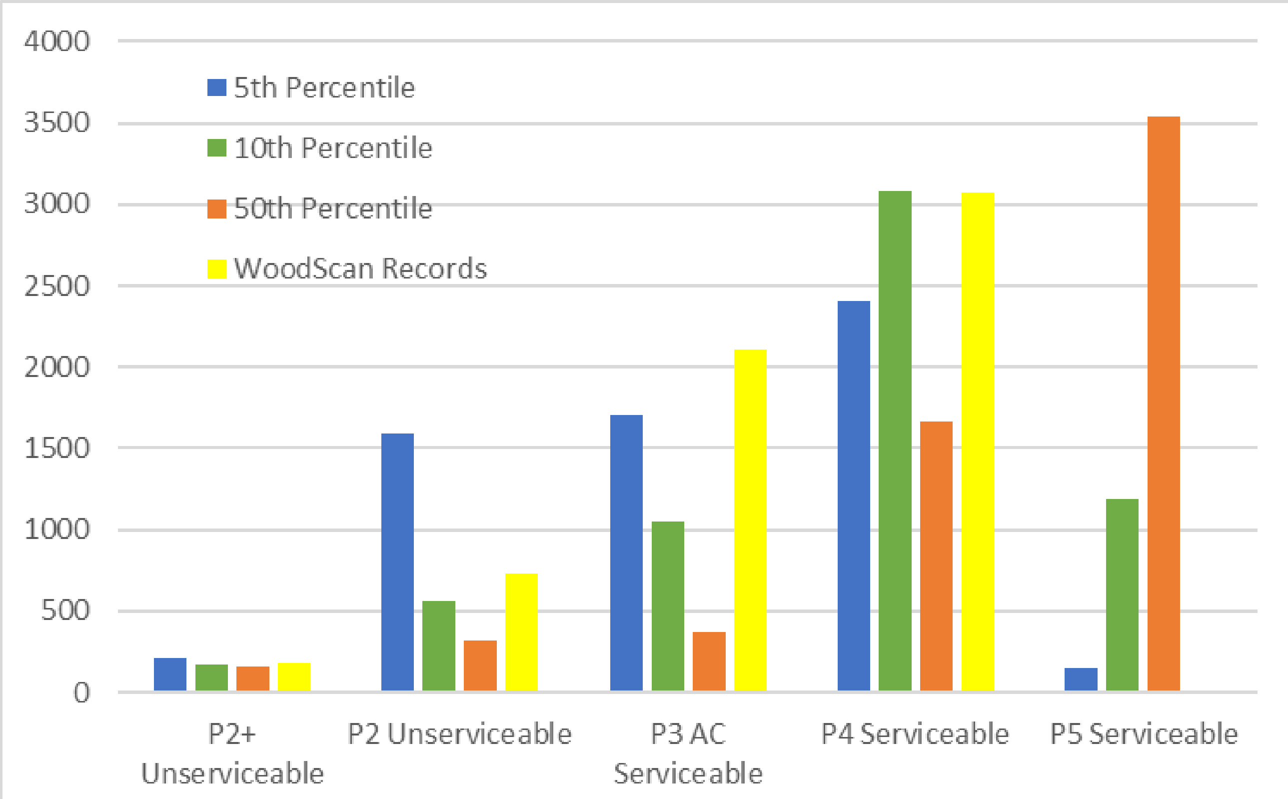

Figure 4: Distribution of serviceability ratings for all WoodScan poles for a range of fibre strength percentiles, compared to the original WoodScan rating.

Because the WoodScan device uses its own in-built calculations that are based on different Serviceability Index (SI) limits and load calculations than used in the revised Pole Calculator document, the distribution changes accordingly. Based on our review of the results, we recommend the use of the 10th percentile fibre strength values for the WoodScan device. This is possible because the cross section is more accurately known, but there is still some uncertainty around the fibre strength and whether or not the scan is taken at the most critical elevation. If the 10th percentile values are used, there is minimal difference compared with the current WoodScan results. In fact, there may be a slight reduction in condemned poles.

5 NUMBER OF INSPECTION HOLES

We were given data for number of inspection holes in each sector of the poles for different inspection times. The numbers were summed to give a total number of holes per pole then a distribution calculated and displayed in Figure 5, with the tabulated results in Appendix A. Noting that the numbers are total per pole, and not maximum within any 500mm length as recommended in the draft Pole Calculator document, the limits of 10mm and 15mm as per the document are considered suitable from a risk of failure perspective, and are unlikely to make a significant difference to the numbers of Unserviceable and AC Serviceable poles because there is likely to be significant overlap of poles in those categories with lots of holes.

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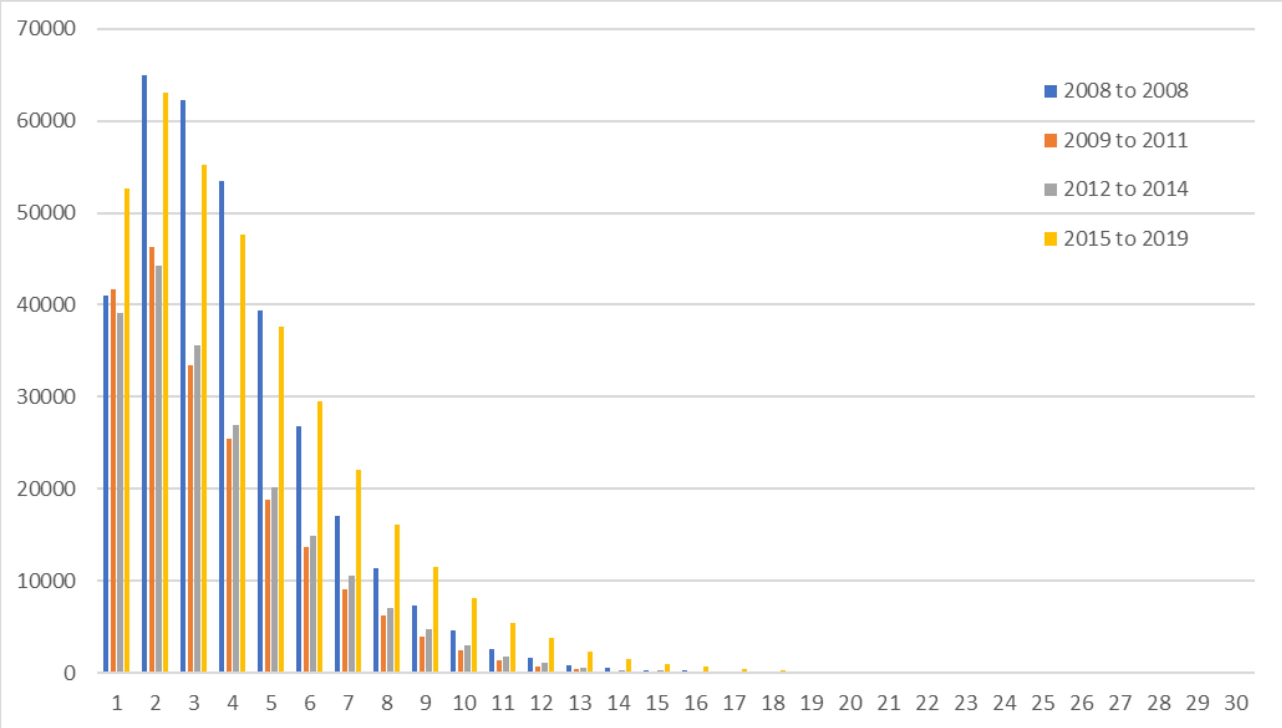

Figure 5: Number of holes per pole for different inspection periods.

6 CONCLUSIONS & RECOMMENDATIONS

Based on the results of the analyses presented in this letter, we recommend the following;

- The 50th percentile fibre strength values appear to give a reasonable improvement to current residual strength determinations, while minimising the economic impacts of implementing the new calculator.
- The new calculations detailed in the "Network Asset Maintenance Policy for Serviceability Assessment of Poles" (Version D draft) Serviceability Assessment policy perform as expected with changes in diameter.
- It is important to maximise the accuracy of diameter measurements with any method, with a range of +/-10mm having what would be considered a relatively minimal impact on the overall number of Unserviceable and AC Serviceable poles.
- There is an apparent improvement in the risk reduction for reinforced poles when using the draft pole calculator equations, with manageable additional P3 AC Serviceable poles. This is achieved through slightly higher Unserviceable P2+ rates, slightly lower Unserviceable P2 rates and higher P3 AC Serviceable rates.
- The 50th Percentile fibre strengths are recommended for reinforced poles.
- There is minimal change to the number of unserviceable poles when re-analysing the WoodScan results with the draft calculations, in fact there is a reduction in the number of P3 unserviceable poles. This is despite different serviceability index criteria used by WoodScan currently.
- The 10th Percentile fibre strength values are recommended for the WoodScan calculations.
- Based on our analysis of the number of holes in the poles from the CPP data provided, we recommend using the limit of ≥15 holes for P3 AC Serviceable and ≥10 and <15 for P4 Serviceable. The data is not configured to be able to do a real-world assessment, so the impact of these numbers needs to be monitored and adjusted if appropriate at a later date.

6.1 CERTIFICATION

We certify that the draft Pole Calculator document “Network Asset Maintenance Policy for Serviceability Assessment of Poles” as per the version D draft, will produce a reasonable reliability-based design assessment of in-service reinforced and non-reinforced wood poles, assuming the inspection data is accurate. We certify that the calculations are based on AS/NZS 7000 and good engineering practice. This certificate is based on;

- The above certificate is applicable as long as the calculations are not affected by other external factors unknown and not noted to the certifying engineer.
- The design certification is provided on the basis that materials used meet Australian Standards, and Construction practices are in accordance with industry standards.
- No modifications of significance shall be made from the documents noted herein.
- The data provided by CPP for the assessment is accurate and representative of the inspection results that are expected.
- The calculations are implemented accurately with good data quality checks in place.

We trust the above information satisfies your requirements.

Sincerely,

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APPENDIX A NUMBER OF HOLES – TABULAR DATA

No. Holes per Pole	Reports provided by Powercor			
	Report 1	Report 2	Report 3	Report 4
1	41016	41699	39154	52690
2	64896	46224	44203	63061
3	62255	33403	35547	55199
4	53461	25459	26900	47640
5	39328	18884	20164	37620
6	26823	13743	14941	29463
7	17016	9136	10555	22119
8	11331	6183	7119	16171
9	7332	3883	4739	11509
10	4569	2497	2937	8099
11	2644	1349	1847	5412
12	1634	658	1061	3752
13	899	401	583	2357
14	590	218	345	1506
15	354	140	243	978
16	242	71	157	670
17	132	46	111	451
18	88	32	48	311
19	53	16	29	195
20	53	17	23	142
21	37	6	8	108
22	22	8	10	57
23	11	3	4	38
24	7	3	3	37
25	6	1	1	21
26	8	0	3	10
27	1	0	0	14
28	4	0	1	6
29	4	0	0	6
30+	8	0	2	11
Total	334824	204080	210738	359653
Sum>=20	161	38	55	450
Sum>=15	1030	343	643	3055
Sum>=10	11366	5466	7416	24181
Min Date	2/01/2008	5/01/2009	2/01/2012	2/01/2015
Max Date	31/12/2008	30/12/2011	31/12/2014	10/12/2019

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APPENDIX B DATA CLEANSING

The following summarises the data cleansing steps that were undertaken to aid in the quality of the data used in this analysis. The headings refer to the title of the spreadsheet that was provided by CPP.

Note, all data was sorted by Equipment Number.

B.1 POLE CALC INPUT_ALL POLE EQUIP

- If the "Sound Wood 400 below stakes" field was >0, the pole was considered to be reinforced.
- There was no diameter at the top of the stakes, so the ground line diameter was used for reinforced pole strength.
- The reinforcement used was not in the data provided, so the reinforcement assessment is based on the capacity of the wood at the top of the reinforcement only, and more condemned poles may be expected when including the reinforcement strength, but this is not expected to be any different to the old pole calculator.
- Figure 7 shows the codes that were used to group different model numbers and species codes to simplify the analysis.
- Pole age was calculated from the construction year and the notification date. Negative numbers are to be ignored. Construction year values of 1900 were set to unknown, as were any blank years or notification dates.
- Added a column of strength groups
- The Strength rating field was simplified to just numbers, as per Figure 6.

B.2 HOLE DATA

- The hole data was aggregated for each pole based on the data provided per sector.
- Only the most recent inspection data was used for each sector.

B.3 WOODSCAN DATA

- The species was cleansed as per the same process for the other sheets above.
- The rest of the data was used as presented.

EQP: Strength	Strength (kN)
12 Kilonewton	12
1.5 Kilonewton	1.5
8 Kilonewton	8
3 Kilonewton	3
5 Kilonewton	5
1 Kilonewton	1
20 Kilonewton	20
Unknown	Unknown
2 Kilonewton	2
A	5
6 Kilonewton	6
B	8
24 Kilonewton	24
60 Kilonewton	60
40 Kilonewton	40

Figure 6: Consolidated strength field relationship for Steel & Concrete.

EQP: Model number	Simple Material	Strength Group	Consolidated Code
CC-CONCRETE	Concrete	NA	CC-CONCRETE
GS-GALVANISED STEEL	Steel	NA	GS-GALVANISED STEEL
SP-STEEL PAINTED	Steel	NA	SP-STEEL PAINTED
CI-CAST IRON	Steel	NA	CI-CAST IRON
SB-STOBIE	Steel	NA	SB-STOBIE
IR-STEEL I BEAM	Steel	NA	IR-STEEL I BEAM
GG-MOUNTAIN GREY GUM	Wood	S3	MT-MOUNTAIN GREY GUM
GI-GREY IRONBARK	Wood	S1	GI-GREY IRONBARK
TW-TALLOWWOOD	Wood	S2	TW-TALLOWWOOD
ZZ-WOOD UNKNOWN	Wood	S3	ZZ-WOOD UNKNOWN
PR-PINUS RADIATA	Wood	S6	PR-PINUS RADIATA
IB-IRONBARK	Wood	S2	IB-IRONBARK
BW-RED BLOODWOOD	Wood	S3	BW-RED BLOODWOOD
GG-GREY GUM	Wood	S1	GG-GREY GUM
GB-GREY BOX	Wood	S1	GB-GREY BOX
RI-RED IRONBARK	Wood	S2	RI-RED IRONBARK
WM-WHITE MAHOGANY	Wood	S2	WM-WHITE MAHOGANY
BI-BROAD LEAF IBARK	Wood	S1	BI-BROAD LEAF IBARK
BB-BLACKBUTT	Wood	S2	BB-BLACKBUTT
WSB-WHITE STRINGB	Wood	S3	WS-WHITE STRINGB
MS-MESSMATE STRINGB	Wood	S3	MS-MESSMATE STRINGB
SG-SPOTTED GUM	Wood	S2	SG-SPOTTED GUM
YSB-YELLOW STRINGB	Wood	S3	YS-YELLOW STRINGB
MA-MOUNTAIN ASH	Wood	S4	MA-MOUNTAIN ASH
CG-MOUNTAIN GREY GUM	Wood	S3	MT-MOUNTAIN GREY GUM
MM-MESSMATE STRINGB	Wood	S3	MS-MESSMATE STRINGB
MT-MOUNTAIN GREY GUM	Wood	S3	MT-MOUNTAIN GREY GUM
BS-STRINGB BROWN	Wood	S3	BS-STRINGB BROWN
WS-WHITE STRINGB	Wood	S3	WS-WHITE STRINGB
RW-RED BLOODWOOD	Wood	S3	BW-RED BLOODWOOD
QB-WHITE TOPPED BOX	Wood	S3	QB-WHITE TOPPED BOX
ST-SILVERTOP ASH	Wood	S3	ST-SILVERTOP ASH
ZW-WOOD DISC UNKNOWN	Wood	S3	ZZ-WOOD UNKNOWN
VT-VERTEC HUME	Concrete	NA	VT-VERTEC HUME
YS-YELLOW STRINGB	Wood	S3	YS-YELLOW STRINGB
P-PINUS RADIATA	Wood	S6	PR-PINUS RADIATA
RS-RED STRINGB	Wood	S3	RS-RED STRINGB
CB-COSTAL GREY BOX	Wood	S1	GB-GREY BOX
TP-TURPENTINE	Wood	S3	TP-TURPENTINE
SS-SILVERTOP STRINGB	Wood	S2	SS-SILVERTOP STRINGB
SY-SYDNEY BLUE GUM	Wood	S3	SY-SYDNEY BLUE GUM
NI-NARROW LEAF IBARK	Wood	S2	NI-NARROW LEAF IBARK
RG-RED GUM	Wood	S3	RG-RED GUM
WT-WHITE TOPPED BOX	Wood	S2	QB-WHITE TOPPED BOX
NB-BLACKBUTT NENG	Wood	S3	NB-BLACKBUTT NENG
RM-RED MAHOGANY	Wood	S2	RM-RED MAHOGANY

Figure 7: Consolidated values for Wood Pole Records.

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