NEED/OPPORTUNITY STATEMENT (NOS)

TL Grillage Condition

NOS- 000000001523 revision 4.0

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Project reason: Capability - Asset Replacement for end of life condition
Project category: Asset Renewal Strategy

Approvals

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Date submitted for approval	25 November 2016	

Change history

Revision	Date	Amendment
0	13 July 2016	Initial issue
1	9 August 2016	Update to 2016/17 dollars
2	19 October 2016	Updates to document
3	21 October 2016	Updates to document
4	25 November 2016	Update to format

1. Background

A considerable number of TransGrid's earliest transmission towers have been installed with grillage foundations, where the footings are constructed from hot-dip galvanised steel members formed into a grill and direct buried. This type of foundation did not use any concrete relying on the steel frame and the encapsulated soil as the foundation support for the tower superstructure. These towers are approximately 50 to 60 years old. Sacrificial anodes have been installed at various times on these towers to provide galvanic cathodic protection as a mitigation measure against footing corrosion. Grillage footings on 26 structures in the Dapto area were concrete encased in 1988. This was largely to address grillage steelwork corrosion issues.

A field assessment of the cathodic protection system and grillage condition on a sample of towers conducted in April 2016 has concluded that the installed sacrificial anodes are no longer providing sufficient protection against tower footing steelwork corrosion[1]. It is expected that these anodes have been consumed while providing sacrificial protection to the buried tower foundations and therefore have reached the end of their useful life. Furthermore, metal loss of the footings is expected in areas of aggressive soil. Buried wooden grillages also exist on 97K line, which are expected to be in poor condition.

2. Need/opportunity

Corrosion of buried steelwork is coupled to the soil exposure classification, as described in AS2159[2], which determines the rate at which buried steel is expected to corrode in various ground and environmental conditions. Each structure with grillage foundations in the network has been assessed by a Subject Matter Expert using the following inputs to estimate soil aggressiveness:

- Australian Soil Classification
- Acid Sulphate Soils
- Proximity of Estuary/Watercourse
- Salinity

The results of the assessment are summarised in Table 1.

Based on the results of the April 2016 field assessment, it is expected that the currently installed sacrificial anodes have depleted and are no longer providing protection against corrosion of buried steelwork.

Condition assessments have since been carried out on three grillage footings on three structures by excavating the grillage, inspecting for corrosion and backfilling with concrete. The findings are summarised in Table 2. One footing was identified with significant steel loss on the major grillage member. It is expected that this level of steel loss has occurred, despite the mild soil aggressiveness ranking, as no sacrificial anode had been installed on the structure. The other two footings investigated had sacrificial anodes in the past and exhibited only minor rusting consistent with their soil aggressiveness classification.

[1] Refer to Grillage Foundations Investigation Report on PDGS.
[2] AS2159 – Piling-Design and Installation

Table 1 – Classification of Grillage Soil Aggressiveness

Aggressiveness Ranking	Location Features	Expected Soil Aggressiveness	Quantity of Structures
1	Rocky terrain with nil probability of Acid Sulphate Soils	Non-aggressive	Nil
2	Acid sulphate soils class C or any other unclassified soils	Mild	1,165
3	Acid sulphate soils class B typically sodosol in wet/riparian areas or dermasols close to a watercourse	Moderate	883
4	Acid sulphate soils class B or C AND a soloth/solodic soils (saline) soil type	Severe	219
5	Acid sulphate soils class A typically hydrosols located in wet/riparian areas or floodplains	Very Severe	94

Table 2 – Grillage Condition Assessment Findings

Transmission line	Structure	Anode previously installed	Inspection findings	Soil aggressiveness ranking
18	5	Yes	Minor rusting	2 (Mild)
18	61	No	Significant metal loss (approx. 4mm)	2 (Mild)
24	8	Yes	Minimal rusting	2 (Mild)

As accelerated steel corrosion of the critical foundation members can lead to structural failure of tower, it has been identified that this issue will require rectification on all identified towers. It is expected that in non-aggressive to moderately aggressive soils, steel grillage foundations will require as a minimum installation of a new sacrificial anode to extend the life of the foundation by preventing further metal loss. In severely to very severely aggressive soils, past experience would suggest the footings are expected to already have experienced significant metal loss and require rectification work. A summary of the soil aggressiveness classification quantities for structures with grillage foundations on each transmission line is in Table 3.

Table 3 – Transmission line soil aggressiveness classification summary

Line	Soil Aggressivity Score				Total
	1	2	3	4	5	
1		99	139	33	7	278
10		2				2
11		27				27
16		69				69
17		19				19
18		64				64
2		159	189	55	7	410
21		107				107
24		36				36
2M		18				18
35		1				1
36		1				1
4		99	129	31	3	262
5		101	138	32	8	279
65		11	12	4		27
66		15	27	5		47
8		138				138
88		14				14
9		31	60	12	4	107
90		1				1
970		11	9	3		23
97K (timber)					36	36
990			3	1		4
995		1	2			3
999		106	126	29	27	288
99X		7	9	5	1	22

Line	Soil Aggressivity Score					Total
	1	2	3	4	5	
9R5		6	9	2		17
9R6		1	1	1		3
U1		6	9	3		18
U3		3	12	2		17
U5		5	6		1	12
U7		7	3	1		11
Grand Total	0	1165	883	219	94	2361

The risk cost associated with the issues identified in Table 1 is $15.84m per annum (refer Attachment 1).

Considering the prevalence of severe and very severe corrosive soil conditions in the vicinity of many of the towers the risk of section loss of grillage foundations steel members may be significant without some form of corrosion protection in place. In areas where the soil is more aggressive, it is expected that some section loss of grillage foundations steel members has already occurred. As these members are critical load bearing and support members of the tower, they cannot be easily remediated if the condition passes a stage where rectification work is not possible.

As grillage foundations are the primary support for the towers, relying on the soil around them to provide the required capacity as a system, accurate inspection of the foundations is extremely difficult with high risk in the case of tension structures in up-lift.

The benefit of addressing the grillage condition issues across the entire network is to continue providing the service at a lower risk of failure.

3. Related needs/opportunities

A number of transmission lines with grillages are planned for refurbishment in 2018-2023. There may be delivery efficiencies in combining the works.

4. Recommendation

It is recommended that options be considered to address the identified need/opportunity by 2023.

Attachment 1 - Risk costs summary

Summary of results is attached below. Refer to supporting document in PDGS for full risk assessment.

Current Option Assessment - Risk Summary

Project Name: Grillage Foundation Cathodic Protection Renewal

Option Name: 1523 - Base Case

Option Assessment Name: 1523 - Option 1 - Assessment 1

Rev Reset Period: Next (2018-23)

Major Component	No.	Minor Component	Sel. Hazardous Event	LoC x CoF ($M)	Failure Mechanism	NoxLoC xCoF ($M)	PoF (Yr 1)	Total Risk ($M)	Risk ($M) (Rel)	Risk ($M) (Op)	Risk ($M) (Fin)	Risk ($M) (Peo)	Risk ($M) (Env)	Risk ($M) (Rep)
Structure - Mild	2048	Steel Structure	Unplanned Outage - HV (Structure - Mild)	$0.16	Structural Failure	$324.71	0.09%	$0.28	$0.28		$0.00			$0.00
Structure - Mild	2048	Steel Structure (inc Footings)	Conductor / Earth Wire / OPGW Drop (Structure - Mild)	$3.52	Structural Failure	$7,198.91	0.09%	$6.12			$0.53	$0.68	$4.90	$0.01
Structure - Moderate	313	Steel Structure	Unplanned Outage - HV (Structure - Moderate)	$0.06	Structural Failure	$19.58	0.94%	$0.18	$0.18		$0.00			$0.00
Structure - Moderate	313	Steel Structure (inc Footings)	Conductor / Earth Wire / OPGW Drop (Structure - Moderate)	$3.15	Structural Failure	$984.81	0.94%	$9.26			$0.89	$0.99	$7.37	$0.02
				$6.88		$8,528.00		$15.84	$0.46		$1.42	$1.66	$12.27	$0.03

Total VCR Risk: $0.46

Total ENS Risk: $0.00

Number of Components

The number of components used in the Risk costs summary model has been derived as follows:

- Steel Structures in mild and moderate soils as identified in Table 3 (2048).
- Steel Structures in severe and very severe soils as identified in Table 3 (313).

Probability of Failure

As per the Risk costs summary model.

Consequence of Failure

As per the Risk costs summary model.