Risk Based Vegetation Management Guide

A Guide to assessing and prioritising vegetation management outside of the requirements specified in the Electricity (Hazards from Trees) Regulations 2003

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This Guide has been prepared on the basis that the user will be appropriately trained, qualified, authorised and competent.

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Preface

The purpose of this Guide is to present a risk based methodology that provides direction on how to proactively manage fall zone trees and vegetation to improve the overall security, performance and safety of an electricity network.

A reliable and secure electricity supply is essential for communities and businesses, from a social, economic and safety perspective.

Vegetation management is critical to the performance of overhead lines. Interference with overhead lines by trees and other vegetation causes a variety of electricity supply issues ranging from transient interruptions due to vegetation touching the line, through to severe damage and outages from trees or parts of trees falling onto lines or supporting structures. Fires and other public safety issues may also arise.

Network Operators are required in accordance with the Electricity (Hazards from Trees) Regulations 2003 (the Tree Regulations) to advise tree/land owners of the tree hazard when vegetation is close to encroaching the Notice Zone or the Growth Limit Zone requirements of the Regulations.

The Tree Regulations however, do not generally deal with trees, branches and other vegetation outside of the Notice Zone. Such vegetation often affects network reliability because it is either in the fall zone of an overhead line, or the type of tree is susceptible to producing debris which can be blown into nearby lines.

Damage to lines is most evident under adverse weather conditions, and this can lead to large scale electricity outages, with some supply restorations taking many days. Respondents to an industry survey in 2012/13 estimated that about 13% of their total System Average Interruption Duration Index (SAIDI) minutes were caused by trees. The industry working group considering this survey noted that in their experience approximately 60 - 70% of outages in big storms could be attributed to trees.

Predicting exactly which trees or branches are hazardous or likely to fail can be difficult. The industry also recognises that removal of all fall zone vegetation to eliminate potential outages is unacceptable from a social, economic, environmental and/or aesthetic perspective.

Therefore, a risk based approach that considers a range of attributes including tree species, the risks (likelihood and consequence) and costs of vegetation around lines has been proposed.

The Guide will assist Network Operators in prioritising trees and vegetation not covered by the requirements of the Tree Regulations but that may damage or otherwise contact electric lines because of their close proximity.

Being outside the scope of the regulations, achieving these clearances will be reliant on the agreement and buy-in from tree owners.

It is recognised that there is additional cost of managing or removing vegetation in the fall zone, but costs may be minimised if this work can be incorporated with Notice Zone or Growth Limit Zone work.

Additional costs may also be considered worthwhile when weighed against the benefits – for example when the work improves the security of supply, reducing the likelihood of a major disruption.

The Guide will be monitored and revised periodically.

Suggestions for changes should be sent to the Electricity Networks Association.

See www.electricity.org.nz for contact details.

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1 Introduction

The purpose of this Guide is to present a risk based methodology that provides direction on how to proactively manage vegetation risk, for the purpose of improving the overall security of supply, performance and safety of an electricity network. It also provides commentary on working with land/tree owners to manage vegetation risk near lines.

A risk based methodology can improve the resilience of the network to vegetation related faults that can occur under normal or adverse weather conditions, and will help identify where vegetation management work beyond that mandated by the Electricity (Hazards from Trees) Regulations 2003 (the Tree Regulations) can be most effective in improving reliability. This Guide describes a general approach (one example) to a risk based methodology. It is recognised that individual Network Operators may have documented and implemented other methodologies based on their company's risk management strategies.

Risk based work should be considered as part of a complete approach to vegetation management alongside Tree Regulations programmes of tree trimming and tree removal, growth inhibitor application, track clearance and public safety education.

Use of this Guide is encouraged but not mandatory. Adopting a risk based approach is considered to be good practice, but in adoption of this approach, Network Operators need to recognise that there are limitations of physical and financial resources, and there may be conflicting priorities.

2 Background

Vegetation attributed outages were the third highest contributor to unplanned supply interruptions[1] on New Zealand electricity networks in 2014. These outages can affect tens of thousands of residential customers and disrupt businesses and communities. Public safety issues can also arise, for example when trees can contact or bring down lines.

ENA members reported in a 2012/13 survey that approximately 13% of all recorded SAIDI (system interruptions) was due to trees, despite a decade of work under the Tree Regulations, and considerable expenditure on vegetation management. The industry working group considering this survey noted that in their experience approximately 60 - 70% of outages in storm events could be attributed to trees. The industry working group concluded that this was because the Tree Regulations have a relatively narrow coverage. Trees outside of the zones mandated by the Regulations can fall onto lines, and branches and other bits of vegetation can also contact lines in certain situations such as storm events. Trees can also fail due to, for example, disease or age. While predicting exactly which trees or branches will contact lines can be difficult, a risk management approach to vegetation within the fall zone may reduce the likelihood and impact of such events. Equally, industry recognised that removal of all fall zone vegetation is unacceptable from a social, economic, environmental or aesthetic perspective, and recommended that a risk based approach be prepared. This approach could then be utilised by Network Operators and inform discussions with tree/land owners to reduce the risks associated with trees near power lines. Risk management also considers the impact or consequence of an event.

[1] PWC Electricity Line Business 2014 Information Disclosure Compendium – data relates to the year end 31 March 2014.

The industry is also conscious that between 2010 and 2015, there has been an increase in the number of major storm events in New Zealand – and globally, resulting in significant damage to overhead lines and prolonged outages lasting several days. The Government agency NIWA, predicts that these events are likely to increase in frequency over the next 50 years[2] and therefore it can be expected that more attention will be needed to ensure that tree related outages don't cause undue disruption to electricity supply. Drier conditions have also increased fire risks, requiring careful management of both network assets and vegetation in the vicinity of electric lines.

3 Scope

This document provides guidance for Electricity Network Operators on how to improve public safety and network performance outcomes by increasing the resilience of the network to vegetation related incidents through the process of identification and ranking the risk of potentially hazardous trees, and the removal or treatment of the hazards.

The Guide describes an example of a risk based approach. A risk based approach will help determine priorities in regard to seeking wider vegetation clearances (beyond that set out in the Tree Regulations) for the purpose of improving network resilience.

It uses the underlying principles of risk management as described in AS/NZS ISO 31000:2009. Appropriate risk assessment will identify areas of the network where it is advisable to either carry out vegetation management to a set of deterministic criteria and/or take alternative actions to reduce the risk of network damage. Figure 1 below shows a hierarchy of risk with respect to the influence of business outcomes, starting with the highest level of system risk, and moving down to individual tree risk. Detail level increases as individual tree risks are identified.

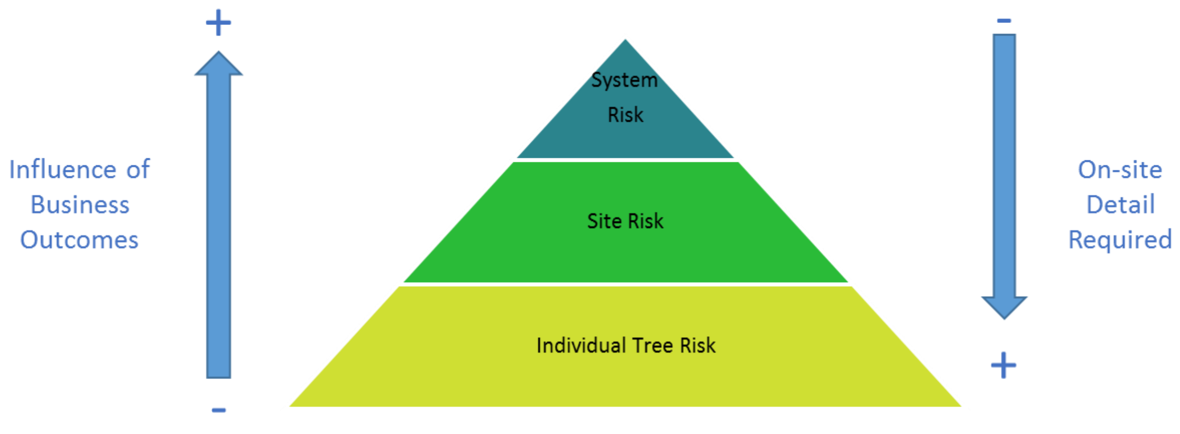


Figure 1: Risk Hierarchy

It also highlights the need for the co-operation of all stakeholders. Network Operators should consider the benefits of good engagement with tree/land owners including educating and informing tree owners of the reasons for, and the benefits of, risk reduction. Clearly, benefits to both tree/land owners and

[2] NIWA Client Report WLG2010-31 – Scenarios of storminess and Regional Wind Extremes under Climate Change. March 2011.

Network Operators include reduced potential for damage, increased reliability of electricity supply, and improved safety.

> Note 1: The Guide focuses on vegetation management to improve network resilience. It is noted that there are other options for improving resilience but these are outside the scope of this document.
>
> Note 2: The Guide is essentially a technical document. While there are other important issues such as environmental protection, standards of workmanship, and dealing with land owners and tree owners, these issues are outside the scope of this document.
>
> Note 3: The Guide only deals with planned proactive measures. It is not designed to provide guidance on management of vegetation under emergency conditions such as in a major storm event, or regular works undertaken to meet the requirements of the Regulations.

Inappropriate planting of trees under lines, and planting of trees that may in future encroach the Growth Limit Zone can be a real risk to Network Operators. It is recognised that tree growth rates and mature tree heights vary across the country due to climatic conditions, therefore any planting guides should be developed by Network Operators to suit the local conditions. Planting guides are outside the scope of this Guide.

The document should also be helpful in assessing and prioritising current and future budgets by allocation of appropriate funding to risk based activities.

4 Glossary

General definitions are included in the Electricity Act, Regulations, Standards, Industry Guides and Codes of Practice. Terms, definitions and acronyms used in this Guide have the following meaning:

Adverse – Weather or Conditions

> Weather conditions or weather related events with the potential to cause vegetation related faults that have a widespread impact because of the number of faults and/or the system affected. Of particular relevance are high-wind events. Snow risk may also be relevant.

Fall Zone or Distance

> The space between a tree and a network conductor or structure whereby if the tree falls, it may make contact with the conductor or structure.

Hazard Tree

> A tree (or tree branch) that has the potential to damage a network conductor or structure due to the proximity of the tree with respect to the network, or due to the tree being unsound or diseased. A fall zone tree is an example of a hazard tree.

Network

> All of those elements of the Network Operator’s electrical infrastructure associated with the transmission and distribution of electricity. This includes, but is not limited to: overhead lines; overhead line supports; stay wires; open terminal transformers; and switchgear.

Network Operator

> The organisation that owns and/or operates an electricity transmission or distribution network.

Overhead Line

Any electric line operating at more than 230 volts AC, which is placed above ground and in the open air.

Protection Zone

A defined section of the network which is designed to automatically disconnect from the supply on detection of a fault.

Risk

The effect of uncertainty on objectives. In the context of this Guide, the term risk is used to quantify the likelihood of a vegetation versus overhead line event, and the potential consequences of that event.

Vegetation

All plants including, but not limited to, trees, shrubs and grasses - but excluding lawns.

Vegetation Management

An all-encompassing term used to describe the process of vegetation management including but not limited to planning and implementing of tree felling and pruning, and shelterbelt trimming.

5 Referenced and related documents

The following documents contain reference information that may provide useful guidance to a Network Operator when developing a risk based vegetation management programme:

Electricity (Hazards from Trees) Regulations 2003

AS/NZS ISO 31000:2009 Risk management – Principles and guidelines

ACOP Safety and Health in Tree Work around Power Lines

NZECP 34 Electrical Safe Distances

Safety Manual Electricity Industry (SM-EI)

EEA Guide to Electrical Safety for Forest and Woodlot Felling and Logging Operations

New Zealand Arboricultural Association Best Practice Guideline for Amenity Tree Pruning

ENA (UK) Engineering Technical Report 132 – Improving network performance under abnormal weather conditions by use of a risk based approach to vegetation management near overhead electric lines

ENA (UK) Engineering Technical Report 136 – Vegetation management near electricity equipment – Principles of good practice

ANSI A300 series guides for Tree Care Operations

ANSI Tree Risk Assessment Best Management Practices Guide

6 Risk Management

6.1 Background

Before embarking on a risk based approach to vegetation management, Network Operators should firstly confirm their organisations' mandate and commitment to this process. AS/NZS ISO 31000:2009 describes the principles and guidelines of risk management and it is recommended that this standard is followed in the development of risk based plans for vegetation management.

AS/NZS ISO 31000 defines the three steps in the risk management process as being; establishing the context, risk assessment, and risk treatment. The context will be network company specific and is not discussed further in this Guide.

The Guide outlines a generic approach to the risk assessment and risk treatment process for vegetation management using hypothetical network data. It is recognised that each Network Operator will have feeder/line and network sections that may need different prioritisation based on a wide range of input data such as SAIDI, SAIFI (interruption frequency), faults per unit length of line, number of customers, etc.

6.2 Reliability & Safety

A reliable electricity supply is essential for communities and businesses from a social, economic and safety perspective. Communities and businesses have a high dependence upon a reliable and secure supply of electricity, therefore prioritisation of vegetation work should include an assessment of the relative risk and the effect of loss of supply for communities and businesses.

There are safety components that should be considered when planning vegetation management works. These include but are not limited to:

Public safety. This may include the importance of continuity of supply to safety of the community and the operation of essential services; the location of the works with respect to high use public areas; schools, kindergartens, bus stops, swimming pools etc. For example, the trees or vegetation may provide access for children to contact an overhead line, or an overhead line may be brought down in a populated area due to a tree failure.

Worker safety. Worker safety is not discussed in detail in this Guide as it is appropriately covered in relevant WorkSafe documentation supported by industry guidance such as SM-EI and other industry safety documentation. Worker safety however needs to be considered when planning and implementing the works.

6.3 Additional Vegetation Management Costs

As noted above, Network Operators are required to adhere to the Tree Regulations. This risk based guide helps identify priorities for additional vegetation management. Risk based vegetation management should not be considered as a substitute for Tree Regulations vegetation works, however the cost of risk based vegetation management can be significant, particularly when dealing with fall zone trees. Therefore, it is recommended that Network Operators identify, establish and monitor a separate budget for risk based work.

There are likely to be efficiencies however in incorporating the objectives of wider vegetation management into the Tree Regulation programmes e.g. in seeking tree/land owner agreement to clear wider than prescribed by the Regulations when carrying out work required under the Tree Regulations. It is important to document these agreements.

While Network Operators are responsible for the cost of first cut clearances in accordance with the Tree Regulations, the cost of subsequent cuts are the responsibility of the tree/land owner. Getting agreement to greater clearances (than those mandated by the Regulations) can reduce the costs to all parties down the track. Taking the time to explain the future cost savings and the risk reductions to the tree/land owners and to the wider community can lead to more efficient and optimal outcomes for all parties. It is recognised that where significant clearance is sought by a Network Operator to minimise risk, the cost of the work may be negotiated with the tree/land owner with recognition of the benefit to the tree/land owner with respect to contribution to risk reduction.

6.4 Overview of the Risk Approach

The Guide presents one example of developing a risk based approach to vegetation management. Network Operators may have their own guiding principles and documented approach to risk based vegetation management. It is recognised that one model does not necessarily fit all Network Operators or individual situations - the example provided sets out a methodology using ‘protection zones’, whereas some Network Operators may favour a ‘complete feeder’ based approach. Another approach may be preferable for identifying safety priorities. It is however important to ensure that whatever model and principles are used, that there is good, clear documentation and accurate records of what has been done in the way of notifications and physical works.

Figure 2 below shows the possible steps involved in development of a risk based approach to vegetation management. An explanation of the various steps is included in the Guide.

System Level Assessment Attributes	• Derive list of protection zones • Create list of impacts if a vegetation related fault occurs • Create a list of factors that influence the likelihood of a vegetation related fault occurring (IF) • Weight impact and likelihood attributes in accordance with business objectives
System Level Risk Assessment	• For each protection zone assign relevant impact and likelihood attributes and score accordingly • Apply weightings • For each protection zone, multiply combined impact factors and combined likelihood factors • Rank protection zones based on level of risk
Site Identification	• Through field inspections, identify sites where trees pose a risk (either due to fall distance or line corridor encroachment)
Site Risk Assessment	• Assess the site for overall risk. A site outside a school may for example have a greater risk and therefore be assigned higher priority.
Tree Risk Assessment	• Conduct an individual risk assessment for each tree within each individual site.
Resources and Constraints	• Assess the amount of work that can be undertaken based on the available budget, workers and other constraints.
Work Planning and Execution	• Develop a work plan based on the prioritised sites, logical sequence of work and site restrictions. • Record and analyse results with focus on what was achieved and what can be improved in future.

Figure 2: Example of a Risk Based Approach to Vegetation Management

6.5 Risk Assessment

6.5.1 Identify Protection Zones and Influencing Factors

The first step in the assessment process is to identify the extent of the network under consideration. This could be based on voltage level (usually working from highest to lowest) or feeder, and then disaggregated into protection zone within each voltage level or feeder. The extent of network under consideration should also include an evaluation of probability or consequence of failure in other parts of the network. For each section being assessed, the Network Operator will need to review the relevant Influencing Factors (IF) for that section. Examples of Influencing Factors could (in no particular order of importance) include:

- Critical network sections providing significant supply to the community
- Areas where public safety is of greater impact - for example hospitals, emergency services, essential services infrastructure, schools, kindergartens, parks, swimming pools, and bus stops
- Importance of line (for example sub-transmission)
- Areas with known hazard or fall zone trees
- Areas with high volumes of trees
- Tree species and the attributes of trees (for example prone to limb breakage)
- Local growth rates
- Areas where system security is an issue
- Areas or sections with high cost of network repair
- Value of direct and indirect loss due to an outage
- The cost of treatment per tree site, or span, or kilometre of line
- Customer numbers affected
- Customer service level agreements
- Forestry areas
- Fire risk areas
- Land stability
- Land access
- The available budget
- Network section security rating
- Network performance data including SAIDI and SAIFI
- Potential SAIDI impact

The initial system risk assessment (identifying which protection zones have the highest risk) is typically done as a desktop exercise by gathering all relevant information and then deciding on which Influencing Factors are to be considered. The output of this will be a prioritised list of protection zones, feeders or individual sites under consideration. Network Operators will make a judgement on their specific priorities based on Influencing Factors and consequences.

6.5.2 Initial Priority Assessment

Using relevant impact and likelihood Influencing Factors such as security rating, population density and historical SAIDI, a matrix of protection zones can be constructed that ranks these zones according to priority. The assessment information may include a map showing the length of overhead line that is affected by vegetation to develop a better understanding of vegetation density and possible target areas. It may also be based on other network performance statistics, or specific knowledge of sites or areas of concern.

The Influencing Factors used to construct the matrix will be determined by the Network Operator based on what is relevant for any particular section of network. The matrix should reduce to an initial assessment priority list so that the relative importance of each section can be assessed. Refer to Table 1 following for an example of an initial assessment for an exercise to improve reliability.

Substation	Feeder	3 Year Historical Average SAIDI (A)	Security Rating (B)	Population Density (C)	Priority
A3	A33	0.7	n	5	1
A4	A41	1.2	n	3	2
A2	A21	1.1	n	3	3
A2	A23	0.12	n	4	4
A3	A32	0.06	n-1	4	5
A1	A11	0.05	n-1	3	6
A1	A14	0.1	n	1	7
A1	A13	0.01	n	1	8

Table 1: Example of Initial Assessment and Ranking

Notes on the above example:

Note 1: Historical average SAIDI (A) is vegetation related only.

Note 2: Security Rating (B) is the industry standard rating where ‘n’ represents a feeder with no backup or alternate supply, and ‘n-1’ means a loss of one supply source will reduce the security to ‘n’.

Note 3: Population Density (C) is on a scale of 1 to 5 based on number of customers connected to the feeder or protection zone.

Note 4: Priority in this example is calculated from Total Risk = aA * (bB +cC) where a,b,c are normalised weightings as determined by the Network Operator.

6.5.3 Site Assessment

Following the initial desk top assessment, the next step is to use competent assessors to carry out a site assessment of the vegetation and the risks for each of the protection zones (or whatever approach has been taken - in this example it was feeders). The number of protection zones etc. assessed will depend on the resources and budget available to the Network Operator. It is expected that assessments will be carried out in the order of priority ranking determined in step 6.5.2

Refer to Appendix A for examples of Fall Zone (Hazard) trees and to Appendix B for an example of site specific Risk Assessment Output.

Site assessments are not necessarily undertaken as an independent exercise and risks should also be considered as part of routine (Tree Regulations) inspection and vegetation management works.

The on site assessment should (in no particular order) record:

- The extent of vegetation in the vicinity of the protection zone lines that could degrade resilience under adverse weather conditions. For example, this may include eucalypt trees outside the fall zone, which could shed debris in adverse weather
- Trees that are within the fall zone of, or could otherwise contact, the overhead line
- Trees that although being within the fall zone are assessed as likely to be arboriculturally secure during adverse weather due to the species (particularly native trees) that could therefore be retained
- Trees that are diseased or structurally unsound or likely to fall
- Overhanging or climbable limbs
- Vegetation or blown in debris that presents a fire risk due to potential contact with lines. Fire risk can also arise from falling windblown trees
- Unstable land conditions which may result in trees making contact with lines
- The cost of vegetation management work to meet resilience requirements
- The cost of network damage repair work
- Potential wider costs such as fire damage
- Any constraints that could affect vegetation management (e.g district plan trimming or removal limitations)
- Vegetation management options analysis (multiple cutting option or removal for example)
- Alternative solutions to vegetation management (undergrounding or relocation of lines for example).

Consideration should be given to removal or reduction of fall zone trees, or the establishment of an open ceiling or ‘V’ shaped clearance above the overhead line.

6.5.4 Prioritisation of Sites

Ranking in order of importance of different sites can be relatively subjective. However, it is recommended that public safety should have the highest ranking, followed by reliability (based on historical data) and then other factors as determined by the Network Operator. Individual Network Operators should develop rankings and weightings based on their company risk plan.

A tree is a living organism and therefore historical tree location data may not always be appropriate. A tree may have been removed, or a new future risk tree planted or grown in any location. Site assessment is therefore needed in order to properly prioritise sites.

6.5.5 Constraints and Alternatives

At this point, it is necessary to consider any constraints that could have an effect on vegetation management and that it might be necessary to consider an alternative solution to improve network resilience. It could be that the constraint is so severe as to suggest that the cost of improving network resilience cannot be justified in terms of customer benefits alone. Examples of a constraint could include a large stand of protected native trees in close proximity to an overhead line or legislative requirements concerning deforestation. Each constraint could have a different level of impact depending on the importance of the protection zone under consideration and the consequence of addressing one constraint could have an impact on other constraints or other protection zones in the matrix.

In order to consistently assess the impact of each constraint, it is recommended that a three stage approach is applied:

Stage 1: Input – identify the extent of the constraint
Stage 2: Analysis – assess the consequences of the constraint
Stage 3: Output – determine what actions are necessary to mitigate the effect of the constraint

This three stage assessment will allow Network Operators to assess the costs and timescales associated with each constraint. Note that costs need to be considered both in terms of financial and non-financial costs; e.g. the impact on relationship with tree owners and land owners.

6.6 Risk Treatment

6.6.1 Resilient Clearance

Detailed site assessments are undertaken to ascertain the extent of resilient clearance required to mitigate the risk of current and future potential damage to the network. Current risks may be mitigated by tree removal or cutting back vegetation to outside the fall distance of the overhead line. Future risks may be mitigated by removal of vegetation underneath or adjacent to the overhead line, that has yet to encroach the Growth Limit Zone but has the potential to do so before the next planned vegetation management cycle. It may be more economical to manage future risk vegetation at an early stage (i.e. seedlings are easier to treat or remove than trees).

Figure 3 below shows an example of resilient clearance

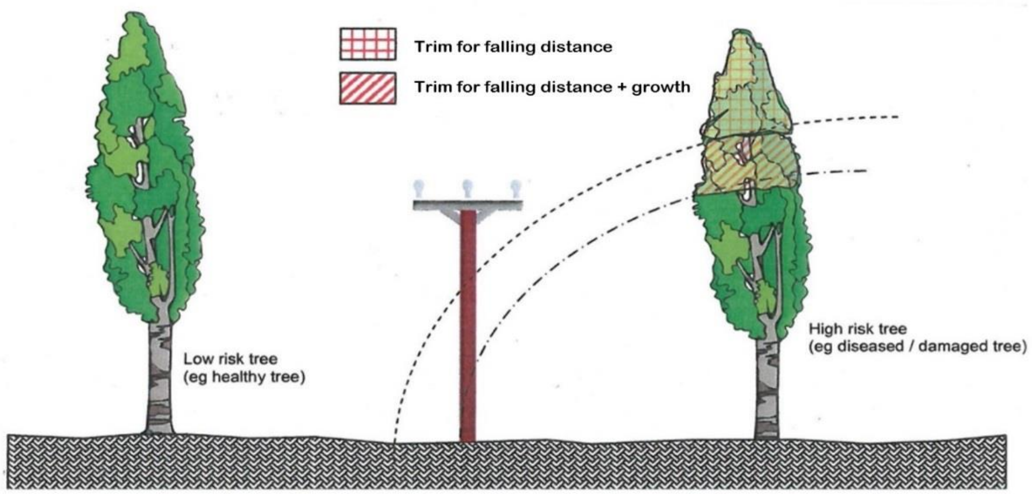


Figure 3: Example of Resilient Clearance

Notes on the interpretation of Figure 3:

Note 1: Both trees in this example are assessed to be beyond the Growth Limit Zone and Notice Zone defined in the Regulations

Note 2: The tree on the left although within fall distance of the overhead line, has been assessed as being stable and not expected to be a threat to the network, even in adverse weather conditions. It is a low risk tree.

Note 3: The tree on the right is within fall distance of the overhead line and has been assessed as a high risk.

Note 4: The square hatching indicates the amount of the tree that will need to be cut in order to prevent the tree falling onto the overhead line. It should be noted that this includes a safety distance i.e. the distance between the overhead line and the dotted line. The diagonal hatching indicates the additional cutting required to take account of tree growth between this cut and the next.

Note 5: Consideration should be given to complete felling of the tree on the right, subject to tree/land owner agreement, if it is cost effective, and aesthetically and environmentally acceptable to do so.

Note 6: Figure 3 is not a practical guide on how to cut trees. It is an illustrative example indicating the amount of cutting required to deliver resilient clearance. All vegetation management should be carried out in accordance with the Network Operator's standards and/or with the New Zealand Arboricultural Best Practice Guide for Amenity Tree Pruning.

Where there are stands of trees (for example in forests), clearing the leading edge trees can expose trees further into the stand, and cause them to fail due to the loss of protection the leading edge trees previously provided. A resilient strategy should consider stand density, relative tree size and local weather conditions to determine if trees further into the stand will be compromised and may fail.

6.6.2 Site Prioritisation

When the extent of the vegetation management works and the impact in terms of performance and cost has been determined for each site, the next level of priority assessment can be undertaken. Table 2 below shows the results of a priority ranking[3] of sites based on specific site assessments and costs as part of an exercise to improve reliability. .

[3] Care should be taken in the assessment process to ensure that the final priority rankings are sensible, and are not unduly influenced by simple mathematical calculation. A degree of subjectivity may be appropriate.

Substation	Feeder	Span Reference (start pole, end pole)	Failure Likelihood (A)	Security Rating Factor (B)	Failure Repair Cost $ (C)	Failure Risk (D)	Hazard Removal Cost $ (E)	Priority $ (F)	Priority
A3	A33	101220, 101225	5	0.6	$10,000	$30,000	$1,000	$29,000	1
A3	A33	100221, 100222	1	5.0	$5,000	$25,000	$2,000	$23,000	2
A3	A32	5477, 5481	3	1.0	$5,000	$15,000	$1,000	$14,000	3
A3	A32	5499, 5500	2	1.0	$2,000	$4,000	$500	$3,500	4
A3	A33	101200, 101201	2	1.0	$2,000	$4,000	$1,000	$3,000	5
A3	A32	5467, 5469	1	3.0	$2,000	$6,000	$3,000	$3,000	6
A3	A32	5400, 5401	2	0.2	$1,000	$400	$2,500	-$2,100	7
A3	A33	100225, 100226	1	3.0	$500	$1,500	$10,000	-$8,500	8

Table 2: Example of Detailed Cost Benefit and Priority Ranking

Notes on the above example:

Note 1: Failure Likelihood (A) is the likelihood of tree damage to the network at the specific site on a scale of 0 to 5, with 0 being low and 5 being high.

Note 2: Security Rating Factor (B) is on a scale of 0.2 to 5 based on the security of the feeder where 5 is an ‘n’ security high density 33 kV urban feeder without backup and 0.2 is a rural ‘n’ security 11 kV feeder on a protected spur line or in the area beyond a remote recloser. Refer to Appendix C for further details.

Note 3: Failure Repair Cost (C) is the estimated cost to repair the feeder in the event of tree damage at the specific site.

Note4: Failure Risk (D) is the product of A, B and C.

Note 5: Hazard Removal Cost (E) is the cost involved in removing the specific site hazard by trimming or felling the tree.

Note 6: Priority (F) is the difference between D and E.

Note 7: Priority is the cost/benefit ranking with the highest benefit ranking being 1. No weightings have been applied in deriving the individual ratings or factors that result in this priority table.

6.6.3 Work Plan

From the information in Table 2, and the detail of work identified in the individual site assessments, the Network Operator will know the estimated cost and relative importance of improving network resilience for the feeders within the matrix. The Network Operator will then need to identify how many of the protection zones or feeders can have their resilience improved. The key considerations may include:

- Health and safety requirements
- The amount of budget available to improve network resilience
- The availability of suitably skilled and equipped resources

Having used the risk based approach to identify where and when to apply network resilience measures, it will be necessary for the Network Operator to confirm the most appropriate solution to be employed for each particular span or site and to develop a work plan. This should generally be in line with the site assessment that was previously carried out. Work at any particular site would generally be undertaken in conjunction with other routine vegetation clearance in that area, unless the risk assessment identifies the need for the risk to be dealt with separately

6.6.4 Records

Evaluating the benefits of this risk management approach may require considerable time – probably years – to establish statistical data. Auditing of site works within the Network Operator's work management procedures will assist to establish that the quality of vegetation management meets the requirements specified in the Network Operator's policy documents. Performance data can then be used to review and improve the risk management process.

Suggested records to be kept and analysed for each site include:

Vegetation-related fault information, including:

- Tree species
- Direct tree contact
- Broken tree branch
- Complete tree failure
- Windblown debris
- Location of tree with respect to the line
- Inside or outside the GLZ

Planned vegetation works undertaken, including:

- Tree species
- Tree/land owner consent
- Extent of trimming and clearances achieved
- Tree removal
- Responsibility for debris disposal
- Cost of works
- If trimmed, expected re-growth rate based on local environment

Residual risks, including:

- Extent of any unmitigated risk
- Recommended reinspection timeframe
- Alternative power supply options in the event of a future fault

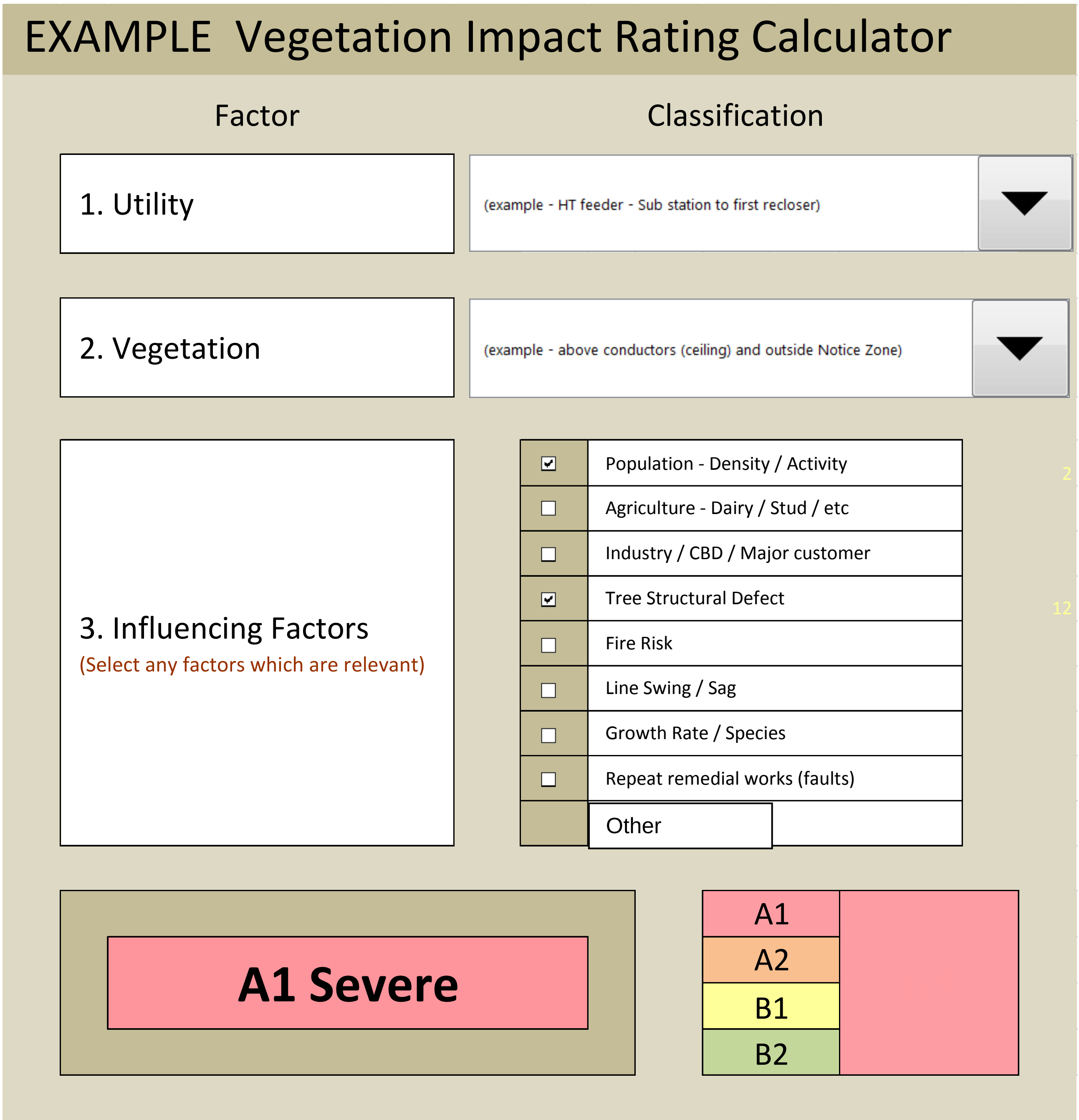
It is recommended that records are kept in the Network Operator's electronic data system and are made accessible to Network Operations staff to assist in the identification and analysis of network faults and risks.

Appendix A – Fall Zone (Hazard) Trees

Below are examples of trees where the tree branches are outside of the Notice Zone and Growth Limit Zone as defined in the Regulations, but the branches and the trees present a risk of damage to/contact with the overhead line due to their size and position with respect to the line. These are 'Fall Zone' trees.

Appendix B – Risk Assessment Output

Data from a risk assessment model can be presented in many ways. The example below shows the output from one model for a specific site, and indicates an ‘A1 Severe’ rating for this tree site. This model is built in an Excel spreadsheet. The rating derived in the output is mainly driven by the ‘Tree Structural Defect’ Influencing Factor, due to the weighting assigned to this Factor in the model. Output can be used to assign work crews on a prioritised basis.



Appendix C – Network Security Rating Example

Network security ratings and the values assigned to them for prioritisation will be dependent on the individual network configuration, and the Network Operator’s specific assessment process and values. This prioritisation may also be influenced by and include other factors such as customer density, customer criticality, average response times etc. Table 3 below lists a suggested set of security ratings for network sections. These ratings were used in the example in Table 2 of Section 6.6.2:

Network Section Type	Rating
Urban 33 kV without backup circuit	5
Rural 33 kV without backup circuit	3
Urban 33 kV with backup circuit	2
Rural 33 kV with backup circuit	1
Urban 11 kV feeder	1
Rural radial 11 kV feeder	0.6
Rural radial 11 kV feeder beyond 1^{st} recloser	0.4
Rural radial 11 kV feeder beyond remote recloser	0.2

Table 3: Example of Network Security Ratings

