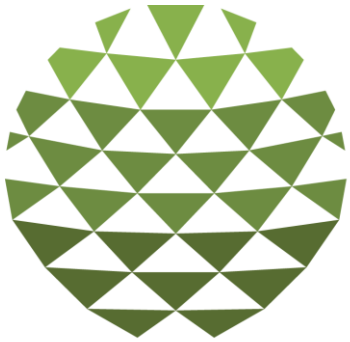

CRAIG WEBB
Consultant Arborist

# WESTERN SPRINGS FOREST

Client: Society for the Protection of Western Springs Forest/
Friends of Western Springs Forest

REPORT PREPARED BY: CRAIG WEBB

DATE: 12 DECEMBER 2019

# 1 EXECUTIVE SUMMARY

Quantified Tree Risk Assessment (QTRA) and Tree Risk Assessment Qualification (TRAQ) are two international methods used for assessment of the risk of harm caused by trees. Despite their limitations, the two methods can be used to provide guidance to tree-owners on the risk of harm to people or property by quantifying or qualifying the risk associated with tree failure.

Both methods have been applied to pine trees within the Western Springs Forest. Fifteen trees that represent the most likely cause of harm and various scenarios involving people and property have been considered using the two tree risk assessment methods.

Using conservative inputs for QTRA, the risk of harm to people and property from these 15 trees has been found to range between 1/30,000 at the top end and <1/1,000,000. This is lower than the upper limit of what is considered a 'tolerable risk' according to QTRA.

According to QTRA, risk of a magnitude of 1/10,000 should be considered tolerable (when imposed on others) if the risk is 'as low as reasonably practical' (ALARP). QTRA is the methodology used to guide risk management in the Auckland Domain according to the document *Tree Consultancy Company, Arboricultural inspection, Auckland Domain Oak tree inspection and work program dated 19 November 2018 with tree inspection record and recommendations and site drawings*.

The greatest risk (at 1/30,000) in the Western Springs Forest has been found to be in relation to property (the QTRA highest 'tolerable' risk magnitude is 1/10,000). Failure of trees on to the studio at 14 West View Road, the conservatory at 16 West View Road, structures at 28 West View Road, the zoo fence and building, or the pedestrian footbridge at Western Springs Park represent the scenarios having the greatest risk of harm from property damage but even these are all well below the upper limit of QTRA's definition of tolerable risk.

The risk of harm to people has been found to be between 1/400,000 (well within 'tolerable') and <1/1,000,000 ('broadly acceptable'). The frequency of use of the walking track and back yards during the conditions that are most likely to result in tree failure (i.e. storms, high winds), is considered to be a significant factor in reducing the risk to pedestrians and residents in back yards.

Similar to QTRA, TRAQ outputs found Low risk for most scenarios and Moderate risk for scenarios involving the conservatory at 16 West View Road, the studio at 14 West View Road, the zoo fence and the footbridge.

Recommended tree management options include removal of defective branches, pruning to reduce or remove over-extended branches, height reduction pruning to reduce the load exerted on the trees and impact on potential target areas. Such management would reduce the risk of these trees; however the cost of such work is likely to be not reasonably practicable and disproportionate to the benefits. If the risk is tolerable, I would recommend to monitor the trees on a regular basis.

Based on the findings of the QTRA assessment being at worst within the 'tolerable' range, tree removal is not recommended.

*TABLE OF CONTENTS*

# 2 INTRODUCTION

CWCA Limited has been engaged by the Western Springs Forest Protection Society (WSFPS) and Friends of the Western Springs Forest to prepare a tree risk assessment relating to pine trees growing within the Western Springs Forest.

## 2.1 BRIEF/BACKGROUND

This report has been compiled with reference to material provided to me for the purposes of the brief. Reports and plans by Chris Benton, Gerald Collett and Stacy Colyer (GreensceneNZ) have provided valuable background information to assist with the compilation of this report.

## 2.2 SCOPE OF REPORT/ METHODOLOGY

This report presents information relating to selected pine trees within the Western Springs Forest. This report includes:

- A brief assessment relating to pine trees that are adjacent to identified targets;
- An assessment of hazards relating to the trees, based on the presence of targets;
- Quantified Tree Risk Assessment (QTRA) and Tree Risk Assessment Qualification (TRAQ) analysis of the identified trees and targets.

The tree assessment was conducted using visual tree assessment (VTA) methods, from a ground-based reconnaissance of the Western Springs Forest. The assessment of trees was predominantly target-led, meaning that it is focused on the trees that pose the most-obvious hazard in relation to human targets or structures. Several trees with obvious and significant defects have been assessed along with trees within close proximity to, or that lean heavily towards, significant targets.

The assessment involved visual inspection of the root-flare and basal trunk area of the selected trees, visual inspection of tree trunks, branch attachment and overall tree morphology, and a comparative visual crown health assessment, based on coloration and density of foliage.

The assessment of 'risk of harm' was conducted using two methods, as follows:

- The Quantified Tree Risk Assessment (QTRA) method. The inputs and outputs form this method are described below. For the purposes of this assessment the *Target Range* has been based on estimates and anecdotal evidence and the *Probability of Failure* has been assessed using the methodology described in Section 4.1 of this report.
- The ISA Tree Risk Assessment Qualification (TRAQ). This involved using the ISA Tree Risk Assessment form and completing the *Risk Categorisation* risk matrices based on my own inputs.

## 2.3 QUALIFICATIONS/EXPERIENCE

I confirm that I am a consultant arborist with experience and qualifications suitable to provide specialist assessment and advice in relation to arboricultural matters. I hold the New Zealand Diploma in Arboriculture (with distinction) from WINTEC and I have 18 years' experience as an arborist in the regulatory and commercial sectors.

I hold the International Society of Arboriculture (ISA) Tree Risk Assessment Qualification (TRAQ) and I am a trained and registered user of the Quantified Tree Risk Assessment (QTRA) method.

### 2.4 LIMITATIONS

This report is based on a ground-based visual assessment only.

A specific assessment of each individual tree has been carried out by Chris Benton. Trees of particular concern have been identified during Mr Benton's assessment. In addition, during arborist expert witness conferencing a selection of trees was assessed with an emphasis on the trees that pose the greatest hazard to high-value targets. The assessment that follows identifies fifteen trees that are considered representative of the trees that pose the greatest hazard to high-value targets. The assessment that follows is not exhaustive or comprehensive, but should be considered suitable for establishing risk thresholds based on the trees that are most likely to cause harm.

This assessment is independent of the tree assessment that is being carried out as component of mediation proceedings and the arborist expert witness conferencing.

## 3 SITE VISIT

Site visits were carried out on 23 July, 1 August, 14-15 August, 28 August and 3 September 2019.

The first site visit involved assessing selected trees (both randomly selected and guided to particular trees of interest) and reviewing the work of Chris Benton.

The second site visit and two subsequent site visits were conducted in the presence of arborists involved in the mediation process that is (at the time of writing) in progress.

The site visit on 28 August was conducted with arborists and ecologists involved in the mediation process.

The latter site visits were concentrated on the trees that were selected for further analysis in order to assist the mediation process. This focused on trees that were adjacent to several high-value (or high consequence) targets. This allowed me to conduct a more detailed analysis of trees that have the greatest potential to cause harm, due to proximity to targets and/or factors that may increase the likelihood of failure.

The final site visit was undertaken for verification of tree numbers and to confirm relevant inputs for the methodologies of tree risk assessment.

## 4 ASSESSMENT

### 4.1 TREE ASSESSMENT - OVERVIEW

The trees in question are an aging stand of *Pinus radiata*, which is also known as Monterey pine or radiata pine.

The trees are up to approximately 40m in height, which is an approximate maximum height of the species. In general, the trees are single-stemmed and upright, with natural leans. Trees on the edge of the group

tend to have leaning trunks and/or heavy lateral branches that offset the canopy relative to the trunks. This is a natural phototropic growth response that occurs where trees in competition with other trees tend to grow towards light.

Limb failure, whole tree failure (toppling) and stem snapping has occurred throughout the stand of trees. This usually occurs during severe weather events.

Dead wood is present in abundance throughout the trees. The dead wood includes the branches that are naturally shed as they become moribund and dead branches that are attributed to poor tree health. Whole trees are dead and dying throughout the stand.

As a group, the trees are assessed to be in an overall condition of decline. This is based on an assessment of the density and coloration of the foliar canopy and the presence of multiple dead and declining branches throughout their crowns. The trees are mature specimens, and age is the overriding factor affecting tree vitality and structural character. While it is easy to focus on the poor health and structural flaws in individual trees, it is evident that many of the remaining trees are in better condition, with large, apparently healthy crowns.

Many past tree failures through toppling and trunk snapping have been identified in the work by Chris Benton and Gerald Collett. Trees within the stand have been affected by historic tree removals, particularly when 30-odd trees were removed at the western edge of the stand at the request of Auckland Zoo. This is considered to be a contributing factor affecting tree failure due to alteration of the stand dynamics, resulting in greater exposure to wind. This factor, along with site characteristics and tree predispositions, has been attributed as a major reason for whole tree failure. Trunk snapping has been found by Gerald Collett to be associated with boring insect (termite) activity within trunks of living trees. Crown failure (branches or larger parts of the tree crown) has been a common feature of the stand also. This is a failure pattern that is commonly seen in mature radiata pine, often associated with over-extended branches with heavy end weight, or in trees with poor crown architecture.

## 4.2 RISK ASSESSMENT - OVERVIEW

Hazards associated with trees are present if there are targets. A target is something of value within the impact area of a tree, should the tree, or part of the tree fail and fall. Risk is defined as the probability of something adverse occurring. The degree of risk inherent in individual trees varies according to factors such as form, health, species type, structure, growing conditions and specific location. Hazards associated with trees generally involve the potential of harm to persons or property from a tree, or part of a tree, failing.

In assessing the risk associated with trees, three factors have to be considered: occupancy of something of value within the fall zone (targets), the likelihood (probability) of failure and the size of the part that is most likely to fail and cause harm (consequences of impact).

For the purpose of assessing the probability of failure, consideration of the species characteristics and failure patterns, coupled with the findings of a visual tree assessment is required. The probability factor in relation to tree or tree part failure is based on the assessor's experience, knowledge of the species characteristics and familiarity with tree structure and related defects. The history of the site and stand-failure characteristics have also been taken into account when assessing the likelihood of failure.

The most probable scenarios with regards to failure in the trees are whole tree failure (toppling), stem failure (snapping) and the failure of branches, codominant stems and/or dead wood.

The hazard assessment for this report has considered four main targets, as follows:

- Residential properties in the block of houses to the north east of the stand of trees, being addresses 14 to 28 West View Road, Grey Lynn, including:
    a. The dwellings and habitable buildings;
    b. The backyards, associated structures and landscaping;
    c. Occupancy of the backyards by persons;
- The users of the public walkway through the reserve (the path is currently closed so has very low occupancy, but the risk assessment assumes that the path is open for public use);
- The boundary fence of the Auckland Zoological Park to the southwest of the stand of trees;
- An aerial sewer pipe bridge across Meola Creek.

For the purposes of carrying out a risk assessment, these are the targets that have been assessed to have the greatest consequences in the event of being struck by a tree or tree part in event of failure. There is no ranking or priority implied in the list of targets above.

The size of part involved with the tree failure scenarios that could lead to harm on contact with potential targets needs to be considered in order to assess the potential scale or consequences of the contact.

Deadwood of relatively small size could be a significant hazard given the height from which it may fall. For the purposes of this assessment, it has been assumed that all significant deadwood that overhangs a target would be removed as part of standard tree maintenance by Auckland Council.

Stem snapping and whole crown failure has occurred throughout the stand. This appears to occur in trees with poor stem taper and/or decay pockets. The decay pockets in these trees are likely to be associated with old branch stubs and/or pruning wounds. The presence of native termites has also been reported (Collett) and these have been linked with stem weaknesses leading to failure. Alteration to stand dynamics that result from historic tree loss (through removal and failure) needs to taken into account in relation to the most-likely failure patterns for individual trees.

This report has been written without the benefit of any advanced assessment techniques, which may be required to allow further certainty as to the condition of individual trees.

Whole tree failure has been observed to have occurred throughout the stand of trees. This is attributed to a combination of factors, such as ground conditions, proximity of other trees and exposure. Alteration to stand dynamics that result from historic tree loss (through removal and failure) must be taken into account in relation to the likelihood of whole tree failure.

# 5 QUANTIFIED TREE RISK ASSESSMENT

An excerpt from the QTRA User Manual – Version 5 has been copied below to provide a summary of the system used for tree risk assessment.

**What is Quantified Tree Risk Assessment?**

**A Non-technical Summary**

Tree safety management is a matter of limiting the risk harm from tree failure while maintaining the benefits conferred by trees. Although it may seem counter intuitive, the condition of trees should not be the first consideration. Instead, tree managers should first take account of the usage of the land on which the trees stand, which in turn will inform the process of assessing the trees.

The Quantified Tree Risk Assessment (QTRA) system applies established and accepted risk management principles to tree safety management. Firstly, the targets (people and property) upon which trees could fail are assessed and quantified, thus enabling tree managers to determine whether to assess trees and to what degree of rigour a survey or inspection of the trees is required. Where necessary, the tree is then considered in terms of both size (potential impact) and probability of tree or branch failure. Values derived from the assessment of these three components (target, size and probability of failure) are combined to calculate the probability of significant harm occurring.

The system moves the management of tree safety away from labelling trees as either 'safe' or 'unsafe' and requiring definitive statements of tree safety from either tree surveyors or tree managers. Instead, QTRA quantifies the risk of harm from tree failure in a way that enables tree managers to balance safety with tree value and operate to predetermined risk thresholds.

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The methodology is described in the following sections. The workings for the QTRA method applied to the selected pine trees are shown in Tables 2 & 3. Colour-coding added to these tables is as per the QTRA calculator, which ranks the risk according to the QTRA Advisory Risk Threshold, as follows:

| | |
|---|---|
| > 1/1,000,000 | Broadly Acceptable |
| 1/1,000,000 - >1/10,000 | Tolerable (where imposed on others, if ALARP) |
| 1/10,000 - >1/1,000 | Unacceptable (where imposed on others)<br>Tolerable (by agreement) |
| < 1/1,000 | Unacceptable |

## 5.1 PROBABILITY OF FAILURE (POF)

The *Probability of Failure* (*PoF*)category of the QTRA requires the assessor to take into account benchmarks at each end of the scale to settle on a *PoF*. A tree/branch with a *PoF* in Range 1 is expected to be certain to fail or have a 1/10 chance of failing within one year. A tree/branch with a *PoF* in *Range 7* represents a structurally acclimatised tree/branch or a tree/branch that presents no signs of being structurally compromised. The assessor must decide whether the branch or tree is within either benchmark range, or 1, 2 or 3 orders of magnitude more or less likely to fail from a starting point at either benchmark.

For the purposes of the QTRA input of *PoF*, the failure of whole trees or substantial parts of trees (e.g. trunk snapping) must take into account the occurrence of past tree failures from various modes of failure. Many of the trees may look structurally acclimatised and show no sign of structural abnormality, however, the age and health of the trees warrants their condition to be assessed with a degree of caution.

Whole tree, or main stem failure could be reasonably expected to occur on a relatively frequent basis given the age and morphology of the trees and the history of failure in the stand. For this reason, the selected trees (with few exceptions) have been assessed from a benchmark of no greater than *PoF Range 5* (i.e. two orders of magnitude more likely to fail than a structurally acclimatised tree with no sign of structural abnormality). Each tree has been assessed from the point of view of benchmark established after consideration of 1 or 2 orders of magnitude from benchmark *Range 7* (1/1,000,000 – 1/10, 000,000).

Individual trees that have been assessed for the purposes of this assessment are identified in Table 1 below, with the rationale for the *PoF Range* described against each tree.

Table 1 – Probability of Failure analysis for the selected trees. Tree No. is from Benton (2019)

| Tree No. | Notes | Relevant targets | PoF Range | Comments |
|---|---|---|---|---|
| 1 | Envivo #1874, referred to as 'stormwater' tree | Walking track entrance, footpath of West View Road, dwelling at 28 West View Road | 4 | Relatively good crown condition, structurally acclimatised tree. Benchmark 6. Under-mining by erosion and girdling root shifts PoF two orders of magnitude, from 6 to 4. |
| 10 | referred to as 'hanger' tree | Walking track occupants | 2 | Failed branch hanging immediately adjacent to path, significantly defective. Benchmark 1. Likely to fall, however has been present for several months. Hanging branches can remain for many years, so PoF shifts from 1 to 2. |
| 11 | Envivo #753, referred to as Sione's tree | Back yard of 28 West View Road | 3 | Fair to good crown condition, structurally acclimatised tree but with history of failures nearby. Benchmark 5. Increased exposure shifts PoF for trunk snapping or whole tree failure by two orders of magnitude, from 5 to 3 |
| 19 | Envivo #2024 | 16-18 West View Road | 5/4 | Fair to good crown condition, structurally acclimatised tree. Benchmark 5. Trunk failure or whole tree failure maintained at Pof Range 5. Crown failure PoF shifts from 5 to 4 due to poor architecture. |
| 20 | Envivo #2025 | 16-18 West View Road and studio at 14 West View Road | 4 | Fair to good crown condition, structurally acclimatised tree. Benchmark 5 Trunk failure or whole tree reduced from PoF 5 to 4 due to decay at base. Crown failure PoF shifts from 5 to 4 due to poor architecture. |
| 21 | Envivo #2307 | Studio at 14 West View Road | 5/4 | Fair crown condition, structurally acclimatised tree, but with some poor architecture and decline. Benchmark 5. Branch failure PoF shifts from 5 to 4 due to over extended branches. Whole tree failure likelihood maintained at PoF 5. |
| 22 | Envivo #2305 | Studio, dwelling and back yard at 14 West View Road | 4 | Fair crown condition, structurally acclimatised tree, but with poor architecture and decline. Benchmark 5. Branch failure PoF shifts from 5 to 4 due to over extended branches. Whole tree failure likelihood increases (shift from 5 to 4) due to fill on rootplate. |
| 23 | Envivo #2292 | Dwelling and back yard at 14 West View Road | 4 | Fair crown condition, structurally acclimatised tree, but with poor architecture, history of major pruning and decline. Benchmark 5. Trunk failure PoF shifts from 5 to 4 due to poor architecture. Whole tree failure likelihood increases (shift from 5 to 4) fill on rootplate. |
| 67 | Envivo #832 | Zoo building, fence, aerial sewer pipe | 4 | Fair crown condition, structurally acclimatised tree, but with poor architecture and increased exposure. Benchmark 5. Trunk failure PoF shifts from 5 to 4 due to exposure from recent failure. |
| 69 | Envivo #803 | Zoo building, fence, aerial sewer pipe | 4/3 | Fair to good crown condition, structurally acclimatised tree, but with poor architecture and increased exposure. Benchmark 5. Trunk failure PoF shifts from 5 to 4 due to exposure from recent failure. Whole tree failure PoF shifts from 5 to 3 due to exposure from recent failure and rootplate compaction. |
| 74 | Envivo #869 | Open space SW of Meola Creek | 3 | Fair to good crown condition, structurally acclimatised tree. Large burl on trunk at ¾ height. Benchmark 5. Some concern over heavy lean and possible rootplate instability shifts PoF from 5 to 3. |

| Tree No. | Notes | Relevant targets | PoF Range | Comments |
|---|---|---|---|---|
| 81 | Envivo #942 | Zoo fence and elephant enclosure | 6/5 | Good crown condition, structurally acclimatised tree. Benchmark 6. PoF of crown failure reduced from 6 to 5 due to bark inclusion in main stem union. PoF for whole tree maintained at 6 due to good health. |
| 84 | Envivo #937 | Open space SW of Meola Creek | 4 | Fair crown condition, structurally acclimatised tree, but with heavy lean. Benchmark 5. Trunk failure PoF shifts from 5 to 4 due to heavy lean. |
| 94 | Envivo #109? | Footbridge over Meola Creek | 4 | Fair to good crown condition, structurally acclimatised tree, but with poor architecture. Benchmark 5. Whole tree failure PoF shifts from 5 to 4 due to boggy ground. |
| 114 | Envivo #2099, referred to as 'fire' tree | Walking track occupants | 2 | Has been assessed as being most likely to fail due to significant decay in base. Benchmark 1. Very likely to be hung-up in neighbouring trees and to have reduced mass, so PoF shifts one order of magnitude from 1 to 2. |

## 5.2 IMPACT POTENTIAL (SIZE OF PART)

The mass of a falling tree or tree part contributes to the force that will be generated upon impact with a target. However the size of part is not the sole determinant as the distance and orientation of the tree/branch and failure relative to the target also affects the outcome. The presence of other trees that may impede or deflect the falling part can also influence the force of impact.

QTRA uses an equation derived from weight measurements of trees of different stem diameters (Tritton & Hornbeck 1982) to produce a data set of comparative weight estimates of trees and branches ranging from 25 to 600mm in diameter.

For the purposes of the size of part inputs, *Size Range 4*, which is 25mm-100mm Φ has been used for dead wood, as most deadwood falling from the trees would be within this range. For whole trunks, *Size Range 1*, which is >450mm Φ has been used. Values between these size ranges, which are at each end of the scale, may apply to some trees and targets under various scenarios.

No size of part input is required for the property (buildings), as the input for the range of the cost of repair under *Target Range* considers the severity of damage based on the size of part contacting the target.

The size of part for trees falling on the path or back-yards varies significantly and is largely determined by the proximity of the tree to the target. A conservative approach has been taken when considering the impact potential for human targets.

Dwellings on West View Road have been assessed to be at the edge of the potential target area of trees that are nearest to the inhabited buildings. In the event of whole tree failure it has therefore been assessed that property damage would be relatively superficial and not result in major structural damage. One exception to this is the studio building at the rear of 14 West View Road, which is much closer to the trees that the dwellings.

A conservatory attached to the southern side of 16 West View Road provides another exception in relation to the potential consequences of impact, due to the reduced protection factor that the glass structure

provides when compared with solid building walls. In this case the occupancy by human targets has been considered as a precaution.

## 5.3 TARGET RATING - STRUCTURES

As identified above, the value of property that may be damaged in the event of tree failure varies significantly. For habitable buildings this ranges from minor/superficial damage to buildings and fixtures, to destruction of a conservatory or substantial damage to a studio. Other structures and landscaping within the backyards include garden sheds, fences and garden furniture. These features have relatively low value and have been conservatively placed within *Target Range 3*.

The boundary fence of the Auckland Zoological Park is subject to requirements for zoo containment facilities, under the Biosecurity Act (1993) and the HSNO Act (1996). This implies significant consequences if the zoo boundary bench is breached by a falling tree or tree part. It is evident that part of the fence that borders the Western Springs Forest is adjacent to a service area and zoo maintenance building, while another part of the fence borders the elephant enclosure. The scenarios involved with these two quite situations require different *Target Range* inputs. For a breach of the elephant enclosure, significant consequences could occur, so *Target Range 1* is relevant to trees within falling range sufficient to cause substantial damage to the security fence. The scenario of an elephant being present within the fall zone has not been assessed.

For the zoo building, it has been assessed that superficial damage could occur at the edge of the potential fall zone of branches (at tree tips). Damage to the fence in this location does not appear to present a risk to animal enclosures and the trees are sufficiently distanced from the fence to result in a relatively low level of damage, so the *Target Range* has been lowered two orders of magnitude to *Target Range 3*. Occupancy by zoo workers (during the weather periods most likely to result in tree failure) has been assessed to be suitably low to rule out any significant harm.

Due to the position of the dwellings (excluding the studio at 14 West View Road) relative to the trees, it has been assessed that damage to the dwellings would be relatively minor in the event of whole tree failure. Given the distance between inhabited dwellings and the trees it has been assessed that only the branches at the height extremities of trees would strike the dwellings in the event of failure in most cases. Damage might include broken windows and fixtures but is unlikely to be major structural damage. This has been assessed to fall within *Target Range 3* (NZ$38,000 to $3,800)

For the studio at 14 West View Road, whole tree failure in an immediately adjacent tree would likely cause catastrophic damage to the structure. Limb failure may cause minor damage or superficial breakage of roofing and fixtures. In the event that a tree falls directly onto the studio, the value has been assumed to fall with *Target Range 2* (£200,000 - £20,000 multiplied by currency conversion factor of 1.9, which gives a value of NZ$380,000 - $38,000). For branch failure the *Target Range* shifts one order of magnitude lower to *Target Range 3* (NZ$38,000 – $3,800). The human occupancy of the studio is very infrequent and due to the target protection that the building would provide in the event of tree failure, no human occupancy has been assessed for this building.

For the conservatory attached to the rear of the dwelling at 16 West View, the replacement value has been conservatively estimated to be in *Target Range 2* (NZ$380,000 - $38,000)

The rear of the target properties contain fences and landscaping, ancillary structures and garden sheds of various description. These have all been assessed to fall within *Target Range 3* (NZ$38,000 – $3,800).

## 5.4 TARGET RATING – HUMAN OCCUPATION

Anecdotal evidence suggests that the path from West View Road to Western Springs Lake Park is used by 50 persons per day. The number of users throughout the course of one year will naturally vary considerably on account of season and weather conditions. The assessor using QTRA must consider what weather conditions that are expected to result in the likelihood of tree failure to significantly increase and estimate human occupation during those conditions. The use of *Target Range 4* (between 1 pedestrian per hour and 3 pedestrians per day) is considered to be a suitable input for path use for this site. The use of the path during periods of weather that are most likely to result in tree/branch failure is likely to be considerably less than the usual rates of use. The open space areas southwest of Meola Creek have been similarly assessed, but are likely to have far fewer visitors on a daily basis.

Occupancy by contractors and other persons that access areas that are off the main path is considerably less frequent than path use. The frequency of occupation of these areas has been assessed to fall within *Target Range 6* (between 1/week and 6/year). It is expected that the contractors will not be present within the forest during the weather conditions that are most likely to result in tree/tree part failure, so with such low frequency of occupation the risk of harm is certain to be within the broadly acceptable range (>1/1,000,000).

Occupancy of the rear yards and the conservatory at 16 West View Road also needs to be considered in terms of human targets. It is reasonable to assume that recreation and maintenance activities occur within these properties on a regular basis. These activities are far less likely to occur during periods of weather that are most likely to result in tree/branch failure. For this reason the occupancy for back yards has been assessed to fall within *Target Range 5* (1 minute/week – 2 minutes /month).

The occupancy of the conservatory at 16 West View Road is not weather dependent in the same way as outdoor activities. The occupancy for this space falls within *Target Range 2* (2.4 hours/day – 15 minutes/day).

## 5.5 ANOTHER SCENARIO

Another way of looking at the risk of harm to occupants within the forest is to assume that the *PoF* of any tree failing onto the path has a 1/1 probability, i.e. on an annual basis, it could be assumed that one tree or tree part will fall onto the walking track. This assumption is supported by the frequency of branches and tree trunks that currently lie across the path of the walking track.

The walking track from West View Road to the footbridge at Western Springs Lakeside Park is approximately 300m long. Assuming that the random tree could fall across any part of this track, the target value would be extrapolated across the entire length of the track. The size of part that could fall onto the track would range from whole trunks (*Size Range 1*, >450mm) to the top of the canopy (*Size Range 4*, 100-25mm), depending on the position of the tree relative to the track. The size of the target area on the track therefore varies from about a metre (trunk width) to about 12m (full crown spread of an individual tree).

When the length of track (300m) is divided by the worst-case target area (12m) the *Target Rating* would be 1/25 of the occupancy of the walking track. This is equivalent to a shift in the *Target Rating* by one order of magnitude, from *Target Range 4* to *Target Range 5*.

When the track length is divided by the target area of the larger *Size Ranges* (1m) the *Target Rating* would be 1/300 of the occupancy of the walking track. This is equivalent to a shift in the *Target Rating* by two orders of magnitude, from *Target Range 4* to *Target Range 6*.

## 5.6 QTRA ANALYSIS

Table 2 – Quantified Tree Risk Assessment scenarios, targets, inputs and outputs.

| Tree No. | Scenario | | PoF Range | Size Range | Target Range | Output |
|---|---|---|---|---|---|---|
| | **Mode of failure** | **Target** | | | | |
| 1 | Whole tree failure | Human occupants on walking track and footpath of West View Road | 4 | 3 | 4 | < 1/1,000,000 |
| | | Dwelling at 28 West View Road | | n/a | 3 | 1/300,000 |
| 10 | Branch failure | Human occupants on walking track | 2 | 3 | 4 | 1/500,000 |
| 11 | Whole tree failure | Structures in back yard of 28 West View Road | 3 | n/a | 3 | 1/30,000 |
| | | Human occupants in back yard of 28 West View Road | | 3 | 5 | < 1/1,000,000 |
| | Trunk snapping | Structures in back yard of 28 West View Road | 3 | n/a | 4 | 1/300,000 |
| | | Human occupants in back yard of 28 West View Road | | 4 | 5 | < 1/1,000,000 |
| 19 | Whole tree failure | Dwellings at 16-18 West View Road | 5 | n/a | 3 | < 1/1,000,000 |
| | | Conservatory at 16 West View Road | | n/a | 2 | 1/300,000 |
| | | Human occupants in back yards | | 2 | 5 | < 1/1,000,000 |
| | | Human occupants in conservatory | | 3 | 2 | < 1/1,000,000 |
| | | Back yards at 16-18 West View Road | | n/a | 3 | < 1/1,000,000 |
| | Crown failure (1st order branch) | Human occupants in back yards | 4 | 4 | 5 | < 1/1,000,000 |
| | | Back yards at 16-18 West View Road | | n/a | 4 | < 1/1,000,000 |
| 20 | Whole tree failure | Dwellings at 16-18 West View Road | 4 | n/a | 4 | < 1/1,000,000 |
| | | Conservatory at 16 West View Road | | n/a | 2 | 1/30,000 |
| | | Back yards at 16-18 West View Road | | n/a | 3 | 1/300,000 |
| | | Human occupants in conservatory | | 3 | 2 | <1/500,000 |
| | | Human occupants in back yards | | 2 | 5 | < 1/1,000,000 |
| | Crown failure (1st order branch) | Back yards at 16-18 West View Road | 4 | n/a | 4 | < 1/1,000,000 |
| | | Human occupants in back yards | | 4 | 5 | < 1/1,000,000 |
| 21 | Whole tree failure | Studio at 14 West View Road | 5 | n/a | 2 | 1/300,000 |
| | Crown failure (1st order branch) | Studio at 14 West View Road | 4 | n/a | 3 | 1/300,000 |
| 22 | Whole tree failure | Studio at 14 West View Road | 4 | n/a | 2 | 1/30,000 |
| | | Dwelling at 14 West View Road | | n/a | 3 | 1/300,000 |
| 23 | Whole tree failure | Studio at 14 West View Road | 4 | n/a | 3 | 1/300,000 |
| | | Dwelling at 14 West View Road | | n/a | 3 | 1/300,000 |
| 67 | Trunk failure | Zoo building | 4 | n/a | 3 | 1/300,000 |
| | | Zoo fence | | n/a | 3 | 1/300,000 |
| 69 | Whole tree failure | Zoo building | 3 | n/a | 3 | 1/30,000 |
| | | Zoo fence | | n/a | 3 | 1/30,000 |
| | Trunk failure | Zoo building | 4 | n/a | 3 | 1/300,000 |
| | | Zoo fence | | n/a | 3 | 1/300,000 |

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| Tree No. | Scenario | | PoF Range | Size Range | Target Range | Output |
|---|---|---|---|---|---|---|
| | Mode of failure | Target | | | | |
| 74 | Whole tree failure | Human occupants of open space SW of Meola Creek | 3 | 4 | 4 | < 1/1,000,000 |
| 81 | Whole tree failure | Zoo fence, elephant enclosure | 6 | n/a | 1 | 1/300,000 |
| | Crown failure (included branch union) | Human occupants of open space SW of Meola Creek | 5 | 4 | 4 | < 1/1,000,000 |
| 94 | Whole tree failure | Footbridge over Meola Creek | 4 | n/a | 2 | 1/30,000 |
| | | Human occupants of walking track or footbridge | | 2 | 4 | < 1/1,000,000 |
| | Crown failure (1st order branch) | Human occupants of walking track or footbridge | | 3 | 3 | < 1/1,000,000 |
| 114 | Whole tree failure | Human occupants of walking track | 2 | 4 | 4 | < 1/1,000,000 |

Table 3 – Another scenario - QTRA inputs and output for a random tree falling across the path.

| Tree No. | Scenario | | PoF Range | Size Range | Target Range | Output |
|---|---|---|---|---|---|---|
| | Mode of failure | Target | | | | |
| - | Random tree or tree part falling onto walking track | Human occupants of walking track (300m) | 1 | 4 | 5 | < 1/1,000,000 |
| | | | | 3 | 5 | 1/500,000 |
| | | | | 2 | 6 | 1/1,000,000 |
| | | | | 1 | 6 | 1/400,000 |

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Table 4 – Risk rating and risk mitigation for QTRA assessment. Tree No. is from Benton (2019)

| Tree No. | Notes | Relevant targets | Probability of harm (worst case) | Risk mitigation * |
|---|---|---|---|---|
| 1 | Envivo #1874, referred to as 'stormwater' tree | Dwelling at 28 West View Road | 1/300,000 | Reduce load in upper portion of tree |
| 10 | referred to as 'hanger' tree | Walking track occupants | 1/500,000 | Remove hanging branch |
| 11 | Envivo #753, referred to as Sione's tree | Structures in back yard of 28 West View Road | 1/30,000 | Reduce load in upper portion of tree |
| 19 | Envivo #2024 | Conservatory at 16 West View Road | 1/300,000 | Reduce load in upper portion of tree |
| 20 | Envivo #2025 | Conservatory at 16 West View Road | 1/30,000 | Reduce load in upper portion of tree |
| 21 | Envivo #2307 | Studio at 14 West View Road | 1,300,000 | Reduce load on lateral branches and in upper portion of tree |
| 22 | Envivo #2305 | Studio at 14 West View Road | 1/30,000 | Reduce load in upper portion of tree |
| 23 | Envivo #2292 | Studio and dwelling at 14 West View Road | 1/300,000 | Reduce load in upper portion of tree |
| 67 | Envivo #832 | Zoo building and fence | 1/300,000 | Reduce load in upper portion of tree |
| 69 | Envivo #803 | Zoo building and fence | 1/30,000 | Reduce load in upper portion of tree |
| 74 | Envivo #869 | Human occupants on open space SW of Meola Creek | < 1/1,000,000 | No risk mitigation currently required |
| 81 | Envivo #942 | Zoo fence and elephant enclosure | 1/300,000 | Reduce load in upper portion of tree |
| 94 | Envivo #109? | Footbridge over Meola Creek | 1/300,000 | Reduce load on lateral branches and in upper portion of tree |
| 114 | Envivo #2099, referred to as 'fire' tree | Walking track occupants | < 1/1,000,000 | No risk mitigation currently required |

* risk mitigation options are likely to be grossly disproportionate when considering the costs vs benefits of the work required to reduce the risk further and therefore risk mitigation may not be reasonably practical.

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# 6 TRAQ

The Risk Categorisation inputs of the ISA Basic Tree Risk Assessment form have been reproduced in Table 4. Colour-coding added to the table ranks the four qualifiers in each category and the overall risk rating from lowest (Green) to Highest (Red)

Table 5 – Tree Risk Assessment Qualification scenarios, targets, inputs and overall risk rating

| Tree No. | Scenario | | Likelihood | | | Consequences | Risk rating |
|---|---|---|---|---|---|---|---|
| | Mode of failure | Target | Failure | Impact | Failure and Impact | | |
| 1 | Whole tree failure | Human occupants on walking track | Possible | Low | Unlikely | Severe | Low |
| | | Dwelling at 28 West View Road | | Medium | Unlikely | Significant | Low |
| 10 | Branch failure | Human occupants on walking track | Probable | Very Low | Unlikely | Severe | Low |
| 11 | Whole tree failure | Human occupants in back yard of28 West View Road | Possible | Low | Unlikely | Severe | Low |
| | | Back yard of West View Road | | High | Somewhat likely | Minor | Low |
| | Trunk snapping | Human occupants in back yard of28 West View Road | Possible | Very Low | Unlikely | Severe | Low |
| | | Back yard of West View Road | | Medium | Unlikely | Negligible | Low |
| 19 | Whole tree failure | Dwellings at 16-18 West View Road | Possible | High | Somewhat likely | Minor | Low |
| | | Conservatory at 16 West View Road | Possible | High | Somewhat likely | Significant | Moderate |
| | | Human occupants in back yards | Possible | Low | Unlikely | Severe | Low |
| | | Human occupants in conservatory | Possible | Medium | Unlikely | Severe | Low |
| | | Back yards at 16-18 West View Road | Possible | High | Somewhat likely | Negligible | Low |
| | Crown failure (1st order branch) | Human occupants in back yards | Possible | Very Low | Unlikely | Severe | Low |
| | | Back yards at 16-18 West View Road | Possible | High | Somewhat likely | Negligible | Low |
| 20 | Whole tree failure | Dwellings at 16-18 West View Road | Possible | High | Somewhat likely | Minor | Low |
| | | Conservatory at 16 West View Road | Possible | High | Somewhat likely | Significant | Moderate |
| | | Human occupants in back yards | Possible | Very Low | Unlikely | Severe | Low |
| | | Human occupants in conservatory | Possible | Medium | Unlikely | Severe | Low |
| | | Back yards at 16-18 West View Road | Possible | High | Somewhat likely | Negligible | Low |
| | Crown failure (1st order branch) | Human occupants in back yards | Possible | Very Low | Unlikely | Severe | Low |
| | | Back yards at 16-18 West View Road | Possible | High | Somewhat likely | Negligible | Low |
| 21 | Whole tree failure | Studio at 14 West View Road | Possible | High | Somewhat likely | Significant | Moderate |
| | Crown failure (1st order branch) | Studio at 14 West View Road | Possible | High | Somewhat likely | Minor | Low |
| 22 | Whole tree failure | Studio at 14 West View Road | Possible | Medium | Unlikely | Minor | Low |
| | | Dwelling at 14 West View Road | Possible | Medium | Unlikely | Minor | Low |

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| Tree No. | Scenario | | Likelihood | | | Consequences | Risk rating |
|---|---|---|---|---|---|---|---|
| | Mode of failure | Target | Failure | Impact | Failure and Impact | | |
| 23 | Whole tree failure | Studio at 14 West View Road | Possible | Low | Unlikely | Negligible | Low |
| | | Dwelling at 14 West View Road | Possible | Medium | Unlikely | Minor | Low |
| 67 | Trunk failure | Zoo building | Possible | Low | Unlikely | Minor | Low |
| | | Zoo fence | Possible | Medium | Unlikely | Significant | Low |
| 69 | Whole tree failure | Zoo building | Possible | Medium | Unlikely | Minor | Low |
| | | Zoo fence | Possible | High | Somewhat likely | Significant | Moderate |
| | Trunk failure | Zoo building | Possible | Low | Unlikely | Minor | Low |
| | | Zoo fence | Possible | Medium | Unlikely | Significant | Low |
| 74 | Whole tree failure | Human occupants of open space SW of Meola Creek | Possible | Very Low | Unlikely | Severe | Low |
| 81 | Whole tree failure | Zoo fence, elephant enclosure | Possible | High | Somewhat likely | Severe | Moderate |
| | Crown failure (included branch union) | Human occupants of open space SW of Meola Creek | Possible | Very low | Unlikely | Severe | Low |
| 94 | Whole tree failure | Footbridge over Meola Creek | Possible | High | Somewhat likely | Significant | Moderate |
| | | Human occupants of walking track or footbridge | Possible | Low | Unlikely | Severe | Low |
| | Crown failure (1st order branch) | Human occupants of walking track or footbridge | Possible | Low | Unlikely | Severe | Low |
| 114 | Whole tree failure | Human occupants of walking track | Probable | Very low | Unlikely | Severe | Low |

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# 7 FINDINGS

The QTRA outputs for the risk of harm to pedestrians within Western Springs Forest has been found to represent a risk of harm between 1/400,000 and >1/1,000,000. The hanger in Tree 10 and the probability of a random tree falling across the walking track pose the greatest risks. Risk of this magnitude should be considered tolerable (where imposed on others) if the risk is as low and reasonably practical (ALARP).

The QTRA outputs for the risk of harm to occupants of dwellings (including the conservatory at 16 West View Road) and back yards has been found to represent a risk of harm between 1/500,000 and >1/1,000,000. The greatest risk exists to occupants of the conservatory at 16 West View Road in the event that Tree 20 fails completely. Risk of this magnitude should be considered tolerable (where imposed on others) if the risk is as low and reasonably practical (ALARP).

The QTRA outputs for the risk of harm to dwellings and other privately-owned structures has been found to represent a risk of harm between 1/30,000 and >1/1,000,000. The greatest risk exists to the Studio at 14 West View Road and the structures at 28 West View Road. Risk of this magnitude should be considered tolerable (where imposed on others) if the risk is as low and reasonably practical (ALARP).

The QTRA outputs for the risk of harm to structures at the zoo and Western Springs Park (footbridge) has been found to represent a risk of harm between 1/30,000 and 1/300,000. The greatest risk exists to the zoo fence and the footbridge in the event of complete failure of Tree 69 or 94. Risk of this magnitude should be considered tolerable (where imposed on others) if the risk is as low and reasonably practical (ALARP).

The TRAQ outputs found Moderate risk for scenarios involving:

- the conservatory at 16 West View Road, in relation to Trees 19 & 20;
- the studio at 14 West View Road, in relation to Tree 21;
- the zoo fence, in relation to Trees 69 & 81, and;
- the footbridge, in relation to Tree 94.

The TRAQ outputs found Low risk for all other scenarios.

# 8 RECOMMENDATIONS

In order to ensure that the risk imposed on others is as low as reasonably practical (ALARP), Trees 10, 19, 20, 21, 69, 81 and 94 require management. Tree management options include (but are not limited to) removal of defective branches (the hanger in Tree 10), pruning to reduce or remove over-extended branches (e.g. Tree 21), height reduction pruning to reduce the impact on target areas (zoo fence/building and dwellings) or tree removal.

# 9 REFERENCES

The following documents were useful in compiling this report:

Benton C, Ask the Arborist Limited (2019): Preliminary Arboricultural Report: Tree Risk Assessment - Western Springs Forest – Pine Stand

Benton C, Ask the Arborist Limited (2019): Table of Findings - Preliminary Arboricultural Report: Tree Risk Assessment - Western Springs Forest – Pine Stand

Collett G, Treecare Services Limited (2006): Western Springs Lakeside Park - Stand of pines (*Pinus radiata*) bordered by the Auckland Zoo, Western Springs Stadium, and West View Rd - Review of tree safety

Collett C, Geotree Limited (2018): Memorandum to David Stejskal, Auckland Council: Western Springs – Stand of radiata pines below West View Rd – Current tally

Collett C, Geotree Limited (2018): Memorandum to David Stejskal, Auckland Council: Western Springs – Stand of radiata pines below West View Rd - West View Rd boundary trees

Geotree Limited (2018): Plan set titled: Western Springs – pines below West View Rd; current tally: see GeoTree memo to Auckland Council, 28 May 2018

International Society of Arboriculture (2017): Tree Risk Assessment Manual, Second Edition

Quantified Tree Risk Assessment Ltd. (2017): User Manual Version 5

Stejskal D, Auckland Council (2018): Western Springs Pine Trees – Arboricultural Assessment

Western Springs Pine Tree Evaluation Report and accompanying raw data produced and provided by GreensceneNZ Limited following joint site visits on 14-15 August 2019