Arborlab

Creating Green Space
Sustainability

Arboricultural Report

November 2021

Job No. 35419

Arboricultural Report

Prepared for: **Project Team**

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Date: **November 2021**

Re: **Application to relocate the Museum St Oak Tree**

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Contents

1. Introduction

1.1 Arborlab have been instructed by Simon Warburton of The Building Intelligence Group to assess the proposed relocation of the Heritage listed Museum Street Oak Tree. The purpose of the assessment was to determine the health and condition of the tree and the effects of any proposed relocation on its health and condition.

1.2 A methodology to successful relocate the tree is to be outlined along with future aftercare requirements.

1.3 The assessment is based on the proposal to relocate the tree to a position, known as site 10, approximately 30m to the west. Other sites have been assessed for relocation, however discounted due to various factors. Arborlab and the project team reviewed all 10 proposed sites and determined site 10 was the most appropriate location.

1.4 Arboriculturally the preferred option would have been to retain the tree in its current location (Site 8), however Site 8 is within the proposed building footprint, so has been discounted.

1.5 Previous work has been undertaken to assess the health of the tree's root system and measure its dimension to determine the feasibility of any transplant operation. The results of these investigations are contained within the Memorandum titled – Initial Notes Parliament Oak and are included as Appendix 3.

1.6 This report is to accompany a planning application for the proposed Future Accommodation Strategy of the Parliamentary Precinct.

2. The site

2.1 The Heritage Oak is in the car park to the rear of Parliament House (The Beehive). There is a sloped access ramp to the east of the tree and car parking area to the north, south and west. The tree is growing within a garden area that was created during the refurbishment of the grounds in 1992.

2.2 The tree can be seen in the following aerial photograph Figure 1.

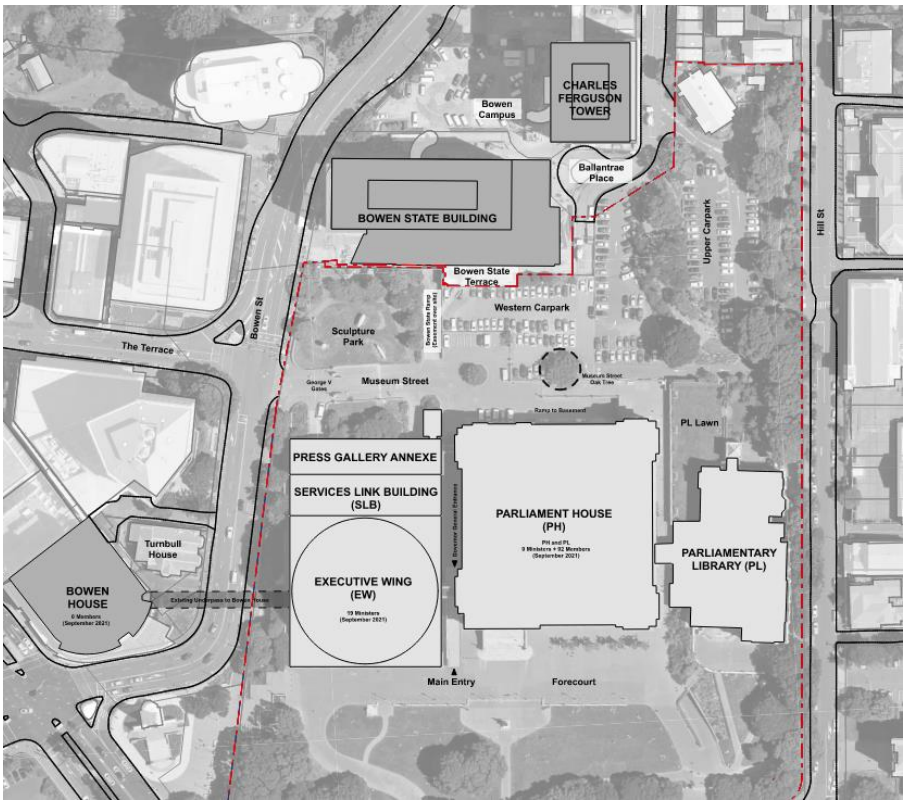


Figure 1: The site with the tree circled.

2.3 The tree's existing location and proposed future location can been seen in Figures 2 and 3 respectively, which are taken from the Future Accommodation Strategy (FAS) Master Plan.

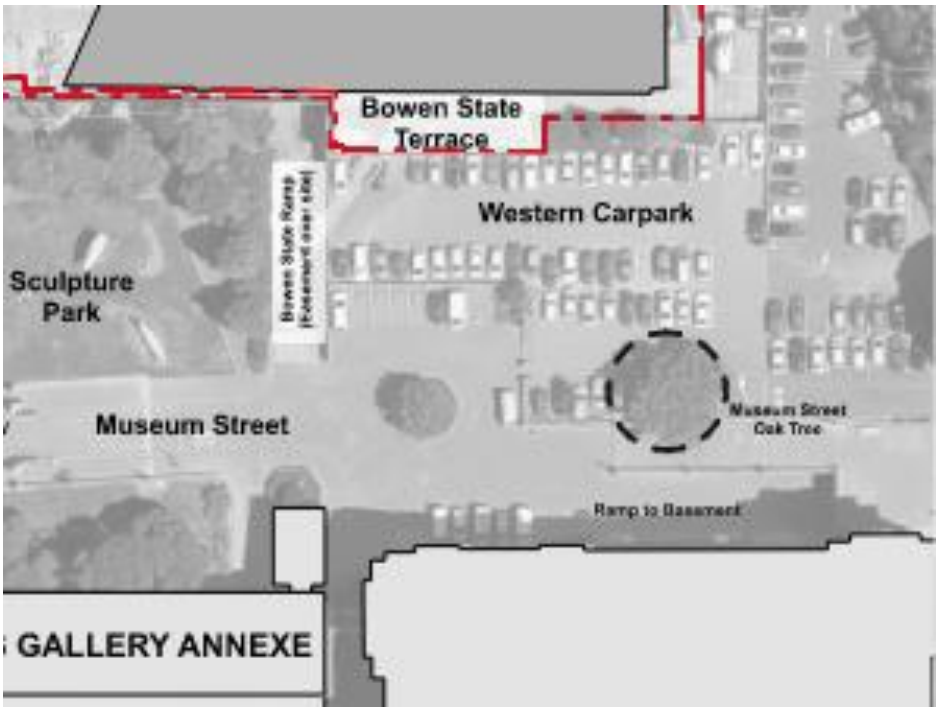


Figure 2. Existing location of the Museum St Oak Tree.

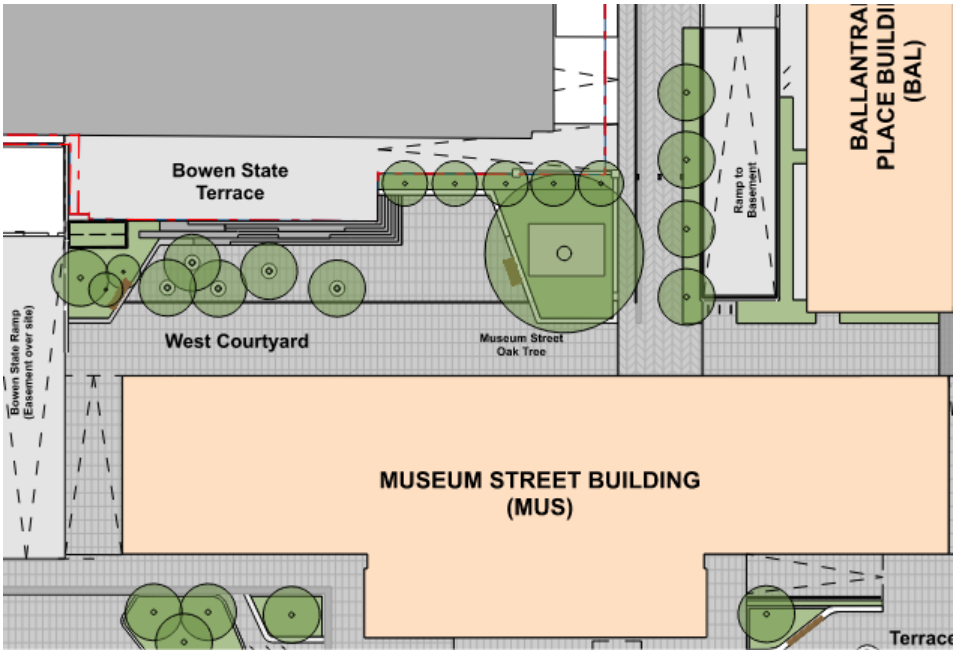


Figure 3. Proposed new location of the Museum Street Oak tree.

2.4 The site has been heavily modified over the lifespan of the tree. After being planted in a cottage garden, the tree is now essentially in a car park between large buildings. The following photographs 1 and 2 show the tree in its original environment and then more recently.

Photograph 1: Museum Street Oak Tree (centre left) c.1900 in the grounds of the Government Gardens cottage from Museum Street.

Photograph 2: Museum Street Oak Tree in June 2021.

3. Tree Assessment Methodology

3.1 A Visual Tree Assessment (VTA) consistent with modern arboricultural practices (Mattheck and Breloer, 1994) was conducted during April 2021. The assessment was carried out at ground level which is classified as a 'Level 2' assessment (Dunster et al., 2013).

3.2 Hand-held laser range finding devices have been used to record data onsite. The tree girth has been measured conventionally with a tape measure and the height and canopy spread measured with the laser range finder. Although considered to be acceptable for a general tree survey, all measurements should be considered an approximate with a degree of error.

3.3 Several previous reports and studies have been reviewed and aided the overall assessment of the feasibility of relocating the tree. In addition, on site investigations to determine root growth and architecture were carried out. A climbing inspection was also undertaken to inspect the larger scaffold branches and any cavities or pruning wounds.

3.4 Soil testing was carried out to determine soil health along with fungal and bacterial activity,

3.5 The cavity at the base of the trunk was assessed using sonic tomography in September of 2019.

4. Limitations

4.1 It should be noted that trees are dynamic organisms affected by environmental, biotic and mechanical stressors, which can impact health, vitality and structural integrity. Response symptoms of stress can often not be apparent within trees for a number of years. Given the changeable nature of trees, the nature of transplant operations, tree assessments are generally relevant for a 6–12-month period.

4.2 A visual assessment of the soil profile was made in conjunction with a soil texture test.[1]

5. Regulatory Considerations

5.1 The tree is listed on the Heritage Trees list in Chapter 21 of Volume 1 of the Wellington City District Plan.

Table 1: Wellington City District Plan Heritage Tree Reference

Symbol Reference	Number	Street	Map Reference:	Species	Common name
187		Museum Street	18	Quercus robur	English Oak

5.2 The following section from the District Plan is the rules applicable to listed heritage trees.

21C HERITAGE RULES: TREES

21C.1 Permitted Activities

The following activities are Permitted Activities provided they comply with any specified conditions.

21C.1.1 The minor trimming of any listed tree that will not adversely affect the health or appearance of the tree is a Permitted Activity.

Minor trimming is:

- *The removal of broken branches, dead wood or diseased vegetation.*
- *The removal of branches interfering with buildings, structures, overhead wires or utility networks, but only to the extent that they are touching those buildings, or structures, or interfering with those overhead wires or utility networks.*
- *Other trimming necessary to maintain the health of a listed tree, certified by a person with an appropriate level of expertise.*

21C.1.2 Any activity within the dripline of a listed tree is a Permitted Activity except for:

[1] https://www.agric.wa.gov.au/soil-constraints/soil-texture-estimating-hand or for a video explanation https://www.youtube.com/watch?v=GWZwbVJCNec

➢ the destruction, removal or partial removal of the listed tree
➢ the alteration of existing ground levels by excavations or deposition of soil including thrust boring and directional drilling
➢ the covering of the ground by erection of any building or structure or the storage of goods, including the parking of vehicles
➢ the laying of any impervious surface
➢ the discharge of any toxic substance unless certified by a person with an appropriate level of expertise that the health of the tree will not be adversely affected.

21C.2 Discretionary Activities (Unrestricted)

21C.2 Describes which activities are Discretionary Activities (Unrestricted) in respect of any listed tree.

➢ destruction, removal or partial removal of any listed tree that is not a Permitted Activity
➢ the trimming of any listed tree that is not a Permitted Activity
➢ any activity within the dripline of a listed tree that is not a Permitted Activity
is a Discretionary Activity (Unrestricted).

5.3. Relocating the Museum Street Oak Tree should be considered a Discretionary Activity (Unrestricted).

6. Considerations for transplant

6.1 Successfully transplanting a mature tree is complex operation and the specifics of any transplant methodology would need to be tailored to the tree being moved, its original growing location and the transplant site. Any relocation operation carries a degree of risk to the viability of the tree to be transplanted. There are many factors that can adversely affect the viability of any transplant operation. These factors need to be identified and remediated to ensure a high likelihood of success.

6.2 The following factors should be considered prior to undertaking a mature tree transplant operation.

- Can a root ball of sufficient size be retained and moved as part of the transplant?
- Is the trees health sufficient, as a tree in good health is more likely to withstand the physiological stresses encountered?
- The tree structural condition should be considered – can the tree cope with the mechanical loading of the operation.
- The species tolerance to root disturbance.
- The soil type and profile including quantity and type of rock in the soil.
- The ground contours surrounding the tree (flat, slight elevation, steep angle).
- The presence of services and freedom to excavate around the trees as required.
- Access into the site and setup space for the safe operation of large crane and other machinery.
- Transporting the trees around the site or off site will require, crawler crane, trailer or truck of sufficient size.

7. Dimensions for relocation

7.1 In general, a root ball of up to 10 to 12 times the diameter of the main stem measured at 300mm from ground level needs to be achieved to ensure a successful transplant (Harris et al 2010).

7.2 With a diameter of approximately 1 meter at 300mm from ground level, the root ball requirements above would be approximately 10 meters. However, the tree's root system is mostly contained within the planted area and is dense and compact within that area.

8. Findings of Tree assessments

Table 2: Tree Details

Botanical name	Height (m)	Trunk girth (m)	Canopy radii (m) – N, S, E and W	Form	Structure	Health
Quercus robur	14.1	2.74	7.6, 7.1, 6.5 and 7.6m	Good	Good	Good

8.1 The Form, Structure and Health assessment are selected from the following ranges.

Form	Structure	Health
Poor	Hazardous	Poor
Fair	Poor	Fair
Good	Fair	Good
Excellent	Good	Excellent

8.2 The tree's health and vitality are considered to be good. There is a dense canopy with good extension growth and numerous emergent buds ready for development in spring/summer.

8.3 The excavations within the root zone found numerous roots and all appeared in good health. The roots were evenly dispersed around all sides of the tree and were found down to a depth of 1.3m.

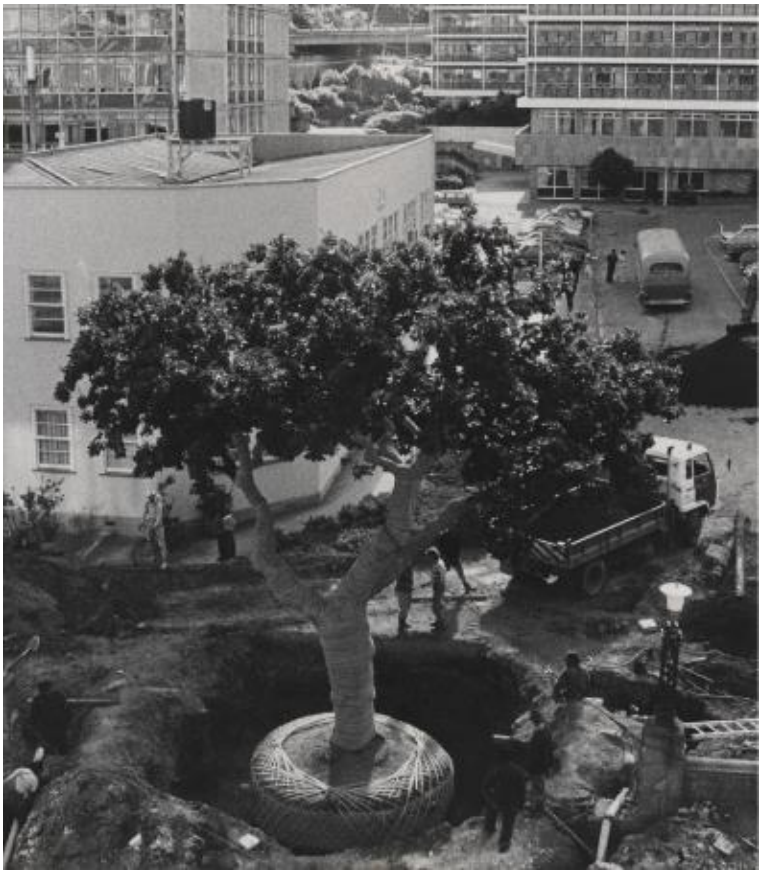
8.4 In the southern corner there was a greater propensity of roots to a depth of 1.5m. The soil profile was slightly loamier in this location. The development of extra roots at a greater depth could be due to this corner being the lowest point and therefore increased soil moisture levels.

8.5 The soil area within the proposed root ball size of 4.6m by 6.7m by 1.6m had a significant quantity of root mass within the planted area and was denser than expected. This indicated the tree has developed a more compact and contained root system. This is likely to have been

influenced by the previous root ball preparation, the soil preparation and irrigation within the current site. The amount of roots mass discovered in this area and the low number of roots, that have left the planting area mean the proposed root ball size will contain enough root mass to enable successful establishment of the tree in the new location.

9. Root Architecture

9.1 In1986-7 the tree was previously prepared for relocation. At this time significant pruning of both the canopy and root system were carried out. This can be seen in the following photograph 3.



Photograph 3. Tree in preparation for relocation (1986-7)

9.2 The root pruning and removal at this time will have affected root architecture of the tree.

9.3 On site investigations have shown the tree's root system is compact and dense and generally contained within the current planting area. In addition, the soil that was used to back fill the hole created in 1986-7 was of good quality and combined with the regular application of mulch and existing irrigation system has led to a healthy root mass within the planter area.

9.4 The root system is deeper than expected and continues to be healthy and dense to approximately 1.6m in depth.

10. Soil Analysis

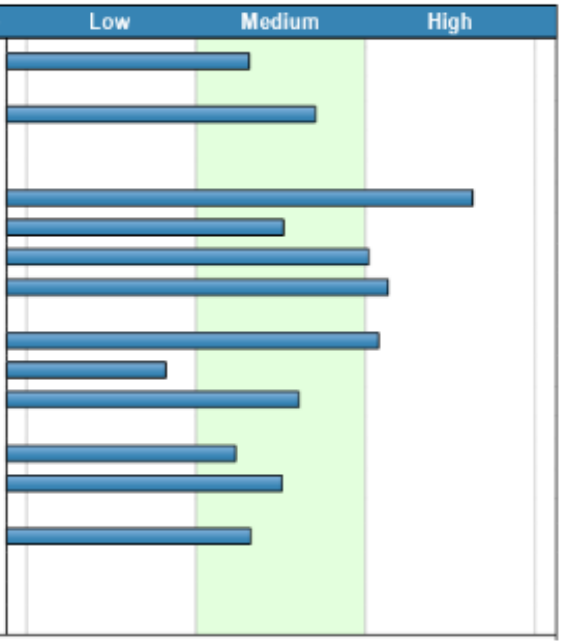
10.1 Previously soil testing was carried out in November of 2017 and September 2019 and provided the following sets of results shown in tables 3 and 4 following.

Table 3. Soil test results from November 2017.

Test	Existing Location
Hills – Basic and Melich 3	Low Ph and high trace elements, could indicate chemical application
Soil Food Web Analysis	Low fungal activity, but excellent fungal diversity

Table 4. Soil test results from September 2019

Analysis		Level Found	Medium Range
pH	pH Units	6.0	5.8 - 6.5
Olsen Phosphorus	mg/L	43	25 - 50
Anion Storage Capacity*	%	57	
Potassium	me/100g	1.64	0.50 - 1.00
Calcium	me/100g	9.1	6.0 - 12.0
Magnesium	me/100g	3.10	1.00 - 3.00
Sodium	me/100g	0.64	0.00 - 0.50
CEC	me/100g	27	12 - 25
Total Base Saturation	%	54	60 - 85
Volume Weight	g/mL	0.84	0.60 - 1.00
Sulphate Sulphur	mg/kg	12	10 - 20
Extractable Organic Sulphur*	mg/kg	8	4 - 12
Organic Matter*	%	10.2	7.0 - 17.0
Total Carbon*	%	5.9	
Soil Sample Depth*	mm	0-150	



10.2 Both sets of results are consistent with healthy tree growth, however improvements to the soil could be made to further enhance the growing environment.

11. Assessment of cavity, main stem, and scaffold branches

Sonic Tomography

11.1 Sonic tomography uses sound waves to map the internal structure of a trees stem. A series of measuring points are positioned around the trees stem in a horizontal plane where a greater understanding of the internal wood quality is required. The geometry of the tree is plotted accurately using a calliper and sensors are then affixed to each measuring point, with sensor number 1 positioned at north.

11.2 The measuring points are then struck sending a sound wave through the tree. The time it takes for the sound wave to reach each of the sensors is recorded by the device and used to generate a map or tomograph of the internal structure of the tree.

11.3 Sound waves pass through healthy wood at high velocities, whereas decayed or damaged regions can slow the path of the sound wave. The tomographic computer software interprets the data and presents a coloured cross section of the tree trunk in the location where the tomogram was made. High velocities are represented by black or brown, whereas low velocities are represented by a purple or blue. Green represents intermediate velocities. The colour scale is depicted at the top of each tomogram for interpretation purposes and the velocities are relative in each instance.

11.4 In September 2019 the cavity at the base of the tree and its lower trunk were assessed using sonic tomography. The tomograms were taken at 300mm from ground level, just above the cavity and at 1800mm from ground level. They can be seen in Figures 4 and 5 respectively.

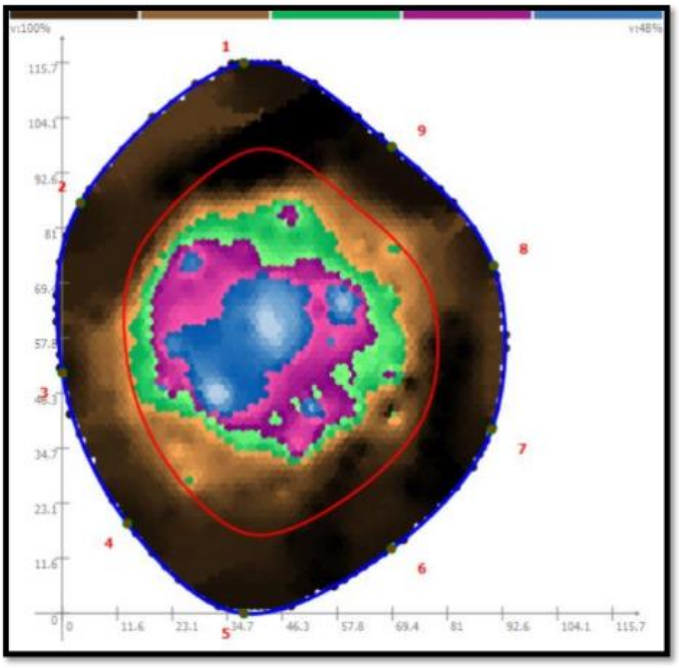


Figure 4. Tomogram at 300mm.

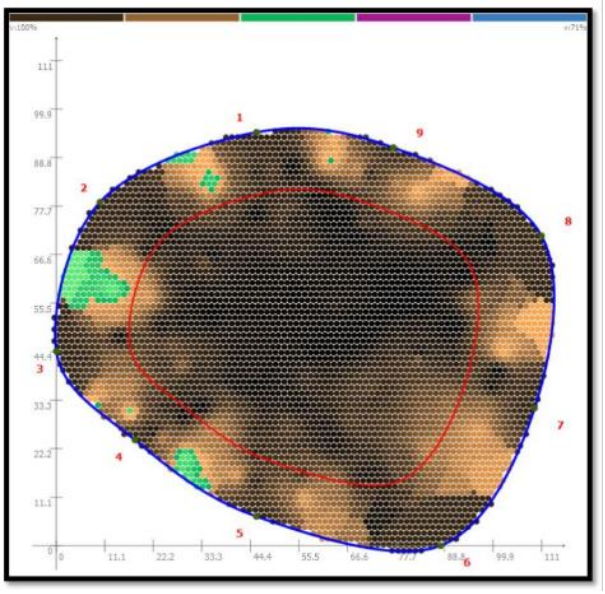


Figure 5. Tomogram at 1800mm

11.5 The tomographs undertaken indicate that while there is decay at the base of the trees main stem it should not be sufficient to affect the integrity of the stem during the transplant. There are no causes for concern with this amount of decay on a tree of this age. It is in fact, expected to find decay on trees of this age and size.

Climbing inspection

11.6 During the September 2019 inspection cavities were noted in the tree's structural or scaffold limbs. As a result, a climbing inspection was carried out in June 2021 to assess these cavities and any affect they may have on the tree's structure.

11.7 All the cavities were found to be minor and unlikely to affect the tree's structural strength or cause any issues during the transplant operation.

11.8 The tree's vitality and adaptive growth were again visually inspected in June 2021to determine whether any new growth was sufficient, or the tree's structural strength has reduced or was compromised. No concerns were discovered.

12. Existing sun light, shade, and artificial lighting

12.1 In 2019 it was noted that there are clusters of mature foliage present throughout the trees crown.

12.2 These clumps of mature foliage are probably due to the high levels of artificial light in the trees growing environment. High levels of artificial light have been shown to affect the tree day night cycle or photoperiod. This altered photoperiod impacts upon tree dormancy, shoot growth, and flowering. More specifically alterations in photoperiod can influence leaf shape, leaf pubescence, pigment formation, autumn drop time, root development and the onset of breaking of bud dormancy. This can result is a detrimental impact upon tree health (Chaney, 2002).

12.3 The artificial light referred to here is most likely from the streetlight located to the west of the tree.

12.4 The light and shade levels the tree will be exposed to in its new location will need to be considered both from a natural and artificial light perspective.

13. Site Selection

13.1 In July 2021 an investigation into possible new locations for the tree were carried out. The selection was based on the following criteria.

- Soil volume requirements – inclusive of underground services.
- Changes to sunlight hours and amounts.
- Assessment of wind load changes
- Distance to relocate tree
- Future growth and root area requirements.

13.2 To evaluate the possible relocation sites a gateway system was used. Any significant item that was identified as likely to mean the relocation will not be successful has been described and discounted the possible relocation site.

13.3 More detail on these sites and the assessment made can be found in the Memorandum titled Initial Notes Parliament Oak, July 2021 and included in Appendix 3.

13.4 As a result of these investigations Site 10 was determined to be the most appropriate relocation site.

14. Relocation Method

14.1 To relocate the tree, numerous factors need to be considered. The tree's current dimension and its future dimensions will determine whether the tree can be transported to the new site and the new location is viable.

14.2 To give the relocation operation the highest likelihood of success, the largest root ball possible needs to be created to ensure the greatest practical number of roots are moved with the tree. It is also extremely important to ensure that the soil area within the root ball does not twist or fracture during the relocation operation. Excessive movement of the soil within the root ball during the relocation operation can cause roots to be damaged or severed and adversely affect the tree's ongoing health. It is also important that the tree does not 'slump' or slip down through the centre of the root ball.

14.3 The previous investigations indicated the tree has developed a more compact contained root system. Therefore, it is likely a greater percentage of existing roots can be taken with the proposed sized root ball than if it was a tree in an open ground area.

14.4 Based on the discovered root architecture and characteristics the root ball size of 4.6m wide [east to west] and 6.7m long [north to south] and 1.5 to 1.6m deep, will be sufficient. This will allow the majority of the important root system to be retained and relocated with the tree. Thus, significantly reducing any potential relocation shock.

14.5 To ensure the root ball is stable during the relocation operation a lifting strategy has been developed by Holmes Consulting and included as Appendix 1. It is proposed to thrust steel pipes under the tree root ball at a depth below 1.6m. This will form a continuous bed of steel pipes. These would extend out beyond the root ball. Under the steel pipes, iron girders are thrust and welded to the steel pipes to create a lifting frame. The deflection of this framing at the lifting points will be less than 25mm.

14.6 This is likely to require a work area of 10m to the west side of the tree and 12m to the southern side of the tree. The work area will need to be excavated to a similar depth(2m) to install the steel frames under the tree root ball.

14.7 To ensure a large enough root ball can be excavated and steel frames thrust underneath as described above, a large working area is required. This area should be sufficient to allow the pipes to be thrust under the root ball from the south and the girders from the west. The following aerial image Figure 6 indicates the required work area in red.

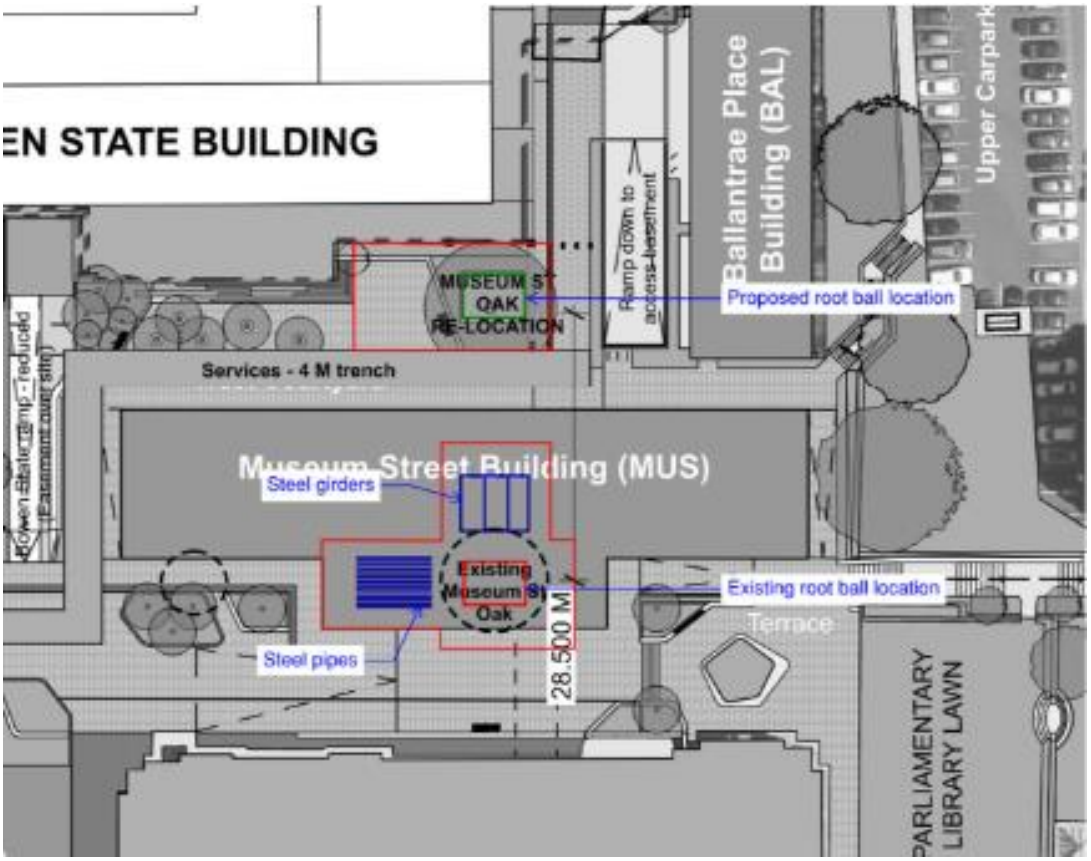


Figure 6. Likely excavation requirements.

14.8 The approximate weight of the root ball, above ground parts of the tree and the relocating equipment (frames, boxing, and transporter) is approximately 130 to 150 tonnes.

14.9 To further minimise any soil loss and drying of the root ball it will be wrapped in a protective cloth and bound to the lifting frame. The cloth will be wetted and kept wet throughout the transplant operation. The root ball will also be framed in wooden boxing to stop soil falling out.

14.10 The canopy will be secured with soft strops and binders to hold tree secure during lifting and transport.

14.11 When in transport, the canopy will need approximately 8m either side of the trunk and a clearance height of approximately 15m to safely pass between any structures.

Photograph 4. Example of Large Tree Relocation Utilising Pipes and Air Bags[2]

14.12 It is understood that underground services within the car park need to be relocated. This involves the installation of new services followed by the decommissioning of the existing services.

14.13 This should be timed to ensure the tree can be relocated in winter and be carried out in such a way that the new services do not interfere with the excavation required for a successful transplant.

[2] *Photo credit - Treemovers.com*

14.14 The new services trench can be seen in the following figures 7 and 8.

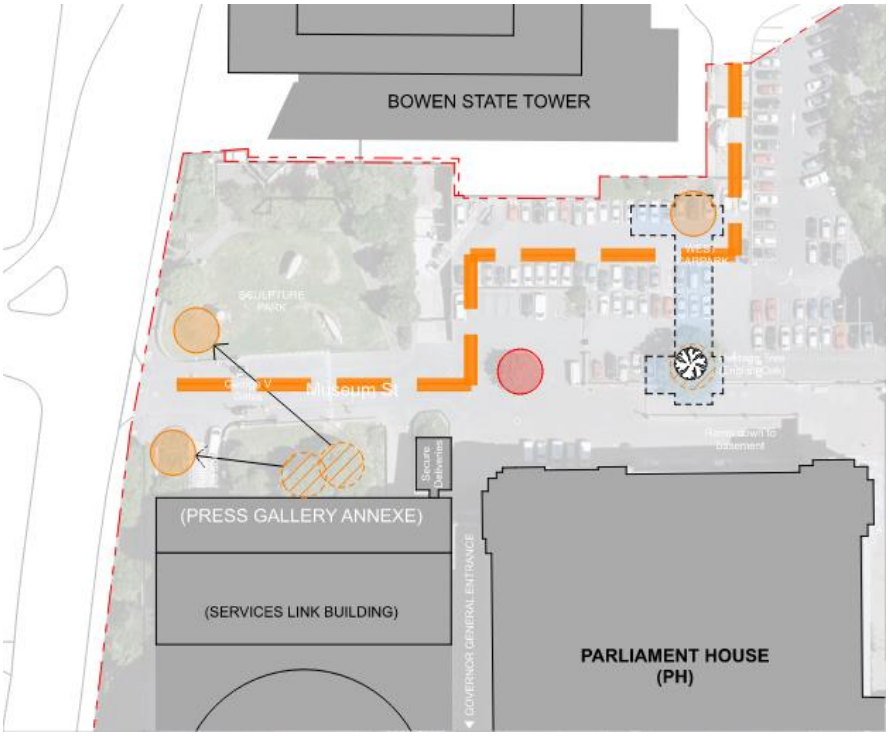


Figure 7. Services trench marked in orange

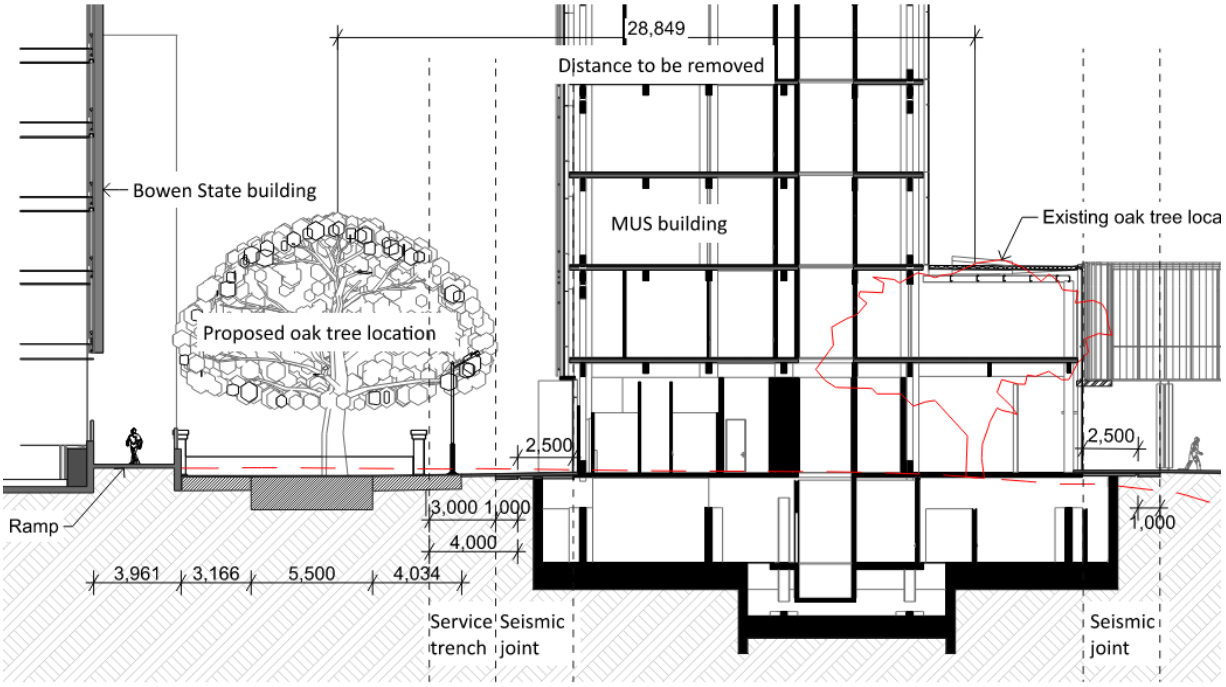


Figure 8. Services trench cross section.

14.15 Once the tree is securely in its new location, the frames, load binders, wooden frame, protective cloth, and pipes will all be removed. The pipes will be removed in a careful sequence and gaps back filled with soil to prevent any large air pockets being left.

14.16 The girders will be left in situ and the any gaps between these again packed with soil.

15. Relocation sites

15.1 Several options for the relocated site were evaluated. The possible relocation sites are shown in the following aerial image Figure 9.

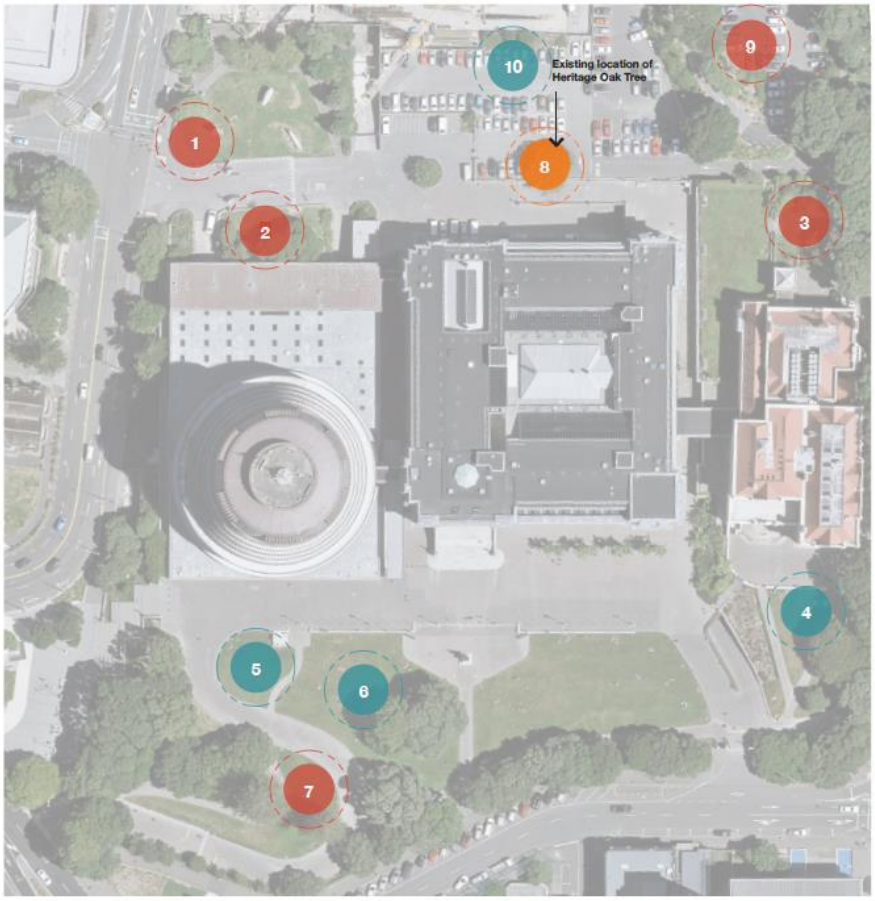


Figure 9. Possible relocation sites.

15.2 Each site was examined in some detail and the findings are described in Appendix 3 – Initial Notes Parliament Oak.

15.3 After careful consideration site 10 was determined to be the most appropriate new location for the tree, when factoring in all the complexities of any transplant operation. Site 10 was slightly adjusted to move the tree to north and the final location is shown in Figure 10 following.

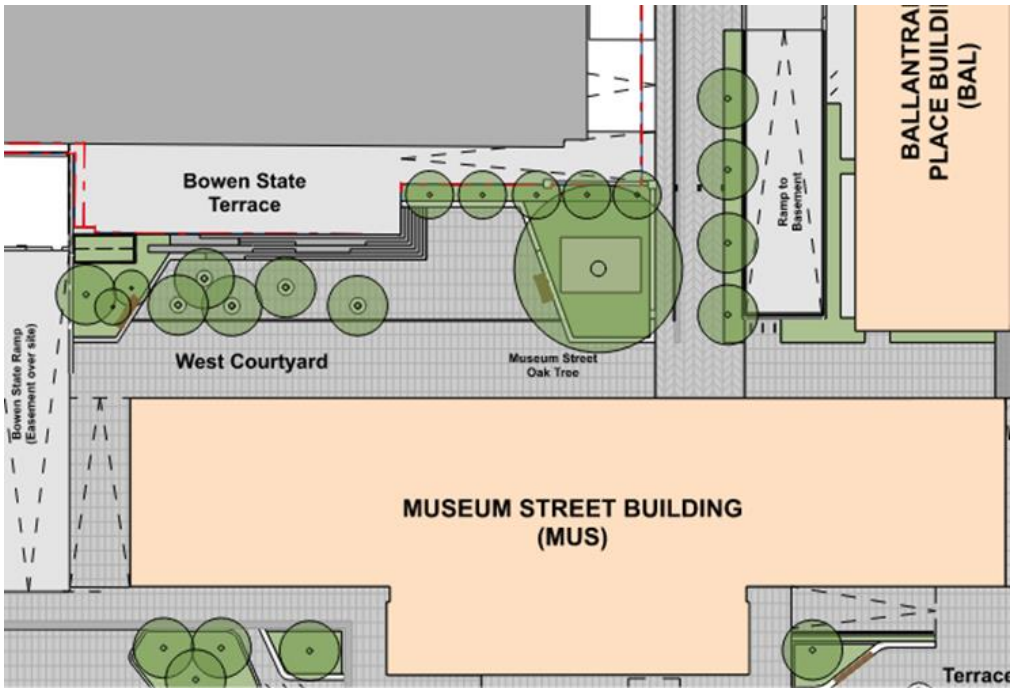


Figure 10. New Tree Location – Site 10.

16. Requirements at the new location – Site 10

16.1 To ensure the successful relocation of the tree, the new site must meet several criteria as outlined below.

16.2 The centre of the tree is to be set back from the existing building and proposed building by 9m to allow for future canopy growth.

16.3 An unpaved area over the existing root ball and at a minimum 0.5m outside the existing root ball dimensions will be provided to allow the addition of mulch and irrigation as required. The area outside the existing root ball is required to allow inspection of soil condition, root growth and access to existing root ball edges.

16.4 The creation of a soil vault around the root ball has been designed to allow the tree roots to develop in the imported soil. A section of this area could be paved over.

16.5 Any soil vault should be linked underground with other areas of newly planted trees.

16.6 Irrigation should be provided in the new location, inclusive of soil moisture monitoring. The soil moisture levels should replicate the current growing environment. Drainage should be included to ensure the soil vault is not excessively saturated for a sustained period (72 hours or longer).

17. Sun effect study

17.1 The sun study shows modelling for the tree in its existing location and site 10 (Proposed location 2 in Appendix 2). The below table 2 compares the sunlight hours at each location.

Table 5: Sun study comparison

	Existing					Site 10					
	First	Full	Last Full	Shade	Hours	First	Full	Last Full	Dark	Hours	Difference
15-Sep	08:30	09:45	16:15	16:45	8.25	10:15	11:15	15:30	16:30	6.25	2.00
15-Dec	07:00	08:30	16:30	17:30	10.5	09:30	11:45	13:30	16:00	6.50	4.00
15-Mar	08:15	09:45	16:00	16:45	8.5	10:30	12:00	15:00	16:15	5.75	2.75

17.2 The table shows the time at which light is first (First) cast onto the tree in the morning for each location and the time at which the canopy is in full shade (Shade). It also shows the times when the tree is in full sun (Full) and when it starts to become shaded again (Last Full).

17.3 The average sun light hours lost between locations is approximately 2.9 hours per day. During the winter when the tree has lost its leaves this is less relevant, so the June measurement can effectively be discounted.

17.4 The greatest loss of sunlight hours is during Summer (the December measurement) as would be expected.

17.5 However, this is a measure of direct sunlight only and does not account for diffuse light or light from other sources and angles.

17.6 It should also be noted that the tree will not be absorbing all the available light in its current location, only what is required for photosynthesis and the production of carbohydrates.

17.7 Although the direct sunlight levels in the new location will be reduced throughout the day, the tree can absorb a higher amount of this reduced light level to meet its photosynthetic requirements.

17.8 This will be done initially by the chloroplast (light absorbing cells) adjusting the amount of light they absorb. If this is insufficient the tree will then alter the size and shape of any new leaves, producing large, thinner leaves in areas with lower light levels. This will again allow the tree to absorb more light. This is the first observable sign of any response to light level changes.

17.9 If these options do not allow those sections of the tree with lower light levels to effectively absorb more energy than the use, then the tree will close them down, and replace the growth elsewhere.

17.10 Since the tree has an existing energy store, this process will occur over many years, thus allowing the tree to adequately compensate. However, to ensure no detrimental effects to the tree's health occur in the new location an artificial light system should be developed to provide

light that replaces the lost direct sunlight hours.

17.11 The artificial lighting system should replicate the existing light exposure, compensating for the loss of early morning and afternoon sun light. The artificial lights should be turned off when not needed during the day and at night.

17.12 This light will need to be provided to the upper canopy and be of wavelengths at the red end of the visible light spectrum (680 to 700nm). This can be done with the use of sodium lamps.

17.13 Any other lighting systems for security or general lighting at night should consider the tree and be of a wavelength that will not affect the tree's photoperiod.

18. Wind Effect Changes

18.1 The following aerial image shows the locations of the various sites used from the wind tunnel study.

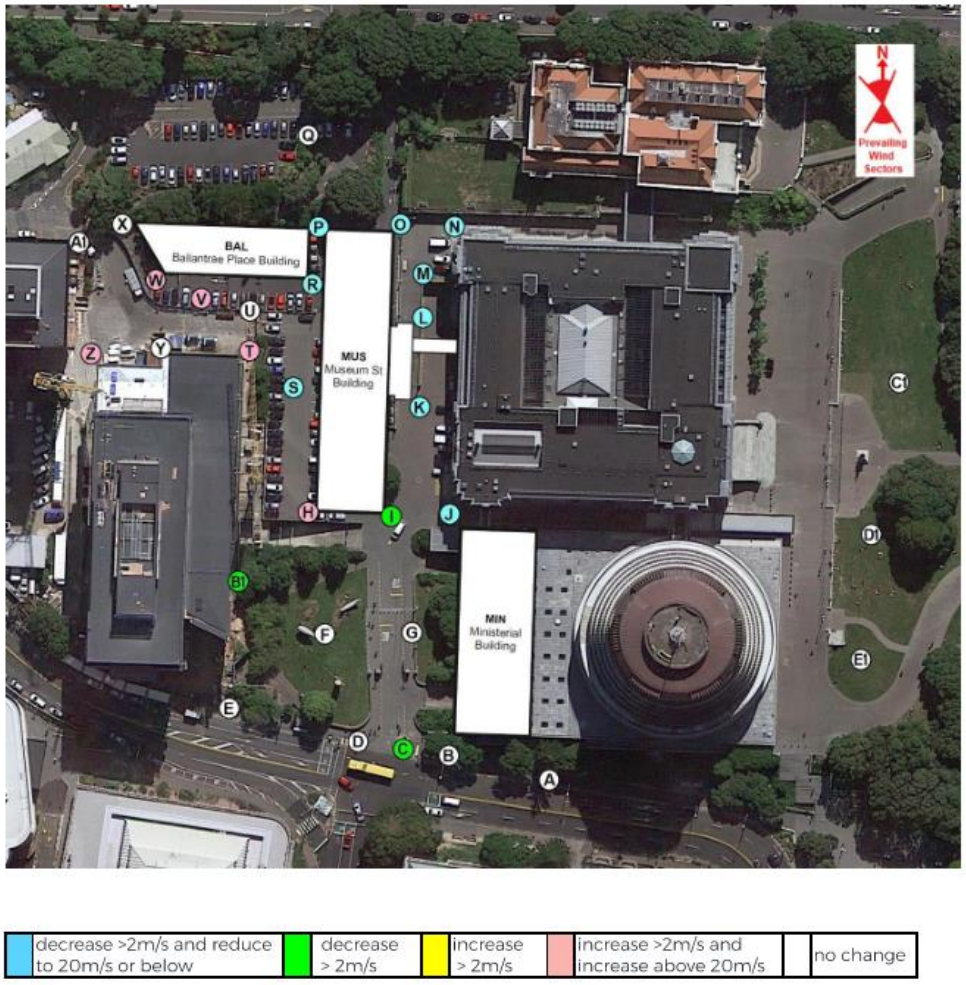


Figure 11. Wind tunnel study sites.

18.2 It is important to note this study was performed with the wind effects on pedestrians in mind, so the wind conditions are those at a height of 1.5m. In general, it is accepted that winds speeds increase with height, so at the top of the tree (14m) the wind speeds are likely to be greater, this is however true at all locations (existing and proposed). Of importance for this study is the change in wind speeds and frequency between the existing and the proposed site.

18.3 The wind study compares the wind speed and maximum gusts at the existing and proposed new location. The existing location (Site 8) is closest to site K in the wind study and the proposed location (Site 10) is between sites S and T in the wind study. The following table 7 shows the results for the existing location and the proposed location.

Table 7. Annual maximum wind gust speed comparison.

Location	Annual maximum Gust Speed	Average
Existing (K)	24 m/s	23 m/s
Existing (L)	22 m/s	
Proposed (T)	30 m/s	26.5 m/s
Proposed (S)	23m/s	

18.4 The existing location has a maximum gust speed of between 23 and 24 m/s. The new location has a maximum gust speed of between 23 and 30m/s. Taking an average of the two measurement sites nearest the proposed and existing locations, this is an increase of approximately 15%.

18.5 The higher wind speeds in the proposed location are caused by the channelling effect of the new building (MUS), which redirects wind flowing off the existing Bowen State building. Once the MUS building is constructed the wind is channelled between the two buildings, instead of hitting Bowen State and then flowing across the existing car park area.

18.6 The highest wind speed in the proposed location will occur at the northeast corner of the Bowen State building and then flow down onto the plaza area and tree, reducing in speed as the wind moves away from the Bowen State building, hence the lower wind gusts at wind measurement site S.

18.7 As well as the change in wind gust speed the frequency of winds speeds exceeding the District Plan thresholds have been measured i.e., number of days per year with mean wind speeds of 2.5 m/s and 3.5 m/s. The following table 8 compares the existing and proposed locations.

Table 8. Comparison of mean wind speed exceedance across a year.

Location	Days per year that a mean wind speed of 2.5m/s is equalled or exceeded.	
Existing (K)	99	Average of 81.5
Existing (L)	64	
Proposed (T)	138	Average of 122.5
Proposed (S)	107	

18.8 The existing location has between 64 and 99 days per year exceeding the threshold and the proposed location has between 107 and 138 days per year exceeding the threshold. Taking an average there is an approximate increase of 50%.

18.9 Further to this the rates at which the wind speeds will change is an important consideration. The construction of the new MUS building will take time to complete, so the channelling effects will not occur immediately after any proposed relocation of the tree. The tree relocation is proposed to occur between June – August, ahead of any construction works commencing.

18.10 The proposed construction is in anticipated to take up to 3 years, with the full effects of new wind conditions not being felt until the latter stages of this anticipated duration.

18.11 This gives the tree some time to adapt to any new wind loads as they change.

18.12 The tree's current vitality is very good, and it will be able to adapt to new wind loads over time. The improved soil environment will aid the tree in producing any adaptive growth.

18.13 To further mitigate the wind load changes it is proposed to carry out some selective reduction of branches on the western side and top of the tree. The following photograph 5 shows the proposed reduction work.

Photograph 5. Proposed canopy reduction on western side and top of the museum oak.

18.14 The proposed reduction work will reduce the load on the branches and therefore lessen the likelihood of failure due to changes in wind loading.

18.15 This requires removal of less than 10% of the trees overall canopy and will be limited to third and fourth order branches only. Therefore, it is within the tree's tolerance to pruning. The pruning will also be carried out in a way that ensures the overall shape and form of the tree are not adversely affected.

18.16 This pruning is proposed to be carried out in winter of 2022 to allow the tree time to adapt before transplanting. Carrying out the pruning at the time of transplant creates a need for the tree's resources at the time of transplant.

18.17 Additional tree planting is proposed in the plaza and adjacent to the ramp to the Ballantrae Place building (BAL). If these trees grow to a similar height to the Museum Oak, they will help to mitigate the wind effects.

18.18 Any mitigation should not cause more shading on the tree in its new location, than is currently proposed. Careful consideration for species selection or ongoing maintenance is required to ensure shading of the tree in the future does not occur.

18.19 The wind study compares the wind speed and maximum gusts at the existing and proposed

new location. The new location has a maximum gust speed of 23 m/s. The wind speed at the proposed tree location is greater than the existing location, however this can be reduced by mitigation, so it is acceptable.

18.20 Any mitigation should not cause more shading on the tree in its new location, than is currently proposed. If landscaping is to be used, careful consideration for species selection or ongoing maintenance is required to ensure shading of the tree in the future does not occur.

19. Soil Volume Requirements

19.1 To ensure a successful transplant, any new location should be able to adequately accommodate the relocated tree, inclusive of its root ball, and allow for future growth of both the canopy and roots. Canopy growth requires 9m of space from the centre of the trunk radially in all directions.

19.2 Root growth is more difficult to accommodate as it requires soil volume. The existing root ball that is proposed to be relocated is 6.7m long, by 4.6m wide and 1.6m deep. This gives a soil volume of 49.3 m3.

19.3 The following graph figure 12 has been used to calculate the required soil volume.

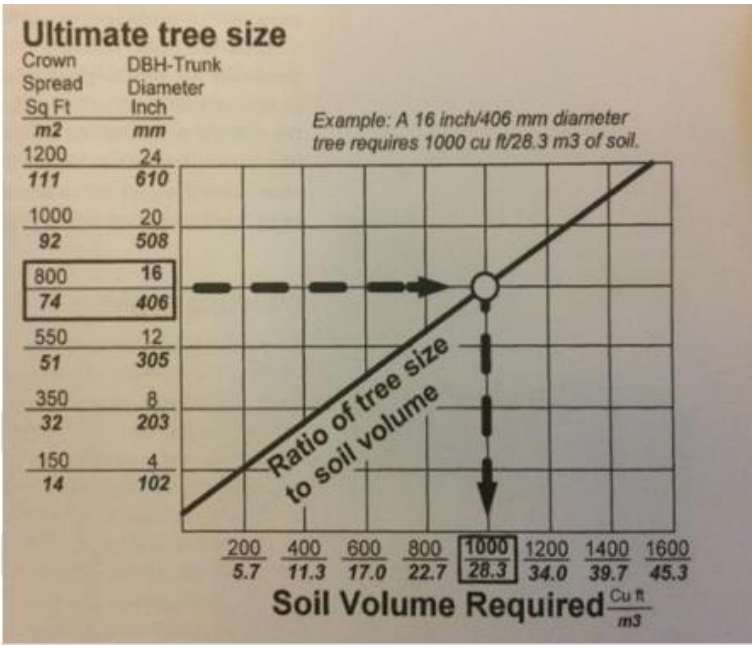


Figure 12. Tree size to soil volume relationship (Urban 1992).

19.4 The current trunk diameter at breast height (DBH) is 873mm. To allow for future growth it is reasonable to assume the Oak tree will achieve a DBH in excess of 1m. In fact, the largest

measured English Oak in Wellington3 has a DBH of 1.2m.

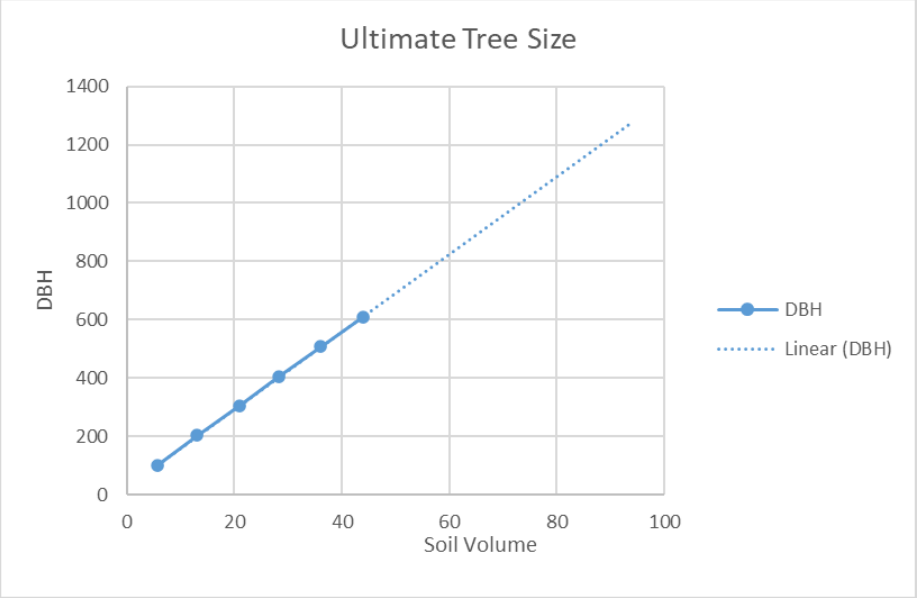


Figure 13. Extrapolated DBH vs Soil Volume with trend line.

19.5 The graph in Figure 12 does not accommodate trees of these dimension, however the data has been used to calculate the soil volume required for larger trees which is shown in the graph in Figure 13.

19.6 A tree with a DBH of 1m requires a soil volume of approximately 75m3. This gives an approximate difference of an additional 25m3 required for the tree in its new location.

19.7 This should be provided with a minimum of 0.5m around the edge of the relocated root ball at a depth of 1.5m. The remaining soil volume can be provided in any direction and placed to avoid underground services, structures and any other requirements of the existing buildings or the proposed building.

19.8 At 0.5m wide, the additional soil volume at the edge of the existing root ball will provide around 9m3 of the additional requirement, at a depth of 1.5m. Any further soil volume can be added at a depth of 1m.

19.9 When relocated the top of the tree's root ball should be level with any provided soil volume and mulched only. This will encourage root growth into the new soil. The existing root ball level should not be above the level of the new soil to accommodate surfaces or structures. This may require the creation of an edge or fence, depending on design requirements.

19.10 In addition, the existing root ball should be accessible, and no surfaces should be allowed to

[3] https://register.notabletrees.org.nz/tree/view/301

cover this area. This will allow for ongoing soil testing, the addition of mulch and irrigation as required.

19.11 This finished surface above the existing root ball should be mulched with aged wood or bark mulch and not any other permeable surface.

19.12 The design for the new site can be seen in Appendix 4 and will provide sufficient root space and room for the canopy to grow as required. In addition, the existing root ball will be left uncovered for access and level with the newly provided soil volume.

19.13 During the root investigations excess was retained and should be used to create the basis of the new soil to be imported into the new location. This retained soil can be enhanced by the addition of leaf duff from the existing tree location and other healthy oaks within the Wellington region.

20. Timing of the transplant

20.1 The most appropriate time of year to transplant trees is during their dormant period, this is generally late autumn to late winter. This is signalled when leaf fall is complete but prior to bud burst. For oak trees in Wellington this is from June to August.

20.2 As the tree is dormant during this period the requirement for water transport within the tree is greatly reduced. As the transplant operation will remove a portion of the tree's root system, the timing of the transplant is a key factor.

21. Conclusion

21.1 The existing rooting environment, root density and condition, tree health and condition have all been investigated to determine the likely success of any relocation operation. The investigation provided favourable results.

21.2 The soil environment, sun and wind exposure at the existing and proposed locations have been investigated. Although a relocation operation is proposed requiring the removal of a few roots that have escaped the existing planter. The alternative of leaving the tree in situ and building around it will likely have the same effects in terms of sun exposure. The gust wind speeds and frequencies are also likely to change in the existing location, with a modified building surrounding the tree on three sides. So, as the available soil volume at the new site will be improved, it is reasonable to assume that the overall risks to the tree by relocating it to the proposed new site are acceptable.

21.3 During the investigations and assessment of this proposal a relocation plan has been developed that would significantly mitigate the risks that are generally encountered during tree relocation operations.

21.4 It is possible to relocate the tree with a low risk to its health, providing a tree relocation plan is developed to mitigate all the concerns and requirements outlined in this report.

21.5 The proposed relocation position overall will enhance the setting of the tree and enable the Precinct to be developed in the most optimal way.

21.6 From an arboricultural perspective transplanting a tree of this species, size, age and condition is acceptable provided the recommendations in this report are followed.

22. Recommendations

22.1 Develop a tree relocation methodology to ensure the recommendations in this report are adhered to.

22.2 An aftercare strategy should be developed to include the following.

- Monitoring of foliar colour and density
- Monitoring of annual growth extension
- Overall canopy health and tree condition.
- Soil and mulch type, depth, volume, and structure,

22.3 Soil moisture monitors should be installed along with an irrigation system to ensure the soil levels are maintained to provide optimum growing conditions. The irrigation system, the monitoring system and soil moisture levels should be inspected regularly when the trees canopy condition is monitored to ensure it is working correctly.

22.4 The above monitoring should be carried out once a month first 6 months then quarterly for the second year and annually for the following 3 years. The monitoring regime should also be adjustable depending on the findings of each inspection.

22.5 A budget should be developed to ensure any required remediation can be carried out. This should include an allowance for the following.

- Regular monitoring and reporting
- Soil testing
- Mulch applications
- Pruning
- Sonic tomography
- Foliar sample testing
- Nutrient addition
- Application of fungal inoculants

23. Appendices

Appendix 1 – 210903 - Oak Tree Relocation Lifting Strategy – Holmes Consulting
Appendix 2 - Sun Study with Trees_V2
Appendix 3 - Initial Notes Parliament Oak

Holmes Consulting

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Christchurch Central
PO Box 6718
Christchurch 8442
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Memorandum

To:	Simon Warburton		
Company:	TBIG		
From:	Jared Zarifeh		
Date	3 September 2021	Project No:	141588.00
Subject:	Parliament Future Accommodation Strategy – Museum Street Oak Tree Relocation - Lifting Strategy		

At the Heritage Oak Tree Relocation Workshop on 1st September, we were asked to provide high level feedback on the feasibility of the relocation strategy including a scheme for a structural lifting frame that could be installed in place beneath the existing tree roots.

The proposed relocation process is outlined in section 3 of the arborist report (Arborlab - August 2021), with the key points relating to the structural lifting frame as follows:

- The root ball is 5m x 7m in plan and 1.6m deep.
- Excavate four sides of the root ball with work area to the south and west.
- Thrust steel pipes below the root ball in the north-south direction to form a continuous layer. Approx 8m length.
- Thrust steel girders below the steel pipes in the east-west direction. Approx 6m length.
- Weld pipes to girders around perimeter and install perimeter girder to form frame.
- Lift by crane to new location.

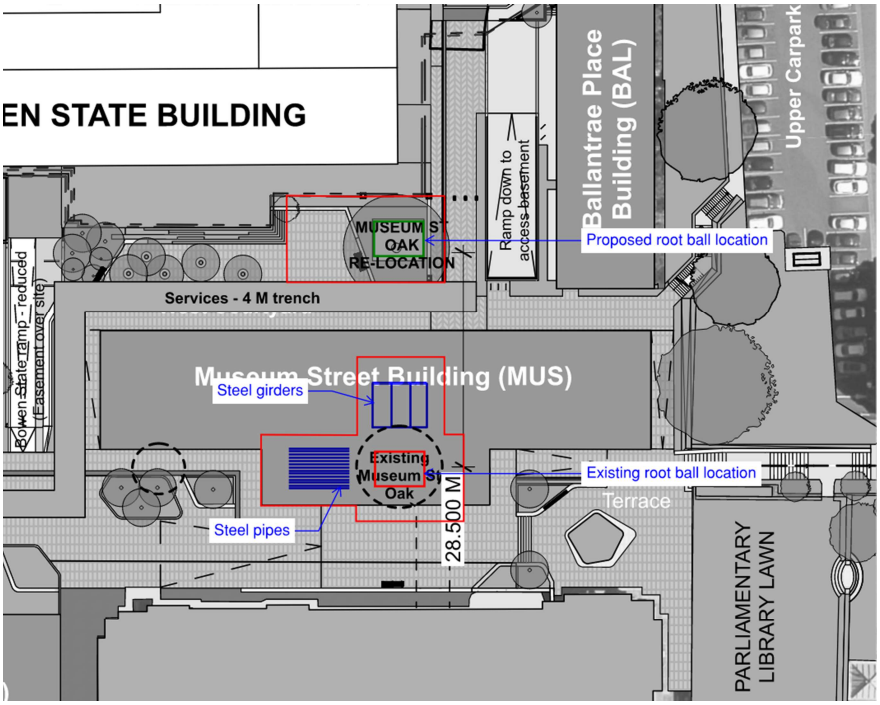


Figure 1: Plan of site showing existing and proposed tree location and working area to install the structural lifting frame.

We have investigated the steel member sizes for the lifting frame geometry shown in Figure 2. There are many ways the frame can be iterated with member size, layout and spacing, so the initial geometry is informed by the parameters discussed during the workshop. A cross section of the frame is also shown in Figure 3.

- 220CHS tubes at 275mm crs in the n-s direction.
- 4x girders in the e-w direction, spaced at 2.5m crs.
- 2x edge girders in the n-s direction, connected to the perpendicular girders.
- 4x crane lifting points at 6m x 6m spacing.

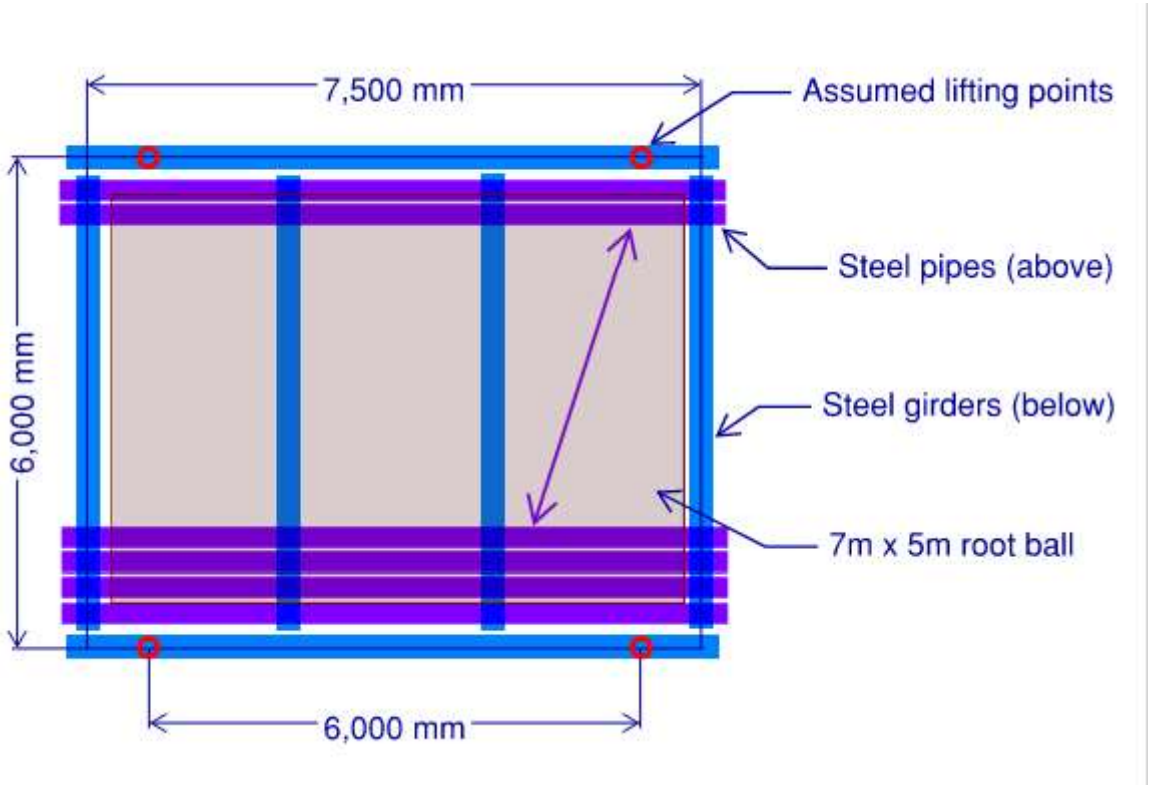


Figure 2: Initial geometry of the structural lifting frame.

The preliminary calculations are based on the following design parameters and assumptions.

- Root ball size 7m x 5m x 1.6m = 56m^3
- Saturated soil weight = 22 kN/m^3
- Tree weight = 8 T , applied centrally
- Formwork allowance = 1 kPa
- Self weight of steel pipes and girders modelled.
- Approximate total weight = 130 – 150 T
- Live load factor of 1.5 applied to root ball and tree weight only.

Table 1 reports the required structural member sizes forming the lifting frame for the following design criteria:

1. The minimum steel girder size required for strength, assuming a live load factor of 1.5.

2. The minimum steel girder size required to limit mid span deflection to ~25mm relative to the corner lifting point. Although a strict limit was not set during the workshop, it is understood a stiffer system is desirable to prevent root damage during the lifting process.

Table 1: Structural member sizes forming the lifting frame.

Design element	1. Strength criteria	2. Deflection criteria
Steel pipes	219x12.7 CHS at 275mm crs	219x12.7 CHS at 275mm crs
Girders	350WC230	400WC303
Relative mid-span deflection to corner.	-45mm	-25mm

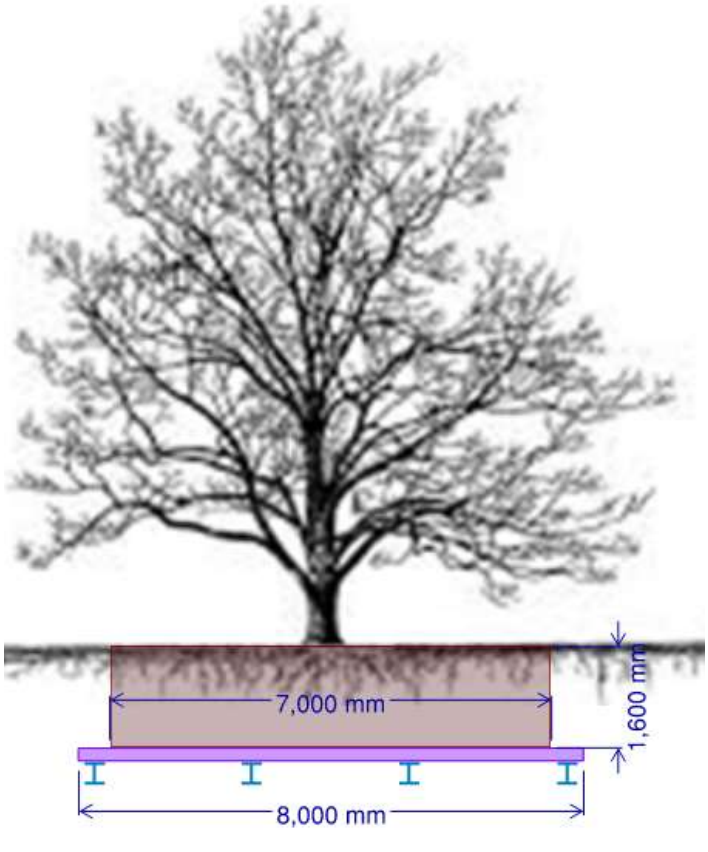


Figure 3: Cross section of the structural frame below the tree and root ball.

Summary:

The proposed lifting strategy was found to require a structural frame formed by a grillage of 220mm diameter CHS tubes, supported on a 350-400mm deep structural frame. The frame would be supported the four corners (lifted by crane).

The site plan shows sufficient working area for installation of the lifting frame. The working area adjacent to the proposed tree location is not as generous and it is understood that some frame elements will be sacrificial due to the complexity of removing them against the existing services trench. The steel pipes are still intended to be recovered to the south, however the proximity to the Bowen Street building and terrace foundations on the east side will need to be reviewed in the detailed relocation plan.

Following confirmation of this relocation strategy, we recommend a detailed structural design of the cradle system is undertaken in collaboration with the arborist and feedback from a crane operator.

Jared Zarifeh
PROJECT ENGINEER
Holmes Consulting LP

Copies to: Russel Allen, TBIG
David Spencer, Karl Burgisser, Arborlab
Julie Stewart, Blair Brixton, Michael Davis, Daryl Calder, Studio Pacific Architecture
Graham Nash, Marcus Welby, Aurecon

FAS LAN

Museum Oak Tree Sun Study

June 2021

For internal use only

Parliamentary Services

studiopacificarchitecture

Sun Study
Heritage Oak Tree Relocation

This sun-shade study has been produced in order to confirm suitability for transplant of the Heritage Oak tree on the grounds of Parliament. It follows confirmation of a preferred location (refer separate study) and the identificatin of a new alternative location. It aims to provide a comparison of existing and proposed sun and shade conditions imposed on the tree by its locations. A separate wind assessment is being carried out.

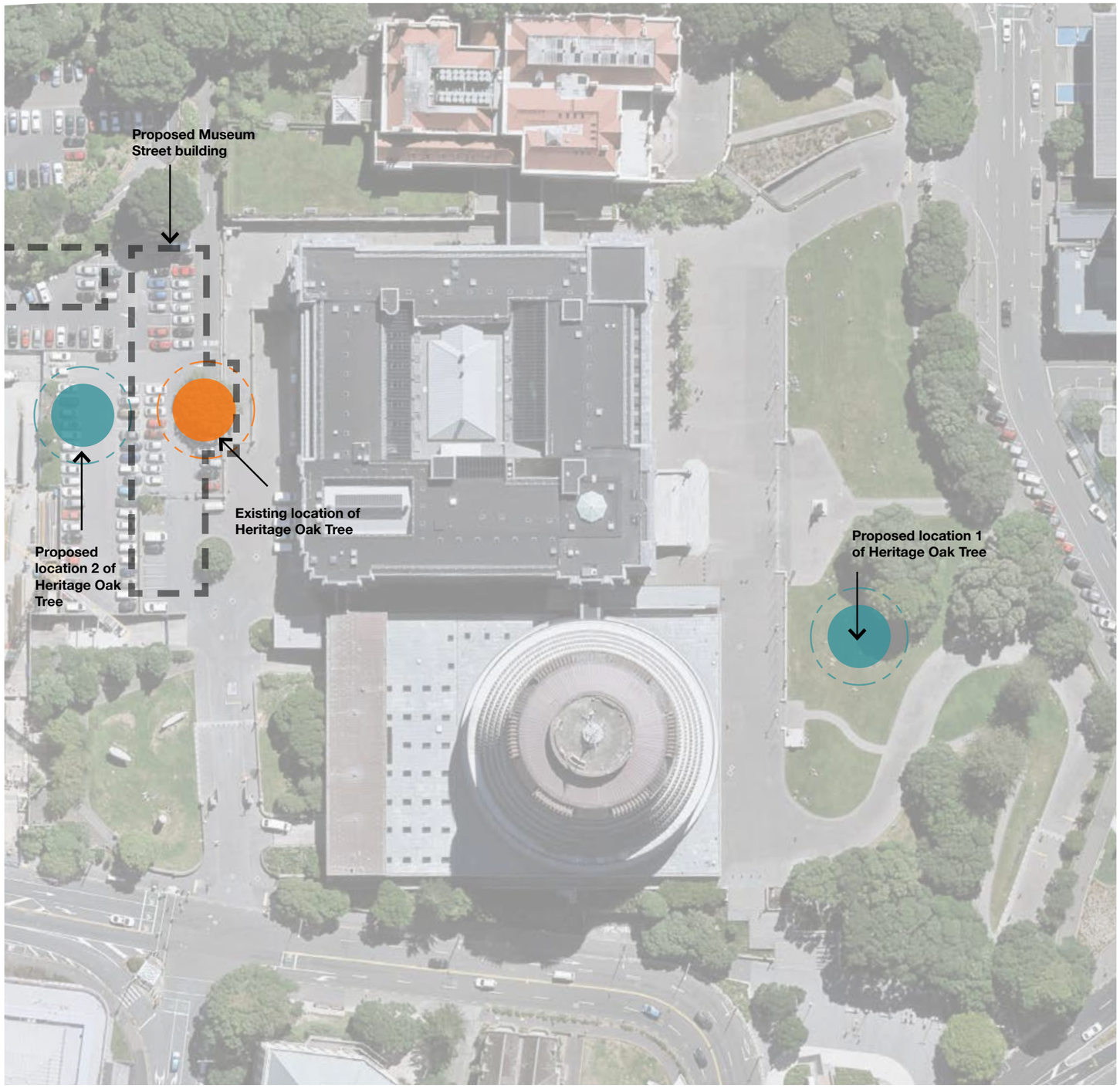
Tree sizes and spreads have been derived from:

- Site survey information including point cloud survey information for the western precinct dated 2017
- Separate arboricultural assessments provided for the western precinct dated 2017
- The Museum St Oak tree and for specific trees in the eastern precinct dated 2017

The adjacent plan shows the existing and proposed locations of the Heritage Oak tree – currently located within the Western Precinct / Museum Street carpark.

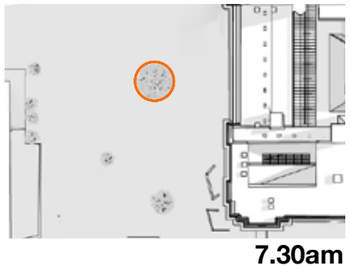
Proposed location 1; (within the Eastern Precinct) adjoins the frontage to Parliament and its forecourt. This is the preferred location of several locations suggested within the eastern precinct - situated on a grassed bank adjoining the forecourt and next to two existing mature trees.

Proposed location 2; (within the Western Precinct) would sit between the existing Bowen State building and the proposed Museum Street building. The modelling shows the implications of existing and proposed buildings on the trees possible location.



Sun Study
22nd March

Existing Location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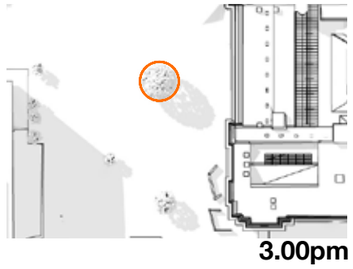
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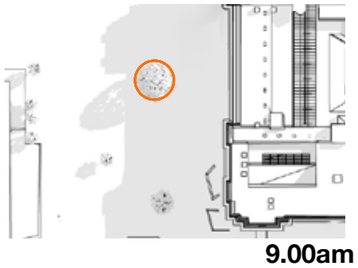
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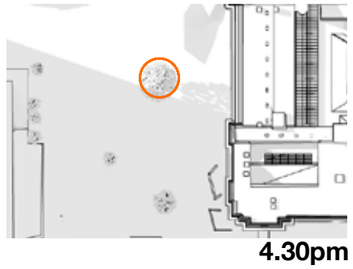
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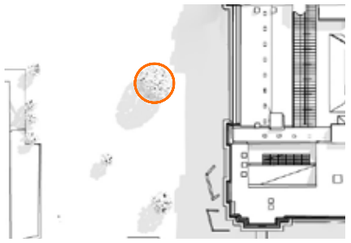
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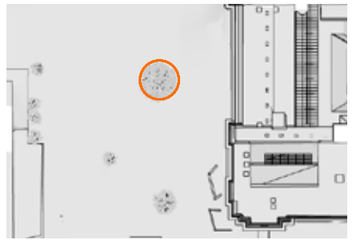
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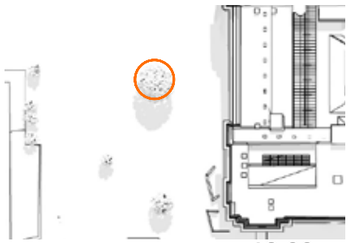
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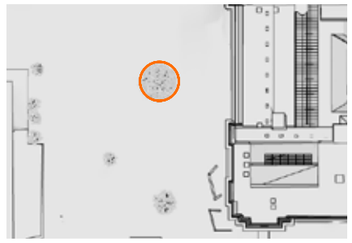
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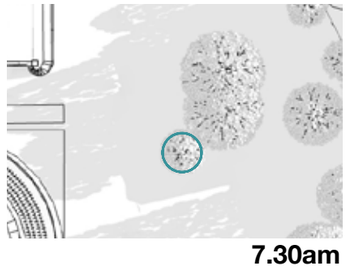
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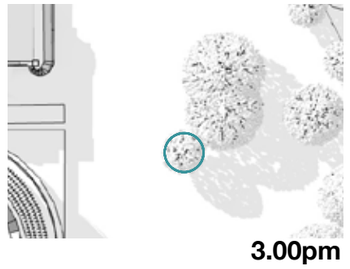
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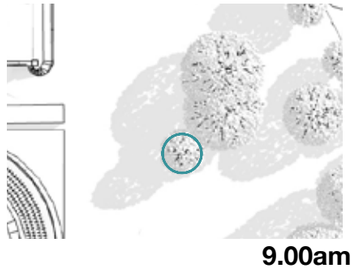
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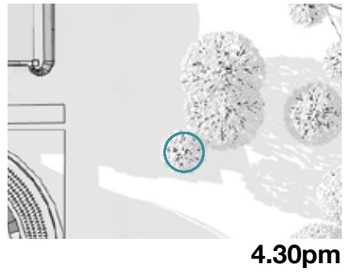
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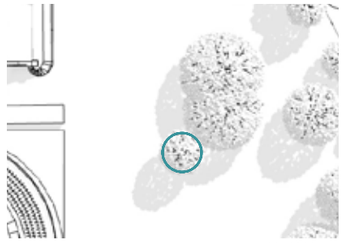
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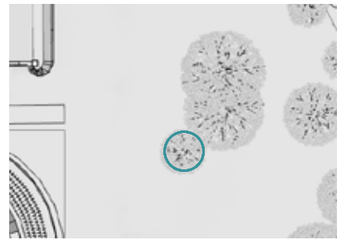
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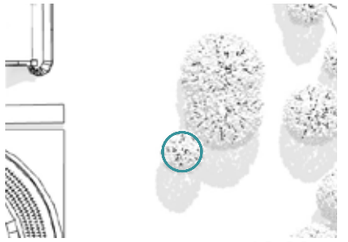
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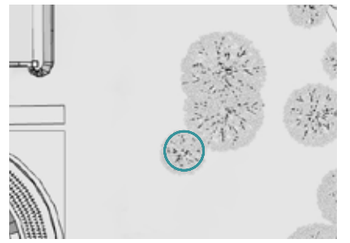
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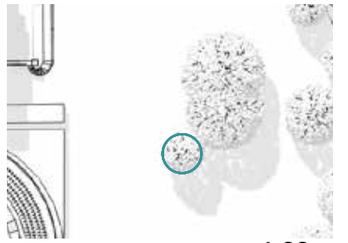
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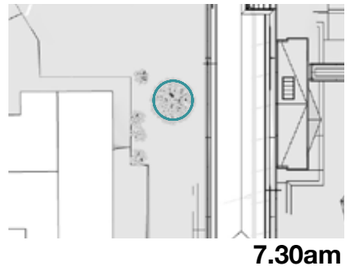
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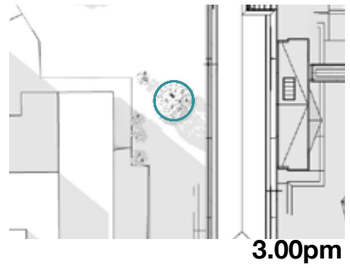
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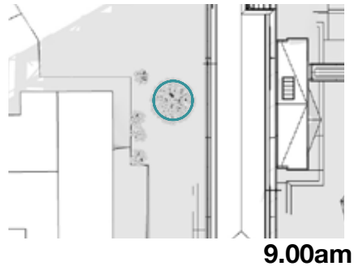
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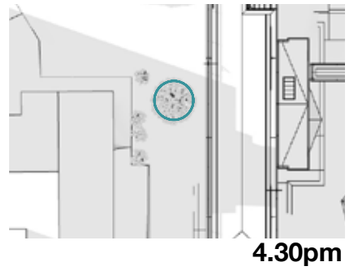
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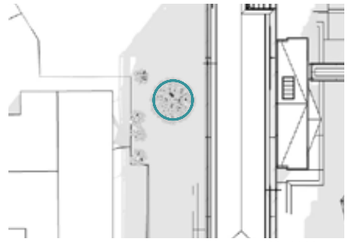
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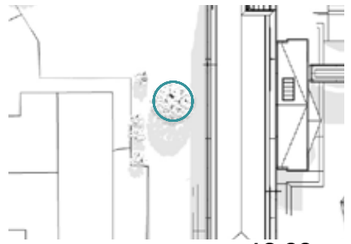
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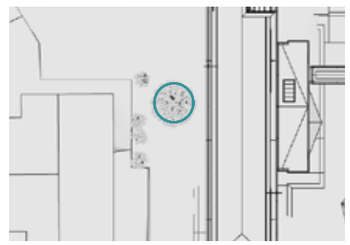
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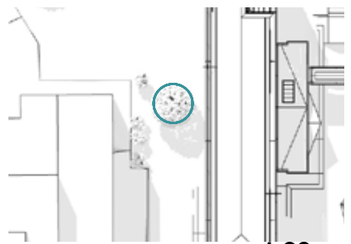
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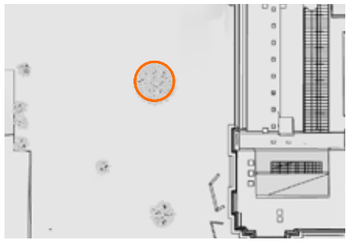
Sun Study
21st June

Existing Location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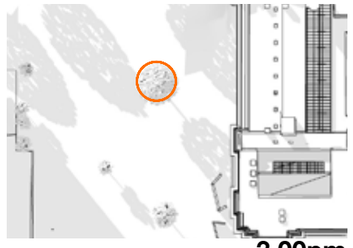
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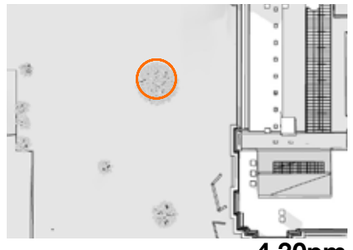
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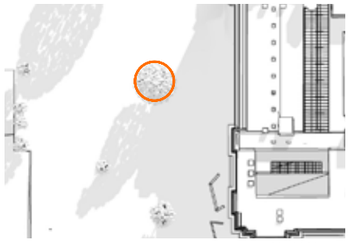
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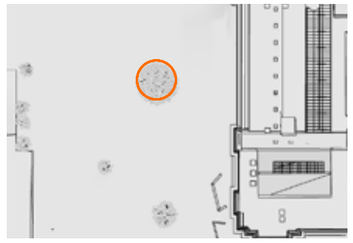
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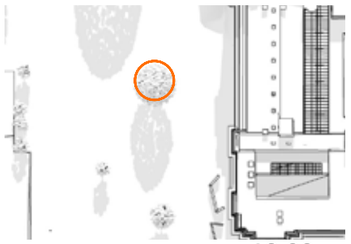
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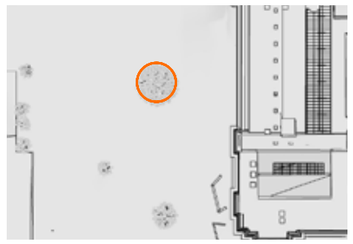
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Proposed Location 1


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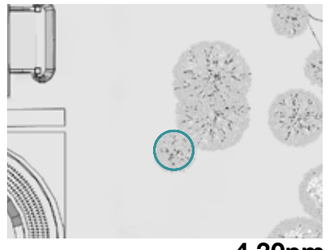
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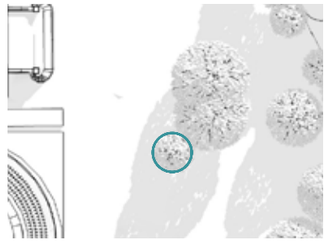
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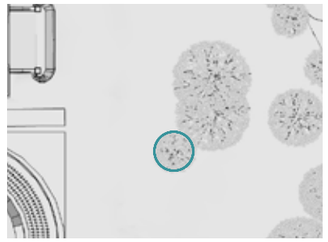
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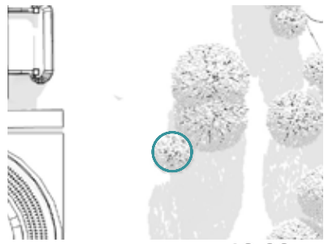
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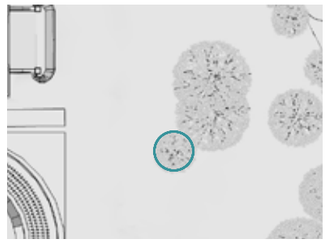
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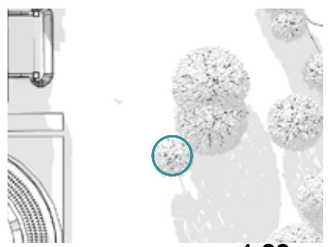
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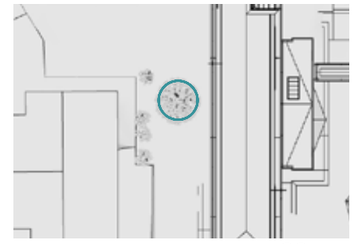
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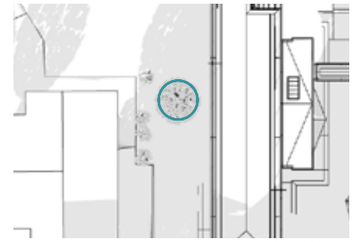
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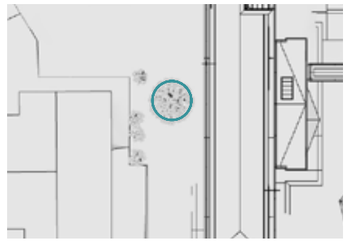
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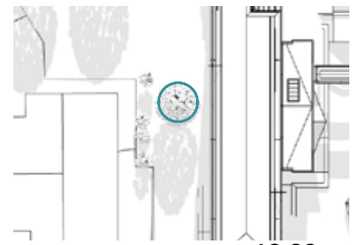
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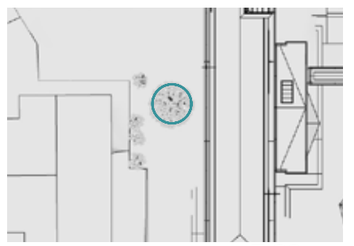
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Sun Study
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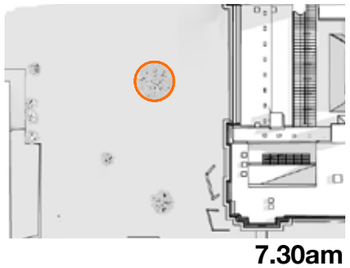
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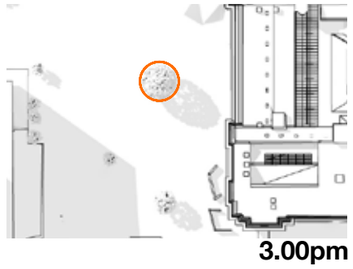
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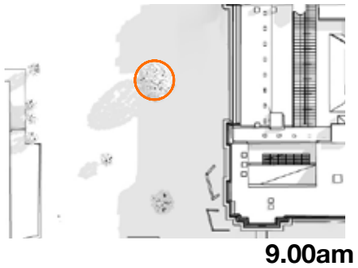
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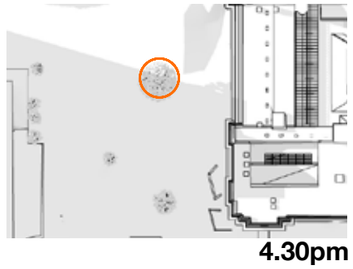
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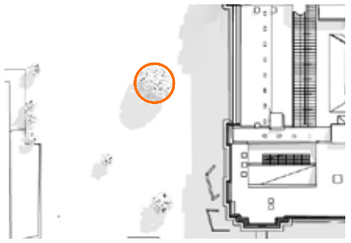
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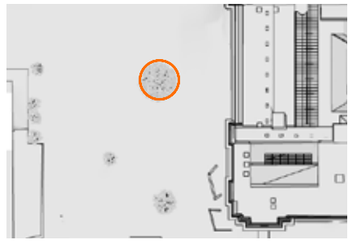
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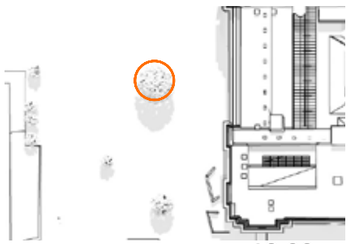
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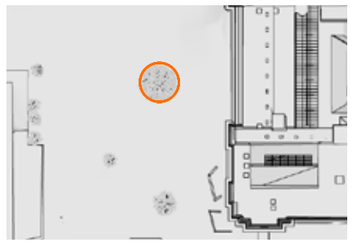
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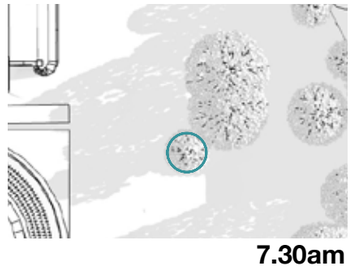
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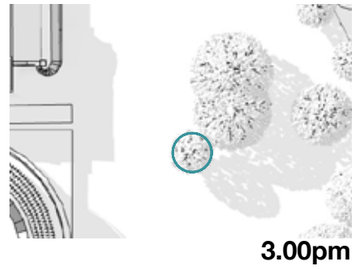
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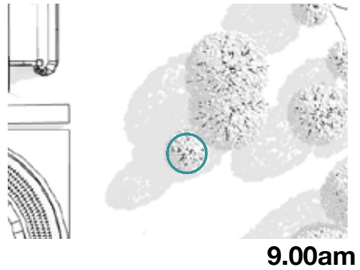
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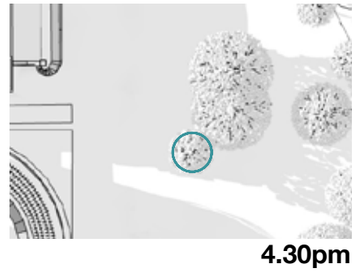
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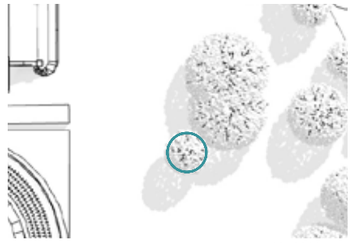
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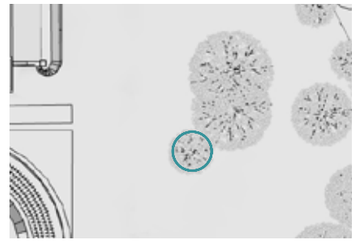
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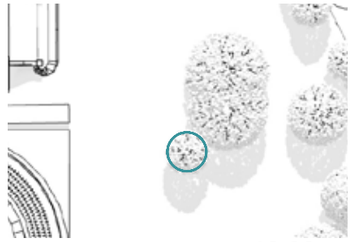
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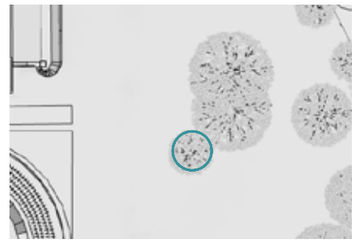
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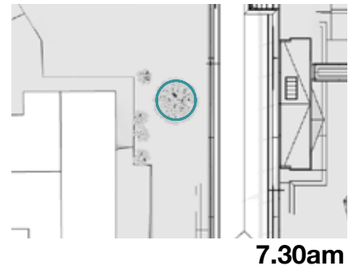
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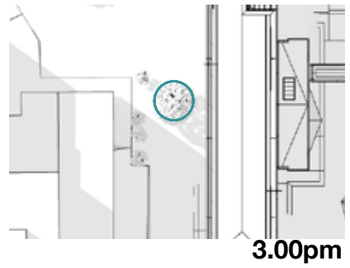
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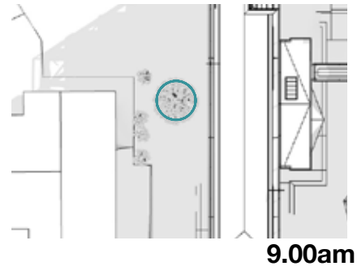
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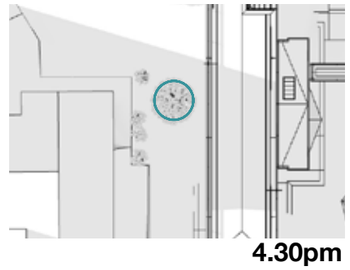
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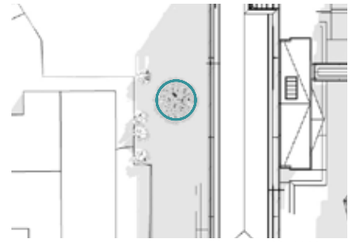
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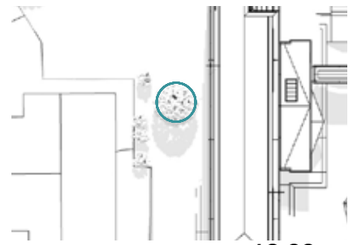
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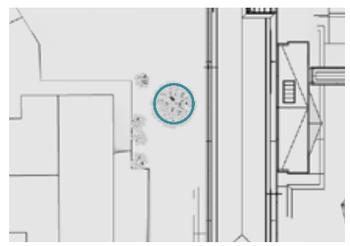
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Sun Study
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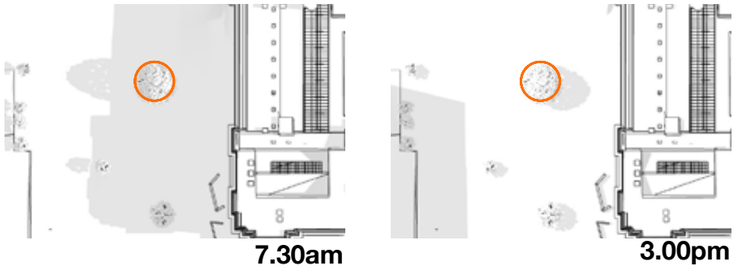
Existing Location



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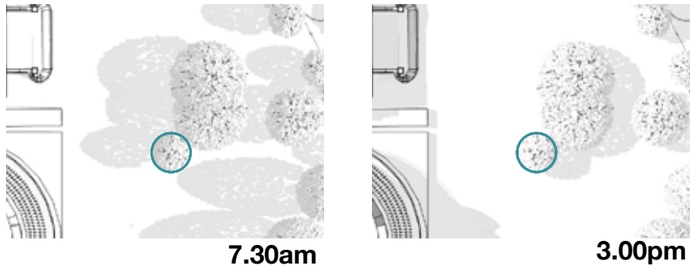

Proposed Location 2

Arborlab
Creating Green Space Sustainability

Memorandum

Prepared for: Project Team

Prepared by: David Spencer – Consultant Arborist

Reviewed by: Karl Burgisser – Consultant Arborist
027 495 7420

Date: July 2021

Re: Initial Notes Parliament Oak

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Browns Bay
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Head Office
76D Paul Matthews Road,
Albany Auckland 0632

Job Ref. 35419

Contents

1. Introduction

1.1 Arborlab have been instructed to undertake investigations to evaluate the proposed relocation of the Heritage Oak based on the supplied Documents. This includes the Future Accommodation Strategy [FAS] dated July 2021. This outlines 10 possible locations including location 8 which is to retain in position.

1.2 The investigation will be used to inform the project team and will also be used as the basis of any technical report that maybe required to support a resource Consent.

1.3 The investigation project is twofold. The first part is to investigate the status of the heritage Oak, including the growing environment and root ball dimensions are sufficient to achieve a successful relocation. The second part is to investigate the proposed final locations and outline any risks and challenges to a successful relocation.

1.4 Investigations into the root structure were carried out using air excavation. To gather data an airvac machine was used to excavate within the rootzone. The intention was to excavate within the planter area which appears to contain the roots of the oak. The extent of the root system and soil profile can then be determined. It was also important to determine whether the roots had been retained within the planter area or had moved underneath the car park and if so, to what extent the root system had left the planter.

1.5 As part of the investigation a climbing arborist inspected the upper branches and crown. While the climbers were inspecting the crown, they also implemented a propagation process to enable cuttings to be taken from the tree next year. This involved scraping the bark on newly developed upright stems and wrapping them with sphagnum moss and black polyethene. This hopefully will stimulate root development and allow the cuttings to be taken and grown in bags.

1.6 The purpose of this memorandum is to provide the following.

- An assessment of the health of the tree,
- Give tree dimensions inclusive of any root ball proposed to be relocated,
- Provide comment on relocation options,
- Give an overview of the relocation methodology, inclusive of required work area
- Recommend any measures that would mitigate the proposed relocation,
- Comment on the proposed relocation options,
- Requirements for next steps.

2. The site

2.1 The Heritage Oak is in the car park to the rear of Parliament House (The Beehive). There is a sloped access ramp to the east and car parking area to the North, South and West. The tree is planted within a garden area that was created during refurbishment of the grounds in 1992.

2.2 The tree can be seen in the following aerial photograph Figure 1.

Figure 1: The site with the tree circled in red.

2.3 The site has been heavily modified over the lifespan of the tree. After being planted in a cottage garden, the tree is now essentially in a car park between large buildings.

3. Tree Assessment Methodology

3.1 A Visual Tree Assessment (VTA) consistent with modern arboricultural practices (Mattheck and Breloer, 1994) was conducted during April 2021. The assessment was carried out at ground level which is classified as a 'Level 2' assessment (Dunster et al., 2013).

3.2 Hand-held laser range finding devices have been used to record data onsite. The tree girth has been measured conventionally with a tape measure and the height and canopy spread estimated based on experience. Although considered to be acceptable for a general tree survey, all measurements should be considered an approximate with a degree of error.

3.3 An air vacuum machine was used in combination with careful hand digging to excavate within the rootzone. The excavation was always monitored by an experience monitoring arborist.

4. Limitations

4.1 It should be noted that trees are dynamic organisms affected by environmental, biotic and mechanical stressors, which can impact health, vitality and structural integrity. Response symptoms of stress can often not be apparent within trees for a number of years. Given the changeable nature of trees, tree assessments are generally relevant for a 6-12month period.

4.2 No detailed soil analysis, tissue sampling and/or geological investigations were carried out. A visual assessment of the soil profile was made in conjunction with a soil texture test.[1] Soil Texture By Feel

4.3 All data was collected without the use of any invasive and/or diagnostic tools. This assessment of effects has not been commissioned to provide a risk assessment of the tree.

5. Regulatory Considerations

5.1 The tree is listed on the heritage trees list in Chapter 21 of Volume 1 of the Wellington City District Plan.

Table 1: Wellington City District Plan Notable Tree Reference

Symbol Reference	Number	Street	Map Reference:	Species	Common name
187		Museum Street	18	Quercus robur	English Oak

21C HERITAGE RULES: TREES

21C.1 Permitted Activities

The following activities are Permitted Activities provided they comply with any specified conditions.

21C.1.1 The minor trimming of any listed tree that will not adversely affect the health or appearance of the tree is a Permitted Activity.

Minor trimming is:

➢ *The removal of broken branches, dead wood or diseased vegetation.*

➢ *The removal of branches interfering with buildings, structures, overhead wires or utility networks, but only to the extent that they are touching those buildings, or structures, or interfering with those overhead wires or utility networks.*

➢ *Other trimming necessary to maintain the health of a listed tree, certified by a person with an appropriate level of expertise.*

[1] https://www.youtube.com/watch?v=GWZwbVJCNec

21C.1.2 Any activity within the dripline of a listed tree is a Permitted Activity except for:

➢ *the destruction, removal or partial removal of the listed tree*
➢ *the alteration of existing ground levels by excavations or deposition of soil including thrust boring and directional drilling*
➢ *the covering of the ground by erection of any building or structure or the storage of goods, including the parking of vehicles*
➢ *the laying of any impervious surface*
➢ *the discharge of any toxic substance unless certified by a person with an appropriate level of expertise that the health of the tree will not be adversely affected.*

21C.2 Discretionary Activities (Unrestricted)

21C.2 Describes which activities are Discretionary Activities (Unrestricted) in respect of any listed tree.

➢ *destruction, removal or partial removal of any listed tree that is not a Permitted Activity*
➢ *the trimming of any listed tree that is not a Permitted Activity*
➢ *any activity within the dripline of a listed tree that is not a Permitted Activity*
is a Discretionary Activity (Unrestricted).

5.2. Relocating the Museum Oak heritage tree is a Discretionary Activity (Unrestricted).

6. Air Vacuum Findings

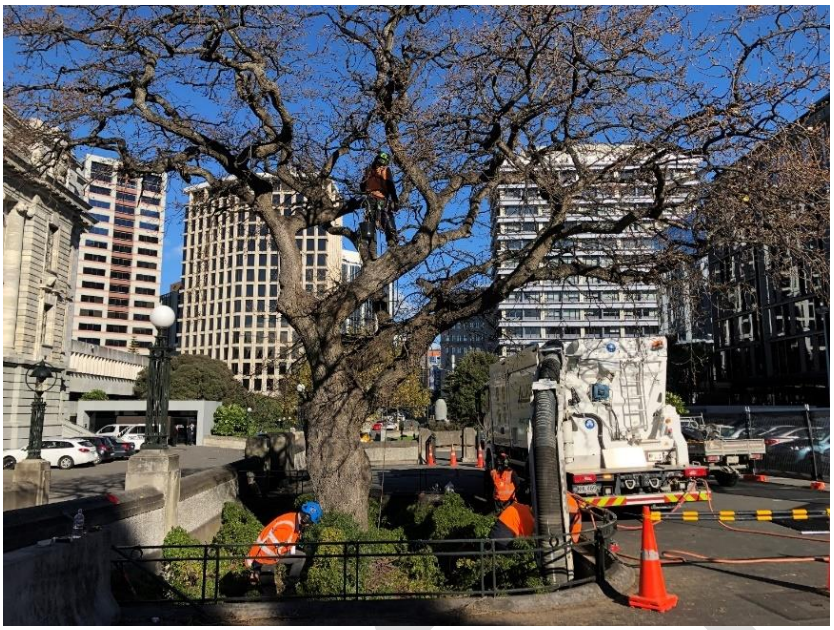
6.1 The air excavations determined that there is extensive root development around the entire circumference of the tree. The soil was excavated to a depth of 1.5m on the southeast corner which showed considerable root development down to this depth. [2] Air Excavation Around Trees

6.2 The excavation on the northern side of the planter bed was limited by a hard compacted soil layer, which could not be penetrated by air excavation. The final excavation depth was approximately 500mm. There was good root development to this depth.

6.3 The eastern side was excavated to between 1.2m and 1.4m with considerable root development discovered.

6.4 Appendix 1 shows the locations of any excavations, their depths and notes on what was discovered. The following photograph 1 shows the air excavation in progress.

[2] https://youtu.be/Ug1psaAmFpk



Photograph 1. Air excavation with an air vac.

Visual Refence of Works

6.5 The following photographs show the root development in the air excavated holes.

Photograph 1. Southeast corner of root zone depth to 1.8m

Figure 1: Typical soil profile and root development

6.6 Information has been supplied in the form of photos that clearly show the tree was previously excavated around when the tree was prepared for relocation in 1986-1987 and roots were severed around the circumference of the tree. This strongly indicated the majority of roots were pruned approximately 1.5m from the tree base. We have not been able to confirm if the roots were severed below the tree. Photograph 3 shows the tree when previously prepared for relocating.

Photograph 3. Museum Oak, 1986 relocation preparations (severe crown reduction and root prune).

7. Findings

Table 1 – Tree Details

Botanical name	Height (m)	Trunk girth (m)	Canopy radii (m) – N, S, E and W	Form	Structure	Health
Quercus robur	14.1	2.74	7.6, 7.1, 6.5 and 7.6m	Good	Good	Good

7.1 The trees health and vitality can be considered good. There is a dense canopy with good extension growth and numerous buds ready for development in spring/summer.

7.2 The excavations within the root zone found numerous roots and all appeared in good health. The roots were reasonably evenly dispersed around all sides of the tree and were found evenly dispersed to a depth of 1.3m. In the southern corner there was a greater propensity of roots to a depth of 1.5m. The soil profile was slightly loamier in this location. The development of extra roots at a greater depth could be due to this corner being the lowest point and therefore increasing soil moisture levels. The soil area within the proposed root ball size of 4.6m by 6.7m by 1.6m had a significant quantity of root mass. This indicated the tree has developed a more compact and contained root system. This is likely to have been influenced by the previous root ball preparation, the soil preparation and irrigation within the current site.

8. Relocation Method

8.1 To relocate the tree numerous factors, need to be considered. The tree's current dimension and its future dimensions will determine whether the new location is viable, and the tree can be transported to the new site.

8.2 To give the relocation operation the highest likelihood of success the largest root ball possible needs to be created and moved with the tree to ensure the greatest practical number of roots are taken with the tree. It is also extremely important to ensure that the soil area within the root ball does not twist or fracture during the relocation operation. Excessive movement of the soil within the root ball during the relocation operation can cause roots to be damaged or severed and adversely affect the ongoing tree health.

8.3 The investigation indicates the tree has developed a more compact contained root system. Therefore, it is likely a greater percentage of existing roots can be taken with the proposed sized root ball than if it was a tree in an open ground area.

8.4 The root ball needs to be 4.6m wide [east to west] and 6.7m long [north to south] and 1.5 to 1.6m deep. This will allow the majority of the important root system to be retained and relocated with the tree. Thus, significantly reducing any potential relocation shock.

8.5 To ensure the root ball is stable during the relocation operation it is proposed to thrust steel

pipes under the tree root ball at a depth below 1.6m. This will form a continuous bed of steel pipes. These would extend out beyond the root ball. Under the steel pipes iron girders are thrust and welded to the steel pipes to create a lifting frame. This is likely to require a work area of 10m to the west side of the tree and 12m to the southern side of the tree. The work area will need to be excavated to a similar depth to install the steel frames under the tree root ball.

8.6 The approximate weight of the root ball, above ground parts of the tree and relocating equipment (frames, boxing, and transporter) are likely to be in excess of 120 tonnes.

8.7 When in transport the canopy will need approximately 8m either side of the trunk and a clearance height of approximately 15m to safely pass between structures, such as streetlights, building, traffic lights, flag poles, statues, and gates.

Photograph 4. Example of Large Tree Relocation Utilising Pipes and Air Bags

Photo - Treemovers.com

9. Relocation sites 1-10

9.1 To evaluate the possible relocation sites a gateway system was used. Any significant item that has been identified as likely to mean the relocation will not be successful has been described and will discount a possible relocation site. These sites have been listed and not actively investigated any further.

9.2 The possible relocation sites are shown in the following aerial image Figure 2.

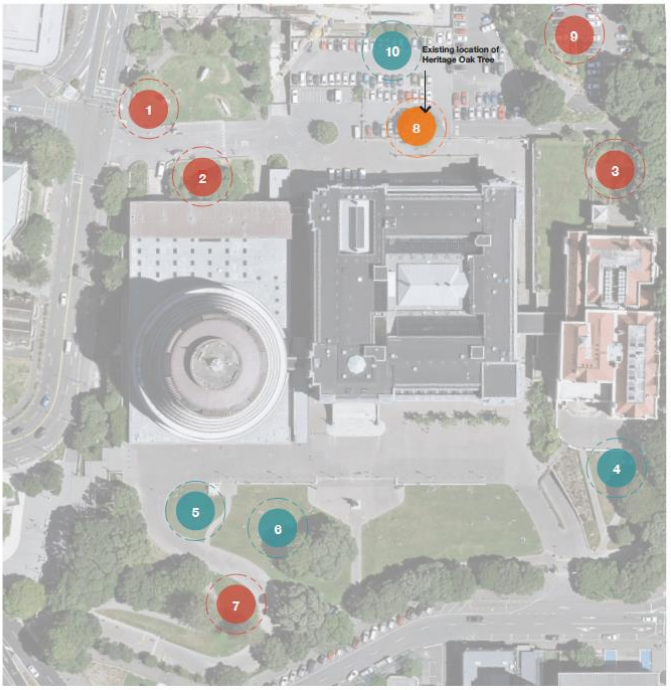


Figure 2. Possible relocation sites.

9.3 When considering options, the items in point 12 need to be considered. Each site has been evaluated and the outline comments are listed below.

Option1

9.4 Not viable. Likely site for future development.

Option 2

9.5 Not viable. The final location of the centre of the trunk would be close to or within the access road (Museum Street) to allow for the canopy spread and future growth next to the proposed new building.

Option 3

9.6 Not viable. To successfully access this site the walls, Kowhai and Camelia trees, wooden gates and other structures would need to be removed. This site would require travelling up a steep road from the existing location or accessing through the upper car park and under a large Pohutukawa, requiring significant pruning of this tree and the construction of a temporary road within its root zone.

Option 4

9.7 Exceedingly difficult/not viable. Tree would be centred 1m from path to accommodate the approximate 9m crown radius required for future growth. This would block the view of library building. Would require removal of some roses and their garden area. The area would need to be levelled and to be terraced to accommodate the rootzone. The whole area would need to be excavated to undertake the relocation operation.

Option 5,6,7

9.8 Exceedingly difficult. Access to this side of Parliament grounds appears to be restrictive. The weight of the load is upwards of 120 tonnes. This weight may not be possible over the paved area over the underground carpark? Further investigation is required here to determine if the car park could carry that load or requires additional support. The lights and flag poles along the front of parliament would need to be removed to allow access for the tree.

9.9 In addition, there is a tight turn near the southern end of this route opposite the cenotaph, which is likely to require the transporter to carry out a difficult if not impossible turning manoeuvre.

9.10 If this route cannot be achieved, then a road would need to be constructed across the lawn at the front of Parliament. The gap between the Richard Sneddon statue and the large Pohutukawa does not allow access. The pruning required on the Pohutukawa would be detrimental to its health and be disfiguring. The alternative is to temporarily move the statue to allow the tree to pass.

Option 7

9.11 In addition to the access restriction above a 9m radius for the Oak trees canopy is required. This could be achieved by pruning the Norfolk Island Pines, however it would require significant excavations and earthworks within the root zone of the Norfolk Island Pines. To ensure the Norfolk Island Pines are not adversely affected the centre position of the Oak would need to be adjusted to the edge of the drive. This will require modifications to the current drive access and likely ongoing repairs to the driveway.

9.12 In addition to these restrictions for sites 4, 5, 6, and 7 the route to the front of the site should be considered. The list of pinch points in section 10 require further investigation.

Option 8

9.13 This option leaves the trees in its current location. It should be noted that this is the preferred location from an Arboricultural perspective. Leaving the tree in situ and redesigning the proposed building to accommodate the tree and its ultimate dimensions would be considerably less risky than any relocation operation. Provided of course the building design does not compromise the tree and it can be protected adequately during construction.

Option 9

9.14 To access this site the tree needs to pass a large glass building, which creates a pinch point between this building and a Pohutukawa on the corner of the access to the upper carpark. There is currently only 8m clearance. The tree needs 15m. Therefore, the Pohutukawa needs to be removed. This may happen due to other site activities during the construction. To travel up the slope to the upper car park requires an access road to be created that is a much lower gradient than the current road.

Option 10

9.15 Awaiting some feedback on this option. This appears to be the favoured position if the tree has to be relocated.

Factors to be confirmed

9.16 This location requires the centre of the tree to be set back from the existing building and proposed building by 9m to allow for future canopy growth.

9.17 An unpaved area over the existing root ball should be provided.

9.18 The creation of a soil vault around the root ball to allow the tree roots to develop into imported soil, this area could be paved over. Ideally 1m out beyond existing relocated root ball.

9.19 Any soil vault should be linked underground with other areas with newly planted trees.

9.20 Check the effect of any radiated heat from adjacent building and proposed building.

9.21 Confirm shading model and extent of changes to sun exposure.

10. Different route options

10.1 To aid understanding of what is required for the tree to be relocated to each location the below aerial photograph has been marked showing each of the proposed routes for the tree.

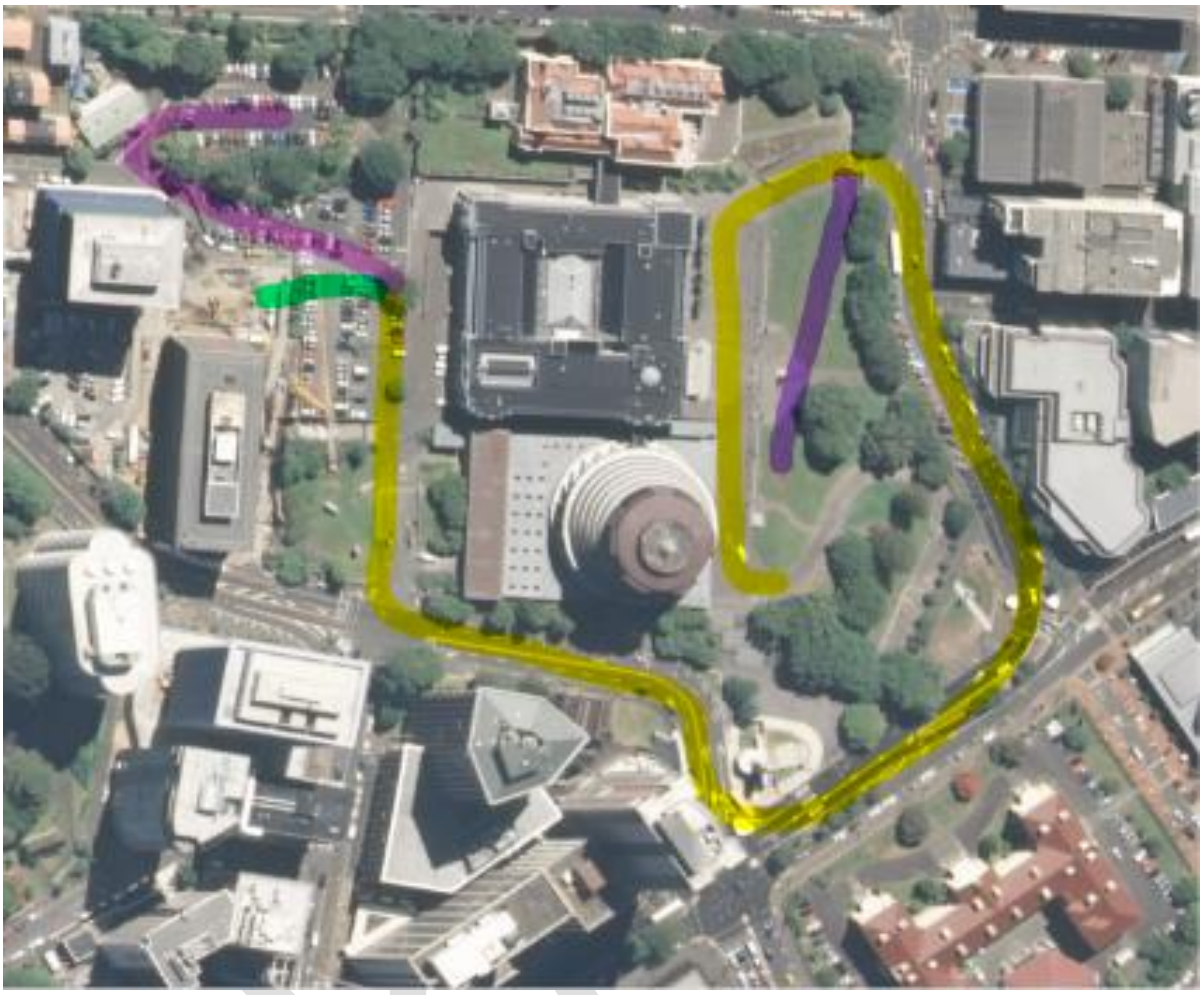


Figure 3. Possible relocation routes.

10.2 Each of the routes has been colour coded and the below list shows which route is associated with each new site.

- Yellow route – 1, 2, 4, 5, 6 and 7.
- Purple route – Alternate option for 5, 6 and 7 after entering front of site.
- Pink route – 3 and 9
- Green route – 10.

10.3 Along the routes for sites 4, 5, 6 and 7 there are pinch points which are described in the following section.

11. Other pinch points for road access from site 8 to sites 4, 5, 6 and 7.

11.1 The main gate is 5.35m to block pillars. The iron gates would need to be removed temporarily. Minor pruning of adjacent Pohutukawa is required. In addition, the lights on top of the pillars

need to be temporarily removed to allow access for the tree.

11.2 On Lambton Quay a concrete pole needs to be removed or moved out of the way temporarily.

11.3 On the corner of Lambton Quay and Bowen Street a pole needs be removed. There are overhead cables in this location that also need to be dropped for the tree to pass.

11.4 On Bowen Street the light needs turning to allow the turn out from the side access point on Museum Street.

11.5 At the entrance to Museum Street the light on top of the gate pillars needs to be removed along with the iron gates themselves. The pillar and console with access keypad and intercom needs to be removed.

12. Requirements at the new location - All sites

12.1 To ensure a successful relocation any new location should be able to adequately accommodate the relocated tree, inclusive of its root ball and allow for future growth of both the canopy and roots.

12.2 Canopy growth requires a separation of 9m from the centre of the trunk radially in all directions.

12.3 Root growth is more difficult to accommodate as it requires soil volume. The existing root ball that is proposed to be relocated is 6.7m long, by 4.6m wide and 1.6m deep. This gives a soil volume of 49.3 m3.

12.4 The following graph figure 4 has been used to calculate the required soil volume.

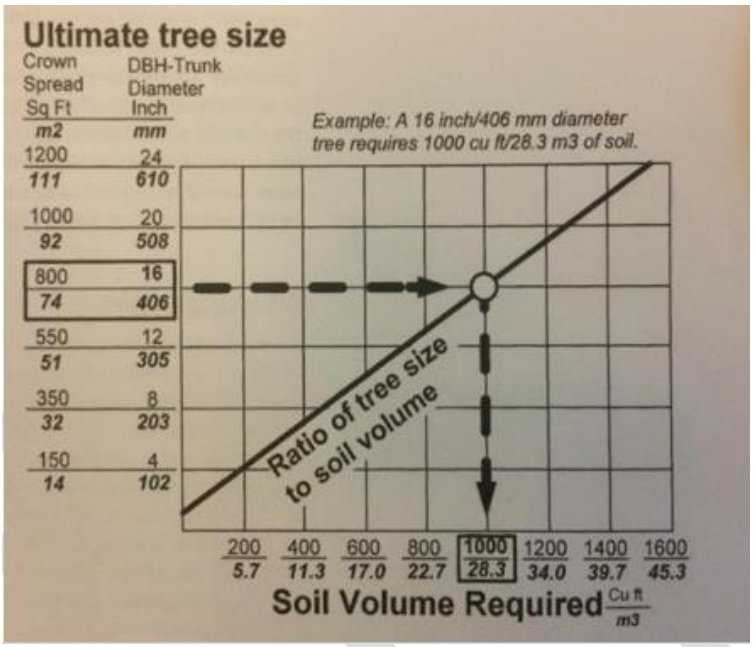
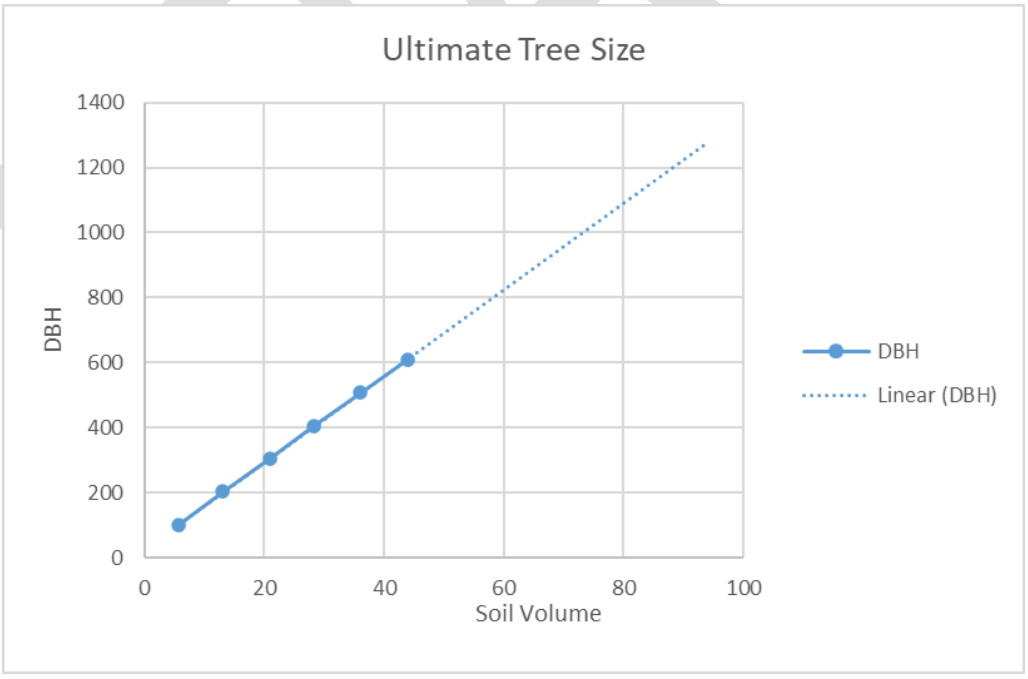


Figure 4. Tree size to soil volume relationship (Urban 1992).

12.5 The current trunk diameter at breast height (DBH) is 873mm. To allow for future growth it is reasonable to assume the Oak tree will achieve a DBH in excess of 1m. In fact, the largest measured English Oak in Wellington has a DBH of 1.2m2.[3] Largest Recorded DBH Oak Wellington



[3] https://register.notabletrees.org.nz/tree/view/301

Figure 5. Extrapolated DBH vs Soil Volume with trend line.

12.6 The graph in Figure 4 does not accommodate trees of these dimension, however the data has been used to calculate the soil volume required for larger trees and the graph in Figure 5 produced.

12.7 A tree with a DBH of 1m, requires a soil volume of approximately 75m3. This gives a difference of an additional 25m3 required for the tree in its new location.

12.8 This should be provided with a minimum of 0.5m around the edge of the relocated root ball at a depth of 1m, so 25m2. The remaining soil volume can be provided in any direction and placed to avoid underground services, structures and other requirements of any existing buildings or the proposed building.

12.9 At 0.5m wide the additional 0.5m of soil volume at the edge of the existing root ball will provide around 12m3 of the additional requirement at a depth of 1m.

12.10 When relocated the top of the tree's root ball should be level with any provided soil volume. This will encourage root growth into the new soil. The existing root ball level should not be above the level of the new soil to accommodate surfaces or structures. This may require the creation of an edge or fence, depending on design requirements.

12.11 In addition, the existing root ball should be accessible and mulched only. No surfaces should be allowed to cover this area. This will allow for ongoing soil testing, the addition of mulch and irrigation as required.

13. Conclusion

13.1 The existing rooting environment, root density and condition, tree health and condition have all been investigated to determine the likely success of any relocation operation. The investigation provided favourable results.

13.2 Eleven individual attempts have been made to propagate new cuttings from the tree. The success of these cannot be determined until a 12-month period has elapsed.

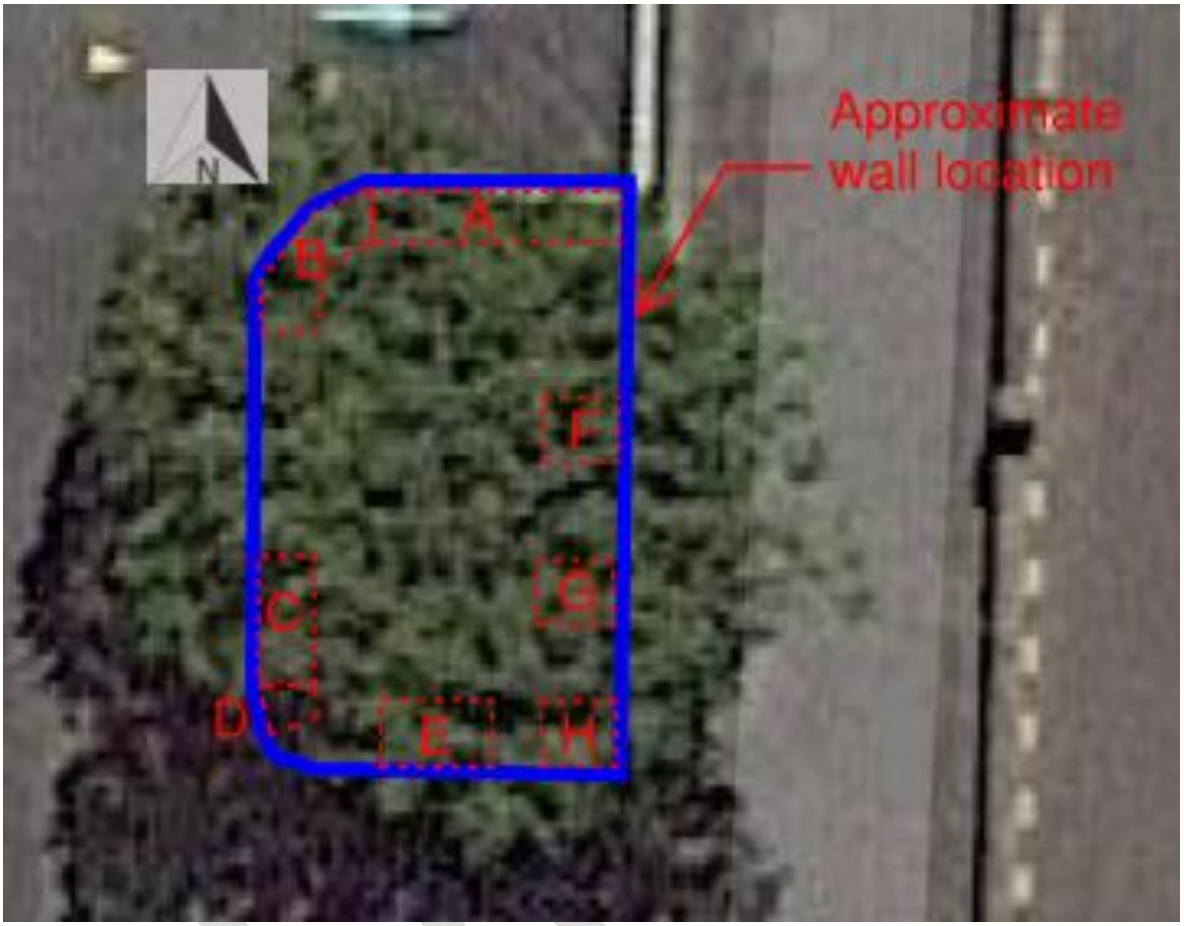
13.3 Various new locations for the tree have been investigated. Locations 1, 2, 3, 4 and 7 have been deemed not viable for various reasons.

13.4 New locations 5, 6, 8, 9 and 10 are currently viable pending the results of further investigations and design inputs.

14. Appendices

- **Appendix 1 – Soil investigation locations and findings notes.**

Appendix 1 – Soil investigation locations and findings notes.



Excavation Location	Root Depth	Notes
A	500mm	Hard compacted material
B	1.4m	Roots consistently found to 1.2m
C	1.2m	Roots consistently found. One root 50mm diameter growing under wall
D	600mm	Roots consistently found. Bricks and broken pottery found. Stopped excavation.
E	1.4m	80 roots at 2-2.5mm in 1m section. Clay at 1.4 to 1.5m
F	600mm	Dense clusters of roots in top 500mm, Watermain and power at 1.6m
G	1.6m	Extensive roots. One 50mm root. Roots down to 1.5m from 1mm to 30mm. Clay changed at 1.5m.
H	600mm	Mass of roots.