Report Title: Feasibility Study for Pull Testing the Laman Street Fig Trees

Client:	**Reporting Company:**
Newcastle City Council	Total Height Safety Pty Ltd
Infrastructure Management Services	PO Box 230
282 King Street	Milsons Point, NSW, 1565
Newcastle, NSW, 2300	02 9966 9070

Client Contact:	**Report Writer**
Mr Lindsay Field	Mr William James Goddard
City Arborist	Restraint System Consultant
02 4974 2625	02 9966 9070
lfield@ncc.nsw.gov.au	bill@ths.com.au

Report Type:	Feasibility Study	**External Consultant:**
Report Topic:	Pull Testing Trees	Partridge Partners
Subject Site:	Laman Street	Structural Engineering
Site Meeting Date:	30th November 2010	Morgan Sheehy
Report Date:	10th December 2010	morgan.sheehy@partridge.com.au

Section 1: Introduction

This report is written in response to a request from Newcastle Council to provide a feasibility assessment of the proposal by community representatives to conduct a Pull Test on the Laman Street Figs in accordance with Council Meeting "Notice of Motion 16/11/10 - Late Item Of Business - Laman Street trees. That Council before enacting any resolution of Council or undertaking any works at this site a) Investigate the feasibility of a pull test on the above mentioned 14 trees and report back to Council." Total Height Safety Pty Ltd has also commissioned the services of Partridge Partners as Structural Engineers to consult and report on their findings. Partridge Partners have been asked to assess the wind loadings and provide recommended pull test forces. Please refer to the Partridge Partners report for any information relating to the calculations on surface areas, wind loadings or the pull test forces required to test the subject trees. This report is limited to the subject of pull testing the trees from a practical point of view. No attempt has been made to comment on previous reports or the findings from Arboricultural organisations or other experts in the field of trees. This document should be read in association with the Partridge Partners report of a similar date. The report will look closely at the outcome expected from the pull testing and its affect on the trees in question. This report focuses on pull testing the trees for root plate failure or failure below ground.

We write this report as the company that may be asked to perform the pull tests should this report find that pull testing the trees is practical and feasible. Acceptance of responsibility and liability has also been added to the report as we feel it is an important factor in the decision making process. Any company attempting the pull tests would have a similar view to risk as I describe in this report.

Section 2: About the Author

Bill Goddard is an advanced rigger with over 20 years experience in the tree industry. He has specialised in the field of engineered structural tree restraint systems. The restraint systems he has designed and installed are some of the most advanced in the world today. He lectures on the subject at Ryde School of Horticulture and for his own companies training division. His restraint systems have meant the preservation of many significant and heritage trees and the reduction of the risks associated with structural defects in trees.

He has also designed and manufactured specialised rigging equipment that has greatly improved safety and productivity in the tree industry. He is an active committee member for the development and review of the tree industry code of practice in NSW and provided assistance to develop new units of competency for rigging in the tree industry-training package. His background as a rigger and tree climber has given him extensive knowledge and experience in the use of rigging equipment for tree restraint, dismantling and testing the strength of trees.

Section 3: Important Information

This report is based on information provided by Newcastle City Council and Partridge Partners Structural Engineers. Possible outcomes and conclusions are base on the evidence provided by these organisations. Total Height Safety Pty Ltd and the Author of this report are not experts in the field of structural engineering or the calculation of wind loadings. We really on the information provided to determine the most effective or productive cause of action as defined by the scope of works. Every effort has been made to ensure the information is concise and accurate from the author's findings and research. No responsibility will be accepted for incorrect or misleading information provided by the subject experts or our client.

Section 4: Scope of works as defined by Newcastle City Council

Lindsay Field (City Arborist - Newcastle City Council) provided a scope of works in an email on 18 November 2010 that included:

1. the Council Notice of Motion 16/11/2010
2. the timeframe for delivery; and
3. need for the feasibility to determine
    - Is the Pull Test practical in this instance – a public road with underground water, fibre optics and 33 kV within the root zone.
    - Would a pull test compromise the trees biological functions. i.e. Compression of vascular tissues
    - Would pull test damage the trees structure. i.e. fracture roots or fracture tear out limbs, weaken inclusions.
    - Would the level of test available having regard for points 2 and 3 provide meaningful data that would assist in determining how stable the trees are, what forces would be required to for them to fail and what force they could withstand.

Section 5: Site Meeting

Bill Goddard from Total Height Safety - Tree Restraint Division and Morgan Sheehy from Partridge Partners - Structural Engineers attended a site meeting on Tuesday the 30th of November 2010. This meeting was designed to gather data required to calculate the wind loadings and to determine the requirements of the pull testing of the trees.

We meet with council representatives who provided background information and site plans of the street, the trees and underground services. Bill Goddard has previously attended a site meeting to review the feasibility of installing a tree restraint system in the trees.

Section 6: Methodology

Before we consider pull testing a tree, we must determine the amount of force to be applied and at what height it will be applied in the tree. Static pull test forces are generally determined by calculating the possible wind force experienced by the tree in its site-specific environment. The tree shape, structural form, growth habit and the force applied, generally dictates the height of connection in the tree. The higher the connect point the more stems may divide depending on the tree species and its growth habit. The diameter of each stem will dictate the amount of force that can be applied without causing damage or failure of that stem.

The fourteen trees in question may not be capable of supporting the applied test loads without partial or total stem or root plate failure. Most of the fourteen trees have multiple stems at a height of four meters above ground. These stems would need to support the test loads without causing bruising of the bark or partial or total failure of the stems. The lower the connection point to the tree the greater the applied force would need to be.

During the pull testing the above ground section of tree would flex from the point of attachment to the root plate. This force may cause early failure of one or more stems at a localised weakness before the force is transferred to the root plate. These broken stems would need to be pruned back to branch junctions after consultation with the consulting Arborist.

We would recommend removal of the tree should the broken stem or stems structurally weaken the tree. We would accept no liability should the tree be retained beyond this point.

The trees would need to be loaded to at least 1.5 times the calculated wind loading to provide a valid margin of safety. The margin of safety is designed to allow for increased tree growth, loss or damage to the root system and to ensure the tree will not fail at just over the calculated possible wind loading.

Even though pull testing of tree is not a new concept, it has not been fully researched to prove a direct relationship with the probability of total tree failure. Pull tests only show that the tree has not failed at the applied load. If the pull test is not in excess of the estimated wind loading, then it proves very little. An example of this is that a tree did not fail at 30kN but could fail at 32kN if loaded to that figure. The pull test only shows that the tree did not fail at 30kN. We already know that the remaining trees have not failed during high winds and have withstood peak wind gusts as defined in the Partridge Partners report. So testing them to this peak load achieves very little.

The maximum wind loading over a five or ten year period can be said to be a working load limit. This is the normal working load the trees experience on a regular basis including storm events. A safety factor should then be applied to provide a margin of safety. This margin of safety would allow for increased tree growth, loss of roots or soil, decay or other defects, removal of supporting infrastructures and for a combination of all of the above.

An example of a safety factor applied to a synthetic lifting sling is that the sling has a working load limit (WLL) of 1 Tonne but a breaking load on 7 Tonne. This demonstrates that a safety factor of 7-1 has been applied to this synthetic lifting sling. A similar rule should apply to trees but we do not have a predetermined safety factor to apply to trees. Using a risk calculator may be the best method to determine the safety factor to be applied. This would mean that a street tree in a shopping precinct would have a higher safety factor then a tree in a bush land setting.

The pull testing requires the installation of load equalising slings on a number of stems in the tree. The Structural Engineer and the Consulting Arborist would provide information to determine the most suitable height for the slings. The slings would be connected to a winch line that would be connected to a digital load cell and then to the winch. The winch would be truck mounted and depending on the force to be applied would vary from a small tow truck to a heavy vehicle recovery tow truck. The heavy vehicle recovery tow truck will extend diagonal outriggers into the ground for stability and resistance from the pull test force. This will result in repairable damage to the turf surface and shallow irrigation if any.

The load is applied gradually using the winch until the specific test force has been reached and then held for a period of time. If no movement in the ground or stem failures are recorded then the tree passes the pull test and we move on to testing the next tree.

Section 7: Destruction Testing

The scope of works asks us to determine “what forces would be required for them to fail and what force they could withstand”. To determine what force it would take for a tree to fail requires virtually a full destruction test. That is to load a tree to the point of failure and then document the force required to achieve that outcome. Generally at this point the tree would need to be cut to ground level if it had not already totally failed. We would never recommend the retention of a partly failed tree that had moved in the ground. If the failed section was above ground and could be pruned back to a suitable junction then the tree could remain.

Destruction testing can prove that a tree could fail at very low loads. This failure may occur at a localized weakness or defect above or below ground. Destruction testing obviously defeats the purpose of testing for tree preservation but can prove that a row of trees may have a similar outcome. You should compare the destruction test force with the possible wind loading before making a decision for tree retention. If the destruction test results in a load less then the wind loading then it would be an indication that the tree was unstable.

Section 8: Infrastructure Damage

It is our understanding that underground optical fiber cables and high voltage electricity cables are located within the root zone. These cables present a major risk to the pull testing operations. Newcastle City Council has provided a document detailing the location of these services.

It must be assumed that a pull test may result in total tree failure and every effort must be made to prevent injury and/or death to persons and to minimise damage to infrastructure. Laman Street and the park will need to be closed during the testing process. Damage to the grass, gardens, lighting, pavement, underground services and retaining walls should be expected if failure occurs.

The underground services must be considered during the planning stage. The services would need to be isolated or relocated prior to any pull testing. We would not attempt the pull tests without these services being isolated or relocated prior to commencement of works. No liability would be accepted for damage of unknown services or poorly relocated services.

Risk management systems would be implemented to minimise damage to infrastructure but no guarantee can be given that no damage will occur. Guy ropes will be installed to limit excessive tree movement during the testing process but these may not always be effective.

Should the tree move in the ground during the testing process it is very likely that the pavement will be damaged and that tree roots may be fractures or broken. The trees structural stability would then be compromised and tree removal will be required.

If the pull testing were to proceed we would recommend testing the trees that would cause the least amount of damage to infrastructure first. If one or more of these trees failed the test it is highly likely that we would terminate the testing process.

The cost of replacing or repairing the infrastructure must be considered in this study. Council should consult with the appropriate authorities and companies to assess the costs associated with this work.

Section 9: Direction of the Pull Test

The applied force of the pull test would be limited to a northern direction. This is the natural direction of crown weight distribution and is the dominant direction of the wind and storm events. The pull test from the north also allows a largely cleared space of the park for installing the winching equipment. It is not practical or cost effective to pull test the trees in multiple directions and in this case proves very little.

Section 10: Number of Trees to be Pull Tested

We see no point in pull testing only a sample of the trees, the variable are great and can not be calculated. Each tree is different in size, shape, structure, wind loading, root development and ground conditions. You could not assume that if one tree passes the pull test that every other tree in the street will or will not pass the test.

We would recommend that the testing be carried out on every tree in the street and only terminated should consistent failures occur in the first test trees. Testing a sample of trees would be a waste of time and money as no two trees are alike in structural or environmental conditions.

Section 11: The Estimated Cost of the Pull Tests

It is estimated that the cost of the pull test could cost up to $48,300.00 + GST. This figure takes into account the following costs:

1. Calculation of the individual wind loadings of each tree
2. Development of a work method plan and site safety plan
3. Consulting structural engineer supervision and advice
4. Site preparation and closures of roads and parks
5. Consulting Arborist Supervision and advice
6. Tree crew on standby to prune or remove trees as directed by the Consulting Arborist
7. Pull test equipment hire including the winch vehicle
8. Rigging and pull testing of the trees
9. Restoration of turf and other soft surfaces

This estimate assumes council will provide internal labour and resources for closures of parks and roads, pedestrian and vehicle management and tree pruning or removal.

Please note this estimation excludes the following:

1. Isolation or relocation of underground services
2. Replacement or repair of any hard surfaces, infrastructure or fittings

Section 12: Conclusion:

The community must be prepared for stem and tree failure should we proceed with the pull tests of the trees. It is clear that the indicated forces required to test the stability of the trees is likely to result in the loss of some of the trees. Partridge Partners has indicated in their report the very high forces required to test the trees for stability. To pull test the trees to anything less then 1.5 times their working load limit (Standard wind loading) is a waste of time and money. It is very likely that the winch or the supporting vehicle will be unable to apply such loads without the vehicle losing traction and being dragged towards the tree being tested.

The facts presented to me indicate that pull testing the trees is possible but is unlikely to provide accurate data to assess the trees future stability. It is also realistic to assume that pull testing the trees may result it loss of the trees we are trying to justify retaining. The underground services present a high risk should tree failure occur.

If a static pull test method can be demonstrated to be none wounding and none destructive it should be considered for the value of the data provided. The organisation proposing the static pull test must provide a detailed work method statement. This document must clearly detail effective risk controls for managing damage or risk to persons.

The following points should be considered in the work method statement:

1. Method of preventing damage to the above ground and under ground services
2. Method of preventing damage to infrastructure and soft and hard surfaces
3. Method of managing public interaction or prevention of injury
4. Method of managing vehicle access to loading docks and Laman Street
5. Method of preventing stem and/or possible tree failure
6. Method of establishing ground anchors and/or moveable anchors

It should also be determined how effective this testing method is in relationship to predicting the likelihood of total failure of the root plate. The council should also determine what guarantees are provided with this testing. We would expect no less then a 1.5 safety factor to be applied to the testing process.

Our estimated wind loadings should be very similar to those provided by the testing company. It would be wise to have an independent assessment of the wind loading provided by the testing company. It is also assumed that every subject tree will be static pull tested and not just a sample.

Please phone or email if you require additional information or clarification of any of the document content.

William James Goddard
Structural Tree Restraint Division
Total Height Safety Pty Ltd

10th December 2010

Reference Documents

	Organisation/Source	Author	Title	Date
1.	Tree Logic	Dean Simonsen	Tree Report	2nd Sept 2009
2.	The Sugar Factory	Dennis Marsden	Tree Report	7th Aug 2009
3.	American Journal of Botany	Ken James	Mechanical Stability of Trees	2006
4.	Journal of Arboriculture	Ken James	Dynamic Loading Of Trees	May 2003
5.	Unknown	Ken James	Tree Stability in Winds	Unknown
6.	Unknown	Ken James	Tree stability in winds Static & Dynamic Methods	Unknown
7.	Isaac	Ken James	Dynamic Wind Loads on Trees	2005
8.	University of Melbourne,	Ken James	Tree Structure - Dynamics	Unknown
9.	The Sugar Factory	Dennis Marsden	Fractometer Results of Fig Trees on Laman Street outside Art Gallery.	15 Oct 2007
10.	Integrated Vegetation Management	Anna Hopwood & Andrew Simpson	Peer Review of Assessment of Hill's Weeping Fig *Ficus microcarpa* var. *Hilli*	10th Dec 2009
11.	Newcastle City Council	Councillors N Nelmes & M Jackson	Action Item: Nom 16/11/10 - late item of business - laman street trees	16th Nov 1010