**Playground plant and mulch trial**
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**Abstract**


There is demand and interest in growing non-woody plants in playground mulch in and around play equipment, including fall zones. This planting allows playgrounds to look more natural and to reduce the open, bare appearance of equipment in mulch, without compromising safety. This trial has the potential to greatly increase the amount of plants used in the landscape in Australia and New Zealand into the millions.

Incorporating plants into playgrounds forms a more attractive and stimulating environment than mulch alone, which benefits children using the playground in numerous ways. Plants also increase the biodiversity of the playground, enhancing it as a natural environment.

Ozbreed, in conjunction with Fiona Robbé Landscape Architects, The Hills BARK BLOWER and Acousto-Scan investigated planting techniques to use when incorporating non-woody plants within the surfacing around play equipment. Two planting methods were trialed to ascertain optimal conditions to achieve robust plant establishment and growth.

Two plant varieties and two planting methods were trialed in two types of playground mulch. Three sizes of plants were used in the trial: 140mm, 200mm and 300mm diameter pots. The area was monitored for three and a half years from 2010 to 2014. In this period two Critical Fall Height (CFH) tests were undertaken to ascertain the impact attenuation properties of the mulch surfacing, in accordance with the Standard test method AS/NZ4422:1996. This resulted in positive findings and recommendations which confirm that plants can be grown in mulched fallzones, and provide complying impact attenuation properties. The trial is ongoing.

**Aim of trial**
To systematically determine the optimal growth conditions for non-woody plants in 300mm depth playground mulch.
To accurately test the safety implications of plants grown in fall zones of playground equipment as per the requirements of the Australian Playground Standards.

**Trial methods, observations and results**

**1 Set up and planting of trial beds**
In August 2010 trial planting areas were established in the display gardens at Ozbreed's property at Clarendon, NSW in Australia.

**1.1 Trial bed construction**
Two garden beds, Bed A and Bed B, were established for the trial. Both beds were 3.5x3m in size on a level site in full sun. Site soil was excavated from each bed to a depth of 300mm and replaced with playground mulch. The beds were mulched in accordance with the Australian Standard for Playground mulches (AS/NZS4422: 1996 Playground Surfacing - Specifications, Requirements & Test Methods).
Bed A was mulched with Playbark pine bark mulch (Mulch 1: 10-15mm bark chips) to a depth of 300mm. See Figure 1.1. Bed B was mulched with pine mulch (Mulch 2: 2-15mm wood chips) to a depth of 300mm. See Figure 1.2.

*Figure 1.1 – Bed A: Playbark pine bark mulch*

*Figure 1.2 – Bed B: Pine mulch*

## 1.2 Plant selection

Two plant varieties were chosen for the trial and planted into the mulched beds using two planting methods. The plants used were Naringa™ *Westringia* 'WES01' PBR and Tanika® *Lomandra longifolia* 'LM300' PBR. These plants are already used in playground plantings. Tanika® is a popular planting choice for playgrounds because it is soft to touch and looks lush. Naringa™ has the potential for edges of fall zones where a plant with dense height and structure can define spaces readily.

Fourteen plants were planted in each bed, made up of six Naringa™ and eight Tanika® plants. The planting pattern is shown in the plan in Appendix A.

Half of the plants were planted directly into the mulches (Mulch Planting Method), while the other half were planted with soil placed under the root ball (Soil Base Method) as shown in Figure 1.3. Twelve Naringa™ Westringia were planted from 140mm pots (6 in each trial bed), eight Tanika® Lomandra were planted from 200mm pots (4 in each trial bed) and eight Tanika® Lomandra were planted from 300mm pots (4 in each trial bed).

A general slow release pelletised fertiliser (Osmocote Exact Standard 8-9 months) was added to the base of the planting hole prior to planting. Fertiliser was applied prior to planting in both the direct mulch planting and the soil base method. See Figure 1.4.

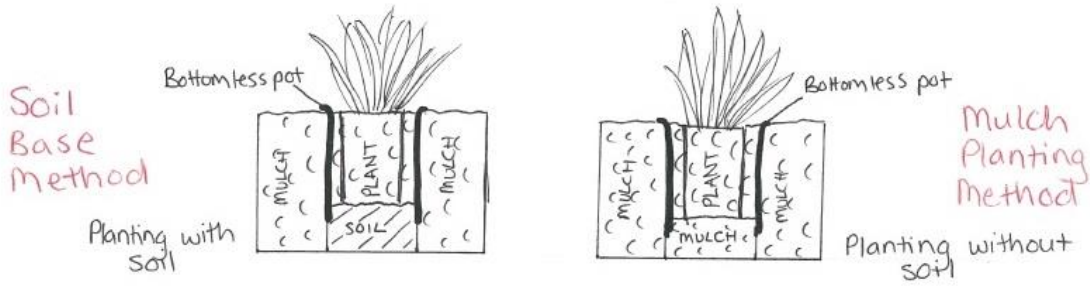



*Figure 1.3 – Planting methods (left: soil base method, right: mulch planting method)*


*Figure 1.4 – application of fertiliser in planting hole*

## 1.3 Detailed planting methods

Soil Base Method: Round planting holes were dug into the playground mulch deeper than the root ball. A bottomless pot was sunk into the planting hole. Around 10cm of sandy loam was added to the base of each planting hole as shown in Figure 1.5. The amount of soil varied with the depth of the planting hole and size of the root ball. A loamy sand mix was also placed around the outside of the plant within the bottomless pot, see Figure 1.6. Slow release pelletised fertiliser was added then the plant was set in the hole (see Figure 1.4) and back filled with mulch before the bottomless pot was carefully removed. See Figure 1.7. All plants were planted so the top of the root ball was level with the top of the mulch.

Mulch Planting Method: Round planting holes were dug into the playground mulch as deep as the root ball. Fertiliser was added to the base of the hole, then the plant was placed directly in the hole and back filled with mulch. See Figure 1.8. All plants were planted so the top of the root ball was level with the top of the mulch.

*Figure 1.5 – Soil base method: addition of sandy loam at base of planting hole*

*Figure 1.6 – Soil base method: Bottomless pot (base cut off from pot)*

*Figure 1.7 – Soil base method: removal of bottomless pot after backfilling with mulch*

*Figure 1.8 – Mulch planting method: planted directly into the mulch*

### 1.4 Control planting

As a control, plants of both varieties were also planted directly into soil in nearby garden beds. The site soil is a clay soil.

### 1.5 Ongoing care and management

After planting, all plants were watered regularly during a 10-week establishment period. For the first two weeks plants were watered three times a week. For the

following four weeks, watering was carried out twice a week. For the final four weeks of establishment, plants were watered once a week. After this time plants relied on rainfall alone unless there was more than three weeks without rain when supplementary watering was provided. These conditions replicate construction site establishment practices.
Weeds were removed regularly by hand however few weeds grew in the heavily mulched beds. No additional fertiliser was applied until the following spring after 12-month's growth.

## 2 Evaluation at three months

### 2.1 Plant assessment

In November 2010, after three months growth, all plants were assessed for their size, spread and root establishment.

### 2.2 Results

After three months all plants were growing well however those planted using the Soil Base Method were found to be larger, denser and with a larger root ball. See Figure 2.1. There was no observed difference in growth rates between the different pot sizes planted however the larger, more advanced plants maintained their larger, fuller size.
When the growth of plants in the two beds were compared, it was found that growth of all plants in the pine mulch (Mulch 2) were stronger with all plants larger, denser and with better root formation, with optimum growth occurring with the soil base method. See Figure 2.2.

*Figure 2.1 – Playbark pine bark mulch (left: Naringa™ plant soil base method, right: mulch planting method)*

*Figure 2.2 – Pine mulch (left: Naringa™ plant soil base method, right: mulch planting method)*

## 3 Evaluation at six months

### 3.1 Plant assessment

In February 2011 further assessment was carried out. Again plants were assessed for their size, spread and root establishment.

### 3.2 Results

Assessment of the plants showed they had continued to thrive although some plants were showing foliage damage and indications of failing. Overall, the plants in Bed A and Bed B appeared to be larger and more robust than the control plants growing in heavy clay site soil. When plants in Bed A and Bed B were compared, those growing in Bed B pine mulch (mulch 2) showed better overall growth. The plants established using the soil base method in both beds were slightly larger than those planted directly into mulch. See Figures 3.1-3.6

*Figure 3.1 – Early signs of failing plants due to poor drainage*

*Figure 3.2 – Right: Control plants not performing or growing as well as those in mulch due to heavy clay soil*

*Figure 3.3 – Bed A: Playbark pine bark mulch*

*Figure 3.4 – Bed B: Pine mulch (better plant growth compared to Bed A)*

*Figure 3.5 – Playbark pine bark mulch (left: Naringa™ plant soil base method, right: much planting method)*

*Figure 3.6 – Pine mulch (left: Naringa™ plant mulch planting method, right: soil base method)*

## 4 Evaluation at seven months

### 4.1 Plant assessment

By March 2011 of the trial some plant deaths had occurred. One specimen of Tanika® lomandra had died in Bed A (Playbark pine bark mulch- mulch 1). This specimen had been planted directly into the mulch. In Bed B (Pine mulch -mulch

2) four plants had died including two of the Naringa™ westringia (one planted directly in mulch and the other using the soil base method) and two Tanika® lomandra (one planted directly in mulch and the other using the soil base method). All other plants were still growing strongly. See Appendix A for recorded plant deaths.

### 4.2 Results and discussion

The plant deaths recorded above attributed to root rot due to poor soil drainage conditions in the base of the planting bed and did not reflect the planting methods employed (direct into mulch or using the soil base method). The dead plants were left in the trial bed. All other plants using both planting methods had established well.

## 5 Critical Fall Height testing at two years

### 5.1 Testing

In August 2012, testing was done to determine if the mulch and plants met the impact attenuation requirements of AS/NZ 4422:1996 Playground Surfacing – Specifications, requirements and test method. The testing was conducted by Acousto-Scan, which is an independent testing company (NATA accredited to ISO/IEC 17025). The tests measured the Critical Fall Height (CFH) for playground surfacing and plants in accordance with Appendix A. CFH tests were conducted on mulches in Bed A (Playbark pine bark mulch- mulch 1) and Bed B (pine mulch -mulch 2) and on the plants installed within these mulches. These trials are illustrated in Figures 5.1-5.9.

*Figure 5.1 – Pine mulch (mulch 2) test 1 indentation on bare mulch*

*Figure 5.2 – Pine mulch (mulch 2) test 2 on dead Tanika® plant*

*Figure 5.3 – Test 3 on soil outside mulch area*

*Figure 5.4 – Pine mulch (mulch 2) test 4 on Naringa™ plant, soil base method*

*Figure 5.5 – Playbark pine bark mulch (mulch 1) test 5 on Tanika® plant, soil base method*

*Figure 5.6 – Playbark pine bark mulch (mulch 2) test 6 on Tanika® plant, mulch planting method*

*Figure 5.7 - Playbark pine bark mulch (mulch 2) test 7 on bare mulch*

*Figure 5.8 - Playbark pine bark mulch (mulch 2) test 9 on dead Tanika® plant*

*Figure 5.9 – Test 10 on soil outside mulch area*

## 5.2 Results

Both mulches and all the plants, including those carried out on a dead plant specimen met and surpassed the requirements of the Australian Standard. The CFH minimum for the two complete areas was 3.2m (Refer to Table 1). For full results, see Appendix B.

**Table 1**

| Test Date | Test | Material Test Conditions | Critical Fall Height | Material Allowance |
|---|---|---|---|---|
| Pine mulch (bed B, mulch 2) | | | | |
| 30 August 2012 | 1 | Pine mulch – Bare mulch | **5.9 m** | 60mm |
| 30 August 2012 | 2 | Pine mulch - Dead Tanika® plant | **6.2 m** | 60mm |
| 30 August 2012 | 3 | On soil outside test area | **1.4 m** | 20mm |
| 30 August 2012 | 4 | Pine mulch - On Naringa™ plant | **5.9 m** | 60mm |
| Playbark pine bark mulch (bed A, mulch 1) | | | | |
| 30 August 2012 | 5 | Playbark mulch - On Tanika® with soil | **6.2 m** | 60mm |
| 30 August 2012 | 6 | Playbark mulch - On Tanika® without soil | **4.4 m** | 60mm |
| 30 August 2012 | 7 | Playbark mulch – Bare mulch | **3.2 m** | 60mm |
| 30 August 2012 | 9 | Playbark - Dead Tanika® plant | **3.2 m** | 60mm |
| 30 August 2012 | 10 | Soil outside test area | **1.8m** | 20mm |

Notes for Table 1
The Australian Standard AS/NZS4422:1996 Amdt 1 details the usage of impact absorbing materials in children's playgrounds and defines relevant terms and conditions.

CFH= this is the minimum free fall height rating of the mulches resulting from the drop tests/impact measurements. This measurement is the greatest vertical distance between a part of play equipment to which a child has foreseeable access, and the mulch surface below. The current CFH in Australia is limited to 3m.

These results have been obtained on mulch 300mm in depth. Loose fill material should be installed to the depth shown in the test report, which should be not less than 200mm.

## 6 Evaluation at 34 months

### 6.1 Plant and mulch assessment

In June 2013 further assessment was carried out. Plants were assessed for their size and health.

### 6.2 Results and discussion

Assessment showed the plants in Bed A (Playbark pine bark mulch – Mulch 1) continued to thrive and grow to full size. Whereas the plants in Bed B (Pine

mulch – Mulch 2) had not continued growing and in some cases had declined in vigor. This differed from observations made at earlier stages of the trial. The slower rate of plant growth can be attributed to the noticeable amount of slumpage that had occurred on the pine mulch (mulch 2) which had exposed some of the root balls. See Figures 6.1-6.4.

By this stage three Tanika® plants had some foliage die back, showing signs of root rot. In Bed A, one Tanika® plant which had been planted with the soil base method. In Bed B, one Tanika® plant with the soil base method, and another one with direct mulch planting method. This can be attributed to poor drainage and extremely wet conditions through summer, it does not reflect the planting methods used. They had begun to recover with the drier conditions over winter. One of the Naringa™ plants in the control area of clay soil had also died and had been removed. See Appendix A for recorded plant survival.

*Figure 6.1 – Bed A (Playbark pine bark mulch: mulch 1) full plant growth*

*Figure 6.2 – Bed B (Pine mulch: mulch 2) plants not at full size compared to Bed A*

*Figure 6.3 – Bed B (Pine mulch: mulch 2) slumped noticeably*

*Figure 6.4 – Bed B (Pine mulch: mulch 2) exposed roots of Naringa™ plant due to slumpage of mulch*

## 7 Mulch slumpage at three years

### 7.1 Measurements

Both mulches were measured in August 2013 for the amount they had slumped compared to the site soil. These measurements were taken in four random positions of Bed A and Bed B to compare the difference in slumpage between the mulches.

### 7.2 Results

The measurements in table 2 show that on average, mulch 2 slumped 3.8 times more than mulch 1.

**Table 2**

| **Measurement of slumpage compared to site soil** | | | |
|---|---|---|---|
| **Measurement (cm)** | | | |
| **Bed A: Playbark pine bark mulch (mulch 1)** | | **Bed B: Pine mulch (mulch 2)** | |
| Spot 1 | 5 | Spot 1 | 20 |
| Spot 2 | 4 | Spot 2 | 17 |
| Spot 3 | 3 | Spot 3 | 14 |
| Spot 4 | 4 | Spot 4 | 10 |
| **Average** | **4** | **Average** | **15.25** |

## 8 Critical Fall Height testing at 3 and a half years

### 8.1 Testing

In February 2014, testing was conducted to determine if the mulch and plants met the CFH requirements of the Australian Standard after a longer period of time. The testing was conducted by Acousto-Scan, which is an independent testing company (NATA accredited to ISO/IEC 17025). The tests measured the Critical Fall Height (CFH) for playground surfacing and plants in accordance with the Australian Standard test method AS/NZ4422:1996. CFH tests were conducted on bark mulches in Bed A (mulch 1) and Bed B (mulch 2) and on the plants installed within these mulches. These trials are illustrated in Figures 8.1-8.7.

*Figure 8.1 - Pine mulch (mulch 2) test 2 on dead Tanika® plant*

*Figure 8.2 – Pine mulch (mulch 2) test 3 on Tanika® plant, mulch planting method*

*Figure 8.3 - Pine mulch (mulch 2) test 4 on Naringa™ plant*

*Figure 8.4 – Playbark pine bark mulch (mulch 1) test 5 on Tanika® plant, soil base method*

*Figure 8.5 – Playbark pine bark mulch (mulch 1) test 6 on Tanika® plant, mulch planting method*

*Figure 8.6 - Playbark pine bark mulch (mulch 1) test 7 on bare mulch*

*Figure 8.7 – Playbark pine bark mulch (mulch 1) test 9 on dead Tanika® plant*

## 8.2 Results and discussion

Both mulches and all the plants, including those carried out on a dead plant specimen met and surpassed the requirements of the Australian Standard. The CFH minimum for the two complete areas was at least 3.4m (refer to Tables 3 and 4). For full results, see Appendix C.

Since the first CFH testing in 2012, the CFH of the Playbark pine bark mulch (mulch 1) has stayed fairly consistent. However some spots the CFH have risen, see chart 1 below. Observations were made of the fibrous root systems that were growing throughout these spots, this was not as noticeable when the first tests were done in 2012. See Figure 8.8.

The CFH of the pine mulch (mulch 2) in the test spots 1 and 2 have declined. This can be attributed to a few things; the slumpage of the mulch in these spots; test 1 was of bare mulch with no plants; test 2 was of a plant that had died almost three years earlier. Test 3 cannot be compared as the testing spot had changed since the first test in 2012. Test 4 had risen slightly, this can be attributed to the fact that it was on top of a Naringa™ plant. See chart 2 below.

**Table 3**

| Results Dry | | | | |
|---|---|---|---|---|
| **Test Date** | **Test** | **Material Test Conditions** | **Critical Fall Height** | **Material Allowance** |
| Pine mulch (bed B, mulch 2) | | | | |
| 3 February 2014 | 1 | Pine mulch 2-15mm – Bare mulch | **3.5 m** | 60mm |
| 3 February 2014 | 2 | Pine mulch 2-15mm - Dead Tanika® plant | **3.4 m** | 60mm |
| 3 February 2014 | 3 | Pine mulch 2-15mm - On Tanika® plant without soil | **5.7 m** | 70mm |
| 3 February 2014 | 4 | Pine mulch 2-15mm - On Naringa™ plant | **6.3 m** | 60mm |
| Playbark pine bark mulch (bed A, mulch 1) | | | | |
| 3 February 2014 | 5 | Playbark mulch - On Tanika® plant with soil | **6.7 m** | 60mm |
| 3 February 2014 | 6 | Playbark mulch - On Tanika® plant without soil | **3.9 m** | 60mm |
| 3 February 2014 | 7 | Playbark mulch – Bare mulch | **5.3 m** | 70mm |
| 3 February 2014 | 9 | Playbark - Dead Tanika® plant | **5.2 m** | 60mm |

**Table 4**

| Results Wet | | | | |
|---|---|---|---|---|
| **Test Date** | **Test** | **Material Test Conditions** | **Critical Fall Height** | **Material Allowance** |
| Pine mulch (bed B, mulch 2) | | | | |
| 3 February 2014 | 1W | Pine mulch 2-15mm – Bare mulch | **4.5 m** | 60mm |
| 3 February 2014 | 2W | Pine mulch 2-15mm - Dead Tanika® plant | **4.5 m** | 60mm |
| 3 February 2014 | 3W | Pine mulch 2-15mm - On Tanika® plant without soil | **3.9 m** | 20mm |
| 3 February 2014 | 4W | Pine mulch 2-15mm - On Naringa™ plant | **4.3 m** | 60mm |
| Playbark pine bark mulch (bed A, mulch 1) | | | | |
| 3 February 2014 | 5W | Playbark mulch - On Tanika® plant with soil | **4.4 m** | 60mm |
| 3 February 2014 | 6W | Playbark mulch - On Tanika® plant without soil | **4.4 m** | 60mm |
| 3 February 2014 | 7W | Playbark mulch – Bare mulch | **5.7 m** | 60mm |
| 3 February 2014 | 9W | Playbark - Dead Tanika® plant | **6.2 m** | 60mm |

Notes for tables 3 and 4
The Australian Standard AS/NZS4422:1996 Amdt 1 details the usage of impact absorbing materials in children's playgrounds and defines relevant terms and conditions.

CFH= this is the minimum free fall height rating of the mulches resulting from the drop tests/impact measurements. This measurement is the greatest vertical distance between a part of play equipment to which a child has foreseeable access, and the mulch surface below. The current CFH in Australia is limited to 3m.

These results have been obtained on mulch 300mm in depth. Loose fill material should be installed to the depth shown in the test report, which should be not less than 200mm.

**Chart 1**

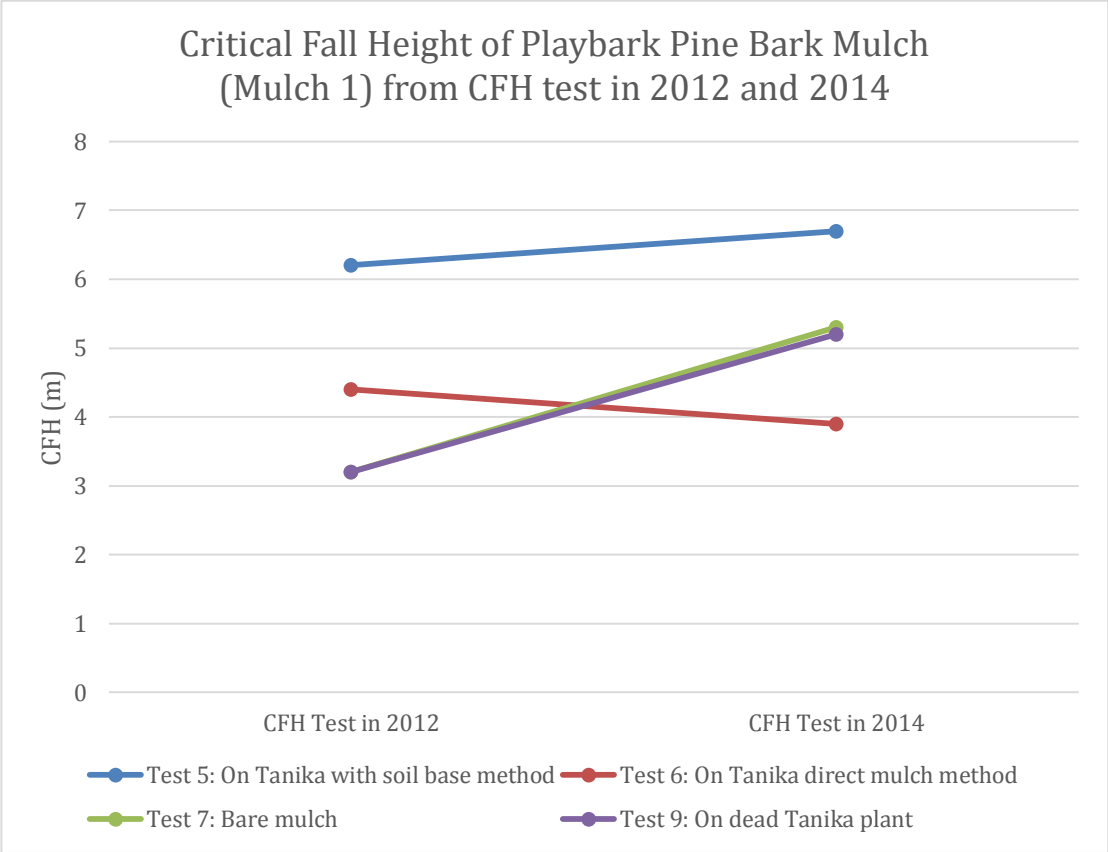


**Chart 2**

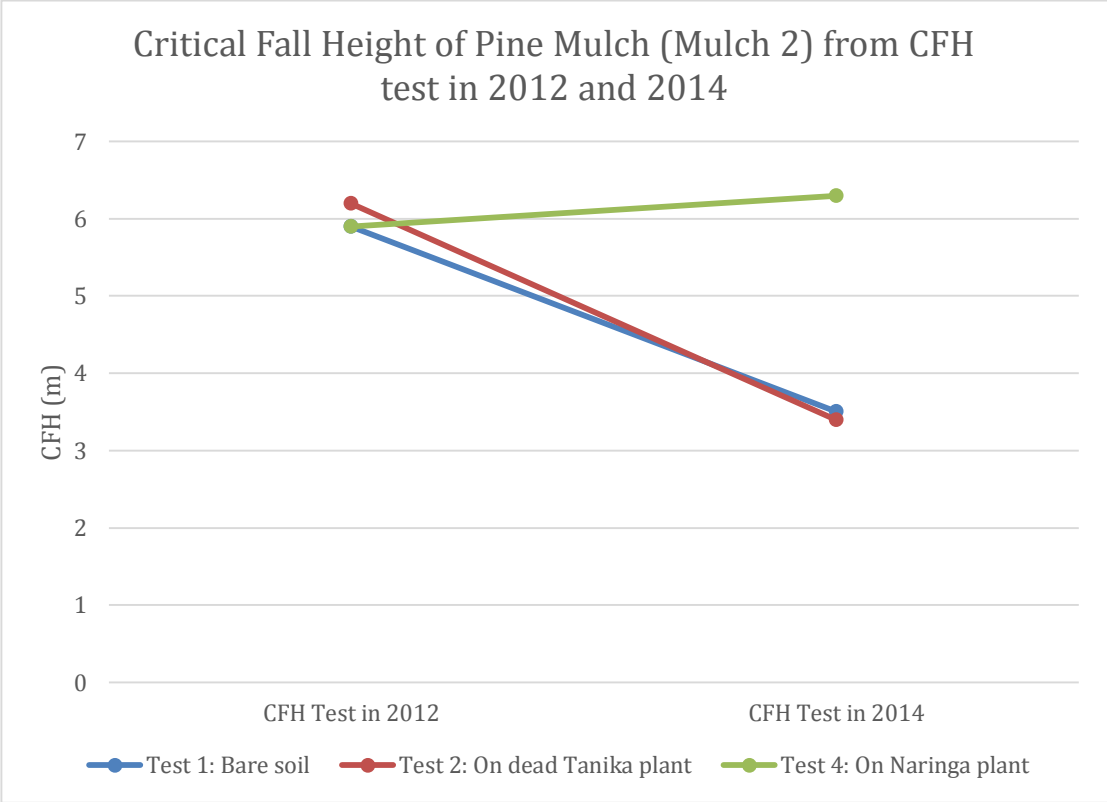



*Figure 8.8 – Fibrous root system observed to be growing throughout Playbark pine bark mulch (mulch 1)*

## 9 Conclusions after two years' growth

### 9.1 Planting method

As plants established faster when planted using the Soil Base Method, this method is the recommended technique for establishing plants in undersurfacing mulches in playground areas. Speed of establishment is of interest as established plants are less likely to be pulled out or vandalized. After two years growth however there were no clear differences between the two planting methods.

### 9.2 Plant survival and growing conditions

In the first year of the trial, plant growth and establishment in the pine mulch (mulch 2) was observed to be better than that of plants in the Playbark pine bark mulch (mulch 1). After 6 months, a handful of plants had shown signs of die back, although the growth of plants in the pine mulch (mulch 2) was still observed to be better than that of mulch 1. After 7 months, four plants had died in mulch 2, and 1 plant had died in mulch 1. This was due to heavy rains and poor drainage in bed B. All surviving plants were continuing to grow well at this stage and better than the control plants growing in heavy clay soil. Adequate drainage is critical to the success of planting in mulch fallzones.

### 9.3 Variety selection

The soft clumping Tanika® plants grew particularly well and would be a variety recommended for planting into a fall zone area of a playground.
It is important to note that although Naringa™ plants passed the CFH tests, the branches could present a hazard if a child fell onto this shrub so it is not recommended to use in immediate fall zones, but can be used in the edges of fallzones.
Note: Since the trial commenced in 2010 small forms of Westringia including Mundi™, Grey Box™, Low Horizon™ and Ozbreed Aussie Box® are now available. These require less pruning than Naringa™ and could be planted on the edge of the fall zone to provide contrast and interest from both their foliage and plant shape.

It can be extrapolated that other fine leaved grass-like plants similar to Tanika® Lomandra, with its soft foliage, could be anticipated to perform well in fallzones. For example, the Lomandras Shara™, Variegated Tanika™ and Tropic Cascade™. It must be noted Lomandras such as Nyalla®, 'Katrinus' and Sungold™ that have spiky leaf tips or spiky flowers would not be suitable. Other grass-like examples include Little Jess™ Dianella, Sweet Mist® Phormium, and Liriopes Just Right®, Amethyst™, Isabella®, Silverstar™ and Pink Pearl™.

Soft groundcover plants and small shrubs could also be anticipated to perform well in fallzones. Selections that don't get too woody, do not produce seeds or other choking hazards, and do not attract lots of bees are recommended. For example the Nandinas Blush™, Flirt™ and Obsession™ would be suitable as they have not produced berries. Callistemons would not be suitable as the flowers would attract too many bees and the seed could become a choking hazard.

### 9.4 Pot size

Three different pot sizes (140mm, 200mm, 300mm) were planted in the trial. All established well, although the plants in the larger pot sizes created the appearance of a more mature landscape from day 1. These larger plants were also considered to be more robust and less likely to be pulled up, damaged or stolen. Larger plants have proved to be more cost effective in real projects due to faster establishment which gives them a better chance at survival than smaller sizes, also a lower rate of losses. It is recommended to plant using the soil base method, provide regular care and to keep children away from the plants in the early establishment phase.

## 10 Conclusions after three and a half years

### 10.1 Mulch

After nearly three years, the mulch in both beds has slumped. Bed B (Pine mulch - mulch 2) showed significant slumping with measurements of the slumpage indicating the mulch had slumped 3.8 times more than the mulch in Bed A (Playbark pine bark mulch - mulch 1). Areas in Bed A (mulch 1) slumped between 3-5cm while the mulch in Bed B (mulch 2) slumped between 10-20cm as shown in Figure 6.3 where some plant roots were exposed as shown in Figure 6.4. The suspected cause for this large difference in slumpage is Bed B (mulch 2) didn't have agricultural pipe installed, whereas Bed A (mulch 1) had agricultural pipe installed to improve drainage. This pooling of water could have increased the rate of slumpage, although it still would have slumped more because of its smaller particle size. Also the pine mulch is made from pine wood, which is a soft wood that will break down more quickly than hard wood or the bark of a tree. These trial beds had not been topped up since their installation.

### 10.2 Plant survival and growing conditions

Although plant growth and establishment early on in the trial was observed to be better in the pine mulch (mulch 2), in the long term, plants in Playbark pine bark mulch (mulch 2) had better plant survival and had grown to their full height. The slumpage and poor drainage conditions in mulch 2 had caused the plant growth to slow and their vigor to decline.

### 10.3 Effect of plants on Critical Fall Height

Based on this trial, it can be concluded that the fibrous root system of the plants used had, overtime, increased the CFH. Plants can be confidently planted in the fallzones of play equipment, and can be used for any equipment with a stated free height of fall of up to 3m (the current limit for equipment in Australia).
The plants in the Playbark pine bark mulch (mulch 1) had shown that 3 out of 4 testing spots had an increased CFH, with an average rise of 1.5m.
The plants in the pine mulch (mulch 2) had shown that 2 out of 4 tests had a decreased CFH where the mulch was bare (due to slumpage). However the test 4 CFH had risen by 0.4m despite the slumpage as it was conducted on a Naringa™ plant.
These results show that plants with fibrous root systems overall will improve the CFH of a mulch, by how much is variable. However, this is a good indication that overall, plants will not be detrimental to the CFH. In the case of slumpage it shows that plants will help stabilise mulch as seen with the pine mulch (mulch 2).

The tests also show that the collar of soil used for the soil base planting method does not impact negatively on the CFH, it actually increased the CFH based on test 5 and 6 for both testing periods. By how much it increases is variable, especially depending on what type of soil or mix is used.

## 11 Discussion and recommendations for mulch selection

Based on this trial, the use of coarse mulch such as Playbark mulch (the 10-15mm pine bark mulch used in Bed A) is recommended. Although initial growth results were better in the finer mulch used in Bed B (2-15mm pine mulch), possibly as the finer particle size mimics soil, the long-term slumpage and resulting exposed roots and poor growth that was observed make it a less desirable choice. Overall, plants in Playbark mulch have performed better and the planting area has been more stable over the time of the trial. Where fine grade mulch is selected (with particle size under 10mm), the mulch should be topped up regularly. Check with the mulch supplier for recommendations for slumpage rates.

However for any mulch that is used it is recommended that the bulking out factor of delivered mulch plus 20 per cent more depth of mulch is used. This is to compensate for the expected slumping that can occur as the mulch breaks down or is compacted through use. It is also recommended that all playgrounds have a maintenance check conducted after the first 3 months, then an annual check thereafter with mulch top ups where needed. For playgrounds with high traffic, more frequent maintenance checks and top up may be needed. Most councils and childcare centres have a standard playground maintenance schedule or similar document.

## 12 Recommended best practice and overall conclusions

It can be confidently concluded that:

- Plants (especially soft wooded plants) can successfully be grown in mulched fallzone areas in playgrounds ie that 300mm deep mulch can be used as a growth medium
- That plants in mulched areas contribute positively to the CFH rating of the mulch they are planted in
- That plants can be used in fallzones of play equipment of any height up to 3m (within the requirements of the Australian Standards). It is recommended to check the CFH of the planted area every 3 years when mulch areas are also tested.

The following is recommended best practice based on this trial to comply with AS/NZ4422:1996 and promote best possible plant health and growth.

- Playbark pine bark mulch should be used at a 300mm depth (see heading 12 above)
- Adequate drainage is important (1:50 slope to base of mulch area plus use of agricultural pipe to drain the excavated area)
- Larger pot size i.e. 200mm/5L pot or larger (see 9.3)
- Plant selection of non woody plants (see 9.2. Tanika® Lomandra so far is the only non woody plant tested to the Australian Standard test method AS/NZ4422:1996)
- Plant using the Soil Base Method (see heading 1.3)

- Recommended establishment period of at least 1 month with no traffic on plant areas
- Plants should be placed judiciously in fallzones - they should not be planted where they may become trip hazards, but rather be used to the side of anticipated trafficked areas.
- If selecting plants other than Tanika® Lomandra or Naringa™ Westringia, plant species should be carefully selected not to pose hazards to children eg choking hazards, toxicity, thorns, etc.
- Fertilising of plants in freshly laid mulch will aid the initial establishment of the plants as there is little competition for the required nutrients.

## 13 Awards

### 13.1 Kidsafe award

In October 2012 this trial was Highly Commended by Kidsafe (Child Accident Prevention Foundation of Australia) as part of their 2012 National Awards. See Appendix D.

## 14 Further information

### 14.1 Biographical information

Katrina Layt is a landscape horticulturist at Ozbreed Katrina Layt who designed the trial area, investigated planting techniques, monitored and recorded plant health and growth, and contributed towards the paper.
Fiona Robbé is a landscape architect and principal of Fiona Robbé Landscape Architects. Fiona identified the need for this trial, coordinated CFH testing and contributed towards the paper with her expertise of playground design.
Grant Humphreys is a Laboratory Director at Acousto-Scan, an independent NATA accredited Laboratory. Grant conducted the CFH testing and contributed towards the paper with his expertise in playground surfacing requirements.
Jennifer Stackhouse is a horticulturist and freelance writer and editor who contributed towards the paper.

### 14.2 References

This trial was set up with reference to Australian Standard AS/NZ4422:1996. For Playground Safety Surface Test Reports for both the Playbark and Pine Mulch under surfacing products, visit www.ozbreed.com.au/plant-turf-research.html

### 14.3 Disclosure

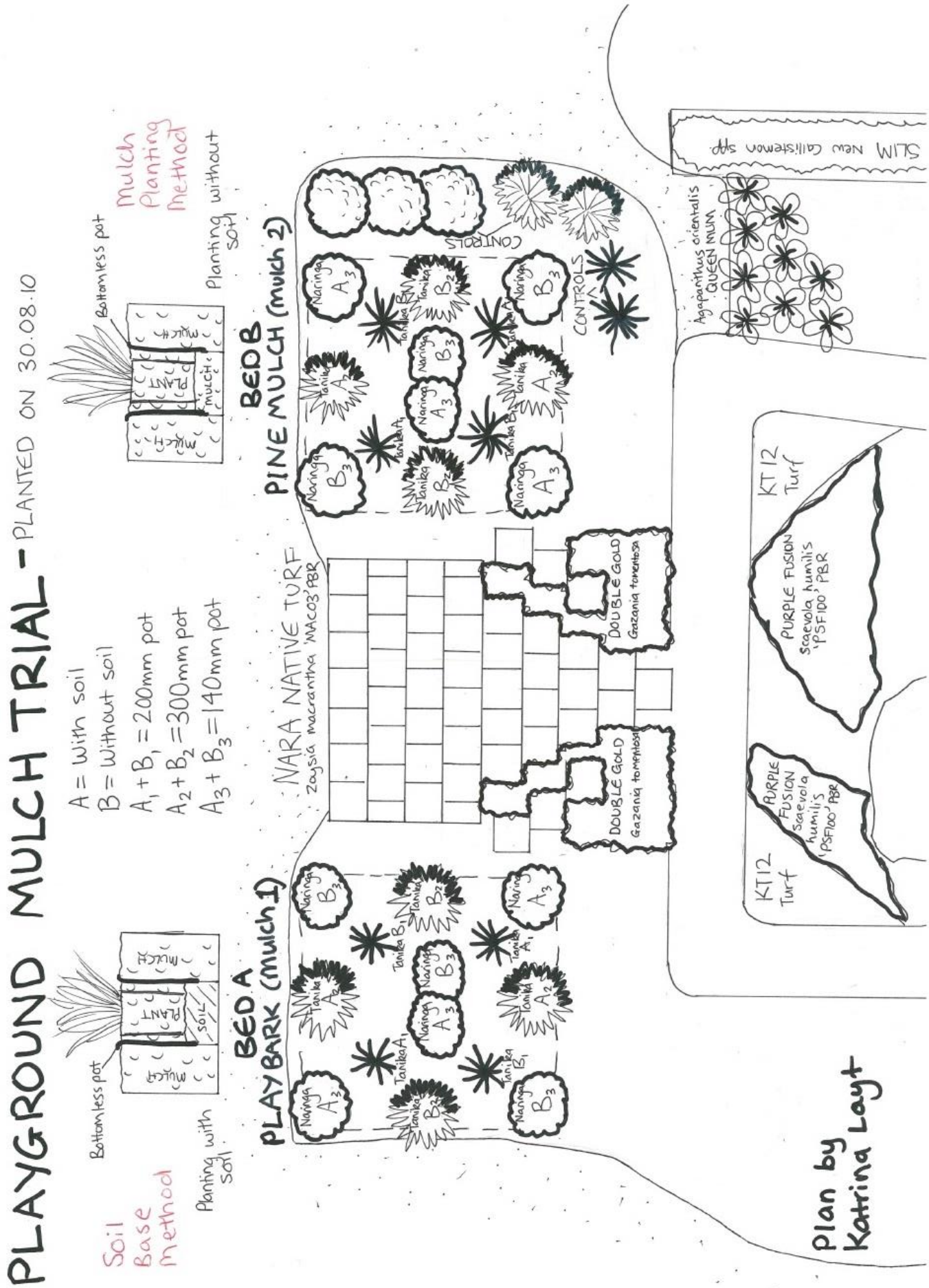
The results in this investigation were achieved in what we believe was an accurate and unbiased manner, and should anyone follow the same experiment again, Ozbreed believes they should get similar results. For purposes of full disclosure, the following information is tabled. This trial was overseen by Katrina Layt, a horticulturist employed by Ozbreed, who monitored and recorded plant health and growth.

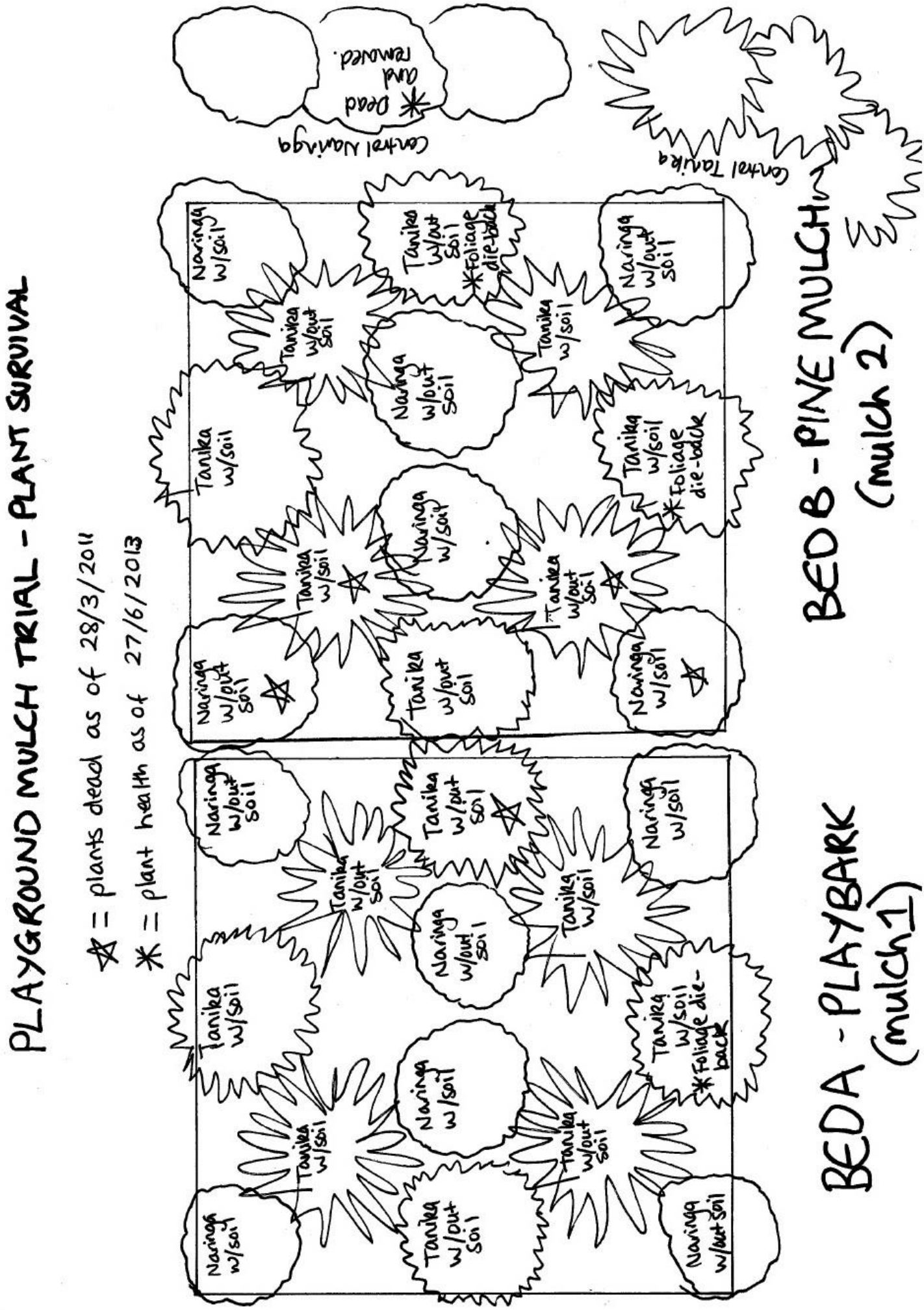
### 14.4 Acknowledgements

Mulches used in this trial were donated by The Hills BARK BLOWER (www.barkblower.com.au).

Critical Fall Height testing was undertaken by Acousto-Scan (www.acoustoscan.com.au).

**Appendix A**


PLAYGROUND MULCH TRIAL - PLANTED ON 30.08.10
A = With soil
B = Without soil
$A_1 + B_1 = 200mm$ pot
$A_2 + B_2 = 300mm$ pot
$A_3 + B_3 = 140mm$ pot
Soil Base Method
Bottomless pot
Planting with soil
Mulch Planting Method
Bottomless pot
Planting without soil
BED A
PLAYBARK (mulch 1)
BED B
PINE MULCH (mulch 2)
NARA NATIVE TURF
Zoysia macrantha 'NACO3' PBR
DOUBLE GOLD
Gazania tomentosa
CONTROLS
KT12 Turf
PURPLE FUSION
Scaevola humilis 'PSF100' PBR
Agapanthus orientalis QUEEN NUM
SLIM New Callistemon spp.
Plan by Katrina Layt


PLAYGROUND MULCH TRIAL - PLANT SURVIVAL
☆ = plants dead as of 28/3/2011
* = plant health as of 27/6/2013
BED B - PINE MULCH (mulch 2)
BED A - PLAYBARK (mulch 1)
Central Tanika
Central Moringa
Dead and removed.
Naringa w/out soil
Tanika w/out soil
Tanika w/out soil *Foliage die-back
Naringa w/out soil
Tanika w/soil
Naringa w/out soil
Tanika w/soil
Tanika w/soil
Naringa w/soil
Tanika w/soil *Foliage die-back
Naringa w/out soil
Tanika w/out soil
Tanika w/out soil
Naringa w/soil
Naringa w/soil
Tanika w/out soil
Tanika w/out soil
Naringa w/soil
Tanika w/soil
Naringa w/out soil
Tanika w/soil
Tanika w/soil *Foliage die-back
Naringa 3 /soil
Tanika w/soil
Tanika w/out soil
Naringa w/out soil

**Appendix B**
2012 Critical Fall Height test report from Acousto-Scan (on following 6 pages).

ACOUSTOSCAN
ABN 36 062 949 973
20/109A Bonds Rd Punchbowl NSW 2196

# Test Report
# for the determination of Critical Fall Height for "Under Playground Surfacing with Plants"

**Specification:** Australian Standard AS/NZS4422:1996 Amdt 1
Playground surfacing Specifications, requirements and test method

| | |
|---|---|
| **Client:** | OZ Breed<br>14 Cupitts Lane<br>Clarendon NSW 2756 |
| **Contact:** | Katrina Layt |
| **Date of Test:** | 15 August 2012 |
| **Location of test** | 14 Cupitts Lane<br>Clarendon NSW 2756 |
| **Date of Report:** | 30 August 2012 |
| **Report Number:** | 2956 |

**Acousto-Scan is an Accredited ISO/IEC 17025 NATA Laboratory and IS0 9001 Quality Company**

Date

30 Aug 2012

Laboratory Director

Grant Humphreys

*This report contains* 6 pages
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**Material Identification: Under Playground Surfacing**

The product comprised of 1. Playbark Area A Mulch 10 - 15 mm bark chips with plants
2. Port Stephens Pine Area B Mulch 10 – 15 mm bark chips and with plants

**Archiving:**

None

**Dates of test:** 15 Aug 2012

**Location of Testing:** OZbreed 14 Cupitts Lane
Clarendon NSW 2756SW 2196, Australia

**Temperature (surface):** Dry test 17°C

**Testing to:** Australian test method AS/NZS4422:1996 Amdt 1

The prepared samples of material were tested in accordance with Australian test method AS/NZS4422:1996 Amdt 1. This method involves impacting the material with an instrumented head-form and measuring the deceleration of the head-form on impact. Two impact parameters are determined from the recorded acceleration-time relationship - the Head Injury Criterion (HIC) and the maximum deceleration produced (G-max).

HIC is a measure of the severity of the impact and takes into account the time duration of the impact as well as its magnitude. It is defined in the Standard by the following integral formula:

$$HIC = \left[ (t_2 - t_1) \left\{ \frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a.dt \right\}^{2.5} \right]_{max}$$

where $t_1$ and $t_2$ are times between the starting and finishing times of the impact chosen to maximise the function, and ***a*** is the instantaneous value of deceleration during the impact measured in g, the acceleration due to gravity.
The critical fall height (CFH) for a particular surfacing material is the lowest drop height of the head-form, which produces an HIC of 1000 and a G-max of 200 G, whichever is the lower. These threshold values, which determine the critical fall height, are set in regard to minimising head injuries resulting from an impact of a human head with a surface. Thus, the greater the critical fall height, the safer is the surfacing material. This critical fall height can be referenced to the platform heights of particular items of playground equipment installed in playgrounds from which children might fall.
The fall height has been calculated relative to the nominated piece of equipment, and that no assumption has been made about the height of the user above that equipment.


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**Test equipment:**

The following test equipment conforming AS/NZS4422:1996 Amdt 1 was used.

**Head-form:** Aluminium alloy head-form #, AS0005
ISO Size J, mass 5.0 kg

**Equipment:** Uniaxe-II impact tester #AS0019

**Calibration factor:** 4 mV/g (g = 9.80665 m/s/s)

**Drop method**: guiding rails

**Timing:** infra-red gates

**Errors and Uncertainties:**

The Standard AS/NZS4422:1996 Amdt 1 Appendix A calls for an expression of critical fall height rounded down to the nearest 0.1 m.

Uncertainties were calculated in accordance with the ISO Guide to the Expression of Uncertainty in Measurement ISO/IEC GUIDE 98-3:2010

Uncertainty Confidence Level = 95%: Coverage Factor k=2

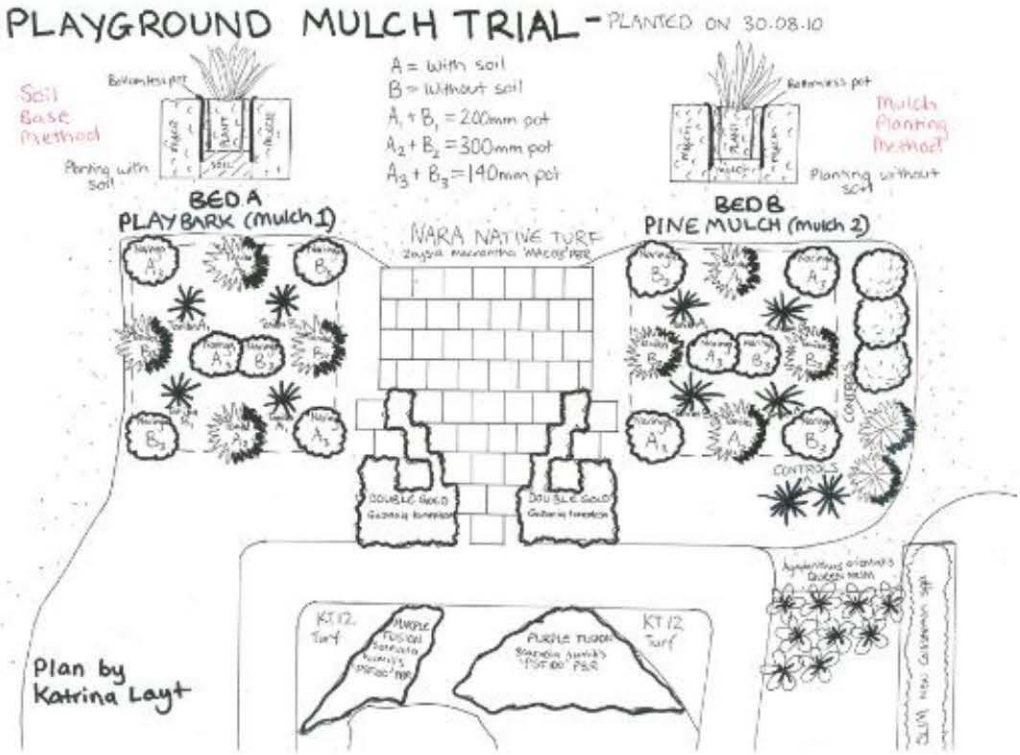
**Procedure:**

Two types of bark mulch where tested for impact attenuation to Australian Standard AS/NZS4422:1996 Amdt 1 Playground surfacing Specifications, requirements and test method .

The testing was carried out in accordance with Acousto-Scan's Work Instruction L4_09_05
All equipment was in calibration and traceable to national Standards.

The maximum G-max and HIC where recorded and later entered into the processing sheet.

Fig1: Layout of positions





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## Results

| Test Date | Test | Material Test Conditions | Critical Fall Height | Material Allowance |
|---|---|---|---|---|
| 30 August 2012 | 1 | Pine Mulch (Mulch 2)-M3 Indentation | **5.9 m** | 60mm |
| 30 August 2012 | 2 | Pine Mulch (Mulch 2) Dead Tanika | **6.2 m** | 60mm |
| 30 August 2012 | 3 | On Soil outside test area | **1.4 m** | 20mm |
| 30 August 2012 | 4 | Pine Mulch (Mulch 2) On Naringa plant | **5.9 m** | 60mm |
| 30 August 2012 | 5 | Playbark (Mulch 1) On Tanika with soil | **6.2 m** | 60mm |
| 30 August 2012 | 6 | Playbark (Mulch 1) On Tanika without soil | **4.4 m** | 60mm |
| 30 August 2012 | 7 | Playbark (Mulch 1). | **3.2 m** | 60mm |
| 30 August 2012 | 9 | Playbark (Mulch 1).-Dead Tanika | **3.2 m** | 60mm |
| 30 August 2012 | 10 | Soil outside test area | **1.8m** | 20mm |

The Australian Standard AS/NZS4422:1996 Amdt 1 details the usage of impact absorbing materials in children's playgrounds and defines relevant terms and conditions.

The fall height has been calculated relative to the nominated piece of equipment, and that no assumption has been made about the height of the user above that equipment.

Loose fill material should be installed to the depth shown in the test report, which should be not less than 200 mm. And because it will deteriorate during use, an additional depth (the material allowance) should be laid. In high traffic areas, such as under swings and slippery dips, an additional 20% in depth is recommended .


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Photo 1: Pine Mulch (Mulch 2)-M3 Indentation

Photo 2 Pine Mulch (Mulch 2) Dead Tanika

Photo 3: On Soil

Photo 4 Pine Mulch (Mulch 2)- On Naringa plant with soil

Photo 5 Playbark On Tanika with soil

Photo 6 Playbark- On Tanika without soil


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Photo 7 Playbark

Photo 8 Playbark- Dead Tanika

Photo 9 On Soil

Photo 10 Pine Mulch (Mulch 2)

**Comments:**

Two types of bark mulch where tested for impact attenuation to Australian Standard AS/NZS4422:1996 Amdt 1 Playground surfacing Specifications, requirements and test method .
It was observed that there were no hard areas due to roots or root matting .
The dead plant root ball was small and when impacted on, the CFH was 3.2m
The CFH minimum for the two complete areas was 3.2m .


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**Appendix C**
2014 Critical Fall Height test report from Acousto-Scan (on following 7 pages).

ACOUSTOSCAN
ABN 36 062 949 973
20/109A Bonds Rd Punchbowl NSW 2196

# Test Report
# for the determination of Critical Fall Height for "Re test from 2012 to 2014 Under Playground Surfacing with Plants"

**Specification:** Australian Standard AS/NZS4422:1996 Amdt 1
Playground surfacing Specifications, requirements and test method

| | |
|---|---|
| **Client:** | OZ Breed<br>14 Cupitts Lane<br>Clarendon NSW 2756 |
| **Contact:** | Katrina Layt |
| **Date of Test:** | 3 February 2014 |
| **Location of test** | 14 Cupitts Lane<br>Clarendon NSW 2756 |
| **Date of Report:** | 10 March 2014 |
| **Report Number:** | 3153 |

**Acousto-Scan is an Accredited ISO/IEC 17025 NATA Laboratory and IS0 9001 Quality Company**

Date

10 March 2014

Laboratory Director

Grant Humphreys

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**Material Identification: Under Playground Surfacing**

The product comprised of
1. Playbark Area A Mulch 10 - 15 mm bark chips with plants
2. Port Stephens Pine Area B Mulch 10 – 15 mm bark chips and with plants

**Archiving:**

None

**Dates of test:** 3 Feb 2014

**Location of Testing:** OZbreed 14 Cupitts Lane
Clarendon NSW 2756SW 2196, Australia

**Temperature (surface):** Dry test 27°C
Wet 27°C

**Testing to:** Australian test method AS/NZS4422:1996 Amdt 1

The prepared samples of material were tested in accordance with Australian test method AS/NZS4422:1996 Amdt 1. This method involves impacting the material with an instrumented head-form and measuring the deceleration of the head-form on impact. Two impact parameters are determined from the recorded acceleration-time relationship - the Head Injury Criterion (HIC) and the maximum deceleration produced (G-max).

HIC is a measure of the severity of the impact and takes into account the time duration of the impact as well as its magnitude. It is defined in the Standard by the following integral formula:

$$HIC = \left[ (t_2 - t_1) \left\{ \frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a.dt \right\}^{2.5} \right]_{max}$$

where $t_1$ and $t_2$ are times between the starting and finishing times of the impact chosen to maximise the function, and ***a*** is the instantaneous value of deceleration during the impact measured in g, the acceleration due to gravity.
The critical fall height (CFH) for a particular surfacing material is the lowest drop height of the head-form, which produces an HIC of 1000 and a G-max of 200 G, whichever is the lower. These threshold values, which determine the critical fall height, are set in regard to minimising head injuries resulting from an impact of a human head with a surface. Thus, the greater the critical fall height, the safer is the surfacing material. This critical fall height can be referenced to the platform heights of particular items of playground equipment installed in playgrounds from which children might fall.
The fall height has been calculated relative to the nominated piece of equipment, and that no assumption has been made about the height of the user above that equipment.


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**Test equipment:**

The following test equipment conforming AS/NZS4422:1996 Amdt 1 was used.

**Head-form:** Aluminium alloy head-form #, AS0005
ISO Size J, mass 5.0 kg

**Equipment:** Uniaxe-II impact tester #AS0019

**Calibration factor:** 4 mV/g (g = 9.80665 m/s/s)

**Drop method**: guiding rails

**Timing:** infra-red gates

**Errors and Uncertainties:**

The Standard AS/NZS4422:1996 Amdt 1 Appendix A calls for an expression of critical fall height rounded down to the nearest 0.1 m.

Uncertainties were calculated in accordance with the ISO Guide to the Expression of Uncertainty in Measurement ISO/IEC GUIDE 98-3:2010

Uncertainty Confidence Level = 95%: Coverage Factor k=2

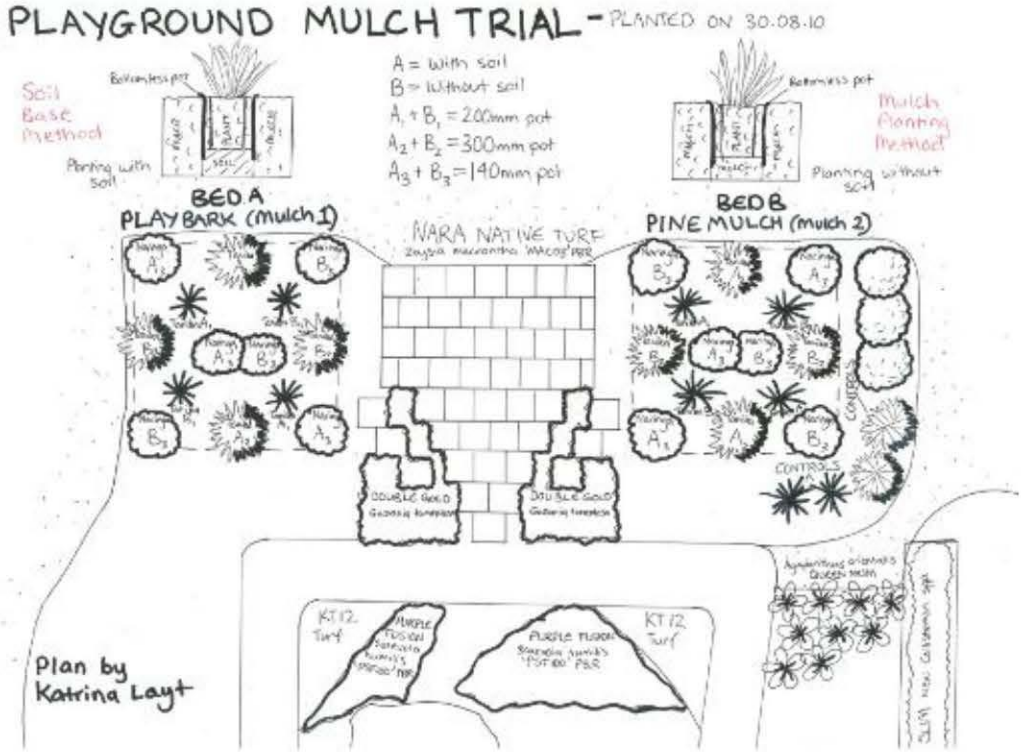
**Procedure:**

Two types of bark mulch where tested for impact attenuation to Australian Standard AS/NZS4422:1996 Amdt 1 Playground surfacing Specifications, requirements and test method .

The testing was carried out in accordance with Acousto-Scan's Work Instruction L4_09_05
All equipment was in calibration and traceable to national Standards.

The maximum G-max and HIC where recorded and later entered into the processing sheet.

Fig1: Layout of positions





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## Results Dry

| Test Date | Test | Material Test Conditions | Critical Fall Height | Material Allowance |
|---|---|---|---|---|
| 3 February 2014 | 1 | Pine Mulch (Mulch 2)-M3 Indentation | **3.5 m** | 60mm |
| 3 February 2014 | 2 | Pine Mulch (Mulch 2)Dead Tanika | **3.4 m** | 60mm |
| 3 February 2014 | 3 | On a Tanika plant without soil | **5.7 m** | 70mm |
| 3 February 2014 | 4 | Pine Mulch (Mulch 2)Mulch - On Naringa plant | **6.3 m** | 60mm |
| 3 February 2014 | 5 | Playbark pine bark mulch (Mulch 1). On Tanika with soil | **6.7 m** | 60mm |
| 30 August 2012 | 6 | Playbark pine bark mulch (Mulch 1). On Tanika without soil | **3.9 m** | 60mm |
| 3 February 2014 | 7 | Playbark pine bark mulch (Mulch 1). | **5.3 m** | 70mm |
| 3 February 2014 | 9 | Playbark pine bark mulch (Mulch 1). Dead Tanika | **5.2 m** | 60mm |


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## Results Wet

| Test Date | Test | Material Test Conditions | Critical Fall Height | Material Allowance |
|---|---|---|---|---|
| 3 February 2014 | 1W | Pine Mulch (Mulch 2) -M3 Indentation | **4.5 m** | 60mm |
| 3 February 2014 | 2W | Pine Mulch (Mulch 2) Dead Tanika | **4.5 m** | 60mm |
| 3 February 2014 | 3W | On a Tanika plant without soil | **3.9 m** | 20mm |
| 3 February 2014 | 4W | Pine Mulch (Mulch 2) On Naringa plant | **4.3 m** | 60mm |
| 3 February 2014 | 5W | Playbark (Mulch 1). On Tanika with soil | **4.4 m** | 60mm |
| 3 February 2014 | 6W | Playbark (Mulch 1). On Tanika without soil | **4.4 m** | 60mm |
| 3 February 2014 | 7W | Playbark (Mulch 1). | **5.7 m** | 60mm |
| 3 February 2014 | 9W | Playbark (Mulch 1). Dead Tanika | **6.2 m** | 60mm |

The Australian Standard AS/NZS4422:1996 Amdt 1 details the usage of impact absorbing materials in children's playgrounds and defines relevant terms and conditions.

The fall height has been calculated relative to the nominated piece of equipment, and that no assumption has been made about the height of the user above that equipment.

Loose fill material should be installed to the depth shown in the test report, which should be not less than 200 mm. And because it will deteriorate during use, an additional depth (the material allowance) should be laid. In high traffic areas, such as under swings and slippery dips, an additional 20% in depth is recommended .


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Photo 1: Pine Mulch (Mulch 2)-M3 Indentation

Photo 2 Pine Mulch (Mulch 2)Dead Tanika

Photo 3: On Soil

Photo 4 Pine Mulch (Mulch 2)- On Naringa plant with soil

Photo 5 Playbark (Mulch 1). on Tanika with soil without soil

Photo 6 Playbark (Mulch.1) On Tanika


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Photo 7 Playbark (Mulch 1).

Photo 8 Playbark (Mulch 1).- Dead Tanika

Photo 9 On Soil

Photo 10 Pine Mulch (Mulch 2)

**Comments:**
Retest of plant area. Last test 2012.

Two types of bark mulch where tested for impact attenuation to Australian Standard AS/NZS4422:1996 Amdt 1 Playground surfacing Specifications, requirements and test method .

It was observed that there were no hard areas due to roots or root matting.
The dead plant root ball was small and when impacted on, the CFH was 6.2m
The CFH minimum for the two complete areas was 4m.


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**Appendix D**

KIDSAFE 2012 NATIONAL PLAYSPACE DESIGN AWARDS

Kidsafe

Child Accident Prevention Foundation of Australia

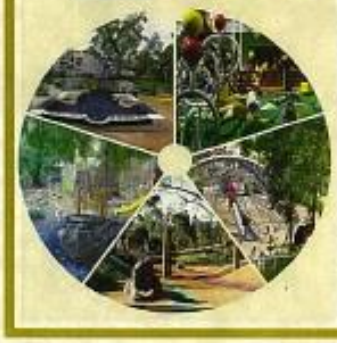
# Highly Commended

## Playground Mulch Trial NSW

**Entrant:**
**Fiona Robbé Landscape Architects, Ozbreed, Hills Bark Blower, and Acoustoscan**

## in the category of Innovative Design Elements

The Kidsafe 2012 National Playspace Design Awards recognise excellence and innovation in the provision of safe, creative playspaces across Australia.



**Peter Gibson**
President
October 2012