Impact of Stand-off Surface on the Welfare of Late Gestation Dairy Cows in Winter

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Abstract of a Thesis submitted in partial fulfilment of the requirement for the Degree of Agricultural Science (Honours)

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In New Zealand it is increasingly common practice for farmers to remove cows from pasture and crops for periods of the day, as a mitigation strategy to reduce nitrate leaching. There are no rules governing the type of 'stand-off' system used, and as a result farmers may select stand-off system based on cost. There is limited evidence from New Zealand regarding how different stand-off pad surfaces may impact on the welfare of dairy cows. An experiment was conducted in Canterbury, New Zealand between June and August 2017 to investigate the effects of different stand-off pad surface types on aspects of dairy cow welfare. One hundred and sixty multiparous, non-lactating, pregnant Friesian x Jersey cows were blocked and assigned to five treatments within a winter system. All treatment groups grazed fodder beet *in situ* following supplement feeding on a feed pad. The stand-off pad treatments were: no stand-off (control); stand off on a woodchip pad for 16 hr/day (woodchip); Stand-off on a stones for 16 h/day (stones); stand-off on sand for 16 h/day (sand) stand off on geotextile carpet for 16 h/day (carpet).

Welfare requirements for lameness and nutrition were met by all surface types, though some surfaces performed better than others with regards body condition score gain. The average hours lying per 24 hrs was greater than 8 hours for all surfaces except sand, however, there were cows in every group that did not achieve 8hrs or more each day. Surface type had an effect on average lying time ($P<0.05$) and lying bouts ($P<0.001$), with stones having significantly higher lying hours and fewer lying bouts in 24hrs, than other surfaces. There was also an interaction between time and surface type ($P=<0.001$); lying hours increased from week one to week four for most surfaces. Surface type had a significant effect on hygiene scores, with the stones group being the cleanest (1.04) and sand being the dirtiest (1.66; $P=0.02$), and an interaction between time and hygiene score for cows on sand, where cows got dirtier with each week on the pad ($P=<0.001$). Although all groups gained body condition score during the experiment, final and change in body condition score were significantly different between surface groups ($P<0.001$ and $P<0.005$, respectively) and the stones and carpet groups gained significantly more than the other groups. There was no effect of surface on lameness scores or live weight. Taken together, our results indicate that adaptation to a new environment for lying may take several weeks, and that most surface types have both positive and negative effects on cow welfare and need to be managed to minimise those negative effects.

While our results indicated an effect of surface type on certain aspects of cow health and welfare during winter, a longer study, covering the whole winter season, would be required to confirm these results.

Keywords: Lameness, hygiene, cleanliness, nutrient, management, lying, stand-off pad, feed utilisation, BCS, welfare.

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"*My oldest sister is freakin' awesome and I'm going to buy her lots of soft rind cheese, biltong and cider*!" - J.E. McGowan, 2017

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1 INTRODUCTION

1.1 Background

The New Zealand dairy industry is predominantly pasture based, with a temperate climate that allows farmers to grow adequate feed most of the year, and the ability to conserve feed for periods where growth is inadequate. Due to New Zealand not having particularly adverse conditions, such as extreme heat or cold that may harm the cows, combined with the ability to grow and conserve ample quality pasture, there are very few instances of barn confined cows. Traditionally, farmers have removed cows from pasture to the cow shed yard or a stand-off pad as a management strategy to prevent damage to waterlogged soils and pasture from pugging, as well as enable supplementary feeding. In a 2015 survey of farmers, AgResearch reported that 24.2% of farms had an off-paddock facility, 81% of which were uncovered and the most common period of use was 6-12 weeks during winter, for 12-20 hrs per day (Botha & O'Connor, 2012).

However, since stand-off pads can also allow for the capture of urine and water, and the mitigation of nitrate leaching, use of stand-off pads in New Zealand may be on the rise. Livestock production systems such as dairy farms have been found to be major contributors to nitrogen losses, and in 2012, 81% of N leached in New Zealand was from livestock waste (Statistics New Zealand, n.d). Nitrate leaching is of concern due to the negative effects it has on water quality and the biggest contributor to nitrate leaching on a dairy platform is cow urine (Ledgard *et al.* 1996). As farmers endeavour to reduce their environmental footprint, increased use of stand-off pads to capture urine is one possible solution. Web traffic to the DairyNZ 'off paddock' pages indicate that interest in on stand-off facilities has increased between 2016 and 2017, with page visits up 253% for the 'stand-off pad' page (*personal communication:* Helen Thoday, 2017).

The AgResearch survey reported that farmers often designed their own off-paddock facilities and had a high level of confidence that these facilities were adequately caring for cows. "Content" cows were described as quiet and relaxed, with high milk production and gut fill, whereas cow discomfort was described as agitated, not eating and noisy. The farmers' descriptions of what indicates comfort and discomfort in cows reveals a limited understanding of cow welfare in off-paddock systems. This naïve understanding, combined with potential for poor design and surface choice through self-design, could result in stand-off pads that do not support good cow welfare. When stand-off pads are used for limited periods, only to minimise soil and pasture damage during wet weather, impacts of poor design or management on welfare are also limited. However, extended use of stand-off pads to mitigate of nitrate leaching could exacerbate impacts on cow welfare.

The importance of these effects are considered in the literature reviewed, which focuses on the welfare aspects that are involved with facilities such as stand-off pad areas, and how they align with the internationally accepted Five Freedoms (the basis of the Animal Welfare Act, 1999) and the Code of Welfare for Dairy Cattle (National Animal Welfare Advisory Committee, 2016).

There is limited evidence of what how different stand-off pad surfaces will affect the welfare of non-lactating dairy cows in winter. We hypothesised that there would be significant differences between stand-off pad surfaces and their impact on cow welfare parameters. To test this, we compared four different stand-off pad surfaces against what would be a common expected surface for New Zealand dairy cows in winter, a fodder beet paddock (control).

1.2 Aims and Objectives

The research objectives of this study were:

1. To measure and compare the effects of four different stand-off pad surfaces (woodchip, stones, sand and carpet) and a control paddock of fodder beet on the welfare of non-lactating dairy cows. Factors measured are lying activity, indicators of lameness, hygiene and feed intake.

2. To measure and compare the temperature and moisture content of the stand-off surfaces and paddock.

1.3 Hypothesis

H0 = there are no differences in stand-off surface on cow welfare parameters.

2 REVIEW OF THE LITERATURE

2.1 Introduction

During winter cows may be taken off pasture and held on stand-off pads or in barns for part of the day, to prevent damage to waterlogged soils and pasture, or to enable supplementary feeding. Stand-off pads can also allow for the capture of urine and water through the use of in-built drainage systems. The biggest contributor to nitrate leaching on a dairy platform is cow urine, with concentrations of up to 1,000kgN/ha per urinary patch (Ledgard *et al.* 1996). Consequently, farmers are being encouraged to incorporate the use of stand-off pads and barns as a method to mitigate nitrate leaching by capturing more of the urine off-pasture, especially during the wetter winter period.

If stand-off pads and barns are going to be used more intensively, it is important to consider how animal health and behaviour will be affected, making the choice of bedding type/surface extremely important. As outlined in the Animal Welfare Act (1999), there are 5 freedoms that are internationally recognised as animal welfare standards to adhere to when caring for animals:

1. Freedom from hunger and thirst: Animals are fed a suitable and well suited, balanced diet and have access to clean drinking water.

2. Freedom from discomfort: Animals have appropriate shelter and comfortable resting area.

3. Freedom from pain, injury and disease: Animals receive adequate care and veterinary attention when sick or injured.

4. Freedom to express normal behaviour: Animals are able to express behaviour which is normal for them if they were in their natural environment. So they have enough space for movement and also have opportunity to interact with other animals.

5. Freedom from stress and fear: Ensuring conditions avoid unnecessary anxiety and stress to reduce mental suffering.

The New Zealand Code of Welfare for Dairy Cattle (2016) aligns with the 5 freedoms, and sets out minimum standards for stand-off and feed pad areas (Shown in Appendix E). The Ministry for Primary Industries (MPI) are currently considering a code of welfare that is specifically tailored surrounding barns or housing for dairy cattle.
Because most farmers have only used stand-off pads for short periods until recently, there has been limited research about the effect of long periods of use on cow welfare. Therefore this review will include research from cows that are confined in barns as there can be similarities in surface type, cleanliness and space per cow.

2.2 Freedom from Hunger & Thirst

2.2.1 Nutritional Requirements

Animals being held in captivity must be provided with access to suitable drinking water and adequate feed to ensure the individual animal's minimum maintenance requirements are met. The feed maintenance of dairy cows can change depending on animal size, level of physical activity, physiological state, milk production level and the environment they are in. For dairy cows being grazed over winter, there is maintenance, pregnancy, live weight gain and the environment to factor in.

Rattray *et al*. (2007) states that maintenance is the ME required to "keep an animal at a constant body weight or energy content" and calculates maintenance for dairy cows as "$lwt^{0.75}$ x 0.53-0.58."Maintenance provides the animal with the basic energy to complete necessary daily processes needed to sustain life, such as breathing and digestion, and excludes energy required for lactation, pregnancy, live weight gain or loss.

How much energy a dairy cow will need during pregnancy depends on what stage of pregnancy she is in, and how quickly/well the foetus is growing. Moe & Tyrell (1972) state that at full term, a pregnant dairy cow has metabolisable energy requirements 75% higher than maintenance, which is supported by Table 1 below (Rattray *et al*., 2007), where a 500kg cow's maintenance is 58 MJ ME/day and at 0 weeks before calving, pregnancy costs an additional 45 MJ ME/day for a 40kg calf. This increase in energy demand is often not able to be fulfilled, as dairy cows in late pregnancy have the lowest dry matter intake levels at this stage of pregnancy (Grummer *et al*., 2004)

Table 1: The ME requirements for different stages of pregnancy in adult dairy cattle (adapted from Rattray *et al*., 2007)

Calf birth weight	**Weeks before calving**						
(Kg)	**-12**	**-8**	**-6**	**-4**	**-2**	**0**	**Total for pregnancy[1, 2]**
			MJ ME/cow/day				
25	5	9	12	16	21	28	1415
30	6	11	15	19	25	34	1705
35	7	13	17	23	30	39	2000
40	9	15	20	26	34	45	2295

[1] ME requirements for pregnancy are additional to maintenance

[2] Based on 11.0 MJ ME/kg DM of feed.

Energy requirements are also affected by the environment, and by the cow's size and BCS. If stand-off pad surfaces are cold enough during winter to cause heat loss, it can increase a cows DMI, indicating their maintenance energy requirements increase, meaning there is an importance on how a surface will interact with environment conditions. A cow's ability to withstand cold conditions and heat loss will vary with cow size and BCS, with cows of higher live weight having greater resistance to cold stress, due to increased surface to volume ratio (Fregonesi *et al*., 2007b). Energy requirements for maintenance are increased during cold stress, therefore feed allocation should be monitored and increased if needed to allow for the extra energy spent in adverse conditions (Figure 1; Mader, 2003; Young, 1981).

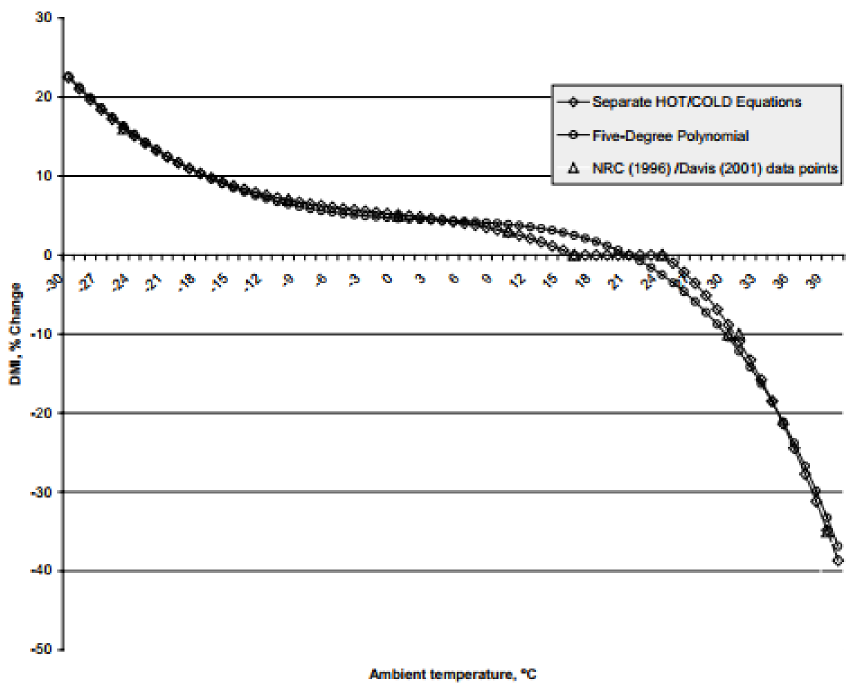

Figure 1: Graphical representation of the effects of temperature, (T), on DMI, where Cold is <16°C, and Hot is >24°C (Mader, 2003)

Furthermore, stand-off pad areas need to be appropriately stocked to allow lower ranking cows' access to water and the feed source, ensuring there is enough space or points of supply to minimise competition (Huzzey *et al*, 2006; Fregonesi & Leaver, 2002). This potential for competition is particularly important for cows on stand-off pads that are fed on separate feed pad areas or crop faces, as the cows are expected to consume their entire daily feed allowance in a short period of time, therefore increased competition for feed is to be expected. There should be adequate space to allow subordinate cows to feed and drink.

With energy requirements of dairy cows often fluctuating depending on stage of pregnancy, cow size and live weight, physical activity and climate, it is important to monitor the effect these factors have on energy requirements. It is critical to ensure that cows have this access to drinkable water and adequate energy from feed, to remain free from thirst and hunger.

2.2.2 Body Condition Score

Body condition score is a subjective measure of a cow's long term nutritional status, using assessment of the animals fat deposits (Bewley & Schutz, 2008; Mandok *et al*., 2014; Roche *et al*., 2009), which can be used to inform management decisions such as feed allocation, milking frequency and dry-off dates. Farmers use body condition score (BCS) to give an approximation of a cow's energy reserves (fatness), using the 1-10-point system, and this is estimated throughout the year at key physiological stages e.g. start of lactation, pre-mating, late lactation and during the dry period. With cows often being dried off in late autumn, the non-lactation period is an important time for cows to regain the body condition score that was lost as a result of the large demand of lactation from the previous season (Little *et al*., 2017). Good BCS management is critical as cows that have too low or high BCS at calving are at greater risk of disease, such as mastitis, uterine infections, metabolic disorders, and decreased reproductive efficiency (Bewley and Schutz, 2008; Roche *et al*., 2013). DairyNZ suggests an optimal body condition score for mature dairy cows of 5.0, and 5.5 for first and second calvers (DairyNZ, 2012), and a suitable rate of BCS gain of 0.5/month. Cows in New Zealand dairy systems typically have to gain 1.0 BCS or more between end of lactation and subsequent calving, making BCS management during the dry period (usually winter) extremely important.

Cows with low body condition at calving have an extended anoestrus period post-calving (Roche *et al*., 2009; Roche *et al*., 2007), which can result in later heat detection and pregnancy, lower 6-week in-calf rates, or failure to get in-calf. This reduced reproductive status could be influenced by the reported increase in metritis of cows with low BCS (Roche *et al*., 2009; Kim & Suh, 2003).

Cows with too high BCS show reduced DMI (Roche *et al*., 2009; Broster and Broster, 1998) which could negatively impact on milk production. There is also an association with increased incidence of metabolic disorders in fatter cows, such as milk fever, which can be due to reduced DMI coupled with high milk production drawing such a large amount of calcium from the animal (Roche *et al*., 2009; Roche *et al*, 2007).

Despite the importance of BCS to production and profitability, farmers often fail to get their cows BCS to pre-calving targets with current wintering systems in New Zealand, such as wintering on crops or on pasture with supplementary feed in the paddock (Dalley *et al.*, 2012; Hudson *et al.*, 2010). In a BCS initiative run by DairyNZ on 300 herds, even with coaching from BCS accredited assessors in February on feed budgeting and how to increase BCS, 80% of herds failed to get to average of 5.0 and 6% had more than half the herd below 4.5 by April/May (Figure 2).

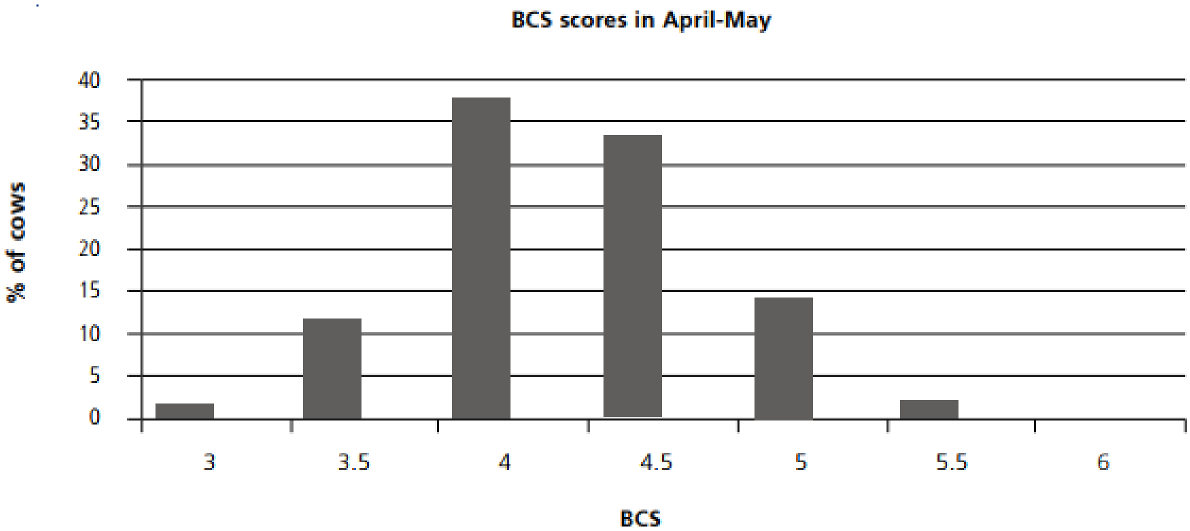

Figure 2: Graph representing the BCS range for 300 herds 90 days before calving, assessed by accredited BCS advisors (Peel & DairyNZ, 2014)

It is possible that taking cows off pasture and onto a stand-off pad for the majority of winter would support better BCS management due to control over feed allocation, reduced feed wastage, reduced activity and ease of sheltering a stand-off pad to protect from cold stress compared to grazing in a paddock.

2.3 Freedom from Discomfort & Freedom to Express Natural Behaviour

2.3.1 Cow Comfort

Comfortably lying down and resting is highly important for a cow's welfare. In dairy cows, lying time had a higher priority than feed intake and social interaction, when these were limited (Fisher *et al.*, 2003; Krohn & Munksgaard, 1993; Munksgaard *et al.*, 2005). Therefore Minimum standard 8 sets out requirements for surface area types; "Dairy cattle must be able to lie down and rest comfortably for sufficient periods to meet their behavioural needs" (New Zealand Code of Welfare for Dairy Cattle, 2016).

When choosing a surface type for a stand-off pad or housing structure, it is important to understand what is deemed as comfortable lying for cows, and also take into account what effect the surface will have on the cow's ability to lie down and stand back up, as this could affect how often/how many lying bouts she may have. Reduced lying bouts could be due to the cow not wanting to lie down/stand up on a hard or uncomfortable surface, which could affect lying times as the cow may be hesitant to lie down at all, or once lying may be hesitant to get up again. Excessive lying bouts can indicate cow restlessness and discomfort and therefore inadequate resting time (Hill *et al*., 2009; Dalley *et al*., 2012)

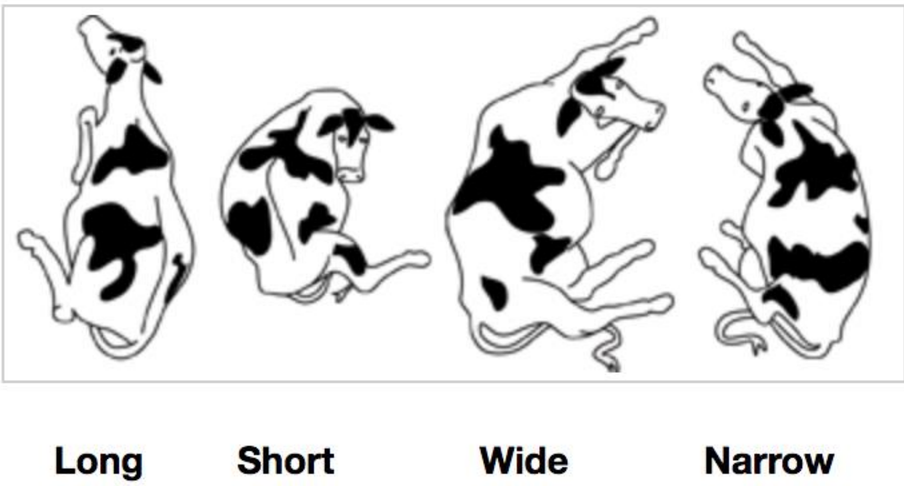

Figure 3: Potential lying/resting positions for dairy cows (DeLaval, 2007)

As shown in Figure 3 above by DeLaval (2007), there are 4 main positions that cows use when lying and resting, therefore enough space should be provided so that every cow can rest comfortably using whichever lying position she naturally chooses.

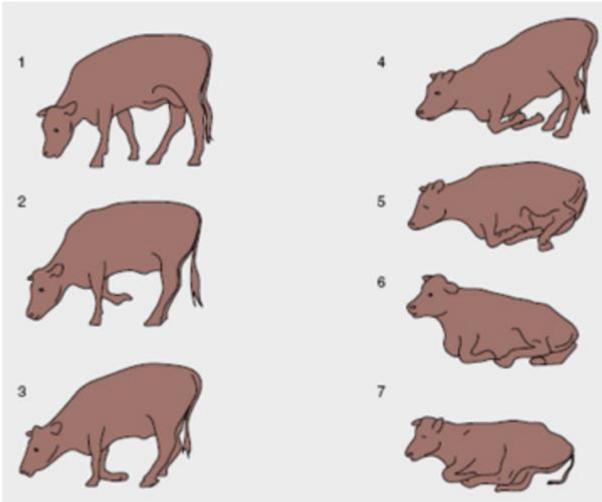

Figure 4: The process in which a cow uses to lie down (DeLaval, 2007)

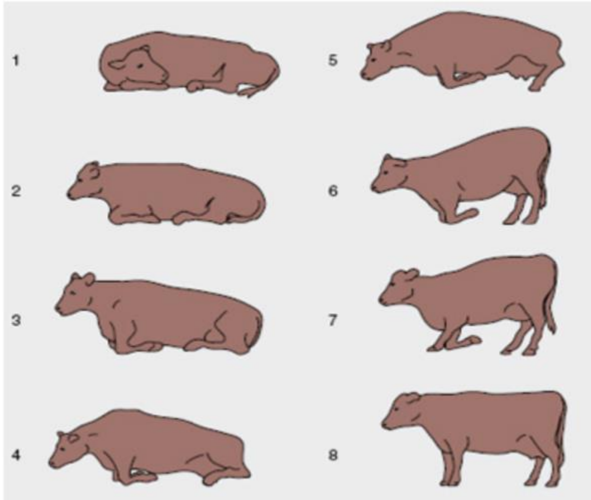

Figure 5: The process in which a cow uses to stand up (DeLaval, 2007)

The above Figures 4 and 5 (DeLaval, 2007) illustrate the multiple movements a cow must make to lie down and stand up. In Figure 4, through steps 2-3, the cow drops approximately 20-30cm down to one knee and then to both, during which time she can put around two thirds of her body weight (350-500kg depending on breed) through those front knees (steps 3-5) before dropping the rest of her body to the ground. This weight bearing on the knees indicates the importance of surface type, as a hard surface is not comfortable to drop down into a lying position and could result in less lying bouts. Haley *et al*. (2001) found that cows on concrete surfaces had decreased lying bout frequency and lying time but increased lying bout duration compared to woodchip, paddock and laneway. It was speculated that it was due to the cows being hesitant to get up and lie down from discomfort and that cows prefer to remain standing, rather than experience the pain associated with lying down or standing up when on rough surfaces which results in less time spent lying (Haley *et al*., 2001; Fisher *et al*., 2003)

In Figure 5, when standing up, the cow lunges forward with her body weight up onto her knees (steps 1-4), then lifting onto her back legs (steps 5 & 6) before rising up off her knees (7 & 8). This lunging forwards is necessary in assisting the cow back up to a standing position, therefore cows must be provided enough space to lunge. Bed areas that are too small, or stand-off areas that are overstocked could reduce ability to stand up.

2.3.2 Lying Time

Cows need to be given adequate space and a comfortable surface as they spend large portion of the day lying down. Webster & DairyNZ (2014) and the National Animal Welfare Advisory Committee (2016) recommend that dairy cows have the ability to lie for a minimum of 8 hours/day.

International research consistently reports that cows lie down for an average of 10-13 hours per day (Fregonesi *et al*., 2007a; Mattachini *et al*., 2013; Munksgaard *et al*., 2005). Reported lying times for cows in New Zealand are typically shorter, approximately 10 hours (Fisher *et al*., 2008; Schutz *et al*., 2014). It is possible that cows on pasture have a reduced need to lie down, as the surface is softer and more comfortable natural lying surface (Hernandez-Mendo *et al*., 2007) and grazing consumes more of their time budget, therefore overseas measures of welfare may not be relevant.

Reduced lying time in dairy cows is reported to increase discomfort and potential negative impacts on affective state (pain, hunger, stress etc.) (Cooper *et al*., 2008). There is behavioural evidence that lying deprivation causes stress and discomfort when lying time is reduced by as little as 2-4 hours, with time spent feeding decreasing as lying became a priority (Cooper *et al*., 2007; Cooper *et al*, 2008). Lying is so high priority that within 40 hours after deprivation was lifted, the cows had made up 40% of the lying time they had missed. Metz (1985), found that depriving cows of lying down for as little as 3 hours resulted in increased motivation to lie down, at the expense of feeding, which could explain the recovery in lying time from Cooper *et al*. (2007; 2008).

The surface of an off-pasture facility can impact on lying time. Multiple studies have found that concrete surfaces resulted in lower total lying times per day compared to other surfaces such as woodchip, rubber matting, stall mattresses and laneways (Fisher *et al*., 2003; Haley *et al*., 2001; Schutz & Cox, 2014). The reduction in lying time from hard surfaces could be linked to cow comfort and ease of lying and standing. As previously mentioned, cows will lie less frequently and remain standing rather than experience the discomfort from lying down and standing up on a hard or rough surface (Haley *et al*., 2001; Fisher *et al*., 2003). In addition to the reduction in lying time when the surface is too hard, cold and wet surfaces also reduce lying time. Fisher *et al*., (2003) found that cows in a muddy laneway or small paddock spent less time lying, and had fewer lying bouts, than cows on a dryer woodchip stand-off pad. As seen in Figure 6, woodchip cows spent 5-6 hours more lying down than the laneway and paddock, which were deemed very muddy and presumably wet. Similar increases in lying times was observed by Tucker *et al*. (2009), where cows kept outside in cold, wet conditions spent 7 hours less lying down compared to cows housed inside (7h ± 0.3% versus 14h ± 0.3% lying time; P < 0.001). And both Schutz *et al*. (2010) and Webster *et al*. (2008) reported a clear decline in the lying time of cows exposed to wet surface conditions.

Because lying is such a high value activity to cows, selection of an appropriate lying surface and proper drainage is essential, to ensure surfaces don't become waterlogged and muddy.

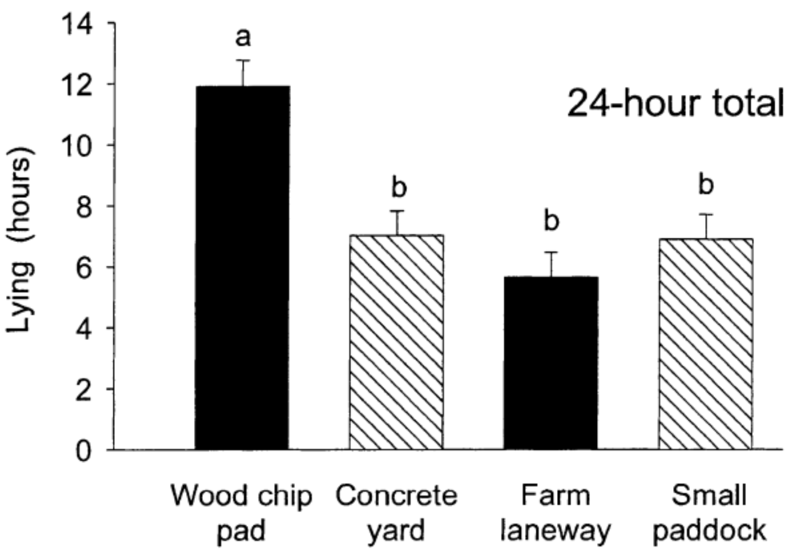

Figure 6: The amount of time spent lying down by cows, assigned different stand-off pad treatments (Fisher et al., 2003)

2.3.3 Hygiene

Cow hygiene or cleanliness is an important animal welfare factor to consider when choosing a stand-off pad surface due to the potentially negative effects that lying in cold and muddy conditions can have on lameness and mastitis incidence, lying time and associated dry matter intake reduction due to heat loss (Mader, 2003).

The surface condition of the stand-off pads, including moisture content, is one factor that can impact cleanliness score of cows (Schreiner & Ruegg, 2002) with higher cleanliness scores (higher=dirtier) when cows are held on excessively wet or muddy surfaces (Fisher *et al*. 2003). Schutz & Cox (2014) measured hygiene and lying times of cows on woodchip, 12 and 24mm rubber matting and concrete, and found that cows on both rubber matting surfaces had hygiene scores almost 3 times higher than cows on concrete or woodchips (Figure 7).

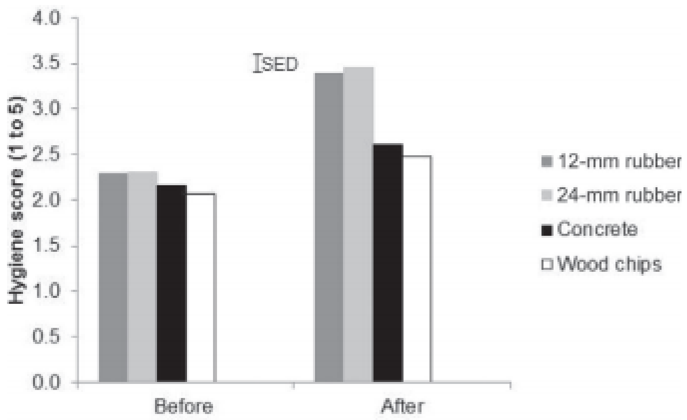

Figure 7: Hygiene scores of dairy cattle before and after a 4-day stand-off period, repeated 4 times, on 12mm and 24mm rubber matting, concrete and woodchip (Schutz & Cox, 2014)

Cold and wet conditions also result in increased energy requirement, because the animal has to expend energy to keep warm as mentioned previously (Young, 1981; Mader, 2003).

2.4 Freedom from Pain, Injury & Disease

2.4.1 Mastitis

Mastitis is the most costly animal health issue farmers face, causing losses through decreased milk production, lost milk from adhering to withholding periods as well as the cost of treatment and potential culling or replacement in serious or repeat cases (Sischo *et. al.* 1990), as well as the pain and discomfort it can cause cows. The surface condition of stand-off pads, including moisture content, is one factor that can impact cleanliness score of the cows (Schreiner & Ruegg, 2002), with cows having higher dirtiness scores when they are kept on extremely wet or muddy surfaces (Fisher *et al*. 2003)

In confined cows, there is a much greater chance of cows having cases of environmental mastitis due to their decreased levels of sanitation and the increased presence of faeces and *Strep. uberis* and *E. coli* (Bartlett *et al*. 1992). Cook (2002) also confirmed that cows with poor hygiene had a higher risk of mastitis during an udder hygiene trial in Wisconsin shown in Figure 8.

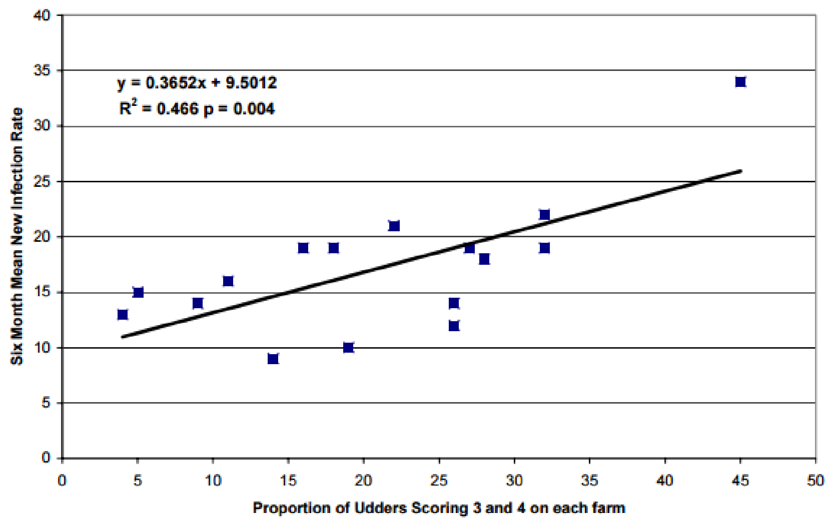

Figure 8: The association between udder hygiene score and new mastitis infection rate on 16 Wisconsin dairy farms (Cook, 2002)

Cow hygiene or cleanliness is an important animal welfare factor to consider when choosing a stand-off pad surface, due to the risk of increased lameness and mastitis. Dirty and moist conditions are an ideal environment and transfer medium for bacteria, and also soften hoof and mammary tissues.

2.4.2 Lameness

Lameness is a large problem in the New Zealand dairy industry, with reported average prevalence ranging from 2-38% per year (Table 2; Brownlie, 2013; Chawala *et al*., 2013; Gibbs, 2010; Tranter & Morris, 1991). It is a major health and welfare issue, due to the pain and stress it can cause an animal (Clarkson *et al*., 1996), reduced DMI and reproductive performance, coupled with production losses and increased animal health costs. Lameness can also make a cow hypersensitive to pain long after treatment and returning to the herd (Laven *et al*., 2008), even triggering pain responses from stimuli not initially associated with the lameness (allodynia). This extended period of pain response indicates that early detection and prevention of lameness rather than remedial or medicinal treatment is key to reducing the pain associated with lameness.

Table 2: Recorded lameness prevalence figures from New Zealand dairy farms.

	Prevalence (%)	**Origin of data**
Brownlie, 2013	6.30%	From farmer records
Chawala *et al*., 2013	3.70%	From farmer records
Gibbs, 2010	26.20%	South Island: Farmer diagnosed
Tranter & Morris, 1991	2-38%	3 North Island farms

There is evidence that farmers are not detecting lameness in the minor stages, only the advanced critical stages (Leach *et al*., 2010) where immediate action is needed. Alawneh *et al*. (2012) reported a three week delay between when a cow is identified as lame by an observer and when the farmer drafts her for treatment. Fabian *et al*. (2014) reported that farmers underestimated the level of lameness in their herds; the average farmer estimate was 73% lower than the actual incidence.

In the New Zealand dairy industry, the most common causes of lameness are white line disease and sole injuries, accounting for approximately 70% of the lameness cases treated in New Zealand by veterinarians (Chesterton *et al*. 2008), whereas in barn confined scenarios, there is a much higher prevalence of sole ulcers and digital dermatitis, which currently uncommon in New Zealand (Hedges *et al*. 2001). In wintering systems where stand-off pads are used, lameness is the biggest welfare concern due to the range in surfaces on which cows have to stand in poor climatic conditions and due to the types of feed commonly used.

Multiple studies on the effect of surface type on cow lameness have found that using hard surfaces, such as concrete stand-off pads, result in increased lameness incidence (Wynn *et al*., 2011; Adams *et al*., 2011; Stewart *et al*., 2002). For instance, white line disease which was mentioned above is a separation of the inner zone of the hoof wall (O'Grady, 2010). A major risk for white line disease is thinning of the sole from rough and hard surfaces such as concrete, or wet conditions softening the hardened sole and allowing potential penetration and splitting of the white line (Cook & Nordlund, 2009). Olmos *et al*. expressed that sole injuries are indicators of “constant mechanical insult” (2009), which could be associated with walking long distances to the milking shed or walking/standing on a hard or rough surface such as a stand-off pad. Wet conditions can also have an effect on lameness incidence, because the hoof horn tissue can quickly absorb water, softening the tissue and increasing the risk of damage (Potterton *et al*., 2012; Bonser *et al*., 2003, Gregory *et al*., 2006, Shakespeare, 2009), as well as the potential for rain to expose previously covered stones, or conceal stones in puddles. Potterton *et al*. (2012) also mentioned that exposure to manure slurry, which would be present on a stand-off pad surface, can soften hoof tissue, increasing risk for increased white line disease and sole injuries.

The second lameness risk is associated with feeding as there is a relationship between laminitis and rumen acidosis. Rumen acidosis is a decreased rumen pH due to the overproduction of lactic acid when the diet is high in starchy, readily digestible feed with low effective fibre content (Woodacre, 2006), which is common in total mixed rations (TMR) systems. The low rumen pH results in the inflammation of hoof laminar tissue, which is very painful (Bicalho *et al*., 2009). If using a stand-off pad, cows need to be provided with adequate fibre and be monitored for acidosis to reduce the risk of laminitis

On stand-off pads, cows are potentially exposed to surfaces which are generally covered with slurry (faeces and urine) with the risk of foot rot and digital dermatitis, which are highly infectious diseases easily spread in the confined environment (Laven & Holmes, 2008). “Bovine Digital dermatitis (BDD) is an ulcerative lesion of the bovine digital skin which causes severe lameness in dairy cattle” (Sullivan *et al*. 2015). The main cause of digital dermatitis has been highlighted as a spirochetal bacterium (Evans et. al. 2011), which is incredibly contagious and is easily transferred via direct contact or via substances such as slurry. In scenarios such as a stand-off pads, the transfer of this bacteria is incredibly easy as the cows are not only standing in slurry and faecal matter for majority of the day but they are also in close contact with each other (Palmer & O'Connell, 2015). Foot rot or interdigital necrobacillosis occurs in the interdigital space and is caused by bacteria that degrades the flesh, requiring antibiotic treatment. Infection is common where cows spend long periods of time in places such as muddy yards, laneways or paddocks (Vermunt & Parkinson).

All of the aforementioned hoof injuries are very painful and it is shown that the pain associated with lameness can last well after it has been treated, making it important to monitor surfaces and be proactive with lameness detection. Without careful design of facilities such as stand-off pads, suitable selection, maintenance and drainage of surface, and correct stock handling practices, the risk of lameness is amplified.

2.4.3 Lameness Indicators

Gait or stride length is often used as an indirect indicator of lameness, as it can identify if a cow has a shortened stride, which usually indicates lameness or discomfort (Blackie *et al*., 2013; Telezhenko & Bergsten, 2005). Gait length can be calculated by distance travelled divided by the number of steps taken by the hind limbs (Fisher *et al*., 2003). Fisher *et al*., (2003) found that cows on a concrete stand-off pad had a gait length decrease of 0.07m (0.71m initially decreased to 0.64m) whereas cows on woodchip, laneway and paddock experienced no change. This is supported by Galindo & Broom, who found that lameness in dairy cows increased with increased time spent on concrete floors due to increased incidence of hoof lesions (2000).

Similarly, Haufe *et al*., (2009) compared rubber flooring, mastic asphalt (graded limestone aggregates bound together with asphalt cement), and slatted concrete, and found that dairy cows took 0.11m longer strides on rubber matting, and 0.05m longer strides on mastic asphalt compared to stride length on slatted concrete flooring (shown in Figure 9). This is in agreeance with Telezhenko (2007), where cows stride lengths increased on slatted and solid rubber flooring compared to slatted or solid concrete. They also reported that moderately to severely lame animals had slower walking speed and reduced stride length compared to non-lame or mildly lame animals, which suggests a relationship between stride length and lameness severity. Schutz & Cox (2014) also found that concrete resulted in a decreased stride length/increased strides/m, but no significant difference between 12mm and 24mm rubber matting or woodchips (Figure 10).

Walking speed can also be an indicator of lameness, or discomfort. Decreased walking speeds can show a lack of friction between the hoof and the surface which can result in slipping, thus reducing a cows confidence in her steps and slowing how fast she travels. Concrete floors have been found to result in decreased walking speeds (m/s) of cows compared to other surfaces such as rubber matting or asphalt (Telezhenko & Bergsten, 2005; Flower *et al*., 2007; Chapinal *et al*., 2011)

Hard surfaces such as concrete have been found to reduce the stride length of dairy cows, indicating a potentially negative impact on lameness shown as stiffness or discomfort. Using gait as a means of measuring lameness is a proactive method of reducing the lameness incidence before lame cows get to a higher lameness score and experience more pain, for longer.

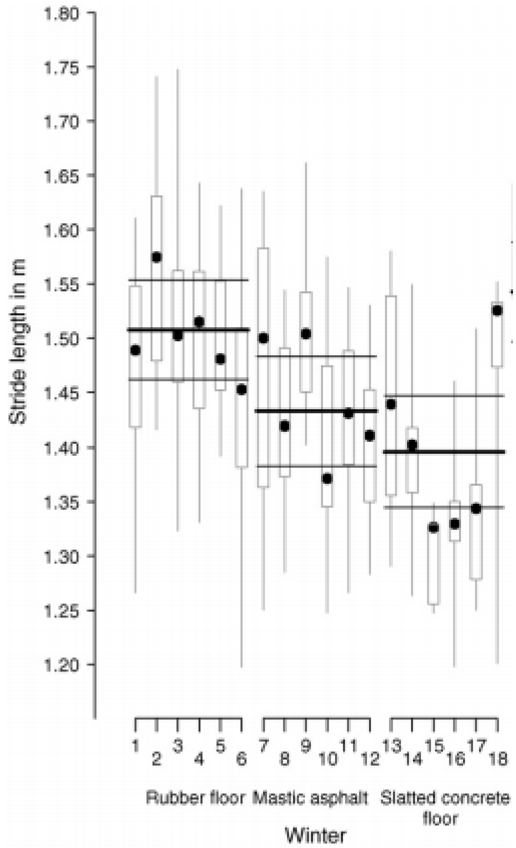

Figure 9: Effect of floor type on the stride length of dairy cows on 18 dairy farms. Thick lines indicate the means (▬) (Haufe et al., 2009)

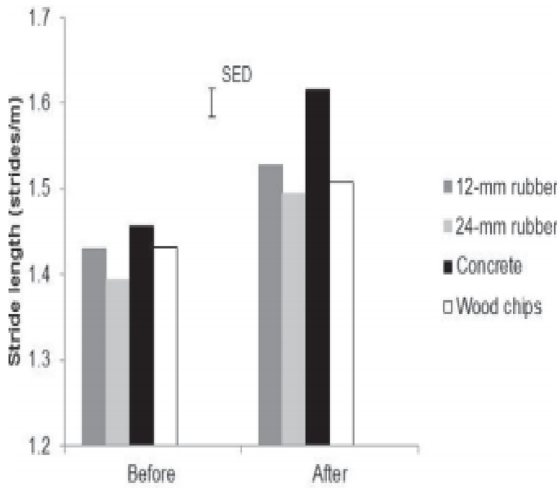

Figure 10: Stride length of dairy cattle before and after a 4-day stand-off period, repeated 4 times, on 12mm and 24mm rubber matting, concrete and woodchip (Schutz & Cox, 2014)

2.5 Summary

Use of off-pasture facilities is likely to increase as a strategy to mitigate environmental risks of dairy farming. However, without careful design and management, cow welfare could be compromised. Lying behaviour, gait, hygiene, lameness and body condition score are all factors that may be negatively impacted by poor choice and management of stand-off pad surface. In majority of aspects, concrete is considered the worst performing surface type, with noticeable reductions in lying time and bouts, and increased lameness. Regardless of how soft or comfortable a surface is, it is necessary to monitor drainage and moisture, as wet surfaces can become cold; reducing lying time, and dirty; which increasing the risk of infection for mastitis and lameness. Therefore, we did this study to describe the risk factors of various stand-off pad surfaces, are applicable to the New Zealand dairy scenario and our use of stand-off pads.

3 MATERIALS AND METHODS

3.1 Experimental Site and Design

All procedures conducted in this experiment were approved by Lincoln University Animal Ethics Committee. The experiment was carried out at Ashley Dene Research and Development Station (-43.65º N, 172.34º E), Canterbury, New Zealand between the 26th June and 14th August 2017. The site of the fodder beet paddocks consists of a combination of Balmoral and Lismore soil types (Lucas *et al*., 2012). Balmoral soils (B3) are a stony silt loam which is excessive drained, has an available water holding capacity (WHC) of 60-80mm with stones found at depths <200mm. Lismore soils (L3) are also a stony silt loam and are somewhat excessively drained, with a WHC of 70-100mm and stones found at depths of 450-750mm (McLenaghan & Webb, 2012). The experimental site comprised of 5 fodder beet paddocks, each 1.792ha. The fodder beet paddocks totalled 8.96ha, each paddock was 1.792ha

The experiment was a prospective longitudinal study looking at the effects of different stand-off surface materials on cow welfare over six weeks. There were five treatments: 1. Control (cows remained in the crop paddock), 2. Woodchip (conventional stand-off material) 3. Stones, (cheap re-usable material) 4. Sand (alternative conventional stand-off material) and 5. Geotextile carpet (expensive alternative with perceived better welfare benefits).

Each stand-off pad area was lined with a high density polyethylene (HDPE) liner with BIDIM® nonwoven needle-punched continuous filament polyester geotextile A24 filter fabric above and below the HDPE liner. Two 110mm NEXUSFLO™ double walled, polyethylene punched pipes were installed at the bottom of the liner to provide drainage for the stand-off pads (add in appendix showing picture of layout). The liner and drainage system was then covered with a base material of 40mm compacted angular graded gravel (AP40) which was then covered with approved drainage aggregate to form the layer below the chosen stand-off pad bedding surfaces. The woodchip, stones, sand and carpet (WC, ST, SA & C) were laid at a depth of 400mm. Although the total stand-off area for each pad was 1104.4m^2/0.11ha, electric fencing was used to confine cows to an area of

10m^2/cow, double the minimum requirement of 5m^2/cow as recommended by DairyNZ for cows on stand-off pads for medium – long term, more than 12hrs/day for 3 or more days in a row (2014). As no cows calved during the measurement period, there was no requirement to decrease the fenced stand-off pad area to adjust for cows leaving the experiment once calved.

3.2 Animals and Management

3.2.1 Animal Management

One hundred and sixty multiparous, late calving, non-lactating mixed age cows (Holstein-Friesian x Jersey) were randomly blocked into 5 treatment groups of 32 based on their average calving date (11/09/2017), live weight (462.21± 54.19kg), body condition score (4.16 ± 0.43 BCS) and age (4.57 ± 1.33 years).

Cows were transitioned onto fodder beet following the similar method of Edwards *et al.*, (2014) over 7 days from June 19th until June 26th, with fodder beet allocation increasing 0.5kgDM/cow/day over the 7 days until 8kgDM/cow/day allocation was reached. The fodder beet paddocks were break fenced, according to feed allocation per cow and the DM/ha yield of fodder beet per paddock (yield measured every fortnight). Fodder beet paddocks were not back fenced, so the area/cow increased daily throughout the measurement period.

A second transition onto stand-off pads and feed pad took place over 7 days from the 26th June until the 3rd July. Cows on the stand-off treatment groups were shifted to the SOPs at 9pm on days 1 and 2; at 7pm on days 3 and 4; at 5pm on days 5 and 6, and finally, 4pm on day 7, the intended time of moving cows to SOPs. Cows were removed from paddock to stand-off at 4pm for the remainder of the experiment.

Each day at 08:00hrs, cows were shifted from paddock or stand-off area to the feed pad where they were offered 4kg DM/cow/day silage. After two hours, or until utilisation of silage was >90% (visual assessment) cows were then walked to their respective paddocks and received their crop allocation. Subsequently, all 5 treatments walked a similar distance along the same laneway daily. All cows had access to *ad libitum* water while in fodder beet paddocks and stand-off pads. A summary of timing and feeding for the five treatments are listed below:

1. Control: Cows grazed in-situ on fodder beet entirely from 10:00am – 8:00am (22 hours). Once crop was grazed, the paddock surface was bare soil or mud.

2. Woodchip (WC): Cows grazed in-situ on fodder beet from 10am until 4pm daily (6 hours). From 4pm until 8am (16 hours) spent on stand-off pad with a surface of woodchips (40mm), 500mm deep. Wood chip was residual from 2016, so has been sitting for 12 months before experiment commenced.

3. Stones (ST): Cows grazed in-situ on fodder beet from 10am until 4pm daily (6 hours). From 4pm until 8am (16 hours) spent on stand-off pad with a surface of greywacke stones (40-60mm in diameter).

4. Sand (SA): Cows grazed in-situ on fodder beet from 10am until 4pm daily (6 hours). From 4pm until 8am (16 hours) spent on stand-off pad with a surface of sand.

5. Carpet (C): Cows grazed in-situ on fodder beet from 10am until 4pm daily (6 hours). From 4pm until 8am (16 hours) spent on stand-off pad with a surface of carpet. The geotextile 'carpet' was designed by CowmaxTM and was fitted over a 100 mm layer of sand to ensure drainage. The carpet surface was cleaned 3 times weekly if needed, to remove the build-up of faecal matter.

3.2.2 Stand-off Pad Management

Sand and woodchip stand-off pad surfaces were turned weekly starting from the third week of the experiment. The geotextile carpet stand-off pad was cleaned three times weekly using a purpose built motorised brush cleaner (Photograph 1.)

Photograph 1: Geotextile carpet being cleaned using motorised rotating brush sweeper.

3.3 Stand-off Pad Surface Measurements

3.3.1 Temperature

Temperature of each stand-off pad surface and the control paddock were measured every day at approximately the same time (8:30-9am) in 6 separate areas (see Appendix D), and also a control temperature reading was taken for every surface on an area where the cows were not using. Temperature was taken using the FLIR MR77 moisture meter, which used infrared laser-spot light to detect surface temperature.

3.3.2 Moisture

Moisture (%) of each stand-off pad surface and the control paddock were measured every day at approximately the same time (8:30-9am) in 6 separate areas (see Appendix D), and also a control moisture reading was taken for every surface on an area where the cows were not using. Moisture was taken using the FLIR MR77 moisture meter, where a two pronged probe was inserted into the top of the surface.

3.4 Crop Measurements

3.4.1 Fodder Beet Intake

Fodder beet intake was calculated from disappearance of crop yield before and after grazing. Yield was determined for each treatment fortnightly. In each treatment, three samples were measured representing left to right gradient of the crop face. Each cut involved harvesting 2 x 3m rows of fodder beet (side by side), each bulb then had the dirt removed and bulbs and leaf matter were weighed separately in the paddock to give a fresh weight. From the collected bulbs, one bulb and a handful of sub-sampled leaf matter were collected (per cut, equalling 3 per paddock) and were taken for laboratory analysis for dry weight (DW), dry matter (DM) and nutritive value (NIRS).

3.4.2 Fodder Beet Utilisation

Post grazing mass/residual was calculated by taking 5 x 1m^2 quadrat cuts in each paddock where cows had recently grazed (and where there was currently yield data for). In each quadrat, any residual fodder beet bulb was dug from the ground and bagged, then weighed in the lab.

Fodder beet utilisation measurements were calculated as:

$$\frac{pre\ grazing\ mass - post\ grazing\ mass}{post\ grazing\ mass}\ x\ 100$$

This calculation showed how much fodder beet (as a percentage) the cows were eating and how much was left over.

3.4.3 Grass Silage Intake & Utilisation

4 kg DM/cow was fed out daily onto the feed pad (Photograph 2) using the farms feed out wagon, weekly grab samples were taken from each treatment’s allocation of silage to be analysed using the NIRS technique outlined above. Utilisation was measured by compiling and weighing the residual silage left per treatment.

Unfortunately due to time and staffing constraints, NIRS analysis was unable to be done on both the fodder beet and silage samples so actual ME was unable to be calculated.

Photograph 2: Cows on feed-pad with silage allocation.

3.5 Animal Measurements

3.5.1 Body Condition Score & Live Weight

Cows were weighed and body conditioned scored every 3 weeks, with BCS being done by the same farm technician every time.

3.5.2 Activity

Prior to the experiment period, each cow was fitted with an AfiAct pedometer above their rear fetlock joint. The AfiAct pedometer recorded lying and standing time, lying bouts and steps taken, which was then relayed back to the data reader, or stored in the pedometer itself until the animal was within range of the reader. The data was downloaded from the pedometers as per Al-Marashdeh (2017), when cows were walking to between stand-off pads, feed pads and fodder beet paddocks as this involved walking past the reader that was attached to the milking shed.

Pedometers were previously validated for accuracy using visual assessment against pedometer data with a correlation coefficient of r^2=0.96 for lying time, (Arends, 2016; Coveney, 2016).

3.5.3 Lameness

Each cow from every treatment group were scored for lameness once a week. Scores were given to each cow as they walked, single file, from the feed pad to the paddock, on the laneway. Cows were given a score using the DairyNZ Lameness Scoring System from 0-3, where 0: cow is walking evenly; 1: not walking evenly and needs to be monitored; 2: cow is lame and needs to be drafted, recorded and examined within 48 hours and 3: cow is severely lame and cow urgently needs to be drafted, recorded and examined within 24 hours and may require a vet. Lameness scores were analysed against treatment to measure any effect.

See Appendix A and B for the DairyNZ scoring system from the Lameness Field Guide (2017).

3.5.4 Hygiene

Each cow from every treatment group was individually hygiene scored once a week, for the duration of the measurement period. Scores were given to cows while they were eating on the feed pad, which allowed for a score to be given while they were feeding and not moving around (Photograph 3). Cows were scored 0, 1 or 2 for if they were clean (0), dirty (1) or very dirty (2) using the DairyNZ Hygiene Scoring system in Appendix C.

Photograph 3: Hygiene scoring of cows whilst on the feed-pad.

3.5.5 Gait

Once a week for the entire experimental duration, every cow was recorded with 720p sports video cameras, as the cow walked single file down a 10m length of raceway (Photograph 2.). For each cow, the number of steps her back left foot took within the 10m distance was counted, then divided by the distance of 10 metres. This is referred to as a gait score or stride length.

Photograph 4: Gait scoring of cows walking single file down a narrowed race to measure stride length

3.5.6 On & Off Timings

Cows on stand-off pads were timed, as a group, to see how long it took to move onto and off of the stand-off pad area. Timing began once the first step was taken on or off the stand-off pad, and timing commenced when the last step was taken on or off the stand-off pad. Timing for cows going onto the stand-off pad was done without pressure on the herd, however light pressure was applied if cows were not moving onto the stand-off pad after 3 minutes.

3.6 Statistical Analysis

Each experiment was analysed separately using GenStat v16. Lying behaviour, walking behaviour, hygiene, cow BCS, live weight and lameness data were analysed using one and two-way ANOVA with stand-off surface type as the treatment and observation day or week as the random term. The surface temperature and moisture were analysed using repeated-measure ANOVA with stand-off surface type as treatment effect and week as the time effect and days within weeks as the random term in the model. Results were declared significant when $P<0.05$.

4 RESULTS

4.1 Climate Conditions

Weather data (air temperature and rainfall) were sourced from The National Climate Database, New Zealand (NIWA), Broadfields station 17603, and are shown in Figure 11. below. Rainfall for July and August was 127.6mm and 33.6mm respectively, which differs from the mean rainfall over the last 30 years of 57.8mm and 61mm for July and August. Mean air temperature for July and August was 6.0°C and 8.5°C (mean min 2.6; mean max 11.1 °C), which is similar to 30 year averages which were 6.1°C and 7.6°C for July and August.

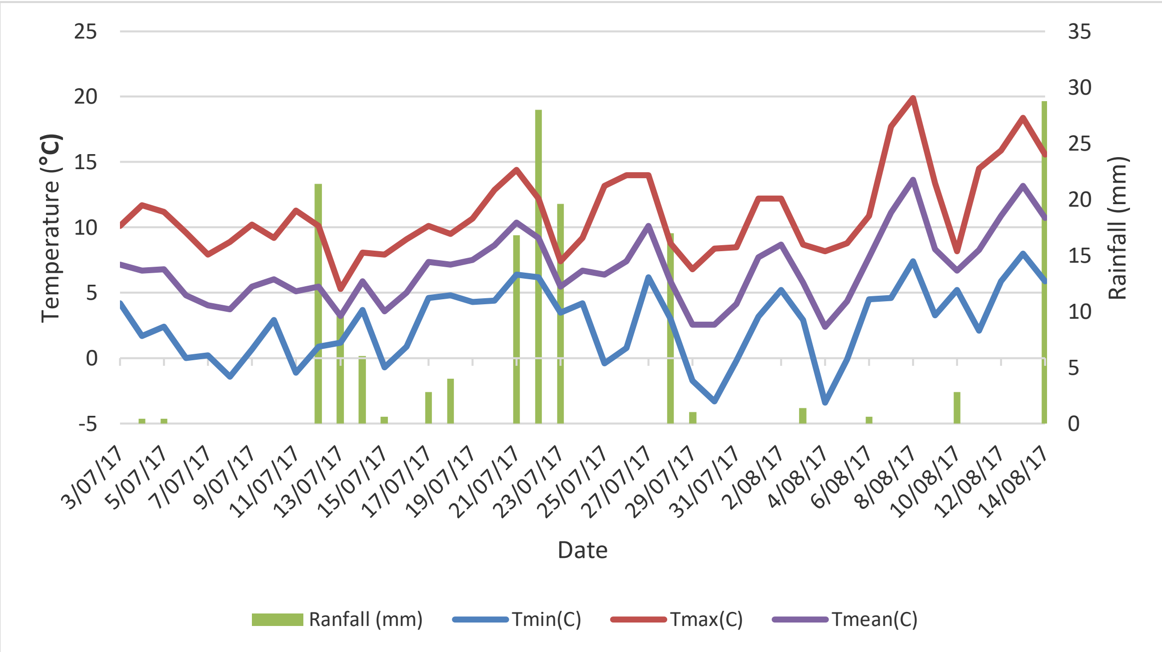

Figure 11: Total daily rainfall (mm), minimum and maximum temperature (°C) from 3/07/17 to 14/07/17 (taken from NIWA weather station 17603 at Broadfields, Lincoln)

4.2 Surface Conditions

4.2.1 Moisture

Surface moisture of the stand-off pad surfaces are shown in Figure 12. There was an interaction ($P<0.05$) between surface type and time which reflected the increasing moisture content of stones over time. The control, sand and woodchip had the highest average moisture content throughout the experiment compared with carpet or stones (Table 3).

Table 3: Average surface moisture of different stand-off pad surfaces

	Control	Woodchip	Stones	Sand	Carpet	SEM[1]	P Value
Average surface moisture (%)	88.5	77.2	48.2	77.4	69.0	3.16	<0.001

[1] SEM is standard error of the mean

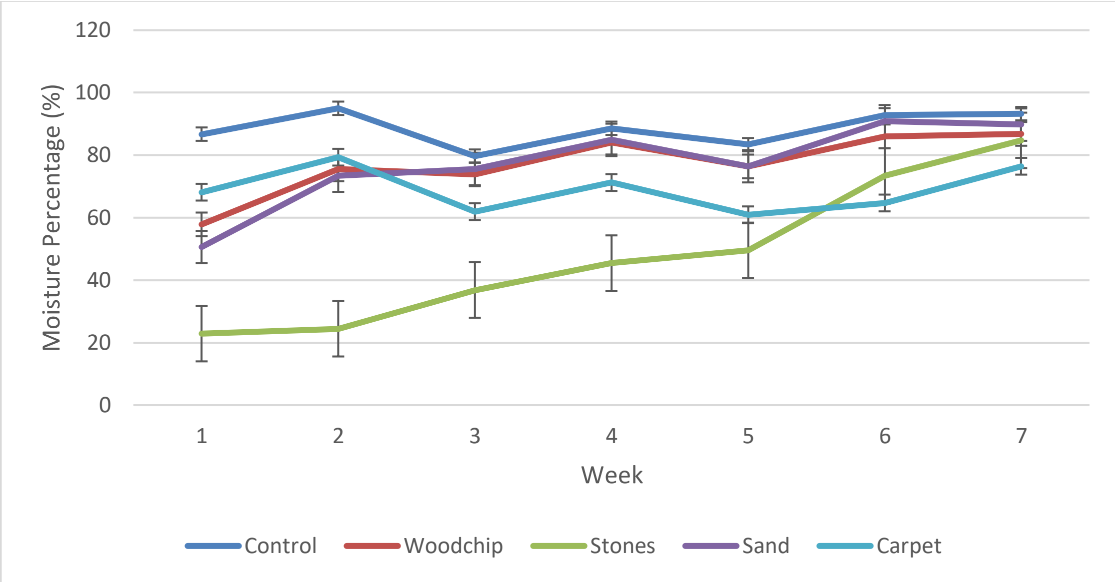

Figure 12: Average weekly surface moisture (%) of different stand-off pad areas, where cows were contained on from 4:00pm – 8:00am.

4.2.2 Temperature

Surface temperatures of the stand-off pad surfaces are shown in Figure 13. There was no difference between surfaces for mean temperature which was on average 2.99±0.26° C, P=0.54) for the experimental period. There were fluctuations in surface temperature over time (P<0.001) which were coldest in week 2 (-0.44°C) and warmest in week 7 (6.39°C).

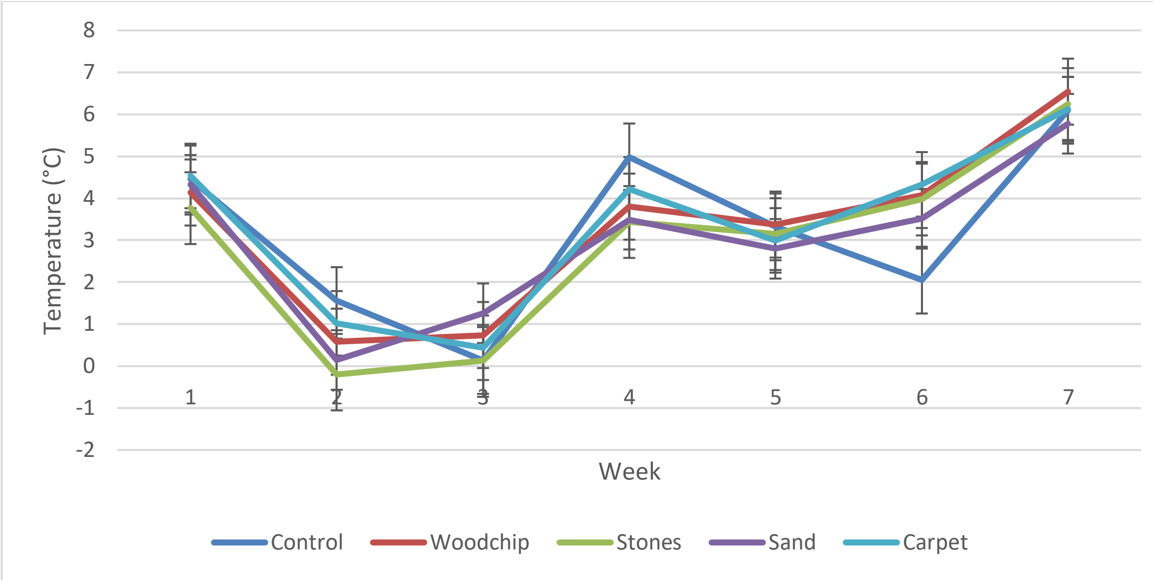

Figure 13: Average weekly surface temperature (°C) of different stand-off pad surfaces where cows were contained on from 4:00pm – 8:00am.

4.3 Feeding & Live Weight

Utilisation of both fodder beet and silage was greater than 90% of the allocations for all treatments, with no significant differences between treatments (P=0.615).

Table 4: Average total utilisation of fodder beet and silage offered daily to cows on different stand-off pad surface types.

	Control	Woodchip	Stones	Sand	Carpet	SEM[1]	P Value
FB utilisation	0.99	0.96	0.94	0.90	0.92	0.029	0.056
Silage utilisation	0.96	0.93	0.92	0.97	0.97	0.020	0.308

[1] SEM is standard error of the mean

There was no effect of stand-off surface on final live weight or live weight change between start of measurement period 4/7 and end of measurement period 14/8. However, there was an effect of surface type on change in body condition score between 4/7 and 14/8 (P=0.003) and final BCS on 14/8.

Table 5: Final and change in live weight and body condition score for cows on control, woodchip, stones, sand and carpet.

	Control	Woodchip	Stones	Sand	Carpet	SEM[1]	P Value
Final BCS	4.74	4.6	4.78	4.88	5.1	0.079	<0.001
Final LWT (kg)	519.3	511.5	507.0	504.0	519.7	11.83	0.838
Change in BCS	0.23	0.26	0.48	0.41	0.55	0.032	0.003
Change in LWT	23.7	20.2	24.1	20.0	24.7	1.328	0.689

[1] SEM is standard error of the mean

4.4 Comfort

4.4.1 Lying Behaviour

The average lying time and number of lying bouts for each surface type are presented in Table 6, as well as the proportion (%) of cows that spend less or more than 8 hours per day for each surface. The average lying time across all the groups was 8.48 hours ± 0.318, with cows on sand having the lowest lying time and cows on stone had the longest lying time (P=0.05). There was an interaction between lying time and weeks of the experiment, which reflected the increasing lying time of cows on sand over time (P=<0.001), and by week 6, there was no significant difference between surface types with the mean lying time of 9.86 hours ± 0.22 (Figure 15; P=0.973). Average lying bouts across all surfaces was 6.52 ± 0.414, and there was a significant (P=<0.001) effect of surface on lying bouts, with cows on stones having fewest lying bouts and cows on sand having the most lying bouts. There was a significant effect of surface (P=0.015) on the proportion of cows that spent <8 hours lying down.

Table 6: Lying behaviour for cows on control, woodchip, stones, sand and carpet.

	Control	Woodchip	Stones	Sand	Carpet	SEM[1]	P Value (<0.05)
Average lying hours	8.11^{ab}	8.43^{b}	9.45^{c}	7.57^{a}	8.82^{b}	0.459	0.05
% < 8hrs	40.85^{ab}	36.27^{a}	23.61^{a}	53.91^{b}	32.68^{a}	6.25	0.015
% > 8hrs	58.28^{ab}	63.36^{bc}	75.81^{c}	45.91^{a}	66.94^{bc}	6.21	0.015
Average lying bouts[1]	6.53^{b}	6.99^{b}	4.61^{a}	7.58^{b}	6.90^{b}	0.416	<0.001

[1] Average lying bouts is how many times cows lay down per day. SEM is standard error of the mean.

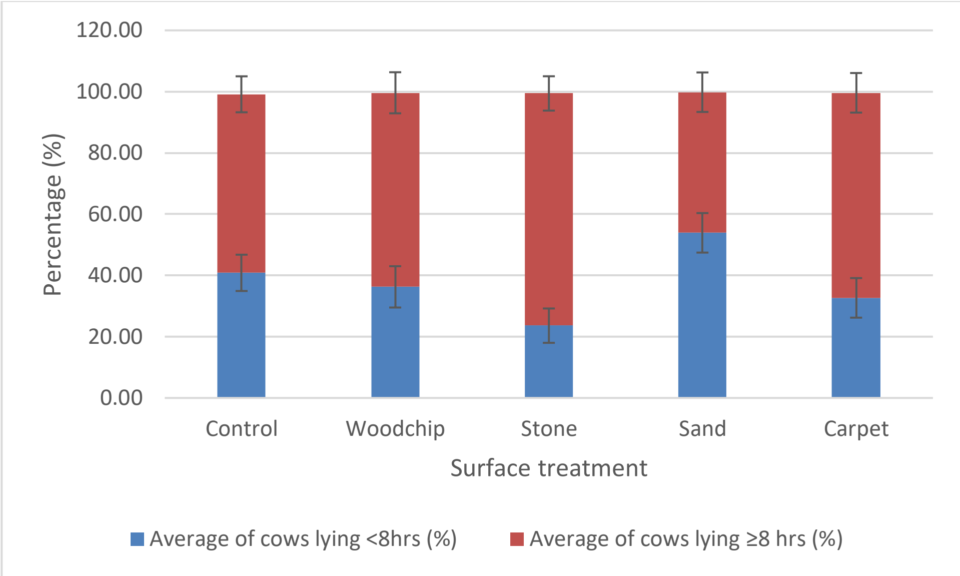

Figure 14: Percentage of cows lying for <8 hours and >8 hours over 24 hours, for different stand-off surface types.

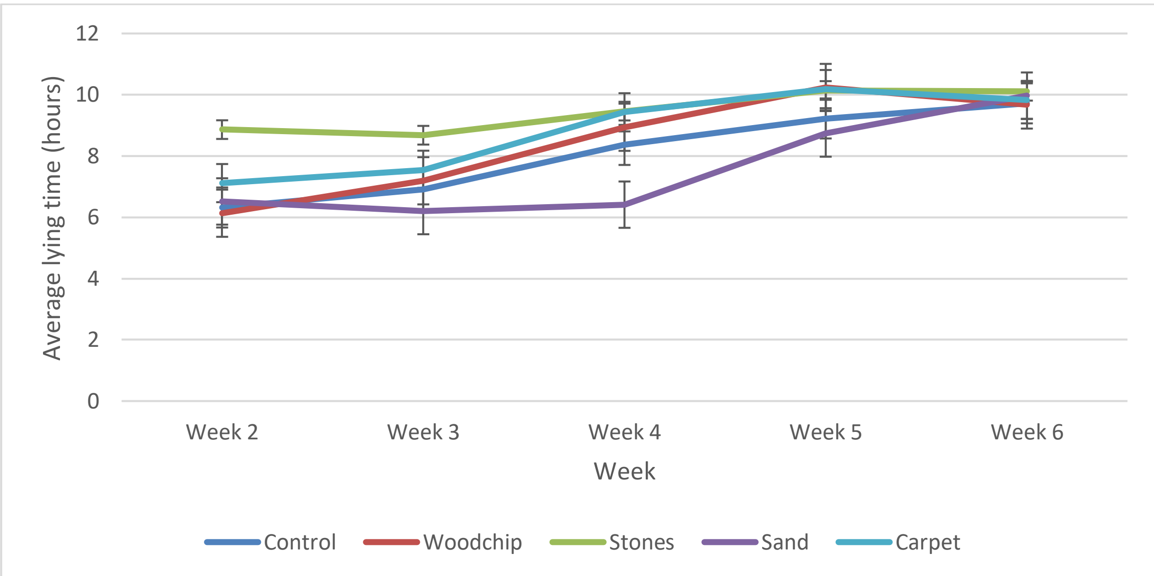

Figure 15: Average weekly lying times of non-lactating dairy cows on different stand-off pad surfaces.

4.5 Lameness & Hygiene

As shown in Table 7, there was no significant surface type effect on the lameness scores of any of the groups (P=0.251), however there was a significant effect of surface on the gait score (P=0.02) and daily steps (P=<0.001). There was no interaction between time and lameness for any of the surface types (P=0.065)

Surface type had a significant effect on the hygiene scores of the cows, with the stones group being the cleanest (1.04) and sand being the dirtiest (1.66; P=0.02). There was an interaction between hygiene score and time for sand, where hygiene scores increased with each week passing (P=<0.001), however the interaction was not present across all surface types (P=0.062).

Table 7: Lameness scores, gait scores**,** average steps (per day) and hygiene scores of non-lactating cows on different stand-off pad surfaces.

	Control	**Woodchip**	**Stones**	**Sand**	**Carpet**	**SEM**	**P value**
Lameness Score[1]	0.103	0.047	0.113	0.158	0.07	0.035	0.251
Gait score (steps/10m)	18.11[ab]	17.09[a]	18.71[b]	18.68[b]	17.32[a]	0.197	0.02
Stride length (m)	1.81	1.71	1.87	1.87	1.73		
Steps (total daily)	3058[bc]	2766[a]	2807[ab]	3401[d]	3259[cd]	96.5	<0.001
Hygiene Score[2]	1.13[ab]	1.29[ab]	1.04[a]	1.66[c]	1.45[bc]	0.124	0.020

[1] Score out of 3 with 0 being not lame and 3 being severely lame.

[2] Score out of two with 0 being clean and 2 being dirty. SEM is standard error of the mean

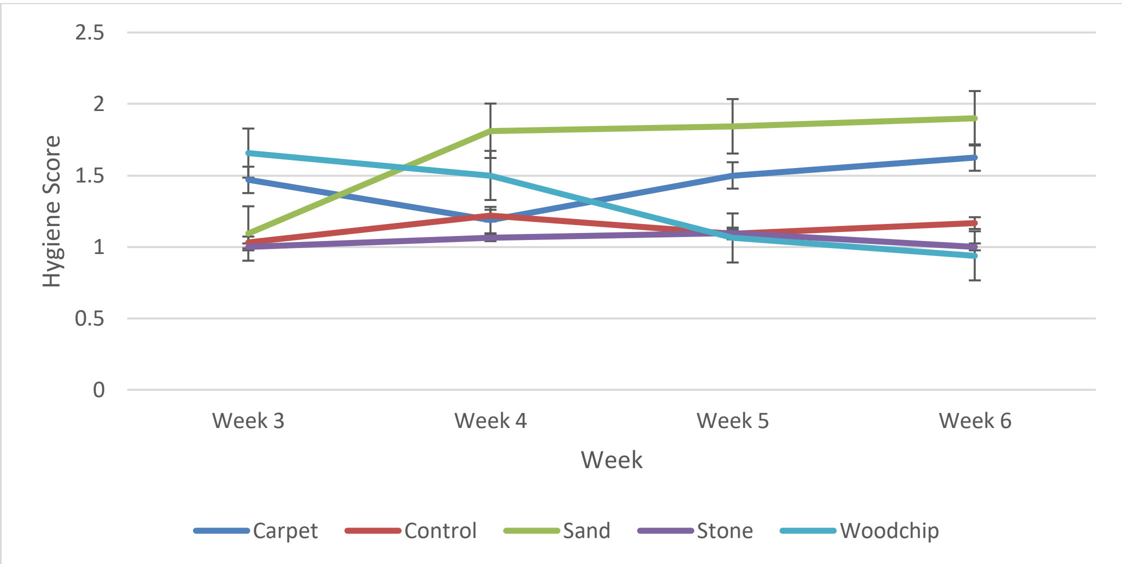

Figure 16: Hygiene scores of cows on control, woodchip, stones, sand and carpet over a 4 week period.

Cows entering stand-off with stones took the longest on average at 4:09 minutes and cows entering woodchip entered the fastest at 1:39 minutes (Table 8, P<0.05). (P=0.081) There was a tendency for cows leaving stone stand off to take longer than cows on other surface types.

Table 8: Average time taken for cows on control, woodchip, stones, sand and carpet to go onto or come off of the stand-off pad surfaces (minutes).

	Control	Woodchip	Stones	Sand	Carpet	SEM[1] (secs)	P value
Average time on to SOP	N/A	1:39a	4:09b	2:13a	2:01a	48.2	0.029
Average time off of SOP	N/A	0:33	1:09	0:37	0:31	11.04	0.081

[1] SEM is standard error of the mean

4.6 General Observations

Cows on stones were visibly reluctant and slower to move around the space, giving some indication why their time to move onto and off the pad was slower. For example, they would not begin moving onto the stones stand-off pad without some pressure applied to the herd. When moving off the stand-off pad movement of the cows on stones was awkward and tentative despite having motivation to leave the area, which was silage on the feed pad.

Secondly, it was noticed in the group on sand that when there had been heavy rainfall, the sand surface became very wet (Photograph 5) and cows would race into the area to try and find one of the few dry patches to lie down on.

Photograph 5: Sand stand-off area with extensive surface ponding after heavy rainfall in July. Area is fenced to achieve 10m2/cow stocking rate and area behind the tape is unstocked.

5 DISCUSSION

The purpose of this study was to ascertain whether stand-off surface impacted cow welfare. The key welfare parameters for these types of winter systems were identified in the review as being nutrition, lameness and comfort. With regards to nutrition and lameness we can accept the null hypothesis but with regards to comfort we reject the null hypothesis that surface has no effect on welfare. These will now be discussed below

5.1 Surface Moisture

Stones may have supported higher lying times because they provided a drier surface for lying. Stones had the overall lowest surface moisture of 48.2% (P=<0.001), compared with sand who had the second highest surface moisture of 77.4%, second only to control (88.5%). Stones also recorded the longest lying times, with sand recording the shortest. There was an interaction between surface moisture and time, in that the surface moisture of the stones increased as the experiment progressed. All of the surface types were subjected to the same fluctuations in temperature, and there was no significant difference in the mean surface temperatures of the surfaces (P=0.54)

July had 127.6 mm of rainfall, over 2 times the mean rainfall in July over the last 30 years of 57.8mm. This resulted in a very wet period, potentially affecting the stand-off pad surfaces drainage capabilities and therefore increasing potential surface moisture. The increase in surface moisture of the stones over time could be a result of the build-up of faecal matter as the total time spent on the stand-off pad increased. Because the carpet was cleaned three times a week, the build-up of faecal matter was removed often, however, even though the woodchip and sand was stirred once a week (from week 3 onwards), the impaired drainage and increased rainfall may have impacted on surface moisture. This increase in surface moisture may have resulted in the decreased lying times and bouts seen in the sand groups, as previous literature has shown a link between decreased lying times and wet surfaces (Fisher *et al*., 2003; Schutz *et al*., 2010; Webster *et al*., 2008). The sand group showed a 10% decrease in lying times compared to the mean lying time of all groups. This decrease is as not dramatic as the 50% decrease in lying time of cows subjected to wet conditions observed by Tucker *et al*., (2009).

The reduced lying times of the sand group in the initial weeks could have been a result of the rainfall, and subsequent drainage issues and once this was overcome, lying times increased to similar levels between all groups. Although control had the highest surface moisture of 88.5%, we can speculate that sand is inherently colder compared to soil due to the organic nature of soil, therefore not impacting on the lying times of cows on control, however this would need to be explored further

The drainage of stand-off pad surfaces is hugely important to ensure that surface moisture doesn't have an effect on the lying behaviour of cows, as mentioned above, it is such a high priority behaviour for cows (Fisher *et al*., 2003; Munksgaard *et al.*, 2005)

5.2 Utilisation & Nutritional Requirements

Every surface group had feed utilisation above 90% for both fodder beet and silage, with no significant effect of surface type. Although it didn't reach significance, sand had the lowest utilisation of fodder beet (90%) but the highest silage utilisation (97%, as did carpet), which could be related to their lower lying times. Cows have shown to prioritise lying down over feeding (Fisher *et al*., 2003; Krohn & Munksgaard, 1993; Munksgaard *et al*., 2005) and even show compensatory increases in lying time at the expense of feeding, when the ability to lie down is reduced (Metz, 1985; Cooper *et al*., 2007; 2008). This determination to lie down may explain why cows on sand experienced decreased FB utilisation. The concrete feed pad was a hard and crowded surface, which prohibits lying (Fregonesi *et al*., 2007a) and cows may have been spending more time lying down in the fodder beet instead of grazing. Pedometer data would need to be further analysed to determine whether cows from the sand group lay down more in the fodder beet paddocks, than other groups.

All groups were allocated sufficient fodder beet and silage to meet energy requirements for maintenance, pregnancy and BCS gain. Each group was allocated 8kgDM/cow/day of fodder beet and 4kgDM/cow/day of silage, and combined feed utilisation of fodder beet and silage was over 90% for all surface types (Table 4), with apparent total DM intakes ranging from 10.88 to 11.8 kg DM. Using a conservative estimate ME of 11.5

MJME/kgDM, ME intakes would be between 125.12 and 135.7 MJME/day. A dairy cow in late pregnancy has a ME requirement of up to 39 MJME (for a 35kg calf), in addition to maintenance of approximately 58MJME (for a 500kg cow), a total of 97MJME/day (Rattray *et al*., 2007). The extra 30 MJME/day should have supported approximately 0.5 BCS gain during the measurement period, even allowing for walking and cold weather.

There is little data available on the utilisation of fodder beet due to the difficulty of measurement, with visual analysis alone not accurately representing what may be left in the ground, however, the values we recorded are slightly less than those of Edwards *et al*., (2014), who recorded fodder beet utilisation as 99.6%, with our results showing average fodder beet utilisation across all treatments of 94.2% ± 0.009.

Adequate utilisation results from the six hours on crop may have been influenced by cows feeling deprived of feed when held on the stand-off pad surfaces for the 16 hours daily, and thus the high utilisation was a result of gorging. However, cows were transitioned onto the fodder beet appropriately, using the same methods as outlined by Edwards *et al*. (2014), to reduce the risk of rumen acidosis, due to fodder beet characteristically having high levels of metabolisable energy and soluble sugars but low fibre (Nichol. 2007). There is also evidence that dairy cows consume majority of their feed allocation rapidly, with Jenkinson *et al*. (2014) recording that cows consumed 90.1% of their fodder beet allocation within six hours, and similar seen by Thompson & Stevens (2012) and Rugoho (2013) who had 94% of swedes and 91% of kale intake consumed within 6 hours respectively.

As NIRS analysis was not able to be done, there is no evidence whether any differences in utilisation would have had an effect on energy intakes, however the utilisation results suggest that all groups met their nutritional requirements for energy and were free from hunger, complying with Minimum Standard No. 2. From the code of welfare for dairy cattle (NAWAC, 2016).

The high utilisation rates of the fodder beet in particular, along with supporting literature, shows that 6 hours is adequate time for cows to feed before being able to remove them from the paddock and onto a stand-off pad area, where nutrient leaching is able to be mitigated

5.3 Body Condition Score & Live Weight

Cows gained weight and BCS on all stand-off surfaces during the experiment. While there was no significant effect of surface type on final live weight or change in live weight, there was a significant effect of surface on final BCS and change in BCS. At the final body condition score, only the carpet group met the BCS target with an average BCS of 5.1, with the remaining four groups falling short between 4.6-4.9.

Failure to meet 5.0 BCS at calving is very common in New Zealand dairy systems, as previously reported/stated by Dalley *et al*., and Hudson *et al*., (2012; 2010). Although four out of the five groups failed to reach 5.0 average BCS, all five groups had average BCS score over 4.6, with no cows scored below 4.0. This represents a better performance than farms in the BCS initiative run by DairyNZ in 2014, where 80% of cows failed to reach a BCS of 5.0. Carpet, sand and stone all gained, or were close to gaining the 0.5 BCS that DairyNZ suggests is normal on a winter crop such as fodder beet (2012). The failure for all cows to reach 5.0 highlights the difficulty it is to achieve, as the level of skill and resources available at Ashley Dene is higher than what is available on most farms.

Control and woodchip group gained just 0.23 and 0.26 BCS, respectively which is unexpected, considering they both had average lying times above 8 hours, no effect of surface type on lameness, and feed utilisation of between 93-99%. However the BCS spread that was achieved would not be a risk to health or reproduction (Roche *et al.,* 2009).

Cows in late pregnancy experience a large increase in energy demand, with pregnancy accounting for 60% of energy requirements in the last month of pregnancy (Rattray *et al*., 2007; DairyNZ, 2012) but this is met with the lowest dry matter intakes occurring in the later stages of pregnancy (Grummer *et al*., 2004). This could partly explain the failure for groups to reach target BCS and BCS gain as the cows were in the late stages of pregnancy, within one month of the average calving date.

There are several possible reasons why the groups on the stone, and carpet stand-off pads gained more BCS that the other groups, when all groups had similar estimated feed intake (>90%). Both groups had higher lying times than the other groups, which may have resulted in better conversion of feed to BCS, though all groups had similar levels of activity. The longer adaption period to the other stand-off pad surfaces may also have played a part in those groups' failure to reach BCS targets, when compared to the short adaptation to lying on stones or carpet. Alternatively, the inexperienced BCS assessor may have made an error which is not uncommon due to the subjective nature of this type of measurement. In any case, the change in BCS from group allocation to the end of the measurement period was comparable to the other groups.

5.4 Lying Time

Stand-off pad surfaces met minimum lying times recommended by the NAWAC (2016), except for sand. Control, woodchip, stones and carpet all had average lying times that were above 8 hours, whereas sand had an average lying time of 7.57 hours. However, across all five surfaces, there were a proportion of cows that did not meet the minimum recommended 8 hours of lying time. Sand had the highest proportion of cows not achieving the 8 hour lying standard, with 54% of the group lying for less than 8 hours. Unexpectedly, stones had the highest average lying time and proportion of cows lying > 8 hours of 9.45 and 75.8% respectively. The interaction between time and surface type showed that, although some groups had lower lying times in the first week, by the end all groups spent similar time lying by the end suggests that adaption to the lying surface can take several weeks. This reduced lying in the initial weeks of the experiment may have influenced the failure to gain BCS in some groups, as depriving a cow of adequate lying time can also have a flow on effect on feed intake and therefore live weight and body condition score, as cows will be motivated to lie down, instead of feeding (Metz, 1985; Cooper *et al*., 2007).

The results recorded for average lying times were unexpected, as previous research has found that a hard or uncomfortable surface can result in decreased lying times (Fisher *et al*., 2003; Haley *et al*., 2001; Schutz & Cox, 2014). The higher than expected lying time on stones could be partly explained by the observation that, while the stones themselves are hard, in large quantities they can mould to the body, and although there may be discomfort in standing up/lying down, once lying, it may have been a comfortable surface.

5.5 Lying Bouts

Our results indicate that stones might be an uncomfortable surface for cows to move on. In regards to average number of lying bouts, stones stood out as having the lowest lying bouts of 4.6/day; control, woodchip, and carpet all had average lying bouts over 6.5/day, and sand had the most at 7.6 lying bouts per day.

Cows on uncomfortable surfaces have been reported to have reduced lying bouts but increased lying times, similar to our results in the stones group, potentially due to cows being reluctant to stand once they have already lay down (Hill *et al*., 2009; Dalley *et al*., 2012). We observed that cows on the stones surface were visibly reluctant to move around the stand-off pad area, and pedometer data shows that they had the second lowest recorded steps per day which could support this. However, pedometer data would need to be specified to only the 16 hours spent on the stand-off pads to further validate this theory.

The group on sand had the highest lying bouts per day, which can be an indicator of restlessness or discomfort (Hill *et al*., 2009). This increased bout frequency can reduce total resting time (Dalley *et al*., 2012), an effect of surface type that sand showed. From observations, it was noted that after periods of high rainfall, the sand surface became very wet and water-logged, potentially affecting the stand-off pad surfaces drainage capabilities, and there was increased competition between cows for available space to lie on that was not water-logged. July had 127.6mm of rainfall which was over twice the mean rainfall over the last 30 years of 57.8mm for July. The water-logging seen on the sand surface resulted in a decreased perceived area for lying, effectively reducing the m^2/cow and increasing the stocking rate (Fregonesi *et al*., 2007a). Fregonesi *et al*. (2007a) reported that there was a “scramble” competition to occupy available lying stalls in overstocking scenarios, which was also seen in the sand group, and overcrowding of dairy cows can contribute to increased lying bouts, due to the increased opportunity for displacement from other cows. Dalley *et al*. (2012) found that when increasing the area per cow, lying times also increased, supporting the importance of stocking rate and how it can affect lying behaviour in cows.

There was a significant difference in time taken to go onto the stand-off pads, with woodchip being the fastest 1:39 minutes, sand and carpet were faster than 2:00 minutes and stones were the slowest at 4:09 minutes (P=0.029). All surface types except stones needed no pressure from the herder, whereas the stones group needed constant pressure and would not go onto the stones without it which shows a reluctance to go into the area.

There was no significant difference in the average time taken for the groups to leave their respective stand-off pad areas, however there was a tendency for the cows on the stone pad to be slower exiting the pad (P=0.081). All cows should have had the same motivation to leave the stand-off pads to be fed silage on the feed pad. Therefore, the difference of up to 38 seconds (between carpet and stones) to leave the stand-off pad, coupled with observations of tentative movement of the stones group could indicate that the cows had difficulty moving off the stones.

Although the stones group recorded the highest average lying times, the evidence surrounding lying bouts and the observations made of their movement indicates that overall cow comfort was diminished, potentially increasing stress and anxiety which negatively impacts on the cows perceived welfare.

5.7 Lameness & Gait

No stand-off pad surface had higher incidences of lameness than any of the other groups and there was also no effect of time on lameness. However, gait scores were found to be significantly lower in the woodchip and carpet groups, which may be an indicator of lameness. Lameness scores across all surfaces were deemed insignificant (P=0.251), yet gait scores revealed significant differences between surface types where

Gait score has been found to be a potential indicator for lameness with reduced stride length showing a cow's discomfort (Blackie *et al*., 2013; Telezhenko & Bergsten, 2005). There was not any significant effect of surface type on lameness, but there was on gait score. The minimal experience of the scorer to detect cows in the minor stages of lameness (e.g. lameness scores of 1), instead scoring them as not lame, which is common in New Zealand (Leach *et al*., 2010). Over the experimental period, 18 cows were recorded as being treated, which equates to a lameness prevalence of 11.25%, this is low compared to previously recorded lameness prevalence range in New Zealand of 2-38% (Brownlie, 2013; Chawala *et al*., 2013; Gibbs, 2010; Tranter & Morris, 1991). However our lameness records were only over a two month period, with most lameness in the dairy industry occurring during lactation (spring and summer), therefore 11.5% in the dry period could be relatively high.

There was a significant difference in the total time it took for the cows to go onto the stand-off pads, with stones taking by the longest with an average time of 4:09 minutes, and the remaining surface groups taking between 1:39 and 2:13 minutes (P=0.029). Rather than showing any difference in lameness, this illustrates the reluctance of the cows to even enter the stones stand-off pad, as all timings of the stones group required a herder to provide pressure and encourage them to move onto the stand-off pad. Although differences in the time taken to leave the stand-off pads was not deemed significant, there was a tendency for cows on stones to take on average 32-38 seconds longer than the other surface types (P=0.081). The extra time taken to come of the stones stand-off pad, combined with the observation of tentative movements coming off the stand-off pad suggests that there was a level of discomfort when moving around on the stones that was not reflected in the lameness or gait scores of the stones group. There is a lack of data on the effect that a surface such as stones may have on a cow's mobility and walking speed. As surface friction is important to reduce slipping (Telezhenko & Bergsten, 2005; Flower *et al*., 2007; Chapinal *et al*., 2011), it could be said that the stones do not provide this as they move relatively freely when pressure is applied. This lack of stability in the stones as a surface may have reduced friction and therefore explain the tendency for the cows on stones to move slower of the stand-off pad area (P=0.081).

With lameness being one of the major health and welfare issues in the dairy industry, prevention and early detection is crucial to reducing the risk of lameness and the impaired welfare of cows that is associated with it. This highlights the importance of choosing a suitable stand-off pad that will hopefully reduce, or at the least, not exacerbate current lameness prevalence in New Zealand. Although there seemed to be a lack of lameness from our results, it is not possible to conclude that there wouldn't be a surface type effect on lameness if the measurement period was extended.

5.8 Hygiene

Cows on sand recorded the highest and therefore dirtiest hygiene scores overall which increased as the experiment progressed. The stones group were notably the cleanest, control, woodchip and carpet were intermediate, with sand being the dirtiest (1.04 and 1.66 respectively; P=<0.001). There was no interaction between time and surface type on hygiene (P=0.062) except in the case of the sand group, where hygiene scores increased over time (P=<0.001).

With July rainfall being over double what has been recorded in the last 30 years (127.6 versus 57.8mm), surfaces were subjected to unexpected rainfall resulting in the sand surface in particular, becoming very waterlogged and failing to drain adequately. This was reflected in the surface moisture of sand being the second highest at 77.4% averaged across the experiment. Our results of increased hygiene scores with the increase of surface moisture content are in agreeance with Schreiner & Reugg (2002) and Fisher *et al*. (2003), who reported increased hygiene score with wet and muddy/dirty surfaces.

Mastitis is a common and costly disease and overseas experience indicates that mastitis incidence increases with increased time off pasture (Laven & Holmes, 2008). As this experiment was not carried out during the lactation period, we cannot comment on what effect stand-off pad surface may have had on mastitis incidence in the groups. However, we can speculate that the dirtier cows on sand may have had increased risk for mastitis due to the moisture and slurry that the udder was exposed to, as poor hygiene has been linked to increased mastitis incidence in dairy cows (Bartlett et. al. 1992; Cook, 2002). Farmers need to ensure stand-off pads are well drained and as dry as possible to help to keep cows cleaner, and should protect dry cows with teat sealant, to minimise additional risk of mastitis.

6 CONCLUSIONS

In conclusion, when comparing the surface type of different stand-off pads in winter and their impact on the welfare of non-lactating dairy cows, there was a significant effect on body condition score, lying behaviour, gait score and hygiene. There was a significant difference in surface moisture % between treatments that may have contributed to the decreased lying times recorded for cows on sand. Although, there were no significant effects of surface type on lameness or live weight, a slow adaptation is potentially a disadvantage of those surface types, a longer measurement period covering the whole winter would be recommended to confirm this.

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8 APPENDICES

Appendix A: Treatment calendar for fodder beet paddocks at Ashley Dene Research & Development Station

Date:	**Treatment:**	**Product used**
1/10/16	Spray	Roundup
8/10/16	Cultivation	
12/10/16	Fertilised	Lime 2T/ha Cropmaster 250kg/ha Muriate of Potash 100kg/ha NaCl 150kg/ha Boronate 15kg/ha
18/10/16	Sowing – Harrow & roller drill	Cultivar: Rivage & Cerise Sowing rate: 8,500 seeds/ha
25/11/16	Fertiliser	Urea 85kgs/ha
23/12/16	Fertiliser	Urea 85kgs/ha
N.D	Spray	Notron 2L/ha Lorsban 50EC 250ml/ha Magister 100ml/ha
Over entire season	Irrigation	360mls

Appendix B: DairyNZ Lameness Scoring System (0-1) (DairyNZ, 2017)

Identifying a lame cow

Score	Walking speed	Stride	Weight bearing	Backline	Head
0 **Walks evenly** **No action required** No action required – this cow is normal.	Confident. Similar walking speed to a person. Maintains position in the herd.	Long, even and regular. Rear foot placement matches front foot placement.	Evenly placed and weight bearing when standing and walking.	Straight (level) at all times.	Held in line or slightly below the backline and steady when walking.

Score	Walking speed	Stride	Weight bearing	Backline	Head
1 **Walks unevenly** **Minor action required** Record and keep an eye on her – some cows normally walk unevenly.	Not normally affected, should easily maintain position in the herd.	May have uneven stride and/or rhythm. Rear foot placement may miss front foot placement.	May stand or walk unevenly but difficult to identify which leg/s are affected.	Straight when standing, may be mildy arched when walking.	May have slight bob and or may be held lower than normal.

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Appendix C: DairyNZ Lameness Scoring System (2-3) (DairyNZ, 2017)

Score	Walking speed	Stride	Weight bearing	Backline	Head
2 **Lame**	May be slower than normal; may stop, especially when turning a corner.	Shortened strides rear foot placement falls short of front foot placement.	Uneven – lame leg can be identified.	Often arched when standing and walking.	Bobs up and down when walking.
Action required This cow is lame and needs to be reported, drafted and examined within 48 hours.					

Score	Walking speed	Stride	Weight bearing	Backline	Head
3 **Very lame**	Very slow, stops often and will lie down in paddock. Cannot keep up with the healthy herd.	Shortened and very uneven. Non lame leg will swing through quickly.	Lame leg easy to identify - 'limping'; may barely stand on lame leg/s.	Arched when standing and walking.	Large head movements up and down when walking.
Urgent action required This cows is very lame and needs urgent attention. Draft and examine as soon as possible.					

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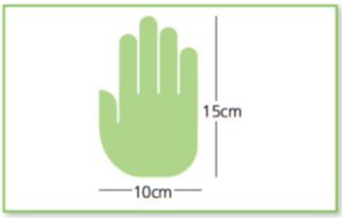
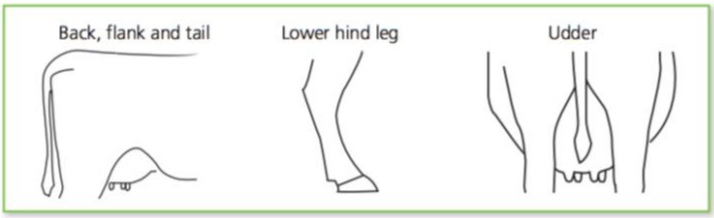
Appendix D: DairyNZ Cow Hygiene Scoring Guide (n.d.)

Housed cow cleanliness score card

This simple scoring system helps you to estimate the current cleanliness of your herd and your housing facility. Most cows in most herds should score 0 or 1. If you have more than 20% of your cows scoring 2, they may be at greater risk of animal health issues and milk quality may be affected. When you have scored the cows, go to **dairynz.co.nz/clean-cows** to find out what your herd's score indicates.





Score		Back, flank and tail	Lower hind leg	Udder
0 **Clean**	No dirt or less than 10% (a hand-size) is splashed with fresh or dry material.			
Total number of cows with any body part scored @ 0 =		Tally		
1 **Dirty**	There is at least a hand-sized area of dirt, but less than 50% of the area is dirty.			
Total number of cows with any body part scored @ 1 =		Tally		
2 **Very dirty**	More than 50% of the area is very dirty and hair is hard to see. Tail may have significant dagging.			
Total number of cows with any body part scored @ 2 =		Tally		

Check your score at dairynz.co.nz/clean-cows

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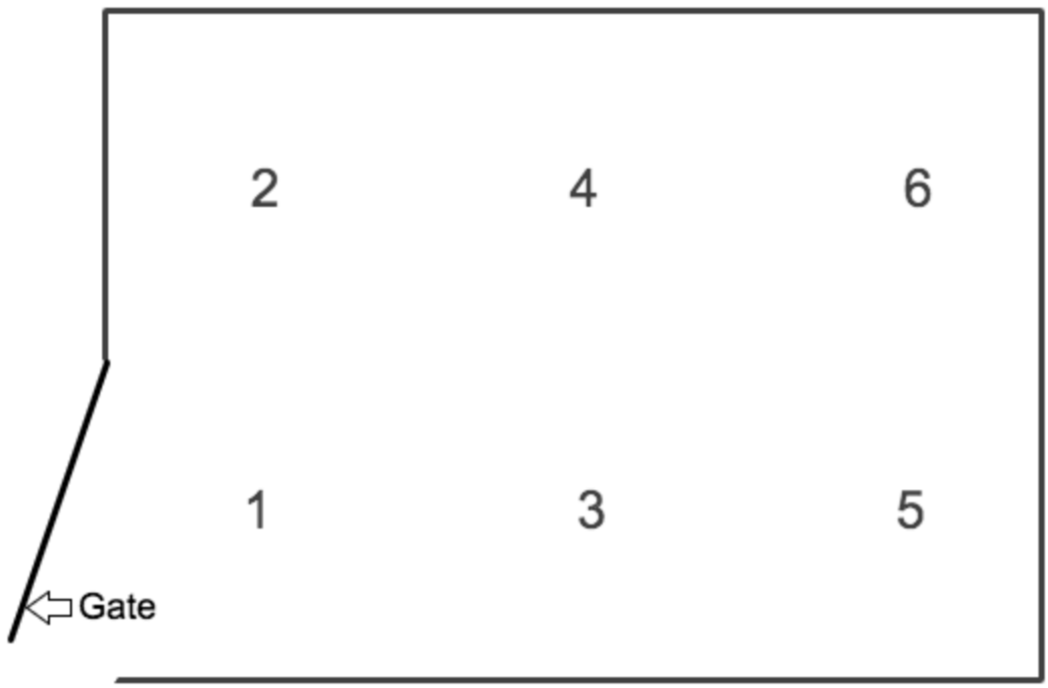
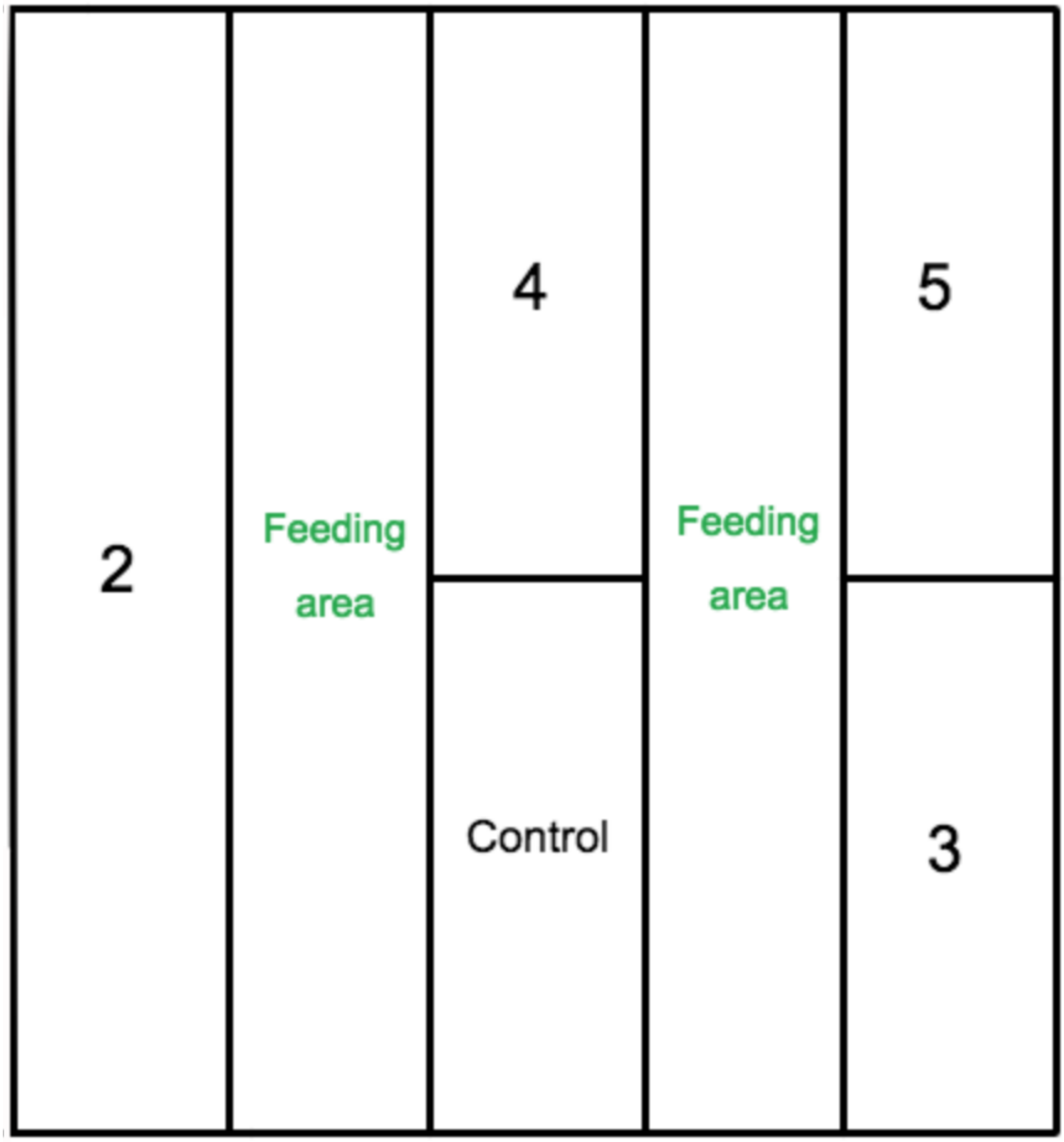
Appendix E: Plan showing temperature and moisture sampling sites



Appendix F: Plan showing stand-off pad surface group placement on feed pad



Appendix G: Code of Welfare: Dairy Cattle (adapted from the National Animal Welfare Advisory Committee, 2016)

Minimum Standard No. 2 - Food
(a) Dairy cattle of all ages must receive sufficient quantities of food and nutrients to enable each animal to: i) maintain good health; ii) meet their physiological requirements; and iii) minimise metabolic and nutritional disorder. (b) When the body condition score of any animal falls below 3 (on a scale of 1-10), urgent remedial action must be taken to improve condition. (c) Automated feeding systems must be monitored at least once every 24 hours to ensure they are in working order and any problems rectified promptly. (d) Feeding must be managed so that any injury and/or conditions resulting in ill health, as a consequence of the food or feeding methods, are minimised.
Minimum Standard No. 5 – Water
(a) All dairy cattle must have access to a daily supply of drinking water sufficient for their needs and that is not harmful to their health. (b) The water delivery system must be reliable and maintained to meet daily demand. (c) In the event of a water delivery system failure, remedial action must be taken to ensure that daily water requirements are met.
Minimum Standard No. 6 - Shelter
(a) All classes of dairy cattle must be provided with the means to minimise the effects of adverse weather. (b) New-born calves that have been removed from their mothers must be provided with shelter from conditions that are likely to affect their welfare adversely. (c) Sick animals and calves that are not suckling their mother must have access to shelter from adverse weather. (d) Where animals develop health problems associated with exposure to adverse weather conditions, priority must be given to remedial action that will minimise the consequences of such exposure.
Minimum Standard No. 8 – Stand-off Areas and Feed Pads
Dairy cattle must be able to lie down and rest comfortably for sufficient periods to meet their behavioural needs.
Minimum Standard No. 9 – Housing Cows and Calves
(a) Dairy cattle must be able to lie down and rest comfortably for sufficient periods each day to meet their behavioural needs. (b) All fittings and internal surfaces, including entry races and adjoining yards that may be used by the housed animals, must be constructed and maintained to ensure there are no hazards likely to cause injury to the animals. (c) Ventilation must be sufficient to prevent a build-up of harmful concentrations of gases such as ammonia and carbon dioxide. (d) If ammonia levels of 25 ppm or more are detected within the housing, immediate action must be taken to reduce the ammonia levels. (e) All sharp objects, protrusions and edges, including damaged flooring likely to cause injury to dairy cattle, must be removed, repaired or covered.
Minimum Standard No. 19 - Health

(a) Those responsible for the welfare of the dairy cattle must be competent at recognising ill-health or injury and take remedial action as appropriate.
(b) Veterinary medicines must only be used in accordance with registration conditions, manufacturer's instructions or professional advice.
(c) Professional advice must be sought where there is any significant injury or disease, or if a problem persists.