Humps and hollows on West Coast dairy farms: farmer management practices and responses to nutrient runoff solutions

NIWA Client Report: CHC2005-062
July 2005

NIWA Project: LCT04501

Humps and hollows on West Coast dairy farms: farmer management practices and responses to nutrient runoff solutions

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1. Introduction

The West Coast of the South Island is a region of high rainfall, steep topography, extensive tracts of indigenous forests and wetlands, and an increasing number of dairy farms (West Coast Regional Council 2004). One of the biggest challenges for dairy farms is drainage issues both in the improvement of existing pasture and the development of new pastures from pakihi lands.

Annual rainfalls range from 8m/yr near the Southern Alps to around 2m/yr at the coast resulting in large numbers of streams and rivers (West Coast Regional Council 2004). Drainage problems are compounded by large areas of poorly draining soils, particularly peat, pakihi, recent gley and leached podsolised soils or compacted gravels and sand (West Coast Regional Council 2004). In addition, iron pans (or hard pans) in the soil profile are a common impediment to drainage. Various methods have been employed to drain these soils over the years, ranging from standard drains, sub-soiling, tile drains, and deep ripping to more unusual methods, including explosives to break iron pans (MacPherson 1912). The most common method in recent times is land contouring via the creation of humps and hollows. This method not only contours the land, but mixes soil profiles removing impediments to drainage, effectively helping turn "scrub-covered wasteland into lush pasture land" (Lee 2003 pg 26).

Expansion of dairy farming on the West Coast coupled with an increase in hump and hollow developments has led to concerns over potential nutrient runoff to waterways and its resulting effects. These concerns are not unfounded or unexpected given the suite of recent scientific publications (Smith et al., 1993; Parkyn et al., 2002; Parliamentary Commissioner For The Environment, 2004) and media coverage (through the 'dirty dairying debate) the effects of dairy farming on freshwater environments have generated in the last decade. Moreover, little is known about the effects of humping and hollowing on receiving waters both in terms of hydrological changes or nutrient runoff. There is a significant gap in knowledge, despite Dairy Company (Westland Milk Products and Fonterra) initiatives to improve on-farm environmental management in order to protect the 'clean green' international perception of New Zealand dairy products.

A collaborative research project between the New Zealand Landcare Trust, NIWA, West Coast Regional Council, Westland Milk Products, and the Department of Conservation is currently investigating nutrient runoff from humps and hollows on the West Coast, and assessing acceptable, practical solutions to minimise the potential effects of nutrient runoff. A series of social-science research interviews were designed and conducted to compliment scientific research on the effects of humped and hollowed pasture on nutrient runoff and assist in achieving appropriate practical

solutions for West Coast Dairy farmers. Scientists can assist the dairy farming community to find solutions to nutrient runoff that are both socially acceptable and continue to meet environmental objectives if they have a good understanding of the wider social and economic contexts of humping and hollowing. The interviews explored:

1. why farmers hump and hollow their farms
2. the benefits and costs of humps and hollows
3. processes used to establish and maintain humps and hollows
4. farmers perception of the environmental effects of humps and hollows
5. the acceptability and practicality of proposed nutrient runoff mitigation strategies.

2. Methods

The area chosen for the interviews corresponded with known regions of humped and hollowed pasture on the West Coast of the South Island, primarily around Lake Brunner, the Grey River Valley, Hokitika and Westport/Karamea. Dairy farm owners or sharemilkers were selected as randomly as possible from a list of suppliers provided by Westland Milk Products and included a mix of farms with, and without humped and hollowed pasture. The second set of interviews only had farmers with humped and hollowed pasture.

Potential interviewees were recruited verbally (phone) by Katie Nimmo and Shelley Washington (New Zealand Landcare Trust). Each participant was subsequently sent a written description of the project (participant information sheet – Appendix A) and a consent form (Appendix B). At the beginning of each interview participants were asked to sign a consent form agreeing to the interview and tape recording of the event and were informed that they may withdraw the information provided at any stage (until a cut off point) without giving a reason. Interviews were conducted at a suitable location for the interviewee, usually their private residence, and took around an hour. All contributions were considered confidential, and the participants are not identified, unless they chose to identify themselves. It was made clear to the participants that information they provided would be used as part of various reports and publications but that their identity would be protected.

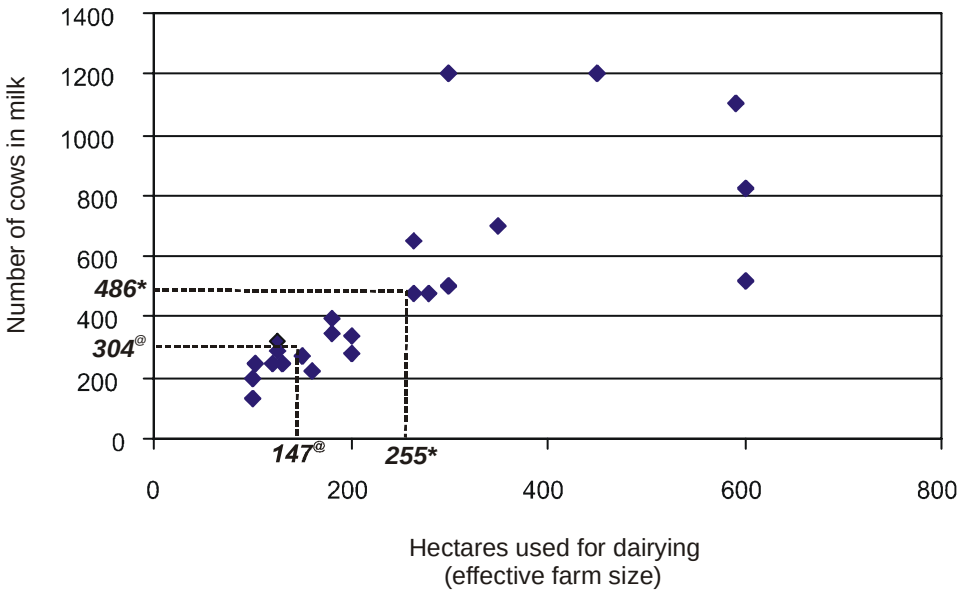
The interviews were semi-structured and based around the series of questions (Appendix C), the order and wording of which varied between participants. Points of interest were followed up with additional questions.

Interviews were carried out in two sets, in June 2004 (16 farmers around Lake Brunner and the Grey River Valley) and November 2004 (12 farmers around Hokitika and Westport/Karamea), by Paula Blackett, Katie Nimmo and Shelley Washington. One interviewer took the lead in the discussion while the other listened and interjected with questions where appropriate.

3. Results and discussion

3.1. Farm and farmer characteristics

A total of 28 farmers were interviewed. 26 of these ran dairy farms and the remaining two were dry stock farmers. The variation in farm size (effective area – amount used for dairying) and number of milking cows operated by interviewees are illustrated in Figure 1. Please note that the smallest dairy farm (at 20 ha with 20 milking cows) has been excluded because it was unusual for the region. In addition, the dry stock farms are absent from this figure.



* Average this study
@ Westland average (Livestock Improvement 2004)

Figure 1: Effective farm size against the number of cows milked for the participants interviewed in this study.

Participants operated farms that were generally large, supporting herd sizes that were greater than the average for the West Coast and the national average (herd size 302 and effective area of 110 ha) for the 2003/2004 season (Livestock Improvement Corporation 2004). Several large farms probably affect the average.

The average stocking density for the West Coast is quoted at 2.13 cows/ha (Livestock Improvement Corporation 2004) and density for participants in this study ranged from 0.8 to 4 cows/ha, with an average of 1.9 cows/ha.

The total farm sizes are quite large with most farms consisting of a runoff (an area for grazing and rearing young stock and non milking cows) and bush and pakihi blocks that have not been farmed. This is different to many farms in the traditional and intensive dairying regions of Waikato and Taranaki, where all but a few hectares are used for dairying. As a result of owning larger properties, participants do not currently appear to feel the same pressure to convert all the property to effective dairy pasture. Most of the farmers showed an appreciation of the bush blocks and some desire to protect these areas. However, in contrast, pakihi swamp and scrub (i.e. regenerating bush consisting mainly of manuka) were not valued and seemed to be viewed as messy and a waste of land.

The majority of the farmers interviews had lived on the West Coast for most of their lives, and many had taken over family farms. However, there were several farmers originally from other parts of New Zealand. Several farmers in the Hokitika area owned one or more farms.

3.2. Challenges to dairy farming on the West Coast

The participants believed the most significant challenge to dairy framing practices on the West Coast was dealing with high rainfall. Most farmers could quote the amount of local rainfall and felt the problems they face over drainage and cattle management differentiate them from farms in other regions. This is not an unreasonable assumption as one farmer recorded yearly rainfall on his property at 13 m.

Common strategies for dealing with waterlogging problems include, use of sacrifice paddocks, stand off pads, rapid paddock rotation during heavy rains, extensive drainage networks and humping and hollowing (contouring). Farmers seem to select between the alternatives based primarily around soil type. Areas of poor draining soils (either mineral or organic soils), where other options are impractical, or fail, are humped and hollowed; “Drains don’t work in some of the wetter country … I have tried, water won’t come through the pug, will drain about a foot either side and you can still only graze in January” (Farmer 2).

During the interviews we identified several different soil types where humps and hollows have been applied;

1. Peaty soils: these are probably either formed under pakihi, bog, fen or swamp vegetation (for descriptions of these types of wetland see Johnson and Gerbeaux 2004). They may be quite deep and may or may not have an iron pan in the soil profile;

    (a) Soils around Lake Brunner and on farms at the head of the Hokitika River Valley area tend to be deep peat with peat in the base of the hollows. These areas tend to be very wet. In some cases the base of the hollows may reach silt/clays.

    (b) In the Nelson Creek area and in some areas around Lake Brunner, and the Grey River Valley, there is peat on the surface, which is underlain by compacted gravels (often an iron pan). Humps and hollows in these areas tend to have gravely hollows that drain freely.

    (c) In Karamea, the peat may be underlain with hard sands (may or may not have an iron pan) or heavy clay.

2. Heavy clay/silts (often called grey pug) are common on farms around Hokitika. This material does not drain well probably because of its structure rather than the presence of an iron pan. Peat pockets seem reasonably common, but not that extensive. Bases of hollows probably remain wet but are very likely to dry out during dry periods.

The humping and hollowing process and overall size of the contouring appear to vary with soil type.

3.3. The process of humping and hollowing

The aim of humping and hollowing pasture is to produce a contoured pasture resembling that illustrated in Figure 2. It improves drainage in two main ways;

1. In deep peaty soils or heavy silts/clays the water runs off the top of the humps and drains into the hollows, creating dry areas on the humps. Water may collect in the hollows to some extent.

2. It exposes the underlying free draining soil horizons (may involve breaking through the iron pan) in the hollows, which allows water to drain away.

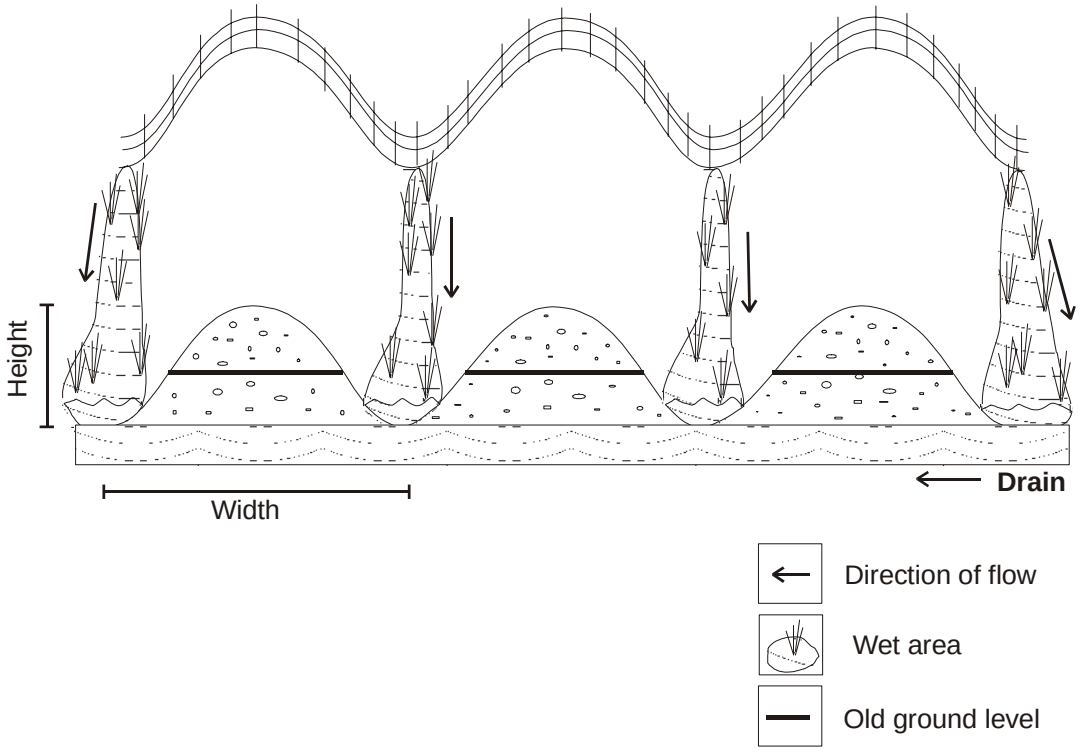


Figure 2: Humped and hollowed pasture.

3.3.1. Historical methods

In Karamea and Hokitika, humping and hollowing as a means to drain waterlogged land has been applied for at least 30 years, probably longer. Early methods involved using a bulldozer with a v-blade (like a snow plough) to create small, shallow humps and hollows about 3 m wide. Several participants remembered their fathers and grandfathers contouring land in this manner. Diggers have replaced bulldozers as the machinery of choice as 12-20 tonne diggers have become more widespread and available.

The use of humping and hollowing around Lake Brunner and the Grey River Valley seems to have occurred later (last 12-15 years) and involved diggers; there was no mention of early work using bulldozers. The author suspects this may be because these areas have large amounts of peat that may not hold the weight of a bulldozer. Landcorp began humping and hollowing at Nelson Creek and Bell Hill around 10-12 years ago and are widely considered to be the pioneers of the process in the Greymouth area. However, several participants suggested that the process was already occurring on a smaller scale on farms around Lake Brunner.

3.3.2. Recent methods

Many farmers employ local contractors to undertake the work using 12-20 tonne diggers. The width and height of the humps and hollows vary from place to place due to soil type and size of the digger used. Participants described two main methods used to shape humps and hollows.

Method One (Figure 3):

Step 1: establish the existing fall of the land and work out where the drains need to go, clear vegetation.

Step 2: Dig pilot drains to discover what soil type is present, if there are iron pans, and if it is possible to reach a free draining material, ideally gravels.

Step 3: Scrape any woody debris and surface material into the pilot drain to bury this material, excavate the hollows halfway between two pilot trenches to a depth equal to the pilot trenches. Mix the soil profile, and ensure that the old ground level is broken up to avoid weep lines.

Method Two (Figure 3)

Step 1 and 2: Same for Method one

Step 3: Material from the drains and adjacent to the drains is mixed up to form the humps. Ensure that the old ground level is broken up to avoid weep lines.

Method One allows for the burial of debris wood and is probably more common in peat where stumps and logs may occur. Both methods result in a mixed soil profile, which exposes acidic low nutrient subsurface soils to the surface.

There appears to be some regional variation in size of the humps and hollows; on the farms around Lake Brunner and the Grey River Valley, they tended to be 40 m wide and 2 m high, while 28-30 m wide and 1 m high humps and hollows were more common around Hokitika and Karamea. Differences are probably due to the size of digger used (12 or 20 tonne), contractors design preference, local soil type and the depth to suitable free draining substrate.

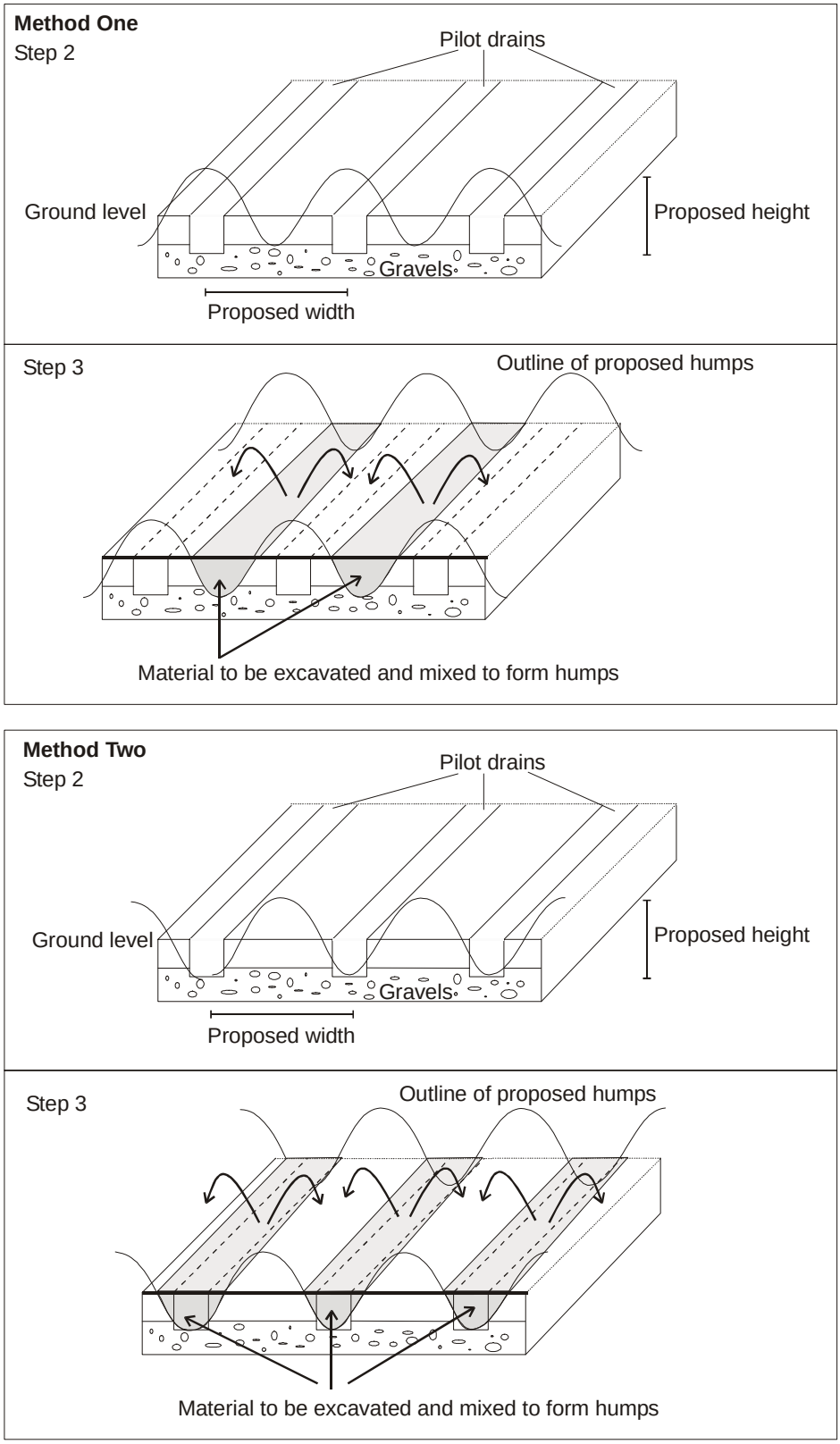


Figure 3: Different methods of hump and hollowing obtained from the interviews.

3.4. Extent of humping and hollowing on the West Coast

Humping and hollowing was present (in some form) on 23 out of the 28 farms visited, but varied in area from a few hectares to the entire farm (200 ha+). Figure 4 illustrates the percentages of farms with different amounts of humped and hollowed land. Although the second set of interviews was conducted only with farmers with humping and hollowing, this pie chart gives some indication of the area of farms that are contoured. It is clear from the chart that humps and hollows occur over significant part of the participants' properties.

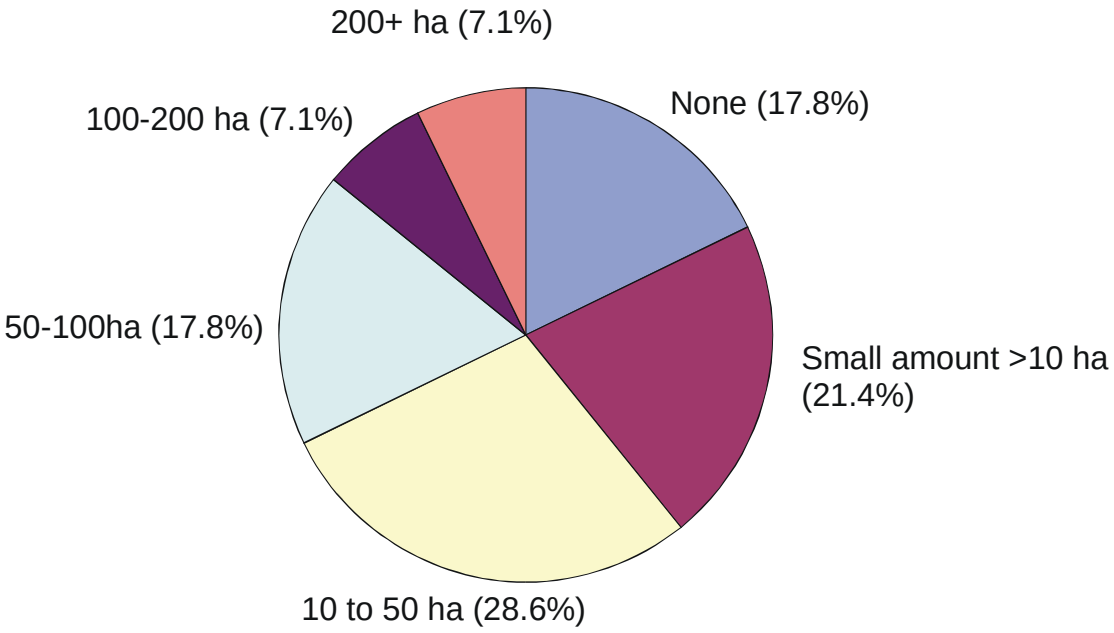


Figure 4: Percentages of farms visited with varying areas of hump and hollowed pasture.

The reason for not humping and hollowing was predominantly because the farm was free draining (generally river gravels in the Grey River Valley) and therefore it was unnecessary. Many of the smaller areas occurred because only small parts of the farm were considered wet enough to hump and hollow or were experiments, where the land owners had contoured land to see what could be gained. Eleven of the farmers with humping and hollowing planed to contour more of their land, and three farmers had, or were applying for a resource consent to do so.

Around Lake Brunner, the Grey River Valley and Karamea humping and hollowing appears to be commonly used to bring new land (usually pakihi land) into dairy production, rather than improve existing pasture. It is clearly contributing to dairy expansion in the area as it represents a cheaper way to obtain dairying land. "You get land for $3000 rather than having to buy it at the market rate which is three times that" (Farmer 18). In the Hokitika area, it was more often used to improve existing poor

quality pasture, although it was also used to bring new land into dairying. In Karamea, it was a mix of both.

3.5. Benefits and costs

3.5.1. The perceived value of humps and hollows

The dominant view of humping and hollowing is favourable because it turns ”absolute crap land (which rates are being paid on) that can’t be used for anything into productive pasture”(Farmer 1) or increases pasture quality to” support more than just a dozen steers” (Farmer 26). It improves pasture quality and production by increasing drainage allowing the “water to get away quicker” (Farmer 14) and for some farmers it provides an ideal environment to graze cows during the wet season (Farmer 18).

One farmer reported increases in grass productivity after humping and hollowing poor quality existing pasture of “at least 30%, but usually 50-70%” (Farmer 6). Three others believed it had doubled the milk solids production from the contoured areas. Moreover, most farmers agreed humping and hollowing was very important to milk solids production on the West Coast and was essential to farming success in high rainfall poor draining areas.

The increase in humping and hollowing was thought to be good for the region, economically, through increased work opportunities in the dairy sector (as farm hands, dairy factory jobs, plus farm and earth moving contractors) as farms expand.

Humping and hollowing does have opponents. One farmer suggested humping and hollowing was a technique used to disguise poor pasture wet weather management skills. Another suggested farmers were contouring their land because it was “the thing to do and everybody else is” (Farmer 7) rather than looking for solutions that suited their properties. Farmers opposed to humps and hollows tended to have reasonably free draining properties.

3.5.2. Financial cost

The estimates of cost varied considerably because of the range of soil types, difference in hump and hollow design, and access to machinery and labour.

The general consensus was that it cost around between $1500 and $3000/ha for a contractor to do the work, and as high as $5000/ha if scrub clearance or stump and

rock removal was required. This cost does not include grass, fertiliser inputs and other costs associated with areas of the farm not being available for a while.

Farmers with their own equipment estimated the costs at around $1000/ha. There were a number of other issues with financial costs that farmers did not quantify but do represent a cost;

New humps and hollows require grassing and often considerable applications of fertiliser and lime because of the acidic and poor nutrient status of the subsurface layers. Farmers were not very clear about how much fertiliser and lime they put on these areas. Interviewers noted that fertiliser use was not a comfortable discussion topic for some farmers. The actual costs of getting the land to dairy grazing quality has probably not been quantified by many, much beyond the actual earth moving costs.

Young stock is put out to graze (usually calves) as soon as the grass cover on the humps and hollows has developed enough to avoid being uprooted by the animals. Over several months the ground stabilises enough to support progressively heavier animals (e.g., heifers) until finally the farmer judges it suitable for the main herd. This may take several months to almost a year, depending on the soil type.

3.5.3. Disadvantages of humps and hollows

Participants described several main disadvantages of humped and hollowed paddocks over flat paddocks;

It results in wear and tear of farm equipment “wears our tractor tyres out in one place as we are always on a lean” (Farmer 1). Farm equipment may get stuck in the hollows and be very difficult to retrieve.

Machinery operation and general paddock work is more difficult and time consuming. Examples include difficulties with fertiliser spreading, tractor work, topping (taking the tops off the grass), sub-soiling, and problems with break feeding, It is difficult to make hay or silage because a farmer “might lose a bale down into the hollows and in some cases not be able to retrieve it” (Farmer 16). Cows often find it hard to walk from one side of the paddock to the other.

Grazing management could be complicated because grass growth in the summer may be affected in systems with gravel hollows because the grass may “burn off” (i.e. die due to lack of water) or the tops of the humps may be affected by wind drying. However overall the paddocks hollows in peat or silts were thought to be more productive in summer as they remain wetter.

Farmers cannot use hump and hollowed pasture for calving, as cows and calves may get stuck in the hollows. It is important to note that farmers do not generally use paddocks with drains for calving either. Pasture cover does not last as long in some situations and rye grass needs to be resown every few years. In addition the drier humps may be prone to grass grub (Farmer 4). Several farmers noted slumping of the humps that require maintenance every few years. This problem was mainly noticed in areas without free draining hollows.

Cost is a strong disadvantage, and several farmers thought it was better to 'buy decent land to begin with rather than spending time and money trying to farm on swamp"… "if you don't get it right it's like farming on a giant jelly mould and it reverts back" (Farmer 7). Farmers holding this view already owned free draining land where drainage was managed using more traditional methods.

There was general agreement that humped and hollowed pastures are more difficult to manage, however there was also recognition that without the contouring the areas would not be productive paddocks at all. However, questions of how profitable humps and hollows would be in the long term arose because of the cost of maintaining the systems through fertiliser and food supplements (e.g. maize, or silage). Unfortunately, it is unlikely that many farmers keep records that would allow comparisons between inputs for flat and humped and hollowed lands.

3.6. Sources of information on humps and hollows

Almost all the farmers in this series of interviews got (or would get) information on humps and hollows from friends and neighbours or local contractors; "we looked around at people who had done a good job and talked to them about what they did and how" (Farmer 12).

The general belief appears to be that humps and hollows is not a difficult concept to grasp and act on. In fact, several of the participants had run small scale experiments (with their own equipment) in their wettest paddocks to see how it could be done and what the benefits would be.

Two farmers had read Westland Milk Products pamphlet on humping and hollowing and another had attended dairy company meetings.

The decision to hump and hollow and information gathering activities was summed up well by Farmer 26 "There has been a lot of talk about it on the West Coast and … the neighbour got at it and got some very good results….. so we thought we would give it a go."

3.6.1. Advice and suggestions for other farmers

The interviewees had several important pieces of advice for other farmers considering contouring their paddocks, to help avoid some of the disadvantages of humps and hollows;

The contouring needs to be carefully considered and be well planned for each farm especially in peaty soils because they can settle and slump. It is important to know if the soil will settle otherwise the final product may be too steep, leading to erosion by water and cattle, or too gentle and ineffective.

Diggers may need to be on planks when working with peaty soils as there were several reports of diggers becoming mired.

Race and gate positioning is important, in order to prevent the cows from walking over humps and hollows to get to the milking shed.

Cows can damage (pug) the hump and hollowed paddocks if they are left in the paddocks too long.

3.7. Farmer perceptions of the environmental effects of humps and hollows

Participants did not think humps and hollows had any effects on the environment except increased water volumes during high rainfall events and a reduction in the amount of swamp/pakihi land. These effects were not often considered negative; they were simply effects.

There was some disagreement over whether humps and hollows would show increased water and nutrient runoff when compared to flat land or naturally hilly areas. Many farmers did not believe runoff would increase much, however, they were concerned over possible consequences, mainly, lowland flooding and river scouring issues. One farmer personally experienced flooding on their property, which they attributed to the neighbours large humped and hollowed block. It was only a small section of the farm but the volume of water and the speed of the flooding was a concern. Furthermore it had an effect on their grazing rotation and it was a serious point of contention between the adjacent landowners. They felt the resource consent process should pay more attention to downstream flooding issues related to hump and hollow developments.

Water quality was not considered a problem on the West Coast because of the "dilution given the amount of rain and volume of groundwater" (Farmer 21). Few participants thought water quality was poor because "there are still plenty of fish and

frogs" (Farmer 3) and the water was still clear (i.e., low turbidity). Many farmers had seen trout, eels and native fish in local rivers and streams and two participants were white baiters. There were some comments and concerns over rumours of smaller whitebait catches in the 2004 season.

A visual measurement of water quality using water clarity and amount of fish life, particularly eels, was very common amongst the farmers interviewed. Unfortunately it is not always an accurate measure because many 'pollutants' cannot be seen, for example nitrate, ammonia and faecal coliforms. In addition, eels are not a good indicator of water quality because they are a very hardy species.

Considerable areas of forest and wetland reserves are managed by Department of Conservation in the area (some 85-90% of the land area) compared to other regions. The general feeling appears to be that there are plenty of wetlands without protecting them on potential farmland, and it is not surprising that drainage of wetlands on private land was considered positive. An understanding that different wetland and forest types existed under different environmental conditions (i.e., soil type, water source and altitude) was lacking amongst research participants. This could represent an impediment to conservation initiatives in the region because farmers cannot differentiate between vegetation types on their land and what they see all around. Hence, they do not place additional value on rare vegetation types. However, it is important to note that many participants had fenced forest and wetlands but mainly for aesthetic rather than ecological values.

3.8. Farmer environmental knowledge

Environmental knowledge of the research participants was generally patchy and lacked cohesion. This patchy knowledge impacts on farmers' ability to understand the potential environmental impacts of their farming practices, their neighbours practices and inter-linkages and effects within the local catchment. However, farmer environmental awareness is improving over time and continued interaction between local communities and agencies involved in resource management (New Zealand Landcare Trust, Regional Council, Dexcel, Westland Milk Products, Department of Conservation, Crown Research Institutes etc.) will contribute to further gains in understanding.

However, there were a couple of exceptions with a reasonably good grasp of environmental issues facing dairy farmers. Knowledge is probably generated through experiences and there were a number of interesting innovations and practices adopted by the participants;

One farmer had fenced and maintained the bush (at least 50 m) around his standoff pad (which was on the top of a small hill) to treat the runoff. He decided that this was a good way to not only shelter the cows from the wind but also deal with runoff without collecting it in the dairy shed effluent system.

Commercial eel fishing had been halted on another farm as the farmer became aware of role of eels in reducing liver fluke transmission to cattle. Cattle are exposed to liver fluke by consuming wetland vegetation inhabited by one of its hosts, the New Zealand mud snail (*Potamopyrgus antipodarum*). Eels prey on snails, reducing population densities and lowering the risk of transmission to cattle. By increasing the numbers of eels in the farm waterways a noticeable reduction in the incidence of liver fluke was observed by the farmer.

At least half of the farmers interviewed have fenced off bush blocks ”we keep stands of White Pine because they look nice” (Farmer 5). However scrub and pakihi are not viewed so favourably. The numbers with fenced native forest may be related to the large size of the farms, many properties already have large dairy platforms without bringing these areas into production – for now. Farm sizes in the traditional dairying regions (Waikato and Taranaki) tend to be a lot smaller and every available area is usually required to make an economic unit. In some areas, native forest on the West Coast remains on the hills because the land is not suitable for dairy grazing.

Confusion over classifications of ‘drains’ and ‘streams’ between landowners and scientists and resource mangers is another feature highlighted by these interviews. A drain to a farmer appears to be something they clean out or maintain irrespective of whether it started as natural waterway or not. Streams tend to have more value than drains. Scientists and resource managers tend to have other definitions, which frequently clash with those of farmers. It is particularly difficult in some areas, because some waterways dug by farmers look very much like natural streams as they are fast flowing with stony substrates.

3.9. Consent requirements

Farmers are confused over when humping and hollowing is a permitted activity and when it requires a consent. Around half believed it was a permitted activity if it was less than 20ha/yr for a single title. Other ideas included 20% of the land area.

Appendix D contains an extract from the proposed Regional Land and Riverbed Management Plan (West Coast Regional Council 2004) which states that humping and hollowing is a permitted activity if it occurs outside a riparian zone or wetland (of an area greater than 2 ha), is on slopes of less than 12 degrees, is less than 5ha/yr on a

landholding, has no effect on water quality, and does not occur too close to a waterbody or a wetland. The term land holding is not very clear, and many farms are multiple tittles. This needs to be clarified with farmers more effectively because many may be contouring their land without realising they require a resource consent.

Those who had applied for a resource consent were frustrated by the time it took, with several farmers reporting 1-2 yrs for approval. At least two farmers did not wait for the consent before beginning the contouring.

3.10. Proposed solutions

This series of interviews was part of a broader study to quantify nutrient runoff from humps and hollows and investigate possible mitigation strategies. One of the key strategies proposed involves encouraging small wetlands at the end of the hollows in an attempt to process some of the nutrients before they enter waterbodies. The author believes this approach could be applicable in hump and hollow systems where water is retained in the hollows for example, deep peaty soil (Lake Brunner, farms at the head of the Hokitika River Valley), poorly drained heavy silts and clays (Hokitika). However it will not work where the hollows reach free draining material, because wetland plants are less likely to survive (e.g. Nelson Creek). An entirely different mitigation approach is required for systems with hollows of free draining substrate, because nutrients will be directly entering groundwater.

3.10.1. Perceptions of wetlands as a solution to nutrient runoff

Farmer perceptions of leaving wetlands (or planting wetlands) in hollows to mitigate nutrient runoff was generally negative. There are several reasons for this;

Land contouring was undertaken to reduce the wetland area and improve pasture, and this solution was viewed by farmers as allowing the pasture to begin reverting to its original state. Many farmers felt the wetland in the hollows would simply get larger and larger and eventually take over the humps; “wetlands would be ok for a few years but after a while would get bigger and bigger and revert to wetland” (Farmer 27) or “can’t have a wet area because it will hold up the water and the cows will pug it and make it bigger and it will just keep expanding” (Farmer 23). Several farmers described situations where wet areas in the hollows had grown over time due to cattle pugging or rushes ‘moving up the hollows”. There were also concerns it would increase hump and hollow maintenance. Fencing off the hollows would solve the problem, but it would be costly, make paddock work even more difficult, and may be a risk to stock that get through the fence.

There was concerns over the wetland areas acting as a haven for pests; “Don’t want it to get too wet in the bottom as that will allow blackberry and gorse to get started, especially if you fence it off … then possums and other pests get into that and next you have got TB in the valley, you need to get rid of all the rubbish” (Farmer 21).

Wetlands do not fit well into many farmers concept of a tidy farm because rushes (*Juncus* sp.) are often considered a pest that need weed wiping as they make paddock look untidy. Several farmers commented that their neighbours needed to control the rushes on the humps and hollows because they were taking over and looking messy.

However, there were several farmers to whom wetlands in hollows were a perfectly reasonable solution because “there are wetlands there anyway, naturally” (Farmer 24). In particular, this solution appealed to those who could not use the hollows because they were simply too wet for most of the year.

In addition to discussing a particular mitigation system, farmers were asked to consider other potentially more acceptable mitigation strategies. Vegetated drains emerged as a possible system. Almost all the participants had extensive drainage networks on their properties that they maintained, which are periodically deepened and cleared of wetland vegetation. They were quite happy to clean these out in sections and retain areas with wetland vegetation to act as filters ”The water can sit there comfortably and won’t affect the pasture and you have to have drains anyway” (Farmer 24). This idea warrants further investigation from a scientific perspective in order to provide farmers with practical drain management tools.

Another farmer had drained his property by using a series of drains based on techniques developed by Chinese gold miners. Each drain was flat and involved a series of overflow weirs, which worked well on the small property. He did not contour his land into humps as such. Interviewers noted that the soils on his farm were relatively stony and drained well compared to peaty soils. He believed the idea could be scaled up.

It is clear that the ideal is to offer farmers a range of mitigation measures that they can adapt to fit their farming situation and personal beliefs and values.

3.11. Trusted sources of information

Information from trusted sources tends to be assimilated more readily because it originates from a person whose experiences and views are valued. It is important to identify and engage local information networks in order to develop and promote acceptable and practical solutions to environmental issues.

Neighbours and friends represent an important and trusted source of information and advice for most participants. One of the West Coast Regional Council officers is well respected in the area for his knowledge on dairy farming issues as is the local Dexcel consulting officer. As a consequence they both represent good and trusted points of contact for dairy farmers. Perceptions of the Regional Council overall were quite mixed, with some farmers citing good experiences and others bad. These were often constructed from a single event, usually associated with resource consent applications or onsite visits/inspections.

Overall the perception of the Department of Conservation tended to be negative. Reasons for this were not fully explored but generally relate to what many perceived as heavy handed conservation estate management strategies on the Coast.

We did not ask if Westland Milk Products were a trusted source of information, however, it can be assumed that dairy company policy and perspectives are taken seriously for product sales reasons.

West Coast rural communities are close knit and information and news will spread quite quickly. Of course the strongest connections occur at the local level and three communities can be derived from these interviews; Lake Brunner/Grey River Valley, Hokitika and Karamea.

4. Environmental effects of dairying on the West Coast

It is important to note that the majority of participants believed that water quality on the West Coast was high. This contrasts with increasing evidence that West Coast streams in dairying catchments contain comparable levels of plant nutrients and faecal coliforms to waterways in other dairying catchments (Davies-Colley and Nagels 2002; R. Wilcock, pers. comm.. 2005), where water quality is generally described as poor (Parkyn et al. 2002). The misconception needs to be dismantled in order for farmers to take nutrient runoff seriously. All the agencies involved in resource management in the region can take steps towards this goal by promoting consistent messages on water quality and nutrient management to farmers.

During this study other concerns were uncovered that deserve mentioning and probably future research. Fertiliser use on the West Coast appears to be high compared to other parts of the country and warrants further investigation. Only a handful of farmers had nutrient budgets (or soil tests) and many appeared to fertilise heavily after each grazing rotation. Some farms have poor pasture clover cover, which may be related to climatic conditions but may equally be a feature of urea overuse. A farmer

who had moved to the West Coast from another region had "never seen so much urea used as what I have seen here, some farmers put it on every six weeks" (Farmer 7).

Farmers were somewhat reluctant to discuss fertiliser application. However a number of farmers used between 400 kg/ha to 800 kg/ha of urea per year, which equates to around 160-400 kgN/ha/yr above the upper limit (200kg/ha/yr) recommended by Dexcel (Dexcel 2001). This is probably causing significant leaching and may not be profitable for the farmers (Ledgard and Thorrold 2004). Application rates to recently humped and hollowed land are likely to be higher still, as farmers try to increase the fertility of the newly contoured land. Fertiliser applied to bare ground may be more easily mobilised into waterways during rainfall events. In short, fertiliser application rates on the West Coast represent a serious nutrient runoff risk to waterways and require investigation in the very near future.

Irrigation of dairy shed effluent onto humps and hollows, especially where the hollows have gravel bases, needs to be monitored very carefully. Several farmers irrigated under such circumstances, which may lead to surface and groundwater pollution problems in the future. It is probably not wise to irrigate dairy shed waste to land designed to facilitate rapid drainage to surface water.

5. Conclusions

As long as dairying remains profitable humping and hollowing of marginal lands will continue. Many areas of the West Coast could not be successfully farmed without contouring the land to improve drainage. It is perceived very favourably and is not believed to have any effect on receiving waters. In fact, water quality on the West Coast is thought to be good, because of the high rainfall, high water clarity and abundance of fish life. This contrasts with scientific evidence, which suggests that water quality in dairy catchments tends to be poor and that the West Coast is on a par with dairy farming catchments in other regions.

The costs of humping and hollowing is high but still initially lower than purchasing free draining land. The long-term maintenance costs are not known.

Knowledge on humping and hollowing tends to be gained from neighbours and other members of the local community, but few are aware of current resource consent requirements.

Small wetlands planted at the bottom of a hollow as a solution to nutrient runoff was not favourably received by many farmers. This is because wetlands are perceived as untidy and represent a return to the original state of the land. However, treatment in

farm drains is a possible alternative that needs further research. Overall a range of solutions should to be developed so that farmers can select a suitable alternative that fits their beliefs and individual farming situation.

6. Acknowledgments

Thank you to the participants who gave their time to be interviewed.

Westland Milk Products are thanked (Maria Lockington) for providing the list of their suppliers

Thanks are also due to Carol Whaitiri (NIWA) and Lela Freeman, Anna Broms and Kimberly Burnside (New Zealand Landcare Trust) for transcribing the tapes.

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Appendix A: Participant information sheet

Participant Information Sheet

Solutions to Nutrient Runoff from West Coast Land Conversions

To: Interview Participants

The humping and hollowing of West Coast pastures to improve drainage is becoming more common. Many people believe that humping and hollowing is an important means by which land productivity can be increased, and others believe it has significant environmental impacts on waterways. A team of people from New Zealand Landcare Trust, NIWA and others, (Westland Milk Products, DOC, and Westland Regional Council) have recently begun investigating nutrient runoff from land that has been humped and hollowed to see if there are any effects. If there are effects on streams and rivers we will be looking for practical solutions to reduce the impacts. An important part of this research involves seeking your views and thoughts on humping and hollowing as well as ideas you many have on practical solutions to any environmental problems. You are invited to participate in the research and we would appreciate any assistance you can offer us.

We would like to talk to you about various issues regarding humping and hollowing including

- what you think about the approach
- why you have or haven't applied the technique to your property
- your views on the benefits and costs of humping and hollowing
- your thoughts on what, if any, environmental effects may be associated with humping and hollowing and ideas on how these could be mitigated.

We would like you to participate in our study, but you are under no obligation at all to be interviewed. Interviews would take about half an hour to an hour and a half and would take place at a time and place convenient to you. We would prefer to audio tape the interview but this would only be done with your consent and could be turned off at any time. You can withdraw information any time up to April 2005. The information collected will be incorporated into a report to Sustainable Farming Fund - related publications. All information you provide in an interview is confidential and your name will not be used.

If you do wish to be interviewed please let Shelley Washington or Katie Nimmo (NZ Landcare Trust) know by filling in a Consent Form and sending it to them, or contacting them by any of the means listed below. The first set of interviews will be conducted between Monday 28th June and Friday 2nd July. There will be another set later in the year or early 2005 if these times are not convenient.

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more please contact Shelly Washington, Katie Nimmo or Paula Blackett at:

Shelley Washington Regional Coordinator Central South Island New Zealand Landcare Trust P.O Box 39 141 Christchurch Ph (03) 962 9555 Or 025 367 974 Fax (03) 962 9557 shelley.washington@landcare.org.nz Katie Nimmo New Zealand Landcare Trust Research and Information Coordinator katie.nimmo@landcare.org.nz Contact details as above for Shelley	Paula Blackett NIWA P.O Box 11-115 Hillcrest Hamilton Ph (07) 856 7026 Or 021 495656 Fax (07) 856 0151 e-mail p.blackett@niwa.co.nz

Appendix B: Consent Form

CONSENT FORM

Solutions to Nutrient Runoff from West Coast Land Conversions

Researchers: Paula Blackett, Shelley Washington and Katie Nimmo

I have been given and have understood an explanation of this research project. I have had an opportunity to ask questions and have them answered.

I understand that I may withdraw myself or any information traceable to me at any time up to April 2005 without giving a reason.

I understand the information I provide will be used in a report to the Sustainable Farming Fund any related publications.

- I agree to take part in this research.
- I agree/do not agree that the interview will be audio taped

Signed:

Name:
(please print clearly)

Date:

Appendix C: Interview question guidelines

General issues

1) How big is your farm and how much is used for dairy farming
2) How many cows
3) How long have you been on the property, changes in area

Knowledge of hump and hollowing

1) What do you know about H&H?
2) Where did you get this knowledge?
3) Do you think you need any more information?, if so where would you seek it?
4) Do you have water logging problems? How do you currently deal with water logging problems on your property.
5) Do manage the waterways on your property?

Benefits and cost of the process

1) Have you considered hump and hollowing your property?
2) What do you see as the main benefits of the process (i.e., increased productivity, improved farm management through reduced waterlogging
3) Have you estimated the cost for H&H?
4) What are the main disadvantages (i.e., farm rotation disturbance?).
5) What do you think your main reasons is for not undertaking the process (note: if process requires a resource consent this may act as a barrier)

if the farmer has already H& H –

1) How much of your land has been humped and hollowed? Why did you chose these areas? How did you decide what to do and what to leave?
2) Who did the work, were you happy their work?
3) How did you go about finding the info to do the job
4) Are the actual benefits equal to what you expected? i.e., was it worth it?
5) Has it improved your ability to manage the property.
6) What level of maintenance is required?
7) Has your fertiliser input increased? (what is your current input, how is this spread across the year)
8) Does the land require special management e.g. fertiliser applications (timing and amounts), grazing management
9) Did you require a resource consent? If so Does it require monitoring of water.

Environmental effects

1) Do you think there are any environmental effects of the H and H process? If so what?
2) As part of the nutrient solutions project we have collected some preliminary data that suggests nutrients are running off H&H land and entering waterways in reasonable concentrations – do you have any thoughts on this? (i.e., do you think nutrients are problem in west coast water ways, how? And why?)
3) How do you think nutrients could be getting into waterways

4) Some of our scientist's ideas on how to reduce this problem involve putting in small wetland (use pictures) – what are your thoughts on this sort of thing? how would you go about reducing this problem? get some ideas on farmer solutions). Do we need to do anything at all? Would wetlands in the hollows appear messy to you? Affect your land management (i.e., silage collection?)
5) Follow up advantages and disadvantages of the ideas each idea as it comes up.

Appendix D: Proposed Rules on hump and hollows

Source : West Coast Regional Council, 2004: Proposed Regional Land and Riverbed Management Plan Incorporating Decisions, West Coast Regional Council, September 2004, Greymouth.

6.1.1 Humping and Hollowing, Flipping, or V Blading Outside of Riparian Margins and Wetlands greater than 2 Hectares

6.1.1.1 Humping and Hollowing, Flipping, or V Blading in the Non-Erosion Prone Area (less than 120 slope) outside of riparian margins and wetlands greater than 2 Hectares are ***permitted activities*** if **all** of the following conditions are met:

(a) (1) For Humping & Hollowing and Flipping, the area of the activity does not exceed 5 Hectares per landholding in any 12 month period; and

(2) For V-blading **either**:
(i) The land area for new works does not exceed 10 Hectares per landholding in any 12 month period; **or**
(ii) The activity is undertaken on land that has previously been Vbladed; and

(b) The activity must not cause the visual clarity of any receiving water to decrease by more than 40%, as measured by black disc beyond 12 times the river's width or 200 metres of the activity, whichever is the lesser; and

(c) No soil or debris is placed directly in any river or lake bed; and

(d) There is no conspicuous deposition of sediment on the bed of any water body; and

(e) The activity does not affect any surface water take; and

(f) The activity is not within:

(1) 50 metres of the Coastal Marine Area on the open coast line; or
(2) 10 metres of the Coastal Marine Area elsewhere; and

(g) The activity is not within 50 metres of a wetland greater than 2 Hectares; and

(h) When operating alongside a riverbed and there is an iron pan or hard pan layer below the surface of the land then the iron pan or hard pan is not to be disturbed or broken within a distance of 20 metres from the edge of the riverbank; and

(i) Any culverts or cut and fill batters are designed, and constructed or installed to prevent their failure and avoid causing erosion; and

(j) The Council is notified in writing of the location and extent of the activity, at least seven working days prior to the works commencing.

Note: *Condition (h) will ensure that low permeability strata within 20 metre of a waterway is maintained to ensure continuity of flow in the waterway. The land within*

the 20 metres buffer can still be contoured, in accordance with other conditions/rules provided the iron pan or hard pan is not broken.

Ngai Tahu own all pounamu (greenstone) previously vested in the Crown. Appendix 3 contains the accidental discovery protocols of the pounamu management plan and they should be taken into account when undertaking any earthworks.

Refer to Definitions A-C at the beginning of Chapter 6 for an explanation of Riparian Margins, Dominant Slope, and Proneness to Erosion slope categories.

Principal Reasons for Adopting
This rule is intended to address the range of Land Contouring Activities, which can be carried out with minor adverse effects on the environment if all of the above conditions are complied with.

6.1.5 Restricted Discretionary Activities on Land

6.1.5.1 Humping & Hollowing, Flipping, and V-Blading that cannot meet any one of the conditions of permitted activity rule 6.1.1.1, or that occurs within a riparian margin or wetland greater than 2 hectares, is a restricted discretionary activity. In considering any resource consent under this rule, the council will restrict the exercise of its discretion to the following:

(a) The effects of erosion, sedimentation of waterways, changes in surface runoff, and measures to avoid, remedy, or mitigate adverse effects on affected persons and infrastructure located downstream;

(b) Effects on the stability of beds and banks of rivers and streams;

(c) Adherence to a certified engineering plan;

(d) Setback distances from wetlands, lakes, rivers, and the coastal marine area;

(e) Timing of the activity;

(f) Damage to riparian vegetation, soil, natural habitats and features, and significant sites;

(g) Effects on surface and sub surface water levels, flows, and quality;

(h) Erosion and sediment control methods;

(i) Measures to avoid, remedy, or mitigate adverse effects on stream morphology and substrate composition;

(j) Cumulative effects;

(k) Potential damage to any cultural or heritage site/area;

(l) The relationship of Ngai Tahu and their culture and traditions with their ancestral lands, waters, sites, wahi tapu, and other taonga;

(m) Monitoring provisions;

(n) The duration of the resource consent;

(o) Bonds and financial contributions;

(p) Review conditions of the resource consent.

An application for resource consent under this rule does not need to be notified and does not need to be served on persons who may be adversely affected by the activity unless either the applicant requests notification or the council considers that because of special circumstances the application should be publicly notified.

Note: *Ngai Tahu own all pounamu (greenstone) previously vested in the Crown. Appendix 3 contains the accidental discovery protocols of the pounamu management plan and they should be taken into account when undertaking any earthworks.*

Principal Reasons for Adopting

V blading and humping and hollowing are forms of land drainage commonly employed on the West Coast for reshaping the ground surface, and along with flipping, alter the structure of the soil substrate. This may result in change in the hydrology of the catchment. Depending on the soil structure, it may result in an increase in surface runoff due to an increase in the land surface gradient, or a reduction in surface runoff due to significantly increased drainage to groundwater.

During heavy rainfall an increase in surface runoff could significantly increase the flow and velocity of receiving rivers and streams, and can lead to scouring and erosion, ponding of water beyond the subject property boundary, as well as causing damage and destruction of aquatic habitats, including trout fisheries. Such adverse effects are likely to be more significant in the catchments of smaller streams, depending on the scale and type of land drainage carried out.

Elevated levels of surface runoff can also result in adverse effects on downstream landowners and network utility operators. It may be necessary for those who carry out land drainage to address adverse effects. There is also a need to consider whether cumulative effects may arise because of other areas in the same catchment that have been already been drained. Furthermore, a significantly increased drainage to groundwater from the developed pasture may result in an effect on groundwater quality and level.