Figure 54. Area to the right in figure Figure 53. This surface was treated in the 1970's by contour chisel ploughing. Some gullies have reformed and scattered sinkholes across the surface indicate that under-runners are present. Sheet erosion and sediment re-deposition on lower slopes is taking place.

Figure 55. An area previously treated for erosion control with new gullies forming.

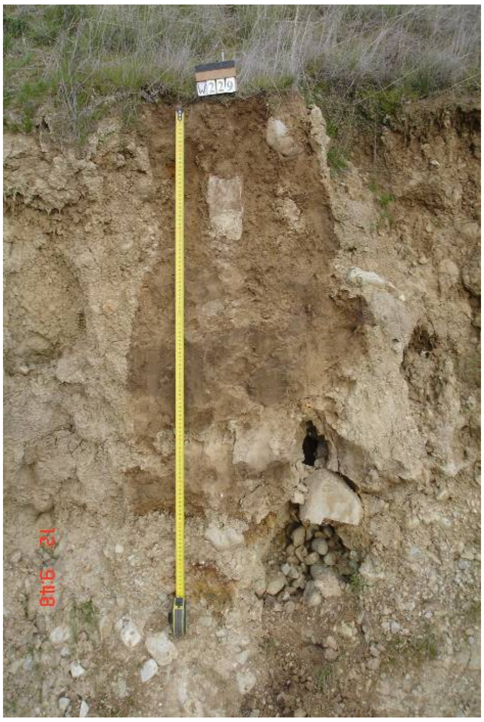

Figure 56. A soil formed on an erosion control surface by gully infilling. The old topsoil has been buried and a new pipe is developing below.

Figure 57. A soil formed on an infilled gully with a buried topsoil. An active under-runner has formed and soil collapse is occurring on the re-formed surface.

Figure 58. Surface soil material formed during mechanical gully infilling showing active dispersal. The dispersed soil either washes away in flood waters or may be re-deposited on lower slopes.

7.8. Sedgemere Soils

Sedgemere soils are mapped over 42 ha in the northeast part of the survey area on dissected undulating Pleistocene terraces (Figs. 59 & 60). These dissected terraces were mapped as outwash deposits of the Speargrass Formation (Lensen 1962), which are of Late Pleistocene Otira Glaciation age. However, it is apparent from the elevation of the terraces (up to 70 m above sea level), from the degree of landsurface dissection and the loess cover that the land surface part of a much older terrace system. It is likely that this landform was part of a broad fan formed by sediment that was deposited at the mouth of the valley occupied by Utawai Creek (Fig.1).

Figure 59. Old dissected terrace lands with Sedgemere soils on the undulating surfaces.

Figure 60. Gently undulating landscape of the old dissected terraces with Sedgemere soils.

Sedgemere soils, like Wither soils, are formed from Late Last Glaciation loess that was deposited in more than one episode. The profile morphology is similar to that for Wither soils with a brown to dark brown A horizon overlying a light yellowish brown or pale brown B horizon that merges into blocky structured mottled clay loam (Fig 61). Mottling in this horizon is strong on parts of the terrace surface where lateral drainage is slight. This horizon overlies a prismatic structured very firm Bx horizon or hard pan (sometimes with a few stones) that in turn overlies firm clay loam (Fig. 62). This later horizon is similar to that found in Wither soils in that it has a higher tendency for slaking than the horizons above. Not seen in the Sedgemere soil however, is the highly dispersible silty gravel layer that underlies most of the Wither soils.

The land surface for Sedgemere soils is flat to gently undulating with most slopes below 10° and with no signs of the gully erosion that characterise Wither and Vernon soils. However, on the margins of the dissected terrace land where slopes are greater than 12° shallow gullying was observed (Figs 63 & 64) with some piping in the lower B horizon. This suggests that a sloping surface that allows significant lateral transmission of water through readily dispersible subsurface horizons is an essential requirement for tunnel gullying to form.

Figure 61. Typical profile of a moderately well drained Sedgemere soil where drainage is impeded. The lower B horizon shows the effects of some dispersion and slaking.

Figure 62. Profile of Sedgemere soil near the edge of a terrace where the soil is better drained. Dispersal and slaking is occurring in the exposed lower silty clay below the fragic horizon.

Figure 63. Shallow gullying (foreground) on a gently sloping terrace margin associated with Sedgemere soils.

Figure 64. A shallow gully with a small piping channel formed in the loessial materials on the dissected terrace margins associated with Sedgemere soils.

7.10. Tahunanui Soils

Tahunanui soils are mapped in one small area of 3 ha where they occur on the margin of the Wither Hills adjacent to the Wairau Plains. They are formed from wind-blown coastal sand, deposited in Recent geological times some 5-6 km further inland from the present coastline. This deposit appears to be a south-easterly extension of the dune sands that occur at Riverlands and which forms part of an intermittent arcuate dune-sand deposit that stretches northwards across the lower Wairau Plain and marks the position of a former coastline. The sands extend into a small valley (Fig. 65) and up the northwest facing slope to an elevation of approximately 40 m. The dunes have a crescentic shape that suggests that they were deposited in a period of extremely strong northerly winds. The overall land surface is strongly rolling to moderately steep.

The soil formed on the sand is uncohesive and weakly weathered. The topsoil is intermittent and where present is thin brown to olive brown sand and overlies unweathered loose olive brown sand (Fig 66).

7.10.1. Erosion and Stability of Tahunanui Soils

Tahunanui soils have a high susceptibility to wind erosion because the surface soil material is loose and is easily displaced if the vegetation cover is disturbed.

Figure 65. Tahunanui soils formed on dune sand deposits that extend to about 40 metres elevation above the Wairau Plain. Their crescentic shape is indicative of extremely strong winds.

Figure 66. A soil profile of Tahunanui sand from auger borings.

7.10.2. Discussion

As outlined earlier, the present survey has shown that when compared with the existing soil maps, the highly erodable, tunnel gully susceptible Wither soils on loess deposits occupy a smaller proportion of the total area, while the more stable Waihopai soils formed from the underlying conglomerate are much more extensive. Vernon soils, which are not identified in the New Zealand Land Inventory database, are akin to Wither soils in also being susceptible to tunnel gully erosion and largely occupy an intermediate position between Wither and Waihopai soils. The survey has also shown that the landscapes are extremely varied and complex with approximately 50% classed as steepland soils.

In assessing the relative stability of the various soils in the survey area, some consideration of the landscape history is essential for risk assessment.

The studies that were reported by Laffan (1973) and Laffan and Cutler (1977a, 1977b) described the sequence of deposits that accompany Wither soils and suggested that the lowermost materials overlying the conglomerate could be Waimean (second last glaciation >120K) to Waimungan (third last glaciation >240K) in age. Implicit in this is a very high degree of overall land and slope stability, especially considering that the uppermost loess material including the fragic horizon was only thought to date from the early Holocene (12K). The absence of deep weathering in Waihopai soils on stable ridge sites would tend to discount the possibility for an old stable landscape system. The sequence of layers that are present in the Wither soils appear to be essentially conformable and no evidence was seen in any of the sections examined of erosional disconformities or old infilled gullies, which might be expected for a landscape that must have undergone the effects of numerous climatic changes over a prolonged period of time. Also not observed in the many sections that were examined was Kawakawa Tephra (Campbell 1986, Alloway *et al*. 2007), a widespread volcanic ash marker bed (26 095 $\pm$ 750 yrs.) that is widely found in loess and gravelly slope deposits elsewhere in the Nelson/Marlborough region.

The New Zealand climatic change sequence outlined by Alloway *et al*. (2007) for the past 30 000 years (Late Otirian) includes the following: Last Glacial Phase Onset around or before 28,000 yrs; between 27 000 to 21 000 yrs a mid Last Glacial Phase Warming; termination of the Last Glacial Phase at 18 000 yrs; a Cold Climate reversal between 14 000 to 11 000 yrs; Holocene warm phase after 11 000 yrs.

Table 1 outlines a suggested correlation of the various components of the Wither soils with the glacio-climatic sequence described by Alloway *et al*. (2007). If this correlation is correct, the Wither Hills/Redwood Pass area can be regarded as being a landscape where geological erosion, downcutting and slope rejuvenation are active processes, with the age of the soil materials probably dating from mid to Late Otirian (<50k).

Table 1: Correlation of layers in Wither soil materials with paleoclimate records

Loess deposition & present soil weathering:	*Early Holocene <11 000 yrs*
Loess deposition & Fragic horizon:	*Cold climate 11-14 000 yrs Reversal*
Loess & weathering; dispersible horizon:	*End of Last Glacial Phase 18 000 yrs*
Loess deposition with stones & weathering:	*Last Glacial warming phase 21-27 000yrs*
Stony loess deposition:	*Last Glacial stage onset 28 000 yrs & before*

7.12. Environment of Loess Deposition

It is probable that the patchy distribution of loess deposits and Wither soils across the landscape is a largely a result of differential fallout, with thicker loess deposits accumulating in sites sheltered from strong winds and negligible loess on exposed windward faces. In the present day environment during stormy conditions, very strong winds are experienced on ridge tops with relatively calm conditions on lee slopes. The environment at the time of loess deposition was probably very cold, arid and extremely windy with an inland continental climate, because sea level was much lower (approximately 130 m) at that time. It was noted that some boulders on ridge tops have distinct ventiforms (faceted shapes Fig.