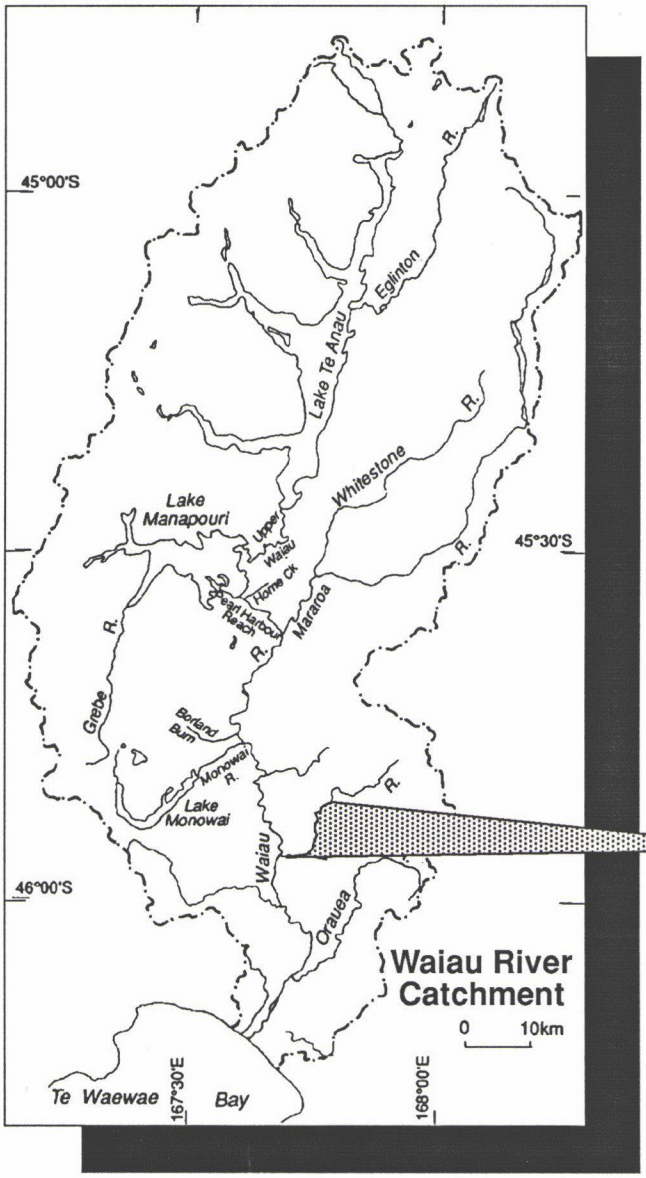
WAIRAKI RIVER
Reach Analysis

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Wairaki River

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REACH NAME : WAIRAKI RIVER

Geographic description of reach : Wairaki River was examined from 1 km upstream of Loudon Hill down to Waiau River confluence. Two subreaches are determined. Loudon Hill subreach extends from 1 km upstream of Loudon Hill to a confined terrace abutment 2 km upstream of Clifden-Blackmount road bridge. This subreach is characterized by broad valley flats with a distinct flight of terraces on the left bank. Alluvial flats are extensive. Within the alluvial flats there is a distinct channelized zone. Although Wairaki River is multichannelled in this subreach, with two or three channels generally, a primary channel is typically well-defined. This pattern is locally variable within-reach, and at the downstream end of Loudon Hill subreach there is a large complex bar assemblage which is dissected by five or six active channels at a series of topographic levels.

Wairaki Hill subreach extends from 2 km upstream of Clifden-Blackmount road bridge to Waiau River confluence. Wairaki River is less multi-channelled than upstream, with an imposed low sinuosity course constrained by bedrock cliffs. At Waiau confluence a large shallow fan has developed.

Analysts : GB, AB, AH Date of Analysis : 26.01.93 and 27.01.93

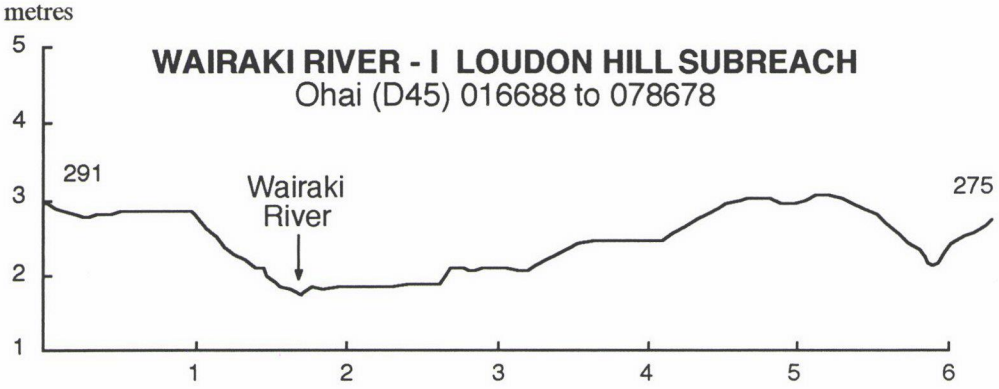
Grid co-ordinates of reach : Takitimu (D44) 1:50,000 053707 to Ohai (D45), 1:50,000, 979614 (Waiau Confluence).

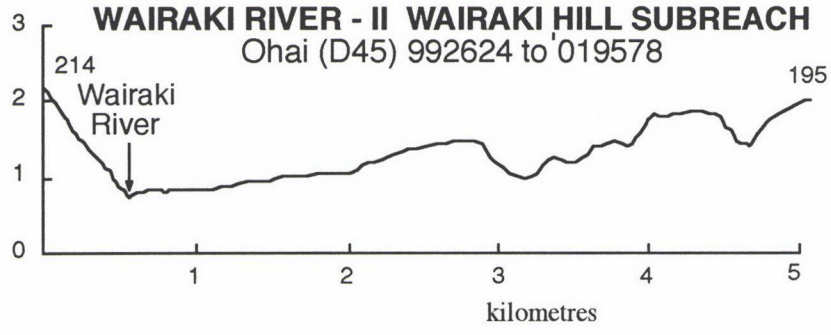
Loudon Hill subreach GR Takitimu (D44) 053707 to Ohai (D45) 016616
Wairaki Hill subreach GR 016616 to 979614

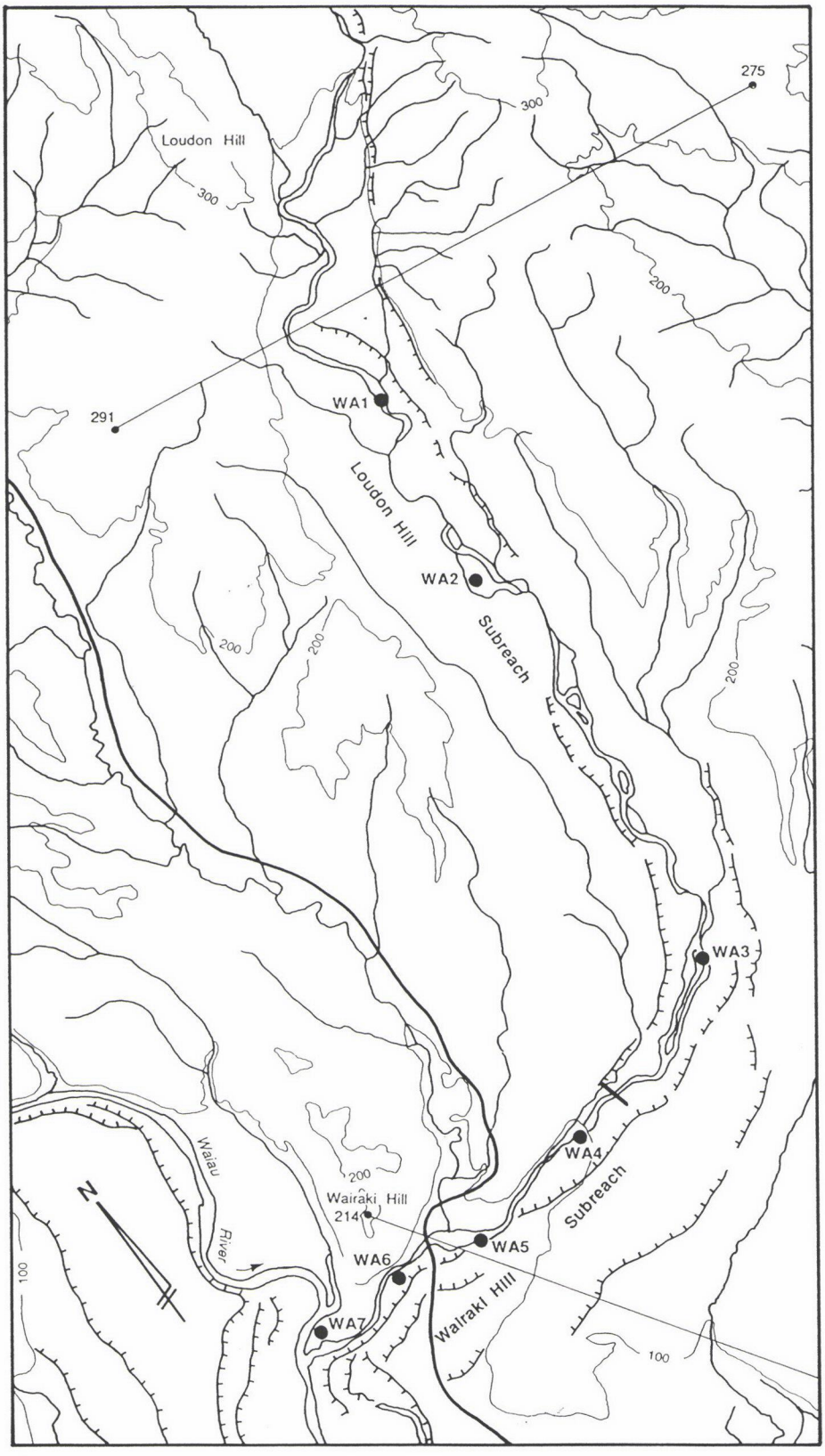
Air Photos used : 1:8,000, 21.6.84

VALLEY CHARACTERISTICS

Valley cross section







0 1 2km

LEGEND

- Road
- 500 — Contours (metres)
- Terrace riser
- Creeks / rivers
- Cross section
- WA — Sample location
- Reach margin
- Catchment margin

Valley setting
Wairaki River drains a large, highly dissected catchment in the Takitimu Mountains. The reach studied lies in a fairly broad valley immediately downstream of the foothills of the Takitimu's.

Extent of Valley flat
As Wairaki River exits the Takitimu Mountains it is a narrow, steep-sided valley. Other than occasional swamps in tributary valleys, valley flats are scarcely evident. Between Gibralter Hill and Barcoo Bush (at the bottom of Takitimu map sheet (D44)) valley flats are non-existent. Immediately downstream of this point the valley widens to several hundred metres. This subreach retains a relatively uniform valley width from Mackinnons Garden down to 1 km upstream of Loudon Hill.

Downstream of Loudon Hill the valley flats extend up to 2 km wide. Between the power line at GR 033673 and Lonekers Bush, the valley narrows to a uniform width of about 1.5 km. As the valley converges with Waiau Valley, adjacent to Otahu Flat, valley width opens up considerably to greater than 3 km.

Terrace character
Upstream of Loudon Hill, terraces are scarcely evident as valley flats are very poorly defined. Terraces are extremely discontinuous, remnant, valley-marginal features. Downstream of Loudon Hill, terraces are much better defined on the left bank of Wairaki River. Terraces are generally unpaired, with a distinct upper terrace evident only on the left bank.

Left bank
Immediately downstream of Loudon Hill there are three continuous, well-defined terraces, the upper of which is the most substantive (30-40 m above terrace 2). Terrace 2 is about 8-10 m above the present channel. Terrace 1 is a discontinuous feature 4-5 m above the channel. Moving downstream the lower terrace surface is only 2-3 m above the channel, and is a much more extensive and continuous surface (especially between Run 47 Road and Waiau River confluence). Upstream of Clifden-Blackmount road bridge (at GR 998 614) a distinct flight of teraces is evident on the left bank, with the upper surface especially prevalent. At Waiau River confluence the Wairaki terraces merge with Waiau Valley terraces. The alignment of terraces reflects the former sediment build up at this point, with subsequent reworking evident.

Right bank
Downstream of Loudon Hill the upper left bank terrace evident is a discontinuous, remnant feature on the right bank. The 8-10 m high terraces is also not evident at this stage, but this feature is evident by GR 033647, and is locally eroding between GR 016617 and the downstream end of the terrace (GR 007615) where the river abuts against bedrock. Upstream of Clifden-Blackmount road bridge (at GR 998 614) there is a discontinuous terrace 15-20 m above the channel. This feature is attached at its head to a high remnant outwash cliff. This terrace pinches out to a 5-6 m high terrace at the confluence with an unnamed large, narrow tributary. Downstream of GR 991615 (beyond Clifden-Blackmount road bridge) the channel abuts against the ridge of ancient outwash bedrock once more, forming a cliff 30-40 m high.

Extent of Alluvial flat
Upstream of Loudon Hill, alluvial flats are generally restricted to narrow zones between broad bends. Flats becomes much more extensive beyond Loudon Hill. At the upstream end of Loudon Hill subreach, flats are up to 1 km wide. Within this area there is a broadly sweeping channelized zone, which occupies about 25 % of the alluvial flats. The active channel(s) takes up 20-25 % of the channelized zone.

At GR 036676 the alluvial flats have a highly dissected, irregular surface, with a large number of abandoned channels/islands of differing topographic level and vegetation cover. Active channel surfaces are spread over a channelized zone 150-200 m wide, among flats that may be up to 500 m wide.

At GR 033658 the surface has become even more dissected, with areas of 4 or 5 channels in an active channel zone > 200 m wide.

At GR 028621 the alluvial flats are laterally extensive and highly dissected, with broom cover and occasional willow plantings at channel margins.

Upstream of the Clifden-Blackmount road bridge (GR 991615) the alluvial flats are up to 1 km wide, but are locally constrained to a few hundred metres wide by bedrock cliffs and lower terraces.

Immediately downstream of the Clifden-Blackmount road bridge (GR 991615) the alluvial flats are much less extensive, as the channel is constrained by bedrock or the lower terrace on the right bank. This bedrock is also partially evident on the left bank, confining the channelized zone to about 80-100 m. This channelized zone is dominated by barely vegetated bar platform gravels and the channel itself.

Beyond the cliff constriction the flats widen significantly (at GR 984615). These extensive, broom covered surfaces are somewhat jumbled, with abundant coarse pavement materials. At the confluence itself the flats have loose sheets of smaller gravels up to 50 mm thick on the surface.

Degree and character of channel constriction

Upstream of Loudon Hill, Wairaki River flows in a bedrock-constrained narrow valley. The right bank of Wairaki River abuts against Loudon Hill. Downstream of this point the channel is relatively unconstrained for about 7 km, until Wairaki River abuts against bedrock cliffs 2 km upstream of Clifden-Blackmount road bridge. This constraint defines Loudon Hill and Wairaki Hill subreaches. In the upper, Loudon Hill subreach there are at least two points at which the right bank of the Wairaki River is eroding the lower terrace (e.g. downstream of the pine plantation at GR 033658) and immediately upstream of the cliff between GR 016617 and 007615.

The right bank of the channel locally abuts against cemented terraces and bedrock in the zone immediately upstream and downstream of Clifden-Blackmount road bridge. Terraces appear to be less reworked than upstream, with more extensive lower surfaces. This could imply greater stability of the channel at this location, or simply the fact that there is a greater volume of materials to be removed in this area. Immediately downstream of Clifden-Blackmount road bridge (at GR 991615) the channel is more confined that at any other point upstream. The valley widens considerably beyond this bedrock-constrained zone.

Character and impact of tributary streams

Widening of Wairaki Valley, and the concomitant development of alternating gravel bars in the reach upstream of Loudon Hill, are coincident with Telford Burn and Gibralter Burn confluences. Downstream of Gibralter Burn confluence, a series of small right bank tributaries join Wairaki River from the foothills of Takitimu Mountains. The small catchments of these tributaries ensures that they exert negligible impact on Wairaki channel itself. Cessnock Creek, which drains a larger right bank catchment, also exerts little impact on Wairaki River. Downstream of Loudon Hill a number of small streams/ditches enter Wairaki River. Most of these tributaries are aligned down-valley on the alluvial flats prior to joining the river. This indicates that they exert relatively little control on the character of the Wairaki. Just upstream of Clifden-Blackmount road bridge, at GR 997615, the Wairaki is joined by a substantial channel on its right bank. This tributary drains an extensive catchment, but it appears to exert negligible impact on the Wairaki. The tributary has a low W:D, and appears to be incised into its own deposits.

Surficial geology

Wairaki River is the primary south-draining catchment in the volcanic Takitimu Mountains. The Takitimu Group comprises sub-vertical sediments and intercalated lavas of Permian age. Rock types include grey, red and green tuffaceous sandstone and tuff, volcanic breccia, pillow lavas, and andesitic flows and sills. Foothills, including Loudon Hill, are composed of tilted sedimentary strata of Tertiary age. These include quartzo-feldspathic sandstone and mudstone, calcareous sandstone and limestone (and grey massive mudstone). Further downstream, in the cliffs both upstream and downstream of Clifden-Blackmount road bridge and adjacent to Wairaki Hill, tilted sedimentary strata consist of marine siltstones and mudstones, along with cemented outwash gravels. Substantial outwash terraces indicate the dominant role played by the glacial history in shaping the configuration of the landscape and hence sediment availability.

Vegetation

Valley side/flats : Pasture with occasional scrub. Manuka with occasional cabbage trees are evident on terrace risers. These become more densely vegetated down-reach. Pine plantations are evident on the right bank downstream of the power line, and on the left bank at the valley bend prior to the cliffed reach upstream of the bridge.

Alluvial flats/Bank/Bars : Grasses and broom, with occasional exotic weeds and toi toi on the flats. Lupins become more extensive downstream.

Land use

Pasture. Local pine plantations.

Direct human impacts

Many diversion channels are evident, with much gravel reworking in the channel zone and on the adjacent alluvial flats. This includes discontinuous stop banks (e.g. GR 034662), ditching of flats and tributary streams, and local willow plantings on banks. The gravel bar upstream of Clifden-Blackmount road bridge is used for gravel extraction, while various segments of the alluvial flats downstream of the bridge have ploughed-up and bulldozed gravel surfaces. Immediately downstream of Waiau confluence there are a series of pole-planted willows.

LOUDON HILL SUBREACH (Takitimu (D44), GR 053707 to Ohai (D45) 016616)

CHANNEL CHARACTERISTICS

Number of channels : Locally variable dependent on the degree of definition of the primary channel and the extent of dissection of adjacent bars and alluvial flats. Although there are typically 2-3 channels at the reach head, at GR 033658 one primary channel is evident, but 5 or 6 flood channels dissect bars and flats. At GR028621 the primary channel is less distinct, and flow is more equally divided among 4-6 channels, with additional channels at the margins of the channelized zone. At GR 012615 the primary channel is well-defined once more, with a prominent thalweg, but several other channels are still active and there are a number of additional channels on the adjacent flats.

Channel geometry : Highly variable. The thalweg is occasionally well-defined but typically the W:D approaches 40. At GR 033658 a section of white water indicates that there is a coarse lag material on the channel bed. At GR 028621 the channel has a highly irregular geometry. Shallow banks permit rapid channel adjustment and realignment and development of a chaotic channel pattern. Even as the definition of the channel thalweg improves downstream (at GR 012615), the banks are still shallow.

Sinuosity : At the reach head the channel has a low sinuosity, although the broad channelized zone appears to alternate between broad bends and relatively straight sections. The pattern adopted by individual smaller channels is highly variable, but the primary direction of bar movement appears to be downstream rather than lateral, and sinuosity is generally low. At GR 028621 the pattern of channel alignment/division is chaotic, but few channels are other than low sinuosity. Many channels are aligned diagonally down-valley. At GR 012615 the broad channel outline has become more sinuous as the primary channel becomes better defined. By GR 998614, however, the sinuousity is generally very low once more.

Lateral stability of channel(s) : At the reach head the channels are clearly unstable, with many eroding shallow banks, evidence of stripped alluvial flats, and large areas of active gravel surfaces. Dissection of islands is prominent, and banks are generally very shallow. At GR 012615 the channel abuts against a 10-12 m terrace on the right banks, but remains unconstrained on the left bank.

Bar type and scale

The head of Loudon Hill subreach is characterized by large, dissected bank-attached compound bars. At high discharge stages many of these will appear as mid-channel features, as chute and side channels are occupied. A series of topographic levels are evident. As the number of channels increases downstream, bars become more complex features. At lower discharge stages the subreach at GR 033658 takes the form of a wandering gravel-bed river, with one primary channel and well-established bank-attached compound bars. The active gravel surface is locally very extensive, especially on the insides of broad bends in the channelized area. Flow over these surfaces is often diagonally aligned, producing a large number of discrete lobes over the bar surface. At GR 028621 there is an extremely chaotic dissected gravel sheet, with mid-channel compound bars commonly cut by 2-3 channels. These smaller channels may have small scale unit bars within (commonly longitudinal forms). Flow and gravel movement tracks are aligned down-valley rather than laterally, with many long thin neck at the bar tail.

Bed/Bank character (extent and materials)

At the head of Loudon Hill subreach, banks on islands are locally eroding. A sand layer is noted at the bank surface, and appears to comprise almost half of the 1 m high bank. This depositional unit appears to represent a relatively recent accumulation zone which is being readily reworked. Bar surfaces do not appear to be well packed, and are only moderately sorted. Bar surfaces are locally quite well imbricated. Fine gravel sheets have spread over some bar surfaces, while some flats have been stripped.

Between GR 033676 and 033658 the sand unit that makes up part of the right bank has 30-50 cm of fine gravels atop. This seemingly confirms the pattern of local aggradation and subsequent incision. Bar surfaces appear more jumbled and less imbricated than upstream, with a large number of loose clasts between 20-200 mm liberally spread over an irregular surface of reworked lag clasts up to 300 mm wide. Deposits in chute and side channels are commonly very well sorted, with large accumulations of relatively thick gravels. In one instance, a 40 cm thick lens was observed, while in an adjacent channel a lens fill between 50-120 mm is liberally spread over the channel floor. These are extremely loose, well winnowed and highly mobile surfaces, and contrast starkly with lag deposits evident on reworked flats and islands.

At GR 028621 banks are very poorly defined and composed of loose, highly erodible gravels. The lack of cohesive bank material, associated with the vast availabilty of clasts, has exceeded the capacity limit of Wairaki River and a braided planform has been induced.

Flow character

Flow character is locally variable in Loudon Hill subreach, conditioned largely by the pattern of channel multiplicity. Close to the reach head (at GR 033676) flow is shallow and rapid, although riffles are irregularly spaced. A few kilometres downstream (at GR 033658) flow and riffle-spacing are locally uniform. As flow is highly dissected around a series of dissected mid-channel bars at the downstream end of Loudon Hill subreach, there are a large number of small riffles. These are irregularly spaced, with occasional pools as flow rejoins.

Other comments

At the downstream end of Loudon Hill subreach (GR 028621), Wairaki River flows around a complex gravel sheet, with remnant pavement/basal gravels drowned out by smaller clasts. This sheet has a shallow fan morphology. At this point the system is considerably more multichannelled than upstream, indicating that the large sediment volume that has built up in the past is now being actively reworked. Many channels actually appear to be perched within the sediment lobe, and are actually higher than the adjacent alluvial flats. This is a highly localized feature, as 1 km downstream, in Wairaki Hill subreach, the channel regime is much more regular, with a single-channelled course around large compound point bars (at GR 012615). This implies either that reworking of the former fan surface is complete or that the fan has yet to over-ride Wairaki Hill subreach.

SAMPLE SITE CHARACTERISTICS

Sample number : **WA1** Analysts : GB, AB, AH

Grid reference : Ohai (D45) 1:50,000; 036676

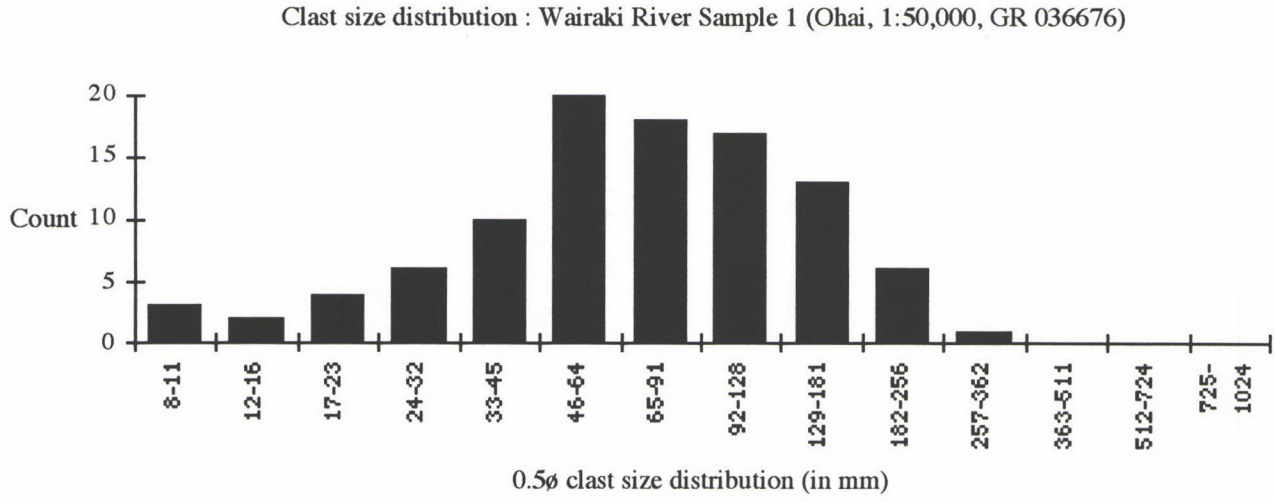
Sample type : 1 x 50 @ 0.5 m interval

Bar type : Large bank-attached compound bar, cut off by a side channel on the left bank. Exposed gravel surface is primarily one depositional unit, with lobes of fine gravel/sand atop. The larger bar is a complex, dissected feature.

Sample position on bar : On exposed gravel surface at the channel margin, immediately downstream from a riffle close to the head of the bar.

'Particle characteristics'

0.5ø Clast size frequency Histogram



D95 190 mm; D84 145 mm; D50 70 mm; D16 35 mm; D5 15 mm

Mean 86.4 mm; Sorting 58.5 mm

Sorting : Very poor, as indicated by the spread in the histogram above.

Packing arrangement : No pavement evident, but some of the larger clasts do appear to act as a basal lag. Bar surface is jumbled and relatively loose, although some clasts are well-buried. Poor to moderate imbrication. Lobes of finer gravels/sand cover certain areas of the bar.

Shape : Blocky, subrounded, with a small proportion of blades/discs.

Lithology : Mixed, with a relatively large proportion of sedimentary-derived clasts.

Other characteristics : Area of bar sampled is largely unvegetated.

Sample number : **WA2** Analysts : GB, AB, AH

Grid reference : Ohai (D45) 1:50,000; 033658

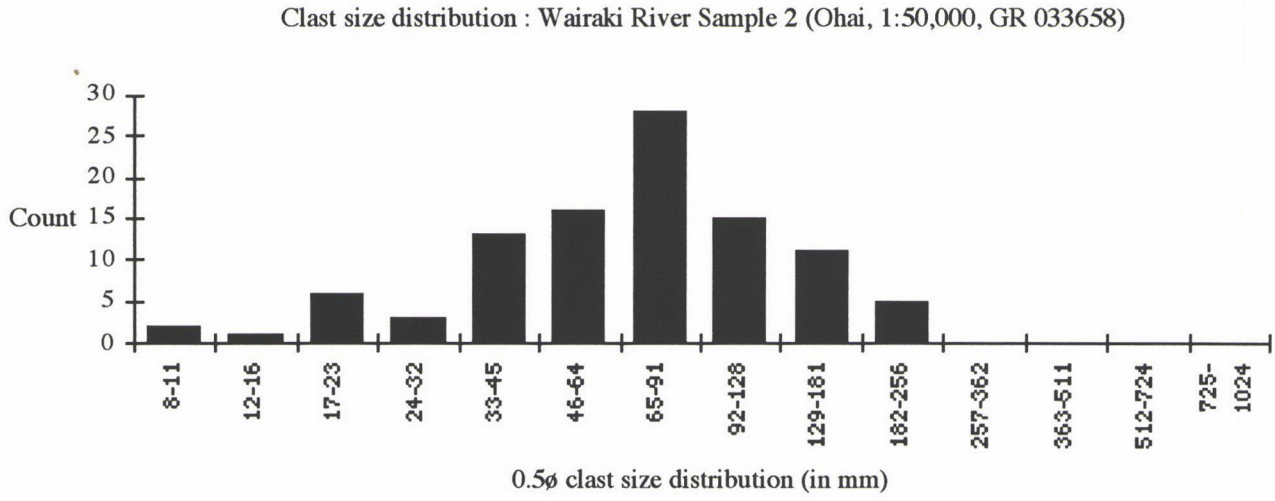
Sample type : 1 x 50 m @ 0.5 m interval

Bar type : Dissected bank-attached compound bar, separated from alluvial flats by a major chute channel. Pioneer broom are evident in a fine-gravel locale at the bar margin, while young willows have established at the bar tail.

Sample position on bar : Water's edge sample close to the bar head.

'Particle characteristics'

0.5ø Clast size frequency Histogram



D95 180 mm; D84 125 mm; D50 70 mm; D16 40 mm; D5 20 mm

Mean 82.4 mm; Sorting 48.8 mm

Sorting : Moderately poor, with locally well-sorted discrete lobes of finer-grained material.

Packing arrangement : Highly jumbled/chaotic surface, with a mixed gravel population. Surface is unwinnowed, with some evidence of lag deposits. Surface does not appear paved, and there is little evidence of imbrication.

Shape : Subrounded to subangular, with a large number of fractured gravels.

Lithology : Mixed.

Other characteristics : Some human modification evident in the channel upstream, with bulldozed gravel mounds and stop-bank development. Gravels are locally sorted in the adjacent channels. Strips of willow are evident at the tail of the bar, while pioneer broom has established on the supraplatform.

Sample number : **WA3** Analysts : GB, AB, AH

Grid reference : Ohai (D45) 1:50,000; 028 621

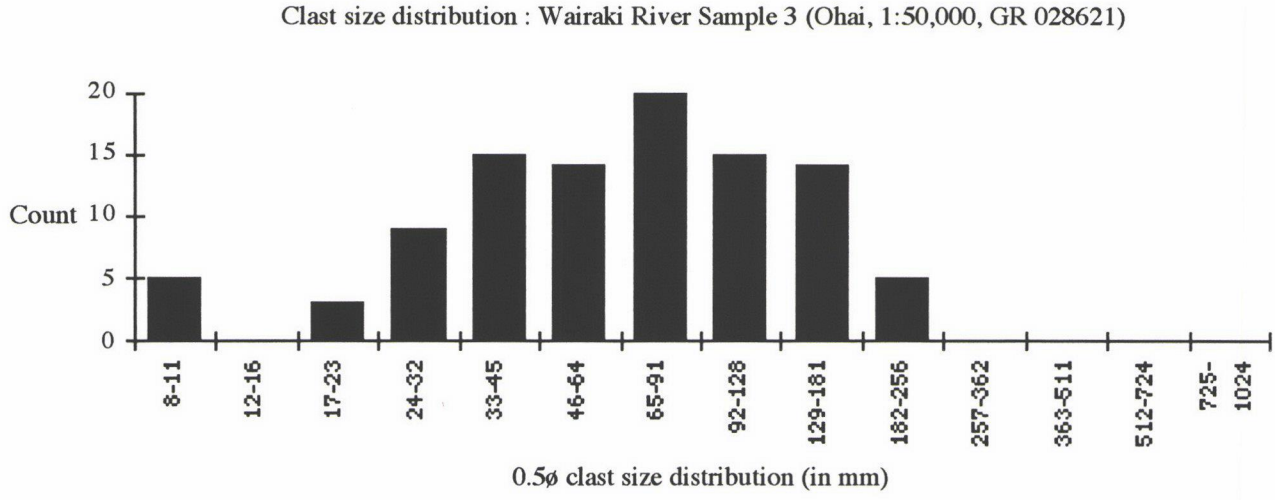
Sample type : 1 x 50 m @ 0.5 m

Bar type : Mid-channel compound bar that forms part of a large, highly dissected gravel sheet. This is part of a large fan-like complex, with a large number of diverse morphostratigraphic units. The sampled bar has a major ridge down its spine. This is the focal point for the coarsest gravels, while finer materials have accumulated at the tail of the bar and along the flanks of the ridge.

Sample position on bar : In the middle of the bar complex, in a transect aligned down-riffle at the water's edge.

'Particle characteristics'

0.5ø Clast size frequency Histogram



D95 180 mm; D84 130 mm; D50 70 mm; D16 40 mm; D5 10 mm

Mean 80.6 mm; Sorting 51.5 mm

Sorting : Very poor, with a widely dispersed distribution.

Packing arrangement : No pavement; jumbled surface in the coarse clast zones, while the finer gravel units appear to be more tightly packed. Coarse clasts are relatively loose, with some finer materials trapped at their lee. Moderately imbricated unit, with little or no winnowing.

Shape : Blocky; subangular to subrounded.

Lithology : Mixed.

Other characteristics : Relatively young accumulation zone, with grasses, weeds, lupins and other low-lying plants. .

Wairaki River Photo 1, Loudon Hill subreach
Gibralter Burn confluence with Wairaki River, looking upstream. Note the extensive active gravel surfaces with a well-defined primary channel. Secondary channels are generally restricted to side channels associated with the pattern of bends.
16.01.93 AHF 1/27 Takitimu (D44) 1:50,000, GR 093718



Wairaki River Photo 2, Loudon Hill subreach
View upstream of Wairaki River immediately downstream of Gilbralter Burn (in the background). Mackinnons Gardens are evident on the left hand side. Note the extensive gravel surfaces, with occasional channel division in bends.
16.01.93 AHF 1/28 Takitimu (D44) 1:50,000, GR 076714



Wairaki River Photo 3, Loudon Hill subreach
Wairaki River looking upstream, 4 km upstream of Loudon Hill. Note the irregular sinuosity of differing bends, with varying degrees of channel division.
16.01.93 GBF 1/27 Takitimu (D44) 1:50,000, GR 068727



Wairaki River Photo 4, Loudon Hill subreach
Wairaki River looking downstream, 3 km upstream of Loudon Hill. Note the narrower valley flats in this subreach, with increased valley width downstream (in the background).
16.01.93 GBF 2/13 Takitimu (D44) 1:50,000, GR 060728



Wairaki River Photo 5, Loudon Hill subreach
Wairaki River looking downstream, with Cessnock Creek on the right hand side in mid-photo and London Hill behind. Note the less well-defined sequence of bends in this reach, with much greater channel division. Valley flats are much more extensive than upstream.
16.01.93 GBF 2/15 Takitimu (D44) 1:50,000, GR 056714



Wairaki River Photo 6, Loudon Hill subreach
Wairaki River 2 km downstream of Loudon Hill. Flow direction is to the left. Note the irregular channel morphology and extensive alluvial flats and terraces. Sample site WA1 was located on the mid-channel compound bar on the left hand side of the photograph in mid-photo.
16.01.93 GBF 2/17 Ohai (D45) 1:50,000, GR 036680



Wairaki River Photo 7, Loudon Hill subreach
View upstream of Wairaki River, with Loudon Hill in mid-photo. Channel division is irregular in this reach, with some prominent side channels.
26.01.93 8-18 Ohai (D45) 1:50,000, GR 034672



Wairaki River Photo 8, Loudon Hill subreach
Sample site WA1, located on a mid-channel compound bar. The adjacent alluvial flats have been scoured. The right bank is locally eroding, and has a distinct fine-grained cap.
26.01.93 8-16 Ohai (D45) 1:50,000, GR 036676



Wairaki River Photo 9, Loudon Hill subreach
Wairaki River, between sample site WA1 and WA2. Note the downstream transition from a single channel, to a divided channel in the broad bend.
26.01.93 8-17 Ohai (D45) 1:50,000, GR 034672



Wairaki River Photo 10, Loudon Hill subreach
Downstream of sample site WA1 the primary channel becomes less well defined and active alluvial flats become more extensive. Several high-stage chute and side channels are evident. These are generally unvegetated.
26.01.93 8-19 Ohai (D45) 1:50,000, GR 033668



Wairaki River Photo 11, Loudon Hill subreach
Wairaki River, between 4-5 km downstream of Loudon Hill. Flow is from right to left. The primary channel is less well defined than upstream.
16.01.93 GBF 2/18 Ohai (D45) 1:50,000, GR 035655



Wairaki River Photo 12, Loudon Hill subreach
Sample site WA2, looking downstream. This dissected compound point bar is located immediately downstream at the right bank pine plantation shown on the photograph above. Note the extensive broom and willow in the channelized zone.
26.01.93 8-21 Ohai (D45) 1:50,000, GR 033658



Wairaki River Photo 13, Loudon Hill subreach
Erosion of the right bank immediately downstream of sample site WA2. Note the eroded fence and the extensive proportion of fines in the bank exposure, and the planted willows on the left bank.
26.01.93 8-22 Ohai (D45) 1:50,000, GR 033657



Wairaki River Photo 14, Loudon Hill subreach
View upstream of Wairaki River, with the Takitimus in the background. The well-defined channelized zone becomes wider downstream, with an according increase in the extent of active gravel surfaces. Sample site WA3 was located on the highly dissected bar complex in mid-photo.
16.01.93 AHF 1/29



Wairaki River Photo 15, Loudon Hill subreach
View upstream towards Loudon Hill, taken from Run 47 Road. Note the extensive valley flats and the well-defined channelized zone.
26.01.93 8-14 Ohai (D45) 1:50,000, GR 043644



Wairaki River Photo 16, Loudon Hill subreach
View upstream of Wairaki River, with Loudon Hill in the background. The highly dissected bar complex in mid-photo is actually perched above adjacent alluvial flat. Sample site WA 3 was located on one of the small mid-channel bars at the downstream end of this complex.
16.01.93 GBF 2/24 Ohai (D45) 1:50,000, GR 026610



Wairaki River Photo 17, Loudon Hill subreach
View downstream at Sample site WA3. This small mid-channel bar forms part of a large complex bar complex with 5 or 6 active channels.
26.01.93 8-26 Ohai (D45) 1:50,000, GR 028621



Wairaki River Photo 18, Loudon Hill subreach
Aerial view downstream overlooking the lower course of Wairaki River, with Waiau valley in the background. Sample site WA3 was located on the bar complex on the extreme right hand side of the photograph. Downstream of this point the primary channel is better defined, although some subreaches are multi-channelled. A sequence of dissected broad bends is evident. The transition from Loudon Hill subreach to Wairaki Hill subreach is determined by the upper terrace margin in mid-photo. The river is clearly more confined and less multichannelled in the downstream subreach.
16.01.93 GBF 2/22



WAIRAKI HILL SUBREACH (Ohai, GR 016616 to 979614)

CHANNEL CHARACTERISTICS

Number of channels : The number of channels is extremely variable over very short distances. At the head of a bank-attached bar 1 km upstream of Clifden-Blackmount road bridge, four channels are evident. These rejoin at the bar head. Between Clifden-Blackmount road bridge and the first downstream fisherman's hut the channel divides into two or three channels. At GR 994615 the channel becomes bedrock-constrained on both banks, and a single channel is adopted. Beyond the bedrock confined subreach (at GR 988614) the channel divides around dissected mid-channel bars with 3 or 4 channels evident, prior to a shallow fan surface at the confluence. While 4 or 5 channels are evident over the fan surface, flow is presently constrained within a single channel that is deflected to the northern (i.e. upstream) end of the fan. The Waiau itself seemingly exerts no influence on the fan or channel position.

Channel geometry : Upstream of Clifden-Blackmount road bridge (at GR 998614), channel geometry is extremely variable. Some sections are characterized by a large number of riffles, while sections immediately downstream have a single channel with a well-defined thalweg. Downstream of Clifden-Blackmount road bridge the channel becomes much more regular, although flow is disrupted around boulders on the channel bed. At the Waiau confluence, Wairaki River has adopted a well-defined, regular channel cross-section.

Sinuosity : Wairaki Hill subreach is characterized by a very low sinuosity channelized zone, within which the character of individual channels is locally variable. As the channel abuts against bedrock downstream of Clifden-Blackmount road bridge it has adopted a broad bend configuration, with well-defined point bars on the inside of bends. Immediately upstream of the Waiau confluence Wairaki River has a very low sinuosity course, with some sections that are virtually straight.

Lateral stability of channel(s) : In general Wairaki River is more laterally stable in Wairaki Hill subreach compared to upstream, conditioned largely by imposed bedrock cliff and terrace constraints on the channel. Upstream of Clifden-Blackmount road bridge (at GR 998614) there are a series of diagonally or down-valley aligned bars, in dissected bar complexes. Minimal lateral component to movement is evident.

Downstream of Clifden-Blackmount road bridge the channel is laterally constrained by bedrock on both banks. Large gravel point bars have developed on the insides of broad bends. The channelized zone is about 80-100 m wide, with the channel itself 20-30 m wide. Bars become less dissected by chute channels downstream. At the Waiau confluence bar types are extremely unstable, with a very large, unvegetated shallow fan surface dissected by a large number of channels.

Bar type and scale

In Wairaki Hill subreach, the primary channel is generally better-defined than upstream. At the subreach head the channel is locally more sinuous than upstream, and a series of compound point bars have developed (e.g. GR 012615). These exemplify a more significant lateral component of flow, but bars are still highly dissected by chute channels. For example, upstream of Clifden-Blackmount road bridge at GR 998614 there are a series of small dissected diagonal and longitudinal bars in a large dissected sheet. This sub-reach is abruptly transitional to a single-channelled section with bank-attached compound bars.

Immediately downstream of Clifden-Blackmount road bridge a series of down-valley oriented dissected mid-channel bars and unit bars are transitional to an alternating sequence of broad point bars in a laterally confined reach. Prominent riffles are noted at the bar heads. Point bars have well-defined platforms. These are generally unvegetated other than a few pioneer grasses. Large chute channels are also evident.

Beyond the bedrock confinement, flow divides once more around a series of dissected mid-channel bars. At the Waiau confluence there is an extensive sheet of active gravels in a shallow fan form. A large number of channel forms indicate that this would be a highly dissected surface at higher flow stages. A number of depositional lobes are evident over the fan surface.

Bed/Bank character (extent and materials)
At the head of Wairaki Hill subreach (GR 012615) the bar surface is moderately imbricated, with discrete lobes of finer gravel atop. Immediately upstream of Clifden-Blackmount road bridge (at GR 998614), many discrete sedimentary lobes are evident over bar surfaces. This attests to the large volume and availability of highly mobile material. Locally undercut banks are shallow and composed of loose, moderately sorted gravels with a fine gravel/sand cap.

Downstream of Clifden-Blackmount road bridge (at GR 991615) the riffle at the head of a large point bar is composed of well-sorted finer clasts. This indicates that a veneer/lobe of smaller-grained material is moving over the mixed gravel population that comprises the bar itself. The bar surface is moderately imbricated, with occasional very large boulders (> 600 mm wide) that appear to be mobile at high flow stages. Bedrock banks are locally eroding at the outside of bends.

Beyond the bedrock reach, banks become shallow once more. Bars are composed of loose pavement gravels with finer gravel caps that are easily removed. These surfaces are mixes of reworked pavement with extensive sheets of smaller clasts and sands.

Flow character
At the head of Wairaki Hill subreach, where Wairaki River has adopted a single-channelled course with a series of broad bends, the thalweg is better defined than upstream. At GR 012615 there are a series of standing waves as flow energy becomes concentrated within the primary channel. Upstream of Clifden-Blackmount road bridge (at GR 998614), Wairaki River is locally divided into a series of small channels with abundant riffles. Flow is highly irregular in this section. Downstream, however, single-channelled sections are dominant, and flow is transitional from uniform to occasional rapid flow, with some standing waves in deeper water downstream of larger riffles. Flow remains more regular downstream of the Clifden-Blackmount road bridge, with increased spacing between riffles. Occasional white water is evident around boulders eroded from the adjacent cliffs at GR 991615. The single channelled section at the confluence has a sequence of standing waves. Riffles are still irregularly spaced, probably associated with the movement of different sediment lobes and their downstream position.

Other comments
The pattern of incision/aggradation is unclear around Clifden-Blackmount road bridge. The pronounced local variability in channel character suggests that there is significant reworking of large volumes of available material. As the channel becomes constrained in the bedrock confined reach downstream of Clifden-Blackmount road bridge, finer clasts are more efficiently 'flushed' through the lower course of the river. These are optimal conditions for gravel movement. There is a large slug of available sediment upstream, the discharge regime is quite variable, there is little vegetation to stabilize bar surface, and bedrock constriction at the bottom end of the system constrains flow. Widening of the valley adjacent to Waiau confluence presents an ideal circumstance for gravel accumulation. At the confluence, fine sheets are found atop coarse basal gravels.

SAMPLE SITE CHARACTERISTICS

Sample number : **WA4** Analysts : GB, AB, AH

Grid reference : Ohai (D45) 1:50,000; 012615

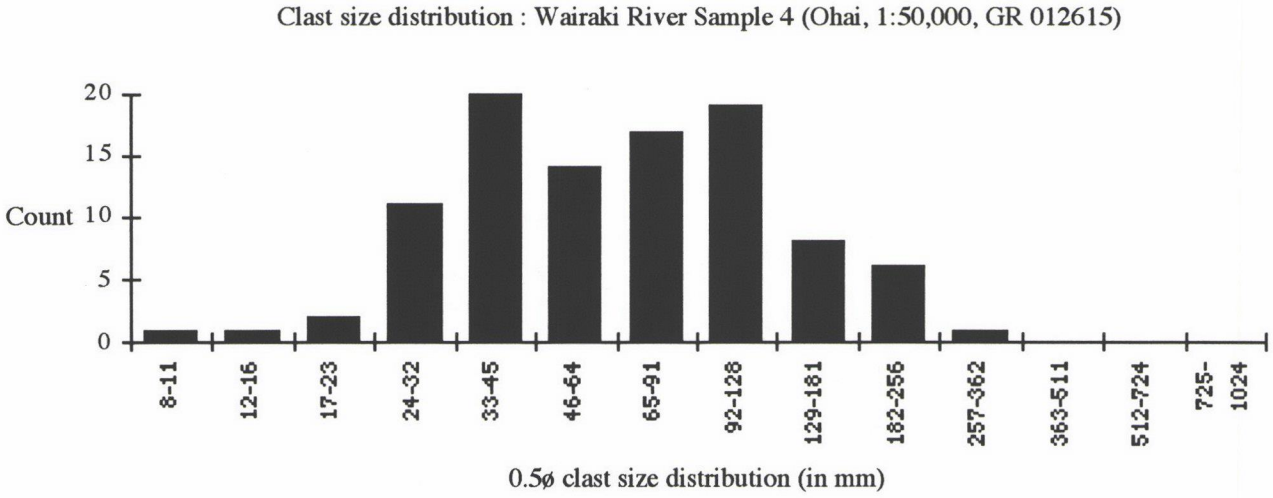
Sample type : 2 x 25 m @ 0.5 m interval

Bar type : Dissected compound point bar, with a riffle at the bar head. Sheets of finer gravels make up a partial platform on the bar. Smaller chute channels are also evident dissecting the bar surface.

Sample position on bar : Aligned down-chute adjacent to the bar head. Transects located 5 and 7 m from the water's edge.

'Particle characteristics'

0.5ø Clast size frequency Histogram



D95 200 mm; D84 120 mm; D50 65 mm; D16 35 mm; D5 25 mm

Mean 79.6 mm; Sorting 51.7 mm

Sorting : Poor, with a widely spread distribution.

Packing arrangement : Moderately packed, with loose, finer gravels atop. Moderately imbricated at the bar head. Clasts become more jumbled down-chute. Largely an unwinnowed surface.

Shape : Blocky; subangular to subrounded.

Lithology : Mixed

Other characteristics : Some organic debris on bar surface. Sparse small vegetation, including broom, grasses and lupins.

Sample number : **WA5** Analysts : GB, AB, AH

Grid reference : Ohai (D45) 1:50,000; 998614

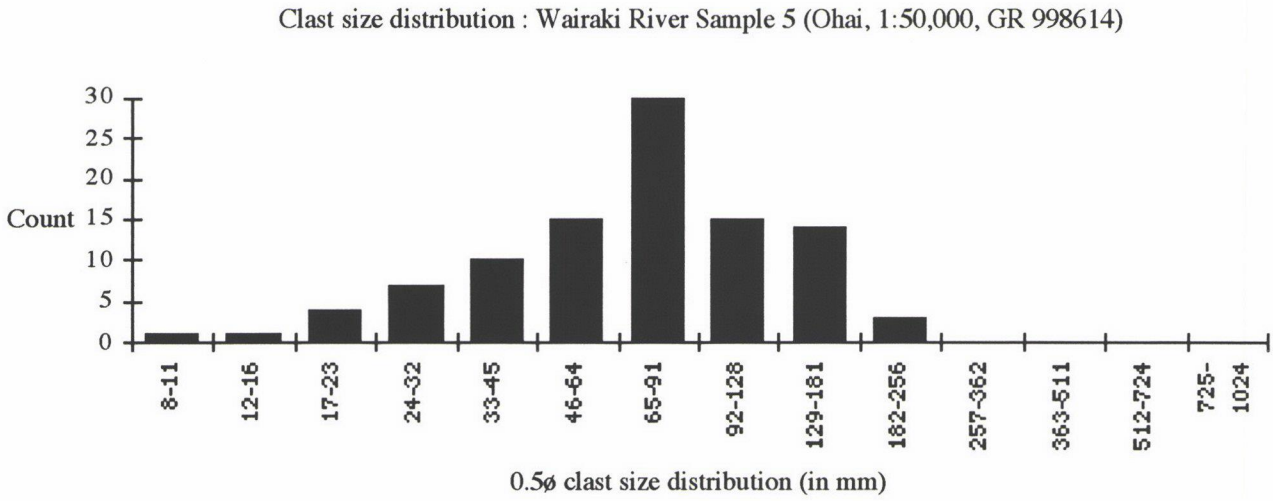
Sample type : 2 x 25 @ 0.5 m interval

Bar type : Bank-attached compound bar. Bar has a large riffle at its head, as a series of channels merge at the downstream limit of a multi-channelled subreach. Bar platform is prominent, with a small chute channel at the bar margin.

Sample position on bar : Head of bar, immediately downstream of a riffle. Transects located at water's edge and 2 m inshore.

'Particle characteristics'

0.5ø Clast size frequency Histogram



D95 165 mm; D84 130 mm; D50 75 mm; D16 40 mm; D5 20 mm

Mean 81.9 mm; Sorting 45.7 mm

Sorting : Moderately sorted clusters of equivalent size, but grain size range is similar to elsewhere and grades down to sands.

Packing arrangement : Low to moderate packing, with loose clasts on the bar surface. Imbrication is patchy, rather than uniform over the surface. Distinct sand sheet at the bar head, with further lobes and patches of sand over the bar surface are indicative of no winnowing.

Shape : Blocky; subrounded with some subangular clasts.

Lithology : Mixed population, with a significant number of sedimentary clasts.

Other characteristics : Unvegetated surface, with some clumps of organic debris on the bank and bar surface. Distinct reduction in grain size from the water's edge to the bar margin. Banks are well vegetated with broom, grasses and lupins.

Sample number : **WA6** Analysts : GB, AB, AH

Grid reference : Ohai (D45) 1:50,000; 991615

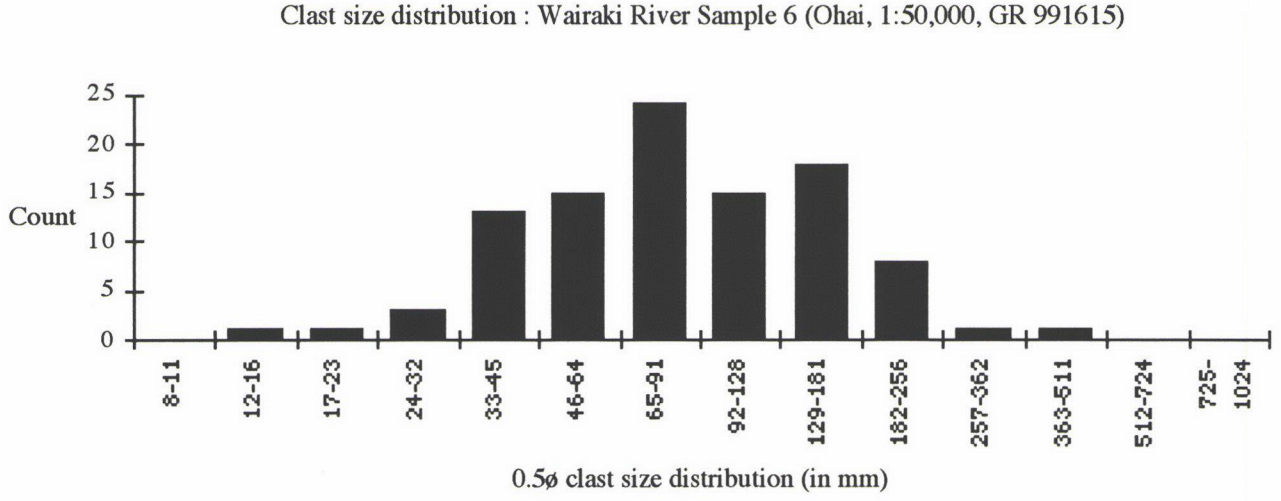
Sample type : 1 x 50 @ 0.5 m interval

Bar type : Bank-attached compound bar. Riffle at the head of the bar and a major chute channel against left bank, while right bank abuts against cliffed bedrock. Distinct bar platform at the water's edge.

Sample position on bar : At the bar head, downstream of the riffle; water's edge transect.

'Particle characteristics'

0.5ø Clast size frequency Histogram



D95 200 mm; D84 145 mm; D50 85 mm; D16 45 mm; D5 30 mm

Mean 99.4 mm; Sorting 59.6 mm

Sorting : Moderately poorly sorted.

Packing arrangement : No pavement visible; reasonably packed surface with a number of loose claste. Little or no imbrication. Winnowed down to 10-15 mm.

Shape : Rounded to subrounded; blocky, with a number of split blocks.

Lithology : Mixed, with a significant proportion of sandstone-derived clasts.

Other characteristics : Sparsely vegetated bar surface, with a number of sand layers.

Sample number : **WA-riffle** Analysts : GB, AB, AH

Grid reference : Ohai (D45) 1:50,000; 991615

Sample type : 1 x 20 m @ 0.2 m interval

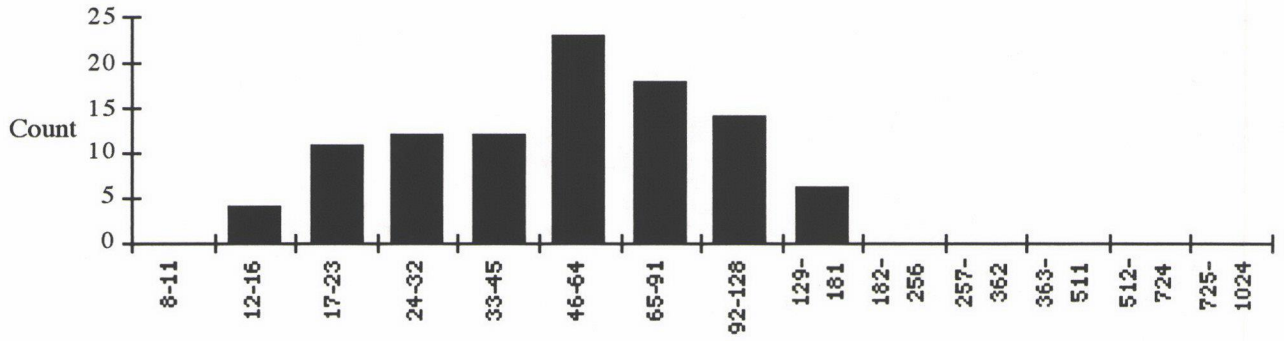
Bar type : Steep-fronted riffle at the head of a bank-attached compound bar. Located in a single-channelled section of river, as the right bank abuts against bedrock cliffs.

Sample position on bar : Along the top of the face of the steep riffle.

'Particle characteristics'

0.5ø Clast size frequency Histogram

Clast size distribution : Wairaki River Sample on riffle adjacent to WA6 (Ohai, 1:50,000, GR 991615)



D95 134 mm; D84 105 mm; D50 52 mm; D16 26 mm; D5 17 mm

Mean 61.3 mm; Sorting 36.8 mm

Sorting : Fairly well sorted. Clearly better sorted that other sample sites.

Packing arrangement : No pavement; Jumbled surface of very loose gravels with few buried or wedged clasts. No imbrication. Clasts winnowed down to 15 mm.

Shape : Rounded to subrounded; blocky.

Lithology : Mixed gravel population

Other characteristics : No vegetation. Many clasts are slime-covered. Within-riffle gradation in clast size evident, with coarsening upstream and downstream (i.e. possibility of a finer lens in mid-transect).

Sample number : **WA7** Analysts : GB, AB, AH

Grid reference : Ohai (D45) 1:50,000; 984615

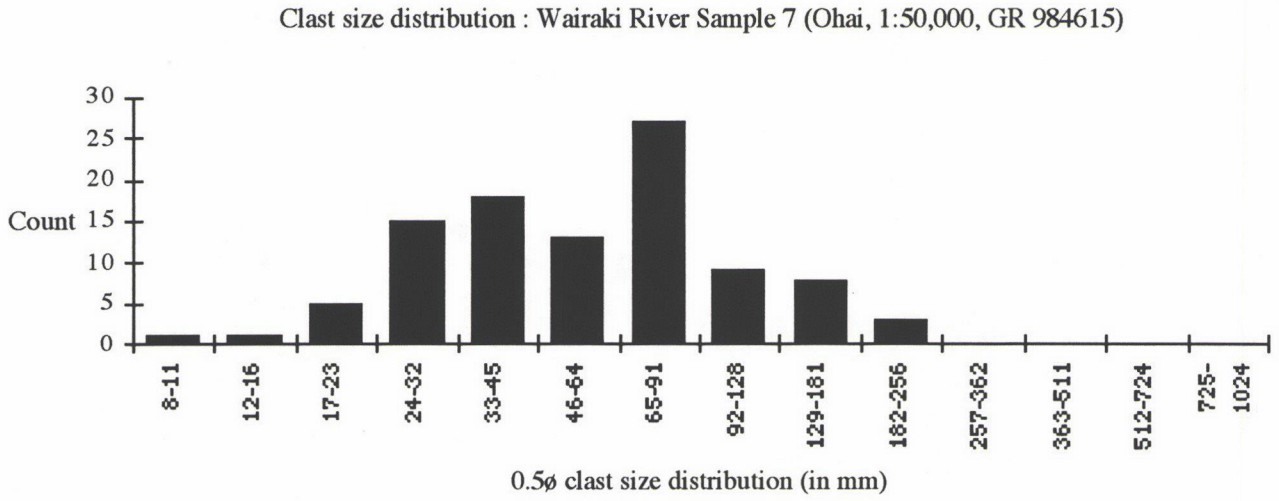
Sample type : 1 x 50 m @ 0.5 m interval

Bar type : Confluence bar with a shallow fan appearance. Bar has an extensive platform, with a chute channel at the left bank margin and a large riffle at its downstream junction with the Waiau.

Sample position on bar : Downstream from the head of the bar at the water's edge.

'Particle characteristics'

0.5ø Clast size frequency Histogram



D95 180 mm; D84 100 mm; D50 60 mm; D16 30 mm; D5 20 mm

Mean 69.2 mm; Sorting 45.9 mm

Sorting : Moderately poorly sorted, although sheets of moderately sorted gravels are evident over the bar surface. Bar becomes better sorted at the confluence itself.

Packing arrangement : No pavement. Many loose gravels at the head of the transect, grading down-transect to a well-packed and imbricated unit at the tail. Little winnowing evident.

Shape : Blocky; subrounded with occasional subangular.

Lithology : Mixed.

Other characteristics : Occasional grasses and lupins. Organic debris has been washed over the bar surface, along with sheets of sands and finer gravels.

Wairaki River Photo 19, Wairaki Hill subreach
View downstream showing the lower course of Wairaki River. Photograph is taken from Run 47 Road. Note the broad valley setting, with a distinct flight of terraces on the left bank, while the channel abuts (and is actually eroding) the right bank terrace. Sample site WA4 was located immediatlely upstream of this eroding terrace.
26.01.93 8-15 Ohai (D45) 1:50,000, GR 035616



Wairaki River Photo 20, Wairaki Hill subreach
View downstream at sample site WA4, located on a very large compound point bar with a major chute channel. Note the eroding right bank terrace in the background.
26.01.93 8-28 Ohai (D45) 1:50,000, GR 012616



Wairaki River Photo 21, Wairaki Hill subreach
The downstream end of Wairaki River, showing the confluence with Waiau River. Note the relative scales of Wairaki and Waiau River. The extensive shallow fan surface at Waiau River confluence is essentially of equivalent scale to the large point bar on the opposite bend upstream.
16.01.93 GBF 2/29



Wairaki River Photo 22, Wairaki Hill subreach
View downstream at the lower end of Wairaki River. Sample site WA5 was located at the head of the left bank bank-attached compound bar immediately upstream of Clifden-Blackmount road bridge. Channel multiplicity and sinuosity are locally variable in this subreach, controlled largely by the pattern of bedrock imposed constraints on channel movement.
16.01.93 GBF 2/26



Wairaki River Photo 23, Wairaki Hill subreach
View upstream of a locally dissected bar complex at the head of Sample Site WA5. Note the planted willows at the base of the terrace upstream.
27.01.93 8-29 Ohai (D45) 1:50,000, GR 999614



Wairaki River Photo 24, Wairaki Hill subreach
Sample site WA 5, located at the head of a bank-attached compound bar immediately upstream of Clifton-Blackmount road bridge. Note the much finer gravel unit in mid-photo.
27.01.93 8-30 Ohai (D45) 1:50,000, GR 998614



Wairaki River Photo 25, Wairaki Hill subreach
Wairaki-Waiau confluence. Note the right bank constriction on Wairaki River as it abuts against bedrock cliffs. Sample site WA 6 was located on the compound point bar adjacent to the white water in mid-photo.
16.01.93 GBF 2/27



Wairaki River Photo 26, Wairaki Hill subreach
Sample site WA 6. A second transect (WA-riffle) was completed on the distinct riffle at the bar head.
27.01.93 8-33 Ohai (D45) 1:50,000, GR 993615



Wairaki River Photo 27, Wairaki Hill subreach
Sample site WA 6, looking upstream. Sample site WA-riffle was collected on the large riffle in mid-photo. Note the distinctly finer nature of the gravels that are moving atop the materials on the bar surface. A number of boulders have fallen from the eroding bedrock cliffs.
27.01.93 8-35 Ohai (D45) 1:50,000, GR 990615



Wairaki River Photo 28, Wairaki Hill subreach
Bedrock constraints in lower Wairaki River are not restricted to the right bank. Both upstream and downstream of the large compound bar on which sample sites WA6 and WA-riffle were located the shallow left bank terrace was a bedrock base. This photo, taken at the downstream end of the sampled bar, shows the bedrock at the base of the left bank and even on the channel bed itself.
27.01.93 9/X Ohai (D45) 1:50,000, GR 988614



Wairaki River Photo 29, Wairaki Hill subreach
View upstream of Wairaki Hill, showing the downstream limit of the bedrock constriction on the right bank and the well-defined single channel of this subreach.
27.01.93 9/5 Ohai (D45) 1:50,000, GR 987613



Wairaki River Photo 30, Wairaki Hill subreach
View downstream of Wairaki-Waiau confluence. Sample site WA7 was located on the extensive gravel sheet that forms part of the shallow angle far at the confluence.
27.01.93 9/4 Ohai (D45) 1:50,000, GR 984614



Wairaki River Photo 31, Wairaki Hill subreach
Accumulation of fine gravels atop a coarse pavement at the head of the shallow angle far surface at Sample Site WA7. The sample was collected immediately downstream of this exposure.
27.01.93 9/1 Ohai (D45) 1:50,000, GR 983615



Wairaki River Photo 32, Wairaki Hill subreach
Expansive sheet of poorly sorted fine gravels and sands that extend over the shallow-angle fan surface at Wairaki-Waiau confluence.
27.01.93 9/2 Ohai (D45) 1:50,000, GR 982615



Wairaki River Photo 33, Wairaki Hill subreach
The shallow angle Wairaki fan at Waiau confluence.
27.01.93 9/3 Ohai (D45) 1:50,000, GR 983616



Wairaki River Photo 34, Wairaki Hill subreach
Aerial photograph of Waiau-Wairaki confluence, viewed from above Motu Bush.
16.01.93 GBF 3/15

