Environment Canterbury

Priority 2 Rivers Report Status of Gravel Resources and Management Implications

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1. Introduction

As part of Environment Canterbury's wider "Regional Gravel Management Investigation" MWH have been commissioned to prepare reports on the Status of Gravel Resources and Management Implications for twenty "List 2" rivers within the Canterbury Region.

Consideration of the List 2 river's gravel resources is important because:

- River gravels are used extensively throughout Canterbury (including from the List 2 rivers) as a construction material for roads, buildings and other infrastructure.
- Gravel aggradation in rivers is a crucial aspect of flood management. Allowing gravel to accumulate in the channel has the effect of reducing the channel capacity and increases the likelihood of a flood escaping the main channel.
- Extracting too much gravel risks damage to infrastructure such as stopbank collapse and bridge pier undermining. These types of events are hazardous to life and property.

The consideration of the List 2 rivers follows on from more detailed assessments of ten "Priority 1" rivers. Taken together with some previous studies by EMA, the Priority 1 and List 2 river assessments form the basis for a regional river gravel assessment.

2. List 2 Rivers

The List 2 rivers and some relevant descriptors for each are listed in Table 2.1.

Table 2.1: List 2 Rivers

River	General Location	Catchment Area (km^2)	Gravel Extraction (m^3/yr)	Comment
Clarence	Kaikoura	1,758	350[2]	
Oaro	Kaikoura	51	95[2]	
Conway	Kaikoura	503	23,350[2]	
Waiau	North Canterbury	3,334	19,020[2]	
Hurunui	North Canterbury	2,297[3]	4,430[2]	
Pahau	North Canterbury	360	280[2]	Tributary of Hurunui River
Kowai	North Canterbury	217	7,690[2]	
Selwyn	Mid Canterbury	633[4]	19,150[2]	
Waianawaniwa	Mid Canterbury	122	0[2]	Tributary of Selwyn River
Rakaia	Mid Canterbury	3,105	16,770[2]	
Kakahu	South Canterbury	149	60[2]	Tributary of Te Moana River
Twizel	Mackenzie Country	300	520[2]	
Lower Waitaki	Waitaki Valley	301[5]	510[1]	Below Waitaki Dam, no gravel from upstream
Hakataramea	Waitaki Valley	899	3,160[1]	Tributary of Waitaki River
Penticotico	Waitaki Valley	51	440[1]	Tributary of Waitaki River
Elephant Hill	Waitaki Valley	58	2,050[1]	Tributary of Waitaki River
Kurow	Waitaki Valley	47	2,630[1]	Tributary of Waitaki River
Otiake	Waitaki Valley	61	310[1]	Tributary of Waitaki River
Otekaieke	Waitaki Valley	116	1,010[1]	Tributary of Waitaki River
Maerewhenua	Waitaki Valley	290	420[1]	Tributary of Waitaki River

1. From ECAN gravel returns data 1990-June 2003.
2. From ECAN gravel returns data 1993-June 2005.
3. Listed Hurunui catchment area excludes Pahau River catchment area
4. Listed Selwyn catchment area excludes Waianawaniwa River catchment area
5. Listed Lower Waitaki catchment area excludes Hakataramea, Penticotico, Elephant Hill, Kurow, Otiake, Otekaieke and Maerewhenua River catchment areas

3. Estimates of Gravel Supply

3.1 Use of Waimakariri River Estimate

The estimated sustainable gravel yields for the Clarence, Conway, Waiau, Hurunui and Rakaia Rivers have all been derived from the Waimakariri River estimate. All of these rivers have large catchments that with the exception of the Conway extend to the Southern Alp's main divide.

When the Waimakariri River figure is used as the basis, the method used to estimate a List 2 river's sustainable gravel yields is to firstly prorata the Waimakariri figure using:

- The relative catchment areas
- The relative suspended sediment yields (as reported by NIWA in the Sediment from New Zealand Rivers Chart).

A further adjustment is made to reflect the slope of the river.

The Waimakariri River bed slope reduces markedly at the coast (the approximate slope 50km from the coast at RL 200m is 0.005 and the final 20m fall to the sea has a slope of around 0.0015). An effect of the Waimakariri River bed slope becoming more gradual at the coast is that the river's ability to transport gravel is reduced. This is shown by the tendency of gravel to aggrade in the Lower Waimakariri and the silty nature of the river mouth.

Other rivers without a similar flattening of the bed slope at the coast retain the ability to transport gravel to the coast and into the sea. This means the sustainable gravel yield of these rivers will be less than would be the case had they a relatively gradually sloping coastal reach and mouth.

Therefore, the prorated Waimakariri figure is further adjusted by reducing it by 30 to 75 percent (depending on the nature of the river in question) to calculate the estimated sustainable gravel yield.

3.2 Clarence River

The Clarence River is assessed using the suspended sediment yields from the NIWA "Sediment from New Zealand Rivers" map and the assumption that the proportion of bed load to total load is similar for the Clarence and the Waimakariri. The assessment estimates the Clarence River sustainable gravel yield from the Waimakariri's sustainable gravel yield of 250,000m^3/yr by:

- Pro-rating by 0.50 (= 1,758km^2 /3,543km^2) to account for the smaller catchment.
- Pro-rating by 0.42 (= 370/875) to account for the lower suspended sediment yield shown on the NIWA map.
- Reducing the yield by 60% to reflect the Waimakariri's higher specific yield due to the reduction of bed slope in the Waimakariri River at the mouth.

To give the estimated Clarence River sustainable gravel yield of 21,000m^3/yr.

3.3 Oaro River

To provide a desktop assessment of the gravel resource of the Oaro we have used the more detailed river gravel reports to find a proxy river against which to assess the Oaro. The Kowhai River stands out as the most similar river to the Oaro.

Specific similarities are:

- Geographical, the rivers are within 15 km of each other at their mouths.
- Bed slope, where both rivers are steep with reducing slopes to around 0.01 at the sea.

A couple of key differences between the two rivers are:

- Sediment yield potential, where the Kowhai River extends further inland than the Oaro and drains parts of the Seaward Kaikoura Range which have a relatively high sediment yield compared to those of the Oaro catchment and the remainder of the Kowhai catchment.
- Catchment area, where the Oaro catchment area (51km^2) is about 60 percent of the Kowhai (87km^2).

The specific sustainable gravel yield from the Kowhai River was estimated at about 210m^3/km^2/yr. On the basis of the listed similarities and differences between the Oaro and Kowhai Rivers the estimated specific sustainable gravel yield for the Oaro River is about 50m^3/km^2/yr. This corresponds to the estimated Oaro River sustainable gravel yield of 2,500m^3/yr.

3.4 Conway River

The Conway River is assessed using the using the suspended sediment yields from the NIWA "Sediment from New Zealand Rivers" map and the assumption that the proportion of bed load to total load is similar for the Conway and the Waimakariri. The assessment estimates the Conway River sustainable gravel yield from the Waimakariri's sustainable gravel yield of 250,000m^3/yr by:

- Pro-rating by 0.14 (= 503km^2 /3,543km^2) to account for the smaller catchment.
- Pro-rating by 0.5 (= 437/875) to account for the lower suspended sediment yield shown on the NIWA map.
- Reducing the yield by 60% to reflect the Waimakariri's higher specific yield due to the reduction of bed slope in the Waimakariri River at the mouth.

To give the estimated Conway River sustainable gravel yield of 7,000 m^3/yr.

3.5 Waiau River

The Waiau River is assessed using the using the suspended sediment yields from the NIWA "Sediment from New Zealand Rivers" map and the assumption that the proportion of bed load to total load is similar for the Waiau and the Waimakariri. The assessment estimates the Waiau River sustainable gravel yield from the Waimakariri's sustainable gravel yield of 250,000m^3/yr by:

- Pro-rating by 0.94 (= 3,334km^2 /3,543km^2) to account for the smaller catchment.
- Pro-rating by 840/875 to account for the lower suspended sediment yield shown on the NIWA map.
- Reducing the yield by 30% to reflect the Waimakariri's higher specific yield due to the reduction of bed slope in the Waimakariri River at the mouth.

To give the estimated Waiau River sustainable gravel yield of 158,000m^3/yr.

3.6 Hurunui River

The Hurunui River (excluding the Pahau River sub-catchment) is assessed using the using the suspended sediment yields from the NIWA "Sediment from New Zealand Rivers" map

and the assumption that the proportion of bed load to total load is similar for the Hurunui and the Waimakariri.
The assessment estimates the Hurunui River sustainable gravel yield from the Waimakariri's sustainable gravel yield of 250,000 m^3/yr by:

- Pro-rating by 0.65 (= 2,297km^2 /3,543km^2) to account for the smaller catchment.
- Pro-rating by 199/875 to account for the lower suspended sediment yield shown on the NIWA map.
- Reducing the yield by 60% to reflect the Waimakariri's higher specific yield due to the reduction of bed slope in the Waimakariri River at the mouth.

To give the estimated Hurunui sustainable gravel yield of 15,000m^3/yr.

3.7 Pahau River

The Pahau River is a tributary of the Hurunui River with its headwaters in the Tekoa Range. The NIWA "Sediment from New Zealand Rivers" map shows that the Pahau River catchment is around 60 percent within 10–50t/km^2/yr and around 40 percent within 50–200t/km^2/yr, specific suspended sediment yield areas. Using a weighted average approach averaged specific suspended sediment yield across the full catchment is estimated to be around 70t/km^2/yr.

If the bed load component of the sediment load is 20 percent of the total sediment load, the specific bedload yield would be 17t/km^2/yr. On this basis the sustainable gravel yield from the Pahau River could be around 3,000m^3/yr.

3.8 Kowai River

Of the ten Priority One rivers the Waipara River most closely resembles the Kowai River. Both rivers are located in North Canterbury and do not extend too far inland. Their coastal reaches cross similar glacial outwash gravels.

The estimated sustainable gravel yield from the Waipara River is 2,000m^3/yr. Pro-rating this figure on an area basis yields an estimated sustainable gravel yield of around 600m^3/yr.

3.9 Selwyn River

The Priority One river reports have no closely comparable river to the Selwyn River to make a "like" assessment from.

The NIWA "Sediment from New Zealand Rivers" map shows that the Selwyn River catchment is around 80 percent within 10–50t/km^2/yr and around 20 percent within 50–200t/km^2/yr, specific suspended sediment yield areas. Using a weighted average approach averaged specific suspended sediment yield across the full catchment is estimated to be around 50t/km^2/yr.

If the bed load component is 10 percent of the total sediment load, the specific bedload yield would be 5.5t/km^2/yr. On this basis the sustainable gravel yield from the Selwyn River could be around 1,800m^3/yr.

3.10 Waianawaniwa River

The Priority One river reports have no closely comparable river to the Waianawaniwa River to make a "like" assessment from.

The NIWA "Sediment from New Zealand Rivers" map shows that the Waianawaniwa River catchment is wholy within 10–50t/km^2/yr specific suspended sediment yield areas. The suspended sediment yield is estimated to be around 30t/km^2/yr.

If the bed load component of the sediment load is 10 percent of the total sediment load, the specific bedload yield would be 3.3t/km^2/yr. On this basis the sustainable gravel yield from the Waianawaniwa River could be around 200m^3/yr.

3.11 Rakaia River

The Rakaia River is assessed using the using the suspended sediment yields from the NIWA "Sediment from New Zealand Rivers" map and the assumption that the proportion of bed load to total load is similar for the Rakaia and the Waimakariri. The assessment estimates the Rakaia River sustainable gravel yield from the Waimakariri's sustainable gravel yield of 250,000 m^3/yr by:

- Pro-rating by 0.88 (=3,105km^2 /3,543km^2) to account for the smaller catchment.
- Pro-rating by 1.55 (=1,353/875) to account for the higher suspended sediment yield shown on the NIWA map.
- Reducing the yield by 75% to reflect the Waimakariri's higher specific yield due to the reduction of bed slope in the Waimakariri River at the mouth.

To give the estimated Rakaia sustainable gravel yield of 85,000m^3/yr.

3.12 Kakahu River

The Kakahu River is a tributary of the Te Moana River, which is one of the Priority One rivers. The estimated sustainable gravel yield for the Te Moana River is 4,000m^3/yr. Based on relative catchment areas, about half of that amount or 2,000m^3/yr is estimated to be from the Kakahu River catchment.

3.13 Twizel River

The Priority One river reports have no closely comparable river to the Twizel River to make a "like" assessment from.

The reported measured specific total sediment yield for the Twizel River is 144 t/km^2/yr (McSaveney and Whitehouse, 1989). Assuming ten percent of the total sediment load is bedload, the specific bedload sediment yield is around 15 t/km^2/yr.

The Twizel River bed slope across the lower outwash gravel part of the catchment is 0.015, which is steep enough to allow good bed load transport.

On this basis the sustainable gravel yield from the Twizel River could be around 2,000m^3/yr.

3.14 Waitaki River and Tributaries

The NIWA "Sediment from New Zealand Rivers" map shows that the parts of the Waitaki River catchment with the highest specific suspended sediment yields are all located in the upper areas of the catchment above the Waitaki Dam. The specific bed load yields would logically be similarly distributed.

To provide a desktop assessment of the gravel resource of the Lower Waitaki we have used the more detailed river gravel reports to find a proxy river against which to assess the Lower Waitaki. The Waihao River stands out as the most similar river to the Lower Waitaki. Specific similarities are:

- Geographical, where the rivers run parallel and within 15 to 20km of each other
- Geological, where the rivers flow to the ocean across glacial outwash fans of greywacke and schist and drain hill country predominantly of greywacke and argillite
- Bed slope, where both rivers have a slope of around 0.003.

A couple of key differences between the two rivers are:

- The Waihao bed slope becomes more gradual (around 0.0015) at the mouth, whereas the Waitaki appears to maintain its slope to the sea.
- The Waitaki River has much greater flows (at 373m^3/s the average Waitaki River flow is 100 times greater than that of the Waihao River, 3.7m^3/s)

The specific sustainable gravel yield from the Waihao River was estimated at about 22m^3/km^2/yr. On the basis of the listed similarities and differences between the Lower Waitaki and Waihao Rivers the estimated specific sustainable gravel yield from the Lower Waitaki is half that of the Waihao's, or about 11m^3/km^2/yr. The lower value reflects the flux of gravel from the Lower Waitaki to the sea, which does not happen from the silt based gradually sloped Waihao mouth.

The "global" gravel yield figure applying to the Lower Waitaki is distributed between the List 2 river catchments as per the following table. The yield for each sub catchment was derived by:

- assigning higher values to the steeper rivers
- lesser values to the more gradually sloping rivers
- a low value to the main stem,

whilst ensuring the weighted average for the entire Lower Waitaki catchment equalled 11m^3/km^2/yr.

Sub-Catchment	Sub-Catchment Area (km^2)	Bed Slope (m/m)	"Sustainable" Bed Load Specific Yield ($m^3/km^2/yr$)	Sustainable Gravel Yield (m^3/yr)
Lower Waitaki (excluding other sub-catchment)	301	0.003	1	300
Hakataramea	899	0.0055	12	10,800
Penticotico	51	0.016	15	800
Elephant Hill	58	0.009	13	800
Kurow	47	0.022	18	800
Otiake	61	0.023	18	1,100
Otekaieke	116	0.011	15	1,700
Maraewhenua	290	0.007	13	3,800
Total Lower Waitaki	**1,823**		**11**	**20,100**

4. Summary of List 2 River Gravel Yield Estimates

River	Estimated Sustainable Gravel Yield (m^3/yr)
Clarence	21,000
Oaro	2,500
Conway	7,000
Waiau	158,000
Hurunui	15,000
Pahau	3,000
Kowai	600
Selwyn	1,800
Waianawaniwa	200
Rakaia	85,000
Kakahu	2,000
Twizel	2,000
Lower Waitaki	300
Hakataramea	10,800
Penticotico	800
Elephant Hill	800
Kurow	800
Otiake	1,100
Otekaieke	1,700
Maerewhenua	3,800
Total	**318,000**

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