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Cross section, scour chain and particle size data for Gulungul and Ngarradj Creeks 2005

MJ Saynor & BL Smith

March 2006

(Release status – unrestricted)

Cross section, scour chain and particle size data for Gulungul and Ngarradj Creeks 2005

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Cross section, scour chain and particle size data for Gulungul and Ngarradj Creeks 2005

MJ Saynor & BL Smith

1 Introduction

This report contains the dry season channel stability data collected in 2005 for Gulungul Creek and Ngarradj Creek. The research program on Gulungul Creek is continuing whilst the work program in the Ngarradj catchment has been greatly reduced compared with previous years.

1.1 Gulungul Creek

Ranger mine lies partly within the catchment of Gulungul Creek, a small left bank tributary of Magela Creek (Fig 1). Current mine infrastructure in the catchment includes part of the tailings dam and minor road works and the final rehabilitated landform will also lie partly within the catchment. A review of the literature found that there is limited data on the geomorphology of Gulungul Creek (Crossing 2002).

A program of geomorphic research and monitoring in Gulungul Creek is required both to assess any current mine impact on the stream system, with particular reference to channel stability and sediment load, and to determine a baseline and assessment strategy for future monitoring of the final rehabilitated landform. A research program similar to that proposed by Erskine et al (2001) for the Ngarradj catchment was established in Gulungul Creek.

Initial field inspections were conducted in the Gulungul Creek catchment during the dry season of 2002. In order to measure the amount of large-scale bank erosion along Gulungul Creek, permanently marked channel cross sections were established (Fig 2). Bulk bed material samples at each of the cross sections were collected and scour chains were used at some of the cross sections to measure scour and fill. The initial set up of cross sections and survey data are described in Crossing (2002) and more recent data are presented in Saynor et al (2005a).

Data for the annual cross section surveys, bulk bed material samples and scour chain measurements on Gulungul creek for the dry season of 2005 are presented in this report. Annual data reports (Internal Reports) will be produced so that a record of the data is retained. Analysis of the data will be presented in refereed documents at a later date.

1.2 Ngarradj Creek

The first field inspections were conducted in the Ngarradj catchment during the dry season of 1998 as initial work on the Jabiluka project had commenced. Erskine et al (2001) proposed that a sediment budget framework should be adopted by ***eriss*** to assess the physical impacts, if any, of the Jabiluka project on the Ngarradj catchment (Fig 1). During these field trips, various fluvial erosion processes were identified (Erskine et al 2001). Bank erosion and scour and fill of the sandy creek beds were observed as active processes.

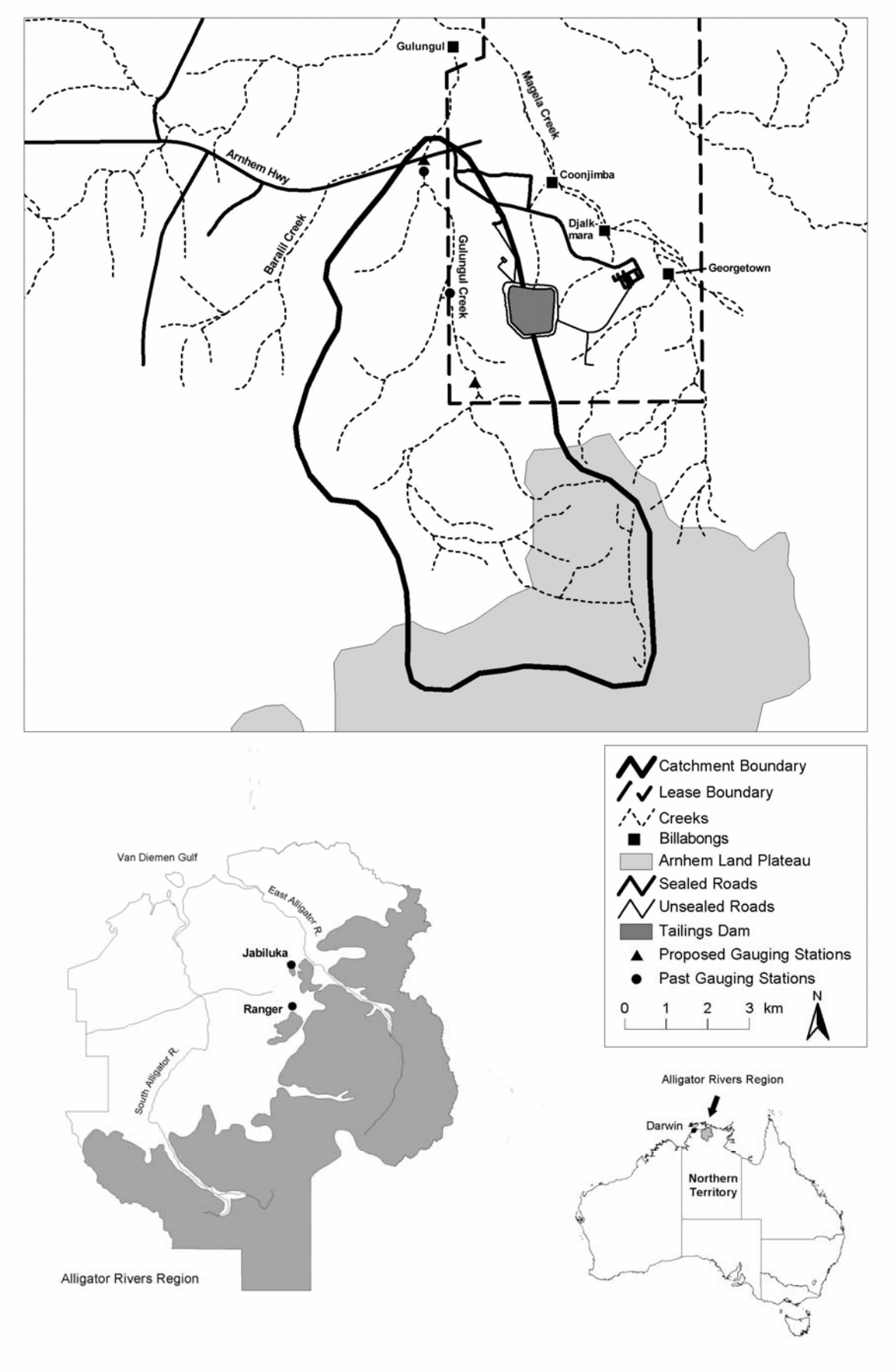

Figure 1 Gulungul Creek catchment showing the main creeks and tributaries, Ranger Mineral Lease and mine infrastructure, gauging stations and the Arnhem Land Plateau. Sourced from Crossing (2002).

To measure the amount of large-scale bank erosion permanently marked channel cross sections were installed on the project area tributaries (Tributaries North and Central) and at the three ***eriss*** gauging stations (Moliere et al 2002) (Fig 1). Scour chains were used at some of the above cross sections to measure scour and fill (Saynor 2000, Erskine et al 2001). Bulk samples of bed material were collected for particle size analysis from each cross section (Saynor 2000, Erskine et al 2001). The complete ***eriss*** field program initiated in the Ngarradj catchment to assess the physical impacts of the Jabiluka project is described in Saynor et al (2001).

The results for the annual cross section surveys, bulk bed material particle size distribution and scour and fill measurements in the Ngarradj catchment between 1998 and 2003 are presented in the following reports:

- Cross section change data, 1998 to 2001 – Saynor et al (2002a);
- Scour and fill by scour chains, 1998 to 2001 – Saynor et al (2002b);
- Cross section and scour chain data, 2002 to 2003 – Saynor et al (2004a);
- Bed material grain size data, 1998 to 2003 – Saynor et al (2004b);
- Analysis of cross section and scour and fill changes, 1998 to 2003 - Saynor et al (2004c);
- Analysis of bed material grains size changes, 1998 to 2003 – Saynor et al (2006); and
- Cross section, scour chain and particle size data in the Ngarradj catchment for 2004 – Saynor and Smith (2005).

The channel stability work in Ngarradj Creek is being finalised and the work programme is winding down. During the 2005 dry season only limited cross section surveys and bed material particle size analysis samples were completed. The scour chains were all measured and then removed during the fieldwork program. This report contains the limited cross sections data and particle size distributions for the Ngarradj catchment for 2005 as well as all the scour chain measurements.

2 Methods

The methods described here relate to the continuing work being undertaken on Gulungul Creek. The work that has been completed in Ngarradj creek is of a very similar nature and has been described in the publications listed above. No additional diagrams for Ngarradj Creek will be shown in this report.

2.1 Cross Section survey

Twelve cross sections were installed along Gulungul Creek at different sites between the upstream lease boundary and the junction with Baralil Creek (a few hundred metres downstream of the Arnhem Highway (Fig 1)). The location of these sections is shown in figure 2. These sections were installed and surveyed in the 2002 dry season and are surveyed on an annual basis to provide a baseline for monitoring change in the channel banks and bed over time.

The cross-sections were surveyed into two concrete plinths, one either side of the main channel. Some channels were surveyed only between these two plinths, while others extended away from the channel beyond one or both plinths, using the same instrument set up. A star picket was used to mark the end of the cross-section in these cases. UG01 is a longer section with 5 plinths, and involved three instrument setups. Details of survey setup points are given in table 1. Table 1 is adapted from Crossing (2002) with some changes to the originally

published table to correct transcription errors. Section UG01 is located through the upstream gauging station (Fig 1). A gauging station was installed prior to the 2003–04 wet season and stage-discharge gauging measurements have been carried out each wet season since. The sections immediately upstream and downstream of UG01 (UG02, 03 and 04) were chosen to ensure the channel reach around the gauging station is adequately characterised.

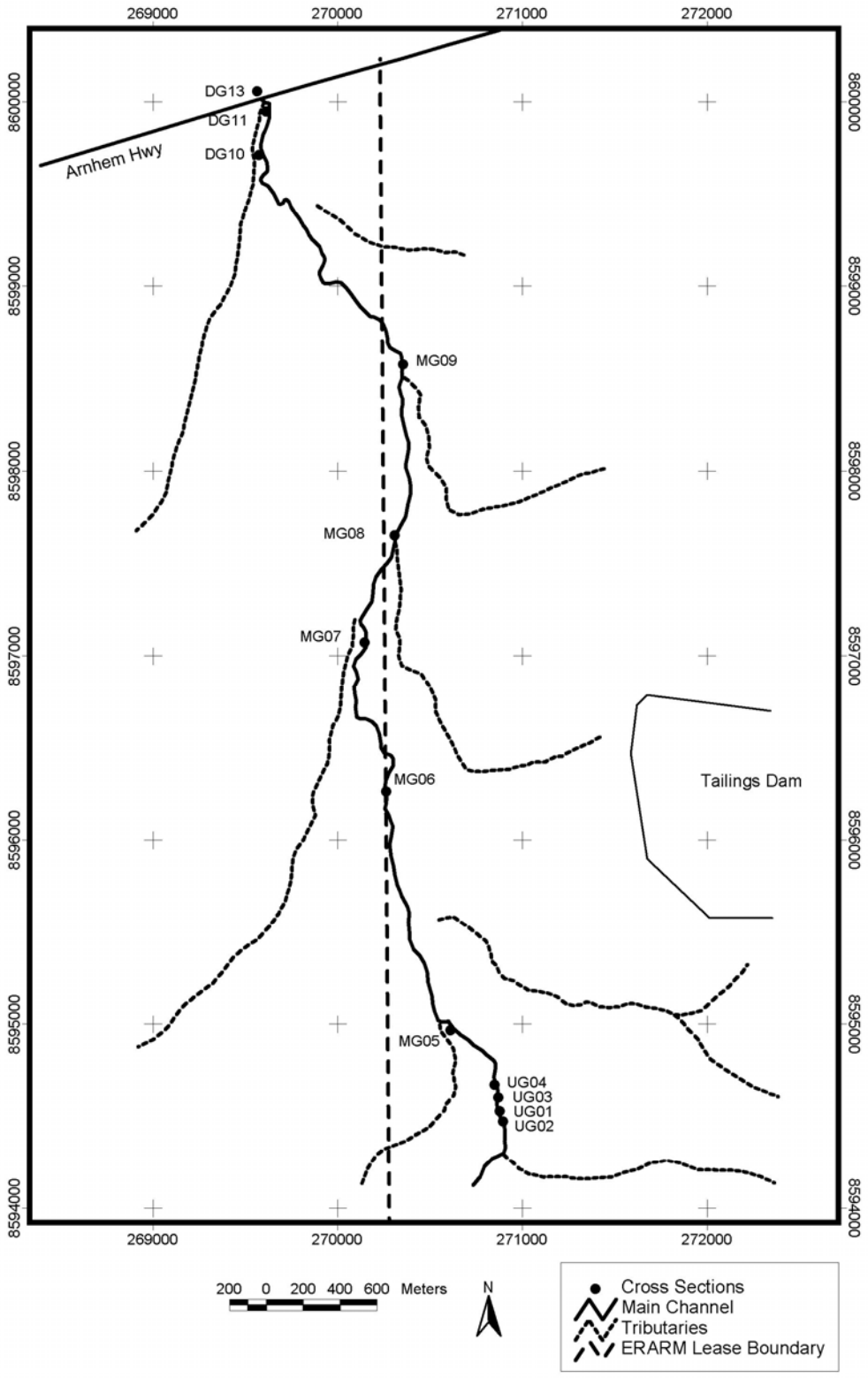

Figure 2 Gulungul Creek showing location of cross sections. Sourced from Crossing (2002)

Table 1 Details of the cross-section surveys carried out in the 2002 dry season. This information should be used whenever the cross-sections are re-surveyed.

Section	Instrument set up	Arbitrary coordinates (m) [a]			Sighted to	Sighting angle (degrees)
		North	East	Height		
UG01 - A	Plinth 1 (RB)	5000	2000	50	Plinth 3	270
UG01 - B	Plinth 3[a]	1864.60	5000	50.43	Plinth 1	90
UG01 - C	Plinth 4[a]	1747.45	5000	49.88	Plinth 3	Approx. 90 [b]
UG02	RB plinth	3000	1000	50	LB plinth	270
UG03	RB plinth	3000	1000	50	LB plinth	270
UG04	RB plinth	3000	1000	50	LB plinth	270
MG05	RB plinth	3000	1000	50	LB plinth	270
MG06	RB plinth	3000	1000	50	LB plinth	270
MG07	LB plinth	3000	1000	50	RB plinth	90
MG08	LB plinth	3000	1000	50	RB plinth	90
MG09	RB plinth	3000	1000	50	LB plinth	270
DG10	RB plinth	3000	1000	50	LB plinth	270
DG11	RB plinth	3000	1000	50	LB plinth	270
DG13	RB plinth	3000	1000	50	LB plinth	270

a The coordinates for Plinth 3 and 4 on cross-section UG01 are not arbitrary, and were measured from the coordinates at Plinth 1 on cross-section UG01. It should be noted that apart from these cross sections, no other cross sections can be related to each other.

b The backsight for Section UG01 – C was sighted on Plinth 3, but rather than specifying a sighting angle, the coordinates of Plinth 3 were entered.

Plots of the cross section surveys are contained in section 3 and the survey data are shown in Appendix A. Hydraulic Geometry calculations will be made when several more annual surveys have been completed.

2.2 Bed material field collection for particle size analysis

Bulk samples of specific depositional environments are the accepted method of sampling fluvial sediments. This involves the collection of all material from a predetermined volume within a specific depositional or geomorphic environment (Kellerhals & Bray 1971). Where collection of all sediment from a specific depositional environment is impossible because the mass is too large for collection, transport and/or analysis, sub-sampling is practised. Nevertheless, there are potential problems with bulk sampling that must be recognised. Very large sample masses are required to obtain reproducible measures of the grain size distributions of samples containing individual large clasts or gravels (de Vries 1970, Church et al 1987, Gale & Hoare 1992, Ferguson & Paola 1997). Recommended minimum sample mass also depends on sediment sorting or grading (Gale & Hoare 1994, Ferguson & Paola 1997). For a particular depositional environment, poorly sorted sediments, such as found in mixed sand-bed and gravel-bed rivers, require larger masses than better sorted samples (Gale & Hoare 1994, Ferguson & Paola 1997). Bulk sampling is also usually restricted to small areas that may not be representative of all of a specific depositional environment (Wolman 1954, Muir 1969). This is a major concern on large rivers with spatially variable depositional environments (Mosley & Tindale 1985) but is not a problem on the smaller channels in the Gulungul Creek catchment.

During the dry season of 2005 a total of 12 bed material samples were collected, one from each of the cross sections. Bulk bed material samples were collected by a trowel or small spade from at least 3 (usually 6) equally spaced points across the stream bed and then combined into a single sample for each section.

2.3 Particle size analysis laboratory methods

All bulk bed-material samples were oven dried at 105°C for 24 hours before being subjected to particle size analysis. Initial field observations indicated that there was little mud (ie< 0.063 mm in diameter) present. The phi (ϕ) notation system is often used to describe the grain size of clastic sediment by sedimentologists. It is a logarithmic scale in which each grade limit is twice as large as the next smaller grade limit (Folk 1974) and is denoted by:

$$\phi = -\log_2 d \qquad (1)$$

where d is the grain diameter in mm.

Any gravel fraction of the samples was manually sieved in its entirety at $\phi/2$ intervals. If the fraction less than 2 mm in diameter (fine earth fraction) was greater than 150 g it was passed through a riffle box to obtain a sample of approximately 100 g to ensure that the analytical stainless steel sieves were not damaged by excessive loading. This sub-sample was then dry sieved through a nest of stainless steel sieves at $\phi/2$ intervals using a 15 minutes shake time. For the fine earth fraction sample masses less than 150 g, the sample was sieved in its entirety.

2.4 Sediment texture

The sediment textural classification used for all fluviatile samples is that of Folk (1954, 1974, 1980) for unconsolidated materials and is based on a ternary diagram showing the proportions of gravel, sand and mud on separate axes (Fig 3). This texture triangle is split into 15 groups and the median diameter is determined, where possible, for each component fraction. Each sediment fraction can be expressed in terms of one of the Wentworth size classes (table 2). To place a sample into one of the 15 major groups, only two properties need to be determined, namely the gravel percentage (boundaries at 80, 30, 5 and a trace or 0.01 %) and the ratio of sand to mud with boundaries at 9:1, 1:1 and 1:9 (Folk 1954, 1974, 1980). The gravel content is partly a function of the highest current velocity and the maximum grain size of the supplied sediment. The sand:mud ratio reflects the amount of winnowing (washing away of fine sediment) that has occurred. For samples lacking gravel, a further ternary diagram (Fig 4) is used which expands the bottom tier of figure 3. It is based on the proportions of sand, silt and clay (see Folk 1954, 1974, 1980).

Table 2 The Wentworth grain size scale for sediments (after Folk 1974)

Finest Grain Size (mm)	Finest Grain Size (ϕ)	Wentworth Size Class
256	-8	Boulder
64	-6	Cobble
4	-2	Pebble
2	-1	Granule
1.00	0	Very coarse sand
0.50	1	Coarse sand
0.25	2	Medium sand
0.125	3	Fine sand
0.0625	4	Very fine sand
0.031	5	Coarse silt
0.0156	6	Medium silt
0.0078	7	Fine silt
0.0039	8	Very fine silt
0.00006	14	Clay

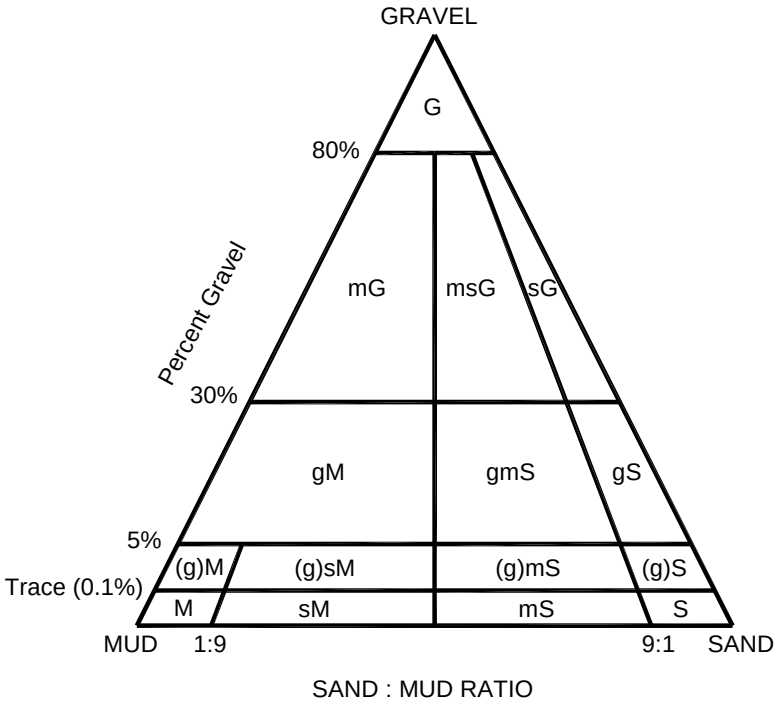

Figure 3 Folk's (1974) textural groups. G is gravel; sG sandy gravel; msG muddy sandy gravel; mG muddy gravel; gS gravelly sand; gmS gravelly muddy sand; gM gravelly mud; (g)S slightly gravelly sand; (g)mS slightly gravelly muddy sand; (g)sM slightly gravelly sandy mud; (g)M slightly gravelly mud; S sand; mS muddy sand; sM sandy mud; M mud.

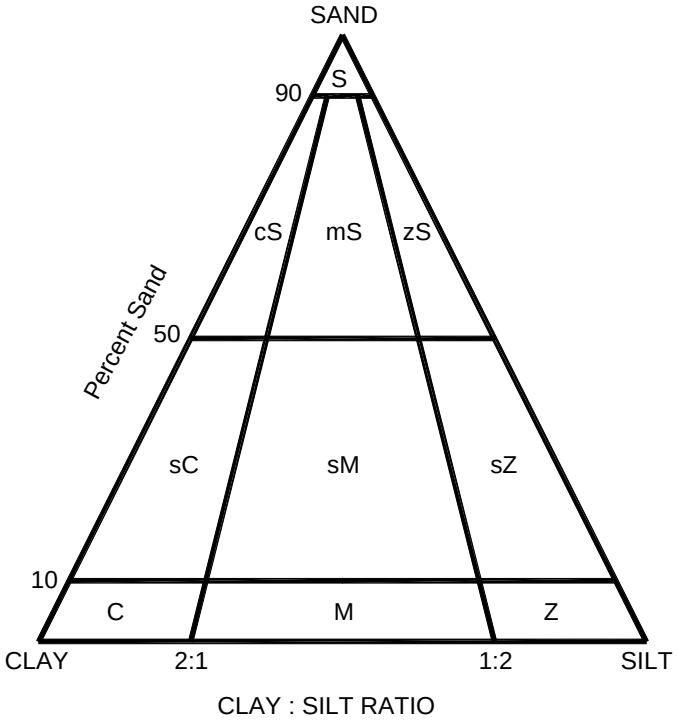

Figure 4 Folk's (1974) expansion of the bottom tier of figure 3 to show textural classes for sediments lacking gravel. S is sand; zS silty sand; mS muddy sand; cS clayey sand; sZ sandy silt; sM sandy mud; sC sandy clay; Z silt; M mud; and C clay

2.5 Scour Chains

Depths of scour and fill can be measured by scour chains, as described by Emmett and Leopold (1963) and Emmett (1965). Scour chains were installed in various reaches of the Gulungul Creek catchment (table 3) during the late dry season of 2002. The chains were installed with all links vertical. Table 3 contains information on the number of scour chains installed and at which cross sections. The scour chains were always located on a surveyed cross section. After each wet season, the elevation of the stream bed was resurveyed and the bed was excavated until the chain was exposed (Fig 5). The difference between the existing bed elevation and the horizontal chain was the depth of fill. If no scour had occurred, the amount of fill was the depth of sediment above the top of the buried chain. If the amount of fill equalled scour, there was no net change in bed level although scour and fill had occurred.

Table 3 Number of scour chains installed and on which cross sections in Gulungul Creek

Cross Section name	No. of scour chains	Cross Section name	No. of scour chains
UG02	2	MG08	3
UG03	3	DG10	2
MG06	3	DG11	2

Late in each dry season when the water table was at its lowest, the scour chains were relocated (using the measurements in Saynor et al (2001)) and, more importantly, a metal detector. The metal detector was particularly effective in locating the chains. Measurements of the depth to the scour chain and the bed surface level were obtained. Figure 5 shows an example of an excavated scour chain.

Figure 5 Scour chain orientated essentially downstream at MG08-3 on 24 November 2004. Arrow marked on paper indicates flow direction.

A wooden board was positioned over the upstream face of the excavation and all measurements were taken to the bottom of this board which equated to the then bed level. A photograph was usually taken to show the position of the chain and an indication of the direction of flow was given by a trowel, arrow on paper, pen or ruler pointing downstream. As the scoured part of the chain was not always lying horizontal, two measurements were taken to determine the scour depth (Fig 6). These were:

- Depth to top of first link (i.e. the link to which flagging tape had been tied) and
- Depth to the first vertical link.

After these measurements were made the chain was carefully straightened and then a further measurement made:

- Depth to straightened chain (DSC) from the base of the wooden board.

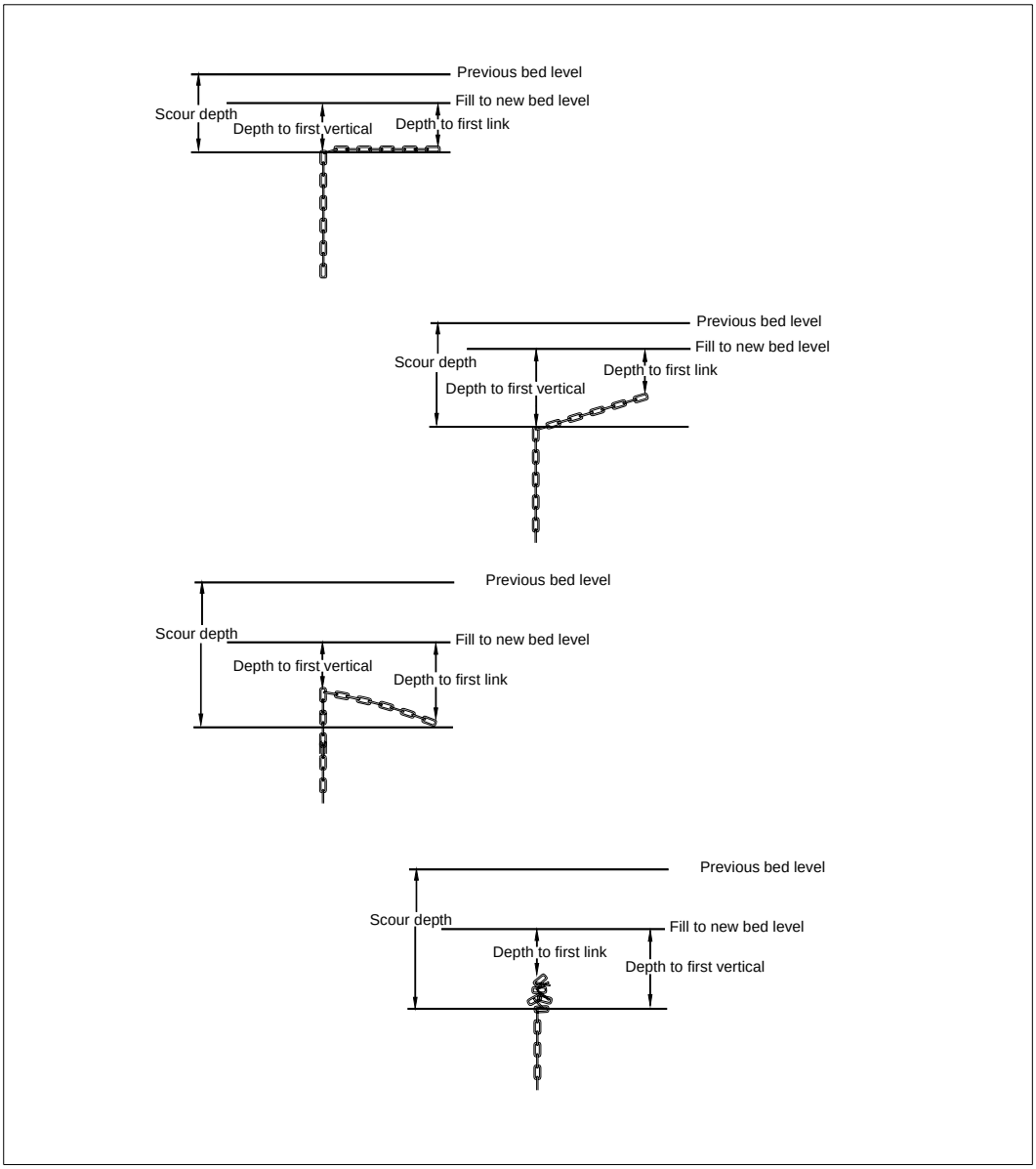

Figure 6 Diagrammatic representation of the full range of scour chain behaviour when there was net scour depicted by the middle example in figure 7.

All measurements were made as positive values except when the straightened chain was higher than the current bed level (wooden board) when the value was assigned a negative value. These measurements are used to determine scour and fill and are explained in the next section. Once all the measurements had been made, the chain was reset. If the chain could not be reset for any reason the difference was noted so that adjustments could be made to the measurements and calculations in the following years.

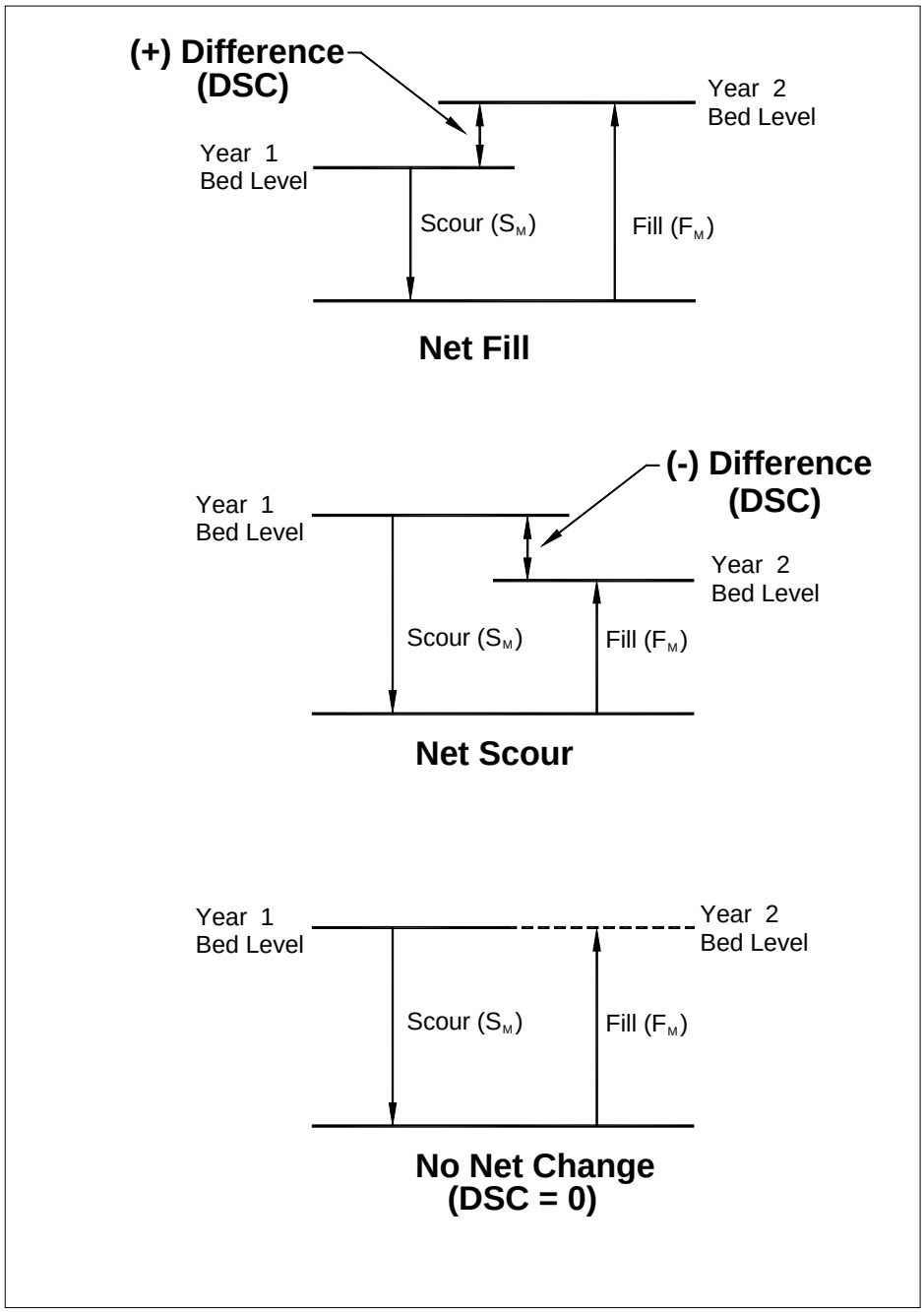

Figure 7 Three examples of net channel bed change during the wet season measured by scour chains. Net fill occurs when the bed level for the 2nd year is higher than for the 1st (top). Net scour occurs when the bed level for the 2nd year is lower than for the 1st (middle). No net change occurs when the bed level for the 1st and 2nd years is the same (bottom).

2.6 Scour and fill calculations

The top of the highest link of each chain is the zero datum for the next wet season. The values are all made to this datum even though some of the measurements are made to the bed level for year 2 (Fig 7). Once the scour chains are reset the datum is then also reset and the bed level is called Year 1 for the following year (Fig 7) i.e the DSC value for net fill is +ve and for net scour is –ve.

The maximum amount of fill (F_M) is the actual fill during the wet season. The depth to the straightened chain (DSC) is used in equation 1 to determine the maximum scour depth (S_M) and it is essential to keep the mathematical signs as shown in figure 7.

$$S_M = F_M - DSC \quad (2)$$

The net change in bed level (BL_N) is determined by equation 3:

$$BL_N = F_M - S_M = DSC \quad (3)$$

A positive value indicates net fill from year 1 to year 2 and a negative value, net scour. This convention of positive values for fill and negative values for scour has been used by, among others, Emmett (1965), Leopold et al (1966), Roberts (1991), Fowler and Wilson (1995) and Locher (1997). Figure 7 shows the three possible situations, net fill, net scour and no net change.

3 Gulungul Creek results

3.1 Gulungul Creek annual cross section survey

The plots of the 12 cross sections for 2002, 2003, 2004 and 2005 are shown in figures 8–19. The location of the cross sections is shown in figure 2. The cross section survey data for all sections for 2005 are contained in Appendix A.

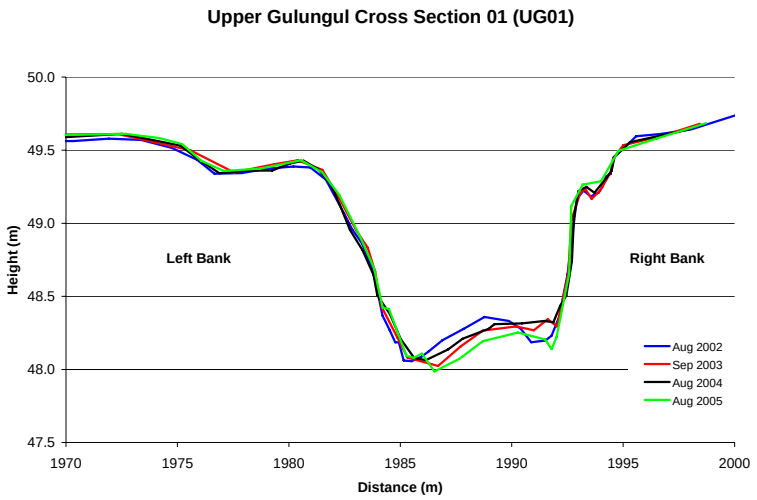

Figure 8 Cross section plot of upper Gulungul Cross section 01 for 2002, 2003, 2004 & 2005

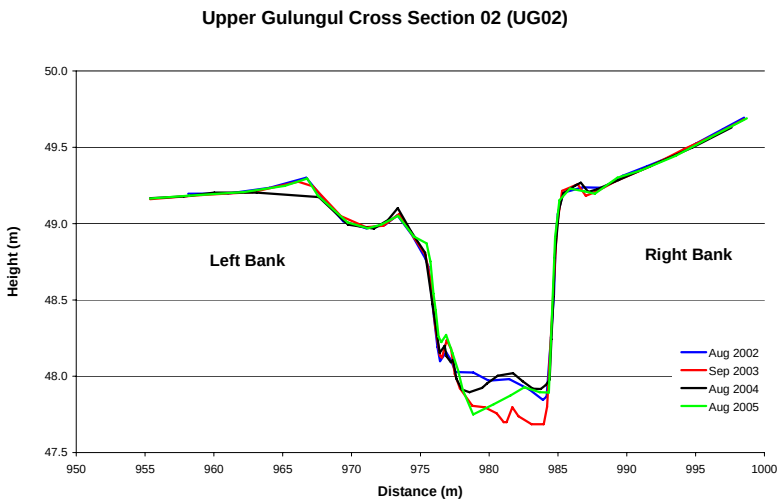

Figure 9 Cross section plot of upper Gulungul Cross section 02 for 2002, 2003, 2004 & 2005

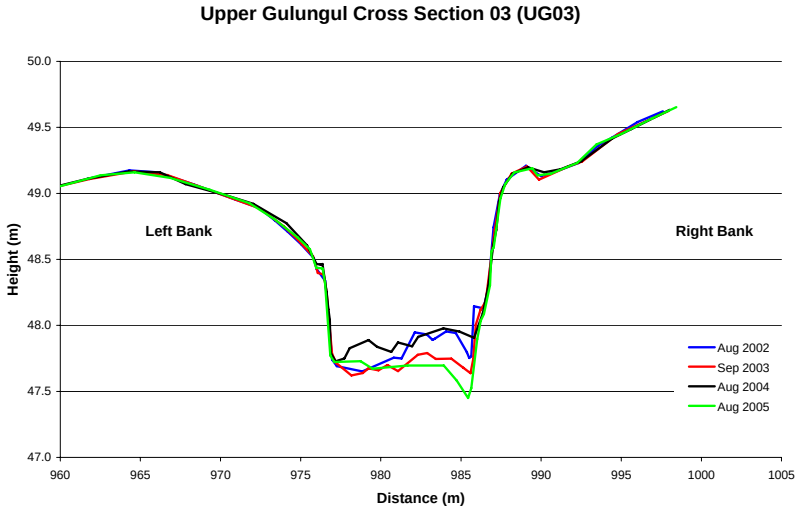

Figure 10 Cross section plot of upper Gulungul Cross section 03 for 2002, 2003, 2004 & 2005

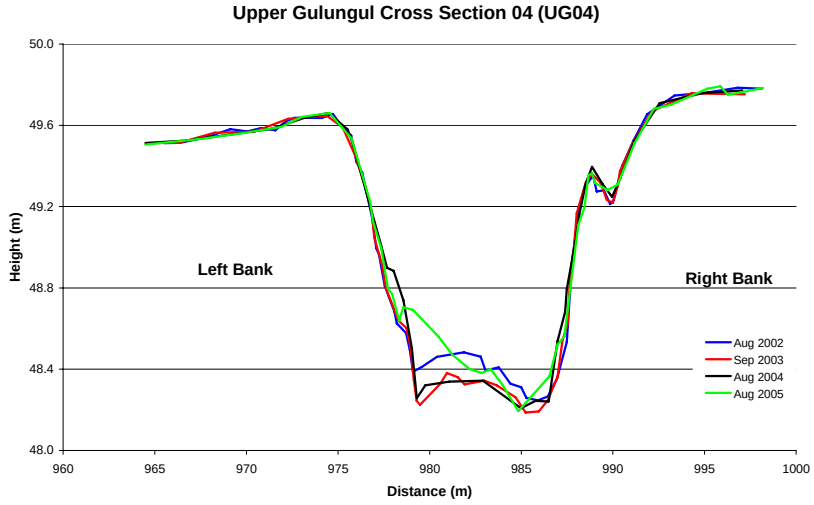

Figure 11 Cross section plot of upper Gulungul Cross section 04 for 2002, 2003, 2004 & 2005

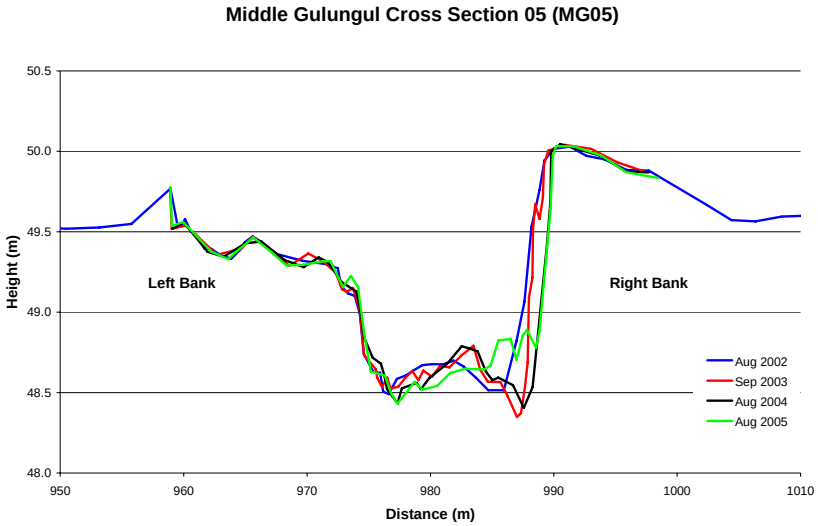

Figure 12 Cross section plot of Middle Gulungul Cross section 05 for 2002, 2003, 2004 & 2005

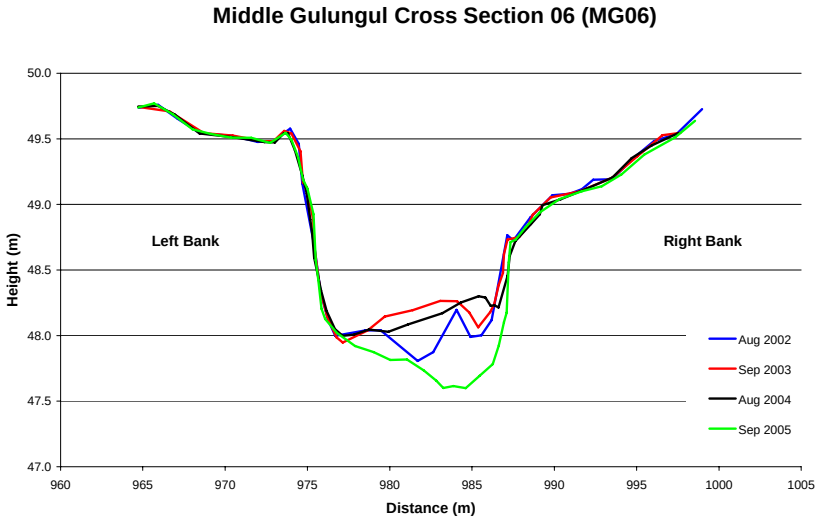

Figure 13 Cross section plot of Middle Gulungul Cross section 06 for 2002, 2003, 2004 & 2005

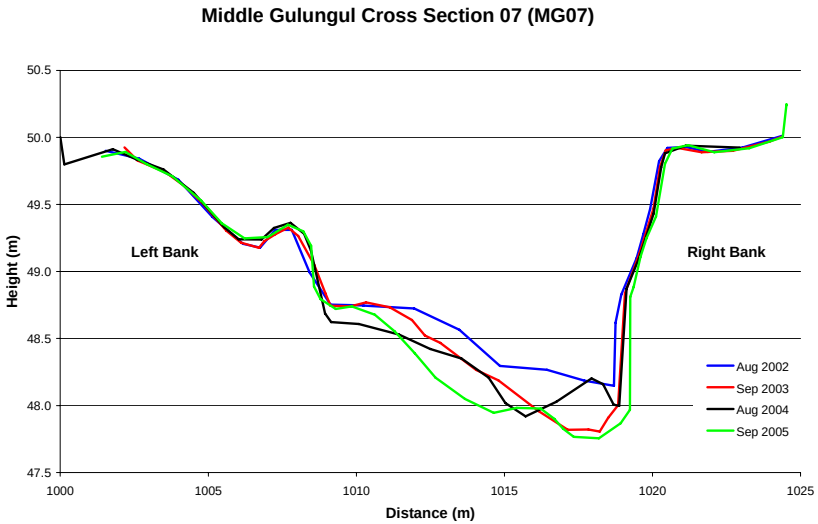

Figure 14 Cross section plot of Middle Gulungul Cross section 07 for 2002, 2003, 2004 & 2005

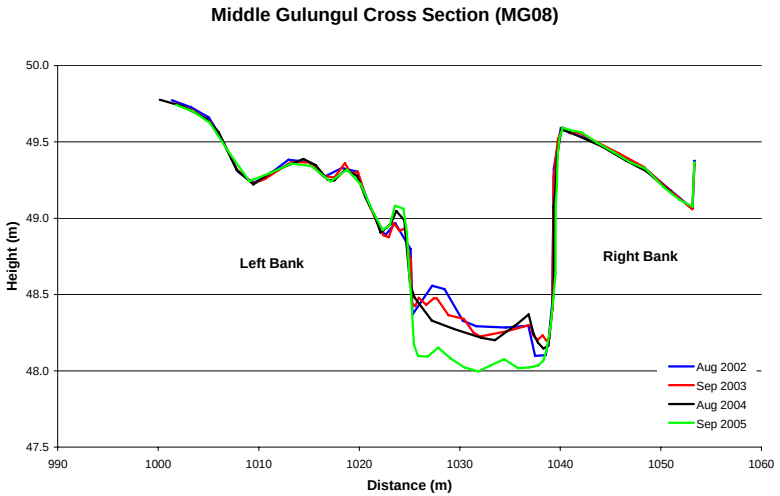

Figure 15 Cross section plot of Middle Gulungul Cross section 08 for 2002, 2003, 2004 & 2005

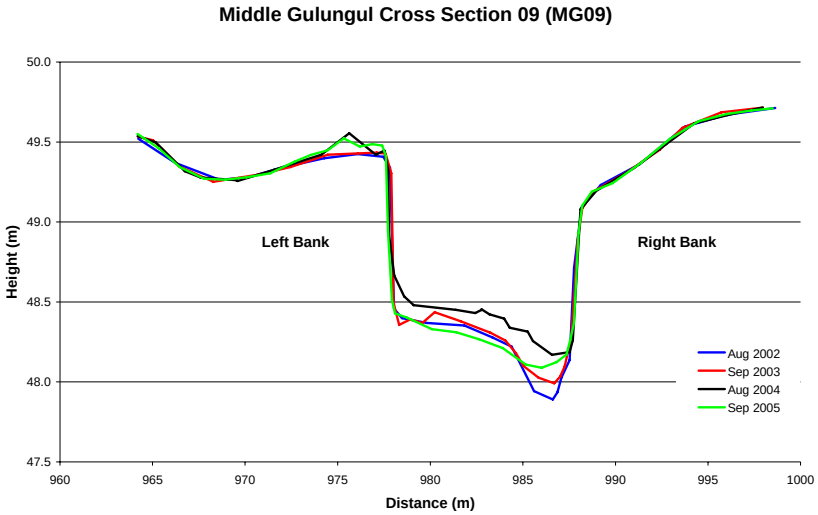

Figure 16 Cross section plot of Middle Gulungul Cross section 09 for 2002, 2003, 2004 & 2005

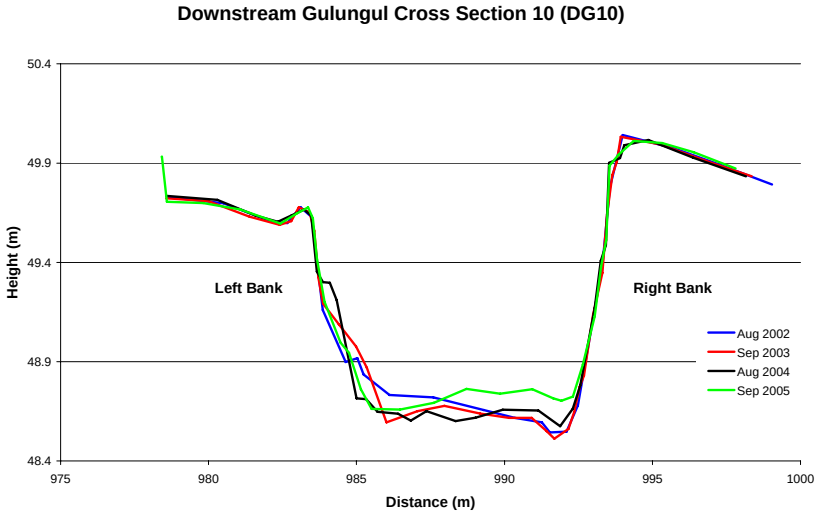

Figure 17 Cross section plot of Downstream Gulungul Cross section 10 for 2002, 2003, 2004 & 2005

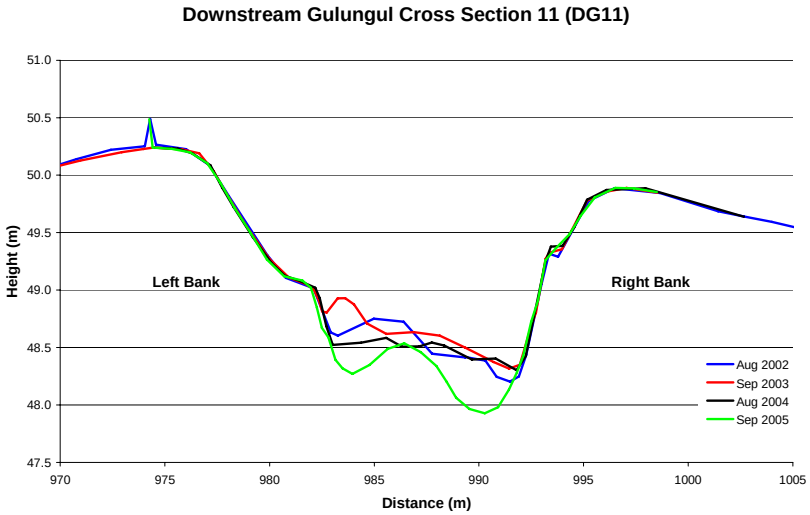

Figure 18 Cross section plot of Downstream Gulungul Cross section 11 for 2002, 2003, 2004 & 2005

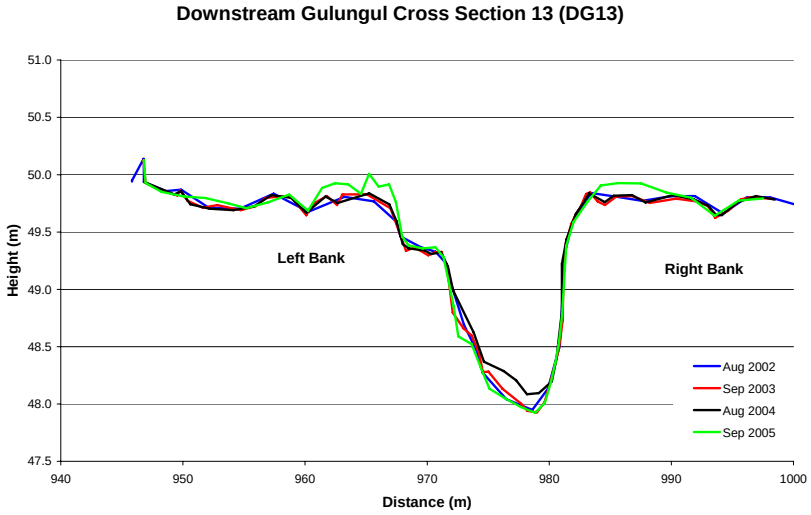

Figure 19 Cross section plot of Downstream Gulungul Cross section 13 for 2002, 2003, 2004 & 2005

3.2 Gulungul Creek particle size analysis

Figure 2 shows the location of the channel cross sections at which the bed material was bulk sampled. Sample masses for each year are summarised in table 4. From the criteria of de Vries (1970), Church et al (1987) and Gale and Hoare (1992), the sample masses were adequate to obtain reproducible measures of the grain size distribution for these bed-material sediments.

Table 4 Summary of oven dry bulk bed-material sample masses collected on Gulungul Creek for each year of the sediment program

Sample Mass	2002	2003	2004	2005
Mean (g)	1523.3	2197.8	2634.0	1893.3
Standard Error of Estimate (g)	113.7	103.8	176.7	154.67
Minimum (g)	1104.5	1459.9	1664.7	1067.4
Maximum (g)	2486.5	2859.8	3582.1	2950.3

The cumulative frequency grain size distributions and Folk (1954, 1974) texture group for each sediment sample collected on Gulungul Creek are contained in Appendix B.

3.3 Gulungul Creek scour chain

Scour chains were installed during the late dry season of 2002 at six cross sections. The following cross sections had three chains installed in the bed: UG03, MG06 and MG08, while only two chains were installed at: UG02, DG10 and DG11 due to the narrow bed width at these sections. The location of the cross sections is shown in figure 2. Appendix C has schematic diagrams that can be used to assist with locating the scour chains.

3.3.1 Upper Gulungul cross section (UG02)

There were two chains located across the bed of the channel at UG02.

UG02-1

This chain was found on 7 November 2005 and was located toward the right bank. The chain was buried and orientated perpendicular to flow and towards the right bank. Measurements were:

- Depth to first link……..107 mm,
- Depth to first vertical link…….212 mm, and
- Depth to straightened chain……..-125 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 337 mm and fill was 212 mm. The 2005 bed level was 125 mm below the 2004 bed.

UG02-2

This chain was found on 7 November 2005 and was located toward the left bank. The chain was buried and oriented towards the right bank in a spiral pattern. Measurements were:

- Depth to first link……..48 mm,
- Depth to first vertical link…….64 mm, and
- Depth to straightened chain……..-123 mm (relative to 2004 bed level).

The 2004-2005 wet season scour was 187 mm and fill was 64 mm. The 2005 bed level was 123 mm below the 2004 bed.

At Upper Gulungul Cross section 2 (UG02) the average scour for the 2004–2005 wet season was 262 mm and the average fill was 138 mm.

3.3.2 Upper Gulungul cross section (UG03)

There were three chains located across the bed of the channel at UG03.

UG03-1

The chain was found 7 November 2005 and was located towards the right bank. The chain was buried and orientated straight upstream against the flow. Measurements were:

- Depth to first link……..265 mm,
- Depth to first vertical link…….287 mm, and
- Depth to straightened chain……..-270 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 557 mm and fill was 287 mm. The 2005 bed level was 270 mm below the 2004 bed.

UG03-2

The chain was found 7 November 2005 and was located in the middle of the bed and was pointing towards the right bank initially for a few links and then diagonally upstream. Measurements were:

- Depth to first link……..255 mm,
- Depth to first vertical link…….265 mm, and
- Depth to straightened chain……..-170 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 435 mm and fill was 265 mm. The 2005 bed level was 170 mm below the 2004 bed.

UG03-3

The chain was found 7 November 2005 and was located toward the left bank and initially fell towards the middle of the channel and then curled upstream and around 180^0 and was pointing towards the right bank. Measurements were:

- Depth to first link……..285 mm,
- Depth to first vertical link…….330 mm, and
- Depth to straightened chain……..-125 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 455 mm and fill 330 mm. The 2005 bed level was 125 mm below the 2004 bed.

At Upper Gulungul Cross section 3 (UG03) the average scour for the 2004–2005 wet season was 482 mm and the average fill was 294 mm.

3.3.3 Mid Gulungul cross section (MG06)

There were three chains located across the bed of the channel.

MG06-1

The chain was found on 9 November 2005 located toward the right bank. The chain was orientated downstream initially, then towards the left bank. This chain could not be reset in 2004 and was left 100 mm above the bed. Measurements were:

- Depth to first link……..300 mm,
- Depth to first vertical link…….370 mm, and
- Depth to straightened chain……..-600 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 870 mm and fill was 370 mm. The 2005 bed level was 500 mm below the 2004 bed.

MG06-2

The chain found on 9 November 2005 was located in the middle of the bed. The chain was pointing towards the left bank and downstream initially, then curled upstream and around 270^0 to point diagonally towards the right bank. Measurements were:

- Depth to first link……..390 mm,
- Depth to first vertical link…….365 mm, and
- Depth to straightened chain……..-315 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 705 mm and fill was 390 mm. The 2005 bed level was 315 mm below the 2004 bed.

MG06-3

The chain was found on 9 November 2005 located toward the left bank. The chain was pointing downstream and slightly towards the right bank. Measurements were:

- Depth to first link……..20 mm,
- Depth to first vertical link…….40 mm, and
- Depth to straightened chain……..-165 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 205 mm and fill was 40 mm. The 2004 bed level was 165 mm below the 2005 bed.

At Mid Gulungul Cross section 6 (MG06) the average scour for the 2004–2005 wet season was 593 mm and the average fill was 267 mm.

3.3.4 Mid Gulungul cross section (MG08)

There were three chains located across the bed of the channel.

MG08-1

The chain found on 9 November 2005 and was located toward the right bank. The chain was buried and orientated perpendicular to flow toward the left bank. Measurements were:

- Depth to first link……..410 mm,
- Depth to first vertical link…….375 mm, and
- Depth to straightened chain……..-240 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 650 mm and fill was 410. The 2005 bed level was 240 mm below the 2004 bed.

MG08-2

The chain was found on 9 November 2005 located in the middle of the bed. The chain was buried and orientated upstream against the flow direction. Measurements were:

- Depth to first link……..420 mm,
- Depth to first vertical link…….440 mm, and

- Depth to straightened chain……..-255 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 695 mm and fill was 440 mm. The 2005 bed level was 255 mm below the 2004 bed.

MG08-3

The chain was found on 9 November 2005 located toward the left bank. The chain was buried and orientated diagonally upstream towards the right bank. Measurements were:

- Depth to first link……..125 mm,
- Depth to first vertical link…….265 mm, and
- Depth to straightened chain……..-285 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 550 mm and fill was 265 mm. The 2005 bed level was 285 mm below the 2004 bed.

At Mid Gulungul Cross section 8 (MG08) the average scour for the 2004–2005 wet season was 632 mm and the average fill was 372 mm.

3.3.5 Downstream Gulungul cross section (DG10)

There were two chains located across the bed of the channel.

DG10-1

The chain was found on 9 November 2005 located toward the right bank. The chain was buried and orientated straight toward the left bank perpendicular to the flow direction. Measurements were:

- Depth to first link……..260 mm,
- Depth to first vertical link…….270 mm, and
- Depth to straightened chain……..135 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 135 mm and fill was 270 mm. The 2005 bed level was 135 mm higher than the 2004 bed.

DG10-2

The chain was found on 9 November 2005 located toward the left bank. The chain was buried and orientated across the bed toward right bank. Measurements were:

- Depth to first link……..250 mm,
- Depth to first vertical link…….265 mm, and
- Depth to straightened chain……..50 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 215 mm and fill was 265 mm.. The 2005 bed level was 50 mm higher than the 2004 bed.

At downstream Gulungul Cross section 10 (MG10) the average scour for the 2004–2005 wet season was 175 mm and the average fill was 268 mm.

3.3.6 Downstream Gulungul cross section (DG11)

There were two chains located across the bed of the channel.

DG11-1

The chain was located on 9 November 2005 and was buried and orientated towards the right bank initially, then curled upstream 270^0 to eventually point straight downstream. This chain could not be reset in 2004 and was left 35 mm below the bed. Measurements were:

- Depth to first link……..15 mm,
- Depth to first vertical link…….60 mm, and
- Depth to straightened chain……..-428 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 523 mm and fill was 60 mm. The 2005 bed level was 463 mm below the 2004 bed.

DG11-2

The chain was located on 9 November 2005 and was buried and orientated perpendicular to flow towards the left bank. Measurements were:

- Depth to first link……..290 mm,
- Depth to first vertical link…….305 mm, and
- Depth to straightened chain……..10 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 295 mm and fill was 305 mm. The 2005 bed level was 10 mm higher than the 2004 bed.

At downstream Gulungul Cross section 11 (MG11) the average scour for the 2004–2005 wet season was 409 mm and the average fill was 183 mm.

3.4 Presentation of scour chain data

The presentation of the data associated with the scour chain measurements has in the past looked cumbersome with lots of words used to describe the data. Table 5 shows the same information presented in section 3.3 above in collated and summary format. It is recommended that in subsequent reports the scour chain data be presented in similar tables.

Table 5 Tubular form of the scour chain data for Gulungul Creek data presented in section 3.3. Note that straightened chain measurement = bed level change relative to 2004.

Section	Location	Date	Depth to (mm)			Scour (mm)	Fill (mm)	Section average		Notes
			First Link	First Vertical Link	Straightened Chain (2004 bed level)			Scour (mm)	Fill (mm)	
UG02-1	R Bank	07/11/2005	107	212	-125	337	212	262	138	Orientated perpendicular to flow toward R bank
UG02-1	L Bank	07/11/2005	48	64	-123	187	64			Orientated in spiral patter toward R bank
UG03-1	R bank	07/11/2005	265	287	-270	557	287	482	294	Orientated upstream against flow
UG03-2	Middle	07/11/2005	255	265	-170	435	265			Orientated diagonally upstream toward R bank
UG03-3	L bank	07/11/2005	285	330	-125	455	330			Curled them orientated towards the L bank
MG06-1	R bank	09/11/2005	300	370	-600	870	370	593	267	Orientated downstream. Chain not reset in 2004, 100 mm left above bed
MG06-2	Middle	09/11/2005	390	365	-315	705	390			Orientated toward L bank then curls upstream
MG06-3	L bank	09/11/2005	20	40	-165	205	40			Orientated downstream slightly toward the L bank
MG08-1	R bank	09/11/2005	410	375	-240	650	410	632	372	Orientated perpendicular to flow toward L bank
MG08-2	Middle	09/11/2005	420	440	-255	695	440			Orientated upstream against flow
MG08-3	L bank	09/11/2005	125	265	-285	550	265			Orientated diagonally upstream toward R bank
DG10-1	R bank	09/11/2005	260	270	135	135	270	175	268	Perpendicular to flow toward L bank
DG10-2	L bank	09/11/2005	250	265	50	215	265			Across bed toward R bank
DG11-1	R bank	09/11/2005	15	60	-463	523	60	409	183	Orientated toward R bank then curls upstream. Chain not reset in 2004, 35 mm left below bed.
DG11-2	L bank	09/11/2005	290	305	10	295	305			Perpendicular to flow toward L bank

4 Ngarradj Creek results

4.1 Ngarradj cross section survey

The field program in Ngarradj creek has been scaled back dramatically. In 2005 cross section surveys were only undertaken at each of the gauging wires at the ***eriss*** gauging stations and also of the knickpoint retreat on Tributary North. The plots from the four surveys are shown in figures 20–23.

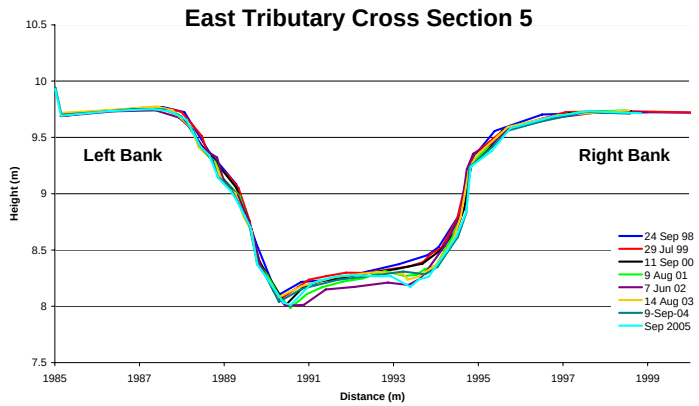

Figure 20 Cross section plot of East Tributary Cross section 05 for 1998 to 2005

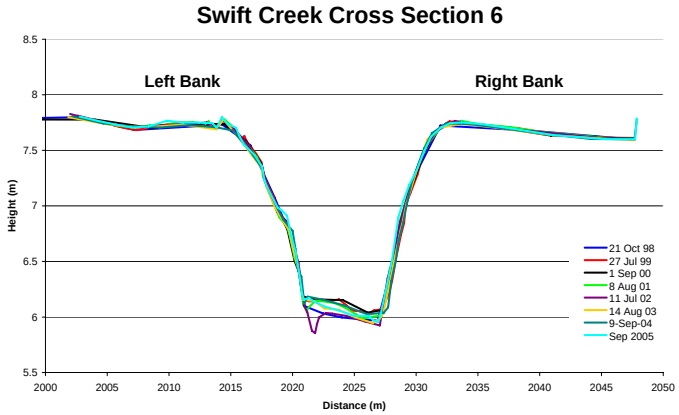

Figure 21 Cross section plot of Swift Creek Cross section 06 for 1998 to 2005

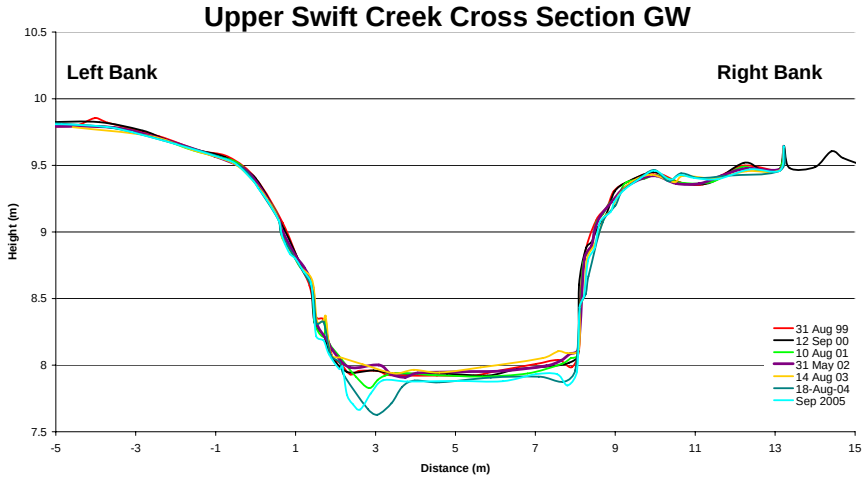

Figure 22 Cross section plot of Upper Swift Creek Cross section GW for 1999 to 2005

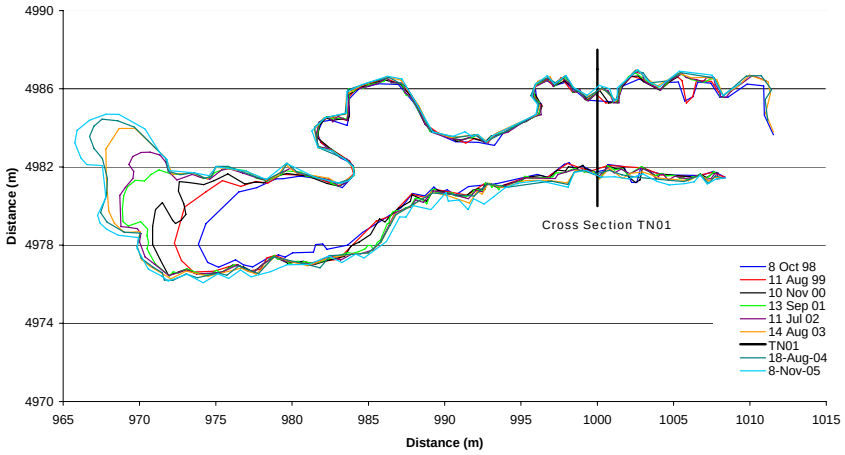

Figure 23 Annual surveys of the primary knickpoint at the head of Erskine et al's (2001) gullied reach on Tributary North.1998 to 2005. This refers to the main gully.

4.2 Ngarradj Creek particle size analysis

As part of the reduced field programme in Ngarradj Creek samples were only collected for particle size analysis from the three gauging wire cross sections at each of the ***eriss*** gauging stations. The cumulative frequency grain size distributions and Folk (1954, 1974) texture group for each sediment sample collected on Gulungul Creek are contained in Appendix E.

4.3 Ngarradj creek scour chain

Data for the scour chain measurements for 1998 to 2004 are contained in Saynor et al (2002b), Saynor et al (2004a) and Saynor & Smith 2005. Analysis of the scour chain data for the period 1998 to 2003 is contained in Saynor et al (2004c). With the reduction in the field programme in Ngarradj creek the scour chains were removed in the late dry season of 2005. Prior to removing the chains the standard measurements were made and are outlined below.

4.3.1. Tributary North

Chains were installed during the late dry season of 1999 at five cross sections. These chains were measured annually and removed after the 2005 measurements.

4.3.1.1 Tributary North cross section 2 (TN02)

There is one chain located in the middle of the gully which was found on 8 November 2005. The chain was buried and was orientated downstream. Measurements were:

- Depth to first link……..0 mm,
- Depth to first vertical link…….0 mm, and
- Depth to straightened chain……..-300 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 300 mm and there was no fill. The 2005 bed level was 300 mm below the 2004 bed. This chain was removed on 8 November 2005.

4.3.1.2 Tributary North cross section 4 (TN04)

There was one chain in the middle of the main gully which was found on 8 November 2005. This chain was not reset in 2004 and was left 150 mm below the bed. The chain was located with all links vertical which indicates that only scour occurred during the 2004/2005 wet season. Measurements were:

- Depth to first link……..110 mm,
- Depth to first vertical link…….110 mm, and
- Depth to straightened chain……..110 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 40 mm and there was no fill. The 2005 bed level was 40 mm lower than the 2004 level. This chain was removed on 8 November 2005.

4.3.1.3 Tributary North cross section 5 (TN05)

Tributary North cross section 5 (TN05) is located on the tributary gully channel and has one chain located in the middle of the gully. This chain was located on 8 November 2005. This chain was not reset in 2004 and was left 40 mm below the bed. Measurements were:

- Depth to first link……..70 mm,
- Depth to first vertical link…….70 mm, and
- Depth to straightened chain……..70 mm (relative to 2004 bed level).

The 2004–2005 wet season had no scour and there was 30 mm of fill. The 2005 bed level was 30 mm higher than the 2004 level. This chain was removed on 8 November 2005.

4.3.1.4 Tributary North cross section 7 (TN07)

Cross section 7 is located across both the main channel and the tributary gully. A single scour chain was installed in each channel.

TN07-main gully

The chain was located on 8 November 2005 and was buried with all links vertical. This chain could not be reset in 2004 and was left 50 mm below the bed. Measurements were:

- Depth to first link……..40 mm,
- Depth to first vertical link…….40 mm, and
- Depth to straightened chain……..40 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was scour 10 mm and there was no fill. The 2005 bed level was 10 mm below the 2004 bed. This chain was removed on 8 November 2005.

TN07-tributary gully

The chain was located on 8 November 2005 and was buried and all links still vertical. Measurements were:

- Depth to first link……..5 mm,
- Depth to first vertical link…….5 mm, and
- Depth to straightened chain……..5 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was nil and the fill was 5 mm. The 2005 bed level was 5 mm higher than the 2004 bed. This chain was removed on 8 November 2005.

4.3.1.5 Tributary North cross section 9 (TN09)

Cross section 9 is located on the main gully downstream of the confluence with the left bank tributary gully but upstream of the junction with Ngarradj.

TN09-scour chain 1

The chain was located on 8 November 2005 and was buried with all links vertical. This chain could not be reset in 2004 and was left 40 mm below the bed. Measurements were:

- Depth to first link……..70 mm,
- Depth to first vertical link…….70 mm, and
- Depth to straightened chain……..70 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was nil and the fill was 30 mm. The 2005 bed level was 30 mm higher than the 2004 bed. This chain was removed on 8 November 2005.

TN09-scour chain 2

The chain was located on 8 November 2005 and was buried and all links still vertical. This chain could not be reset in 2004 and was left 58 mm below the bed. Measurements were:

- Depth to first link……..35 mm,
- Depth to first vertical link…….35 mm, and
- Depth to straightened chain……..35 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 23 mm and there was no fill. The 2005 bed level was 23 mm lower than the 2004 bed. This chain was removed on 8 November 2005.

At TN09 there was an average of 11.5 mm scour and 15 mm of fill even though there was only scour (23 mm of scour) at TN09-2 and fill (30 mm of fill) at TN09-1.

4.3.2 Tributary Central

A single chain was located on each of the three cross sections,TC03, TC09 and TC11 before the 1998/1999 wet season. The scour chain results for 2004/2005 wet season are presented below. These chains were measured annually and were removed after the 2005 measurements

4.3.2.1 Tributary Central cross section 3 (TC03)

There is one chain located in the middle of the channel which was found on 8 November 2005. It was buried and orientated downstream with the flow direction. This chain could not be reset in 2004 and was left 80 mm above the bed. Measurements were:

- Depth to first link……..90 mm,
- Depth to first vertical link…….165 mm, and
- Depth to straightened chain……..-90 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was 85 mm and the fill was 75 mm. The 2005 bed level was 10 mm lower than the 2004 bed. This chain was removed on 8 November 2005.

4.3.2.2 Tributary Central cross section 9 (TC09)

There is one chain located in the middle of the channel which was found on 8 November 2005. The chain was found buried and all links still vertical. This chain was no longer in the middle of the channel as the right bank was eroded and moving laterally. Measurements were:

- Depth to first link……..30 mm,
- Depth to first vertical link…….30 mm, and
- Depth to straightened chain……..30 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was nil and the fill was 30 mm. The 2005 bed level was 30 mm higher than the 2004 bed. This chain was removed on 8 November 2005.

4.3.2.3 Tributary Central cross section 11 (TC11)

There is one chain located in the middle of the channel which was found on 8 November 2005. The chain was found buried and all links still vertical. This chain was no longer in the middle of the channel due to lateral migration of the creek bed. This chain was not reset in 2004 and was left 25 mm below the bed. Measurements were:

- Depth to first link……..70 mm,
- Depth to first vertical link…….70 mm, and
- Depth to straightened chain……..70 mm (relative to 2004 bed level).

The 2004–2005 wet season scour was nil and the fill was 45 mm. The 2005 bed level was 45 mm higher than the 2004 bed. This chain was removed on 8 November 2005.

4.3.3 East Tributary scour chains

Scour chains were installed at four cross sections at the East Tributary gauging station before the 1998/99 wet season. Two chains were located on cross section ET01 and one chain was located on ET04, ET07 and ET08.

4.3.3.1 East Tributary cross section 1 (ET01)

Chain 1 (ET01-1)

Scour chain 1 is located towards the left bank and was found on 8 November 2005. The chain was buried and appears to have fallen on itself as the links were in a pile rather than stretched in a downstream or other direction. Measurements were:

- Depth to first link……..155 mm,
- Depth to first vertical link…….135 mm, and
- Depth to straightened chain……..-55 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 210 mm and was filled by 155 mm over the wet season. The 2005 bed level was 55 mm lower than the 2004 bed. This chain was removed on 8 November 2005.

Chain 2 (ET01-2)

Scour chain 2 is located towards the right bank and was found on 8 November 2005. The chain was buried and orientated almost diagonally downstream and toward the right bank. This chain was not reset in 2004 and was left 100 mm below the bed. Measurements were:

- Depth to first link……..265 mm,
- Depth to first vertical link…….260 mm, and
- Depth to straightened chain……..110 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 165 mm and was filled by 175 mm over the wet season. The 2005 bed level was 10 mm higher than the 2004 bed. This chain was removed on 8 November 2005.

For East Tributary Cross Section 1 the 2004/2005 wet season average scour was 188 mm and the average fill was 165 mm.

4.3.3.2 East Tributary cross section 4 (ET04)

There is one chain in the middle of the channel which was located on 8 November 2005. The chain was buried and was orientated diagonally downstream and towards the right bank. This chain could not be reset in 2004 and was left 60 mm above the bed. Measurements were:

- Depth to first link……..20 mm,
- Depth to first vertical link…….35 mm, and
- Depth to straightened chain……..-85 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 60 mm and was filled by 35 mm over the wet season. The 2005 bed level was 25 mm lower than the 2004 bed. This chain was removed on 8 November 2005.

4.3.3.3 East Tributary cross section 7 (ET07)

There is one chain in the middle of the channel which was located on 8 November 2005. The chain was buried and was orientated diagonally towards the right bank and downstream. Measurements were:

- Depth to first link……..285 mm,
- Depth to first vertical link…….270 mm, and
- Depth to straightened chain……..-40 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 325 mm and was filled by 285 mm over the wet season. The 2005 bed level was 40 mm lower than the 2004 bed. This chain was removed on 8 November 2005.

4.3.3.4 East Tributary cross section 8 (ET08)

There is one chain located near the thalweg on the outside of the point bar towards the left bank. This chain was located on 8 November 2005, was buried and orientated slightly towards the right bank and downstream. This chain could not be reset in 2004 and was left 120 mm above the bed. Measurements were:

- Depth to first link……..15 mm,
- Depth to first vertical link…….15 mm, and
- Depth to straightened chain……..-205 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 100 mm and was filled by 15 mm over the wet season. The 2005 bed level was 85 mm lower than the 2004 bed. This chain was removed on 8 November 2005.

4.3.4 Upper Swift Creek scour chains

Scour chains were installed at three cross sections at the Upper Swift Creek gauging station before the 1998/99 wet season. Two chains were located on cross sections UM02, UM05 and UM07.

4.3.4.1 Upper Swift Creek cross section 2 (UM02)

Chain 1 was located closer to the left bank and chain 2 was closer to the right bank.

Chain 1 (UM02-1)

This chain was located on 8 November 2005. It was buried and orientated perpendicular towards the right bank and slightly downstream. This chain could not be reset in 2004 and was left 110 mm above the bed. Measurements were:

- Depth to first link……..255 mm,
- Depth to first vertical link…….275 mm, and
- Depth to straightened chain……..-110 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 275 mm and was filled by the same amount over the wet season. The 2005 bed level was the same as the 2004 bed. This chain was removed on 8 November 2005.

Chain 2 (UM02-2)

This chain was located on 8 November 2005 and was buried and orientated towards the right bank initially and then spiralled in a downstream direction. This chain could not be reset in 2004 and was left 85 mm above the bed. Measurements were:

- Depth to first link……..385 mm,
- Depth to first vertical link…….350 mm, and
- Depth to straightened chain……..20 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 490 mm and had filled by 385mm over the wet season. The 2005 bed level was 105 mm lower than the 2004 bed. This chain was removed on 8 November 2005.

For Upper Swift Creek Cross Section 2 the 2004/2005 wet season average scour was 383 mm and the average fill was 330 mm.

4.3.4.2 Upper Swift Creek cross section 5 (UM05)

Chain 1 was located closer to the left bank and chain 2 was closer to the right bank.

Chain 1 (UM05-1)

This chain was located on 8 November 2005. It was buried and orientated slightly upstream and towards the right bank. This chain could not be reset in 2004 and was left 60 mm above the bed. Measurements were:

- Depth to first link……..170 mm,
- Depth to first vertical link…….190 mm, and
- Depth to straightened chain……..-35 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 165 mm and was filled by 190 mm over the wet season. The 2005 bed level was 25 mm higher than the 2004 bed. This chain was removed on 8 November 2005.

Chain 2 (UM05-2)

This chain was located on 8 November 2005 and was buried and orientated perpendicular to the flow towards the left bank. This chain could not be reset in 2004 and was left 32 mm above the bed. Measurements were:

- Depth to first link……..225 mm,
- Depth to first vertical link…….200 mm, and
- Depth to straightened chain……..-40 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 233 mm and had filled by 225mm over the wet season. The 2005 bed level was 8 mm lower than the 2004 bed. This chain was removed on 8 November 2005.

For Upper Swift Creek Cross Section 5 the 2004/2005 wet season average scour was 199 mm and the average fill was 208 mm.

4.3.4.3 Upper Swift Creek cross section 7 (UM07)

Chain 1 was located closer to the left bank and chain 2 was closer to the right bank.

Chain 1 (UM07-1)

This chain was located on 8 November 2005. It was buried and orientated upstream against the flow direction. This chain could not be reset in 2004 and was left 95 mm above the bed. Measurements were:

- Depth to first link……..183 mm,
- Depth to first vertical link…….195 mm, and
- Depth to straightened chain……..-110 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 210 mm and was filled by 195 mm over the wet season. The 2005 bed level was 15 mm lower than the 2004 bed. This chain was removed on 8 November 2005.

Chain 2 (UM07-2)

This chain was located on 8 November 2005, was buried and orientated perpendicular to the flow slightly upstream towards the left bank. This chain could not be reset in 2004 and was left 35 mm above the bed. Measurements were:

- Depth to first link……..275 mm,
- Depth to first vertical link…….240 mm, and
- Depth to straightened chain……..-105 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 345 mm and had filled by 275mm over the wet season. The 2005 bed level was 70 mm lower than the 2004 bed. This chain was removed on 8 November 2005.

For Upper Swift Creek Cross Section 7 the 2004/2005 wet season average scour was 278 mm and the average fill was 330 mm.

4.3.5 Swift Creek scour chains

Scour chains were installed at two cross sections at the Swift Creek gauging station before the 1998/99 wet season. Three chains were located on cross sections SM05 and SM08. Additional chains were installed at cross section SM02 before the 1999/2000 wet season

4.3.5.1 Swift Creek cross section 5 (SM05)

The three chains at cross section 5 were searched for again in 2005 and were unable to be located as in previous years, therefore, no scour and fill data is available for this site.

4.3.5.2 Swift Creek cross section 2 (SM02)

Chain 1 (SM02-1)

This chain was located on 10 November 2005. It was buried and orientated downstream and towards the right bank. Measurements were:

- Depth to first link……..170 mm,
- Depth to first vertical link…….183 mm, and
- Depth to straightened chain……..103 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 80 mm and was filled by 183 mm over the wet season. The 2005 bed level was 103 mm higher than the 2004 bed. This chain was removed on 10 November 2005.

Chain 2 (SM02-2)

This chain was located on 10 November 2005 and was buried and orientated in a downstream direction. Measurements were:

- Depth to first link……..10 mm,
- Depth to first vertical link…….10 mm, and
- Depth to straightened chain……..-45 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 55 mm and had filled by 10 mm over the wet season. The 2005 bed level was 45 mm lower than the 2004 bed. This chain was removed on 10 November 2005.

Chain 3 (SM02-3)

This chain was located on 10 November 2005 and was buried and orientated almost perpendicular to flow towards the left bank but slightly downstream. This chain could not be reset in 2004 and was left 283 mm below the bed. Measurements were:

- Depth to first link……..35 mm,
- Depth to first vertical link…….55 mm, and
- Depth to straightened chain……..80 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 308 mm and had filled by 80 mm over the wet season. The 2005 bed level was 228 mm lower than the 2004 bed. This chain was removed on 10 November 2005.

For the 2004/2005 wet season, the average scour was 148 mm and the average fill was 91 mm.

4.3.5.3 Swift Creek cross section 8 (SM08)

Chain 1 (SM08-1)

This chain was located on 10 November 2005. It was buried and orientated towards the right bank perpendicular to the flow. Measurements were:

- Depth to first link……..380 mm,
- Depth to first vertical link…….415 mm, and
- Depth to straightened chain……..-10 mm (2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 425 mm and was filled by 415 mm over the wet season. The 2005 bed level was 10 mm lower than the 2004 bed. This chain was removed on 10 November 2005.

Chain 2 (SM08-2)

This chain was located on 10 November 2005 and was buried and orientated almost diagonally toward the right bank and downstream. Measurements were:

- Depth to first link……..300 mm,
- Depth to first vertical link…….395 mm, and
- Depth to straightened chain……..35 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 360 mm and had filled by 395 mm over the wet season. The 2005 bed level was 35 mm higher than the 2004 bed. This chain was removed on 10 November 2005.

Chain 3 (SM08-3)

This chain was located on 10 November 2005 and was buried and orientated diagonally upstream toward the left bank. Measurements were:

- Depth to first link……..210 mm,
- Depth to first vertical link…….200 mm, and
- Depth to straightened chain……..45 mm (relative to 2004 bed level).

These measurements show that during the 2004–2005 wet season the bed was scoured to a depth of 165 mm and had filled by 210 mm over the wet season. The 2005 bed level was 45 mm higher than the 2004 bed. This chain was removed on 10 November 2005.

For the 2004/2005 wet season, the average scour was 317 mm and the average fill was 340 mm.

5 Summary

The channel cross sectional data collected by ***eriss*** on Gulungul Creek for 2005 have been presented in this report as survey data (appendix A). There are now 13 permanently monumented (marked) cross sections installed on Gulungul Creek following the Vigil Network method of the US Geological Survey developed for the International Hydrological Decade. These cross sections have been surveyed during the dry seasons of 2002, 2003, 2004 and 2005 to determine baseline characteristics of Gulungul Creek. Bulk bed material grab samples were collected each year at each of the cross sections to characterise the sediments using particle size analysis. Scour chains have been installed at some of the cross sections to provide information about the scour and fill that occurs during each wet season.

This report also contains limited information collected from Ngarradj Creek in 2005 as well and serves as a data repository for this information.

Continued monitoring of the cross sections, bed material samples and scour chains in Gulungul Creek is recommended prior to the rehabilitation of the Ranger mine to determine/establish the baseline characteristics. This will provide an data set of current conditions against which any impacts of the minesite rehabilitation can be evaluated.

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Appendix A

Survey data for each cross section for 2005

This appendix contains the survey data for each cross section for the 2005 dry season. The sections are listed in increasing numerical order which does not always correspond to their location in downstream sequence. Refer to the relevant diagrams in Section 3 to determine where they are located.

The datum used for each section is an assumed datum with a horizontal angle of either 0°, 90°, 180°, 270° so that there is a distance (chainage) and a height for each survey point. All measurements are in metres and each cross section is independent of each other cross section. The assumed datum is often different between cross sections.

The location of the data files on SSD explorer is in the following directories:

\\Landscape Characterisation and Monitoring\Gulungul Creek\Sediment transport in Gulungul Creek catchment\Data\xsections

Gulungul Creek Cross sections 2005							
UG02 Distance (m)	**16-Aug-05 Assumed Height (m)**	**UG01 Distance (m)**	**16-Aug-05 Assumed Height (m)**	**UG03 Distance (m)**	**16-Aug-05 Assumed Height (m)**	**UG04 Distance (m)**	**16-Aug-05 Assumed Height (m)**
955.235	49.393	1961.794	49.835	958.665	49.265	964.351	49.718
955.235	49.395	1961.792	49.835	958.662	49.265	964.484	49.505
955.359	49.164	1961.897	49.571	958.821	49.015	967.333	49.531
958.207	49.183	1965.581	49.579	962.504	49.136	969.878	49.563
962.143	49.206	1969.63	49.602	964.641	49.159	971.892	49.592
965.145	49.247	1972.675	49.612	966.87	49.117	973.037	49.642
966.775	49.295	1974.177	49.583	969.334	49.027	974.537	49.66
967.55	49.184	1975.219	49.541	971.798	48.925	975.737	49.535
969.702	49.008	1976.066	49.427	973.348	48.805	976.76	49.222
971.18	48.97	1977.089	49.357	974.805	48.668	976.901	49.129
972.158	48.994	1978.717	49.374	975.587	48.577	977.362	48.994
973.385	49.051	1980.548	49.43	975.971	48.437	977.727	48.797
974.524	48.916	1981.488	49.35	976.369	48.431	977.958	48.77
975.447	48.871	1982.264	49.193	976.518	48.323	978.336	48.639
975.731	48.752	1983.203	48.905	976.847	47.773	978.559	48.704
975.947	48.541	1983.83	48.692	977.1	47.723	979.077	48.692
976.116	48.432	1984.209	48.423	978.729	47.729	980.471	48.562
976.331	48.259	1984.496	48.413	979.482	47.672	981.231	48.471
976.53	48.223	1985.279	48.094	981.668	47.696	982.19	48.4
976.878	48.271	1985.605	48.079	983.923	47.696	982.844	48.381
977.34	48.151	1985.972	48.108	984.737	47.583	983.317	48.4
977.748	48.038	1986.527	47.987	985.44	47.45	983.95	48.326
978.073	47.912	1987.646	48.072	985.649	47.525	984.831	48.194
978.838	47.75	1988.71	48.193	986.008	47.896	985.203	48.231
980.333	47.816	1990.279	48.253	986.233	48.036	986.536	48.366
981.558	47.875	1991.491	48.206	986.431	48.087	986.983	48.523
982.548	47.928	1991.784	48.14	986.819	48.305	987.345	48.561
983.676	47.896	1992.009	48.221	986.903	48.561	988.112	49.111
984.337	47.893	1992.575	48.657	987.045	48.59	988.453	49.196
984.787	48.91	1992.666	49.117	987.458	48.962	988.664	49.353
985.11	49.153	1993.187	49.264	987.757	49.072	988.853	49.363
985.868	49.23	1994.008	49.287	988.329	49.158	989.027	49.316
986.918	49.211	1994.788	49.495	989.44	49.189	989.694	49.282
987.679	49.196	1996.503	49.58	989.784	49.136	990.256	49.307
989.308	49.301	1998.717	49.684	990.599	49.148	991.182	49.512
991.004	49.348	2028.457	51.147	992.243	49.231	992.232	49.681
993.566	49.444	2028.149	51.134	993.454	49.371	993.165	49.701
996.076	49.566	2027.772	51.118	995.012	49.45	995.148	49.78
998.719	49.689	2027.476	51.094	996.92	49.567	995.864	49.792

Gulungul Creek Cross sections 2005							
UG02 Distance (m)	**16-Aug-05 Assumed Height (m)**	**UG01 Distance (m)**	**16-Aug-05 Assumed Height (m)**	**UG03 Distance (m)**	**16-Aug-05 Assumed Height (m)**	**UG04 Distance (m)**	**16-Aug-05 Assumed Height (m)**
		2027.001	51.111	998.431	49.654	996.273	49.75
		2026.764	51.117			998.188	49.784
		2026.323	51.097			964.357	49.719
		2025.564	51.122				
		2025.03	51.118				
		2024.176	51.08				
		2023.079	51.014				

Gulungul Creek Cross sections 2005							
MG05 Distance (m)	**16-Aug-05 Assumed Height (m)**	**MG06 Distance (m)**	**22-Sep-05 Assumed Height (m)**	**MG07 Distance (m)**	**22-Sep-05 Assumed Height (m)**	**MG08 Distance (m)**	**22-Sep-05 Assumed Height (m)**
958.914	49.773	964.565	49.981	1024.522	50.247	1053.327	49.365
958.92	49.773	964.565	49.981	1024.521	50.247	1053.325	49.365
958.909	49.774	964.716	49.739	1024.398	50.002	1053.14	49.077
958.92	49.774	965.684	49.77	1023.264	49.919	1051.842	49.121
958.915	49.773	966.818	49.687	1022.087	49.889	1050.24	49.206
958.924	49.774	968.017	49.572	1021.204	49.942	1048.503	49.324
959.054	49.537	969.137	49.537	1020.674	49.917	1046.947	49.366
959.956	49.56	970.353	49.509	1020.42	49.804	1045.31	49.433
961.09	49.47	971.579	49.508	1020.119	49.411	1043.662	49.495
962.247	49.376	972.729	49.469	1019.792	49.246	1042.101	49.562
963.617	49.33	973.674	49.546	1019.594	49.11	1040.882	49.579
964.26	49.376	974.034	49.493	1019.361	48.884	1040.237	49.594
965.652	49.464	974.433	49.359	1019.246	48.811	1039.931	49.534
967.172	49.369	974.739	49.188	1019.234	47.969	1039.743	49.425
968.312	49.291	974.998	49.122	1018.926	47.867	1039.657	49.208
969.685	49.294	975.366	48.925	1018.188	47.755	1039.54	49.093
971.321	49.317	975.502	48.576	1017.338	47.767	1039.532	48.644
971.891	49.318	975.654	48.424	1016.974	47.827	1039.314	48.481
972.908	49.157	975.859	48.204	1016.687	47.901	1039.009	48.287
973.544	49.225	976.078	48.126	1016.223	47.977	1038.634	48.138
974.14	49.157	976.79	48.02	1015.413	47.983	1038.306	48.069
974.641	48.864	977.898	47.92	1014.638	47.945	1037.794	48.036
975.176	48.632	979.027	47.874	1013.666	48.05	1036.933	48.023
976.306	48.605	980.037	47.814	1012.675	48.208	1035.8	48.017
976.812	48.497	981.052	47.817	1011.974	48.389	1034.395	48.076
977.321	48.431	982.083	47.734	1011.298	48.553	1033.069	48.035
958.916	49.773	982.838	47.655	1010.626	48.678	1031.836	47.996
978.705	48.566	983.251	47.601	1009.845	48.739	1030.441	48.023
979.351	48.518	983.873	47.615	1009.304	48.72	1029.099	48.08
980.533	48.541	984.616	47.599	1008.793	48.794	1027.85	48.151
981.622	48.622	985.462	47.693	1008.572	48.888	1026.786	48.093
982.821	48.648	986.266	47.782	1008.469	49.191	1025.842	48.098
984.33	48.644	986.625	47.925	1008.204	49.3	1025.429	48.172
984.874	48.667	986.944	48.101	1007.689	49.349	1025.14	48.509
985.51	48.824	987.099	48.175	1007.011	49.257	1024.955	48.649
986.495	48.834	987.232	48.559	1006.222	49.248	1024.742	48.905
986.977	48.703	987.34	48.712	1005.457	49.36	1024.388	49.062
987.48	48.854	987.632	48.731	1004.759	49.528	1023.562	49.082

Gulungul Creek Cross sections 2005							
MG05 Distance (m)	**16-Aug-05 Assumed Height (m)**	**MG06 Distance (m)**	**22-Sep-05 Assumed Height (m)**	**MG07 Distance (m)**	**22-Sep-05 Assumed Height (m)**	**MG08 Distance (m)**	**22-Sep-05 Assumed Height (m)**
987.827	48.891	988.231	48.824	1003.79	49.71	1023.028	48.954
988.544	48.778	989.118	48.939	1002.917	49.8	1022.306	48.924
988.841	48.884	990.314	49.04	1002.201	49.892	1021.298	49.051
989.727	49.643	991.675	49.1	1001.404	49.856	1020.136	49.222
989.928	49.974	992.872	49.138			1018.774	49.319
990.206	50.033	994.078	49.228			1017.139	49.24
991.632	50.03	995.465	49.38			1015.23	49.342
993.854	49.974	997.341	49.51			1013.231	49.358
995.856	49.871	998.548	49.637			1011.172	49.297
998.44	49.834	907.984	49.914			1009.058	49.243
		910.789	49.847			1007.146	49.42
		914.017	49.753			1005.107	49.625
		917.141	49.671			1003.473	49.7
		920.098	49.605			1001.747	49.743
		923.025	49.536				
		926.07	49.464				
		929.089	49.392				
		932.185	49.325				
		935.775	49.282				
		939.047	49.233				
		942.122	49.219				
		944.795	49.224				
		947.414	49.254				
		949.453	49.386				
		952.17	49.377				
		954.85	49.47				
		957.876	49.607				
		960.61	49.677				
		963.059	49.732				
		970.814	49.514				
		941.826	49.214				

Gulungul Creek Cross sections 2005							
MG09 Distance (m)	**22-Sep-05 Assumed Height (m)**	**DG10 Distance (m)**	**22-Sep-05 Assumed Height (m)**	**DG11 Distance (m)**	**22-Sep-05 Assumed Height (m)**	**DG13 Distance (m)**	**22-Sep-05 Assumed Height (m)**
964.076	49.772	978.423	49.932	974.252	50.487	946.793	50.126
964.076	49.772	978.427	49.932	974.417	50.24	946.793	50.125
964.18	49.551	978.591	49.706	975.326	50.229	946.941	49.927
965.333	49.462	979.824	49.699	976.211	50.198	948.252	49.85
966.474	49.343	981.062	49.667	977.025	50.103	950.109	49.81
967.78	49.27	982.425	49.596	977.652	49.934	951.817	49.797
968.933	49.264	982.966	49.645	978.338	49.712	953.721	49.75
970.08	49.279	983.363	49.677	979.102	49.495	955.182	49.707
971.367	49.304	983.527	49.622	979.875	49.265	956.968	49.759
972.653	49.376	983.665	49.416	980.693	49.121	958.71	49.826
973.552	49.419	983.92	49.202	981.574	49.083	960.242	49.687
974.461	49.449	984.461	48.996	981.976	49.02	961.392	49.885
975.33	49.522	984.748	48.944	982.262	48.847	962.456	49.925
976.187	49.471	985.149	48.761	982.497	48.672	963.535	49.916
976.869	49.487	985.51	48.662	982.813	48.588	964.585	49.833
977.4	49.477	986.472	48.659	983.148	48.394	965.248	50.008
977.604	49.412	987.615	48.693	983.48	48.319	966.019	49.897
977.718	48.949	988.717	48.763	983.956	48.271	966.874	49.916
977.933	48.512	989.849	48.739	984.774	48.349	967.432	49.76
978.093	48.428	990.938	48.761	985.643	48.488	967.945	49.46
978.731	48.402	991.643	48.715	986.44	48.536	968.473	49.383
980.095	48.33	991.922	48.703	987.22	48.46	969.631	49.358
981.397	48.31	992.313	48.724	987.975	48.34	970.677	49.367
982.637	48.267	992.648	48.885	988.452	48.204	971.339	49.282
983.914	48.212	993.049	49.128	988.908	48.063	971.756	49.072
985.161	48.109	993.263	49.379	989.546	47.965	972.158	48.855
986.008	48.089	993.437	49.512	990.28	47.928	972.552	48.589
986.811	48.124	993.551	49.888	990.912	47.98	973.63	48.522
987.352	48.17	993.86	49.943	991.441	48.135	974.37	48.325
987.559	48.26	994.369	50.012	991.815	48.285	975.091	48.134
987.759	48.369	995.321	50.001	992.115	48.426	976.407	48.048
988.013	48.933	996.401	49.954	992.5	48.726	977.675	47.974
988.212	49.102	997.806	49.873	992.817	48.907	978.832	47.924
988.723	49.189			993.177	49.259	979.623	48.009
989.86	49.243			993.693	49.366	980.146	48.199
991.394	49.371			994.321	49.486	980.495	48.359
992.944	49.519			994.858	49.644	980.776	48.519
994.485	49.63			995.54	49.806	981.054	48.772

Gulungul Creek Cross sections 2005							
MG09 Distance (m)	**22-Sep-05 Assumed Height (m)**	**DG10 Distance (m)**	**22-Sep-05 Assumed Height (m)**	**DG11 Distance (m)**	**22-Sep-05 Assumed Height (m)**	**DG13 Distance (m)**	**22-Sep-05 Assumed Height (m)**
995.993	49.674			996.512	49.89	981.395	49.38
997.335	49.696			997.403	49.885	981.995	49.588
998.49	49.71			998.499	49.852	983.147	49.767
						984.219	49.906
						985.612	49.926
						987.519	49.924
						989.589	49.844
						991.596	49.799
						993.541	49.643
						995.52	49.775
						997.515	49.793

Appendix B

Cumulative frequency grain size distributions for bulk bed-material samples on Gulungul Creek for 2005

Table B1 Cumulative frequency grain size distributions for bulk bed-material samples on the Gulungul Creek for 2005

Sample	UG02	Gravel Mass = 5.91 g	
Date	16-aug-05	Remaining Mass = 1061.48 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	5.91	0.55
-0.5	1.4 mm	1.47	1.84
0.0	1.0 mm	5.28	5.16
0.5	710 μm	19.49	17.57
1.0	500 μm	53.98	47.70
1.5	355 μm	82.39	72.51
2.0	250 μm	109.03	95.77
2.5	180 μm	113.46	99.64
3.0	125 μm	113.79	99.93
3.5	90 μm	113.84	99.97
4.0	63 μm	113.86	99.99
<4.0	<63 μm	113.87	100.00

Folk (1974) Texture Group: Slightly granular medium sand

Sample	UG01	Gravel Mass = 10.75 g	
Date	16-aug-05	Remaining Mass = 1448.47 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	10.75	0.74
-0.5	1.4 mm	1.07	1.69
0.0	1.0 mm	4.09	4.39
0.5	710 μm	15.66	14.73
1.0	500 μm	48.68	44.25
1.5	355 μm	76.79	69.37
2.0	250 μm	101.58	91.53
2.5	180 μm	108.42	97.64
3.0	125 μm	110.23	99.26
3.5	90 μm	110.75	99.72
4.0	63 μm	110.95	99.90
<4.0	<63 μm	111.06	100.00

Folk (1974) Texture Group: Slightly granular medium sand

Sample	UG03	Gravel Mass = 2.31 g	
Date	16-aug-05	Remaining Mass = 1819.88 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	2.31	0.13
-0.5	1.4 mm	0.25	0.35
0.0	1.0 mm	1.73	1.68
0.5	710 μm	12.81	11.62
1.0	500 μm	53.39	48.05
1.5	355 μm	82.61	74.28
2.0	250 μm	106.04	95.31
2.5	180 μm	110.7	99.49
3.0	125 μm	111.12	99.87
3.5	90 μm	111.2	99.94
4.0	63 μm	111.24	99.97
<4.0	<63 μm	111.27	100.00

Folk (1974) Texture Group: Slightly granular medium sand

Sample	UG04	Gravel Mass = 4.76 g	
Date	16-aug-05	Remaining Mass = 1532.97 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	4.76	0.31
-0.5	1.4 mm	0.61	0.88
0.0	1.0 mm	3.41	3.49
0.5	710 μm	16.63	15.84
1.0	500 μm	67.15	63.04
1.5	355 μm	92.55	86.76
2.0	250 μm	102.98	96.51
2.5	180 μm	105.98	99.31
3.0	125 μm	106.58	99.87
3.5	90 μm	106.68	99.96
4.0	63 μm	106.71	99.99
<4.0	<63 μm	106.72	100.00

Folk (1974) Texture Group: Slightly granular coarse sand

Table B1 (Cont.) Cumulative frequency grain size distributions for bulk bed-material samples on the Gulungul Creek for 2005

Sample	MG05	Gravel Mass = 8.35 g	
Date	16-aug-05	Remaining Mass = 1738.58 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	8.35	0.48
-0.5	1.4 mm	1.3	1.58
0.0	1.0 mm	4.76	4.50
0.5	710 μm	19.33	16.83
1.0	500 μm	58.84	50.25
1.5	355 μm	89.36	76.07
2.0	250 μm	111.36	94.68
2.5	180 μm	117.04	99.48
3.0	125 μm	117.58	99.94
3.5	90 μm	117.63	99.98
4.0	63 μm	117.64	99.99
<4.0	<63 μm	117.65	100.00

Folk (1974) Texture Group: Slightly granular coarse sand

Sample	MG06	Gravel Mass = 5.71 g	
Date	23-sep-05	Remaining Mass = 2944.58 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	5.71	0.19
-0.5	1.4 mm	0.22	0.38
0.0	1.0 mm	1.49	1.45
0.5	710 μm	8.77	7.57
1.0	500 μm	49.33	41.66
1.5	355 μm	91.61	77.21
2.0	250 μm	113.08	95.26
2.5	180 μm	117.57	99.03
3.0	125 μm	118.41	99.74
3.5	90 μm	118.61	99.91
4.0	63 μm	118.68	99.97
<4.0	<63 μm	118.72	100.00

Folk (1974) Texture Group: Slightly granular medium sand

Sample	MG07	Gravel Mass = 2.81 g	
Date	22-sep-05	Remaining Mass = 2661.74 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	2.81	0.11
-0.5	1.4 mm	0.27	0.36
0.0	1.0 mm	1.48	1.50
0.5	710 μm	8.91	8.48
1.0	500 μm	38.86	36.64
1.5	355 μm	67.71	63.76
2.0	250 μm	92.61	87.17
2.5	180 μm	102.92	96.86
3.0	125 μm	105.49	99.28
3.5	90 μm	105.98	99.74
4.0	63 μm	106.13	99.88
<4.0	<63 μm	106.26	100.00

Folk (1974) Texture Group: Slightly granular medium sand

Sample	MG08	Gravel Mass = 6.96 g	
Date	22-sep-05	Remaining Mass = 2339.68 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	6.96	0.30
-0.5	1.4 mm	0.48	0.72
0.0	1.0 mm	2.28	2.30
0.5	710 μm	11.34	10.24
1.0	500 μm	51.78	45.71
1.5	355 μm	88.12	77.59
2.0	250 μm	108.38	95.36
2.5	180 μm	112.83	99.26
3.0	125 μm	113.49	99.84
3.5	90 μm	113.62	99.96
4.0	63 μm	113.65	99.98
<4.0	<63 μm	113.67	100.00

Folk (1974) Texture Group: Slightly granular medium sand

Table B1 (Cont.) Cumulative frequency grain size distributions for bulk bed-material samples on the Gulungul Creek for 2005

Sample	MG09	Gravel Mass = 5.7 g	
Date	22-sep-05	Remaining Mass = 2095.78 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	5.7	0.27
-0.5	1.4 mm	0.64	0.85
0.0	1.0 mm	3.09	3.05
0.5	710 μm	13.46	12.39
1.0	500 μm	58.05	52.53
1.5	355 μm	93.8	84.72
2.0	250 μm	107.25	96.83
2.5	180 μm	109.74	99.07
3.0	125 μm	110.61	99.86
3.5	90 μm	110.73	99.96
4.0	63 μm	110.76	99.99
<4.0	<63 μm	110.77	100.00

Folk (1974) Texture Group: Slightly granular coarse sand

Sample	DG10	Gravel Mass = 1.67 g	
Date	22-sep-05	Remaining Mass = 1577.5 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	1.67	0.11
-0.5	1.4 mm	0.4	0.47
0.0	1.0 mm	2.76	2.59
0.5	710 μm	16.65	15.11
1.0	500 μm	62	55.97
1.5	355 μm	92.71	83.64
2.0	250 μm	108.19	97.59
2.5	180 μm	110.65	99.80
3.0	125 μm	110.83	99.96
3.5	90 μm	110.85	99.98
4.0	63 μm	110.86	99.99
<4.0	<63 μm	110.87	100.00

Folk (1974) Texture Group: Slightly granular coarse sand

Sample	DG11	Gravel Mass = 7.87 g	
Date	22-sep-05	Remaining Mass = 1623.95 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	7.87	0.48
-0.5	1.4 mm	0.38	0.81
0.0	1.0 mm	2.27	2.41
0.5	710 μm	13.27	11.78
1.0	500 μm	52.46	45.13
1.5	355 μm	86.57	74.16
2.0	250 μm	112.66	96.37
2.5	180 μm	116.61	99.73
3.0	125 μm	116.85	99.93
3.5	90 μm	116.89	99.97
4.0	63 μm	116.91	99.98
<4.0	<63 μm	116.93	100.00

Folk (1974) Texture Group: Slightly granular medium sand

Sample	DG13	Gravel Mass = 24.12 g	
Date	22-sep-05	Remaining Mass = 1787.82 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	24.12	1.33
-0.5	1.4 mm	0.2	1.51
0.0	1.0 mm	0.89	2.11
0.5	710 μm	4.81	5.52
1.0	500 μm	22.95	21.32
1.5	355 μm	51.65	46.33
2.0	250 μm	98.03	86.73
2.5	180 μm	111.68	98.62
3.0	125 μm	112.96	99.74
3.5	90 μm	113.15	99.90
4.0	63 μm	113.21	99.96
<4.0	<63 μm	113.26	100.00

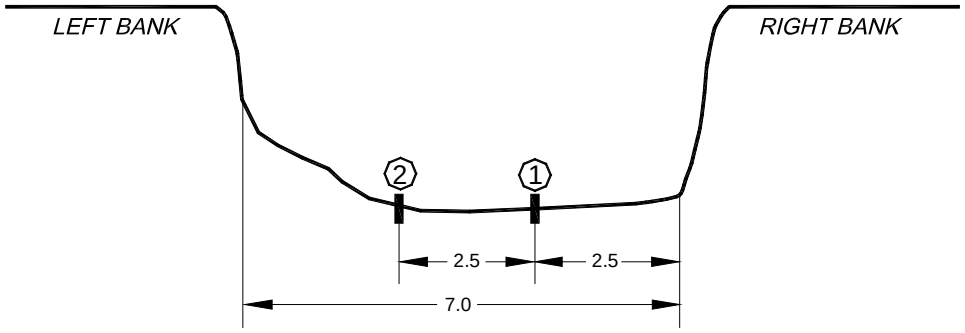
Folk (1974) Texture Group: Slightly granular medium sand

Appendix C

Schematic diagrams to locate the scour chains in Gulungul Creek

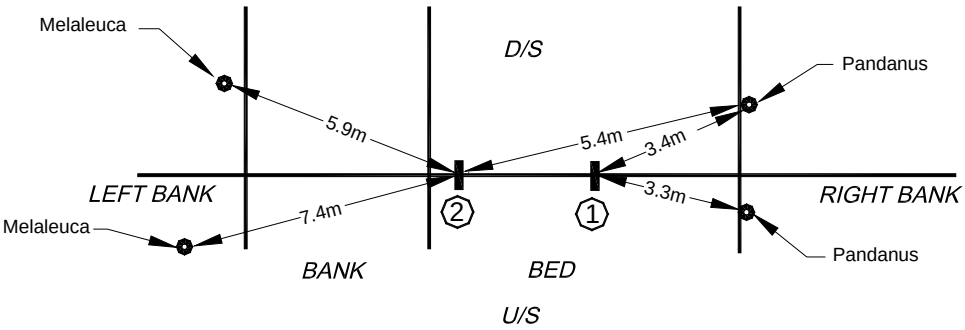
UG02

Chains Initially Installed 30 Oct 02



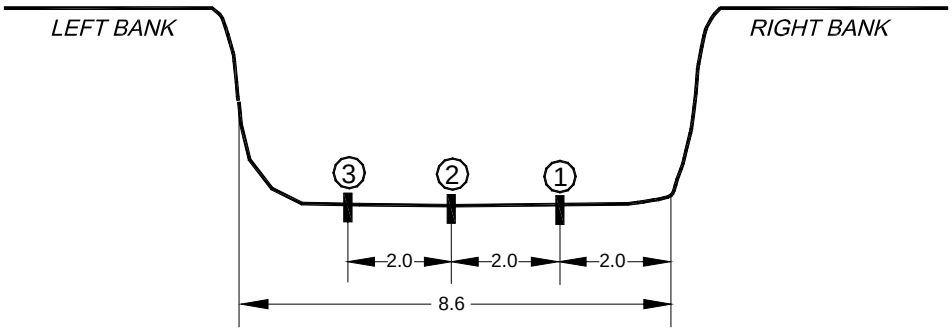
SCOUR CHAIN 1 1.0m All Links Vertical

SCOUR CHAIN 2 1.0m All Links Vertical

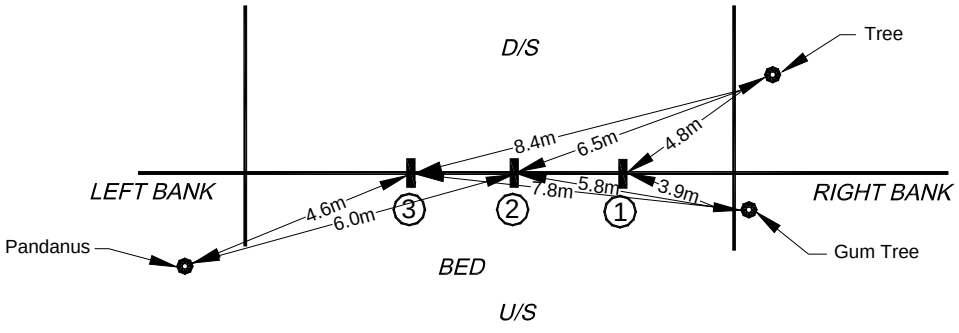


UG03

Chains Initially Installed 30 Oct 02

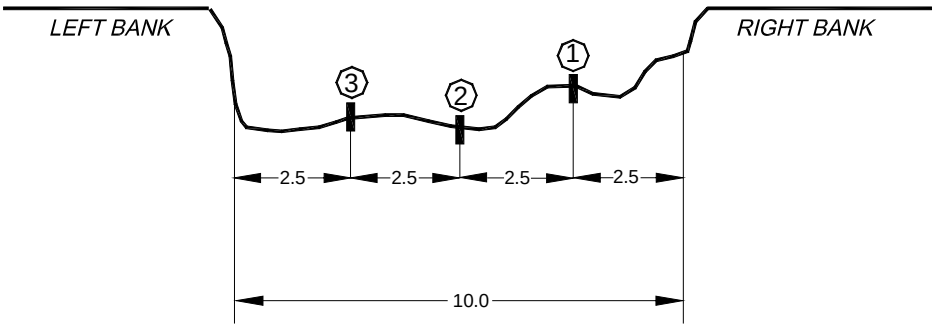


SCOUR CHAIN 1 1.0m All Links Vertical
SCOUR CHAIN 2 1.0m All Links Vertical
SCOUR CHAIN 3 1.0m All Links Vertical

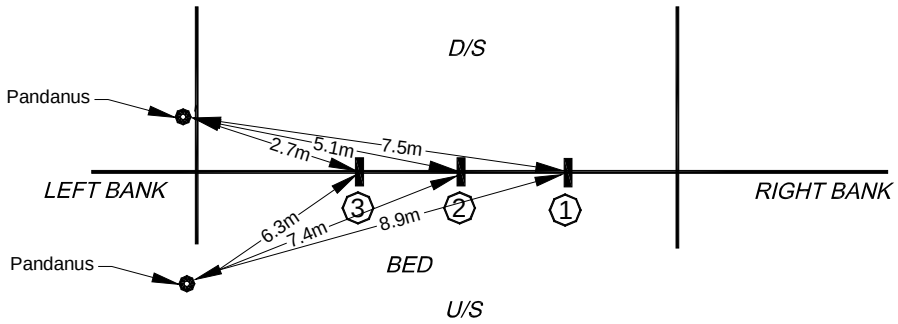


MG06

Chains Initially Installed 30 Oct 02

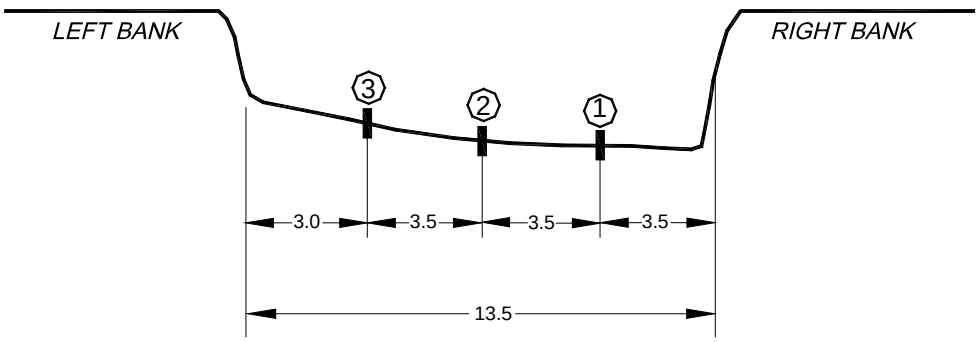


SCOUR CHAIN 1 1.0m All Links Vertical
SCOUR CHAIN 2 0.6m All Links Vertical
SCOUR CHAIN 3 1.0m All Links Vertical

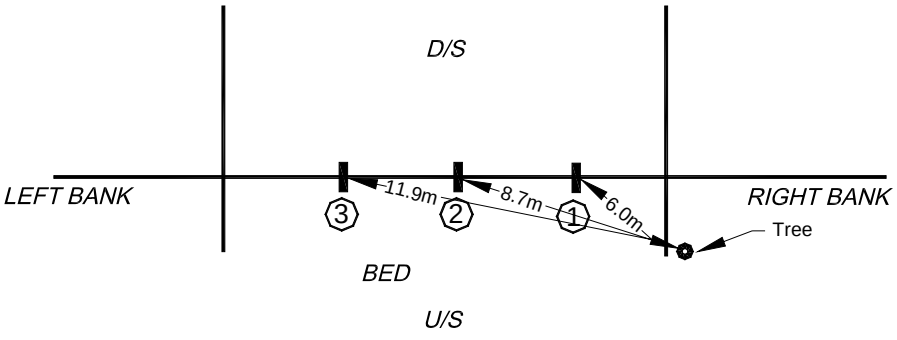


MG08

Chains Initially Installed 30 Oct 02

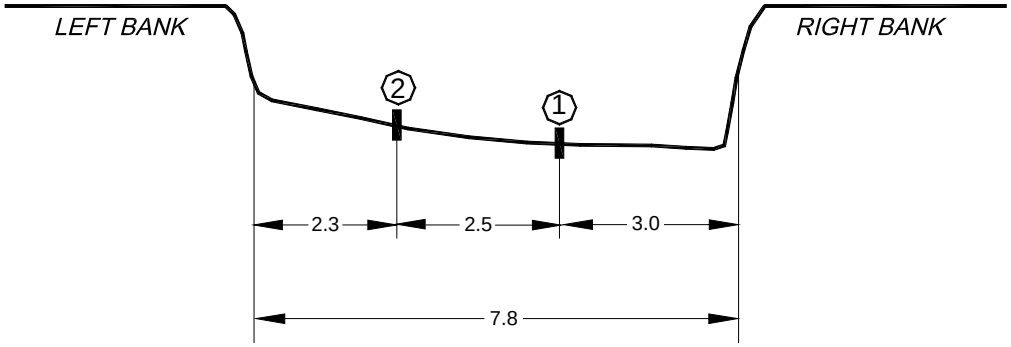


SCOUR CHAIN 1 1.0m All Links Vertical
SCOUR CHAIN 2 1.0m All Links Vertical
SCOUR CHAIN 3 1.0m All Links Vertical

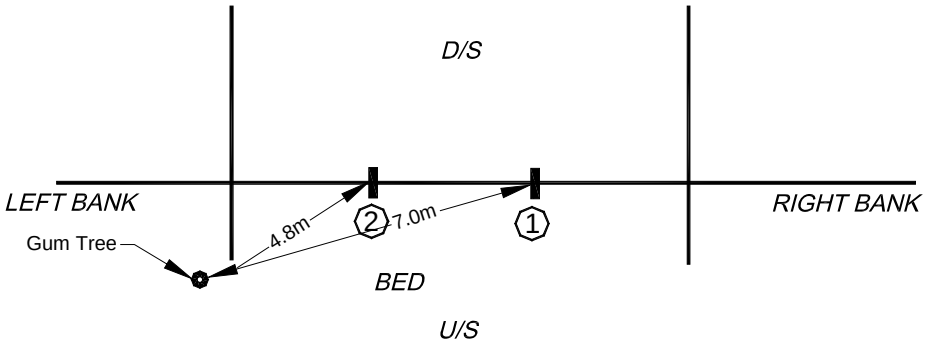


DG10

Chains Initially Installed 30 Oct 02

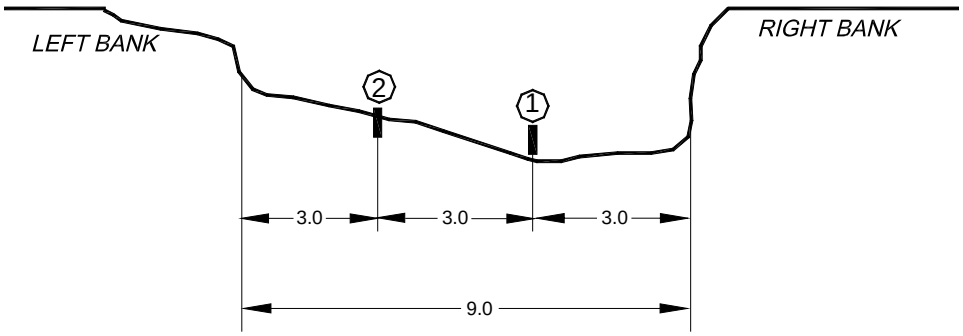


SCOUR CHAIN 1 0.8m All Links Vertical
SCOUR CHAIN 2 0.8m All Links Vertical

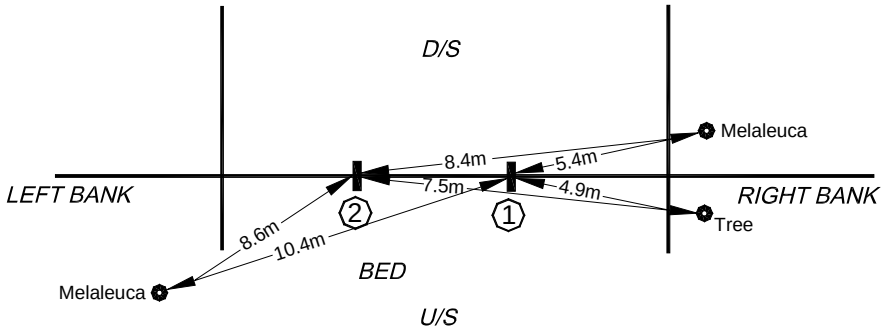


DG11

Chains Initially Installed 30 Oct 02



SCOUR CHAIN 1 1.0m All Links Vertical
SCOUR CHAIN 2 1.0m All Links Vertical



Appendix D Survey data for four cross sections surveyed during the 2005 dry season

This appendix contains the survey data for four cross sections surveyed during the 2005 dry season.

The location of the data files on the ***eriss*** network is in the following directories:

\\Landscape Characterisation and Monitoring\Jabiluka\(Dry) Channel stability in the Ngarradj catchment\Data\Survey xsections*location*

where *location* refers to one of the five sites at which the cross sections are located, namely Tributary North, Tributary Central, East Tributary, Upper Swift Creek and Swift Creek.

Ngarradj Cross sections 2005							
ET05 Distance (m)	**19-Sep-05 Assumed Height (m)**	**SM06 Distance (m)**	**19-Sep-05 Assumed Height (m)**	**UMGW Distance (m)**	**8-Nov-05 Assumed Height (m)**	**GULLYPLAN Distance (m)**	**8-Nov-05 Assumed Height (m)**
9.927	1985.004	2047.86	7.785	13.211	9.641	1008.414	4981.434
9.927	1985.011	2047.857	7.785	13.211	9.641	1007.799	4981.391
9.692	1985.149	2047.714	7.599	13.115	9.46	1007.197	4981.125
9.733	1986.273	2045.264	7.601	12.364	9.469	1006.738	4981.588
9.751	1987.304	2041.099	7.637	11.557	9.396	1006.342	4981.238
9.732	1987.713	2037.671	7.698	10.967	9.406	1006.341	4981.24
9.656	1988.108	2035.252	7.736	10.624	9.427	1005.729	4981.141
9.55	1988.255	2033.702	7.751	10.362	9.393	1004.708	4981.079
9.417	1988.437	2032.791	7.745	9.984	9.46	1003.893	4981.269
9.339	1988.647	2032.019	7.705	9.614	9.4	1002.989	4981.651
9.14	1988.859	2031.215	7.623	9.212	9.313	1002.027	4981.388
9.028	1989.15	2030.638	7.488	8.972	9.225	1001.148	4981.503
8.949	1989.278	2030.068	7.324	8.884	9.151	1000.24	4981.487
8.802	1989.485	2029.428	7.186	8.62	9.074	999.293	4981.822
8.703	1989.62	2028.963	7.043	8.482	8.882	998.503	4981.728
8.37	1989.783	2028.559	6.897	8.317	8.782	998.08	4980.964
8.221	1990.057	2028.041	6.506	8.217	8.519	996.201	4981.3
8.034	1990.392	2027.511	6.223	8.107	8.432	994.779	4981.172
8.011	1990.568	2027.118	6.021	8.04	7.952	994.779	4981.171
8.195	1991.041	2026.916	5.953	7.807	7.848	993.927	4980.923
8.229	1991.257	2026.5	5.973	7.546	7.932	993.214	4980.482
8.267	1991.691	2026.156	6.011	7.015	7.933	992.575	4980.105
8.276	1992.123	2024.971	6.01	6.193	7.88	991.888	4980.374
8.266	1992.536	2023.802	6.057	5.076	7.881	991.535	4979.824
8.266	1992.936	2022.622	6.092	3.799	7.878	990.932	4980.311
8.172	1993.395	2021.626	6.146	3.186	7.886	990.231	4980.254
8.24	1993.602	2021.33	6.171	2.879	7.786	990.081	4980.688
8.26	1993.822	2020.919	6.154	2.617	7.667	989.093	4979.819
8.486	1994.251	2020.774	6.206	2.439	7.706	987.928	4980.023
8.621	1994.484	2020.454	6.455	2.285	7.777	987.459	4979.432
8.841	1994.721	2020.251	6.584	2.174	7.99	987.053	4979.443
9.24	1994.818	2019.895	6.731	2.096	7.971	986.181	4978.189
9.381	1995.321	2019.548	6.911	1.84	8.079	984.718	4977.341
9.581	1995.752	2019.121	6.96	1.697	8.187	984.164	4977.545
9.687	1996.798	2018.792	6.986	1.515	8.219	983.258	4977.108
9.732	1997.583	2018.088	7.135	1.392	8.608	982.406	4977.44
9.715	1998.842	2017.731	7.227	1.208	8.7	981.095	4977.013
		2017.585	7.315	0.997	8.798	979.645	4976.995

Ngarradj Cross sections 2005							
ET05 Distance (m)	**19-Sep-05 Assumed Height (m)**	**SM06 Distance (m)**	**19-Sep-05 Assumed Height (m)**	**UMGW Distance (m)**	**8-Nov-05 Assumed Height (m)**	**GULLYPLAN Distance (m)**	**8-Nov-05 Assumed Height (m)**
		2017.491	7.359	0.857	8.837	978.578	4976.642
		2016.911	7.459	0.727	8.915	977.309	4976.376
		2016.053	7.552	0.645	8.986	976.613	4976.729
		2015.75	7.617	0.576	9.087	975.835	4976.291
		2015.411	7.704	0.283	9.238	975.141	4976.534
		2014.755	7.736	0.061	9.33	974.178	4976.077
		2014.288	7.8	-0.042	9.377	973.107	4976.51
		2013.855	7.705	-0.463	9.505	971.874	4976.158
		2013.505	7.744	-0.733	9.544	971.453	4976.421
		2012.405	7.75	-1.991	9.658	970.569	4976.772
		2011.153	7.749	-3.094	9.749	969.845	4977.836
		2009.849	7.767	-3.727	9.788	969.926	4978.385
		2008.358	7.714	-4.857	9.808	968.606	4978.508
		2006.959	7.706	-5.927	9.802	967.847	4978.809
		2005.687	7.731			967.417	4979.123
		2004.226	7.764			967.246	4979.529
		2002.77	7.804			967.801	4980.44
						967.571	4982.064
						966.554	4982.125
						966.175	4982.446
						965.766	4983.23
						965.91	4983.872
						966.707	4984.393
						967.811	4984.702
						968.642	4984.692
						970.355	4983.95
						971.322	4982.745
						971.799	4982.391
						971.978	4981.808
						973.488	4981.709
						974.567	4981.557
						975.042	4982.013
						977.004	4981.786
						978.303	4981.36
						979.626	4982.18
						981.517	4981.458
						983.185	4981.164
						983.72	4981.301
						984.055	4981.604

Ngarradj Cross sections 2005							
ET05	**19-Sep-05**	**SM06**	**19-Sep-05**	**UMGW**	**8-Nov-05**	**GULLYPLAN**	**8-Nov-05**
Distance	**Assumed**	**Distance**	**Assumed**	**Distance**	**Assumed**	**Distance**	**Assumed**
(m)	**Height (m)**	**(m)**	**Height (m)**	**(m)**	**Height (m)**	**(m)**	**Height (m)**
						983.991	4982.012
						983.463	4982.396
						982.611	4982.81
						981.686	4982.999
						981.295	4983.843
						982.149	4984.516
						983.562	4984.766
						983.59	4985.841
						984.551	4986.211
						986.266	4986.64
						987.205	4986.5
						989.221	4983.79
						990.513	4983.558
						991.33	4983.803
						991.772	4983.57
						992.177	4983.669
						992.716	4983.277
						993.124	4983.601
						994.439	4984.093
						995.985	4984.679
						996.092	4985.183
						995.701	4985.604
						995.944	4986.232
						996.715	4986.674
						997.194	4986.242
						997.95	4986.691
						998.436	4986.068
						999.332	4985.663
						1000.134	4986.174
						1000.807	4985.998
						1001.088	4985.371
						1001.305	4985.503
						1001.314	4986.055
						1002.653	4986.985
				GULLYPLAN	**8-Nov-05**	1003.431	4986.323
				Continued		1004.086	4986.1
				1008.221	4985.661	1005.372	4986.897
				1009.428	4986.3	1007.525	4986.701

Appendix E

Cumulative frequency grain size distributions for bulk bed-material samples on Ngarradj Creek for 2005

Table E1 Cumulative frequency grain size distributions for bulk bed-material samples on the Ngarradj sites for 2005

Sample	UMGW	Gravel Mass = 24.81 g	
Date	8-nov-05	Remaining Mass = 1551.41 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	24.81	1.57
-0.5	1.4 mm	2.68	4.07
0.0	1.0 mm	9.39	10.32
0.5	710 μm	24.65	24.54
1.0	500 μm	55.19	52.99
1.5	355 μm	81.14	77.17
2.0	250 μm	100.34	95.05
2.5	180 μm	105.14	99.52
3.0	125 μm	105.63	99.98
3.5	90 μm	105.64	99.99
4.0	63 μm	105.64	99.99
<4.0	<63 μm	105.65	100.00

Folk (1974) Texture Group: Slightly granular coarse sand

Sample	SM06	Gravel Mass = 125.07 g	
Date	19-sep-05	Remaining Mass = 1880.91 g	
Phi		Mass (g)	Cumulative %
-3.25	9.5 mm	1.31	0.07
-2.0	4.0 mm	16.26	0.81
-1.5	2.4 mm	107.38	5.35
-1.0	2.0 mm	125.07	6.23
-0.5	1.4 mm	8.57	13.53
0.0	1.0 mm	19.77	23.06
0.5	710 μm	37.31	37.99
1.0	500 μm	69.49	65.37
1.5	355 μm	95.18	87.23
2.0	250 μm	106.95	97.25
2.5	180 μm	109.6	99.51
3.0	125 μm	110.09	99.92
3.5	90 μm	110.14	99.97
4.0	63 μm	110.16	99.98
<4.0	<63 μm	110.18	100.00

Folk (1974) Texture Group: Granular coarse sand

Sample	ET05	Gravel Mass = 6.25 g	
Date	19-sep-05	Remaining Mass = 1296.8 g	
Phi		Mass (g)	Cumulative %
-2.0	4.0 mm		
-1.5	2.4 mm		
-1.0	2.0 mm	6.25	0.48
-0.5	1.4 mm	1.07	1.47
0.0	1.0 mm	3.83	4.01
0.5	710 μm	11.64	11.22
1.0	500 μm	38.28	35.81
1.5	355 μm	71.03	66.04
2.0	250 μm	97.41	90.39
2.5	180 μm	106.46	98.74
3.0	125 μm	107.63	99.82
3.5	90 μm	107.75	99.94
4.0	63 μm	107.8	99.98
<4.0	<63 μm	107.82	100.00

Folk (1974) Texture Group: Slightly granular medium sand