OK TEDI MINING LIMITED

ENVIRONMENT DEPARTMENT

FLY RIVER NAVIGATION REPORT
JULY 2002

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CONTENTS

EXECUTIVE SUMMARY

1.0 RIVER BED CHANGE

1.1 Kuambit

The river bed in the Kuambit zone has stabilised since 1997 with no significant increases in bed level. Major problems for river navigability include the constrained width of the navigation channel between ARM 434 and ARM432 as well as the expected increase in aggradation in this channel if adverse climatic conditions eventuate. Navigation is not expected to be a problem with average river levels. With reduced river levels the width of the channel and the expected aggradation in the channel will severely restrict shipping.

1.2 Erekta

The river bed in the Erekta zone is relatively stable, although there is little long term data for comparison. The navigation channel has moved to the northern bank with the 1981 definition being approximately mid-channel. There are some significant bed topography changes that may influence navigability into the future. These changes will be analysed during the next detailed survey. Navigation at the channel crossings (ARM425 and ARM423) are expected to be a major problem if river levels drop below 6 metres at Kiunga.

1.3 Wygerin

Although the lateral extents of the channel at Wygerin have not been evaluated, indications are that the bed in the reach is stable, particularly the bed in the shallower zones. Wygerin has been a site of navigation problems at low river levels and this is expected to be the case into the future. Current data does not show an increased risk due to bed aggradation. Planned detailed work during the next epoch will attempt to define the thalweg and confirm the above.

1.4 MugaMuga

At present the navigability of the MugaMuga reach (ARM90 to ARM75) is not a problem with the eastern channel allowing passage at low tide. The site is, however, undergoing dynamic change and the impact of such change could well be evident in the short term. Continued monitoring of the changes to the bed topography will allow safe and optimised passage through the reach.

2.0 CLIMATIC IMPACTS

While the indicators show that an El Nino in the latter half of 2002 or early in 2003 is not definite there remains a high probability that there will be reduced rainfall in the Fly River catchment during the period, whether or not an El Nino eventuates. This reduction in rainfall will impact on river navigability, particularly in the Kuambit, Erekta and Wygerin reaches. For the period to July 2003, adverse climatic conditions will be the major impediment to river navigability. Trends indicate that reduced river flow is likely to increase sedimentation in many of the navigation channels. This will compound the problem of low river levels and may see some of the channels have severe navigation problems earlier than expected.

1.0 INTRODUCTION

This report details the investigations into the navigability of the Fly River, as at March 2002, and introduces predictions for river navigability during the twelve months to July 2003 based on river bed sedimentation trends and expected climatic conditions.

The report covers investigations undertaken during the March 2002 river survey, with emphasis on the known navigation problem sites of Kuambit (ARM436 to ARM432), Erekta (ARM 425 to ARM 423), Wygerin (ARM 402 to ARM 399) and MugaMuga (ARM90 to ARM75). In addition the report details the latest climatic predictions for the latter half of 2002 and early 2003, looks at the potential of an El Nino developing and the implications of this to Fly River navigability.

2.0 RIVER BED CHANGES / SEDIMENTATION

River navigability is of concern at several sites down the Fly River. Although navigation of the whole river is of concern during periods of low rainfall, and consequently low discharge, the sites to be detailed in this section of the report comprise the major choke points to navigation.

The sites to be evaluated include Kuambit (ARM436 to ARM432), Erekta (ARM 425 to ARM 423), Wygerin (ARM 401 to ARM 399) and MugaMuga (ARM90 to ARM75). The investigations at Erekta and MugaMuga have been detailed. These detailed investigations will enable reliable predictions into the future changes of these zones and the implications for navigability into the future. Such predictions will be possible after the next epoch of investigation (planned for August 2002). Detailed investigations were not undertaken at Kuambit and Wygerin due to constraints on time schedules and problems with local landowners. The detailed investigations are planned to commence at these locations in August 2002.

2.1 KUAMBIT (ARM436 to ARM432)

The Kuambit site has been a site of considerable bed aggradation since mine operations commenced in 1982. Bed rises of approximately 4.0 metres over the reach have been reported over this period. This rise has contributed to significant river navigability problems, particularly during periods of low flow. The rates of bed aggradation have stabilised since 1999 with the introduction of dredging operations in the Lower Ok Tedi. Navigation is, however, still a concern in the following zones:

- channel crossing at ARM434
- Constrained channel on the eastern bank of the Fly River between ARM434 and ARM432.

In order to monitor this zone four cross-sections and a long profile have been analysed over the reach. The long profile is the centre of the river channel and not the thalweg. Figure 1 detail the sites evaluated and the location of the long profile.

Site FR02 is located immediately below D'Albertis Junction and is subject to significant fluctuations in bed profile as a function of river discharge and sedimentation load. Although the section has changed significantly in the past six months (i.e. a narrowing of the channel, with an associated increase in depth at the centre) there has been no average bed level change at this site. Figure 2 shows the FR02 cross-section, with data since monitoring commenced in 1997.

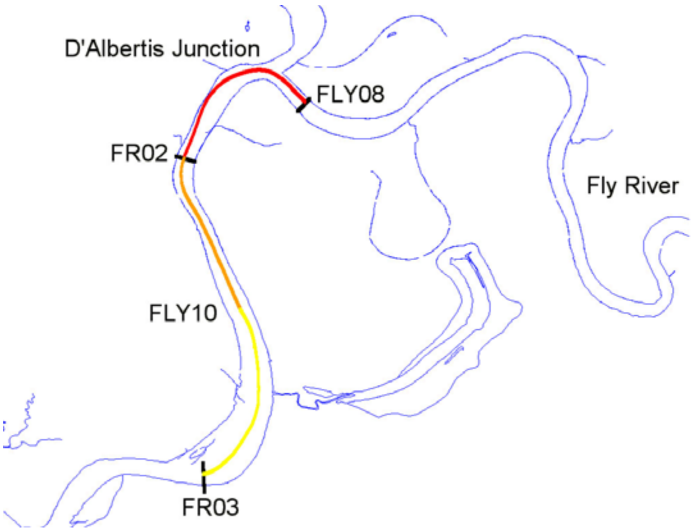

Figure 1 – Cross Section Sites and Profile Location - Kuambit

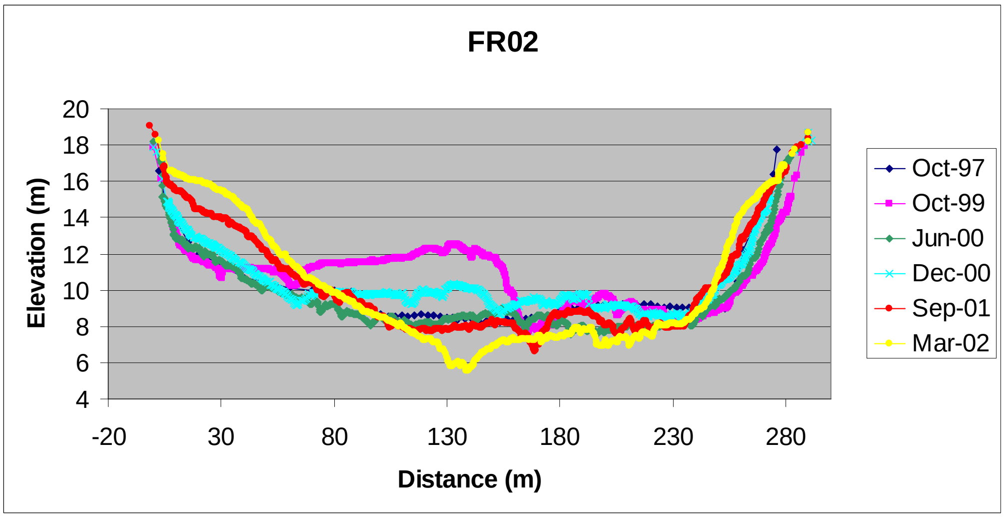

Figure 2 – Cross-Section FR02

Site FLY10 has been a monitoring site since prior to mine commencement and is located across the channel crossing at ARM434. Aggradation at this site since mine commencement has been 3.5 metres, however the site has stabilised over recent years with no net aggradation or significant channel change.

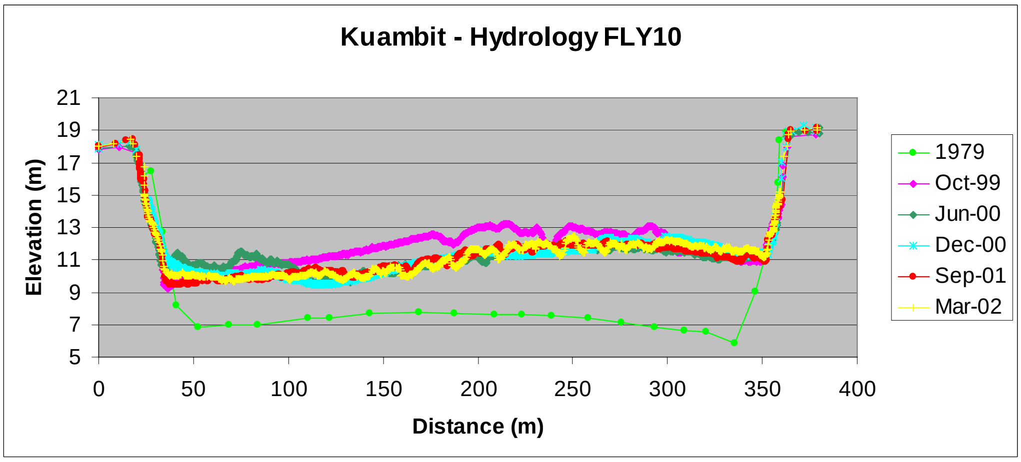

Figure 3 – Cross-Section FLY10

Site FLY10_1.2 is located 1.2km downstream of FLY10 and was included in the monitoring to try to predict changes to the constrained navigation channel in the reach. Although the channel width is not reducing the bed of the navigation channel has reduced in depth by approximately 2 metres in the past six months. Aggradation in the deeper channels is evident along much of the river during periods of reduced flow and the result at this site follows a similar trend. Average aggradation at this site over the past six months is 0.2 metres.

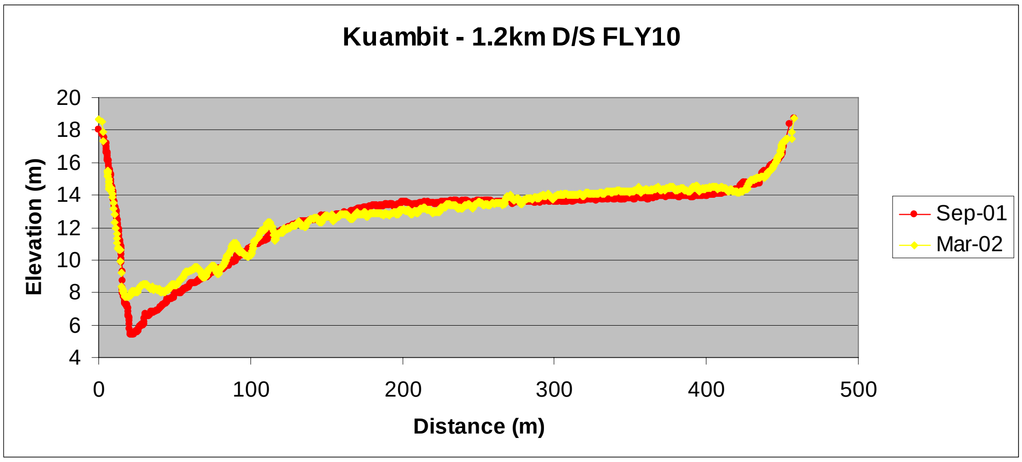

Figure 4 – Cross-Section FLY10_1.2

Site FR03 is located at the downstream end of the monitoring zone at ARM432. The navigation channel at this site has not reduced in width, however is subject to approximately 2 metres of aggradation at the thalweg. Average aggradation across the section is negligible.

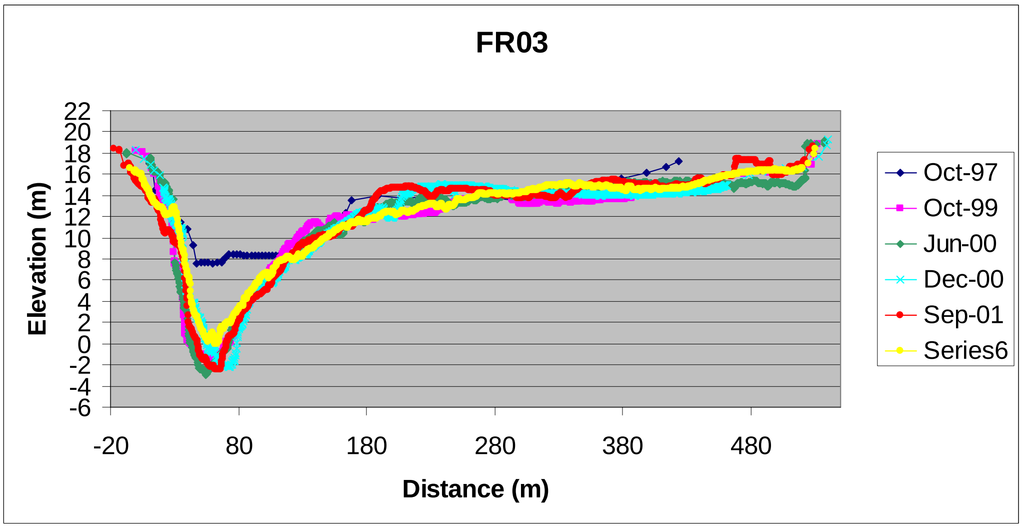

Figure 5 – Cross-Section FR03

The significant thalweg aggradation during the 1997 El Nino is evident in Figure 5. A repeat of such a trend is expected if the expected climatic conditions for 2002 – 2003 eventuate. Navigation channels which are operational at present may not be functional with lower river levels.

A long profile has been analysed down the centre of the channel, between ARM 436 and ARM432. Average aggradation over the profile is 0.1 metres, with 0.3 metres between D'Albertis Junction and FR02, 0.3 metres between FR02 and FLY10 and -0.2 metres between FLY10 and FR03. The significant observation over the long profile is that the majority of aggradation is occurring in the deeper holes with the shallower zones being relatively stable.

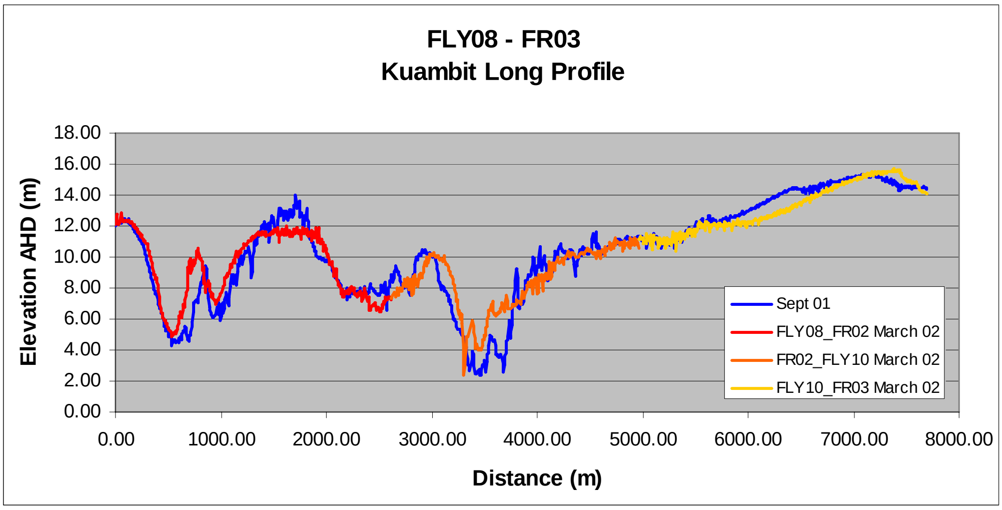

Figure 6 – Long Profile ARM436 – ARM432

The river bed in the Kuambit zone has stabilised since 1997 with no significant increases in bed level. Major problems for river navigability include the constrained width of the navigation channel between ARM 434 and ARM432 as well as the expected increase in aggradation in this channel if adverse climatic conditions eventuate. Navigation is not expected to be a problem with average river levels. With reduced river levels the width of the channel and the expected aggradation in the channel will severely restrict shipping.

2.2 EREKTA (ARM425 to ARM423)

The Erekta site has been monitored, in detail, with the aim of predicting future navigability through the reach. A series of forty sections was established in March 2002 and an optimal navigation channel derived from the data. In addition a long profile and a cross-section were acquired at the standard monitoring locations. This was undertaken to provide preliminary aggradation estimates until the next detailed survey has been undertaken. Figure 7 shows the location of the monitoring sites while Figure 8 shows the results of the detailed survey. All analysis has been based on a Kiunga River Level of 5.8 metres.

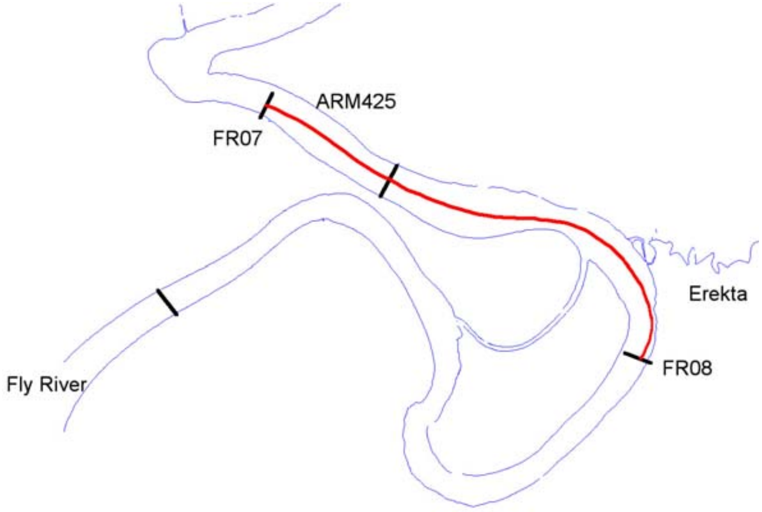

Figure 7 – Cross-Section and Profile Locations – Erekta

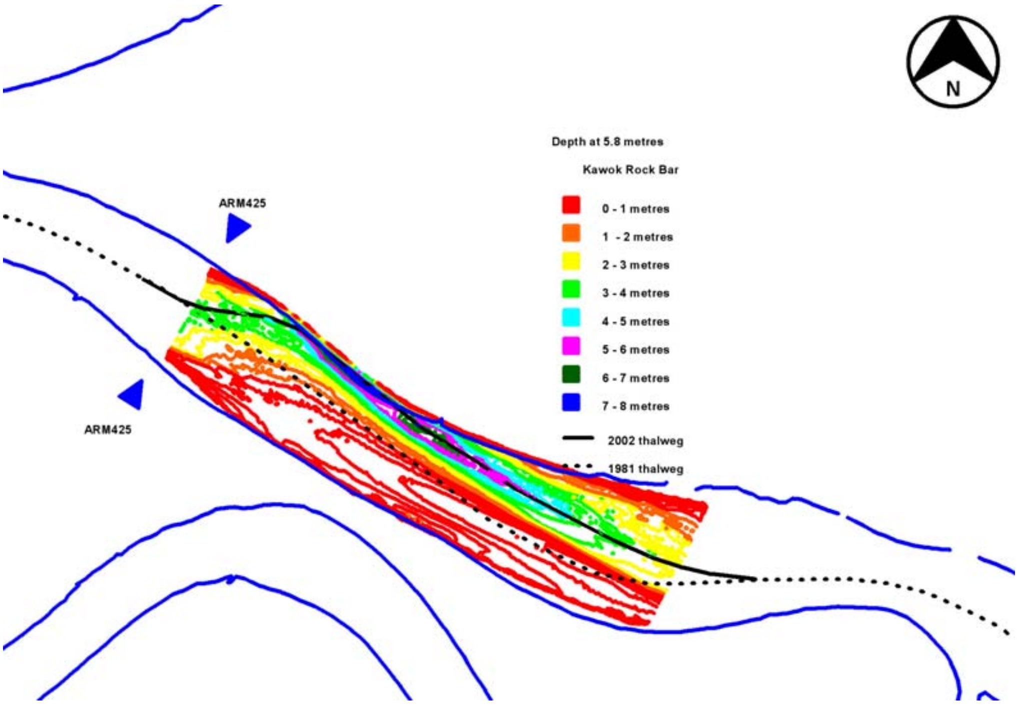

Figure 8 – Erekta Detailed Analysis, 2002 Thalweg

At Kiunga 5.8 metres there is expected to be significant navigation restrictions in this zone. The crossings at ARM425 and ARM 423 will both be at a depth of approximately 3 metres. Navigation through the remainder of the zone will be possible through the channel on the northern bank of the Fly River; however channel width is expected to be a problem if river levels drop. Waypoints for the revised 2002 thalweg have been included in this report as Appendix A (WGS84) and Appendix B (AGD66).

Cross-Section ARM424 is located in the centre of the detailed zone and shows changes to the bed over the past six months. Although there has been negligible average change to the bed there has been some aggradation in the navigation channel. This will only be significant if river levels drop significantly and channel aggradation increases.

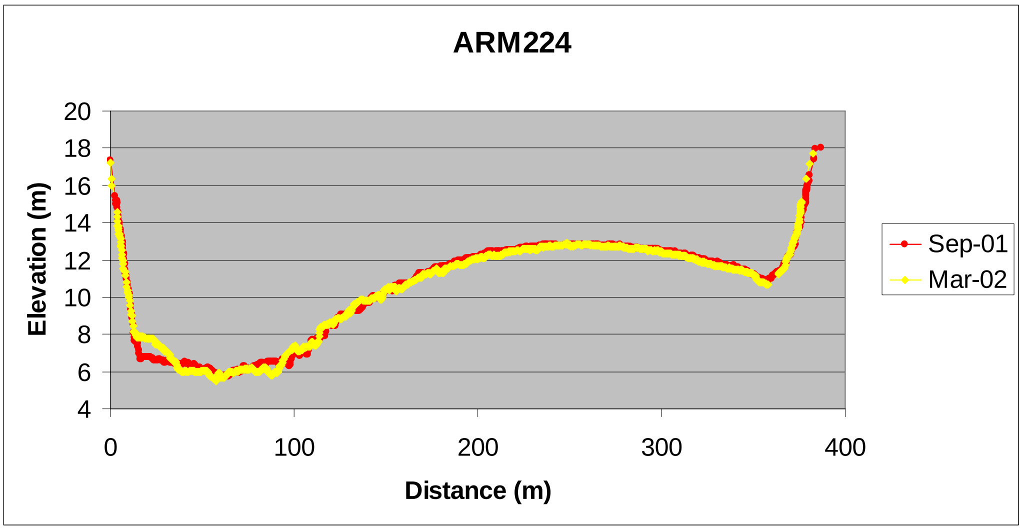

Figure 9 Cross-Section ARM424

The long profile through the zone is shown in Figure 10. Average aggradation through the profile is negligible however there are some significant changes to the bed topography. Future detailed survey will enable prediction of whether this will have any impacts on navigation through the reach.

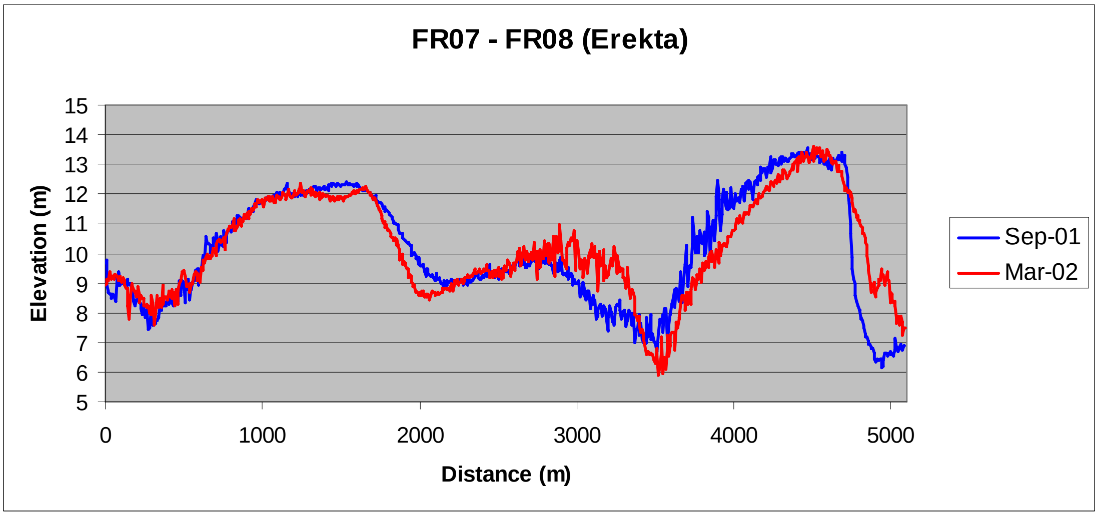

Figure 10 Long Profile Erekta (ARM426 – ARM423)

The river bed in the Erekta zone is relatively stable, although there is little long term data for comparison. The navigation channel has moved to the northern bank with the 1981 definition being approximately mid-channel. There are some significant bed topography changes that may influence navigability into the future. These changes will be analysed during the next detailed survey. Navigation at the channel crossings (ARM425 and ARM423) are expected to be a major problem if river levels drop below 6 metres at Kiunga.

2.3 WYGERIN (ARM402 to ARM399)

Monitoring at the Wygerin Crossing (ARM400) has been restricted due to problems with the local village people. The monitoring has been restricted to a long profile through the reach. The location of the Wygerin long profile is shown in Figure 11.

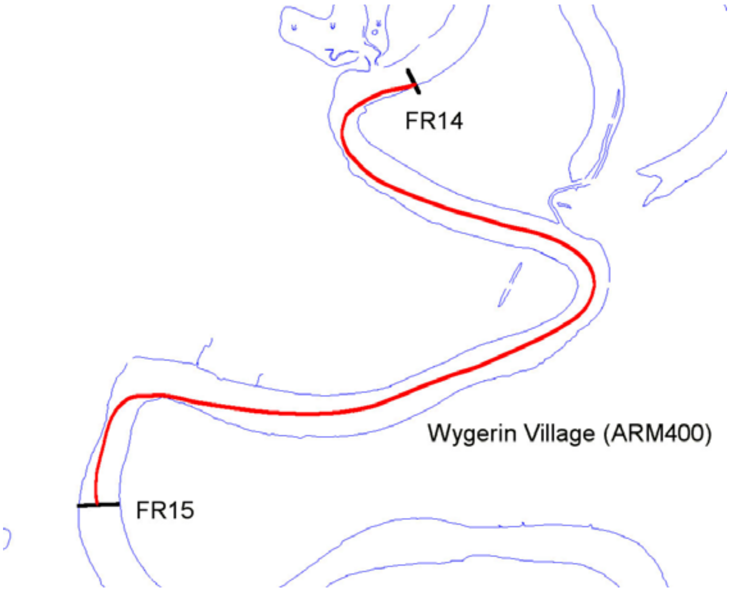

Figure 11 Profile Location - Wygerin

Figure 12 shows the profile with the Wygerin Crossing (ARM400) being between 4000 and 6500. The average aggradation over the whole profile is 0.2 metres, however average aggradation over the Wygerin Crossing reach is -0.1 metres.

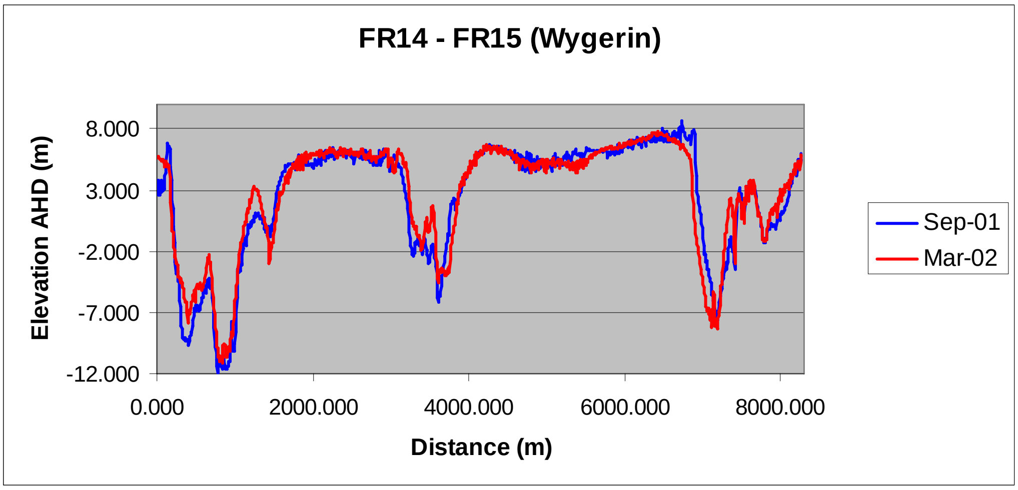

Figure 12 Long Profile Wygerin (ARM402 to ARM399)

Although the lateral extents of the channel at Wygerin have not been evaluated, indications are that the bed in the reach is stable, particularly the bed in the shallower zones. Wygerin has been a site of navigation problems at low river levels and this is expected to be the case into the future. Current data does not show an increased risk due to bed aggradation. Planned detailed work during the next epoch will attempt to define the thalweg and confirm the above.

2.4 MUGAMUGA (ARM90 to ARM75)

The MugaMuga site has been analysed between ARM90 and ARM75 with the aim of assessing the navigability of the reach and to predict future changes that may influence navigation. Unlike the previous zones, the MugaMuga site is tidal and consequently less affected by river levels and adverse climatic conditions. The site has, however been changing significantly over the past several years and the analysis attempts to predict the influence of changes on navigation into the future.

The MugaMuga site is a reach of the river with an average width of 4km. The western bank of the river has been migrating westward at a rate of 20m per annum since the mid 1960s. The reach is characterised by deeper channels on the east and west banks with a large sand bank mid-channel. Prior to 2000 the navigation passage was to cross the sandbank, usually only possible at high tide. With the formation of the eastern channel the crossing has not been required. A detailed analysis of the reach has been undertaken to assess the future navigability of the reach.

Figure 13 shows the location of the study and the changes to the navigation channel between 1981 and 2002. Figure 14 shows the detail of the bed topography over the reach, with an emphasis on the eastern channel. The depths indicated are with respect to Low Water on the 6th April 2002. The tidal range was 2.65 metres.

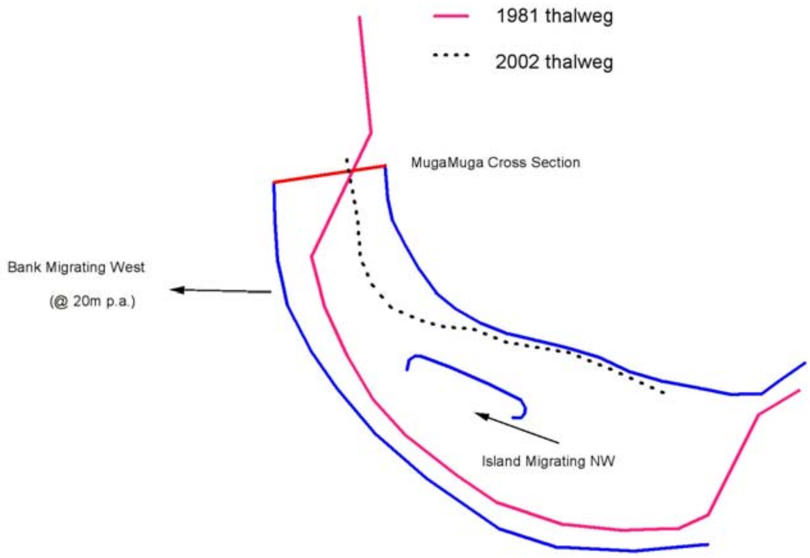

Figure 12 Cross-Section Location and Thalweg – MugaMuga

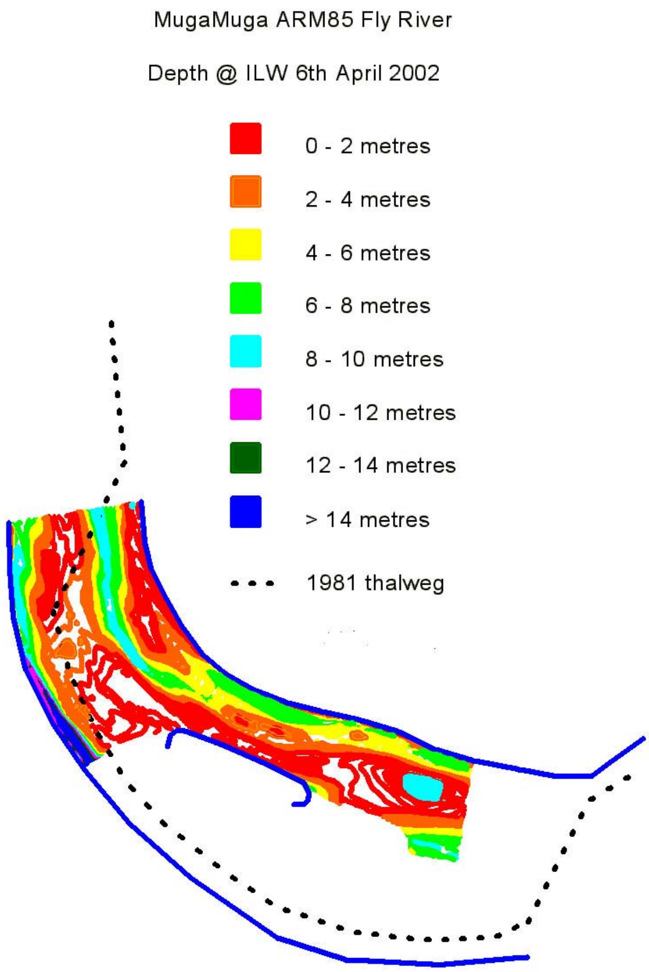

Figure 13 Detailed Analyses – MugaMuga Crossing and Eastern Navigation Channel

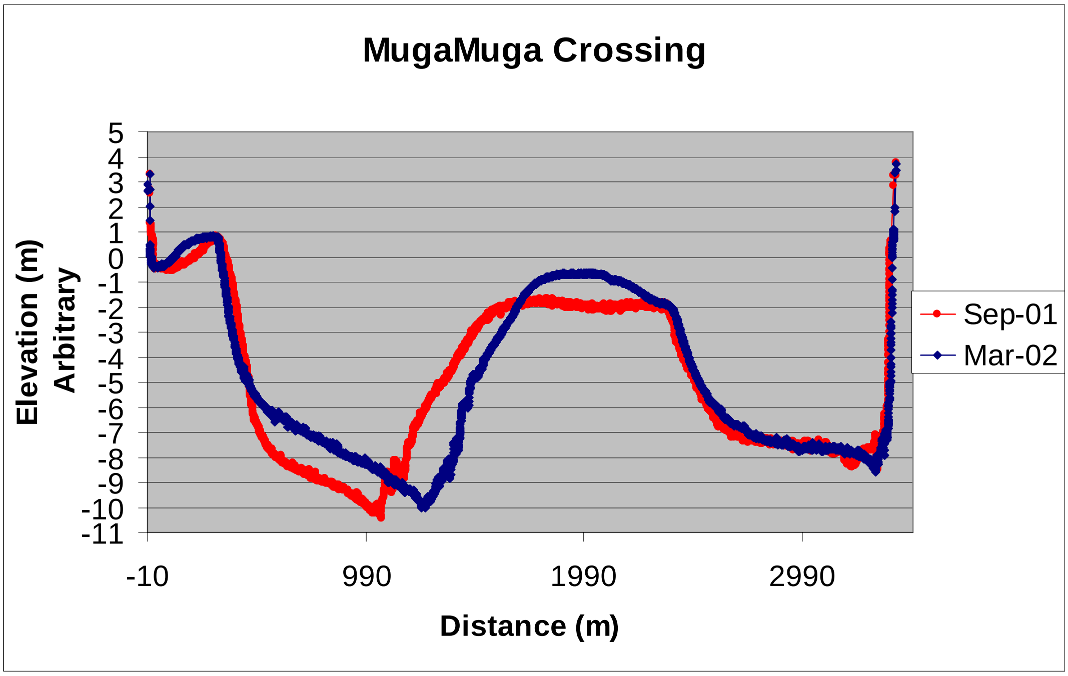

Figure 14 – MugaMuga Crossing Cross-Section

A cross-section has been analysed to estimate channel changes in the absence of a second epoch of detailed survey. Figure 14 shows a cross section immediately upstream of the MugaMuga Crossing.

Average aggradation over this section is 0.1 metres in six months. A trend over several reporting epochs will be required to assess whether this is significant. Of significance from the section is the reduction in width of the main navigation channel (by 200 metres). Although the channel is still functional, monitoring of the central sandbar will be required to determine the future impact to the navigability of the reach.

The MugaMuga site has a western bank that is migrating outwards at a rate of 20 metres per annum. Increased bed aggradation is possible over the reach if the migration of the bank continues. The central island at ARM82 has migrated north-west by two kilometres since the mid 1960s. Detailed monitoring of the reach will give the potential to predict navigability of the reach and to optimise shipping passage as channel changes occur.

At present the navigability of the MugaMuga reach (ARM90 to ARM75) is not a problem with the eastern channel allowing passage at low tide. The site is, however, undergoing dynamic change and the impact of such change could well be evident in the short term. Continued monitoring of the changes to the bed topography will allow safe and optimised passage through the reach.

3.0 CLIMATIC PREDICTIONS

Of significantly greater consequence to the potential navigability of the Fly River is the future climatic conditions. Such conditions, if characterised by low rainfall in the catchment, will have immediate consequences for shipping passage and navigation. Bed topography changes, while significant in localised reaches, tend to become evident slowly and alternatives, including waiting for slightly higher river levels, are generally practical. Longer term periods of low rainfall tend to have immediate detrimental consequences for navigation particularly in periods of El Nino.

During the 1997 El Nino river navigation was impossible for all but smaller dinghies and canoes. There was no passage of container or copper vessels during this period. Between 1998 and 2001 the climatic conditions have been favourable, with above average rainfall and hence above average river levels. There was little impediment to shipping during this period.

Early indications are that El Nino conditions are developing across the Pacific. Although there is some fluctuation of the El Nino indicators and no consistent pattern has yet established, most predictors indicate the development of El Nino conditions in the latter half of 2002 and into 2003.

The SOI (Southern Oscillation Index) is calculated from the monthly fluctuations in air pressure between Tahiti and Darwin. Sustained periods of negative SOI values often indicate El Nino episodes. Positive periods of SOI values will indicate La Nina episodes. Figure 15 shows the SOI figures for the period 1997 to the present. The SOI values clearly show the 1997 El Nino, the 1999 – 2000 La Nina and show the trend towards El Nino conditions through July 2002. A continued negative trend in the SOI in coming months will be associated with an El Nino. The 30 day average SOI at 1 August 2002 is -7.03. The 90 day average SOI at 1 August 2002 is -9.74.

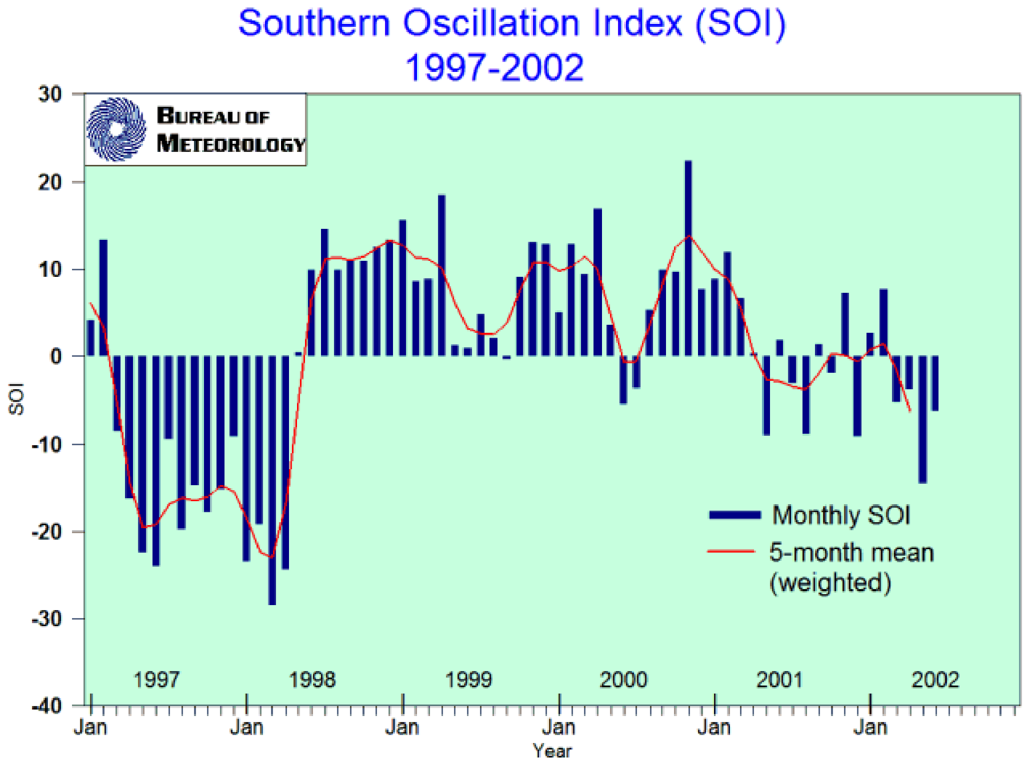

Figure 15 Southern Oscillation Index 1997 – July 2002

An El Nino is characterised by warming of the central and eastern tropical Pacific Ocean, by a decrease in the strength of the Pacific Trade Winds and a reduction in rainfall over Eastern Australia and South-East Asia.

Although the SOI is a strong indicator of a potential El Nino another indicator is the Sea Surface Temperatures (SST) along the equator between South America and Australia. An El Nino is characterised by above average SST. Figures 16 and 17 show a SST plot for the major El Nino events of 1982 and 1997. The band of above average SST values ridging from the Eastern Pacific is clearly evident.

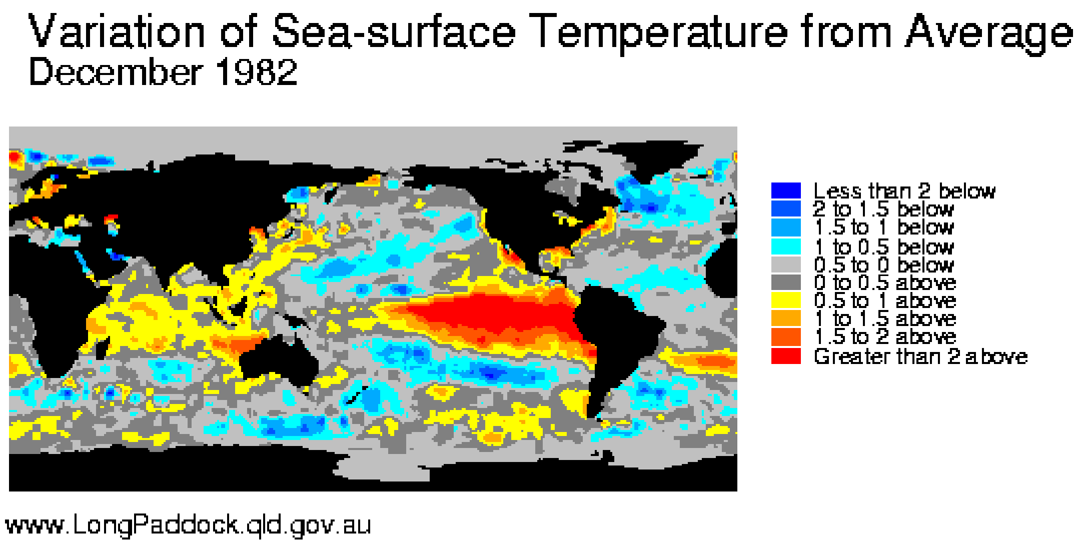

Figure 16 SST Variations from Average December 1982

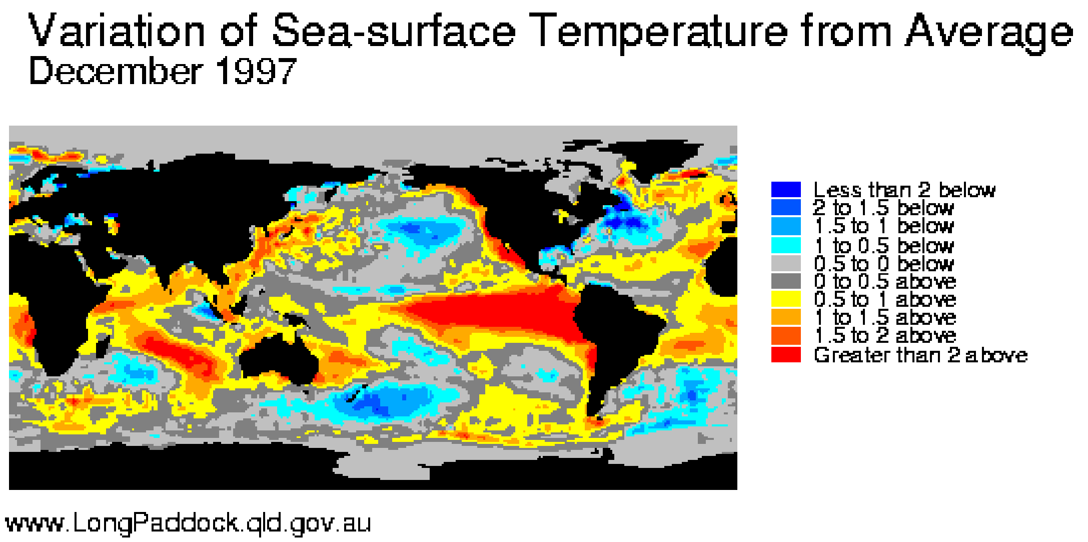

Figure 16 SST Variations from Average December 1997

Although there is currently a warming trend across the Pacific, a counter is the colder zone in the Eastern Pacific as shown in Figure 17. This indicates that the El Nino pattern has not developed and gives uncertainty to the final state. Changes over the next months will confirm whether an El Nino event is likely in 2002 – 2003. The SST measure shows that the development of an El Nino event is probable, however with some of the indicators being inconclusive, cannot be confirmed.

The prediction of El Nino events is undertaken by numerous organisations, including NOAA, Australian Bureau of Meteorology and CSIRO. Predictions for the probability of an El Nino in the latter half of 2002 and into 2003 vary with some organisations predicting "warm" conditions and others "neutral" conditions. Comparison of June and July 2002 predictions show a slight reduction in the probability of an El Nino with an increasing number of organisations predicting "neutral" conditions. The Australian Bureau of Meteorology prediction is that the chance of an El Nino event into the rest of 2002 remains high – about 80 to 90%.

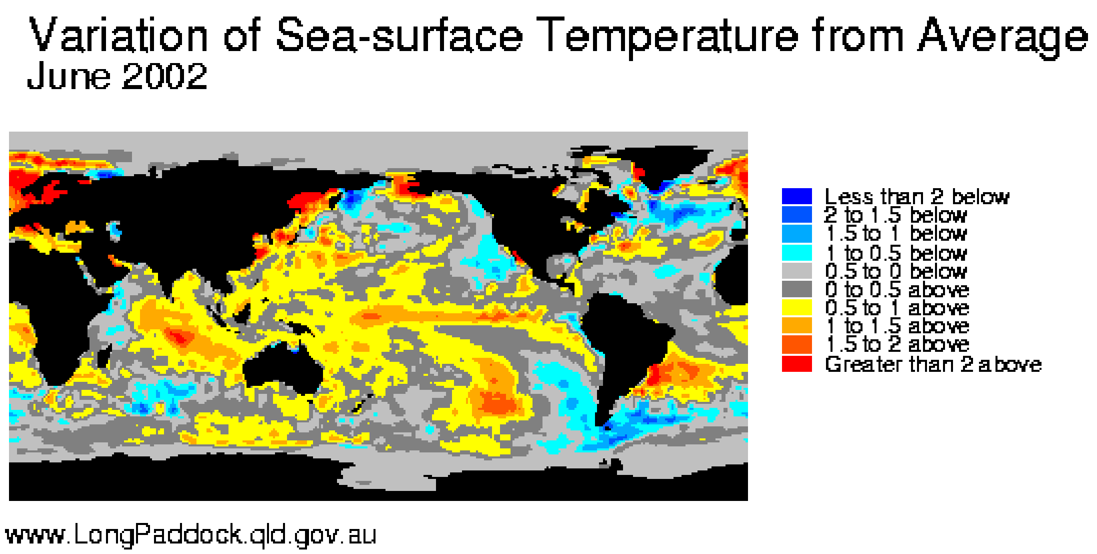

Figure 17 SST Variations from Average June 2002

With respect to river navigability the implications for an El Nino are that rainfall is expected to be lower than average. Figure 18 shows the probability predictions for exceeding median rainfall in the period August – October. Predictions for south-western PNG are at the 40 – 50%. This is a decrease in probability from the previous period predictions (July – September) where the probability was 20 – 30%.

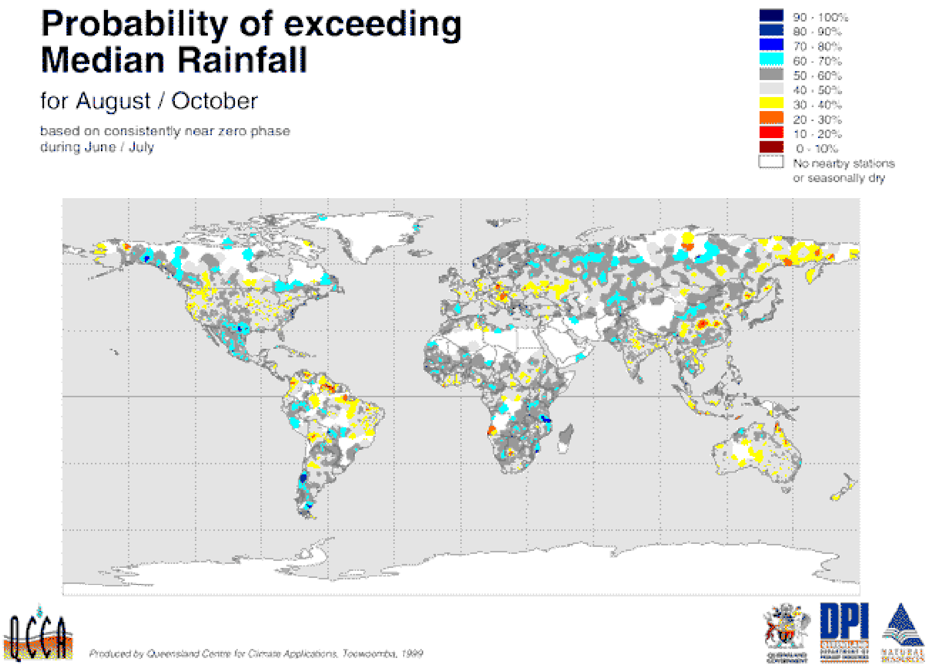

Figure 18 Probability of Exceeding Median Rainfall (July – September 2002)

4.0 CONCLUSIONS

While the indicators show that an El Nino in the latter half of 2002 or early in 2003 is not definite there remains a high probability that there will be reduced rainfall in the Fly River catchment during the period, whether or not an El Nino eventuates. This reduction in rainfall will impact on river navigability, particularly in the zones identified in section 2. For the period to July 2003, adverse climatic conditions will be the major impediment to river navigability. Trends indicate that reduced river flow is likely to increase sedimentation in many of the navigation channels. This will compound the problem of low river levels and may see some of the channels have severe navigation problems earlier than expected.

With average rainfall conditions for the next twelve months, increased bed aggradation will not be a major impediment to navigation. The monitoring of selected navigation problem zones should continue to aid in the assessment of optimal passage and to predict future changes that may impact on navigability.

5.0 REFERENCES

General

Australian Bureau of Meteorology
www.bom.gov.au/climate/

Queensland DPI / QCCA
www.longpaddock.qld.gov.au/SeasonalClimaticOutlook/

Predictions

www.bom.gov.au/climate/ahead/

Links

www.noaanews.noaa.gov/stories/s860.htm

Commentary

"The El-Nino Southern Oscillation (ENSO)" John L.Daly
www.vision.net.au/~daly/elnino.htm

APPENDIX A MugaMuga / Erekta Thalweg Waypoints Datum WGS84

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MugaMuga Thalweg - March 2002
Geodetic Coordinates WGS84

 1 8 15.9683 S 142 24.2895 E
 2 8 16.9470 S 142 24.4772 E
 3 8 17.5794 S 142 24.5204 E
 4 8 18.0073 S 142 24.6960 E
 5 8 18.4141 S 142 25.0454 E
 6 8 18.6265 S 142 25.5478 E
 7 8 18.7170 S 142 25.9166 E
 8 8 18.7455 S 142 26.3564 E
 9 8 18.9786 S 142 26.9513 E
10 8 19.1381 S 142 27.9449 E
11 8 19.3597 S 142 28.5492 E
12 8 19.8252 S 142 29.5847 E
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Erekta Thalweg - March 2002
Geodetic Coordinates WGS84

 1 6 15.7226 S 141  4.5849 E
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2	6	15.7386	S	141	4.6302	E
3	6	15.7473	S	141	4.6916	E
4	6	15.7551	S	141	4.7540	E
5	6	15.7805	S	141	4.8172	E
6	6	15.8289	S	141	4.8762	E
7	6	15.8753	S	141	4.9352	E
8	6	15.9681	S	141	5.0489	E
9	6	16.0356	S	141	5.1585	E
10	6	16.0841	S	141	5.2259	E
11	6	16.1305	S	141	5.3144	E
12	6	16.1853	S	141	5.4177	E
13	6	16.2190	S	141	5.4935	E
14	6	16.2360	S	141	5.5464	E
15	6	16.2591	S	141	5.6896	E

APPENDIX A MugaMuga / Erekta Thalweg Waypoints Datum AGD66

MugaMuga Thalweg - March 2002
Geodetic Coordinates AGD66

1	8	16.0548	S	142	24.2177	E
2	8	17.0335	S	142	24.4054	E
3	8	17.6659	S	142	24.4486	E
4	8	18.0938	S	142	24.6242	E
5	8	18.5006	S	142	24.9737	E
6	8	18.7130	S	142	25.4760	E
7	8	18.8036	S	142	25.8448	E
8	8	18.8320	S	142	26.2846	E
9	8	19.0651	S	142	26.8796	E
10	8	19.2246	S	142	27.8731	E
11	8	19.4462	S	142	28.4774	E
12	8	19.9117	S	142	29.5130	E

Erekta Thalweg - March 2002
Geodetic Coordinates AGD66

1	6	15.8080	S	141	4.5125	E
2	6	15.8240	S	141	4.5578	E

```
 3 6 15.8326 S 141  4.6191 E
 4 6 15.8405 S 141  4.6816 E
 5 6 15.8658 S 141  4.7448 E
 6 6 15.9142 S 141  4.8038 E
 7 6 15.9606 S 141  4.8628 E
 8 6 16.0534 S 141  4.9765 E
 9 6 16.1209 S 141  5.0861 E
10 6 16.1694 S 141  5.1535 E
11 6 16.2158 S 141  5.2420 E
12 6 16.2706 S 141  5.3452 E
13 6 16.3043 S 141  5.4211 E
14 6 16.3213 S 141  5.4740 E
15 6 16.3444 S 141  5.6172 E
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APPENDIX C LATEST CLIMATIC UPDATE (AUGUST 2002)

SUMMARY – Update 20th August 2002 (Bureau of Meteorology, Australia)

The early stage of an El Nino remains across the Pacific with further consolidation of the main indicators being observed during the last week. We now have low SOI, warm water in the central Pacific, weakened Trade Winds and increased cloud, but the critical question is "will they last?" (these conditions need to persist for about 5 or 6 months to be called El Nino). We think the chance is very high (about 90%) that they will, but there is still some level of uncertainty due to the fluctuating nature of some of the indicators. For Example, the waters near the South American Coast remain cooler, not warmer, than average, even though there was a slight warming there during the past week.

IN BRIEF

- We are in the early stages of an El Nino event.
- Sea Surface Temperatures continue to be about 1 to 1.5^{o}C above average across parts of the central equatorial Pacific.
- Preliminary subsurface data for August shows a strengthening of above average temperatures across most of the central to eastern Pacific.
- The SOI fell in July to a value of -8, 2 points below the June value of -6. The approximate 30 day SOI at 18th August was -12.
- Cloudiness remained above average around the dateline in the central Pacific over the past week.

- Trade Winds continued to be reversed (westerly) in the western Tropical Pacific, but were near normal elsewhere during the past week.
- Seven computer models out of twelve surveyed predict central to eastern Pacific conditions in the last half of 2002 – early 2003 period to be sufficiently warm as to be classed as El Nino.

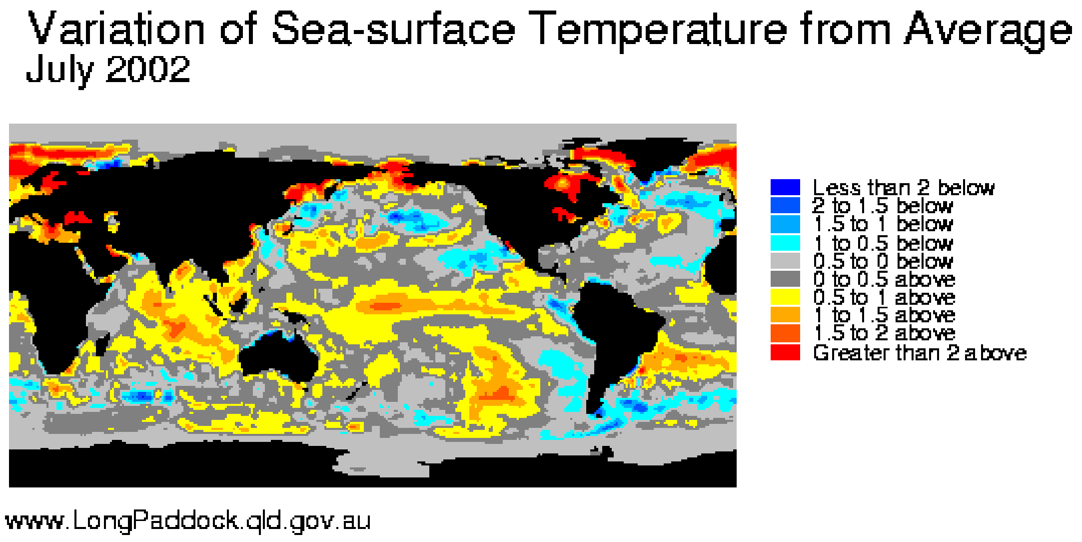

Figure C1 SST Variations from Average July 2002

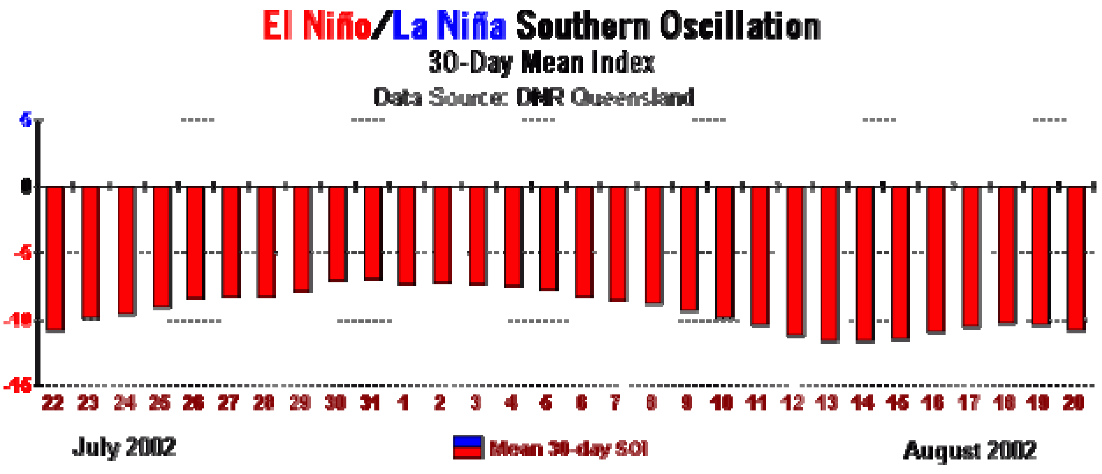

Figure C2 Mean 30-day SOI (July-August 2002)

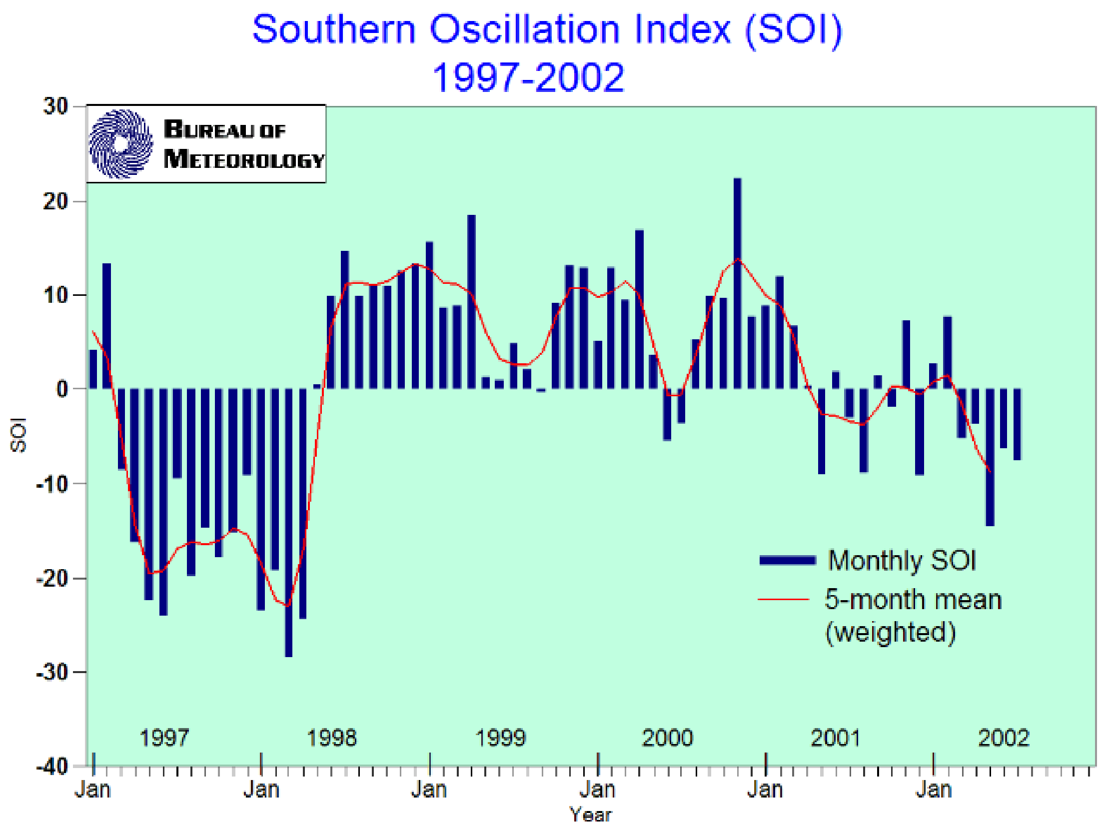

Figure C3 Southern Oscillation Index 1997 – August 2002