River? What River

A Status Investigation of The Macleay River Frederickton to Smithtown

Geoff Songberg
Registered Surveyor
Department Of Lands [2]

Abstract

This paper examines the virtual disappearance of the Macleay River as a consequence of significant changes to the course of the river. The river now passes across freehold properties that were once on the left bank while the former bed has been sold to extend properties on the right bank. Now there is potential for overlap as there has not been any consideration of bank relationships or the manner of river changes. In conducting the investigation a number of methods are examined that can assist in determining whether or not the changes in the course of the river have been gradual.

Introduction

The Macleay River although remaining close to the original bed when European settlement first commenced in the valley, for much of its length it has significantly altered the alignment of its banks. Comparison between the earlier 1850s surveys the alignment of today show shifts of up to 300 metres (Fig 2). A new entrance breakthrough of the beach dune system near South West Rocks in 1886 with further widening in 1893 has probably destabilised the whole river course. There are now many kilometres of rock protected banks built during the 1950s, '60s and '70s to help prevent further erosion of arable farmland. Other investigations of ambulatory boundaries along the river show that much of the river could benefit from a similar assessment to the one carried out here, however the scope of such an investigation is large. It is considered too great for this investigation so the area has been limited to only a small section that is perhaps typical of the whole situation.

Area of Investigation

This investigation covers an 8.5km stretch of the tidal section of the Macleay River between Frederickton and Smithtown. The investigation is specifically targeted at portions 203, 204, 205, 271 to 279 and 285 in the Parish of Cooroobongatti, County of Dudley (Fig 1) along the left bank of the river downstream from Frederickton. Review of only this part of the river bank in isolation would not provide an adequate or true picture or necessarily provide an informative outcome. Therefore the scope of the investigation has been widened to that part of the river between Frederickton and Smithtown (Fig 1) and includes both banks.

[2] The views expressed in this report are those of the author and not necessarily those of the Department of Lands

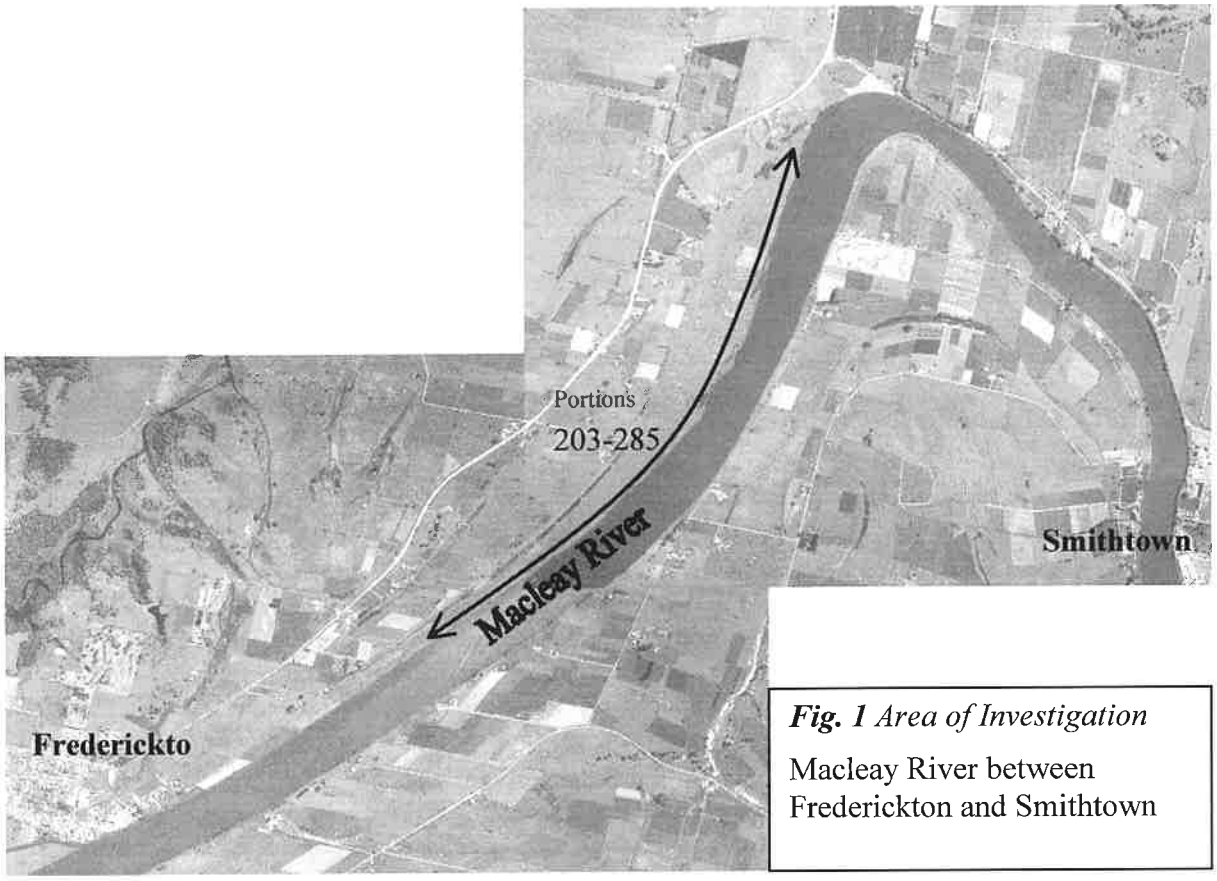


***Fig. 1** Area of Investigation*
Macleay River between Frederickton and Smithtown

The Situation

Status of lands along the current banks of the Macleay River between Frederickton and Smithtown has long been in contention. Three parcels of land below the former bank, 20, 203 and 204 were surveyed in 1887 with the remaining parcels surveyed in 1914. A resurvey of 20 in 1951 created 285 but with the distinct feature of being bounded by right lines offset from the mean high water and a lagoon separating it from the old bank. To date grants have only been issued for 203, 204 and 285 (Fig 3). Most of the lands have simply been occupied with only one owner paying rent to the Crown for a permissive occupancy. There is also one parcel that was incorporated into subsequent title subdivision despite no grant being issued. Over the years inconsistent status investigations, unsubstantiated statements issued as to ownership and concerns by surveyors and land owners has only increased the need for a comprehensive review. Also the river as shifted again since the majority of portions were identified in 1914 and now up to twice the amount of land exists, mostly unsurveyed.

There is also the added dilemma of the physical river for its entire width in one section now occupies what was once and could still be freehold land. Property ownership on the opposite bank has crept into the former river bed so that there is now technically no river (fig 2). Certainly the navigable waterway is no longer in the bed of the river but passes across freehold property.

Although the boundary of lands, and for that matter the river, is technically the mean high water mark due to its tidal nature, the bank is often referred to as the boundary. For this investigation the bank and mean high water mark are considered interchangeable.

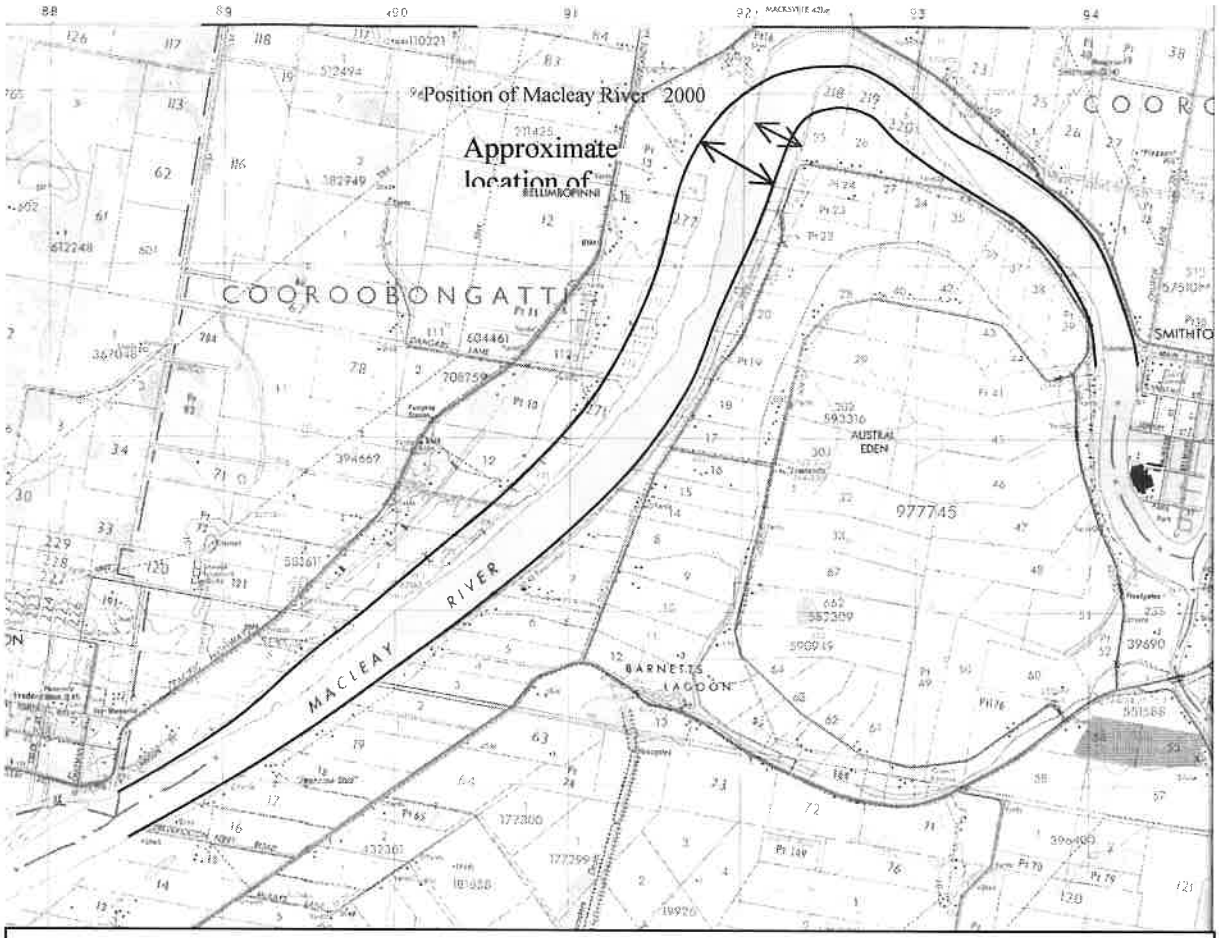


Fig. 2 *Comparative changes in the location of the Macleay River from 1850 to 2000*

Investigation Methodology

Cadastral boundaries along rivers and streams are considered to be ambulatory in that they can move with the physical movement of the river. Physical changes in the location of a river are controlled by the dictates of nature. Changes to a cadastral boundary however are determined through application of laws derived through the judicial system. Those laws require the physical movement of the river to behave in a specified manner before a cadastral boundary can change with the physical river. The physical movement must be classed as gradual and imperceptible in accordance with the doctrine of accretion/erosion for the boundary to also move.

Over the intervening 150 years there have been many surveys conducted along this stretch of the Macleay. Those surveys may or may not have considered the doctrine in determining the boundary location. The surveys do however show the banks of the river at various locations at the time of the survey as the surveyor either adopted the current bank (or MHW) as the boundary or showed its location. One method used in this investigation is to map the multiple locations of the bank from which it should be possible to determine if any trends exist. If the movement of the banks is a reasonably regular and continuous process the calculated movement rates between successive surveys at the same location should also be regular or constant. Variable shifts should show up as variable rates between surveys. It is however not adequate to simply say that the river moved at the rate of x metres per year between surveys. The movement regime must be qualified in that it is possible that the entire shift may have occurred in one instance. There also might be only three surveys in the 150 year interval, a very limited sample upon which to make a fully qualified judgment.

To complement the calculation of movement rates, mapping will also be coupled with river flow characteristics to provide some insight into the behaviour of the river between determinations. Carrying out analysis on long term river flow data can provide the answers to what time interval

and water level might be required to cause shifts in the banks (Songberg 2002). For the change process to be reasonably continuous the river must be regularly flowing at a rate that will bring about the change. Dissimilar flow regimes will more than likely result in irregular changes to the bank.

River flow is also combined with a typical profile across accreted land to attempt to quantify what character could have created the land. Much of the land is now elevated 2 to 3 metres above the water level. Logic dictates that there must have been a considerable increase in the water height, and thus flow, to deposit material at such an elevation above the normal river level. Flow data should provide the necessary information to determine how often the river had risen to increase the land to the existing level.

The commonality between all segments of the investigation is to determine under what classification the change(s) could have occurred. If the change process were to regular then it could likely be classed as gradual and the old boundaries would change with the river bank changes. If on the other hand the change has been caused other than by gradual and imperceptible accretion or erosion, the boundary must be relocated as it was immediately before the change. The old boundaries would remain and never move. The river if it changed enough would end up on freehold land. Central to all is understanding the criteria for conformity to the gradual and imperceptible principle.

Gradual and Imperceptible

The criterion for gradual and imperceptible that has been handed down to us from the legal system has many facets. Each is derived from various court cases. For the change to be considered gradual that change

- Must be the result of a natural process (Trafford v Thrower 1929)
- Not caused by a deliberate act (Attorney General of Nigeria v Holt 1915)
- Cannot be by regular seasonal high flows such as monsoon flows (Boyle Concessions Ltd v Yukon Gold Co 1917)
- Must be by horizontal progression rather than vertical silting or avulsion (Re Bulman 1966)
- Based on the premise that change is not noticeable from day to day, week to week and month to month (Hindson v Ashby 1896)
- Is predominantly a long term steady movement, be it by water or other natural agents (Southern Centre of Theosophy Inc v State of South Australia 1982)

(See Hallmann, Sloane and Willis for further cases and explanation)

Simplistically if the change is reasonably continuous occurring in up to monthly intervals, but not as great as yearly intervals then the change could be considered as being gradual. If however the change is random occurring at intervals of greater than yearly (seasonal) then the change is not gradual.

Mapping

The State of NSW maintains a graphical cadastral database (DCDB) which unfortunately is not spatially correct. Land parcels, although showing the general shape, are somewhat distorted, not correctly sized and not necessarily depict the appropriate ambulatory boundary. This database also only holds the most current record so that historical determinations of the bank or mean high water cannot be shown. Therefore the mapping for this investigation has been undertaken by compilation of all obtainable survey plans, plotting the boundaries as per the plan dimensions. Not all areas are covered, especially the Austral Eden part, as plans are not available. Land identification in this area is by way of old system descriptions, which were not obtained. Spatial control has been achieved through the use of hand held GPS which during tests showed a positional accuracy of less than 5 metres and generally around 2 metres. Some form of control was required, as there had not been any surveyed connection across the Macleay River, at least in the area of investigation. General anomalies between plans have not been removed or investigated, as they were most likely to be

less that the tolerance derived from the control. Some attempt however has been made to reconcile large scale anomalies, which were few.

Mapping Results

Migration of the river eastward has occurred along the section running north east from Frederickton (see figures 3 and 4). Up to 100 metres has been lost of the Austral Eden bank towards the northern end. Changes to the Cooroobongatti side are more significant where the shift in the bank is as much as 350 metres. Some of this movement could have occurred from bars or spits migrating downstream rather than a lateral movement of the bank. The November 1864 and October 1855 plans, as well as indications on other plans and current air photos, show inlets existing behind downstream facing land spits. Those inlets now exist as freshwater lagoons, low swampy sections or depressions in the land profile (see fig 5). A lot of the perimeter of this bank is now confused reedy swampy land and small islands making it difficult to establish the real mean high water. Because of the disparity in the bank shifts the river in this section has narrowed. In Frederickton itself one survey in September 1927 (Diagram A figure 3) seems to defy the overall trend and shows a quantity of erosion. Prior investigations of this area failed to establish a reason for this. Possibilities included either a singular episode of erosion or the survey was to the top of the bank of that time and not the mean high water.

North of Austral Eden the tight bend has been moving northwards. It is unclear precisely where the Austral Eden bank was in 1850 as there was no reliable survey. A 1919 subdivision, the Verges Estate, carried out through old system descriptions is the first identification of the bank. Review of aerial photography suggests that either there may not have been any large shifts in this part of the bank during the intervening time or the subdivision was made to the original bank. However by 1925 the point is shown to exist some 250 metres north of the previous location.

Along the south east reach towards Smithtown there is a general trend for the river to migrate north easterly. The shift becomes less the closer to Smithtown where the banks are relatively stable. One exception to the trend is identified in a March 1940 survey (Diagram C figure 4), which may have located a bar attached to the bank rather than the true bank. The bar appears to have been migrating downstream, as the remnant now seems to be located about 200 metres downstream with the latest identification being the March 1986 survey. The bar is now fully incorporated into the bank as a result of rock revetment walls.

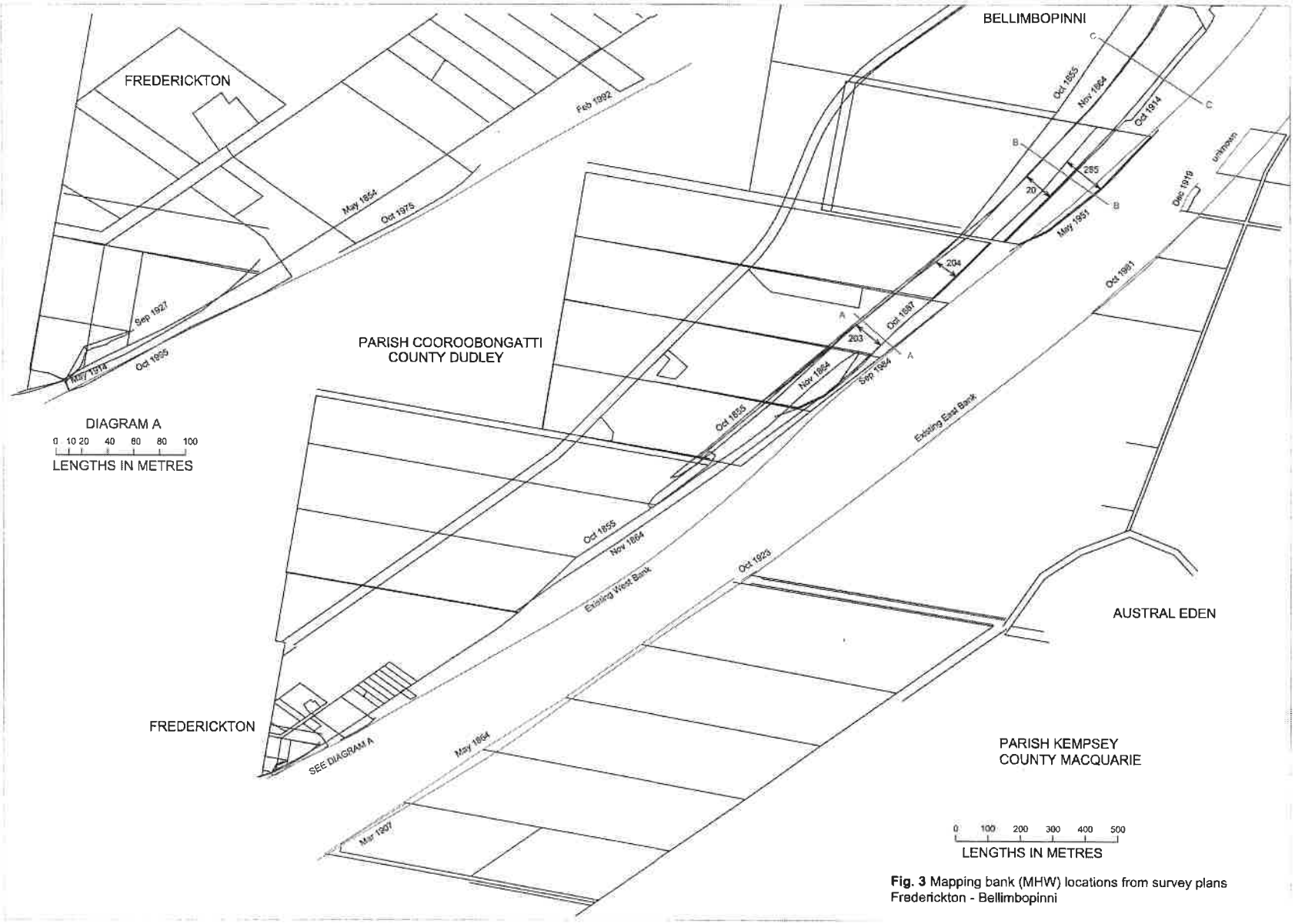


Fig. 3 Mapping bank (MHW) locations from survey plans Frederickton - Bellimbopinni

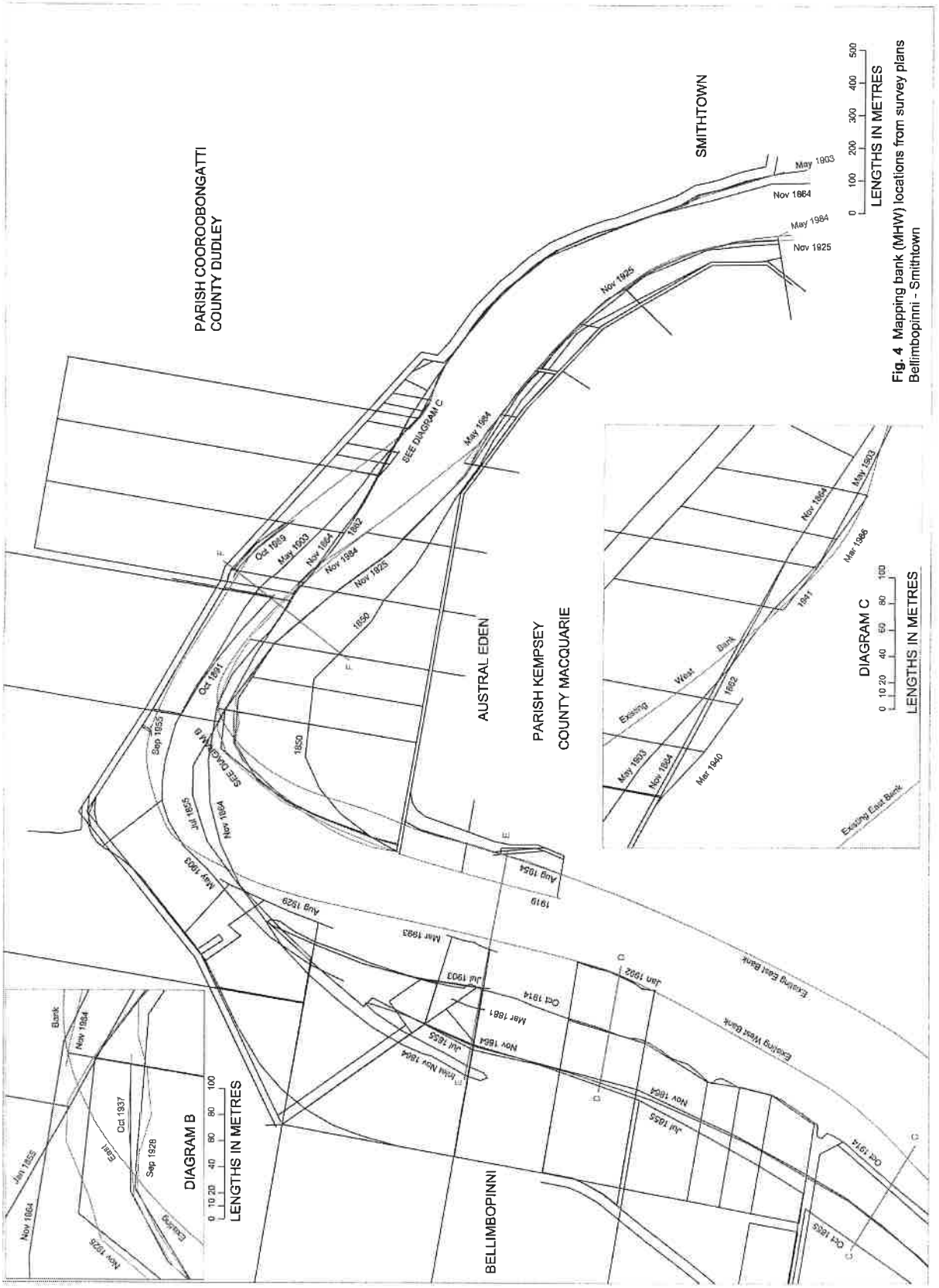


Fig. 4 Mapping bank (MHW) locations from survey plans
Bellimbopinni - Smithtown

Movement of the river has mostly been halted, presumably as a result of rock armouring of the eroding banks during the 1950s, 1960s and 1970s. There may be some movement of the unprotected banks since but review of aerial photography from 1974 onwards does not reveal any large movements. Earlier photography of 1967, 1956 and 1942 could not be easily obtained, thus not reviewed so it is unclear as to exactly when the river migration process was halted. Small scale erosion and deposition was evident during field survey so that the forces causing the initial changes still appear to be at work although contained by the rock walls.

Although mapping has provided some insight into the overall trends the exercise has been unable to determine how those shifts came about. One thing that is clear is the 1850 location of the river at the northern end of Austral Eden is completely on what is now dry land. The freehold properties may have just overlapped onto what was, or could still be, freehold property on the opposite bank. The land has accreted further since the 1925-28 surveys as a November 1984 survey shows the new land as accreted Crown land. It overlaps the original opposite bank boundaries by approximately 40-50 metres and if alienated may in some instances overlap existing titles. Some of the accreted lands might also be a result of bars attached to the bank migrating or extending in a downstream direction. Effectively the river has been lost in this section.

Movement Rates

Accretion needs to occur in a lateral continuous manner extending the bank outwards for change to be considered a gradual process. The passing or extension of a bar might not comply with the gradual criteria as the land steps out quickly at the time the bar is created or reaches the property boundary. Significant downstream shifts in bars might even occur in a single flood event. Rates of movement calculated perpendicular to the bank cannot determine the existence of downstream migrating bars but may give some indication of possible lateral bank shifts. Sections A though E (figures 3 and 4) have been arbitrarily chosen to make comparison. For any one section if the lateral shift between surveys is found to be a constant rate then the process of accretion or erosion might fall into the gradual category. Not all sections will exhibit the same rate of movement as forces within the river change from location to location. The existing bank location, shown in green, has not been included, as it is only an approximation compiled from GPS readings and aerial photography. It at least gives some indication of the present location of the river.

Table 1 **Section A-A** accretion to Cooroobongatti bank			
Survey plan date	**Amount of shift m**	**Time interval yrs**	**Movement rate m/y**
Oct 1855			
Nov 1864	7	9.1	0.8
Oct 1887	94	22.9	4.1
Sep 1984	30	97	0.3

The large difference in movement rate between 1864 and 1887 might possibly be attributed to the migration of a bar identified in the 1864 plan.

Table 2 **Section B-B** accretion to Cooroobongatti bank			
Survey plan date	**Amount of shift m**	**Time interval yrs**	**Movement rate m/y**
Oct 1855			
Nov 1864	53	9.1	5.8
Oct 1914	100	49.9	2
May 1951	94	36.6	2.6

The bar from section A does not seem to have influenced the accretion this far downstream. Other forces seem to be at work, particularly between 1855 and 1864, as the movement rate is high and out of step with the other rates.

Table 3 **Section C-C** accretion to Cooroobongatti bank			
Survey plan date	**Amount of shift m**	**Time interval yrs**	**Movement rate m/y**
Oct 1855	0		
Nov 1864	91	9.1	10
Oct 1914	122	49.9	2.4

Movement rates for this section are remarkably similar to that of section B suggesting similar forces involved. The 1855-1864 rate however is double. There is no indication from the plans as to the reason for the differences.

Table 4 **Section D-D** accretion to Cooroobongatti bank			
Survey plan date	**Amount of shift m**	**Time interval yrs**	**Movement rate m/y**
Jul 1855			
Nov 1864	10	9.3	1.1
Oct 1914	160	49.9	3.2
Jan 1992	173	77.3	2.2

This area contains the greatest amount of change, up to about 350 metres. The rates of movement however are not consistent across the time span. Actions causing the change appear to be variable.

Table 5 **Section E-E** accretion to Cooroobongatti bank			
Survey plan date	**Amount of shift m**	**Time interval yrs**	**Movement rate m/y**
Jul 1855			
Nov 1864	15	9.3	1.6
Mar 1881	110	16.3	6.7
Jul 1903	61	22.3	2.7
Oct 1914	0	11.3	0
Mar 1993	124	78.5	1.6

This section is perhaps the most telling. An inlet identified in the 1864 survey has not been included in the assessment as it was only diagrammatically shown and is incorporated into the land title. It was only marginally depicted in the 1855 survey. The inlet can be identified on the ground as a depression running parallel to the bank (fig 5). Another tidal inlet shows up in the 1881 survey close to the surveyed bank. Erosion on the eastern bank was also not assessed as it is unclear as to whether the identified old bank is from 1919 or 1850. Movement rates across the section are highly variable indicating that the conditions within the river causing the change are most probably also highly variable. Most telling is the 1903-1914 period where minimal or no change occurred. Review of the flood history (Laurie Montgomerie & Pettit 1980), annexure B, reveal no flooding occurring during these eleven years, only minor freshes. This strongly suggests that changes to the banks are flood induced. Being of a random nature and sometimes not occurring for many years, flood controlled movements could not be classed as gradual. Changes to the banks that occur as a result of a flood generally would only be noticed following inspection after the flood. Unfortunately inspections or records of the bank location after every flood were never undertaken so it is still a little speculative as to how much movement occurred and when.

Table 6
Section F-F erosion from Cooroobongatti bank

Survey plan date	**Amount of shift m**	**Time interval yrs**	**Movement rate m/y**
Jul 1855			
Nov 1864	0	9.3	0
Oct 1891	56	26.9	2.1
May 1903	47	11.6	4.1
Oct 1989	88	86.5	1
Section F-F accretion to Kempsey (Austral Eden) bank			
1850			
Nov 1925	158	75	2.1
Nov 1984	77	59	1.3

Again there is very little consistency in the movement rates for either bank. Movement in the later years does appear to have slowed down but this might be due to the armouring of the banks during the 1950's and 1960's. Reducing the time period by 30 years (exactly when the works were carried out is unknown) increases the last rates to 1.6m/y (Cooroobongatti) and 2.7m/y (Kempsey). This makes the accretion rate on the Kempsey side a little more consistent however it only adds speculation as to the sequence of events on the Cooroobongatti side.

Movement rates of the banks do not show a great deal of consistency from survey to survey. If the banks had been moving in a long term steady rate then it could be expected that the calculated quantities would be similar between surveys. Although the rates themselves do not provide an answer as to the character of the movements, they do however provide a strong indication that the banks have been moving in an inconsistent or random manner. Section E-E provides the strongest indication as to what forces have brought about the changes. With no significant river rises occurring between two successive surveys and no change occurring in the location of the bank a strong supposition is suggested that it is major floods that bring about change. The minor differences between the two surveys could be contributed to differences of opinion between the surveyors conducting each survey.

River Flow

Ideally a long term gauging station would need to have been set up on site in order to establish the character of river flow that brings about change. Regular cross sectional data would also need to be obtained and coupled with the flow information before a complete and comprehensive picture can be obtained. Unfortunately such a situation is extremely rare and definitely not available in this case.

To achieve a picture of what could be occurring within the study area, flow data has been obtained from gauge sites up stream. A short term set of data for the Kempsey road bridge was obtained

from Manly Hydraulics Laboratory which provides some insight into the character of the tidal flow on a typical day to day basis without influence from flood waters. Longer term data from Hydsys for the Turners Flat gauge site for the period December 1945 to February 2002 was also obtained. Although not in the tidal range the site is close to the tidal limit and downstream of all major tributaries so that the flow passing this site would be close to the flow passing the investigation site. This set of data is more likely to provide a flow character that would bring about changes to the banks.

Changes in the bank, be it mean high water or non tidal stream bank, will only occur when the forces in the river flow exceed the ability of the bank and bed material to withstand those forces (Brooks A 1996; Harvey & Watson 1986 Janicke 2000; Leopold et al 1964). Changes will occur within the bed of the river channel, in this instance below mean high water, depending on the flow capacity and the bed material (Carling 1996; Pickup & Warner 1976) but still not be of sufficient capacity to bring about changes in the bank.

A measure of critical bank shaping flow is the bank full discharge (Church 1996; Department Natural Resources 1999; Leopold et al 1964; Page 1988; Pickup & Warner 1976; Rutherfurd et al 1999 b) sometimes equated to the mean annual flood (Church 1996). In a floodplain situation such as this, the bank is considered the top of the natural levee usually formed on either side of the main river. For the most part flood waters greater than the bank full discharge spread out across the flood plain and dissipate their energy outside the channel. Another measure of critical flow is a unit stream power of 35 Watts per metre squared (Brooks A 1987). Flows with greater power than this tend to alter the banks. This measure is independent of recurrence interval determinations and can be used as verification for critical bank full discharge. Unit stream power is also used within the department to assess whether a stream is likely to be stable or not.

The theoretical recurrence interval of the bank full discharge, 1.5 to 2 years, would normally rule out the this flow as being of a gradual nature however much of the analysis that derived this is from the northern hemisphere and may not necessarily apply to Australian conditions. Since European settlement Australian rivers have adjusted in extreme fashions (Brooks AP 1999) with possible bank full discharges blowing out to at least 10 times the theory. The different measures of critical flow can however be used to see what the relationship exists between possible bank movement and the interval in which they might occur within the study area.

River flow analysis

Analysis of the Turners Flat data shows that the frequency of daily flow quantity is highly skewed to the lower order of flows (Table 7). The variable nature of river flow is also reinforced by the coefficient of variation calculated at 4 compared to a European average of 0.28 and North America 0.36 (Finlayson & McMahon 1964). The ratio between the average yearly flood (if a flood did occur in any one year) and the 1:100 year flood is much higher for Australia (10-20) compared to the world average (2-4) (Prosser et al 1999). This is due to the situation that for the most part Australian rivers flow at a considerably lower level than the full capacity of the river where a high flow or flood may not even occur in any one year. The ratio for the Macleay calculated at 8 still providing for a fairly high degree of variability.

Australian river flows are more variable in both the annual flow character and flooding cycle than that considered to be normal for northern hemisphere experiences where much of our cadastral boundary ideals were generated. Rivers in Australia, if flowing with some force, do so with a fair degree of unpredictability in both scale and timing (Department Natural Resources 1999). Flows can often be intermittent intense and often flashy (Janicke 2000) with the larger flows responsible for shaping the channel (Edgar 2000; Pickup & Warner 1976). This points to river characteristics that are not consistent with the ideals of gradual and imperceptible movement.

Flows in the Macleay that have sufficient capacity to alter the bank would statistically only likely to occur for 1-5 days on an annual reckoning. These flow capacities are only 10-20% of the largest recorded flows but for 98-99% of the time the river stages were equal to or less than such a level. Unit stream power determination of critical flow level falls between the 1.5 and 2 year recurrence interval flows reinforcing the supposition that water levels required for critical flow occur at

statistically greater than yearly intervals. The day to day or most frequent flow is at a substantially lower level than the flows required to change the banks. The river flows at or less than the most frequent stage for 37% of the time.

Table 7
Statistical data from Macleay River, Turner's Flat gauge site
Daily maximum flow data

Stage	Flow (MgL/d)	% of max flow	% flow < stage	Days p.a. >= stage	Gauge (m)	% total gauge
Maximum	699552				11.9	100
Minimum	1.5				-0.6	0
Mean	5390	0.8	85	55	1.4	16
Mean annual flood	148614	21	99.5	2	5.7	50
Mean annual low flow	186	0.03	7	339	-0.3	2
1:2 ARI flow	155000	20	99.6	1	5.8	51
1:1.5 ARI flow	70000	10	98.6	5	3.9	36
Stream power 35W/m^2	91500	13	99	4	4.5	41
Most frequent flow	700	0.1	37	230	0.2	6
Skewness	12					
Coefficent of variation	3.8					
Period of record	17 January 1970 – 19 February 2002					

The data on a monthly average (Table 8), although covering a longer period, does not significantly alter the situation. Note that stream power is not determined, as gauge heights are not available on the monthly figures.

Table 8
Statistical data from Macleay River, Turner's Flat gauge site
Monthly maximum/minimum flow data

Stage	Flow (ML/d)	% of max flow	% flow < stage	Days p.a. >= stage	Gauge (m)	% total gauge
Maximum	1235520					
Minimum	1.5					
Mean	14983.4	1%	86%	52		
Mean annual flood	170402.2	14%	98%	7		
Mean annual low flow	195.8	0.02%	12%	323		
1:2 ARI flow	149000	12%	97%	10		
1:1.5 ARI flow	62000	5%	94%	20		
Stream power 35W/m2						
Most frequent flow	1240	0.1%	52%	175		
Skewness	10.8					
Coefficient of variation	4.0					
Period of record	December 1945 - February 2002					

Coupled to this data are the results from the Manly Hydraulics gauge at the Kempsey road bridge. Although the data set was only for a 4.5 day period the selection was random and provides insight as to conditions on a typical day in an area similar to the study site. The average daily cumulative flow was determined to be 680Mgl/d which closely matches the typical daily flow (700Mgl/d) at Turners Flat. On a general day to day basis it would seem that what is flowing through Turners Flat is also flowing by Frederickton and Smithtown. Such a flow is so far below that which is required

to alter the banks that it would be considered to be insignificant. Even the peak tidal flow does not come close to be a critical bank shaping flow. At 19,000 Mgl/d, upstream in this instance, the flow occurs only for a very short period of time and is a calculated quantity derived from flow velocities. It should again be noted that any bank bars point downstream. The tidal flow upstream is unlikely to have any effect on the bars. Correlating the tidal flow with unit stream power it is found that the 19,000Mgl/d only corresponds to 1.4W/m^2 at Turners Flat. Again this flow capacity is significantly less that that required to alter the banks (35W/m^2).

Flow analysis does not categorically determine at what stage the bank is likely to erode or accrete, as many other factors need to be considered. Factors such as bank material, vegetation covering, riverine growth below the mean high water and sediment movement also need to be taken into consideration. Flow analysis however does provide a good strong indication as to the most likely conditions required to bring about change.

Although the quantity of data is perhaps overwhelming the scenario it portrays is of a river that generally flows at a level considerably below that required to alter the banks. Water flows that would be considered sufficient to alter the banks only occur at intervals greater than annually. This is particularly evident when examining the accreted land where surface levels could be as much as two to three metres above normal tide level.

Cross section E-E

The accreted flats below the original bank stand approximately 2 metres above the present high water level (Fig 5). Through river flow analysis it is found that the height of these flats falls within the critical flow range required for bank change. Statistically, floods would only reach this level at

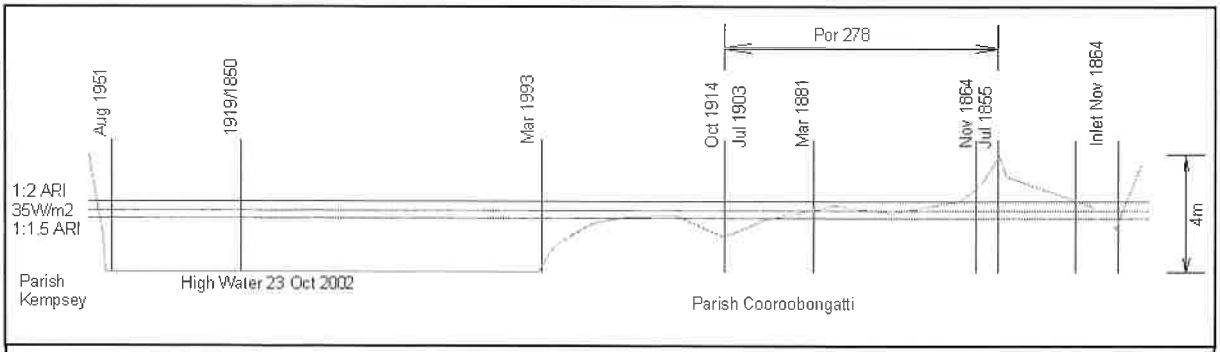


Fig 5. *Cross section E-E critical water levels and various surveyed location of MHW*

a frequency of greater than 1 in 1.5 years; a frequency beyond what is required for gradual change. Floods do not occur on a regular statistical interval but rather happen randomly. It may be many years between events that reach a level high enough to effect change. This is evident from the location of the bank (or MHW) in the 1903 and 1914 surveys where no change occurred. Records (Appendix B) show that no floods occurred in this period that where of high enough levels to cause change or even reach today's level of land on the flats. Levels greater than 2.5 at the Kempsey road bridge would be needed before even the 1:1.5 ARI level was reached (4.6 for the 1:2 ARI level).

Lateral vs Vertical

How the accreted land accumulated is not entirely clear. Review of aerial photography (Appendix A) and field investigation suggest that the land has accreted in a series of steps. Shallow or islets

Fig. 6

Bars, shallows and islets outside the existing bank or mean high water trap material behind during flood events.

and bars within the river (Fig 6) accumulate material firstly along an outer shallow until it is raised above the water level. Further deposition occurs behind the bar in a vertical manner during flood events. What was once shallows or swampy reed beds becomes dry land once sufficient material is deposited. The accretion between 1914 and 1993 shown in section E-E (fig 5) perhaps provides a view of the vertical nature with the old mean high water still visible as a depression and higher land existing between the determinations. How much deposition occurs with each flood is unknown but anecdotal reports suggest it can be quite substantial.

In the eroded areas the process is unclear, as the land has now gone. Supposition dictates that the erosive process is in a lateral shift but by how much each time is unknown. Departmental records show that the District Surveyors report for an investigation of DP505059 (just downstream from Kempsey) on file PKS 63/809 gives a picture of large singular changes.

> "Evidence on the ground, combined with the advice of local residents, makes it obvious that a major flood between the 6th and 11th May 1963 caused drastic erosion of this bank to the extent of about 43 feet."

The file is silent on how the accretion that was eroded away occurred as initial bank/mean high water determinations were landward of the 1963 erosion line.

Wave Action

In many estuary situations wave action can attribute to significant changes in the location of banks (Public Works 1988). Banks along the stretch of river under investigation are for the most part either armoured with rock or protected by significant reed beds and bank vegetation. Strong winds pushing up 0.5 –1 metre waves during one field inspection were for the most part not reaching the bank through the reeds. Erosion scarps typically undermined from wind action are also not to be found. Observations suggest that wave action, be it from wind or boating, has very little if no effect on the movement of the banks. The waves certainly could not have pushed up the land 2 metres above the normal high water level. Wave action may have had some influence following early clearing of the banks and prior to the rock stabilisation taking place however indicators suggest that it was not the case or now no longer is a factor.

Conclusion

Our ideals of cadastral boundary law have evolved from the English system, experience or perception of what was happening along the banks of English streams. The character of streams in Australia does not necessarily follow the same flow regime. Many studies of the Australian river paint a picture of river flows that are highly variable (Department Natural Resources 1999; Edgar 2001; Finlayson & McMahon 1964; Prosser et al 1999) intermittent and often flashy (Janicke 2000). It is the larger flows that are responsible for shaping the channel (Edgar 2001; Pickup & Warner 1976) and thus the bank, the mean high water and ultimately the cadastral boundary.

Every indicator investigated suggests strongly that the section of the Macleay River between Frederickton and Smithtown is no exception to the generalisations above. Everything points towards individual random flood events as the main force behind the shaping of the river. Statistical analysis shows that the minimum event cycle causing change is outside the limits of what could be considered as gradual and imperceptible.

Even though the changes cannot be contributed to any one singular event the process involved does not have a gradual nature. It would appear that it requires a minimum flood level to occur before any change could be expected. One event of sufficient magnitude alone may not necessarily bring about change as it may require a series of events before the final shift occurs and even then it may not necessarily be the biggest event (Patterson Britton 1995). Each shift also might not leave the land in the shape that is found today. Mapping (figs 3 & 4) shows that changes have occurred in a series of steps, not necessarily in the same direction (Diagram C, fig 4). Unfortunately mapping has not been frequent enough to determine how much if any change occurred as a result of each significant flood event. It is left to investigations such as this to try and fill in the gaps.

The accreted land on both the Cooroobongatti and Kempsey banks must have once been considered as Crown land for the Crown surveyors to survey the land as Crown parcels identified

for sale. Unfortunately time and different officers opinions have clouded the original process and even the land status. Titles were never issued for most of the land on the Cooroobongatti side but they were issued on the Kempsey side. Just because the land is on a different side of the river does not mean that it was made in a different manner. The river processes that caused the land are still the same, either side of the river.

It is the firm conclusion of this investigation that the accreted land between Frederickton and Smithtown is Crown land, formerly the bed of the Macleay River, despite any other statement to the contrary. Conversely any land that has been eroded is still in freehold ownership. Movement of the banks has not been by gradual means, it has occurred as a result of individual random flood events.

Implications

The Surveying Regulation 2001 requires that "if, since the date of a previous survey, there has been a change in the position of a high-water mark forming a boundary of land to be surveyed and that change has been caused otherwise than by natural, gradual and imperceptible accretion or erosion, in any subsequent survey the position of the mean high-water mark as it was immediately before the change must be adopted." Such a direction is not unique to the 2001 regulation but is carried through from previous regulations and is a direct implementation of the doctrine of accretion.

From the mapping exercise it is quite apparent that scant regard has been made to the doctrine of accretion. Surveys for the most part have been conducted to the existing mean high water of the time, which was subsequently adopted as the cadastral boundary. There have been a few exceptions such as the Crown surveys of 1914 along the Cooroobongatti bank and 1925 along the Kempsey bank plus a few later day surveys on the northern end of Austral Eden (Kempsey bank). What has been left is section of river where the mean high water cadastral boundaries along either bank have been lost.

If the doctrine were to be strictly applied then the boundaries should not have been shifted since the original 1850s surveys. An application was made to the department to purchase the accreted Crown land identified in 1984 surveys on the northern end of Austral Eden. If the application were to proceed it is highly probable that property would physically occupy the same land as at least one property that still exists on the northern side of the river, although under water. The river has shifted to a position where it is now no longer within the bounds of its former bed (fig 2).

There are many issues that now need to be considered. A few that come to mind include:

- Navigation rights across freehold land
- Occupation of accreted Crown land by adjacent land owners.
- Management of riverine lands
- Property owner rights to the bed of the existing river
- Crown rights to manage or lease below mean high water, which mean high water
- Determining the "true" cadastral boundaries of all lands along the river irrespective of subsequent surveys since original 1850 grants. Many early surveys may not be of sufficient accuracy to correctly determine the boundary for today's standards.
- Mapping of the accreted/eroded lands to meet with today's survey standards
- Determining ownership of eroded lands that should be freehold but no longer identified as such because of inappropriate identification of the mean high water boundary in subsequent survey plans
- Correction of the State's DCDB, to what boundary is yet to be determined
- What other parts of the Macleay suffer from the same problem
- Is the problem unique to the Macleay
- How far should such an investigation go
- How to proceed

References

Brooks, A. (1987). The distribution and management of channelised streams in Denmark. In *Regulated Rivers*. Vol1 No1 pp 3-16. Wiley, Chichester, Sussex.

Brookes, A. (1996). River channel change. In *Rivers flows and channel forms,* ed. G. Potts & P. Calow. Blackwell: Oxford

Brooks, A.P. (1999). Lessons for river managers from the fluvial tardis (direct insight into post European channel changes from a near intact alluvial river. In *Proceedings Second Australian stream management conference.* Adelaide, South Australia, February 8-11, pp.121-127

Carling, P. (1996). In stream hydraulics and sediment transport. In *Rivers flows and channel forms,* ed. G. Potts & P. Calow. Blackwell: Oxford

Church, M. (1996). Channel Morphology and Typology. In *Rivers flows and channel forms,* ed. G. Potts & P. Calow. Blackwell: Oxford

Department of Natural Resources (1999), Queensland. *River guide: River processes.* Ed, D. Telfer

Edgar, B. (2000). Inland rivers and riparian zones. In *Rivers for the future,* **18**, pp 1-5. Land & Water Resources Research & Development Corporation. Canberra.

Erskine, W. & Warner, R. (1988). Geomorphic effects of alternating flood and drought dominated regimes on NSW coastal rivers. In *Fluvial Geomorphology of Australia,* ed. R. F. Warner. Academic Press, Sydney.

Finlayson, B., & McMahon, T. (1988). Australia *v* the World: A comparative analysis of stream flow characteristics. In *Fluvial Geomorphology of Australia,* ed. R. F. Warner. Academic Press, Sydney.

Hallmann, F. *Legal aspects of boundary surveying as apply in New South Wales.* Second edition, ed F. Ticehurst (1994). The Institution of Surveyors Australia, New South Wales Division.

Harvey, M. & Watson, C. (1986). Fluvial processes and morphological thresholds in incised channel restoration. In *Water Resources Bulletin.* Vol 22 No3 pp 359-368

Janicke, S. (2000). Stream channel processes. Fluvial geomorphology: the laws governing water in motion. In *River Restoration.* Water and Rivers Commission. Western Australia.

(On Line February 2001)

http://www.wrc.wa.gov.au/public/RiverRestoration/publications/rr6/index.htm

Legislation

Surveyors (Practice) Regulation 2001 (NSW)

Laurie, Montgomerie & Pettit Pty Ltd (1980), *New South Wales coastal rivers flood plain management studies, Macleay Valley.*

Leopold, L., Wolman, M. and Miller, J. (1964). *Fluvial processes in geomorphology*. Freeman, San Francisco.

Page, K. (1988). Bankfull discharge frequency for the Murrumbidgee River of New South Wales. In *Fluvial Geomorphology of Australia*, ed. R. F. Warner. Academic Press, Sydney.

Patterson Britton & Partners Pty Ltd. (1995). *Wyong River and Ourimbah Creek bank management study.*

Pickup, G. & Warner, R. (1976). Effects of hydrological regime on magnitude and frequency of dominant discharge. In *Journal of hydrology*. Vol 29 pp 51-75. Elsevier, Amsterdam.

Prosser, I., Ogden, R., Bunn, S. (1999). The influence of space and time. *In Riparian land management technical guidelines, volume 1: principles of sound management*. Eds Lovett, S., & Price, P. Land and Water Resource Research and Development Corporation. Canberra. Chapter 2 pp 9-16

Public Works (1988). *Shoalhaven River bank erosion study – phase 1: channel morphology 1805-1985.*

Rutherfurd, I., Jerie, K. and Marsh, N. (1999). *A rehabilitation manual for Australian streams. Volumes 1 & 2*. Land and Water Resource Research Development Corporation, Canberra. On line June 2001 http://www.rivers.gov.au

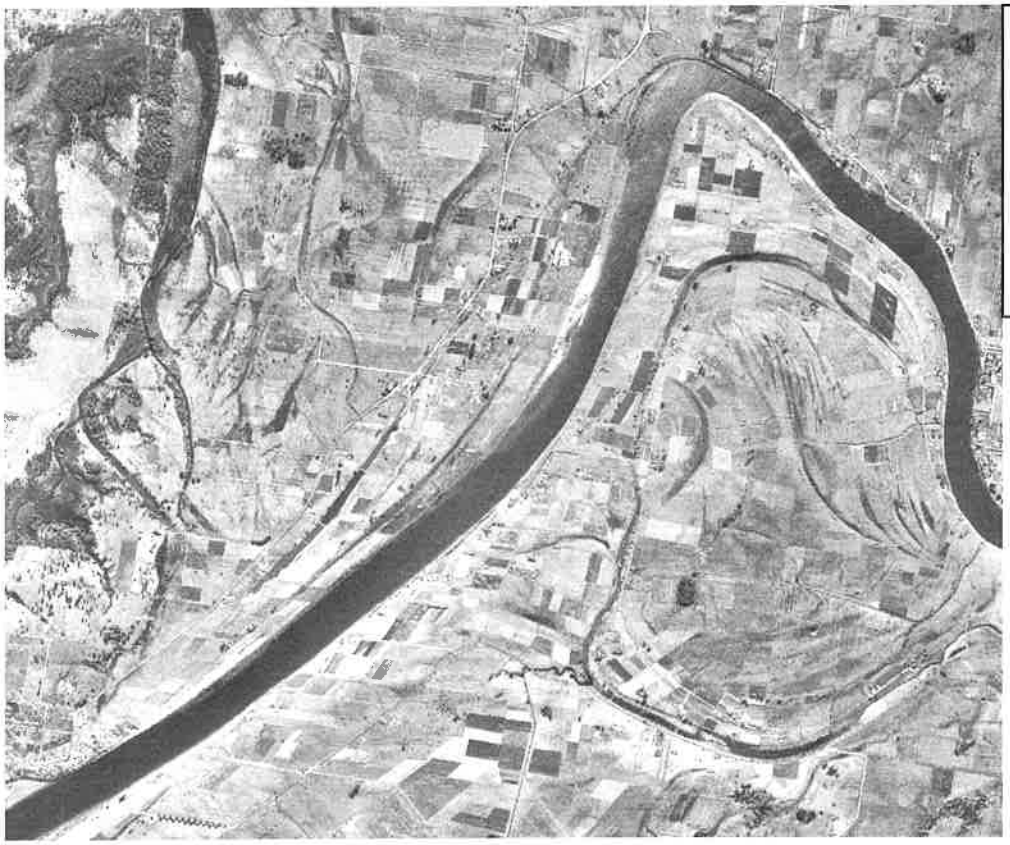
Sloane, J. (1989). *Water as a boundary*. Department of Lands, NSW

Songberg, G. (2002). Spatio-temporal anomalies in cadastral boundaries. In Association of Public Authority Surveyors. *8th Annual Conference.* Sutton, NSW, March 5-8, pp. 43-57.

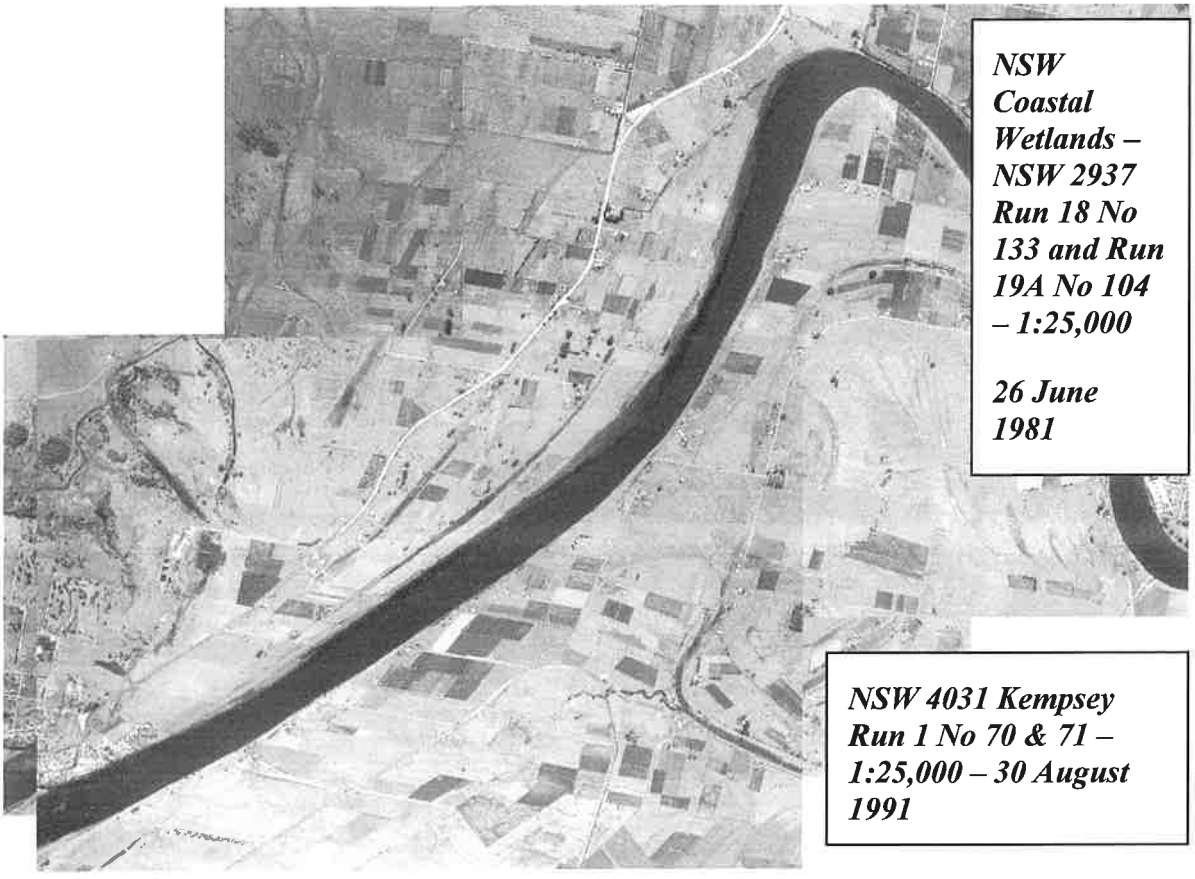
Willis, R. (1974). Notes On Survey Investigation. Registrar General's Department, NSW.

Appendix A

AERIAL PHOTOGRAPHY



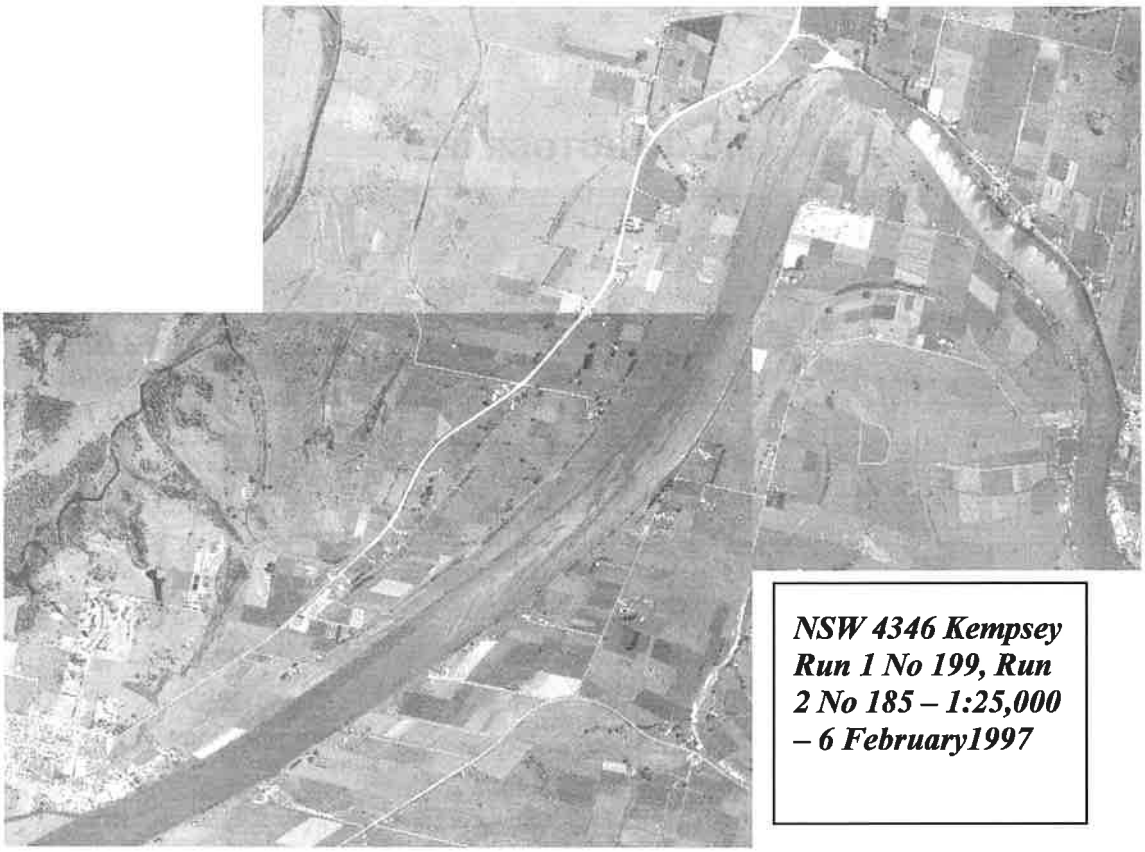
1976 Census - Kempsey NSW 2251 Run 2 No 21 - 1:40,000 - 28 July 1974



NSW Coastal Wetlands – NSW 2937 Run 18 No 133 and Run 19A No 104 – 1:25,000

26 June 1981

NSW 4031 Kempsey Run 1 No 70 & 71 – 1:25,000 – 30 August 1991



NSW 4346 Kempsey Run 1 No 199, Run 2 No 185 – 1:25,000 – 6 February1997

Appendix B

FLOOD RECORD

KEMPSEY ROAD BRIDGE

Hawkesbury River.
Kevin Montgomery & Partners
December 1980.

PEAK GAUGE HEIGHT AT KEMPSEY TRAFFIC BRIDGE

Date (Approximate)	Peak Gauge Height (m)	Used in Stage/Frequency Analysis 1863-1978 ≥ 5.18 m	Used in Stage/Frequency Analysis 1920-1978 ≥ 4.0 m
1838	6.71		
1840	6.71		
January 1848	5.03		
21 August 1848	5.79		
16 January 1863	5.34	x	
15 February 1863	6.10	x	
April 1863	5.34	x	
16 February 1864	7.37	x	
March 1864	5.34		
March 1864	4.27		
May 1864	4.27		
June 1864	5.34	x	
June 1864	4.27		
15 July 1864	6.25	x	
11 August 1864	6.86		
19 August 1864	7.32	x	
13 July 1866	6.25	x	
April 1866	4.27		
April 1866	6.25	x	
25 April 1867	6.10		
29 April 1867	6.71	x	
20 March 1870	6.25	x	
November 1870	Fresh		
February 1873	5.34	x	
June 1873	5.34	x	
1 March 1875	7.62	x	
July 1876	5.34	x	
7 February 1878	4.27		
February 1878	4.27		
26 June 1879	6.10	x	

Date (Approximate)	Peak Gauge Height (m)	Used in Stage/Frequency Analysis 1863-1978 ≥ 5.18 m	Used in Stage/Frequency Analysis 1920-1978 ≥ 4.0 m
16 February 1887	4.42		
July 1889	Fresh		
August 1889	Fresh		
January 1890	4.57		
February 1890	3.66		
February 1890	4.57		
March 1890	5.18		
March 1890	6.10	x	
January 1891	Fresh		
June 1891	Fresh		
3 April 1892	6.10	x	
November 1892	5.18	x	
February 1893	5.18	x	
March 1893	6.71	x	
12 June 1893	7.54	x	
5 March 1894	5.49	x	
July 1900	Fresh		
August 1900	3.99		
4 June 1903	5.03		
August 1906	Fresh		
March 1908	Fresh		
January 1910	Fresh		
March 1910	Fresh		
February 1912	Fresh		
March 1912.	Fresh		
April 1913	Fresh		
May 1913	Fresh		
June 1913	Fresh		
September 1914	Fresh		
May 1916	Fresh		

Date (Approximate)	Peak Gauge Height (m)	Used in Stage/Frequency Analysis 1863-1978 ≥ 5.18 m	Used in Stage/Frequency Analysis 1920-1978 ≥ 4.0 m
December 1916	Fresh		
November 1917	3.81		
12 May 1921	4.57		x
June 1921	Fresh		
24 July 1921	7.32	x	x
3 January 1922	3.35		
July 1922	4.88		x
July 1924	Fresh		
January 1927	Fresh		
February 1928	5.18		
20 February 1928	5.56	x	x
June 1928	Fresh		
June 1928	4.11		x
9 February 1929	6.25	x	x
April 1930	Fresh		
June 1930	5.18	x	x
April 1931	4.88		x
September 1932	3.05		
July 1933	5.18	x	x
January 1935	3.05		
March 1937	2.44		
August 1943	5.18	x	x
February 1944	Fresh		
August 1944	4.19		x
June 1945	4.01		x
26 March 1946	5.99	x	x
3 March 1947	2.74		
11 December 1947	1.22		
3 May 1948	3.05		
17 June 1948	3.94		

PEAK GAUGE HEIGHT AT KEMPSEY TRAFFIC BRIDGE

Date (Approximate)	Peak Gauge Height (m)	Used in Stage/Frequency Analysis 1863–1978 ≥5.18 m	Used in Stage/Frequency Analysis 1920–1978 ≥4.0 m
4 March 1949	1.17		
July 1949	4.27		x
27 August 1949	7.92	x	x
20 February 1950	2.90		
25 June 1950	7.77	x	x
23 July 1950	4.88		x
August 1950	3.05		
18 November 1950	1.22		
23 November 1950	2.13		
March 1951	3.05		
15 August 1952	6.02	x	x
12 October 1952	2.59		
22 February 1953	4.80		x
24 March 1953	3.05		
October 1953	3.00		
22 February 1954	5.79	x	x
15 July 1954	1.75		
26 February 1955	4.83		x
7 April 1955	1.14		
1 May 1955	2.74		
25 October 1955	2.57		
7 February 1956	1.89		
10 February 1956	5.33		
19 February 1956	5.36		x
25 February 1956	3.26		
1 March 1956	4.44		
3 May 1956	2.21		
26 June 1956	2.92		
July 1956	2.90		
23 January 1959	5.33	x	x
19 February 1959	3.35		
11 November 1959	5.59	x	x
21 January 1960	Fresh		
March 1960	Fresh		
19 February 1961	Fresh		
8 January 1962	Fresh		
12 January 1962	4.11		x
6 April 1962	5.54	x	x
11 May 1962	Fresh		
10 July	5.31	x	x
December 1962	1.63		
3 January 1963	4.06		x
28 March 1963	Fresh		
28 April 1963	5.03		x
7 May 1963	7.14		
14 January 1964	3.61		
8 March 1964	4.70		
19 July 1965	1.07		
2 December 1965	Fresh		
6 December 1965	Fresh		
15 December 1965	Fresh		
8 November 1966	Fresh		
5 January 1967	Fresh		
8 March 1967	Fresh		
10 June 1967	6.02	x	x
20 June 1967	0.91		
26 June 1967	Fresh		
22 October 1967	Fresh		
8 November 1967	Fresh		
12 January 1968	5.77	x	x
11 February 1969	Fresh		
15 May 1969	Fresh		
4 June 1969	Fresh		
20 June 1969	Fresh		
24 August 1969	Fresh		
14 October 1969	Fresh		
30 October 1969	Fresh		
14 September 1970	Fresh		
9 December 1970	Fresh		
6 February 1971	Fresh		
12 February 1971	Fresh		
17 February 1971	4.57		x
16 June 1971	Fresh		
15 December 1971	Fresh		
3 April 1972	Fresh		
18 October 1972	Fresh		
28 October 1972	5.41	x	x
11 February 1973	Fresh		
27 February 1973	Fresh		
9 January 1974	5.56	x	x
12 January 1974	5.21		
11 March 1974	5.69	x	x
22 April 1974	3.63		
4 June 1974	3.18		
12 November 1975	4.39		
15 November 1975	5.18	x	x
15 January 1976	2.84		
25 January 1976	3.89		
26 January 1976	4.39		
10 February 1976	5.54	x	x
24 February 1976	3.00		
28 February 1976	2.67		
3 March 1976	1.17		
14 March 1976	3.53		
25 June 1976	3.68		
23 February 1977	1.75		
3 March 1977	4.32		
7 March 1977	4.80		x
16 May 1977	5.56	x	x
19 March 1978	5.05		x
2 April 1978	2.16		
24 January 1979	1.03		

(Table 9.1 Laurie, Montgomerie & Pettit 1980)