Comparison of Turbidity Concentrations Resulting from Dredging at the Bar Cutting

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Synopsis:	Measurement of the dredging plume turbidities for the PBC dredger *Brisbane* and a comparison with previous results for the *Sir Thomas Hiley*.

REVISION/CHECKING HISTORY

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1 INTRODUCTION

The Port of Brisbane Corporation operates dredging plant to maintain navigable depth within declared channels. From the 1970's until November 2000, the Corporation operated the *Sir Thomas Hiley*. In November 2000, this vessel was replaced with the *Brisbane*.

The two vessels are essentially similar, being trailing suction hopper dredges. The *Brisbane* has a larger hopper capacity (2,900m^3) than the *Sir Thomas Hiley* (approx 2,000m^3). The other principal difference is the method of hopper discharge during loading. The Corporation has incorporated a discharge at keel level in the *Brisbane*, whereas the *Sir Thomas Hiley* discharged via overflow ports at deck level.

This alteration provides for hopper discharge at depth (some 5m below surface), providing a greater opportunity for material settlement and reducing plume dispersion. Further, the *Brisbane* has a central weir which allows more control over the overflow from the hopper, potentially allowing greater sediment retention within the hopper and reduced suspended sediment concentration.

WBM Oceanics Australia undertook measurements of plume generation and degradation associated with the *Sir Thomas Hiley* operating at the Bar Cutting (Brisbane River) in September 1995. To develop an understanding of the efficiencies gained from the improvements made in the *Brisbane*, the same range of measurements were made during dredging of the Bar Cutting by the *Brisbane*.

As the percentage of material released into suspension by hopper overflow depends upon the characteristics of the sediment to be dredged, the same working area was specified for the *Brisbane* as was previously used for the *Sir Thomas Hiley.* The trial dredging area specified consisted of fine-grained (sand/silt) sediments from the Bar Cutting in the vicinity of the 'Coffee Pots' (beacons 11 and 12) between beacon pairs 9 and 10 and 13 and 14 (refer to Figure 1.1). Dredging was scheduled for the morning of Friday 11th January 2002 with a favourable light wind forecast and an ebb tidal range similar to that which occurred in 1995 (1.8m compared with 1.9m in 1995). Weather conditions on the day were fine and sunny. Calm winds were experienced until 0930 hours, followed by a slight easterly wind until noon and afterwards by a 10knot north-easterly wind.

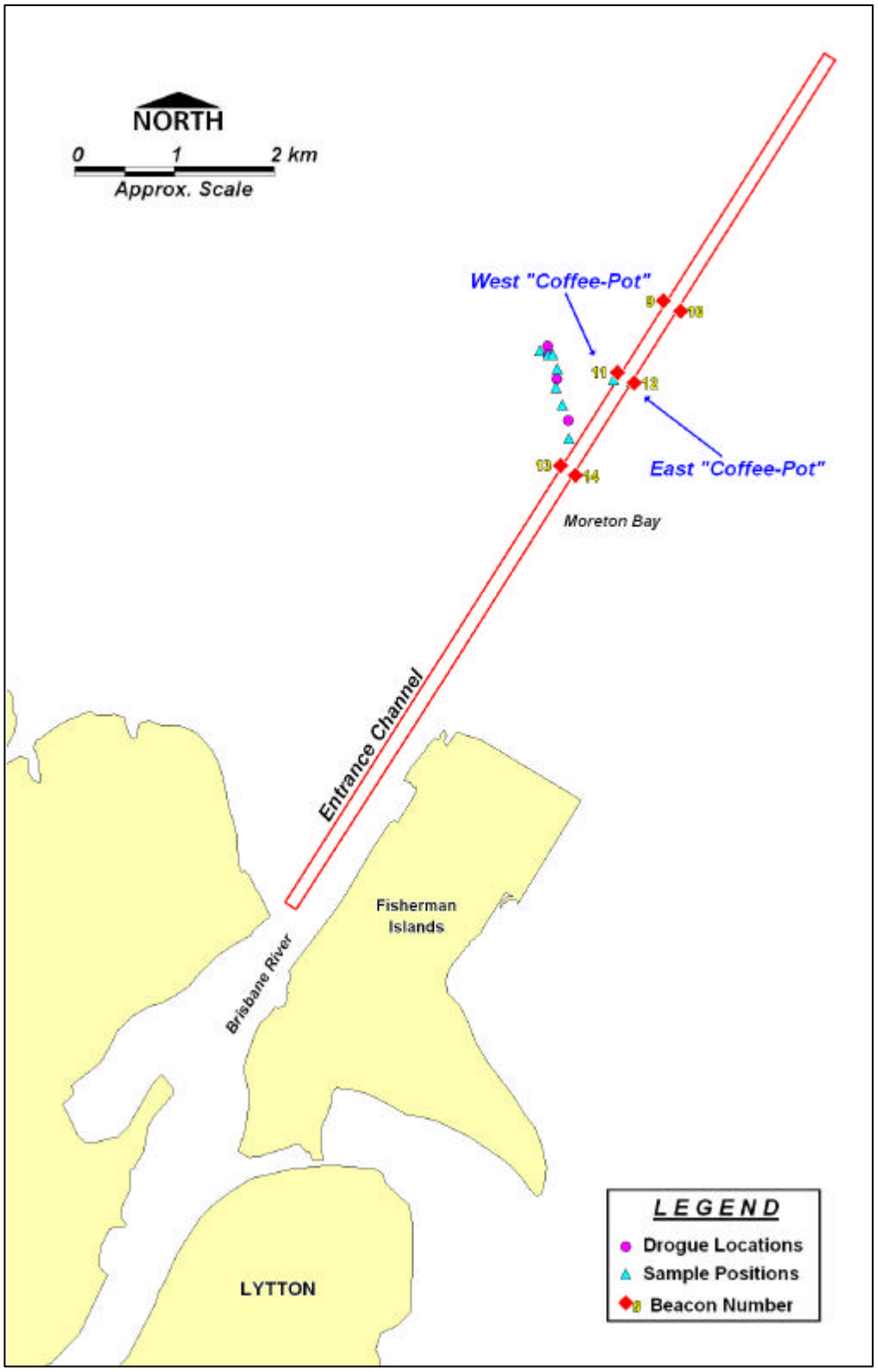

Figure 1.1 Locality Plan - Drogue Locations

2 METHODS

Turbidity was measured aboard the survey vessel using a using a calibrated Yeokal 611 water quality instrument. A Secchi disc deployed from the survey vessel was used to record the surface water clarity. Background and dredging overflow plume water samples were collected coincident with the turbidity measurements to provide a relationship between turbidity and suspended solids in the vicinity of the Bar Cutting. Additionally, samples of the hopper overflow water were scheduled for collection at routine intervals during dredging, by PBC personnel aboard the *Brisbane*. These samples were to be collected to provide a comparative measure of the mass of suspended solids lost via the hopper overflow. (Similar samples were collected in 1995, from the deck overflow on the *Sir Thomas Hiley*).

As undertaken in 1995, aerial photography of the dredge overflow plumes generated on the ebbing tide was also scheduled, this time using a helicopter based at Brisbane Airport. Aerial photography was planned, prior to dredging, during dredging and approximately 1 hour after dredging. The first pre-dredging aerial photographs were recorded in calm conditions at approximately 0900 hours (approximately 1 hour after local high water).

Prior to dredging, background turbidity measurements were made at two locations within the entrance channel (between beacon pairs 13 and 14 and 9 and 10). The only influence on the background turbidities may have been occasioned by the seaward passage of the container vessel 'Cape Conway' at 0915 hours. Dredging commenced as scheduled at 0930 hours.

The spot measurement of dredging related turbidity and collection of coincident water samples for suspended solids analysis and secchi disc measurements were begun near beacon 10 after the first seaward passage of the dredger at approximately 0940 hours. Dredging concluded at approximately 1005 hours after completion of the second pass of the *Brisbane* through the trial dredging area. Plume measurement activities were transferred to the vicinity of beacon 13, where the visible intensity of the hopper overflow plume was greatest. The *Brisbane* departed the trial dredging area at approximately 1010 hours headed for the Fisherman Island pump-out.

As the visual intensity of the overflow plume reduced with time, a drogue was released into the plume to mark its location (refer to Figure 1.1). The drogue was launched at approximately 1030 hours, approximately half an hour after the completion of dredging and was tracked for a further hour until the dredging related plume was no longer visible or evident from the turbidity measurements.

The water samples collected from the dredger and from the vicinity of the Bar Cutting were analysed for suspended solids by Australian Laboratory Services Pty Ltd.

3 RESULTS

A summary of the turbidity results for the ebb tide dredging using the *Brisbane* is presented in Table 3.1.

Table 3.1 Outer Bar Cutting Turbidity Profiles, 11/01/02

OUTER BAR CUTTING - Ebb Tide				
Time (h) Background Before Dredging	**Total Depth (m)**	**Depth**	**Turbidity (NTU)**	**Secchi Disc Visibility (m)**
0825	15.0	surface mid-depth bed	4.2 - 4.9 4.9 - 6.8 7.4 - 10.4	1.5
0900	15.0	surface mid-depth bed	 11.0	
0920	15.0	surface mid-depth bed	5.3 - 7.0 5.3 - 6.4 5.3 - 8.7	1.6
Time (h) (Start Dredging at 0930, Finish Dredging at 1005)	**Total Depth (m)**	**Depth**	**Turbidity (NTU)**	**Secchi Disc Visibility (m)**
0950	15.0	surface mid-depth bed	91.0 112.0 100.0	≈ 0.1-0.2
1000	15.0	surface mid-depth bed	60.0	≈ 0.3-0.4
1015	6.0	surface mid-depth bed	40.0	
1030	6.0	surface mid-depth bed	18.3 - 22.6 8.1 10.5	
1055	6.0	surface mid-depth bed	9.4 8.4 7.7	
1100	6.0	surface mid-depth bed	8.3 6.5 8.0	
1110	6.0	surface mid-depth bed	5.0 - 5.3 6.1 8.2	1.5
1120	6.0	surface mid-depth bed	5.2 6.0 8.1	

Figure 3.2 illustrates the baseline and comparative turbidities for the dredgers *Brisbane* and *Sir Thomas Hiley* as measured in the surface, mid-depth and near bed areas of the water column. (Note

that no comparative baseline water turbidity measurements were made prior to ebb tide dredging operations in 1995).

Figure 3.1 Comparative Plume Turbidities Versus Time

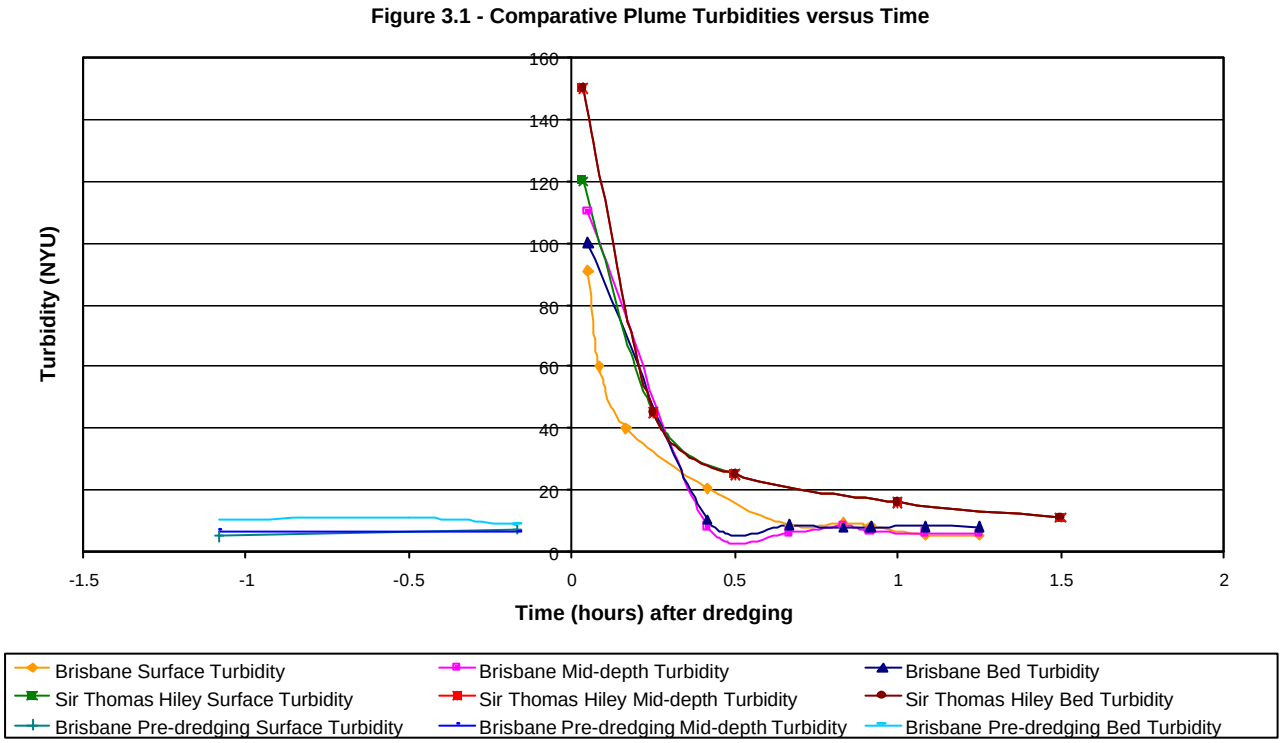

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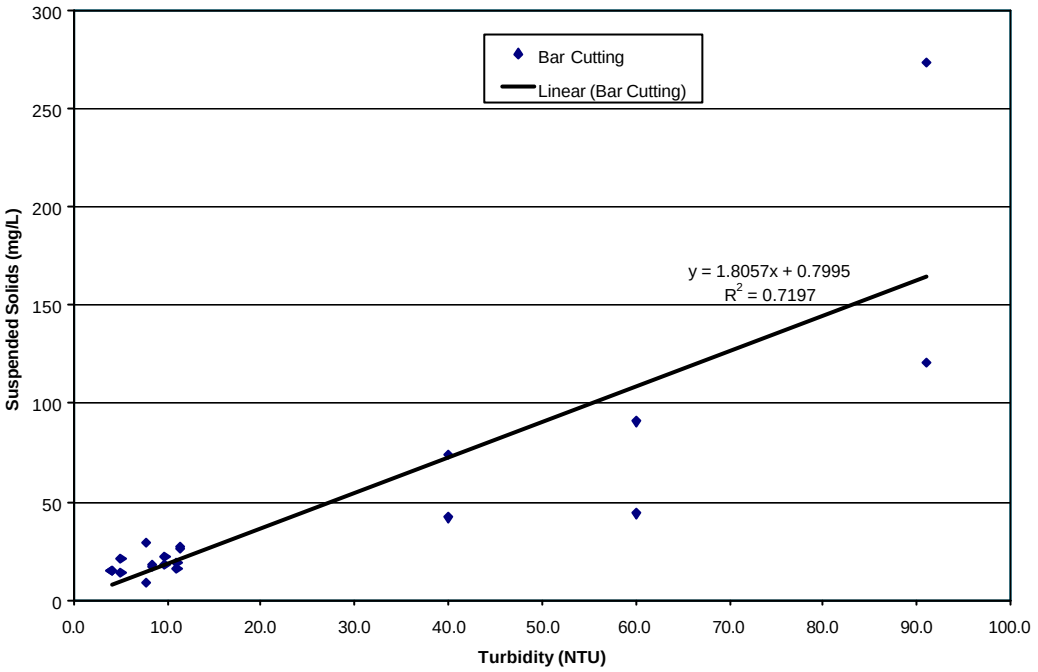
Figure 3.2 depicts the turbidity vs suspended solids relationship for the Bar Cutting sediments, based upon the analysis of a range of twenty (20) collected water samples including background and plume samples.

Figure 3.2 Turbidity versus Suspended Solids Concentrations at the Bar Cutting



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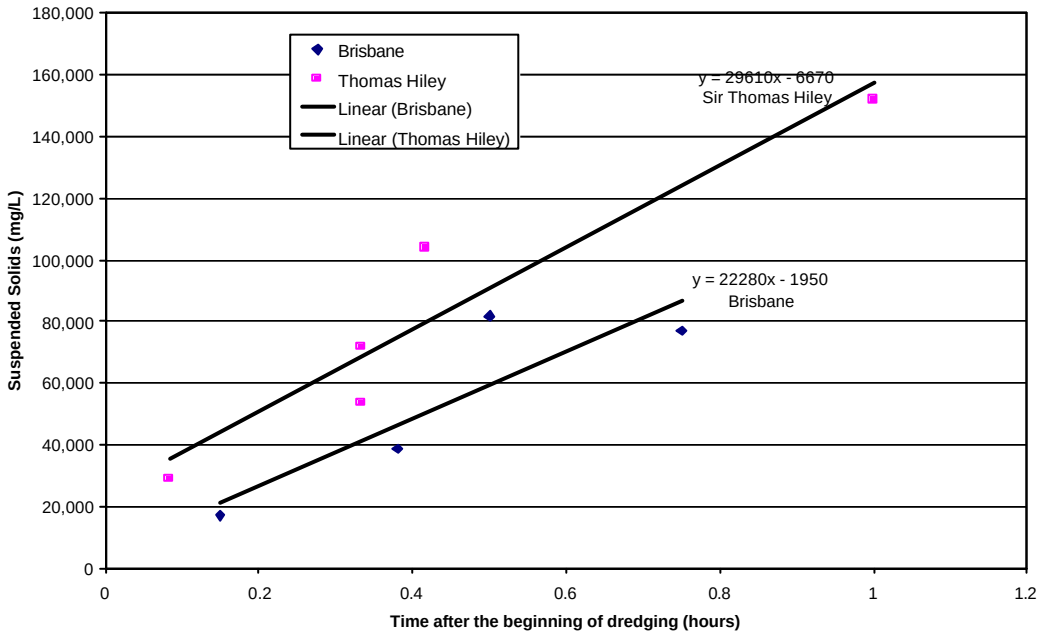
The suspended solids concentration results for the collected samples of hopper overflow water from the *Brisbane* are summarised in Table 3.2.

Table 3.2 TSD *Brisbane* – Hopper Overflow Suspended Solids Concentrations During Trial Dredging – 11/1/02

Sample No.	Time	Date	Location	Suspended Solids Concentration (mg/L)
1	0939	11/01/02	TSD Brisbane	17,300
2	0953	11/01/02	TSD Brisbane	38,700
3	1000	11/01/02	TSD Brisbane	81,800
4	1015	11/01/02	TSD Brisbane	77,200

Figure 3.3 illustrates the comparative increase in suspended solids concentrations with time in the dredge hopper overflow for both the *Brisbane* and *Sir Thomas Hiley* whilst operating at the Bar Cutting.

Figure 3.3 Hopper Overflow Suspended Solids for the *Brisbane* and *Sir Thomas Hiley*



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4 DISCUSSION

The results of the background and plume turbidity measurements for the *Brisbane* are summarised as follows:

- Background turbidity samples approximately 15 minutes after high water at 0810 showed a small variation with approximately 5 NTU near the water surface (0-2m depth), 5-7 NTU at mid-depth (4-9m) and 7-10 NTU close to the seabed (12.0-14.0m). Background turbidities through the water column just prior to dredging appeared slightly elevated possibly due to the influence of the passing vessel *Cape Conway*. The turbidities at this time ranged from 5-7 NTU near the water surface and mid-depth to 5-8 NTU near the seabed.
- The results of turbidity measurements within the stern wake of the *Brisbane* show elevated turbidities as a result of the dredging. Surface water turbidities in the vicinity of Beacon 10 were approximately 90 NTU, immediately following the first pass of the dredge (Secchi disc transparency of approximately 0.1-0.2m). Corresponding mid-depth and near bed turbidities were highly variable with a range between 50 and 110 NTU. Close to Beacon 13 (i.e. shortly after the conclusion of dredging), turbidity levels of approximately 60 NTU were recorded near the water surface in the turbid wake of the *Brisbane*. This was equivalent to a Secchi disc visibility of approximately 0.3-0.4m.
- The direction of the ebb tide current was approximately northerly, which quickly directed the plume formed following the second (inbound) pass of the dredger out of the navigation channel (typical depth 15.0m) and into the comparatively shallow water west of the navigation channel (6m depth). Aerial photographs taken coincident with the conclusion of dredging illustrate two lines of turbid plumes generated from each pass of the dredger. The turbid water bands generally appeared to keep their original pattern of formation with a slight deflection to the north of the channel alignment.
- Approximately half an hour after the completion of dredging, turbidity levels were in the range of 18-23 NTU near the water surface, 8 NTU at mid-depth and approximately 10 NTU close to the seabed.
- Approximately 1 hour after the completion of dredging, the turbidity levels had dropped close to the background levels measured prior to dredging (a range of 5-8 NTU).

These results shown in Table 3.1 compared favourably with those compiled for the *Sir Thomas Hiley* on the ebb tide in 1995. On that occasion, the time for a reduction in the turbidity within the plume to the background concentration was approximately 1.5 hours – refer to Figure 3.1. Measured plume turbidities were slightly lower for the *Brisbane* during operation than for the *Sir Thomas Hiley*.

A comparison of the aerial photographs of the dredging plumes from the *Brisbane* and *Sir Thomas Hiley* (refer to Plates 5-6 and 7-8) illustrates that the plume dimensions and their apparent spread and form were approximately comparable with each other on similar tidal conditions. The only perceptible difference is that the plumes generated by the *Brisbane* did not initially appear as intense as those generated by the *Sir Thomas Hiley*.

As shown in Figure 3.2, the line of best fit indicates that a suspended solids concentration (mg/L) in the vicinity of the Bar Cutting is estimated as approximately two times the measured turbidity in NTU (Nephelometric Turbidity Units).

The suspended solids concentrations shown in Table 3.2 (and Figure 3.3) illustrate considerable variation in the discharged concentrations from the start to the end of the trial dredging period. This was expected since the concentration of solids in the hopper overflow is dependant upon the level and the rate of increase of bulk dredged material in the hopper. The general trend of increasing discharged suspended solids concentrations with time is evident in Table 3.2. As illustrated in Figure 3.3, the comparative suspended solids concentrations in the hopper overflow depicted for the *Brisbane* appear to be smaller. This is consistent with the lower measured plume turbidities and the lower visual intensity of the plume as evidenced from the aerial photographs. Therefore the retention of fines in the hopper of the *Brisbane* appears to be superior to that of the *Sir Thomas Hiley*. This results in a hopper overflow plume that has a lower initial concentration of suspended solids when compared to the *Sir Thomas Hiley.*

5 AERIAL PHOTOGRAPHS

Plate 1 (above) showing calm pre-dredging conditions without any existing turbid plumes.

Plate 2 showing the northward movement of the turbid plumes resulting from the hopper overflow from the dredger *Brisbane* on the ebb tide.

Plate 3 showing survey vessel near Beacon 13 undertaking turbidity measurements within the turbid plume created during the second pass of the dredger.

Plate 4 showing the survey vessel in mid photo, approximately one hour after the conclusion of dredging with no visible plume.

Plates 5 and 6 showing the size and shape of dredging plumes associated with operation of the *Brisbane* on the ebb tide of 11th January 2002.

Plates 7 and 8 showing the comparative size and shape of dredging plumes associated with operation of the *Sir Thomas Hiley* on the ebb tide of 27th September 1995.