BRIDGE OVER HAWKESBURY RIVER
AT WINDSOR
GRAPHITISATION OF CAST IRON PIERS

References: CTI Consultants' report of 1 July 2011;
Commercial Diving Solutions report of 15 June, 2011.
(These reports relate to site activities at the Bridge Site on 9 to 21 May 2011).

Attachments: (1) Table 1, page 9 of CTI report entitled 'Summary of Core Samples (2005 and 2011)';
(2) Bed Level Depths at piles (page 13 of CDS report);
(3) Page 24 of CDS report (Pier 5 U/S pile);
(4) Page 30 of CDS report (Pier 5 D/S pile);
(5) Page 36 of CDS report (Pier 6 D/S pile).

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Graphitisation of the cast iron piers at Windsor Bridge is a chemical transformation of carbon to graphite resulting from the immersion in or contact with "polluted water" of the cast iron tube piles in the piers. This phenomenon results in a loss of cross section and therefore strength. There are two piles at each pier position. The water into which the piles were established has been tested and can be described as standard soft water with no saline content.

Graphitisation is a phenomenon that can result in severe deterioration of cast iron sewer pipes at elevated temperatures, but is very slow acting in the benign conditions at Windsor. In addition, the graphite formed usually provides protection to the cast iron underneath.

The degree of graphitisation has been measured by taking core samples from the walls of the cast iron pile cylinders. The cylinders were manufactured pre-metrics to Imperial Units; the nominal wall thickness would have been one inch (25.4mm).

For sections "below water", core boring results are listed in Attachment 1. There are two columns of results, the first being Casting Length, i.e. which refers to the original wall thickness of each cylinder, and the second being Residual Cast Iron. The difference between the two is the loss of wall thickness from graphitisation. The average of the first column is 24mm while the average of the second column is 16mm, the difference being 8mm, which is the average loss over 144 years of pier cylinder life.

After being sunk into position through bedrock, the cast iron cylinders were filled with a core of concrete in a surround of bricks, which enhances and adds to their load carrying capacity. Thus the loss of one third or more of the cylinder wall thickness would only result in a minimal reduction in the strength of the piers. This loss of cylinder wall thickness is equivalent to one mm in 18 years of the pier life.

In the records of Attachment 1 there are two low readings for samples from Pier 5. These are:

i) Upstream pile, NW, 6-10mm @ 0.7m below water level, i.e. loss of 15 -19mm;
ii) Upstream pile, SW, 2-9mm @ 0.7m below water level, i.e. loss of 16- 23mm.

Whilst these results are worrying, they should not cause the panic obviously felt by inexperienced RMS Project Managers, as the cylinders now have a competent infill, which substantially adds to their strength.

There are also two readings in the "Casting Length" column of 38mm (Piers 7 and 9), most likely as a result of a supply issue. (38mm being the metric equivalent of one and a half inches).

It will be noted that for the six "above water" samples and the first "below water" sample (which is actually above water) there has been no graphitisation loss. One sample is 35mm thick, most likely because of a supply issue. The remaining above water samples are 26, 27, 23, 25, 26 and 25mm, with an average length (wall thickness) of 25.1mm. Thus there has been negligible loss from this sample group.

It appears that the higher losses occur within the 1m range of water depth, suggesting that turbulence in the surface water may be a contributing factor to the loss.

Attachment 2 is a schedule of bed level depths measured from the datum point. With the exception of Piers 1 and 10 (which have negligible water depths), the average water depth is 6.5m for Piers 2 and 9 and 7m to 8m for the remaining Piers.

We propose that a skin of mild steel half rounds be clamped around each cylinder between bed level to above water level. The half cylinders would be welded along joint lines (vertically and horizontally) out of the water before insertion and have external vertical flanges for jointing by bolts to form a protective cover.

Initially, the existing cylinders would be cleaned by high pressure water blasting. The cracks illustrated in Attachments 3, 4 and 5 would be protected by the skin of steel proposed above after treatment by an approved filler. Each component of the skin would extend from bed level to above water level,, with the top section located to finish at a constant height above the high tide water level, for both practical and aesthetic purposes.

Finally, we suggest that the plate thickness would be within the range 16mm to 20mm. It is envisaged that the proposal outlined above would provide protection to the piles for at least another century.

Brian Pearson*
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ATTACHMENT 1
SCHEDULE OF CORE SAMPLES (2005 AND 2011)

Table 1 Summary of Core Samples (2005 and 2011)

Date Cored	Pier	Column	Aspect	Height	Casting Length	Residual Cast Iron	Comment
Above Water							
10/03/2005	1	D		Above water, above flange	35	35	Column extension
10/03/2005	1	D		300mm below flange	26	26	Upper limit of immersed column sections
May 2011	5	D		Ref less 2m	26	26	Above MHWS
May 2011	5	D		Ref less 2m	23	23	Above MHWS
May 2011	5	D		Ref less 2m	25	25	Above MHWS
May 2011	5	D		Ref less 2m	26	23	Above MHWS
Below Water							
10/03/2005	1	D		1600mm below flange	25	25	
11/03/2005	5	D		Underwater	31	> 20	At internal thickening
11/03/2005	5	D		Underwater	~30	20	1.6m from bed
11/03/2005	7	D		Underwater	~ 38	18	1.6m from bed
11/03/2005	9	U		Underwater	~38	27	1.6m from bed
May 2011	5	U	NW	Ref less 4m	22	6-10	~ 0.7m below water
May 2011	5	U	NE	Ref less 4m	24	14-15	~ 0.7m below water
May 2011	5	U	SE	Ref less 4m	24	10-11	~ 0.7m below water
May 2011	5	U	SW	Ref less 4m	22-23	8-13	~ 0.7m below water
May 2011	5	U	SW	Ref less 4m	22-23	2-9	~ 0.7m below water
May 2011	5	U	NW	Ref less 5m	22	14-17	~ 1.7m below water
May 2011	5	U	NE	Ref less 5m	29	21-27	~ 1.7m below water
May 2011	5	U	SE	Ref less 5m	~28	18-20	~ 1.7m below water
May 2011	5	U	SW	Ref less 5m	27	16-21	~ 1.7m below water
May 2011	5	D		Ref less 3.6 m	23	11	50mm core through crack
May 2011	5	U		Ref less 3.35 m	27	15-17	50mm core through crack
May 2011	5	D		Ref less 6m	22	21	Sea-Bed core

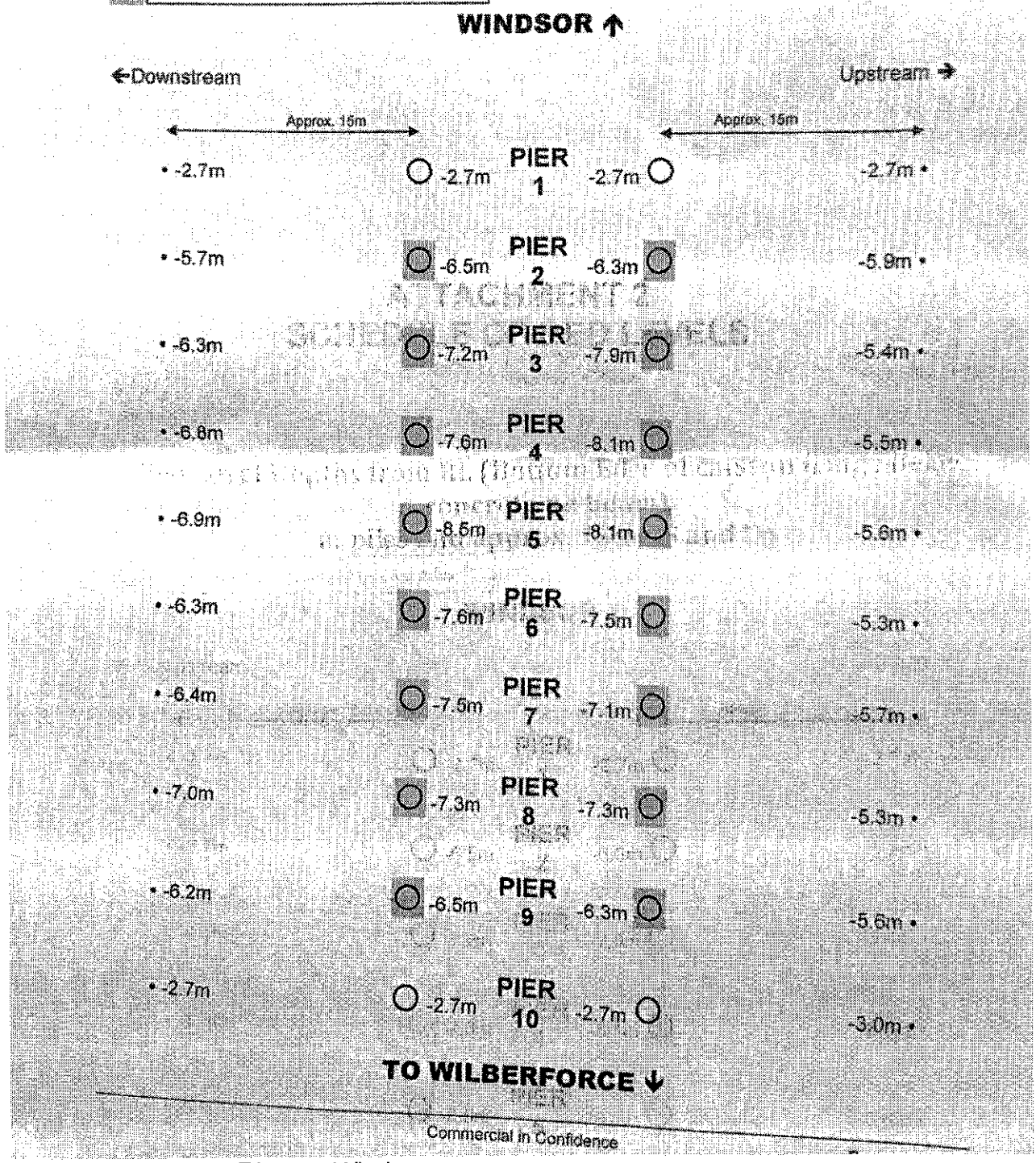
ATTACHMENT 2
SCHEDULE OF BED LEVELS

Commercial Diving Solutions Pty Ltd
ABN 60 091 624 805

B 415 Windsor Bridge

Bed Level Depths from RL (Bottom Edge of caisson flange below concrete tie beam) at piles and approx. 15m US and DS

○ Indicates cleaned and inspected piles



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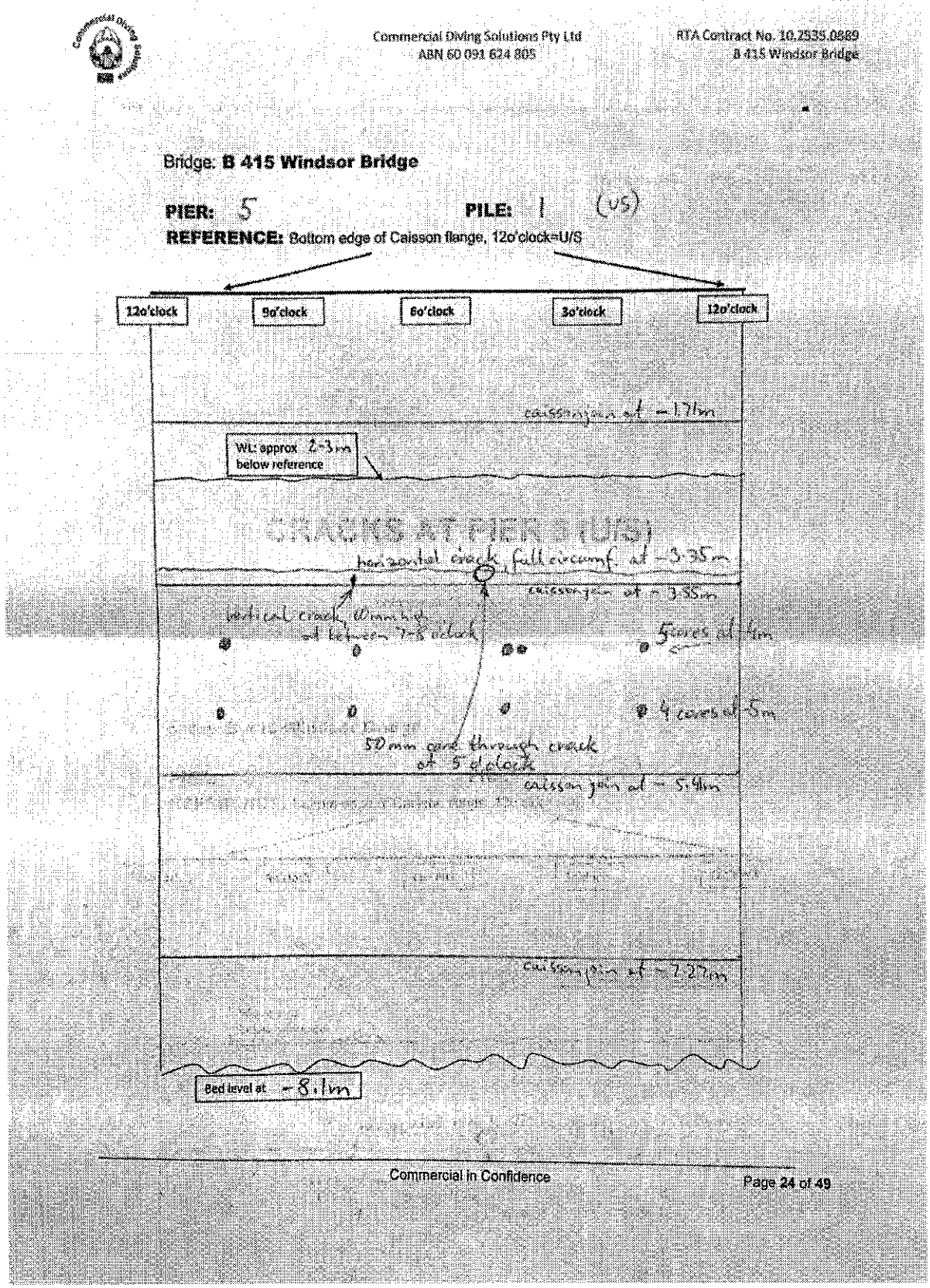
ATTACHMENT 3

CRACKS AT PIER 5 (U/S)



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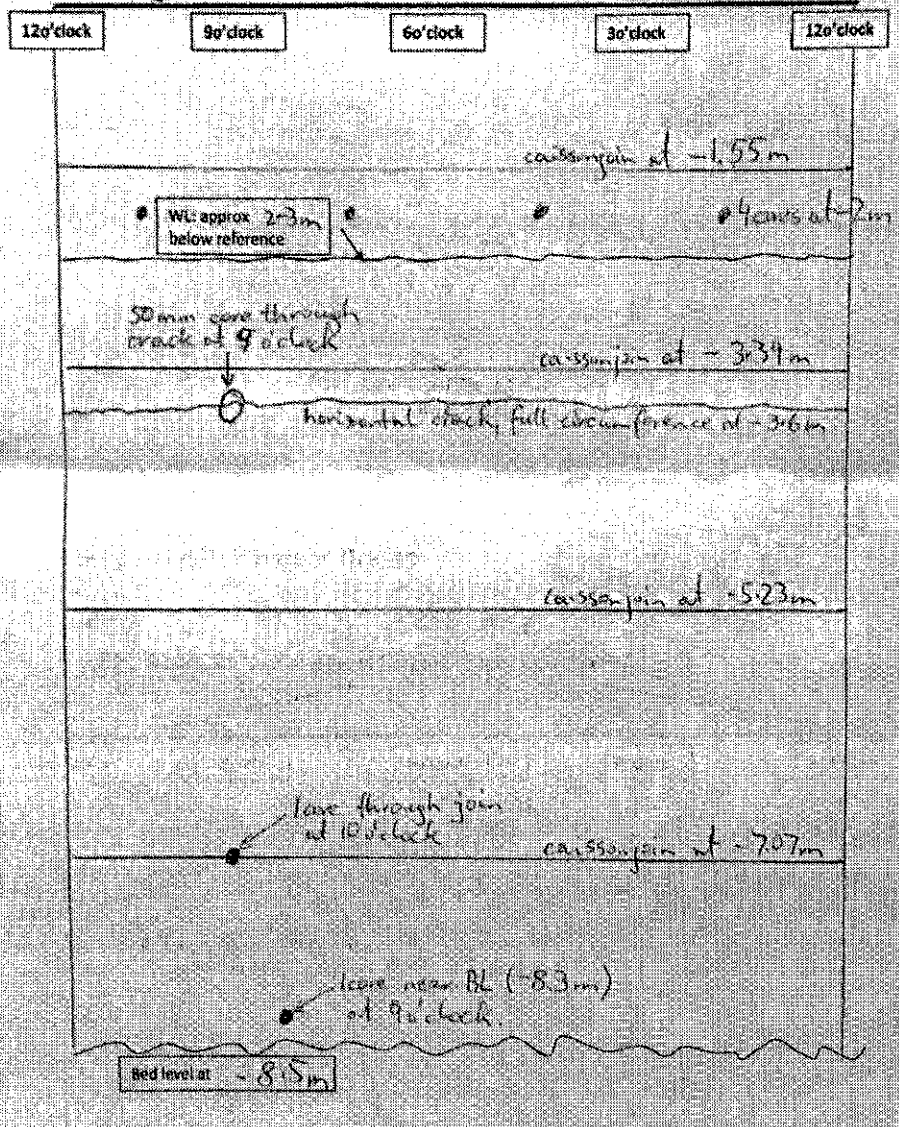
ATTACHMENT 4
CRACKS AT PIER 5 (D/S)

Bridge: **B 415 Windsor Bridge**

PIER: 5 **PILE:** 2 (DS)

REFERENCE: Bottom edge of Caisson flange, 12o'clock=U/S



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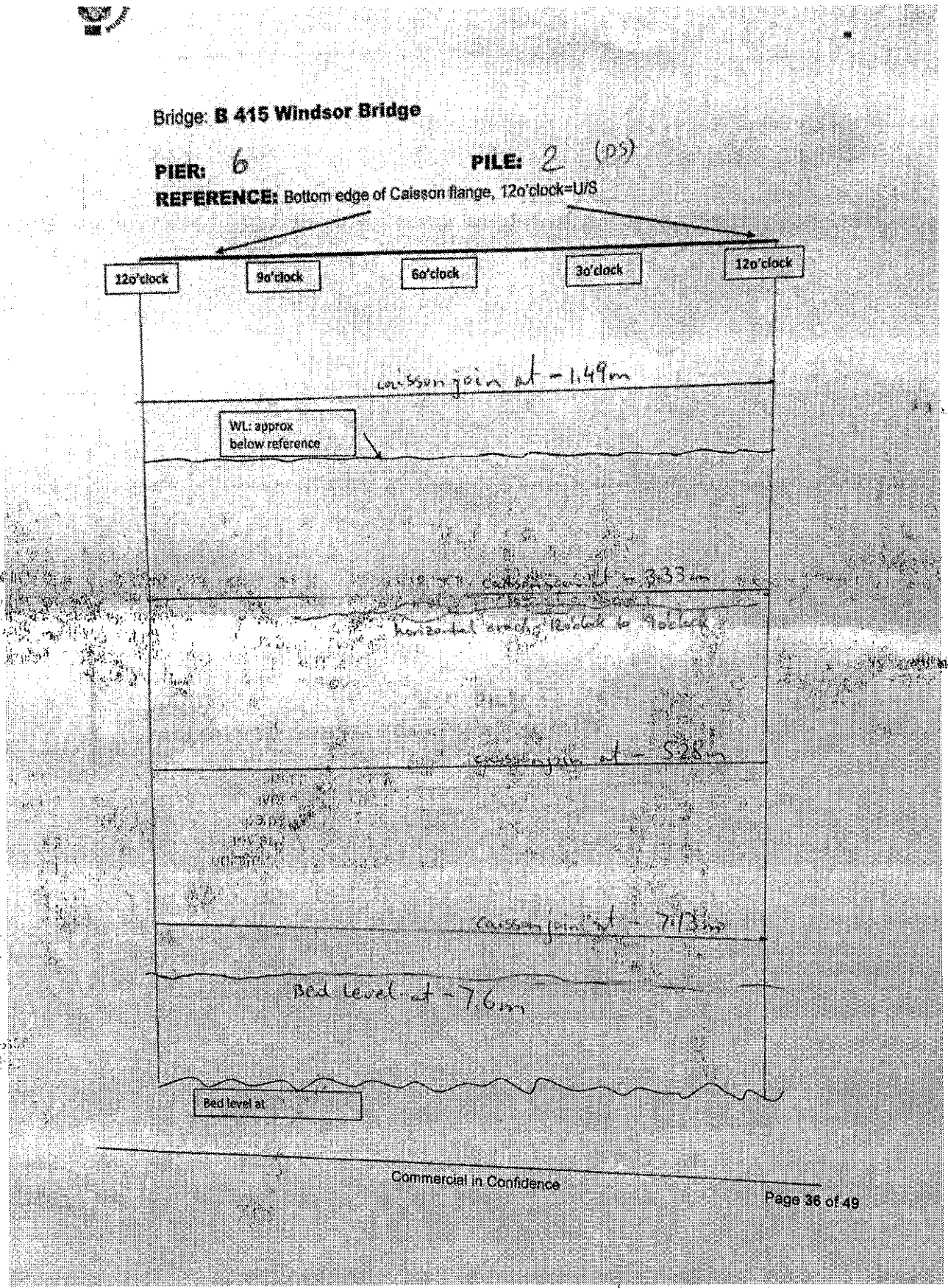
ATTACHMENT 5
CRACKS AT PIER 6 (D/S



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