ANNEX A – SCC BOREHOLE TESTING REPORT

Geotechnical report sent via email on 3 November 2014.

SS Dicky Geotechnical Investigations 08/10/2014

On the 8th October 2014 Cardno Bowler and Council officers underwent geotechnical investigations in the immediate area surrounding the SS Dicky. The purpose of the investigations was to see if there was presence of clay material under the wreck.

The investigations showed that there is a consistent clay bed under the sand layer at Dicky Beach (see attached borehole log sheets & Nearmap overlay showing approximate locations of the boreholes from the day of investigation).

The level of the sand layer and the clay bedding layer are represented on the log sheet have been converted to AHD measurements by Council officers (see handwritten notes on the borehole log sheet).

The AHD measurements seem to indicate that the clay bedding layer is runs on an approximate 5% slope towards the ocean approximately 1.7m below the sand layer. At this location the clay layer seems to have an approximate 1.5% slope heading southwards.

Please be aware that whilst these logs are a reasonable representation of the strata at the site and are accurate at the time of sampling the tide has the potential to change the depth of the sand layer on a daily basis. It is reasonable, however, to assume that the AHD measurements of the clay layer will remain consistent.

Also, the locations of the boreholes shown in the Nearmap overlay are indicative only and during investigations the bore holing extended to the furthest possible point towards the ocean and was completed at a full moon, dead low tide and therefore the best possible outcome. Although the location of BH6 & 7 seem to be far from the stern they were approximately 1-2m west of it.

Cardno
Shaping the Future

Cardno Construction Sciences
ABN: 74 128 806 735
32 Hi-Tech Drive,
Kunda Park QLD 4556

Laboratory: Sunshine Coast Laboratory
Phone: 07 5452 0100
Fax: 07 5452 0133

BOREHOLE LOG SHEET

Client: Sunshine Coast Council
Project: Dicky Beach Drilling Investigation
Driller: BC
Logged By: Paul Mayes
Drilling Commenced: 08/10/2014
Drilling Completed: 08/10/2014
Rig Type: Auger
Date Logged: 08/10/2014
Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°
Borehole Number: BH1
Lab Reference: 3740/S/37023
Location: BH1

Depth (m)	RL	DCP	Auger 'V' Bit / Auger 'TC' Bit / Washbore / Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0 – 1.8							SP	SAND, fine to coarse grained, pale brown, shell fragments present
1.8 – 2.8							CI	SANDY CLAY, medium plasticity, pale grey, fine to medium grained sand
2.8 – 6.0							CH	CLAY, high plasticity, very dark grey, trace fine grained sand

See Standard Sheets for details of abbreviations & basis of descriptions

Cardno
Shaping the Future

Cardno Construction Sciences
ABN: 74 128 806 735
32 Hi-Tech Drive,
Kunde Park QLD 4556

Laboratory: Sunshine Coast Laboratory
Phone: 07 5452 0100
Fax: 07 5452 0133

BOREHOLE LOG SHEET

Client: Sunshine Coast Council
Project: Dicky Beach Drilling Investigation
Driller: BC
Logged By: Paul Mayes
Drilling Commenced: 08/10/2014
Drilling Completed: 08/10/2014
Rig Type: Auger
Date Logged: 08/10/2014
Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°
Borehole Number: BH1
Lab Reference: 3740/S/37023
Location: BH1

Depth (m)	RL	DCP	Auger 'V' Bit / Auger 'TC' Bit / Washbore / Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0							CH	CLAY, high plasticity, very dark grey, trace fine grained sand
7.0								Borehole Terminated at 7.00m.

See Standard Sheets for details of abbreviations & basis of descriptions

Cardno
Shaping the Future

Cardno Construction Sciences
ABN: 74 128 806 735
32 Hi-Tech Drive,
Kunda Park QLD 4556

Laboratory: Sunshine Coast Laboratory
Phone: 07 5452 0100
Fax: 07 5452 0133

BOREHOLE LOG SHEET

Page 1 of 1

Client: Sunshine Coast Council
Project: Dicky Beach Drilling Investigation

Driller: BC
Logged By: Paul Mayes

Drilling Commenced: 08/10/2014
Drilling Completed: 08/10/2014
Rig Type: Auger
Date Logged: 20/10/2014

Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°

Borehole Number: BH2
Lab Reference: 3740/S/37024
Location: BH2

Depth (m)	RL	DCP	Auger 'V' Bit / Auger 'TC' Bit / Washbore / Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0							SP	SAND, fine to coarse grained, pale brown, shell fragments present
1.5							CI	SANDY CLAY, medium plasticity, pale grey becoming pale grey mottled yellow-brown, fine to medium grained sand
4.0								Borehole Terminated at 4.00m.
5.0								

See Standard Sheets for details of abbreviations & basis of descriptions

Cardno
Shaping the Future

Cardno Construction Sciences
ABN: 74 128 806 735
32 Hi-Tech Drive,
Kunda Park QLD 4556

Laboratory: Sunshine Coast Laboratory
Phone: 07 5452 0100
Fax: 07 5452 0133

BOREHOLE LOG SHEET

Page 1 of 1

Client: Sunshine Coast Council
Project: Dicky Beach Drilling Investigation
Driller: BC
Logged By: Paul Mayes
Drilling Commenced: 08/10/2014
Drilling Completed: 08/10/2014
Rig Type: Auger
Date Logged: 20/10/2014
Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°
Borehole Number: BH3
Lab Reference: 3740/S/37025
Location: BH3

Depth (m)	RL	DCP	Auger "A" Bit / Auger "C" Bit / Washbore / Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0							SP	SAND, fine to coarse grained, pale brown, shell fragments present
1.8							CI	SANDY CLAY, medium plasticity, pale grey, fine to medium grained sand
4.0								Borehole Terminated at 4.00m.
5.0								

See Standard Sheets for details of abbreviations & basis of descriptions

Cardno
Shaping the Future

Cardno Construction Sciences
ABN: 74 128 806 735
32 Hi-Tech Drive,
Kunda Park QLD 4556

Laboratory: Sunshine Coast Laboratory
Phone: 07 5452 0100
Fax: 07 5452 0133

BOREHOLE LOG SHEET

Client: Sunshine Coast Council
Project: Dicky Beach Drilling Investigation
Driller: BC
Logged By: Paul Mayes

Drilling Commenced: 08/10/2014
Drilling Completed: 08/10/2014
Rig Type: Auger
Date Logged: 20/10/2014

Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°

Borehole Number: BH4
Lab Reference: 3740/S/37026
Location: BH4

Depth (m)	RL	DCP	Auger 'A' Bit / Auger 'TC' Bit / Washbore / Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle chereceristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0							SP	SAND, fine to coarse grained, pale brown, shell fragments present
2.0							CI	SANDY CLAY, medium plasticity, pale grey, fine to medium grained sand
4.0								Borehole Terminated at 4.00m.

See Standard Sheets for details of abbreviations & basis of descriptions

Cardno
Shaping the Future

Cardno Construction Sciences
ABN: 74 128 806 735
32 Hi-Tech Drive,
Kunda Park QLD 4556

Laboratory: Sunshine Coast Laboratory
Phone: 07 5452 0100
Fax: 07 5452 0133

BOREHOLE LOG SHEET

Client: Sunshine Coast Council
Project: Dicky Beach Drilling Investigation
Driller: BC
Logged By: Paul Mayes

Drilling Commenced: 08/10/2014
Drilling Completed: 08/10/2014
Rig Type: Auger
Date Logged: 20/10/2014

Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°

Borehole Number: BH5
Lab Reference: 3740/5/37027
Location: BH5

Depth (m)	RL	DCP	Auger 'V' Bit / Auger 'TC' Bit / Washbore / Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0							SP	SAND, fine to coarse grained, pale brown, shell fragments present
1.5							CI	SANDY CLAY, medium plasticity, pale grey mottled pale red, fine to medium grained sand
4.0								Borehole Terminated at 4.00m.

See Standard Sheets for details of abbreviations & basis of descriptions

Cardno
Shaping the Future

Cardno Construction Sciences
ABN: 74 128 806 735
32 Hi-Tech Drive,
Kunda Park QLD 4556

Laboratory: Sunshine Coast Laboratory
Phone: 07 5452 0100
Fax: 07 5452 0133

BOREHOLE LOG SHEET

Page 1 of 1

Client: Sunshine Coast Council
Project: Dicky Beach Drilling Investigation
Driller: BC
Logged By: Paul Mayes
Drilling Commenced: 08/10/2014
Drilling Completed: 08/10/2014
Rig Type: Auger
Date Logged: 20/10/2014
Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°
Borehole Number: BH6
Lab Reference: 3740/S/37028
Location: BH6

Depth (m)	RL	DCP	Auger 'V' Bit / Auger 'TC' Bit / Washbore / Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0							SP	SAND, fine to coarse grained, pale brown, shell fragments present
0.5								
1.0								
1.5							CI	SANDY CLAY, medium plasticity, pale grey, fine to medium grained sand
								Borehole terminated at 1.7m to avoid tide
2.0								

See Standard Sheets for details of abbreviations & basis of descriptions

Cardno
Shaping the Future

Cardno Construction Sciences
ABN: 74 128 806 735
32 Hi-Tech Drive,
Kunda Park QLD 4556

Laboratory: Sunshine Coast Laboratory
Phone: 07 5452 0100
Fax: 07 5452 0133

BOREHOLE LOG SHEET

Page 1 of 1

Client: Sunshine Coast Council
Project: Dicky Beach Drilling Investigation
Driller: BC
Logged By: Paul Mayes
Drilling Commenced: 08/10/2014
Drilling Completed: 08/10/2014
Rig Type: Auger
Date Logged: 20/10/2014
Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°
Borehole Number: BH7
Lab Reference: 3740/5/37029
Location: BH7

Depth (m)	RL	DCP	Auger "A" Bit / Auger "C" Bit / Washbore / Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0							SP	SAND, fine to coarse grained, pale brown, shell fragments present
1.5							CI	SANDY CLAY, medium plasticity, pale grey, fine to medium grained sand
4.0								Borehole Terminated at 4.00m.

See Standard Sheets for details of abbreviations & basis of descriptions

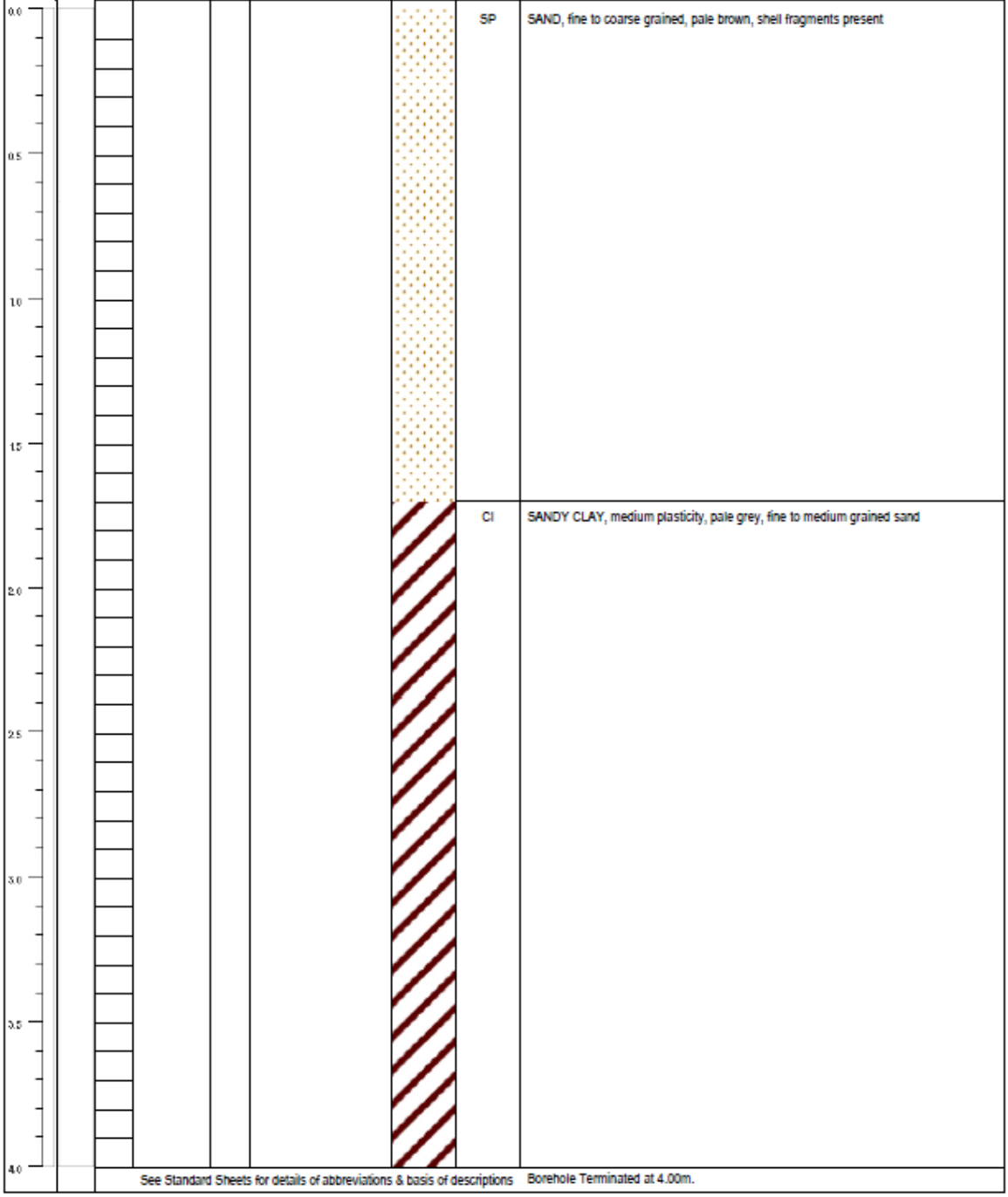
Cardno
Shaping the Future

Cardno Construction Sciences
ABN: 74 128 806 735
32 Hi-Tech Drive,
Kunda Park QLD 4556

Laboratory: Sunshine Coast Laboratory
Phone: 07 5452 0100
Fax: 07 5452 0133

BOREHOLE LOG SHEET

Client: Sunshine Coast Council
Project: Dicky Beach Drilling Investigation
Driller: BC
Logged By: Paul Mayes
Drilling Commenced: 08/10/2014
Drilling Completed: 08/10/2014
Rig Type: Auger
Date Logged: 20/10/2014
Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°
Borehole Number: BH8
Lab Reference: 3740/5/37030
Location: BH8



Depth (m)	RL	DCP	Auger 'V' Bit / Auger 'TC' Bit / Washbore / Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0							SP	SAND, fine to coarse grained, pale brown, shell fragments present
1.8							CI	SANDY CLAY, medium plasticity, pale grey, fine to medium grained sand
4.0								Borehole Terminated at 4.00m.

See Standard Sheets for details of abbreviations & basis of descriptions

ANNEX B – 2015 TIDE TIMETABLES

The adjustment from Mooloolaba to Caloundra is -00:03 minutes.

AUSTRALIA, EAST COAST – MOOLOOLABA

LAT 26° 41' S LONG 153° 08' E

Times and Heights of High and Low Waters

2015

Time Zone –1000

JANUARY

	Time	m		Time	m
1 TH	0522	1.68	16 FR	0449	1.53
	1142	0.59		1103	0.70
	1717	1.35		1625	1.30
	2334	0.26		2243	0.36
2 FR	0612	1.78	17 SA	0538	1.68
	1236	0.53		1201	0.59
	1810	1.35		1725	1.34
				2336	0.27
3 SA	0019	0.22	18 SU	0624	1.82
	0655	1.85		1250	0.48
	1321	0.48		1819	1.41
	1857	1.36			
4 SU	0101	0.20	19 MO	0026	0.17
	0735	1.89		0709	1.96
	1402	0.44		1335	0.36
	1939	1.37		1910	1.48
5 MO ○	0139	0.19	20 TU ●	0114	0.08
	0813	1.90		0754	2.06
	1439	0.42		1420	0.27
	2018	1.37		1959	1.54
6 TU	0214	0.21	21 WE	0201	0.03
	0848	1.89		0839	2.12
	1513	0.41		1504	0.21
	2055	1.37		2048	1.59
7 WE	0248	0.24	22 TH	0248	0.03
	0922	1.86		0924	2.12
	1547	0.42		1550	0.18
	2131	1.36		2137	1.61
8 TH	0323	0.30	23 FR	0336	0.09
	0956	1.82		1009	2.06
	1620	0.43		1635	0.19
	2206	1.35		2228	1.61
9 FR	0358	0.37	24 SA	0426	0.20
	1030	1.75		1055	1.94
	1655	0.45		1722	0.24
	2245	1.32		2320	1.58
10 SA	0436	0.45	25 SU	0519	0.35
	1105	1.67		1142	1.78
	1732	0.47		1812	0.30
	2327	1.30			
11 SU	0517	0.55	26 MO	0019	1.54
	1142	1.58		0619	0.51
	1811	0.50		1233	1.60
				1905	0.37
12 MO	0017	1.27	27 TU ◑	0129	1.51
	0606	0.65		0733	0.65
	1223	1.49		1332	1.44
	1857	0.51		2005	0.42
13 TU ◐	0120	1.27	28 WE	0249	1.52
	0708	0.74		0903	0.72
	1312	1.40		1443	1.32
	1949	0.52		2111	0.44
14 WE	0239	1.31	29 TH	0404	1.58
	0826	0.79		1030	0.72
	1412	1.33		1559	1.27
	2048	0.49		2218	0.43
15 TH	0351	1.40	30 FR	0506	1.65
	0950	0.77		1137	0.66
	1520	1.29		1707	1.27
	2147	0.44		2317	0.39
			31 SA	0557	1.73
				1228	0.59
				1801	1.31

FEBRUARY

	Time	m		Time	m
1 SU	0006	0.34	16 MO	0600	1.84
	0640	1.79		1230	0.46
	1308	0.53		1804	1.45
	1846	1.36			
2 MO	0048	0.30	17 TU	0011	0.22
	0718	1.83		0648	1.98
	1344	0.48		1315	0.32
	1925	1.40		1857	1.56
3 TU	0125	0.27	18 WE	0102	0.12
	0752	1.86		0734	2.08
	1415	0.44		1358	0.22
	2001	1.44		1946	1.67
4 WE ○	0159	0.26	19 TH ●	0150	0.05
	0825	1.86		0819	2.12
	1446	0.41		1441	0.15
	2036	1.47		2034	1.75
5 TH	0232	0.27	20 FR	0238	0.05
	0858	1.85		0903	2.10
	1517	0.40		1524	0.12
	2109	1.48		2121	1.79
6 FR	0305	0.31	21 SA	0325	0.11
	0928	1.81		0947	2.01
	1546	0.40		1606	0.15
	2143	1.49		2210	1.79
7 SA	0338	0.36	22 SU	0414	0.22
	1000	1.76		1031	1.87
	1617	0.41		1649	0.21
	2217	1.48		2300	1.75
8 SU	0413	0.44	23 MO	0506	0.38
	1032	1.68		1116	1.69
	1649	0.43		1734	0.30
	2254	1.45		2354	1.68
9 MO	0451	0.53	24 TU	0605	0.55
	1105	1.59		1204	1.50
	1722	0.46		1824	0.40
	2336	1.43			
10 TU	0534	0.63	25 WE	0057	1.61
	1141	1.49		0721	0.68
	1801	0.49		1302	1.34
				1921	0.50
11 WE	0026	1.40	26 TH ◑	0215	1.56
	0627	0.72		0852	0.75
	1224	1.39		1421	1.23
	1847	0.52		2033	0.56
12 TH ◐	0133	1.39	27 FR	0335	1.57
	0739	0.79		1018	0.74
	1321	1.30		1547	1.20
	1947	0.54		2151	0.56
13 FR	0257	1.44	28 SA	0441	1.61
	0912	0.79		1122	0.68
	1439	1.25		1656	1.25
	2057	0.52		2258	0.52
14 SA	0410	1.55			
	1037	0.72			
	1559	1.27			
	2209	0.45			
15 SU	0509	1.69			
	1140	0.60			
	1706	1.34			
	2314	0.34			

MARCH

	Time	m		Time	m
1 SU	0532	1.66	16 MO	0437	1.71
	1207	0.61		1115	0.55
	1749	1.32		1653	1.38
	2350	0.46		2255	0.42
2 MO	0615	1.72	17 TU	0533	1.85
	1244	0.54		1205	0.40
	1832	1.40		1751	1.52
				2355	0.29
3 TU	0031	0.41	18 WE	0623	1.96
	0652	1.76		1250	0.27
	1316	0.48		1842	1.67
	1909	1.47			
4 WE	0108	0.36	19 TH	0048	0.19
	0726	1.79		0709	2.02
	1346	0.43		1332	0.17
	1942	1.53		1930	1.80
5 TH	0142	0.33	20 FR ●	0137	0.12
	0758	1.80		0755	2.03
	1415	0.39		1413	0.10
	2015	1.58		2017	1.90
6 FR ○	0215	0.33	21 SA	0225	0.12
	0829	1.79		0839	1.98
	1443	0.36		1454	0.09
	2047	1.61		2105	1.95
7 SA	0248	0.35	22 SU	0313	0.18
	0900	1.76		0923	1.87
	1511	0.36		1536	0.13
	2119	1.63		2151	1.94
8 SU	0321	0.39	23 MO	0402	0.29
	0930	1.70		1006	1.72
	1540	0.36		1616	0.21
	2152	1.63		2239	1.89
9 MO	0355	0.45	24 TU	0455	0.43
	1001	1.63		1051	1.55
	1609	0.38		1658	0.32
	2228	1.62		2329	1.80
10 TU	0432	0.53	25 WE	0554	0.57
	1033	1.54		1139	1.39
	1642	0.42		1744	0.45
	2306	1.59			
11 WE	0514	0.61	26 TH	0026	1.70
	1109	1.45		0708	0.68
	1718	0.47		1237	1.26
	2351	1.55		1839	0.56
12 TH	0605	0.69	27 FR ◑	0136	1.61
	1153	1.35		0831	0.73
	1803	0.52		1400	1.18
				1951	0.64
13 FR	0050	1.52	28 SA	0252	1.56
	0715	0.75		0948	0.72
	1251	1.27		1528	1.19
	1902	0.56		2115	0.67
14 SA ◐	0210	1.52	29 SU	0359	1.57
	0848	0.75		1049	0.67
	1415	1.23		1637	1.26
	2019	0.57		2228	0.64
15 SU	0332	1.59	30 MO	0454	1.60
	1012	0.67		1133	0.60
	1543	1.27		1728	1.35
	2141	0.52		2324	0.58
			31 TU	0539	1.64
				1209	0.53
				1810	1.45

APRIL

	Time	m		Time	m
1 WE	0008	0.52	16 TH	0555	1.87
	0617	1.67		1221	0.23
	1241	0.46		1826	1.77
	1847	1.54			
2 TH	0046	0.46	17 FR	0033	0.29
	0652	1.70		0643	1.89
	1311	0.41		1303	0.14
	1920	1.61		1914	1.91
3 FR	0121	0.43	18 SA	0124	0.24
	0725	1.71		0729	1.87
	1339	0.36		1344	0.10
	1952	1.68		2001	2.00
4 SA ○	0156	0.41	19 SU ●	0213	0.24
	0757	1.69		0815	1.80
	1407	0.33		1425	0.10
	2024	1.73		2046	2.04
5 SU	0229	0.41	20 MO	0302	0.28
	0829	1.66		0859	1.69
	1435	0.32		1505	0.15
	2056	1.76		2132	2.03
6 MO	0304	0.43	21 TU	0352	0.36
	0900	1.61		0944	1.57
	1505	0.32		1545	0.24
	2129	1.77		2218	1.97
7 TU	0340	0.47	22 WE	0444	0.47
	0933	1.55		1029	1.43
	1535	0.34		1626	0.35
	2205	1.76		2305	1.87
8 WE	0420	0.52	23 TH	0541	0.57
	1008	1.47		1117	1.32
	1609	0.39		1710	0.48
	2244	1.73		2354	1.76
9 TH	0504	0.59	24 FR	0645	0.65
	1048	1.39		1212	1.22
	1647	0.45		1802	0.59
	2329	1.69			
10 FR	0558	0.65	25 SA	0052	1.65
	1136	1.31		0753	0.69
	1734	0.51		1328	1.18
				1906	0.69
11 SA	0026	1.64	26 SU ◑	0158	1.57
	0709	0.68		0858	0.69
	1240	1.25		1453	1.20
	1836	0.58		2026	0.73
12 SU ◐	0139	1.63	27 MO	0305	1.54
	0832	0.66		0957	0.65
	1408	1.24		1602	1.27
	1955	0.60		2144	0.73
13 MO	0258	1.66	28 TU	0402	1.54
	0945	0.58		1045	0.59
	1531	1.32		1656	1.37
	2121	0.57		2247	0.68
14 TU	0405	1.73	29 WE	0451	1.55
	1045	0.47		1124	0.52
	1638	1.46		1741	1.48
	2237	0.48		2337	0.62
15 WE	0503	1.81	30 TH	0535	1.58
	1135	0.34		1200	0.45
	1734	1.62		1818	1.58
	2339	0.38			

Datum of Predictions is Lowest Astronomical Tide

Moon Symbols ● New Moon ◑ First Quarter ○ Full Moon ◐ Last Quarter

AUSTRALIA, EAST COAST – MOOLOOLABA

LAT 26° 41' S LONG 153° 08' E

Times and Heights of High and Low Waters

2015

Time Zone –1000

MAY

	Time	m		Time	m
1 FR	0020	0.57	16 SA	0021	0.40
	0613	1.59		0617	1.71
	1231	0.39		1235	0.16
	1853	1.67		1858	1.96
2 SA	0058	0.52	17 SU	0113	0.36
	0649	1.59		0706	1.67
	1301	0.34		1317	0.13
	1926	1.75		1944	2.03
3 SU	0135	0.48	18 MO ●	0203	0.35
	0723	1.58		0752	1.61
	1330	0.30		1358	0.14
	1959	1.81		2029	2.06
4 MO ○	0211	0.46	19 TU	0252	0.37
	0758	1.56		0838	1.53
	1401	0.28		1439	0.19
	2033	1.86		2113	2.04
5 TU	0248	0.45	20 WE	0340	0.41
	0833	1.52		0923	1.45
	1434	0.28		1519	0.26
	2109	1.88		2156	1.98
6 WE	0328	0.46	21 TH	0428	0.47
	0910	1.48		1007	1.37
	1508	0.30		1559	0.36
	2147	1.88		2239	1.89
7 TH	0411	0.49	22 FR	0517	0.54
	0951	1.42		1053	1.30
	1546	0.34		1641	0.47
	2229	1.85		2322	1.78
8 FR	0458	0.53	23 SA	0607	0.59
	1037	1.36		1143	1.24
	1629	0.41		1728	0.58
	2316	1.81			
9 SA	0555	0.56	24 SU	0009	1.68
	1130	1.31		0701	0.63
	1720	0.49		1243	1.21
				1824	0.67
10 SU	0011	1.76	25 MO	0101	1.59
	0701	0.57		0757	0.63
	1237	1.28		1400	1.22
	1823	0.56		1932	0.74
11 MO ◐	0117	1.71	26 TU ◑	0200	1.52
	0811	0.55		0853	0.61
	1358	1.30		1514	1.27
	1939	0.60		2048	0.77
12 TU	0228	1.70	27 WE	0301	1.49
	0916	0.48		0945	0.57
	1515	1.39		1615	1.36
	2103	0.60		2200	0.75
13 WE	0333	1.71	28 TH	0357	1.47
	1013	0.40		1031	0.51
	1621	1.53		1704	1.47
	2219	0.54		2301	0.71
14 TH	0432	1.73	29 FR	0446	1.47
	1104	0.30		1112	0.45
	1718	1.69		1746	1.58
	2324	0.47		2351	0.65
15 FR	0527	1.73	30 SA	0529	1.47
	1151	0.22		1148	0.39
	1809	1.84		1823	1.68
			31 SU	0033	0.58
				0610	1.48
				1222	0.33
				1859	1.78

JUNE

	Time	m		Time	m
1 MO	0114	0.53	16 TU	0154	0.41
	0650	1.48		0735	1.46
	1256	0.28		1338	0.17
	1935	1.86		2013	2.02
2 TU	0153	0.48	17 WE ●	0239	0.41
	0729	1.47		0820	1.43
	1332	0.24		1418	0.21
	2012	1.92		2054	2.00
3 WE ○	0233	0.44	18 TH	0322	0.42
	0810	1.46		0902	1.39
	1409	0.22		1458	0.26
	2051	1.96		2133	1.95
4 TH	0315	0.42	19 FR	0404	0.45
	0853	1.45		0945	1.36
	1449	0.23		1536	0.34
	2132	1.97		2211	1.87
5 FR	0401	0.42	20 SA	0444	0.49
	0939	1.42		1025	1.32
	1533	0.27		1615	0.42
	2216	1.95		2249	1.78
6 SA	0449	0.43	21 SU	0524	0.52
	1029	1.39		1109	1.28
	1620	0.34		1656	0.52
	2304	1.90		2329	1.69
7 SU	0543	0.44	22 MO	0607	0.55
	1124	1.36		1158	1.26
	1713	0.42		1743	0.62
	2356	1.83			
8 MO	0643	0.45	23 TU	0011	1.60
	1228	1.35		0654	0.56
	1813	0.51		1257	1.25
				1839	0.70
9 TU	0054	1.75	24 WE ◑	0058	1.51
	0744	0.44		0746	0.56
	1341	1.38		1410	1.27
	1925	0.58		1949	0.77
10 WE ◐	0158	1.68	25 TH	0154	1.43
	0843	0.40		0839	0.54
	1455	1.46		1523	1.33
	2046	0.62		2107	0.79
11 TH	0303	1.63	26 FR	0255	1.38
	0940	0.35		0931	0.50
	1602	1.58		1621	1.43
	2205	0.60		2219	0.76
12 FR	0404	1.59	27 SA	0353	1.36
	1033	0.29		1019	0.45
	1703	1.71		1710	1.54
	2314	0.55		2320	0.70
13 SA	0502	1.55	28 SU	0446	1.36
	1124	0.24		1103	0.39
	1755	1.84		1752	1.65
14 SU	0014	0.50	29 MO	0009	0.62
	0557	1.52		0534	1.37
	1211	0.19		1146	0.32
	1844	1.94		1832	1.77
15 MO	0106	0.44	30 TU	0053	0.53
	0647	1.50		0620	1.39
	1255	0.17		1226	0.24
	1930	2.00		1911	1.87

JULY

	Time	m		Time	m
1 WE	0135	0.45	16 TH ●	0222	0.40
	0706	1.42		0803	1.39
	1309	0.18		1401	0.21
	1951	1.96		2033	1.92
2 TH ○	0217	0.38	17 FR	0258	0.39
	0751	1.45		0842	1.39
	1351	0.14		1438	0.24
	2034	2.01		2109	1.88
3 FR	0300	0.33	18 SA	0333	0.40
	0838	1.47		0920	1.38
	1436	0.13		1514	0.29
	2117	2.04		2143	1.83
4 SA	0345	0.30	19 SU	0407	0.41
	0926	1.47		0957	1.37
	1522	0.16		1550	0.36
	2202	2.01		2217	1.75
5 SU	0432	0.29	20 MO	0442	0.43
	1017	1.47		1036	1.34
	1611	0.23		1627	0.45
	2248	1.95		2251	1.67
6 MO	0522	0.31	21 TU	0518	0.45
	1111	1.46		1117	1.32
	1703	0.34		1708	0.54
	2336	1.85		2327	1.57
7 TU	0615	0.33	22 WE	0557	0.48
	1210	1.45		1205	1.30
	1802	0.45		1755	0.64
8 WE	0030	1.72	23 TH	0008	1.47
	0711	0.34		0642	0.49
	1319	1.46		1304	1.29
	1911	0.56		1854	0.73
9 TH ◐	0129	1.59	24 FR ◑	0055	1.37
	0810	0.35		0732	0.50
	1434	1.50		1418	1.31
	2034	0.63		2011	0.78
10 FR	0235	1.48	25 SA	0154	1.29
	0908	0.34		0828	0.49
	1545	1.58		1532	1.38
	2158	0.64		2137	0.77
11 SA	0343	1.41	26 SU	0302	1.25
	1007	0.32		0926	0.45
	1649	1.69		1631	1.48
	2311	0.60		2250	0.70
12 SU	0447	1.37	27 MO	0408	1.25
	1103	0.28		1021	0.39
	1744	1.79		1720	1.61
				2346	0.60
13 MO	0010	0.53	28 TU	0506	1.28
	0544	1.36		1113	0.31
	1154	0.24		1805	1.74
	1832	1.87			
14 TU	0100	0.47	29 WE	0032	0.49
	0635	1.37		0558	1.34
	1240	0.21		1203	0.21
	1916	1.91		1848	1.87
15 WE	0143	0.42	30 TH	0115	0.38
	0721	1.38		0647	1.41
	1323	0.20		1251	0.12
	1956	1.93		1931	1.97
			31 FR ○	0156	0.28
				0735	1.48
				1337	0.06
				2014	2.04

AUGUST

	Time	m		Time	m
1 SA	0239	0.20	16 SU	0300	0.32
	0823	1.53		0855	1.44
	1424	0.04		1453	0.25
	2058	2.06		2112	1.75
2 SU	0322	0.16	17 MO	0330	0.32
	0912	1.57		0930	1.44
	1512	0.06		1526	0.31
	2142	2.02		2143	1.69
3 MO	0407	0.15	18 TU	0401	0.33
	1002	1.59		1005	1.43
	1600	0.14		1602	0.39
	2227	1.92		2216	1.60
4 TU	0454	0.18	19 WE	0433	0.36
	1054	1.57		1043	1.40
	1651	0.27		1639	0.48
	2313	1.78		2249	1.51
5 WE	0543	0.23	20 TH	0507	0.39
	1150	1.55		1124	1.37
	1749	0.42		1722	0.57
				2325	1.40
6 TH	0003	1.61	21 FR	0546	0.43
	0636	0.28		1213	1.34
	1255	1.52		1813	0.66
	1859	0.56			
7 FR ◐	0101	1.44	22 SA	0007	1.29
	0735	0.33		0631	0.46
	1412	1.52		1316	1.33
	2027	0.64		1924	0.73
8 SA	0213	1.31	23 SU ◑	0104	1.20
	0839	0.36		0728	0.48
	1529	1.56		1436	1.36
	2157	0.65		2058	0.73
9 SU	0330	1.24	24 MO	0220	1.15
	0945	0.36		0836	0.46
	1636	1.63		1550	1.45
	2310	0.59		2222	0.66
10 MO	0440	1.24	25 TU	0340	1.16
	1048	0.33		0944	0.41
	1732	1.70		1648	1.57
				2322	0.55
11 TU	0005	0.52	26 WE	0445	1.23
	0537	1.27		1047	0.31
	1141	0.29		1738	1.71
	1818	1.77			
12 WE	0047	0.45	27 TH	0009	0.41
	0625	1.32		0540	1.33
	1228	0.24		1143	0.20
	1858	1.81		1824	1.85
13 TH	0125	0.39	28 FR	0051	0.28
	0707	1.36		0630	1.45
	1308	0.21		1235	0.09
	1935	1.83		1908	1.96
14 FR	0158	0.35	29 SA	0132	0.16
	0745	1.40		0718	1.55
	1344	0.21		1323	0.01
	2008	1.82		1951	2.02
15 SA ●	0229	0.33	30 SU ○	0214	0.07
	0820	1.42		0806	1.64
	1419	0.22		1411	-0.02
	2041	1.80		2035	2.01
			31 MO	0255	0.03
				0855	1.70
				1459	0.01
				2119	1.95

Bureau of Meteorology

National Tidal Centre

Datum of Predictions is Lowest Astronomical Tide

Moon Symbols ● New Moon ◑ First Quarter ○ Full Moon ◐ Last Quarter

AUSTRALIA, EAST COAST – MOOLOOLABA

LAT 26° 41' S LONG 153° 08' E

Times and Heights of High and Low Waters

2015

Time Zone –1000

SEPTEMBER

	Time	m		Time	m
1	0338	0.03	**16**	0321	0.25
	0943	1.72		0938	1.53
TU	1547	0.11	WE	1541	0.36
	2203	1.82		2143	1.51
2	0423	0.08	**17**	0352	0.27
	1034	1.70		1013	1.51
WE	1639	0.25	TH	1618	0.43
	2249	1.64		2215	1.42
3	0508	0.16	**18**	0423	0.31
	1128	1.65		1052	1.48
TH	1738	0.40	FR	1658	0.52
	2338	1.45		2250	1.32
4	0558	0.26	**19**	0459	0.37
	1231	1.58		1136	1.44
FR	1851	0.54	SA	1748	0.60
				2332	1.22
5	0036	1.28	**20**	0543	0.42
	0657	0.35		1231	1.40
SA	1346	1.53	SU	1854	0.66
◐	2024	0.62			
6	0156	1.16	**21**	0028	1.13
	0808	0.42		0640	0.47
SU	1505	1.53	MO	1346	1.40
	2152	0.61	◑	2028	0.66
7	0324	1.13	**22**	0151	1.09
	0924	0.43		0754	0.48
MO	1615	1.56	TU	1507	1.45
	2259	0.55		2152	0.59
8	0434	1.17	**23**	0321	1.13
	1032	0.40		0913	0.44
TU	1710	1.61	WE	1612	1.56
	2348	0.48		2252	0.46
9	0528	1.24	**24**	0428	1.24
	1127	0.35		1025	0.34
WE	1755	1.66	TH	1707	1.69
				2341	0.32
10	0025	0.41	**25**	0524	1.38
	0612	1.32		1125	0.22
TH	1212	0.30	FR	1755	1.81
	1833	1.69			
11	0058	0.35	**26**	0024	0.18
	0650	1.39		0614	1.53
FR	1250	0.26	SA	1219	0.11
	1908	1.71		1841	1.89
12	0128	0.30	**27**	0105	0.06
	0725	1.44		0702	1.66
SA	1325	0.24	SU	1309	0.03
	1940	1.71		1926	1.92
13	0157	0.26	**28**	0146	-0.02
	0758	1.49		0749	1.77
SU	1359	0.23	MO	1358	0.01
●	2011	1.69	○	2010	1.89
14	0225	0.24	**29**	0227	-0.06
	0831	1.52		0837	1.84
MO	1432	0.25	TU	1446	0.04
	2041	1.65		2055	1.80
15	0253	0.23	**30**	0308	-0.03
	0904	1.53		0925	1.86
TU	1506	0.30	WE	1536	0.13
	2112	1.59		2140	1.66

OCTOBER

	Time	m		Time	m
1	0351	0.04	**16**	0316	0.22
	1014	1.82		0949	1.64
TH	1629	0.26	FR	1603	0.41
	2225	1.48		2149	1.34
2	0435	0.15	**17**	0348	0.26
	1106	1.75		1028	1.60
FR	1729	0.40	SA	1645	0.47
	2315	1.31		2226	1.26
3	0522	0.27	**18**	0425	0.33
	1204	1.65		1110	1.56
SA	1843	0.52	SU	1735	0.53
				2311	1.18
4	0014	1.16	**19**	0510	0.40
	0620	0.39		1202	1.52
SU	1313	1.56	MO	1840	0.58
	2008	0.58			
5	0139	1.08	**20**	0011	1.11
	0733	0.48		0607	0.46
MO	1429	1.50	TU	1309	1.49
◐	2127	0.57		2002	0.57
6	0309	1.08	**21**	0135	1.09
	0854	0.52		0722	0.50
TU	1538	1.49	WE	1426	1.51
	2230	0.52	◑	2119	0.49
7	0418	1.15	**22**	0303	1.16
	1006	0.50		0846	0.48
WE	1634	1.51	TH	1535	1.58
	2316	0.45		2219	0.38
8	0510	1.25	**23**	0411	1.29
	1103	0.45		1002	0.40
TH	1720	1.54	FR	1632	1.66
	2353	0.38		2309	0.25
9	0553	1.35	**24**	0507	1.46
	1149	0.39		1107	0.30
FR	1800	1.57	SA	1725	1.73
				2354	0.12
10	0024	0.31	**25**	0558	1.62
	0629	1.44		1204	0.20
SA	1229	0.34	SU	1814	1.77
	1836	1.59			
11	0054	0.26	**26**	0036	0.01
	0703	1.51		0646	1.77
SU	1305	0.31	MO	1256	0.13
	1909	1.59		1901	1.77
12	0123	0.22	**27**	0118	-0.05
	0736	1.57		0733	1.89
MO	1340	0.29	TU	1347	0.11
	1940	1.58	○	1947	1.72
13	0150	0.19	**28**	0159	-0.07
	0808	1.62		0820	1.95
TU	1415	0.29	WE	1436	0.13
●	2011	1.54		2032	1.63
14	0217	0.18	**29**	0241	-0.03
	0840	1.64		0907	1.96
WE	1449	0.32	TH	1527	0.19
	2043	1.49		2119	1.50
15	0246	0.19	**30**	0322	0.05
	0914	1.65		0955	1.92
TH	1525	0.36	FR	1620	0.29
	2114	1.42		2205	1.37
			31	0405	0.16
				1044	1.83
			SA	1717	0.39
				2254	1.24

NOVEMBER

	Time	m		Time	m
1	0451	0.29	**16**	0404	0.29
	1136	1.71		1053	1.70
SU	1822	0.48	MO	1726	0.46
	2351	1.13		2301	1.20
2	0543	0.42	**17**	0451	0.37
	1233	1.60		1142	1.65
MO	1932	0.54	TU	1826	0.48
3	0106	1.07	**18**	0000	1.16
	0649	0.53		0548	0.44
TU	1338	1.51	WE	1241	1.61
◐	2041	0.55		1935	0.47
4	0235	1.09	**19**	0117	1.16
	0808	0.59		0659	0.50
WE	1444	1.46	TH	1349	1.59
	2141	0.51	◑	2042	0.42
5	0347	1.16	**20**	0240	1.24
	0924	0.60		0820	0.52
TH	1543	1.44	FR	1457	1.59
	2230	0.46		2142	0.33
6	0442	1.26	**21**	0350	1.37
	1028	0.57		0940	0.48
FR	1634	1.45	SA	1558	1.61
	2310	0.39		2235	0.23
7	0526	1.37	**22**	0449	1.54
	1120	0.52		1050	0.41
SA	1718	1.46	SU	1655	1.62
	2346	0.32		2324	0.13
8	0605	1.48	**23**	0542	1.70
	1205	0.47		1151	0.34
SU	1758	1.47	MO	1748	1.62
9	0017	0.26	**24**	0009	0.04
	0639	1.57		0631	1.85
MO	1245	0.42	TU	1247	0.27
	1834	1.48		1838	1.60
10	0047	0.21	**25**	0052	-0.01
	0712	1.64		0719	1.96
TU	1322	0.38	WE	1339	0.24
	1909	1.47		1927	1.55
11	0116	0.18	**26**	0135	-0.02
	0745	1.71		0806	2.01
WE	1358	0.36	TH	1429	0.24
	1942	1.44	○	2015	1.49
12	0146	0.16	**27**	0217	0.01
	0819	1.75		0852	2.02
TH	1434	0.36	FR	1519	0.27
●	2017	1.41		2101	1.41
13	0216	0.16	**28**	0300	0.08
	0853	1.77		0938	1.97
FR	1512	0.37	SA	1607	0.32
	2053	1.37		2147	1.33
14	0248	0.18	**29**	0341	0.19
	0930	1.76		1022	1.89
SA	1552	0.39	SU	1657	0.39
	2130	1.31		2233	1.25
15	0324	0.23	**30**	0424	0.31
	1009	1.74		1107	1.78
SU	1636	0.43	MO	1748	0.46
	2212	1.26		2322	1.18

DECEMBER

	Time	m		Time	m
1	0510	0.43	**16**	0441	0.32
	1153	1.66		1126	1.79
TU	1840	0.51	WE	1805	0.39
				2348	1.28
2	0021	1.14	**17**	0536	0.41
	0605	0.55		1217	1.72
WE	1243	1.55	TH	1903	0.39
	1937	0.53			
3	0136	1.13	**18**	0055	1.29
	0709	0.64		0640	0.50
TH	1338	1.47	FR	1316	1.64
◐	2034	0.53		2004	0.37
4	0255	1.18	**19**	0213	1.34
	0825	0.69		0758	0.56
FR	1439	1.41	SA	1420	1.57
	2128	0.49	◑	2105	0.33
5	0400	1.27	**20**	0326	1.45
	0939	0.69		0920	0.58
SA	1537	1.38	SU	1526	1.52
	2218	0.44		2202	0.27
6	0452	1.37	**21**	0432	1.59
	1044	0.65		1037	0.54
SU	1630	1.37	MO	1629	1.49
	2301	0.38		2256	0.20
7	0535	1.49	**22**	0529	1.74
	1138	0.60		1144	0.48
MO	1717	1.37	TU	1728	1.47
	2338	0.31		2347	0.14
8	0614	1.59	**23**	0620	1.87
	1224	0.54		1242	0.41
TU	1759	1.38	WE	1823	1.46
9	0012	0.26	**24**	0034	0.09
	0649	1.68		0709	1.96
WE	1304	0.48	TH	1333	0.36
	1839	1.38		1913	1.45
10	0045	0.21	**25**	0119	0.07
	0724	1.76		0754	2.01
TH	1343	0.43	FR	1421	0.33
	1917	1.39	○	2001	1.43
11	0118	0.17	**26**	0201	0.09
	0759	1.83		0837	2.02
FR	1421	0.40	SA	1505	0.33
●	1956	1.38		2046	1.40
12	0154	0.15	**27**	0242	0.13
	0836	1.87		0919	1.98
SA	1500	0.37	SU	1547	0.35
	2035	1.37		2128	1.37
13	0230	0.15	**28**	0321	0.21
	0914	1.89		0959	1.91
SU	1541	0.36	MO	1628	0.39
	2117	1.36		2209	1.33
14	0310	0.18	**29**	0401	0.31
	0955	1.88		1037	1.82
MO	1625	0.37	TU	1708	0.44
	2202	1.33		2251	1.29
15	0353	0.24	**30**	0442	0.41
	1039	1.85		1115	1.71
TU	1713	0.38	WE	1748	0.48
	2251	1.31		2336	1.25
			31	0526	0.53
				1154	1.61
			TH	1831	0.51

Bureau of Meteorology

National Tidal Centre

Datum of Predictions is Lowest Astronomical Tide

Moon Symbols ● New Moon ◑ First Quarter ○ Full Moon ◐ Last Quarter

ANNEX C – CASE STUDIES

C.1 Engineering

C.1.1 *Wyola* – Cutting Sections and leaving *In-Situ*

Wyola was an iron hulled steam driven tug boat, built in 1912 and serving the Swan River Shipping Company in Fremantle for most of its working life. In 1970, the vessel was beached for scrapping, although this was not completed and a large amount of hull still remains in the intertidal zone of C. Y. O'Connor Beach, Cockburn, Western Australia.[121] The stern of the vessel and a low section of portside hull were the only exposed elements of the wreck and the stern is still a prominent feature in the beach, appreciated by the public for its aesthetic qualities (Figure 47). In 2012, a horse had reportedly injured itself on the wreck, leading to recommendations by the local mayor for the remains to be removed before being advised by the Western Australian Museum of the significance of the wreck. Concerns for public safety lead to the council to dig along the low section of hull then use an oxy cutter to cut away at the rusted frames and hull, removing approximately 1 m depth of hull (Figure 48). The stern piece was left intact.[122] The removed pieces of hull were badly degraded and held no archaeological potential. It is believed these hull pieces were discarded.

Figure 47. Prominent section of* Wyola *with lower section behind to the right. (Source: Mark Polzer, 3 December 2011).

Figure 48. Exposed hull of* Wyola *before cutting. (Source: Patrick E. Baker, Western Australian Museum,)

[121] **Wilkinson, D., 2013**, 'From Beef to Reef: The Maritime Cultural Landscape of Robb Jetty', Masters thesis, Flinders University of South Australia, Adelaide.

[122] *Ibid.*

C.1.2 S.S. *Xantho* – Raising the Engine

One of the largest studies of an iron shipwreck in Australia to date has been of the S.S. *Xantho* wreck in Western Australia. S.S. *Xantho* was the Swan River colony's first coastal steamer, built in 1848 in Scotland as an iron-hulled paddle steamer 114.8 feet (35 m) in length. In 1871 it was refitted as a screw steamship, rigged as a schooner, and fitted with a new 'Scotch type' steam boiler and horizontal trunk engine. It arrived in Western Australia in May 1872, but sunk in November the same year under after being laden with too much cargo which caused the vessel to take on water before it struck a sandbank.[123]

The S.S. *Xantho* wreck was relocated in the 1970s and inspected by the Western Australian Museum in 1979. Work was conducted on the wreck in 1983 by the museum's Department of Material Conservation who were driven by questions aimed at investigating an iron-hulled steamship, a type of site which had not been previously researched in Australia. The work showed that there was very little residual metal left in the hull, but the engine and associated machinery appeared to be in good condition. Test excavations revealed very few loose artefacts as a result of the original salvage work undertaken soon after wrecking. Historical research found that that the engine was highly significant and it was decided to remove the engine from the site for further study and display.[124]

The site was first recorded manually and with 2D and 3D photography. Thermal lance equipment was then used to cut around the engine, with the lance creating neat cuts of around 25 mm width and proving successful although somewhat difficult to use underwater. The engine was then slowly settled onto pre-positioned timbers below it to prepare for the lift.[125] The 7.4 tonne engine was stropped with thick mooring rope in 120 mm wide lifting strops and sand bags to cushion the concretion between.[126] Lifting bags were attached, and the engine was raised and towed to a steel sled positioned in shallow water which was then dragged ashore (Figure 49).[127]

Figure 49. Lift-bags being used to move the engine off site.
(Source: Western Australian Museum)

Difficulties encountered included a slight swell which, while the engine was being lifted, caused it to rock alarmingly inside the very limited work space available. Other than this

[123] **McCarthy, M., 2007,** 'SS *Xantho* 1872: Treasure from the scrapheap,' in Nash, M. (ed.) *Shipwreck Archaeology in Australia*, University of Western Australia Press, Crawley, Western Australia:157-160

[124] *Ibid.*

[125] **McCarthy, M., 1988**, 'S.S. *Xantho*: The pre-disturbance, assessment, excavation and management of an iron steam shipwreck off the coast of Western Australia,' *The International Journal of Nautical Archaeology and Underwater Exploration* 17(4): 339-347

[126] **Western Australian Maritime Museum, n.d.**, "Information – SS Xantho: Western Australia's First Coastal Steamer," information brochure, Western Australian Maritme Museum, Fremantle, Western Australia.

[127] *Op. Cit.* **McCarthy, M., 1988**

concern, the lift and tow of the engine occurred very successfully.[128] Once ashore, a crane and truck transported the engine to Fremantle.

C.1.3 *Day Dawn* – Relocation

Although a wooden wreck, *Day Dawn* is an example of a shipwreck that has been relocated for continued preservation. Built in 1851, *Day Dawn* was used as a whaler before being cut down to a barque. The vessel was wrecked in 1886 while unloading timber at Quindalup, Western Australia, and uncovered again by dredging in 1976.[129] Due to the proximity of nearby works, it was decided that the wreck had to be relocated. Measuring 31 m in length and 7 m in width, the vessel had substantial deterioration to its timbers although the hull was largely intact. The wreck was assessed to have historical and archaeological significance, and that cutting of the wreck would be an unacceptable impact to this significance. Instead it was decided to move the wreck into deeper water.[130]

The strength of hull timbers was unknown so the first step of the relocation operation was to clear the hull of loose artefacts and examine the hull to determine structural integrity. Following this, tunnels were dug under the hull with six 20 mm cables threaded through and evenly dispersing the wrecks 265.5 tonne weight for lifting. The tunnels were attempted with a water jet and 25 mm plastic semi-flexible pipe but was not successful. Instead, a 10 mm bent steel rod was rammed in and out with the cable threaded behind. Spreader bars were used to keep the cables apart, with sacrificial timber placed between the cables and the planks, then the cables were drawn tight and made fast to a barge at low spring tide. It was calculated that a tidal rise of 0.8 m would be enough to free the wreck. This was successful, and the navy towed the wreck out to deeper water. Once in place, the wreck was inspected and it was noted that the relocation had successfully moved the wreck without causing damage to the hull. Sediment was jetted over the wreck to aid in conservation and later interpretation of the site was provided in the form of an information brochure and shore- line plaque.[131]

C.1.4 Skuldelev Viking Ships – Cofferdam Excavation

In the mid-1950s, some timbers that had been raised by divers from the Roskilde fjord, an inlet on the northern coast of the Danish island of Zeeland, were identified by the National Museum at Copenhagen as originating from the Viking period. This led to a major archaeological investigation in 1962 of five Viking ships which had been sunk to block a channel.[132] As the fjord in this area is less than 3 feet (1 m) in depth and its waters were so muddy, it was decided to build a cofferdam around the five wrecks and pump out the water (Figure 50). Catwalks were positioned over the top of the cofferdam and enabled archaeologists to excavate the wrecks from above. Although this cofferdam worked well to aid excavation, its low walls were almost breached in storm conditions.[133]

---

[128] *Op. Cit.* **Western Australian Maritime Museum, n.d.**

[129] **Kimpton, G., Henderson, G., 1991,** 'The last voyage of the *Day Dawn* wreck,' *Bulletin of the Australian Institute for Maritime Archaeology* 15(2): 25-28

[130] *Op. Cit.* **Kimpton, G., Henderson, G., 1991**

[131] *Ibid*

[132] **Martin, C., 1987,** 'The Viking World,' in Throckmorton, P. (ed.) *History from the Sea: Shipwrecks and Archaeology from Homer's* Odyssey *to the* Titanic*,* RD Press, Surry Hills, New South Wales, Australia: 128-133

[133] *Ibid*

Figure 50. Cofferdam in Roskilde Fjord constructed during 1962 for excavation and recovery of five Viking ships.[134]

C.1.5 *La Belle* – Cofferdam Excavation

La Belle was the last of four ships that formed the expedition of Robert Cavelier, sieur de La Salle, who had sought to establish a French colony near the mouth of the Mississippi River. After many unfortunate incidents on the voyage, *La Belle* ended up running aground on the Texas coast in 1687.[135] The wreck was not found until 1995 when the Texas Historical Commission were able to identify the wreck after years of searching. Buried under gooey grey mud, the hull and its contents had been sealed and preserved. The ships stores carried everything needed to establish a new colony and became an incredible archaeological resource. [136]

The wreck was submerged only 12 feet (3.7 m) below the surface but visibility was especially poor. The other main concern was that the wreck had been buried for over 300 years and the material would require careful and immediate conservation. For these reasons it was decided to excavate the wreck inside a specially designed metal double-walled cofferdam, at a cost of over US$2 million (Figure 51 and Figure 52.[137] It took six months to build the cofferdam, made of two concentric walls of interlocking steel sheet piling driven 40 feet (12.2 m) into the bed of the bay. Tons of sand were then poured into the gap to form a wall and the water was drained. The presence of leaks was overcome with sump pumps at the bottom of the cofferdam. Excavations lasted eight months.[138]

---

[134] **Rackl, H-W., 1968,** *Diving into the Past: Archaeology Under Water*, Charles Schribner's Sons, New York: 237.

[135] **Texas Beyond History, 2008a**, "*La Belle* Shipwreck," The University of Texas at Austin, College of Liberal Arts, available http://www.texasbeyondhistory.net/belle/, accessed 29 October 2014.

[136] *Ibid*

[137] **Texas Beyond History, 2008b**, "*La Belle* Shipwreck – Discovery and Investigations: The Recovery of *La Belle*," The University of Texas at Austin, College of Liberal Arts, available http://www.texasbeyondhistory.net/belle/excavations.html, accessed 29 October 2014.

[138] *Ibid*

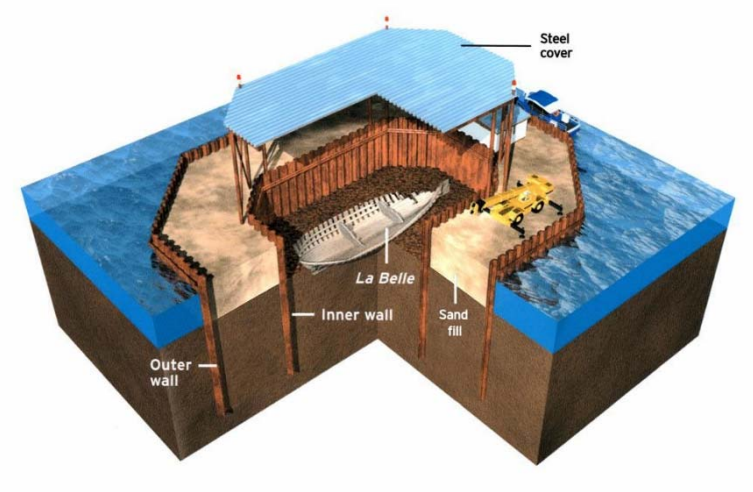


Figure 51. Cutaway showing elements of the cofferdam construction.[139]

Figure 52. Archaeological excavation inside the cofferdam walls.[140]

C.1.6 *Amsterdam* – Bund Excavation

Built in Amsterdam in 1748, the VOC ship *Amsterdam* was 150 feet (45.7 m) long with 54 guns. The vessel was beached at Bulverhythe, near Hastings, East Sussex, United Kingdom, after the crew mutinied. Although visible in the inter-tidal zone, the wreck was not widely known until 1969 when it was damaged by a mechanical excavator.[141] English Heritage conducted pre-disturbance survey work and the wreck gained so much interest that the VOC-Ship Amsterdam Foundation was formed to study and assess the feasibility of raising the wreck. The site of the *Amsterdam* is within a surf zone with tidal ranges of over 6 m. A U-shaped bund of steel sheet piles was constructed to protect the ship's hull around the seaward end along with a diving platform to aid in the underwater archaeological excavation and recording of the wreck (Figure 53). [142] Excavation ran from 1984 to 1986, removing a

[139] **Texas Beyond History, 2008c**, "*La Belle* Shipwreck – Discovery and Investigations: The Recovery of *La Belle* – *Images, Cutaway*," The University of Texas at Austin, College of Liberal Arts, available http://www.texasbeyondhistory.net/belle/images/cutaway.html, accessed 10 November 2014.

[140] *Op. Cit.* **Texas Beyond History, 2008b**

[141] **English Heritage, n.d.** "Amsterdam," English Heritage, available https://www.english-heritage.org.uk/discover/maritime/map/amsterdam/, accessed 29 October 2014.

[142] *Ibid.*

large amount of artefact material but leaving the hull *in situ* but with additional reinforcement against natural forces and decay.[143]

Figure 53. Amsterdam in 2006.[144]

C.1.7 Yorktown Shipwreck – Bund Excavation

An aspect of the Yorktown Shipwreck Archaeological Project's study of British vessels sunk during the Battle of Yorktown in 1781 was the construction of a steel cofferdam and filtration system. This was to offset adverse site conditions in the undertaking of an underwater excavation of shipwreck 44YO88. This wooden shipwreck was in an excellent state of preservation and the archaeological team considered that a full excavation of the site would yield significant information. The site was also threatened by degradation from natural and cultural factors.[145]

The rigid steel bund was to surround the shipwreck and contain filtration systems to clarify the enclosed water in order to excavate. Public access was encouraged with a connecting pier to shore and interpreters on site. First the piles were placed, and then the bund constructed of interlocking sheet-steel pilings to form an enclosure. Unfortunately, river water leaked through seams in the bund wall and came through the river bottom, mixing with the interior water. Pool filters, filtration systems, salt and chorine were used to clean the water but were unsuccessful. Experiments were made with different types of sealing and, although none eliminated the contaminating water, it did reduce it to a manageable level. After two years of making improvements to the bund, a large filter company supplied assistance and some commercial sized pool filters which improved the conditions. In 1982, the first year of the establishment of this bund, it had cost US$412,000, although this was substantially increased by the need to pile 80 to 100 feet deep. It was completed in 1985 and stood until 1990 when the site was backfilled and the cofferdam removed (Figure 54 and Figure 55).[146]

---

[143] **Gawronski, J. H. G., 1990**, 'The *Amsterdam* project,' *The International Journal of Nautical Archaeology and Underwater Exploration* 19(1): 53-61.

[144] *Op. Cit.* **English Heritage, n.d.**

[145] **Broadwater, J. D., 1992,** ' Shipwreck in a Swimming Pool: An Assessment of the Methodology and Technology Utilized on the Yorktown Shipwreck Archaeological Project,' *Historical Archaeology* 26(4): 36-46

[146] *Ibid.*

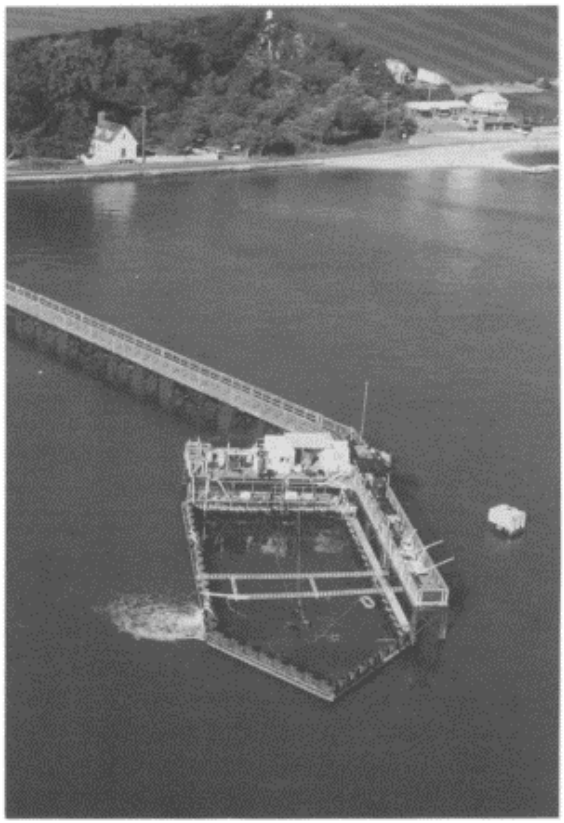


Figure 54. Aerial photograph of completed Yorktown cofferdam, 1988.[147]

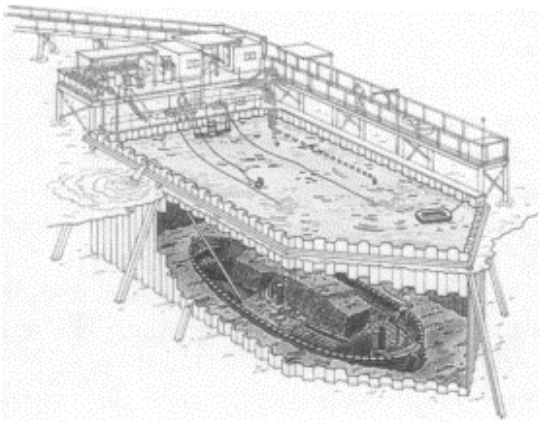


Figure 55. Yorktown cofferdam schematic, 1988.[148]

C.2 Archaeology

C.2.1 The Phanagorian Shipwreck – Photogrammetry

In 2012, a wooden shipwreck was discovered buried under 1.5 m of seabed sediments and 1 m of water in Taman Bay, near Phanagoria, the largest known ancient Greek settlement in Russia. The wooden parts were in an excellent state of preservation, buried as it was by the accumulation of silt sediments.[149] Due to the vulnerability of the wreck and materials, it was determined that field documentation and recording should be conducted within a very limited time span. Photogrammetry was chosen for this process.[150]

Agisoft PhotoScan software was used for point cloud extraction procedure. This provides an automated process for producing geometrically correct 3D models with only minimal manual refining required. Underwater, three main concerns included optical distortions caused by water and camera, optical 'noise' by the natural environment and suspension, as well as low transparency of water and lack of light. The shallow depth of the site cased the water column to be heavily influenced by waves and turbulence.[151]

Water visibility did not exceed 3 m, with only a two to three hour window of accessibility before the turbulence and current covered the site with grass and sand. A set of control

---

[147] Op. Cit. **Broadwater, J. D., 1992,**

[148] *Ibid.*

[149] **Zhukovsky, M.O, Kuznetsov, V.D., Olkhovsky, S.V, 2013,** 'Photogrammetric techniques for 3-D underwater record of the antique time ship from Phanagoria,' *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* XL-5/W2, XXIV International CIPA Symposium, 2-6 September 2013, Strasbourg, France: 717-721

[150] *Ibid.*

[151] *Ibid.*

points, more than 300, were marked over the hull by pins with coloured heads arranged in an irregular grid and then the positions recorded using total station.[152]

Photographs were captured using a boxed DSLR full-frame camera from straight and oblique angles, taken at 0.5 to 1 m distance (Figure 56). Railing across the site was used in combination with a moving platform to ensure complete coverage and stable positioning for the straight shot photos. Three sets of photos were taken at different spacings to achieve sufficient overlap. The eventual 663 selected images were processed by point matching software, with only the densest set of photos successfully matched (0.4 to 0.5 m spacing).[153]

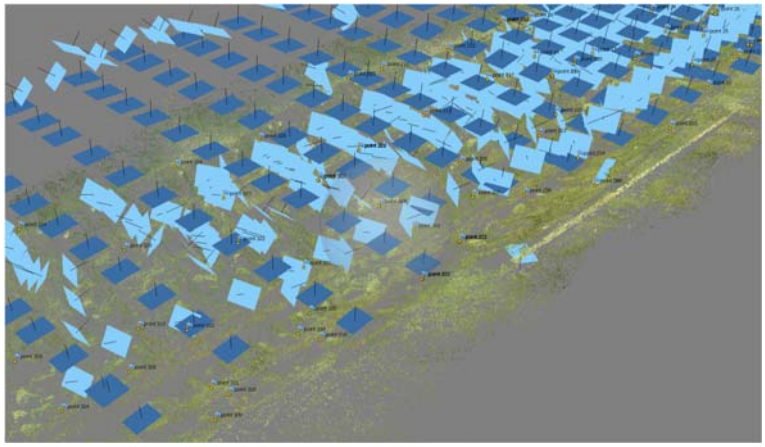


Figure 56. A detail of the point cloud extracted from the photoset. Colour squares mark reconstructed camera positions, blue for straight photos and cyan for oblique photos.[154]

Photogrammetry was used with high efficiency to record this shipwreck, demonstrating the capability of automated point cloud extraction software to create precise models of underwater sites in poor conditions. Techniques involved in the successful use of this application underwater involved extensive photo coverage with 50-60% overlap, use of high quality camera optics and presence of distinct control points with measured coordinates (Figure 57).[155]

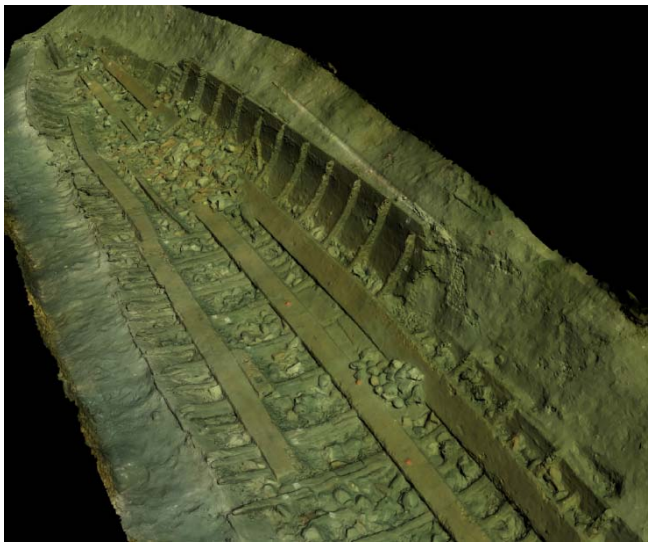


Figure 57. Shaded render of the ship's 3D model.[156]

[152] *Op. Cit.* **Zhukovsky, M.O, Kuznetsov, V.D., Olkhovsky, S.V, 2013**

[153] *Ibid.*

[154] *Ibid.*

[155] *Ibid.*

[156] *Ibid.*

C.2.2 HMCS *Protector* – 3D Recording

HMCS *Protector* was a purpose-built warship of the South Australian colonial navy, Commonwealth Naval Force and Royal Australian Navy. The vessel arrived in Adelaide in 1884, participating in two major conflicts before being decommissioned in 1924. It was requisitioned by the U.S. Army during World War II before colliding with another vessel and being abandoned at the Queensland Port of Gladstone. In 1943 the vessel was installed as a breakwater at Heron Island and has since become an icon of the Heron Island landscape, regularly visited by patrons.[157]

A team of researchers conducted a comprehensive archaeological survey of the wreck in 2013. Digital video, 3D photogrammetry and laser scanning was undertaken to capture the extent of *Protector* above the water line. Traditional methods of manual recording, video and photography were also employed. It is intended for the findings to be generated into 3D digital and physical models (Figure 58).[158]

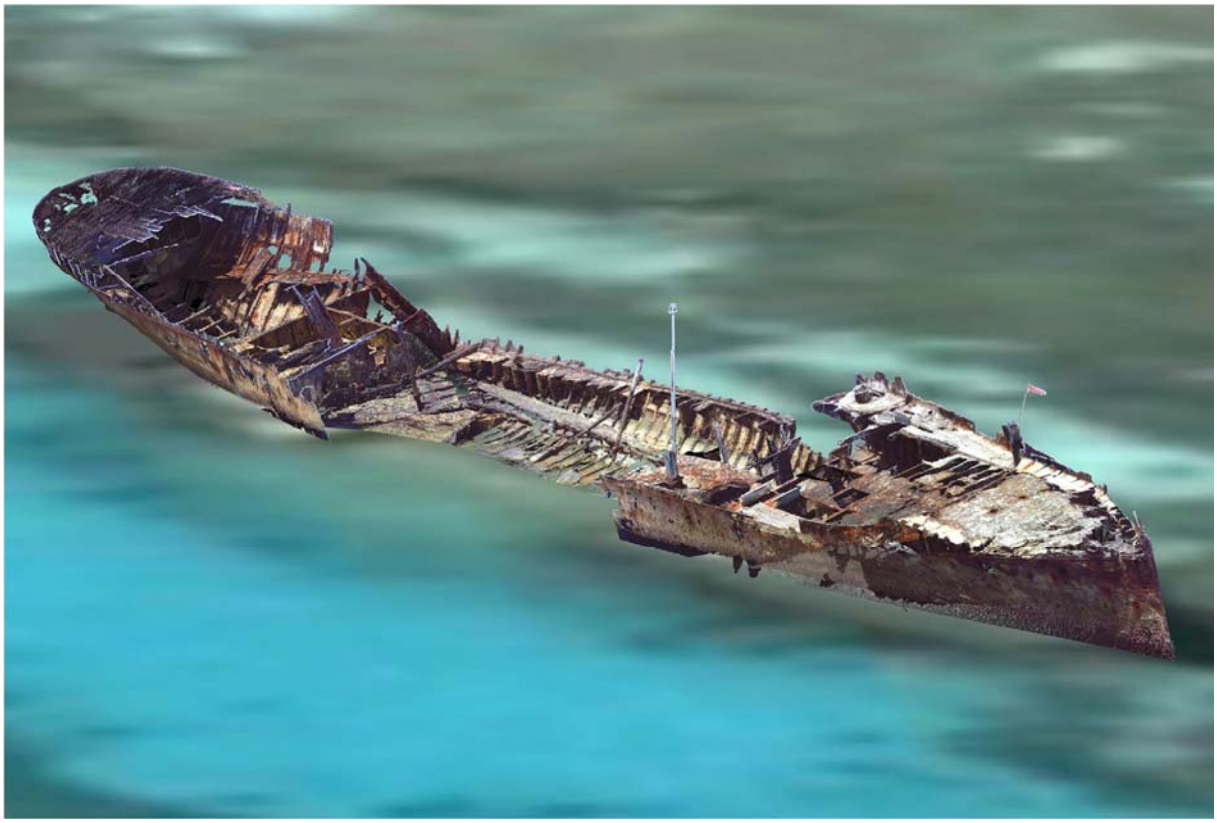


***Figure 58. Screen capture of 3D digital model of* Protector*'s external hull.*[159]**

C.2.3 S.S. *Xantho* – 3D Scanning

The S.S. *Xantho* engine was the subject of a pilot project employing 3D digitisation. This aimed to use inexpensive close-range laser scanning hardware to record the items for collection management and research purposes. A NextEngine 3D Scanner HD (model 2020i) triangulations scanner was used with supplied ScanStudio HD Pro software package.[160] Each individual piece and artefact was scanned. A number of issues arose including noise and gaps, false depth data, shadows and occlusions. These were as a result of highly

[157] **Hunter, J.W., September 2013,** 'Protecting the *Protector*: An initiative to document, assess, interpret, exhibit and preserve an early Australian Warship,' *Australasian Institute for Maritime Archaeology Newsletter*, 32(3): 1, 5-6.

[158] *Ibid.*

[159] *Ibid.*

[160] **Edwards, K., Cooper, D., 2013**, 'Digitizing *Xantho*: Notes on a project to digitally record an assemblage of complex engine components from a 19th-century steamship,' *Bulletin of the Australasian Institute for Maritime Archaeology* 37: 42-27

reflective surfaces, very dark surfaces, complex shapes. The scanning process is ongoing but initial testing has proceeded well.[161]

C.2.4 P.S. *Leo* – Archaeological Excavation

The shipwreck of P.S. *Leo* was examined by Cosmos Archaeology in 2007, who was subcontracted to AMAC Group to provide maritime heritage advice. The wreck was discovered in reclaimed foreshore land adjoining a development area. P.S. *Leo* was an iron built tugboat of unique design, built in 1871 by J. Payne without usual components of iron and steel vessels of its size as a testament to the confidence in the shipwright's craft and quality of materials used. Excavation encountered water at 1.5 to 2 m depth while the wreck remains were up to 3 m deep. The site was de-watered using spikes in order to allow for controlled manual and mechanical excavation and recording of the entire hull. Bilges of the vessel were manually excavated and removed sediment was sieved for artefacts. The intact nature of the hull enabled recording of the ship lines of the vessel, using total station and manual offset recording methods. Other methods of recording included photography and measured drawings. No photogrammetry was used in the recording of this vessel. The overall archaeological project report has not been finalised as far as is known, though the chapter on the construction details of the P.S. *Leo* based on the archaeological recording has been submitted.[162]

C.2.5 *City of Launceston* – Archaeological Recording of Form

The wrecking of the iron-hulled intercolonial steamship *City of Launceston* in 1865 was a national calamity at the time, following a collision in Port Phillip Bay. Due to its historical significance and preservation, this 177.2 feet long (54 m) iron-hulled vessel became the first Victorian shipwreck to be protected under new state legislation in 1982.[163] The wreck had been located in 1980 by the Maritime Archaeological Association of Victoria (MAAV) after a year of searching, at a depth of 22 m.[164] It was determined that 76% of the ship's hull remained intact and in a good state of preservation. As its condition deteriorated and areas started to collapse, excavation was encouraged.[165]

No ships plans or half model was available for the *City of Launceston*. Instead, the layout of this vessel was used in comparison with the layouts of other ships. Excavation was not concerned with construction aspects, but with the ship's structure and compartments in order to understand the locations of likely archaeological deposits. Test trenches were excavated following the terrestrial procedure with defining units. Issues were encountered with a think fine siltation layer covering the wreck. The wreck structure was recorded by using datums and trilateration, side scan sonar, hull profiling by offset measurements, photography and videography. Two 3D scale models were created, one of the wreck in its current condition and exposure above the seabed and another of an estimate of the complete hull.[166]

---

[161] *Op Cit.* **Edwards, K., Cooper, D., 2013**,

[162] **Coroneos, C.** pers. comm. 23rd November 2014

[163] **Arnott, T., 1996**, '*SS City of Launceston* 1863-1865', *Project Reports 1996,* Maritime Archaeology Association of Victoria, Melbourne: 54-72. In Anderson, R. (ed.) 2010 *Final report on S.S.* City of Launceston *(1863-1865) an inter-colonial steamship wreck Port Phillip, Victoria: Maritime archaeological survey, excavation, artefact analysis, corrosion survey, conservation and site management 1997-2009*, Australian National Centre of Excellence for Maritime Archaeology Special Publication No. 14, Australasian Institute for Maritime Archaeology Special Publication No. 16: 4-14.

[164] *Ibid*

[165] **Anderson, R., 2010**, 'Report on SS *City of Launceston* site survey and excavations 1997-2002,' in Anderson, R. (ed.) 2010 *Final report on S.S.* City of Launceston *(1863-1865) an inter-colonial steamship wreck Port Phillip, Victoria: Maritime archaeological survey, excavation, artefact analysis, corrosion survey, conservation and site management 1997-2009*, Australian National Centre of Excellence for Maritime Archaeology Special Publication No. 14, Australasian Institute for Maritime Archaeology Special Publication No. 16: 15-44

[166] *Ibid*

C.3 Conservation

C.3.1 S.S. *Xantho* – Long Term Conservation

The engine of the S.S. *Xantho* wreck was raised by the Western Australian Museum in 1983. Conservation on the engine of S.S. Xantho began immediately upon its leaving the water. After removal, the engine was wetted with fresh water and sprinkled with sodium carbonate powder to prevent further corrosion before being covered in wet hessian. The hessian was coated with polyamide erosel to seal in the moisture and prevent the engine from drying out before the deconcreting process could begin.[167]

Once arriving in Fremantle, the engine was placed in a large metal tank measuring 3 m by 3.5 m by 2 m and deconcretion began. Deconcretion was undertaken with the use of manual percussive removal and took 11 days, with sprinklers and hessian used to keep it wet between sessions. After removing 2.5 tonnes of concretion, the engine almost looked new and all remaining copper piping and brass fittings were sound, as was the cast iron elements. [168] The engine underwent electrolytic reduction treatment in its complete state. Eventually, beginning in 1993, some parts of the engine were separated and disassembled for individual conservation treatment leaving only cast and wrought iron structure.[169]

The electrolytic reduction treatment process had caused localised cracking of the surface of the graphitised iron and some spalling. Despite this, electrolytic reduction was considered the best treatment process. Once this treatment was complete, the engine components were applied with corrosion inhibitors and surface coatings to prepare them for being reassembled.[170]

C.3.2 *Santiago – In situ* Anode Protection

Santiago was an iron hulled vessel built in 1856, eventually abandoned in 1945. The remains of the vessel are inundated in high tide but exposed in lower tides – this cyclic pattern of wetting and drying perhaps being the most destructive in terms of conservation. The wreck is the oldest vessel in the Port Adelaide Ship Graveyard so attempts were made to reduce the rate of corrosion.[171] Anodes for cathodic protection were applied in 1994 with this intention, as well as a coating system applied to sections that were exposed above the water line with the tide. These methods were successful, with a decrease of 45% of the corrosion rate over a 12 month period, although monitoring since 2001 has noted increased degradation.[172]

C.4 Interpretation

C.4.1 Hanse Kogge at Deutsches Schiffahrts Museum – Museum Display

The wreck of a cog was discovered in the river Weser in Bremen-Rablinghausen, Germany in 1962, being the first example ever found. The vessel was built in 1380 but was flooded by a storm before being completed and remained on the seabed.[173] After being raised, conservation was a concern as the wood had been in water for almost 600 years.

---

[167] *Op. Cit.* **McCarthy, M., 1988**

[168] *Op. Cit.* **Western Australian Maritime Museum, n.d.**

[169] **Carpenter, J., 2009**, "The *Xantho* Engine – conserving the iron components," in McCarthy, M (ed) *Iron, Steel and Steamship Archaeology: Proceedings of the 2nd Australian Seminar, Held in Perth, Melbourne and Sydney 2006*, Australian National Centre of Excellence for Maritime Archaeology Special Publication No. 13, Australasian Institute for Maritime Archaeology Special Publication No. 15: 89-91

[170] *Op. Cit.* **Carpenter, J., 2009**

[171] **Bigourdan, N., 2007**, 'S.S. Dicky 1883-1893 (Caloundra, QLD, Australia): Report on Similar Management and Conservation Programs for Intertidal Iron Shipwrecks,' report for Cosmos Archaeology.

[172] *Ibid.*

[173] **Deutsches Schiffahrts Museum, n.d.**, 'Der Fund, die Bergung und der lange Weg der Restaurierung,' Hansekogge, available http://www.dsm.museum/ausstellung/dauerausstellung/hansekogge.175.de.html, accessed 7 November 2014.

Conservation via an impregnation method took 17 years to complete before the vessel was put on display inside the museum building (Figure 59).[174]

Figure 59. The Hanse Kogge on display at the Deutsches Schiffahrts Museum.[175]

C.4.2 Port Arthur Historic Dockyard – Interpretive Elements

The Dockyard precinct of Port Arthur contains elements to interpret past use of the area as a busy and productive ship yard. This includes a 25 m long ship sculpture, steel outlines of the buildings that stood there and a soundscape featuring the noise of industries that were present (Figure 60 and Figure 61).[176] The features incorporated archaeology, historical research, planning and design to tell the story of the Dockyards precinct for visitors.[177]

Figure 60. Dockyard Ship sculpture to scale resting in the slipway.[178]

[174] *Op. Cit.* ***Deutsches Schiffahrts Museum, n.d.,***

[175] *Ibid.*

[176] **Port Arthur Historic Site Management Authority, 2011**, 'Attractions – Dockyard,' available http://www.portarthur.org.au/index.aspx?base=1474, accessed 7 November 2014.

[177] **Port Arthur Historic Site Management Authority, 2007**, 'Port Arthur Dockyard Project awarded,' available http://www.portarthur.org.au/index.aspx?sys=Archived%20News%20Article&intID=1842, accessed 7 November 2014.

[178] *Op. Cit.* **Port Arthur Historic Site Management Authority, 2011**

Figure 61. Dockyard plaque.[179]

C.4.3 Lady of St. Kilda – Art Installation

The schooner *Lady of St. Kilda* was built in 1834, and is the origin of the name of the city, St. Kilda. In 2006 an art installation representing the shipwreck was installed at St Kilda Main Beach (Figure 62 and Figure 63). This was later disassembled due to concerns of public safety.

Figure 62. Front view of the* Lady of St Kilda *shipwreck installation.[180]

Figure 63. Inside view of the* Lady of St Kilda *shipwreck installation.[181]

[179] *Op. Cit.* **Port Arthur Historic Site Management Authority, 2007**

[180] **Corey Thomas Sculptures, 2009**, 'Lady of St Kilda,' available http://coreythomassculptures.com/lady, accessed 7 November 2014.

[181] **MacLeod Consulting, 2006**, 'Lady of St Kilda,' available http://www.macleodconsulting.com.au/projects/lady-of-st-kilda.html#, accessed 7 November 2014.

C.5 Intertidal Iron Shipwreck Studies in Australia

C.5.1 *Cerberus*

The breastwork monitor HMVS *Cerberus*, built in 1871, was the first historic vessel to be placed on the National Heritage List. The vessel was scuttled as a breakwater in Port Phillip Bay in 1926, but storms in 1993 resulted in the wreck being considered a public danger.[182] The wreck lies in 5 m of water with the turrets and conning tower exposed above water level (Figure 64). *Cerberus* is a unique vessel due to construction and design aspects as well as being historically significant. Since the 1970s there had been interest in conserving the hull with a number of proposals for preservation. In light of the impending collapse of the main deck under the weight of the two turrets, the four 18 ton guns were removed in 2005. The guns were coated with a preservative and subjected to electrolysis process on the seabed. An avocation group Friends of the Cerberus, with over 500 members, continues to work closely with Heritage Victoria, GHD Pty Ltd and the National Trust in the ongoing monitoring and future proposals for the *Cerberus* wreck and guns.[183]

Figure 64. Cerberus in 2006.[184]

C.5.2 *Santiago*

Located in the Port Adelaide Ship Graveyard, *Santiago* was an iron hulled vessel originally built in 1856 for the British South American trade. It was converted into a hulk by the Adelaide Steam Tug Company in 1901 and was later abandoned in 1945.[185] The remains of the vessel are inundated in high tide but mostly exposed in lower tides (Figure 65). In order

---

[182] **Tulley, P., 2009**, 'Our heritage to arise from the waters? HMVS Cerberus,' in McCarthy, M., (ed.) Iron, Steel and Steamship Archaeology: Proceedings of the 2nd Australian Seminar, Held in Fremantle, Melbourne and Sydney, 2006, Western Australian Museum Special Publication, Australian National Centre of Excellence for Maritime Archaeology No. 13, Australasian Institute for Maritime Archaeology Special Publication No. 15: 131-132.

[183] *Ibid.*

[184] **Stepanow, L., 2006**, photograph of Cerberus in 'Image Library', Friends of Cerberus Inc., available http://www.cerberus.com.au/image_library.html#imagewindow, accessed 11 November 2014.

[185] **South Australian Department for Environment and Heritage, n.d.**, 'Santiago – Garden Island,' Ships' Graveyards of South Australia, flyer, available https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB8QFjAA&url=http%3A%2F%2Fwww.environment.sa.gov.au%2Ffiles%2Fa378d1ad-6d05-4f52-b8ae-9e2900d17af7%2Fsantiago.pdf&ei=z0BkVJeoIIXVmgXs8YDIAQ&usg=AFQjCNHI89WkxFEtdQCoY2UXUU2I4SVMPw&sig2=K5VazprPWP6JP2seGwF7-A, accessed 11 November 2014.

to preserve this wreck, being the oldest vessel in the Graveyard, anodes for cathodic protection were applied in 1994 to reduce the rate of corrosion as well as a coating system applied to sections of the wreck exposed above the water line.[186] These methods were initially successful with a decrease of corrosion but monitoring since 2001 has noted increased degradation.[187]

***Figure 65. Abandoned wreck of the* Santiago *in the Adelaide Port River, SA, 2000.*[188]**

C.5.3 S.S. *Brisbane*

The S.S. *Brisbane* ocean-going steamship was built in 1874 for carrying passengers, general cargo and mail for the Eastern and Australian Mail Steam Company. It continued in this function until it became stranded upon Fish Reef, approximately 25 nm west of Darwin Harbour, Northern Territory, in 1881.[189] A portion remains continually submerged with the changing tide, another portion is also exposed at intervals particularly with spring low tide (Figure 66). A 2005 Management Plan for the wreck was produced by the Museum and Art Gallery of the Northern Territory, recommending that salvage by recreational divers be considered a major threat to the site and a number of interpretation measures.[190] Interpretation recommendations included a brochure, a display at the NT Chinese Museum, a laminated site plan card for visitors, and the installation of an underwater plinth.

***Figure 66. Bow section of S.S.* Brisbane.[191]**

[186] *Op. Cit.* **Bigourdan, N., 2007**

[187] *Ibid.*

[188] *Op. Cit.* **South Australian Department for Environment and Heritage, n.d.**

[189] **Steinberg, D., 2005,** 'The Historic Shipwreck SS *Brisbane* (1874-1881): A Plan of Management,' Museum and Art Gallery of the Northern Territory Research Report No. 10, available http://artsandmuseums.nt.gov.au/__data/assets/pdf_file/0007/16990/report10.pdf, accessed 11 November 2014.

[190] *Ibid.*

[191] *Ibid.*

C.5.4 *Ozone*

The bay steamer P.S. *Ozone* was commissioned in by George Coppin and built in 1886 for recreational voyages from Melbourne to tourist ports that were developing around Port Phillip Bay.[192] The vessel was later sold, stripped and intended to be sunk at Indented Head before adverse weather conditions caused it to ground in shallow water near the shore. A fire later broke out and destroyed what was left. Sections are still exposed above the water line including three boilers and paddle wheels which children use as jumping platforms, and the remains below water have formed an artificial reef (Figure 67). Members of the maritime Archaeological Association of Victoria (MAAV) have conducted a number of site visits to record the remains. A small memorial is erected on the cliff overlooking the site with one of *Ozone*'s anchors and plaques containing a brief history, but no other management strategy has been planned.[193]

Figure 67. The remaining paddle wheel of the S.S. Ozone.[194]

C.5.5 *Maheno*

Maheno, built in 1905, was operated by the Union Steam Navigation Company in the Trans-Tasman trade as a passenger ship. It was later converted into a hospital ship for the New Zealand Government in 1915, transporting Allied wounded from Gallipoli and the Western Front for the next five years.[195] *Maheno* returned to civilian use in 1920 but quickly became obsolete and was sold to Japanese wreckers in 1935. During the two to Japan, the vessel broke free in a cyclone and wrecked against Fraser Island. Equipment was salvaged but the vessel could not be re-floated, remaining on the beach as a tourist attraction (Figure 68).[196] There are no current management or conservation plans in place for this wreck.

Figure 68. Maheno Shipwreck on RACQ tourism page.[197]

---

[192] **Langenberg, E.F.**, 2011, 'Ozone 1886-1925,' from Charlesworth, P., 1992, *A Ship for her Time*, unpublished manuscript, Maritime Archaeological Association of Victoria, available http://home.vicnet.net.au/~maav/ozone.htm, accessed 12 November 2014.

[193] *Ibid.*

[194] *Ibid.*

[195] **Department of the Environment, n.d.**, 'View Shipwreck – Maheno,' Australian National Shipwreck Database, available https://dmzapp17p.ris.environment.gov.au/shipwreck/public/wreck/wreck.do?key=2805, accessed 12 November 2014.

[196] *Ibid.*

[197] **RACQ, n.d.**, 'Maheno Shipwreck,' Visitor Information Guide, Fraser island Getaway, available http://tourism.racq.com.au/__data/assets/image/0004/66604/7-maheno-wreck.jpg, accessed 12 November 2014.

C.5.6 *Cherry Venture*

The 91.4 m long and 1625 tonne cargo ship was built in 1944 in Sweden, changing hands four times before being sold to Sea Tanker Shipping Co (Singapore) renamed *Cherry Venture*. In 1973, while on its way to New Zealand, the vessel was caught in a ferocious storm and pushed dangerously close to shore.[198] All attempts made by the crew to regain control of the vessel failed, as did attempts of the Royal Australian Air Force (RAAF) to reach the ship and winch the crew to safety. Eventually *Cherry Venture* grounded and most of the crew made their way to shore with no fatalities or injuries. The remaining crew were airlifted by the RAAD to safety.[199]

A tugboat unsuccessfully attempted to drag the ship seaward and, after being sold, another eight salvage attempts failed. In 1979 the vessel was sold for scrapping, however the thick steel was too hard for oxy equipment and the vessel remained in the sand.[200] It became a tourist attraction for those visiting the Cooloola coast until its disintegrating condition led to removal of the now dangerous remains (Figure 69). In 2007, Australia Wide Demolition and Earthmoving Pty Ltd removed the remains of the wreck, with the stainless steel propeller restored and put on display.[201]

It seems that removal did not include the lower sections of the hull, as a news article from 25 June 2013 describes how king tides caused erosion that exposed remnants of the shipwreck.[202] Authorities were warning four-wheel drivers who access the site to exercise caution, and that the remains will not be removed but will be covered again naturally by beach sand.[203]

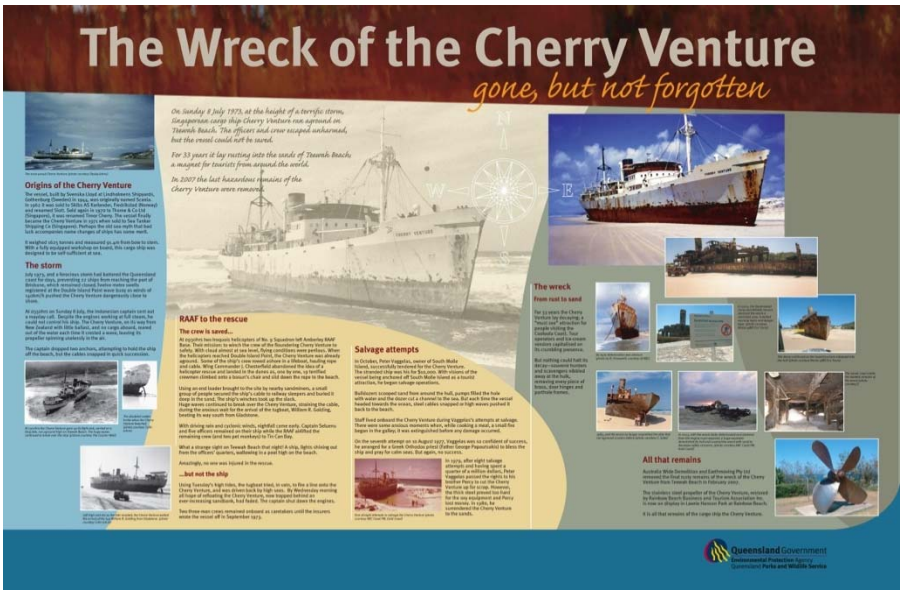


***Figure 69. Sign about the* Cherry Venture *which stands where the shipwreck was once located.*[204]**

---

[198] **Jacobsen, D. L. 2007**, 'The Wreck of the Cherry Venturem', sign at shipwreck site, Queensland Parks and Wildlife Service, Environmental Protection Agency, Queensland Government, available http://dalelornajacobsen.com/yahoo_site_admin/assets/docs/Cherry_Venture.24180337.pdf, accessed 19 November 2014.

[199] *Ibid.*

[200] *Ibid.*

[201] ***Sunshine Coast Daily*, 5 February 2007**, 'Cherry Venture will be gone in weeks,' available http://www.sunshinecoastdaily.com.au/news/scd-cherry-venture-will-be-gone-in-weeks/315419/, accessed 19 November 2014.

[202] **ABC News, 25 June 2013**, 'King tide exposes Cherry Venture shipwreck,' available http://www.abc.net.au/news/2013-06-25/king-tides-expose-cherry-venture-shipwreck/4778096, accessed 19 November 2014.

[203] *Ibid.*

[204] *Op. Cit.* **Jacobsen, D. L. 2007**

ANNEX D – POEMS OF THE S.S. DICKY

The "Dickey" By; Martin Haley (*Nambour Chronicle* 18 March 1960, page 22)

You were not very big as
vessels go.
Here you have rusted fifty
years or so.
And will for fifty more, per-
haps , and then.
'Twill as if you've never been.
And men
Will ask how came it a so
lovely beach
Should bear so odd a name,
and some will stretch
The derivation back to Latin
root,
Or Greek: or say, "An aborig-
inal fruit,
Diki, thrives in the dunes
there." The absurd
Will trace it back, no doubt,
to Dicky Bird.
But I, who saw your iron
strength decay,
For future time will write the
truth today:
"You were a steamer from
Maroochydore,
Cargoed with cedar. Cycloned
here ashore,
You gave this happy place it's
name for evermore."

The Wreck of the Dicky By Eric Williamson (held by CCC Local Studies Library)

Founding waves on the shore and the wind's screeching roar
Made a nightmare of sound in their ears,
And the limits of sight in the dark stormy night
Added fantasy fuel to fears.
The captain and crew of the Dicky all knew
That their hope of survival was slight,
But their chances were more if they got to the shore
As the ship mightn't last out the night.
At the captain's request for the main that was best
Young Milligan sprang to the fore.
He dived overboard with a long line of cord
And he strongly struck out for the shore.
Bu the ocean was wild with the meddlesome child
With the nerve to be cheating his grave,
And the line was too short and the poor man was caught
In a towering sand dumping wave.
Only will to survive kept the sailor alive
As he fought through the foam for some air.
When it seemed that the beach would remain out of reach
He was dumped by a wave and was there.
Then a seaman unnamed with a spirit untamed
Took the plunge with the lead line in hand.
He thought that each wave was his watery grave,
But he finally made it to land.
That thin line of rope was a bright ray of hope
To the victims who clung to the deck,
And the two men, then more, started hauling ashore
All their mates who were still on the wreck.
In the dawn's early light they took stock of their plight
As the storm faded out of the sea,
And a search of the land found a house close to hand,
T'was a haven for each escapee
The Dicky's last gasp in the sea's sandy grasp
Was the groan of her hull as the storm
Pushed her up on the beach and away out of reach
Of the hope of becoming reborn.
For the captain and crew life could start off anew
In the gamble for fortune and fame,
Bu the Dicky's short life had been ended in strife
On the beach that now carries her name

ANNEX E – ENGINEERING OPTION ASSESSMENTS

E-1 REMOVAL OF UPPER PORTIONS OVER MULITPLE TIDES WITHOUT BARRIER	
General requirements include	• Pre-supposes recording of upper hull has been completed so that remaining hull profile is known. • Cutting away of hull on port side down to turn of bilge. • Mechanical excavator with lifting gear to remove the cut portions.
Equipment required includes	• Mechanical excavator; • Lifting gear; • Cutting and welding equipment.
Personnel required includes	• Rigger; • Mechanical excavator operator; • Welder; • Supervising engineer, and; • Archaeologist supervisor.
Estimated time required	• One to two days
Risks	• Danger that high tides, weather and sea state could affect work. • Removal of upper portion of hull may destabilise the remainder of the wreck. • Not all wreck removed.
Advantages	Minimal impact to the wreck site and relatively low cost.
Cost estimate	Substantially low costs related to hire of plant and labour
Heritage impact assessment	The removal of the upper portions of the port hull will have minimal impact on the archaeological values of the wreck – form, construction and content. This statement should be read in the context that the wreck could not be satisfactorily archaeologically recorded and excavated before the removal (see Section 5.3: A-2) and that the archaeological work would be carried out away from the tide and surf zone (see Section 5.3: A-2). The wreck would remain its context in the intertidal zone thereby retaining its social and historical values. The removal of the few remaining hull portions that are regularly visible will reduce slightly the aesthetic and interpretative values of the wreck. Removing the remaining portion of port hull above the turn of the bilge is an *acceptable* option.
Archaeological mitigation options	• Pre-disturbance survey and recording of surrounding debris (see Section 5.3: A-0)

E-2 REMOVAL LANDWARD IN ONE PIECE DURING A SINGLE TIDE WITH NO BARRIER	
General requirements include	• Pre-supposes for best chance of success that hull recording has been completed so that remaining hull profile and extent is known. • Little remaining metal and poor structural integrity in centreline and bottom structure is expected. Wreck remains will have little structural strength and there is a strong likelihood of hull failure if a lift by cables alone is attempted. Therefore, a lifting cradle is required to be designed and prefabricated according to hull profile and extent data. • Lifting cradle also needs to take into account additional weight of remaining sediment within wreck and adhesion of wreck to substrate. • Lifting cradle needs to be readily reassembled in position around and under hull in minimal time. • Tunnelling under hull is required to allow cradle to be installed. (Tunnelling would also be required for wire strops or polymer straps but tunnels would be smaller) • Lifting gear, spreader bars and strops will need to be connected to cradle and adjusted prior to lift. • Sand accumulated within wreck needs to be removed by mechanical excavator as much as possible within time available. • Lift capacity must include weight of hull remains, weight of cradle, weight of lifting gear plus weight of sand remaining within wreck, plus effort to overcome adhesion of wreck to sand/ sandy clay/clay substrate. Crane(s) required to handle lift must be deployable over sand

	beach terrain.
Equipment required includes	• Pre-fabricated cradle • Directional boring machine • Mechanical excavator; • Cranes; • Lifting gear • Cutting and welding equipment for cradle; • Electric power generator, and; • Lighting depending on tide time.
Personnel required includes	• Fabricators • Riggers • Directional boring machine operator(s) • Mechanical excavator operator(s); • Crane operator(s); • Supervising engineer, and; • Archaeologist supervisor.
Estimated time required	• To design cradle = estimated one week • To prefabricate cradle = estimated three weeks. • To mobilise personnel and equipment at site ready for tide opportunity = estimated two days.
Risks	• Hull recording is insufficiently accurate to allow good fit of cradle (particularly if recording/measuring is carried out wet and in sections). • Lifting cradle requires adjustment/modification during the installation process; requiring removal for rectification. May require several trial fittings. • Cradle cannot be quickly reassembled within 1 tide and parts become buried during subsequent tides and require further excavation. • Insufficient time to complete tunnelling under hull during tide. • Tunnels under hull are not accurately placed. Cradle does not re-assemble quickly or correctly. • Tunnelling under hull results in collapse of hull, collapse of tunnels or both. • Major adjustment of lifting gear is required. • Crane has insufficient capacity to lift total weight. • Rising tide causes lift to be abandoned at some stage during the activity and cradle/lifting gear becomes buried by sand requiring re-excavation. • Concentration of several key concurrent activities requiring machinery causes interference, delay through restriction of access. OH&S issues, or in the worst case an accident.. • OH&S considerations for deep excavation in mobile sand deposits. Excavation below water table is required. • Contractors' machinery becomes trapped by rising tide, moving sand or sudden weather/sea state deterioration. • Weather becomes impossible and lift is abandoned. Remobilisation is required causing cost escalation. • All work associated with lift in proximity to the wreck would have to be performed in-water probably in zero-visibility. performing any work requiring precision under such conditions, danger aside, takes at least ten times as long as might otherwise be expected. • Ultimately, the risk of the task not being completed during one tide is overwhelmingly great. • Not a positive media image if wreck breaks apart during lift.
Advantages	Relatively cheap cost in terms of time taken to move wreck. Lift would attract considerable media attention
Cost estimate	Most cost will be in hire of plant and fabrication.
Heritage impact assessment	The removal of the wreck intact and in one section would have minimal impact on the archaeological values of the wreck – form, construction and content. This statement should be read in the context that the wreck could not be satisfactorily archaeologically recorded and excavated before the removal (see Section 5.3: A-2) and that the archaeological work would be carried out away from the tide and surf zone (see Section 5.3: A-2). The wreck would be removed from its context in the intertidal zone but this impact could be mitigated by the relocation of the wreck, or suitable components of, nearby as part of a public display. However, the risks involved in moving the wreck in one low spring tide and in one piece are such that it is very likely that the wreck would break apart during the lift and so would lose form and much of its content. Construction information would survive and interpretation options

	would be limited with an uncontrolled breaking up of the wreck. On the basis that there is a very high likelihood that there would be highly detrimental impact to the archaeological significance of the wreck, it is assessed that removing of the wreck intact and in one section one low spring tide is *unacceptable*.
Archaeological mitigation options	• Pre-disturbance survey and recording of surrounding debris (see Section 5.3: A-0) • Excavation and recording in dry environment after removal (see Section 5.3: A-1) and archaeological monitoring during removal, or; • Excavation and recording in situ without barrier prior to removal (see Section 5.3: A-2) and archaeological monitoring during removal.

E-3 REMOVAL LANDWARD IN ONE PIECE DURING MULITPLE TIDES WITH NO BARRIER		
General requirements include	• Pre-supposes for best chance of success that hull recording has been completed so that remaining hull profile and extent is known. • Little remaining metal and poor structural integrity in centreline and bottom structure is expected. Wreck remains will have little structural strength. Strong likelihood of hull failure if lift by cables alone is attempted, therefore cradle(s) required. • Lifting cradle(s) designed and prefabricated according to hull profile and extent data. • Lifting cradle(s) also need to take into account additional weight of remaining sediment within wreck and adhesion of wreck to substrate. • Lifting cradle(s) to be readily reassembled in position around and under hull in minimal time. • Tunnelling under hull is required to allow cradle(s) to be installed. (Tunnelling would also be required for wire strops or polymer straps but tunnels would be smaller) • Lifting gear, spreader bars and strops to be connected to cradle and adjusted prior to lift. • Sand accumulated within wreck to be removed by mechanical excavator as much as possible within time available. • Lift capacity must include weight of hull remains (whole wreck estimated at around 50 tons), weight of cradle, weight of lifting gear plus weight of sand remaining within wreck plus effort to overcome adhesion of wreck to sand/ sandy clay/clay substrate. Crane(s) required to handle lift must be deployable over sand beach terrain.	
Equipment required includes	• Pre-fabricated cradle • Directional boring machine • Mechanical excavator; • Cranes; • Lifting gear;	• Cutting and welding equipment for cradle; • Electric power generator; • Lighting depending on tide time, and; • Breathing air supply, diver gear, communication devices.
Personnel required includes	• Fabricators • Riggers • Directional boring machine operator(s) • Mechanical excavator operator(s); • Crane operator(s);	• Supervising engineer; • Commercial divers, and; • Archaeologist supervisor
Estimated time required	• To design cradle = estimated one week • To prefabricate cradle = estimated three weeks. • To mobilise personnel and equipment at site ready for tide opportunity = estimated two days.	
Risks	• Hull recording insufficiently accurate to allow good fit of lift cradle (particularly if recording/measuring is carried out wet and in sections). • Lift cradle(s) requires adjustment/modification. Will require removal for rectification. May require several trial fittings or commercial diver with cutting/welding certification. • Tunnels under hull are not accurately placed. Lift cradle does not re-assemble correctly. Manual and mechanical excavation under hull will be required to fit cradle elements. • Tunnelling under hull results in collapse of hull, collapse of tunnels or both. • OH&S considerations for deep excavation in mobile wet sand deposits. Excavation below water table is required. Possibly, manual water jetting under hull may be required to fit cradle. Zero visibility in ground/tide water.	

	• Difficulty in assembling and installing lift cradle underwater with zero visibility. • Rigging the lift cables to the cradle underwater with zero visibility. • Lift capacity of cranes insufficient to lift wreck plus cradle plus wet residual sand and to overcome adhesion to wet substrate. • Danger that high tides, weather and sea state will affect work greatly. Sand may tend to refill excavations between low tides and bury lift cradle during installation/rectification. • All work associated with lift in proximity to the wreck would have to be performed in-water probably in zero-visibility. performing any work requiring precision under such conditions, danger aside, takes at least ten times as long as might otherwise be expected. • Not a positive media image if wreck breaks apart during lift.
Advantages	Relatively cheap cost in terms of time taken to move wreck. Lift would attract considerable media attention
Cost estimate	Most cost will be in hire of plant and fabrication over a relatively longer period of time than E-1
Heritage impact assessment	The removal of the wreck intact and in one section would have minimal impact on the archaeological values of the wreck – form, construction and content. This statement should be read in the context that the wreck could not be satisfactorily archaeologically recorded and excavated before the removal (see Section 5.3: A-2) and that the archaeological work would be carried out away from the tide and surf zone (see Section 5.3: A-2). The wreck would be removed from its context in the intertidal zone but this impact could be mitigated by the relocation of the wreck, or suitable components of, nearby as part of a public display. However, the risks involved in moving the wreck in one section over multiple tides are such that it is very likely that the wreck would break apart during the lift and so would lose form and much of its content. Construction information would survive and interpretation options would be limited with an uncontrolled breaking up of the wreck. On the basis that there is a very high likelihood that there would be highly detrimental impact to the archaeological significance of the wreck, it is assessed that removing of the wreck intact and in one section over multiple tides is ***unacceptable***.
Archaeological mitigation options	• Pre-disturbance survey and recording of surrounding debris (see Section 5.3: A-0) • Excavation and recording in dry environment after removal (see Section 5.3: A-1) and archaeological monitoring during removal, or; • Excavation and recording in situ without barrier prior to removal (see Section 5.3: A-2) and archaeological monitoring during removal.

E-4 REMOVAL OF SECTIONS OVER MULTIPLE TIDES WITH NO BARRIER	
General requirements include	• Pre-supposes for the best chances for success that hull excavation and recording has been completed; perhaps following part exposure of the remaining structure so that remaining hull profile and extent is known. • Pre-supposes that decision has been made regarding which parts of the vessel will be lifted for retention and what will be done with the remainder, i.e. deconstruct, scrap, bury or drag/tow to seaward. • Little remaining metal and poor structural integrity in centreline and bottom structure is expected. Wreck remains will have little structural strength. Strong likelihood of failure of hull sections selected for retention if lift by cables alone is attempted, therefore cradle or skid/cradle required for each part to be retained. • Other sections where keeping form intact is not desired could be slung and/or dragged if small enough. • Multiple cradles required to be fabricated for sections, which are desired to be retained as intact as possible. • Lifting cradles designed and prefabricated according to hull profile and extent data for each section to be retained. • Lifting cradles to be readily reassembled in position around and under sections of hull to be retained in minimal time. • Tunnelling under hull section is required to allow cradles to be installed. (Tunnelling would also be required for wire strops or polymer straps but tunnels would be smaller)

	• After cradle is assembled under a section of hull to be lifted, the section must be cut away from remaining structure. Underwater cutting by appropriately ticketed certified commercial diving contractor will be required. • Lifting gear, spreader bars and strops to be connected to cradle or skid/cradle and adjusted prior to lift and preferably (for diver safety) prior to cut. • Sand accumulated within section of wreck about to be lifted to be removed by mechanical excavator as much as possible within time available. • Lift capacity must include weight of hull section, weight of cradle, weight of lifting gear plus weight of sand remaining within wreck plus effort to overcome adhesion of wreck to sand/ sandy clay/clay substrate. Crane(s) required to handle lift must be deployable over sand beach terrain. • Crane capacity requirement will be lower than that needed to lift complete wreck.
Equipment required includes	• Pre-fabricated cradles • Mechanical excavator; • Crane; • Lifting gear; • Directional boring machine • Cutting and welding equipment; • Breathing air supply, diver gear, communication devices; • Electric power generator, and; • Lighting depending on tide time.
Personnel required includes	• Fabricators • Riggers • Mechanical excavator operator(s); • Crane operator(s); • • Directional boring machine operator; • Commercial dive team; • Supervising engineer, and; • Archaeologist supervisor
Estimated time required	• To design cradle(s) = one week. • To prefabricate cradle(s) = three weeks. • To mobilise personnel and equipment at site = five days contingent upon number of sections to be lifted and intended disposal of remainder.
Risks	• Hull recording insufficiently accurate to allow good fit of lift cradle (particularly if recording/measuring is carried out wet and in sections). • Lift cradle(s) requires adjustment/modification. Will require removal for rectification. May require several trial fittings or commercial diver with cutting/welding certification. • Tunnels under hull are not accurately placed. Lift cradle does not re-assemble correctly. Manual and mechanical excavation under hull will be required to fit cradle elements. • Tunnelling under hull results in collapse of hull, collapse of tunnels or both. • OH&S considerations for deep excavation in mobile wet sand deposits. Excavation below water table is required. Possibly, manual water jetting under hull may be required to fit cradle. Zero visibility in ground/tide water. • Difficulty in assembling and installing lift cradle underwater with zero visibility. • Rigging the lift cables to the cradle underwater with zero visibility. • Lift capacity of cranes insufficient to lift wreck plus cradle plus wet residual sand and to overcome adhesion to wet substrate. • Danger that tides, weather and sea state will affect work greatly. Sand may tend to refill excavations between low tides and bury lift cradle during installation/rectification. • All work associated with lift from at least amidships to the stern would have to be performed in-water probably in zero-visibility. Performing any work requiring precision under such conditions, danger aside, takes at least ten times as long as might otherwise be expected. • Note that when lifting sections, fit of cradle will be much less critical than for entire wreck.
Advantages	More control over the process of removal and doesn't risk all of the wreck in one lift.
Cost estimate	Most cost will be in hire of plant and fabrication over a relatively longer period of time than E-2
Heritage impact assessment	The removal of the wreck in multiple sections in principle would have a low impact on the archaeological values of the wreck – construction and content. This statement should be read in the context that the wreck could not be satisfactorily archaeologically recorded and excavated before the removal (see Section 5.3: A-2) and that the archaeological work would be carried out away from the tide and surf zone (see Section 5.3: A-2). The wreck would be removed from its context in the intertidal zone but this impact could be

	mitigated by the relocation of the wreck, or suitable components of, nearby as part of a public display. The risks involved in moving the wreck in sections over multiple tides are not as great as attempting to move it as one piece, however there is the risk that one or more sections may break apart during the lift and so would lose form and much of its content. Construction information would survive and interpretation options would be limited with an uncontrolled breaking up of an undeterminable proportion of the wreck. On the basis that there is a high likelihood that there would be highly detrimental impact to the archaeological significance of the wreck, it is assessed that removing of the wreck in sections without a barrier over multiple tides is *unacceptable*.
Archaeological mitigation options	• Pre-disturbance survey and recording of surrounding debris (see Section 5.3: A-0). • Excavation and recording in situ without barrier prior to cutting and removal (see Section 5.3 A-2) and archaeological monitoring during removal.

E-5 REMOVAL LANDWARDS IN ONE PIECE WITHIN A COFFERDAM		
General requirements include	• Hull recording and internal archaeological excavation would proceed following mechanical removal of overburden subsequent to installation of sheet piling cofferdam (approximately 100 m long) and depression of water table using Shorco pumping system with spear array surrounding wreck. • Little remaining metal and poor structural integrity in centreline and bottom structure is expected. Wreck remains will have little structural strength. Strong likelihood of hull failure if lift by cables alone is attempted, therefore cradle required. • Lifting cradle fabricated on site to fit exposed hull remains. • Lifting cradle also needs to take into account additional weight of remaining sediment within wreck and adhesion of wreck to substrate. • Excavation of trenches required alongside wreck on all sides. Tunnelling under hull using directional boring is required to allow cradle to be installed. (Tunnelling would also be required for wire strops or polymer straps but tunnels would be smaller) • Lifting gear, spreader bars and strops to be connected to cradle and adjusted prior to lift. • Lift capacity must include weight of hull remains, weight of cradle, weight of lifting gear, plus effort to overcome adhesion of wreck to sand/sandy clay/clay substrate. Crane(s) required to handle lift must be deployable over sand beach terrain.	
Equipment required includes	• Mechanical excavator; • 100 m long sheet piling cofferdam and means of driving it (mechanical excavator?); • Structural steel sections for fabrication of cradle on site; • Lifting gear; • Cranes;	• Directional boring machine; • Cutting and welding equipment for cradle; • Electric power generator; • Lighting only if night work is contemplated, and; • Shorco pumping system with spear array and piping to drain approximately 1200 cubic metres of sand and clay.
Personnel required includes	• Mechanical excavator operator; • Crane operator; • Directional borer operator; • Fabricators;	• Riggers; • Archaeological supervisor, and; • Engineering supervisor.
Estimated time required	• Install cofferdam = up to one week • Cradle designed and fabricated on site = approximately five days • To mobilise personnel and equipment at site = one day. • Excavation (including archaeological work) and removal = up to three weeks.	
Risks	• Tunnelling under hull results in collapse of hull, collapse of tunnels or both. • OH&S considerations for deep excavation in mobile dry sand deposits. Shoring or battering will be required. Manual and mechanical excavation under hull will be required to fit cradle elements. • Danger that high tide, weather and sea state may cause overtopping of cofferdam. • Cofferdam leakage or excess groundwater drainage overloading pumping system.	

	• Unseen obstructions, rock outcrops or discontinuity in clay unit disrupts cofferdam installation.
Advantages	Will receive National, if not international coverage. Wreck will be exposed for public viewing.
Cost estimate	The installation of the 100 m long cofferdam and constant de-watering will form a substantial cost. It is estimated to be in excess of $1M.
Heritage impact assessment	The removal of the wreck intact and in one section after having been excavated within a cofferdam would have minimal impact on the archaeological values of the wreck – form, construction and content. This statement is based on the premise that the wreck had been satisfactorily archaeologically recorded and excavated before the removal (see Section 5.3: A-4). The wreck would be removed from its context in the intertidal zone but this impact could be mitigated by the relocation of the wreck, or suitable components of, nearby as part of a public display. The use of a cofferdam as part of the process for removal of the wreck reduces the risks to the heritage values of the wreck substantially. This option is assessed to be an *acceptable* heritage impact.
Archaeological mitigation options	• Pre-disturbance survey and recording of surrounding debris (see Section 5.3: A-0) • Dry excavation and recording in situ within a cofferdam before removal (see Section 5.3 A-4) and archaeological monitoring during removal.

E-6 WORK WITHIN A COFFERDAM AND REMOVAL SEAWARDS BY DRAGGING AS ONE PIECE	
General requirements include	• Hull recording and internal archaeological excavation would proceed following mechanical removal of overburden subsequent to installation of sheet piling cofferdam (approximately 100 m long) and depression of water table using Shorco pumping system with spear array surrounding wreck. • Pre-supposes that hull recording has been completed so that remaining hull profile and extent is known. • Little remaining metal and poor structural integrity in centreline and bottom structure is expected. Wreck remains will have little structural strength. Strong likelihood of hull failure if dragging by cables alone is attempted, therefore skid/cradle required. • Skid/cradle designed and prefabricated according to hull profile and extent data. • Skid/cradle also needs to take into account additional weight of remaining sediment within wreck and adhesion of wreck to substrate. • Skid/cradle must be readily reassembled in position around and under hull in minimal time. • Tunnelling under hull is required to allow skid/cradle to be installed. • Mechanical excavator required to excavate trenches on both sides of wreck, undercutting structure to allow skid installation. • Mechanical excavator required to remove overburden and internal sand deposit from wreck. • Mechanical excavator will be required to dredge out sand from seaward of the wreck to provide exit path. • Flotation devices to be attached to skid/cradle to reduce loading on skid • Attach tow cable and bridle to skid/cradle • Tug to pick up cable using small craft capable of operating in shallow water as intermediary. • Tug to tow the wreck on skid/cradle to desired location. • May require permit under Environment Protection (Sea Dumping) Act 1981.
Equipment required includes	• Mechanical excavator; • 100 m long sheet piling cofferdam and means of driving it (mechanical excavator?); • Pre-fabricated skid/cradle, towing gear; • Lifting gear; • Cranes; • Small work boat; • Electric power generator; • Breathing air supply and diver communications. • Lighting only if night work is contemplated, and; • Shorco pumping system with spear array and piping to drain approximately 1200 cubic metres of sand and clay.

	• Directional boring machine; • Cutting and welding equipment for cradle;
Personnel required includes	• Mechanical excavator operator; • Crane operator; • Directional borer operator; • Fabricators; • Tug boat skipper and crew; • Riggers; • Commercial divers • Archaeological supervisor, and; • Engineering supervisor.
Estimated time required	• To design skid/cradle = one week • Install cofferdam = up to one week • To pre-fabricate cradle/skid = approximately three weeks • To mobilise personnel and equipment at site ready for tide opportunity = two days. • Excavation (including archaeological work) and removal = up to three weeks.
Risks	• Danger that high tide, weather and sea state may cause overtopping of cofferdam. • Cofferdam leakage or excess groundwater drainage overloading pumping system. • Unseen obstructions, rock outcrops or discontinuity in clay unit disrupts cofferdam installation. • Hull recording insufficiently accurate to allow good fit of skid/cradle. • Skid/cradle requires adjustment/modification. Will require removal for rectification. May require several trial fittings. • Tunnels under hull are not accurately placed. Skid/cradle does not re-assemble quickly or correctly. Manual and mechanical excavation under hull will be required to fit cradle elements. • Tunnelling under hull results in collapse of hull, collapse of tunnels or both. • OH&S considerations for deep excavation in mobile dry sand deposits. Shoring or battering will be required. Manual and mechanical excavation under hull will be required to fit cradle elements • Tug may have insufficient bollard pull to drag wreck seaward. • Tug may have insufficient draft for job. • Tug might foul tow cable/bridle.
Advantages	Will receive National, if not international coverage. Wreck will be exposed for public viewing.
Cost estimate	The installation of the 100 m long cofferdam, constant de-watering and charter of tug boat will form a substantial cost. It is estimated that the cofferdam and dewatering alone will be in excess of $1M.
Heritage impact assessment	The removal of the wreck intact and in one section after having been excavated within a cofferdam would have minimal impact on the archaeological values of the wreck – form, construction and content. This statement is based on the premise that the wreck had been satisfactorily archaeologically recorded and excavated before the removal (see Section 5.3: A-4). The wreck would be removed from its context in the intertidal zone and placed in an environment where there is restricted public access, but this impact could be mitigated by the use of wreck material as part of a public display nearby. The use of a cofferdam as part of the process for removal of the wreck reduces the risks to the heritage values of the wreck substantially. This option is assessed to be an *acceptable* heritage impact.
Archaeological mitigation options	• Pre-disturbance survey and recording of surrounding debris (see Section 5.3: A-0) • Dry excavation and recording in situ within a cofferdam before removal (see Section 5.3 A-4) and archaeological monitoring during removal.

E-7 WORK WITHIN A COFFERDAM AND REMOVAL SEAWARDS ON PONTOONS AS ONE PIECE	
General requirements include	• Hull recording and internal archaeological excavation would proceed following mechanical removal of overburden subsequent to installation of sheet piling cofferdam (approximately 100 m long) and depression of water table using Shorco pumping system with spear array surrounding wreck. • Pre-supposes that hull recording has been completed so that remaining hull profile and extent is known.

	• Little remaining metal and poor structural integrity in centreline and bottom structure is expected. Wreck remains will have little structural strength. Strong likelihood of hull failure if lift and support by cables alone is attempted, therefore lift cradle required. • Lift cradle designed and prefabricated according to hull profile and extent data. • Lift cradle also needs to take into account additional weight of remaining sediment within wreck and adhesion of wreck to substrate. • Lift cradle to be readily reassembled in position around and under hull in minimal time. • Tunnelling under hull is required to allow lift cradle to be installed. • Mechanical excavator required to excavate trenches on both sides of wreck, undercutting structure to allow installation of lift cradle. • Mechanical excavator required to dig substantial trenches either side of wreck to allow placement of flotation pontoons adequate for tidal lift of wreck, cradle, remaining sand burden and to overcome adhesion of wreck to substrate. • Crane required to lift pontoons into position adjacent to lift cradle • Attachment of lift cables to the pontoons and cradle. • Mechanical excavator required to remove overburden and internal sand deposit from wreck. • Mechanical excavator will be required to dredge out sand from seaward of the wreck to provide exit path. • Attach tow cable and bridle to lift cradle and pontoons. • At highest tide, tug to pick up tow and bridles using small craft capable of operating in shallow water as intermediary. • Tug to tow the wreck supported under pontoons on lift cradle to desired location. • Pontoons to be flooded, detached and recovered. • May require permit under Environment Protection (Sea Dumping) Act 1981.
Equipment required includes	• Mechanical excavator; • 100 m long sheet piling cofferdam and means of driving it (mechanical excavator?); • Pre-fabricated skid/cradle, • Tow cable and bridles; • Lifting gear; • Cranes; • Small work boat; • Buoyancy devices; • Directional boring machine; • Cutting and welding equipment for skid / cradle; • Electric power generator; • Breathing air supply and diver communications. • Lighting only if night work is contemplated, and; • Shorco pumping system with spear array and piping to drain approximately 1200 cubic metres of sand and clay
Personnel required includes	• Mechanical excavator operator; • Crane operator; • Directional borer operator; • Fabricators; • Tug boat skipper and crew; • Riggers; • Commercial divers • Archaeological supervisor, and; • Engineering supervisor.
Estimated time required	• To design skid/cradle = one week • Install cofferdam = up to one week • To pre-fabricate cradle/skid = approximately three weeks • To mobilise personnel and equipment at site ready for tide opportunity = two days. • Excavation (including archaeological work) and removal = up to three weeks.
Risks	• Danger that high tide, weather and sea state may cause overtopping of cofferdam. • Cofferdam leakage or excess groundwater drainage overloading pumping system. • Unseen obstructions, rock outcrops or discontinuity in clay unit disrupts cofferdam installation. • Hull recording insufficiently accurate to allow good fit of lift cradle (particularly if recording/measuring is carried out wet and in sections). • Lift cradle requires adjustment/modification. Will require removal for rectification. May require several trial fittings. • Tunnels under hull are not accurately placed. Lift cradle does not re-assemble quickly or

	correctly. Manual and mechanical excavation under hull will be required to fit cradle elements. • Tunnelling under hull results in collapse of hull, collapse of tunnels or both. • OH&S considerations for deep excavation in mobile dry sand deposits. Shoring or battering will be required. Manual and mechanical excavation under hull will be required to fit cradle elements • Insufficient lift from tide rise. • Insufficient buoyancy from pontoons to lift wreck plus additional weight and adhesion. • Tug may have insufficient bollard pull to tow wreck and pontoons seaward. • Tug may have insufficient draft for job. • Tug might foul tow cable/bridles/ pontoons.
Advantages	Will receive National, if not international coverage. Wreck will be exposed for public viewing.
Cost estimate	The installation of the 100 m long cofferdam, constant de-watering and charter of tug boat will form a substantial cost. It is estimated that the cofferdam and dewatering alone will be in excess of $1M.
Heritage impact assessment	The removal of the wreck intact and in one section after having been excavated within a cofferdam would have minimal impact on the archaeological values of the wreck – form, construction and content. This statement is based on the premise that the wreck had been satisfactorily archaeologically recorded and excavated before the removal (see Section 5.3: A-4). The wreck would be removed from its context in the intertidal zone and placed in an environment where there is restricted public access, but this impact could be mitigated by the use of wreck material as part of a public display nearby. The use of a cofferdam as part of the process for removal of the wreck reduces the risks to the heritage values of the wreck substantially. This option is assessed to be an *acceptable* heritage impact.
Archaeological mitigation options	Dry excavation and recording *in situ* within a cofferdam before removal (see Section 5.3 A-4) and archaeological monitoring during removal.

E-8 WORK WITHIN A COFFERDAM AND REMOVAL AS SECTIONS	
General requirements include	• Hull recording and internal archaeological excavation would proceed following mechanical removal of overburden subsequent to installation of sheet piling cofferdam (approximately 100 m long) and depression of water table using Shorco pumping system with spear array surrounding wreck. • Pre-supposes for the best chances for success that hull excavation and recording has been completed; perhaps following part exposure of the remaining structure so that remaining hull profile and extent is known. • Pre-supposes that decision has been made regarding which parts of the vessel will be lifted for retention and what will be done with the remainder, i.e. deconstruct, scrap, bury or drag/tow to seaward. • Little remaining metal and poor structural integrity in centreline and bottom structure is expected. Wreck remains will have little structural strength. Strong likelihood of failure of hull sections selected for retention if lift by cables alone is attempted, therefore cradle or skid/cradle required for each part to be retained. • Other sections where keeping form intact is not desired could be slung and/or dragged if small enough. • Multiple cradles required to be fabricated for sections, which are desired to be retained as intact as possible. • Lifting cradles designed and prefabricated according to hull profile and extent data for each section to be retained. • Lifting cradles to be readily reassembled in position around and under sections of hull to be retained in minimal time. • Lifting cradles also needs to take into account additional weight of remaining sediment within wreck and adhesion of wreck to substrate.

	• Excavation of trenches required alongside wreck on all sides where lift is to be performed. Tunnelling under hull using directional boring is required to allow cradles to be installed. (Tunnelling would also be required for wire strops or polymer straps but tunnels would be smaller) • Lifting gear, spreader bars and strops to be connected to cradle and adjusted prior to cut and lift. • Cutting of hull remains to detach sections to be retained and lifted done dry by fabricator using gas or arc-air equipment. • Lift capacity must include weight of hull section, weight of cradle, weight of lifting gear, plus effort to overcome adhesion of wreck to sand/sandy clay/clay substrate. Crane(s) required to handle lift must be deployable over sand beach terrain. Crane capacity requirement will be lower than that needed to lift complete wreck. • If one or more sections to be placed in the water a permit under Environment Protection (Sea Dumping) Act 1981 may be required.
Equipment required includes	• Mechanical excavator; • 100 m long sheet piling cofferdam and means of driving it (mechanical excavator?); • structural steel sections for fabrication of cradles on site; • Lifting gear; • Cranes; • Directional boring machine; • Cutting and welding equipment; • Electric power generator; • Lighting only if night work is contemplated, and; • Shorco pumping system with spear array and piping to drain approximately 1200 cubic metres of sand and clay
Personnel required includes	• Mechanical excavator operator; • Crane operator; • Directional borer operator; • Fabricators; • Riggers; • Archaeological supervisor, and; • Engineering supervisor.
Estimated time required	• To design cradle(s) = up to one week. • To prefabricate cradle(s) = up to three weeks. • To mobilise personnel and equipment at site = five days contingent upon number of sections to be lifted and intended disposal of remainder. • Excavation (including archaeological work) and removal = could take up to three weeks.
Risks	• Tunnelling under hull results in collapse of hull, collapse of tunnels or both. • OH&S considerations for deep excavation in mobile dry sand deposits. Shoring or battering will be required. Manual and mechanical excavation under hull will be required to fit cradle elements to selected sections. • Danger that high tide, weather and sea state may cause overtopping of cofferdam. • Cofferdam leakage or excess groundwater drainage overloading pumping system • Unseen obstructions, rock outcrops or discontinuity in clay unit disrupts cofferdam installation.
Advantages	Will receive State if not national coverage. Parts of wreck will be exposed for public viewing.
Cost estimate	The installation of the 100 m long cofferdam and constant de-watering will form a substantial cost. It is estimated to be in excess of $1M.
Heritage impact assessment	The removal of the wreck in sections after having been excavated within a cofferdam would have a low impact on the archaeological values of the wreck - construction and content. This statement is based on the premise that the wreck had been satisfactorily archaeologically recorded and excavated before the removal (see Section 5.3: A-4). The wreck would be removed from its context in the intertidal zone but this impact could be mitigated by the relocation of one or more of the wreck sections, or suitable components nearby as part of a public display. The use of a cofferdam as part of the process for removal of the wreck reduces the risks to the archaeological values of the wreck substantially if this work is carried out before removal. The risks involved in moving the wreck in sections within a cofferdam are not as great as attempting to move it as one piece, however there is a risk that one or more sections may break apart during the lift. Construction information would survive and interpretation options would be limited with an uncontrolled breaking up of an undeterminable proportion of the wreck. The use of a cofferdam as part of the process for removal of the wreck reduces the risks to the

	heritage values of the wreck substantially. This option is assessed to be an *acceptable* heritage impact.
Archaeological mitigation options	• Pre-disturbance survey and recording of surrounding debris (see Section 5.3: A-0) • Dry excavation and recording in situ within a cofferdam before removal (see Section 5.3 A-4) and archaeological monitoring during removal.

E-9 WORK WITHIN A BUND AND REMOVAL LANDWARDS AS ONE PIECE		
General requirements include	• Hull recording and internal archaeological excavation would proceed in-water following mechanical removal of wet overburden subsequent to installation of (approximately 100 m long) sand bag/ traffic barrier / rock / Bulka bag bund. • Little remaining metal and poor structural integrity in centreline and bottom structure is expected. Wreck remains will have little structural strength. Strong likelihood of hull failure if lift by cables alone is attempted, therefore cradle required. • Lifting cradle pre-fabricated according to shape of hull remains as determined from archaeological recording. • Lifting cradle also needs to take into account additional weight of any remaining sediment within wreck and adhesion of wreck to substrate. • Excavation of trenches required alongside wreck on all sides. Tunnelling under hull using directional boring is required to allow cradle to be installed. (Tunnelling would also be required for wire strops or polymer straps but tunnels would be smaller) • Lifting gear, spreader bars and strops to be connected to cradle and adjusted prior to lift. • Lift capacity must include weight of hull remains, perhaps 50 tons, weight of cradle, weight of lifting gear, plus effort to overcome adhesion of wreck to wet sand/ sandy clay/clay substrate. Crane(s) required to handle lift must be deployable over sand beach terrain.	
Equipment required includes	• Mechanical excavator; • Bund material (sheet piling, sandbags, traffic barriers, bulka bags and/or rock); • Structural steel sections for fabrication of cradle; • Lifting gear; • Cranes;	• Directional boring machine; • Cutting and welding equipment for cradle; • Electric power generator; • Lighting only if night work is contemplated; and, • Breathing air supply, diver gear, diver communications.
Personnel required includes	• Mechanical excavator operator; • Crane operator(s); • Directional boring machine operator(s); • Fabricators; • Riggers;	• Labour; • Archaeologist supervisor; • Supervising engineer, and; • Diving team and supervisor.
Estimated time required	• Cradle design = one week. • Cradle pre-fabrication off-site = three weeks. • To mobilise personnel and equipment at site = two days	
Risks	• Hull recording insufficiently accurate to allow good fit of lift cradle (particularly if recording/measuring is carried out wet). • Lift cradle requires adjustment/modification. Will require removal for rectification. May require several trial fittings or commercial diver with cutting/welding tickets. • Tunnels under hull are not accurately placed. Lift cradle does not re-assemble correctly. Manual and mechanical excavation under hull will be required to fit cradle elements. • Tunnelling under hull results in collapse of hull, collapse of tunnels or both. • OH&S considerations for deep excavation in mobile wet sand deposits. Excavation below water table is required. Possibly, manual water jetting under hull may be required to fit cradle. Zero visibility in ground/tide water. • Difficulty in assembling and installing lift cradle underwater with zero visibility. • Rigging the lift cables to the cradle underwater with zero visibility. • Lift capacity of cranes insufficient to lift wreck plus cradle plus wet residual sand and to overcome adhesion to wet substrate. • Danger that high tide, weather and sea state may cause overtopping or breaking down of	

	bund. Sand may tend to refill excavations and bury lift cradle during installation and rectification. • All work associated with excavation, recording and lift in proximity to the wreck would have to be performed in-water probably in zero-visibility. Performing any work requiring precision under such conditions, danger aside, takes at least ten times as long as might otherwise be expected.
Advantages	Less costly to erect a bund wall than water tight cofferdam.
Cost estimate	Establishing of bund should be relatively inexpensive but labour costs higher as work will take longer to complete.
Heritage impact assessment	The removal of the wreck intact and in one section after having been excavated within a bund would have minimal impact on the archaeological values of the wreck – form, construction and content. This statement is based on the premise that the wreck had been satisfactorily archaeologically recorded and excavated before the removal (see Section 5.3: A-5). The wreck would be removed from its context in the intertidal zone but this impact could be mitigated by the relocation of the wreck, or suitable components of, nearby as part of a public display. The use of a bund as part of the process for removal of the wreck reduces the risks to the archaeological values of the wreck substantially if this work is carried out before removal. However the risks involved in moving the wreck in one piece with a bund are such that it is very likely that the wreck would break apart during the lift. Construction information would survive and interpretation options would be limited with an uncontrolled breaking up of the wreck. This option is assessed to be an *acceptable* heritage impact.
Archaeological mitigation options	• Pre-disturbance survey and recording of surrounding debris (see Section 5.3: A-0) • Wet excavation and recording *in situ* within a bund before removal (see Section 5.3 A-5) and archaeological monitoring during removal.

E-10 WORK WITHIN A BUND AND REMOVAL SEAWARDS BY DRAGGING AS ONE PIECE	
General requirements include	• Hull recording and internal archaeological excavation would proceed in-water following mechanical removal of wet overburden subsequent to installation of (approximately 100 m long) sand bag / traffic barrier / rock / Bulka bag bund. • Pre-supposes that hull recording has been completed so that remaining hull profile and extent is known. • Little remaining metal and poor structural integrity in centreline and bottom structure is expected. Wreck remains will have little structural strength. Strong likelihood of hull failure if dragging by cables alone is attempted, therefore skid/cradle required. • Skid / cradle designed and prefabricated according to hull profile and extent data. • Skid / cradle also needs to take into account additional weight of remaining sediment within wreck and adhesion of wreck to substrate. • Skid / cradle must be readily reassembled in position around and under hull in minimal time. • Tunnelling under hull is required to allow skid/cradle to be installed. • Mechanical excavator required to excavate trenches on both sides of wreck, undercutting structure to allow skid installation. • Mechanical excavator required to remove overburden and internal sand deposit from wreck. • Mechanical excavator required to remove bund when excavation of wreck is completed and skid/cradle is installed. • Mechanical excavator will be required to dredge out sand from seaward of the wreck to provide exit path. • Flotation devices to be attached to skid / cradle to reduce loading on skid • Attach tow cable and bridle to skid / cradle • Tug to pick up cable using small craft capable of operating in shallow water as intermediary. • Tug to tow the wreck on skid / cradle to desired location. • May require permit under Environment Protection (Sea Dumping) Act 1981

Equipment required includes	• Mechanical excavator; • Bund material (sheet piling, sandbags, traffic barriers, bulka bags and/or rock); • Pre-fabricated skid/cradle, towing gear; • Lifting gear; • Cranes;	• Small work boat; • Directional boring machine; • Cutting and welding equipment for cradle; • Electric power generator; • Breathing air supply and diver communications. • Lighting only if night work is contemplated, and; •
Personnel required includes	• Mechanical excavator operator; • Crane operator; • Directional borer operator; • Fabricators; • Tug boat skipper and crew;	• Riggers; • Commercial divers • Archaeological supervisor, and; • Engineering supervisor.
Estimated time required	• To design skid / cradle = one week. • To prefabricate skid / cradle = three weeks. • To mobilise personnel and equipment at site ready for tide opportunity = two days.	
Risks	• Hull recording insufficiently accurate to allow good fit of skid / cradle (particularly if recording/measuring is carried out wet and in sections). • Skid/cradle requires adjustment/modification. Will require removal for rectification. May require several trial fittings or commercial diver with cutting/welding tickets. • Tunnels under hull are not accurately placed. Skid / cradle does not re-assemble quickly or correctly. Manual and mechanical excavation under hull will be required to fit cradle elements. • Tunnelling under hull results in collapse of hull, collapse of tunnels or both. • OH&S considerations for deep excavation in mobile sand deposits. Excavation below water table is required. • Difficulty in assembling and installing lift cradle underwater with possible zero visibility. • Attachment of tow cable and bridle is in-water task when surf protection may be minimal. • High risk that high tide, weather and sea state may cause overtopping or breaking down of bund. Sand may tend to refill excavations between low tides and bury skid / cradle during installation. • Tug may have insufficient bollard pull to drag wreck seaward. • Tug may have insufficient draft for job. • Tug might foul tow cable / bridle. • All work associated with move in proximity to the wreck would have to be performed in-water probably in zero-visibility. Performing any work requiring precision under such conditions, danger aside, takes at least ten times as long as might otherwise be expected.	
Advantages	Less costly to erect a bund wall than water tight cofferdam	
Cost estimate	Establishing of bund should be relatively inexpensive but labour costs higher as work will take longer to complete. Cost of tug boat charter to be considered.	
Heritage impact assessment	The removal of the wreck intact and in one section after having been excavated within a bund would have minimal impact on the archaeological values of the wreck – form, construction and content. This statement is based on the premise that the wreck had been satisfactorily archaeologically recorded and excavated before the removal (see Section 5.3: A-5). The wreck would be removed from its context in the intertidal zone and placed in an environment where there is restricted public access, but this impact could be mitigated by the use of wreck material as part of a public display nearby. The use of a bund as part of the process for removal of the wreck reduces the risks to the archaeological values of the wreck substantially if this work is carried out before removal. However the risks involved in moving the wreck in one piece with a bund are such that it is possible that the wreck would break apart during the lift. Construction information would survive and interpretation options would be limited with an uncontrolled breaking up of the wreck. This option is assessed to be an *acceptable* heritage impact.	

Archaeological mitigation options	• Pre-disturbance survey and recording of surrounding debris (see Section 5.3: A-0) • Wet excavation and recording *in situ* within a bund before removal (see Section 5.3 A-5) and archaeological monitoring during removal.

E-11 REMOVAL SEAWARDS ON PONTOON AS ONE PIECE WITHIN A BUND	
General requirements include	• Hull recording and internal archaeological excavation would proceed in-water following mechanical removal of wet overburden subsequent to installation of (approximately 100 m long) sand bag / traffic barrier / rock / Bulka bag bund. • Little remaining metal and poor structural integrity in centreline and bottom structure is expected. Wreck remains will have little structural strength. Strong likelihood of hull failure if lift and support by cables alone is attempted, therefore lift cradle required. • Lift cradle designed and prefabricated according to hull profile and extent data. • Lift cradle also needs to take into account additional weight of remaining sediment within wreck and adhesion of wreck to substrate. • Lift cradle to be readily reassembled in position around and under hull in minimal time. • Tunnelling under hull is required to allow lift cradle to be installed. • Mechanical excavator required to excavate trenches on both sides of wreck, undercutting structure to allow installation of lift cradle. • Mechanical excavator required to dig substantial trenches either side of wreck to allow placement of flotation pontoons adequate for tidal lift of wreck, cradle, remaining sand burden and to overcome adhesion of wreck to substrate. • Crane required to lift pontoons into position adjacent to lift cradle • Attachment of lift cables to the pontoons and cradle. • Mechanical excavator required to remove overburden and internal sand deposit from wreck. • Mechanical excavator required to remove bund when excavation of wreck is completed and lift cradle and pontoons are installed. • Mechanical excavator will be required to dredge out sand from seaward of the wreck to provide exit path. • Attach tow cable and bridle to lift cradle and pontoons. • At highest tide, tug to pick up tow and bridles using small craft capable of operating in shallow water as intermediary. • Tug to tow the wreck supported under pontoons on lift cradle to desired location • Pontoons to be flooded, detached and recovered. • May require permit under Environment Protection (Sea Dumping) Act 1981
Equipment required includes	• Mechanical excavator; • Pre-fabricated cradle; • Lifting gear, • Crane; • Directional boring machine; • Tug, workboat; • Cutting and welding equipment for cradle; • Electric power generator; • Lighting depending on tide time; • Tow cable and bridles; • Buoyancy devices, and; • Breathing air supply, diving gear, diver communications.
Personnel required includes	• Operators for mechanical excavator; • Cranes; • Directional boring machine; Fabricators; • Riggers; • Archaeological supervisor; • Engineering supervisor, and; • Commercial dive team.
Estimated time required	• To design cradle = one week. • To prefabricate cradle = three weeks. • To mobilise personnel and equipment at site ready for tide opportunity = two days.
Risks	• Hull recording insufficiently accurate to allow good fit of lift cradle (particularly if recording / measuring is carried out wet and in sections). • Lift cradle requires adjustment / modification. Will require removal for rectification. May require several trial fittings or commercial diver with cutting / welding tickets. • Tunnels under hull are not accurately placed. Lift cradle does not re-assemble quickly or

	correctly. Manual and mechanical excavation under hull will be required to fit cradle elements. • Tunnelling under hull results in collapse of hull, collapse of tunnels or both. • OH&S considerations for deep excavation in mobile sand deposits. Excavation below water table is required. • Difficulty in installing lift cradle underwater. • Attachment of tow cable and bridle is in-water task when surf protection may be minimal. • High risk that high tide, weather and sea state may cause overtopping or breaking down of bund. Sand may tend to refill excavations between low tides and bury lift cradle during installation. • Insufficient lift from tide rise. • Insufficient buoyancy from pontoons to lift wreck plus additional weight and adhesion. • Tug may have insufficient bollard pull to tow wreck and pontoons seaward. • Tug may have insufficient draft for job. • Tug might foul tow cable / bridles / pontoons. • All work associated with move in proximity to the wreck would have to be performed in-water probably in zero-visibility. performing any work requiring precision under such conditions, danger aside, takes at least ten times as long as might otherwise be expected.
Advantages	Less costly to erect a bund wall than water tight cofferdam.
Cost estimate	Establishing of bund should be relatively inexpensive but labour costs higher as work will take longer to complete. Cost of tug boat charter to be considered.
Heritage impact assessment	The removal of the wreck intact and in one section after having been excavated within a bund would have minimal impact on the archaeological values of the wreck – form, construction and content. This statement is based on the premise that the wreck had been satisfactorily archaeologically recorded and excavated before the removal (see Section 5.3: A-5). The wreck would be removed from its context in the intertidal zone and placed in an environment where there is restricted public access, but this impact could be mitigated by the use of wreck material as part of a public display nearby. The use of a bund as part of the process for removal of the wreck reduces the risks to the archaeological values of the wreck substantially if this work is carried out before removal. However the risks involved in moving the wreck in one piece with a bund are such that it is possible that the wreck would break apart during the lift. Construction information would survive and interpretation options would be limited with an uncontrolled breaking up of the wreck. This option is assessed to be an *acceptable* heritage impact.
Archaeological mitigation options	• Pre-disturbance survey and recording of surrounding debris (Section 5.3: A-0) • Wet excavation and recording in situ within a bund before removal (see Section 5.3 A-5) and archaeological monitoring during removal.

E-12 REMOVAL AS SECTIONS WITHIN A BUND	
General requirements include	• Hull recording and internal archaeological excavation would proceed in-water following mechanical removal of wet overburden subsequent to installation of (approximately 100 m long) sand bag/traffic barrier / rock / Bulka bag bund. • Pre-supposes that decision has been made regarding which parts of the vessel will be lifted for retention and what will be done with the remainder, i.e. deconstruct, scrap, bury or drag / tow to seaward. • Little remaining metal and poor structural integrity in centreline and bottom structure is expected. Wreck remains will have little structural strength. Strong likelihood of failure of hull sections selected for retention if lift by cables alone is attempted, therefore cradle or skid / cradle required for each part to be retained. • Other sections where keeping form intact is not desired could be slung and / or dragged if small enough. • Multiple cradles required to be fabricated for sections, which are desired to be retained as intact as possible. • Lifting cradles designed and prefabricated according to hull profile and extent data for each

	section to be retained. • Lifting cradles to be readily reassembled in position around and under sections of hull to be retained in minimal time. • Tunnelling under hull section is required to allow cradles to be installed. (Tunnelling would also be required for wire strops or polymer straps but tunnels would be smaller) • After cradle is assembled under a section of hull to be lifted, the section must be cut away from remaining structure. Underwater cutting by appropriately ticketed certified commercial diving contractor will be required. • Lifting gear, spreader bars and strops to be connected to cradle or skid / cradle and adjusted prior to lift and preferably (for diver safety) prior to cut. • Sand accumulated within section of wreck about to be lifted to be removed by mechanical excavator as much as possible within time available. • Lift capacity must include weight of hull section, weight of cradle, weight of lifting gear plus weight of sand remaining within wreck plus effort to overcome adhesion of wreck to sand / sandy clay / clay substrate. Crane(s) required to handle lift must be deployable over sand beach terrain. • Crane capacity requirement will be lower than that needed to lift complete wreck.
Equipment required includes	• Mechanical excavator; • Bund material (sheet piling, sandbags, traffic barriers, bulka bags and / or rock); • Pre-fabricated cradles; • Lifting gear; • Crane; • Directional boring machine; • Cutting and welding equipment; • Electric power generator; • Lighting only if night work is contemplated; and, • Breathing air supply, diver gear, diver communications.
Personnel required includes	• Mechanical excavator operator; • Crane operator(s); • Directional boring machine operator(s); • Fabricators; • Riggers; • Labour; • Archaeologist supervisor; • Supervising engineer, and; • Commercial divers.
Estimated time required	• To design cradle(s) = one week. • To prefabricate cradle(s) = three weeks. • To mobilise personnel and equipment at site = five days contingent upon number of sections to be lifted and intended disposal of remainder.
Risks	• Hull recording insufficiently accurate to allow good fit of lift cradle (particularly if recording / measuring is carried out wet and in sections). • Lift cradle(s) requires adjustment / modification. Will require removal for rectification. May require several trial fittings or commercial diver with cutting / welding certification. • Tunnels under hull are not accurately placed. Lift cradle does not re-assemble correctly. Manual and mechanical excavation under hull will be required to fit cradle elements. • Tunnelling under hull results in collapse of hull, collapse of tunnels or both. • OH&S considerations for deep excavation in mobile wet sand deposits. Excavation below water table is required. Possibly, manual water jetting under hull may be required to fit cradle. Zero visibility in ground / tide water. • Difficulty in assembling and installing lift cradle underwater with zero visibility. • Rigging the lift cables to the cradle underwater with zero visibility. • Lift capacity of cranes insufficient to lift wreck plus cradle plus wet residual sand and to overcome adhesion to wet substrate. • High risk that tides, weather and sea state will overtop or break down bund. Sand may tend to refill excavations between low tides and bury lift cradle during installation / rectification. • All work associated with lift from at least amidships to the stern would have to be performed in-water probably in zero-visibility. Performing any work requiring precision under such conditions, danger aside, takes at least ten times as long as might otherwise be expected. • Note that when lifting sections, fit of cradle will be much less critical than for entire wreck. • If one or more sections to be placed in the water a permit under Environment Protection (Sea Dumping) Act 1981 may be required.

Advantages	Less costly to erect a bund wall than water tight cofferdam and can achieve near same results. More control over the process of removal and doesn't risk all of the wreck in one lift.
Cost estimate	Establishing of bund should be relatively inexpensive but labour costs higher as work will take longer to complete.
Heritage impact assessment	The removal of the wreck in sections in principle would have a low impact on the archaeological values of the wreck – construction and content. This statement is based on the premise that the wreck had been satisfactorily archaeologically recorded and excavated before the removal (see Section 5.3: A-5). The wreck would be removed from its context in the intertidal zone but this impact could be mitigated by the relocation of one or more of the wreck sections, or suitable components nearby as part of a public display. The use of a bund as part of the process for removal of the wreck reduces the risks to the archaeological values of the wreck considerably if this work is carried out before removal. The risks involved in moving the wreck in sections within a bund are not as great as attempting to move it as one piece, however there is a risk that one or more sections may break apart during the lift. Construction information would survive and interpretation options would be limited with an uncontrolled breaking up of an undeterminable proportion of the wreck. This option is assessed to be an *acceptable* heritage impact.
Archaeological mitigation options	• Pre-disturbance survey and recording of surrounding debris (see Section 5.3: A-0) • Dry excavation and recording *in situ* within a cofferdam before removal (see Section 5.3 A-4) and archaeological monitoring during removal.

ANNEX F – ARCHAEOLOGY OPTION ASSESSMENTS

A-0 PRE-DISTURBANCE SURVEY, REMOVAL UPPER PORTIONS & SURROUNDING DEBRIS ONLY	
General requirements include	• Access to the wreck prior to any disturbance being carried out, and; • Archaeologist present when wreckage surrounding wreck is being searched for and recovered. • Archaeologist present if upper portions being removed.
Equipment required includes	• Above-water cameras; and, • Total Station/DGPS. • Recording sheets
Personnel required includes	• Archaeologists; and, • Surveying team.
Estimated time required	• Recording = one to two days, with up to a week of removing upper portions of the wreck.
Risks	• None identified
Advantages	Ensures that complete record of wreck obtained just prior to any impact.
Cost estimate	• Potentially up to $12,000 in field and $6,000 post excavation analysis and reporting
Heritage impact assessment	• The opportunity to record the exposed portions of the wreck and any associated wreckage around the site is the optimum way to document the archaeological and technical values of the wreck. • This option is assessed to be an *acceptable* mitigation in response to any impact to the site.

A-1 DRY EXCAVATION OF WRECK AFTER REMOVAL	
General requirements include	• Security to prevent vandalism and/or injury to the public.
Equipment required includes	• Manual excavating tools; • Recording sheets; • Above-water cameras; and, • Total Station/DGPS. • Sieves
Personnel required includes	• Archaeologists; and, • Surveying team.
Estimated time required	• Excavation/recording = five days
Risks	• If moving the wreck in sections, the absence of the ability to record the wreck before cutting may result in the loss of archaeological information, such the form of the wreck as well as the potential for artefacts to be lost during the cutting and transfer process. • The change from wet to dry conditions would entail additional conservation measures to preserve the integrity of material. Organic material in particular would be at a higher risk of degradation if not treated appropriately.
Advantages	Allows for a more controlled excavation with less time pressure.
Cost estimate	• $25,000 in field and $20,000 post excavation analysis and reporting
Heritage impact assessment	• The opportunity to excavate and record the wreck away from the surf zone and in dry conditions is the optimum way to document the archaeological and technical values of the wreck. • This option is assessed to be an *acceptable* mitigation in response to any impact to the site.

A-2 WET EXCAVATION BEFORE REMOVAL WITH NO BARRIER

General requirements include	• Will require some excavation and recording to be carried underwater.
Equipment required includes	• Mechanical excavator; • Manual excavating tools; • Recording sheets; • Underwater and above-water cameras; and, • Total Station/DGPS.
Personnel required includes	• Mechanical excavator operator; • Archaeologists; and, • Surveying team.
Estimated time required	• Excavation/recording = up to 15 days over a period of months to expose, excavate and record all sections of the wreck in suitable conditions.
Risks	• Excavation and recording would be hindered by natural forces, restricting access. It is very unlikely that sufficient recording of the wreck could be made in these conditions. • Battling natural forces and wave action will enhance risks to the safety of personnel and equipment. • Wet conditions would prevent the use of 3D photogrammetry as a recording tool.
Advantages	None.
Cost estimate	• Up to $100,000 and $20,000 post excavation analysis and reporting.
Heritage impact assessment	• The physical difficulties in excavating and recording a wreck within a surf zone will result in less than optimal documentation of the archaeological and technical values of the wreck. • This option is assessed to be an *unacceptable* mitigation in response to any impact to the site.

A-3 NO ARCHAEOLOGICAL WORK	
General requirements include	N/A
Equipment required includes	N/A
Personnel required includes	N/A
Estimated time required	N/A
Risks	• The archaeological and technical values of the wreck will be lost
Advantages	None.
Cost estimate	• N/A
Heritage impact assessment	• The archaeological and technical values of the wreck will not be recorded. • This option is assessed to be an *unacceptable* mitigation in response to any impact to the site.

A-4 DRY EXCAVATION BEFORE REMOVAL	
General requirements include	• Security to prevent vandalism and/or injury to the public.
Equipment required includes	• Mechanical excavator; • Manual excavating tools; • Recording sheets; • Above-water cameras; • 3D recording equipment; • Total Station/DGPS, and;

	• Sieves.
Personnel required includes	• Archaeologists; • 3D recorders; and, • Surveying team.
Estimated time required	• Excavation/recording = five days. • Additional two to three days for an archaeologist to be present when the cofferdam is erected.
Risks	• The change from wet to dry conditions would entail additional conservation measures to preserve the integrity of material. Organic material in particular would be at a higher risk of degradation if not treated appropriately. • Removal of water and sand may cause changes to the surrounding stresses being placed on the hull. The structural integrity of the wreck would have to be monitored with preparations in place to support the hull if necessary.
Advantages	Would be able to get best archaeological results in shorter period of time. Would be of interest to the general public who can come and watch.
Cost estimate	• $30,000 in field and $20,000 post excavation analysis and reporting.
Heritage impact assessment	• The opportunity to excavate and record the wreck protected from wave action and in dry conditions is the optimum way to document the archaeological and technical values of the wreck. • This option is assessed to be an *acceptable* mitigation in response to any impact to the site.

A-5 WET EXCAVATION BEFORE REMOVAL WITH BARRIER	
General requirements include	• Security to prevent vandalism and/or injury to public.
Equipment required includes	• Mechanical excavator; • Manual excavating tools; • Dive equipment; • Diver operated water dredge; • Recording sheets; • Underwater and above-water cameras; and, • Total Station/DGPS. • Sieves
Personnel required includes	• Archaeologists; • Trained diving archaeologists; • Commercial dive team; and, • Surveying team.
Estimated time required	• Excavation/recording = 10 days.
Risks	• Removal of sand may cause changes to the surrounding stresses being placed on the hull. The structural integrity of the wreck would have to be monitored with preparations in place to support the hull if necessary. • Being underwater in places may cause risks to material and personnel if the wreck is to be cut into sections. • Excavation and recording underwater in near zero visibility conditions is a process well-used in maritime archaeology, however there may be risk involved in the quality of recording in this environment compared to a dry environment. • Wet conditions would limit the use of 3D photogrammetry as a recording tool.
Advantages	Would be of interest to the general public who can come and watch.
Cost estimate	• $60,000 in field and $20,000 post excavation analysis and reporting.
Heritage impact assessment	• Excavating and recording underwater in anticipated poor visibility will take longer than if the operation was conducted in open air and the results would not be optimum but would be comparable at least.

	• This option is assessed to be an *acceptable* mitigation in response to any impact to the site.

ANNEX G – CONSERVATION OPTION ASSESSMENTS

C-1 CONSERVE IN-SITU	
General requirements include	• This would include analyses in the form of a corrosion survey of the wreck after cathodic protection, which will have to be carried out annually and the anodes replaced if necessary. • If any covering is considered it may require approval under *Coastal Protection and Management Act 1995* • Approval by other statutory bodies as appropriate.
Equipment required includes	• Mechanical excavator; • Sand bags; and, • Geotextile.
Personnel required includes	• Conservators; • Mechanical excavator; and, • Technical officers.
Estimated time required	• Preservation = three to five days.
Risks	• The long-term stability and the structural integrity of the wreck remains cannot be assured and total loss of the artefact is a possibility in the future. • Exposure of the wreck during storm events will increase the deterioration rate of the wreck. • If the wreck remains become exposed then they may become a public hazard.
Advantages	Minimum impact to the wreck and relatively low cost.
Cost estimate	• Up to $25,000
Heritage impact assessment	• The retention of part of the wreck remains for the long term – with other portions used for display purposes on land - would be a suitable mitigation for the impact to its aesthetic, interpretative and social values due to its removal from its present context. This option retains its archaeological and technical values as there would be no need for excavation and recording. This option would also enhance its scientific values. • This option is assessed to be an *acceptable* mitigation in response to any impact to the site if only a portion of the wreck is buried while other elements are used for display.

C-2 CONSERVE THE WHOLE WRECK	
General requirements include	• Possible approvals by other statutory bodies as appropriate (e.g. for dangerous goods).
Equipment required includes	• Coated mild steel tank/s (size and number dependent on whether the remains are intact or in sections); • Mechanical tools (e.g. bolsters, geopicks, etc,); • High pressure water hose; • Chemicals for desalination; • Transformers for electrolytic reduction; • Protective coating; and, • Equipment for application of coating.
Personnel required includes	• Conservators; and, • Technical officers (for deconcretion, establishment of treatment phase, monitoring of treatment, rinsing, protective coating).
Estimated time required	• This is extremely difficult to estimate as the time required to stabilise the wreck remains will depend on a number of factors, such as the following: the extent of concretion coverage, the treatment process chosen, the total surface area of the wreck remains, the quantity of entrapped salts, the porosity of the surface, the type of protective coating applied, etc.

	However a very rough estimate for the following can be suggested: • Deconcretion = two to five days. • Total immersion in sodium carbonate solution = over ten years. • Total immersion in sodium hydroxide solution with electrolytic reduction = three to five years. • Rinsing residual desalination solution = one year. • Application of a protective coating = two to five days. • The treatment will have to be conducted in a secure compound with appropriate safety precautions in accordance with the appropriate standards for the chemicals utilised.
Risks	• If the wreck remains are not stabilised effectively then the long-term stability and the structural integrity of the wreck remains cannot be assured and total loss of the artefact is a possibility in the future. • Desalination is essential and requires an immersion treatment to be effective, preferably in combination with electrolytic reduction. • Desalination means the wreck remains will not be able to be on displayed whilst being actively treated. • There are OH&S issues with handling and the disposal of large quantities of chemical solutions. • The treatment tank/s will need to be bunded. • The desalination MUST be monitored at regular intervals to ensure the success of the treatment. • The most appropriate protective coating for the display conditions must be chosen and then applied correctly for it to be effective.
Advantages	Retains the whole wreck as one unit which allows for ease of study into the future.
Cost estimate	• Personnel = $50,000-$100,000 • Equipment = $200,000-$500,000 • Analyses = $10,000
Heritage impact assessment	• The retention of the wreck remains in total for the long term and for the purposes of display would be a more than adequate mitigation for the impact to its aesthetic, interpretative and social values due to its removal from its present context. This option would also enhance its scientific values. • This option is assessed to be an *acceptable* mitigation in response to removal from its present location.

C-3 CONSERVE PART C-3.1 CONSERVE SECTIONS	
General requirements include	• Essentially the conservation treatment of any sections of the wreck remains would require similar personnel, time allocation, equipment and analyses, however, there would be a decrease in the estimated equipment costing due to the treatment of a smaller section, i.e. the estimated costing for equipment (including chemicals) would effectively decrease by the percentage reduction in surface area to be stabilised.
Equipment required includes	• Coated mild steel tank/s (size and number dependent on whether the remains are intact or in sections); • Mechanical tools (e.g. bolsters, geopicks, etc,); • High pressure water hose; • Chemicals for desalination; • Transformers for electrolytic reduction; • Protective coating; and, • Equipment for application of coating.
Personnel required includes	• Conservators; and, • Technical officers (for deconcretion, establishment of treatment phase, monitoring of treatment, rinsing, protective coating).
Estimated time required	• Cannot be determined at present.
Risks	• If the wreck remains are not stabilised effectively then the long-term stability and the

	structural integrity of the wreck remains cannot be assured and total loss of the artefact is a possibility in the future. • Desalination is essential and requires an immersion treatment to be effective, preferably in combination with electrolytic reduction. • Desalination means the wreck remains will not be able to be on displayed whilst being actively treated. • There are OH&S issues with handling and the disposal of large quantities of chemical solutions. • The treatment tank/s will need to be bunded. • The desalination MUST be monitored at regular intervals to ensure the success of the treatment. • The most appropriate protective coating for the display conditions must be chosen and then applied correctly for it to be effective.
Advantages	Relatively lower costs than conserving the whole wreck and would focus on more representative and more intact parts of the wreck.
Cost estimate	• Cannot be determined at present.
Heritage impact assessment	• The retention of a section or sections of the wreck remains for the long term and for the purposes of display would be an adequate mitigation for the impact to its aesthetic, interpretative and social values due to its removal from its present context. This option would also enhance its scientific values. • This option is assessed to be an *acceptable* mitigation in response to removal from its present location.

C-4 NO CONSERVATION	
General requirements include	N/A
Equipment required includes	N/A
Personnel required includes	N/A
Estimated time required	N/A
Risks	N/A
Advantages	None
Cost estimate	N/A
Heritage impact assessment	• No conservation/retention of any part the wreck be a substantial impact to its aesthetic, interpretative and social value. It would also diminish its archaeological, technical and scientific values as no fabric would be available for future study. • This option is assessed to be an *unacceptable* mitigation.

C-5 REBURIAL C-5.1 REBURIAL ON LAND	
General requirements include	• This would involve lifting the wreck section/s and reburying them in an excavated depot on land, deep enough to afford adequate long-term protection. • This would include analyses in the form of a conservation survey of the intended reburial area. • Approval by other statutory bodies as appropriate.
Equipment required includes	• Mechanical excavator; • Crane; and, • Support straps.
Personnel required	• Conservators; • Mechanical excavator; and,

includes	• Crane operator.
Estimated time required	• Conservation = five days.
Risks	• The long-term stability and the structural integrity of the wreck remains cannot be assured and total loss of the artefact is a possibility in the future. • There is a risk of contamination of the surrounding sediment and ground water table.
Advantages	Relatively accessible.
Cost estimate	• Up to $35,000 and $5,000 for conservation survey and reporting.
Heritage impact assessment	• The retention of the wreck remains for the long term but removing all of the wreck from public access would be a poor mitigation for the impact to its aesthetic, interpretative and social values due to its removal from its present context. • This option is assessed to be an *unacceptable* mitigation

C-5 REBURIAL C-5.2 REBURIAL UNDERWATER	
General requirements include	• This would involve lifting and transporting the wreck section/s out to sea, deep enough to avoid becoming a safety hazard and attaching anodes to ensure long-term protection (see E-6, 7, 10 and 11). • This would include analyses in the form of a conservation survey of the intended reburial area. • Approval by other statutory bodies as appropriate (e.g. AIMS).
Equipment required includes	• Zinc anodes (approximately 5-10) which will need to be replaced at regular intervals when the anode is consumed; • Other personnel dealt with in Engineering Options E-6, 7, 10 and 11
Personnel required includes	• Conservators; • Commercial Divers; • Archaeolgists • Other personnel dealt with in Engineering Options E-6, 7, 10 and 11
Estimated time required	• Reburial = five days.
Risks	• Long-term monitoring and an anode replacement scheme are necessary to ensure the long-term protection of the wreck remains. • If the anodes are not replaced when exhausted then the corrosion rate of the wreck remains will increase, which may lead to structural collapse of the wreck remains. • There is the possibility that the anodes will be illegally salvaged affecting the long-term corrosion rate and stability of the wreck remains.
Advantages	Would also create and artificial reef.
Cost estimate	• Up to $50,000 (which shares costs with E-6, 7, 10 and 11), $1,000-$3,000 to replace anodes, and $5,000 for each corrosion survey.
Heritage impact assessment	• The retention of the wreck remains for the long term but restricting public access to those who can SCUBA dive would be a poor mitigation for the impact to its aesthetic, interpretative and social values due to its removal from its present context. • This option is assessed to be an *unacceptable* mitigation.

ANNEX H – INTERPRETATION OPTION ASSESSMENTS

I-1 EXISTING MUSEUM / GALLERY WITH TRAVELLING CAPABILITY	
General requirements include	• Ideally all extant S.S. *Dicky* objects held by SCC, Landsborough Museum and Dicky Beach Surf Club will be amalgamated with selected objects recovered from forthcoming archaeology excavations for potential display which can travel. • Small original objects and materials to be enclosed in lockable showcases. Larger robust items to be enclosed by railings or similar as required.
Equipment required includes	• Travelling exhibition option would likely comprise a suite of internally lit demountable showcases, multimedia screens and interpretive panels.
Personnel required includes	• Curator; • Exhibition designer; • Graphic designer; • Conservator; and, • Fabrication/builder.
Estimated time required	• Design and construction = two months.
Risks	• Dicky collection isolated from wreck site. • Dicky collection split up amongst various institutions. • Reduced public exposure to S.S. *Dicky* relics.
Advantages	Travelling capability would allow the exhibition to be shared around SCC area.
Cost estimate	• Up to $50,000.
Heritage impact assessment	• The presentation of conserved select components of the wreck in a dedicated space within a building will allow for the opportunity to enhance the historical and interpretative values of the wreck. However the total severance of the wreck from its present context will reduce its aesthetic significance substantially and to a lesser extent its social significance. • This option is assessed to be an *acceptable* mitigation.

I-2 PURPOSE BUILT ENCLOSURE	
General requirements include	• Entire wreck and propeller or sections of wreck and propeller. • Selection of suitable place for an enclosure. • Railings required to separate visitors from original shipwreck components.
Equipment required includes	• Steel protective railings, structure frame and roofing, with cladding in FC sheet, timber panelling or similar.
Personnel required includes	• Curator; • Architect; • Engineer; • Exhibition designer; • Graphic designer; • Conservator; and, • Fabrication/builder.
Estimated time required	• Design and construction = 6-12 months.
Risks	• Wreck de-contextualised by enclosure structure. • Impact of enclosure structure on Dicky Beach Park. • Potential public safety/antisocial behaviour risk in unattended enclosure. • Potential wreck/structure vandalism risk in unattended enclosure.
Advantages	Lower on-going conservation costs for the wreck itself.
Cost estimate	• $150,000-$500,000.
Heritage impact assessment	• The presentation of the conserved wreck, or parts of, in an outdoor and covered environment presents the opportunity to enhance the historical and interpretative values of the wreck while reducing the requirements for on-going conservation treatment.

	• The location of the wreck close to where it was situated would allow it to retain a link with the sea and beach for which it has always been known. • The presentation of the basal elements of the wreck would provide visitors a glimpse of what had been largely buried for over 100 years. It would not be able to reproduce however the visual presence of the wreck as it has appeared over the last 50 to 75 years. • The erection of a barricade would deny the public close interaction with the wreck, an often repeated feature of the wreck in its present location. • The presentation of the wreck in an enclosure near the present site would mitigate in part the impact to the site's aesthetic and social significance. • This option is assessed to be an *acceptable* mitigation.

I-3 PARK INSTALLATION	
General requirements include	• Entire wreck and propeller or sections of wreck and propeller. • Original wreck components to be filed back smooth to reduce safety hazards.
Equipment required includes	• Formed concrete, steel framing structure, timber decking/seating and associated landscaping works.
Personnel required includes	• Curator; • Architect; • Engineer; • Graphic designer; • Landscape architect; • Conservator; and, • Fabrication/builder.
Estimated time required	• Design and construction = 6-12 months.
Risks	• Impact of wreck installation on park. • Park size inadequate to display entire wreck and/or reconstruction. • Potential public injury risk on wreck structure (low). • Potential vandalism risk to wreck elements (low).
Advantages	Allows for greater public interaction and close to wreck site.
Cost estimate	• $150,000-$300,000.
Heritage impact assessment	• The presentation of the conserved wreck, or parts of, in an outdoor environment presents the opportunity to enhance the historical and interpretative values of the wreck. • The location of the wreck close to where it was situated would allow it to retain a link with the sea and beach for which it has always been known. • The presentation of the basal elements of the wreck would provide visitors a glimpse of what had been largely buried for over 100 years. It would not be able to reproduce the visual presence of the wreck as it has appeared over the last 50 to 75 years, though some form of schematic representation is possible. • Rendering the wreck, or elements of, safe for public interaction would go a long way to recreating the recognised enjoyable experience of interacting with the wreck. • The presentation of the wreck in an open environment near the present site would mitigate the impact to the site's aesthetic and social significance. • This option is assessed to be an *acceptable* mitigation.

I-4 BEACH INSTALLATION	
General requirements include	• Key elements of wreck or propeller. • Original wreck components to be filed back smooth to reduce safety hazards.
Equipment required includes	• Formed concrete, steel framing structure and associated landscaping works.

Personnel required includes	• Curator; • Architect; • Engineer; • Graphic designer; • Landscape architect; • Conservator; and, • Fabrication/builder.
Estimated time required	• Design and construction = three to six months.
Risks	• Impact of wreck installation on beach. • Potential public injury risk on wreck structure (low). • Potential vandalism risk to wreck elements (low).
Advantages	Setting very close to the original wreck site.
Cost estimate	• $25,000-$150,000.
Heritage impact assessment	• The presentation of the conserved wreck, or parts of, in an outdoor environment presents the opportunity to enhance the historical and interpretative values of the wreck. • The location of the wreck adjacent to where it was situated would allow it to retain a strong link with the sea and beach for which it has always been known. • The presentation of the basal elements of the wreck would provide visitors a glimpse of what had been largely buried for over 100 years. It would not be able to reproduce however the visual presence of the wreck as it has appeared over the last 50 to 75 years. • Rendering the wreck, or elements of, safe for public interaction would go a long way to recreating the recognised enjoyable experience of interacting with the wreck. • The presentation of the wreck on the beach adjacent to the present site would mitigate in part the impact to the site's aesthetic and social significance. • This option is assessed to be an *acceptable* mitigation.

I-5 COMBINED OPTIONS	
General requirements include	• Contingent on selected interpretation options above.
Equipment required includes	N/A
Personnel required includes	N/A
Estimated time required	N/A
Risks	N/A
Advantages	N/A
Cost estimate	N/A
Heritage impact assessment	• Any combination of the above options would be an *acceptable* mitigation.

I-6 NO INTERPRETATION PROVIDED	
General requirements include	N/A
Equipment required includes	N/A
Personnel	N/A

required includes	
Estimated time required	N/A
Risks	N/A
Advantages	N/A
Cost estimate	N/A
Heritage impact assessment	• The wreck of the S.S. Dicky is has demonstrated moderate to high archaeological, historical, interpretative and social values. The absence of any form of interpretation arising from the removal of the wreck is assessed to be an *unacceptable* mitigation.

I-7 NO PHYSICAL INTERPRETATION PROVIDED	
General requirements include	• Digital and print interpretation.
Equipment required includes	• Web page; and, • A5 flyer (10,000 print run).
Personnel required includes	• Curator; and, • Graphic/web designer.
Estimated time required	• Design = two months
Risks	• Inadequate interpretation on-site.
Advantages	Reduction in on-going conservation and curation of the physical remains of the wreck.
Cost estimate	• $20,000.
Heritage impact assessment	• Two of the key features of the S.S. Dicky wreck is its physical presence and accessibility – form and fabric. Any interpretation of the wreck site that does not address these features will substantially reduce the site's aesthetic, interpretative and social values. • This option is assessed to be an *unacceptable* mitigation.

REFERENCES

***ABC News*, 25 June 2013**, 'King tide exposes Cherry Venture shipwreck,' available http://www.abc.net.au/news/2013-06-25/king-tides-expose-cherry-venture-shipwreck/4778096, accessed 19 November 2014.

AIMA & ACDO 1994 *Guidelines for the management of Australia's historic shipwrecks*

Anderson, R., 2010, 'Report on SS *City of Launceston* site survey and excavations 1997-2002,' in Anderson, R. (ed.) 2010 *Final report on S.S.* City of Launceston *(1863-1865) an inter-colonial steamship wreck Port Phillip, Victoria: Maritime archaeological survey, excavation, artefact analysis, corrosion survey, conservation and site management 1997-2009*, Australian National Centre of Excellence for Maritime Archaeology Special Publication No. 14, Australasian Institute for Maritime Archaeology Special Publication No. 16: 15-44

Arnott, T., 1996, '*SS City of Launceston* 1863-1865', *Project Reports 1996,* Maritime Archaeology Association of Victoria, Melbourne: 54-72. In Anderson, R. (ed.) 2010 *Final report on S.S.* City of Launceston *(1863-1865) an inter-colonial steamship wreck Port Phillip, Victoria: Maritime archaeological survey, excavation, artefact analysis, corrosion survey, conservation and site management 1997-2009*, Australian National Centre of Excellence for Maritime Archaeology Special Publication No. 14, Australasian Institute for Maritime Archaeology Special Publication No. 16: 4-14.

Australia ICOMOS, 1999 *The Australia ICOMOS Burra Charter*. Australia ICOMOS, Canberra

Bigourdan, N., 2007, 'S.S. Dicky 1883-1893 (Caloundra, QLD, Australia): Report on Similar Management and Conservation Programs for Intertidal Iron Shipwrecks,' report for Cosmos Archaeology.

BMT WBM, April 2003, 'Sunshine Coast Regional Council Coastal Processes Study for the Sunshine Coast', report for Sunshine Coast Regional Council, available http://www.sunshinecoast.qld.gov.au/addfiles/documents/environment/coastal/coastal_processes_study_for_sunshine_coastr.pdf, accessed 17 November 2014.

Broadwater, J. D., 1992, ' Shipwreck in a Swimming Pool: An Assessment of the Methodology and Technology Utilized on the Yorktown Shipwreck Archaeological Project,' *Historical Archaeology* 26(4): 36-46

Bureau of Meteorology, 2014a, 'Climate Statistics for Australian Locations – Monthly Climate Statistics – Summary Statistics for Caloundra Signal Station', available http://www.bom.gov.au/climate/averages/tables/cw_040040.shtml, accessed 17 November 2014.

Bureau of Meteorology, 2014b, 'Climate Statistics for Australian Locations – Monthly Climate Statistics – Summary Statistics for Caloundra Signal Station – Annual 9am wind speed vs directional plot', available http://www.bom.gov.au/clim_data/cdio/tables/pdf/windrose/IDCJCM0021.040040.9am.pdf, accessed 17 November 2014.

Bureau of Meteorology, 2014c, 'Climate Statistics for Australian Locations – Monthly Climate Statistics – Summary Statistics for Caloundra Signal Station – Annual 3pm wind speed vs directional plot', available http://www.bom.gov.au/clim_data/cdio/tables/pdf/windrose/IDCJCM0021.040040.3pm.pdf, accessed 17 November 2014.

Bureau of Meteorology, 2014d, 'Tropical Cyclone Information for the Australian Region – 1906-2007 within 100 km of the Sunshine Coast (26.6°S Lat, 153.09°E Long)', available http://www.bom.gov.au/cgi-bin/silo/cyclones.cgi?region=aus&syear=1906&eyear=2006&loc=1&txtloc=&radius=100&ulat=26.6&ulon=153.09, accessed 18 November 2014.

Bureau of Meteorology, 2014e, 'Tropical Cyclone Information for the Australian Region – 1906-2007 within 50 km of the Sunshine Coast (26.6°S Lat, 153.09°E Long),' available http://www.bom.gov.au/cgi-bin/silo/cyclones.cgi?region=aus&syear=1906&eyear=2006&loc=1&txtloc=&radius=50&ulat=26.6&ulon=153.09, accessed 18 November 2014.

***Caloundra Weekly*, 29 November 1963**, 'Premier unveils plaque'

Carpenter, J., 2009, "The *Xantho* Engine – conserving the iron components," in McCarthy, M (ed) *Iron, Steel and Steamship Archaeology: Proceedings of the 2nd Australian Seminar, Held in Perth, Melbourne and Sydney 2006*, Australian National Centre of Excellence for Maritime Archaeology Special Publication No. 13, Australasian Institute for Maritime Archaeology Special Publication No. 15: 89-91

CEE Consultants Pty Ltd, 2009, *Ex HMAS Canberra Dive Site Marine Environmental Considerations*, report for Department of Sustainability and Environment, Victoria, available http://www.hmascanberra.com.au/assets/downloads/2009-07+Attachment+5+-+Marine+Environment+Report.pdf, accessed 25 November 2014

Corey Thomas Sculptures, 2009, 'Lady of St Kilda,' available http://coreythomassculptures.com/lady, accessed 7 November 2014.

Cosmos Archaeology, 2008, *SS* Dicky *Management Plan*, report for Caloundra City **Council.**

Cosmos Archaeology, 2014, *Preliminary Archaeological Investigation of the Wreck of S.S. Dicky*, report for Sunshine Coast Regional Council.

Department of the Environment, n.d. 'Australian National Shipwrecks Database,' Australian Government, available http://www.environment.gov.au/topics/heritage/historic-shipwrecks/australian-national-shipwreck-database, accessed 11 November 2014.

Department of the Environment, n.d., 'View Shipwreck – Maheno,' Australian National Shipwreck Database, available https://dmzapp17p.ris.environment.gov.au/shipwreck/public/wreck/wreck.do?key=2805 , accessed 12 November 2014.

Department of the Environment, 2008, 'Dumping wastes at sea,' available http://www.environment.gov.au/marine/publications/factsheet-dumping-wastes-sea, accessed 24 November 2014.

Department of National Parks, Recreation, Sport and Racing, 2014, 'Ex-HMAS Brisbane Regional Parl – About Ex-HMAS Brisbane,' available http://www.nprsr.qld.gov.au/parks/ex-hmas-brisbane/about.html, accessed 25 November 2014.

Department of Trade and Investment – Crown Lands, 2014, 'Ex-HMAS Adelaide Artificial Reef Central Coast,' available http://www.hmasadelaide.com/home, accessed 25 November 2014

Deutsches Schiffahrts Museum, n.d., 'Der Fund, die Bergung und der lange Weg der Restaurierung,' Hansekogge, available http://www.dsm.museum/ausstellung/dauerausstellung/hansekogge.175.de.html, accessed 7 November 2014.

District Council of Yankalilla, c. 2002, 'Dive the Ex-HMAS Hobart,' available http://www.exhmashobart.com.au/index.html, accessed 25 November 2014.

Edwards, K., Cooper, D., 2013, 'Digitizing *Xantho*: Notes on a project to digitally record an assemblage of complex engine components from a 19th-century steamship,' *Bulletin of the Australasian Institute for Maritime Archaeology* 37: 42-27

English Heritage, n.d. "Amsterdam," English Heritage, available https://www.english-heritage.org.uk/discover/maritime/map/amsterdam/, accessed 29 October 2014.

EPA July 2007, *Queensland EPA Guidelines for Historical Archaeological Studies*

Gawronski, J. H. G., 1990, 'The *Amsterdam* project,' *The International Journal of Nautical Archaeology and Underwater Exploration* 19(1): 53-61.

Hunter, J.W., September 2013, 'Protecting the *Protector*: An initiative to document, assess, interpret, exhibit and preserve an early Australian Warship,' *Australasian Institute for Maritime Archaeology Newsletter*, 32(3): 1, 5-6.

Jacobsen, D. L. 2007, 'The Wreck of the Cherry Venturem', sign at shipwreck site, Queensland Parks and Wildlife Service, Environmental Protection Agency, Queensland Government, available http://dalelornajacobsen.com/yahoo_site_admin/assets/docs/Cherry_Venture.24180337.pdf, accessed 19 November 2014.

Keeshan, G., 2014, 'SS Dicky Geotechnical Investigations 08/10/2014,' unpublished findings, Sunshine Coast Council, in email 'Progress on job' to Cosmos Coroneos, 3 November 2014.

Kimpton, G., Henderson, G., 1991, 'The last voyage of the *Day Dawn* wreck,' *Bulletin of the Australian Institute for Maritime Archaeology* 15(2): 25-28

Langenberg, E.F., 2011, 'Ozone 1886-1925,' from Charlesworth, P., 1992, *A Ship for her Time*, unpublished manuscript, Maritime Archaeological Association of Victoria, available http://home.vicnet.net.au/~maav/ozone.htm, accessed 12 November 2014.

MacLeod Consulting, 2006, 'Lady of St Kilda,' available http://www.macleodconsulting.com.au/projects/lady-of-st-kilda.html#, accessed 7 November 2014.

Mann, C.H., 1985, *The Wreck of the Dicky*, Shire of Landsborough Historical Society Museum.

Martin, C., 1987, 'The Viking World,' in Throckmorton, P. (ed.) *History from the Sea: Shipwrecks and Archaeology from Homer's* Odyssey *to the* Titanic*,* RD Press, Surry Hills, New South Wales, Australia: 128-133

Martin, H., 31st May 2009, "Shipwreck danger: Risk to bathers exposed," *Sunday Mail*, Brisbane.

McCarthy, M., 1988, 'S.S. *Xantho*: The pre-disturbance, assessment, excavation and management of an iron steam shipwreck off the coast of Western Australia,' *The International Journal of Nautical Archaeology and Underwater Exploration* 17(4): 339-347

McCarthy, M., 2007, 'SS *Xantho* 1872: Treasure from the scrapheap,' in Nash, M. (ed.) *Shipwreck Archaeology in Australia*, University of Western Australia Press, Crawley, Western Australia:157-160

Morrison, P. F., c. 1999 *Biological Monitoring of the HMAS* Swan*,* report, available http://www.californiashipstoreefs.org/Resources/Documents/Biological_Monitoring_of_the_HMAS_Swan.pdf, accessed 25 November 2014

Port Arthur Historic Site Management Authority, 2011, 'Attractions – Dockyard,' available http://www.portarthur.org.au/index.aspx?base=1474, accessed 7 November 2014.

Port Arthur Historic Site Management Authority, 2007, 'Port Arthur Dockyard Project awarded,' available http://www.portarthur.org.au/index.aspx?sys=Archived%20News%20Article&intID=1842, accessed 7 November 2014.

Rackl, H-W., 1968, *Diving into the Past: Archaeology Under Water*, Charles Schribner's Sons, New York: 237.

RACQ, n.d., 'Maheno Shipwreck,' Visitor Information Guide, Fraser island Getaway, available http://tourism.racq.com.au/__data/assets/image/0004/66604/7-maheno-wreck.jpg, accessed 12 November 2014.

South Australian Department for Environment and Heritage, n.d., 'Santiago – Garden Island,' Ships' Graveyards of South Australia, flyer, available https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB8QFjAA&url=http%3A%2F%2Fwww.environment.sa.gov.au%2Ffiles%2Fa378d1ad-6d05-4f52-b8ae-9e2900d17af7%2Fsantiago.pdf&ei=z0BkVJeoIIXVmgXs8YDIAQ&usg=AFQjCNHI89WkxFEtdQCoY2UXUU2I4SVMPw&sig2=K5VazprPWP6JP2seGwF7-A, accessed 11 November 2014.

Steinberg, D., 2005, 'The Historic Shipwreck SS *Brisbane* (1874-1881): A Plan of Management,' Museum and Art Gallery of the Northern Territory Research Report No. 10, available http://artsandmuseums.nt.gov.au/__data/assets/pdf_file/0007/16990/report10.pdf, accessed 11 November 2014.

Stepanow, L., 2006, photograph of Cerberus in 'Image Library', Friends of Cerberus Inc., available http://www.cerberus.com.au/image_library.html#imagewindow, accessed 11 November 2014.

***Sunshine Coast Daily*, 20 June 1984,** "Dicky sails again"

***Sunshine Coast Daily*, 22 May 1985**, 'Fight on to save wreck'.

***Sunshine Coast Daily*, 5 February 2007**, 'Cherry Venture will be gone in weeks,' available http://www.sunshinecoastdaily.com.au/news/scd-cherry-venture-will-be-gone-in-weeks/315419/, accessed 19 November 2014.

***Sunshine Coast Daily*, 8 May 2014**, 'SS Dicky wreck: Why we will miss her so much,' available http://www.sunshinecoastdaily.com.au/news/ss-dicky-wreck-sunshine-coast-memories-photos/2246685/, accessed 14 November 2014.

Texas Beyond History, 2008a, "*La Belle* Shipwreck," The University of Texas at Austin, College of Liberal Arts, available http://www.texasbeyondhistory.net/belle/, accessed 29 October 2014.

Texas Beyond History, 2008b, "*La Belle* Shipwreck – Discovery and Investigations: The Recovery of *La Belle*," The University of Texas at Austin, College of Liberal Arts, available http://www.texasbeyondhistory.net/belle/excavations.html, accessed 29 October 2014.

Texas Beyond History, 2008c, "*La Belle* Shipwreck – Discovery and Investigations: The Recovery of *La Belle – Images, Cutaway*," The University of Texas at Austin, College of Liberal Arts, available http://www.texasbeyondhistory.net/belle/images/cutaway.html, accessed 10 November 2014.

Thomson, A.K. (ed) n.d. *The Collected Works of Thomas Welsby*: Volume 1.

Trundle, Gwen 1961 *Caloundra; Gem of the Sunshine Coast*. Landsborough Regional Historical Museum IDNo 0144.

Tulley, P., 2009, 'Our heritage to arise from the waters? HMVS Cerberus,' in McCarthy, M., (ed.) Iron, Steel and Steamship Archaeology: Proceedings of the 2nd Australian Seminar, Held in Fremantle, Melbourne and Sydney, 2006, Western Australian Museum Special Publication, Australian National Centre of Excellence for Maritime Archaeology No. 13, Australasian Institute for Maritime Archaeology Special Publication No. 15: 131-132.

Waterson, P.A., 2013 *S.S.* Dicky *Inspection Report: 20 and 31 May 2013*, Heritage Branch, Environmental Policy and Planning Division, Department of Environment and Heritage Protection, Queensland Government.

Western Australian Maritime Museum, n.d., "Information – SS Xantho: Western Australia's First Coastal Steamer," information brochure, Western Australian Maritme Museum, Fremantle, Western Australia.

Wilkinson, D., 2013, 'From Beef to Reef: The Maritime Cultural Landscape of Robb Jetty', Masters thesis, Flinders University of South Australia, Adelaide.

Zhukovsky, M.O, Kuznetsov, V.D., Olkhovsky, S.V, 2013, 'Photogrammetric techniques for 3-D underwater record of the antique time ship from Phanagoria,' *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* XL-5/W2, XXIV International CIPA Symposium, 2-6 September 2013, Strasbourg, France: 717-721