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<tr>
<th>AUTHOR</th>
<th>J. MILLAR</th>
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<tr>
<td>CHECKED</td>
<td>T. DOVE</td>
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<tr>
<td>CERTIFIED</td>
<td>G. MACDONNALD</td>
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EXECUTIVE SUMMARY

This report follows on from HMVS Cerberus Preservation Concept Solutions Report, delivered by BMT Design and Technology to Bayside City Council in August 2011. It provides an update of the situation following the work that has progressed since the concept solutions report was completed, as well as an updated design proposal for the solution agreed during a stakeholders meeting held on the 8th of May 2013.

The preferred option to be carried forward was agreed to be the filling of the HMVS Cerberus wreck with sand, in order to satisfy the priorities of all stakeholders, being:

a. Ensure the safety of the site and prevent access of recreational divers;
b. Prevent catastrophic collapse of the gun turrets;
c. Cost effective
d. Ensure that the historical value of the wreck is maintained by minimising visual impact;
e. Provide a reversible solution to allow for future works to take place in the preservation of the wreck; and
f. Minimise ongoing costs to preserve the wreck and prevent any safety issues from re-arising.

In addition to developing a detailed design for the sand fill option, BMT Design and Technology were tasked to undertake a feasibility assessment of the turret removal. In completing the second phase of the project, BMT has found that the detailed design of the sand fill will be significantly greater in cost than that allowed for under the original contract and this report serves to present all current options for review and consideration by Bayside City Council.

The cost of the detailed design and environmental assessment for the sand fill has been calculated to be $86,595, with the subsequent construction estimated at $459,826 to a total cost of $546,421. Whilst this is above the remaining budget of $450,000, BMT remain confident that this solution will satisfy all stakeholders and offer an optimal solution to all parties and therefore recommends additional funding be sought to conduct the design and construction of the sand fill option.

This report also reviewed the bracing proposals provided in the BMT HMVS Cerberus Preservation Concept Solutions Report. The ability to implement this proposal hinges on the possibility to access the internals of the wreck to install internal supporting structure, as external structure alone is not practical, given the shear size of structural bracing that would be required. As such, BMT recommends this option is considered no further, until such time as considerably more funds are available to conduct further, detailed, preservation work.
The feasibility of turret removal has been assessed and can be implemented should sufficient budget be available. It is estimated that the budget for removal of the turrets would exceed $700,000. Based on a further analysis of the deck structure supporting the turrets, the strength would remain insufficient and a catastrophic failure of the deck would be imminent. The remaining historical value would be at risk, as well as the safety of the general public unless access was to be fully restricted. Based on current restrictions in budget, BMT recommends the removal of the turrets not be considered further.
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1 INTRODUCTION

1.1 Background

1.1.1 HMVS Cerberus was sunk as a breakwater in 1926 and is now located in Port Philip Bay, just off the coast in Half Moon Bay.

1.1.2 In 1993 Cerberus’ hull suffered extensive damage and collapsed in a storm. Following the structural collapse, preservation efforts of the Cerberus began in 1994. Initial work focussed on a site survey, reporting on the results of the collapse. From here, a number of options were proposed to preserve Cerberus. These have included filling with sand, raising and stabilising, external and/or internal supports and filling with concrete.

1.1.3 As detailed at Reference 1, the vessel has suffered severe corrosive material degradation since being scuttled, resulting in the risk that the weather deck structure supporting the turrets may collapse. However, the installation of a cathodic protection system has minimised this degradation, as shown at Reference 2. The risk remains however that should the structure be unsettled in some way, such as through storm damage, the deck structure will likely fail, thereby removing the historical value of the wreck.

1.2 Objective

1.2.1 The objective of this second phase of the project is to prevent the turrets and superstructure from collapsing through the weather deck to preserve the historical value of the wreck as well as remove safety concerns for people using the wreck for recreational purposes, notably scuba diving. This needs to be achieved by transferring the weight of the turrets and superstructure, from the vessel’s structure, to the sea floor.

1.3 Previous Work

1.3.1 BMT has completed the first phase of the work, delivering several concept design options for the preservation of the turrets as per Reference 3. At this stage, BMT recommended a combination of internal and external supports to stabilise the structure. It also recommended the introduction of an impressed current system to prevent further degradation of the wreck and a dive survey to assess the condition of the site.

1.3.2 A diving survey of the site was subsequently conducted by Defence Science and Technology Organisation (DSTO) in December 2012, facilitated by utilising a Remotely Operated Vehicle (ROV). The ROV was used for this survey as Bayside City Council deemed the risk to divers of entry into the wreck as unacceptable.

1.3.3 The time available for this dive survey was limited due to unfavourable weather conditions and subsequently the results were limited. The results did not provide any further details regarding the strength of the structure supporting the turrets. It did however confirm that the impressed current system has slowed the corrosion rate of the structure.
1.3.4 A stakeholder meeting was held at the offices of BMT with representatives from Bayside City Council, Friends of Cerberus and Heritage Victoria. During this discussion it was determined that the option which was most feasible and met the requirements of all stakeholders, was the support of turrets via infilling of the hull with sand. This option provides for the preservation of the turrets, blocking of access to the public and the reversibility of work carried out.

1.3.5 Due to sand fill becoming the preferred option for preservation, the project scope was modified, diverting from what was originally proposed and recommended for further detailed design at Reference 3 to a solution that had been subjected to minimal feasibility or design consideration.

1.3.6 The change in scope has therefore provided some significant review work in order to facilitate a proposal that would be acceptable to Bayside City Council and remaining stakeholders, within the remaining budget of the contract at Reference 4.

1.3.7 In addition to developing the sand fill option, BMT agreed to assess the feasibility of removing the turrets to maintain their historical value at a site away from the current HMVS Cerberus location.

1.4 Criteria

1.4.1 It is suggested that the following criteria are kept in mind when comparing the options and selecting a way forward for the preservation of HMVS Cerberus:

a. Ensure the safety of the site and prevent access of recreational divers;
b. Prevent catastrophic collapse of the gun turrets;
c. Cost effective
d. Ensure that the historical value of the wreck is maintained by minimising visual impact;
e. Provide a reversible solution to allow for future works to take place in the preservation of the wreck; and
f. Minimise ongoing costs to preserve the wreck and prevent any safety issues from re-arising.

1.4.2 In reviewing the sand fill option at the initial design phase, it became apparent that filling the wreck with sand would also require an environmental impact assessment (EIA) to the local marine environment. As such, the solution also needed to allow for an EIA to be conducted, supporting the application and granting of all associated permits.

1.4.3 The solution is to be developed in collaboration with the ‘Save the Cerberus Alliance’, which consists of Bayside City Council, Friends of Cerberus, National Trust, Heritage Victoria, Parks Victoria and the Melbourne Convention and Marketing Centre. Management decisions must also be approved by the Historic Shipwrecks Advisory Committee of the Heritage Council.
1.5 Approach

1.5.1 Due to the change in scope, BMT have been unable to use this phase of the design to develop a detailed design of the sand fill preservation solution. As such, BMT will first conduct a feasibility assessment of the sand fill options and propose the recommended design and construction solution, which can be subsequently progressed.

1.5.2 In addition, BMT will conduct an assessment as to the feasibility of removing the turrets from the wreck. The initial assessment will undertake a review of the structural integrity of the weather deck following the turret removal, in order to assess the residual risk of the wreck once the turrets are removed. In addition, a brief assessment will be conducted to determine the method of removal and a rough order of magnitude cost, including an outline of all logistic considerations.

1.5.3 The bracing option will also be re-assessed to ensure that the proposed price offered remains valid and that the risks associated with this option are in line with the priorities of the stakeholders. BMT will present this as a fall back option, should it be deemed to better meet the stakeholders priorities.

1.5.4 Finally, BMT will provide details regarding the environmental requirements, in terms of approvals as well as any EIA’s required in order to implement the final solution.

2 SAND FILL OPTIONS

2.1 Background

2.1.1 Filling the interior with dredged sand has been selected as the preferred method for stabilisation and preservation. The two greatest strengths of this solution, in terms of the project requirements, are that it will make the wreck safe by eliminating any risk of divers being able to enter the wreck and secondly, it is reversible.

2.1.2 Several sand fill alternatives have been considered and investigated by BMT D&T in a brief report provided at Annex Error! Reference source not found.. Essentially, the sand fill method remained constant, however the methodology behind retaining the sand varied. In all options, access will be restricted from above the waterline either by the sand infill alone or with the access points also welded closed. Options for sand retention include:

a. Patch up of holes;
b. Reinforced sand bag wall;
c. Crash barrier wall;
d. Rock wall; and
e. Sheet Piling.
2.2 Preferred Method

2.2.1 After the initial investigation BMT D&T recommend that creating an artificial rock wall around the exterior of the hull and then filling the interior with sand would be the most suitable solution. Whilst this solution is anticipated to be the highest cost, relatively, it will ensure that the underwater appearance of the hull is retained using the most natural appearance, and ensure longevity, in terms of minimising ongoing monitoring of the condition of the wreck.

2.2.2 Images obtained from the DSTO underwater dive survey were summarised in a brief report at Annex Error! Reference source not found. and illustrate that the majority of holes, fractures and voids in the hull skin are located within the constraints from the sea floor to a height of approximately one metre. The armour belt above this height appears to be in good condition and no major holes were identified in its structure.

2.2.3 It is proposed that rocks would be placed around the boundary of the hull on the sea floor and then built up in a suitable profile for them to reach the highest hull fracture or the lowest point on the weather deck.

2.2.4 The rock wall will be required to minimise sand outflow from the wreck. It may need to be externally patched with concrete to fill any gaps or lined with a geotextile/polymeric material, if it is found that sediment loss through the wall is likely to be significant.

2.2.5 To provide input for this solution BMT D&T collaborated with specialist rock wall consultants BMT JFA to assess the feasibility of this solution and provide preliminary costing for both the detailed design and construction.

2.2.6 BMT JFA provides niche engineering services for port and maritime developments. They are a specialist consultancy that provides expert services and capabilities in the areas of coastal and maritime structures, coastal dynamics, port and harbour engineering, specialist dredging management and cartography and drafting. With a solid pedigree in detailed design of rock armoured breakwaters, groynes and seawalls, as well as experience in design of geotextile filters/sand filled containers, BMT JFA was able to provide valuable expertise to this study.

3 ASSESSMENT OF ROCK WALL AND SAND FILL

3.1 Introduction

3.1.1 BMT JFA have carried out a feasibility assessment of the solution proposed by BMT D&T for the long term preservation/stabilisation of the HMVS Cerberus shipwreck, to construct a low lying rock wall surrounding the base of the shipwreck and fill the shipwreck with sand. The assessment is provided in full at Annex Error! Reference source not found..

3.1.2 This assessment is intended be high level, to be used for justification to progress the project to the detailed design phase, highlight any major risks and provide ROM costs for construction/implementation works.
3.1.3 During detailed design phase it would be expected that further refinement and optimisation of the construction methodology and design would be undertaken.

3.1.4 To ensure that the rock wall option was the optimal solution, BMT JFA were asked to explore alternative solutions that may be a better option that fit the project objectives. As such, BMT JFA has conducted an assessment of the rock wall option as well as an option to use a sand container type barrier around the base of the wreck.

3.2 Rock Wall Proposed Construction Methodology

3.2.1 The construction methodology has been developed based on use of a small flat-top barge, with support vessel, to transport rock from shore to the HMVS Cerberus shipwreck and a 20 tonne excavator stationed on deck of the flat-top barge transferring and placing rocks on the seabed against the base of the hull of the shipwreck, constructing the rock wall.

3.2.2 The flat-top barge will be loaded with stockpiled rock at the shore by a front end loader. Rocks will be loaded onto designated area on the deck of the flat-top barge.

3.2.3 A layer of geofabric is to be placed and anchored against the shipwreck prior to the placement of rock such that the geofabric forms a seal against the hull of the shipwreck preventing sand from passing through the rock wall. The rock wall is to be built up to a height of one meter above the seabed.

3.2.4 Following construction of the rock wall a diver inspection survey is to be undertaken to identify gaps in the structure. The construction plant will remain on site during this survey and finalise the structure by placing additional rocks in any gaps identified by the divers.

3.3 Sand Fill Proposed Methodology

3.3.1 The methodology for filling of the HMVS Cerberus shipwreck with sand has been developed based on use of slurry pump, with two support vessels and a team of divers manually directing the pump outlet and flow of sand into the shipwreck.

3.3.2 Sand will be pumped into the shipwreck via five different access points located on the weather deck and breastwork deck:

a. The forward hatch;

b. The aft hatch;

c. The boiler room (stoke hold) outlet;

d. The aft breastwork companionway; and

e. The coal loading chute.

3.3.3 Based on ROV survey reports, the majority of the remaining separate compartments within the shipwreck can be filled with sand with this methodology.
3.3.4 It is noted that the angle of the outlet may need to be altered on several occasions during pumping, directing flow to ensure that all of the compartments are filled. Sand will be pumped into the space between the breastwork deck and weather deck to as high level as possible to maximise structural support for the turrets and superstructure.

3.4 Additional Tasks

3.4.1 Given the large amount of debris, external to the hull, situated on the seabed in the vicinity of the shipwreck BMT JFA have recommend that a debris removal/recovery campaign is undertaken prior to the commencement of construction works.

3.5 Construction Cost Estimates

3.5.1 Estimated costs for construction of the proposed low rock wall and sand fill option are provided in Table 1 below.

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<thead>
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<td>Days</td>
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<td>$4,000</td>
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<tr>
<td>Light Support Vessel and Crew for debris recovery/clearing</td>
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<td>Days</td>
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<td>Barge Hire</td>
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<td>Days</td>
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### Table 1 - Low Rock Wall and Sand Fill Solution Cost Estimate

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<tr>
<td>Light Support Vessel and Crew Hire</td>
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<td>Pump Hire and Consumables</td>
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<td><strong>Total (exc. GST)</strong></td>
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### 3.6 Identification of Risks and Issues

#### 3.6.1 The major risk associated with filling the shipwreck with sand is that it may not be possible to fill the shipwreck with sand up to the level of the weather deck to provide the required structural support beneath the turrets and superstructure. In the limited timeframe this issue was not able to be fully investigated but would be further researched before the detailed design phase.

#### 3.6.2 The armour belt on the upper exterior of the shipwreck has been assumed to be intact. However, there is a considerable risk that there are holes/voids in this material or holes/voids may develop whilst the shipwreck is filled with sand.

#### 3.6.3 There lies some risk that the shipwreck may be damaged whilst the excavator is placing rocks against the base of the hull

#### 3.6.4 Given the relatively short duration and high daily costs, delays to the construction program due to inclement weather/sea-state could dramatically increase construction costs.

#### 3.6.5 The ROV survey reports generally indicate that access to the turrets from either the aft hatch or the forward hatch is generally possible and the area beneath the breastwork deck is relatively clear. However there may be some issues with filling the bow and stern ends of the vessel with sand, particularly if bulkheads in these areas are more intact than others.
The environmental approvals to pump sand into the shipwreck may require environmental controls. The cost of this cannot be estimated until an EIA is undertaken, but should be within the cost contingency allowances.

3.7 Discussion

3.7.1 As shown in Table 1 the estimated construction cost of the low lying rock wall and sand fill solution in $459,826 and the estimated duration for construction is 3 weeks.

3.7.2 It is recommended that a hydrographic survey of the seabed levels surrounding the HMVS Cerberus shipwreck, Half Moon Bay and the various marine infrastructures in the surrounding vicinity be undertaken prior to construction works to assist in developing a detailed construction methodology.

3.7.3 In order to mitigate the risk to the HMVS Cerberus hull structure as well as ensure adequate support to the deck structure, BMT D&T will work with BMT JFA to conduct an Finite Element Analysis (FEA) of the hull structure, as well as develop an optimised solution to ensure constant upward pressure is applied to the weather deck in way of the turrets and breastwork to ensure structural integrity is maintained. One method to ensure the upward pressure is to develop a hollow pile that will be welded to the breastwork deck and filled with the sand slurry to provide an effective pressure head upward on the deck. Other alternatives will also be reviewed.

3.7.4 The low-lying rock wall option represents a feasible solution for stabilisation of the HVMS Cerberus shipwreck, with some associated risks (refer Section 3.6).

3.7.5 Sourcing and delivery of suitable rock material may prove difficult given that a relatively small volume (approximately 300m$^3$) of rock is required. Moreover, the relatively low quantity of rock is likely to result in a high unit cost. BMT JFA also does not consider rock to be an ideal material to seal the holes in the base of the shipwreck, without geofabric placement.

3.7.6 As an alternative solution, BMT JFA has proposed that a geotextile sand container (or sand bag) structure could be used.

4 ASSESSMENT OF LOW LYING GEOTEXTILE SAND CONTAINER STRUCTURE AND SAND FILL

4.1 Introduction

4.1.1 It is proposed an alternative solution to the rock wall could be a low lying structure comprised of Geotextile Sand Container (GSCs) or sand bags could be implemented. GSCs are geofabric bags filled with sand or other material to form a brick-like unit. GSCs are typically individually filled onsite, using a small excavator, manually sealed and placed either individually with an excavator fitted with a specialised grab attachment, or bundled and placed several units at a time, using a cargo net.
4.2 Geotextile Sand Container Construction Methodology

4.2.1 The construction methodology for the proposed GSC and sand fill solution has been developed based on use of a small flat-top barge, with support vessel, to transport the GSCs from shore to the shipwreck and a 20 tonne excavator to place the bundled GSCs, either directly place or bundled in cargo nets.

4.2.2 The GSCs are to be filled on shore using a small excavator, delivered sand fill and sealed manually by a working crew. The GSCs will be loaded into a cargo nets onshore and transferred to the flat top barge during loading.

4.2.3 A layer of geofabric is to be placed between the GSC structure and the hull of the shipwreck.

4.2.4 The sand fill methodology will be the same as detailed above in Section 3.3.

4.3 Construction Cost Estimates

4.3.1 Estimated costs for construction of the proposed geotextile sand container structure are provided in Table 2 below.

<table>
<thead>
<tr>
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<th>QTY</th>
<th>UNIT</th>
<th>Rate</th>
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<td>of Construction Barge</td>
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### Table 2 - GSC Structure and Sand Fill Cost Estimate

4.4 Discussion

4.4.1 As shown in Table 2 the estimated construction cost of the low GSC structure and sand fill solution is $452,959 and the estimated duration for construction is 3 weeks.
4.4.2 It can be assumed that the risks associated with this solution are largely the same as those identified above for the low rock wall and sand fill option (Refer Section 3.6 above).

4.4.3 As can be seen in Table 1 and Table 2 the estimated construction cost for duration for both the rock wall and GSC solutions are comparable. In addition to this, supply of geotextile sand containers is considered a simpler process than importing the required amount of rock.

5 DETAILED DESIGN

5.1.1 The detailed design costs have been provided by BMT JFA and are detailed below in Table 3.

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<td>4.2 Tender clarifications</td>
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<td><strong>Totals</strong></td>
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Table 3 - Detailed Design Costs

5.1.2 As part of the detailed design, there will also need to be an EIA completed in parallel. BMT D&T have reviewed this cost with an associate company, BMT WBM, who have extensive environmental impact study and assessment experience. They have provided a rough order of magnitude cost of up to $40,000.

5.1.3 Based on the approximate EIA and detailed design costs, the total development costs will amount to $86,595.

6 EVALUATION OF TURRET REMOVAL

6.1 Introduction

6.1.1 An investigation has been carried out into the feasibility of removing the turrets and relocating them to shore. This included an assessment of their current state and removal methods, as well as a detailed FE analysis.

6.2 Accessibility and Current State

6.2.1 A recent DSTO report at Reference 2 provided some insight into the condition of the turrets, as well as their accessibility for potential removal works. The main point of interest was to get access to the lower deck space to gain a better understanding of the beams underneath the turret and any other existing supports.

6.2.2 The DSTO report concluded that given the intact condition of the armour belt any attempt to enter the vessel directly at a lower deck level was not possible.

6.2.3 Access through the Boiler Room (Stoke Hold) Outlet proved to be the most effective in providing the ROV with access to the underside of the forward turret.

6.2.4 A 1971 photograph depicting the lower half of Cerberus’s forward turret can be seen in Figure 1 below. This provides an idea of what lower half of the forward turret once looked like before this part of the structure became submerged.
6.2.5 The gussets which can be seen in the top portion of Figure 1 correspond to the gussets highlighted in the cross sectional drawing seen below in Figure 2. The turret support rollers housed in a circular cage can be seen in the bottom section of Figure 1; their corresponding position in the overall turret structure is also highlighted in Figure 2.

6.2.6 An image taken by the ROV shows how the lower half of the forward turret appears in the present day (Figure 3).
The DSTO survey did not provide any information regarding the connection of the turret and/or any associated mechanical interfaces to the lower deck. From looking at construction drawings and design of other turrets from a similar period BMT assume that the rollers run on a track and are not housed within a cage or under a lip, which would prevent removal.

It is expected that some material fusion will be present due to corroded connections between parts of the structure; however, BMT does not anticipate that this will be significant and can be allowed for in lifting force calculations.

6.3 Removal Methodology

BMT determined that there are no hard connections between the turrets and the breastwork deck or the shield deck. A clear gap between the armour plating on the turret and the surrounding breastwork deck can be seen in Figure 4 below.
6.3.2 Post consultation with a heavy lift company, BMT propose that the deck structure is cut away around a series of lifting points on the turrets below the breastwork deck. A connection to the armour belt above the weather deck is a possibility; however, due to the unknown condition of the base material between the turret and armour belt, the shear connection would pose a potential risk to the lift.

6.3.3 A previous site investigations report at Reference 6 estimates that the turrets weigh 128 tonnes each (Figure 5).

<table>
<thead>
<tr>
<th>Item</th>
<th>Iron Armour (tonne)</th>
<th>Teak Backing (tonne)</th>
<th>Inner Plate (tonne)</th>
<th>Transverse Frames (tonne)</th>
<th>Total</th>
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<td>130</td>
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Figure 5 - Cerberus Weight Estimates

6.3.4 Due to the heavy weight of the turrets BMT have consulted a heavy lift company and proposes that two barges be utilised and a gantry style jacking system implemented. The proposed solution is detailed in Figure 6 below.
6.3.5 This operation would involve two barges being manoeuvred alongside Cerberus. Following this the turret would be vertically extracted to a height above the surface of the breastwork deck. A third barge would be strategically positioned in front of the vessel to provide a platform for the turret to be lowered down onto.

6.3.6 Once lifted clear of the vessel the two gantry crane barges would be simultaneously floated forward (or aft depending on which turret) until they straddled the third barge. When in position, the turret would be lowered down onto the barge and towed to the nearest load-out facility for transferring ashore.

6.3.7 Due to the extreme weight, it is unlikely that a local load out facility will be capable of lifting the turrets off the barge. As such, in order to transport the turrets to their desired location they would need to be set down onto a heavy haulage trailer situated on the non-lifting barge, such that they can be towed off the barge from a suitable load out facility that can facilitate towage onto shore.

6.4 Weather Deck Assessment After Turret Removal

6.4.1 Following on from the work completed at Reference 3, the FEA model of the weather deck directly underneath the breastwork was prepared to reflect the general arrangement shown in the original structural drawings, and with the turrets removed.

6.4.2 The model was refined to determine residual risk to the weather deck, in terms of collapse, under the remaining weight of the breastwork structure with the forward and aft turrets removed. As the internal vertical pillars are believed to have essentially collapsed the transverse weather deck beams will solely support any remaining structure on the deck.

6.4.3 Figure 7 shows the appearance of the FEA model.
6.5 **Geometry**

6.5.1 In 1994 Dr Ian McLeod performed measurements of residual iron thicknesses of framing inside the hull of HMVS Cerberus in a report at Reference 1. He concluded that the corrosion rate of the iron structure is 0.122 ± 0.009 mm/year.

6.5.2 The plate and beam thicknesses used in the model were approximately based on these assumptions made by Dr MacLeod.

6.5.3 The weather deck beams are based on I-Beam geometry.

6.5.4 A thickness of 15.0 mm was used for the deck plating. This was based on an original plating thickness of 20mm (¾ inch), with the corrosion rates applied and rounding up to the nearest 5mm to establish a best-case scenario.

6.5.5 Similarly, a thickness of 5.0 mm was used for the bottom flange and web of the weather deck beams. A thickness of 20.0 mm was used for the top flange of the weather deck beams, based on the assumed thickness of the flange combined with deck plating.

6.6 **Material**

6.6.1 The material used in calculations was Malleable Cast Iron: Grade 32510, with a tensile and yield strength of 345MPa and 224MPa respectively. This particular grade of Malleable Cast Iron provides for a very conservative estimate of the relevant mechanical properties.

6.7 **Loading**

6.7.1 The load case analysed takes into account the mass of the remaining breastwork structure (once the turrets have been removed), as can be seen in Figure 8 below. The total weight of the breastwork was found to be 350 tonnes, as detailed in Reference 6.
6.8 Results

6.8.1 Figure 9 shows the distribution of the maximum Bending Stress in beam elements generated by the breastwork load. The maximum bending stress was found in the centre of the beams, at 346MPa.

6.9 Conclusion

6.9.1 The results of the FEA performed on the model of the weather deck revealed that weather deck beams exceed the allowable stress in several places.
6.9.2 Whilst the removal of the turrets will facilitate the preservation of the historical value, the risk of deck collapse remains. As such, Bayside City Council would remain responsible for ensuring the safety of the wreck to the general public. Therefore, the wreck would still need to be totally sealed or destroyed to remove the residual risk. Should it be decided to preserve the remaining wreck, BMT would recommend that it be filled with concrete, given the rationale for reversibility no longer remains.

6.9.3 Regardless of whether the turrets are removed, there will be a residual cost to Bayside City Council to ensure the safety of the wreck site.

6.9.4 Should it be decided that the turrets may be removed and that a solution for the wreck after the removal is determined, BMT recommend that a detailed assessment be completed to ascertain the exact lifting and logistic requirements. A very rough order of magnitude cost of $700,000 is estimated by doubling the cost of the lift only, provided to BMT as a quote for $350,000 from a heavy lift company.

7 REVIEW OF PRESERVATION OPTIONS

7.1.1 The external bracing solution has been further revised since the last report at Reference 3. It proposed that driven piles be utilised to transfer the load directly to the seabed. The piles will be sized to resist lateral forces from wave action and axial forces to carry the weight of the vessel. Steel tubular piles 700mm in diameter with 16mm wall thickness were found to be adequate for this application. These will need to be driven open ended to a penetration of approximately 10m into the seabed to achieve the desired capacity.

7.1.2 This solution uses a collar attached to the turret that is connected to supporting bracing on both sides of the turrets. The bracing is made up of horizontal I-beams, connected to the collar at one end and the marine piles at the other. BMT propose that 3 piles on each size of the turret will be utilised, totalling six piles to support each turret. This arrangement can be seen below in Figure 10 and Figure 11.
7.1.3 The size of the I Beams required to support the turrets in this arrangement was further reviewed to determine if it was practical to utilise external support only. It was found that the size of I Beam required would be impractical, unless the bracing arrangement was made considerably more complex. As such, internal bracing is essential and the ability to achieve the braced solution hinges on mitigating the risk to divers undertaking the internal structure installation. Alternatively, ROVs may potentially be utilised should a remotely facilitated jacking system be developed that can utilise the size of ROV deployed by DSTO at Reference 2.
7.1.4 The revised costing can be seen below in Table 4. Based on the risk associated with this option of the internal support, and the subsequent design reviews required to implement this, the cost does not include the internal bracing.

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Table 4 - External Bracing Cost Estimate

8 ENVIRONMENTAL CONSIDERATIONS

8.1.1 Regardless of the solution carried forward, the environmental study will need to be factored into costs, allowing for permit applications and the associated impact assessments for approval. As detailed in Section 5 the approximate cost for the sand fill is $40,000. Whilst bracing would not require the same level of scrutiny, regardless the environmental costs will need to be considered.
9 CONCLUSION

9.1.1 BMT D&T have completed a feasibility assessment to ascertain the viability and approximate cost to design and construct the preferred solution to stabilise/preserve the HMVS Cerberus wreck, in the sand fill, with associated surrounding rock wall. The total solution is estimated to cost in the order of $546,421. This includes the following components:

a. Detailed design - $46,595

b. Environmental assessment - $40,000

c. Construction - $459,826

9.1.2 There are two options available for the implementation of the sand fill. Those are a rock wall or a sand bag type solution. Both are of a similar cost, but the latter will further minimise sand seepage. The implementation of either option would be subject to the conduct of the detailed design. During the detailed design, a solution to ensure that there is sufficient pressure on the weather deck to support the turrets will be determined, in parallel with assuring that structural integrity of the hull is maintained.

9.1.3 As agreed at the stakeholder meeting between BMT D&T, Bayside City Council, Heritage Victoria and the Friends of Cerberus, the feasibility of turret removal was assessed and can be implemented should sufficient budget be available. It is estimated that the budget for removal of the turrets would exceed $700,000, and based on a further analysis of the deck structure supporting the turrets, the strength would remain insufficient and a catastrophic failure of the deck would be imminent, hence the remaining historical value would be at risk, as well as the safety of the general public unless access were fully restricted.

9.1.4 The bracing solution proposed in the Report at Reference 3 was also reviewed. The ability to implement this proposal hinges on the possibility to access the internals of the wreck to install internal supporting structure, as external structure alone is not practical, given the shear size of structure that would be required. A revised cost estimate of $671,213 has been derived, which does not include internal bracing or any form of environmental impact assessment.

10 RECOMMENDATION

10.1.1 BMT recommends that Bayside City Council review all available options and convene a stakeholders meeting to agree on the preferred option.

10.1.2 BMT recommends that the detailed design be progressed for the sand fill. This will facilitate the determination of the best solution in terms of the rock wall or the sand bag type alternative.

10.1.3 Should, this option be carried forward, BMT will develop a revised contract for the proposed work, for acceptance by BCC, in order to undertake the detailed design of the sand fill option.
10.1.4 Should an alternative be desired then BMT remain available for negotiations to facilitate that option.

11 REFERENCES

1. Corrosion of the HMVS Cerberus (1926), Dr Ian Donald MacLeod, Department of Materials Conservation, Western Australia Museum, April 1995

2. Survey of HMVS Cerberus December 2012, Maritime Platforms Division, Defence Science and Technology Organisation (DSTO), Fishermans Bend VIC, April 2013


4. Contract No. 101155Q - Agreement with BMT Design & Technology Pty Ltd

5. Photo courtesy of Leigh Doeg, Friends of Cerberus

ANNEX A

HMVS CERBERUS ASSESSMENT OF SAND FILL OPTIONS REPORT, BMT DESIGN & TECHNOLOGY, REFERENCE: OPS/I/BCC/12019/R0662, COMMERCIAL IN CONFIDENCE, JUNE 2013
HMVS Cerberus
Assessment of Sand Fill Options Report

Reference: OPS/I/BCC/12019/R0662
Date: June 2013
Commercial-In-Confidence
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| AUTHOR         | LACHLAN STAMMERS                                 |
|                |                                                 |

| CHECKED        | JESSE MILLAR                                    |
|                |                                                 |

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1 INTRODUCTION

1.1.1 The HMVS Cerberus was launched in 1868 and served 55 years in the Victoria Navy and Royal Australian Navy. In 1926 Cerberus was scuttled at Half Moon Bay and in 1993 Cerberus’ hull suffered extensive damage and collapsed in a storm. A brief investigation has been carried out into the preservation of this ship wreck and the findings are documented in this report.

1.1.2 Filling the interior with dredged sand has been selected as the preferred method for stabilisation and preservation. The two greatest strengths of this solution, in terms of the project requirements, are that it will make the wreck safe by eliminating any risk of divers being able to enter the wreck and secondly, it is reversible.

2 SOLUTION 1 - DREDGED SAND FILL (PATCH UP HOLES)

2.1 Introduction

2.1.1 A solution proposed and discussed in the 1994 report written by A.R. Colquhoun & Associates (Ref 1) was to fill the ship with dredged sand. The sand would transfer the load carried by the weather deck to the seabed.

2.1.2 Colquhoun presented the dredged sand fill solution with a reinforced concrete wall on braced cement foundations supporting and sealing the wreck so the sand could not leak (Figure 1).

2.1.3 BMT is proposing a variation of this solution; instead of a concrete wall to prevent leaking sand, the holes present in the hull will be patched by divers. The sealed hull will then be pumped full of dredged sand which must be compressed sufficiently to ensure load transfer from the deck.

Figure 1 - Section view of Solution 1
2.2 **Strengths**

2.2.1 Solution 1 has the advantage of improving the safety of the site as access holes will be blocked, which should result in fewer injuries and fatalities.

2.2.2 BMT presents Solution 1 as a reversible solution, as the sand that is pumped into the ship can also be pumped out of it.

2.2.3 Solution 1 is an aesthetically pleasing design as there will be no external structures added around the vessel to encapsulate the sand. Visually, how Cerberus appears from the shore will be fully maintained, which is a major priority of the Save the Cerberus Alliance.

2.2.4 Solution 1 is likely to be the cheapest to implement.

2.2.5 This option should be an effective long-term solution, providing that no more holes emerge in the hull skin.

2.3 **Risks / Weaknesses**

2.3.1 In 1994 Dr Ian McLeod performed measurements of residual iron thicknesses on HMVS Cerberus and concluded that it was in a severely corroded state (Ref 2). Therefore, the hull skin may be too brittle for under water welding or other methods of attaching steel work to patch the existing holes.

2.3.2 Due to the vessel’s corroded state there is significant risk that more holes in the hull skin will develop over time. This would dramatically impact the effectiveness of the solution as the hull could experience major sediment seepage. A consequence of this may be ongoing maintenance costs to constantly monitor and patch any new holes and fractures, as well as the need to top up the levels of dredged sand to compensate for any leakages.

2.3.3 Currently, only limited information is available regarding the quantity and locations of the fractures and holes in the hull skin of HMVS Cerberus. BMT D&T has developed a document of underwater photographs taken from a recent DSTO dive survey which provides some insight into its condition (Ref 3).

2.3.4 The implementation of Solution 1 requires divers to work outside and/or just inside the ship. There are some risks of divers being in close proximity to the ship whilst work is underway which could present potential dangers.

3 **SOLUTION 2 – REINFORCED SAND BAG WALL**

3.1 **Introduction**

3.1.1 For this solution BMT proposes that the exterior of the hull be sand bagged up to the height of the main deck. To hold these sand bags against the hull, steel poles would be driven into the sea floor at regular intervals and then a geotextile fabric or shade cloth would be wrapped around the entire structure. This will essentially form a reinforced sand bagged wall (See Figure 2). Once this has been completed the interior of the vessel would be filled with dredged sand.
3.2 **Strengths**

3.2.1 Solution 2 will significantly improve the safety of the site as it will completely remove any risks associated with scuba divers entering the ship wreck in future.

3.2.2 BMT presents this as a partially reversible solution. The sand can be pumped out of the vessel and the sand bags and external wrapping material removed, however, the steel poles in the sea floor are more difficult to remove.

3.3 **Risks / Weaknesses**

3.3.1 Sand bags are often used to stabilise underwater archaeological sites, however, the choice of material (e.g. Cotton versus ultra-violet (UV) stabilized polymeric sand bags) and the method of deployment is very important. It would be critical that synthetic sand bags are used as any made of natural material will degrade rapidly, probably within months.

3.3.2 As stated above sand bags have a tendency to degrade over time so the long term viability of this solution is not fully known.

3.3.3 This solution may not be as aesthetically pleasing as some of the other alternatives. The reinforced sand bagged wall will protrude above the water line and may detract from some of the visual appeal when viewing the ship wreck.
3.3.4 Deployment of sand bags is often expensive with regard to labour hours, the need for specialist divers and / or equipment and also the difficulty of moving the sand bags underwater.

3.3.5 The material used to wrap around the steel poles would need to be of a fine enough grade to prevent sand from seeping out from within gaps in the sand bag wall. If this cannot be achieved then there may be large maintenance costs incurred from topping up the dredged sand inside the vessel.

4 SOLUTION 3 - CRASH BARRIER WALL

4.1 Introduction

4.1.1 Solution 3 is modelled around a method trialed in the in situ preservation and reburial of the ex-slave ship ‘James Matthews’ located on the north side of Woodman Point in Cockburn Sound, WA. This concept was proposed by Richards and Winton (Ref 4) and utilises chemically and environmentally inert, interlocking medium density polyethylene ‘crash barrier’ units (See Figure 3). The trial involved setting up a test square (Figure 4) situated in close proximity to the intended site, with the aim of implementing the method on a large scale if successful.

4.1.2 These crash barrier units would be constructed into a ring-like arrangement using a pin and hinge system around the periphery of the wreck site. To achieve the required height around the wreck it would require 3 crash barrier units stacked on top of each other. The units would need to be filled with sand to weigh them down and give the structure more rigidity.

Figure 3 – Crash Barrier unit
4.1.3 The crash barrier wall would be wrapped with a marine grade geotextile to hold the units in shape and to minimize sediment loss through gaps within the units.

4.1.4 Once the wall had been constructed, the interior would be filled with dredged sand to above high water level (inside the hull and between the hull and the crash barrier wall).

4.2 **Strengths**

4.2.1 Initial findings from the in-situ preservation of the ‘James Matthews’ found that this ring-like arrangement was structurally very stable, able to withstand wave loading and scouring, and maintained the enclosed depth of sand over time (*Ref 4*).

4.2.2 BMT presents Solution 4 as a reversible solution, as the sand that is pumped into the ship can also be pumped out of it. The crash barrier unit wall could also be deconstructed and removed if required.

4.2.3 Solution 3 will significantly improve the safety of the site as it will completely remove any risks associated with scuba divers being in close proximity to the ship wreck.

4.3 **Risks / Weaknesses**

4.3.1 This solution may not be as aesthetically pleasing as the crash barrier wall will protrude above the water line which will impact onto how the ship wreck appears from the shore.

4.3.2 The sea bed may contain inconsistencies which might make it hard to construct the interlocking ring of units. More information would need to be sought to determine the gradient of the sea floor around the periphery of the vessel.

4.3.3 The method of deployment of the crash barrier units is likely to be expensive and would require specialist cranes to manoeuvre them into place.

---

*Figure 4 - Test square (sourced from Reference 3)*
4.3.4 Environmental impact studies would need to be conducted to look at the effects of introducing these units into the marine environment.

4.3.5 The material used to wrap around the crash barrier units would need to be of a fine enough grade to prevent sand from seeping out. If this cannot be achieved then there may be large maintenance costs incurred in topping up the dredged sand inside the vessel.

### SOLUTION 4 - BREAK WATER ROCK WALL

#### 5.1 Introduction

5.1.1 This solution involves creating a man-made rock wall (See Figure 5) around the exterior of the hull and then filling the interior with dredged sand.

5.1.2 It is proposed that rocks be placed around the periphery of the hull on the sea floor and then built up in a suitable profile for them to reach the highest hull fracture or lowest point on the weather deck.

5.1.3 The rock wall needs to be sufficient enough to ensure minimal to no sand outflow from the wreck. It may need to be externally patched with concrete to fill any gaps or covered in a geotextile/polymeric material if it is found that sediment loss through the wall is likely to be significant.

![Figure 5 - Example of man-made rock wall](image)

#### 5.2 Strengths

5.2.1 This solution is quite natural in appearance and would blend into the surrounding environment.

5.2.2 Solution 4 is a reversible solution. The sand that is pumped into the ship can also be pumped out of it and the rocks removed if required.

5.2.3 Rocks and boulders are readily available and should be relatively cost effective in comparison to some of the other alternatives for constructing a similar wall type structure.
5.3 Risks / Weaknesses

5.3.1 Potential for high maintainability costs if there is significant seepage of sediment from gaps within the rock wall. The solution would need to be monitored once implemented to record the losses of sand through the wall.

5.3.2 Installation and manoeuvring of the rocks may prove to be difficult and expensive. This solution would most likely require specialist cranes mounted on a barge to lift and position the boulders into place.

5.3.3 The rock wall will not protrude above high tide water level around the extremity of the hull, therefore the ship wreck will still be exposed to waves crashing over it and tidal movements. This could result in the dredged sand being washed out of the vessel and carried away which will ultimately reduce the effectiveness of the solution over time.

6 SOLUTION 5 - SHEET PILING

6.1 Introduction

6.1.1 Solution 5 proposes that a sheet piling wall be erected around the boundary of the ship wreck and then the interior of the wall (including the hull itself) would be filled with dredged sand. Sheet piling is a form of driven piling using thin interlocking sheets of steel to obtain a continuous barrier in the ground, as can be seen in Figure 6 below.

![Figure 6 - Examples of Sheet Piling](image)

6.2 Strengths

6.2.1 The main application of sheet piles is in retaining walls and cofferdams erected to enable permanent works to proceed. It is a proven method and has been widely used in marine / coastal environments.

6.2.2 This is the most desirable solution in terms of being able to fully contain the dredged sand within the constraints of the wall. If done properly there should be no seepage from the wall.
6.2.3 An interlocking sheet pile wall is very strong and would be able to withstand any wave forces and / or loads resulting from the entrapped sand.

6.3 Risks / Weaknesses

6.3.1 While this is an effective long-term solution to the problem, it is not easily reversed.

6.3.2 Initial enquiries suggest that this would be an expensive solution. Normally a vibration hammer, T-crane and a crawler drill are used to establish sheet piles and it is likely that there would be high mobilisation and operating costs associated with this equipment.

6.3.3 Aesthetically this may not be the most pleasing solution. The sheet piles will protrude out of the water and will impact onto how the ship wreck appears from an onlooker’s perspective.

6.3.4 Environmental impact studies would need to be carried out to show how the introduction of this material effects the marine environment.

6.3.5 The sheet piles will need to be coated to prevent them from corroding over time.

7 CONCLUSION

7.1.1 Of the solutions presented in this report, BMT recommends that Solution 4 is implemented on HMVS Cerberus. Solution 4 is likely to fall within the budget, is reversible, satisfies the turret load transfer requirements and reduces both the likelihood and severity of risks associated with the ship wreck.

7.1.2 Solution 1, the dredged sand fill with patched up holes option, is likely to be the cheapest to implement. However, it carries numerous major risks associated with patching up an already severely corroded hull.

7.1.3 Although Solution 5 is the most effective solution in containing the dredged sand, BMT understands that it will most likely be unpopular due to its irreversibility, appearance and high cost.

7.1.4 Of the cost effective solutions, Solution 4 is the most visually appealing because of its natural appearance.

8 RECOMMENDATIONS

8.1.1 BMT recommends a diving survey is carried out to confirm the feasibility of the most desirable solutions. The solutions presented in this report are concept designs only and diving surveys are necessary to confirm whether they can be successful or not.

8.1.2 BMT recommends that Solution 4 is developed further with a breakdown of detailed planning and implementation costs.
9 REFERENCES


2. Corrosion of the HMVS Cerberus (1926), Dr Ian Donald MacLeod, Department of Materials Conservation, Western Australian Museum, April 1995.


ANNEX B

HMVS CERBERUS UNDERWATER DIVE SURVEY REPORT, BMT DESIGN & TECHNOLOGY, REFERENCE: OPS/I/BCC/12019/R0663, COMMERCIAL IN CONFIDENCE, JUNE 2013
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**AUTHOR**

LACHLAN STAMMERS

**CHECKED**

JESSE MILLAR

**CERTIFIED**

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2 DIVE SURVEY FOOTAGE ANALYSIS 1
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Figure 1 - Image location diagram 2
1 INTRODUCTION

1.1.1 The *HMVS Cerberus* was launched in 1868 and served 55 years in the Victoria Navy and Royal Australian Navy. In 1926 *Cerberus* was scuttled at Half Moon Bay and in 1993 *Cerberus’* hull suffered extensive damage and collapsed in a storm.

1.1.2 A dive survey was conducted by DSTO (*Ref 1*) to assess the current state of the ship wreck. BMT has analysed the underwater footage to try and determine the quantity and severity of fractures and holes present in the hull skin of HMVS Cerberus. This report contains screen shots from that footage and an associated diagram which approximately maps the corresponding locations of the images.

2 DIVE SURVEY FOOTAGE ANALYSIS

2.1.1 The main aim when analysing the videos taken during the DSTO underwater survey was to attempt to identify any obvious holes, fractures or voids in the hull skin that could allow sediment to escape once the wreck has been pumped full of dredged sand.

2.1.2 The footage also provided insight into the profile of the sea floor immediately surrounding Cerberus. In several of the images it can be seen that there are large pieces of debris and rubble littered alongside the wreck.

2.1.3 Screen shots were captured from various points of interest around the wreck to assist in further developing a preservation solution.

2.1.4 The image locations have been recorded in Figure 1 below, however, it was difficult to establish accurate reference points throughout the underwater survey so the positions of the images should be treated as approximations only.
HMVS Cerberus Dive Inspection

Location of photos: 1 - 34

Figure 1 - Image location diagram
3 DIVE SURVEY IMAGES

3.1.1 Image 1

3.1.2 Image 2
3.1.3 Image 3

3.1.4 Image 4
3.1.5 Image 5

3.1.6 Image 6
3.1.7 Image 7

3.1.8 Image 8
3.1.9 Image 9

3.1.10 Image 10
3.1.11 Image 11

3.1.12 Image 12
3.1.13  Image 13

![Image 13](image13)

3.1.14  Image 14

![Image 14](image14)
3.1.15   Image 15

3.1.16   Image 16
3.1.17  Image 17

3.1.18  Image 18
3.1.19 Image 19

3.1.20 Image 20
3.1.21 Image 21

3.1.22 Image 22
3.1.23 Image 23

3.1.24 Image 24
3.1.25  Image 25

3.1.26  Image 26
3.1.27 Image 27

![Image 27](image-url)

3.1.28 Image 28

![Image 28](image-url)
3.1.29  Image 29

3.1.30  Image 30
3.1.33 Image 33

3.1.34 Image 34
4 CONCLUSION

4.1.1 The images taken from the DSTO dive survey suggest that the majority of the holes, fractures and voids in the hull skin are located within the constraints from the sea floor, to a height of approximately 1 metre.

4.1.2 The breast work appears to be in good condition and no major holes were identified in its structure.

4.1.3 Large amounts of sea weed were present on exterior of the hull and it is unknown whether there are any additional holes underneath this.

4.1.4 BMT found that there were considerably more holes and voids in Cerberus’ hull on the seaward side of the vessel. It can also be seen from the images that more rubble and debris alongside the hull is present on the seaward side of the vessel.

5 REFERENCES

1. Dive Camera HMVS Cerberus Disc 1, 2 & 3, Maritime Platforms Division, DSTO Defence Science and Technology Organisation, Fishermans Bend, Victoria, April 2013.
ANNEX C

HMVS CERBERUS SHIPWRECK STABILISATION FEASIBILITY ASSESSMENT,
BMT JFA, 28 JUNE 2013
1 Introduction

BMT JFA Consultants (BMT JFA) have carried out a brief feasibility assessment of the solution proposed by BMT Design and Technology (BMT D&T) for the long term preservation/stabilisation of the HMVS Cerberus shipwreck, to construct a low lying rock wall surrounding the base of the shipwreck and fill the shipwreck with sand.

The HMVS Cerberus shipwreck is located approximately 300 meters offshore from Half Moon Bay, Port Phillip Bay, Victoria. The shipwreck suffered extensive damage during a storm in 1993 resulting in some structural collapse. A major consideration for preserving the shipwreck is that the solution must be reversible as there is a view to raise the shipwreck and fully restore it should financial backing be sourced. The solution also should prevent further degradation of the shipwreck, prevent access to the shipwreck, thus improving safety of recreational users of the site (e.g. SCUBA divers), and provide structural support in order to prevent the turrets and support structure from collapsing through the weather-deck.

It should be noted that this assessment is intended be high level, to be used for justification to progress the project to the detailed design phase, highlight any major risks and estimate budget costs for construction/implementation works. During detailed design it would be expected that further refinement and optimisation of the construction methodology and design could be undertaken.

This technical note presents the following:

- Methodology for construction of a low lying rock wall surrounding the HMVS Cerberus shipwreck and filling of the shipwreck with sand.
- Estimated construction costs for carrying out this methodology.
- Identification of key risks/issues.
- Construction methodology and estimated construction costs of BMT JFA’s proposed alternative solution of a low lying geotextile sand container (sand bag) structure and sand fill.

2 Key Assumptions

The following general assumptions were made regarding the project and project site:

- Geotechnical information is not available, however based on the information provided the seabed is assumed to be relatively uniform sand.
The risk of scour is not considered to be significant and has not been considered.
The armour belt is capable of supporting the internal load from the sand to be pumped into the hull.
The impact of tidal currents is assumed to be negligible.
Average depth from the seabed to water level of 2.5m.
12 hour working days, 6 day working weeks.

An additional 20% contingency has been included in each of the costs presented in this technical note. Note that all costs discussed in this technical note are GST exclusive.

3 Construction Methodology

This section details the recommended construction methodology for the low lying rock wall and sand fill solution. The following assumptions have been made regarding the construction methodology:

- There is sufficient space at Half Moon Bay for the required volume of rock to stockpiled (approximately 300m³);
- There are the appropriate facilities on site to accommodate loading of a small flat top barge with rocks using a front end loader without requiring significant temporary works.
- Bulk heads within the shipwreck are not intact such that the vessel can be filled with sand by pumping slurry into the various access points outlined in Section 3.2.
- All of these access points are readily accessible by personnel and it is considered safe to do so.
- The armour belt on the hull of the HMVS Cerberus is assumed to be intact with minimal holes/voids in the hull of the vessel above one meter above the seabed.

3.1 Low Rock Wall

The construction methodology has been developed based on use of a small flat-top barge, with support vessel, to transport rock from shore to the HMVS Cerberus shipwreck and a 20 tonne excavator stationed on the deck of the flat-top barge transferring and placing rocks on the seabed against the base of the hull of the shipwreck, constructing the rock wall.

The flat-top barge will be loaded with stockpiled rock at the shore (this is to be investigated and confirmed during detailed design) by a front end loader. Rocks will be loaded onto designated area on the deck of the flat-top barge.

A layer of geofabric is to be placed, and anchored, against the shipwreck prior to the placement of rock such that the geofabric forms a seal against the hull of the shipwreck preventing sand from passing through the rock wall. The rock wall is to be built up to a height of one meter above the seabed. It is envisaged that all of holes/voids in the shipwreck are situated within approximately one meter of the seabed. Above this level the armour belt on the hull of the HMVS Cerberus is assumed to be intact with limited holes/voids.

Following construction of the rock wall a diver inspection survey is to be undertaken to identify gaps in the structure. The construction plant will remain on site during this survey and finalise the structure by placing additional rocks in any gaps identified by the divers.
3.2 Sand Fill Methodology

The methodology for filling of the HMVS Cerberus shipwreck with sand has been developed based on use of slurry pump, with two support vessels and a team of divers manually directing the pump outlet and flow of sand into the shipwreck.

It is envisaged that approvals will be granted for sand fill to be sourced from the seabed within an area of approximately a 150 meter radius of the shipwreck. A slurry pump will be situated on a support vessel and the intake placed on the seabed. A mixture of sea water and sand ‘sucked up’ from the seabed will be pumped into the shipwreck.

Sand will be pumped into the shipwreck via 5 different access points located on the weather-deck and breastwork deck:

- The forward hatch.
- The aft hatch.
- The boiler room (stoker hold) outlet.
- The aft breastwork deck companionway.
- The coal loading chute.

Based on ROV survey reports, the majority of the remaining separate compartments within the shipwreck can be filled with sand with this methodology.

It is noted that the angle of the outlet may need to be altered on several occasions during pumping, directing flow to ensure that all of the compartments are filled. Sand will be pumped into the space between the breastwork deck and weather-deck to as high level as possible to maximise structural support for the turrets and superstructure.

3.3 Additional Tasks

Given the large amount of debris situated on the seabed in the vicinity of the shipwreck BMT JFA recommend that a debris removal/recovery campaign is undertaken prior to the commencement of construction works.

In order to prevent access to the shipwreck each of the access points will be sealed following completion of the sand fill methodology.

4 Construction Cost Estimates

Estimated costs for construction of the proposed low rock wall and sand fill solution are provided in Table 4-1.
Table 4-1: Estimated costs for the Low Rock Wall and Sand Fill Solution

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<tr>
<td>4.0</td>
<td>Additional Costs</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>4.1</td>
<td>Construction Supervision Costs</td>
<td>15</td>
<td>%</td>
<td>$294,760.00</td>
<td>$44,214.00</td>
</tr>
<tr>
<td>4.2</td>
<td>Environmental Monitoring Costs</td>
<td>15</td>
<td>%</td>
<td>$294,760.00</td>
<td>$44,214.00</td>
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<tr>
<td></td>
<td><strong>Sub Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>$88,428.00</td>
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<tr>
<td></td>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td>$383,188.00</td>
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<tr>
<td></td>
<td><strong>+ 20% contingency</strong></td>
<td></td>
<td></td>
<td></td>
<td>$76,637.60</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL COST (exc. GST)</strong></td>
<td></td>
<td></td>
<td></td>
<td>$459,825.60</td>
</tr>
</tbody>
</table>
5 Identification of Risks and Issues

The major risk associated with filling the shipwreck with sand is that it may not be possible to fill the shipwreck with sand up to the level of the breastwork deck (currently slightly above the average water level) and provide the required structural support beneath the breastwork deck to prevent the turrets and superstructure from collapsing. This is an intended outcome for preservation of the shipwreck and hence needs to be considered in detail.

A second sand pumping regime focussed on the area enclosed by the weather-deck and the breastwork deck may be required. This could be undertaken after the original sand pumped into the shipwreck has settled. However, this material may still not reach the underside of the breastwork deck.

Another option is to insert an oblong-shaped large geotextile container into this area and pump it full of sand so that the unit exerts upward pressure onto the breastwork deck. However, this may be difficult to carry out without entering the shipwreck and may result in the geotextile container exerting force outwards on the hulls as well us upwards onto the breastwork deck.

Various other risks and issues that have been identified are outlined below:

- The armour belt on the upper exterior of the shipwreck has been assumed to be intact. However, there is a considerable risk that there are holes/voids in this material or holes/voids may develop whilst the shipwreck is filled with sand. BMT D&T may wish to include a nominal allowance for sealing of these holes/voids if required during construction.
- There lies some risk that the shipwreck may be damaged whilst the excavator is placing rocks against the base of the hull.
- Given the relatively short duration and high daily costs, delays to the construction program due to inclement weather/sea-state could dramatically increase construction costs. In this regard, BMT D&T may wish to schedule construction works during a period of historically benign met-ocean conditions.
- The ROV survey reports generally indicate that access to the turrets from either the aft hatch or the forward hatch is generally possible and the area beneath the breastwork deck is relatively clear, with the ROV being able to descend down approximately to the seabed with little difficulty. However there may be some issues with filling the bow and stern ends of the vessel (aft of the aft hatch and forward of the forward hatch, respectively) with sand, particularly if bulk heads in these areas or more intact than others.
- The approvals process for sourcing sand fill from the seabed within the approximate vicinity of the shipwreck may require some consideration. Local benthic habitat surveys and small scale diver investigation will be required to identify a suitable borrow area.
- The environmental approvals to pump sand into the shipwreck may require a silt curtain to be installed around the work area in order to contain turbidity. The cost of has not been included, but should be within the cost contingency allowances.
6 Discussion

As shown in Table 4-1 the estimated construction cost of the low lying rock wall and sand fill solution is $459,825.60 and the estimated duration for construction is 3 weeks.

BMT JFA recommend that if not already available, a hydrographic survey of the seabed levels surrounding the HMVS Cerberus shipwreck, Half Moon Bay and the various marine infrastructure in the surrounding vicinity be undertaken prior to constructions works.

In addition to sourcing sand from the seabed within the approximate vicinity of the shipwreck there may be some option to source sand from to the berths and jetty area at the Black Rock Yacht Club in shallow areas where the yacht club may benefit from removal of material. This is to be confirmed during detailed design, it is noted that contaminant testing of this material would be required.

The low lying rock wall option represents a generally feasibly solution for stabilisation of the HVMS Cerberus shipwreck, with some associated risks (refer Section 5). However in addition to these risks, sourcing and delivery of suitable rock material may prove difficult given that a relatively small volume (approximately 300m$^3$) of rock is required. Moreover, the relatively low quantity of rock is likely to result in a high unit cost. BMT JFA also does not consider rock to be an ideal material to seal the holes in the base of the shipwreck, without geofabric placement.

In this regard an alternative solution of a geotextile sand container (or sand bag) structure is proposed.

6.1 Low Lying Geotextile Sand Container Structure and Sand Fill

BMT JFA proposes an alternative solution of low lying structure comprised of geotextile sand container (GSCs) or sand bags. GSCs are geofabric bags filled with sand or other material to form a brick-like unit. GSCs are typically individually filled onsite, using a small excavator, manually sealed and placed either individually with an excavator fitted with a specialised grab attachment, or bundled and placed several units at a time, using a cargo net.

As shown in Figure 6-1, GSCs form a relatively flat shape which is generally similar to the shape of the holes/voids at the base of the shipwreck. Hence GSCs are considered to be more suited to the application of sealing holes/voids than rocks, which are generally cubic shape.

Figure 6-1: Left: Construction of a coastal structure with geotextile sand containers. Right: Typical shape of a hole/void at the base of the HMVS Cerberus shipwreck.
The construction methodology for the proposed GSC and sand fill solution has also been developed based on use of a small flat-top barge, with support vessel, to transport the GSCs from shore to the shipwreck and a 20 tonne excavator to place the bundled GSCs, either directly place or bundled in cargo nets.

The GSCs are to be filled on shore using a small excavator, delivered sand fill and sealed manually by a working crew. The GSCs will be loaded into a cargo nets onshore and transferred to the flat top barge during loading.

A layer of geofabric is to be placed between the GSC structure and the hull of the shipwreck.

The sand fill methodology and additional tasks are as presented in Sections 3.2 and 3.3.

6.2 General Comments on GSCs

The option of a sand bag wall has been previously considered by BMT D&T however the risk of the sand bags deteriorating over time was highlighted. Given that GSCs are commonly used for artificial reefs and coastal protection BMT JFA do not consider this to be significant risk, particularly if a UV stabilised fabric is used.

This option was also previously presented based on piling GSCs up to the height of the main deck and using steel poles driven into the sea floor to contain/reinforce the structure. Given that a structure of only 1 meter in height is required, reinforcing of the structure is not required.

Note that the construction methodology has been developed based on use of imported sand to fill the GSCs.

This solution has generally the same associated major risks and issues as the low lying rock wall option.

Estimated costs for construction of BMT JFA’s proposed GSC and sand fill solution are provided in Table 6.1.

Table 6-1: Estimated costs for the GSC Structure and Sand Fill Solution

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QTY</th>
<th>UNIT</th>
<th>RATE</th>
<th>AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Preliminaries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Preparation of HSE Management Plans, Environmental Monitoring Plans etc.</td>
<td>1</td>
<td>LS</td>
<td>$ 20,000.00</td>
<td>$ 20,000.00</td>
</tr>
<tr>
<td>1.2</td>
<td>Preliminaries, Mobilisation and Demobilisation of Construction Barge</td>
<td>1</td>
<td>LS</td>
<td>$ 27,200.00</td>
<td>$ 27,200.00</td>
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<tr>
<td>1.3</td>
<td>Mobilisation and Demobilisation of Barge Workboat</td>
<td>1</td>
<td>LS</td>
<td>$ 18,000.00</td>
<td>$ 18,000.00</td>
</tr>
<tr>
<td>1.4</td>
<td>Mobilisation and Demobilisation of Light Support Vessel</td>
<td>1</td>
<td>LS</td>
<td>$ 10,000.00</td>
<td>$ 10,000.00</td>
</tr>
<tr>
<td>1.5</td>
<td>Mobilisation and Demobilisation of 20 Tonne Excavator</td>
<td>1</td>
<td>LS</td>
<td>$ 5,000.00</td>
<td>$ 5,000.00</td>
</tr>
<tr>
<td>1.6</td>
<td>Mobilisation and Demobilisation of Small Excavator</td>
<td>1</td>
<td>LS</td>
<td>$ 4,000.00</td>
<td>$ 4,000.00</td>
</tr>
<tr>
<td>1.7</td>
<td>Delivery of GSCs to Site and Mobilisation/Demobilisation of GSC Assembly Crew</td>
<td>1</td>
<td>LS</td>
<td>$ 6,000.00</td>
<td>$ 6,000.00</td>
</tr>
<tr>
<td>1.8</td>
<td>Recover/clear debris on seabed prior to construction (1 Day, 2 divers)</td>
<td>1</td>
<td>Days</td>
<td>$ 4,000.00</td>
<td>$ 4,000.00</td>
</tr>
<tr>
<td>1.9</td>
<td>Light Support Vessel and Crew for debris recovery/clearing</td>
<td>1</td>
<td>Days</td>
<td>$ 2,500.00</td>
<td>$ 2,500.00</td>
</tr>
</tbody>
</table>
As shown in Table 6-1 the estimated construction cost of the low GSC structure and sand fill solution is $452,959.20 and the estimated duration for construction is 3 weeks.

7 Conclusion and Recommendations

As shown in Table 4-1 and Table 6-1 the estimated construction cost and duration for both the rock wall GSC structure solutions are comparable. In addition to this, supply of geotextile sand containers is considered a simpler process than importing approximately 300m³ of rock. The risk of shifting of the GSCs, relative to rock, once place is also considered to be lower.

In this regard, BMT JFA recommends that the low lying GSC structure and sand fill option be given further consideration for construction and detailed design development.
ANNEX D

BMT WBM ENVIRONMENTAL WORKS QUOTE, 12 JUNE 2013
Dear Jake,

Request for Quotation - HMVS Cerberus Wreck Stabilisation

As discussed, please find below our appreciation of the study and task requirements associated with the HMVS Cerberus Wreck Stabilisation project. A qualified fee estimate and a copy of relevant staff CVs are also provided.

Context

BMT WBM understands that:

- BMT Design and Technology (BMT D&T) have previously investigated several stabilisation/preservation alternatives for the Cerberus.
- BMT D&T’s proposed solution comprises the construction of an artificial rock wall around the exterior of the hull, followed by filling the interior with dredged sand.
- BMT D&T has requested BMT JFA:
  - Provide a quotation to assess the feasibility of the proposed solution.
  - Develop any alternate solutions if it is believed they would be more suited to the requirements of the project and the priorities of the Save the Cerberus Alliance.
- BMT JFA has requested BMT WBM provide a brief proposal regarding the likely environmental approvals requirements in terms of surveys, studies and permits for both the planning and implementation phases associated with the proposed solution.

Appreciation of Proposed Solution

From a review of BMT D&Ts RFQ dated 5 June 2013, BMT WBM understands that:

- Rocks would be placed around the boundary of the hull on the sea floor and then built up in a suitable profile for them to reach the highest hull fracture or the lowest point on the weather deck.
- The rock wall needs to be sufficient enough to ensure minimal to no sand outflow from the wreck. It may need to be externally patched with concrete to fill any gaps or covered in a geotextile/polymeric material if it is found that sediment loss through the wall is likely to be significant.
- Filling the interior with dredged sand has been selected as the preferred method for stabilisation and preservation. The two greatest strengths of this solution, in terms of the project requirements, are that it will make the wreck safe by eliminating any risk of divers being able to enter the wreck and secondly, it is reversible.
- Approximate volume calculations indicate an internal volume figure of 1519 cubic metres of sand is required to fill the hull in its current state.
- BMT has not been able to ascertain any information concerning flow rates of sand through the wreck.

Proposed Tasks

Based on our discussions of 11 June 2013 and a review of BMT D&Ts RFQ, we consider that the study will comprise the following tasks:
1. Undertake a desktop review of relevant reports and studies, including BMT D&T HMVS Cerberus Assessment of Sand Fill Options Report.

2. Engage with relevant BMT team members.

3. Provide input to the identification of a suitable borrow area for the sand.

4. Provide input into the development of the stabilisation methodology i.e. use of dredge or diver operated venturi lifts to load the dredged material.

5. Identify legislation / policy relevant to the proposed works – at this stage likely to include:
   - Environment Protection Act 1970
   - Planning and Environment Act 1987
   - Coastal Management Act 1995
   - Flora and Fauna Guarantee Act 1988
   - Fisheries Act 1995
   - Aboriginal Heritage Act 2006
   - Heritage Act 1995
   - Commonwealth Historic Shipwrecks Act 1976
   - Port Services Act 1995
   - Marine Safety Act 2010
   - Waste Management Hierarchy (established under the Environment Protection Act 1970)
   - Best Practice Environmental Management: Guidelines for Dredging (EPA, 2001)
   - National Assessment Guidelines for Dredging - NAGD (Commonwealth of Australia 2009)
   - State Environment Protection Policy (SEPP) (Waters of Victoria) Schedule F6 Waters of Port Phillip Bay (EPA 1999b).

6. Determine the environmental approvals required - at this stage likely to include:
   - Consent under the Coastal Management Act 1995. An application for consent must be prepared in accordance with the requirements outlined in the Coastal Management Act 1995 with specific regard to s.40(2). The Department of Environment and Primary Industries (DEPI – formally DSE) is the key decision making authority for the Coastal Management Act 1995 consent but they may refer the project to the EPA for advice.
   - Planning Permit exemption from Bayside City Council (assuming works are under $1M and no other triggers are encountered).
   - A permit Under Section 15 of the Commonwealth Historic Shipwrecks Act 1976 for Entry into a Protected Zone or Disturbance of a Historic Shipwreck or Relic.
   - A works authority from Parks Victoria - the local port manager and water way manager for the designated port of Port Phillip.
   - Permits under the FFG Act 1988 and the Fisheries Act 1995 are required for incidental take of protected species e.g. seahorses (Hippocampus Sp.).

7. Identify any assessment / information requirements associated with these approvals including
   - Biophysical and ecological field data to be collected
   - Management and monitoring plans / programs.

8. Undertake an assessment of the proposed works that incorporates the best practice approach recommended in the Best Practice Environmental Management: Guidelines for Dredging, the National Assessment Guidelines for Dredging - NAGD (Commonwealth of Australia 2009), and the environmental quality objectives of the SEPPs.
9. Develop the approval applications and supporting documentation for submission including:
   - Environmental Assessment and Management Plan
   - Marine Traffic Management Plan¹
   - Heritage Management Plan²

10. Revise reports/applications in line with approval agency feedback.

**Fee Estimate**

We estimate that this study will cost (Ex GST). A breakdown of our fee estimate is provided in Table 1.

<table>
<thead>
<tr>
<th>Task No.</th>
<th>Task Description</th>
<th>Fee Estimate</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Desktop review of relevant reports and studies</td>
<td>$4,000</td>
</tr>
<tr>
<td>2</td>
<td>Engage with relevant BMT team members</td>
<td>$2,000</td>
</tr>
<tr>
<td>3</td>
<td>Provide input to the identification of a suitable borrow area for the dredge sand</td>
<td>$2,000</td>
</tr>
<tr>
<td>4</td>
<td>Provide input into the development of the stabilisation methodology</td>
<td>$1,000</td>
</tr>
<tr>
<td>5</td>
<td>Identify legislation / policy relevant to the proposed works</td>
<td>$1,000</td>
</tr>
<tr>
<td>6</td>
<td>Determine the environmental approvals required</td>
<td>$1,000</td>
</tr>
<tr>
<td>7</td>
<td>Identify any assessment requirements</td>
<td>$1,000</td>
</tr>
<tr>
<td>8</td>
<td>Undertake an assessment of the proposed works</td>
<td>$12,000</td>
</tr>
<tr>
<td>9</td>
<td>Develop the approval applications and supporting documentation</td>
<td>$12,000</td>
</tr>
<tr>
<td>10</td>
<td>Revise reports/applications</td>
<td>$4,000</td>
</tr>
</tbody>
</table>

**Total** $40,000

**Qualifications**

Please note that:

- The identified tasks and fee estimate are based on our current appreciation of the project scope i.e. the use of dredged sand to fill the wreck following the construction of a rock wall.
- The estimate provided does not include any site visits, data collection and or processing costs.
- We have made allowances for a single set of review comments on any submitted reports or approval applications.
- We have assumed that Council will make payment of any fees associated with submission of applications to government. We have not included provision for such costs in our tendered price.
- No allowances to attend briefings outside of BMT have been included in our tender price. Should these be required, fees will be charge on a rates basis. (Andrew Costen hourly rate of $250).
- No modelling or other quantitative/semi-quantitative assessments will be undertaken.
- The development of the approval applications identified in Task 9 will be based on the results of the desktop study only.
- The development of a Heritage Management Plan is not included in this fee estimate. However, I can obtain a quote if required.

¹ To support the issuing of ‘a notice of regulation around works’ under section 211(1) of the Marine Safety Act 2012, Parks Victoria requires a Traffic Management Plan.
² To be developed by a suitable heritage consultant.
I trust the above information will satisfy your requirements. However, please don’t hesitate to contact me should you have any queries or require clarification regarding the content of this proposal.

Regards,

Andrew Costen
Manager
Marine and Coastal Environments
BMT WBM

Attachment: CV Andrew Costen