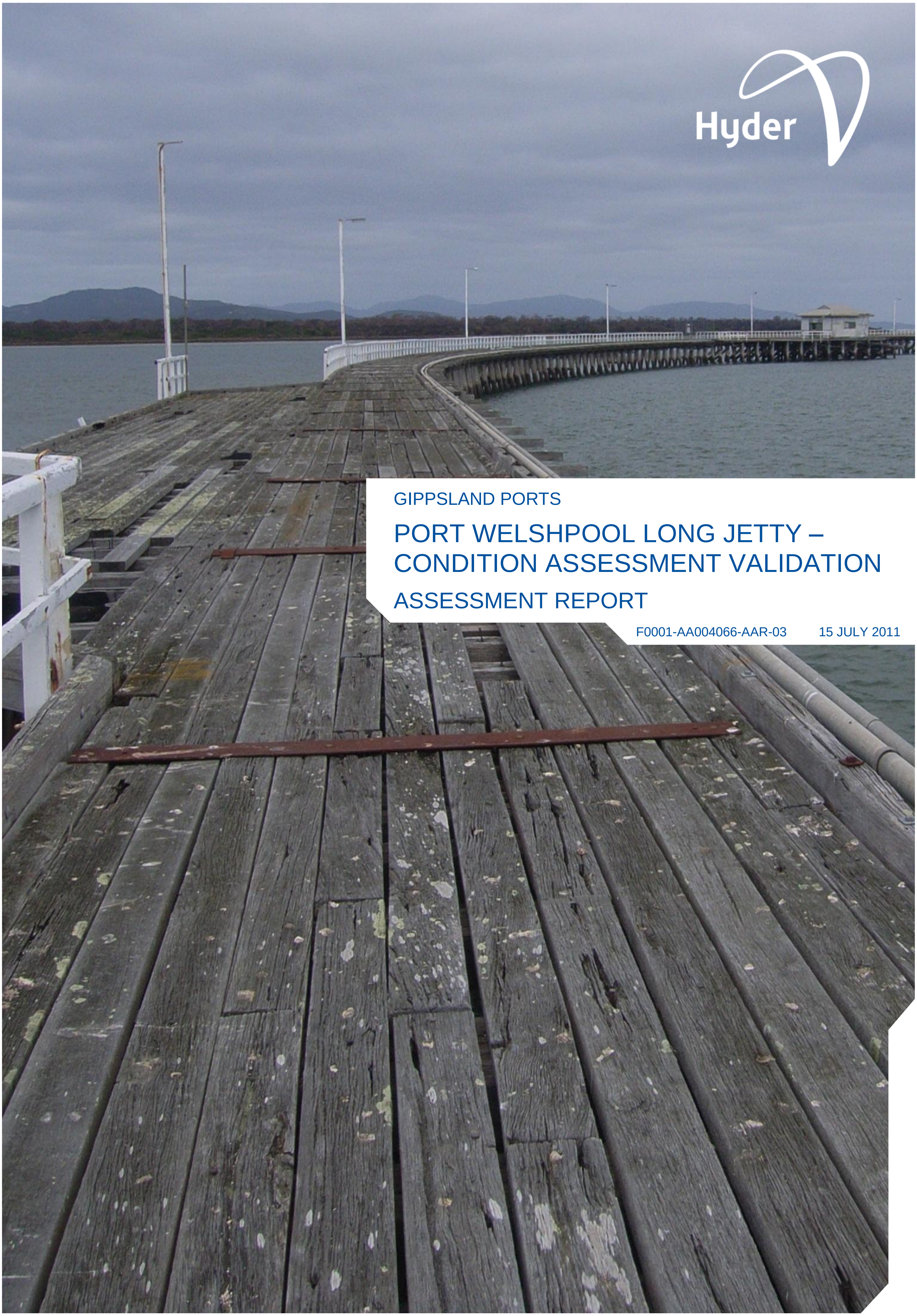

GIPPSLAND PORTS

PORT WELSHPOOL LONG JETTY – CONDITION ASSESSMENT VALIDATION

ASSESSMENT REPORT

F0001-AA004066-AAR-03 15 JULY 2011

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GIPPSLAND PORTS

PORT WELSHPOOL LONG JETTY - CONDITION ASSESSMENT VALIDATION

ASSESSMENT REPORT

Report No	F0001-AA004066-AAR-03
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CONTENTS

APPENDICES

EXECUTIVE SUMMARY

Hyder Consulting has been commissioned by Gippsland Ports to provide a detailed condition assessment of representative areas of the Long Jetty, in order to validate the condition of the structure and inform the preparation of rehabilitation options.

Condition assessments of the Long Jetty have been prepared in the past by consulting engineering firms. Each of these assessments was carried out for a specific purpose and varied in scope and detail. The significant differences and contradictions between the findings of the reports, precludes their reliable use a basis for developing feasible rehabilitation options – including the potential reuse of existing timber elements in the structure.

A desktop review of existing condition reports identified a number of issues that required further investigation. The reports were in agreement that the deck and transoms were in poor condition; however the assessments of the beams, crosshead and piles varied – especially concerning termite deterioration, pile top condition and degree of marine borer attack.

The main types of timber deterioration resulting in loss of strength in structural elements were confirmed as termite attack, rot and marine borer attack. Active termites were confirmed to be present. Marine borers present on the site were identified as Teredo worm and Limnoria. The level of deterioration in the structure increased moving away from the shore, especially in the case of the piles.

Timber species of the sampled piles were identified as yellow stringybark and messmate. Beam and crosshead elements are typically blue gum or silvertop ash. These species are not resistant to termite attack and have a moderate to low resistance to marine borer attack.

Based on current Australian Standards and Timber Design Guides all timber within the structure is beyond its useful life. However, observations of the performance of timber in local conditions are a better indication of its expected life. Based on our condition assessment, a high proportion of beam and crosshead elements are suitable for reuse in a rehabilitated structure, provided that measures are taken to prevent deterioration from termite attack and rot. Elements suffering a high degree of termite deterioration and rot should be removed and replaced. The majority of piles will have to be repaired with plastic wrap and concrete bags if they are to be retained. The piles used in the 1980s extension of the jetty and widening of the turning bay are highly deteriorated and will have to be replaced if these portions of the structure are to be retained.

For the rehabilitated jetty, each element nominated for retention should be assessed by a specialist timber biologist and structural engineer to ensure it does not contain any internal deterioration or defects. It is recommended that a termite management plan be developed with advice from a dedicated termite contractor, as all timber species within the superstructure of the jetty are highly susceptible to termite attack. An inspection and maintenance regime should also be developed and implemented to mitigate the risk of uncertainty in predicting the remaining life of the structure and ongoing rates of deterioration.

Deterioration of the piles in the inter-tidal zone is likely to be worse than observed, due to the limited length of pile exposed at low water during our investigations. Further pile inspections should be undertaken at extreme low tide to confirm the findings of this investigation. The extent of and integrity of existing concrete bag repairs below water level was unable to be determined form the site inspection. It is recommended that a pile inspection survey should be conducted by experienced divers to confirm the integrity of existing piles.

1 INTRODUCTION

Hyder Consulting has been commissioned by Gippsland Ports to provide a detailed condition assessment report of representative areas of the Long Jetty to validate the condition of the structure and inform the preparation of rehabilitation options.

Condition assessments of the Long Jetty have been prepared in the past by consulting engineering firms. Each of these assessments were carried out for a specific purpose and varied in scope and detail. The significant differences and contradictions between the findings of the reports, precludes their reliable use as a basis for developing feasible rehabilitation options – including the potential reuse of existing timber elements in the structure.

1.1 Scope of Services

To provide a condition assessment report on the sample of structural elements nominated by Gippsland Ports, in five specific inspection areas. This report details the following main items:

- Type of timber (species).
- Existing condition (type and extent of deterioration / marine organism attack).
- Suitability for re-use in a rehabilitated structure.
- Steps to take to enable reuse (treatments, etc.).
- Remaining expected life of reused elements.

The structural elements nominated by Gippsland Ports comprised the beams, crossheads, piles and diagonal bracing, along with the connections and bearing surfaces between these elements. The timber decking, transoms, handrails, fender piles, fenders, walers and services on the structure are excluded from the scope of the investigation as all previous condition assessment reports agreed that their condition is poor and they are unsuitable for rehabilitation.

Preparation of the condition assessment report also includes a desktop review of previous condition assessment and rehabilitation option reports commissioned by Gippsland Ports and the Victorian Department of Sustainability and Environment. The desktop review was carried out before the site investigation, to identify any specific items and discrepancies that required validation. Findings of the review are included in the report, along with comment on the validity of the findings from the results of the site investigation.

This report also contains a Disability Discrimination Act (DDA) compliance audit of the structure. The results of the audit and recommendations are included in Appendix F.

2 BACKGROUND

The Port Welshpool Long Jetty is a timber structure that was constructed over two years from 1936 to 1938, including a slipway to service fishing vessels working Corner Inlet. To accommodate additional vessels servicing the offshore oil and gas industry, a 60m long extension was constructed in the 1982 along with a passing bay on the approach section, an enlargement of the vehicle turning bay and a tank stand. The original slipway was demolished in the early 1980s and the extension subsequently closed and fenced off to the public in the 1990s, following the relocation of oil field support work. The jetty has been a popular site for recreational fishermen, however it was finally closed to the public in 2003 due to increased maintenance costs, reduced commercial use and the poor condition of the structure posing a risk to public safety.

Gippsland Ports' staff advised that the transoms and decking have been replaced throughout the life of the structure to maintain the structure in a serviceable condition. Several fires have resulted in damage to the structure, with the January 2010 blaze resulting in the partial removal of 8 bays of the structure.

A further description of the history of the Long Jetty can be found in *Long Jetty, Port Welshpool Stage 1 Heritage Advice* prepared for Gippsland Ports by David Helms Heritage Management and Planning in February 2010.

A timeline of the significant events in the life of the Long Jetty are summarised in Table 2.1.

Table 2.1: Timeline of events in the construction and modification of the Long Jetty

Year	Period	Event
1930	1936-1938	*Construction of the original Long Jetty from CH 0 to 865.* *Pier used to service trans-Tasman and coastal trades, along with fishing vessels.*
1940		*Minesweepers use the Pier as a base of operations during World War 2.* *Pier continued to be used to service trans-Tasman and coastal trades and Bass Straight fishing vessels after WWII.*
1950		
1960		*Vessels exploring for oil and gas in Bass straight begin to use the Jetty as a staging point.*
1970		*Discovery of oil reserves in Bass Straight* *Esso constructs the turning bay and tank stand (CH 760 and 810), along with a 60m Extension.* *Demolition of the Slipway.*
1980		*Construction of passing bay between CH 385 and CH 430.* *Additional, longer transoms added to the superstructure to support water and fuel pipes.*
1990	1993	*Extension to the original Jetty between CH 865 and 935 declared derelict and fenced off from the public.*
2000	2003	*Jetty closed to the public and fenced off by Gippsland Ports.*
2010	2010	*Portion of the Jetty between CH 760 and 790, including the low landing, damaged by fire and subsequently demolished.*

2.1 Structure Overview

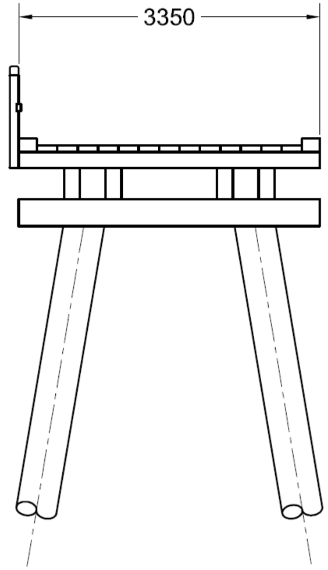
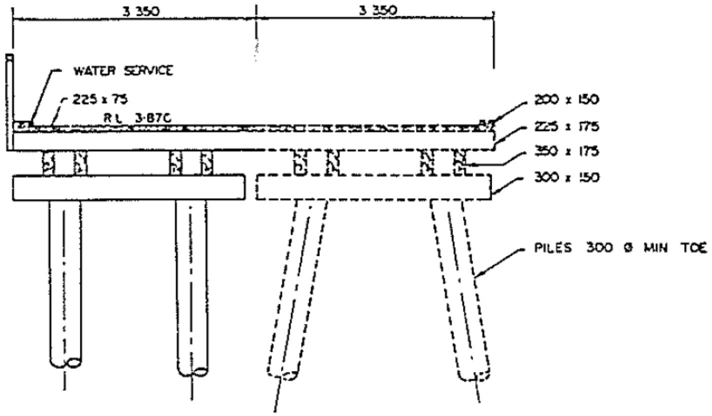
The Port Welshpool Long Jetty is located in Port Welshpool, Victoria. A site location plan and aerial view of the structure is presented in Figures 2.1.1 and 2.1.2.

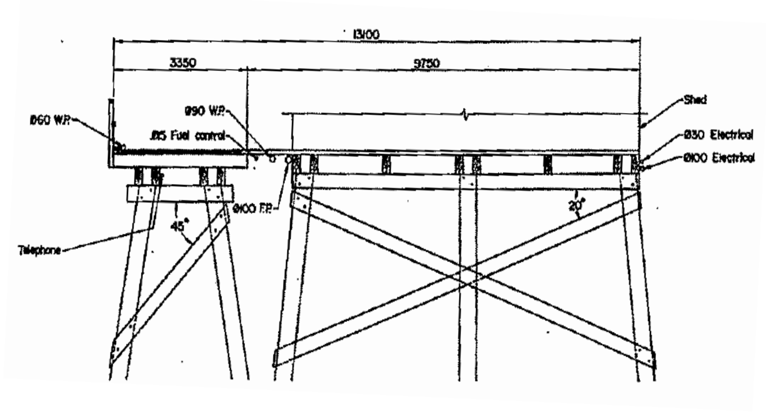
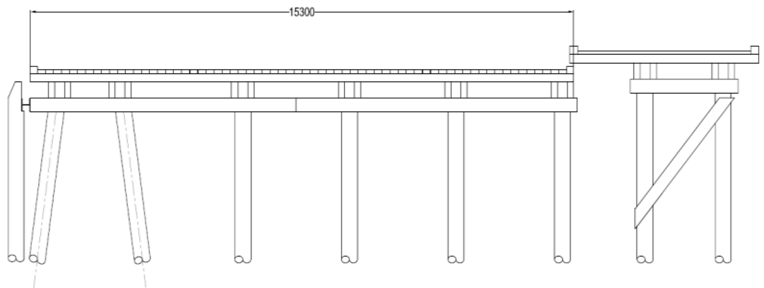
A brief overview of the structural arrangement of the Port Welshpool Long Jetty is provided in Table 2.2. The overview has been based on drawings of the structure provided by Gippsland Ports and confirmed during the course of the site investigation.

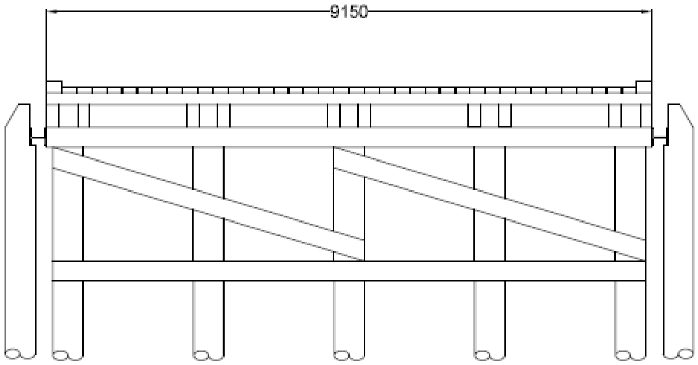
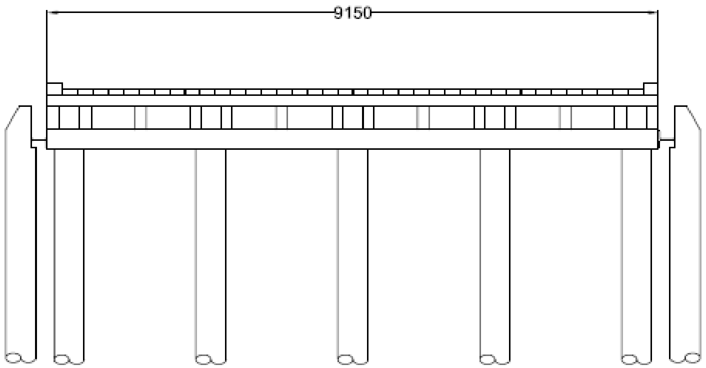
Figure 2.1.1: Port Welshpool Long Jetty Location Plan (Image courtesy of www.street-directory.com.au)

Figure 2.1.2: Port Welshpool Long Jetty Aerial View and Location Plan (Image courtesy of Google Maps)

Table 2.2: Summary of Long Jetty Structure

Section	Chainage	Details	Typical Cross Section
Approach Trestle	0 – 760	▪ Bents are spaced at 3.0m centres and each consists of two raked timber piles. ▪ Piles are capped by a pair of 300mm x 150mm timber crossheads, which rest on a checked-in seat and are bolted through the piles. ▪ Two pairs of 350mm x 175mm timber beams, bearing on the crossheads and checked in to the top of the piles. Beams are typically 6.0m long and joined over the piles by scarf joints, which alternate to ensure continuity over the crossheads in each pair. ▪ 225mm x 175mm timber transoms, spaced at 750mm centres, which bear on the beams and are connected to the beams with deck spikes or dumps. ▪ 13 longitudinal 225mm x 75mm deck planks and two kerb timbers, all of which were originally 6.0m in length and joined at the same location. The deck planks are spiked into the transoms, while the kerbs are bolted. At each joint a steel joint plate has been screwed to the deck planks.	
Passing Bay	381 – 427	▪ The passing bay increases the width of the jetty to 7.85m and was added in the 1980s. ▪ The type of construction duplicates that of the approach trestle section, except that the piles in each bent are vertical, rather than raked.	

Section	Chainage	Details	Typical Cross Section
Slipway Deck	590	▪ The slipway deck extends off the main trestle approach, is of similar construction to the trestle approach, and features 1 to 4 piles per bent. ▪ The slipway deck and associated building have been decommissioned.	
Diagonal Bracing	590 – 865	▪ The diagonal bracing begins in the trestle section, just before the sea bed begins to drop away to deeper water. The bracing continues to the end of the original structure.	
Low Level Landing	750 – 770	▪ This section of the structure was removed in March 2010, following fire damage suffered in January 2010.	No cross section available
Turning Bay and tank stand	770 – 820	▪ This extension to the original turning bay was constructed in the late 1970s or early 1980s. ▪ The section between CH 770 and CH 790 removed in March 2010, following fire damage suffered in January 2010. ▪ The Loading Deck is 15.3m wide and each bent typically consists of six vertical piles. ▪ The Original turning area features diagonal bracing. ▪ The tank stand structure is independent from the main structure and features two piles per bent, with diagonal bracing. ▪ The style of construction of the Loading Deck and Tank Stand superstructures is consistent which that of the Approach Trestle section. ▪ Fender piles and steel I-beam walers are present on the south side, which would have accommodated the berthing of oil exploration vessels.	

Section	Chainage	Details	Typical Cross Section
Original Loading Area	808 – 865	▪ This portion of the structure is 9.2m wide and each bent consists of five vertical piles, with diagonal bracing. ▪ The style of construction of the superstructure is consistent which that of the approach trestle section, however no handrails are present. ▪ Additionally fender piles and steel I-beam walers are present on both sides, which would have accommodated the berthing of oil exploration vessels. ▪ Bollards are present at deck level.	
60m Extension	865 – 935	▪ Constructed in 1982. ▪ Similar form of construction to the section between CH 808 – 846, except that there is no diagonal bracing between the piles. ▪ This area has been declared derelict and has been fenced off by Gippsland Ports.	

2.2 Existing Drawings

A list of the available drawings of the Port Welshpool Long Jetty is provided in Table 2.2. These drawings were reviewed in preparation for conducting the site investigation to identify any items that required particular attention.

Table 2.2: List of Existing Drawings

Drawing Number	Drawing Title
78-2159-01	Public Works Department of Victoria Welshpool Shipping Pier General Arrangement
81-2091-D1 C	Public Works Department of Victoria Welshpool Shipping Pier Site Plan
81-2091-D9 E	Public Works Department of Victoria Welshpool Shipping Pier Turning Bay Extension & Tank Farm
81-2091-D9	Public Works Department of Victoria Welshpool Shipping Pier Turning Bay Details/2
82-2010-W1	Public Works Department of Victoria Proposed Passing Bay General Arrangement
82-2015-W1 A	Public Works Department of Victoria Port Welshpool Shipping Pier As Built Details
82-2015-W2	Public Works Department of Victoria Port Welshpool Shipping Pier As Built Details
MEJ236-01S-DK001 B (prepared by KBR)	Gippsland Ports Port Welshpool Shipping Pier Pile Restoration Works Pile Plan
MEJ236-01S-DK002 B (prepared by KBR)	Gippsland Ports Port Welshpool Shipping Pier Pile Restoration Works Details

The General Arrangement drawing 82-2010-W1 indicated that all piles that were used in the construction of the passing bay between CH 381 and 427 were to be Yellow Stringy Bark (Y.S.B) and the timber elements of the superstructure to be Grade 14 Hardwood, of durability Class 4. Samples of the timber from the piles have been taken during the Site Investigation and tested to confirm the type of timber species used.

Pile jacketing is also known to have been undertaken on a number of piles in the original trestle section in drawing MEJ236-01S-DK001 B. The effectiveness of the jacketing largely depends on the quality of the installation and the extent over which the jacket is installed. The effectiveness of this repair detail will require further assessment during the site investigation.

2.3 Existing Reports

Prior to conducting the Site Investigation a desktop review of previous heritage and condition assessment reports on the structure was conducted. The reports that formed the basis of this review are listed below:

Condition Assessment Reports

Options Study Report, Port Welshpool Long Jetty Options Study, Revision 1, by Aurecon Australia Pty Ltd for Department of Sustainability and Environment, dated 28 June 2010.

Port Welshpool Long Jetty Economic Study – Interim Rehabilitation Report, Revision B, by Maunsell Australia Pty Ltd for Gippsland Ports, dated 30 October 2003.

Heritage Reports

Recording of Works Associated with the Demolition of a Section of the Long Jetty, Port Welshpool, H8120-0018¸ Final, by Terraculture Heritage Consultants for Gippsland Ports and Heritage Victoria, dated 27 April 2010

Long Jetty, Port Welshpool – Stage 1 Heritage Advice, Final, by David Helms Heritage Planning + Management for Gippsland Ports, dated 3 February 2010.

Deep Sea Pier, Port Welshpool, Heritage Assessment, by heritage ALLIANCE Heritage Consultants for Maunsell Australia Pty Ltd, dated October 2003.

The existing condition reports were reviewed with the intent of identifying discrepancies, contradictions and items that would require validation during the site investigation. A review of the reports is provided in the following sections, along with a summary of the items indentified for further investigation and the nature of the investigation to be undertaken.

2.3.1 Condition Assessment Reports

The report prepared by Aurecon was commissioned by the Department of Sustainability and Environment with the purpose of undertaking a structural assessment of the pier and preparing preliminary options and cost estimates for development of the Long Jetty. The report presents the review of previous reports, the results of a site inspection from deck level, water level and below water (diving inspections), and structural analysis. The cost of options for demolition and replacement were provided. A summary of the main findings is provided in Table 2.3.1.

Table 2.3.1: Summary of findings from a review of Aurecon's Assessment Report

Item	Findings	Comparison to Maunsell Assessment
1	Termite damage in the structure is prolific. Activity was most prolific in beams, transoms and deck planks, with some signs in the crossheads.	Termite activity was not observed in previous Maunsell condition assessments.
2	Piles are typically infested with what appears to be Teredo worm. Deterioration that is most probably attributable to Limnoria was commonly observed in piles furthest from shore. 50% of piles exhibited external loss and deterioration in the intertidal zone.	No comment is made by Maunsell on the type of marine organism deterioration in the piles.

Item	Findings	Comparison to Maunsell Assessment
3	Concrete Jackets were commonly not constructed to an adequate height around the piles to prevent infestation by Teredo worm. In piles with concrete jackets constructed to low levels, a dense pattern of worm holes were present above the jacket.	No comment is made on this in previous inspection reports.
4	A high proportion of transoms and planks have deteriorated due to rot. Deterioration in the transoms is generally consistent with top down rot; however a portion of those inspected featured evidence of mudding which could be caused by termite activity.	The Maunsell report highlighted that the majority of transoms exhibited a high degree of rot, however it did not note termite activity.
5	Testings of timber samples indicated that the timber piles in the original section of the wharf were Yellow Stringy Bark, while those used for the construction of the extension in the 1980s are Messmate.	This finding supports the note on drawing 82-2010-W1 that the piles used in the widening of the original trestle section of the Jetty between CH381 and CH247are Y.S.B.
6	The structural assessment conducted revealed the piles with over 25% section loss would not be adequate for pedestrian access to the structure. The residual capacity of the deteriorated transoms would be adequate for pedestrian loading. However, it is recommended that they be replaced for serviceability reasons, due to the level of deterioration posing an ongoing maintenance cost. Beams, crossheads and decking that had not deteriorated significantly would be structurally adequate, however decking would pose a trip hazard.	The Maunsell structural assessment did not include the piles and concluded that the structure would be adequate for pedestrian loading, even with the deterioration in the transoms but not for a crane loading case.
7	A limited divers' inspection was carried out on a sample of piles to establish their condition between the seabed and the intertidal zone. Deterioration was present on a small proportion of piles in this area, however the extent of internal deterioration could not be determined.	Maunsell did not undertake a divers' inspection.

The Interim Rehabilitation Report prepared by Maunsell for Gippsland Ports provides an overall condition assessment of the structure and an initial estimate of the cost to rehabilitate the jetty and return it to service. The report includes the results of inspections of the Jetty and a brief structural analysis of components that Maunsell believed were critical for pedestrian and crane loading criteria. Budget estimates to rehabilitate the Jetty to meet these load cases were also developed and presented. The site investigations consisted of visual inspections, as well as some drilling of test bores into selected timber members to establish the extent of the rot.

Table 2.3.1: Summary of findings from a review of Maunsell's Interim Assessment Report

Item	Findings	Comparison to Aurecon Assessment
1	Most, if not all diagonal braces are in poor condition with little effective residual capacity or they have failed. Braces are severely rotten in the intertidal zone without exception. They are structurally ineffective under the loading area and barely effective elsewhere.	Aurecon agreed with this assessment and does not believe the bracing is required any longer, as its purpose was to resist vessel berthing forces.

Item	Findings	Comparison to Aurecon Assessment
2	Piles supporting trafficked areas have been recently restored by jacketing in the intertidal region. Piles are generally in a good condition above water level, with only occasional rotting and splitting.	Aurecon agreed with these findings.
3	Crossheads are generally in good condition. Splitting in the timber as a consequence of steel connection corrosion is common and occasional rotting at the ends is evident. There is occasional surface rotting on the timbers. Crossheads retain their structural bearing effect when split and require no treatment at this stage.	Aurecon agreed with these findings, however noted that there is suspected termite activity in only a small number of these members.
4	Beams are generally in good condition with occasional surface rotting and occasional severe rot where transoms rest on the bearer. Beams requiring immediate treatment were not observed There is also severe cracking due to corroding connections.	Aurecon disagreed, noting that several beams are now in dire need of replacement due to deterioration by termites.
5	The transom beams are commonly severely rotted. Splitting has also occurred due to corroding of fixings. The top surfaces of the transom exhibited the most extensive deterioration due to rainwater being trapped between the transom and deck, causing a wet environment. There is no pattern or distribution of deterioration. 65% of tested transoms featured severe cracking, or a screwdriver was able to penetrate into 25% of the timber section. Two thirds of the transoms are in poor condition and no longer able to provide their original capacity	Aurecon agreed with these findings but did not undertake any invasive testing of the timber. Appendix B of the Aurecon report notes that over the entire structure only 3% to 10% of transoms were in good condition with the majority exhibiting medium to extreme rot on the top surface, with mudding and potential termite activity in a portion of the transoms.
6	Deck planks range in condition from 'as new' to 'failed'. The planks in the trafficked areas were in noticeably better condition, than those untrafficked areas due to concentrating maintenance resources in locations of highest need. Drill testing confirmed that surface cracks on planks commonly coincided with deep rotting.	Aurecon agreed with this assessment; however it did not undertake invasive testing of the timber.
7	Structural analysis considered a pedestrian loading case and crane loading case. Timber was assumed to be structural grade F14. Load from pedestrians is well below the capacity of new transoms and deck planks (10% capacity), thus transoms and planks in poor condition will still provided sufficient capacity for pedestrian loads.	Aurecon did not undertake an analysis for the crane loading case as it assumed that for a construction case the crane would be barge mounted.

Overall there are a number of inconsistencies between the Aurecon and Maunsell Condition Assessment Reports. For the assessments of the condition of the deck and transom elements both consulting engineers are generally in agreement, however the assessments of the beams, crosshead and piles varies – especially on the point on termite deterioration.

2.3.2 Heritage Reports

Three existing Heritage Reports were provided to Hyder for information. These reports include descriptive histories of the Long Jetty and discuss its heritage and cultural significance. One of the reports documents the works undertaken during the demolition of the burnt out section between CH 760 and CH 790 in March 2010.

The David Helms Heritage Planning and Management Report (2010) is the only report which contains information directly relevant to the development of rehabilitation options for the pier. While the advice was intended to guide the demolition of the section which burnt out in 2010, there are a number of principles that remain relevant to any rehabilitation works undertaken on the Long Jetty;

1. The substructure should be left 'in-situ'.
2. Other elements of the substructure/superstructure being transoms, cross-braces, beams, etc. Should be retained in situ, except where they have been so badly damaged that this is not feasible for safety – e.g. it is in danger of collapse – or other reasons.
3. The condition of all removed material should be assessed for potential re-use in future restoration/reconstruction work of the Jetty. Any viable material should therefore by retained and stored in a suitable location.
4. Wherever possible, representative damaged sections of each part of the jetty superstructure – beams, transoms, bracing, etc. – that are proposed for removal and not suitable for re-use should also be retained and stored for further assessment.

In recommending rehabilitation options for the structural elements comprising the Long Jetty, these principles have been considered.

Context Heritage Consultants are currently undertaking a Heritage Assessment of the structure, as part of its preparation of a Conservation Management Plan, and will present its findings concurrently with Hyder's Condition Assessment Report. Suggested rehabilitation options present in Section 5 should be considered in conjunction with Context's advice.

2.4 Items for further investigation

From the review of existing information the items summarised in Table 2.4 required validation through the site inspection, in addition to the standard condition assessment that will be conducted.

Table 2.4: Items to be validated through Site Inspections

Item	Report / Drawing Reference	Report / Drawing Findings	Site Action
Piles			
Pile Timber Species	82-2010-W1 Aurecon (Jun 2010)	Piles should be Y.S.B (Yellow Stringy Bark) throughout, except in the 60m extension.	Take samples of timber from piles in each section and test to determine timber species.
Jacketing repairs to piles	Aurecon (Jun 2010)	Height of jacketing repairs is inadequate to prevent borer activity and further deterioration of the piles has ensued.	Confirm the extent of the jacketing and its effectiveness in preventing further deterioration from marine organisms.
Marine organism infestation	Aurecon (Jun 2010)	Piles appear to be infested with Teredo worm and deterioration attributable to Limnoria is commonly observed in piles farthest from shore.	Engage Dr Laurie Cookson, timber deterioration specialist, to visit site and provide advice on pile deterioration and organisms present.
Extent of internal marine organism infestation	Aurecon (Jun 2010)	It is difficult to determine the internal extent of Teredo worm attack without the pile being hollowed out by further abrasion and *Limnoria* activity.	Engage Dr Laurie Cookson, timber deterioration specialist, and drill test bores into the piles to determine the level of internal deterioration.
Condition of the pile tops	Maunsell (Oct 2003)	Pile tops are in good condition with only occasional splitting and rot.	Confirm the condition of the pile heads and look for presence of termite attack.
Crossheads, Beams and Bracing			
Timber Species	Aurecon (Apr 2010)	Limited samples of timber were taken.	Take samples of timber elements in each section and test to determine timber species.
Termite Deterioration	Aurecon (Apr 2010)	Isolated instances of potential termite activity were observed in the beams and crossheads.	Validate the presence of termites in the timber elements through sounding test and drilling bores.

3 SITE INVESTIGATION

3.1 Scope

Gippsland Ports nominated five inspection areas within the scope of the site investigation, which broadly encompasses the typical structural arrangements of the Jetty. The locations of these areas are illustrated in Appendix A.

The site investigation consisted of inspections from both deck and water level. Structural elements and connections within the scope of these inspections are listed below.

3.1.1 Deck Level Inspections

The extent of the inspections carried out from deck level in each of the five nominated areas included the following elements and connections:

1. The length of the exposed crossheads for decay and termite infestation, paying particular attention to the top of crossheads at beam bearing, and record member dimensions.
2. The ends of exposed crossheads for decay, termite infestation and splitting.
3. Crosshead to beam connections.
4. The exposed length of the beams for decay and termite infestation, paying particular attention to the top of beams at transom bearing, and record member dimensions.
5. The ends of exposed beams for decay, termite infestation and splitting.
6. Beam to beam connections.
7. Top of exposed piles for decay, termite infestation and splitting.

3.1.2 Water Level Inspections

The extent of the inspections carried out from water level in each of the five nominated areas included the following elements and connections. The water level at low tide while undertaking the pile inspections was between +0.7 and +0.9 CD (based on the Bureau of Meteorology tide predictions).

1. The exposed length of the pile (including the top of pile) for decay, splitting, termite infestation, Teredo and any other marine organism infestation.
2. Determine the extent of pile necking and pile wasting in the tidal zone.
3. Where a pile has been repaired, the nature and effectiveness of the repair.
4. Diagonal bracing for decay, termite and marine organism infestation.
5. Bracing connections.

3.2 Methodology

The Site Inspection team consisted of an experienced Maritime Engineer from Hyder Consulting and Dr Laurie Cookson, of L J Cookson Consulting, a Specialist Marine Organism Biologist. The site inspections were undertaken over four days, from 2 May 2010 to 5 May 2010.

To allow sufficient access to the beams and crossheads for the deck level inspections, Gippsland Ports removed the decking planks that run parallel above each beam, within the nominated inspection areas. Gippsland Ports provided a crewed vessel to facilitate the water level inspections. The Aurecon (2010) report recommended that inspections beneath the structure should not be carried out by walking on the seabed, using waders, at low tide. They found that the seabed beneath the Jetty was very silty to the extent that walking on it was hazardous. Taking this recommendation into account, all inspections below the structure will be undertaken from a vessel, as required.

A flat topped raft, approximately 5.0m long by 1.5m wide was used to gain access to the piles underneath the jetty. The raft was launched from the Gippsland Ports compound and towed into position by a small vessel. It should be noted that the piles assessed as part of inspection Areas 2, 4 and 5 did not correspond to those beneath the Areas indicated on the location map in Appendix A and the inspection location plans in Appendix B. At low tide the draught around Area 2 was too shallow to allow the vessel access to the barge into position. A representative sample of piles shoreward of the slipway shed was inspected instead. The piles beneath Area 4 could not be accessed due to the fenders, walers and bracing restricting clearance for the raft. Piles beneath the widened original turning bay, approximately 15 bents shoreward of Area 4, were inspected in instead. The structure around Area 5 has fender piles in between each bent, preventing access by the raft beneath the structure. Fortunately, three fender piles had been cut off two bents shoreward from inspection area 5, allowing access, and the piles in these two bents were inspected in lieu of those directly beneath area 5. The actual piles inspected are noted in Section 3.4.

Timber elements were rated according to the condition states and guidance provided in the NSW RTA Bridge Inspection Procedure Manual. Particular attention was paid to the condition of interfaces between members, connection locations and locations where load is transferred through bearing.

An assessment of the internal condition was made through sounding timber elements with a hammer. Where internal deterioration was suspected test bores were undertaken for each of the elements. Boring was undertaken by Gippsland Ports' staff using their drilling equipment. The drill bits used in the boring were of a length of equal to the depth of the member under consideration, or the diameter of the pile. The feed from the drill and rate of drilling was monitored during the operation by Hyder's Maritime Engineer to detect any substandard material. The number and extent of bore holes conducted are given in Table 3.1.2.

Table 3.1.2: Number, spacing and extent of test bores for timber elements

Element	Number of Test bores	Spacing and extent
Beams	2 (min.)	At 1.0m centres to assess the extent of the deterioration.
Crossheads	2 (min.)	At 1.0m centres to assess the extent of the deterioration.
Piles	2	Approximately 500mm vertically apart, to the heart of the timber, perpendicular to each other around the pile top.

A total of three timber samples, one of each type of element (beam, crosshead and pile), in each of the five nominated sections, were taken to enable the type of timber used in the construction of the Long Jetty to be established with a reasonable degree of certainty.

During the course of the inspections it was found that within each inspection area some elements appeared to have been subject to termite or marine borer attack, while others appeared unaffected. Additional samples of timber elements that showed signs of attack were taken for the purpose of determining whether these elements where of a different timber species, that was more susceptible to attack, or whether the pattern of attack was random.

3.3 Findings

Photographic records of the condition of inspected elements were taken, highlighting the various types of decay, termite deterioration and marine organism attack. Timber elements were rated according to the condition states and guidance provided in the NSW RTA Bridge Inspection Procedure Manual. Descriptions of the four condition states for timber are provided in Table 3.1.1. To ensure the condition of the timber elements is clearly defined, photographic examples of the four condition states, as they specifically relate to each of the elements in the Long Jetty Structure, are included at the beginning of Appendix C.

Table 3.1.1: Condition States for Timber Elements as per the RTA Bridge Inspection Procedure Manual

Condition State	Description
1	The timber is in good condition with no evidence of decay. There may be cracks, splits and checks having no effect on strength or serviceability. All connections are in good condition and bolts are tight.
2	Minor decay, insect infestation, splitting, cracking, checking or crushing may exist but none is sufficiently advanced to affect serviceability. Joint connections may be slightly loose but does not affect the serviceability.
3	Medium decay, insect infestation, splitting, cracking or crushing has produced loss of strength of the element but not of a sufficient magnitude to affect the serviceability of the bridge. Joint connections may be slightly loose but the serviceability of the bridge is not significantly affected.
4	Advanced deterioration. Heavy decay, insect infestation, splits, cracks or crushing has produced loss of strength that affects the serviceability of the bridge. Connections are very loose causing large movements, bolts are corroded and ineffective or missing, and the serviceability of the bridge is affected.

Dr Laurie Cookson's report has been included in Appendix E and findings from that report have been included in this section. Findings that are common across all inspection areas are summarised below, refer to Sections 3.4.1 to 3.4.5 for specific details of the assessments of individual inspection areas:

- A single vertical split through the centre of beams typically occurs over the crossheads where the beams have been bolted through to the crossheads. Splitting appears to have been caused by these vertical bolts rusting and expanding within the timber. These bolts are heavily corroded and ineffective. No splitting was observed in the beams over crossheads where bolts have not been used. The current level of splitting does not affect serviceability, as the cross-section and bearing area of the beams has not been reduced.

- Minor to moderate horizontal splitting occurs typically at all the bolted connections between the crossheads and the piles. The bolts are heavily corroded and ineffective. These defects do not affect the serviceability or strength of the crossheads as they are not subject to lateral loads and vertical loads are transferred directly to the pile tops through bearing.

- Typically there were no signs of surface rot or decay on the top surfaces of timber elements from water ponding on the beams or crossheads.

- The bearing interfaces between the transoms & beams, beams & crossheads and crossheads & piles were in good condition. In only a few instances was it observed that accelerated deterioration had occurred due to the interfaces acting as a trap for moisture (in inspection Areas 4 and 5 only).

3.3.1 Inspection Area 1

Inspection Area 1 is located on the original trestle structure. Deck level and water level inspections were carried out between pile bents 39 and 47. There is no bracing within this inspection area. A summary of the condition state of the elements inspected, according to the NSW RTA Bridge Inspection Procedure Manual is provided in Figure 3.4.1.

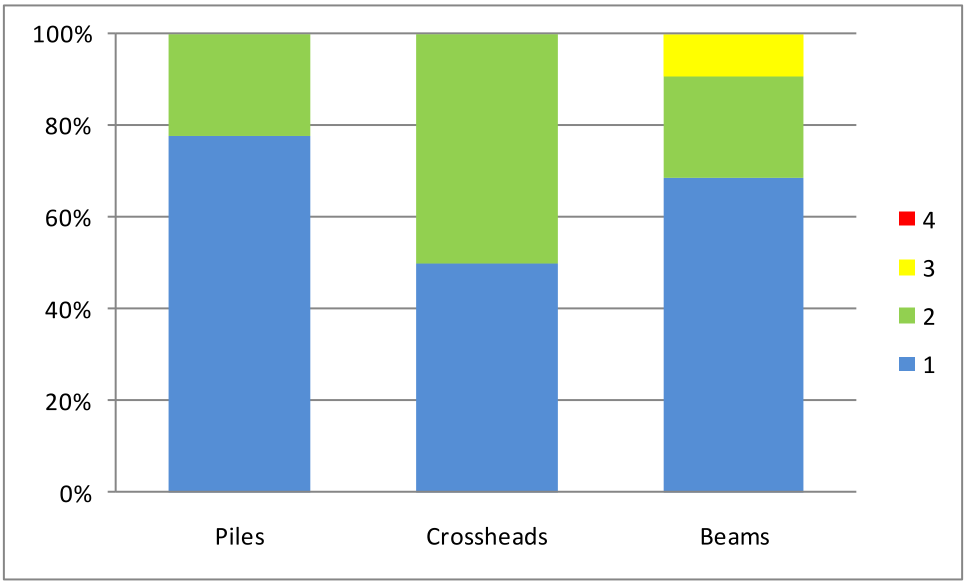


Figure 3.4.1: Inspection Area 1 Condition Rating Summary by Element

The type of deterioration resulting in loss of strength in the **beams** (Conditions State 3) is **rot**. Rot has been instigated from moisture entering the beams through splitting over the crossheads. Splitting is a result of the corrosion and expansion of bolts connecting the beams to the crossheads.

Pile tops have been coated in the past with a black, bitumen type material to prevent water ingress. Generally the pile tops are in good condition. All pile tops featured minor and moderate splitting and two exhibited rot through the inner heartwood. The extent of these defects does not appear to impact on the serviceability of the piles and their connections to the crossheads.

Other notable observations of the condition of elements within Inspection Area 1 are summarised below;

- Piles are in a good condition, with minor splitting through the sapwood around the surface. A number of deeper splits were common throughout the piles; however these do not affect the serviceability of the piles. The average remaining diameter of the piles is 300mm to 350mm.
- No evidence of marine borer attack of the piles or termite deterioration in the members was found.

3.3.2 Inspection Area 2

Inspection Area 2 is located on the original trestle structure. The deck level inspections associated to this inspection area were conducted between pile bents 160 and 168. The water level inspections were conducted between pile bents 188 to 198. There is no bracing within this inspection area. A summary of the condition state of the elements inspected, according to the NSW RTA Bridge Inspection Procedure Manual is provided in Figure 3.4.2.

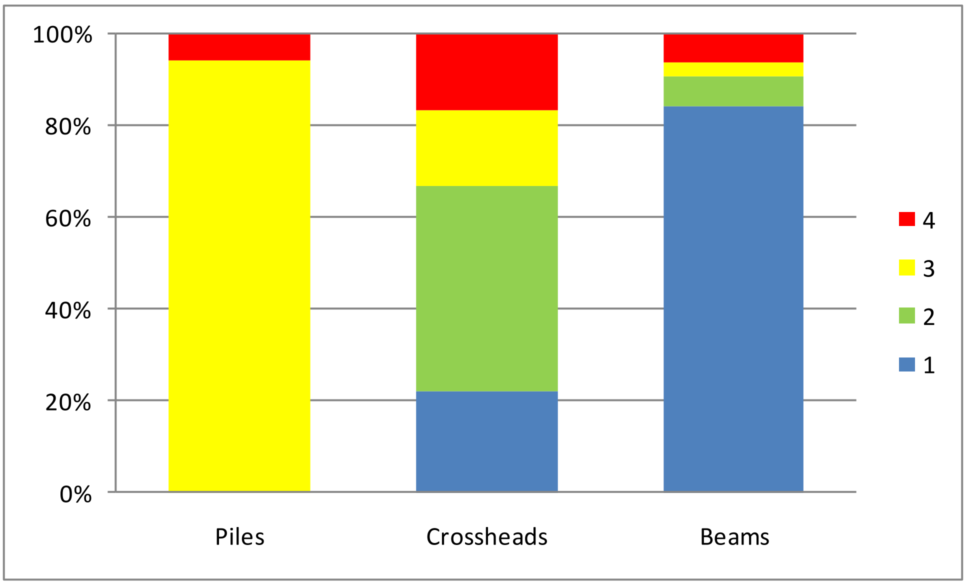


Table 3.4.2: Inspection Area 2 Condition Rating Summary by Element

The rating of the majority of **piles** as Condition State 3 has been based on:

a) Concrete bag repairs not preventing further **marine borer attack** of piles; and

b) Reduction in cross section of unrepaired piles from **marine borer attack** and wave/current erosion.

The pile classed as condition state 4 had failed above its concrete bag repair due to marine borer attack. This may suggest continued attack in the timber pile after the concrete bag was installed.

Concrete bags have been used to repair 60% of piles within this inspection area and extended 100mm to 300mm above low tide water level. Limnoria deterioration has continued above the top of the concrete bag in most cases and minor Toredo worm attack was observed in only a few piles. The cut off level of the concrete bags below the water level could not be determined from the visual assessment. If the bags do not extend to the mud-line, teredo worm attack is likely to have continued. The typical diameters of repaired piles, above the top of the concrete bag, are 270mm to 300mm.

Limnoria deterioration and minor Teredo worm attack was present on all piles without repairs. Typical remaining diameters of unrepaired piles in the intertidal zone are 230mm to 290mm.

The type of deterioration resulting in loss of strength in the **crossheads** and **beams** (Conditions States 3 & 4) is **termite attack**. The typical extent of termite deterioration of the crosshead extended halfway to the full length of the member. Termite deterioration in the beams was localised and found in the tops of these elements and found to extend downwards, into the middle of beam, leaving the inside hollow over a short length.

Pile tops have been coated in the past with a black, bitumen type material to prevent water ingress. The pile tops are in generally in good condition. All pile tops featured minor and moderate splitting with minor rot extending through the inner heartwood. The extent of these defects does not appear to impact on the serviceability of the piles and their connections to the crossheads.

3.3.3 Inspection Area 3

Inspection Area 3 is located on the original trestle structure, past the old slipway shed. Deck level and water level inspections were carried out between pile bents 229 and 237. Cross-bracing is present between piles in each bent through this area. A summary of the condition state of the elements inspected, according to the NSW RTA Bridge Inspection Procedure Manual is provided in Figure 3.4.3.

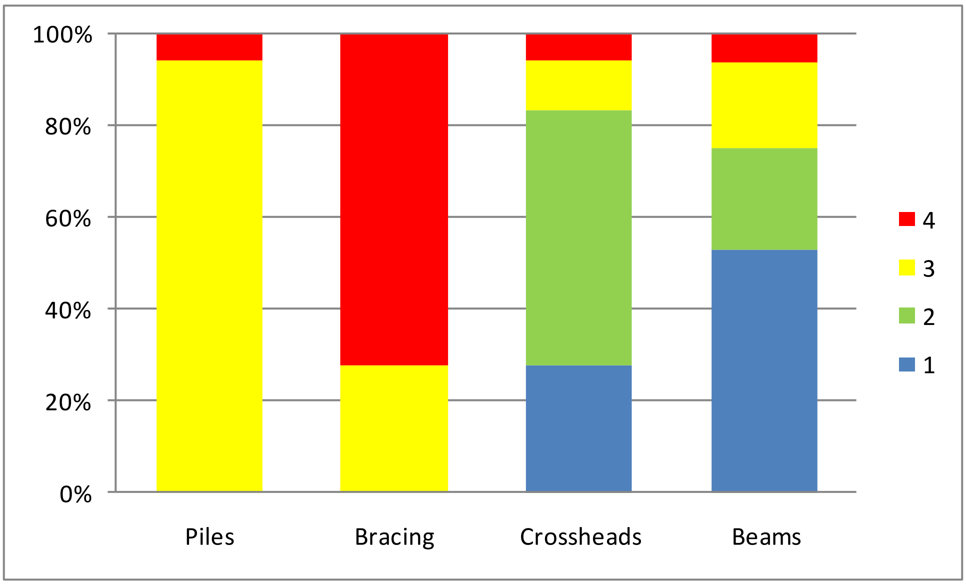


Figure 3.4.3: Inspection Area 3 Condition Rating Summary by Element

The rating of the majority of **piles** as Condition State 3 has been based on:

a) Concrete bag repairs not preventing further **marine borer attack** of piles; and

b) Reduction in cross section of unrepaired piles from **marine borer attack** and wave/current erosion.

The pile classed as condition state 4 had failed due to marine borer attack hollowing out the pile in the inter-tidal zone.

Concrete bags have been used to repair 40% of piles within this inspection area and extended 100mm to 300mm above low tide water level. The top level of the concrete bags finished well below the high tide water level to avoid clashing with diagonal bracing. Limnoria deterioration has continued above the top of the concrete bag in most cases and evidence of old Teredo worm holes was present in a few piles. The cut off level of the concrete bags below the water level could not be determined from the visual assessment. If the bags do not extend to the mud-line, teredo worm attack is likely to have continued. The typical diameters of repaired piles, above the top of the concrete bag, are 290mm to 300mm.

There appears to have been provision for horizontal bracing between the piles, below the diagonal bracing. Piles without concrete bag repairs feature 2 No. holes, along with checks into either side of the piles. It is likely these holes would have originally been 25mm to 30mm diameter bolt holes which have subsequently been bored out to 70mm through Limnoria activity. The holes and checks in the piles are located within the intertidal zone and have accelerated deterioration within this region by exposing the inner, more susceptible pith to Limnoria attack. The resulting cross-section is typically rectangular in shape.

Limnoria deterioration is common to all piles. Light Teredo worm attack was present among 50% of exposed piles. Taking into account checks in the side of the piles and bolt holes, the remaining effective diameter of the piles is between 190mm and 220mm.

The majority of the **diagonal bracing** is close to failure or has failed (Condition State 3 & 4) due to severe section loss around the connection at the bottom end of the element, which is submerged at high tide. In addition, splitting parallel to the grain around the bolts at the top end of the bracing has occurred in 50% of cases. Bolts were heavily corroded at the top and bottom connections and the majority of the bolts at the top connections were missing bolt heads.

The type of deterioration resulting in loss of strength in the **crossheads** (Conditions States 3 & 4) is **rot**. Rot has initiated from top down, through the crosshead, due to vertical splitting in the crosshead around bolt connection to the beam.

The main types of deterioration resulting in loss of strength in the **beams** (Conditions States 3 & 4) are rot and termite attack. Rot has proceeded from the top surface of the beam, down through the member due to bolt holes or splitting at connections trapping moisture. A single localised case of termite deterioration was found through the centre of one of the beams. The deterioration extended along the length of the beam for 600mm, hollowing it out. No other cases of termite deterioration where found when drilling into the beams.

50% of the **pile tops** have been coated in the past with a black, bitumen type material to prevent water ingress. The pile tops are in generally in good condition. All pile tops featured minor and moderate splitting and 10% exhibiting minor rot through the inner heartwood. The extent of these defects does not appear to impact on the serviceability of the piles and their connections to the crossheads.

3.3.4 Inspection Area 4

Inspection Area 4 is located in the original loading area of the Jetty, past the turning bay constructed in the 1980s. Deck level inspections were carried out between pile bents 278 and 282. The water level inspections were carried out between pile bents 262 and 264. While cross-bracing is present between piles in each bent through this area, it was unable to be accessed for assessment. A summary of the condition state of the elements inspected, according to the NSW RTA Bridge Inspection Procedure Manual, is provided in Figure 3.4.4.

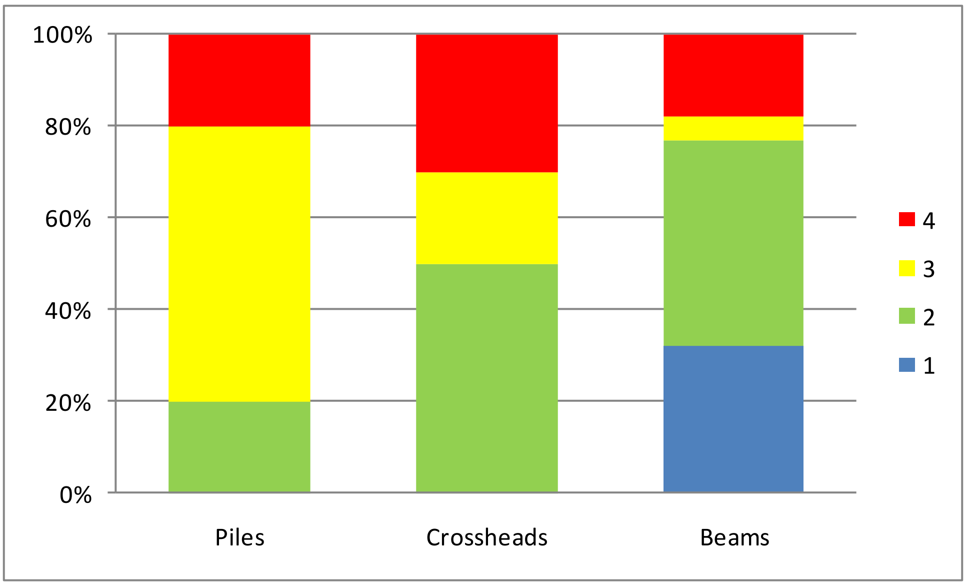


Figure 3.4.4: Inspection Area 4 Condition Rating Summary by Element

The rating of **piles** as Condition States 3 & 4 has been based on the reduction in cross section of unrepaired piles from **marine borer attack** and wave/current erosion. Piles classed as condition state 4 have severely reduced or failed cross sections in the inter-tidal zone. All piles have suffered Teredo worm and Limnoria attack. Piles in condition states 2 & 3 had a remaining effective diameter of between 170mm and 250mm.

Loss of strength in the **crossheads** and **beams** (Conditions States 3 & 4) has resulted from **termite attack**. A single crosshead had been damaged by fire to a moderate degree. Generally termite activity was confined to isolated pockets along the length of the crossheads. In two crossheads termite deterioration was severe, running along the entire length of the member, greatly compromising its strength. Live termites were found in one crosshead that featured severe deterioration. Termite related deterioration was usually found in beams that ran past pile tops that also showed evidence of termite attack. In all cases of termite attack in the beams, the cross-section had been severely reduced.

Signs of termite activity were found in the 20% of **pile tops**. One of these pile tops was completely hollowed out. A single pile out of this group was able to be accessed from water level for investigative drilling. Termite related deterioration appeared to extend between 1.0m and 1.5m from the top of this pile.

Other notable observations of the condition of elements within Inspection Area 4 are summarised below;

- Minor surface rot and areas of deeper pocket rot (60mm to 100mm) were common to most crossheads, however not to a level that significantly impacts on the strength of the member.
- A few cases of top down surface rot and splitting has occurred in the beams but not to a significant degree to affect the structures serviceability.

3.3.5 Inspection Area 5

Inspection Area 5 is located in the 1980s extension of the structure. Deck level inspections were carried out between pile bents 296 and 298. The water level inspections were carried out between pile bents 294 and 296. No cross-bracing was present throughout this area. A summary of the condition state of the elements inspected, according to the NSW RTA Bridge Inspection Procedure Manual, is provided in Figure 3.4.5.

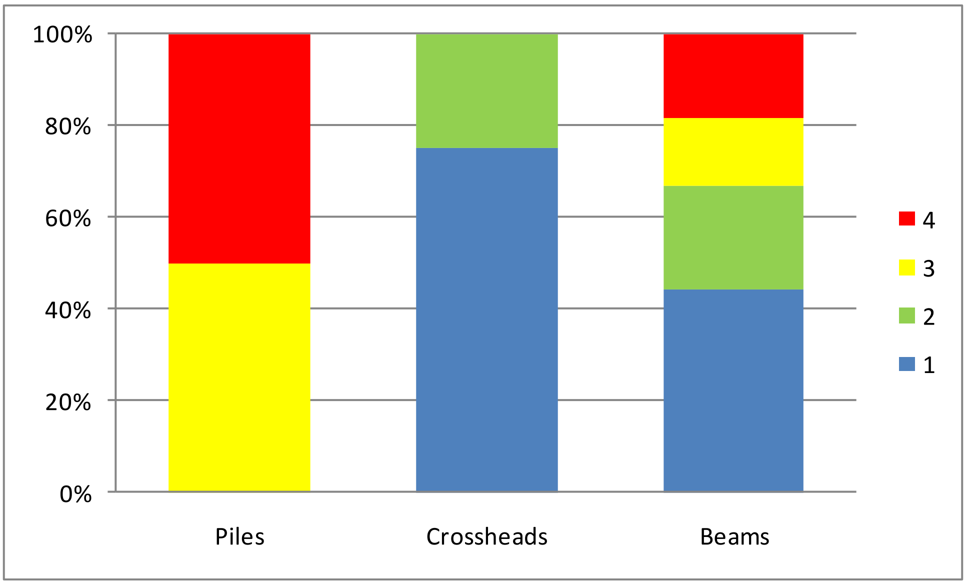


Figure 3.4.5: Inspection Area 5 Condition Rating Summary by Element

The rating of **piles** as Condition States 3 & 4 has been based on the reduction in cross section of unrepaired piles from marine borer attack and wave/current erosion. Piles classed as condition state 4 have severely reduced or failed cross sections in the inter-tidal zone. All Piles have suffered heavy Teredo worm and Limnoria attack. The piles which had not failed or are close to failure (Condition State 4) had a remaining effective diameter between 140mm and 210mm.

The condition of the **crossheads** is generally good, with no evidence of termite activity in the sample inspected, and only minor surface rot. However when conducting the pile inspections between bents 294 and 296, a crosshead was identified that had been completely eaten out by termites along its entire length. While this crosshead has not been included in the inspection results tabulated above, it should be noted that **termites** are present in crossheads.

The main types of deterioration resulting in loss of strength in the **beams** (Conditions States 3 & 4) are **termite attack** and **rot**. A single beam had also been severely damaged by fire. Termite attack completely hollowed out the affected beams along lengths of 1.0m to 1.5m. Rot was typically a result of top down water penetration through bolt holes and splitting over connections.

Black rubber has been fixed to 60% of the inspected **pile tops** using adhesive to prevent water ingress. The pile tops protected in this manner are in generally in good condition, featuring minor to moderate splitting. The extent of these defects does not appear to impact on the serviceability of the piles and their connections to the crossheads. However, signs of **termite activity** were present in one of these 6 pile tops which extended 1.0 to 1.5m below the top of the pile. The remaining 4 piles tops, without protection, featured severe horizontal splitting and piping rot through the inner heartwood.

3.4 Timber Species Identification

Timber species identification was conducted by Dr Jugo Ilic of *Know Your Wood*. The results of the timber identification are presented in Table 3.3, along with durability classifications in accordance with AS5604-2005: Timber – Natural Durability Ratings. The certificate of the timber identification is included in Appendix D.

The locations at which samples have been taken are given in Table 3.3.

When relying upon the results of timber identification and the application of the resistance classes from AS5604, please be aware that:

- The inner heartwood and pith is less resistant to termite and borer attack than the outer heartwood.
- The quality of timber within the trees of the same species and even within a tree varies, and may exhibit different levels of resistance to termite and borer attack.
- Timber species may exhibit different levels on resistance to different local species of termites and borers.

Based on the findings of the timber identification it is reasonable to infer that the timber species of the piles throughout the structure is typically Yellow Stringybark, with the exception of the piles within inspection area 4 which were identified as Messmate. These findings suggest that Yellow stringybark piles were used in the original structure, while a mixture of Yellow stringybark and Messmate piles were used for the extension of the wharf and the widening the original turning bay and tank stand in the 1980s.

Assessed in accordance with AS5604, all piles throughout the structure are beyond their useful life. The probable marine-borer-resistance life expectancy of Yellow stringybark is 21 to 40 years from installation, while Messmate piles are expected to last 0 to 20 years, usually less than 5 years. The level of deterioration of the outer piles from Teredo worm and Limnoria attack was significantly more severe, compared to that in the inner piles, even through the timber species of the piles is consistent. This could be due a poorer quality yellow stringybark being used in the construction of the extension, as resistance to marine borers is known to vary between trees of the same species.

Termite deterioration was observed to be present in the tops of some Yellow stringybark piles and Messmate piles. The inner heartwood (pith) of Yellow stringybark is more susceptible to termite attack than the outer heartwood which is considered resistant. Termites have likely entered the piles from the exposed end to attack the pith, and continued down the pile.

The timber species of the beams and crossheads in inspection areas 1 to 4 (the original structure) is typically Messmate, with some Silvertop Ash. Within inspection area 5, the timber species of the beams and crossheads was identified as Blue Gum. It is worthwhile to note that a replacement beam sampled in inspection area 4 is also Blue Gum. These findings suggest that Messmate and Silvertop Ash beams and crossheads were used to construct the original section of the Jetty, while Blue Gum was used in the extension and for replacement of beams in the original section.

Assessed in accordance with AS5604, none of the beams and crossheads are resistant to termite attack. The site investigation confirmed termite deterioration to be present in beam and crosshead elements throughout the structure. An active termite population in the structure featuring timber species not resistant to termite attack is a great concern to the ongoing serviceability of the Long Jetty.

The timber species of the bracing elements sampled was identified as Yellow stringybark.

Table 3.3: Timber species identification and durability according to AS5604-2005

Sample ID	Location	Element	Notes	Timber Species	Termite Resistance[2]	Borer Resistance Class[3]
Inspection Area 1						
S1-P-1	39B	Pile	-	Yellow stringybark	Resistant	3
S1-X-1	43A	Crosshead	-	Silvertop ash	Not Resistant	N/A
S1-B-1	C	Beam	-	Yellow stringybark	Resistant	N/A
Inspection Area 2						
S2-P-1	190B	Pile	Limnoria	Yellow stringybark	Resistant	3
S2-X-1	167B	Crosshead	Termites	Messmate	Not Resistant	N/A
S2-X-2	160A	Crosshead	-	Messmate	Not Resistant	N/A
S2-B-1	163B	Beam	-	Yellow stringybark	Resistant	N/A
S2-B-2	167A	Beam	Termites	Silvertop ash	Not Resistant	N/A
Inspection Area 3						
S3-P-1	239B	Pile	Teredo	Yellow stringybark	Resistant	3
S3-P-2	233A	Pile	-	Yellow stringybark	Resistant	3
S3-X-1	231A	Crosshead	-	Messmate	Not Resistant	N/A
S3-B-1	B	Beam	Original	Messmate	Not Resistant	N/A
S3-B-2	D	Beam	Replacement	Blue gum	Not Resistant	N/A
S3-R-1	233A	Bracing	-	Yellow stringybark	Resistant	N/A
Inspection Area 4						
S4-P-1	262C	Pile	Teredo	Messmate	Not Resistant	4
S4-X-1	280B	Crosshead	-	Messmate	Not Resistant	N/A
S4-X-2	282B	Crosshead	Termites	Messmate	Not Resistant	N/A
S4-B-1	D	Beam	-	Yellow stringybark	Resistant	N/A
S4-B-2	E	Beam	Termites	Messmate	Not Resistant	N/A
Inspection Area 5						
S5-P-1	295B	Pile	Teredo	Yellow stringybark	Resistant	3
S5-X-1	295A	Crosshead	Termites	Blue gum	Not Resistant	N/A
S5-X-2	296B	Crosshead	-	Blue gum	Not Resistant	N/A
S5-B-1	B	Beam	-	Coast grey box	Resistant	N/A
S5-B-2	E	Beam	Termites	Blue gum	Not Resistant	N/A

Notes:

1. Termite Resistance is based on the guidance provided in AS5604-2005 Timber: Natural Durability Rating, Table A1
2. Borer Resistance Class relates to guidance provided in AS5604-2005 Timber: Natural Durability Rating, Table 2 and Table A1. Resistance Class varies from 1 to 4, with Class 1 timbers having the highest probable life expectancy and Class 4 the lowest.

3.5 Correlation of findings with previous inspection reports

A summary of investigation findings that address the items for further investigation listed in Section 2.4 is provided in Table 3.5.

Table 3.5: Correlation of findings with previous inspection reports

Item	Report / Drawing Reference	Report / Drawing Findings	Site Action	Hyder Investigation Findings
Piles				
Pile Timber Species	82-2010-W1 Aurecon (Jun 2010)	Piles should be Y.S.B (Yellow Stringy Bark) throughout, except in the 60m extension.	Take samples of timber from piles in each section and test to determine timber species.	Piles are typically Yellow stringybark with Messmate used in the extension of the original turning bay and tank stand. These species match those identified in the Aurecon investigation for the various wharf sections.
Jacketing repairs to piles	Aurecon (Jun 2010)	Height of jacketing repairs is inadequate to prevent borer activity and further deterioration of the piles has ensued.	Confirm the extent of the jacketing and its effectiveness in preventing further deterioration from marine organisms.	Limnoria deterioration has continued above the top of the concrete bag in most cases and evidence of old Teredo worm holes was present in a few piles. The cut off level of the concrete bags below the water level could not be determined from the visual assessment. If the bags do not extend to the mud-line, teredo worm attack is likely to have continued.
Marine organism infestation	Aurecon (Jun 2010)	Piles appear to be infested with Teredo worm and deterioration attributable to Limnoria is commonly observed in piles farthest from shore.	Engage Dr Laurie Cookson, timber deterioration specialist, to visit site and provide advice on pile deterioration and organisms present.	Limnoria and Teredo worm deterioration was confirmed in piles, apart from those in Inspection Area 1. The severity of teredo worm deterioration reduced moving from the end of the structure, towards shore.
Extent of internal marine organism infestation	Aurecon (Jun 2010)	It is difficult to determine the internal extent of Teredo worm attack without the pile being hollowed out by further abrasion of *Limnoria* activity.	Engage Dr Laurie Cookson, timber deterioration specialist, and drill test bores into the piles to determine the level of internal deterioration.	Significant teredo activity could usually be found to depths of 20-30 mm from the outside of the pile, in inspection areas 4 and 5. The piles generally lacked teredo attack, or were only lightly attacked to 10 mm depth, in inspection areas 2 and 3.

Item	Report / Drawing Reference	Report / Drawing Findings	Site Action	Hyder Investigation Findings
Condition of the pile tops	Maunsell (Oct 2003)	Pile tops are in good condition with only occasional splitting and rot.	Confirm the condition of the pile heads and look for presence of termite attack.	Generally pile tops are in good condition with minor to moderate splitting and rot. Termite activity was found to be present in a number of piles in inspection areas 4 and 5. A number of pile top in inspection area 5 featured sever splitting and pipe rot.
Crossheads, Beams and Bracing				
Timber Species	Aurecon (Apr 2010)	Limited samples of timber were taken.	Take samples of timber elements in each section and test to determine timber species.	Beams and crossheads are typically Messmate or Silvertop ash in the original structure, with Blue gum being used in the 1980s extension and for replacement timbers. All these species are not resistant to termite attack.
Termite Deterioration	Aurecon (Apr 2010)	Isolated instances of potential termite activity were observed in the beams and crossheads.	Validate the presence of termites in the timber elements through sounding test and drilling bores.	Termite deterioration was confirmed to be present in a number of crossheads and beams across the structure. Live termites were found on site in the crossheads.

4 REUSE AND REHABILITATION OPTIONS

We generally consider that beam, crosshead and bracing elements of condition state 3 & 4 and piles of condition state 4 to be unsuitable for reuse in a rehabilitated structure. Beams and crossheads in condition states 1 and 2 are appropriate for use in a rehabilitated structure, provided that the measures outlined below are applied to these members to protect against the types of deterioration affecting the Long Jetty. Piles rated as condition state 3 have the potential for reuse following the structural treatment outlined below.

The structural capacity of the members to provide the required level of serviceability and strength in a rehabilitated structure has not been assessed. A structural capacity assessment of all elements, especially the piles, must be undertaken once the required level of service has been defined by Gippsland Ports. Based on the structural assessment undertaken by Maunsell and Aurecon the elements of the superstructure in good condition have sufficient capacity to support crowd loading (5 kPa). The piles are critical elements, with the level of deterioration in the intertidal zone having a large impact on their load carrying capacity. Depending on the load the structure is required to support, piles may require more significant rehabilitation works.

Methods to address the main types of deterioration in the structure, in elements suitable for reuse, are discussed in the following sections.

4.1 Termite Deterioration

Termite attack is the main type of deterioration throughout the beams, crossheads and pile tops. Elements subject to termite deterioration are not appropriate for reuse in a rehabilitated structure, and should be removed. Beams and crossheads in condition state 1 and 2, with no evidence of termite deterioration may be suitable for reuse; however there is still risk in retaining these elements. The extent of termite deterioration in timber is difficult to determine with certainty from sounding tests and it is possible that areas of termite deterioration within a beam can be missed.

Elements identified as having potential for reuse should be inspected by a specialist timber biologist to assess their suitability. Investigative drilling should be conducted on elements to confirm that termite deterioration is not present. Any Drill holes should be sealed with epoxy resin and painted over with a sealant to avoid creating a moisture trap that would initiate rot or provide an entry point for termite attack.

The timber species of the crossheads and beams were identified as not being resistant to termite attack. If these elements are reused, a termite management plan should be developed and carried out for the life of the structure. Termite management is an ongoing process that generally proves successful. The management plan should be developed with advice from a specialist termite controller. Should Gippsland Ports wish to halt termite deterioration at its current level, a termite management plan should be initiated as soon as possible. A suitable termite contractor, to assess the extent and method of appropriate control, can be recommended by Dr Laurie Cookson upon request.

Termite deterioration is more difficult to deal with in pile tops. A potential option is to lower the deck level of the jetty. Piles could be cut down approximately 1.5m, removing most of the termite damage occurring the pile tops, or leaving a higher number of piles that have only minor to moderate central piping. Minor piping is not structurally an issue, so long as it is prevented from continuing, as most of the strength in the pile is provided by the outer heartwood. Piles suitable for retention could be identified as each pile is cut down, clearly revealing the damage in each. The rehabilitated structure would essentially be rebuilt on the cut down piles, 1.5m below its current level.

Reducing the height of the structure may affect its serviceability. An assessment of potential overtopping of the structure from waves and a rise in sea level, associated with climate change, should be conducted when considering this option. If reducing the height of the structure is not feasible, piles with a moderate to severe level of termite deterioration in their tops should be replaced.

In piles identified as suitable for reuse, measures to kill any existing termites and prevent their return should be taken. Termites are repelled by seawater and usually only found in the piles above high water level. Bolt holes above high tide should be sealed with an epoxy resin to prevent entry by termites and the tops of piles covered with sheet metal with a sealant applied beneath. Additionally, preservatives such as boron diffusible rods or the application of CN emulsion to the tops of the piles is usually effective in killing and repelling termites.

4.2 Rot

Measures should be taken to prevent rot developing in any beams and crossheads retained or reused in a rehabilitated structure. Beams in condition state 2 which exhibit splitting over the connections should have splits filled with epoxy resin and flashing installed to prevent water ingress. Where surface rot is present on beams, they should be turned over to present the underside that has not been exposed to water ingress from above. Due to the heavy corrosion of the bolts fixing the beams to the crossheads, it may be impractical to remove beams that are suitable for reuse. The section of the beam surrounding the corroded bolt is likely to need to be cut out, limiting the possibility of salvaging a usable length. Alternatively a bituminous damp proof course (DPC) can be applied to the top surfaces of the beams to prevent water ponding and moisture penetration of the timber. All bolts holes should be filled with epoxy resin before the application of the DPC.

Beams and crossheads in Condition State 3 should be removed from the structure and assessed for their reuse potential. The portions of these elements affected by rot can then be cut out. If a beam or crosshead is still a useable length, it can be reused in the structure to replace deteriorated elements. Given the level of rot in these elements, it is unlikely that useable lengths will be salvaged.

Minor piping is not structurally an issue, so long as it is prevented from continuing, as most of the strength in piles is provided by the outer heartwood. Flashing should be placed over the tops of piles to prevent water entering and subsequently rotting the susceptible pith of the timber.

4.3 Marine Organism Deterioration

According to the guidance provided in AS5604, all piles are beyond their probable life expectancy. However based on the site investigation, in conjunction with Dr Laurie Cookson, the majority of yellow stringybark piles in the original section of the structure appear to have some residual life remaining. In these original piles, Teredo worm deterioration is relatively light and the main deterioration has been a result of Limnoria.

We recommended that all piles in condition states 1 and 2 should be wrapped with a protective plastic wrap, from 500mm above high water level to 1000m below mud line, to prevent future marine borer attack.

Depending on the level of service required, concrete bags for piles that are classified as Condition State 3 may be an appropriate rehabilitation option. This type of repair should extend from 500mm above high water level to 500m below mud line, to strengthen the pile and prevent future marine borer attack. Any bracing would have to be removed to conduct these repairs and an assessment of the stability of the structure without bracing will have to be made.

Typically it is best practice to provide protection or strengthening to deteriorated piles along their full length. As the worst deterioration in the yellow stringybark piles appeared to be in the intertidal zone, it may be possible that the length of pile below water level is still in sound condition. If this is the case, concrete bag repairs could be installed to those piles in Condition State 3 in the intertidal zone only, rather than the full length. The condition of the piles below water level would have to be confirmed by a divers' inspection in considering this option. Due to the presence of toredo worm at the site, deterioration may be occurring below water level. A limitation of a concrete bag repair in the intertidal zone only, is that any subsequent repairs required to the pile below water level will be difficult to undertake, without removing the existing concrete bag.

Marine borer attack above the existing concrete bag repairs, while present, is relatively light. There may be the option of retaining these piles if it can be confirmed that the bag repair continues down to the mud-line to prevent further marine borer attack. A wrap type repair should be applied above the concrete bag to provided full protection to above the high water level. If attack is found to have been ongoing, through lack of protection, and given that the piles would have already been heavily deteriorated to require a concrete bag repair, they would be considered beyond their useful life and should be replaced.

Piles classified as condition state 4 have failed and will need to be replaced in a rehabilitated structure. Due to the high level of deterioration and depth of teredo worm attack we recommend that all piles in the 1980s extension and widening of the turning bay are unsuitable for reuse and should be removed or replaced. Splicing of piles which have failed in the inter-tidal zone is not a feasible option for the raked piles in the trestle section of the structure, due to their angle of installation. Splice repairs are an option for rehabilitation of failed vertical piles supporting in the loading area. Repairs conducted to these vertical piles will be complicated by the presence of bracing through this section, which will have to be removed before any type of repair can be undertaken. The condition of the portion of the pile below water level must be confirmed before splice repairs are conducted. Most likely it will be more economical to drive new piles.

It must be noted that deterioration in the piles is likely to be worst than observed, due to the limited length of pile exposed at low water during our investigations. The water level at low tide of +0.7 to +0.9 CD was relatively high compared to those as low as +0.25 CD which are experienced at Port Welshpool. Further pile inspections should be undertaken at extreme low tide to confirm the findings of this investigation.

4.4 Splitting at Connections

All bracing elements should be removed as the majority have failed or are close to failure due to splitting at connections and rot around the connections in the intertidal zone. A structural assessment of the impact of the removal of bracing on the structure should be made to determine if the replacement of bracing is required.

If piles tops are cut down (as suggested in Section 4.1), or piles replaced, the crossheads will have to be removed to allow this operation. Approximately 50% of crossheads featured minor to moderate splitting at the connections to the piles. These split areas would have to be cut out before the crossheads can be replaced and bolted to the pile tops. Once the crossheads are reinstated, L- brackets should then be used to connect the beams to the crossheads.

4.5 Expected Remaining Life

Based on current Australian Standards and Timber Design Guides all timber within the structure is beyond its useful life. However, observations of the performance of timber in local conditions are a better indication of its expected life. The findings of our condition inspection suggest that a high proportion of timber elements within the structure have potential for reuse and a reasonable residual life.

Beam and Crosshead elements in condition state 1 and 2, if protected against termite deterioration and rot could probably be expected to last another 10 to 15 years, based on guidance provided in AS5604. Based on the performance of timbers in the structure to date (crossheads and beams in condition state 1 and 2 are approximately 70 years old), it is possible that they will last longer than 15 years.

We consider the piles used in the 1980s extension of the jetty and in the extension of the turning bay to have no residual life remaining, due to the high level of deterioration in the piles and the susceptibility of Messmate piles to marine borer attack.

If plastic wrap and concrete bag repairs are applied correctly to deteriorated piles (condition state 2 and 3) throughout the original structure, and the pile tops have been treated for termites and further deterioration, piles can typically be expected to last up to 10 years, once repaired.

It is difficult to predict the remaining life of the piles with existing concrete bag repairs with certainty, as the condition of the piles before being repaired and the quality of concrete used in the repair is unknown. Based on the current condition of the piles and the application of a wrap to prevent marine borer attack above the concrete bag, the repairs are likely to last another 5 years, possibly longer. This assessment is contingent upon confirming that the concrete bag repair continues to the mud-line.

Any replacement piles should be double treated (CCA followed by creosote) hardwood and are expected to last greater than 50 years, possibly longer, based on guidance provided by *Forest & Wood Products Australia*.

Predicting the expected remaining life of timber and existing repairs comes with great uncertainty. Uncertainty comes from the natural variability between timber elements, range in types of deterioration affecting timber elements, and uncertainty in the quality of materials used in the repairs. We recommend that Gippsland Ports develop and implement an inspection and maintenance plan for the rehabilitated structure, to monitor condition and perform appropriate maintenance, to mitigate the risk inherent with predicting residual life of existing structures.

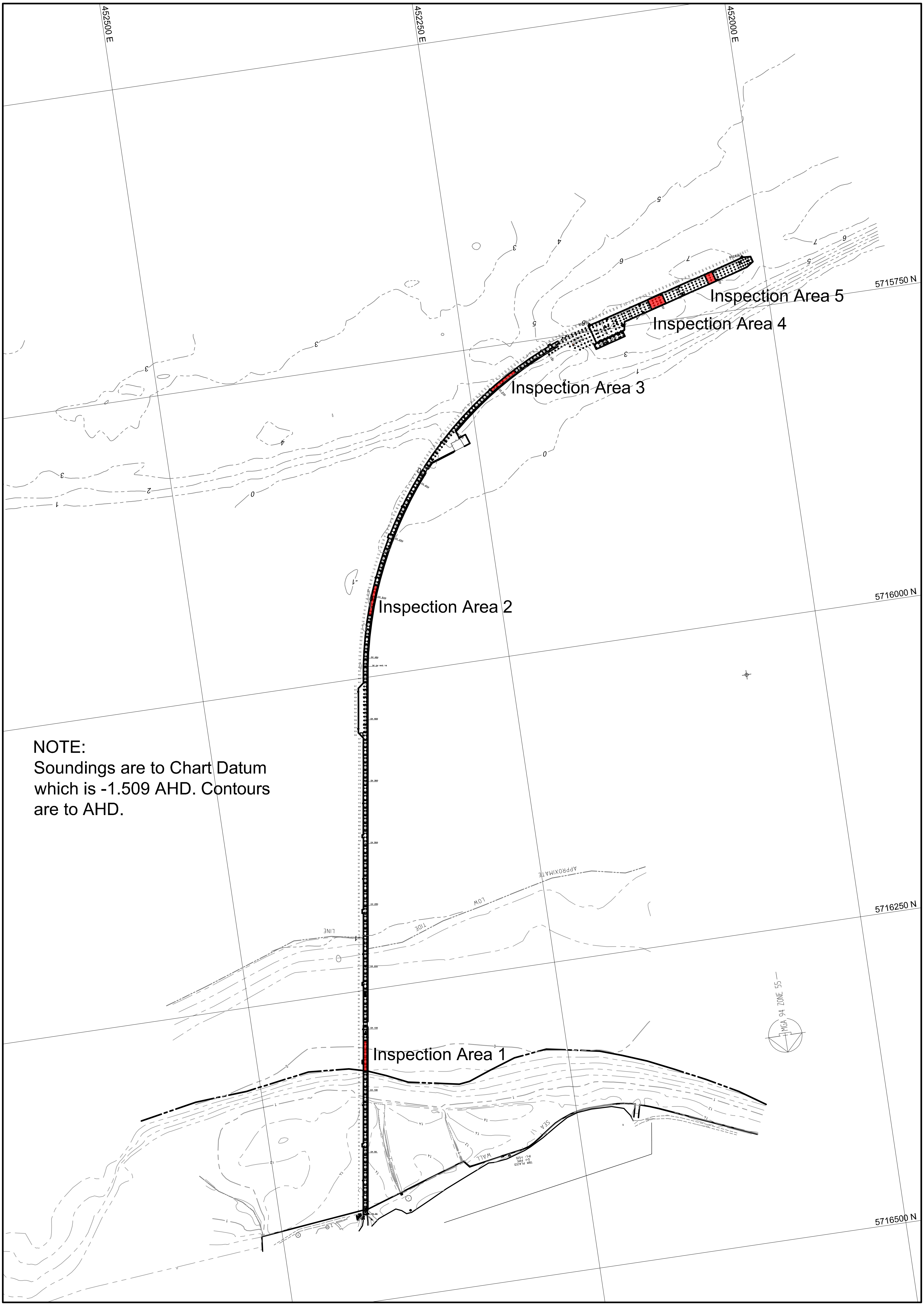
5 ITEMS FOR FURTHER INVESTIGATION

Deterioration in the piles is likely to be worse than observed, due to the limited length of pile exposed at low water during our investigations. The water level at low tide of +0.7 to +0.9 CD was relatively high compared to those as low as +0.25 CD which are experienced at Port Welshpool. Further pile inspections should be undertaken at extreme low tide to confirm the findings of this investigation.

The extent of and integrity of concrete bag repairs below water level was unable to be determined form the site inspection. It is recommended that a pile inspection survey should be conducted by experienced divers to confirm the integrity of the existing piles.

APPENDIX A

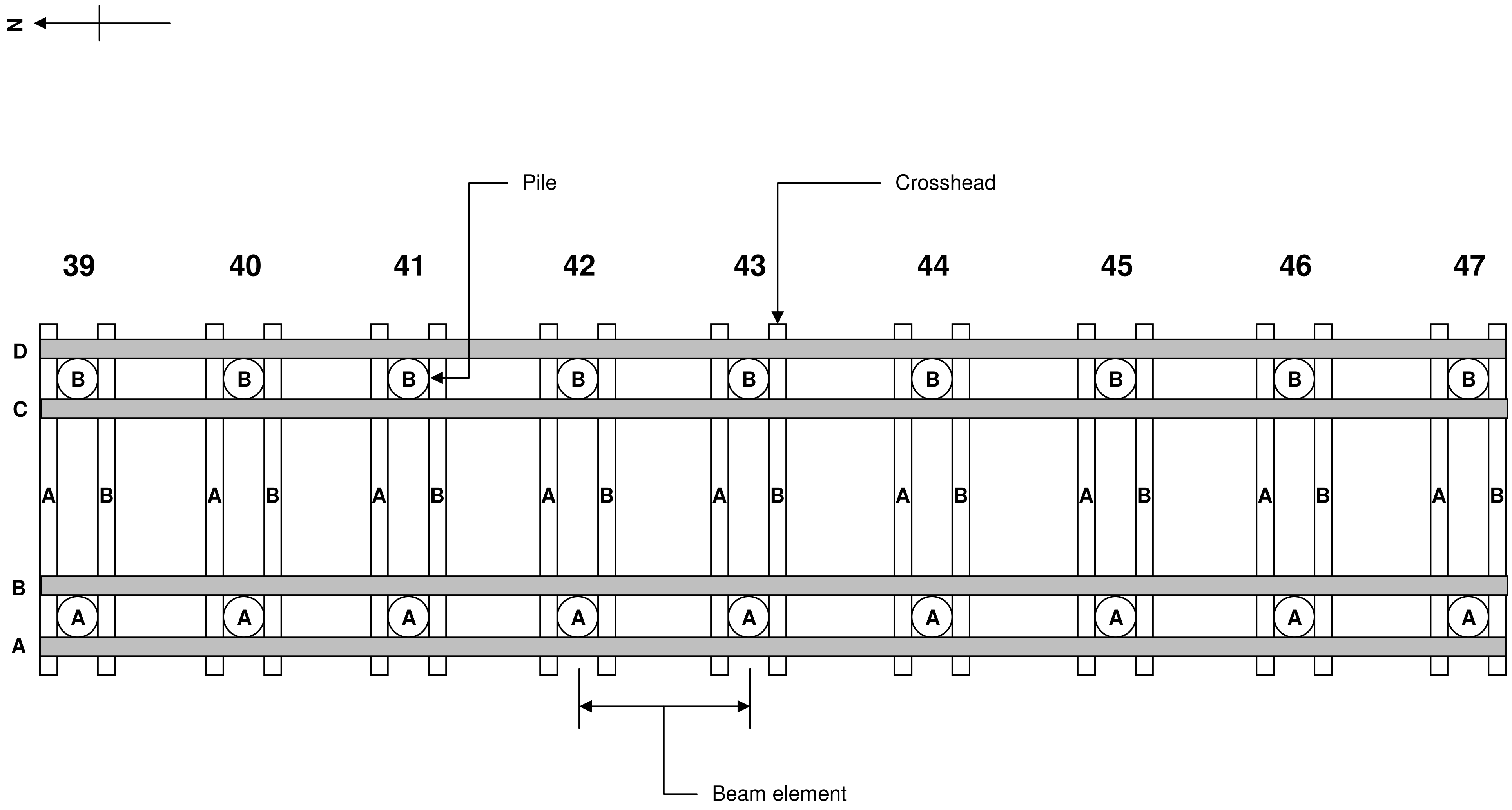
PORT WELSHPOOL LONG JETTY PLAN



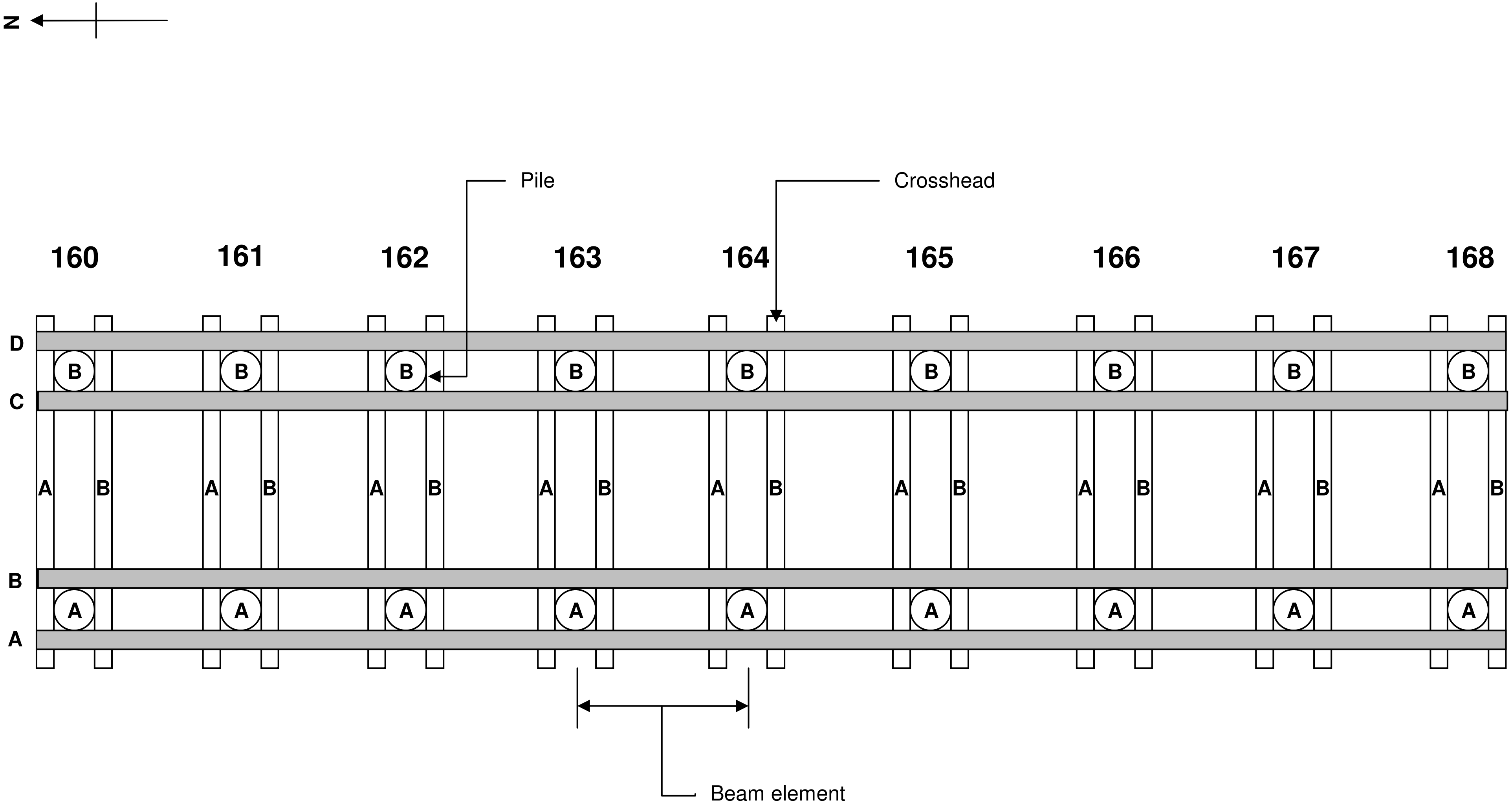
452500 E
452250 E
452000 E
5715750 N
5716000 N
5716250 N
5716500 N
Inspection Area 5
Inspection Area 4
Inspection Area 3
Inspection Area 2
Inspection Area 1
APPROXIMATE
LOW
TIDE
LINE
SEA
WALL
MGA 94 ZONE 55
NOTE:
Soundings are to Chart Datum
which is -1.509 AHD. Contours
are to AHD.

APPENDIX B

INSPECTION AREA LAYOUT PLANS


N
Pile
Crosshead
39
40
41
42
43
44
45
46
47
D
C
B
A
Beam element

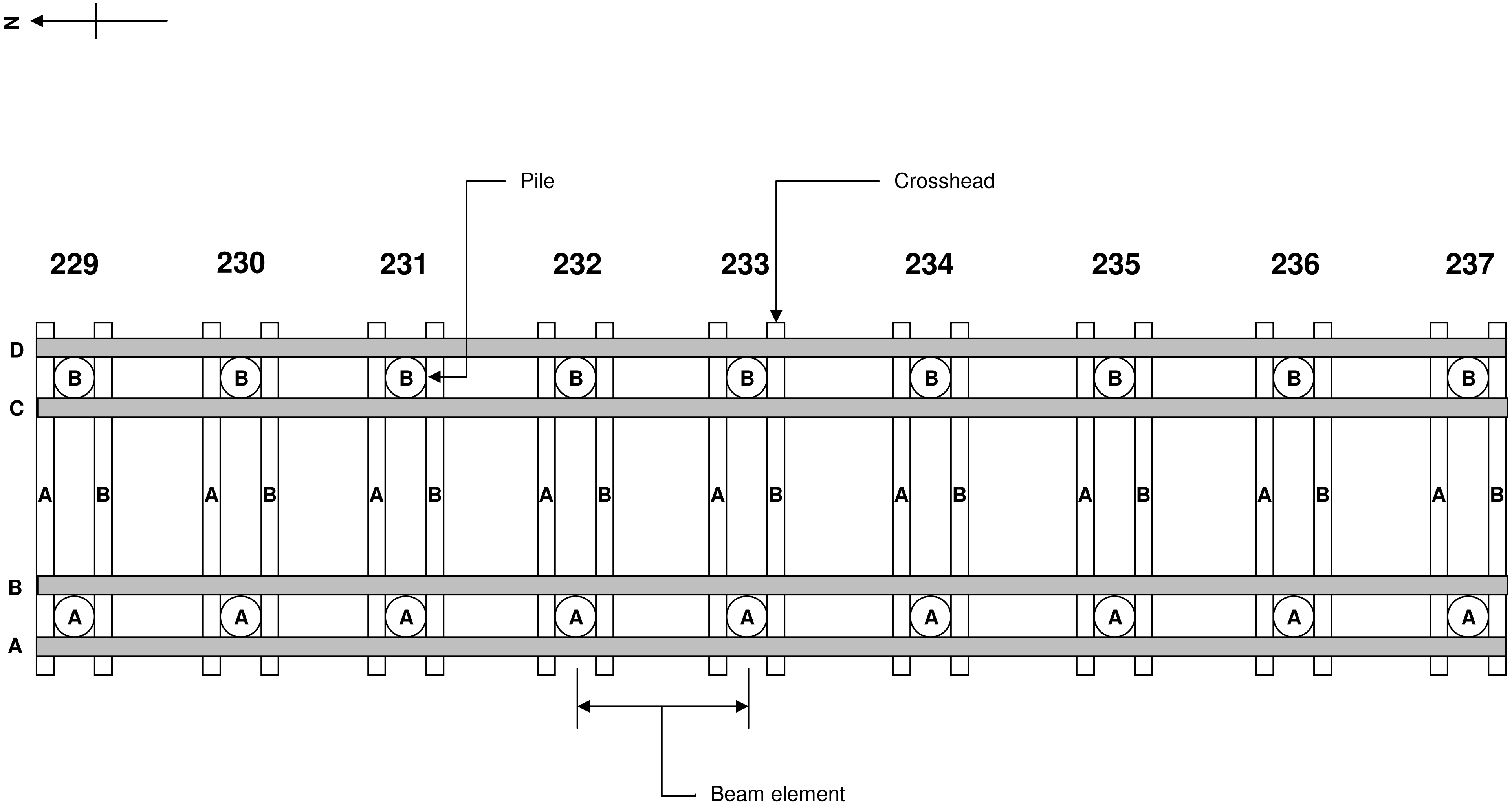
Inspection Layout Sheet – Port Welshpool Long Jetty   Inspection Area: 2   Date: 3 May 2011



Inspection Layout Sheet – Port Welshpool Long Jetty

Inspection Area: 3

Date: 5 May 2011



Inspection Layout Sheet – Port Welshpool Long Jetty   Inspection Area: 4   Date: 4 May 2011

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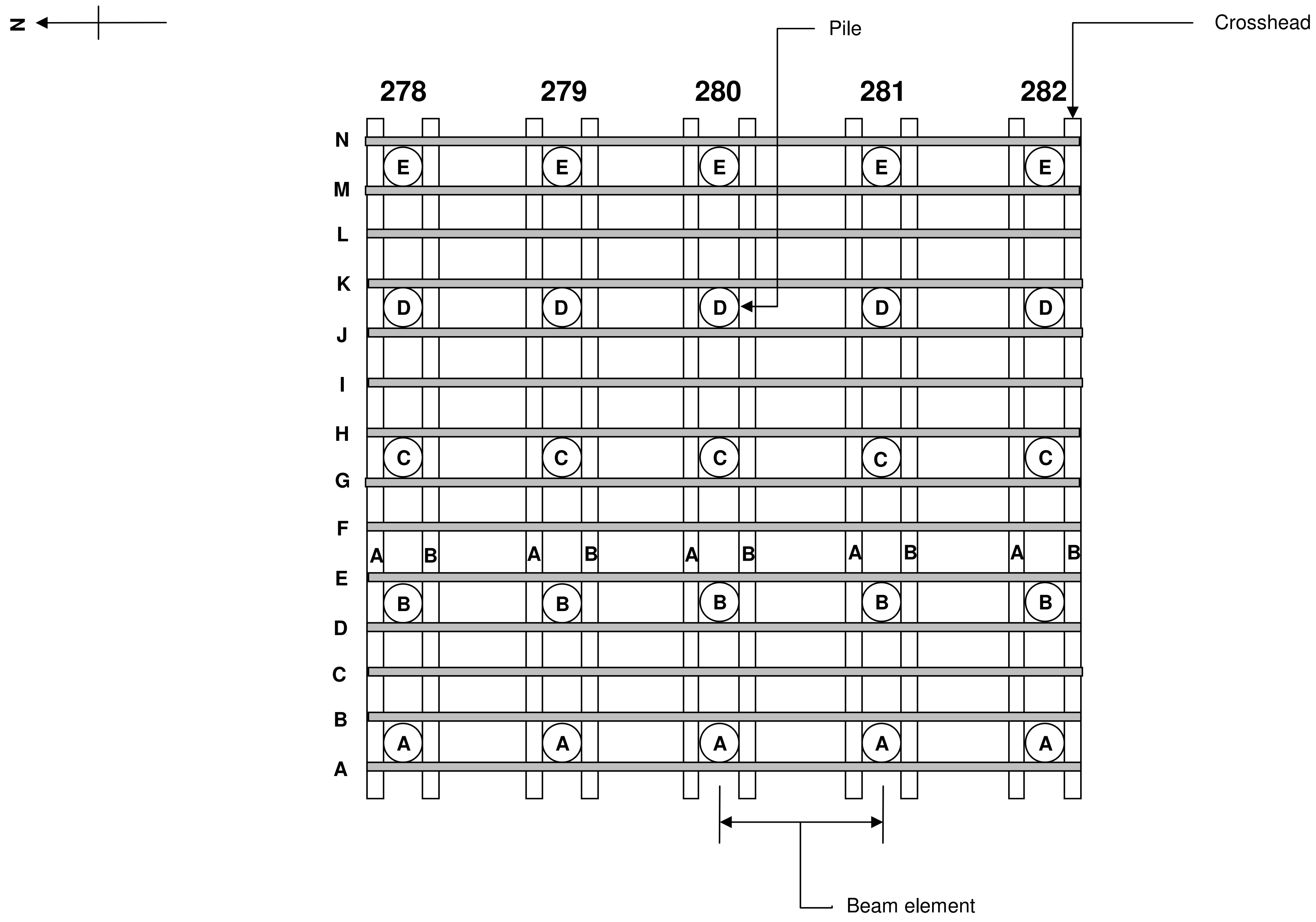
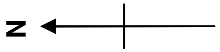
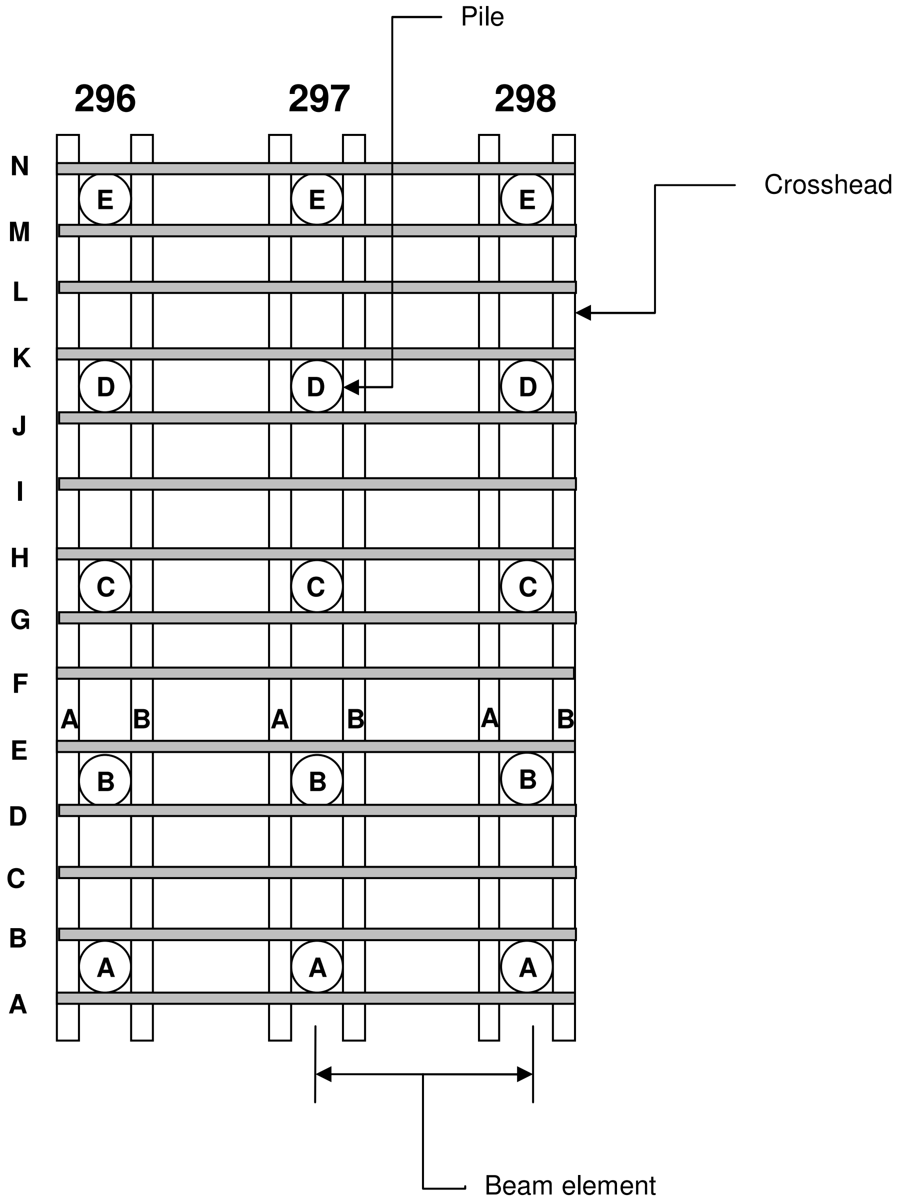


Inspection Layout Sheet – Port Welshpool Long Jetty

Inspection Area: 5

Date: 4 May 2011





APPENDIX C

CONDITION STATE PHOTOGRAPHS

C1: PILE CONDITION STATE EXAMPLES

Condition State	Example
1	
2	

Condition State	Example
3	
4	

C2: CROSSHEADS CONDITION STATE EXAMPLES

Condition State	Example
1	
2	

Condition State	Example
3	
4	

C3: BEAM CONDITION STATE EXAMPLES

Condition State	Example
1	
2	

Condition State	Example
3	
4	

C4: BRACING CONDITION STATE EXAMPLES

Condition State	Example
1	N/A
2	N/A
3	 
4	 

C5: PILE TOP CONDITION STATE EXAMPLES

Condition State	Example
1	
2	

Condition State	Example
3	
4	

C6: TYPICAL DEFECTS REGISTER

Element	Defect	Example
Pile	Rot though inner heart wood at pile top	
Pile	Termite attack in pile top	

Element	Defect	Example
Pile	Pile with heavy Teredo and Limnoria attack.	
Crosshead	Minor degree of splitting at bolted connection of crosshead to piles	

Element	Defect	Example
Crosshead	Moderate degree of splitting at bolted connection of crosshead to piles	
Beam	Splitting at connections over crossheads	

Element	Defect	Example
Beam	Heavy termite attack in beam	

APPENDIX D

WOOD IDENTIFICATION REPORT

KNOW YOUR WOOD
19 Benambra Street, South Oakleigh, Victoria 3167, AUSTRALIA
Phone: 03 95127523
Mobile: 0412786482
Email:knowyourwood@bigpond.com
Provider of wood identification services.

7th May, 2011

WOOD IDENTIFICATION RESULTS

Mr Gareth Jelenich
Senior Maritime Engineer
Hyder Consulting Pty Ltd
Level 16, 31 Queen Street
Melbourne, VIC 3000

Dear Gareth,

Re: **Assessment of 24 wood specimens from Port Welshpool Long Jetty, Gippsland; Your request – 20th May, 2011**.

Following microscopic examination, in my opinion the structure of the wood specimens is consistent with[1]:

Sample Id	Area	Element	Location	Scientific name	Commercial/Trade name	Comment
S1-P-1	1	Pile	39B	*Eucalyptus ?[2] muelleriana*	Yellow stringybark	Stringybark group
S1-X-1	1	Crosshead	43A	*E. ?sieberi*[3]	Silvertop ash	Or stringybark group
S1-B-1	1	Beam	C	*E. ?muelleriana*	Yellow stringybark	Stringybark group
S2-P-1	2	Pile	190B	*E. ?muelleriana*	Yellow stringybark	Stringybark group
S2-X-1	2	Crosshead	167B	*E. obliqua*	Messmate	
S2-X-2	2	Crosshead	160A	*E. obliqua*	Messmate	
S2-B-1	2	Beam	163B	*E. ?muelleriana*	Yellow stringybark	Stringybark group
S2-B-2	2	Beam	167A	*E. ?sieberi*	Silvertop ash	Or stringybark

[1] Disclaimer: The content of this letter is provided in good faith and whilst Dr Jugo Ilic has endeavoured to ensure that the information contained in it is correct and accurate at the time of preparation, he does not accept any liability arising from its use whether provided directly by the above named client or indirectly from the client providing it to a third party in this or any other format

[2] "?" indicates that there are other similar species which cannot be differentiated on the basis of wood structure. Unfortunately the burning splinter test which is important for distinguishing some groups could not be carried out on this material because of the condition of the wood

[3] Silvertop ash is very similar to the stringybark group (the yellow and white stringybarks) and as such it is difficult to discern with certainty. Part of the difficulty in separating the species lies in the degree of overlap of the wood structure.

						group
S3-P-1	3	Pile	239B	*E. ?muelleriana*	Yellow stringybark	Stringybark group
S3-P-2	3	Pile	233A	*E. ?muelleriana*	Yellow stringybark	Stringybark group
S3-X-1	3	Crosshead	231A	*E. obliqua*	Messmate	
S3-B-1	3	Beam	Existing	*E. obliqua*	Messmate	
S3-B-2	3	Beam	New	*E. ?globulus*	Blue gum	Gum group
S3-R-1	3	Bracing	233A	*E. ?muelleriana*	Yellow stringybark	Stringybark group
S4-P-1	4	Pile	262C	*E. obliqua*	Messmate	
S4-X-1	4	Crosshead	280B	*E. obliqua*	Messmate	
S4-X-2	4	Crosshead	282B	*E. obliqua*	Messmate	
S4-B-1	4	Beam	B13	*E. ?muelleriana*	Yellow stringybark	Or white stringybark (*E. globoidea*)
S4-B-2	4	Beam	B14	*E. obliqua*	Messmate	
S5-P-1	5	Pile	295B	*E. ?muelleriana*	Yellow stringybark	Stringybark group
S5-X-1	5	Crosshead	295A	*E. ?globulus*	Blue gum (Gum group)	Gum group
S5-X-2	5	Crosshead	296B	*E. ?globulus*	Blue gum (Gum group)	Gum group
S5-B-1	5	Beam	1st	*E. bosistoana*	Coast grey box	Box group (High density >1000 kgm^{-3})
S5-B-2	5	Beam	4th	*E. ?globulus*	Blue gum (Gum group)	Gum group

I hope the information will help with your research and evaluation process.

Best regards,

Jugo Ilic

Jugo Ilic MSc, Dr(Forest)Sc, FIAWSc

APPENDIX E

LJCOOKSON - TIMBER BIOLOGIST REPORT

Commercial in Confidence

L J Cookson Consulting, Report No.108

The condition of timbers and piles on the Long Jetty at Port Welshpool

L.J. COOKSON
Independent Consulting

Commercial in Confidence

L J Cookson Consulting, Report No.108

The condition of timbers and piles on the Long Jetty at Port Welshpool

Inspection & Report by:

Dr Laurie Cookson

Date: 9 June 2011

Client: Hyder Consulting Pty Ltd, Level 5, 141 Walker St, North Sydney, NSW 2060

Important Disclaimer

LJCookson Consulting advises that this report was prepared for Hyder Consulting Pty Ltd and relates to marine borer, termite and fungal attack of timber piles and associated timbers and does not represent the fitness for purpose or safety of any pile or structure or certify their compliance with any code or standard. No opinion or representation is provided regarding piles which were not examined as described herein. All conclusions herein are based on limited visual observations and mainly non-destructive tests and in some cases marine borer attack or other deterioration in wood soundness may only have been identifiable through destructive testing beyond the scope of the report. Any estimate or model relating to the rate or deterioration, maintenance or replacement requirements of piles whether inspected or otherwise is provided for convenience only and you use this information at your own risk.

L.J. COOKSON
Independent Consulting

EXECUTIVE SUMMARY

Objective

To inspect a selection of timber marine piles and decking timbers at the Long Jetty at Port Welshpool for biodeterioration in and above the tidal zone, and provide comments on durability. Timbers were inspected 2-4 May 2011.

Key Findings

- A total of 46 crossheads and longitudinal beams were examined. There was extensive termite damage in some of the crossheads and longitudinal beams supporting the decking. Termite damage was more extensive than fungal decay, and live termites were found in one of the crossheads. Of those timbers examined, 22% had failed to termites and another 15% had moderate damage from termites and/or fungal decay. However, 63% were in good condition or had only minor damage.
- Those crossheads and longitudinal beams in good condition or with minor damage could be re-used in a new structure. It would be beneficial to turn the beams upside down so that the least weathered bottom surface becomes the new top surface. If re-used, old bolt holes should be sealed from rainwater with a physical plug or cap or protected with a preservative paste such as CN (copper naphthenate) emulsion. Some sections of beams with moderate damage could be re-used if the damaged regions are docked away, and if those beams are still of useful length.
- Pile tops were difficult to inspect from above, as worst damage is often a metre or so below the top end, so that damage is best detected from a boat by drilling into the side of the pile. However, the extent of termite damage found in sawn timbers, and cursory examination of piles tops, suggests that a significant number of piles contain termite nests. The jetty is quite high, built for shipping. However, as a renovated jetty is to be used mainly for recreational purposes, the best way to tackle termite damage in pile tops may be to reduce the height of the jetty by one or 1.5 metres, or to the extent that can be accommodated, remembering that global warming may increase sea level heights to some extent. This modification to jetty height is likely to remove most termite damage occurring in the piles, or at least leave a higher number of piles that have only minor or moderate central piping. Most strength in piles is contained in the outer heartwood. An assessment of which piles to keep could then be made as each pile is cut to its new height, thereby clearly revealing the extent of damage in each.
- After piles tops are docked, steps should be taken to remove any remaining live termites and/or improve the resistance of the piles to new termite attack. Termites are repelled by seawater, so their damage usually ends at or just above high tide. Termites require rainwater moisture. The pile tops could be sealed from rainwater entry (and to some extent from flying termite or alate entry) with a physical barrier of suitable durability (sheet metal, marine ply, or other materials, perhaps with a grease or sealant underneath to improve the seal). It would be difficult to seal the pile top if they need to be checked to seat crossheads and beams. Any bolt holes above the tidal zone should also be sealed to retard entry by alates and rainwater. Preservatives such as boron diffusible rods and/or CN emulsion applied to pile tops should kill or repel termites. The Exterra baiting system is another method that could be used to control termites. A termite control specialist could better advise on which methods would best retard future termite infestations.

- 'Messmate' piles installed at the end of the jetty in 1982 were examined from a small boat at low tide, and may have been a mixture of *E. obliqua* (messmate) and *E. muelleriana* (yellow stringybark) piles. Nine piles were examined. If piles are considered unserviceable when their sound wood diameters are 200 mm or less, then five of the piles were unserviceable or in poor condition. The remaining piles were still serviceable with estimated diameters of 250-270 mm. One of the best piles was identified as *E. muelleriana*. As these piles are in 6-7 more metres of water, it would be useful for a diver to check the mud-line region of some of the piles that are still 'serviceable'. Due to taper the piles will have smaller diameter at mud-line in deep water. If any of these piles were to be maintained for re-use, they may need protection from further deterioration by applying a physical barrier (plastic wrap or concrete collar) positioned from high tide to just below mud-line (mud-line depth can change with time).
- The other selection of piles examined were original piles with cross-bracing in the tidal zone. These and other original piles were mostly identified as *E. muelleriana*. Part way through the inspection it was realised that as well as the diagonal cross-bracing still present, horizontal cross-braces had also been fitted at low tide, and were now lost. Usually in Victoria the condition of piles in the low tide region provides a good indication of condition below low tide especially in waters up to 3-4 m depth. However, such an assessment was confounded by the excessive damage caused by the low tide bracing (pile checked deeply to house bracing, plus further excavations by *Limnoria* within crevices behind the bracing). Pile faces in the east/west direction not checked for bracing were mostly in good condition, and gave a better indication of yellow stringybark durability in these waters. However, a better judgement on the performance of unmodified yellow stringybark sections at Port Welshpool could be made by examining similar piles that did not have bracing attached, or by divers examining some of the braced piles below the damaged low tide regions. Seven of the braced piles were examined, and three appeared to be unserviceable due to complications arising from low tide bracing. Three additional piles with concrete collars extending from the lower tidal zone to partway below low water were in good or serviceable condition in the tidal zone.
- It seems likely that the original yellow stringybark piles should mostly be in good condition below low tide. This is based on the braced piles having useful diameters in the east/west direction, and a cursory view of unbraced piles in shallower water that appeared to be in better condition. However, this contention should be checked by divers for deeper water piles, and a detailed inspection in the tidal zone of unbraced piles in shallower water. If correct, then most of the yellow stringybark piles could be repaired or strengthened using concrete collars for those piles damaged by bracing in the tidal zone region. While it would be best practice to have full length physical barriers, the moderate natural durability of yellow stringybark to marine borers may permit physical barriers to be placed only in the tidal zone of those piles damaged by bracing.
- If jetty height is reduced, diagonal cross-bracing may not be necessary and may be removed. Any bolt holes then exposed would need to be sealed from marine borer entry.
- The marine borers found on piles were teredinids (including *Bankia australis, Lyrodus pedicellatus* and *Teredo fragilis*), *Limnoria quadripunctata*, and more rarely *Sphaeroma quoyana*.

The condition of timbers and piles on the Long Jetty at Port Welshpool

Laurie J. Cookson

June 2011

TABLE OF CONTENTS

INTRODUCTION

Hyder Pty Ltd is conducting a preliminary assessment of the condition of the long jetty at Port Welshpool. This jetty was constructed in 1937. With the assistance of Gareth Jelenich of Hyder, an inspection was made on 2-4 May 2011 of several representative areas within the structure. Marine piles were inspected during low tide. This report describes the timbers examined and the patterns of attack detected.

RESULTS AND DISCUSSION

Timber species identified

Timber samples were identified by Dr Jugo Ilic. Six piles from various locations along the jetty were examined, with five most likely being yellow stringybark (*Eucalyptus muelleriana*) and the sixth being messmate (*E. obliqua*).

Seventeen timber samples were identified from crossheads and beams and were *E. obliqua* (7 samples), *E. globulus* or similar gum (4 samples), probably *E. muelleriana* (3 samples), *E. sieberi* or a stringybark (2 samples) and *E. bosistoana* (1 sample).

Table 1: Natural durability ratings for the timber species identified at Port Welshpool. Ratings obtained from Australian Standard 5604.

Timber species	Common name	In-ground durability	Marine durability
Eucalyptus muelleriana	Yellow stringybark	3	3
Eucalyptus obliqua	Messmate	3	4
Eucalyptus globulus	Southern blue gum	3	4
Eucalyptus sieberi	Silvertop ash	3	4
Eucalyptus bosistoana	Coast grey box	1	3

Piles at end of jetty, Area 5

The piles examined at the end of the jetty were said to have been installed in 1982, making them 29 years old. These piles lacked cross-bracing in the tidal zone. The piles were apparently specified as ‘messmate’ (*E. obliqua*), a timber with relatively low natural durability against marine borers. Nevertheless, the single timber sample identified from this section was most likely yellow stringybark (*E. muelleriana*). The piles were found to have teredinid (shipworms, including *Bankia* species) attack mostly 10-30 mm deep. *Limnoria quadripunctata* was also common on piles to a depth of 2-4 mm. Nine piles in this area were examined. If piles with 200 mm or less sound heartwood remaining are considered to be unserviceable, then four of these piles were failed and another was in poor condition (230 mm diameter). For the other piles, diameters remaining were estimated to range from 250-270 mm and were still serviceable.

This section of jetty may have contained a mixture of *E. obliqua* piles (as was apparently specified) and *E. muelleriana* piles (such as the sample identified). The *E. muelleriana* pile identified was amongst the best performing of the piles in this section and its surface heartwood diameter had eroded only slightly (2-3 mm) although it did have 20 mm additional depth of significant teredinid damage below the surface. It would be interesting to identify whether the failed piles were *E. obliqua*, as this timber is considered to have low natural durability against marine borers compared to *E. muelleriana* (Table 1). It is possible that many of the better performing piles in this area are *E. muelleriana*, and based on performance in the original jetty, should continue to give serviceable performance. It should also be noted that these piles are in 6-7 metres of water so would have a smaller diameter near mud-line. If the serviceable piles are to be retained, a selection should be examined near mud-line by a diver to verify condition. However, retention of some piles may not be practical, when more than half are unserviceable or in poor condition. If serviceable piles are retained, longer service lives can be expected by protecting them with physical barriers (concrete jacket or plastic wrap) and should be positioned full length (high tide to just below mud-line).

Original piles with cross-bracing

These were original piles installed in 1937, making them 74 years old. Four of the piles sampled were identified as probably *E. muelleriana* and another was *E. obliqua* (latter not inspected). These piles had a great deal of damage on their north/south faces due to horizontal cross-bracing that had been attached at low tide. The piles also still had diagonal cross-bracing with the lower end close to mid-tide, and just above the now lost horizontal low tide bracing. The low tide cross-bracing is now missing, however the piles clearly had been checked in on their north/south faces to accommodate the bracing, and their bolts or boltholes were also evident at low tide. Some of the piles had concrete collars applied from mid or lower tide to apparently 1-2 m below low tide.

Seven piles without concrete collars were examined. The piles generally lacked teredinid attack, or were only lightly attacked to 10 mm depth. Most damage was due to *Limnoria quadripunctata*, which is a borer that prefers to live within crevices. Therefore, the low tide cross-bracing had provided them with ideal conditions, so that typically the north/south face cavities into heartwood were each generally 40-70 mm deep (up to 190 mm deep) of which 30-40 mm may have been due to original machining and the remainder due to *Limnoria*. The width of estimated sound heartwood remaining in the north/south direction ranged from 50 to 250 mm averaging 170 mm. In contrast, the east/west faces did not bear cross-bracing, and the estimated sound heartwood remaining in that direction ranged from 100 to 320 mm averaging 250 mm.

Three piles with concrete collars were examined. These piles appeared to be in good condition, especially when the collar reached mid-tide, with estimated sound wood remaining in the tidal zone ranging from 260 to 450 mm. The join at the top end of the collar between concrete and timber was not excavated by *Limnoria*, and it would be worth checking by a diver if the bottom end of the collar below low tide was also tight.

Usually, the condition of marine piles at low tide provides a good indication of likely condition below the tidal zone, especially in water to 3-4 m depth. However, due to the effects from low tide cross-bracing, the condition of the piles below low water is unclear. The often good condition of the piles in the east/west direction where cross-bracing was not attached suggests that the piles should also be in good condition below the notching created for cross-bracing. The condition of piles below low water should be checked by a diver. Also, an inspection of other original piles that did not have cross-bracing attached may give a better indication of how unmodified sections of natural round yellow stringybark has faired at Port Welshpool.

Once more, some of these piles could be repaired using physical barriers (such as the concrete collar already applied to some piles). A check by divers could ascertain whether the barrier is only needed in the low-mid tide region where notching had occurred, or whether full length barriers are needed.

Decking timbers

Crossheads and longitudinal beams were examined in several locations along the jetty, and most damage when found was caused by termites. Some decay, caused by brown or white rotting fungi, was also found most often on the top surfaces. Of the 29 crossheads examined, six were considered failed to termites, and were often hollowed out and gave a dull sound when hit with a hammer. Eleven were considered to be in good condition, with only 1-3 mm decay mostly on the top surface. Six crossheads had only minor damage, such as ‘side with a patch 1000 mm long of decay and termite attack in pith 30 mm deep’, or ‘sapwood corner edge 30 mm thick decayed’ or ‘top surface with several fissures of decay 10-20 mm deep’. Another six crossheads had moderate damage, such as ‘termite damage limited to one end of beam in a crevice 70 mm deep and 1000 mm long near a pile’, or ‘generally in reasonable condition with 2-20 mm decay on top surface, except for one end with 600 mm long cavity caused by termites 100 mm deep and 50 mm wide’.

The longitudinal beams, bearing on the crossheads, showed a similar distribution of damage as the crossheads. For some of the longitudinal beams, 2-3 different lengths were involved. Seventeen longitudinal ‘lengths’ were examined. Of these, seven were in good condition with only minor decay on the top surface and less on the sides. Four lengths were considered failed, mostly to termites but also decay. Five lengths had only minor damage, and one had moderate damage.

Those beams in good condition or with minor damage could be re-used. Perhaps turn them upside down so that the less weathered bottom face becomes the fresh top face where most future weathering will occur. Those with moderate damage are probably still structural at this stage, but should not be reused unless the damaged ends or sections can be removed to leave a solid beam. Shortened crosshead timbers may be too short for other uses, however it may be possible to shorten some longitudinal beams to the length required for crossheads. All timbers detected (by sounding, drilling) with internal damage from termites also had some indication of their presence revealed by the surface condition of the beams. Significant termite damage was usually associated with a narrow crevice on the surface along some portion of the damaged length (especially on the top surface) or timber discolouration, which are signs that could help in termite detection when sorting timbers for re-use.

Pile tops

Few piles tops were examined in detail, as the worst damage caused by termites is often difficult to assess from the top. Nests are often 500 to 1500 mm below the pile tops, and best accessed by drilling from a boat into the side of the pile.

It is worth noting that termites are repelled by seawater, and while they can make their nests in the tops of piles, their damage usually reduces to nil near high tide. Termites in piles require rainwater for their moisture.

DETAILS OF INDIVIDUAL TIMBERS

Area 2 crossheads and beams

Bent 1 = Both crossheads were generally in a good condition, with only 1-3 mm of fungal decay/softening mainly on the top surface. Drilling confirmed good condition.

Bent 2 = One crosshead was mostly hollow due to termite damage (Figure 1). Live termites not found. Second crosshead was in good condition, with only 1-3 mm fungal decay.

Figure 1: Crosshead hollowed out by termites. Right photo showing 'paper thin' layers of wood pulled from hollow, which is typical of termite attack.

Bent 3 = Both crossheads in good condition, with only 1-3 mm decay. However, one has a split at either end, each about 80 mm deep and 500 mm long arising from bolts.

Bent 4 = Both crossheads generally in good condition, with only 1-3 mm decay. One crosshead has a damaged area 10-20 mm deep near a pile. This damage is of minor concern, as it is a pocket of kino and inner pith or heartwood, rather than a result of termites or fungi (Figure 2).

Figure 2: Side of crosshead with 10-20 mm patch of damage from kino and pith, of minor concern. Right photo shows dried kino on removed piece.

Bent 5 = Both crossheads in good condition, with only 1-3 mm decay. One crosshead has several small beetle borer holes caused in the living tree or log that are of no concern as the damage has not progressed in the seasoned sawn timber (Figure 3).

Figure 3: Side of crosshead with minor borer damage caused before the log was sawn, of no concern.

Bent 6 = One crosshead hollowed out by termites. Other (southern side) crosshead in good condition, with only 1-3 mm decay.

Bent 7 = Northern side crosshead with a crevice caused by termites up to 120 mm deep and 20-30 mm wide extending nearly full length of crosshead (Figure 4). Crosshead is probably still structural, as the majority of the remaining timber is in good condition, although the beam should not be reused. Southern side crosshead in better condition, with termite damage limited to one end of beam in a crevice 70 mm deep and 1000 mm long near a pile (Figure 4)

Figure 4: Northern side crosshead (left) with 120 mm deep crevice of termite damage. Southern side crosshead (right) with moderate termite damage at one end.

Bent 8 = Southern side crosshead (167B) identified as *E. obliqua* partially hollowed out by termites, unserviceable (Figure 5). Northern side crosshead with moderate termite attack, heavier damage on eastern end of beam near pile.

Figure 5: Southern side crosshead (left) hollowed by termites. Northern side crosshead (right) with moderate termite damage, heavier damage other end.

Bent 9 = Both crossheads in good condition, with only 1-5 mm decay. Northern crosshead (160A) was identified as *E. obliqua*.

Area 3 original piles with cross-bracing in the tidal zone

These piles had a diagonal cross-brace with the bottom end generally finishing near mid-tide. A lower horizontal cross-brace had apparently also been installed to join each pair of piles at low tide. The problem with this design is that the piles had been checked out at low tide to accommodate the low tide bracing, but then, the crevice between the timbers is a favoured location for *Limnoria.* Therefore, the checked faces were further excavated by *Limnoria*. Also, old bolt holes where bolts had fallen out also provided an entry point for *Limnoria*, often into the less durable inner heartwood or pith. Some piles had concrete collars in and below the tidal zone, which would have prevented further deterioration in this area. As these collars do not extend to mudline, it would be interesting to examine whether *Limnoria* has exploited the bottom edge crevice between concrete and timber pile. Perhaps the crevices favoured by *Limnoria* need to be timber on timber rather than timber on concrete?

Pile 232B = Low tide with 60 mm deep cavity southern side and 90 mm cavity northern side due to low tide cross-bracing now lost. Heartwood with *Limnoria* damage a further 2-4 mm deep plus several streaks of *Limnoria* 10-30 mm deep, teredinids absent. Mid-tide region behind diagonal cross-brace with patch of *Limnoria* erosion 350 mm long x 180 mm wide x 50 mm deep (Figure 6). Estimated sound wood remaining 200 mm wide north/south direction and 320 mm wide east/west direction.

Figure 6: Pile 232B, showing mid-tide region with erosion caused by *Limnoria* behind cross-brace.

Pile 236A = Low tide with 50 mm deep cavity southern side and 60 mm cavity northern side due to low tide cross-bracing now lost. Heartwood with *Limnoria* damage a further 2-4 mm deep, teredinids absent. With two bolt holes excavated to 30 mm diameter by *Limnoria* and 150 mm deep. Several other patches eroded by *Limnoria* to 30 mm deep (Figure 7). Estimated sound wood remaining 210 mm wide north/south direction and 320 mm wide east/west direction.

Figure 7: Pile 236A, showing low tide region with several areas eroded by *Limnoria* to 30 mm deep in north/south faces. Bolt just below waterline in low tide region.

Pile 236B = With concrete collar to above low-tide and below bottom of diagonal cross-brace, and perhaps extending to 1000 mm below low tide. Sapwood 15 mm thick lost in tidal zone, bottom edge of sapwood in high tide region with several 8-10 mm longitudinal tunnels 10-20 mm long caused by *Sphaeroma quoyana*, few fissures from weathering (wetting and drying in tidal zone) above mid-tide 10-15 mm deep. High tide with hole 50 mm diameter and 100 mm deep, perhaps an old bolt hole further hollowed by decay, slaters and *S. quoyana*. *Limnoria* and occasional teredinid present in lower tidal region. Region of pile behind cross-brace checked to fit cross-brace, with additional 40 mm cavity excavated by *Limnoria* into checked region (Figure 8). Estimated sound wood remaining 260 mm wide north/south direction and 300 mm wide east/west direction.

Figure 8: Pile 236B, lower tide region, note pile area near rope notched to fit cross-brace. Concrete collar below cross-brace.

Pile 237A = With concrete collar to just above mid-tide (Figure 9). Sapwood 15 mm thick lost in tidal zone, few fissures from weathering (wetting and drying in tidal zone) above mid-tide 10-15 mm deep. Heartwood without active marine borers, although minor etchings into heartwood from teredinid activity in sapwood (when it was present) was apparent from the collar to 150 mm above the collar. Estimated sound wood remaining 320 mm diameter (present diameter 350 mm).

Figure 9: Pile 237A, pile with concrete collar, without active marine borer attack in tidal zone.

Pile 237B = Low tide with 70 mm deep cavity southern side and 40 mm cavity northern side due to low tide cross-bracing now lost. Heartwood with *Limnoria* damage a further 2-4 mm deep, with light teredinid attack only two specimens found. Heartwood also with two bolt holes 50 mm diameter excavated by *Limnoria* through full diameter of pile, exposing pile pith which is also partially hollowed by *Limnoria* (Figure 10). Estimated sound wood remaining 100 mm diameter, pile unserviceable.

Figure 10: Pile 237B, low tide region showing chisel in one of the 50 mm diameter bolt holes, pile unserviceable.

Pile 238A = Low tide with 70 mm deep cavity southern side and 40 mm cavity northern side due to low tide cross-bracing now lost. Heartwood with *Limnoria* damage a further 2-4 mm deep, teredinids absent. Heartwood also with five holes about 30 mm diameter between low and mid tide 50 to 70 mm deep, possibly arising from *Limnoria* excavation of old drilled holes or eaten out knots (Figure 11). Estimated sound wood remaining 200 mm diameter.

Figure 11: Pile 238A, low tide region showing several 30 mm diameter holes 50-70 mm deep perhaps resulting from old bolt holes or eaten out knots.

Pile 238B = Low tide with 70 mm deep cavity southern side and 70 mm cavity northern side due to low tide cross-bracing now lost. Heartwood with *Limnoria* damage a further 2-4 mm deep, teredinids absent. With several 20-30 mm diameter holes 40 mm deep. Outer face between low and mid tide with 70 mm deep longitudinal cavity 30 mm deep and 100 long excavated by *Limnoria* (possibly old bolt holes) (Figure 12). Estimated sound wood remaining 250 mm diameter.

Figure 12: Pile 238B, left photo showing 70 mm deep cavity from lost cross-brace (below freshly chiseled wood), teredinids absent, two 40 mm deep holes also present. Right photo showing 70 mm deep longitudinal cavity caused by *Limnoria* in old bolt holes.

Pile 239A = With concrete collar to mid-tide (Figure 13), and perhaps extending to 1000 mm below low tide. Sapwood 12 mm thick lost in tidal zone, original diameter of heartwood (450 mm diameter) sound, except for minor weathering fissures 10-15 mm deep. *Limnoria* and teredinids absent, although minor etchings into heartwood from teredinid activity in sapwood (when it was present) was apparent just above the collar. Pile in good condition in the tidal zone.

Figure 13: Pile 239A with concrete collar to about mid-tide, showing fissures 10-15 mm deep due to weathering, marine borer damage mostly absent in tidal zone.

Pile 239B = Identified as *E. ?muelleriana* (probably yellow stringybark). Low tide with 70 mm deep cavity southern side and 80 mm cavity northern side due to low tide cross-bracing now lost (Figure 14). Heartwood with *Limnoria* damage a further 2-4 mm deep and light teredinid attack to 10 mm depth. Estimated sound wood remaining 190 mm wide north/south direction and 250 mm wide east/west direction. Mid-tide region with several cavities 20-30 mm deep into heartwood caused by teredinids and *Limnoria*.

Figure 14: Pile 239B, low tide region showing flattened (checked) face for cross-brace now lost, and projecting end of bolt visible above waterline. Light teredinid attack, freshly chiseled area without teredinid damage.

Pile 240B = Low tide with 190 mm deep cavity southern side (Figure 15) and 70 mm cavity northern side due to low tide cross-bracing now lost. Heartwood with *Limnoria* damage a further 2-4 mm deep and most teredinid attack to 10 mm depth. Estimated sound wood remaining 50 mm wide north/south direction and 300 mm wide east/west direction. If the low tide cross-brace had not been placed, the diameter of good wood remaining in all directions may have been 300 mm. Mid-tide region with several cavities 30-40 mm deep caused by *Limnoria*.

Figure 15: Pile 240B, low tide region showing deep southern cavity at water line on right (below clump of fouling), and shallower cavity on left side. Pile in poor condition.

Area 4 crossheads and beams

Crosshead 279A = with 1-4 mm decay on top surface and sides. One end near a pile top with extensive termite damage over 500 mm length, 100 mm deep from top surface and 120 mm deep from one side. Beam drilled just past termite damaged region and remaining timber was sound (Figure 16). Rest of crosshead in good condition.

Figure 16: Crosshead 279A showing end with extensive termite damage, and drilled shavings ('OK') further from end from which sound timber begins.

Crosshead 279B = with 1-3 mm decay on top surface and sides. One end with termite damage 1000 mm along one side, 60 mm deep from side and 80 mm vertically. Beam drilled just past termite damaged region and remaining timber was sound. Rest of crosshead in good condition.

Crosshead 280A = with 2-5 mm decay on top surface and sides, with several streaks of decay 10-15 mm deep on top surface. Inner pith side of beam with 10 mm brown rot and two pockets of decay to 30 mm deep 30 mm wide and 80 mm long.

Crosshead 280B = identified as *E. obliqua*. Generally in good condition, with 2-5 mm decay on top surface and sides and few 10-15 mm deep streaks of decay on top surface. However, adjacent to one pile is a 1000 mm long and 60 mm wide cavity of decay, possibly where a fish beam had been attached but is now lost.

Crosshead 281A = In good condition, with 2-5 mm decay on top surface and sides, and few 10-20 mm deep streaks of decay on top surface.

Crosshead 281B = generally in reasonable condition with 2-20 mm decay on top surface, except for one end with 600 mm long cavity caused by termites 100 mm deep and 50 mm wide (Figure 17).

Figure 17: Crosshead 281B with termite damage 600 mm along end of beam.

Crosshead 282A = in good condition, except for 400 mm long fissure on top surface due to termite attack up to 80 mm deep and 40 mm wide.

Crosshead 282B = identified as *E. obliqua*. Lower half of northern side (pith side?) with up to 70 mm depth of termite attack, live termites found.

Longitudinal beam 10 (above crosshead 282A), Length 1 = Top surface with two furrows of decay 30 mm deep x 30 mm wide x 1000 mm long. Length 2 = in good condition except for some splitting at one end, where splits are 30 to 50 mm deep x 10 mm wide and 1000 mm long. Beam section over pile 279A with half the width of beam damaged by termites and decay for 900 mm length (Figure 18).

Figure 18: Longitudinal beam 10 over crosshead 279A showing left side of beam damaged by termites and decay (dark coloured shavings) and right side of beam sound (light coloured shavings).

Longitudinal beam 11 = in good condition, near crosshead 280 with lower side area decayed to 20 mm depth from side x 80 mm vertically over 800 mm length.

Longitudinal beam 12 = in good condition, with 1-5 mm decay on top and sides.

Longitudinal beam 13 = Lengths 1 (identified as *E. ?muelleriana* probably coastal grey box) and 2 in good condition, 1-4 mm decay on top and sides, top surface with several 10 mm deep weathering crevices. Northern 'Length 3' hidden under deck, but apparently failed to termites.

Longitudinal beam 14 = Length 1 in good condition. Length 2 (identified as *E. obliqua*) in poor condition, near crosshead 279 with decay 25 mm deep x 30 mm wide x 500 mm long. Length 2 also with northern end near crosshead 278 failed to termites 120 mm from one side and attack extending for 2000 mm (Figure 19).

Figure 19: Longitudinal beam 14 near crosshead 278 with severe termite attack one end for approximately 2000 mm length.

Longitudinal beam 15 = mostly in good condition. Between crossheads 282 and 281 with decay streak 40 mm deep x 15 mm wide and 1100 mm long. Near crosshead 280 with 3000 mm sapwood edge lost or decaying up to 50 mm depth (includes some wane) (Figure 20).

Figure 20: Longitudinal beam 15. Left photo shows streak of decay 15 mm wide, adjacent drilled timber (note shavings) sound. Right photo showing wane and sapwood edge lost or decayed/breaking away.

Longitudinal beam 16 = good condition, with several decay crevices 10-15 mm deep on top surface.

Area 5 piles installed 1982

Pile 296A = Sapwood 20 mm thick lost in tidal zone. Low tide heartwood heavily eroded, with *Limnoria* damage 2-3 mm deep and most teredinid damage to 30 mm deep, so that only 100-120 mm diameter of sound heartwood remains (Figure 21). Pile unserviceable.

Figure 21: Pile 296A, with only 100-120 mm sound wood remaining. Freshly chiseled region near rope showing some white calcareous-lined teredinid tunnels.

Pile 296B = identified as *E. ?muelleriana*, probably yellow stringybark. Sapwood 20 mm thick lost in tidal zone. Low tide heartwood with *Limnoria* damage 2-3 mm deep and most teredinid damage to 20 mm deep, so that approximately 270 mm diameter of sound heartwood remains (Figure 22). Pile still serviceable.

Figure 22: Pile 296B, with ~270 mm sound heartwood remaining. Freshly chiseled region near waterline showing some white calcareous-lined teredinid tunnels.

Pile 296C = Sapwood 20 mm thick lost in tidal zone. Low tide heartwood partially eroded, with *Limnoria* damage 2-3 mm deep and most teredinid damage to 20 mm deep, so that approximately 250 mm diameter of sound heartwood remains. Pile still serviceable.

Pile 296D = Sapwood 20 mm thick lost in tidal zone. Low tide heartwood heavily eroded, with *Limnoria* damage 2-3 mm deep and most teredinid damage to 30 mm deep, so that only 100-200 mm diameter of sound heartwood remains. Pile unserviceable.

Pile 297A = Sapwood 20 mm thick lost in tidal zone. Low tide heartwood about 300 mm diameter not eroded, but with *Limnoria* damage 2-3 mm deep and most teredinid damage 20-25 mm deep, so that about 260 mm of sound heartwood remains. Pile still serviceable.

Pile 297B = Sapwood 20 mm thick lost in tidal zone, and heavily attacked by *Lyctus* borers above the tidal zone (Figure 23). Note that this timber is probably not yellow stringybark, a timber species considered resistant to *Lyctus*. Low tide heartwood about 300 mm diameter not eroded (no 'necking'), but with *Limnoria* damage 2-3 mm deep and most teredinid damage 10-20 mm deep, so that about 270 mm of sound heartwood remains (Figure 23). Pile still serviceable.

Figure 23: Pile 297B, without necking of heartwood and ~270 mm sound heartwood remaining. Left photo showing heavy *Lyctus* borer damage to sapwood (not heartwood) above the tidal zone.

Pile 297C = Sapwood 20 mm thick lost in tidal zone. Low tide heartwood generally with *Limnoria* damage 2-3 mm deep but with 100 mm diameter and 80 mm deep cavity caused by *Limnoria* at low tide, most teredinid damage 20-30 mm deep, so that about 230 mm of sound heartwood remains (Figure 24). Pile in poor condition.

Figure 24: Pile 297C, with cavity caused by *Limnoria* (right side near rope), and probably with ~230 mm sound heartwood remaining. Pile in poor condition.

Pile 297D = Sapwood 20 mm thick lost in tidal zone. Low tide heartwood heavily eroded and with 3 large cavities caused by *Limnoria* and teredinids, generally also with *Limnoria* damage 2-3 mm deep and most teredinid damage 30-40 mm deep, so that about 100 mm of sound heartwood remains (Figure 25). Pile unserviceable.

Figure 25: Pile 297D, with several cavities at low tide and 30-40 mm teredinid attack, with ~100 mm sound heartwood remaining. Pile unserviceable.

Pile 297E = Sapwood 20 mm thick lost in tidal zone. Mid tide to low tide heartwood with several 20 mm deep fissures and low tide with heartwood erosion 20-30 mm deep, generally also with *Limnoria* damage 2-3 mm deep and most teredinid damage 30-40 mm deep, so that about 180 mm of sound heartwood remains. Pile unserviceable.

Area 5 crossheads and beams
Decking transoms (not inspected, generally in poor condition) on longitudinal beams, which rest upon crossheads (Figure 26).

Figure 26: Area 5, transom resting on longitudinal beams resting on crossheads.

Crosshead near pile 295B = in good condition with 1-3 mm decay, side with a patch 1000 mm long of decay and termite attack in pith 30 mm deep (Figure 27). Crosshead mostly in good condition.

Figure 27: Crosshead above 295B pile, showing damaged pith area (closest face) on side, drilled shavings on top face indicate remaining heartwood in good condition.

Crosshead southern side near pile 296B = *E. ?globulus* probably blue gum*.* Top edge with decayed sapwood edge to 30 mm depth (Figure 28), heartwood in good condition with 2-3 mm decay on top edge. Crosshead mostly in good condition.

Figure 28: Crosshead above 296B pile, showing sapwood edge lost to decay (lower edge in photo) and drill shavings 20 mm in from sapwood edge indicating heartwood is sound.

Crosshead above 297 row of piles = *E. ?globulus* probably blue gum. Heavily attacked by termites (Figure 29).

Figure 29: Crosshead above 297 row of piles, heavily attacked by termites (note chisel pushed through timber).

First (western most) longitudinal set of beams = *E. bosistoana* (coastal grey box) in good condition, with 2-5 mm decay on top surface. Fish beam (1.5 m long) alongside longitudinal beams end join with 10-15 mm decay on top and inner edge.

Second longitudinal beams = Mostly in good condition with 2-5 mm decay on top surface, except for few furrows of decay to 20 mm depth on top surface and one end with decay to 30 mm depth.

Third longitudinal beams = Southern beam in good condition, 2-5 mm decay on top surface. Northern beam with end near join decayed on top surface 250 mm long and up to 20 mm deep, adjacent fish beam with inner face decayed to one-third of its depth (about 60 mm decay). Other end of longitudinal beam with white rot to 100 mm depth at end reducing to few mm of decay 250 mm from end (Figure 30), although beam here is still structural as the damaged end is counter-levered away from the crosshead on which it rests.

Figure 30: Longitudinal beams, '3rd' shows southern beam in good condition, joining northern beam to right with 20 mm decay on top surface. 'F' is fish beam with up to 60 mm decay on inner face adjacent to other timbers. Right photo shows northern end of northern beam with 100 mm white rot to 250 mm from end.

Fourth longitudinal beams = Northern beam in good condition, 2-5 mm decay on top surface. Southern beam (identified as *E. ?globulus* probably blue gum) near join with northern beam hollow due to termite attack to 1000 mm from end, but 1500 mm from end termite damage has ended as shown by drilling.

MATERIALS AND METHODS

Piles were examined during low tide from a small boat, for their condition in and above the tidal zone. The condition of piling below low tide was not examined. Fouling was scraped from piles to aid inspection of the timber beneath. Some marine borers were collected for species identification. Small heartwood samples were removed from some piles using a chisel, for timber identification by Dr Jugo Ilic. The piles were probed with a knife and examined to determine the extent of marine borer attack.

Decking timbers were examined by probing with a knife, coupled with 'sounding' by hitting the beams with a hammer. Some beams were also drilled using a drill bit about 12 mm diameter, to detect timber resistance and to find discoloured/decayed drill shavings.

APPENDIX F

DDA AUDIT REPORT

INTRODUCTION

In Australia and the world at large, disability access standards and guidelines have generally been written to cover landside facilities. Following the release of the Disability Discrimination Act (DDA) in 1992, Australian Standard AS1428 was developed to guide Public and Private Asset Managers in ways to upgrade their facilities to provide appropriate access to disabled persons . Applying the guidance in AS1428 to Maritime facilities is problematic as the standard was created with the purpose of improving access to public transport, buildings and public walkways with little to no consideration of jetties, piers and other maritime structures. Limited guidance is included in Australian Maritime Standards AS4997 and AS3962, however these standards do not cover the full suite of requirements prescribed in AS1428.

The approach taken in this audit is to recommend upgrades to improve access to the structure, using the available standards and guidelines where appropriate. The aim is to develop cost-effective solutions which improve access to the Long Jetty by removing impediments that would otherwise prevent a particular demographic from using the facility.

SCOPE OF AUDIT

The Port Welshpool Long Jetty is currently closed to the public. There are several access impediments along the Jetty that need to be addressed if the structure is to be re-opened. This DDA assessment considers;

- Basic upgrades to the jetty's superstructure required to allow access along the Jetty's length.
- Upgrades to achieve DDA compliance, appropriate to the maritime environment and in-line with the anticipated future level of service to be provided at the Long Jetty.
- Recommendations to improve safety in-line with maritime standards.

The standards, codes and guidelines referenced in this audit are summarised below;

Acts;

- Disability Discrimination Act 1992

Australian Standards;

- Disability standards for accessible public transport (2002)
- AS1428.1-2009: General requirements for access - new building work
- AS1428.2-1992: Enhanced and additional requirements – buildings & facilities
- AS1428.3-1992: Requirements for children and adolescents with physical disabilities
- AS1428.4-2009: Means to assist the orientation of people with vision impairment

Maritime Specific Standards;

- PIANC disability access guidelines for recreational boating facilities (2004)
- AS4997-2005: Guidelines for the design of maritime structures
- AS3962-2001: Guidelines for design of marinas

LEVEL OF SERVICE

With the exception of those maritime sites that can be classified as public transport conveyances (of which there are only a handful in Victoria), the majority of piers and jetties do not need to comply fully with AS1428. This should not preclude the Asset Manager from a general obligation to improve access to their facilities for all members the public, by eliminating access restrictions as best as is reasonably practicable. Without clear guidelines for access improvements at maritime facilities, the proposed level of service (LOS) to be provided by the facility should be established, before determining the required upgrades. Sites should be audited based on this required level of service. The level of service to be provided by the Long Jetty has not yet been defined by Gippsland Ports (GP) and any proposed LOS rating should be reviewed by GP to ensure it is appropriate. The LOS to be provided by a pier or jetty is typically determined by considering the following factors;

- The frequency of visitation by members of the public.
- The structural form, age and dilapidation of the structure, including the relative hardship and cost impediment on the owner for any structural upgrade.
- Demographic in the local area and likelihood of visitation by disabled members of the public.
- Economic, social and cultural significance of the site.

It is proposed that recommendations for access upgrades to maritime structures should vary depending on the level of service rating assigned to a site as per Table F1.

Table F1: Levels of Service

Level of Service	Typical Site Description	Extent of Upgrade Recommended
1	Site provides access to public transport modes (i.e. water taxi or ferry). AS4997-2005: Guidelines for the Design of Maritime Structures states that where "Access is required to public transport facilities, structures should comply with the requirements of the Disability Standard for Accessible Public Transport".	*Full compliance with AS1428.*
2	Site is used extensively by the public for promenading and recreational activities. The structural form does not present an overarching access issue. Moderate visitation by disabled members of the public is to be expected. The site may have an economic, social or cultural significance.	*Full compliance with AS1428 or tailored recommendations where appropriate.*
3	Site is private or restricts/limits public access and does not attract much pedestrian traffic. Significant reconstruction of the pier or jetty is required to achieve general access upgrades (i.e. approach is only 1100mm wide). Site does not attract tourism or any particular interest from community groups and is unlikely to be visited by disabled members of the public.	*Limited access improvements recommended as appropriate.*

IMPLEMENTATION

Hyder's previous DDA Compliance commission with Gippsland Ports included a recommended timeframe in which upgrades should be implemented. It is our view that without prescriptive standards to inform the timeframe, it should be at the discretion of the Asset Manager to put forward a practical implementation strategy. This strategy may then be formalised and registered with the Australian Human Rights and Equal Opportunities Commission (HREOC) as an "Action Plan".

Registering an Action Plan with HREOC is completely voluntary and considered a proactive way for an organisation to demonstrate it is taking steps to achieve DDA compliance. In the event of a complaint against an organisation, for failing to provide an adequate level of access, the DDA requires that HREOC consider the organisation's Action Plan. It should be noted that "The success of an action plan, in terms of eliminating disability discrimination and in being used as a defence against complaints, will largely depend on the effectiveness of the actions taken"[1]. A large database of Action Plans from over 500 organisations is available to view online, at the HREOC website, which may be beneficial reference for Gippsland Ports in the development of their implementation strategy.

Implementation of upgrades proposed for sites with a LOS rating of 1 should be subject to the Disability Standards for Accessible Public Transport; Schedule 1 – Target dates for compliance.

LIMITATIONS

A DDA assessment beyond the fire damaged area leading on to the Jetty Head has not been conducted as part of this commission. As the structural form of the jetty is relatively constant between its extents, many of the upgrade recommendations contained within this appendix still apply. An access audit within the old slipway shed was not conducted as it is assumed that it will remain closed to the public if the jetty re-opens. The following items have not been considered as part of this audit;

- Lighting (illumination levels).
- Listening systems and information boards.
- Signage and symbols.
- Food and drink services.
- Slip resistance of the decking surface.
- Ponding.

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[1] Austrailan Human Rights Commission. *Action plans and action plan guides*, 2011. http://www.hreoc.gov.au/disability_rights/action_plans/index.html, Accessed 22 June 2010.

COMPLIANCE AUDIT

Current Use

Port Welshpool Long Jetty is currently closed to the public. If re-opened, it is proposed that access will typically be limited to tourists and fishermen and will not include provision for vessel berthing. It is recommended that this site be assigned an LOS rating of 2, assuming that general repair work will be carried out and the structure will be restored to a serviceable condition.

Figure F1: Port Welshpool Long Jetty

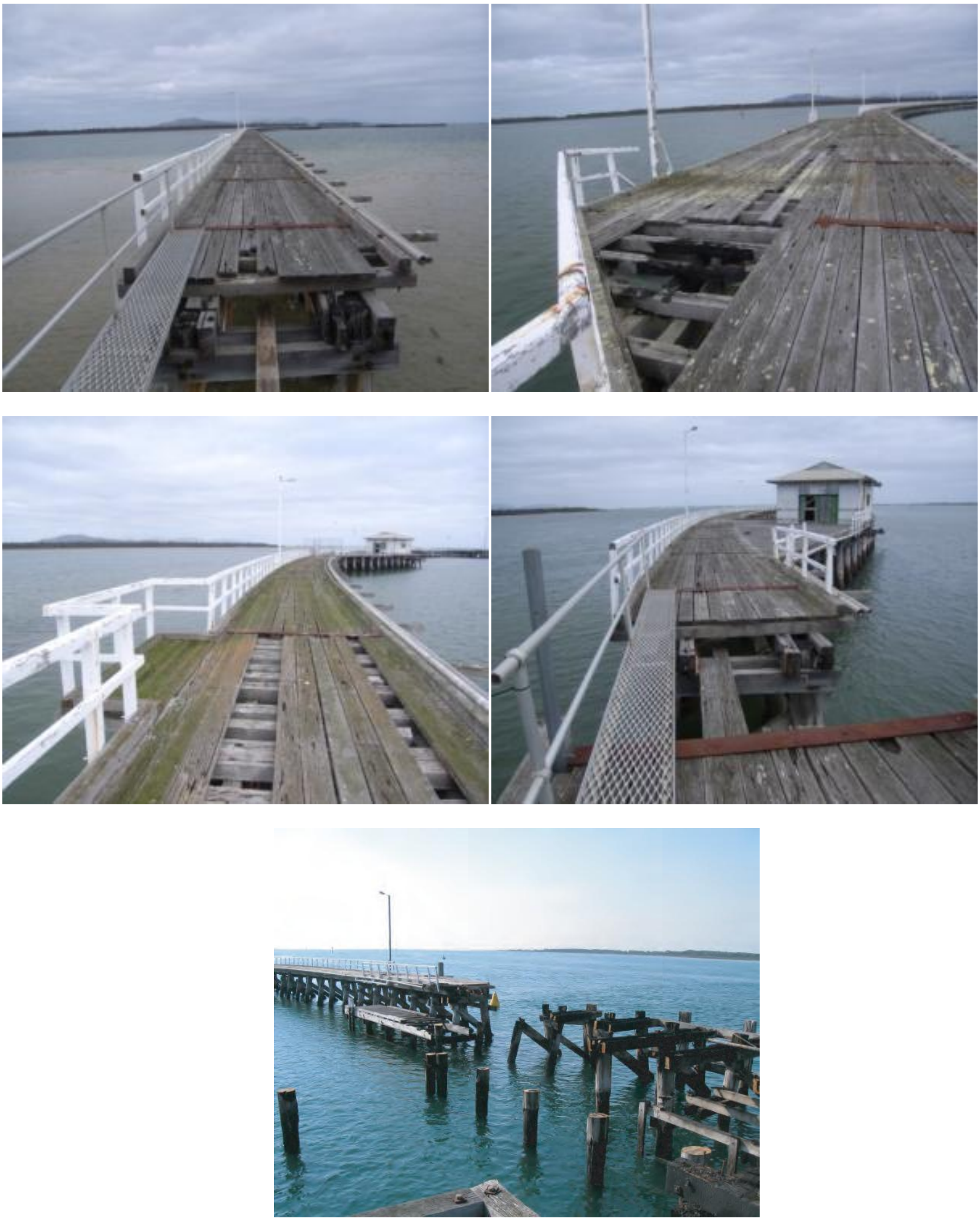
Recommended Access Upgrades

General Repair and Replacement

To provide access to both the general public and disabled persons, there will need to be extensive repair and replacement of structural components at several points along the jetty structure. Prior to the Long Jetty being reopened, a programme of works will have to be undertaken that includes;

- Reconstruction of the jetty in sections where it has burnt out or been purposefully removed.
- Extensive replacement of the jetty superstructure, especially the heavily deteriorated deck planks.

Audit comments hereafter apply to the jetty structure after this programme of works is complete (i.e. post general structural repair and replacement).



Figures F2-6: Current state of Jetty Structure

Trip Hazards

The tolerance for transition between abutting surfaces in AS1428.1 is ± 3mm. This may not be realistically achievable in walkways of timber plank construction, due to the natural variation in thickness and warping of timber elements. Section 6.5.4 of AS4997: Guidelines for the design of maritime structures specifies that *"it is necessary to ensure that trip hazards will not be caused by differences in plank thickness or warping due to drying"*. It is recommended that a tolerance of no more than ± 10mm be considered at Port Welshpool Jetty and that deck planks be "back sawn" where required (or replaced if necessary).

In addition to vertical tolerances between deck planks, the width of the horizontal gap between adjacent deck planks must be considered. The gap should be minimised to avoid posing a trip hazard through causing imbalance or a healed shoe to pass between deck planks. Spacing, natural variation and warping of deck planks at the Long Jetty have resulted in gaps of up to 75mm between planks. It is recommended that gaps between adjacent planks be a maximum of +13mm wide.

It is also recommended that all capping plates over transverse joints be removed or rebated as they are not flush with the decking surface and present a trip hazard.

Figures F7-8: Current state of Jetty Structure

Rest Areas

The Australian Human Rights and Equal Opportunities Commission (HREOC) defines a continuous accessible path of travel as an uninterrupted route to or within premises providing access to all services and facilities. Most jetties and piers fall within this classification. Clause 7 of AS 1428.2 outlines the requirements for accessible paths of travel. It states; *"In areas of use by people with ambulatory disabilities, such as areas frequented by elderly people, seats should be provided no more than 60m apart alongside paths of travel".*

While piers and jetties "are frequented by people with ambulatory disabilities or the elderly", the provision of resting areas every 60m can be considered as a "premium" level of service. As the distance between rest areas increases, the percentage of people with a certain disability who can physically walk between these areas decreases. The percentage of disabled people (in order of disability type) unable to move specified distances between rest areas, is outlined in Clause 7 of AS1428.2. If rest areas are provided every 130m along the Jetty, the percentage of people able to move aptly between these rest areas is as follows;

- *95% of people in wheelchairs;*
- *95% of people with vision impairment;*
- *60% of people with walking aids; and*
- *75% of ambulatory people.*

Based on the guidance in AS1428.2, the majority of disabled persons are still able to use the Jetty with rest areas space at 130m. Combined with the prediction that the Jetty will be used by only tourists and fishermen, the provision of rest areas every 130m as an upgrade to existing piers and jetties, should provide a level of service rated at 2 or 3.

The current configuration of the Port Welshpool Long Jetty allows for the provision of seats where small passing bays are part of the Jetty's superstructure. These passing bays are currently spaced at intervals of approximately 60m. It is recommended that a seat be installed at every second passing bay along the jetty's length.

Figures F9-10: Small passing bays on the Jetty Structure

Site Access

At the time of inspection there was no provision for disabled access to the jetty. It is understood that Gippsland Ports is only responsible for the Jetty structure and that the gravel path and road surrounding the jetty is managed by others. Gippsland Ports should be aware that access to their site by disabled members of the public is not currently complaint with Australian Standards and may limit its use by these members of the community.

Figure F11: Access to the start of the Jetty

Maritime Safety Requirements

Ladders

There are currently no ladders on the Port Welshpool Long Jetty. To comply with Section 3.4.5 of AS4997: Guidelines for the Design of Maritime Structures, ladders should be provided at 60m intervals along the jetty. Amongst other requirements these ladders should include buffer rails, at least 250mm proud of the ladder, be constructed of a durable material and installed so that the bottom rung extends at least 300mm below LAT. Further requirements for safety ladders (extension of ladder stiles, spacing, materials, etc) can be found in the relevant Australian Standards.

Handrails

Port Welshpool Long Jetty features handrails along one side for most of its length. AS 4997: Guidelines for the Design of Maritime Structures states that *"Where access to the water or vessels is not required and where a person falling from the structure is likely to fall more than 1.5m to strike a hard surface or the seabed, a guardrail (handrail) should be provided in accordance with AS1657"*. It is recommended that handrails be provided to both sides of the jetty along its entire length where there is currently no fall prevention (this requirement will change if the jetty will be used for berthing when re-opened). It is recommended that Gippsland Ports investigate the requirements under the relevant Australian standards for handrails before implementing this requirement (i.e. AS1657). The structural adequacy of the existing handrails should also be checked before the structure is re-opened.

Figures F12-13: Timber handrails

Summary of Recommendations

- Rebuild the jetty where it is currently discontinuous to achieve the intended structural form.
- Extensive replacement of missing deck planks.
- Deck planks to be back sawn where required to achieve a vertical tolerance no greater than ±10mm.
- Replace deck planks to ensure gaps between adjacent planks are no greater than 13mm.
- Remove or rebate capping plates.
- Liaise with the relevant authority on current access limitations prior to jetty entry.
- Install ladders at 60m intervals along the jetties length.
- Replace existing handrails where required.
- Provide compliant handrails to both sides of the jetty, along its entire length.