SUMPTER WHARF

OAMARU

CONSERVATION REPORT

Nick Barber, Chartered Engineer, MIPENZ (Civil & Structural)

April 2006

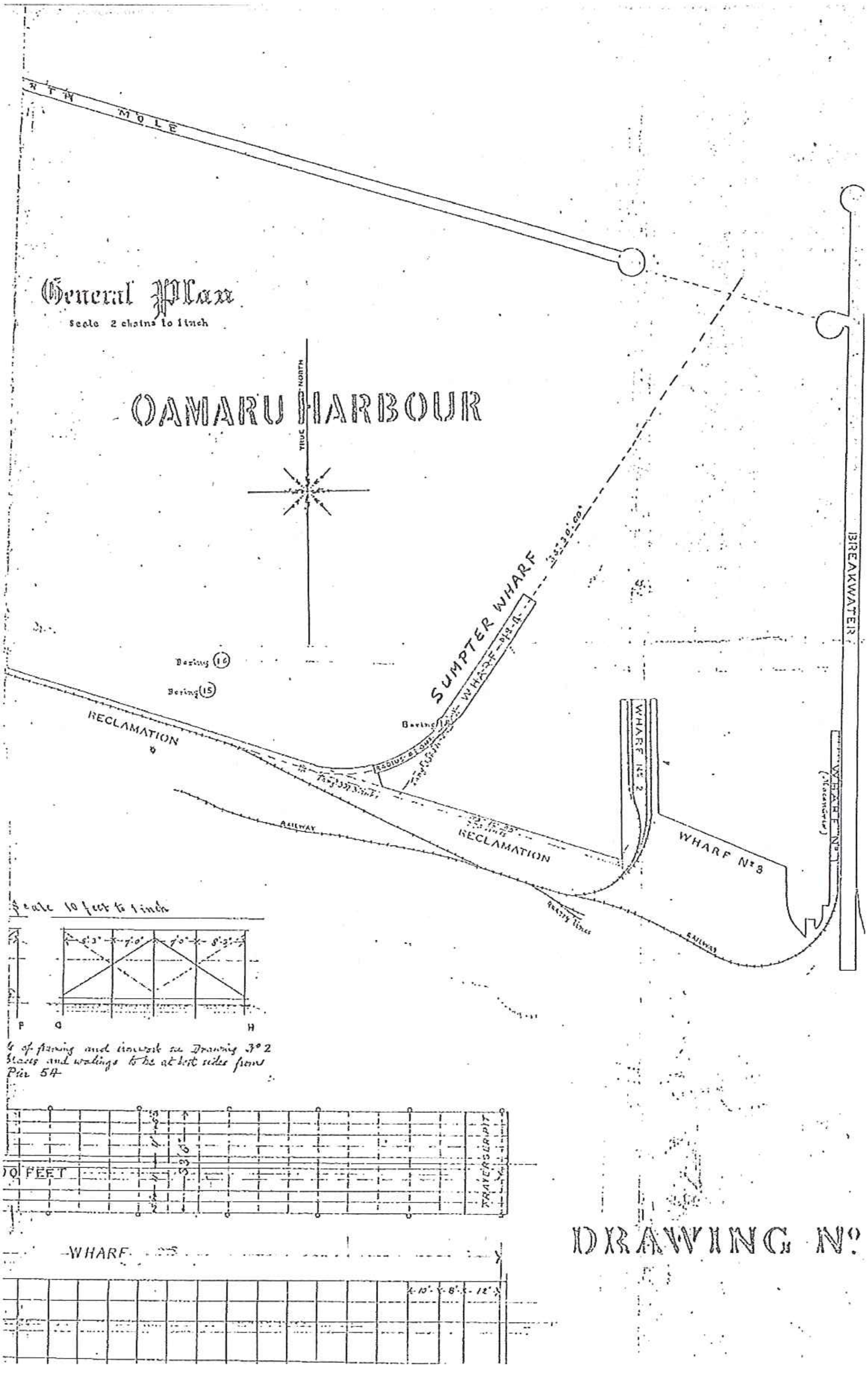
WHARF HISTORY

A history of the port has been written by Gavin McLean in his book 'Oamaru Harbour, Port in a Storm' Dunmore Press 1982. The present report is limited to the Sumpter Wharf itself and addresses the structural requirements needed to salvage the wharf even if it was only able to be kept standing in a derelict form.

In August of 1883, Timaru Contractors Philp & Jones signed the Construction Documents for the wharf originally called No 4 Wharf. The first New Zealand export of frozen meat originated at the Totara Estate just outside Oamaru and although the first shipments went through the Port of Otago, the Sumpter Wharf was the first wharf in New Zealand constructed specifically for the frozen meat trade.

The site chosen for the wharf was within the breakwater harbour in the area where natural water depth was suitable for the international trading vessels of the time. Soil investigation drill holes were sunk and the final site chosen was set clear of bedrock which ensured pile driving would be simple and that dredging could be undertaken in the future when larger vessels with deeper draughts required more depth alongside. Typical of coastal ports, the wharf was aligned pointing towards the harbour entrance so that swell wave induced movement of the vessels would be minimised. (see Drawing No 1A)

The present Port of Oamaru is believed to be unique in the southern hemisphere in that it is very much in the same layout as it was 120 yrs ago with most of the streets, rail-lines and buildings associated with the harbour still in existence. Sumpter Wharf fell into disuse when larger ships entered the meat trade and centralisation of meat export operations saw Oamaru left out of the loop. The wharf therefore, like other parts of the harbour has retained its original form without the modifications and expansion required by containerisation and modernised cargo handling equipment. The North Otago Branch of the Historic Places Trust became aware that for safety reasons the aging Sumpter Wharf was being considered for demolition. They realized the special significance of this historic wharf and that it's loss would be a loss to the whole effort to preserve the harbour & its neighbouring precincts as a tribute to the pioneering efforts of the late 1800's.


NTH MOLE
General Plan
Scale 2 chains to 1 inch
OAMARU HARBOUR
TRUE NORTH
SUMPTER WHARF
BREAKWATER
RECLAMATION
WHARF No 2
WHARF No 3
RAILWAY
Boring (16)
Boring (15)
Scale 10 feet to 1 inch
F
G
H
TRAVERSER PIT
WHARF
DRAWING No

REPORT SUMMARY

This document reports on (i) the structural analysis of the original structure, (ii) an assessment of the wharf's present condition, (iii) the means by which a preservation strategy may be achieved and (iv) an estimate of costs involved. It was decided that a ceiling for expenditure would be set at $600,000 and that as far as can be practically achieved the preservation work would be set out in such a way that less important work could be left till last, or, if budget constraints prevail they could be dropped off the Programme of Works.

Carol Berry, representing the North Otago Branch of the Historic Places Trust suggested the following objectives for preserving the historic Sumpter Wharf:

1. To make the wharf stable against collapse and safe for people to walk on.
2. To protect the existing structure from further deterioration.
3. To reconstruct a section of the structure replacing or repairing unsound rejected material with material and installation methods authentic to the original construction.

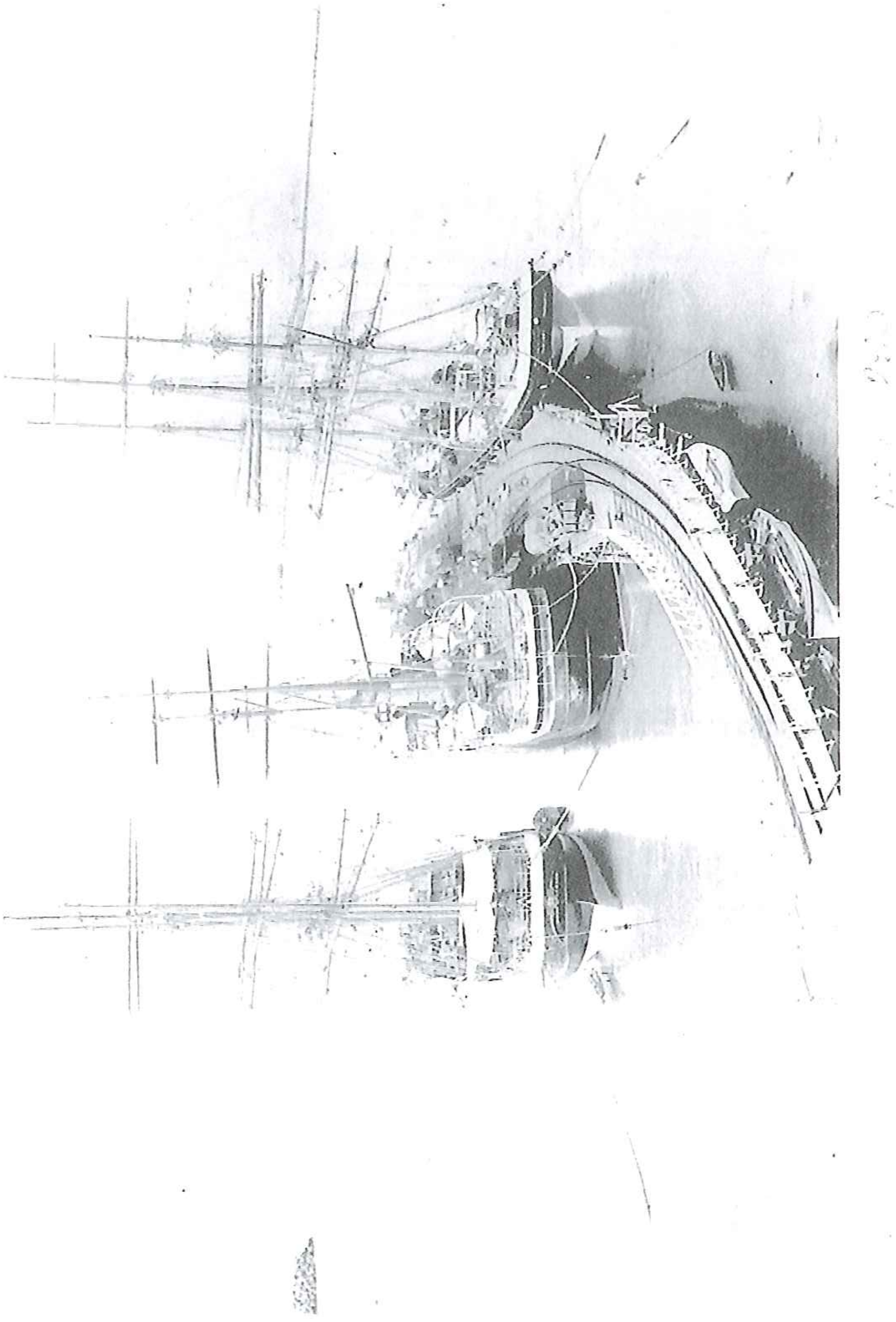
As the investigative work progressed it was realised that the area of the Viaduct access section of the wharf was not large (less than 20% of the total wharf area), and its total re-construction with many interesting features would be less costly than say, repairing all the fenders and bracing. The reconstruction of this part of the structure would certainly be more visible and speak more clearly of the technology prevailing 120 years ago than work beyond the viaduct section.

Reconstruction of the Viaduct section to its original strength would also pave the way for the locally operated restored steam trains extend their restoration work to the wharf and/or give vehicular access to possible development of commercially operated "layup berths" that could be established at the inner ends of the wharf proper for 'super yachts', large launches or other vessels. (A lay-up berth is where vessels are moored for maintenance and repair rather than cargo handling.)

In addition to full repair of the Viaduct section it is proposed that a walkway be installed along the wharf to an area at the end that would be suitable for scenic photographs, wedding party photos etc.

The report concludes that the proposed conservation objectives could be achieved within the proposed budget ceiling.

Structural Assessment of Sumpter Wharf Oamaru
For the NZ Historic Places Trust, North Otago Branch



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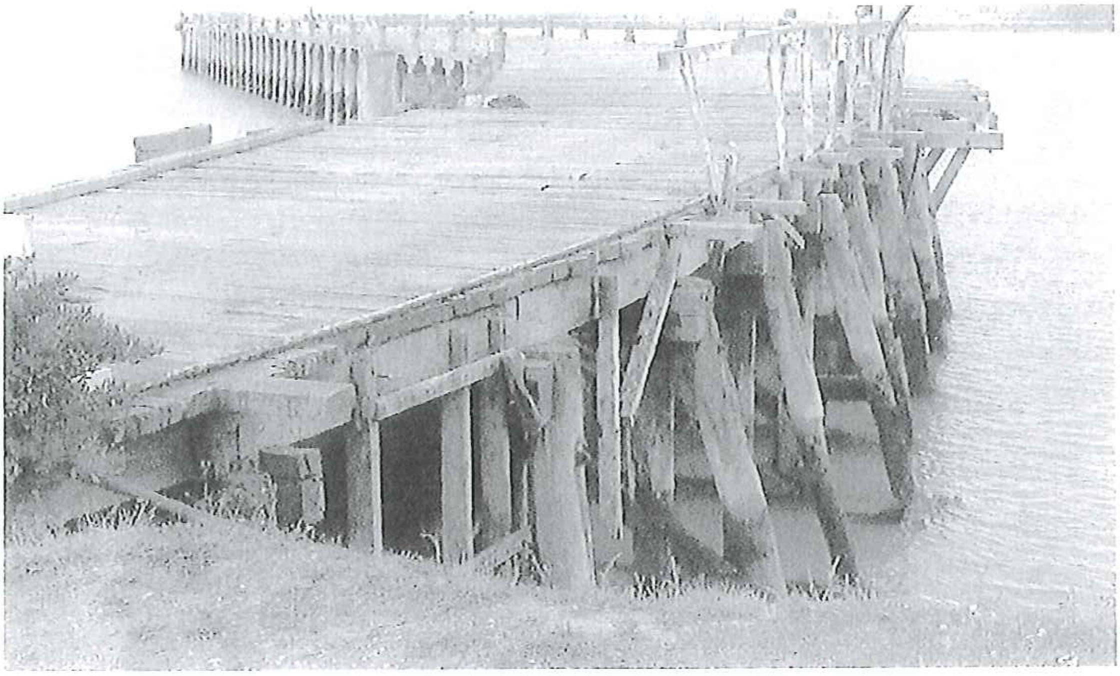
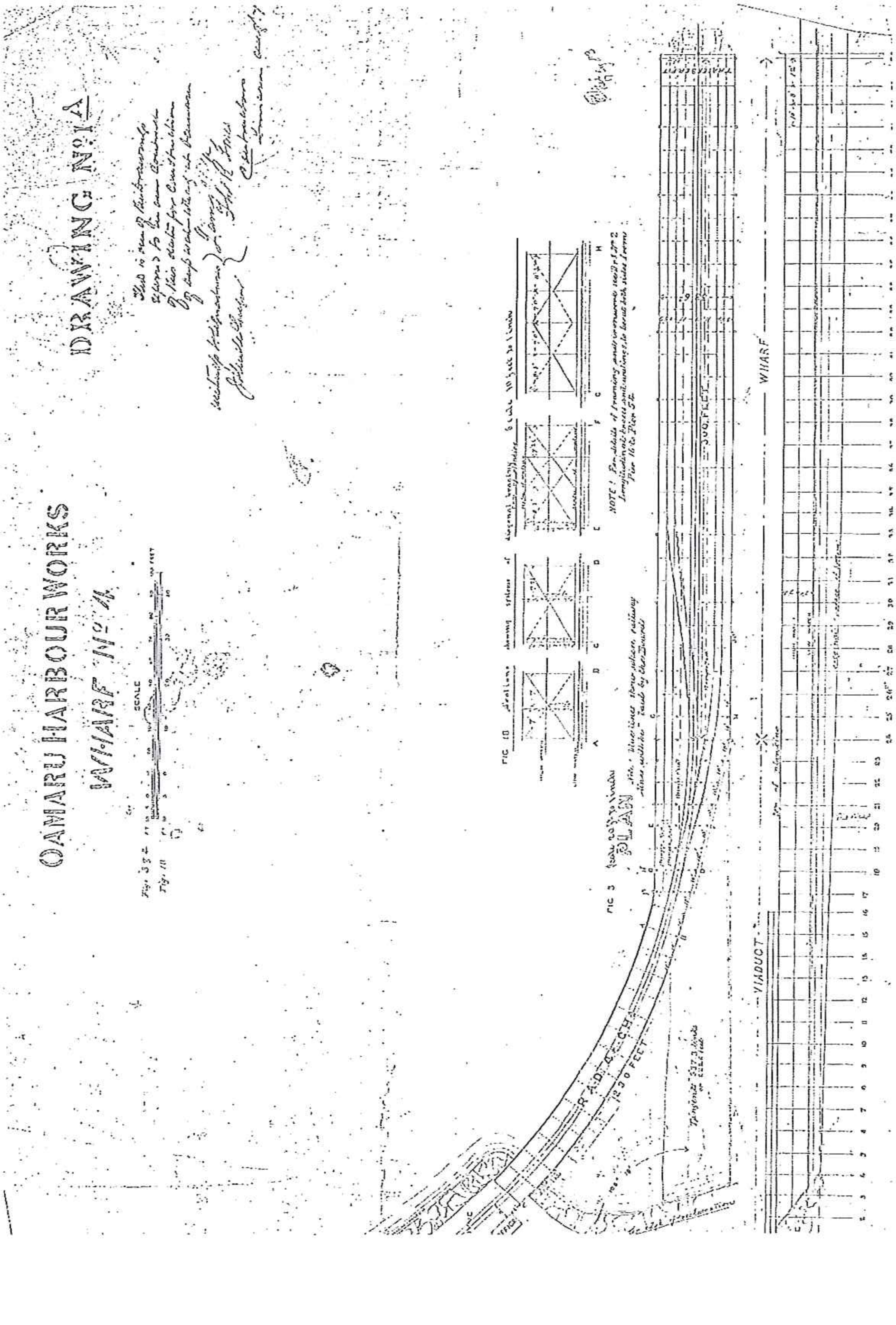


PRESENT DAY SUMPTER WHARF

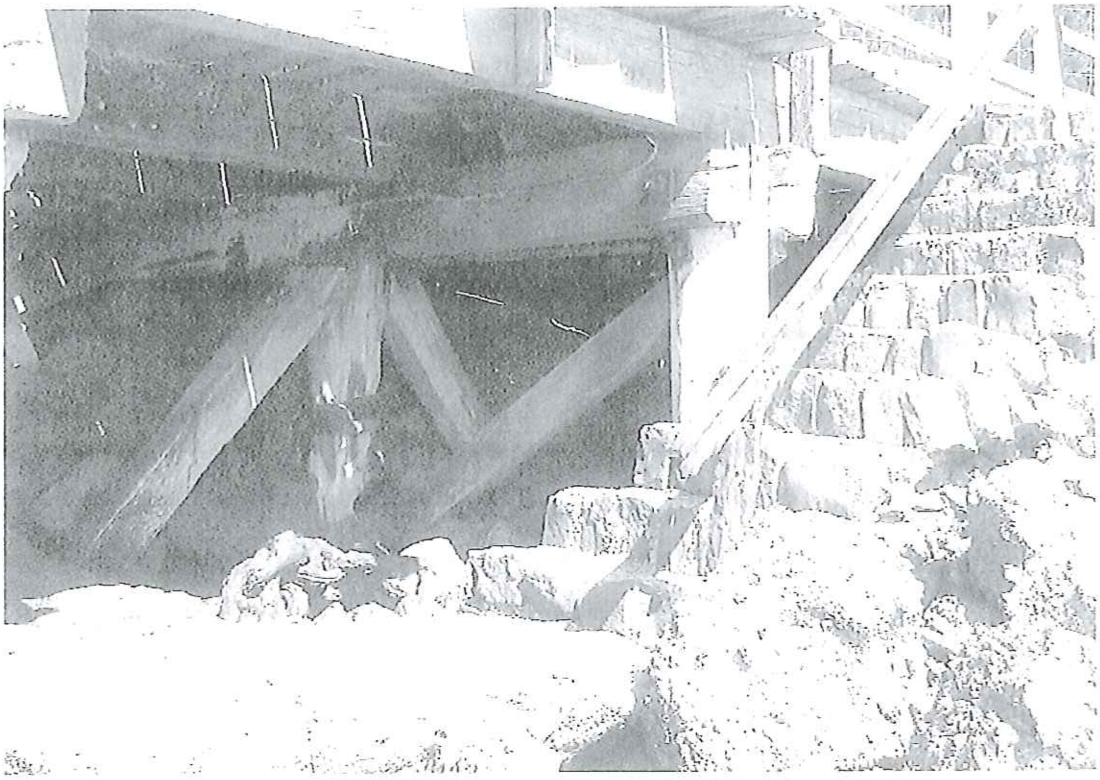

OAMARU HARBOUR WORKS
DRAWING No 1A
WHARF
VIADUCT


Viaduct Reconstruction to Pile Pier 18
FIG 3
PLAN
FIG 18 Sections showing
HIGH WATER
LOW WATER
VIADUCT
230 FEET
top of planking
reclamation

GENERAL DESCRIPTION

The wharf was constructed with Australian Hardwood timber and piles to provide a 300ft, (92 metres) berth on each side, was 33 ft 6 inches (10 metres) wide and was designed to carry 3 rows of railway cars and heavy steam locomotives. The berthage area was positioned in water that was naturally some 12 ft deep at low tide and was connected to the shore via a curved access 'viaduct' 230 ft long. (See Wharf Layout Plan)

The 'Viaduct' section, extending from Pile Pier 1 to Pile Pier 18 provided the link between the wharf proper and land and can be regarded as the entrance or gateway to the historic wharf. It had features that are most likely to give visitors a picture of the historic aspects of the wharf and harbour. The relatively narrow access had safety barriers each side. The barriers were higher than normal barriers of today and a strength analysis suggests that the barriers were installed for the passage of cattle and horses. They conveniently may also have provided security for foot traffic that would have to keep near the edges when the rather narrow access was concurrently in use by rail traffic. Two sets of davits on the south side were installed for the long-boat and the pilot boat and nearby are the remnants of a set of access steps. (A visiting sailing vessel would be at anchor outside the harbour until suitable weather conditions prevailed, then the pilot boat would take the pilot out to board the ship and the long-boat (tug) with crew would tow the vessel through the entrance channel under guidance of the pilot.) This section of wharf also had landing steps on the north side to facilitate landing people being ferried by rowboat to and from vessels at anchor in the harbour. A series of stone steps on the north side of Pile Pier 2 lead to the workers toilets under the wharf. Later a flag pole was erected that would have been used to signal to vessels offshore.



STEPS LEADING TO THE SITE OF THE WORKERS TOILETS

DESCRIPTION OF WHARF DETAILS

Wharf Design 'as built'.

The best description of the Wharf construction details as built is given by the original plans (Typical Cross Section) and early photographs. The original construction was built from the plans and it appears that most features described on the plans were faithfully constructed. Structurally significant additions are 7 raker piles on the outside edge of the curved viaduct access and 7 pairs of raker piles which were driven along the centreline of the wharf with piles angled towards the berthage line at a slant of about 26 degrees from vertical. The viaduct raker piles would have been installed to reduce horizontal movement at deck level caused by the centrifugal force exerted by the loaded train as it moved around the curve. (The more flexible cross bracing would have allowed some movement in the wharf.) The other pairs of raker piles would have been installed to stiffen the wharf against berthage impacts from the large steel steam-powered vessels which were to start using the wharf soon after its completion.

<u>Piles</u>

In general terms the wharf was designed to include :

233 vertical load-bearing piles
27 mooring piles
21 raker piles.

All piles are thought to be Australian Turpentine (Syncarpia Glomulifera) which were known to have a high degree of natural resistance to marine borer attack. (Limnoria and Bankia Neztalia in cool waters and in warmer waters, Teredo and Sphaeroma.) Turpentine piles from coastal Australia were known to have a life expectancy of 35 to 50 years in many situations. The life of piles using NZ timbers would have been measured in months.

As the photo illustrations show, all piles are in sound condition above mean sea level except at the top of the piles where rainwater ingress has provided an environment for fungus attack.

Typical Bankia attack near low tide levels on the lower waling of the pile bracing system.

Notice also the Limnoria pile thinning that has occurred around the half tide mark.

Lower right, bolt holes have provided access for Bankia to attack the pile on several fronts.

Note also that bolts have survived 125 years in seawater.

The 'hour glass' type erosion of the piles indicates that Limnoria is the predominant cause of decay. This borer also known as the gribble or ship worm, has a woodlice shape and burrows through sound timber just below the surface with the attack concentrated around the low water mark.

Bankia is a worm shaped borer that tunnels deep inside the pile and its full affects cannot be so easily assessed. Bankia lava often finds access to inner timber via bolt holes and the result of this can be seen in the photos showing decay around the lower walings of the cross bracing. In warmer climates if an apparently sound timber pile is struck with a heavy hammer and has a hollow sound then it is likely that the Toredo borer has been at work. Bankia Neztalia however, the variety found in the cooler waters of New Zealand, is not such a voracious variety which is why these piles have survived so long. Without divers undertaking a destructive testing survey however only an experience based guess can be made at the number of piles requiring major repairs. Before any contract for repairs is undertaken a more thorough survey of piles will be needed to confirm the assumptions in this report.

OCEL Consultants of Christchurch were employed by Waitaki District Council to inspect the under-water section of the piles and they report that all piles are severely decayed around low water mark, but relatively unaffected at lower depths. This observation encourages the view that most piles can be repaired / strengthened without the need for pile replacement.

It is likely that from the time of construction, the wharf piles would have had an economic life of more than 50 years with only a small amount of regular maintenance required in those areas near low water where holes and cuts were made in the piles for installation of the bracing. Now that the piles are 120 years old the waterline deterioration is very significant and the extent of repairs required for each pile will need individual assessment.

<u>Wharf Bracing</u>

The bracing construction is shown on Fig.8 of the original drawings and was designed to brace the wharf as a whole against ship berthing impacts and also to provide support for individual fender piles against low level impacts. Low-sided small sailing vessels and coastal scows which operated 100 years ago would often exert horizontal impacts to the fender piles at low tide that would break a pile that was spanning from deck level to the seabed without support. It was therefore customary to design a bracing system with horizontal walings to brace the fender piles just above low water mark. When larger vessels began to use the port it became necessary to strengthen the bracing. The vessels were so large however that they only struck the wharf at deck level even when the tide was low. The most cost efficient and effective way of resisting a force at deck level is raker piles, and seven pairs were installed for this purpose. The port visionaries may have foreseen this issue before construction started and these pairs of rakers along with the seven on the viaduct curve may have been added to the design before construction began.

As can be seen in the photo illustrations, the diagonal bracing has deteriorated very badly from the half tide mark downwards. The marine borers Limnoria and Bankia do not survive long out of seawater and their attack is focused on the timber between half tide and just below low water.
As with all older wharves, the bracing bolt holes through timber and piles appear to be the starting point of borer attack and decay.

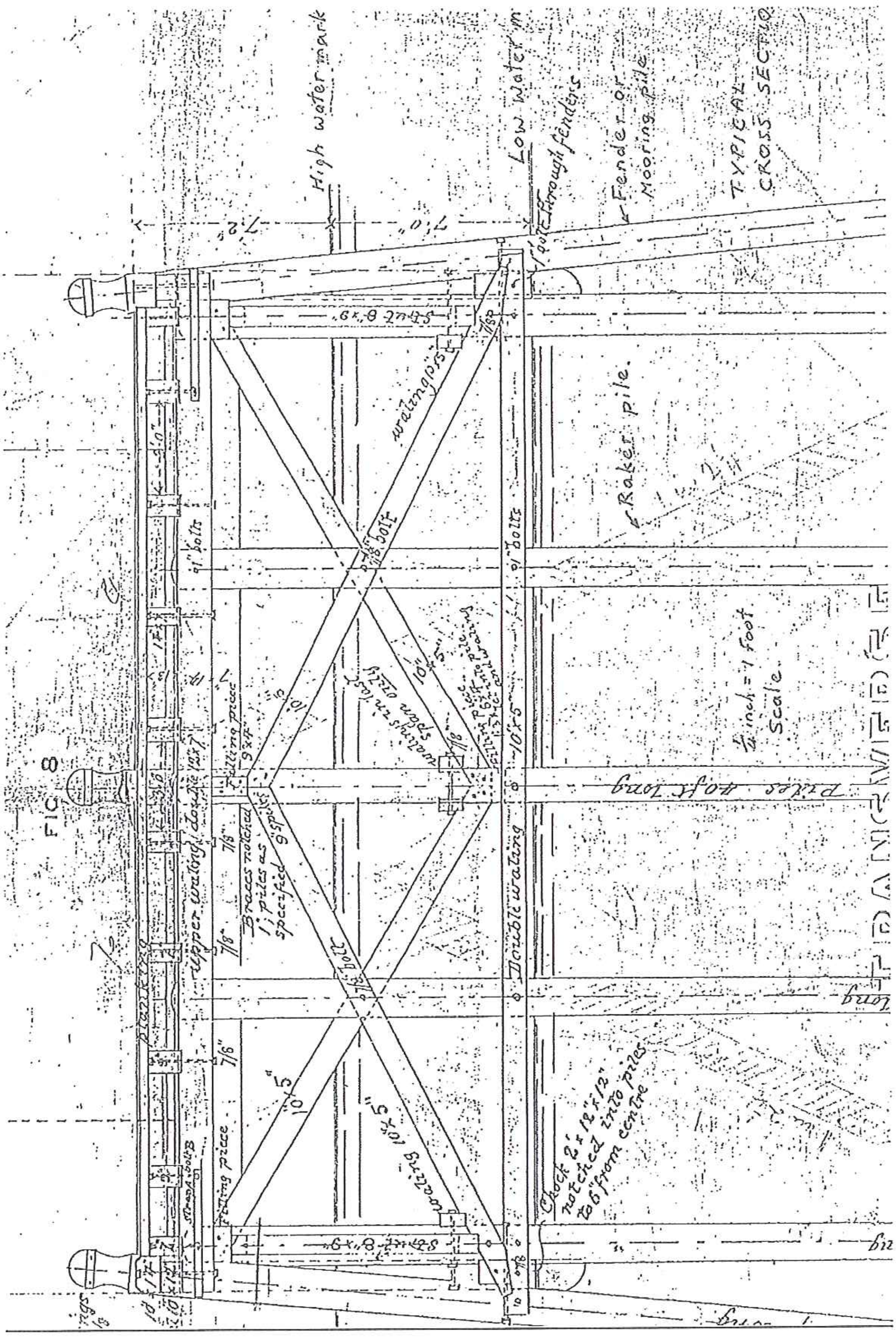
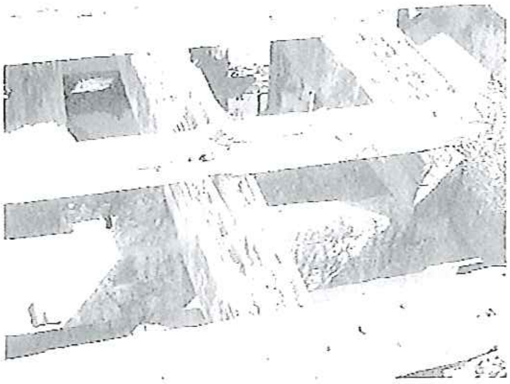
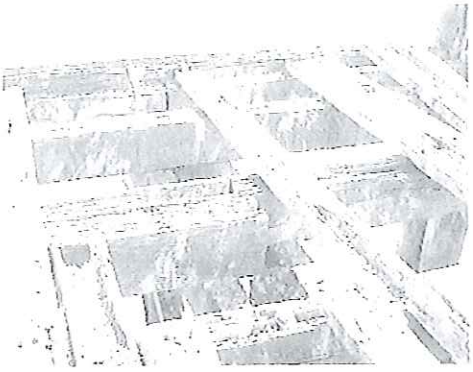
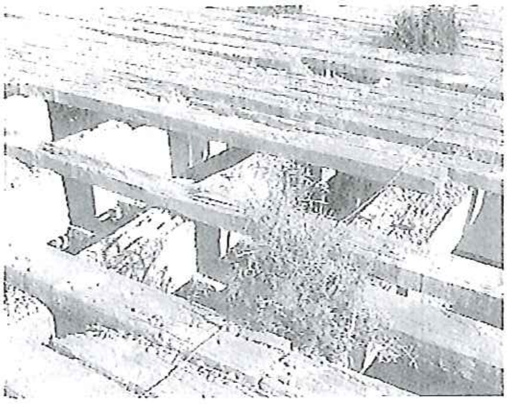
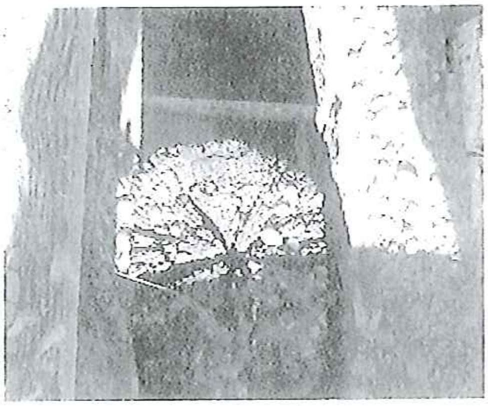


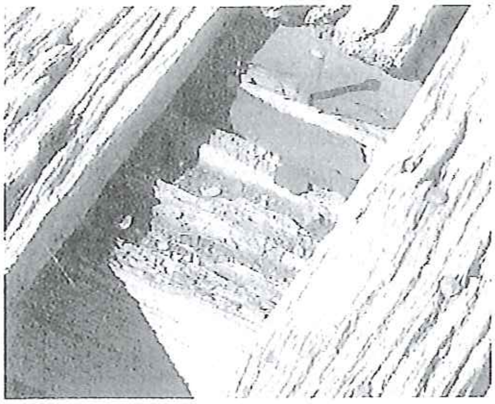
FIG 8
TYPICAL CROSS SECTION
High water mark
Low water m
Fender or Mooring pile
Raker pile
Piles 40ft long
1/4 inch = 1 foot Scale
Double waling
Upper waling
Braces notched 1" piles as specified
Decking

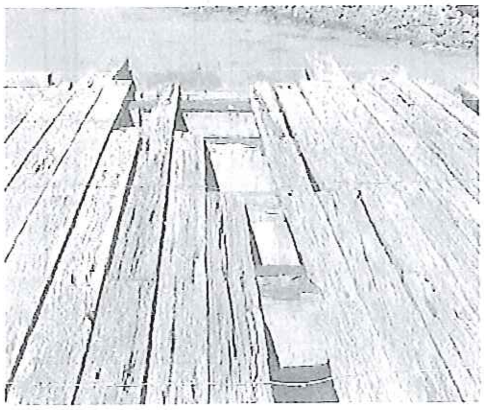








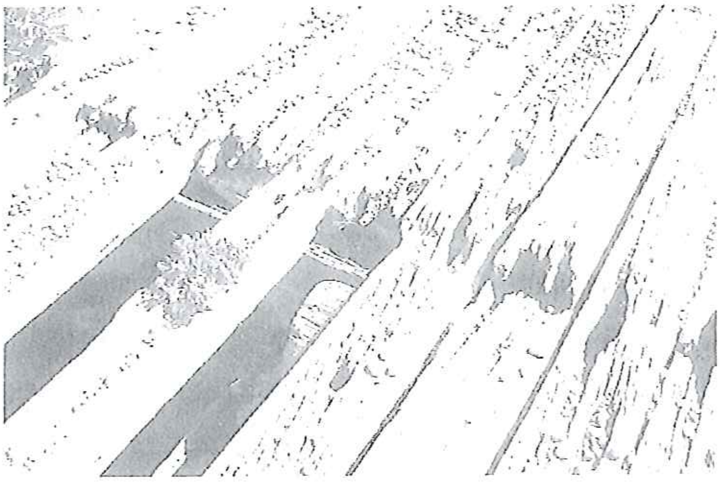


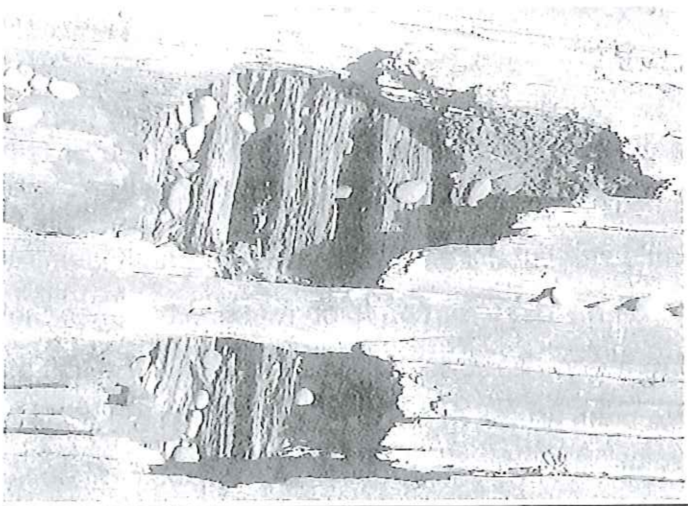


Deterioration caused by fungus flourishng in areas where rainwater has been able to accumulate and dampen the timber for long periods of time. Note that where Malthoid has survived the ravages of time the beams underneath are in much better condition. (Stones have been deposited on the wharf by Spotted Shags.)

Often the most severe areas of deck & beam deterioration has been along a line under where rails were previously positioned.

While the line of decay is severe here, in other areas the decay under the rails has been minimised.





Rainwater was trapped in the dust & debris under the rail and fungus attack created cavities for the trapping of further moisture.

Capping Beams (Upper Walings)

The capping beams made from select grade Australian Hardwood ran in pairs across the wharf and are seated on rebates at the top of the piles and held in place by bolts through the piles.

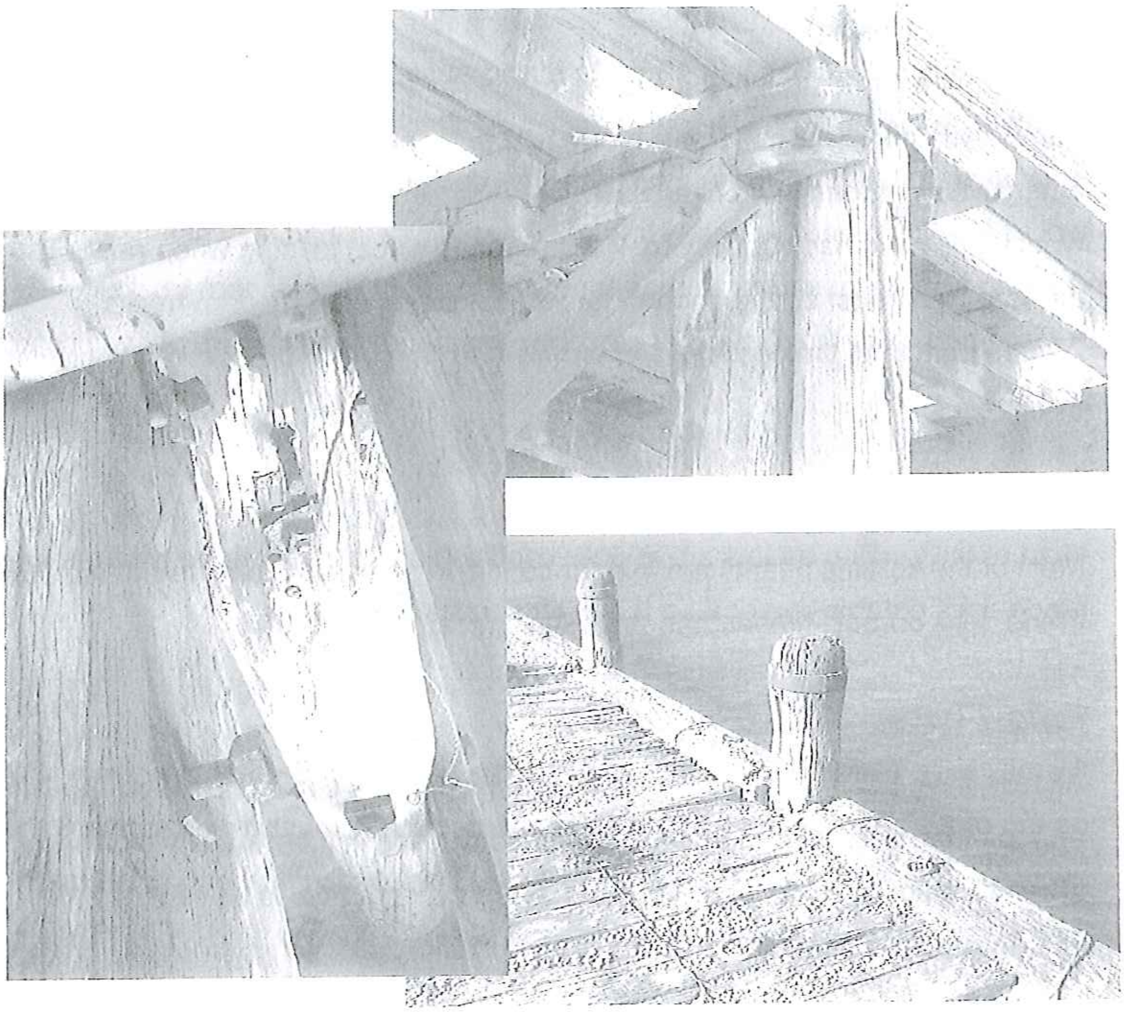
In general the capping beams appear structurally sound and even the bolts have survived in good condition. In most cases the beams ran the full 10.2 m width of wharf in one piece. The likely area of decay is on the tops where deck beams cross over and where rainwater may have dampened the timber joint for long enough for fungus to become established. To survey each beam the decking would need to be removed and each joint probed. There are places in the structure where repairs have been made which signals the possibility that unseen decay has been occurring elsewhere. In any event, most capping beams in their present state are expected to be safe for light traffic loading except where pile support is missing.

Deck Beams (Stringers)

These run along the wharf spaced approximately 1100 mm centres and were designed to support the rails carrying a row of steam locomotive wheels. Only by removing the decking and water-blasting the tops of the beams will the true extent of the decay be established however it is expected that most are in satisfactory condition and would easily support normal highway loading.

Bolts

One surprising aspect of the existing structure is that the 120 year old bolts have not suffered severe corrosion. This because they were made from hand forged iron and not the customary mild steel that was used in later years. It is unlikely that original bolts will need to be replaced for corrosion reasons because there is little corrosion and the loading regime envisaged involves much lower bolt stress than the original design. New bolts will be required where beams are to be replaced and for bracing repairs. An interesting option for replacement bolts and steel fittings would be making bolts and fittings at the blacksmiths forge in the nearby Red Sheds.



Examples of the original forged iron bolts, straps and rings that have survived in relatively good condition after 120 years.

Decking (Planking)

The decking timber, (ex 8" x 4") using mixed Australian Hardwoods of various durability is generally of a lower grade timber than the beams and has suffered extensive weathering and fungus decay. A design check of the decking reveals it would only have had capacity for 2 to 2.5 tonne wheel loading when new. The decking was never strong enough for wheel loading from modern trucks.
A large portion of the decking is presently unsafe for even lightweight vehicular traffic.

Kerbing

Most of the kerbing beams are in poor condition and clearly originated from lower grade, less durable timber than the main structural members.

Railway Tracks

All rails have been removed but marks on the decking show that they were laid on top of the decking and that there was no decking laid between the rails to allow for road traffic on the wharf. It is evident that during its working life the wharf was only used for foot traffic and rail traffic.

DURABILITY CHARACTERISTICS

The piles, bracing timber, "walings" and "stringers" and their fixings are with few exceptions, the original material installed 125 years ago. This is rare for timber structures of this age situated in a marine environment. The piles from trees felled in the 1880's would have been from coastal Australia and coastal trees are often located in soils where uptake of silica into the timber is high. Turpentine piles with high silica content are known to resist borer attack much more than piles from inland trees. Another factor for the pile durability is that the colder seawater temperatures of Oamaru are less suited for marine borer than waters in a more northerly location. Elsewhere some turpentine piles have not lasted 25 years.

Deterioration of the bracing is severe as would be expected from an 1880's wharf. The pile capping beams and deck stringers have been durable as a result of good air circulation around the deck timbers and the relatively dry climate of Oamaru. Most wharves in New Zealand had a second layer of deck timber between the rails to provide a level surface for road vehicles and trolley carts. Sumpter Wharf never had this layer installed and with a designed gap between decking planks, rainwater would drain away and damp timber evaporate dry before fungus could become established.

As the timbers have aged, cracks and crevices in timbers have deepened and filled with debris and rainwater moisture has remained longer in the timber with consequently more rapid weathering in recent years. Spotted Shags from the nearby colony have covered the decking with droppings and this too is retaining moisture and causing more rapid deterioration.

LOAD CARRYING CAPACITY

Piles

Analysis of the wharf structure suggests the piles were each designed to carry up to 35 tonne of loading. The diameter of the piles with at least 5 metres penetration into the seabed confirms that 35 tonnes is the likely 'safe working load' originally attributed to each pile.

Where Limnoria attack has thinned a pile to no less than 250 dia over a length of not more than 4 m and not less than 200 dia for not more than 1.8 m of its length the original design, 'safe working load' of 35 tonnes can be assumed.

Where a pile cross section has diminished to less than 160 dia then strengthening of the pile with a concrete sleeve is recommended.

Where Bankia attack is minor cavities can be plugged with an underwater plaster mix and the pile wrapped. Capacity of the pile will then be based on Limnoria thinning of the pile as above. Piles that have Bankia/Limnoria attack leaving minimum pile diameter between 160mm and 250mm of sound timber should be protected from further decay with the installation of "Denso Seashield" pile protection wrapping.

To calculate the minimum number of 'good' piles needed for alternative design loads, an analysis of the deck structure was carried out with various combinations of piles left out. (see diagram.) It is clear that only about one half the bearing piles and none of the fender(mooring) piles are necessary for the wharf to be made safe for pedestrian loading.(The NZ loading code designates 5kPa for a fully crowded public area such as this.)

While there is a minimum number of piles that must be repaired or protected from further deterioration this report proposes to ensure that minimum is achieved plus the preservation of many more piles that can be protected from further deterioration at moderate cost. Other piles can be repaired, strengthened or replaced in the future if need can justify the cost.

<u>Bracing</u>

Most of the diagonal bracing below half tide has lost its integrity due to borer attack concentrated around bolt holes and furthermore much of this lower bracing will need to be removed in order to carry out repairs to the pile.

Calculations show that for a lightly loaded wharf, there is adequate bracing against Wind and Earthquake loading provided 3 piles in each bay have cross section of 160 dia or more at MLWS but high deflections could be involved.

The 7 pairs of raker piles have sufficient strength to stiffen the whole 92 m (300 ft) berthage section of the wharf, provided the fixings at the tops are in good repair. (At least one pair of raker piles requires reconnection.)

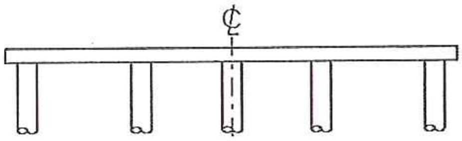
Any sections of wharf left un-braced would have high horizontal deflections that would subject the bolted joints to rotational movement resulting in rapid deterioration of bolts which could lead to sudden failure. If removal of decking leaves a section of wharf vulnerable to high deflections, that section could be stiffened up at reasonable cost by fitting bracing underneath the deck beams.

		CLIENT
SCALE NTS (A4)	DRAWING No.	PROJECT

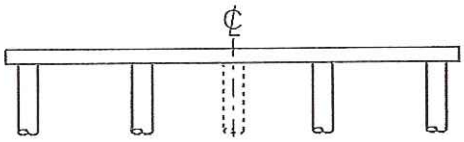
RATED LOADING FOR APPROVED BEARERS SPANNING OVER GAP LEFT BY MISSING OR UNDERSTRENGTH PILES

WHARF CAPACITY

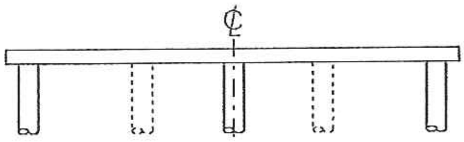
1 FULL CAPACITY 50 kPA



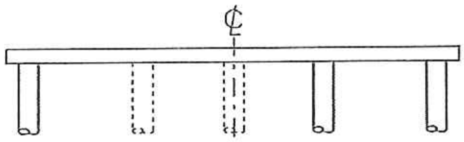
2 16kPa



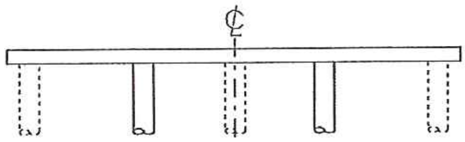
3 14kPa



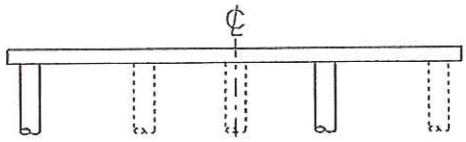
4 6.5kPa



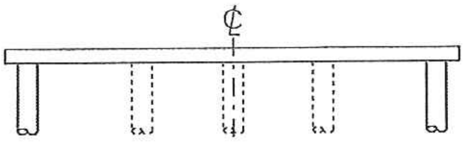
5 6.5kPa



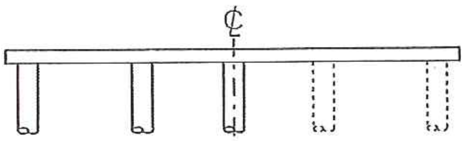
6 6.5kPa



7 NOT SAFE WITHOUT SUPPORT FROM BEAMS SPANNING OVER ADJACENT PIERS

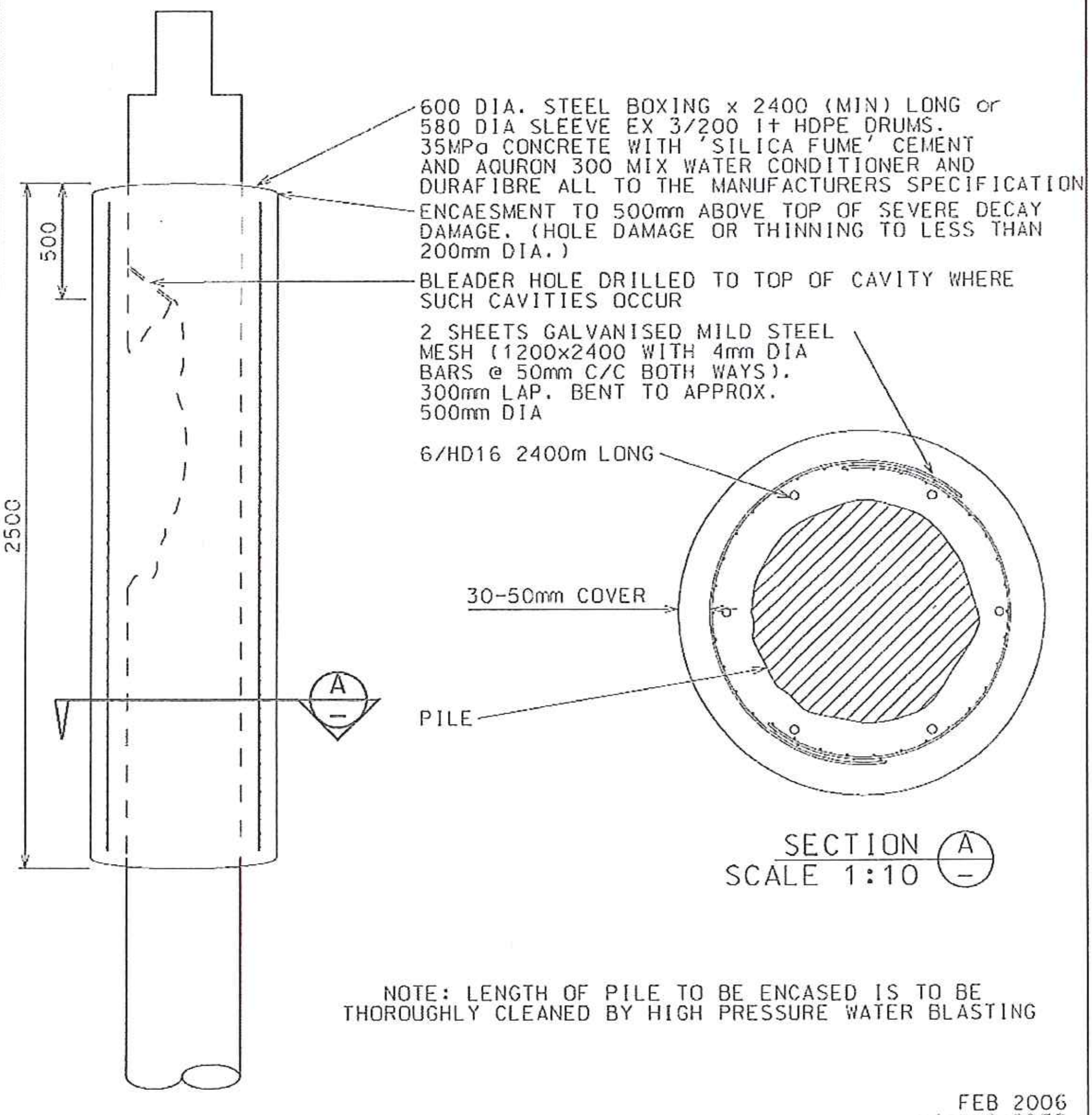


8 NOT SAFE WITHOUT SUPPORT FROM BEAMS SPANNING OVER ADJACENT PIERS



		CLIENT
SCALE 1:20 (A4)	DRAWING No.	PROJECT

CONCRETE COLLAR PILE REPAIR

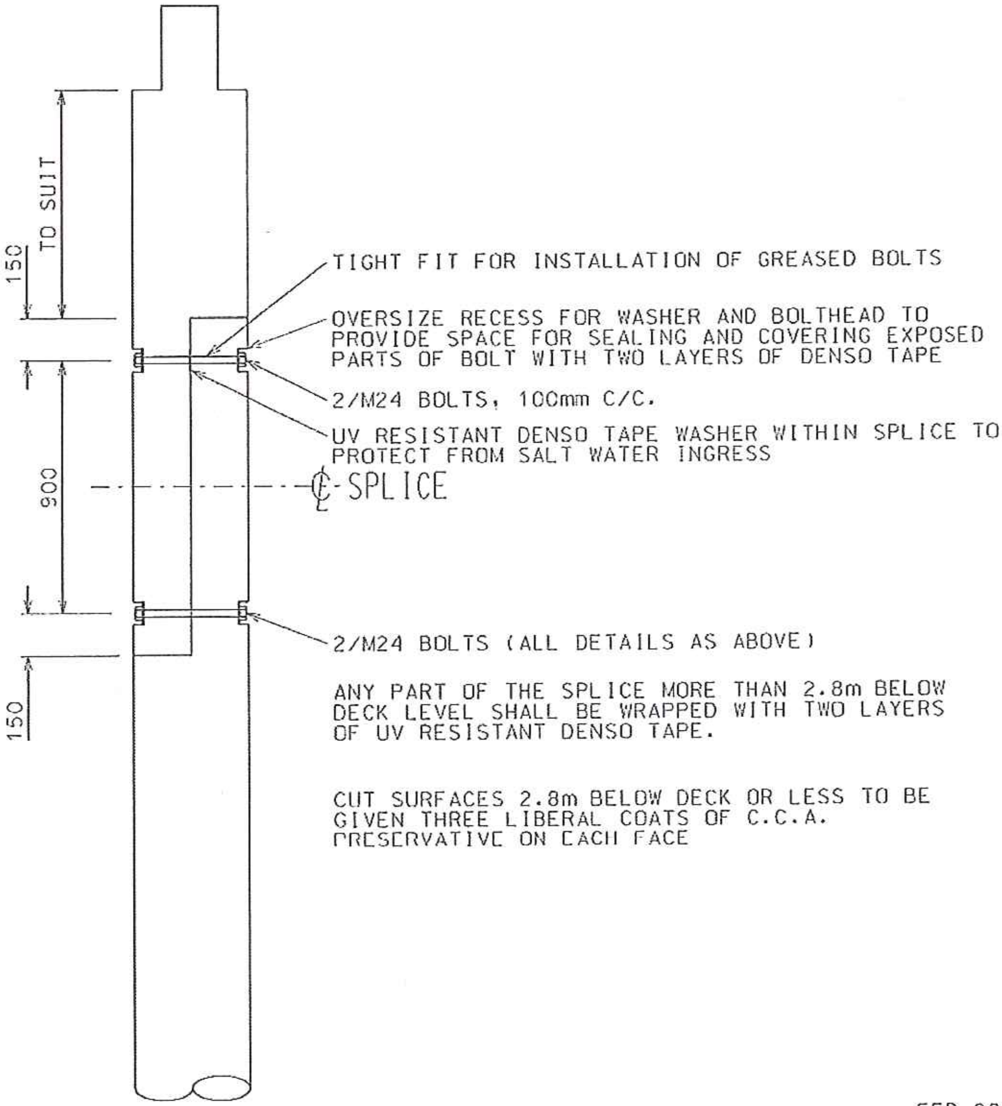


NOTE: LENGTH OF PILE TO BE ENCASED IS TO BE
THOROUGHLY CLEANED BY HIGH PRESSURE WATER BLASTING

FEB 2006
NICK BARBER
MIPENZ, CPEng

	CLIENT
	PROJECT
SCALE 1:20 (A4) / DRAWING No.	

PILE SPLICE REPAIR



ANY PART OF THE SPLICE MORE THAN 2.8m BELOW DECK LEVEL SHALL BE WRAPPED WITH TWO LAYERS OF UV RESISTANT DENSO TAPE.

CUT SURFACES 2.8m BELOW DECK OR LESS TO BE GIVEN THREE LIBERAL COATS OF C.C.A. PRESERVATIVE ON EACH FACE

FEB 2006
NICK BARBER
MIPENZ, CPEng

Bearers (Top Walings)

The bearers span a maximum of only 2.4 m and were originally capable of carrying the 30 tonne design load from the decking design load of 5 tonne / sq. metre or train rail design load of 15 tonnes/ m.

Most of the bearers are in good condition and provided they are seated firmly on the piles would be safe for at least 50% of their design load. Very few bearers will require replacement.

Beams (Stringers)

Originally the design load would have been approx. 8 tonne per metre from the rails with the narrower beams between the rails capable of carrying 6 tonnes per metre. While most beams appear in good condition when viewed from below, some have lost considerable strength due to weathering and fungus attack on the top surface. However a beam with up to half its depth eroded away would be still be safe for pedestrian traffic provided the fungus attack is prevented from progressing further. Very little beam replacement will be required.

Decking

Most of the deck timber is badly weathered and / or suffering fungus attack. In general the decking is unsafe for use by the public. All deck timbers not clearly to be rejected should be High pressure water-blasted, firstly to clean off soft material capable of harbouring fungus, and secondly to assess the condition of the remaining timber.

PRESERVATION PRIORITIES

As stated the objectives for preserving the historic Sumpter Wharf are:

1. To make the wharf stable against collapse and safe for people to walk on.
2. To protect the existing structure from further deterioration.
3. To reconstruct a section of the structure replacing or repairing unsound rejected material with material and installation methods authentic to the original construction.

Priorities in terms of preventing further deterioration and providing an historic site at moderate cost are:

1. Raker and load bearing piles with severe Bankia attack and Limnoria waisted piles with minimum cross section of less than 160 mm dia to be repaired using reinforced concrete sleeves.
2. Weathered and Limnoria-thinned load bearing piles to be wrapped in protective coating over a 2 to 3 metre section centred around the low water mark. (MLWS)
3. Starting at the landward end decking (planking) and kerbing timber shall be lifted and sorted into reusable planks which shall be stored for future use and unsound timber which shall be disposed of.
4. The tops of all bearers and beams shall be water-blasted to remove debris and decayed timber.
5. All hidden surfaces between beams and bearer cross-overs shall be probed for decay. If the decay is significant the beam shall be lifted and joints water-blasted to remove all decayed wood. The clean timber joint faces will then be treated with "C N" Timber Oil, and then plastered with "Sikadur 31" levelling grout on each surface of the contact area. A layer of "Sika Multiseal" shall be fitted over the bearer before replacement of the beam.
6. Decayed Pile Tops. Where the decay does not penetrate to where the bearers are seated on the rebates in the pile the tops can be cleaned with high pressure water blasting, treated with "C N" then protected from rainwater with a covering of "Multiseal."
   Where decay adversely affects the strength of the pile / cap joint the decayed top of the pile can be removed and a new top spliced in place or, alternatively if the damage is less severe, corbels can be installed to increase the load bearing area.
7. Following 4, 5, and 6 above, the top surface of each cap and beam shall be sealed against rainwater ingress by coating with timber oil.
8. The "Viaduct" section of wharf beginning at the landward end shall be reconstructed to its original design and strength. This section shall have

new hardwood decking fixed over existing or replaced beams with Malthoid or an alternative approved coating between deck and beams. New kerbing and safety rails will be installed to pile pier No. 16 as shown on the original drawings. Pile bracing and raker piles to pile bent No. 18 to be repaired or replaced. Replicas of the steps, pilot boat davits and office building to built from original plans or early (1889 – 1901) photos.

8. Decking that was removed but is reusable can be used in the creation of a walkway over the weathered and deteriorated, but preserved remainder of the structure.
9. Remaining fender piles, bollards, kerbing and the most difficult to repair/replace load bearing piles to be left until later or until justified by any proposed use for the wharf.

PRESERVATION OF THE STRUCTURAL BEAMS

Life Expectancy

The present structure has survived 125 years and much of the skeletal structure could be given a 50 year extension of life with quite moderate expenditure. As the Port of Oamaru becomes a focus for tourism and as tourism increases its dominance as the largest industry in New Zealand, so the value of preserving Sumpter Wharf may also increase. The following prescription for preservation of the structures from Pier18 to the outer end is recommended as the best way to ensure there is a usable facility for tourists and a structure suitable for upgrading if future demand requires.

Oak piles from the Roman era have been excavated from river beds in good condition because burial in saturated silt has excluded the presence of oxygen. Similarly the embedded portions of Sumpter Wharf piles can be expected to last indefinitely.

Likewise hardwood timber beams protected from UV rays and moisture can also last indefinitely.

The conservation strategy for Sumpter Wharf is to protect the high quality "Select Grade Ironbark' beams and tops from UV and moisture acclerated degradation and to wrap the most vulnerable sections of the piles in a reinforced concrete collar if strength upgrade is required or 'Denso Seashield' if no strength upgrade is required but deterioration is required to be halted.

This strategy provides the essential work required to put the deterioration of bearing piles, bearers and beams on hold so that the structure can be maintained at minimum cost.

<u>Replacement value of Wharf using Hardwood Timber & Piles</u>

This rough order costing is provided to place the cost of repairs in context with the cost of a total wharf replacement.

The cost of hardwood piles has increased by approximately 60% over the last 10 years. Double treated hardwood piles are now the preferred long-life substitute for Turpentine piles and 13 metre piles are estimated to cost $2,400 each plus gst and possibly $3,000 each to drive and fit in place.

The total number of piles is 275 with a replacement cost in the order of $1,485,000.

New sawn Hardwood Timber imported from Australia would cost some $2,450 per cu.m depending on the NZ dollar value and variable shipping costs. The total quantity of sawn timber in the bearers and beams in Sumpter Wharf is approximately 151 cu. m with a replacement value of $370,000 for timber and $180,000 installation = $550,000.

The Deck timber has a replacement cost of approximately $342,000 plus installation cost.

It is therefore concluded that the cost to totally rebuild the Wharf today using hardwood timber (without demolition costs and without the cross bracing) would be between 3 & 4 million dollars.

PRESERVATION OF WHARF PIER 18 TO PIER 54

PILE REPAIRS:

7 pairs of raker piles –

	14 wrapped @ $500	$7,000.00
	Pile head repairs	$3,000.00

Bearing pile repairs to achieve a minimum 3 satisfactory piles per bay:

Major pile repairs	36 @ $2000	$72,000.00
Pile wrapping	144 @ $500	$72,000.00
Engineering & Contingencies 20%		$30,000.00
	Subtotal 1	**$184,000.00**

DECK CONSERVATION:

Remove & sort decking water-blasting reusable timber:	
1200 sq m @$40	$48,000.00
Water-blast tops of piles, bearers, & beams	$5,000.00
C N 'Timber Oil' treatment to tops of bearers & beams,	
Two coats on 650 sq m @ $20 / m2	$13,000.00
Apply C N 'Timber Emulsion' to pile tops and bearer joints	
to piles along the beam/bearer joints and on exposed ends	
of bearers and beams.	$12,000.00
Pile tops to smooth over cracks and fissures	$3,000.00
Apply synthetic fibre reinforced cement plaster to pile tops	
to smooth over cracks and fissures	$3000.00
Seal pile tops and joints with 'Sika MultiSeal'	$4,000.00
Engineering & Contingencies 20%	$17,000.00
Subtotal 2	**$102,000.00**

VIADUCT RECONSTRUCTION

The re-construction of the viaduct with its many interesting features would be less costly than say, repairing all the fendering and cross bracing, and its reconstruction would certainly be more visible and speak more of the technology prevailing 120 years ago. It may also be appropriate to reconstruct the under-wharf diagonal bracing on this section, firstly because it gives authenticity to the construction of the times and secondly because the bracing along this section is easily visible from the shore.

Materials for Reconstruction

It is recommended that new Australian Hardwood timber be used for decking, but steps and painted safety barriers could be H3 treated Radiata. Small bolts and nails can be stainless steel 316 discoloured to look more like rusted iron while larger bolts and deck spikes would be galvanised steel.

Any bearers or beams that need replacing could be obtained from other parts of the wharf and fixed with galvanised bolts of the same dimensions as the original bolts. Some good beams may be retrieved from the end of the wharf where extra beams were installed to build an infill of the cross traverse well (where rail wagons were shifted across the wharf from one set of rails to another.)

For cost and durability reasons it is recommended that H6 treated Radiata Pine be used for the below deck cross bracing as a substitute for Turpentine.

The treated timber above high water will retain a green stain from the treatment but could be stained light brown to appear more like hardwood.

Bracing bolts may be 24 mm mild steel bolts sleeved where they pass through the hole in the treated timber, with Denso tape under the washers and thread and nut greased with "Rescue Steel".

Extent of the Viaduct Reconstruction

Work on the decking, steps, bollards, safety rails, office and landscaping would start at the landward end and progress to Pier No. 18 while underwater work on the piles and bracing would be undertaken independently.

Total no. of piles in Piers 1 – 18 are; 54 bearing piles, 2 fender piles, and 7 raker piles on the south side. Allowance is made for 20% of these piles to have major repair work and 70% requiring wrapping. It is assumed that some 50% of the bracing will be replaced and that this will all be low tide work.

Any replacement bearers or beams would be obtained from elsewhere in the structure.

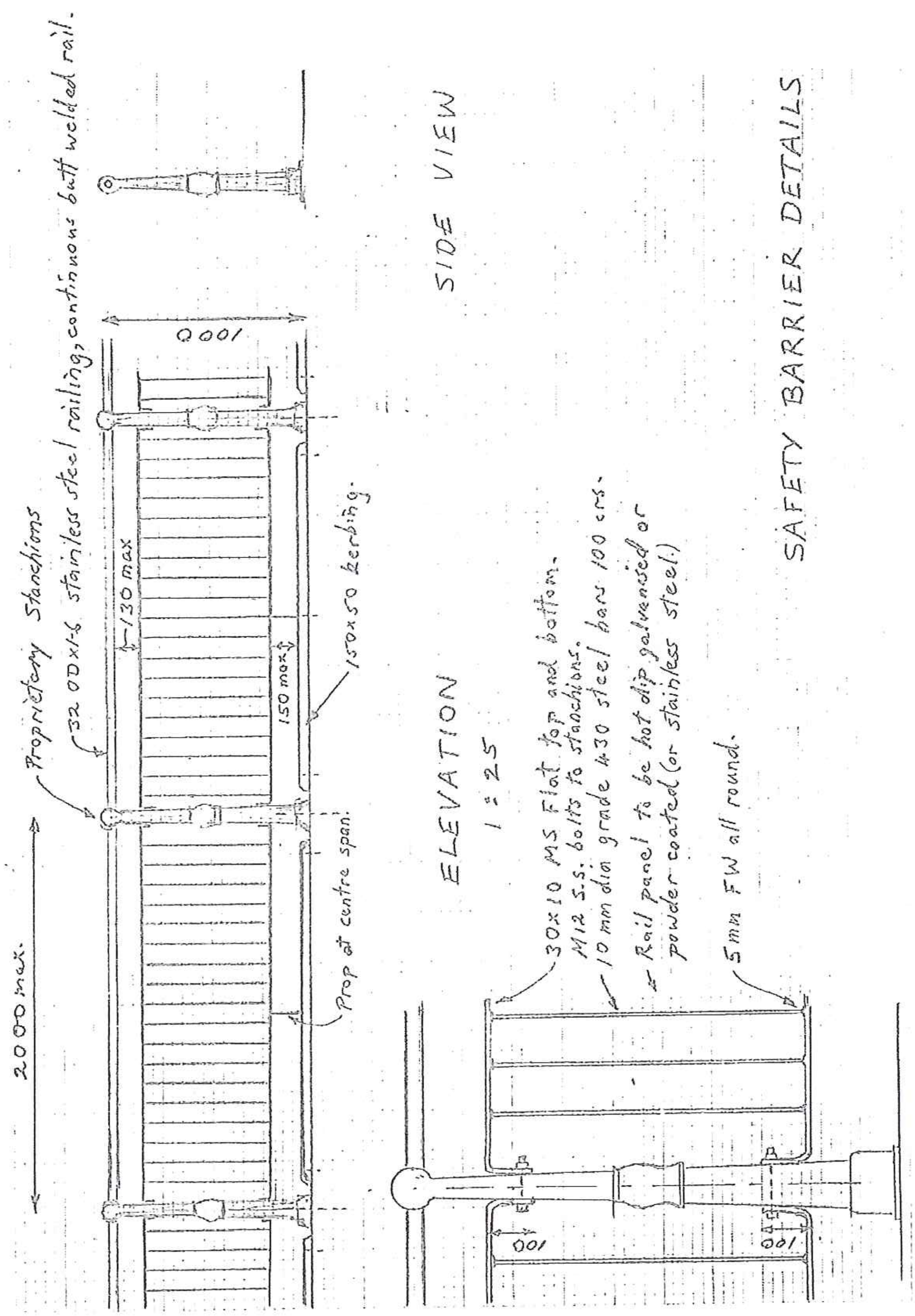
Two new bollards would be spliced into place by dowelling and gluing to existing piles.

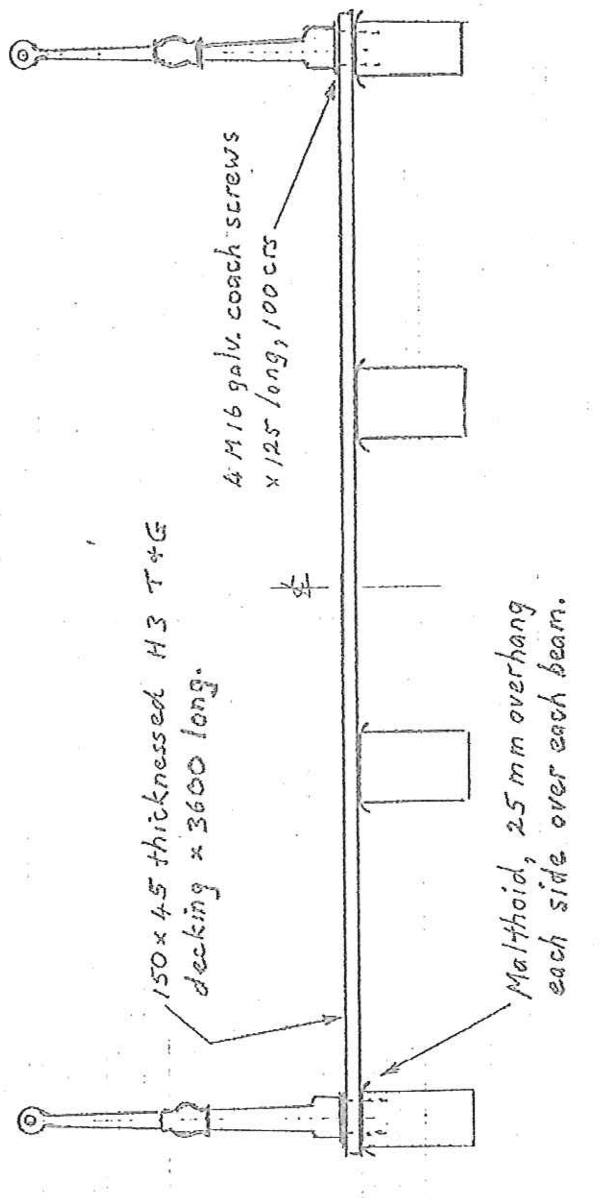
All new work on the viaduct section would be designed for a 50 year life in accordance with the approved documents of the Building Industry Authority

Rough Order Costing

Major pile repairs 12 @ $2,000	$24,000.00
Minor pile repairs 44 @ $500	$22,000.00
Bracing 9 pairs of double walings 250 x 125 x 5m	$11,000.00
Bracing 18 diagonals 225 x 100x 5.7 m	$13,000.00
9 runners 250 x 125 x 6 m	$7,000.00
Bearers 3 350 x 175 x 5 m	$3,600.00
Remove 130 sq m decking, sort & stack and water blast the tops of all bearers and beams	$5,000.00
Purchase new hardwood decking, 1080 linear m 225 x 100 @ $60 / lin.m.	$64,800.00
Install new decking (train rails by others)	$32,400.00
Safety barriers installed and painted 95 m	$15,000.00
Office, Davits, Steps	$16,000.00
Landscape, Seating, Lighting, Signage	$20,000.00
	$233,400.00

Supervision & Contingencies say, 20%		$46,000.00
	Total	**$280,000.00 + gst**


Proprietary Stanchions
32 OD x 1.6 stainless steel railing, continuous butt welded rail.
2000 max.
1000
130 max
150 max
150x50 kerbing.
Prop at centre span.
SIDE VIEW
ELEVATION
1:25
30x10 MS Flat top and bottom.
M12 S.S. bolts to stanchions.
10 mm dia grade 430 steel bars 100 crs.
Rail panel to be hot dip galvanised or powder coated (or stainless steel.)
5mm FW all round.
100
100
SAFETY BARRIER DETAILS



WALKWAY CROSS SECTION
1 : 20

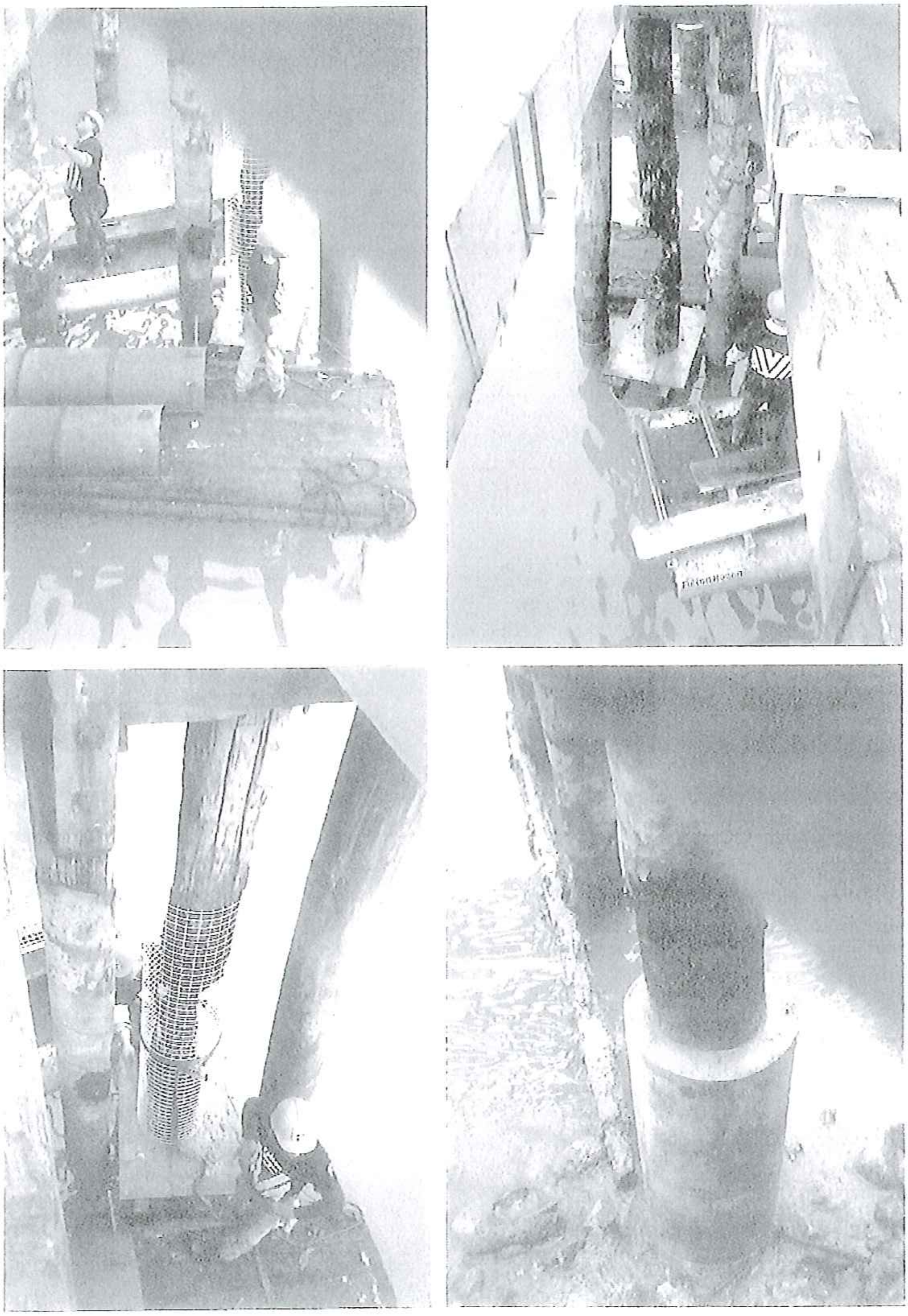
WALKWAY

Form a 100 metre x 3.6 metre walkway to end of wharf	
(H3 treated Radiata decking and safety barriers)	$75,000.00
Use recycled decking to form an area at the end of the wharf	
For public viewing / photography / fishing say	$20,000.00
Engineering & Contingencies 10%	$10,000.00
Subtotal 3	**$105,000.00**

Structural Assessment of Sumpter Wharf Oamaru
For the NZ Historic Places Trust, North Otago Branch

Nick Barber, Chartered Engineer, MIPENZ (Civil & Structural)

April 2006



EXAMPLE OF PILE REPAIRS IN PROGRESS

EXAMPLES OF PILE SPLICE AND PILE REPAIR A FEW YEARS AFTER COMPLETION

CONTRACTS FOR CONSTRUCTION

When repair and maintenance work is contracted out there is a very high prevalence of cost over-runs.
Contractors can find they haven't appreciated the difficulties involved in the work, unforeseen problems can be exposed once the work is started and/or they may engage in repair work that can be justified from a construction perspective but not necessarily from a cost/benefit perspective.

To minimise the impact of unforeseeable costs (I have allowed for some contingencies) I propose that the contracts be staged in sequence as follows:

Contract No.1 - <u>Removal of Decking and Water-blasting</u>.
This Contract will expose the extent of deterioration of pile heads, the tops of beams, and to some degree the beam / bearer joints. It will also give improved access and visibility for a thorough survey of the piles. The amount of reusable decking will also be quantified.

Contract No. 2 - <u>Pile Repairs</u>
Two or three selected contractors experienced in the repair of piles could be engaged to carry out a pile survey of the entire wharf, classifying each pile as follows:

A. Very severe deterioration
B. Very severe, but suitable for a splice repair
C. Severe deterioration, but suitable for concrete encasement.
D. Moderate deterioration, but suitable for Denso-wrap.
E. Low deterioration and suitable for Denso-wrap

With two such survey reports a more reliable assessment can be made of the necessary pile repairs and appropriate contract documents can be prepared. The firms that carried out the surveys can then make an informed tender for the Contract to repair the specific piles required to meet the safety and restoration objectives of the Historic Places Trust. This contract could also include the repair / replacement of bracing for viaduct section to enable bracing / waling / pile joints to be incorporated within some pile repairs.

Contract No. 3 - <u>Walkway Construction and Top of Beams Treatment</u>
Following completion of Contract No. 1 plans & specifications can be finalised for the installation of the walkway. The plans would include the replacement of some beams

and the treatment joints and top surfaces of beams and bearers with preservatives. A temporary low cost walkway with timber safety barriers would be installed across viaduct.

Contract No. 4 - Viaduct Reconstruction

Having repaired the minimum number of piles as part of Contract No. 2 and having stripped the decking and water-blasted the beams and bearers, the viaduct reconstruction requirements become clarified. With better knowledge of the tasks involved contractors will be able to provide more competitive tenders with minimum 'extras'.

If contracts were called in the above order expenditure could take place as follows:

Contract 1 – Deck Removal and Beam Conservation	$112,000.00
Contract 2 - Pile Repairs	$184,000.00
Contract 3 - Walkway construction	
(includes 50 m temp. access walkway)	$125,000.00
Contract 4 - Viaduct Reconstruction	$250,000.00
Note: All prices exclude gst	**$671,000.00**

Note: Some viaduct work would be included in Contracts 1 & 2

Note: Does not include further investigation prior to tendering.

The Viaduct Reconstruction could be regarded as an optional Stage 2 of the Conservation Project or the extent of Contract 4 could be trimmed to meeting budget restrictions, or alternatively restoration work could be expanded so that working lay-up berths could be established on each side of the wharf.

Nick Barber
Chartered Engineer
April 06

WAITAKI DISTRICT COUNCIL

SUMPTER WHARF

INSPECTION REPORT

September 2011

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1.0 INTRODUCTION

This report covers the inspection of the Sumpter wharf undertaken by OCEL Consultants NZ Limited (OCEL) on the 4 May 2011. The principal focus of the inspection was the condition of the piles supporting the wharf. While the replacement of the deck timbers and even the supporting bearers is relatively straight forward and achievable through the use of volunteer labour piling is expensive and requires specialist equipment. Plans currently being considered to preserve and partially reinstate the wharf have envisaged the use of volunteer labour to keep costs down, hence the need to establish the type of work required in order to establish both the likely cost and whether the work is within the scope of a volunteer work force. The inspection was undertaken using a diving team working from an inflatable boat.

Sumpter Wharf was constructed during 1883 to 1884 specifically for the frozen meat trade. It is an important (visual) part of the last surviving Victorian age port in New Zealand. The port has very much the same layout as when it was constructed with most of the streets, railway lines and buildings associated with the harbour still in existence.

The wharf was constructed using Australian hardwood timber and piles to provide a 300 ft (92 m) long berth either side. The curved transition section at the base of the wharf is a unique feature. It aligns the wharf with the direction of the incoming refracted and diffracted swell waves entering the port to reduce the motion of the vessels tied up to the wharf.

The Historic Places Trust (HPT) and the Waitaki District Council (WDC) have a keen interest in preserving the wharf and in returning it to some limited working order as a possible tourist attraction in its own right. One option considered is to obtain an historic vessel and to moor it alongside the wharf. While anything is achievable in technical terms the determining element on whether reinstatement, partial or otherwise, goes ahead will be cost.

2.0 PREVIOUS CONDITION REPORTS

The wharf is currently in a very dilapidated condition and has been so for some time. While from a distance - cover photograph - the wharf looks in relatively good condition considering its age, the original form has been preserved, closer inspection - Photograph No 1 - shows that it is in a precarious condition principally due to the condition of the piles at low tide level. The original design life of the wharf would have been of the order of 50 years, it is now close to 130 years old. While it is no longer capable of taking load and has been fenced off to the public its distinctive form remains. In its current state vessels are not allowed to berth alongside it and it has become a roosting area for hundreds of shags. The deck is carpeted with pebbles regurgitated by the shags and the shag guano has accelerated deterioration of the deck timbers.

The wharf was inspected by OCEL in 2006 and by Nick Barber of Barber and Associates the same year. The OCEL inspection covered above and below water Nick Barber's inspection (pers comm) was restricted to a topside walkover. His report, produced for the HPT estimated the cost of repairing the wharf at $600,000. This estimated cost for the repair was far less than the OCEL assessment but the Barber report sought only to restore pedestrian access not restore full wharf function. The OCEL inspection considered the general condition of the wharf, it was not a pile by pile inspection. It was noted however that the apparent continuity of a number of piles was something of an optical illusion. The connection between the above and below low water lengths of the piles was provided by mussels.

3.0 CURRENT CONDITION

The results of the latest inspection are not dramatically different from the results of the previous inspection however the ongoing deterioration is approaching a tipping point, literally, for some parts of the structure. Partial and progressive collapse of the structure appears imminent in some areas. The deteriorated condition observed is uniform across the complete structure, every element has deteriorated so rather than an element by element description of the deterioration a general summary description is appropriate. The deterioration is concentrated at low water level and only fully apparent though observation either from a boat at low tide or by a diver. Above mean sea level the piles have aged but have substantially retained their section strength other than where rainwater ingress has provided an environment conducive for fungal attack.

3.1 Piles

The latest OCEL inspection included a full inspection by diver of all the piles – 233 vertical load bearing piles, 27 mooring piles and 21 raker piles. Not all these piles are still in existence and all the remaining ones have some degree of deterioration, principally due to marine borer, either Limnoria or Bankia, attack.

All the piles were found to be waisted, ie to have a reduced cross section and diameter at the low water level. This hour glass type of erosion centred on the low water mark is characteristic of Limnoria attack. The Limnoria marine borer burrows just under the surface of sound timber. The Bankia marine borer tunnels deep inside the pile and often finds access to the inner timber via bolt holes. The Bankia marine borer is responsible for much of the hollowing out of pile interiors observed on Sumpter Wharf. The Australian hardwood piles used for the wharf, Australian Turpentine, have a high degree of natural resistance to marine borer attack but are not normally expected to be serviceable after 50 years. The fact that the piles have lasted this long is due in part to the relatively cold water temperatures in Oamaru harbour.

67% of the piles were found to be no longer effective in taking any significant load, principally through waisting of the section at low water level. Waisting of the piles has also been accompanied in many cases by hollowing out of the inside of the piles where bolt holes have allowed access for the Bankia marine borer. Photograph No 2 shows a typical instance of this. While all the piles exhibit some degree of waisting in this area the level of waisting at which the piles were no longer considered as safely capable of taking other than the existing dead load was taken at 80%.

10% of the piles were either broken or had disappeared leaving only stump remnants. Some of these piles extended through the low water level but were completely missing between low water and had been left hanging by the complete failure and disappearance of the below water length. Waisting or hour glass type erosion can be addressed/compensated for by jacketing or splicing the pile but that requires a remnant to connect to.

The pile bent condition shown in Photograph Nos 3 and 4 is representative of the pile and pile bent condition. Where pile support has been lost the remaining piles in each bent have to take the load previously taken by the pile that failed, load transfer to the other piles being effected by truss action developed by the pile bent cross bracing.

3.2 Cross Bracing

The cross bracing in general is not in good condition, the connections have failed at low water level. Figure No 1 shows the original wharf cross section. Much of the original horizontal bracing at low tide level has gone. The angled bracing is in better condition but the bottom end connections have failed because of marine borer attack concentrated around the bolt holes. The pile capping beams are capable of transferring load between piles, as shown in Photograph No 5 where lapping of the capping beams is evident over a missing pile however where the three centre bearing piles are missing or discontinuous below low water in a five pile bent the stability of the wharf structure at that point is dependent on the condition of the cross bracing.

3.3 Wharf Deck Timbers

The wharf deck support timbers – capping and deck beams - are in a deteriorated condition but much of it is salvageable. The capping beams, the beams that run along the top of the piles appear structurally sound in general. Deterioration has occurred where the deck beams run over the capping beam and rainwater has accumulated over time but not in the limited areas where malthoid has been used. Most capping beams in their current state would be capable of safely taking the loads envisaged for the wharf as a tourist asset - light wheel loads and pedestrian access loads. The deck beams or stringers spanning between the capping beams are in a deteriorated condition but would, subject to element by element inspection, support the loadings envisaged for the restored wharf. An assessment would have to be made of each once the decking timber on top of the deck beams had been removed to allow inspection. The decking timber is not in good condition being badly weathered and affected by fungal attack. The shag guano covering has accelerated the deterioration. The deck timbers can however be readily replaced using volunteer labour and would be a low cost item in the wharf restoration, relative to the cost of reinstating the piles.

3.4 Repair/Reinstatement Options

The key problem for the restoration/preservation of the wharf is the repair/reinstatement of the piling. A reduction in the pile cross section area, 'waisting', at low water level is common for old wooden piles. The strength of the pile can be restored by wrapping a metal or geotextile formwork – an assembly or stack of 200 litre drums with the ends cut out is commonly used - around the reduced section and overlapping the formwork onto still serviceable sections of the pile either side of the 'waisting' then filling the formwork with grout. If a geotextile or plastic drum formwork is used for the jacketing reinforcing mesh bent to a cylindrical shape is used on the inside of the formwork to create a length of reinforced concrete. Typical jacket lengths would be of the order of 2 m. A steel sleeve or clamp can be used to restore continuity to the pile. The annular space between the pile and the sleeve is much less than for the formwork option, the steel section takes the bending moments and shear forces across the gap. Grout is used to fill the annular space to lock the pile to the sleeve. Formwork or steel sleeve jackets are relatively expensive. A typical pile sleeve repair for the Christchurch City Council jetties on Banks Peninsula costs in the order of $5,000 per repair, a steel sleeve in the order of $7,000. The latter is often preferred because it is less visually obtrusive, an important consideration for a heritage type structure.

Piling costs are of the same order, inclusive of the pile cost. Hardwood telephone poles have been used as piles for the reinstatement of wharves/jetties on Banks Peninsula and have the advantage of being readily available. The typical cost of a 12 m pile, ex telephone pole, in Christchurch is $1,700. The problem would be gaining access to the centre of the wharf to drive replacement piles. Floating plant can be used to drive the outside piles but the inside ones would have to be driven by plant moving along the deck. Given the current condition of the deck the repair/reinstatement of the wharf would have to start from the inshore end and encompass the complete restoration of the wharf deck structure to allow the piling rig to progress. One way around this to allow the separate work elements – piling, decking repair, deck support beam reinstatement - to progress independently would be to use jacket/splice type repairs on the centre piles. In a normal five bearing pile bent the two piles either side of the centre pile could be left out or not reinstated without impacting on the ability of the wharf to safely take the reduced loadings envisaged for the restored wharf. Even if this was done the cost of the restoration would still be high.

Based on the repair/replacement of 150 piles at an average cost of $6,000 per pile would be $900,000. Denso Seashield wrapping could be used to slow the rate of the deterioration on the remaining piles at an estimated cost of $50,000. The order of magnitude estimate of the cost to restore the wharf for pedestrian/light vehicle access, involving replacement/restoration of the decking and necessary cross bracing is $1.5 million. If an historic vessel were to be moored alongside additional raker and mooring piles would be required to independently take the mooring and berthing impact forces associated with the vessel.

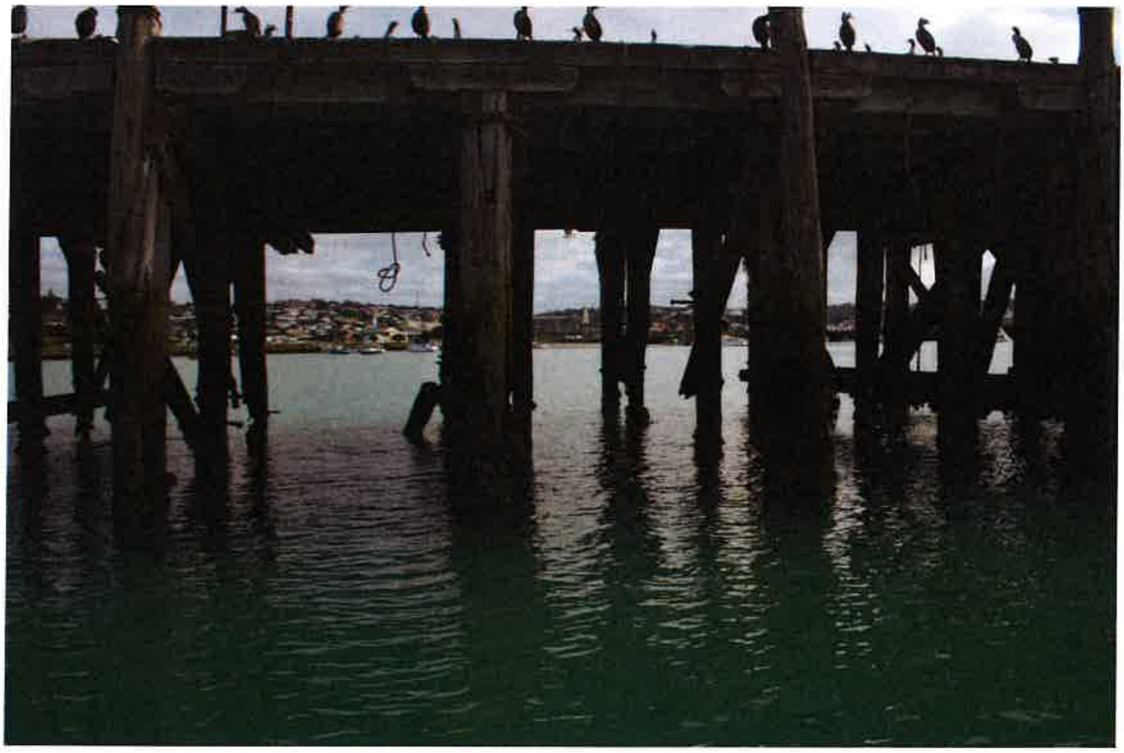
4.0 CONCLUSION

It is difficult to see the repair/reinstatement of the wharf being viable in the absence of a business case establishing its viability. There is a need but not an economic case. While volunteer labour and materials recovered from the demolition of other hardwood structures can be used to reduce the cost of the reinstatement the cost of the piling/pile repair cannot be similarly reduced because of the need for specialist plant and equipment. The progressive, or perhaps more aptly regressive, nature of the deterioration has reached the stage where partial collapse of the structure can be expected. It is beyond the stage where a patch up can be used, the deterioration affects the entire wharf. The cost to demolish the wharf is also significant and of the order of $400,000.

Photograph No 1

Photograph No 2

Photograph No 3

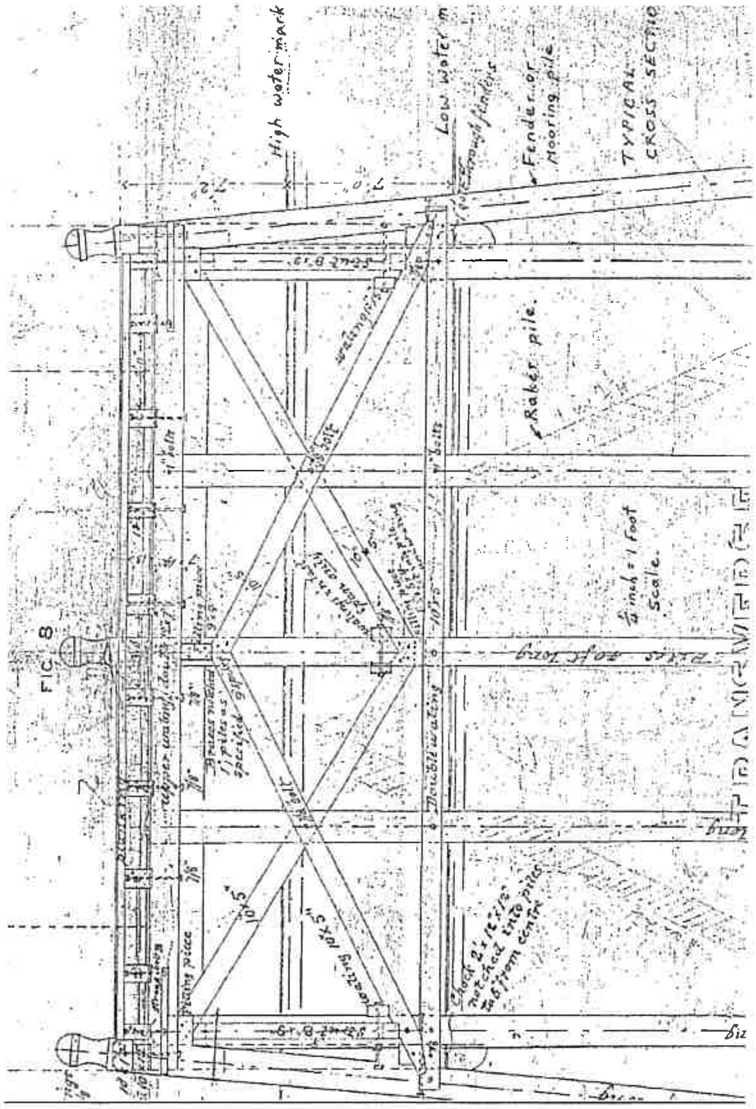


Photograph No 4

Photograph No 5

Photograph No 6

Structural Assessment of Sumpter Wharf Oamaru
For the NZ Historic Places Trust, North Otago Branch



Nick Barber, Chartered Engineer, MIPENZ (Civil & Structural)

April 2006

Sketch No 1

14/9/19

Sumpters Wharf, Oamaru
Brief overview, for Waitaki District Council,

Attention :- Grant Rhodes

The following comments are based upon:-

- General on site discussions with yourself and Kevin, the yacht club commodore;
- 2 inspections of the wharf, at low and high tides;
- A review of the report (42 pages) prepared by Nick Barber, CPEng, dated April 2006.
- (I note that we await an inspection from Bay Underwater Services, (BUS) as regards the condition of the below low water pile portions).

Overview.

The dilapidated state of the wharf is known by all. Various species of shag have subsequently chosen to nest there, with public opinion split as to whether they are a great tourist attraction and should remain, or that they are considered to be a nuisance, due mainly to the smell emanating from the site. The jury is still out on that one!
There are further concerns that the wharf may self destruct totally, or partially as a result of the on-going decay, and/or with a change in seabed conditions further out, (possible dredging) that may cause larger waves to impact on the structure. It is anybody's guess, as to how long it may remain, without any intervention. Without more in depth investigation, which in part is difficult, because the integrity of each pile is impossible to accurately quantify, the condition of the bolts are indeterminate, the amount of rot in the tops of the bearers and joists is mainly hidden. Our collective estimates, ranged from worst case, "imminent partial collapse", to "it might last 10-15 years".
I should say, that under no circumstances should any vessel be allowed to tie up alongside, as the additional windage on the vessel and wave impact loads transferred to the wharf, may be sufficient to overstress that part of the wharf.

The Proposal.

A suggestion that part of the wharf could be refurbished to sufficient strength to allow pedestrian access over the initial 18 pile bents, is the basis of these comments. This access could be limited to say one side or the other initially, in order to reduce costs.
Barber's report, is a well prepared, thorough report, that in essence, is still valid today. His analysis of the structure was interesting, with respect to how the wharf might perform, if various piles were absent. My on site comment, that for the 5 pile bents, that we only need to probably strengthen the outer 2 piles and centre pile, was confirmed by his calculations. Amazing!
He didn't analyse the first 18 bents, but I know that again, we could probably only need to fix the 2 outer piles, plus 1 of the inner ones, or an outer and adjacent pile, should we choose to do a limited width access. This reduces the

initial repair cost, if you want to provide pedestrian access over this first access portion.

He had quite detailed suggestions for cleaning and repairing the tops of the piles and tops of the joists and bearers, where they are likely to have been eaten away.
His proposed repair method for the piles was very similar to what we are doing currently on Holmes Wharf, i.e. small gauge wire mesh reinforcing (but with additional vertical steel), fibre reinforcing and concrete additives, all cast with a casing.

To reduce costs for the project and to add authenticity, I would suggest a partial demolition of the wharf closest to bent no 18 onwards, and recycling the timbers as possible. Perhaps this could be done only on one half of the structure, so that should additional pedestrian access be sought, that this could be done with a narrower footprint, rather than reconstructing the entire wharf.

BUS also need to look at the main structure of the wharf, over the first 18 bents, in order to provide council with a rough budget for the remedial work required to provide the proposed pedestrian access. This may or may not be the pivotal cost that determines whether to proceed or not.

Please let me know how you would like to proceed on this matter, then I can provide some budget amounts for my potential involvement.

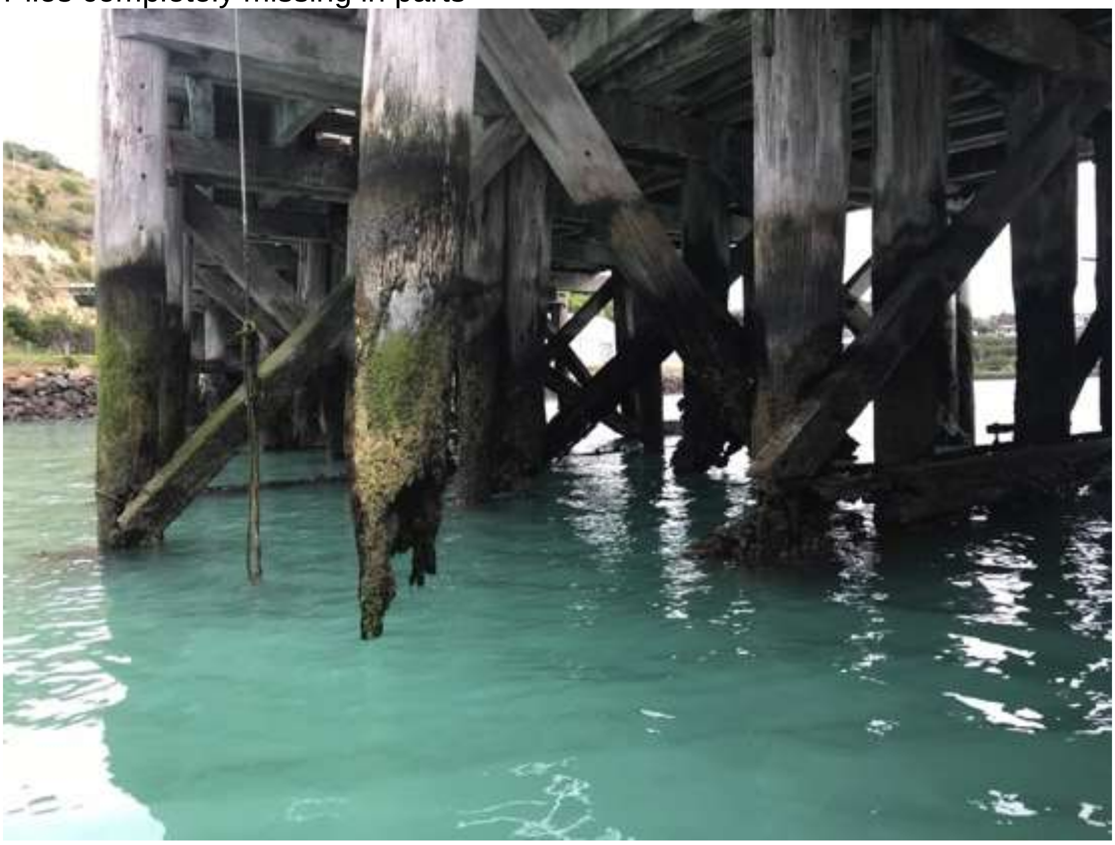
Some general photos have been attached for completeness.

Greg Shaw, CPEng, Int PE, MEngNZ.

<u>Appendix.</u>
<u>General Wharf Photos</u>

Outer section of wharf.

Piles completely missing in parts



Typical pile bent that is proposed to be repaired for pedestrian access only.

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SUMPTERS WHARF

Starting inshore, A, being the town side

ROW	PILES	% WASTED	NOTES	COMMENT
1	A	Good		
	B	Good		
2	A	100%	Case / Box	Case
	B	Good		
	C	Good		Good
3	A	20%	Re-bolt	Good
	B	60-70%	Re-bolt	
	C	Good	Re-bolt	Good
4	A-double	100% gone	Diagonals all 100% / Re-bolt tops	Case
	B – 1	100% gone	Diagonals all 100% / Re-bolt tops	
	B - 2	30% rotten	Diagonals all 100% / Re-bolt tops	Good
	C – 1	100% gone	Diagonals all 100% / Re-bolt tops	
	C - 2	100% gone	Diagonals all 100% / Re-bolt tops	Case
5	A	75%	Wailers & Diagonals 80%	Case
	B	20%	Wailers & Diagonals 80%	
	C	100% gone	Wailers & Diagonals 80%	Case
	D	80% mid &base	Wailers & Diagonals 80%	
	E	90%	Wailers & Diagonals 80%	Case
6	A	20% base	Base / Wailer 100%	Case
	B	20% base	Base / Diagonals 80-90%	Good
	C	100%	Waterline	
	D	85%	Base	Case

ROW	PILES	% WASTED	NOTES	COMMENT
7	A	Good	Wailers 95%	Good
	B	20%	Base / Diagonals 95%	
	C	100%	Waterline	Case
	D	30%	Base	
	E	100%	Base	Case
8	A	40%	Base / Wailers 80-90%	Good
	B	100%	Waterline / Diagonals 80%	
	C	100%	Base	Case
	D	100%	Waterline	
	E	30%	Base	Good
9	A	30%		Case
	B	100%		
	C	100%		Good
	D	100%		
	E	10%		Case
10	A	70%	Base / Wailers 80%	Case
	B	100%	Base / Diagonals 80%	
	C	100%	Base	
	D	100%	Base	Case
	E	70%	Base	Case
11	A	10%	✓ / Wailers 80%	Good
	B	100%	Base / Diagonals 80%	
	C	80%	Base / Waterline	Case
	D	50%	Right through	
	E	30%	Base	Good

ROW	PILES	% WASTED	NOTES	COMMENT
12	A	80%	Base	Case
	B	100%	Base	
	C	40%	Waterline	Good
	D	80%	Waterline	
	E	100%	Base	Case
13	A	80%	Base	Case
	B	30%	Waterline / Wailers 100%	
	C	90%	Base	Case
	D	30%	Through	
	E	30%	Through	Good
14	A	20%	Base	Good
	B	100%	Base	
	C	100%	Waterline	Case
	D	70%	Base 85% / Waterline	
	E	20%	Through	Good
15	A	70%	Base / Wailers	Case
	B	100%	Base	
	C	70%	Base	Case
	D	90%	Waterline	
	E	20%	-	Good
16	A	70%		Case
	B	60%	Base	
	C	90%	Base	Case
	D	70%	Base	
	E	20%		Good

ROW	PILES	% WASTED	NOTES	COMMENT
17	A	Pile gone	Ladder / Wailers 80%	Re-pile
	B	60%	Base / Diagonals 90%	
	C	40%	Base	Good
	D	50%	Base	
	E	60%	Base	Case
	F	70%	Base	
	G	30%	Base	Good
18	A	30%	Base	Good
	B	30%	Base	
	C	30%	Base	Good
	D	100%	Gone	
	E	30%	-	Good
	F	100%	Gone	
	G	30%		Good
19	A	80%	-	Case
	B	20%	-	Good
	C	100%	Waterline	
	D	50%	-	Good
	E	100%	Waterline	
	F	Good		Good
	G	10%		Good
	H	100%	Waterline	
	I	80%	Waterline	Good

ROW	PILES	% WASTED	NOTES	COMMENT
20	A	90%	Base	Case
	B	10%	Gone	
	C	100%	Gone	
	D	100%	Gone	Case
	E	100%	Gone	
	F	30%	Base	
	G	80%	Wailer	Case
21	A	20%	Base	Good
	B	100%	Waterline	
	C	95%	Waterline	
	D	75%	Waterline (20% base)	Case
	E	90%	Base	
	F	100%	Waterline	
	G	100%	Waterline	Case
22	A	100%	Base	Case
	B	100%	Waterline	
	C	40%	Base	
	D	100%	Base	
	E	40%	Base	Good
	F	100%	Waterline	
	G	30%	Waterline	
	H	20%	-	
	I	60%	-	Case