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Attention: Rob Pitkethley

Dear Rob

Rotorua Lakes Council Wharf and Lakeland Queen Wharf Head Qualitative Assessment

1 Introduction

Tonkin & Taylor Ltd. (T+T) has been engaged by Rotorua Lakes Council (RLC) to undertake an independent engineering assessment of the Council Wharf and Lakeland Queen Wharf Head (Berthage). The work was undertaken in accordance with T+T proposal "Rotorua Lakes Council Wharf and Lakeland Queen Berthage Engineering Assessment_v2" dated 17 March 2022.

2 Site description

The RLC Wharf and Lakeland Queen Wharf Head are located at the south end of Lake Rotorua and to the north of the Kawarau Jet Wharf. The general location of the RLC Wharf and Lakeland Queen Wharf Head is presented in Figure 2.1.

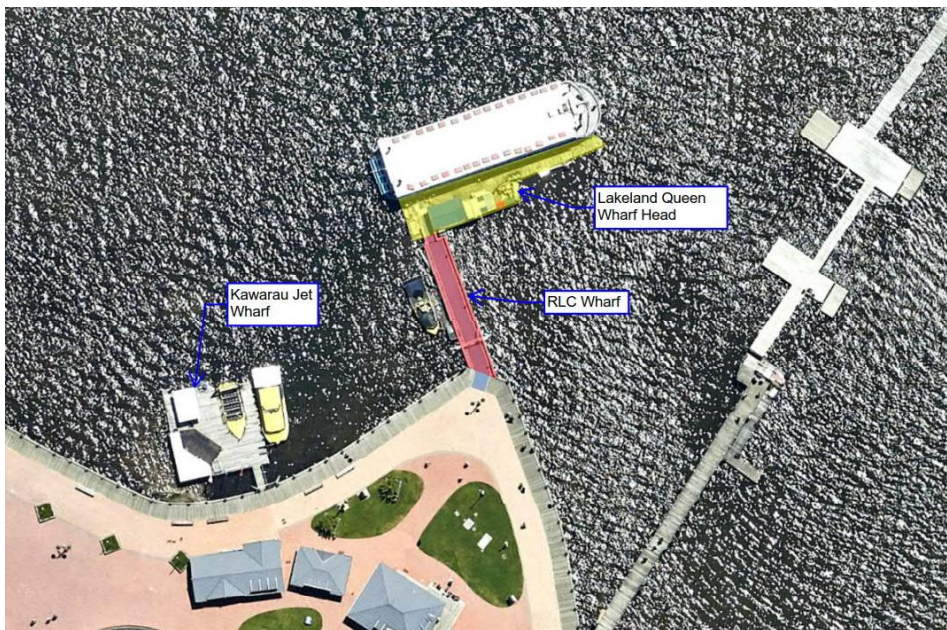


Figure 2.1: Site location

2.1 Lakeland Queen Wharf Head

The Lakeland Queen Wharf Head can generally be considered in two separate portions (refer to Figure 2.2 for indicative dimensions):

- Section 1 (approximately 12.0m long x 1.5m wide).
- Section 2 (approximately 16.0m long x 4.5m wide).

Key features of the Lakeland Queen Wharf Head are summarised in Table 2.1.



Figure 2.2: Lakeland Queen Wharf Head

Table 2.1: Lakeland Queen Wharf Head

| Item | Properties |
|---------------------------|---|
| Section 1 | |
| Dimensions (approximated) | 12 m x 1.5 m |
| Piles | f 300 mm diameter timber poles. Piles spacing are not consistent but are at approximately 4 m centres. |
| Bearers | 100 x 75 steel unequal angles |
| Joists | Intermediate joist – 50 mm x 50 mm steel equal angle (approximated) Edge joist – 75 mm x 100 mm steel unequal angle (approximated) |
| Decking | 50 mm thick timber decking |
| Section 2 | |
| Dimensions (approximated) | 16 m x 4.5 m |
| Piles | f 300 mm diameter timber poles. |

| Item | Properties |
|---|---|
| | Piles spacing are not uniform but are at approximately 4 m centres. |
| Mooring Piles (piles with rubber fenders are considered to be mooring piles in this assessment) | Generally f 300 - 400 mm steel circular hollow sections One of the mooring piles consists of a steel tube bolted to the top of a timber pile. |
| Supporting structures | Structural members supporting this part of the structure consist of a combination of: <ul style="list-style-type: none"> • Steel Universal Beams (200UB). • Steel hollow sections. • Timber beams (200 – 300mm deep). These members do not appear to follow any specific pattern and appear to have been installed and replaced on an as needed basis in the past. |

2.2 RLC Wharf

The RLC Wharf is approximately 20 m long and 3 m wide, and consists of timber bearers, joists and decking supported on timber piles (refer to Figure 2.3 for indicative dimensions).

Key features of the RLC Wharf are summarised in Table 2.2.

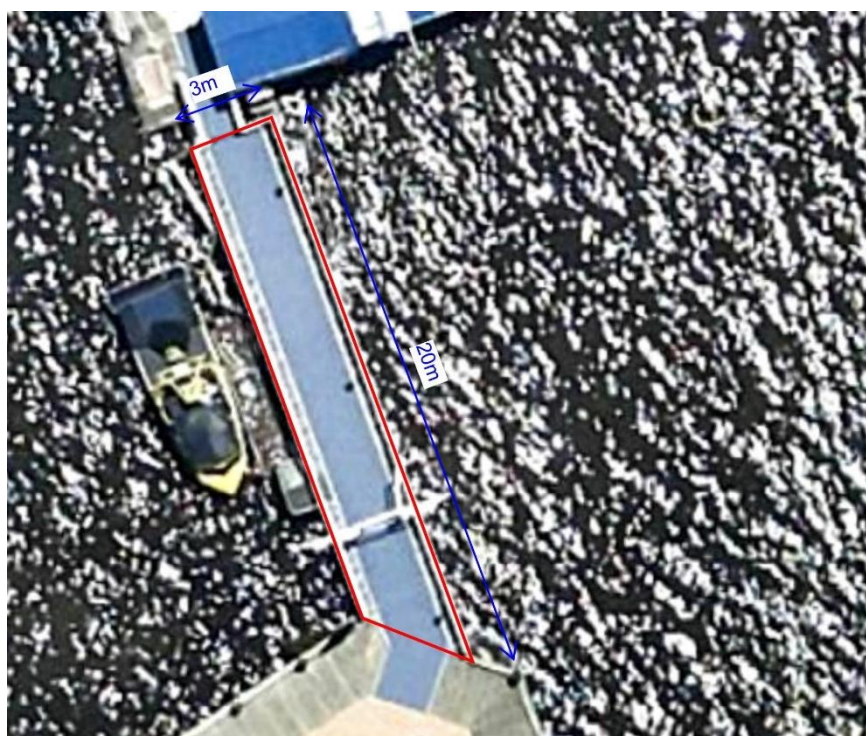


Figure 2.3: RLC Wharf

Table 2.2: RLC Wharf

| Item | Properties |
|------------|------------|
| Dimensions | 20 m x 3 m |

| Item | Properties |
|---------|--|
| Piles | f 200 mm diameter timber poles at approximately 2 m centres. |
| Bearer | 300 mm x 100 mm timber bearers |
| Joist | 250 mm x 50 mm timber intermediate joists 300 mm x 100 mm edge joists |
| Decking | 50 mm thick timber decking |

3 Survey methodology

Visual inspection was undertaken on 22 March 2022 by two T+T Engineers, we have undertaken the following during our inspection:

- Visual inspection of piles, bearers, joists, decking and connections.
- Undertook photographic records of the inspected structures.

The visual inspection was undertaken from the deck level and from wading in lake. The inspection was undertaken for easily accessible and observable members only. Submerged sections could not be visually examined due to presence of lakeweed and murky lake water.

The following terms and meanings are used to describe the condition of the RLC Wharf and Lakeland Queen Wharf Head:

- Satisfactory – the feature is expected to fulfil its intended function.
- Fair – the feature is expected to fulfil its intended function, but maintenance is recommended.
- Poor – the feature may not fulfil its intended function; maintenance is necessary.
- Unsatisfactory – the feature is not expected to fulfil its intended function; repair, replacement, or modification is necessary.

4 Inspection summary:

4.1 Lakeland Queen Wharf Head

The Lakeland Queen Wharf Head is generally in poor to unsatisfactory condition.

- The wharf head timber piles are generally in unsatisfactory condition. Some of the wharf head piles were capped with a steel cap and therefore their condition could not be visually examined. However, piles that were visible showed signs of severe rotting. Areas with the most significant rotting, were pile ends and areas subjected to water to air interface (Appendix A, Photograph A7 and Photograph A8).
- The wharf head substructure consists of a mixture of steel universal beams, steel hollow sections and timber beams. These members do not appear to follow any specific pattern and appeared to have been installed and replaced on an as needed basis over the years. We have noted areas where improvised measures such as makeshift spacers and additional springs were installed to provide additional support to the decking and mooring pile. Some of these measures did not appear to have been fastened securely and may introduce additional loads to the wharf head:
 - Timber joists located at the western end of the wharf head were placed on unsecured timber spacers (100 mm x 50 mm) and are likely to become unstable if subjected to lateral loads (Appendix A, Photograph A4).

- T+T's condition survey undertaken in 2005 (T+T ref: 15821.001) reported that the existing timber piles were on a tilt, a comparison of photographic records indicated that the tilting of the mooring piles have worsened since 2005 (Appendix A, Photograph A5).
- It appeared that some of the timber piles supporting the wharf head have been modified for mooring purposes. These modifications introduced additional loads to the wharf head support piles which damaged a part of the wharf head and may cause further damage to the wharf head:
 - o The eastern end of wharf head section 1 has deformed. It appears to be caused by a mooring pile bearing on the wharf head. (Appendix A, Photograph A5)
 - o A timber pile directly in front of the freezer/cooler shed appears to have been converted to a mooring pile by attachment of a steel tube on top of the existing timber pile. The converted mooring pile is connected to the wharf head with a spring. Such modification increases the applied loads to the wharf head and may damage the wharf head. (Appendix A, Photograph A6)

Some timber piles have rotted severely at locations around the wharf head - timber pile bolted connections. The integrity of these connections is compromised, and they are unlikely to fulfil their original intended functions. (Appendix A, Photograph A7)

- Majority of the steelwork, including bearers, joists and connections have corroded and are generally in a poor to unsatisfactory conditions. The extent varied from surface corrosion to severe corrosions where the steel members have been corroded through.
 - The lakeward 200 UB steel edge beam is severely corroded, and it was noted that a small part of the web has fully corroded through. (Appendix A, Photograph A9)
 - The landward 200 UB steel edge beam (directly below the freezer/cooler shed) is also severely corroded and a significant section of the beam has completely corroded, causing the member to collapse. (Appendix A, Photograph A10)
 - Some of the rectangular hollow section joists showed signs of severe corrosion on the outside, though the inside of these sections could not be inspected, it is likely that the severity of corrosion on the inside face will be similar to that of the outside, given the ends of these members are usually unsealed. (Appendix A, Photograph A11)
 - It should be noted that though some of the rectangular hollow sections appear to have surface corrosion only and further investigation is required to assess the capacity of these members (such as thickness testing). The exterior condition of the member may not be a true reflection of the member condition, as corrosion can occur from inside the member.

4.2 RLC Wharf

The RLC Wharf is generally in fair condition.

- The original 200 mm x 200 mm square timber piles have mostly rotted away, however we note that new f 200 mm diameter timber poles with new 300 mm x 100 mm timber bearers have been installed adjacent to the original piles, providing an alternative load path to support the superstructure. We understand these remedial works were undertaken in two stages circa 2000 and 2005. (Appendix A, Photograph A12 and Photograph A13)
- The new piles are in fair condition. We did not note any obvious rotting of timber piles. However, moss and mould were noted on the surface of these members.
- The timber joists are in fair condition. However, moss and mould were noted on the surface of these members.

- Bolted connections between timber piles and timber bearers are in fair condition. Signs of surface rust on bolts were noted.

5 Conclusions and recommendations

The following conclusion and recommendations are based on our visual assessment. Our assessment is of a qualitative nature only and we have not undertaken an engineering assessment of these structures to establish their structural capacities.

5.1 Lakeland Queen Wharf Head

- The corroded steel substructure should be remediated as a matter of urgency as these are the main members supporting the superstructure. Severely corroded members, in particular the 200 UB steel edge beams, should be replaced. Decking may need to be temporarily removed, and the wharf head may need to be temporarily jacked up to undertake the repair.
- Steelwork with moderate level of corrosion should be cleaned off and undergo thickness testing to establish remaining thickness of members. Members with significant material loss should either be repaired or replaced.
- At the completion of all repair works, all steel members should be cleaned free of rust and contaminations and coated with protective coatings.
- The timber wharf head piles appear to have either reached or are close to reaching their design life, based on the level of observed rotting. Though the timber piles have not rotted through its cores, the rotting will likely be ongoing, and are unlikely to be sustainable in the long term. Replacement of the existing wharf head timber piles or installation of additional new timber piles to support the wharf head is recommended.
- Some of the mooring piles connected to the wharf head resulted in lateral loads being transferred to the wharf head, and in some areas have resulted in deformation of the wharf head. It is likely that the wharf head will require straightening and strengthening to resist the applied loads. Alternatively, the mooring piles will need to be modified and strengthened to resist mooring loads to protect the wharf head.
- Given the irregular arrangement of structural members of the substructure in Section 2, stakeholders may wish to consider re-establishing a simpler load path to transfer vertical and lateral loads by design and addition of new structural members. Note that we have not undertaken an engineering assessment of the Lakeland Queen Wharf Head to establish its current structural capacities.
- The recommended remedial measures are relatively complex and it is difficult to provide a rough order cost estimate for the repair work due to complexity of the repair work. Repair cost would be associated with repair/replacement of bespoke individual members. Stakeholders may wish to consider demolishing the existing wharf head and replacing it with a new structure, as this is likely to be more economical from an engineering perspective.

5.2 RLC Wharf

- The RLC wharf is generally in fair condition. We did not identify any specific structural members that require attention urgently or in the short term.
- To prolong the life of the structure, maintenance is recommended. This includes:
 - Replacing corroded bolts and washers with new galvanised bolts and washers.
 - Removal of surface moss and mould.
 - Application of protective coating to timber members (such as paint) to protect the timber from the elements.

- Stakeholders may wish to consider undertaking an engineering assessment to establish the structural capacity of the wharf and compare it against current day design requirements. The structure may require cross bracing to strengthen its lateral capacity.
- The existing RLC Wharf is unlikely to have sufficient capacity to resist mooring loads from the Lakeland Queen Ferry. If stakeholders wish to remove the existing Lakeland Queen Wharf Head and berth against the RLC Wharf, new independent fender piles will be required to protect the RLC Wharf. In addition, we note that the length of the existing RLC Wharf is insufficient to accommodate the Lakeland Queen, an extension to the RLC Wharf will be required. Dredging will also be required to accommodate the draught of the vessel. Consideration will need to be given to the effect of dredging on the existing lakewalls and the RLC Wharf piles.

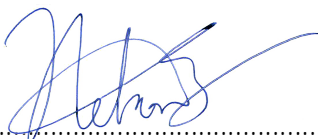
6 Applicability

This report has been prepared for the exclusive use of our client Rotorua District Council, trading as Rotorua Lakes Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

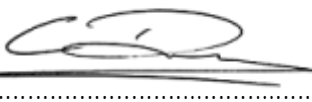
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Appendix A: Site Photographs



Photograph Appendix A.1: Lakeland Queen Wharf Head



Photograph Appendix A.2: RLC Wharf



Photograph Appendix A.3: Lakeland Queen Wharf Head support structure- 1



Photograph Appendix A.4: Lakeland Queen Wharf Head support structure- 2



Photograph Appendix A.5: Lakeland Queen Wharf Head



Photograph Appendix A.6: Lakeland Queen Mooring Pile



Photograph Appendix A.7: Lakeland Queen Wharf Head pile - 1



Photograph Appendix A.8: Lakeland Queen Wharf Head pile - 2



Photograph Appendix A.9: Lakeland Queen Wharf Head 200 UB edge beam



Photograph Appendix A.10: Lakeland Queen Wharf Head 200 UB edge beam



Photograph Appendix A.11: Lakeland Queen Wharf Head support structure



Photograph Appendix A.12: RLC wharf – piles and bearer



Photograph Appendix A.13: RLC Wharf - general