HEROLD ENGINEERING

December 11, 2023 3555-006

Via email: sbagh@oakbay.ca

District of Oak Bay
2167 Oak Bay Avenue
Victoria, BC
V8R 1G2

Attn: Signe Bagh

Re: District of Oak Bay
Oak Bay Marina – Dock - Condition Assessment

Dear Signe:

As requested, we are pleased to provide the following report for the condition assessment of the dock at the Oak Bay Marina. Our observations and recommendations pertain to the timber framing, the flotation billets, and the mooring piles.

We trust this information is sufficient. Please call with any questions.

Yours truly,

HEROLD ENGINEERING LIMITED

Craig Appelman, P.Eng.
Associate, Materials Engineer

Enclosure

Oak Bay Marina – Dock - Condition Assessment

Contents

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1 Executive Summary

The dock at the Oak Bay Marina has been reviewed by structural and materials engineering consultants to assess the current condition of the asset and to provide an opinion on residual service life. The assessment included the review of the dock timber framing and its connections, the polystyrene billets, the steel and timber mooring piles, and the fuel dock structure.

The dock is in fair to good condition overall, no major safety concerns were apparent during the review, and areas of localized damage and deterioration have been identified. It is recommended that the following maintenance activities continue in order to preserve and extend the service life of the dock.

- Replace deteriorated timber components such as deck boards and framing.
- Replace corroded steel connection plates.
- Supplement existing billets with new encapsulated billets to maintain freeboard.
- Monitor deteriorated mooring piles.

The mooring piles that were observed to show signs of damage or deterioration have been rated either 'red' or 'yellow'. Piles marked 'red' have reached the end of their service life and piles marked 'yellow' should be monitored.

The following table provides an opinion of residual service life of the dock components. Plan views are provided in the appendices to summarize the field observations.

Table 1 - Estimated Residual Life of Dock Components

Component	Estimated Residual Service Life
Timber Deck Boards	Three to six years. Damaged boards to be replaced.
Timber Support Framing	Three to five years for members showing minor signs of decay. In excess of five years for sound timber. Damaged members to be replaced.
Polystyrene Billets	Three to five years.
Timber Mooring Piles	Piles flagged 'red' have reached the end of their service life. Piles marked 'yellow' have an estimated three to six years residual service life. Piles that did not show apparent signs of damage or deterioration have an estimated eight to ten years of residual service life.
Steel Mooring Piles	Eight to ten years except for the dolphin near the fuel dock which has an estimated residual service life of three to five years.

1.1 Purpose of the Condition Assessment

It is understood that the District of Oak Bay requires a condition assessment of the dock and associated components to determine if any safety or maintenance issues are apparent and to determine the residual service life of the structure. The following report summarizes the current condition of the dock and provides recommendations on maintenance activities.

1.2 Scope of Work

The scope of the assessment is focused on the dock adjacent to the Oak Bay Marina including the attached fuel dock. The report provides findings on the condition of the timber deck boards, the timber support framing and its connections, the flotation billets (typically expanded polystyrene), and the steel and timber mooring piles. The report also includes an estimate of residual service life and maintenance recommendations for the various components.

In order to provide a sufficiently comprehensive summary of the structure's condition, the scope of work includes a visual site assessment and limited tactile survey by structural and materials engineering consultants along with subconsultant dive inspection services to allow the consultants to review the underwater components.

The scope of work does not include engineering analysis for capacity of the existing structure to resist service loads, such as berthing and wind, nor does it include an analysis of code conformance.

1.3 Limitations

Herold Engineering Ltd. (HEL) does not take responsibility for the existing condition of the property or any related structures or equipment.

This report has been prepared by HEL exclusively for the Client. HEL accepts no responsibility for the improper or unauthorized use of this report by any third party. HEL, its employees, sub-consultants, and agents accept no responsibility to any other party, including contractors, suppliers, consultants and stakeholders, or their employees or agents, for loss or liability incurred as a result of their use of this report.

Information, data, recommendations, and conclusions contained in this report may not be complete or accurate as a result of information provided to HEL which has not been independently verified or that has not been updated. The information, data, recommendations and conclusions contained in this report are based on conditions revealed through limited visual inspections only and subject to budgetary, time and other constraints and limitations contained in the agreement between HEL and the Client.

HEL accepts no responsibility for any deficiency, misstatement, inaccuracy or omissions contained in this report as a result of deficiencies, misstatements, inaccuracies or omissions of persons providing information to HEL for use in this report.

This report is based on visual observations and data acquired from the Client. Unless otherwise agreed in writing by HEL, this report shall not be used to express or imply warranty to the property for any particular purpose.

The work reflects the Consultant's best judgement in light of the information reviewed by them at the time of preparation. HEL does not take responsibility for the existing condition of the structure or any related structures or equipment. HEL is not providing advice about mold, mildew, pollutants, contaminants or other hazardous materials. We recommend an Environmental Consultant be retained for these services.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Herold Engineering Limited and our consultants accept no responsibility for damage, if any, suffered by any third party because of decisions made or actions undertaken based on this report.

The recommendations contained herein do not purport to address any of the safety hazards associated with the completion of this work. It is the responsibility of the contractor to establish appropriate health and safety practices for the scope of work.

2 Description

2.1 Location

The Oak Bay Marina is located at 1327 Beach Drive in the District of Oak Bay at the southern tip of Vancouver Island, British Columbia. The waterfront property features three separate buildings along the west shore including a restaurant, a commercial space, and a boatworks building and features a large parking lot to the east of the buildings.

The dock for the marina is located to the west of the property. Most of the dock was reportedly constructed in 1994 with a section (E Dock) that was replaced in 1996.

The southwestern portion of the dock is in a partially protected area near the south shore and an adjacent rock formation at Queen's Park. The property features a breakwater extending northward beyond the parking lot which provides some additional protection to the northeast portion of the dock.

Refer to Figure 1.

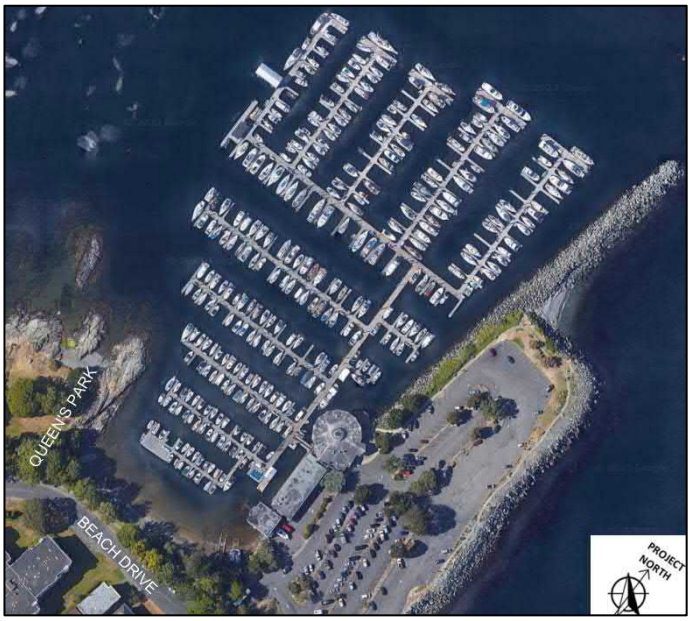

Figure 1 - Plan View of Oak Bay Marina Property

2.2 Dock Typical Configuration

The dock for the marina consists of a timber dock with individual slips and a fuel dock. The individual areas will be referred to by the terminology used on the existing structural drawings including main dock, wing dock, and fingers. Refer to Figure 3. The wing docks are labelled from Dock A to Dock K as shown on Figure 2.

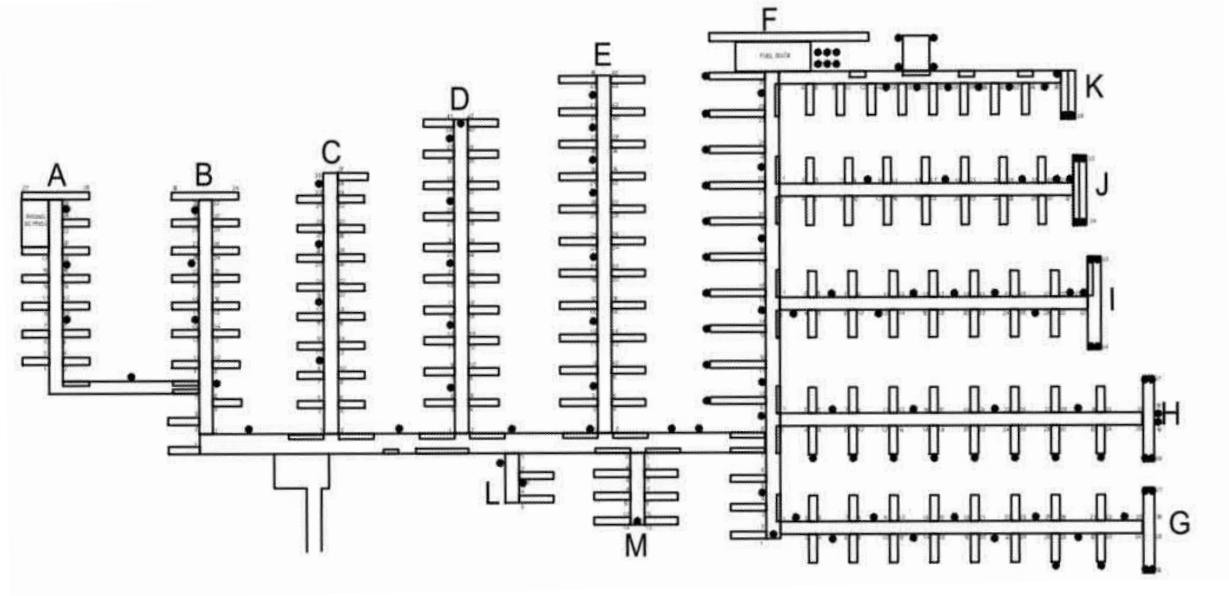

Figure 2 - Plan View of Oak Bay Marina Dock

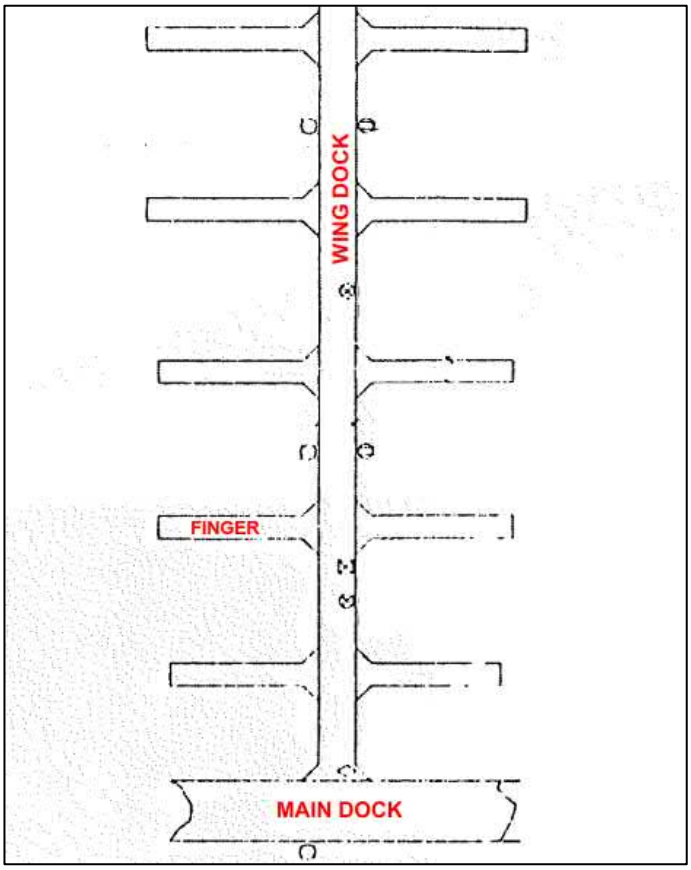

Figure 3 - Dock Component Terminology

The main dock measures approximately 3m (10') wide, the wing docks (Dock A to Dock K) measure approximately 1.8m (6') wide and the fingers measure approximately 1.2m (3'10") wide.

2.2.1 Timber Structure and Connections

Refer to Figure 4 for a schematic view of the dock construction from the original structural drawings (Graeme & Murray, 1991). The configuration reviewed on site is generally consistent with the design drawings although not all components are shown on the schematic view.

The original timber is cedar including the deck boards, the support framing, the bull rails, and the utility posts. The bull rails and utility posts run along the main dock and the wing docks but are not present on the fingers.

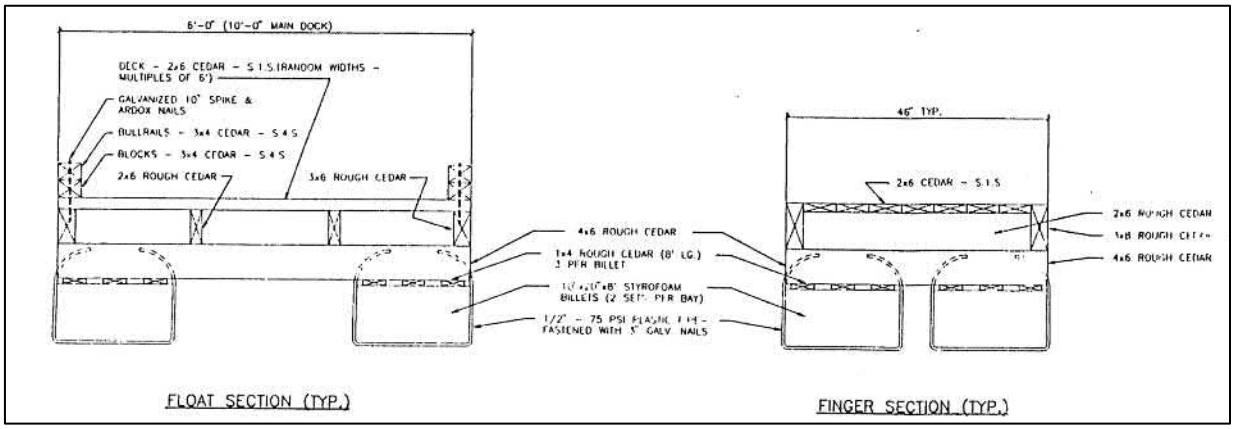

Figure 4 - Schematic View of Dock and Billet Configuration

At the main dock and wing docks, the deck boards are laid flat and nailed to the stringers below. As shown in Figure 6 and Figure 8, the stringers run lengthwise and are 50mm (2") wide by 150mm (6") deep members. The stringers are periodically spliced together with a bolted connection as shown in Figure 8. There are edge members running lengthwise on both sides of the dock which are also 150mm (6") but slightly wider than the stringers (which is consistent with the design drawings).

There are 150mm (6") deep cross members below the stringers which span between edge members and bear on the billets. The billets each feature three lengths of 100mm (4") wide timber laid flat on top of the billets to support the cross members. Refer to Figure 9 and Figure 13.

Figure 5 - Typical Configuration - Topside Main Dock – Showing Bull Rails

Figure 6 - Typical Configuration - Underside Main Dock

Figure 7 - Typical Configuration – Topside Wing Dock – Showing Bull Rails and Utility Posts

Figure 8 - Typical Configuration - Underside Wing Dock – Showing Spliced Stringer Connection (Spliced connection identified with red arrows.)

Figure 9 - Typical Configuration – View of Top of Billets

The edge framing varies depending on the location. At the main dock and wing docks, the edge framing generally consists of a 150mm (6”) deep member running lengthwise that supports the end of the deck boards and bears on the cross members. In this configuration, there is a skirting board that covers the butt end of the cross members. Refer to Figure 10.

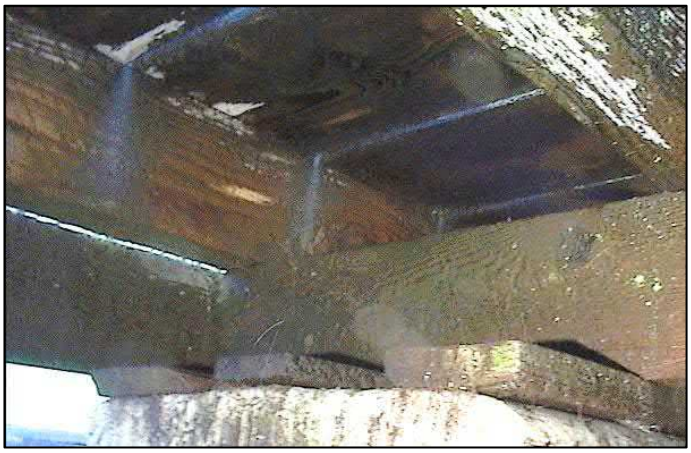

Figure 10 - Typical Configuration - Edge Member - Bearing on Cross Member with Skirting Board

Figure 11 - Typical Configuration - Utility Post

The framing for the finger sections is different than the other dock sections. There are no stringers running lengthwise and instead there are two sets of cross members spanning between the edge members – an upper set supporting the deck boards and a lower set bearing on the billets.

Where the finger joins the wing dock, the connection consists of two stacked edge members (one on top of the other) each measuring 150mm (6”) deep. The edge members on each side of the finger extend into the framing of the wing dock to attach the finger. Refer to Figure 14, Figure 15, and Figure 16.

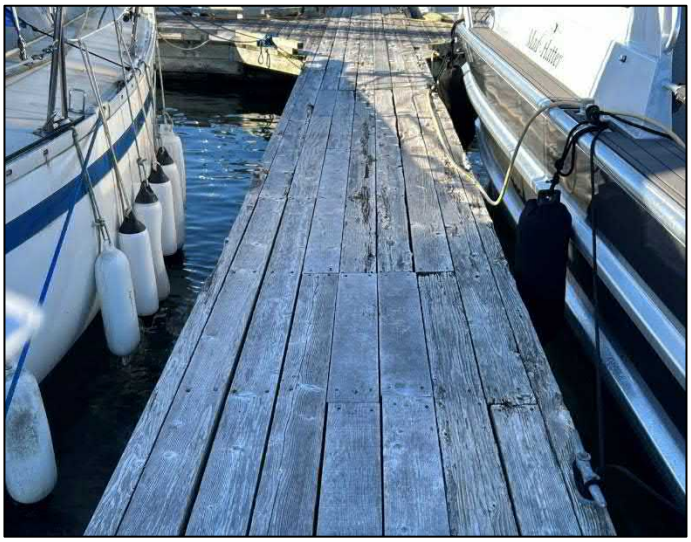

Figure 12 - Typical Configuration – Topside Finger

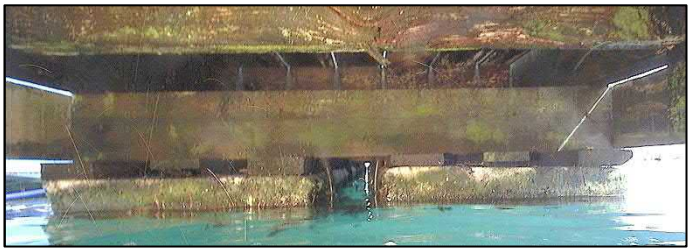

Figure 13 - Typical Configuration - Underside Finger

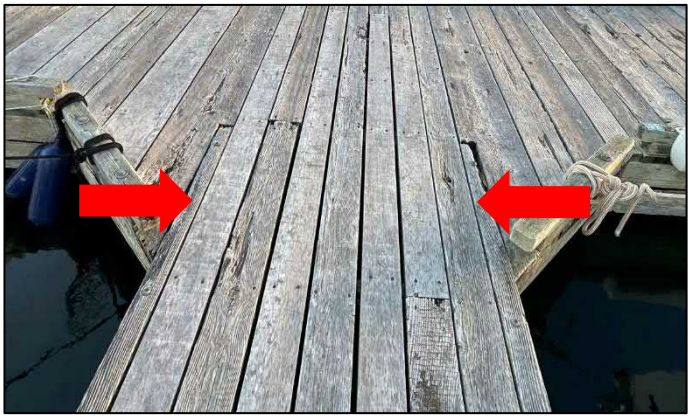

Figure 14 – Typical Configuration - Finger Edge Framing & Connection to Wing Dock
(The red arrows identify the finger edge framing members.)

Figure 15 - Typical Configuration - Finger Connection to Wing Dock

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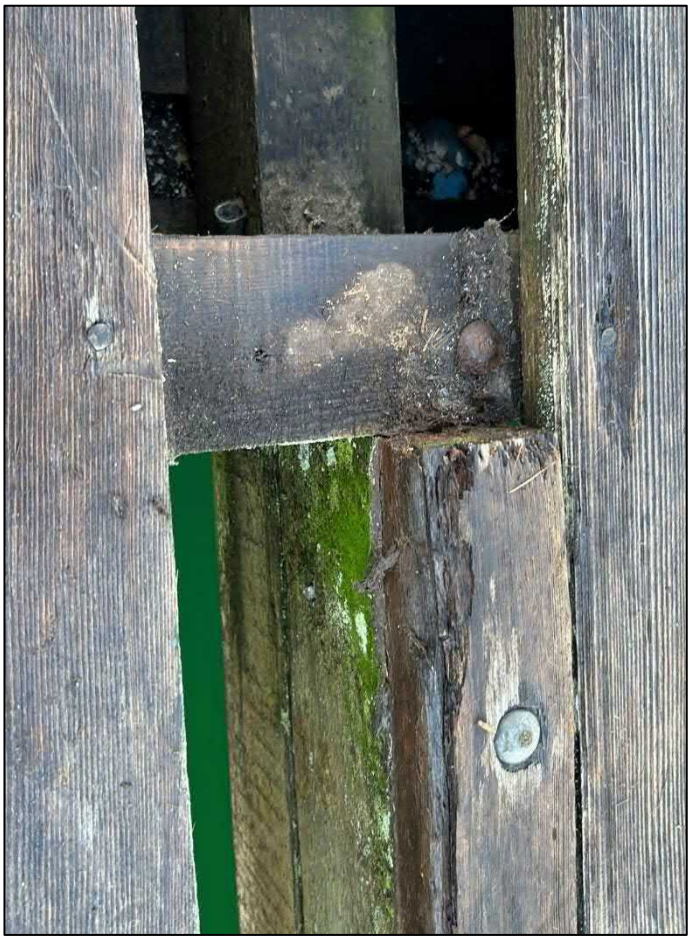

Figure 16 - Typical Configuration - Finger Connection to Wing Dock – Upper and Lower Edge Members

The various components of the dock are fastened together with a combination of nails, spikes, and steel plates. Some of the steel components are galvanized or were likely originally galvanized. The wing docks are attached to the main dock with steel angles and a bolted connection. Refer to Figure 17. In some locations, such as the T-sections at the north ends of Dock G to Dock K, there are additional steel plates bracing the timber framing. Refer to Figure 18.

Figure 17 - Typical Configuration - Wing Dock to Main Dock Connection

Figure 18 - Additional Steel Bracing at End of Dock G to Dock K

2.2.2 Flotation Billets

The original billets are made of unencapsulated expanded polystyrene strapped to the underside of the dock framing with PVC straps secured with nails. The billets are generally arranged in two parallel rows at the underside of the framing and the rows are made up of individual sets of polystyrene blocks measuring approximately 2.4m (8') long which are spaced out with approximately 0.6m (2') spacing between sets. The number of rows and the spacing of the sets varies accordingly in areas where the geometry of the dock is slightly different, for example, there are generally three rows of polystyrene blocks at the T-sections at the north ends of Dock G to Dock K.

Figure 19 - Typical Configuration of Polystyrene Billets in Rows

Figure 20 - Typical Configuration of Polystyrene Billets in Sets

Figure 21 - Typical Configuration of Polystyrene Billets at Underside of Framing

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Figure 22 – Typical PVC Connection Straps for Polystyrene Billets
(The red arrow identifies the single nail connecting the PVC strap to the timber framing.)

In some locations, other billet types were observed including PVC or fiberglass encapsulated units - often referred to as 'envirofloats' - which appear to be either replacement billets or supplemental billets depending on the configuration and location. Refer to Figure 23 and Appendix B.

Figure 23 - Typical PVC Billet - Encapsulated Unit

2.2.3 Steel and Timber Mooring Piles

The dock is held in place with 116 piles (103 timber piles and 13 steel piles) that extend down to the seafloor. Near the northwest corner of the dock, there are a further six steel piles clustered in a mooring dolphin at the fuel dock and an additional four dedicated piles (three steel and one timber) at the Oak Bay Sea Rescue facility.

The steel piles are approximately 300mm (12”) diameter with an assumed original wall thickness of 12.7mm (1/2”) except for the dolphin piles near the fuel dock which are smaller. The timber piles are generally between 250mm (10”) and 300mm (12”) diameter. The timber piles are treated with creosote.

Figure 24 - Northwest Corner of Dock - Near Fuel Dock and Oak Bay Sea Rescue Facility

The piles are either connected with a pile ring bolted to the dock or they are inset in a pile well. Refer to Figure 25 and Figure 26.

Figure 25 - Typical Pile Ring – Shown with a Steel Pile

Figure 26 - Typical Pile Well – Shown with a Timber Pile

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2.3 Other Components

The property features other components that are not in the scope of this review including:

- Marina buildings to the east of the docks.
- Boat hoist at the southwest of the property
- Parking lot to the east of the buildings.
- Gangway to the marina buildings.

The gangway provides access to the dock from shore and the entrance is located between the café and the commercial space. The gangway connection was reviewed in the spring of 2023 along with the assessment of the buildings. Refer to the Oak Bay Marina Condition Assessment Report by Herold Engineering dated June 9, 2023 for recommendations on the gangway connection.

2.4 Reference Material

2.4.1 Existing Drawings and Reports

The following drawings, reports, and other references were provided by the client or other stakeholders. Note that some of the provided references were partially incomplete such as missing drawing sheets out of a drawing set.

- Marina Lease Agreement dated October 14, 2022.
- WSP Facility Condition Assessment Report – Oak Bay Marina – February 18, 2020.
- Structural Drawings – Graeme & Murray Consulting Engineers – June 1991.
- Marina Map – Oak Bay Marina Group – Undated, Accessed on December 4, 2023.
- Oak Bay Marina Condition Assessment Report – Herold Engineering Ltd – June 9, 2023

2.4.2 Reference Standards

- Procedures for Inspection and Assessment of Fixed Timber Docks – R.G. Sexsmith - Canadian Coast Guard Harbours and Ports – 4th Edition September 1994

3 Methodology

The condition assessment included a visual and tactile assessment which was aided by limited non-destructive testing (NDT) methods. The assessment work is generally divided into two categories: the topside assessment which includes components that were able to be visually reviewed while standing on the dock and the below surface assessment which includes components that were reviewed with the aid of a dive team.

The assessment of the timber dock as well as the flotation billets and the mooring piles involved a visual review and a tactile survey to identify areas of damage or deterioration. Structural drawings and

previous assessment reports provided by the client were also reviewed. The various structural elements were reviewed by walking along the surface of the dock, by viewing the piles at low tide, and by using a dive team equipped with cameras to review the underside of the dock and the piles bases.

3.1 Timber Dock Condition Assessment

The assessment of the timber dock includes the deck boards, the support framing, and additional components such as bull rails and posts for utilities. The timber was visually assessed for signs of decay, damage, or deterioration and a limited tactile survey was performed such as pressing a steel awl into or against the timber to evaluate areas of deterioration.

The existing structural drawings were reviewed for framing details and the type of materials. The framing arrangement was verified on site.

In select locations, some deck boards were temporarily removed for a more detailed review of the configuration and the condition of the framing below.

3.1 Flotation Billet Condition Assessment

The assessment of the billets includes a visual review from above where the billets can be partially viewed above the waterline as well as a more detailed visual review with the dive team including the extent of marine growth, the remaining cross-sectional area of the polystyrene blocks, and the condition of the connection straps.

The existing structural drawings were reviewed for the configuration of the original billets. The typical arrangement was verified on site.

3.2 Mooring Piles Condition Assessment

The timber piles were visually reviewed for signs of damage, decay, pierced creosote skin, marine borer attack, or other deterioration. The steel piles were visually reviewed both from the topside and from below the surface to view damage and corrosion and the piles were field tested for wall thickness with an Ultrasonic Thickness Gauge (USTG) as described below. Galvanic anodes were observed on the steel piles and the amount of the anode consumed to date was also noted.

3.3 Materials Testing

Non-destructive field testing including USTG testing was performed on the steel piles to gain further information on the condition of the steel.

3.3.1 Ultrasonic Thickness Gauge (USTG) Testing

USTG testing is performed to measure the wall thickness of a structural steel member to evaluate the extent of corrosion and the associated loss of cross-sectional area. Where some steel members have

surface corrosion that can be noted with a visual review, the ultrasonic testing provides further information on the condition of affected steel members where damage may have occurred in areas that are not visible or accessible such as inner wall corrosion. The results of the USTG testing can be found in Appendix D.

4 Condition Assessment and Maintenance Recommendations

For clarity and ease of reference, the findings of the condition assessment have been divided into categories and marked up on plan views and/or summary tables as follows.

- Appendix A: Plan View – Deck Board, Bull Rail, and Utility Post Condition Assessment
- Appendix B: Plan View – Timber Support Framing Condition Assessment
- Appendix C: Plan View – Mooring Pile Condition Assessment
- Appendix D: Summary Table – Mooring Pile Condition Assessment

As expected with a timber dock in a marine environment, the structure is subject to deterioration from exposure to the elements. Areas of observed damage and decay have been noted on the plan views provided in the appendices.

It was observed that the dock has been subject to periodic maintenance as some components such as deck boards, framing members, bull rails, and billets were observed to have been replaced with new members presumably due to the original components having reached the end of their service life. There is also evidence of additional support being provided to some mooring piles such as underwater steel braces and concrete bases.

It is recommended that maintenance activities continue to address areas of deterioration and replace or reinforce damaged or decayed components. It was noted that some replacement members were observed to be untreated lumber. It is noted that treated lumber is expected to provide an increased service life in marine environments. The use of untreated lumber may result in a shorter life of the individual timber member and result in a more frequent replacement schedule.

4.1 Deck Board, Bull Rail, and Utility Post Observations

The deck boards, the bull rails, and the utility posts generally consist of original cedar components reportedly constructed in 1994.

The deck boards are subject to foot and storage cart traffic as well as seasonal exposure to de-icing salt. Most of the deck boards appear to be original although replacement boards were observed in certain areas. Refer to Figure 34. Many of the original deck boards remain in serviceable condition and areas of damage or decay have been noted on the plan view markup provided in Appendix A.

The deck boards cover a large surface area and there is often variation in the condition of one board to the adjacent board. However, the distribution of the observed decay was relatively consistent throughout the entire dock. The plan view markup intends to show areas of observed decay, ranging from minor decay to more extensive decay, in order to provide an overall summary of the current condition and this does not imply that all flagged areas require replacement at this time.

The majority of the bull rails and utility posts appear to be original although some replacement bull rails were observed in certain areas. Most of the bull rails and utility posts remain in serviceable condition and areas of decay have been noted on the plan views provided in Appendix A.

Figure 27 - Example of Deck Board Decay

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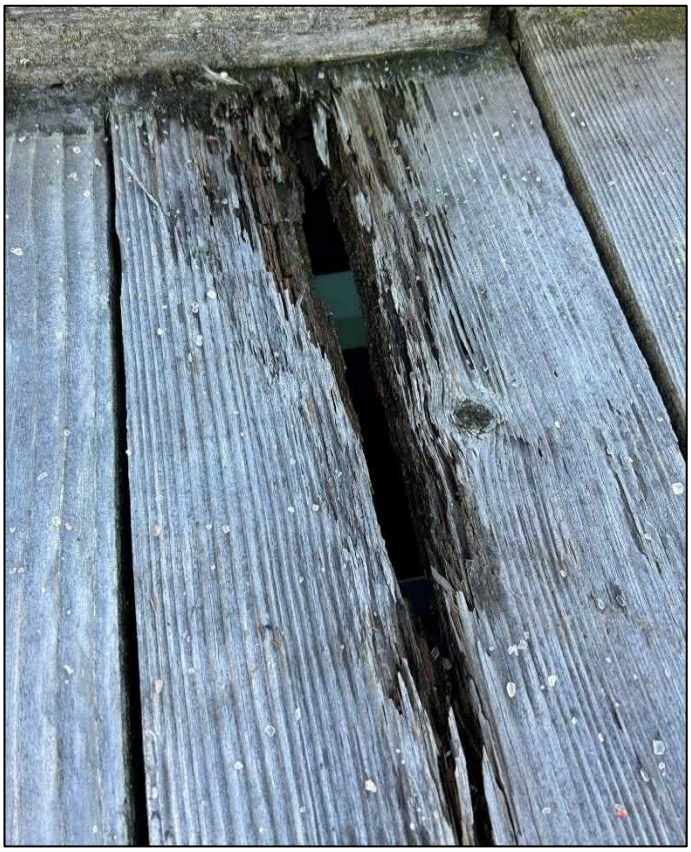

Figure 28 - Example of Deck Board Decay

Figure 29 - Example of Deck Board Decay Near Electrical Kiosk

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Figure 30 - Example of Deck Board Decay

Figure 31 - Example of Deck Board Decay

Figure 32 - Example of Deck Board Decay

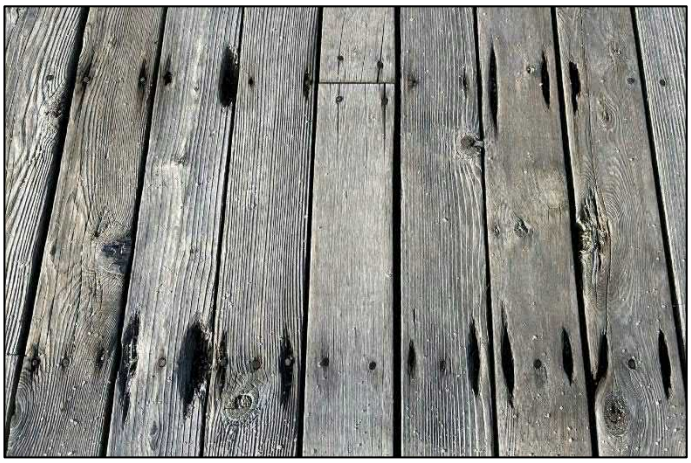

Figure 33 - Example of Deck Board Decay

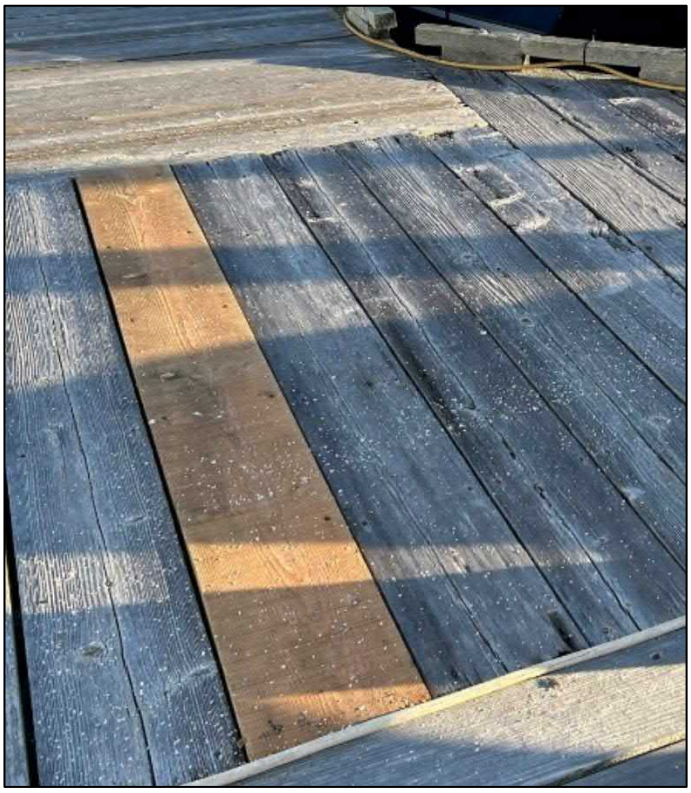

Figure 34 - Example of Deck Board Replacement

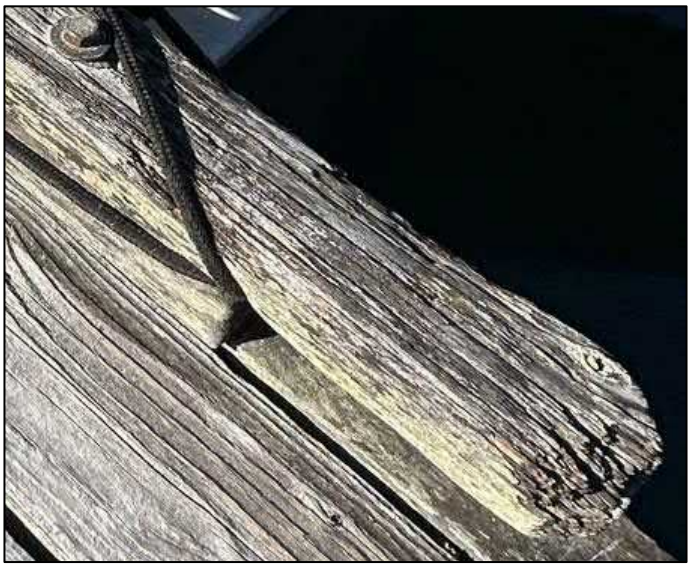

Figure 35 - Example of Decayed Bull Rail

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4.2 Timber Support Framing Observations

The timber support framing of the dock generally consists of original cedar components reportedly constructed in 1994.

The support framing is partially protected above by the deck boards and partially protected by the billets below but large areas of the framing are continuously exposed to saltwater. Most of the framing appears to be original although replacement members were observed in certain areas. Refer to Figure 47.

Many of the original framing members remain in serviceable condition and specific areas of concern have been noted on the plan views provided in Appendix B. In addition to the markups on the plan view, the following notes apply.

4.2.1 Deteriorated Framing

Deteriorated framing was observed in some areas and it is recommended that additional structural support be added in these locations. Specific locations include:

- The typical connection between the finger sections and the wing docks where the edge members and/or the framing below have deteriorated. Refer to Figure 36, Figure 37, and Figure 38.
- Where a separate float structure is tied to the main dock and Dock B near slips B1 to B7, the additional weight of the attached float appears to be pulling the existing dock framing out of place. In this location, framing members were observed to be split, sagging, and disjointed. It is recommended that these components be replaced, that the area is reinforced, and that additional separate flotation be provided for the attached float. Refer to Figure 42 and Figure 43
- The framing near slip B12 on Dock B has experienced decay and the area is sagging. It is recommended that these timber members be replaced. Refer to Figure 41.

Figure 36 - Example of Decayed Connection Member at Finger Connection to Wing Dock

Figure 37 - Example of Decayed Connection Member at Finger Connection to Wing Dock

Figure 38 - Example of Decayed Connection Member at Finger Connection to Wing Dock

Figure 39 - Example of Decayed Edge Framing Member Along Finger

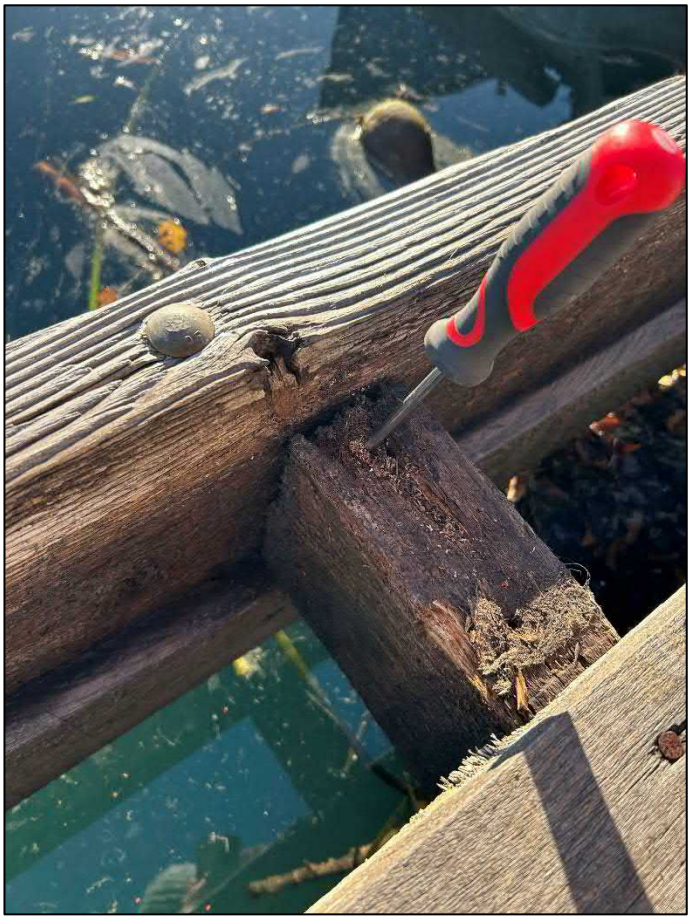

Figure 40 – Example of Decayed Framing Member

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Figure 41 – Decayed Framing Near Slip B12 on Dock B

Figure 42 - Disjointed Connection Near Slip B6 on Dock B

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Figure 43 - Sagging Framing Near Slip B7 on Dock B – Near Location of Attached Float

Figure 44 – Damaged Framing Near Dock C and Main Dock Connection

Figure 45 - Decayed Framing Near Slip E31 on Dock E

Figure 46 - Decayed Framing on Finger Near Slip C30 on Dock C

Figure 47 - Example of Framing Replacement

4.2.2 Fungal Growth on Framing

Fungal growth was observed in some areas. These locations are exhibiting minor signs of decay that are considered typical for a marine environment but that also lead to more extensive damage and decay over time. These locations should be monitored for deterioration and addressed as needed with maintenance activities including cleaning, replacing, or sistering existing framing members.

Figure 48 - Example of Fungal Growth on Framing

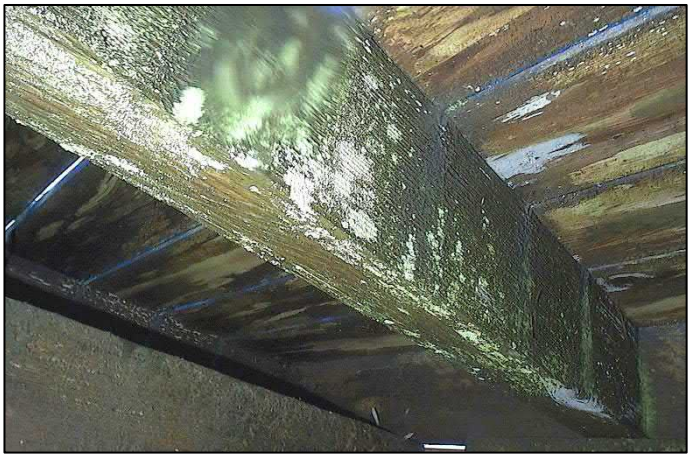

Figure 49 - Example of Fungal Growth on Framing

Figure 50 - Example of Fungal Growth on Framing

Figure 51 - Example of Fungal Growth on Framing

Figure 52 - Example of Fungal Growth on Framing

4.2.3 Steel Connection Plates

Many of the steel connection plates that connect the wing docks to the main dock have experienced varying degrees of corrosion. There is variation in the condition of these plates throughout the dock – some appear to be in relatively good condition and others appear to be at the end of their service life. Refer to Figure 53, Figure 54, Figure 55, and Figure 56. It is unknown if some of the steel plates have been replaced since the original construction although the variable condition may also be caused by different levels of exposure in different locations. It is recommended that the extensively corroded steel plates (i.e., those which have experiences pitting and/or cross-sectional area loss) be replaced.

Figure 53 - Example of a Presumably Galvanized Steel Connection Plate in Good Condition

Figure 54 - Example of a Corroded Connection Plate Between Wing Dock and Main Dock

Figure 55 - Example of an Extensively Corroded Connection Plate Between Wing Dock and Main Dock

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Figure 56 - Example of a Corroded and Failed Steel Brace Near T-Sections at Dock G to Dock K

4.3 Flotation Billets Observations

The flotation billets generally consist of the polystyrene blocks that are assumed to be the original billets reportedly constructed in 1994.

Many of the original billets remain in serviceable condition and specific areas of concern have been noted on the plan views provided in Appendix B. In some locations, additional encapsulated billets have been installed presumably to replace polystyrene units or to increase freeboard of the dock.

The original polystyrene blocks are unencapsulated which has proven to be problematic for marine environments as the polystyrene material tends to slough away and diminish the buoyancy of the dock. It is understood that the unencapsulated units were permissible at the time of construction but that encapsulated billets are now the industry standard.

The billets were observed to have experienced some loss of material resulting in a reduced cross-sectional area and reduced buoyancy. The loss was informally measured with a framing square to show the relative reduction in material at the corners. Refer to Figure 59. Further measurements were not performed as the billets also feature significant marine growth on the submerged portions (which is considered typical in this application) and the removal of the marine growth would likely cause further removal of the polystyrene material. It is noted that at this point in the service life of the billets, the observed layers of marine growth may provide some additional protection to the unencapsulated units therefore the removal of this growth is not recommended.

Also, it is likely that the condition of the billets can effectively be observed through monitoring of the freeboard throughout the dock structure. Areas which are experiencing a loss in freeboard may be experiencing accelerated deterioration of the billets.

Figure 57 - Typical Marine Growth on Polystyrene Billets

Figure 58 - Typical Marine Growth on Polystyrene Billets

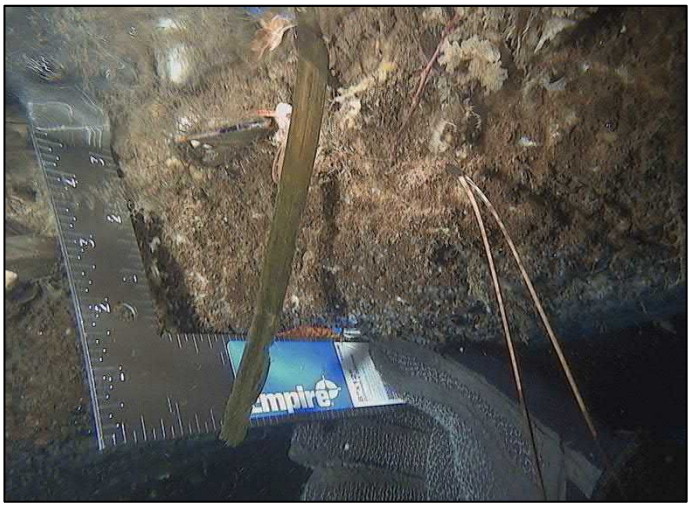

Figure 59 - Relative Measurement of Loss of Cross-Sectional Area on Polystyrene Billet

4.4 Mooring Piles Observations

The majority of the mooring piles are timber and the remainder are steel piles which are generally found along Dock E, Dock M, the main dock, and near the fuel dock. The timber piles appear to generally consist of original 1994 construction and it is reported that the steel piles along Dock E were installed in 1996. The installation dates of other steel piles is unknown.

Many of the piles remain in serviceable condition and specific areas of concern have been noted on the plan views provided in Appendix C and the summary table provided in Appendix D.

In addition to the markups on the plan view and the summary table, the following notes apply:

- The creosote coating on the timber piles appears to be in serviceable condition in most locations. Some piles were observed to have worn faces likely due to prolonged abrasion against pile wells or pile rings. In some cases, it may be that the depth of this wear has compromised the protective creosote layer. These piles require monitoring to observe the presence of decay and/or marine borers.
- As noted, some timber piles have reached the end of their service life as they exhibit signs of marine borer infestation. The true extent of the infestation inside the pile is unknown therefore, once the signs of infestation are observed, the pile is deemed to have reached the end of its service life.
- As expected, the steel piles were observed to have typical increased surface deterioration in the intertidal zone which is the area where the water level fluctuates along the height of the pile and the material is subject to more aggressive conditions. Specific measurements were taken in the intertidal zone on steel piles to measure wall thickness and the results generally

indicated minimal loss of wall thickness. Refer to Appendix D. USTG thickness testing was also performed at the submerged portions of the piles and the results generally indicated minimal loss of wall thickness – except for the dolphin at near the fuel dock which exhibits more extensive signs of deterioration. Refer to Appendix C and Appendix D.

- The steel piles were observed to have galvanic anodes attached which are designed to limit the rate of corrosion. During the course of the review, seasonal maintenance was occurring at the marina dock including anode replacement, therefore some anodes were noted to be recently replaced. Refer to Appendix C.
- Some existing anodes were observed to be nearly unconsumed. For these anodes, it is recommended that all connections points for the anodes be checked for connectivity. It is also recommended that connections be welded instead of clamped for durability.

Figure 60 - Typical Base of Timber Pile

Figure 61 - Typical Hole in Timber Pile

Figure 62 - Typical Galvanic Anode at Steel Pile

Figure 63 - Typical Crack in Timber Pile

Figure 64 - Typical Decayed Timber Pile

4.5 Fuel Dock Observations

The fuel dock structure was subject to a limited review from the surface as the framing is covered with coated plywood. Refer to Figure 65. The underside of the fuel dock was observed to be timber framing with mostly PVC encapsulated billets. Refer to Figure 66.

There are several steel connection plates at the east side of the fuel deck which were observed to be corroded. Refer to Figure 67.

The fingers to west of the fuel dock appear to match the typical construction elsewhere on the dock. The review of the piles, including the dolphin to the north of the fuel dock, is included under the review of the mooring piles in Section 4.4.

The physical or mechanical components of the fueling station are not included in the scope of the review.

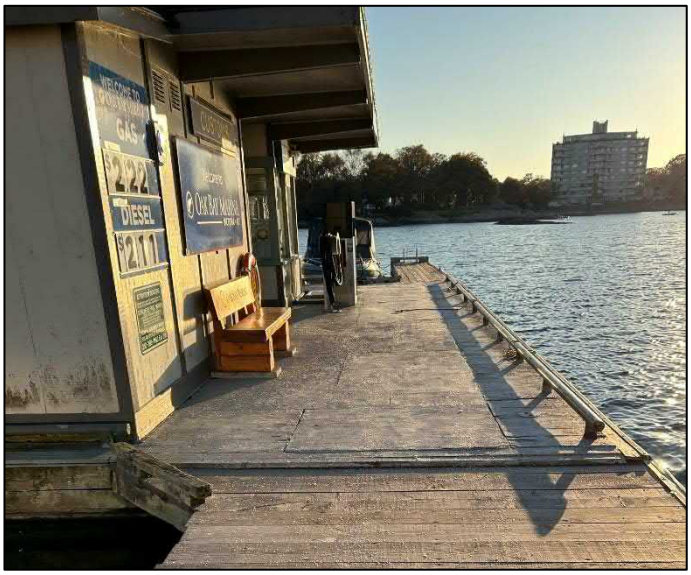

Figure 65 - Fuel Dock Topside View

Figure 66 - Fuel Dock - Underside View with PVC Billet

Figure 67 - Corroded Steel Plates at Fuel Dock

5 Residual Life Estimates

The residual life estimates reflect the typical standards provided in the *Canadian Coast Guard Harbours and Ports – Procedures for Inspection and Assessment of Fixed Timber Docks by R.G. Sexsmith.* The estimates are based on this guide as well as visual observations, a limited tactile survey, and limited field testing.

5.1 Residual Life Estimate - Timber Deck and Timber Support Framing

The timber deck boards will require periodic replacement of damaged members. The majority of the deck boards are assumed to have residual service life of three to six years. Deteriorated boards, due to mechanical damage or decay, should be replaced. It appears that previous maintenance activities have included deck board replacement and it is recommended that this process continues to address the ongoing cycle decay and deterioration.

The timber framing is in serviceable condition overall with some specific locations that require replacement. The majority of the timber framing is assumed to have a residual service life between three to in excess of five years. It is recommended that the dock continue to be monitored for indications of deck deformation, as this may be a sign of decayed and concealed timber framing below. Decayed members require replacement.

Some of the steel connection angles have reached the end of their service life and require replacement. The steel angles that were observed to be in fair condition are assumed to have a residual service life of three to five years and the steel angles observed to be in good condition are assumed to have a residual service life of eight to ten years.

5.2 Residual Life Estimate - Polystyrene Billets

The polystyrene billets are in fair condition overall and the current configuration is assumed to have a residual service life of three to five years. Several areas of decreased freeboard were observed such as tilted finger sections and there is widespread evidence of loss of cross-sectional area from individual billets. It appeared that areas with decreased buoyancy have been retrofitted with supplemental encapsulated PVC units and it is recommended that that this practice continues to address areas of concern for the remainder of the service life.

5.3 Residual Life Estimate - Mooring Piles

The timber piles that were observed to have some level of damage or decay have been rated either 'red' or 'yellow' as reflected in Appendix C and Appendix D. The following notes apply.

- The piles that are flagged as 'red' are considered to have reached the end of their service life. Further analysis of dock loading is required to determine if replacement is required.
- The piles that are flagged as 'yellow' are considered to be in fair condition and are assumed to have a residual service life in the order of three to six years. These piles require ongoing monitoring to observe further indications of deterioration.
- The piles that did not show apparent signs of damage or decay during the review are assumed have a residual service life of eight to ten years.
- The scope of this report does not include engineering analysis of the capacity of the dock structure to resist loads such as berthing loads and wind loads. Therefore, it is unknown what level of performance could be expected from the remaining piles or other components if the damaged piles were to fail.

The observed mooring steel piles are considered to be in good condition and are assumed to have a residual service life of eight to ten years. The dolphin near the fuel dock is considered to be in fair condition and is assumed to have a residual service life of three to five years.

6 Discussion and Conclusions

The dock and its components generally appear to be in fair to good condition overall. The structure is exhibiting typical signs of deterioration as expected given its age and exposure in a marine environment. No major safety concerns were apparent during the review and areas of localized damage or decay have been identified.

Typically for timber structures in a marine environment, the service life is managed or extended with regular maintenance and this maintenance work generally includes periodic replacement of individual members as they deteriorate. Given this type of structure, it is feasible that each member can be replaced therefore there is potential that the service life can be extended indefinitely (without the consideration of economic factors). This type of individual member replacement work was observed on site, and it is recommended that this practice continues as required in order to fulfill the remaining service life requirements of the dock.

It is understood that the property may be subject to renovation, renewal, or replacement in the near future. Once the desired remaining service life is determined, a maintenance program can be tailored to provide adequate service while avoiding potentially unnecessary repairs. This tailored maintenance program may include reinforcement strategies or increased inspections of individual elements in lieu of replacements.

7 Closing

We trust the information contained within this report satisfies your current requirements and provides some context to aid in decision-making.

The conclusions and recommendations presented in this report are based on information available at the time of our review. The conclusion and recommendations cover solely the agreed-upon scope of services. No investigation eliminates the possibility of obtaining imprecise or incomplete information. Professional judgement was exercised in gathering and analyzing information obtained and in the formulation of the conclusions and recommendations; there is a possibility that additional deficiencies are present that were not identified as a result of the agreed-upon scope of work.

Herold Engineering Limited appreciates the opportunity to assist the District of Oak Bay with these recommendations and we are available to provide any further assistance. Please call with any questions.

Yours truly,

HEROLD ENGINEERING LIMITED

Prepared by:

Roxanne Duigou, EIT
Structural Engineer

Reviewed by:

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA C. T. APPELMAN # 38915

12 DECEMBER 2023

Craig Appelman, P.Eng
Associate, Materials Engineer

PERMIT No. 1000201

Unit 600 – 1112 Fort Street, Victoria, BC V8V 3K8
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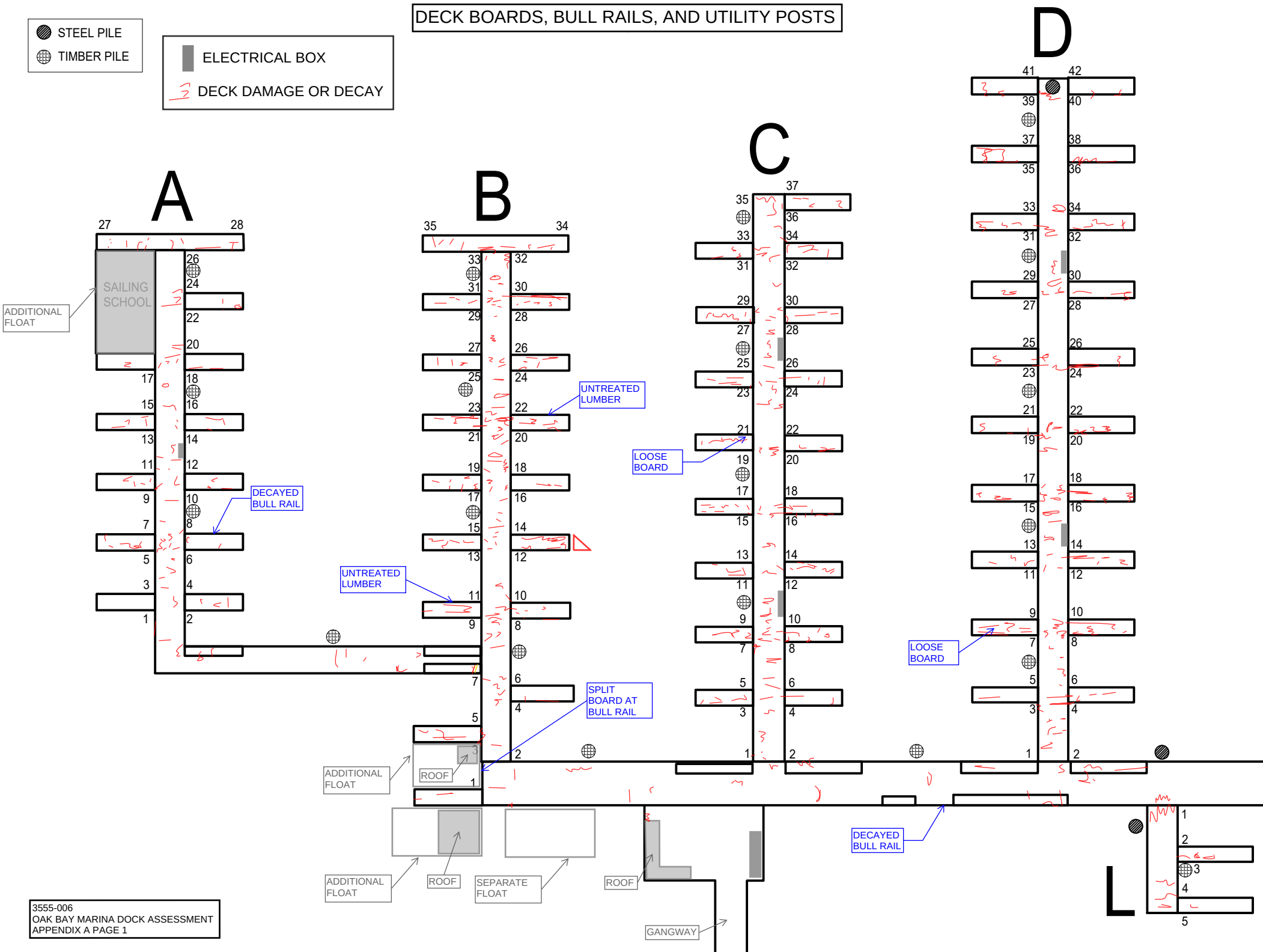
(250)590-4875

Appendix A Plan View – Deck Board, Bull Rail, and Utility Post Condition Assessment

DECK BOARDS, BULL RAILS, AND UTILITY POSTS

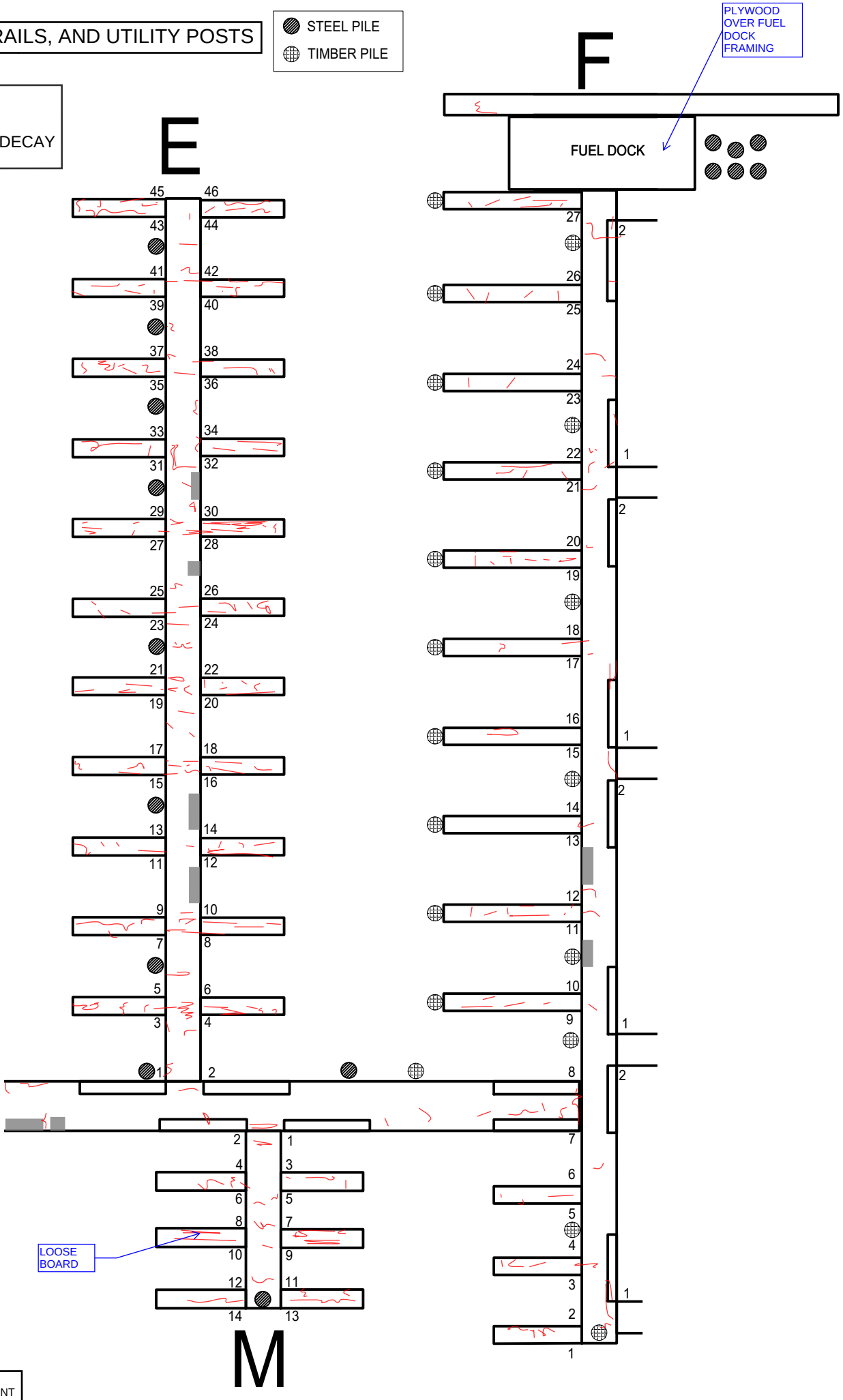
STEEL PILE
TIMBER PILE
ELECTRICAL BOX
DECK DAMAGE OR DECAY



DECK BOARDS, BULL RAILS, AND UTILITY POSTS

STEEL PILE
TIMBER PILE

ELECTRICAL BOX
DECK DAMAGE OR DECAY



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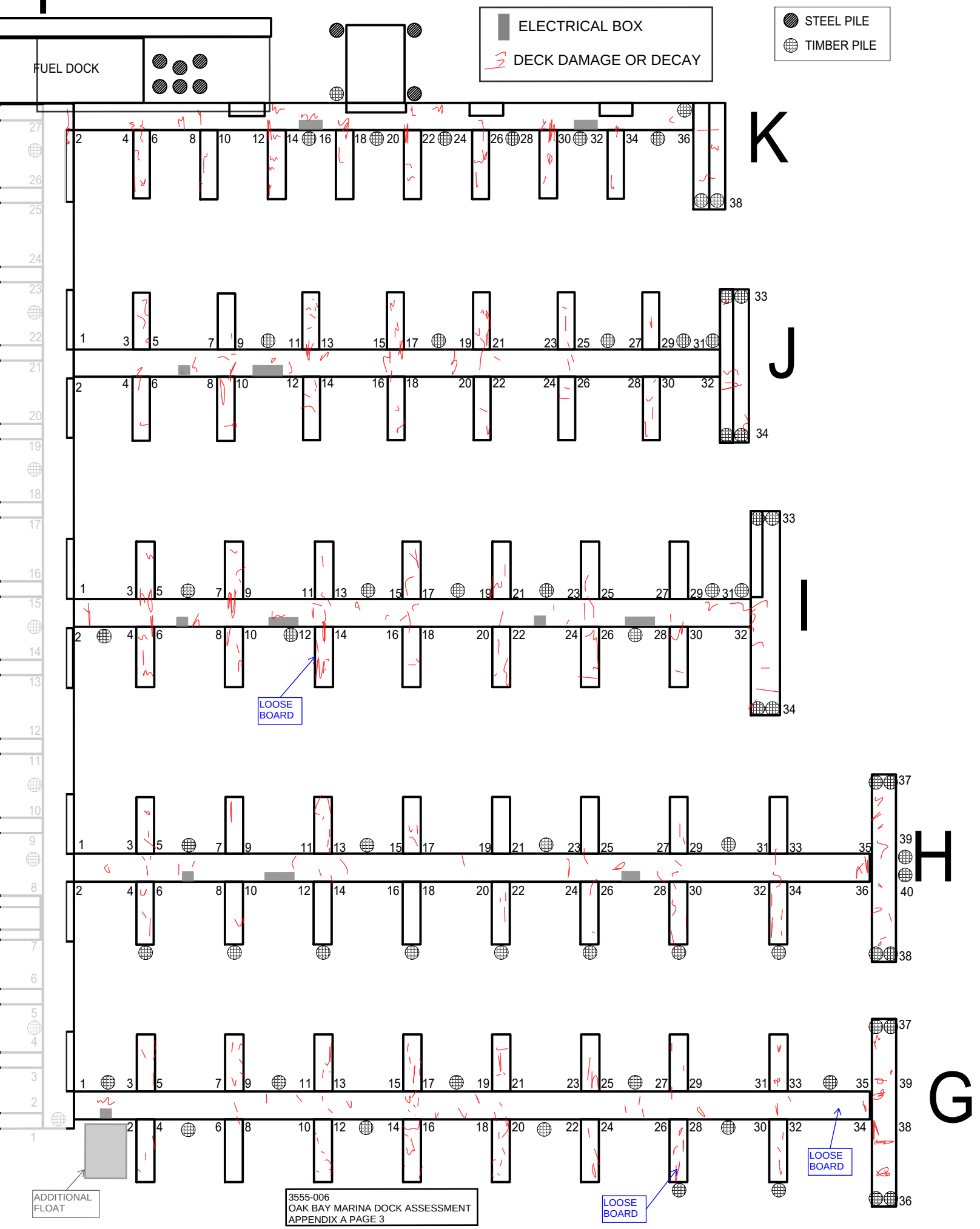
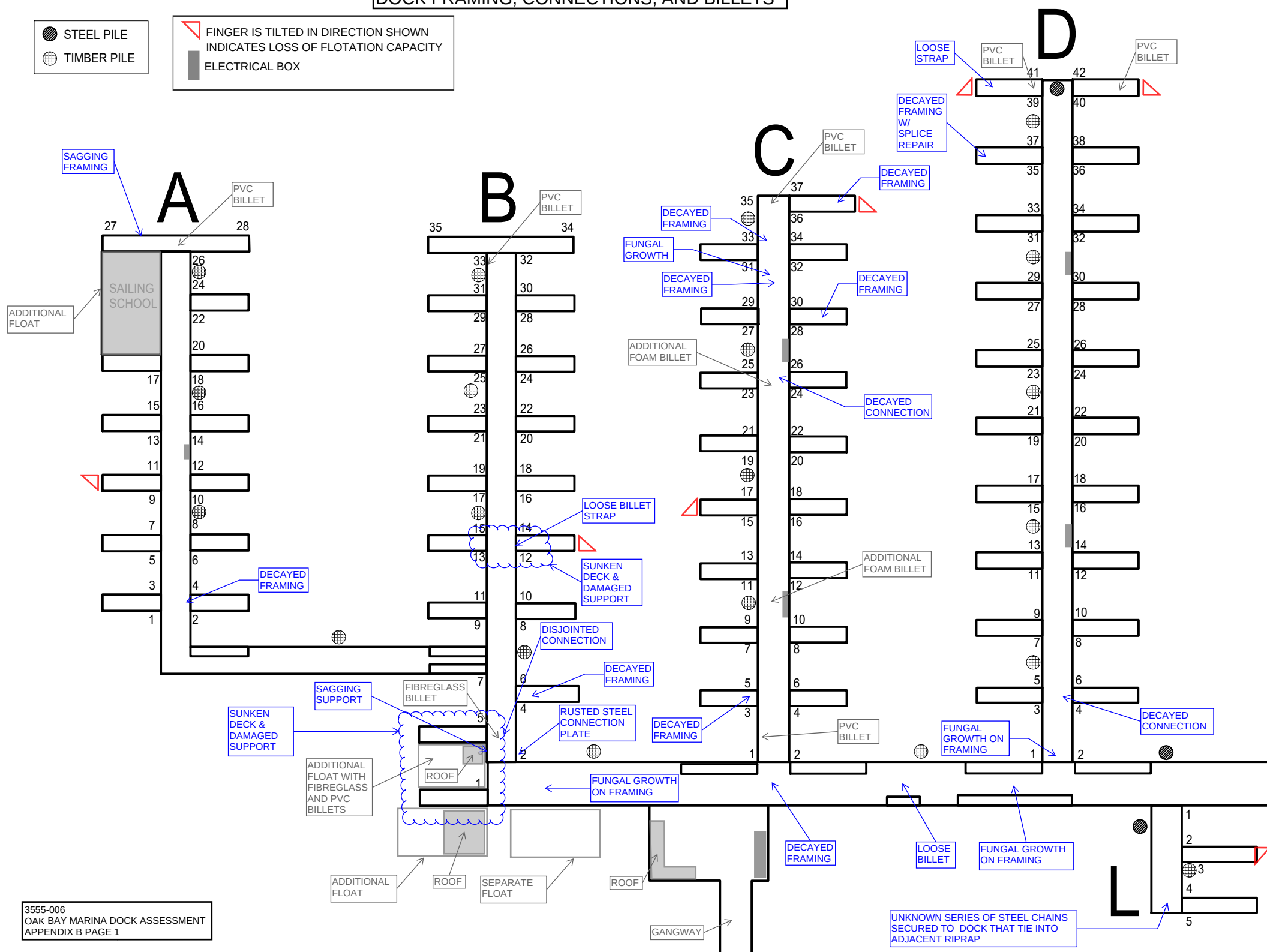
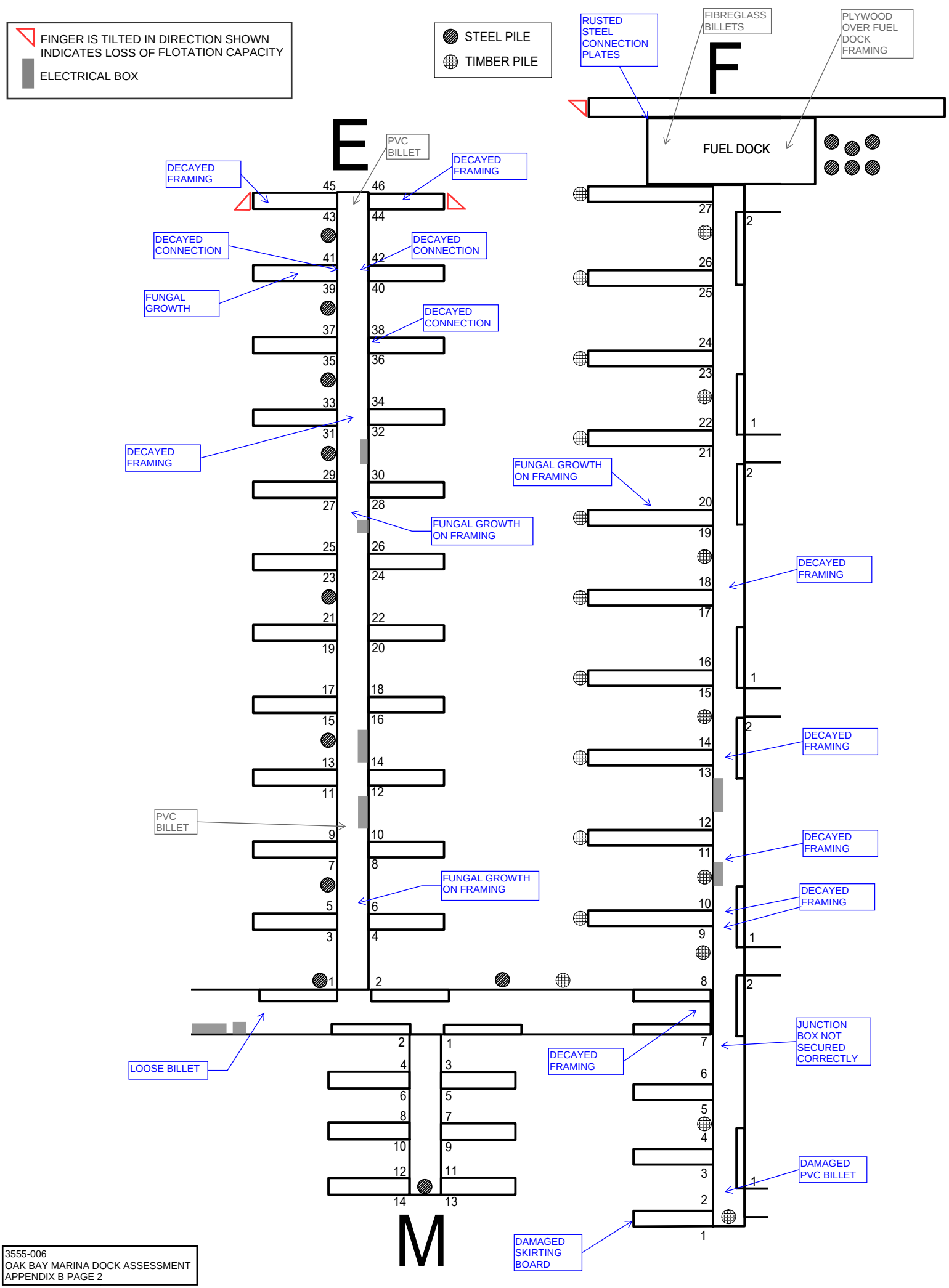
DECK BOARDS, BULL RAILS, AND UTILITY POSTS

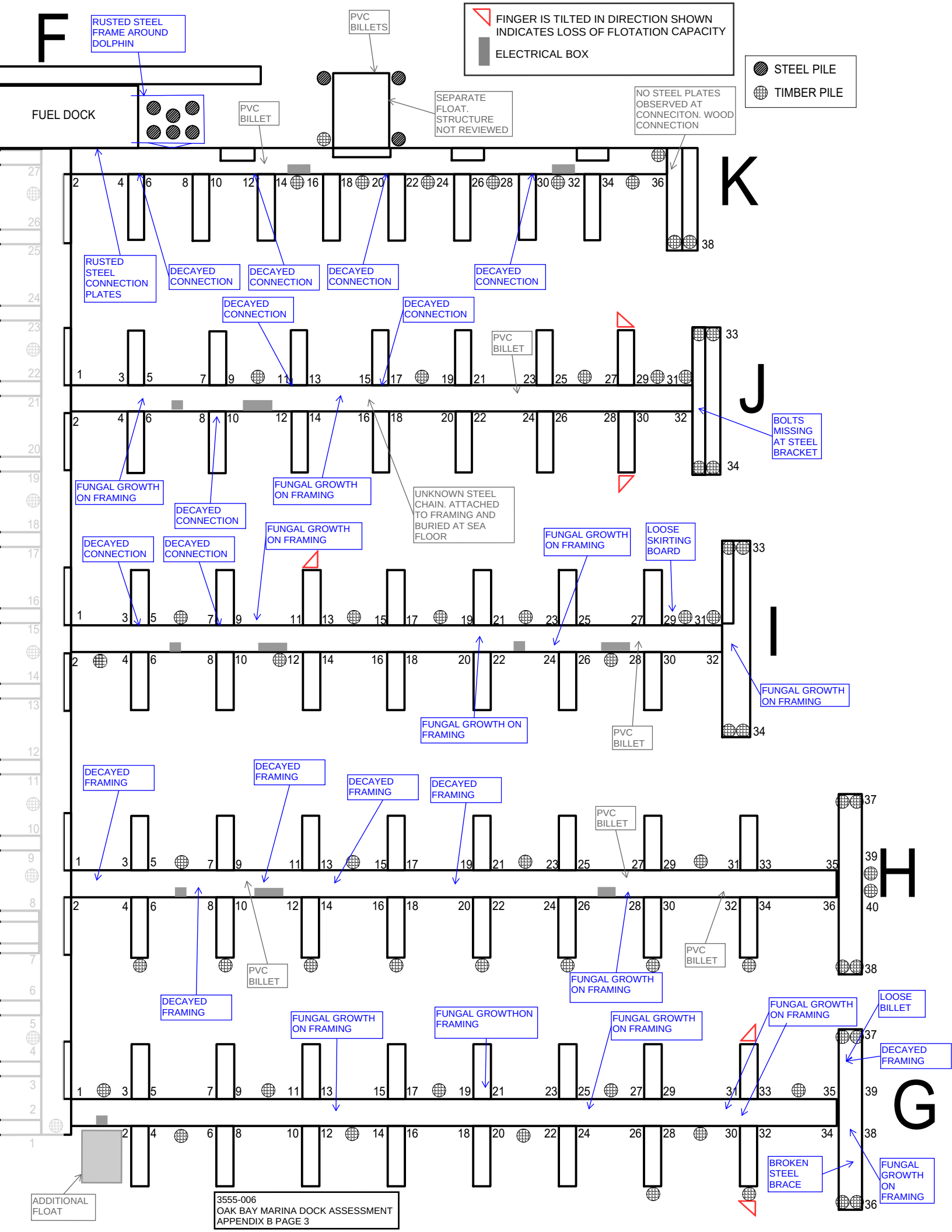


Appendix B Plan View – Timber Support Framing Condition Assessment

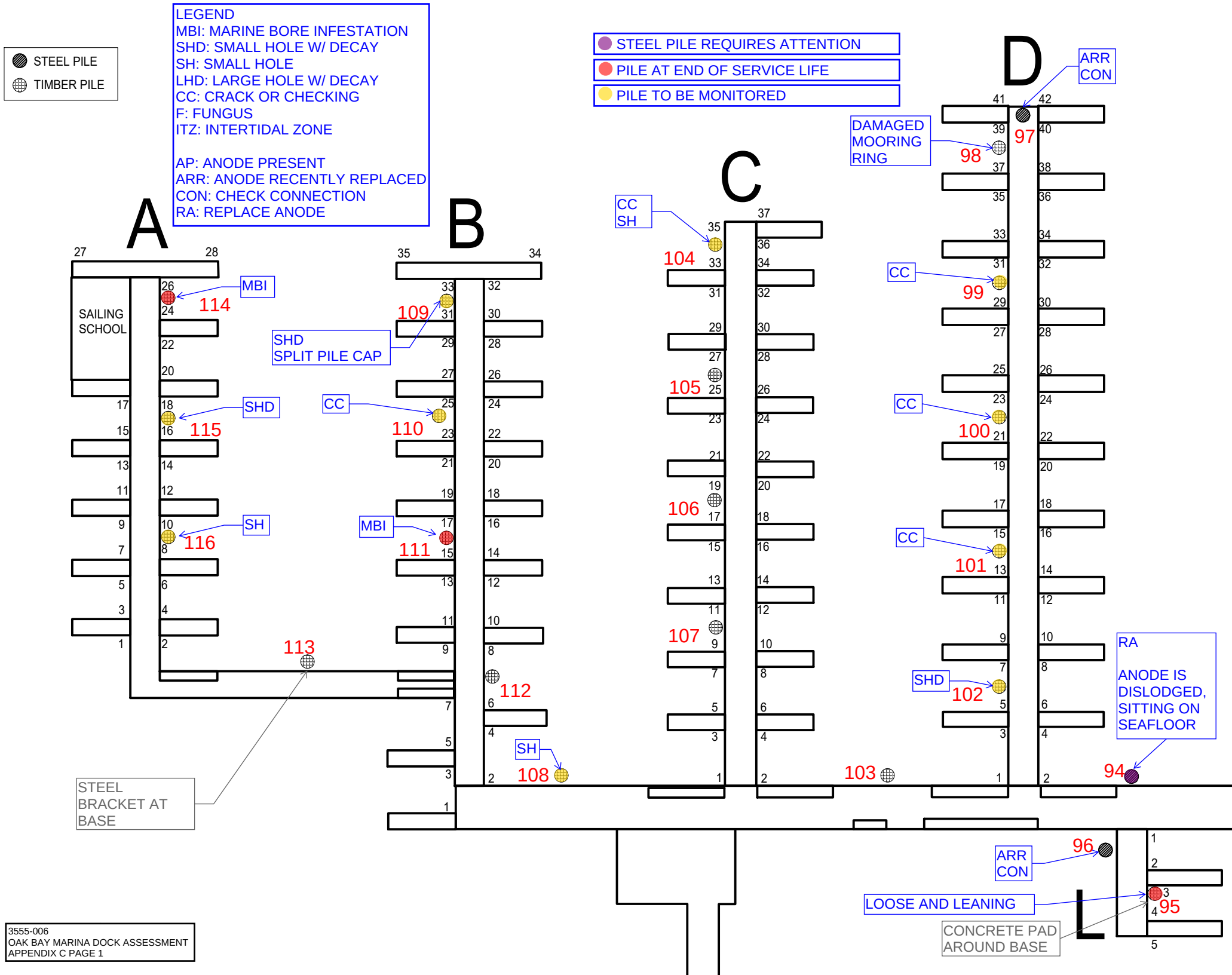
DOCK FRAMING, CONNECTIONS, AND BILLETS

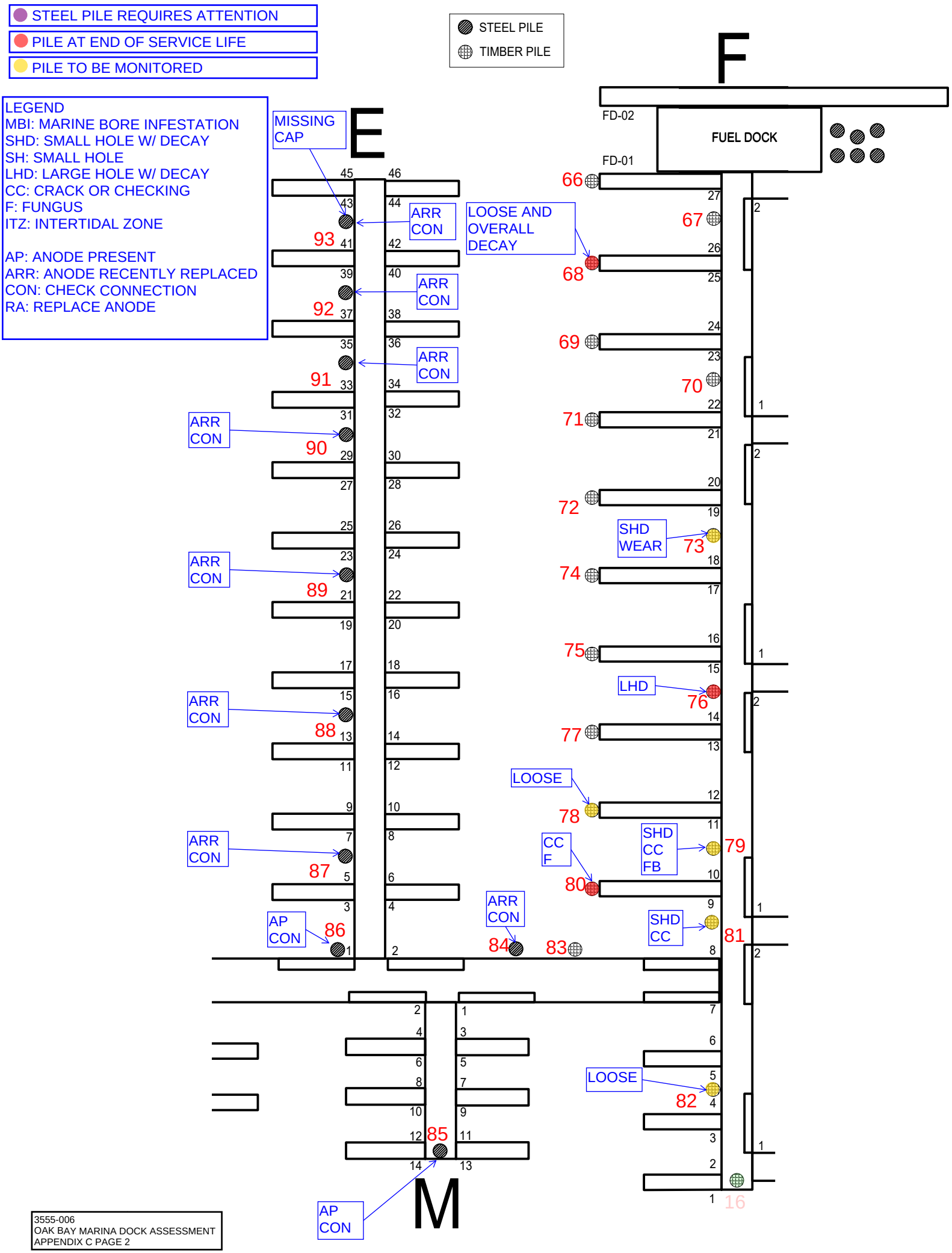



FINGER IS TILTED IN DIRECTION SHOWN INDICATES LOSS OF FLOTATION CAPACITY
ELECTRICAL BOX
STEEL PILE
TIMBER PILE
E
F
M
FUEL DOCK
RUSTED STEEL CONNECTION PLATES
FIBREGLASS BILLETS
PLYWOOD OVER FUEL DOCK FRAMING
PVC BILLET
DECAYED FRAMING
DECAYED CONNECTION
FUNGAL GROWTH
FUNGAL GROWTH ON FRAMING
PVC BILLET
LOOSE BILLET
DECAYED FRAMING
JUNCTION BOX NOT SECURED CORRECTLY
DAMAGED PVC BILLET
DAMAGED SKIRTING BOARD


F
RUSTED STEEL FRAME AROUND DOLPHIN
PVC BILLETS
FINGER IS TILTED IN DIRECTION SHOWN INDICATES LOSS OF FLOTATION CAPACITY
ELECTRICAL BOX
STEEL PILE
TIMBER PILE
FUEL DOCK
PVC BILLET
SEPARATE FLOAT. STRUCTURE NOT REVIEWED
NO STEEL PLATES OBSERVED AT CONNECITON. WOOD CONNECTION
K
RUSTED STEEL CONNECTION PLATES
DECAYED CONNECTION
DECAYED CONNECTION
DECAYED CONNECTION
DECAYED CONNECTION
DECAYED CONNECTION
DECAYED CONNECTION
PVC BILLET
J
BOLTS MISSING AT STEEL BRACKET
FUNGAL GROWTH ON FRAMING
FUNGAL GROWTH ON FRAMING
DECAYED CONNECTION
UNKNOWN STEEL CHAIN. ATTACHED TO FRAMING AND BURIED AT SEA FLOOR
DECAYED CONNECTION
DECAYED CONNECTION
FUNGAL GROWTH ON FRAMING
FUNGAL GROWTH ON FRAMING
LOOSE SKIRTING BOARD
I
FUNGAL GROWTH ON FRAMING
FUNGAL GROWTH ON FRAMING
PVC BILLET
DECAYED FRAMING
DECAYED FRAMING
DECAYED FRAMING
DECAYED FRAMING
PVC BILLET
H
PVC BILLET
PVC BILLET
DECAYED FRAMING
FUNGAL GROWTH ON FRAMING
FUNGAL GROWTH ON FRAMING
FUNGAL GROWTHON FRAMING
FUNGAL GROWTH ON FRAMING
FUNGAL GROWTH ON FRAMING
LOOSE BILLET
DECAYED FRAMING
G
BROKEN STEEL BRACE
FUNGAL GROWTH ON FRAMING
ADDITIONAL FLOAT
3555-006
OAK BAY MARINA DOCK ASSESSMENT
APPENDIX B PAGE 3

Appendix C Plan View – Mooring Pile Condition Assessment


STEEL PILE
TIMBER PILE
LEGEND
MBI: MARINE BORE INFESTATION
SHD: SMALL HOLE W/ DECAY
SH: SMALL HOLE
LHD: LARGE HOLE W/ DECAY
CC: CRACK OR CHECKING
F: FUNGUS
ITZ: INTERTIDAL ZONE
AP: ANODE PRESENT
ARR: ANODE RECENTLY REPLACED
CON: CHECK CONNECTION
RA: REPLACE ANODE
STEEL PILE REQUIRES ATTENTION
PILE AT END OF SERVICE LIFE
PILE TO BE MONITORED
A
B
C
D
SAILING SCHOOL
MBI
114
SHD
115
SH
116
SHD
SPLIT PILE CAP
109
CC
110
MBI
111
SH
108
112
113
STEEL BRACKET AT BASE
CC
SH
104
105
106
107
103
DAMAGED MOORING RING
98
97
ARR
CON
CC
99
CC
100
CC
101
SHD
102
RA
ANODE IS DISLODGED, SITTING ON SEAFLOOR
94
96
ARR
CON
LOOSE AND LEANING
95
CONCRETE PAD AROUND BASE
L


STEEL PILE REQUIRES ATTENTION
PILE AT END OF SERVICE LIFE
PILE TO BE MONITORED
STEEL PILE
TIMBER PILE
LEGEND
MBI: MARINE BORE INFESTATION
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CON: CHECK CONNECTION
RA: REPLACE ANODE
E
F
M
FUEL DOCK
FD-01
FD-02
MISSING CAP
ARR CON
LOOSE AND OVERALL DECAY
SHD WEAR
LHD
LOOSE
CC F
SHD CC FB
SHD CC
AP CON
93
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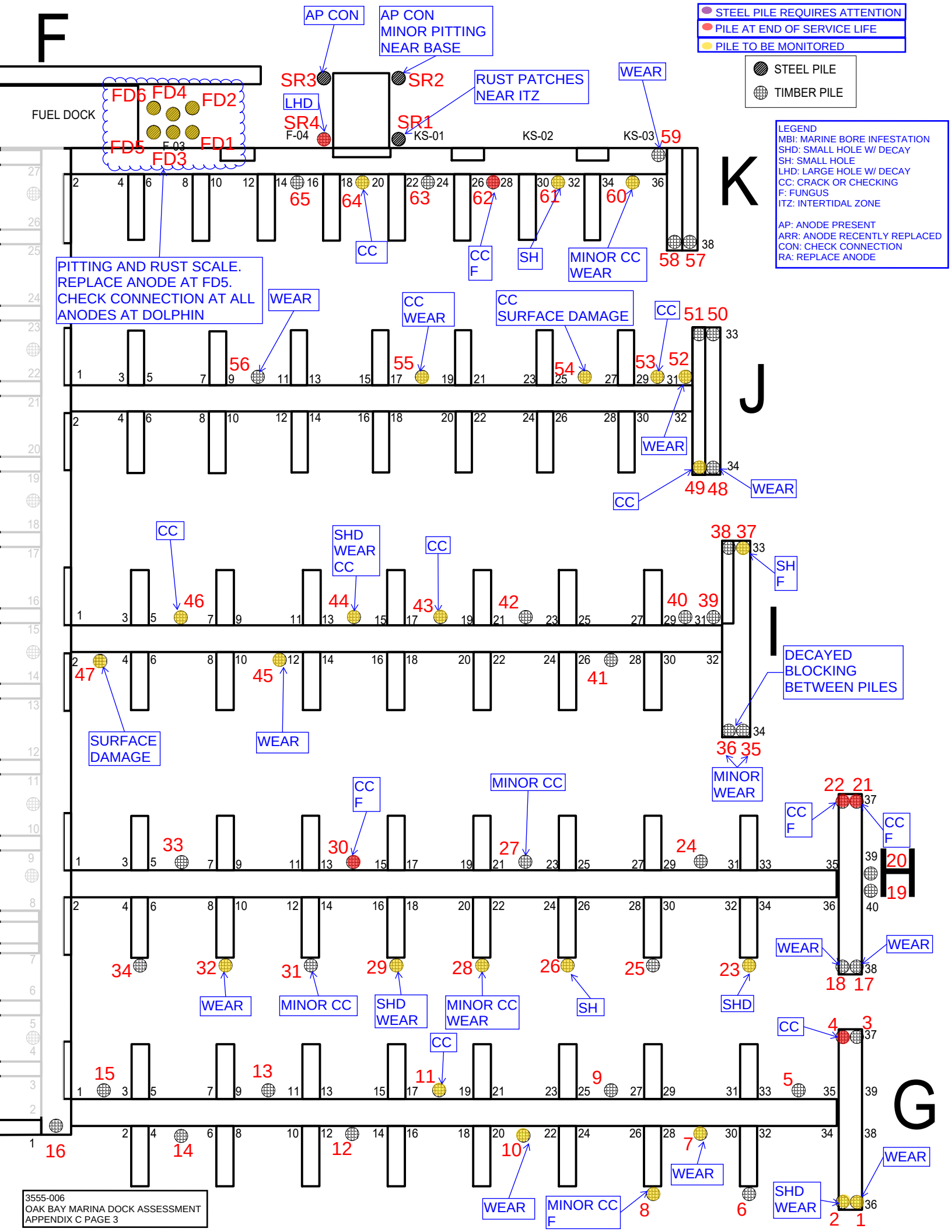
3555-006
OAK BAY MARINA DOCK ASSESSMENT
APPENDIX C PAGE 2


F
AP CON
AP CON
MINOR PITTING
NEAR BASE
SR3
SR2
LHD
SR4
SR1
RUST PATCHES
NEAR ITZ
WEAR
FUEL DOCK
FD6 FD4 FD2
FD5 F-03 FD1
FD3
F-04
KS-01
KS-02
KS-03
59
K
65
64
63
62
61
60
CC
CC
F
SH
MINOR CC
WEAR
58 57
PITTING AND RUST SCALE.
REPLACE ANODE AT FD5.
CHECK CONNECTION AT ALL
ANODES AT DOLPHIN
WEAR
CC
WEAR
CC
SURFACE DAMAGE
CC
51 50
J
56
55
54
53
52
WEAR
49 48
CC
WEAR
CC
SHD
WEAR
CC
38 37
SH
F
I
46
44
43
42
40 39
47
45
41
DECAYED
BLOCKING
BETWEEN PILES
SURFACE
DAMAGE
WEAR
36 35
MINOR
WEAR
CC
F
MINOR CC
22 21
CC
F
CC
F
33
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32
31
29
28
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25
23
WEAR
MINOR CC
SHD
WEAR
MINOR CC
WEAR
SH
SHD
WEAR
WEAR
18 17
CC
4 3
15
13
CC
11
9
5
G
16
14
12
10
WEAR
MINOR CC
F
8
7
WEAR
6
SHD
WEAR
WEAR
2 1
STEEL PILE REQUIRES ATTENTION
PILE AT END OF SERVICE LIFE
PILE TO BE MONITORED
STEEL PILE
TIMBER PILE
LEGEND
MBI: MARINE BORE INFESTATION
SHD: SMALL HOLE W/ DECAY
SH: SMALL HOLE
LHD: LARGE HOLE W/ DECAY
CC: CRACK OR CHECKING
F: FUNGUS
ITZ: INTERTIDAL ZONE
AP: ANODE PRESENT
ARR: ANODE RECENTLY REPLACED
CON: CHECK CONNECTION
RA: REPLACE ANODE

Appendix D Summary Table – Mooring Pile Condition Assessment

Table A - Timber Pile Assessment Notes

PILE #	MATERIAL	NOTES
1	TIMBER	WEAR
2	TIMBER	WEAR, SMALL HOLE
3	TIMBER	NO COMMENT
4	TIMBER	END OF SERVICE LIFE, DEEP CRACK
5	TIMBER	NO COMMENT
6	TIMBER	NO COMMENT
7	TIMBER	WEAR
8	TIMBER	SLIGHT CRACK WITH FUNGUS
9	TIMBER	NO COMMENT
10	TIMBER	WEAR
11	TIMBER	CHECKING
12	TIMBER	NO COMMENT
13	TIMBER	NO COMMENT
14	TIMBER	NO COMMENT
15	TIMBER	NO COMMENT
16	TIMBER	NO COMMENT
17	TIMBER	WEAR
18	TIMBER	WEAR
19	TIMBER	NO COMMENT
20	TIMBER	NO COMMENT

21	TIMBER	END OF SERVICE LIFE, CRACK
22	TIMBER	END OF SERVICE LIFE, CRACK WITH FUNGUS
23	TIMBER	SMALL HOLE
24	TIMBER	SMALL HOLE
25	TIMBER	NO COMMENT
26	TIMBER	SMALL HOLE
27	TIMBER	MINOR SURFACE CRACKS
28	TIMBER	MINOR SURFACE CRACKS, WEAR
29	TIMBER	SMALL HOLE, WEAR
30	TIMBER	END OF SERVICE LIFE, CRACK WITH FUNGUS
31	TIMBER	MINOR SURFACE CRACKS, MINOR FUNGUS
32	TIMBER	WEAR
33	TIMBER	NO COMMENT
34	TIMBER	NO COMMENT
35	TIMBER	MINOR WEAR
36	TIMBER	MINOR WEAR
37	TIMBER	SMALL HOLE WITH FUNGUS
38	TIMBER	NO COMMENT
39	TIMBER	NO COMMENT
40	TIMBER	NO COMMENT
41	TIMBER	NO COMMENT

42	TIMBER	NO COMMENT
43	TIMBER	MINOR CRACK, CHECKING
44	TIMBER	MINOR CRACK, SMALL HOLE, WEAR
45	TIMBER	WEAR
46	TIMBER	CHECKING
47	TIMBER	SURFACE DAMAGE
48	TIMBER	WEAR
49	TIMBER	CHECKING
50	TIMBER	WEAR
51	TIMBER	WEAR
52	TIMBER	WEAR
53	TIMBER	CHECKING
54	TIMBER	CHECKING, SURFACE DAMAGE
55	TIMBER	CHECKING, WEAR
56	TIMBER	NO COMMENT
57	TIMBER	NO COMMENT
58	TIMBER	NO COMMENT
59	TIMBER	WEAR
60	TIMBER	MINOR CHECKING, WEAR
61	TIMBER	SMALL HOLE
62	TIMBER	END OF SERVICE LIFE, CRACK, FUNGUS

63	TIMBER	NO COMMENT
64	TIMBER	SMALL CRACK
65	TIMBER	NO COMMENT
66	TIMBER	NO COMMENT
67	TIMBER	NO COMMENT
68	TIMBER	END OF SERVICE LIFE, LOOSE, OVERALL DECAY
69	TIMBER	NO COMMENT
70	TIMBER	NO COMMENT
71	TIMBER	NO COMMENT
72	TIMBER	NO COMMENT
73	TIMBER	SMALL HOLE, WEAR
74	TIMBER	NO COMMENT
75	TIMBER	NO COMMENT
76	TIMBER	END OF SERVICE LIFE, LARGE HOLE
77	TIMBER	NO COMMENT
78	TIMBER	LOOSE PILE
79	TIMBER	SMALL HOLE, CHECKING
80	TIMBER	END OF SERVICE LIFE, CRACK WITH FUNGUS
81	TIMBER	SMALL HOLE, CHECKING
82	TIMBER	LOOSE PILE
83	TIMBER	NO COMMENT
95	TIMBER	PILE IS LOOSE AND LEANING, CONCRETE BASE AT SEAFLOOR

98	TIMBER	NO COMMENT ON PILE, DAMAGED MOORING RING
99	TIMBER	MINOR CRACK
100	TIMBER	CHECKING
101	TIMBER	CHECKING
102	TIMBER	SMALL HOLE
103	TIMBER	NO COMMENT
104	TIMBER	CRACK, SMALL HOLE
105	TIMBER	NO COMMENT
106	TIMBER	NO COMMENT
107	TIMBER	NO COMMENT
108	TIMBER	SMALL HOLE
109	TIMBER	SMALL HOLE, DAMAGED PILE CAP
110	TIMBER	CRACK
111	TIMBER	END OF SERVICE LIFE, MARINE BORE INFESTATION
112	TIMBER	NO COMMENT
113	TIMBER	NO COMMENT ON PILE, STEEL BRACKET BOLTED AT BASE
114	TIMBER	END OF SERVICE LIFE, MARINE BORE INFESTATION
115	TIMBER	SMALL HOLE
116	TIMBER	SMALL HOLE

Table B - Steel Pile Assessment Notes

#	TYPE	NOTES	UPPER THICKNESS mm	MID THICKNESS mm	BASE THICKNESS mm
84	STEEL	TWO ANODES, OLD AND NEW	12.1	12.1	11.4
85	STEEL	ANODE PRESENT	12.1	11.1	11.2
86	STEEL	OLD ANODE PARTIALLY CONSUMED	12.2	12.3	11.9
87	STEEL	TWO ANODES, OLD AND NEW	12.2	12.2	11.8
88	STEEL	TWO ANODES, OLD AND NEW	12.2	12.1	12.2
89	STEEL	TWO ANODES, OLD AND NEW	12.3	11.9	11.4
90	STEEL	TWO ANODES, OLD AND NEW	12.3	11.6	11
91	STEEL	NEW ANODE	12.2	11.8	11.6
92	STEEL	NEW ANODE	11.9	11.8	11.2
93	STEEL	MISSING PILE CAP, NEW ANODE	11.9	12.0	11.4
94	STEEL	ANODE ON SEAFLOOR - CHECK CONNECTION AND ATTACHMENT	12.2	12.2	12.2
96	STEEL	TWO ANODES, OLD AND NEW	12.2	11.2	11.4
97	STEEL	TWO ANODES, OLD AND NEW	11.9	10.4	11.5

Table C - Steel Piles Near Fuel Dock Assessment Notes

SR1	TYPE	NOTES	UPPER THICKNESS mm	MID THICKNESS mm	BASE THICKNESS mm
SR1	STEEL	RUST PATCHES NEAR INTERTIDAL ZONE	10	10.6	8.7
SR2	STEEL	ANODE PRESENT. MINOR PITTING NEAR BASE	10.6	9.5	8.5
SR3	STEEL	ANODE PRESENT	10.4	10.2	10
SR4	TIMBER	TO BE REPLACED. LARGE HOLE WITH DECAY			
FD1	STEEL	RUST SCALE IN UPPER PORTION, PITTING IN LOWER PORTION	-	6.5	7.6
FD2	STEEL	RUST SCALE IN UPPER PORTION, PITTING IN LOWER PORTION	-	6.8	6.9
FD3	STEEL	RUST SCALE IN UPPER PORTION, PITTING IN LOWER PORTION	-	-	-
FD4	STEEL	RUST SCALE IN UPPER PORTION, PITTING IN LOWER PORTION	-	6.5	7.8
FD5	STEEL	RUST SCALE IN UPPER PORTION, PITTING IN LOWER PORTION. REPLACE ANODE.	-	-	-
FD6	STEEL	RUST SCALE IN UPPER PORTION, PITTING IN LOWER PORTION	-	-	-