Condition Survey and Load Rating Report – FINAL

City of Warrenton
Warrenton Marina Work Pier

Submitted to

City of Warrenton
Warrenton, Oregon

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Submitted by

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CONDITION SURVEY AND LOAD RATING REPORT

City of Warrenton
Warrenton Marina
Work Pier

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CITY OF WARRENTON
WARRENTON MARINA WORK PIER CONDITION SURVEY AND LOAD RATING REPORT

INTRODUCTION

Background

The City of Warrenton retained BergerABAM to perform a limited condition assessment, evaluation, and structural load rating of the work pier located at the Warrenton Marina in Warrenton, Oregon. Warrenton Marina lies north of the Warrenton-Astoria Highway on the Skipanon River, approximately 1.3 miles south of the Columbia River.

Purpose

The overall purpose of the project is to provide an inspection, assessment, and structural load rating of the Warrenton Work Pier. The results of the inspection, assessment, and load rating are intended to assist the City of Warrenton in developing working load limits for the pier and to plan for future pier maintenance and rehabilitation in order to maintain the long-term functionality of the pier. BergerABAM performed a Level I Routine Above-water Inspection. BergerABAM also performed a structural load rating of the pier superstructure.

Documents Reviewed

Original construction drawings for the pier were not available for review. BergerABAM reviewed the following documents as part of the basis for this condition assessment.

- Topography survey for Pier-2, NE 1/4 Section 22 T8N., R10W., W.M. Clatsop County, Oregon, provided by OTAK, dated 31 October 2016.
- Ground Penetrating Radar Field Inspection Report by Carlson Testing, Inc., dated 16 January 2017

Facility Description

Warrenton Marina includes a number of docks located inside and outside the marina harbor along the Skipanon River. The docks inside the harbor and to the west and east of the work pier on the Skipanon River are not included in the assessment. The structure inspected consists of a timber work pier with two access trestles, one at the east end and one at the west end. Original construction drawings of the facility were not available. Based on the type of pier construction and condition of the pier, we assume the work pier and east trestle were built in the 1980s, and the west trestle was built sometime before the work pier and east trestle. See Appendix C – Topography Survey for the pier general arrangement.

PIER CONFIGURATION

The Warrenton Work Pier consists of three primary sections: the west trestle, the east trestle, and the work pier. The west trestle provides access to the west end of the work pier and the east trestle provides access to the east end of the work pier. The work pier structure is configured parallel to the shore and is approximately 285 feet long by approximately 30 feet wide, with 126

timber plumb piles and 4 steel battered pile pairs (8 total steel battered piles). The west trestle is approximately 160 feet long by 16 feet wide, with 28 timber plumb piles and 20 timber battered piles (6 battered timber piles at the abutment). The east trestle is approximately 75 feet long by 12 feet wide, with 18 timber plumb piles. Timber piles at the work pier and access trestles vary from 13.5 to 15 inches in diameter. Steel battered piles at the work pier are 20 inches in diameter. The depth from the pier deck to the mudline below ranges from approximately 28 feet at the riverside edge of the work pier to approximately 7 feet at the west trestle timber bent closest to shore. See Photos 1 through 5 in Appendix A for the general configuration of the work pier and access trestles.

Drawings for the pier structure were developed and include the pier's general configuration, structural elements, pile bent numbers and pile row letters. Pile bent numbers and pile row letters are assigned and grouped by west trestle (WT), east trestle (ET) or work pier (WP). Drawings S-01 through S-08 are included with Appendix B. A topography survey of the trestles and work pier, performed by OTAK in 2016, was used to develop the drawings for this project. The topography survey is included as Appendix C.

The west trestle has 11 bents and are numbered beginning from the shore abutment, WT0, to the furthest north bent of the west trestle, WT10. The east trestle has 9 bents and are numbered beginning from the shore abutment at ET0 to the furthest north bent of the east trestle at ET7. The work pier has 32 bents and are numbered from west to east beginning with WP1 and ending with WP32.

Piles rows are grouped and then lettered independently for each of the three sections: the west trestle, the work pier, and the east trestle. Pile row lettering for both trestles and the work pier begins at the river side of the pier and moves towards the shore. The west trestle pile row lettering begins with WTA and ends at WTG. The east trestle pile rows begin with ETA and ends at ETC. The work pier pile rows begin with WPA and end at WPF.

The west trestle abutment WT0 is a concrete abutment supported by timber battered piles. West trestle bents WT1 through WT7 are timber three-pile bents with the outside piles battered at 1:12 and the center pile plumb. West trestle bents WT8 through WT10 are timber seven-pile bents with all plumb piles. The east trestle abutment ET0 is a two-pile bent with timber plumb piles. Horizontal timber boards span across the piles to retain soil. East trestle bents ET0.5 through ET7 are two-pile bents with all timber plumb piles. Timber diagonal pile bracing is located throughout the west trestle.

The work pier is primarily constructed with timber plumb piles. Bent WP1 is a three-pile bent and bents WP2 and WP4 are two-pile bents. WP3, WP5 through WP25, WP30, and WP32 are all four-pile bents. Work pier bents WP26 through WP29 are six-pile bents and WP31 is a three-pile bent. At the work pier, there are four "A"-frame steel battered pile pairs that replace a single timber plumb pile. These battered pile pairs are located at bents WP8, WP13, WP27, and WP29.

The west trestle framing is constructed primarily of pressure-treated 6x18 timber beams (single-span) at 18 inches on center and supported by pressure-treated 14x12 timber pile caps. The work pier and east trestle framing is constructed primarily of pressure-treated 6x12 timber beams (single and two-span) at 24 inches on center and supported by pressure-treated 12x12 timber pile caps.

The deck of the west trestle is 3-inch-thick unreinforced concrete placed over 1 1/2-inch-deep, corrugated galvanized metal decking with a 4 1/2-inch on-center flute spacing. The deck of the work pier and east trestle is 4-inch-thick reinforced concrete placed over 3/4-inch-deep corrugated galvanized metal decking with a 3-inch-on-center flute spacing. The work pier and east trestle concrete deck has #4 reinforcing bars at 12 inches on center in each direction, located 2 1/4 inches from the surface. The unreinforced concrete deck at the west trestle, and the reinforcing bars present at the work pier and east trestle, were confirmed by a ground penetrating radar inspection performed by Carlson Testing, Inc. The Ground Penetrating Radar Field Inspection Report by Carlson Testing, Inc., dated 16 January 2017, is included as Appendix D.

Bullrails are typically located along all waterside edges of the work pier and access trestles. Bullrails at the west trestle are 8x8 timber with anchor bolts at 5 feet on center. An approximately 20-foot-long section of bullrail at the north end of the west trestle is covered with a steel pipe. Bullrails at the work pier and east trestle are 12x12 timber with anchor bolts at 5 feet on center.

Fenders piles are typically located at each work pier bent or each pile row at the north end of the west trestle. Fender piles are also located around the east end of the work pier. Fender piles are 12 3/4-inch steel pipe piles. At some locations, old broken timber fender piles remain. There are a total of 31 steel fender piles and nine broken timber fender piles. Fender piles are anchored to the structure with a single bolt connection near the top. Timber chocks between fender piles are 12x12.

The pier railing is located along both sides of the west trestle and east trestle and along the shore-side of the work pier. Pier railings are constructed of pressure-treated timber and have posts typically at 5 feet on center and anchored to the bullrail. The railing along the east trestle and work pier is typically 55-inches tall above the concrete deck with 4x6 posts and three horizontal 2x8 members equally spaced above the bullrail. The railing at the west trestle is typically 40-inches tall above the concrete deck with 6x8 posts and a single horizontal 2x8 top rail.

INSPECTION METHODOLOGY

BergerABAM performed the inspection of the work pier and access trestles on 22 March 2017. Brian Board, PE, senior project engineer, led the inspection with assistance from engineer Joe Bachmeier, EIT; and were escorted in a skiff by a city of Warrenton employee. The inspection was conducted in general conformance with a Level I Routine Above-Water Inspection as set forth by the American Society of Civil Engineers (ASCE) *Waterfront Facilities Inspection and*

Assessment manual. Appendix E includes selected reference tables and figures from the manual that was used during the inspection.

The inspection was limited to accessible components of the structure. Inspection methods were visual and tactile and included hammer sounding of a representative sample of structural elements throughout the pier. Underwater inspection and destructive testing were not in the scope of this work.

The inspection assessed the general condition of the pier structure, assigned damage ratings for each of the structural elements, assigned overall condition ratings of the three primary pier sections, and provided recommendations for future maintenance and rehabilitation according to the ASCE manual.

The inspection was also used to develop a structural load capacity rating of the pier structure. The structural load rating for the pier was performed using Allowable Strength Design methods and using guidance from the Oregon Department of Transportation (ODOT) *2009 Bridge Inspection Pocket Coding Guide*. Condition states in accordance with this guide were assigned to each of the pier structural elements. The condition states quantify the current state of deterioration for each structural element in order to determine the as-is structural load rating of the pier. Appendix F includes selected reference tables and figures from the ODOT guide.

The inspection of underdeck elements included timber piles, steel battered piles, fender piles, timber pile caps, timber bracing, timber beams, and the soffit of the deck. The inspection of the above deck elements included the concrete deck surface, timber bullrails, and timber railing.

Appendix G includes field notes from the inspection, element damage ratings, and condition states for each of the pier structural elements. Structural elements are assigned names based on their relative locations to bent numbers and pile rows. Individual beam elements were not assigned a rating or state; instead, beams were combined together in a group spanning between adjacent pile caps, and then a damage rating and condition state was assigned to each span group of beams.

EXISTING CONDITIONS

Abutments

The west trestle abutment is constructed with a concrete abutment wall supported by a concrete pile cap. The concrete pile cap is supported by timber piles. The abutment wall is 1 foot wide and 2 feet 4 inches tall. The concrete cap is 1 foot 4 inches thick by 3 feet wide. Soil and rock around the west abutment has scoured away and exposed the timber piles. The timber piles appear to have 100 percent section loss and the abutment has settled approximately 2 to 6 inches. Concrete bags and cast-in-place concrete have been placed in front of the abutment to control erosion. Photos 6 through 8 show the west trestle abutment existing conditions.

The east trestle abutment is constructed of pressure-treated 6x12 timber boards placed behind the end bent piles and cap to hold back soil and provide support for the asphalt above. No signs

of structural distress was observed at the east trestle abutment. Photo 9 shows the east trestle abutment existing conditions.

Timber Structure

The majority of the timber piles, pile caps, beams, and bracing appear to have no defects and have sound surface material. Detailed information on structural element damage, the locations of damage, structural element damage ratings, and element condition states are included in Appendix G. A summary of the timber structure damage is below.

Approximately 24 timber piles have minor cracks near the top up to 1/2 inch wide by 4 feet long. See Photo 10 for typical crack near the pile top. Two timber-bearing piles have been displaced and do not provide bearing for the pile cap above. The displaced piles are located at bent WP13, pile row WPA; and at WP31, pile row WPD. See Photos 11 and 12 for displaced piles.

Approximately eight pile caps have minor cracks or splits on one side that are 3/8 inch wide or less. See Photo 13 for a typical pile cap crack. Wetness and decay approximately 2 inches deep by 6 inches long by 8 inches high was observed at the east end of pile cap WT7. Pile cap WT10 exhibits moderate to severe damage, including deformation of the pile cap from pile row WTB to WTD, broken pile cap near pile row WTE, and decay of pile cap cross section between 10 to 25 percent. See Photos 14 through 16 for the damage at pile cap WT10.

Beams that span between WT0 and WT1 exhibit minor wetness with growth on the surface. The end of the beams supported by the abutment (WT0) have dropped 2 to 6 inches with the abutment. A beam spanning between WT2 and WT3 has a minor crack 1/8 inch wide by half the member length in one side. Beams spanning from WT8 and WT10 located between WTA and WTC exhibit moderate decay up to approximately 25 percent section loss.

Three diagonal braces at the west trestle were observed to be broken. The location of the broken braces are at pile WT5/C, WT10/E, and WT10/G. Moderate decay up to 25 percent was observed near the top connection of the diagonal brace at pile WT10/G. Typical bracing can be seen in Photo 17.

Steel Structure

Steel elements of the pier include steel battered pile pairs (four locations), steel pile caps (two locations), and miscellaneous steel beams supporting equipment above the deck. The steel elements appear to be unpainted steel. Detailed information on structural element damage, the locations of damage, structural element damage ratings, and element condition states are included in Appendix G. A summary of the steel element damage is below.

The steel battered pile pairs exhibit surface corrosion but no section loss. A typical battered pile pair can be seen in Photo 18.

Steel pile caps at WP27 and WP13 exhibit corrosion at the bottom flange with flaking steel and measurable section loss. The section loss at the bottom flange is considered minor. Typical corrosion at the bottom of the steel pile cap is shown in Photo 19.

Miscellaneous steel beams near WP12 and WP14, as well as at WP26 and WP28, exhibit minor surface corrosion. See Photo 20 for typical corrosion at miscellaneous steel beams.

Fender Piles

Fender piles are 12 3/4 inch in diameter by 3/8 inch wall steel pipe. Old broken timber piles remain in some locations and have not been replaced with new steel fender piles. Detailed information on structural element damage, the locations of damage, structural element damage ratings, and element condition states are included in Appendix G. A summary of the fender pile damage is below.

A majority of the steel fender piles exhibit minor surface corrosion but no section loss. Photo 21 shows typical surface corrosion of fender piles. Four steel fender piles at bent WT10 exhibit moderate damage of a bent or broken connection at the top bolt into the timber pile cap. Typical broken or bent connection is shown in Photo 15. Steel fender piles at bent WP27 and WP29 exhibited small dents approximately 1 inch deep by 8 inches long.

Broken timber piles were observed at eight locations: WP12D, WP14, WP18, WP19D, WP25, WP26D, WP32B, WP32D.5, ET5, and ET6.5. A typical broken timber pile can be seen in Photo 21.

Concrete Deck

Detailed information on the concrete deck structural element damage, the locations of damage, structural element damage ratings, and element condition states are included in Appendix G. A summary of the concrete damage is below.

West Trestle

The west trestle concrete deck exhibits moderate cracks up to 1/16 inch wide at a density between 4 to 6 feet on center spacing. The deck between WT0 and WT2 has major cracks up to 3/16 inch wide at a density of 2 to 3 feet on center spacing. Spalls and delamination over 1 inch deep for approximately 10 percent of the deck surface was present between WT0 and WT2. The deck over the abutment at WT0 has displaced downward and the deck near WT1 has displaced approximately 3 inches upward. Gaps at deck construction joints are present along bents WT8, WP1, and WP3. The gaps range from 1/2 inch wide up to 2 3/8 inches wide. A concrete spall near the intersection of bent WT8 and WP1 is the full depth of the deck and approximately 9 inches wide by 9 inches long. A steel drift pin extends up through the deck at this spall location. The north edge of the concrete deck along WT10 has spalls and missing chunks of concrete below the bullrail. Approximately 40 square feet of the concrete deck has been removed and replaced with timber boards and steel plates along bent WT8 between pile rows WTE and WTG.

The metal decking under the concrete deck that is within 2 feet of both sides of the trestle exhibits active corrosion over about 50 percent of the metal decking surface area. At the west

side of the trestle near WT4, an approximate area of 2 square feet exhibits major section loss of the metal deck and the concrete surface is exposed. The metal decking at the interior of the west trestle typically has isolated areas of rusting over about 10 percent of the metal decking surface area. At the north edge of the trestle along WT10, the metal decking exhibits active corrosion within 2 feet of the deck edge and major section loss up to 100 percent was observed near the metal decking edge below the bullrail. Photos 22 through 28 show damage of the concrete deck and metal decking at the west trestle.

Work Pier
The work pier concrete deck exhibits minor cracks up to 1/16 inch wide at a density between 5 to 12 feet on center spacing. Minor concrete chips were typically present along the concrete deck construction joints throughout the work pier. A small spall 1/2 inch deep by 2 inches wide by 3 inches long was present at the construction join intersection with bent WP29. A small spall 1 inch deep by 3 inches wide by 8 inches long was present at the construction joint intersection with bent WP21. Below the concrete deck, approximately 10 percent of the metal decking surface area exhibits isolated areas of rusting. Photos 29 and 30 show damage of the concrete deck and metal decking at the work pier.

East Trestle
The east trestle concrete deck typically exhibits insignificant cracks less than 1/32-inch wide at a density of approximately 10 feet on center spacing. A general crack 1/16 inch wide by 9 feet long is present along ET4. Below the concrete deck, approximately 10 percent of the metal decking surface area exhibits isolated areas of rusting. Photo 31 shows typical metal decking corrosion at the east trestle.

Timber Railing and Bullrail

The majority of the timber railing and bullrail exhibits sound surface material and no defects. Detailed information on railing and bullrail element damage, locations of damage, structural element damage ratings and element condition states, are included in Appendix G. A summary of the timber railing and bullrail damage is below.

The timber bullrail each side of the west trestle from WT0 to WT8 exhibited minor cracks in the top of the bullrail up to 1/16 inch wide by approximately half the length of the bullrails. Approximately 33 linear feet of bullrail at the west trestle along WT8 and WTA exhibit major to severe decay with section loss from 25 percent to greater than 50 percent. About 6 linear feet of bullrail is missing along WT10 between WTF and WTG. Approximately 20 linear feet of bullrail at WT10 has a modified steel pipe placed over the timber bullrail. The steel pipe does not appear to be positively attached to the deck. At the work pier, the bullrail along the riverside typically has minor rounding of the corners. A missing bullrail support block was observed at the riverside bullrail near bent WP5. An approximately 10-foot-long segment of the east trestle bullrail, along pile row ETB, has a broken connection and is displaced between ET0 and ET0.5.

The timber railing elements and connections to the pier exhibited no defects, with the exception of one location with a loose horizontal mid-rail connection at WP28. The railing along the east

trestle and the work pier appears to be of newer construction than the railing along the west trestle. The east trestle and work pier railing typically has three horizontal rails; however, the lower horizontal rail is missing between ET1 to ET2 and between ET3 to ET6. The full length of the west trestle railing is only constructed with a top rail only and does not have a mid-rail or lower rail.

Photos 32 to 40 show typical bullrail and railing conditions and damage.

EVALUATION AND ASSESSMENT

The evaluation and assessment of the pier was conducted in general conformance with the *Waterfront Facilities Inspection and Assessment Manual*. Overall system ratings are assigned for three distinct sections of the pier: the west trestle, the work pier, and the east trestle. System are assigned ratings of: good, satisfactory, fair, poor, serious and critical. The overall system ratings are based on element damage ratings assigned for the primary structural elements, including abutments, piles, pile caps, beams, fender piles, bullrails, railings, and the pier deck. Elements are assigned damage ratings of: no defects, minor, moderate, major and severe. Element damage ratings are included in Appendix G. Element damage ratings of major and severe are noted on the drawings included in Appendix B.

West Trestle

The west trestle is assigned an overall system rating of "fair" because the majority of structural elements are sound but have minor to moderate defects, and some isolated areas have advanced deterioration and overstressing.

The west trestle abutment and abutment timber piles are assigned an element damage rating of "severe" because the abutment shows signs of advanced deterioration and overstressing caused by settlement of the abutment. The settlement of the abutment appears to be due to scour below the abutment likely leading to the accelerated decay of the supporting timber piles. The west trestle concrete deck exhibits major cracking and upward displacement near WT1. This upward displacement is due to settlement at the abutment causing the supporting deck beams to rotate and displace the deck upward near WT1. The deck between WT0 and WT2 is assigned a damage rating of "moderate" because of the cracking and spalling caused by the settlement of the abutment.

The concrete deck and timber elements near the north edge of the west trestle along pile cap WT10 are assigned element damage ratings of "moderate" to "severe" because advanced deterioration and overstressing was observed. The deterioration at the north edge of the west trestle includes a broken pile cap WT10, a displaced pile at WTC that is not providing bearing support, major decay at the north ends of the timber beams, concrete deck spalls at the deck edge, and metal decking below the concrete with major corrosion and section loss. Other areas of the concrete deck are assigned an element damage rating of "minor"; however, a large opening and three large gaps in the concrete deck are allowing water to leak onto the timber framing elements below, which is causing accelerated deterioration of those timber elements.

Three locations of timber diagonal bracing are assigned element damage rating of "severe," because these braces have broken.

Generally, the bullrail at the west trestle has been assigned an element damage rating of "minor" because of some splits and evidence of decay. Approximately 39 linear feet of bullrail at the northwest corner of the trestle is assigned an element damage rating of "major" to "severe" because of significant decay and section loss of the bullrail.

The timber railing on the west trestle is assigned an element damage rating of "minor"; however, note that the railing on the west trestle does not have any mid-rails, only a single top rail.

Work Pier

The work pier is assigned an overall system rating as "satisfactory" because limited minor to moderate defects or deterioration were observed, but no overstressing was observed.

Although no cases of overstressing were observed, at bent WP31/pile WTD, the pile and pile cap are assigned an element damage rating of "severe" because a bearing pile is displaced from its original position and is not providing support of the pile cap. Because of the displaced pile, the deck loads are likely transmitted to structural supporting elements through a load path that was not intended with the original design, and therefore this area may have a reduced load carrying capacity.

Generally, the bullrail at the work pier shore-side edge has no defects and the bullrail at the riverside edge has minor deterioration with rounding at the top corners. At the riverside edge, a section of the bullrail is missing a support block near WP5 and therefore is assigned an element damage rating of "moderate."

The timber railing on the work pier is assigned an element damage rating of "no defects"; however, there is one location where a mid-rail to post connection near WP28 is loose.

East Trestle

The east trestle is assigned an overall system rating of "good" because only minor visible damage and deterioration was observed, but no overstressing.

A section of the bullrail on the south side of the east trestle is displaced between ET0 and ET0.5 because of a broken connection to the trestle.

STRUCTURE LOAD RATING

A load rating of the pier was performed and included the pier deck, deck beams and pile caps. A load rating of the piles and a seismic evaluation of the pier is not included with this load rating. Load rating calculations are provided in Appendix H.

Two types of loading conditions were evaluated for the pier: (1) a maximum uniform distributed live load on the deck in pounds per square foot (PSF) and (2) a maximum gross

vehicle truck weight in pounds (LBS) based on a Type 3 Legal Truck. A loading diagram of the Type 3 truck is included in the load rating calculations in Appendix H.

Based on our load rating calculations, the maximum uniform distributed live load on the pier deck is 18 PSF and the maximum gross vehicle weight (GVW) is 1,700 LBS, based on a Type 3 truck axle spacing. This load rating is controlled by isolated areas of pier damage as follows.

- Displaced bearing pile at WP31/D
- Broken pile cap at WT10 and displaced bearing pile at WT10/C

If these localized areas of the pier deck are barricaded off, a pier load rating of 95 PSF uniform load and 11,200 LBS GVW can be achieved. These localized areas should be barricaded off as follows.

- East Trestle/Work Pier at WP31/D displaced pile: Barricade off area within 3 feet from the inside of the bullrail along north edge of WP and in between ET7 and WPC
- West Trestle at WT10: Barricade off area within 3 feet from the inside of the bullrail along the north edge at WT10

Alternatively, if the isolated areas of pier damage noted above are repaired, a pier load rating of of 95 PSF uniform load and 11,200 LBS GVW could also be achieved, provided the repairs are inspected and approved by BergerABAM.

CONCLUSION

Overall, the west trestle, work pier, and east trestle are in fair, satisfactory, and good condition, respectively. The majority of the structural elements exhibit no defects or only minor damage. There are some localized areas of moderate, major and severe damage. With typical maintenance and repair activities, further accelerated deterioration can be prevented at the areas with minor to moderate damage, and the long-term functionality of the structure can be achieved. The following maintenance and repairs activities to the work pier and access trestles are recommended in the short term.

- Re-align displaced bearing pile at WP31/D
- Replace pile cap at WT10 and re-align displaced bearing pile at WT10/C
- Re-attach mid-rail at work pier railing near bent WP28.
- Replace decayed bullrails at the northwest corner of the west trestle (approximately 39 linear feet).
- Install missing mid-rail and lower-rail at the east trestle railing (approximately 35 linear feet).

- Replace and reattach displaced bullrail at the east trestle (approximately 10 linear feet).
- Epoxy-inject cracks in the concrete deck that are 1/16 inch wide or wider (approximately 650 linear feet).
- Repair minor spall in concrete deck (approximately five locations).
- Seal large gap 1/2 inch wide up to 2 3/8 inches wide in the concrete deck construction joints between the west trestle and work pier (approximately 70 linear feet).
- Close in and seal the opening in the west trestle concrete deck with new cast-in-place concrete (approximately 40 square feet).

Other localized areas of the work pier and trestles have major and severe damage with observed signs of overstressing of structural elements. These localized areas should be repaired in order to restore them to their original state and original load-carrying capacity. We recommend the following repairs to the major and severe damaged elements of the pier be completed in the long term.

- Replace broken timber brace (three locations).
- Replace or realign bearing piles and reattach to pile caps (two locations).
- Replace timber pile cap at bent WT10 and reattach steel fender pile top connections to the new pile cap.
- Replace concrete deck and bullrail at west trestle bent WT10.
- Replace west trestle concrete abutment and supporting timber piles.
- Replace west trestle concrete deck between abutment and bent WT2 (approximately 520 square feet).
- Replace approximately 3 feet width west trestle concrete deck along west and east edges, between WT0 and WT10, where the metal deck exhibits major corrosion (approximately 825 square feet).

Other recommended repairs that should be considered are as follows.

- Remove any broken timber fender piles along the river side of the work pier and east trestle, and replace these timber fender piles with steel fender piles (six locations).
- Add horizontal mid-rails and lower rails at the west trestle railing (approximately 120 linear feet).
- Full deck replacement at the west trestle (approximately 2,700 square feet)

Furthermore, we recommend the structural elements of the work pier and trestles be regularly monitored for any new damage or deterioration.

Appendix A
Photographs

Photo 1. West Trestle Looking Northwest

Photo 2. Work Pier Looking North

Photo 3. Work Pier (Shore Side) Looking West

Photo 4. Work Pier (River Side) Looking West

Photo 5. East Trestle Looking West

Photo 6. West Trestle Abutment

Photo 7. West Treslte Abutment Scour And Timber Pile Decay

Photo 8. West Treslte Abutment Side View

Photo 9. East Trestle Abutment

Photo 10. Typical Pile Crack (Pile WT5/C)

Photo 11. Displaced Pile At WP13/A

Photo 12. Displaced Pile At WP31/D

Photo 13. Typical Pile Cap Split (Bent WP10)

Photo 14. West Trestle Pile Cap Decay At Pile WT10/A

Photo 15. West Trestle Pile Cap Decay At Bent WT10

Photo 16. West Trestle Pile Cap Decay At Bent WT10

Photo 17. West Trestle Typical Bracing

Photo 18. Typical Steel Battered Pile Pair (Bent WP13)

Photo 19. Typical Steel Beam Corrsosion (Bent WP13)

Photo 20. Typical Corrosion At Miscellaneous Steel Beams (Bent WP27)

Photo 21. Typical Fender Pile Corrosion And Broken Timber Pile (Bent WP24/25)

Photo 22. West Trestle Typical Deck Cracks

Photo 23. West Trestle Cracks And Spalls Between WT0 And WT2

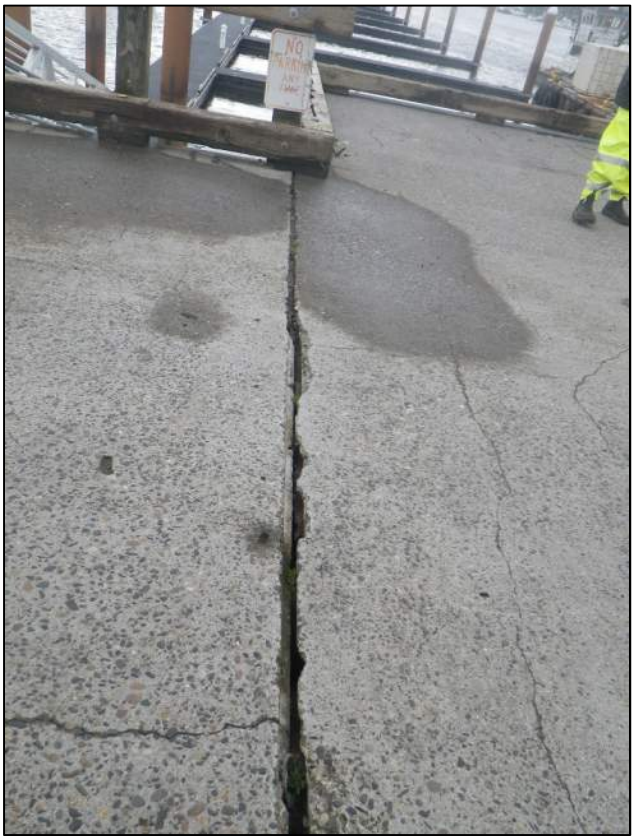


Photo 24. West Trestle Gap In Deck At WT8

Photo 25. West Trestle Spall In Deck At WT8

Photo 26. West Trestle Deck Edge Spalls And Metal Deck Corrosion At WT10

Photo 27. West Trestle Removed Deck At WT8

Photo 28. West Trestle Steel Deck Corrosion And Section Loss At Bent WT4

Photo 29. Work Pier Typical Construction Joint And Cracks (Pile Row WPD Looking West)

Photo 30. Work Pier Typical Deck Corrosion (Bent WP25)

Photo 31. East Trestle Typical Deck Corrosion (Bent ET5)

Photo 32. West Trestle Typical Railing And Bullrail

Photo 33. West Trestle Bullrail Decay At Bent WT8

Photo 34. West Trestle Bullrail Deterioration At Bent WT10

Photo 35. West Trestle Steel Bullrail At Bent WT10

Photo 36. Work Pier Bullrail At River Side Edge

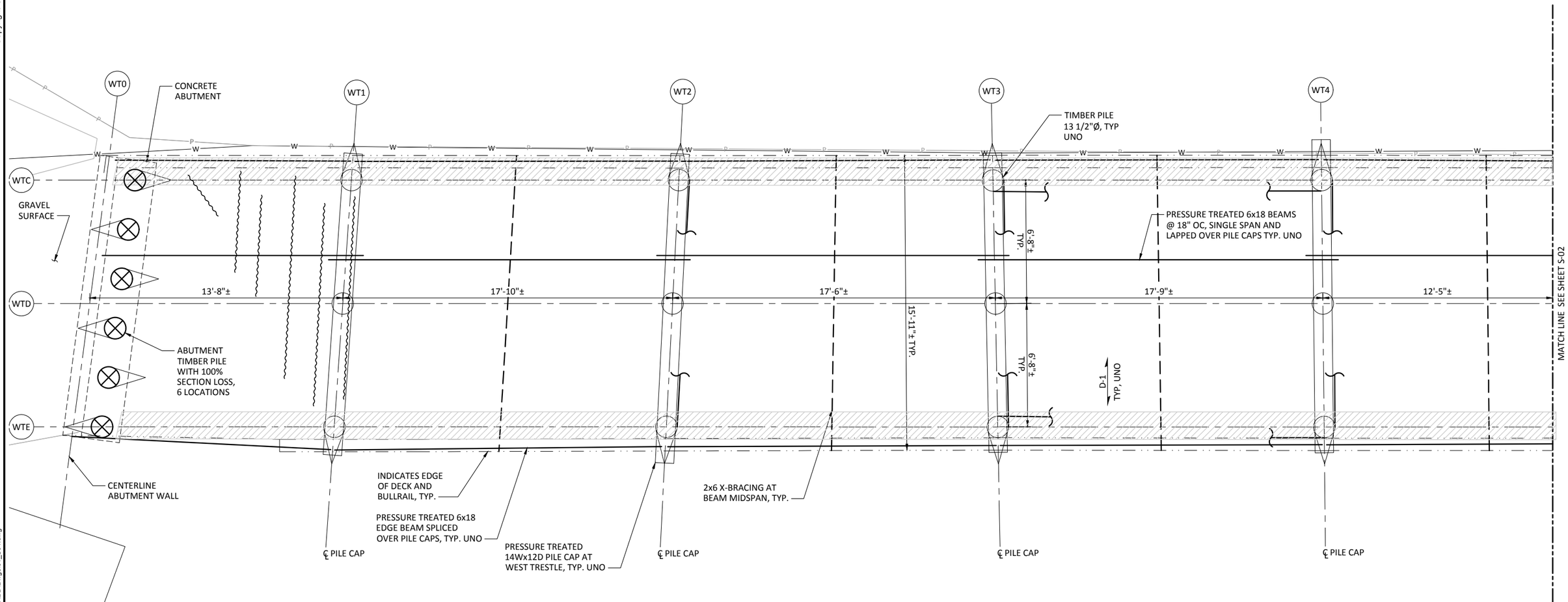
Photo 37. Work Pier Typical Railing And Bullrail

Photo 38. Work Pier Loose Connection At Horizontal Rail At WP28

Photo 39. East Trestle Displaced Bullrail (Bent ET0 to ET0.5)

Photo 40. East Trestle Railing Missing Bottom Rail (Bent ET3 to ET6)

Appendix B
Work Pier and Access Trestle Drawings



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- INDICATES MAJOR TO SEVERE CRACKS IN CONCRETE DECK
- INDICATES MAJOR CORROSION IN UNDERSIDE OF METAL DECK

OC	ON CENTER
TYP.	TYPICAL
UNO	UNLESS NOTED OTHERWISE
CL	CENTERLINE

NOTE:

ALL TIMBER DIMENSIONS ARE NOMINAL SIZES (INCHES).

2 0 2 4
scale feet

PROGRESS PRINT

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BergerABAM
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DESIGN BY BDB
CHECK BY HAW
PROJ MGR HAW

WARRENTON WORK PIER
CONDITION ASSESMENT

EXISTING CONDITIONS PLAN SHEET - 1

DRAWING NO. S-01
PROJECT NO. A17.0189.00
DATE: 3/21/17
SHEET NO. 1 OF 8

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OC	ON CENTER
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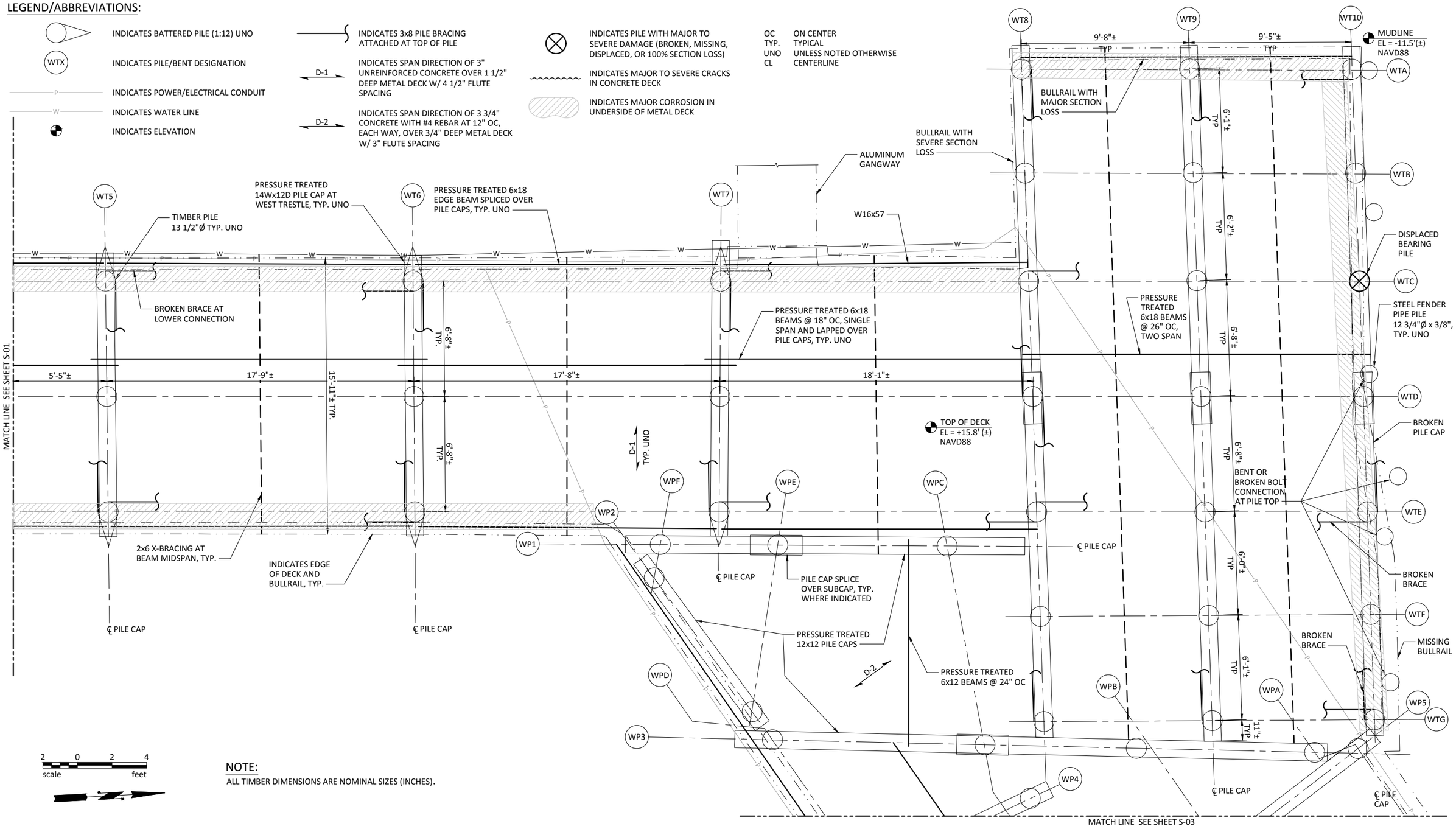
CL	CENTERLINE



2 0 2 4
scale feet

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CONDITION ASSESMENT

EXISTING CONDITIONS PLAN SHEET - 2

DRAWING NO.	S-02
PROJECT NO.	A17.0189.00
DATE:	3/21/17
SHEET NO.	2 OF 8

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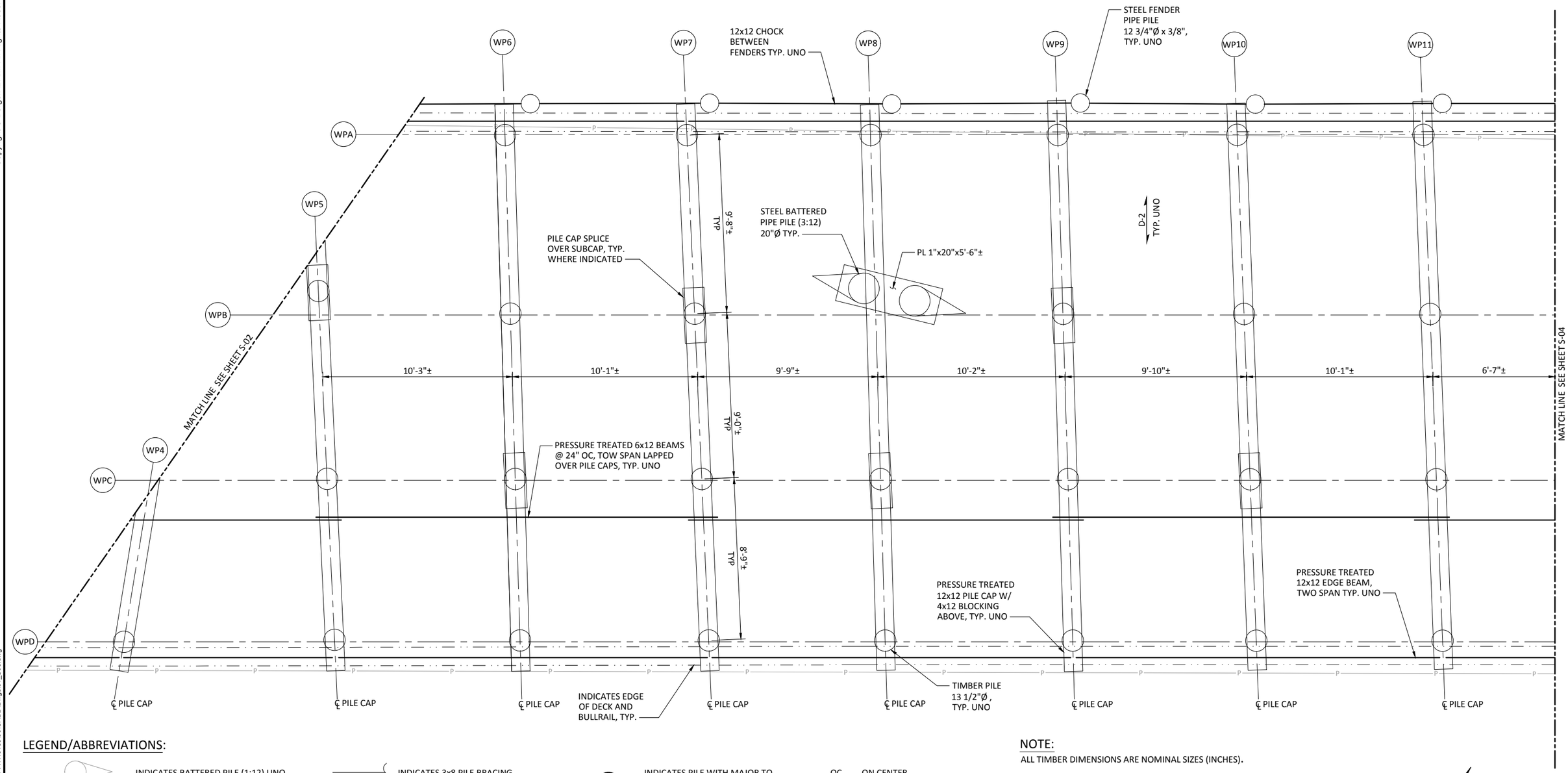

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EXISTING CONDITIONS PLAN SHEET - 3

DRAWING NO. S-03
PROJECT NO. A17.0189.00
DATE: 3/21/17
SHEET NO. 3 OF 8

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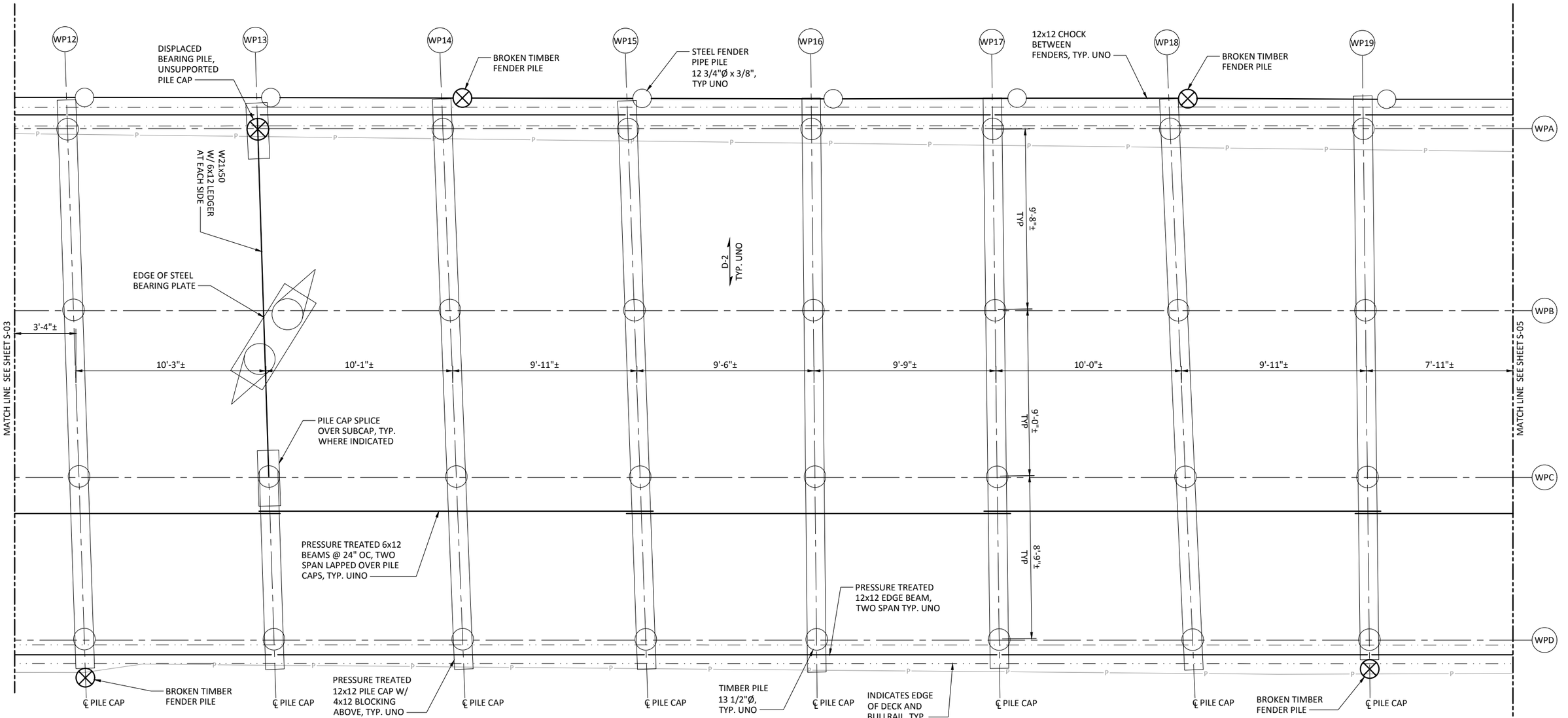

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CONDITION ASSESMENT

EXISTING CONDITIONS PLAN SHEET - 4

DRAWING NO. S-04
PROJECT NO. A17.0189.00
DATE: 3/21/17
SHEET NO. 4 OF 8

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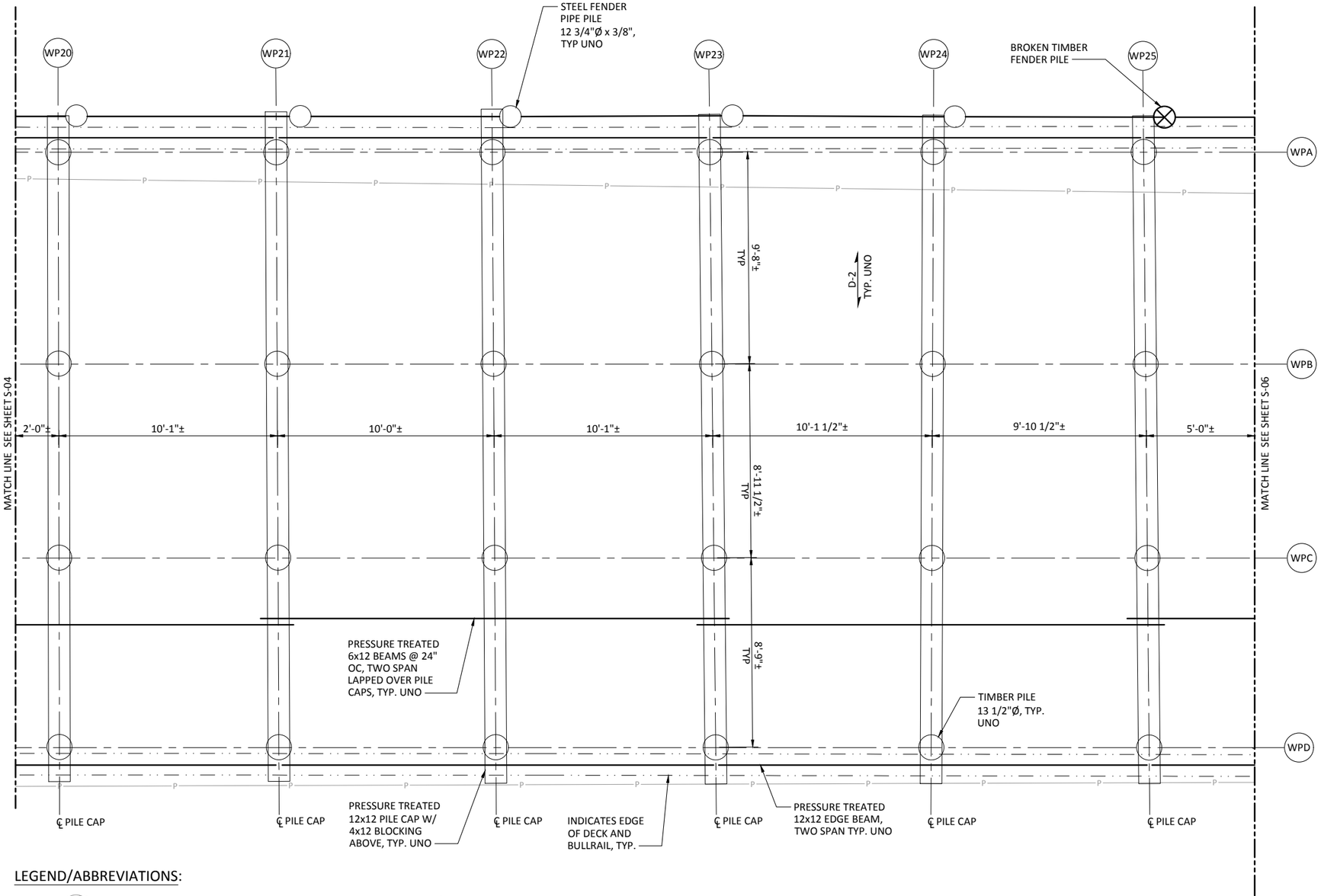

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2 0 2 4
scale feet

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WARRENTON WORK PIER
CONDITION ASSESMENT

EXISTING CONDITIONS PLAN SHEET - 5

DRAWING NO. S-05
PROJECT NO. A17.0189.00
DATE: 3/21/17
SHEET NO. 5 OF 8

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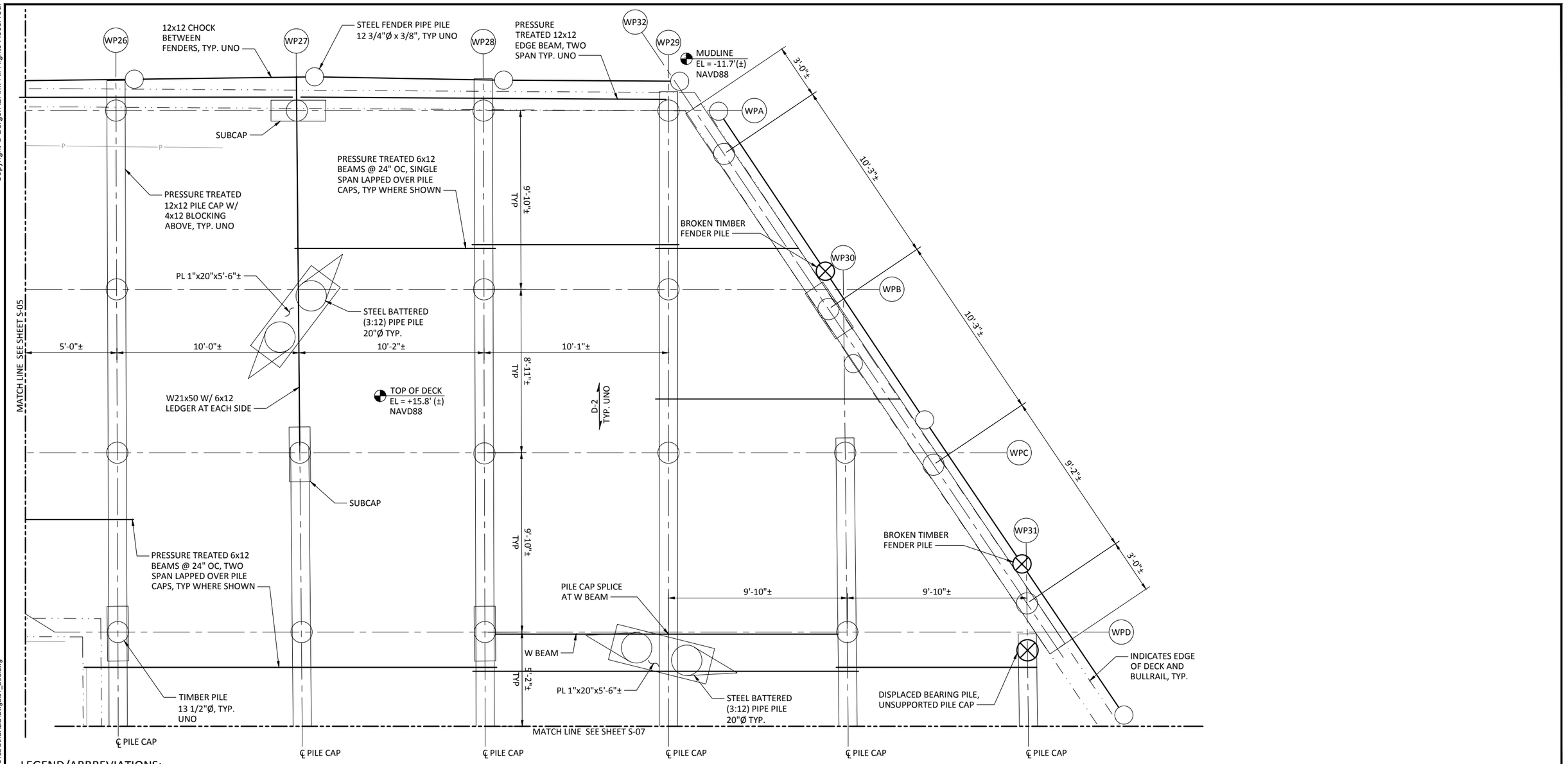

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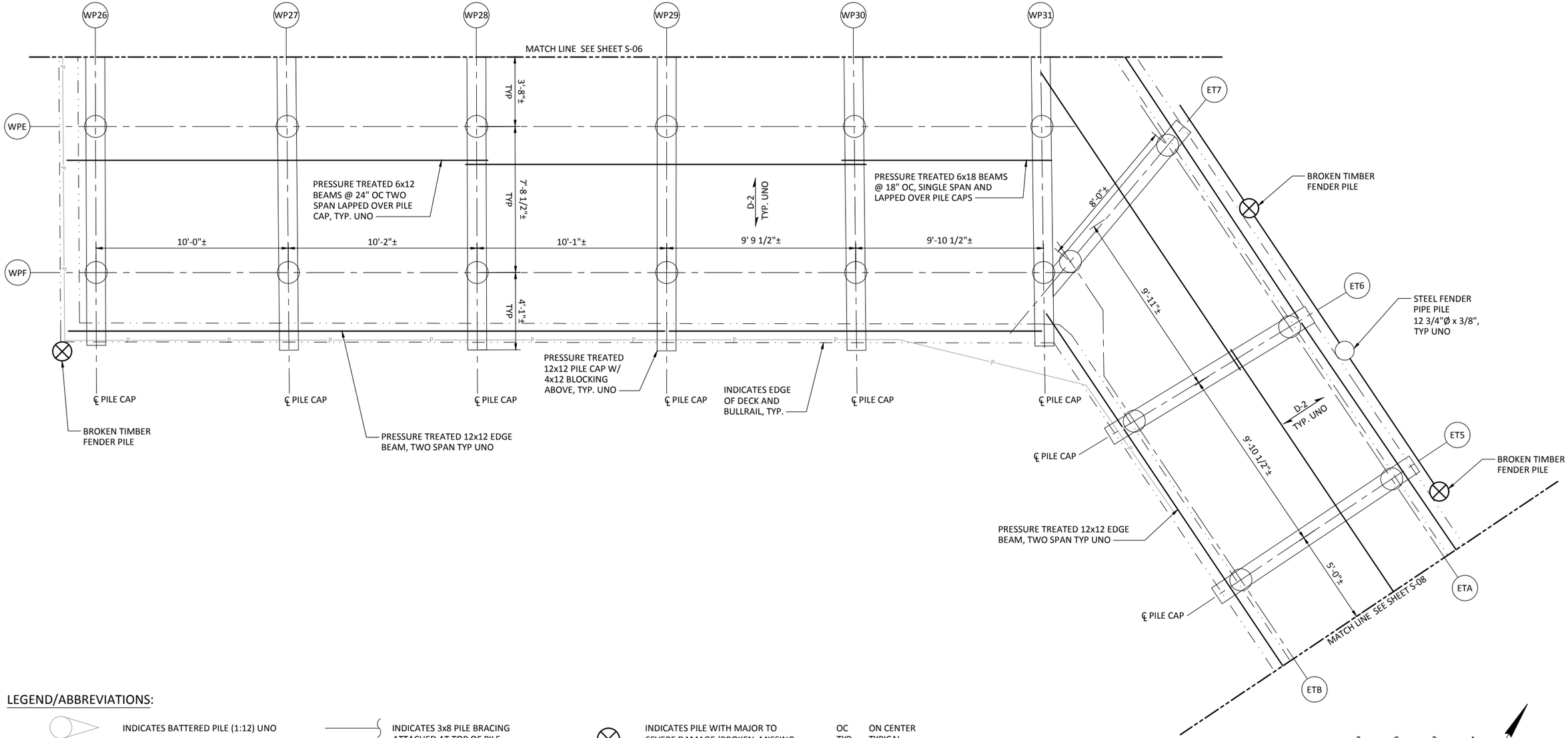
WARRENTON WORK PIER
CONDITION ASSESMENT

EXISTING CONDITIONS PLAN SHEET - 6

DRAWING NO. S-06
PROJECT NO. A17.0189.00
DATE: 3/21/17
SHEET NO. 6 OF 8

Last Saved by: Brian.board on: Jun 2, 2017 11:09 AM File: Q:\Portland\2017\A17.0189000\CADD\Dwgs\01_S06.dwg



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DESIGN BY BDB
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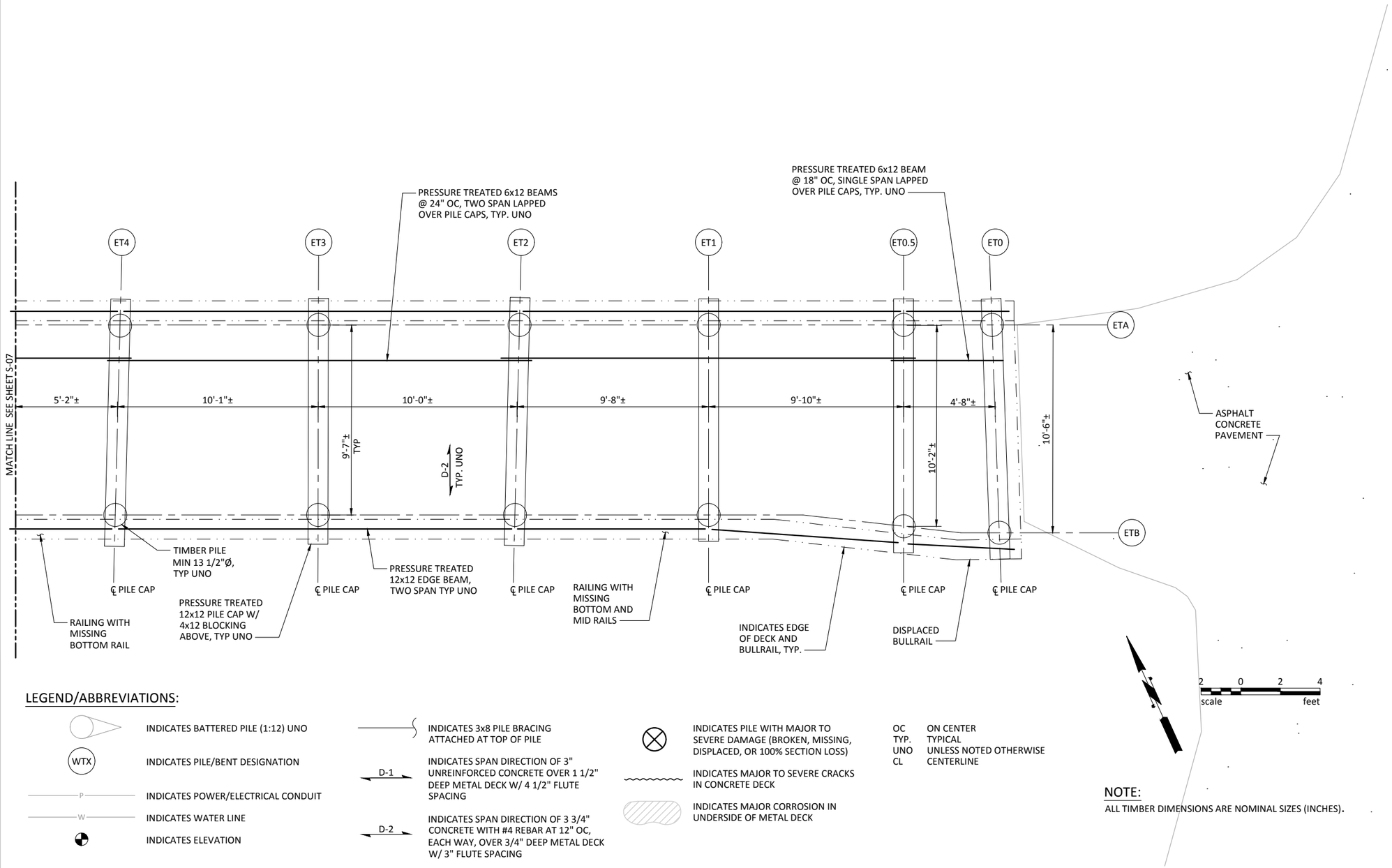
PROJ MGR HAW

WARRENTON WORK PIER CONDITION ASSESMENT

EXISTING CONDITIONS PLAN SHEET - 7

DRAWING NO. S-07
PROJECT NO. A17.0189.00
DATE: 3/21/17
SHEET NO. 7 OF 8



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EXISTING CONDITIONS PLAN SHEET - 8

DRAWING NO. S-08
PROJECT NO. A17.0189.00
DATE: 3/21/17
SHEET NO. 8 OF 8

Appendix C
Topography Survey

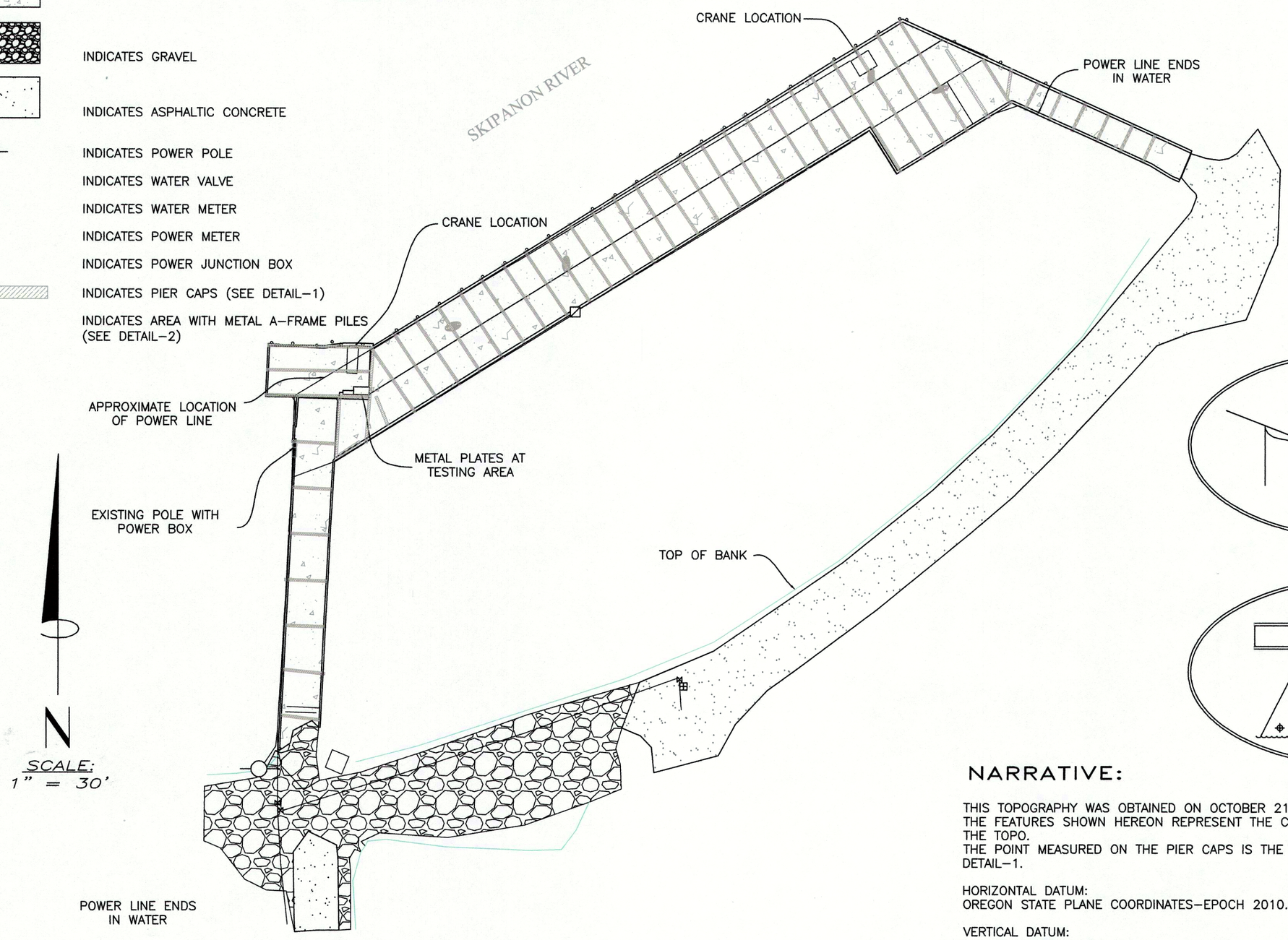
LEGEND

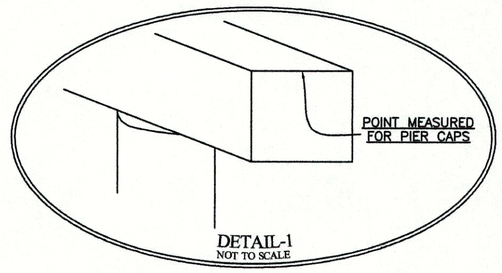
- INDICATES PIER CAPS
- INDICATES CONCRETE
- INDICATES GRAVEL
- INDICATES ASPHALTIC CONCRETE
- INDICATES POWER POLE
- INDICATES WATER VALVE
- INDICATES WATER METER
- INDICATES POWER METER
- INDICATES POWER JUNCTION BOX
- INDICATES PIER CAPS (SEE DETAIL–1)
- INDICATES AREA WITH METAL A–FRAME PILES (SEE DETAIL–2)

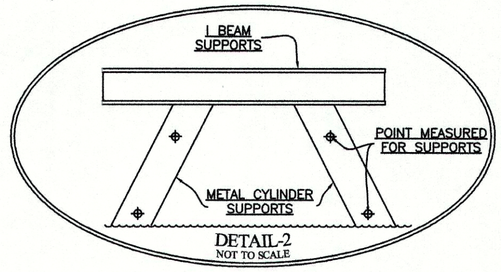
POINT #	NORTHING	EASTING	ELEVATION	DESCRIPTION
3001	929724.672	7336897.198	15.074	FND. MAG NAIL
3004	929241.544	7336832.973	14.485	FND. MAG NAIL
3005	929224.616	7336257.482	11.78	FND. MAG NAIL
3006	929273.408	7336259.274	14.408	FND. MAG NAIL
3007	929348.47	7335843.511	13.677	FND. MAG NAIL
3008	929744.581	7335905.732	13.506	FND. 3" BRASS CAP

BASIS OF BEARINGS:

OREGON STATE PLANE COORDINATE SYSTEM, NORTH ZONE (3601). NAD 83 (11), EPOCH 2010.00 GRID NORTH, GRID COORDINATES, INTERNATIONAL FEET.







NARRATIVE:

THIS TOPOGRAPHY WAS OBTAINED ON OCTOBER 21, 2016 THROUGH OCTOBER 25, 2016. THE FEATURES SHOWN HEREON REPRESENT THE CONDITIONS OF THE SITE AT THE TIME OF THE TOPO.
THE POINT MEASURED ON THE PIER CAPS IS THE TOP CENTERLINE, AS SHOWN ON DETAIL–1.

HORIZONTAL DATUM:
OREGON STATE PLANE COORDINATES–EPOCH 2010.00

VERTICAL DATUM:
NAVD 88 (GEOID–12A)

NOTES:

THE SHADED CLOUD AREAS ARE THE METAL PILES SHOWN ON DETAIL–2. FOR ADDITIONAL INFORMATION ON THE LOCATION OF THESE SUPPORTS, PLEASE CONTACT JON FORRESTER AT OTAK INC.

THE VAST MAJORITY OF PIER CAPS ON THE NORTHERLY SIDE OF THE PIER (NOT BRIDGES) ARE FLUSH WITH THE EDGE OF CONCRETE.

otak
- SURVEYING
- CIVIL ENGINEERING
- PLANNING
- WATER & NATURAL RESOURCES
- WETLAND CONSULTING

CLATSOP COUNTY
4253–A HWY 101 N.
GEARHART, OR 97138
(503) 738–3425
FAX: (503) 738–7455

TILLAMOOK COUNTY
PHONE (503) 368–5394

PACIFIC COUNTY
PHONE (360) 642–4454

WWW.OTAK.COM

DATE	JOB NO.	EQUIPMENT	FIELD	DRAWN	CHECKED
10.31.16	67848	S6/TSC3	MSM, WCC	MGP	DNB

67848–TOPO.DWG

SURVEY FOR:

CITY OF WARRENTON URBAN RENEWAL

DOWNTOWN MARINA
JANE SWEET, HARBORMASTER
PIER–2 TOPO

NE 1/4 SECTION 22 T8N., R10W., W.M.
CLATSOP COUNTY, OREGON

REGISTERED PROFESSIONAL LAND SURVEYOR
Dale N. Barrett
OREGON
JULY 16, 1982
DALE N. BARRETT
1979
RENEWS: DECEMBER 31, 2017

GX-02799

N:\Project\67800\67848\Survey\Maps\67848–TOPO.dwg Plotted: Nov 04, 2016 – 7:32am By: markp

Appendix D
Ground Penetrating Radar Field Inspection Report

Carlson Testing, Inc.

Bend Office	(541) 330-9155
Geotechnical Office	(503) 601-8250
Eugene Office	(541) 345-0289
Salem Office	(503) 589-1252
Tigard Office	(503) 684-3460

January 16, 2017
T1701035
Permit No: N/A

FIELD INSPECTION REPORT

DATES COVERED: January 12, 2017

PROJECT: City of Warrenton – Pier Evaluation
ADDRESS: 501 NE Harbor Place Warrenton OR
INSPECTOR: M. Ober – ACI#00060231, OBOA#1089

01/12/17 - Ground Penetrating Radar (GPR)

As requested, CTI representative was on site to perform radar scanning on a concrete pier deck, CTI met John with Warrenton Marina/OTAK and was advised of the locations to scan. CTI scanned the West, East, North side and South side of pier deck. (2) Locations were exposed for verification of size of reinforcing; both locations were patched with non-shrink grout by CTI. Results from scans are as follows:

West Bridge (Pier)	East Bridge (Pier)
No reinforcing	5" thick
4"-5" thick	12" on center reinforcing mat both direction at 2" – 2 ½" from bottom

North Side (Pier)
5" thick at north side to 8" thick were meets south side (middle of pier)
12" on center reinforcing mat both directions at 2" – 2 ½" from bottom.
#4 bar running east to west (longitudinal)

South Side (Pier)
5" thick at south side to 8" thick were meets north side (middle of pier)
12" on center reinforcing mat both directions at 2" – 2 ½" from bottom.
#4 bar running north to south (transverse)

SE 1/3 (Pier)
5" thick
12" on center reinforcing mat both directions at 2" – 2 ½" from bottom.

CTI utilized the G551 Mini Radar Scanner CTI #4699 to perform task. John with OTAK was on site during scanning.

If there are any further questions regarding this matter, please do not hesitate to contact this office.

Respectfully submitted,
CARLSON TESTING, INC.

Jay Hathaway
Project Manager

MO/sc
cc: Ctiy of Warrenton – Jane Sweet Jsweet@ci.warrenton.or.us
Otak Inc (seaside) – Jon Forrester Jon.forrester@otak.com

Appendix E
American Society of Civil Engineers (ASCE)
Waterfront Facilities Inspection and Assessment Excerpts

condition is properly documented. When unusual conditions, significant structural deficiencies, or unusual construction is encountered, the team leader should personally observe and evaluate the condition. The team leader should periodically communicate with the project manager to report the inspection findings and receive instruction. For underwater inspections, the team leader should also be a trained commercial diver and should actively participate in the inspection by personally conducting the underwater inspection of a minimum of 25% of the structure.

2.4.4 Team Members

Team members involved in inspection and note taking or documentation work shall be trained inspectors who are graduates of a four-year engineering curriculum and certified as an engineer-in-training (EIT), or technicians who have relevant certifications for bridge or related inspections by the National Society of Professional Engineers' (NSPE) program for National Institute for Certification in Engineering Technologies (NICET) or Federal Highway Administration–approved comprehensive inspection training courses. (Outside of the United States, comparable evidence of minimum competence may be substituted.) Other personnel performing manual tasks, such as removing marine growth, or supporting diving operations, but not conducting or reporting inspections, may have lesser qualifications. In addition, other technicians and/or divers with special knowledge, skills, or experience may be part of the team as required to support the objective. Team members involved in underwater inspections should also be trained commercial divers.

2.5 ELEMENT-LEVEL DAMAGE RATING

A damage rating is assigned to each element inspected during an investigation. The rating reflects the condition of the individual element only and is independent of the element's structural importance and the type of inspection being conducted.

Element-level damage ratings are standardized to provide a qualitative description of an element's condition based on a quantified level of damage. By using a quantified scale, objectivity is maintained throughout the inspection.

The following sections present damage ratings typically used for timber, steel, reinforced concrete, and prestressed concrete elements.

2.5.1 Timber Elements

Typical damage ratings used for timber elements are described in Table 2-4 and depicted in Fig. 2-2.

Table 2-4. Damage Ratings for Timber Elements

Damage Rating		Existing Damage[a]	Exclusions [Defects Requiring Elevation to the Next Higher Damage Rating(s)]
NI	Not Inspected	• Not inspected, inaccessible, or passed by[b]	
ND	No Defects	• Sound surface material	
MN	Minor	• Checks, splits, and gouges less than 0.5 in. wide • Evidence of marine borers or fungal decay	Minor damage not appropriate if • Loss of cross section • Marine borer infestation • Displacements, loss of bearing, or connections
MD	Moderate	• Remaining diameter loss up to 15% • Checks and splits wider than 0.5 in. • Cross-section area loss up to 25% • Corroded hardware • Evidence of marine borers or fungal decay, with loss of section	Moderate damage not appropriate if • Displacements, loss of bearing or connections

(Continued)

Table 2-4. Damage Ratings for Timber Elements *(Continued)*

Damage Rating		Existing Damage[a]	Exclusions [Defects Requiring Elevation to the Next Higher Damage Rating(s)]
MJ	Major	• Remaining diameter loss 15 to 30% • Checks and splits through full depth of cross section • Cross-section area loss 25 to 50%; heavily corroded hardware • Displacement and misalignments at connections	Major damage not appropriate if • Partial or complete breakage
SV	Severe	• Remaining diameter loss more than 30% • Cross-section area loss more than 50% • Loss of connections and/or fully nonbearing condition • Partial or complete breakage	

[a] Any defect listed is sufficient to identify relevant damage grade.
[b] If not inspected due to inaccessibility or passed by, note as such.

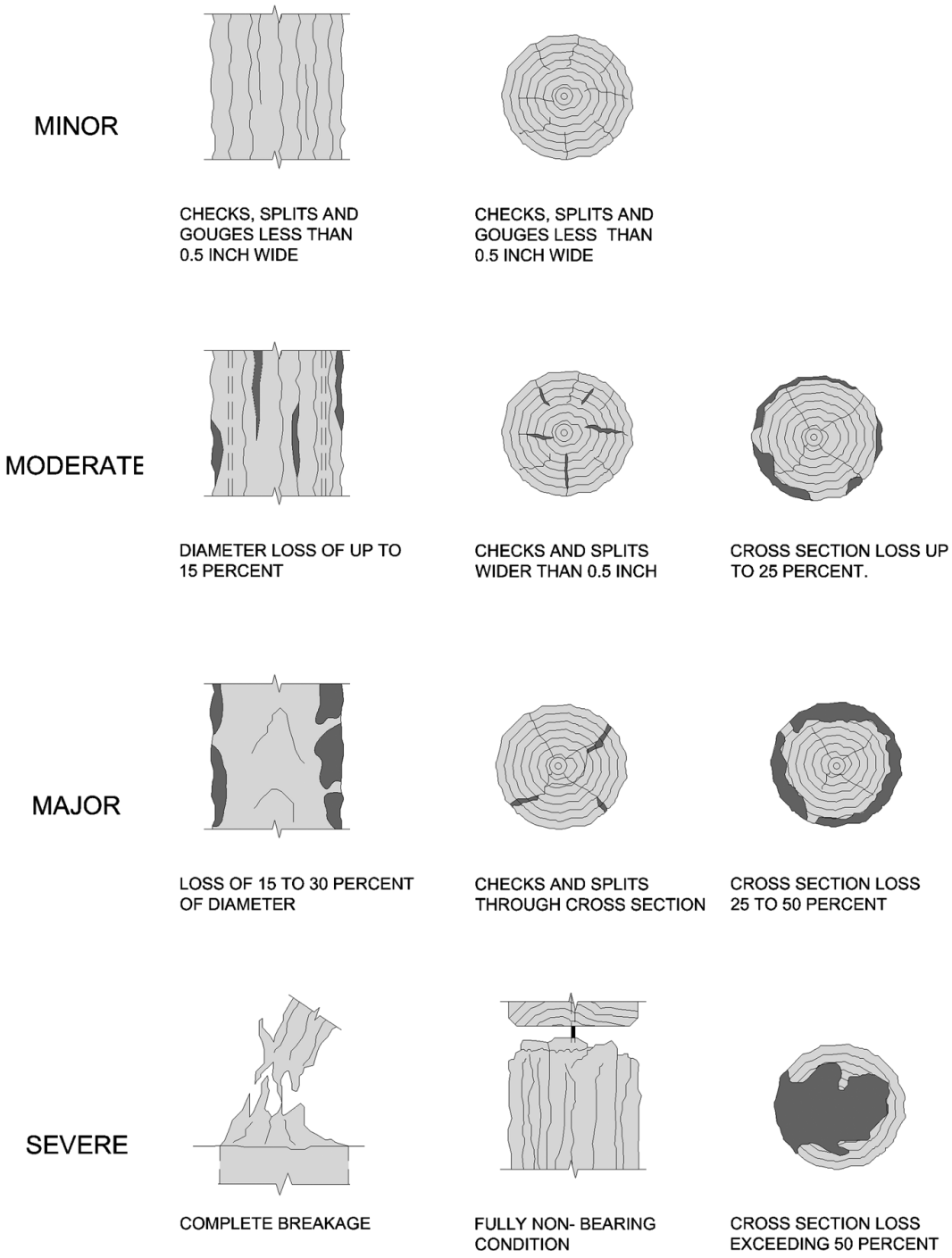


Fig. 2-2. Condition ratings for timber elements
Source: Courtesy of CH2M HILL, Inc. and Ben C. Gerwick, Inc., reproduced with permission.

Table 2-5. Damage Ratings for Steel Elements

Damage Rating		Existing Damage[a]	Exclusions [Defects Requiring Elevation to the Next Higher Damage Rating(s)]
NI	Not Inspected	• Not inspected, inaccessible, or passed by[b]	
ND	No Defects	• Protective coating or wrap intact • Light surface rust • No apparent loss of material	
MN	Minor	• Protective coating or wrap damaged and loss of thickness up to 15% of nominal at any location • Less than 50% of perimeter or circumference affected by corrosion at any elevation or cross section • Loss of thickness up to 15% of nominal at any location	Minor damage not appropriate if • Changes in straight line configuration or local buckling • Corrosion loss exceeding fabrication tolerances (at any location)
MD	Moderate	• Protective coating or wrap damaged and loss of thickness 15 to 30% of nominal at any location • More than 50% of perimeter or circumference affected by corrosion at any elevation or cross section • Loss of thickness 15 to 30% of nominal at any location	Moderate damage not appropriate if • Changes in straight line configuration or local buckling • Loss of thickness exceeding 30% of nominal at any location

(Continued)

Table 2-5. Damage Ratings for Steel Elements *(Continued)*

Damage Rating		Existing Damage[a]	Exclusions [Defects Requiring Elevation to the Next Higher Damage Rating(s)]
MJ	Major	• Protective coating or wrap damaged and loss of nominal thickness 30 to 50% at any location • Partial loss of flange edges or visible reduction of wall thickness on pipe piles • Loss of nominal thickness 30 to 50% at any location	Major damage not appropriate if • Changes in straight line configuration or local buckling • Perforations or loss of wall thickness exceeding 50% of nominal
SV	Severe	• Protective coating or wrap damaged and loss of wall thickness exceeding 50% of nominal at any location • Structural bends or buckling, breakage and displacement at supports, loose or lost connections • Loss of wall thickness exceeding 50% of nominal at any location	

[a]Any defect listed is sufficient to identify relevant damage grade.
[b]If not inspected due to inaccessibility or passed by, note as such.

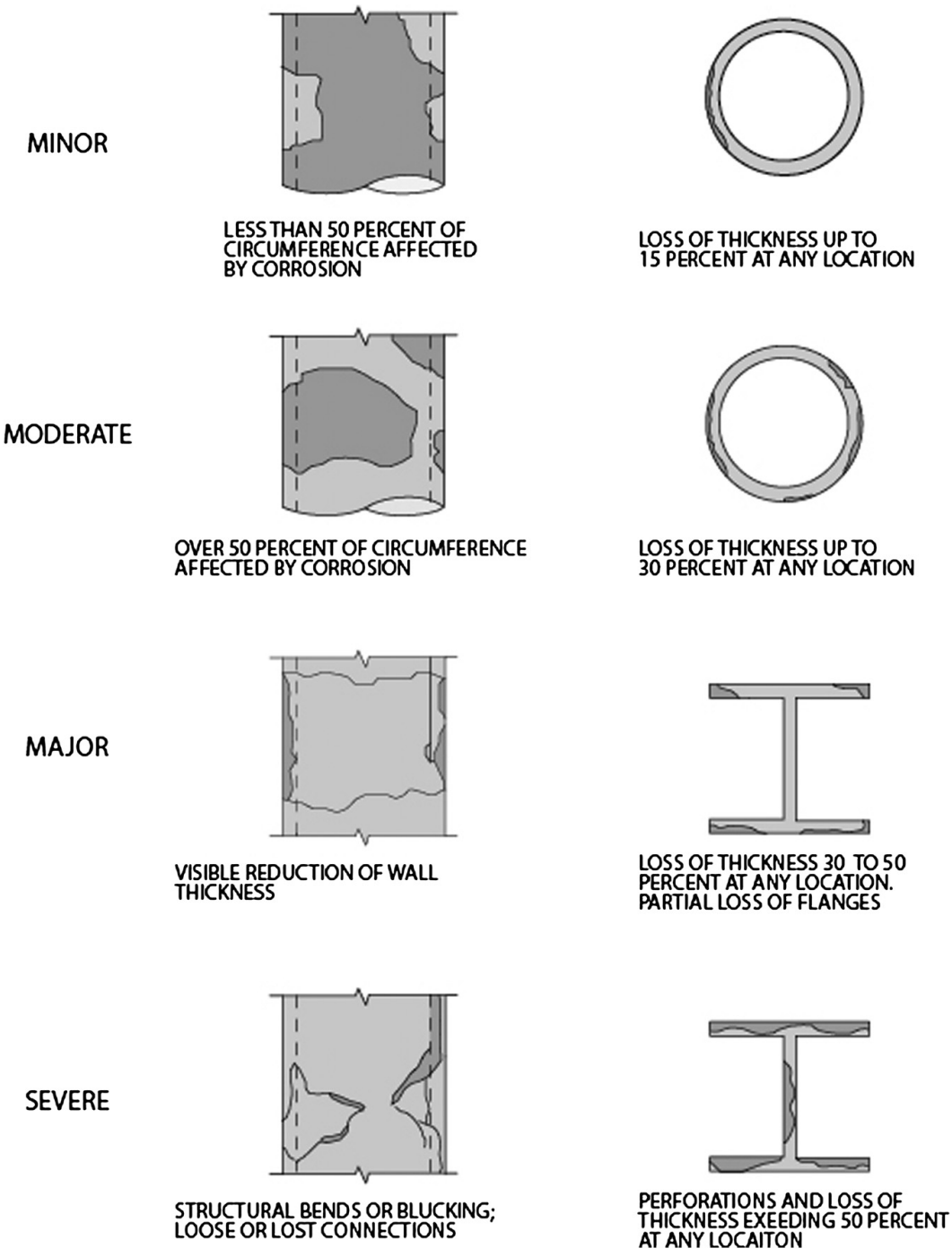


Fig. 2-3. Damage ratings for steel elements
Source: Courtesy of CH2M HILL, Inc. and COWI, Inc., reproduced with permission.

Table 2-6. Damage Ratings for Reinforced Concrete Elements

Damage Rating		Existing Damage[a]	Exclusions [Defects Requiring Elevation to the Next Higher Damage Rating(s)]
NI	Not Inspected	• Not inspected, inaccessible, or passed by[b]	
ND	No Defects	• Good original hard surface, hard material, sound	
MN	Minor	• Mechanical abrasion or impact spalls up to 1 in. in depth • Occasional corrosion stains or small pop-out corrosion spalls • General cracks up to 1/16 in. in width	Minor damage not appropriate if • Structural damage • Corrosion cracks • Chemical deterioration[c]
MD	Moderate	• Structural cracks up to 1/16 in. in width • Corrosion cracks up to 1/4 in. in width • Chemical deterioration: Random cracks up to 1/16 in. in width; "Soft" concrete and/or rounding of corners up to 1 in. deep • Mechanical abrasion or impact spalls greater than 1 in. in depth	Moderate damage not appropriate if • Structural breakage and/or spalls • Exposed reinforcement • Loss of cross section due to chemical deterioration beyond rounding of corner edges

MJ	Major	• Structural cracks 1/16 in. to 1/4 in. in width and partial breakage (through section cracking with structural spalls) • Corrosion cracks wider than 1/4 in. and open or closed corrosion spalls (excluding pop-outs) • Multiple cracks and disintegration of surface layer due to chemical deterioration • Mechanical abrasion or impact spalls exposing the reinforcing	Major damage not appropriate if • Loss of cross section exceeding 30% due to any cause
SV	Severe	• Structural cracks wider than 1/4 in. or complete breakage • Complete loss of concrete cover due to corrosion of reinforcing steel with more than 30% of diameter loss for any main reinforcing bar • Loss of bearing and displacement at connections • Loss of concrete cover (exposed steel) due to chemical deterioration • Loss of more 30% of cross section due to any cause	

[a] Any defect listed is sufficient to identify relevant damage grade.
[b] If not inspected due to inaccessibility or passed by, note as such.
[c] Chemical deterioration: Sulfate attack, alkali-silica reaction, alkali-aggregate reaction, alkali-carbonate reaction ettringite distress, or other chemical/concrete deterioration.

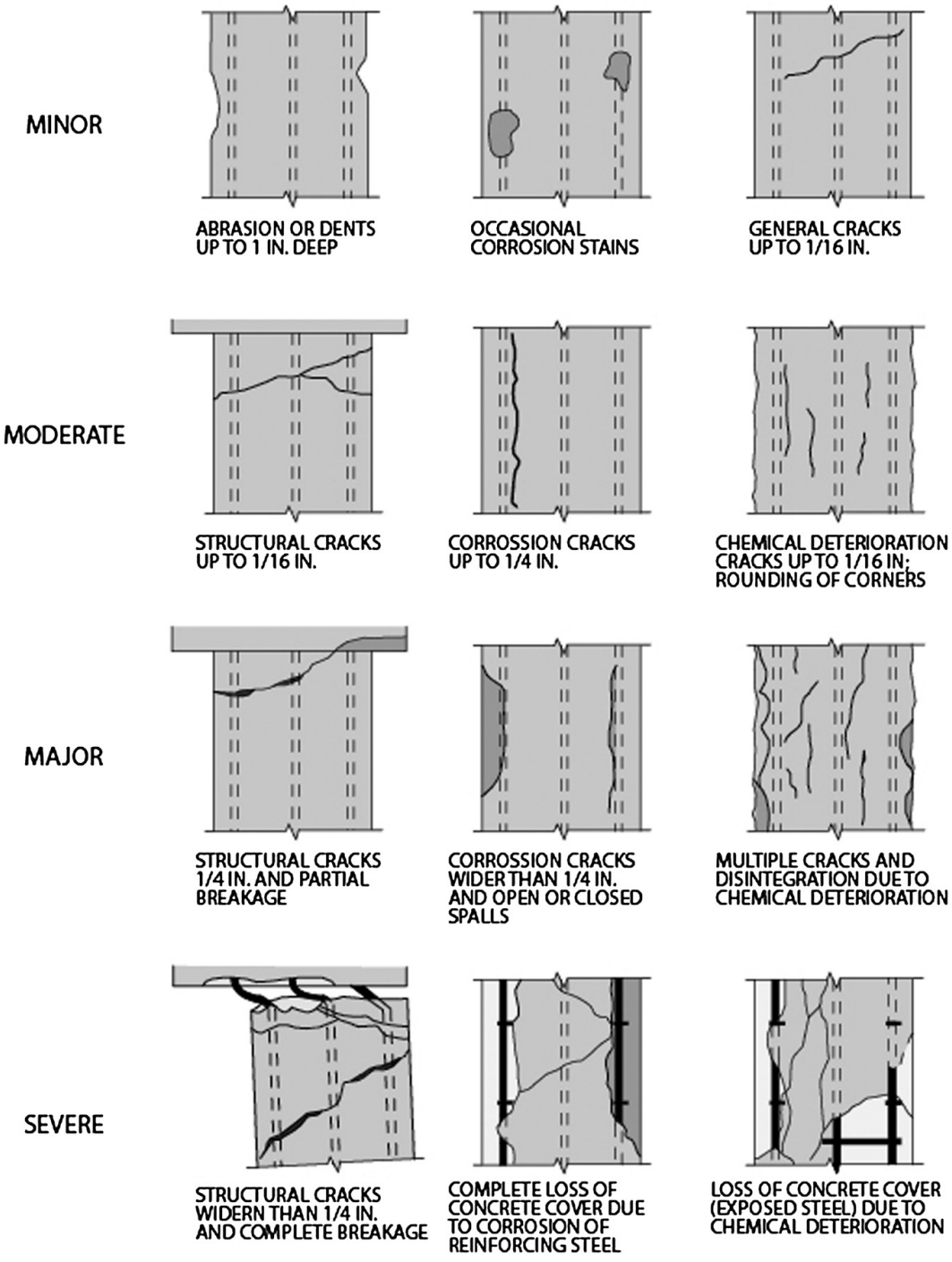


Fig. 2-4. Damage ratings for reinforced concrete elements
Source: Courtesy of CH2M HILL, Inc. and COWI, Inc., reproduced with permission.

Table 2-10. Damage Ratings for Fender Piles

Damage Rating		Existing Damage[a]	Exclusions [Defects Requiring Elevation to the Next Higher Damage Rating(s)]
NI	Not Inspected	• Not inspected, inaccessible, or passed by[b]	
ND	No Defects	• Good original surface, sound, no defects observed	No Defects Rating not appropriate if • Surface coatings worn or damaged
MN	Minor	• Light abrasion less than 1/2-in. deep, light (surface) fungal decay, minimal marine borer activity observed (less than 5% section loss) • Weathering of steel coating, surface corrosion with no significant pitting • Hairline cracking of concrete • Weathered composite elements	Minor Rating not appropriate if • "Softening" of concrete
MD	Moderate	• Timber cracked and checked up to 1/2-in. wide, fungal decay (max 1 in. depth), abrasion up to 2-in. deep, loss of section due to marine borers less than 10% • Corrosion of steel with up to 25% localized section loss • Noticeable cracking of concrete but with no loss of interlock	Moderate Rating not appropriate if • "Softening" of the concrete (up to 1 in.) • Prestressed concrete fender piles (with a low effective prestress) are expected to crack under load; therefore, should be rated minor if no corrosion and the cracks are closed

MJ	Major	• Timber cracked and checked greater than 1/2-in. wide, fungal decay (max 3 in. depth), abrasion damage greater than 2-in. deep, loss of section due to marine borers between 10 and 25% • Corrosion of steel elements with 25 to 50% localized section loss, localized buckling of a flange • Noticeable cracking of concrete with loss of interlock, softening of the concrete greater than 1-in. deep • Composite elements cracked or split
SV	Severe	• Fungal decay on timber members (greater than 3 in. depth), loss of section due to marine borers (more than 25% of the section), broken • Significant corrosion of steel members with more than 50% localized section loss, broken, or yielded • Broken, exposed reinforcing steel or prestressing steel strands, spalling of the concrete, softening of the concrete greater than 3-in. deep • Composite elements broken

[a]Any defect listed is sufficient to identify relevant damage grade.
[b]If not inspected due to inaccessibility or passed by, note as such.

Table 2-14. Condition Assessment Ratings

Rating		Description
6	Good	No visible damage or only minor damage noted. Structural elements may show very minor deterioration, but no overstressing observed. No repairs are required.
5	Satisfactory	Limited minor to moderate defects or deterioration observed but no overstressing observed. No repairs are required.
4	Fair	All primary structural elements are sound but minor to moderate defects or deterioration observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the load-bearing capacity of the structure. Repairs are recommended, but the priority of the recommended repairs is low.
3	Poor	Advanced deterioration or overstressing observed on widespread portions of the structure but does not significantly reduce the load-bearing capacity of the structure. Repairs may need to be carried out with moderate urgency.
2	Serious	Advanced deterioration, overstressing, or breakage may have significantly affected the load-bearing capacity of primary structural components. Local failures are possible, and loading restrictions may be necessary. Repairs may need to be carried out on a high-priority basis with urgency.
1	Critical	Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur, and load restrictions should be implemented as necessary. Repairs may need to be carried out on a very high-priority basis with strong urgency.

2.6.2 Condition Assessment Ratings

The Condition Assessment Rating should be assigned upon completion of the Routine Inspection and remain associated with the structural unit (as defined in Section 3.1.1) until the structure is rerated following a quantitative engineering evaluation and repairs, or upon completion of the next

Fig. A-2. Above water inspection team using a man lift to access the underside of a timber pier deck
Source: Courtesy of CH2M HILL, Inc., reproduced with permission.

by gravity, with lateral restraints between each member. Some steel connectors are provided to provide some load continuity, for example, drift pins and brackets between piles and pile caps, brackets between deck stringers and pile caps, and spikes between decking and stringers (see Figs. A-3 and A-4). Timber piles can be supported by bracing to reduce the effective length of the piles for vertical loads. Timber structures are subjected to rot, fungus, attack by marine borers, and other environmental factors. To provide a long service life, timber elements are typically treated with preservatives or wrapped. Table A-1 provides a summary of what to look for when inspecting the condition of timber open-piled structures.

A.2.2.1 Timber Piles and Bracing Timber piles are found on older structures or on lightly loaded modern docks. Timber piles are commonly used for breasting and fender systems as well. Timber piles are naturally limited in length and diameter by the available size of trees. Typical upper bound length is about 75 ft with nominal diameters ranging between 12 in. and 16 in. Timber piles naturally taper with length, with the smaller diameter being driven into the soil. Due to the limitation in element size, marine structures supported by timber piles often have a comparatively large number of closely spaced piles. This is often on the order of 10 ft on-center. Timber structures in deep waters are also typically braced.

To determine physical condition, inspect piles for rot; checking or splitting; abrasion; shell peeling; attack by marine borers; and vertical,

Fig. A-3. Typical connection detail of a timber wharf showing steel elements connecting a plumb fender and a battered pile to a pile cap (left); steel strapping securing a mooring cleat to the pile cap is also shown on the right
Source: Courtesy of Simpson Gumpertz & Heger, Inc., reproduced with permission.

Fig. A-4. A view of the underside of a typical timber wharf. Note the stringers spanning between pile bents. Bridging is provided at midspan of the stringers to stabilize the members during installation.
Source: Courtesy of Simpson Gumpertz & Heger, Inc., reproduced with permission.

Table A-1. Open-Piled Timber Structures: Checklist for Inspections

Section or Part	What to Look for	Comments
Piles	Damaged or missing piles, alignment (straightness) of piles from top to bottom, scour pits at mudline, pile-head bearing, fungal rot, and wrap conditions	Accelerated rates of deterioration in the splash zone and wet areas
Pile caps, stringers, and braces	Damaged, loose, or missing members; alignment of members along length (rotation); signs of distress at bearing areas; fungal rot on top surfaces or wet areas; deterioration at connections; condition of wrapping	Underside of low decks may need to be inspected by diver Undersides of high decks may need to be inspected by man lifts, snoopers, or other inspection access equipment
Deck	Damaged, loose, or missing members; alignment of members along length (rotation or sagging); rot; wear	Localized removal of deck coatings, surfaces or overlayments may be necessary to assess condition of supporting members Underside of low decks may need to be inspected by diver Undersides of high decks may need to be inspected by man lifts, snoopers, or other inspection access equipment
Over-dredging	Excessive dredging at the face of the structure	Measure mudline depths at the structure face and compare with design dredge depths for the structure

lateral, or rotational displacement. Also check for scour and undermining at the mudline, especially for piles along the berthing area subject to propeller wash and piles in strong currents. Check exterior and fender piles, particularly corner piles, for damage or abrasion from vessel contact, as they are

Fig. A-11. Steel ocean pier; note height of deck that cannot be adequately inspected from water or shore
Source: Courtesy of CH2M HILL, Inc., reproduced with permission.

galvanic corrosion processes. The latter condition can often be found at metallic appurtenances, for example, a stainless steel ladder connected to a carbon steel pile. Also inspect connections for evidence of overstress or damage, for example, fracture of welds.

A.2.4.2 Steel Framing, Bracing, and Decking Perform a general observation of the steel framing and bracing for severe damage or deterioration, misalignment or rotation, and evidence of overloading. At the caps and beams, evidence of overloading may appear at points of maximum bending stress and maximum compression stress as buckling or sagging at mid span between piles or bents and buckling or crushing directly over piles. Inspect welded or bolted connections between the piles, pile caps, and deck beams. Typically, these members are located above the waterline and can be inspected from a workboat as part of the above water inspection. However,

Table A-3. Open-Piled Steel Structures: Checklist for Inspections

Section or Part	What to Look for	Comments
Piles	Damaged or missing piles, alignment (straightness) of piles from top to bottom, scour pits at mudline, corrosion, pitting, impact damage, condition of coatings and wraps	Accelerated rates of deterioration in the splash zone and wet areas
Pile caps, deck framing, and bracing	Damaged or missing members, alignment of members along length (rotation), signs of distress at bearing areas, corrosion, pitting, impact damage, condition of coatings	Underside of low decks may need to be inspected by diver Undersides of high decks may need to be inspected by man lifts, snoopers, or other inspection access equipment
Over-dredging	Excessive dredging at the face of the structure	Measure mudline depths at the structure face and compare with design dredge depths for the structure

if the deck is located significantly above the water, other means of accessing these areas for inspection may be required.

Check all steel members for corrosion (Fig. A-13). Use calipers and scales to determine the remaining thickness of flanges, webs, and stiffeners. Use ultrasonic testing to determine the remaining thickness of hollow steel section (HSS) elements or to record more accurate thickness of other steel elements. If the structure has a cathodic protection system, test and document the system's condition. Locations vulnerable to corrosion include wet locations, welded connections with poorly matched materials, and connections where dissimilar metals can cause galvanic corrosion processes. The latter condition can often be found at metallic appurtenances, e.g., a stainless steel ladder connected to a carbon steel pile. Also check connections for evidence of overstress or damage, e.g., fracture of welds.

Steel decks are used on some structures and often include steel grating. For steel grating, areas of severe corrosion, overloading, or loss of paint or

the top surface. Ramps may have side curbs and end stops to prevent trailers from leaving the ramp. Material for the curbs and stops can include concrete, timber, rubber, or vinyl.

Boarding floats or piers are frequently provided to assist in the launch, retrieval, and queuing of boats. A transition plate spanning between the float and an abutment at the top of the ramp makes the float more accessible. In locations where water levels fluctuate, grounding skids or blocks are provided on the underside of the floats that may ground to prevent damage.

A.17.2 Typical Components and Problem Areas

Because boat ramps are located at the water's edge and consist of in-water and out-of-water elements, above water components are best inspected during low water levels. Table A-20 summarizes some of the more common problem areas associated with boat ramps.

A.17.2.1 Ramps Ramp surfaces are the most important component of a boat ramp; if the surface is in good condition a boat could be launched or retrieved even if it had damaged curbs or boarding floats. Therefore, inspection should focus on the general condition of the ramp. For ramps on natural ground, surfaces should be checked for potholes, buildup or drifting of aggregate, and loose deep soil. Concrete ramps should be inspected for undermining, spalls, cracks, reinforcing steel corrosion, and excessive aggregate exposure. Evaluate traction features, such as V-grooves and surface roughing. Asphalt ramps should be inspected for potholes and cracking. Document evidence of sediment accretion. Figure A-58 shows a boat ramp and boarding floats at low tide, exposing sediment buildup at the lower reaches of the ramp. Curbs should be inspected for damage. Concrete abutments rarely suffer damage but should be examined for evidence of vehicular impact.

Table A-20. Boat Ramps: Checklist for Inspections

Type	Component	What to Look for	Comments
Boarding floats	Grounding skids or blocks	Presence, condition	See Sections A.9 for floats and A.21 for utilities
Ramps	Ramp surface	Concrete condition, undermining, cracking, surface traction	
	Curbs	Damage	
	Abutment	Damage	

Appendix F

Oregon Department of Transportation (ODOT)
2009 Bridge Inspection Pocket Coding Guide Excerpts

Concrete Decks and Slabs without an Overlay

#12 - Concrete Deck - Bare (SF)

Concrete deck with no surface protection of any type and has uncoated rebar

#26 - Concrete Deck - w/ Coated Bars (SF)

Concrete deck with coated reinforcement.

#27 - Concrete Deck - w/ Cathodic System (SF)

Concrete deck w/ cathodic protection system.

#38 - Concrete Slab - Bare (SF)

Concrete slab with no surface protection of any type and has uncoated rebar.

#52 - Concrete Slab - w/ Coated Bars (SF)

Concrete slab with coated reinforcement.

#53 - Concrete Slab - w/ Cathodic System (SF)

Concrete slab w/ cathodic protection sys.

Condition State Descriptions and Feasible Actions
(Work Candidate Action in parentheses)
Note: Put all in one (1) condition state.

1. **No patched areas or spalls/delaminations exist on either side of the deck.** Do Nothing

2. **Patched areas and/or spalls/delaminations exist on either side of the deck. The combined distressed area is 10% or less of the total deck area.**
   Do Nothing; Repair Spalls/Delaminations (*Min Repair)*; Add A Protective System (*Pr Maint)*

3. **Patched areas and/or spalls/delaminations exist on either side of the deck. The combined distressed area is more than 10% but 25% or less of the total area.**
   Do Nothing; Repair Spalls/Delaminations (*Min Repair)*; Rehabilitate The Deck *(Rehab Elem)*

4. **Patched areas and/or spalls/delaminations exist on either side of the deck. The combined distressed area is more than 25% but less than 50% of the total deck area.**
   Do Nothing; Repair Spalls/Delaminations (*Min Repair)*; Rehabilitate The Deck *(Rehab Elem)*

5. **Patched and/or spalls/delaminations exist on either side of the deck. The combined area of distressed is 50% or more of the total deck area.**
   Do Nothing; Rehabilitate The Deck *(Rehab Elem)*; Replace The Deck *(Repl Elem)*

Condition State 1 (CS 1)

Condition State 2 (CS 2)

Condition State 3 (CS 3)

Condition State 4 (CS 4)

Condition State 5 (CS 5)

Note:

#30 - Steel Decks (Corrugated / Orthotropic / Etc.)

Unit of Measure (SF)
Bridge decks constructed of corrugated metal filled with Portland cement concrete or asphaltic concrete. Orthotropic steel deck are also included.

Condition State Descriptions and Feasible Actions
(Work Candidate Action in parentheses)
Note: Put all in one (1) condition state.

1. **There is no evidence of corrosion and any paint system is sound and functioning as intended to protect the metal surface. The surfacing, if any, on the deck has no potholes.** Do Nothing

2. **There is little or no active corrosion. Surface or freckled rust has formed or is forming. The paint system may be chalking, peeling, curling, or showing other early evidence of paint system distress but there is no exposure of metal. Minor cracking or potholes may exist in the surfacing.** Do Nothing; Seal Cracks And/Or Repair Potholes *(Pr. Maint)*

3. **Surface or freckled rust is moderate to heavy. There may be exposed metal but there is no active corrosion that is causing loss of section. Potholes exist in surfacing and there may be significant cracking.** Do Nothing; Surface Clean And Restore Top Coat *(Part Paint)*; Repair Potholes And Cracks *(Min Repair)*

4. **Corrosion may be present but any section loss due to active corrosion does not yet warrant structural analysis of either the element or the bridge. Potholes may be large and exposing the metal decking.** Do Nothing; Spot Blast, Clean And Paint *(Repl Pain)*; Replace Paint System Or Surfacing *(Ovly Deck)*

5. **Corrosion has caused section loss and is sufficient to warrant structural analysis to ascertain the impact on the ultimate strength and/or serviceability of either the element or the bridge. The surfacing has failed.** Do Nothing; Rehab/Replace Protection System *(Rehab Elem)*; Replace The Unit (*Repl Elem)*

CS 1

CS 2

CS 3

CS 4

CS 5

Note:

Unpainted Steel Elements

#219 - Abutment (EA)

#101 - Closed Web/Box Girder (LF)

#140 - Arch (LF) (incl ribs and spandrel columns)

#106 - Open Girder/Beam (LF)

#151 - Floor Beam (LF)

#112 - Stringer (stringer/floorbeam system) (LF)

#201 - Column or Pile Extension (EA)

#120 - Thru Truss (bottom chord) (LF)

#225 - Submerged Pile (EA)

#125 - Thru Truss (excl. bottom chord) (LF)

#230 - Cap (EA)

#130 - Deck Truss (LF) (includes bottom chord)

Condition State Descriptions and Feasible Actions
(Work Candidate Action in parentheses)
Note: Use % for each condition state.

1. **There is little or no corrosion of the unpainted steel. The weathering steel is coated uniformly and remains in excellent condition. Oxide film is tightly adhered. The connectors (welds, rivets, etc.) are sound.** Do Nothing

2. **Surface rust or surface pitting has formed or is forming on the unpainted steel. The weathering steel has not corroded beyond design limits. Oxide film has a dusty to granular texture.** Do Nothing; Clean And Protect *(Part Paint)*

3. **Steel has measurable section loss due to corrosion but does not warrant structural analysis. Oxide film is flaking (1/2 inch in diameter).** Do Nothing; Clean And Protect *(Part Paint)*

4. **Corrosion is advanced. Oxide film has a laminar texture with thin sheets of rust. Section loss is sufficient to warrant structural analysis to ascertain the impact on the ultimate strength and/or serviceability of either the element or the bridge.** Do Nothing; Rehab The Unit (*Rehab Elem)*; Replace The Unit *(Repl Elem)*

CS 1

CS 2

CS 3

CS 4

Note:

Reinforced Concrete Elements

#105 - Closed Web/Box Girder (LF)

#215 - Abutment (EA)

#110 - Open Girder/Beam (LF)

#234 - Cap (EA)

#116 - Stringer (stringer/floorbeam system) (LF)

#251 - Tunnel (LF)

#144 - Arch (LF) (includes arch and bottom chord)

#220 - Submerged Pile Cap / Footing (EA)

#155 - Floorbeam (LF)

#221 - Submerged Concrete Spread Footing (EA)

#205 - Column or Pile Extension (EA)

#223 - Submerged Concrete Footing Seal (EA)

#210 - Pier Wall (EA / LF)

#227 - Continuously Submerged Pile (EA)

#255 - Tunnel Portal Conc (EA)

Condition State Descriptions and Feasible Actions
(Work Candidate Action in parentheses)
Note: Use % for each condition state.

1. **The element shows little or no deterioration. There may be discoloration, efflorescence, and/or superficial cracking but without effect on strength or serviceability.** Do Nothing

2. **Minor structural cracks and spalls may be present but there is no exposed reinforcing or surface evidence of rebar corrosion.** Do Nothing; Seal Cracks, Minor Patch *(Pr Maint)*

3. **Some delaminations and/or spalls are present and some reinforcing may be exposed. Corrosion of rebar may be present but loss of section is incidental and does not significantly affect the strength and/or serviceability of either the element or the bridge.** Do Nothing; Clean, Patch, And/or Seal *(Min Repair)*

4. **Advanced deterioration. Corrosion of reinforcement and/or loss of concrete section is sufficient to warrant an analysis to ascertain the impact on the strength and/or serviceability of either the element or the bridge.** Do Nothing, Rehab The Unit (*Rehab Elem)*; Replace The Unit *(Repl Elem)*

***Note**: Abrasion*
CS1 - Loss Of Fines
CS2 - Loss Of Large Aggregate
CS3 - Exposure Of Rebar

***Note**: Inventory Channel and Tee Beams using **Element 110** - Open Girders/Beams*

***Note**: For crack type / size definitions, refer to crack rating guideline on page 47*

CS 1

CS 2

CS 3

CS 4

Timber Elements

#111 - Open Girder/Beam (LF)

#117 - Stringer (stringer/floorbeam system) (LF)

#135 - Timber Truss / Arch (LF)

#156 - Floorbeam (LF)

#206 - Column or Pile Extension (EA)

#216 - Abutment (EA / LF)

#228 - Continuously Submerged Pile (EA)

#235 - Cap (EA / LF)

#252 - Tunnel (LF)

Condition State Descriptions and Feasible Actions
(Work Candidate Action in parentheses)
Note: Use % for each condition state.

1. Investigation indicates no decay. There may be superficial cracks, splits, and checks having no affect on the strength or serviceability. Do Nothing

2. Decay, insect,/marine borer infestation, abrasion, splitting, cracking, checking, or crushing may exist but none is sufficiently advanced to affect the strength or serviceability of the element. Do Nothing; Rehab, Or Protect The Unit *(Min Repair)*

3. Decay, insect,/marine borer infestation, abrasion, splitting, cracking, or crushing has produced loss of strength or deflection of the element but not of a sufficient magnitude to affect the serviceability of the bridge. Do Nothing; Rehab The Unit *(Rehab Elem)*; Replace The Unit *(Repl Elem)*

4. Advanced deterioration. Decay, insect/marine borer infestation, abrasion, splits cracks, or crushing has produced loss of strength or deflection that affects the serviceability of the bridge. Do Nothing; Rehab The Unit *(Rehab Elem)*; Replace The Unit *(Repl Elem)*


CS 1


CS 2

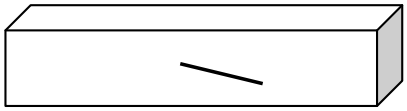

CS 3


CS 4

Timber Member Rating Guide

(Piling or Bridge Members) with Cracks, Splits, or Checks:

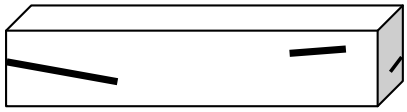
Condition State 1 Superficial cracks, splits, or checks that occur only on one side of the member and have an opening less than 3/8" wide.
(NBI item 59 or 60 condition rating of 7 or 8)



splits on 1 side only and width < 3/8"

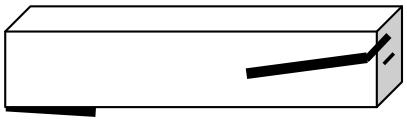
Condition State 2 Includes cracks, splits, or checks that have an opening greater than 3/8" wide, if they occur only one side of the member, or they can have an opening smaller than 3/8" wide, if they occur on both sides of the member.
(NBI item 59 or 60 condition rating of 6)

crack width > 3/8" on 1 side only



crack width < 3/8" on 2 sides

Condition State 3 The operative words are that we now have measurable loss of strength or the cracks, splits, checks that are located on both sides of the member and all have an opening greater than 3/8" wide, but the length of the crack, check, or split is less than 1/2 the full length of the member.
(NBI item 59 or 60 condition rating of 5)



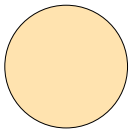
crack width > 3/8" on 2 sides and total length of crack < 1/2 L of member

Condition State 4 The operative wording is the loss of strength is affecting the serviceability of the structure. That is, the cracks, splits, or checks are located on both sides and extend more than 1/2 the full length of the member.
(NBI item 59 or 60 condition rating of ≤ 4)

crack on 2 sides of member

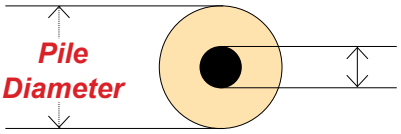
Rating Timber Members that have Decay

Condition State 1 No decay
(NBI item 60 condition rating of 7 or 8)



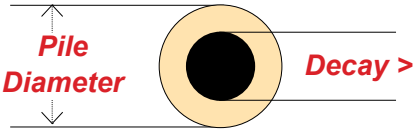
No Decay, wetness or splits

Condition State 2 Decay may exist
- Any noted decay, wetness, soft material or split
(NBI item 60 condition rating of 6)



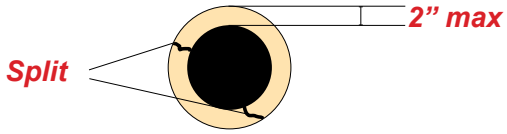
Any Decay or wetness

Condition State 3 Decay not sufficient to affect bridge
- Decay is > 1/2 pile diameter and the shell is > 2
(NBI item 60 condition rating of 5)



Decay > 1/2 diameter

Condition State 4 Decay sufficient to affect bridge
- Wood shell ≤ 2" or the shell has large splits, checks or cracks
(NBI item 60 condition rating of ≤ 4)



***Note**: Decayed Timber members that are located side-by-side, would equate to NBI Rating of "3"*

Timber Member Drilling procedure

1. Sound member and pick the most likely area to drill.
2. Drill a horiz. hole into suspected area that contains the potential decay.
3. If decay is found when drilling (2) drill 1 vertical hole into center of found decay; Drill enough test holes to define the limits of the decay through the member cross section.
4. Sound to locate extent of decay on longitudinal axis.
5. Document findings on the timber boring report.

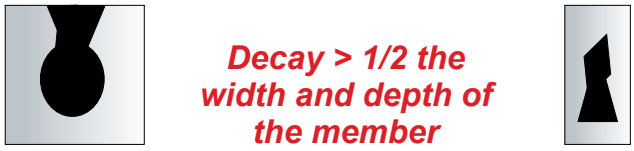
Rating Girders, and Stringers that have Decay:

Conditon State 1 No decay.
(NBI item 59 or 60 condition rating of 7 or 8)

Caps **Girders, Stringers**

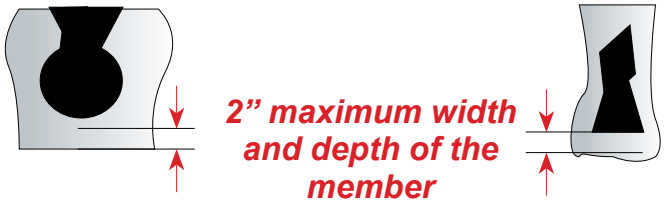
Conditon State 2 Decay may exist -any noted decay, wetness, soft material or split. Decay is > 10% cross-sectional area
(NBI item 59 or 60 condition rating of 5 or 6)

Condition State 3 Decay sufficient to affect element.
Decay is > 30% cross-sectional area
(NBI item 59 or 60 condition rating of 4)



Condition State 4 Decay sufficient to affect bridge or element.
Decay is > 50% cross-sectional area with bulging and crushing of member.
(NBI item 59 or 60 condition rating of ≤ 3)

Bulging, Crush **Bulging, Crush**



#358 - Deck Cracking Smart Flag

Unit of Measure (EA)

This condition state language addresses deck cracking on the topside. It does not include the condition of any AC.

Condition State Descriptions

Note: Use % for each condition state.

1. **The surface of the deck is cracked, but the cracks are either filled/sealed or insignificant in size and density to warrant repair activities.**

2. **Unsealed cracks exist in the deck that are of moderate size (0.025 to 0.060 in. wide) or density (3' to 10' apart).**

3. **Unsealed cracks exist in the deck that are of moderate size (0.025 to 0.060 in. wide) and density (3' to 10' apart).**

4. **Unsealed cracks exist in the deck that are of severe size (>0.060 in. wide) and/or density (<3' apart).**

CS 1

CS 2

CS 3

CS 4

Appendix G
Field Notes, Condition States and Damage Ratings

Deck Cracking

West Trestle

Location	General Description	Condition State	Damage Rating
WT0 to WT2	Structural cracks 1/16" to 3/16" wide at 2 to 3 feet on center in concrete deck along WT1. Concrete deck displaced upwards along WT1 approx. 3 inches	CS-4	Major
WT2 to WT10	General cracks up to 1/16" wide over pile caps and throughout trestle at 4 to 6 feet on center	CS-3	Moderate

Work Pier

Location	General Description	Condition State	Damage Rating
WP1 to WP5	General cracks 1/16" wide present at spacing approx. 12 feet apart	CS-2	Minor
WP5 to WP21	General cracks 1/16" wide present at spacings between 5 feet and 10 feet apart	CS-3	Minor
WP21 to WP25	General cracks 1/16" wide present at spacings approx. 10 feet apart	CS-2	Minor
WP25 to WP32	General cracks 1/16" wide present at spacings approx. 7 feet to 11 feet apart	CS-2	Minor

East Trestle

Location	General Description	Condition State	Damage Rating
ET1 to ET7	Insignificant cracks (less than 1/32" wide) occur approximately 10 feet on center. A general crack up to 1/16" wide by 9'-0" long exists at ET4.	CS-1	Minor

Concrete Decks without Overlay

West Trestle

Location	General Description	Condition State	Damage Rating
WT0 to WT2	Spalls and delamination are present near WT1. Spalls and delamination are greater than 1 inch deep over approx. 10% of the deck area.	CS-4	Major
WT2 to WT10	Gaps in concrete deck are present at construction joints. A gap 1/2" to 1-1/2" wide is present along WT8. A gap 1" wide is present along WP1. A gap 1-1/2" to 2-3/8" wide is present along WP3. Gaps are a source of water leakage on timber framing below. A spall 3" deep by 9" wide by 9" long is present at intersection of WT8 and WP1. A drift pin from a pile below is also exposed at this location. A portion of the concrete deck has been removed along WT8 between WP1 and WP3 and covered with timber decking and steel plates. This removed deck is also a source of leakage below. Edge of deck along WT10 exhibits spalls near bullrail.	CS-2	Minor

Concrete Decks without Overlay (Continued)

Work Pier

Location	General Description	Condition State	Damage Rating
WP1 to WP32	A small spall 1/2" deep by 2" wide by 3" long exist at the construction joint intersection with WP29. A small spall 1" deep by 3" wide by 8" long exist at the construction joint intersection with WP21.	CS-2	Minor

East Trestle

Location	General Description	Condition State	Damage Rating
ET1 to ET7		CS-1	No Defects

Steel Decks (Corrugated)

West Trestle

Location	General Description	Condition State	Damage Rating
WT0 to WT10 exterior metal deck span each side of trestle	Metal deck exhibits active corrosion for about 50% of the metal deck exposed within the exterior metal deck span each side of the trestle. An approximate 2 square foot section of metal deck near WT4 has100% section loss exposing the underside of the concrete deck	CS-4	Major
WT0 to WT10 interior metal deck spans	Approximately 10% of metal deck surface area exhibits isolated areas of rusting and corrosion of the interior metal deck spans.	CS-3	Moderate
WT10	Metal deck exhibits active corrosion within 2 feet from north edge of deck and up to 100% section loss	CS-4	Major

Work Pier

Location	General Description	Condition State	Damage Rating
WP1 to WP32	Approximately 10% of metal deck surface area exhibits isolated areas of rusting and corrosion.	CS-3	Moderate

East Trestle

Location	General Description	Condition State	Damage Rating
ET1 to ET7	Approximately 10% of metal deck surface area exhibits isolated areas of rusting and corrosion.	CS-3	Moderate

Timber Piles

West Trestle

Location	General Description	Condition State	Damage Rating
WT0/C	Abutment pile with decay and 100% section loss	CS-4	Severe
WT0/C.3	Abutment pile with decay and 100% section loss	CS-4	Severe
WT0/C.7	Abutment pile with decay and 100% section loss	CS-4	Severe
WT0/D.3	Abutment pile with decay and 100% section loss	CS-4	Severe

Timber Piles (Continued)

West Trestle (Continued)

Location	General Description	Condition State	Damage Rating
WT0/D.7	Abutment pile with decay and 100% section loss	CS-4	Severe
WT0/E	Abutment pile with decay and 100% section loss	CS-4	Severe
WT1/C		CS-1	No Defects
WT1/D		CS-1	No Defects
WT1/E		CS-1	No Defects
WT2/C		CS-1	No Defects
WT2/D		CS-1	No Defects
WT2/E		CS-1	No Defects
WT3/C		CS-1	No Defects
WT3/D	1/4" split x 2'-0" long @ top	CS-1	Minor
WT3/E	3/8" split x 4'-0" long @ top	CS-2	Minor
WT4/C		CS-1	No Defects
WT4/D		CS-1	No Defects
WT4/E		CS-1	No Defects
WT5/C	1/4" split x 4'-0" long @ top	CS-1	Minor
WT5/D	1/8" split x 4'-0" long @ top	CS-1	Minor
WT5/E		CS-1	No Defects
WT6/C		CS-1	No Defects
WT6/D		CS-1	No Defects
WT6/E	1/4" split x 4'-0" long @ top	CS-1	Minor
WT7/C		CS-1	No Defects
WT7/D		CS-1	No Defects
WT7/E		CS-1	No Defects
WT8/A		CS-1	No Defects
WT8/B		CS-1	No Defects
WT8/C		CS-1	No Defects
WT8/D		CS-1	No Defects
WT8/E		CS-1	No Defects
WT8/F		CS-1	No Defects
WT8/G		CS-1	No Defects
WT9/A		CS-1	No Defects
WT9/B		CS-1	No Defects
WT9/C		CS-1	No Defects
WT9/D		CS-1	No Defects
WT9/E		CS-1	No Defects
WT9/F		CS-1	No Defects
WT9/G		CS-1	No Defects
WT10/A		CS-1	No Defects
WT10/B		CS-1	No Defects
WT10/C	Pile is displaced, loss of bearing	CS-4	Severe
WT10/D		CS-1	No Defects
WT10/E		CS-1	No Defects
WT10/F		CS-1	No Defects
WT10/G		CS-1	No Defects

Timber Piles (Continued)

Work Pier

Location	General Description	Condition State	Damage Rating
WP1/C		CS-1	No Defects
WP1/E		CS-1	No Defects
WP1/F		CS-1	No Defects
WP2/E	1/4" split x 3'-0" long @ top	CS-1	Minor
WP2/F		CS-1	No Defects
WP3/A		CS-1	No Defects
WP3/B		CS-1	No Defects
WP3/C		CS-1	No Defects
WP3/D		CS-1	No Defects
WP4/C		CS-1	No Defects
WP4/D	1/4" split x 2'-0" long @ top	CS-1	Minor
WP5/A		CS-1	No Defects
WP5/B	3/8" split x 3'-0" long @ top	CS-1	Minor
WP5/C		CS-1	No Defects
WP5/D		CS-1	No Defects
WP6/A		CS-1	No Defects
WP6/B		CS-1	No Defects
WP6/C		CS-1	No Defects
WP6/D		CS-1	No Defects
WP7/A		CS-1	No Defects
WP7/B	1/4" split x 2'-6" long @ top	CS-1	Minor
WP7/C		CS-1	No Defects
WP7/D	1/8" split x 1'-6" long @ top	CS-1	Minor
WP8/A		CS-1	No Defects
WP8/B		CS-1	No Defects
WP8/C		CS-1	No Defects
WP8/D		CS-1	No Defects
WP9/A		CS-1	No Defects
WP9/B		CS-1	No Defects
WP9/C		CS-1	No Defects
WP9/D		CS-1	No Defects
WP10/A		CS-1	No Defects
WP10/B	1/4" split x 3'-0" long @ top	CS-1	Minor
WP10/C		CS-1	No Defects
WP10/D		CS-1	No Defects
WP11/A	1/4" split x 3'-0" long @ top	CS-1	Minor
WP11/B		CS-1	No Defects
WP11/C		CS-1	No Defects
WP11/D		CS-1	No Defects
WP12/A		CS-1	No Defects
WP12/B		CS-1	No Defects
WP12/C		CS-1	No Defects
WP12/D		CS-1	No Defects
WP13/A	Displaced pile	CS-4	Severe
WP13/B		CS-1	No Defects
WP13/C		CS-1	No Defects

Timber Piles (Continued)

Work Pier (Continued)

Location	General Description	Condition State	Damage Rating
WP13/D		CS-1	No Defects
WP14/A	1/2" split x 2'-0" long @ top	CS-2	Minor
WP14/B		CS-1	No Defects
WP14/C		CS-1	No Defects
WP14/D		CS-1	No Defects
WP15/A		CS-1	No Defects
WP15/B		CS-1	No Defects
WP15/C		CS-1	No Defects
WP15/D		CS-1	No Defects
WP16/A	1/4" split x 4'-0" long @ top	CS-1	Minor
WP16/B		CS-1	No Defects
WP16/C		CS-1	No Defects
WP16/D		CS-1	No Defects
WP17/A		CS-1	No Defects
WP17/B		CS-1	No Defects
WP17/C		CS-1	No Defects
WP17/D		CS-1	No Defects
WP18/A		CS-1	No Defects
WP18/B		CS-1	No Defects
WP18/C		CS-1	No Defects
WP18/D		CS-1	No Defects
WP19/A		CS-1	No Defects
WP19/B		CS-1	No Defects
WP19/C		CS-1	No Defects
WP19/D		CS-1	No Defects
WP20/A		CS-1	No Defects
WP20/B		CS-1	No Defects
WP20/C		CS-1	No Defects
WP20/D		CS-1	No Defects
WP21/A		CS-1	No Defects
WP21/B		CS-1	No Defects
WP21/C		CS-1	No Defects
WP21/D		CS-1	No Defects
WP22/A		CS-1	No Defects
WP22/B		CS-1	No Defects
WP22/C		CS-1	No Defects
WP22/D		CS-1	No Defects
WP23/A		CS-1	No Defects
WP23/B		CS-1	No Defects
WP23/C		CS-1	No Defects
WP23/D		CS-1	No Defects
WP24/A		CS-1	No Defects
WP24/B	1/4" split x 3'-0" long @ top	CS-1	Minor
WP24/C		CS-1	No Defects
WP24/D		CS-1	No Defects
WP25/A		CS-1	No Defects

Timber Piles (Continued)

Work Pier (Continued)

Location	General Description	Condition State	Damage Rating
WP25/B		CS-1	No Defects
WP25/C		CS-1	No Defects
WP25/D		CS-1	No Defects
WP26/A		CS-1	No Defects
WP26/B	1/4" split x 3'-0" long @ top	CS-1	Minor
WP26/C		CS-1	No Defects
WP26/D		CS-1	No Defects
WP26/E		CS-1	No Defects
WP26/F		CS-1	No Defects
WP27/A		CS-1	No Defects
WP27/B		CS-1	No Defects
WP27/C		CS-1	No Defects
WP27/D	3/16" split x 3'-0" long @ top	CS-1	Minor
WP27/E		CS-1	No Defects
WP27/F		CS-1	No Defects
WP28/A		CS-1	No Defects
WP28/B	1/2" split x 3'-6" long @ top	CS-2	Minor
WP28/C		CS-1	No Defects
WP28/D		CS-1	No Defects
WP28/E		CS-1	No Defects
WP28/F		CS-1	No Defects
WP29/A		CS-1	No Defects
WP29/B		CS-1	No Defects
WP29/C	1/8" split x 3'-0" long @ top	CS-1	Minor
WP29/D		CS-1	No Defects
WP29/E		CS-1	No Defects
WP29/F		CS-1	No Defects
WP30/C		CS-1	No Defects
WP30/D		CS-1	No Defects
WP30/E		CS-1	No Defects
WP30/F		CS-1	No Defects
WP31/D	Pile is displaced, loss of bearing	CS-4	Severe
WP31/E		CS-1	No Defects
WP31/F	1/8" split x 2'-0" long @ top	CS-1	Minor
WP32/A		CS-1	No Defects
WP32/B		CS-1	No Defects
WP32/C		CS-1	No Defects
WP32/D		CS-1	No Defects

Timber Piles (Continued)

East Trestle

Location	General Description	Condition State	Damage Rating
ET0/A		CS-1	No Defects
ET0/B		CS-1	No Defects
ET0.5/A		CS-1	No Defects
ET0.5/B		CS-1	No Defects
ET1/A		CS-1	No Defects
ET1/B		CS-1	No Defects
ET2/A		CS-1	No Defects
ET2/B		CS-1	No Defects
ET3/A		CS-1	No Defects
ET3/B	1/2" split x 3'-0" long @ top	CS-2	Minor
ET4/A		CS-1	No Defects
ET4/B	1/2" split x 3'-0" long @ top	CS-2	Minor
ET5/A	1/2" split x 4'-0" long @ top	CS-2	Minor
ET5/B		CS-1	No Defects
ET6/A	1/2" split x 4'-0" long @ top	CS-2	Minor
ET6/B		CS-1	No Defects
ET7/A		CS-1	No Defects
ET7/B		CS-1	No Defects

Fender Piles (Steel, UNO)

West Trestle

Location	General Description	Condition State	Damage Rating
WT10/A	Surface corrosion but no section loss	N/A	Minor
WT10/B	Surface corrosion but no section loss	N/A	Minor
WT10/D	Surface corrosion but no section loss. Bent or broken bolt connection at pile top	N/A	Moderate
WT10/D.8	Surface corrosion but no section loss. Bent or broken bolt connection at pile top	N/A	Moderate
WT10/E.2	Surface corrosion but no section loss. Bent or broken bolt connection at pile top	N/A	Moderate
WT10/G	Surface corrosion but no section loss. Bent or broken bolt connection at pile top	N/A	Moderate

Work Pier

Location	General Description	Condition State	Damage Rating
WP6	Surface corrosion but no section loss	N/A	Minor
WP7	Surface corrosion but no section loss	N/A	Minor
WP8	Surface corrosion but no section loss	N/A	Minor
WP9	Surface corrosion but no section loss	N/A	Minor
WP10	Surface corrosion but no section loss	N/A	Minor
WP11	Surface corrosion but no section loss	N/A	Minor
WP12A	Surface corrosion but no section loss	N/A	Minor
WP12D	Broken Timber Pile	N/A	Severe
WP13	Surface corrosion but no section loss	N/A	Minor
WP14	Broken Timber Pile	N/A	Severe

Fender Piles (Continued)

Work Pier (Continued)

Location	General Description	Condition State	Damage Rating
WP15	Surface corrosion but no section loss	N/A	Minor
WP16	Surface corrosion but no section loss	N/A	Minor
WP17	Surface corrosion but no section loss	N/A	Minor
WP18	Broken Timber Pile	N/A	Severe
WP19	Surface corrosion but no section loss	N/A	Minor
WP19D	Broken Timber Pile	N/A	Severe
WP20	Surface corrosion but no section loss	N/A	Minor
WP21	Surface corrosion but no section loss	N/A	Minor
WP22	Surface corrosion but no section loss	N/A	Minor
WP23	Surface corrosion but no section loss	N/A	Minor
WP24	Surface corrosion but no section loss	N/A	Minor
WP25	Broken Timber Pile	N/A	Severe
WP26	Surface corrosion but no section loss	N/A	Minor
WP26F	Broken Timber Pile	N/A	Severe
WP27	Surface corrosion but no section loss. Impact dents in pile approximately 6" long by 1" deep, 2 places. Permanent pile deformation	N/A	Moderate
WP28	Surface corrosion but no section loss	N/A	Minor
WP29	Surface corrosion but no section loss. Impact dent in pile approximately 6" long by 1" deep, 1 place. Permanent pile deformation	N/A	Moderate
WP32A	Surface corrosion but no section loss	N/A	Minor
WP32B	Broken Timber Pile	N/A	Severe
WP32C	Surface corrosion but no section loss	N/A	Minor
WP32C.5	Broken Timber Pile	N/A	Severe
WP32D.5	Surface corrosion but no section loss	N/A	Minor

East Trestle

Location	General Description	Condition State	Damage Rating
ET5	Broken Timber Pile	N/A	Severe
ET6	Surface corrosion but no section loss	N/A	Minor
ET6.5	Broken Timber Pile	N/A	Severe

Timber Pile Caps

West Trestle

Location	General Description	Condition State	Damage Rating
WT1		CS-1	No Defects
WT2	Small superficial split at east end of pile cap	CS-1	No Defects
WT3		CS-1	No Defects
WT4		CS-1	No Defects
WT5		CS-1	No Defects
WT6		CS-1	No Defects
WT7	Wetness & decay, ~2" deep x 6" long x 8" high at east end of pile cap, in bearing area	CS-2	Minor

Timber Pile Caps (Continued)

West Trestle (Continued)

Location	General Description	Condition State	Damage Rating
WT8	Wetness, no decay but growth on exterior surface, between piles WTC & WTG	CS-1	No Defects
WT9		CS-1	No Defects
WT10: Pile A to B	Decay at west end of pile cap ~3" deep. Wetness and evidence of decay throughout length ~ 10%<decay<25% (8LF).	CS-2	Moderate
WT10: Pile B to D	Pile WT10C displaced and not providing bearing support. Deformation of pile cap (13LF).	CS-4	Severe
WT10: Pile D to F	Broken pile cap at WT10E (13LF).	CS-4	Severe
WT10: Pile A to B	Wetness and evidence of decay throughout length ~ 10%<decay<25% (7LF).	CS-2	Moderate

Work Pier

Location	General Description	Condition State	Damage Rating
WP1		CS-1	No Defects
WP2		CS-1	No Defects
WP3		CS-1	No Defects
WP4		CS-1	No Defects
WP5		CS-1	No Defects
WP6		CS-1	No Defects
WP7		CS-1	No Defects
WP8		CS-1	No Defects
WP9		CS-1	No Defects
WP10	1/4" split x 1/2 member length on one face	CS-1	Minor
WP11		CS-1	No Defects
WP12		CS-1	No Defects
WP13	6x12 ledger each side of steel beam with 1/4" split x 1/2 member length at 1-side. Fracture and decay at west end of ledger. Pile WP13/A displaced and not providing support and subcap fractured and displaced.	CS-4	Severe
WP14		CS-1	No Defects
WP15		CS-1	No Defects
WP16		CS-1	No Defects
WP17		CS-1	No Defects
WP18		CS-1	No Defects
WP19		CS-1	No Defects
WP20		CS-1	No Defects
WP21		CS-1	No Defects
WP22		CS-1	No Defects
WP23		CS-1	No Defects
WP24	1/8" split x 1/3 member length at bottom	CS-1	Minor
WP25	3/16" split x 3/4 member length at one face, middle	CS-1	Minor
WP26	3/8" split x 1/4 member length at one face, south end	CS-2	Minor

Timber Pile Caps (Continued)

Work Pier (Continued)

Location	General Description	Condition State	Damage Rating
WP27	6x12 ledger each side of steel beam	CS-1	No Defects
WP28	1/8" split x 1/4 member length at bottom south end, split at north end of cap bottom 1/8" x 3'-0"	CS-2	Minor
WP29	1/4" split x 1/2 member length on one face, south end	CS-1	Minor
WP30		CS-1	No Defects
WP31	Pile WP31D displaced and not providing bearing support.	CS-4	Severe
WP32		CS-1	No Defects

East Trestle

Location	General Description	Condition State	Damage Rating
ET0		CS-1	No Defects
ET0.5		CS-1	No Defects
ET1	1/4" split x 3/4 member length at one face	CS-1	Minor
ET2		CS-1	No Defects
ET3		CS-1	No Defects
ET4		CS-1	No Defects
ET5		CS-1	No Defects
ET6		CS-1	No Defects
ET7		CS-1	No Defects

Unpainted Steel Beams & Pile Caps

Work Pier

Location	General Description	Condition State	Damage Rating
WP13	Pile cap (~W21x50) corrosion at bottom flange, flaking with measurable section loss. Pile WP13/A displaced and not providing support.	CS-4	Severe
Between WP12 &14 and WPA & C	Miscellaneous steel hold-down beams and bolts exhibit surface corrosion.	CS-2	Minor
WP27	Pile cap (~W21x50) corrosion at bottom flange, flaking with measurable section loss.	CS-3	Minor
Between WP26 &28 and WPA & B	Miscellaneous steel hold-down beams and bolts for crane on deck above exhibit surface corrosion.	CS-2	Minor
WPD/28 to 30	Wide flange beam exhibits surface corrosion.	CS-2	Minor

Unpainted Steel Battered Piles

Work Pier

Location	General Description	Condition State	Damage Rating
WP8/B	Steel battered piles and connection plates exhibit surface corrosion.	CS-2	Minor
WP13/B	Steel battered piles and connection plates exhibit surface corrosion.	CS-2	Minor
WP27/B	Steel battered piles and connection plates exhibit surface corrosion.	CS-2	Minor
WP29/D	Steel battered piles and connection plates exhibit surface corrosion.	CS-2	Minor

Reinforced Concrete Abutment

West Trestle

Location	General Description	Condition State	Damage Rating
WT0	Scour has occurred below concrete abutment. Timber piles supporting concrete abutment exhibit 100% section loss. Abutment has settled 2 to 6 inches. Minor cracks present in abutment.	CS-4	Severe

Timber Beams/Joists

West Trestle

Location	General Description	Condition State	Damage Rating
Span WT0-1	Single-span beams. Exterior beams exhibit wetness with some growth on exterior face. Joists have rotated due to settlement of abutment.	CS-2	Minor
Span WT1-2	Single-span beams. Exterior beams exhibit wetness with some growth on exterior face. Wetness at beams near WT1 from cracks in deck.	CS-1	No Defects
Span WT2-3	Single-span beams. Exterior beams exhibit wetness with some growth on exterior face. 1/8" split x 1/2 member length at 2nd beam from west exterior side of trestle	CS-1	Minor
Span WT3-4	Single-span beams. Exterior beams exhibit wetness with some growth on exterior face.	CS-1	No Defects
Span WT4-5	Single-span beams. Exterior beams exhibit wetness with some growth on exterior face.	CS-1	No Defects
Span WT5-6	Single-span beams. Exterior beams exhibit wetness with some growth on exterior face.	CS-1	No Defects
Span WT6-7	Single-span beams. Exterior beams exhibit wetness with some growth on exterior face.	CS-1	No Defects
Span WT7-8	Single-span beams. Exterior beams exhibit wetness with some growth on exterior face.	CS-1	No Defects

Timber Beams/Joists (Continued)

West Trestle (Continued)

Location	General Description	Condition State	Damage Rating
Span WT8-10 between WTA & WTC	Two-span beams. West exterior beam near north end exhibits decay for middle 1/2 beam depth by 2 1/2" deep by 1'-6" long from north end (approximately 25% section loss) . Other beams exhibit approximately 10% decay at north ends of beam by 6" long, but decay is beyond the bearing area. All other locations of beams are sound.	CS-2	Moderate
Span WT8-10 between WTC & WTE	Two-span beams. Beams exhibit approximately 10% decay at north ends of beam by 6" long, but decay is beyond the bearing area. All other locations of beams are sound.	CS-2	Moderate
Span WT8-10 between WTE & WTF	Two-span beams. Leakage in deck above causing wetness at south end of beams. South end of beams exhibit 1" deep decay, but this is outside of the beam bearing area. Beam just east of grid WP1 exhibits 3 1/2" deep decay in bearing area x 1/4 the beam height. Approximately 10% decay present at north ends of beam by 1'-0" long and partially into bearing area. All other locations of beams are sound.	CS-2	Moderate

Work Pier

Location	General Description	Condition State	Damage Rating
Span WP1-3	Single-span beams	CS-1	No defects
Span WP3-5	Two-span beams	CS-1	No defects
Span WP5-7	Two-span beams	CS-1	No defects
Span WP7-9	Two-span beams	CS-1	No defects
Span WP9-11	Two-span beams	CS-1	No defects
Span WP11-13	Two-span beams	CS-1	No defects
Span WP13-15	Two-span beams	CS-1	No defects
Span WP15-17	Two-span beams	CS-1	No defects
Span WP17-19	Two-span beams	CS-1	No defects
Span WP19-21	Two-span beams	CS-1	No defects
Span WP21-23	Two-span beams	CS-1	No defects
Span WP23-25	Two-span beams	CS-1	No defects
Span WP25-27	Two-span beams	CS-1	No defects
Span WP26-28	Two-span beams	CS-1	No defects
Span WP27-28	Single-span beams	CS-1	No defects
Span WP26-28	Two-span beams	CS-1	No defects
Span WP28-29	Single-span beams	CS-1	No defects
Span WP28-30	Two-span beams	CS-1	No defects
Span WP29-32	Single-span beams	CS-1	No defects
Span WP30-31	Single-span beams	CS-1	No defects

Timber Beams/Joists (Continued)

East Trestle

Location	General Description	Condition State	Damage Rating
Span ET0-0.5	Single-span beams	CS-1	No defects
Span ET0.5-2	Two-span beams	CS-1	No defects
Span ET2-4	Two-span beams	CS-1	No defects
Span ET4-6	Two-span beams	CS-1	No defects
Span ET6-WP31	Two-span beams	CS-1	No defects

Timber Braces

West Trestle

Location	General Description	Condition State	Damage Rating
Pile top WT2/C		N/A	No defects
Pile top WT2/E		N/A	No defects
Pile top WT3/C		N/A	No defects
Pile top WT3/E		N/A	No defects
Pile top WT4/C		N/A	No defects
Pile top WT4/E	Brace in longitudinal direction with split at top	N/A	Minor
Pile top WT5/C	Brace in longitudinal direction broken at lower connection, below water.	N/A	Severe
Pile top WT5/E		N/A	No defects
Pile top WT6/C		N/A	No defects
Pile top WT6/E		N/A	No defects
Pile top WT7/C		N/A	No defects
Pile top WT7/E		N/A	No defects
Pile top WT8/A		N/A	No defects
Pile top WT8/C		N/A	No defects
Pile top WT8/D		N/A	No defects
Pile top WT8/E		N/A	No defects
Pile top WT8/G		N/A	No defects
Pile top WT9/A		N/A	No defects
Pile top WT9/D		N/A	No defects
Pile top WT9/G		N/A	No defects
Pile top WT10/A	Brace in longitudinal direction with 1/8" split at top	N/A	Minor
Pile top WT10/E	Brace in longitudinal direction broken	N/A	Severe
Pile top WT10/G	Brace in transverse direction broken at lower connection	N/A	Severe
Pile top WT10/G	Brace in longitudinal direction, decay near top approx. 25%	N/A	Moderate

Timber Bullrail

West Trestle

Location	General Description	Condition State	Damage Rating
WT0 to WT8 West Side	1/16" splits at top of bullrail for approx. 1/4 length of bullrail. Evidence of minor decay.	N/A	Minor
WT8 from WTA to WTC West Side	Decay with cross section loss greater than 50%	N/A	Severe
WT8 to WT10 West Side	Decay with cross section loss between 25% and 50%	N/A	Major
WT10 from WTA to WTC North Side	Checks and splits less than 0.5 inches, evidence of decay	N/A	Minor
WT10 from WTC to WTE North Side	Steel pipe bullrail over timber bullrail. Pipe does not appear to have connection to deck.	N/A	Moderate
WT10 from WTF to WTG North Side	No bullrail present	N/A	Major
WT0 to WT7 East Side	1/16" to 1/8" splits at top of bullrail for approx. 1/2 length of bullrail. Evidence of minor decay.	N/A	Minor

Work Pier

Location	General Description	Condition State	Damage Rating
WP1 to WP31 Shore Side		N/A	No Defects
WP5 River Side	Missing bullrail support block	N/A	Moderate
WP1 to WP31 River Side	12x12 bullrail with minor rounding at top edges	N/A	Minor

East Trestle

Location	General Description	Condition State	Damage Rating
ET0 to ET0.5 South Side	12x12 bullrail displaced and connection broken. Approx. 9'-9" long section	N/A	Major
ET0.5 to ET7 South Side	12x12 bullrail with minor rounding at top edges	N/A	No Defects
ET0 to ET7 North Side	12x12 bullrail with minor rounding at top edges	N/A	No Defects

Timber Railing

West Trestle

Location	General Description	Condition State	Damage Rating
WT0 to WT8 West Side	No horizontal mid rails present	N/A	Minor
WT0 to WT7 East Side	No horizontal mid rails present	N/A	Minor

Work Pier

Location	General Description	Condition State	Damage Rating
WP1 to WP28		N/A	No defects
WP28	Loose connection at horizontal rail	N/A	Minor
WP28 to WP31		N/A	No defects

East Trestle

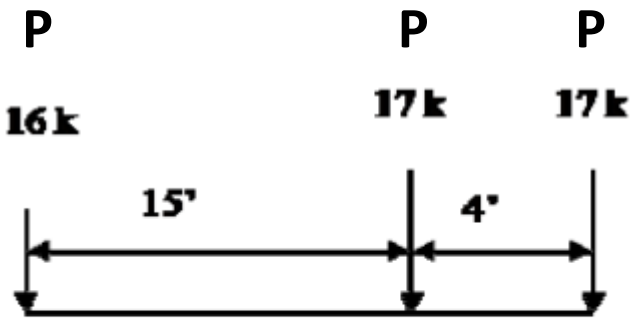
Location	General Description	Condition State	Damage Rating
ET1 to ET2	Missing bottom and mid rail at south side of trestle	N/A	Severe
ET2 to ET3		N/A	No defects
ET3 to ET6	Missing bottom rail at south side of trestle	N/A	Severe
ET6 to ET7		N/A	No defects

Appendix H
Load Rating Calculations

WARRENTON MARINA WORK PIER – LOAD RATING ASSUMPTIONS

List of Assumptions – General:

1. The load rating includes deck elements, pile caps, joists and concrete over metal deck.
2. Piles are not included with load rating.
3. Railings are not included with the load rating.
4. For beam element analysis, conservatively neglect effects of cantilevers when the cantilever length is less than 25% of the adjacent span length.
5. RISA 3D software used to analyze maximum moments and shears for flexural elements with cantilevers and/or unequal spans.
6. RISA 3D software used to analyze maximum moments and shears for flexural elements with rolling Type 3 truck load.
7. Maximum allowable uniform load w_{max} was determined using Excel spreadsheets
8. Maximum truck load is based on a Type 3 truck axle spacing and loads then loads are factored down to provide maximum gross vehicle truck weight in pounds.
9. Check load rating for Type 3 legal truck only. Bull rail plus 1 foot vehicle clearance prevents load from being applied on outer stringer. Apply truck load to interior beams only.
10. Truck wheels are spaced at 6 feet apart



Type 3 (LRFR & LFR Methods)
Figure 13.1-3

List of Assumptions – Floor Joist Analysis:

1. C_D = 1.0 for all, Occupancy Live Load
2. C_M = 1.0 for all, shielded by floor deck above, not fully saturated
3. C_L = 1.0 for all areas. Whole system is stable even where blocking is not located, the thick concrete decking above prevents joists from rotation since a very rigid system
4. C_F = 1.0 for all members
5. C_i = 0.8 for Bending and Shear, = 0.95 for E, most all wood was incised, controlling cases were incised.
6. All joists are 5x5 timbers or larger therefore assumed Doug Fir Larch, Structural Gr. 1, Fb = 1350 psi, Fv = 170 psi
7. Max Moment for Single Span = $wL^2/8$
8. Max Moment for Double Span, Unequal Spans = - $(wL_2^3+wL_1^3)/(8(L_1+L_2))$ [Negative Moment over support Controls]

9. Max Moment for Cantilevered Condition = $wa^2/2$
10. No composite action between deck slab and joists was assumed.
11. No fixity at end of joists was assumed.
12. 2" bearing of joists on pile cap was used for design span used throughout calculations.
13. Joist live load distribution factor for Type 3 Truck assumes 2 joists resist one wheel load, therefore live load distribution is 1/2 of single wheel load, or 1/4 of single Type 3 Truck axle load.
14. For Type 3 Truck axle loads on joists, full axle loads was used in the RISA 3D analysis to determine moment and shear envelope forces. Then the forces were reduced by appropriate distribution factors

List of Assumptions – Pile Cap Analysis:

1. Pile caps were analyzed as single, double or triple spans. Some with cantilevers, where occurs.
2. All pile caps were analyzed as incised
3. All pile caps are 5x5 timbers or larger therefore assumed Doug Fir Larch, Structural Gr. 1, Fb = 1350 psi, Fv = 170 psi

List of Assumptions – Concrete Deck Analysis:

1. Assume concentrate wheel loads are applied as follows
    a. Contact area of two tires on tandem rear axle is 10" x 20"
    b. Contact area of single tire on single front axle is 10" x 10"
2. Assume wheel contact area loads at the slab surface are distributed to the metal deck below at a 1 to 1 ratio.
3. Assume metal decking non-composite with concrete slab. Metal deck checked for flexure without considering concrete slab.
4. The deck at the Work Pier and East Trestle is reinforced with #4 @ 12" O.C. near mid-depth of the 3 3/4" slab thickness. The deck capacity was determined using a reinforced concrete slab section 3 3/4" deep (f'c = 3000psi assumed). Moment capacity of reinforced slab is based on simple span.
5. The deck at the West Trestle is unreinforced concrete approximately 3" thick over 1 1/2" metal deck. The deck capacity was determined using a unreinforced concrete slab section 3" deep (f'c = 3000psi assumed). Sm = $bd^2/6$, tension controlled, b = 1 ft (per unit width of slab), use Chapter 22 equation 22-2 ACI 318-11 to find capacity. Compare that to demand, Mu = $wL^2/8$
6. Pile cap live load distribution factor for Type 3 Truck axle loads is the (Trib Width - 2ft)/Trib Width. A simple span between pile caps. Note: Reaction is based on two axle loads of 17 kips spaced 4 feet apart.
7. For Type 3 Truck axle loads on pile caps, two 17 kip axle loads placed 6 feet apart was modeled as a rolling load and used in the RISA 3D analysis to determine moment and shear envelope forces. Then the forces were reduced

Beam Moment and Shears Diagrams

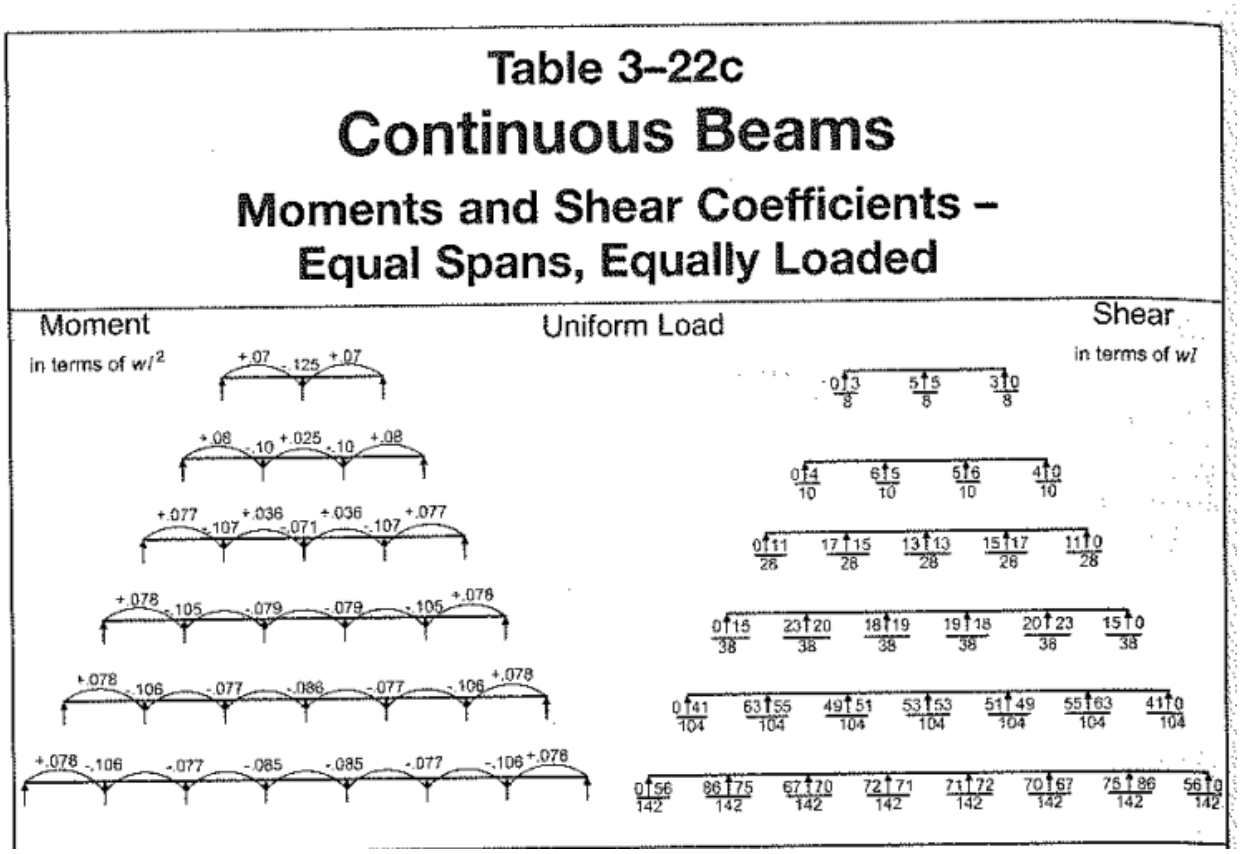
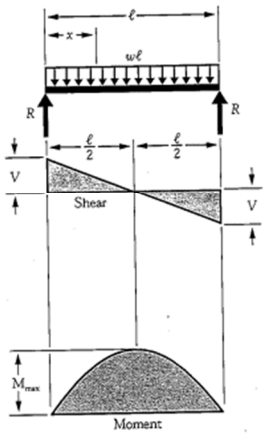


Figure 1 Simple Beam – Uniformly Distributed Load



$$R = V \quad \ldots\ldots\ldots\ldots = \frac{w\ell}{2}$$

$$V_x \quad \ldots\ldots\ldots\ldots = w\left(\frac{\ell}{2} - x\right)$$

$$M_{max}\ (\text{at center}) \quad \ldots\ldots = \frac{w\ell^2}{8}$$

$$M_x \quad \ldots\ldots\ldots\ldots = \frac{wx}{2}(\ell - x)$$

$$\Delta_{max}\ (\text{at center}) \quad \ldots\ldots = \frac{5w\ell^4}{384\,EI}$$

$$\Delta_x \quad \ldots\ldots\ldots\ldots = \frac{wx}{24\,EI}(\ell^3 - 2\ell x^2 + x^3)$$

Timber Elements

Location		Beam Description				Cantilver/Span Lengths (ft)					Properties						Allowable Bending Stress (psi)												Allowable Shear Stress						Total Allowable Load From Bending			Total Allowable Load From Shear				Controlling Total Load (PSF)	Element Self Weights (PSF)				Maximum Live Load (PSF)
Section	Grids	Notes	Type	Size (nom.)	Trib. Width (ft)	Cant-L	L1	L2	L3	Cant-R	b (in)	d (in)	A (in2)	S (in3)	I (in4)	d/b	Fb	CD	CM	Ct	CF	Cfu	Ci	Cr	Fb*	CL	Fb'	Fv	CD	CM	Ct	Ci	Fv'	Ma= Fb'*S (ft-lbs)	Md/1plf	wa= Ma/(Md/1plf)	wa/trib (PSF)	Va= (A*Fv'/1.5) (lbs)	Vd/1plf	wa= Va/(Vd/1plf)	wa/trib (PSF)		Deck	Joists	Pile Caps	Total	
East Trestle	ET0 to ET0.5	Typical single span	Joist	6x12	2.0		4.67				5.5	11.5	63.3	121.2	697.1	2.1	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	10910.6	2.73	4002.3	2001.1	5734.7	2.3	2456.0	1228.0	1228.0	50.2	7.7		57.9	1170.1
	ET2 to ET4	Typical double equal span	Joist	6x12	2.0		10.10	10.10			5.5	11.5	63.3	121.2	697.1	2.1	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	10910.6	12.75	855.7	427.8	5734.7	6.3	908.5	454.2	427.8	50.2	7.7		57.9	369.9
	Typical	Typical single span	Pile Cap	12x12	10.1		9.67				11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	22813.1	11.69	1951.7	193.2	11990.7	4.8	2480.0	245.5	193.2	50.2	7.7	3.2	61.1	132.2
																																											Controlling Live Load (PSF)					132.2
Work Pier	WP1 to WP3	Typical single span	Joist	6x12	2.0		11.50				5.5	11.5	63.3	121.2	697.1	2.1	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	10910.6	16.53	660.0	330.0	5734.7	5.8	997.3	498.7	330.0	50.2	7.7		57.9	272.1
	WP5 to WP7	Typical double equal span	Joist	6x12	2.0		10.25	10.25			5.5	11.5	63.3	121.2	697.1	2.1	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	10910.6	13.13	830.8	415.4	5734.7	6.4	895.2	447.6	415.4	50.2	7.7		57.9	357.5
	At WP1, WPC to WPE	1 span + cantilever	Pile Cap	12x12	6.5		9.75			5.25	11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	22813.1	14.00	1629.5	250.7	11990.7	6.0	1998.4	307.5	250.7	50.2	7.7	4.9	62.8	187.9
	At WP3, WPC to WPD	Single span	Pile Cap	12x12	8.8		11.50				11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	22813.1	16.53	1380.0	157.7	11990.7	5.8	2085.3	238.3	157.7	50.2	7.7	3.7	61.6	96.2
	At WP6, WPA to WPC	Double equal span	Pile Cap	12x12	10.2		9.67	9.67			11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	22813.1	11.69	1951.7	191.9	11990.7	6.0	1984.0	195.1	191.9	50.2	7.7	3.2	61.0	130.9
	At WP6, WPC to WPD	Single span	Pile Cap	12x12	10.2		8.75				11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	22813.1	9.57	2383.7	234.4	11990.7	4.4	2740.7	269.5	234.4	50.2	7.7	3.2	61.0	173.3
	At WP28, WPA to WPD	Triple equal span	Pile Cap	12x12	10.2		9.83	9.83	9.83		11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	22813.1	9.66	2360.9	232.1	11990.7	5.9	2033.0	199.9	199.9	50.2	7.7	3.2	61.0	138.9
	At WP28, WPD to WPF	2 spans + cantilever	Pile Cap	12x12	10.2		8.83	7.71		3.17	11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	22813.1	7.00	3259.0	320.5	11990.7	5.0	2398.1	235.8	235.8	50.2	7.7	3.2	61.0	174.8
																																											Controlling Live Load (PSF)					96.2
Work Pier w/ deterioration	At WP31, WPD to WPF	Displaced pile, worst case	Pile Cap	12x12	8.9	8.00	7.71			3.17	11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	22813.1	32.00	712.9	80.0	11990.7	8.0	1498.8	168.1	80.0	50.2	7.7	3.6	61.5	18.5
	At WP31, WPD to WPF_100psf	Displaced pile (max cantilever for 100psf LL)	Pile Cap	12x12	8.9	5.50	7.71			3.17	11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	22813.1	15.00	1520.9	170.6	11990.7	6.0	1998.4	224.2	170.6	50.2	7.7	3.6	61.5	109.1
																																											Controlling Live Load (PSF)					18.5
West Trestle	WT7 to WT8	Typical single span	Joist	6x18	1.5		18.08				5.5	17.5	96.3	280.7	2456.4	3.2	1350.0	1.00	1.00	1.00	0.96	1.00	0.80	1.00	1036	1.00	1036	170	1.00	1.00	1.00	0.80	136	24228.3	40.86	592.9	395.3	8726.7	9.0	965.3	643.6	395.3	42.7	15.6		58.3	337.0
	WT8 to WT10	Typical double equal span	Joist	6x18	1.5		9.67	9.67			5.5	17.5	96.3	280.7	2456.4	3.2	1350.0	1.00	1.00	1.00	0.96	1.00	0.80	1.00	1036	1.00	1036	170	1.00	1.00	1.00	0.80	136	24228.3	11.69	2072.8	1381.9	8726.7	6.0	1443.9	962.6	962.6	42.7	15.6		58.3	904.3
	Typical	Typical double equal span	Pile Cap	14x12	17.9		6.67	6.67			13.5	11.5	155.3	297.6	1711.0	0.9	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	26780.6	5.56	4815.7	269.4	14076.0	4.2	3376.6	188.9	188.9	42.7	15.6	2.1	60.4	128.5
	At WT9, WTA to WTD	Triple equal span	Pile Cap	14x12	9.5		6.67	6.67	6.67		13.5	11.5	155.3	297.6	1711.0	0.9	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	26780.6	4.45	6019.6	630.7	14076.0	4.0	3517.2	368.5	368.5	42.7	15.6	4.0	62.2	306.2
																																											Controlling Live Load (PSF)					128.5
West Trestle w/ deterioration	WT8 to WT10	Cant. Joist at broken pile cap	Joist	6x18	1.5		9.67			9.67	5.5	17.5	96.3	280.7	2456.4	3.2	1350.0	1.00	1.00	1.00	0.96	1.00	0.80	1.00	1036	1.00	1036	170	1.00	1.00	1.00	0.80	136	24228.3	47.00	515.5	343.7	8726.7	10.0	872.7	581.8	343.7	42.7	15.6		58.3	285.4
	At WT9, WTA to WTD	Pile cap supporting cantilever joist, worst case	Pile Cap	14x12	14.5		6.67	6.67	6.67		13.5	11.5	155.3	297.6	1711.0	0.9	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	26780.6	4.45	6019.6	415.0	14076.0	4.0	3517.2	242.5	242.5	42.7	15.6	2.6	60.9	181.6
																																											Controlling Live Load (PSF)					181.6

Steel Elements

Location		Beam Description				Cantilver/Span Lengths					Properties					Allowable Moment		Moment Demand	Allowable Load From Bending			Allowable Shear		Shear Demand	Allowable Load From Shear		Controlling Total Load (PSF)	Element Self Weights (PSF)				Maximum Live Load (PSF)
Section	Grids	Notes	Type	Size (nom.)	Trib. Width (ft)	Cant-L	L1	L2	L3	Cant-R	A (in2)	S (in3)	Z (in4)	I (in4)	Fy (ksi)	Ωb	Ma= FyZ/Ω (k-ft)	Md/1klf	wa= Ma/(Md/1klf)	wa/trib (PSF)	Ωv	Va= 0.6(A*Fv)/Ω (kip)	Vd/1klf	wa= Va/(Vd/1klf)	wa/trib (PSF)		Deck	Joists	Pile Caps	Total	
Work Pier	AT WP13, WPA to WPC	Displaced pile, steel beam	Pile Cap	W21x50	10.2	10.9	9.0				14.7	94.5	110.0	984.0	50.0	1.67	274.5	59.4	4.6	454.3	1.67	264.1	11.1	23.8	2339.3	454.3	50.2	7.7	4.9	62.8	391.5
																										Controlling Live Load (PSF)					391.5

Deck

Location		Beam Description				Cantilver/Span Lengths					Properties					Allowable Moment		Moment Demand	Allowable Load From Bending		Allowable Shear		Shear Demand	Allowable Load From Shear		Governing Total Load (PSF)	Element Self Weights (PSF)				Maximum Live Load (PSF)
Section	Grids	Notes	Type	Size (nom.)	Trib. Width (ft)	Cant-L	L1	L2	L3	Cant-R	A (in2)	S (in3)	Z (in4)	I (in4)	Fy (ksi)	Ωb	Ma= FyS/Ω (k-ft)	Md/1klf	Ma/(Md/1klf)=wa	wa/trib=PSF	Ωv	er ASC 26ga, 3" End be	Vd/1klf	Va/(Vd/1klf)=wa	wa/trib=PSF		Deck	Joists	Pile Caps	Total	
East Trestle/Worl	Typical Deck	Assume 26gage, 7/8" deck similar to ASC C0.9-32	Decking	7/8"	1.0		2.0				0.285	0.060	N/A	0.028	80.0	1.67	0.240	0.500	0.479	479.0	1.67	0.460	1.0	0.460	460.0	460.0	50.2			50.2	409.8
																										Controlling Live Load (PSF)					409.8
West Trestle	Typical Deck	Assume 26gage, 1 3/8" deck similar to ASC C1.4-32	Decking	1 3/8"	1.0		1.5				0.172	0.101	N/A	0.078	80.0	1.67	0.403	0.281	1.434	1433.6	1.67	0.517	0.8	0.689	689.3	689.3	42.7			42.7	646.6
																										Controlling Live Load (PSF)					646.6
West Trestle w/ Deterioration	West/east edge	50% section loss average	Decking	1 3/8"	1.0		1.5				0.086	0.051	N/A	0.078	80.0	1.67	0.202	0.281	0.717	716.8	1.67	0.259	0.8	0.345	344.7	344.7	42.7			42.7	302.0
																										Controlling Live Load (PSF)					302.0

Notes:

1 Conservatively neglect effects of cantilevers when cantilever length is less than 25% of adjacent span length
2 Ma = Moment capacity of section
3 Va = Shear capacity of section
4 Md/1plf = maximum moment demand per applied uniform unit load of 1plf (ft-lbs/1plf)
5 Vd/1plf = maximum shear demand per applied uniform unit load of 1plf (lbs/1plf)
6 Single span moment Md/1plf is simple span beam moment per distributed unit load of 1plf = L^2/8
7 Single span shear Vd/1plf is simple span beam shear per distributed unit load of 1plf = L/2
8 Double equal span moment Md/1plf is maximum double equal span negative beam moment over the support for a distributed unit load of 1plf = 0.125*L^2
9 Double equal span shear Vd/1plf is maximum double equal span shear at intermediate support for a distributed unit load of 1plf = 0.625*L
10 Triple equal span moment Md/1plf is maximum triple equal span negative beam moment over the support for a distributed unit load of 1plf = 0.10*L^2
11 Trible equal span shear Vd/1plf is maximum triple equal span shear at intermediate support for a distributed unit load of 1plf = 0.60*L
12 Beams with cantilvers use RISA 3D analysis to determine maximum bending (Md/1plf) and shear (Vd/1plf) in elememnt per unit load of 1plf

Timber Elements

Location		Beam Description				Cantilever & Span Lengths (ft)					Properties						Allowable Bending Stress (psi)												Allowable Shear Stress					Element Self Weights					Beam Moment Capacity	Beam Shear Capacity	Beam Forces From Self Weights Only			Allowable Live Load Moment		Allowable Live Load Shear	Type 3 Truck Load (RISA 3D Forces)			Truck Axle Load Distribution Factor to Beam	Type 3 Truck Load with LL Distribution Factor			Controling Ratio of Allowable LL Force to Type 3 Truck LL Force	Maximum GVW based on Type 3 Truck (kips)
Section	Grids	Notes	Type	Size (nom.)	Trib. Width (ft)	Cant-L	L1	L2	L3	Cant-R	b (in)	d (in)	A (in2)	S (in3)	I (in4)	d/b	Fb	CD	CM	Ct	CF	Cfu	Ci	Cr	Fb*	CL	Fb'	Fv	CD	CM	Ct	Ci	Fv'	Deck (PSF)	Joists (PSF)	Pile Caps (PSF)	Total (PSF)	Total PSF x trib (PLF)	Ma= Fb'*S (ft-lbs)	Va= (A*Fv'/1.5) (lbs)	Moment +Md (ft-lbs)	Moment -Md (ft-lbs)	Shear Vd (lbs)	+MLLa = Ma - (+M)	-MLLa = Ma - (-M)	VLLa = Va - Vd	Moment +M (ft-lbs)	Moment -M (ft-lbs)	Shear V (lbs)		Moment +M (ft-lbs)	Moment - M (ft-lbs)	Shear V (lbs)		
East Trestle	ET0 to ET0.5	Typical single span	Joist	6x12	2.0		4.67				5.5	11.5	63.3	121.2	697.1	2.1	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7		57.9	115.8	10910.6	5734.7	315.6	0.0	270.3	10595.0	10910.6	5464.3	19385.0	0.0	14561.0	0.25	4846.25	0.00	3640.25	1.50	75.1
	ET2 to ET4	Typical double equal span	Joist	6x12	2.0		10.10	10.10			5.5	11.5	63.3	121.2	697.1	2.1	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7		57.9	115.8	10910.6	5734.7	826.7	1476.3	730.8	10083.9	9434.4	5003.8	44546.0	27123.0	28600.0	0.25	11136.50	6780.75	7150.00	0.70	35.0
	Typical	Typical single span	Pile Cap	12x12	10.1		9.67				11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7	3.2	61.1	616.8	22813.1	11990.7	7209.5	0.0	2982.2	15603.6	22813.1	9008.4	51496.0	0.0	24612.0	0.80	41298.77	0.00	19738.34	0.38	18.9
																																																					Controlling GVW (kips)	18.9
Work Pier	WP1 to WP3	Typical single span	Joist	6x12	2.0		11.50				5.5	11.5	63.3	121.2	697.1	2.1	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7		57.9	115.8	10910.6	5734.7	1913.9	0.0	665.7	8996.7	10910.6	5069.0	66406.0	0.0	26609.0	0.25	16601.50	0.00	6652.25	0.54	27.1
	WP5 to WP7	Typical double equal span	Joist	6x12	2.0		10.25	10.25			5.5	11.5	63.3	121.2	697.1	2.1	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7		57.9	115.8	10910.6	5734.7	851.4	1520.4	741.7	10059.2	9390.2	4993.0	45562.0	27796.0	28364.0	0.25	11390.50	6949.00	7091.00	0.70	35.2
	At WP1, WPC to WPE	1 span + cantilever	Pile Cap	12x12	6.5		9.75			5.25	11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7	4.9	62.8	408.4	22813.1	11990.7	2444.0	5623.0	2566.0	20369.1	17190.1	9424.7	52284.0	110500.0	34000.0	0.69	36196.62	76500.00	23538.46	0.22	11.2
	At WP3, WPC to WPD	Single span	Pile Cap	12x12	8.8		11.50				11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7	3.7	61.6	538.7	22813.1	11990.7	8904.6	0.0	3097.2	13908.5	22813.1	8893.4	66406.0	0.0	26609.0	0.77	51227.49	0.00	20526.94	0.27	13.6
	At WP6, WPA to WPC	Double equal span	Pile Cap	12x12	10.2		9.67	9.67			11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7	3.2	61.0	620.9	22813.1	11990.7	4063.9	7256.9	3752.3	18749.3	15556.2	8238.4	41818.0	25567.0	27705.0	0.80	33594.2	20539.1	22256.6	0.37	18.5
	At WP6, WPC to WPD	Single span	Pile Cap	12x12	10.2		8.75				11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7	3.2	61.0	620.9	22813.1	11990.7	5941.7	0.0	2716.2	16871.4	22813.1	9274.4	43695.0	0.0	23314.0	0.80	35102.08	0.00	18729.14	0.48	24.0
	At WP28, WPA to WPD	Triple equal span	Pile Cap	12x12	10.2		9.83	9.83	9.83		11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7	3.2	61.0	620.9	22813.1	11990.7	4799.4	5999.2	3661.8	18013.8	16813.9	8328.9	43413.0	27835.0	27931.0	0.80	34875.5	22361.1	22438.2	0.37	18.6
	At WP28, WPD to WPF	2 spans + cantilever	Pile Cap	12x12	10.2		8.83	7.71		3.17	11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7	3.2	61.0	620.9	22813.1	11990.7	3960.0	4628.0	3266.0	18853.1	18185.1	8724.7	36035.0	53890.0	27675.0	0.80	28948.5	43292.2	22232.5	0.39	19.6
																																																			Controlling GVW (kips)	11.2
Work Pier w/ deterioration	At WP31, WPD to WPF	Displaced pile, worst case	Pile Cap	12x12	8.9	8.00	7.71			3.17	11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7	3.6	61.5	548.2	22813.1	11990.7	0.0	17536.0	4384.0	22813.1	5277.1	7606.7	35891.0	204000.0	34000.0	0.78	27839.2	158234.4	26372.4	0.03	1.7
	At WP31, WPD to WPF_13.1kip	Displaced pile (max cantilever for 13.1kip LL)	Pile Cap	12x12	8.9	4.50	7.71			3.17	11.5	11.5	132.3	253.5	1457.5	1.0	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	50.2	7.7	3.6	61.5	548.2	22813.1	11990.7	0.0	5549.0	2475.0	22813.1	17264.1	9515.7	35891.0	85000.0	34000.0	0.78	27839.2	65931.0	26372.4	0.26	13.1
																																																		Controlling GVW (kips)	1.7
West Trestle	WT7 to WT8	Typical single span	Joist	6x18	1.5		18.08				5.5	17.5	96.3	280.7	2456.4	3.2	1350.0	1.00	1.00	1.00	0.96	1.00	0.80	1.00	1036	1.00	1036	170	1.00	1.00	1.00	0.80	136	42.7	15.6		58.3	87.4	24228.3	8726.7	3573.0	0.0	790.5	20655.3	24228.3	7936.2	121522.0	0.0	30088.0	0.25	30380.50	0.00	7522.00	0.68	34.0
	WT8 to WT10	Typical double equal span	Joist	6x18	1.5		9.67	9.67			5.5	17.5	96.3	280.7	2456.4	3.2	1350.0	1.00	1.00	1.00	0.96	1.00	0.80	1.00	1036	1.00	1036	170	1.00	1.00	1.00	0.80	136	42.7	15.6		58.3	87.4	24228.3	8726.7	572.4	1022.1	528.5	23656.0	23206.2	8198.2	41818.0	25567.0	27705.0	0.25	10454.50	6391.75	6926.25	1.18	59.2
	Typical	Typical double equal span	Pile Cap	14x12	17.9		6.67	6.67			13.5	11.5	155.3	297.6	1711.0	0.9	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	42.7	15.6	2.1	60.4	1079.8	26780.6	14076.0	3362.7	6004.8	4501.3	23418.0	20775.9	9574.7	3409.0	5923.0	4490.0	0.89	23731.00	19797.00	23794.00	0.40	20.1
	At WT9, WTA to WTD	Triple equal span	Pile Cap	14x12	9.5		6.67	6.67	6.67		13.5	11.5	155.3	297.6	1711.0	0.9	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	42.7	15.6	4.0	62.2	594.2	26780.6	14076.0	2114.7	2643.4	2377.9	24665.9	24137.2	11698.1	23998.0	18836.0	22387.0	0.79	23731.00	19797.00	23794.00	0.49	24.6
																																																		Controlling GVW (kips)	20.1
West Trestle w/ deterioration	WT8 to WT10	Cant. Joist at broken pile	Joist	6x18	1.5		9.67			9.67	5.5	17.5	96.3	280.7	2456.4	3.2	1350.0	1.00	1.00	1.00	0.96	1.00	0.80	1.00	1036	1.00	1036	170	1.00	1.00	1.00	0.80	136	42.7	15.6		58.3	87.4	24228.3	8726.7	0.0	4086.0	845.0	24228.3	20142.3	7881.7	51496.0	260780.0	34000.0	0.25	12874.00	65195.00	8500.00	0.31	15.4
	At WT9, WTA to WTD	Pile cap supporting cantilever joist, worst case	Pile Cap	14x12	14.5		6.67	6.67	6.67		13.5	11.5	155.3	297.6	1711.0	0.9	1350.0	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1080	1.00	1080	170	1.00	1.00	1.00	0.80	136	42.7	15.6	2.6	60.9	883.3	26780.6	14076.0	3143.8	3929.8	3535.0	23636.8	22850.8	10541.0	23998.0	18836.0	22387.0	0.86	20689.07	16238.83	19300.20	0.55	27.3
																																																		Controlling GVW (kips)	15.4

Notes:

1 Conservatively neglect effects of cantilevers when cantilever length is less than 25% of adjacent span length
2 Ma = Moment capacity of section
3 Va = Shear capacity of section
4 Joist live load distribution factor for Type 3 Truck assumes 2 joists resist one wheel load, therefore live load distribution is 1/2 of single wheel load, or 1/4 of single Type 3 Truck axle load.
5 For Type 3 Truck axle loads on joists, full axle loads was used in the RISA 3D analysis to determine moment and shear envelope forces. Then the forces were reduced by appropriate distribution factors
6 Pile cap live load distribution factor for Type 3 Truck axle loads is the (Trib Width - 2ft)/Trib Width. a simple span between pile caps. Note: Reaction is based on two axle loads of 17 kips spaced 4 feet apart.
7 For Type 3 Truck axle loads on pile caps, two 17 kip axle loads placed 6 feet apart was modeled as a rolling load and used in the RISA 3D analysis to determine moment and shear envelope forces. Then the forces were reduced by appropriate distribution factors

Unreinforced Slab (Clear Span) (per unit width)

Location	Description	Slab thickness (in)	Max. Joist Spacing (in)	Clear Span + 2" bearing (in)	S (in^3)	f'c	Mn (ft-lb)	ϕ	Capacity-Rupture ϕMn (ft-lb)	w_{MAX} (plf)	PSF_{MAX} (LRFD)	Equivalent Single Wheel Load = PSF x Area (kips)	Equivalent Front Axle Load = Front Wheel x 2	GVW for Type 3 Truck Reduced (kips)
West Trestle	3" Slab over Assume 26gage, 1 3/8" deck similar to ASC C1.4-32	3	18	16.5	18.00	3,000	411	0.6	246	1043	1,043	1.97	3.94	12.32

Notes:

1 Loaded area = 10 inches square + slab depth each side = 16 inches square which is approximately equal to the clear span + bearing between joists

Reinforced Slab (Clear Span) (per unit width)

Location	Description	Slab thickness (in)	Max. Joist Spacing (in)	Clear Span + 2" bearing (in)	d (in)	b (in)	As (in^2)	f'c (ksi)	fy (ksi)	a = Asfy/0.85(f'c)b	Mn = Asfy (d-a/2) (k-ft/ft)	ϕ	ϕMn (k-ft/ft)	w_{MAX} = (klf)	PSF_{MAX} (LRFD)	Equivalent Single Wheel Load = PSF x 16 inches square	Equivalent Front Axle Load = Front	GVW for Type 3 Truck Reduced (kips)
k Pier and East Tre	3 3/4" Slab over Assume 26gage, 7/8" deck	3.75	24	22.5	1.875	12	0.2	3	60	0.392156863	1.68	0.9	1.51	3.4	3.4	6.11	12.23	38.20

Notes:

1 Assume uniformly loaded over simple span of slab and over a width of 10 inches + slab depth each side = 16 inches.