

Bowen Wharf Diving Inspection Report Summary



In April 2024, North Queensland Bulk Ports commissioned underwater diving inspections of the existing concrete piles at Bowen Wharf.

These inspections aimed to increase the sample size of condition data collected in 2019 and provide a more comprehensive understanding of the wharf's condition.

Subsea Pty Ltd conducted the underwater inspections, and a detailed inspection report can be viewed in Attachment A.

Close-up visual diving inspections were carried out on 16 randomly selected piles across the Middle Wharf Stem, Outer Stem, and Public Wharf Areas. None of the piles inspected in 2019 were included in this selection, bringing the total number of inspected piles to 10% of all piles. This percentage is considered indicative of the condition of the piles throughout the entire structure.

The observations from both the 2019 and 2024 inspections indicate similar conditions across the structure.

The nature, type, and extent of defects—such as cracking, spalling, and concrete breakage—are consistent across most of the inspected piles.

The report concludes that, considering the nature, severity, and widespread extent of the defects observed (including cracks located below water and possibly below the seabed), the age of the structure (over 100 years old), and the 100-year design life requirement for future use of the jetty, repairing the existing piles to support a new deck is not a practical solution for the Bowen Wharf project.

The data collected from the diving inspections, reviewed against industry standards such as Wharf Structures Condition Assessment Manual (WSCAM) and informed by the report writers' understanding of the deterioration mechanisms of reinforced concrete structures, suggest that the best outcome for the Bowen Wharf project is to replace the piles.

This replacement will eliminate any safety risks associated with the long-term performance of the existing piles and ensure a safe and durable structure.

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Technical Note

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1. Introduction

This document summarises the findings of the underwater diving inspections for the existing concrete piles at Bowen Wharf and provides a comparison to the inspection undertaken in 2019. The purpose of the inspection work was to increase the sample size of condition data of the piles collected by Arup in 2019, to provide more information on the condition across the entire wharf and jetty structures.

The procurement of the diving contractor was coordinated directly by NQBP, who commissioned Subsea Pty Ltd (Subsea) to undertake the work. A factual inspection report has been provided by Subsea and is included in Attachment A.

1.1 Reference Information

Background information relevant to this testing is included in the documents listed below:

- Arup: Bowen Wharf Future Options Assessment – Testing Report (REV 2), 15 March 2020 (264408-00-REP-004)
- Shoreline Civil and Marine Consulting: Bowen Wharf Refurbishment Study – Design Report, 16 November 2023 (SCMC-23029-RPT-001)

2. Scope of Work

The scope for the Subsea diving inspection included the following items:

- Undertake close-up visual diving inspection on a minimum of 18 piles across the Middle Wharf Stem, Outer Stem and Public Wharf Areas. This included:
 - Cleaning marine growth from pile within a minimum 300mm high band (all around) at two levels (just below LAT and just above seabed level)
 - Visual inspection for defects including tilting, breakage, mechanical damage, overstress/cracking, spalling, weathering, sulphate attack.

- Capture photo and video of the inspections where possible.
- Preparation a factual dive inspection report (included in Attachment A) outlining the inspection results and observations.

The nominated piles inspected were randomly selected prior to the inspection across the publicly accessible areas of Bowen Wharf, ensuring that no previously inspected piles were re-inspected. These nominated piles are outlined in Table 1 (refer to Attachment A for pile gridlines for each location).

Table 1: Nominated piles for below-water inspection

Location	Pile ID (refer to plans for exact location)
Middle Wharf Stem	57B, 64A, 65A, 67A
Outer Wharf Stem	81B, 87A, 89A, 97B, 105B, 113B, 116D, 120B
Public Wharf	202C, 206B, 208H, 210G, 216H, 218C

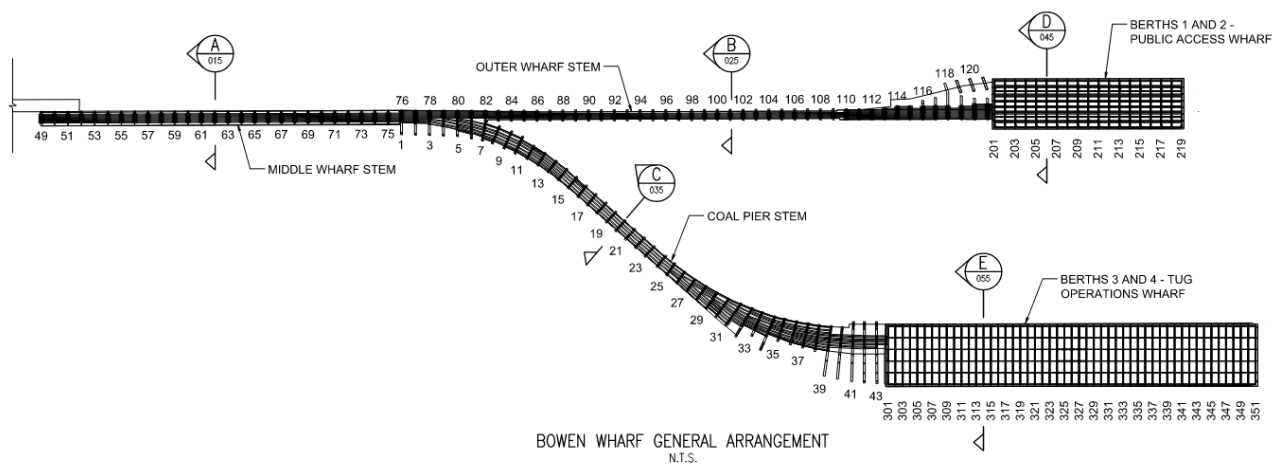


Figure 1: Bowen Wharf General Arrangement

3. Inspection Methodology

The inspection was carried out on 8th-10th April using a boat (Subsea vessel ‘Big Rig’), with 16 of the 18 nominated piles to be inspected being completed, with the remaining 2 piles unable to be completed within the inspection timeframe and shall be completed at a later date.

The divers cleaned marine growth from the piles from below the LAT level and at the seabed using mechanical scrapers as well as a pneumatic chipping hammer where necessary. For piles that were fully exposed at low tide level, piles were cleaned from approximately halfway below the headstock to seabed (approximately 0.9-1m long).

Underwater CCTV video and still photo cameras were used to capture visual recordings of the inspections.

4. Basis for Level and Extent of Testing

The proposed test locations have been selected across the Middle Stem, Outer Stem and Public Wharf sections as the areas of the jetty/wharf that are publicly accessible. The exact location of the specified piles for below-water inspection have been selected at random (to avoid selection bias), with the following permutations:

- No piles previously inspected in 2019 have been included in this selection.
- Raker piles on the Public Wharf area not to be included in this selection.
- Piles on pier 49-52 not included due to being mostly concealed by causeway rock.

For the avoidance of confusion to previous pile identification system, a new set of pile ID's have been marked up on the drawings in the diving report in Attachment A (and link to Table 1).




Following a review of the 2019 inspection, a total of 16 piles have already been inspected along the Publicly accessible areas of the wharf (considering the above exclusions). A total of 339 piles are within this area and this amounts to 4.7% of the total piles that were inspected previously. From this calculation, a further 18 piles are required to be inspected to achieve a 10% overall inspection coverage of the total piles within the publicly accessible areas of the structure.


This basis for the total number of pile inspections is as per the SIGTTO/OCIMF Jetty Maintenance and Inspection Guide (2008) Section 3.2.3.3, which provides guidance for underwater inspections for jetty structures. Typically, 5-10% of piles are recommended to be spot cleaned to look for deterioration beneath the marine growth and with the additional testing being carried out within this scope, the upper bound of this guidance will be achieved.

5. Inspection Findings Summary



A summary of the diving inspection observations with example photos is presented in the tables below:




5.1 Middle Wharf Stem


Location	Piles Inspected and Key Observations	Photo Examples
<p>Middle Wharf Stem 4 piles inspected</p>	<p>1. Pile 57B</p> <ul style="list-style-type: none"> Vertical cracking observed on all sides of the pile, varying from 400-1000mm in length and up to 2mm wide. Evidence that cracking runs into the seabed. No evidence of breakage, visual corrosion, spalling or sulphate attack. Pile covered in hard marine growth. 	
	<p>2. Pile 64A</p> <ul style="list-style-type: none"> Vertical cracking observed on 3 of the 4 sides of the pile, varying from 400-800mm in length and up to 3mm wide. Evidence that cracking is running into the seabed. No evidence of breakage, visual corrosion, spalling or sulphate attack. Pile covered in hard marine growth. 	
	<p>3. Pile 65A</p> <ul style="list-style-type: none"> Vertical cracking observed on all sides of the pile, varying from 300-800mm in length and up to 3mm wide. Evidence that cracking runs into the seabed. No evidence of breakage, visual corrosion, spalling or sulphate attack. Pile covered in hard marine growth. 	

Location	Piles Inspected and Key Observations	Photo Examples
	<p>4. Pile 67A</p> <ul style="list-style-type: none"> Vertical cracking observed on 2 of the 4 sides of the pile, varying from 200-900mm in length and up to 2mm wide. Evidence that cracking is running into the seabed. No evidence of breakage, visual corrosion, spalling or sulphate attack. Pile covered in hard marine growth 	



5.2 Outer Wharf Stem





Location	Piles Inspected and Key Observations	Photos
Outer Wharf Stem 6 piles inspected (2 nominated piles not inspected)	<p>1. Pile 85A (note: this pile was inspected mistakenly instead of pile 81B)</p> <ul style="list-style-type: none"> Vertical cracking observed on 3 of the 4 sides of the pile, varying from 600-1300mm in length and up to 3mm wide. Evidence that cracking runs into the seabed. No evidence of breakage, visual corrosion, spalling or sulphate attack. Pile covered in hard marine growth at top of pile, changing to a mix of hard and soft marine growth near the seabed. 	
	<p>2. Pile 97B</p> <ul style="list-style-type: none"> Vertical cracking observed (approx. 200mm long, 1mm wide) on one side of the upper cleaned band, with small hole of unknown depth also noted. Vertical cracking on all sides of the pile on the lower cleaned section, ranging from 100-500mm in length and up to 5mm wide. Minor section of spalling on one edge of the lower pile section, approximately 30x40mm size. No evidence of breakage, visual corrosion, spalling or sulphate attack. Pile covered in hard marine growth at top of pile, changing to a mix of hard and soft marine growth near the seabed. 	

Location	Piles Inspected and Key Observations	Photos
	<p>3. Pile 105B</p> <ul style="list-style-type: none"> Vertical cracking observed on 3 of the 4 sides of the pile across the top and bottom cleaned sections, varying from 100-300mm long and up to 2mm wide. Multiple spalled sections on pile edges (30x10mm spalled section and another 20x20mm spalled section). No evidence of other breakage, visual corrosion or sulphate attack. Pile covered in hard marine growth at top of pile, changing to a mix of hard and soft marine growth near the seabed. 	
	<p>4. Pile 113B</p> <ul style="list-style-type: none"> Vertical cracking observed on all 4 sides of the pile, varying in length from 100-200mm cracks, to some that cover the full cleaned patch and continue behind marine growth. Some cracks noted to extend down into seabed. Crack widths measured up to 2mm wide. Some minor chipping on one edge noted to be approximately 30mm wide. No evidence of other breakage, visual corrosion or sulphate attack. Pile covered in hard marine growth at top of pile, changing to a mix of hard and soft marine growth near the seabed. 	
	<p>5. Pile 116D</p> <ul style="list-style-type: none"> Significant spalling and breakage of concrete observed on one side of the upper cleaned section, with exposed reinforcement bar and discolouration of concrete (rust staining) across an area 170x300mm. Vertical cracking on 3 of the 4 sides of the pile, with some cracking noted to be major with crack widths up to 4mm, with cracking extending down into seabed. No evidence of sulphate attack Pile covered in hard marine growth at top of pile, changing to a mix of hard and soft marine growth near the seabed. 	

Location	Piles Inspected and Key Observations	Photos
	<p>6. Pile 120B</p> <ul style="list-style-type: none"> Vertical cracking observed on all 4 sides of the pile, with lengths extending above and below the cleaned sections of the pile. Crack widths measured were up to 2mm width. Multiple large cracks / spalled sections (one section 35x5mm and another section 65x5mm). No sign of breakage, visual corrosion or sulphate attack. Pile covered in hard marine growth at top of pile, changing to a mix of hard and soft marine growth near the seabed. 	

5.3 Public Wharf

Location	Piles Inspected and Key Observations	Photos
Public Wharf 6 piles inspected	<p>1. Pile 202C</p> <ul style="list-style-type: none"> Vertical cracking observed on 3 of the 4 sides of the pile, ranging from 150mm long to 500mm long and up to 2mm wide. Some discolouration of concrete (rust staining) noted towards the bottom of one crack, indicating exposed reinforcement. No evidence of breakage, visual corrosion, spalling or sulphate attack. Pile covered in hard marine growth at top of pile, changing to a mix of hard and soft marine growth near the seabed. 	
	<p>2. Pile 206B</p> <ul style="list-style-type: none"> Vertical cracking observed on all 4 sides of the pile, ranging from 300-500mm and up to 2mm wide. Damage on one edge with material loss estimated at 400x70x20mm. Another section estimated at 180x400x5mm loss on the lower cleaned section of the pile. Some radial cracking noted on the lower cleaned section that appears to be stemming from the central vertical cracking. No evidence of spalling or sulphate attack. Pile covered in hard marine growth at top of pile, changing to a mix of hard and soft marine growth near the seabed. 	

Location	Piles Inspected and Key Observations	Photos
	<p>3. Pile 208H</p> <ul style="list-style-type: none"> Vertical cracking observed on 3 of the 4 sides of the pile, with lengths ranging from 300-600mm and up to 2mm width. Some diagonal cracking noted up to 1mm width. No evidence of breakage, visual corrosion or sulphate attack. Pile covered in hard marine growth at top of pile, changing to a mix of hard and soft marine growth near the seabed. 	
	<p>4. Pile 210G</p> <ul style="list-style-type: none"> Vertical cracking observed on all 4 sides of the pile, ranging from 100-500mm in length and up to 2mm width. Diagonal cracking noted on two faces of the pile. No evidence of breakage, visual corrosion or sulphate attack. Pile covered in hard marine growth at top of pile, changing to a mix of hard and soft marine growth near the seabed. 	
	<p>5. Pile 216H</p> <ul style="list-style-type: none"> Vertical cracking observed on 3 of the 4 sides of the pile, ranging from 100-400mm length and up to 2mm width. No evidence of breakage, visual corrosion or sulphate attack Pile covered in hard marine growth at top of pile, changing to a mix of hard and soft marine growth near the seabed. 	
	<p>6. Pile 218C</p> <ul style="list-style-type: none"> Vertical cracking observed on 3 of the 4 sides of the pile, ranging from 150-300mm in length and up to 1mm width. Breakage of material observed in one location, approximately 25x60mm. Another area of apparent spalling/loss of material of 30x30x5mm. No sign of visual corrosion or sulphate attack. Pile covered in hard marine growth at top of pile, changing to a mix of hard and soft marine growth near the seabed. 	

6. Interpretation of Results

6.1 Overall Assessment of Findings

The 2024 diving inspection clearly shows every pile inspected with significant vertical cracking over significant lengths and up to 4-5mm width in some areas. Many piles were also observed have

patches of larger gaps, spalling and some breakage of concrete. The location of the vertical cracks was consistent on the upper and lower sections of the pile and were observed extend down into the seabed in a number of locations. Vertical cracking was typical in the central part of each face of the pile and on the chamfered edges, but some diagonal cracking was also recorded stemming from central cracks towards the edges.

The severity of these defects can also be referenced against industry standard assessment guidelines which highlight the significance of the findings. According to the Wharf Structures Condition Assessment Manual (WSCAM), for concrete specific defects including cracking major cracks, many of the piles fall within the condition rating 6 criteria (crack with >2mm). This level of condition rating indicates minimal expected remaining life (1-15% as a percentage of the original design life).

CONDITION RATING	DESCRIPTION	EXPECTED REM. LIFE (% of original design life)	RECOMMENDED ACTIONS
1	New with no visible defects/damage.	91-100	No repairs required. Re-inspection at next scheduled inspection may be considered.
2	As new. Hairline cracks (<0.1mm). No exposed reinforcement or surface evidence of corrosion of reinforcement. Minor efflorescence, no observable dampness or leakage.	56-90	No repairs required. Re-inspection at next scheduled inspection may be considered.
3	Fine cracking (0.1mm - <0.3mm), surface staining from weathering, minor voids, rust stains, minor surface erosion or honeycombing.	41-55	Planned and preventative maintenance works may be considered.
4	Medium cracking (0.3mm - 0.5mm) and rust staining present. Minor spalling and exposed reinforcement affecting less than 5 percent of surface area; <20% of surface area undergoing delamination. Moderate surface erosion.	26-40	Further testing; reactive maintenance and some minor upgrades may be considered. Structural assessment is recommended in the case of significant localised deterioration.
5	Large cracks (>0.5mm - 2mm), moderate concrete spalling and exposed reinforcement affecting up to 20% of surface area. Moderate delamination up to 50% surface area. Up to 10% section loss of reinforcement.	16-25	Structural assessment is recommended. Further investigation may be required to inform the structural assessment. Maintenance; upgrade or rehabilitation works may be considered.
6	Major cracks (>2mm), severe concrete spalling and exposed reinforcement affecting up to 50% of surface area. Severe delamination >50% surface area. 10- 20% section loss of reinforcement.	1-15	Structural assessment is recommended. Further investigation may be required to inform the structural assessment. Rehabilitation or renewal works may be considered.
7	Very severe concrete spalling with exposed reinforcement and reinforcement section loss of > 20%. Component has failed.	0	Rehabilitation required immediately or replace component/asset. Structural assessment is recommended where rehabilitation works are to be undertaken. Further investigation may be required to inform the structural assessment.

Figure 2: Material-specific condition ratings for reinforced concrete

The type of cracking seen across the piles indicates corrosion is already occurring in the reinforcement bars within the concrete pile. As the steel corrodes, the corrosion product expands and applies pressure to the concrete surrounding the bar that triggers cracking in the concrete and consequent spalling of the concrete cover to the reinforcement layer. Once the cracking has set in (as observed in this inspection), deterioration of the structure is accelerated by concrete spalling (as observed in some piles). The concrete spalling undermines the integrity of the pile, decreases its structural capacity to support loads and compromises the safety of the structure. The visual inspection of the piles has detected cracking in all piles and spalling of the concrete cover at some pile locations. As the pile material, age and environment exposure are common to all piles, the findings from the diving inspection are considered representative for all piles in the structure.

6.2 Comparison of Findings to 2019 Diving Inspection

In 2019, 16 piles were inspected by PMG along the publicly accessible areas of Bowen Wharf (out of 48 total piles inspected), which has now been increased by an additional 16 piles inspected by Subsea in 2024. Prior to the inspection, Arup nominated 18 piles at random (with the permutations as specified in Section 4) within the publicly accessible areas of the wharf such that a total of 34 out of 339 total piles were inspected to reach 10% of the total piles. This was intended to achieve an upper-bound recommendation (as per SIGTTO/OCIMF Jetty Maintenance and Inspection Guide (2008) Section 3.2.3.3) of inspecting 10% of the piles to provide more certainty of the conditions that can be assumed broadly across the entire structure. Noting that only 16 piles were inspected instead of the intended 18, this does not have a significant impact on the nature of the results, due to the consistency at which defects were found across both inspections. Based on the trends observed, the remaining 2 piles are likely to provide similar results and will not significantly change the conclusions of this report.

The observations from the 2019 and 2024 inspections provide the same evidence and are indicative of the conditions of the piles across the full structure. The nature, type and extent of defects such as cracking, spalling and breakage of concrete are consistent across most piles that have been inspected. The coverage and spread of the pile inspected (10%) is representative of the trend of conditions of the piles in the whole structure.

6.3 Impact to Future Durability and Capacity of the Structure

Considering the nature, severity and large extent of the defects observed on the piles (i.e. location of the cracks being below water and likely below the seabed), the age of the structure (over 100-year-old), and the 100-year design life requirement for future use of the jetty, repairing the existing piles to support a new deck is not a practical solution for the project.

The data collected with the diving inspections, which have been reviewed against industry standards such as WSCAM, and our understanding of the deterioration mechanism of reinforced concrete structures, suggest that the best outcome for the project is to replace the piles. The pile replacement will eliminate any safety risks associated with the long-term performance of the existing piles and provide a safe and durable structure.

Attachment A – Subsea Pty Ltd Factual Underwater Condition Report

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Pile Inspections April 2024-Iss1A

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Document Revision No.: **A**

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UNDERWATER INSPECTION
REPORT
for



PILE INSPECTIONS – BOWEN WHARF
BOWEN – APRIL 2024

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PILE INSPECTIONS – BOWEN WHARF – APRIL 2024

INTERNAL DOCUMENT REVIEW ACTIVITIES

COMPANY	ACTIVITY	NAME / ROLE	SIGNATURE	DATE
Subsea	Prepared By			24/05/2024
	Reviewed By			24/05/2024
	Approved By			24/05/2024

Remarks / Comments:

UNDERWATER INSPECTION REPORT

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1.0 DOCUMENT AMENDMENT RECORDS

Issue	Rev	Section	Details of the Changes	Date of Changes
01	A	All	First Issue for Customer / Client Review	

2.0 GENERAL

2.1 Background

Subsea Pty Ltd (Subsea) was commissioned by North Queensland Bulk Ports (NQBP) in consultation with ARUP to undertake a dive inspection of selected piles on Bowen Wharf as part of redevelopment discussions and proposals.

A total of 18 concrete piles were selected for inspection by ARUP/NQBP, with a total of 16 successfully inspected with available weather windows across the Middle and Outer Wharf stems and Public Wharf.

This report has been prepared to summarise the inspection data gathered as part of this inspection undertaken in April 2024. Illustrations showing the selected piles for inspection have been included in Attachment 1.

2.2 Scope

As per the brief, the scope of works for the inspection of Bowen Wharf piles included:

- Removal of marine growth on selected concrete piles within a minimum 300mm band all around, at just below LAT and just above seabed level.
- Visual inspection of piles for defects including tilting, breakage, mechanical damage, horizontal and vertical cracking, spalling, weathering, sulphate attack or other signs of deterioration.
- Photos and video of the inspections where possible.
- Completion of an Inspection Report (this report).
- Summary of additional repair requirements (if any) resulting from the Inspection Works.

2.3 Method

Dive inspections were undertaken on 08–10 April 2024 in accordance with the brief requirements.

Divers inspected each of the piles selected as illustrated in Attachment 1. Inspections were undertaken as per the brief requirements summarised in Section 2.2.

Divers cleaned marine growth from below the LAT level and at seabed level for minimum band length of 300mm using mechanical scrapers as well as a pneumatic chipping hammer where necessary. For piles that were fully exposed at low tide level (predominantly those at the Middle Stem region), piles were fully cleaned from

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approximately halfway below the headstock to seabed (approximately 900mm-1m of area cleaned).

Visual inspection was then completed on each of the pile faces (total of four per pile), with face 1 generally facing to shore (approximate north), face 2 to the east, face 3 to the south and face 4 to the west.

Observations are discussed in Section 4.0.

CCTV video and photos were captured for the entirety of the inspected elements. These are summarised in Tables 1 and 2 of Attachment 2.

3.0 SERVICE DESCRIPTION PROVIDED

3.1 Inspections Completed

As per NQBP/ARUP requirements, the visual inspection considered the below elements where applicable:

- Marine Growth Coverage of Piles;
- Presence of breakage, mechanical damage, horizontal/vertical cracking, spalling, weathering or sulphate attack;

Observations are discussed in Section 4.0.

3.2 Information Recorded

CCTV video was captured for the inspected assets. CCTV video files have been included on a Dropbox link provided to NQBP, with titles summarised in Attachment 3.

3.3 Ancillary Plant / Equipment Utilised

- Subsea vessel 'Big Rig' was utilised for dive operations.
- SSBA Dive spread.
- Air Compressor and Pneumatic Chipping Hammer
- Hand tools
- Underwater CCTV video and still photo cameras.

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4.0 OBSERVATIONS AND RECOMMENDATIONS

Key observations from the inspections are discussed below.

4.1 Observations

4.1.1 Middle Wharf Stem

Pile 57B: (Pile fully exposed and inspected at low tide). Pile 100% covered in hard marine growth (oysters and barnacles) to seabed prior to cleaning. Vertical cracking to 600-900mm in length running into seabed on face 1 to along the centre and outside edge of the pile to 1mm width. Vertical crack radiating from edge to pile centre to 600mm length x 1mm width running into seabed on face 2. Vertical crack towards pile edge to face 2 1000mm length x 2mm width running into seabed on face 3. Vertical cracking to 400-1000mm in length running into seabed on outside edges of face 4 to 2mm width. No sign of any breakage, corrosion, spalling or sulphate attack.

Pile 64A: (Pile fully exposed and inspected at low tide). Pile 100% covered in hard marine growth (oysters and barnacles) to seabed prior to cleaning. No defects observed on face 1. Vertical cracking to 400mm running into seabed in middle of face 2 to 1mm width. Vertical cracking to 500mm in length running into seabed on the left side of face 3 to 3mm width. Vertical cracking to the outer edge of face 4 to 800mm running into seabed to 2mm width. No sign of any breakage, corrosion, spalling or sulphate attack.

Pile 65A: (Pile fully exposed and inspected at low tide). Pile 100% covered in hard marine growth (oysters and barnacles) to seabed prior to cleaning. Vertical cracking across centre of face 1 330mm in length running into seabed to 3mm width. Vertical cracking across the centre of face 2 660mm in length running into seabed to 2mm width. Vertical cracking across the centre of face 3 800mm in length running into seabed to 1mm width. Vertical cracking across centre of face 360mm in length running into seabed to 3mm width. No sign of any breakage, corrosion, spalling or sulphate attack.

Pile 67A: (Pile fully exposed and inspected at low tide). Pile 100% covered in hard marine growth (oysters and barnacles) to seabed prior to cleaning. Vertical cracking at middle of face 1 200mm in length running into seabed to 2mm width. No defects observed on face 2. Vertical cracking towards left side of face 3 900mm in length running into seabed to 2mm width. No defects observed on face 4. No sign of any breakage, corrosion, spalling or sulphate attack.

4.1.2 Outer Wharf Stem

Pile 85A: (Pile mostly exposed and inspected at low tide). Pile 100% covered in hard marine growth (oysters and barnacles) at top of pile, changing to 100% coverage of soft (sponge, conglomerate, algae etc) and hard growth to seabed prior to cleaning. Vertical cracking radiating from left side of face 1 down to centre of face 1 1300mm in length running into seabed to 2mm width. Further vertical cracking from edge of face 1 onto face 2 900mm in length running into seabed to 1mm width. Vertical cracking across centre of face 2 1340mm in length running into seabed to 2mm width. No defect observed on face 3. Vertical cracking in centre of face 4 800mm into seabed to 2mm width. Additional cracking to left side of face 4 600mm in length running into seabed to 3mm width. No sign of any breakage, corrosion, spalling or sulphate attack.

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Pile 97B: (Pile partially submerged at all tides and inspected by divers). Pile 100% covered in hard marine growth (oysters and barnacles) at top of pile, changing to 100% coverage of soft (sponge, conglomerate, algae etc) and hard growth to seabed prior to cleaning. Vertical cracking on upper face 3 180mm to 1mm width as well as a small hole of unknown depth on upper cleaned section. No other defects noted on any face at the upper cleaned section. Vertical crack on lower face 1 (seabed level) 150mm into seabed (5mm depth x 5mm width). Additional cracking on the middle of lower face 1 200mm in length to 2mm width. Minor section of spalling on edge between lower face 1 and 2 along the edge (30mm x 40mm). Vertical cracking along the edge between lower face 2 and 3 (at bottom) 200mm into growth above to 2mm width. Vertical cracking on lower face 4 500mm into growth to 3mm width. No sign of any breakage, corrosion or sulphate attack.

Pile 105B: (Pile partially submerged at all tides and inspected by divers). Pile 100% covered in hard marine growth (oysters and barnacles) at top of pile, changing to 100% coverage of soft (sponge, conglomerate, algae etc) and hard growth to seabed prior to cleaning. Minor vertical cracking on upper face 1 towards edge 100mm to 2mm width. Minor spalling of concrete on edge of upper face 4 and 1 20mm x 20mm to 5mm depth. No other defects noted on any upper face. No defect on lower face 1. Very minor spalling on lower face 2 (seabed) 30mm length x 10mm width x 3mm depth. Vertical cracking across centre of lower face 3 (seabed) starting 300mm from bottom into growth above to 1mm width. Vertical cracking up the edge between lower face 4 and 1 (seabed) 4-5mm width approximately 100mm in length with depth approximately 2mm. No sign of any breakage, corrosion or sulphate attack.

Pile 113B: (Pile partially submerged at all tides and inspected by divers). Pile 100% covered in hard marine growth (oysters and barnacles) at top of pile, changing to 100% coverage of soft (sponge, conglomerate, algae etc) and hard growth to seabed prior to cleaning. Vertical crack on upper face 1 across length of face into marine growth below to 1mm width. No defect on upper face 2. Vertical cracking on upper face 3 across entire face into marine growth above to 2mm width. Some chipping of edge of pile between upper face 3 and 4 to 30mm width. Vertical cracking across upper face 4 between growth above and below to 1mm width. Additional vertical cracking along edge between upper face 1 and 4 to 5mm width across exposed edge area. Vertical cracking on lower face 1 approximately 200mm in length to 2mm width into seabed. Additional vertical cracking on edge of lower face 1 and 2 160mm above seabed up into growth above to 1mm width. Vertical cracking on lower face 2 from seabed into growth above to 2mm width. Additional vertical crack between edge of lower face 2 and 3 from seabed into growth above to 1mm width. Vertical cracking on lower face 3 from seabed 250mm length to 1mm width. Vertical cracking on edge between lower face 4 and 1 from seabed into growth above, to 1mm width. No sign of any spalling, breakage, corrosion or sulphate attack.

Pile 116D: (Pile partially submerged at all tides and inspected by divers). Pile 100% covered in hard marine growth (oysters and barnacles) at top of pile, changing to 100% coverage of soft (sponge, conglomerate, algae etc) and hard growth to seabed prior to cleaning. No defect on upper face 1. Significant spalling and breakage of concrete away from the left side of upper face 2 including the edge between upper face 2 and 3 with exposed reinforcement bar and discolouration of the concrete (rust staining), across an area 170mm wide x 300mm minimum to 110mm depth (see Figure 1). Additional vertical cracking on middle of upper face 2 from lower growth to upper growth 2mm width.

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Multiple large vertical cracking across upper face 3 extending full length of cleaned area to 4mm width, with spalling back towards the edge with upper face 2 (see Figure 2). Vertical cracking on middle of upper face 4 into growth below (approximately 140mm length) to 1mm width. No defect on lower face 1. Vertical cracking on lower face 2 from seabed to growth above to 3mm width. Additional vertical cracking along edge between lower face 2 and 3 from seabed to growth above to 3mm width (to 5mm depth). Vertical cracking on lower face 3 from seabed into growth above to 4mm width to 10mm depth with branching towards upper length of crack. Vertical cracking on lower face 4 from seabed into growth above to 5mm width and 5mm depth. No sign of any sulphate attack.



Figure 1: Significant spalling and exposed reinforcement bar towards edge of upper face 2 (Pile 116D) and face 3 with significant material loss.



Figure 2: Significant spalling and exposed reinforcement bar towards right edge of upper face 3 (Pile 116D) and face 2 with extensive vertical cracking on upper face 3.

Pile 120B: (Pile partially submerged at all tides and inspected by divers). Pile 100% covered in hard marine growth (oysters and barnacles) at top of pile, changing to 100% coverage of soft (sponge, conglomerate, algae etc) and hard growth to seabed prior to cleaning. Vertical cracking on upper face 1 across cleaned area to 2mm width. Vertical cracking on upper face 2 across cleaned area to 1mm width. Additional vertical cracking towards the edge of upper face 2 to 1mm width (possible start of spall 35mm x 5mm to 2mm width). Vertical cracking across upper face 3 across cleaned area to 1mm width and additional vertical cracking on the right side of the upper face 3 65mm in length x 5mm width to 3mm depth. Vertical cracking on upper face 4 across cleaned area to 1mm width. Vertical cracking across centre of lower face 1 from growth to just above seabed to 3mm width. Vertical cracking across centre of lower face 2 from growth down into seabed to 4mm width to 7mm depth. Vertical cracking on lower face 3 from marine growth to just above seabed to 2mm width. Vertical cracking across lower face 4 from growth above into seabed to 2mm width. No sign of any spalling, breakage, corrosion or sulphate attack.

4.1.3 Public Wharf

Pile 202C: (Pile partially submerged at all tides and inspected by divers). Pile 100% covered in hard marine growth (oysters and barnacles) at top of pile, changing to 100% coverage of soft (sponge, conglomerate, algae etc) and hard growth to seabed prior to cleaning. No defect on upper face 1. Two vertical cracking across centre of upper face 2 across approximately 400mm length to 2mm width. Vertical cracking across centre of

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upper face 3 approximately 300mm length to 1mm width. Additional large vertical cracking along edge between upper face 3 and 4 to 500mm length to 20mm width with minor loss of material. Some discolouration of concrete (rust staining) towards the bottom of this crack indicating exposed reinforcement to seawater (see Figure 3). Vertical cracking at centre of upper face 4 radiating towards the edge of the pile approximately 500mm length to 1mm width. Additional vertical cracking towards right side of upper face 4 300mm in length to 1mm width. No defect on lower face 1. Vertical cracking to 140mm with hairline horizontal cracking running from this to 70mm length to 1mm width on lower face 2. Vertical cracking on lower face 3 to 300mm length to 1mm width. No defect on lower face 4. No sign of any spalling, breakage, corrosion or sulphate attack.



Figure 3: Large vertical cracking at edge of upper face 3 and 4 with crack width to 20mm and rust staining towards lower end of crack.

Pile 206B: (Pile partially submerged at all tides and inspected by divers). Pile 100% covered in hard marine growth (oysters and barnacles) at top of pile, changing to 100% coverage of soft (sponge, conglomerate, algae etc) and hard growth to seabed prior to cleaning. Three vertical cracks across upper face 1 across cleaned area to 1mm width. Vertical cracking on centre of upper face 2 360mm in length to 1mm width. Vertical cracking on upper face 3 500mm in length to 1mm width. Damage to edge between upper face 3 to face 4 with material loss over an area 400mm x 70mm to 20mm depth with some staining of concrete and small cracking radiating from the top onto upper face 4. Two vertical cracks on lower face 1 across cleaned area into seabed to 2mm width. No defect on lower face 2. Vertical cracking across centre of lower face 3 450mm in length into seabed to 3mm width. Some material loss is observed off the right side of this crack across an area 180mm x 400mm to 5mm loss. Vertical cracking across centre of lower face 4 with fine spider web cracks radiating from centre cracking to 1mm width. No sign of any spalling or sulphate attack.

Pile 208H: (Pile partially submerged at all tides and inspected by divers). Pile 100% covered in hard marine growth (oysters and barnacles) at top of pile, changing to 100% coverage of soft (sponge, conglomerate, algae etc) and hard growth to seabed prior to cleaning. No defect on upper face 1 or 2. Two vertical cracking parallel across centre of upper face 3 300-330mm in length to 2mm width. Three vertical cracks on upper face 4

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the length of cleaned area to 390mm length to 1mm width. No defect on lower face 1. Vertical cracking on centre of lower face 2 radiating towards right side to 600mm length to 1mm width. Diagonal cracking radiating 400mm length to 1mm width (highest point to edge on right side of face, down to lower edge on left side of face). No defect on lower face 4. No sign of any spalling, breakage, corrosion or sulphate attack.

Pile 210G: (Pile partially submerged at all tides and inspected by divers). Pile 100% covered in hard marine growth (oysters and barnacles) at top of pile, changing to 100% coverage of soft (sponge, conglomerate, algae etc) and hard growth to seabed prior to cleaning. No defect on upper face 1, 2 or 4. Vertical diagonal crack across cleaned area to 1mm width. Vertical cracking on centre of lower face 1 across cleaned area into seabed to 1mm width. Vertical cracking at centre of lower face 2 into seabed 300mm length to 1mm width. Vertical diagonal cracking towards centre of lower face 3 500mm length into seabed to 2mm width. Minor diagonal cracking on lower face 4 100mm in length to 1mm width. No sign of any spalling, breakage, corrosion or sulphate attack.

Pile 216H: (Pile partially submerged at all tides and inspected by divers). Pile 100% covered in hard marine growth (oysters and barnacles) at top of pile, changing to 100% coverage of soft (sponge, conglomerate, algae etc) and hard growth to seabed prior to cleaning. No defect on upper face 1. Vertical cracking on centre of upper face 2 approximately 320mm length to 2mm width. Vertical cracking to the right side of upper face 3 400mm length to 1mm width. There is an additional vertical cracking on the centre face of upper face 3 100mm in length to 1mm width. Two vertical cracks on the left side of upper face 4 approximately 350mm length to 2mm width. No defect on lower face 1, 2 or 3. Vertical cracking across cleaned area on lower face 4 into seabed 400mm length to 2mm width. No sign of any spalling, breakage, corrosion or sulphate attack.

Pile 218C: (Pile partially submerged at all tides and inspected by divers). Pile 100% covered in hard marine growth (oysters and barnacles) at top of pile, changing to 100% coverage of soft (sponge, conglomerate, algae etc) and hard growth to seabed prior to cleaning. No defect on upper face 1, 2 or 4. Vertical cracking along centre of upper face 3 across cleaned area into growth with minor loss/spalling of material 30mm x 30mm x 5mm depth. Additional vertical diagonal hairline crack along the right side of upper face 3 200mm length to 1mm depth. Vertical cracking on lower face 1 300mm length to 1mm width into seabed. Breakage of material from right side edge of lower face 1 60mm x 25mm. Additional horizontal crack running inward from right side edge of lower face 1 150mm length to 1mm width. No defect on lower face 2 or 3. Vertical cracking on lower face 4 300mm length into seabed to 1mm width. No sign of any corrosion or sulphate attack.

4.2 Recommendations

Most piles exhibit vertical cracking on several pile faces (both on the pile faces and chamfered edges) ranging from hairline 1mm to 5mm width indicating potential ongoing corrosion of the reinforcement steel. Piles 116B and 202C exhibit more advanced damage (spalling and gaping cracks) and may require sooner remedial attention (to be reviewed by Engineers).

It is recommended that piles be surveyed regularly to monitor further deterioration.

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5.0 INSPECTION WORKFORCE DETAIL

5.1 Divers

Inspections were undertaken by a dive crew consisting of the following people:

- Josh Thomas – Diver (ADAS Part 3 Diver accredited)
- Clay Roper – Diver (ADAS Part 3 Diver accredited)
- Max Rey - Diver (ADAS Part 3 Diver accredited)

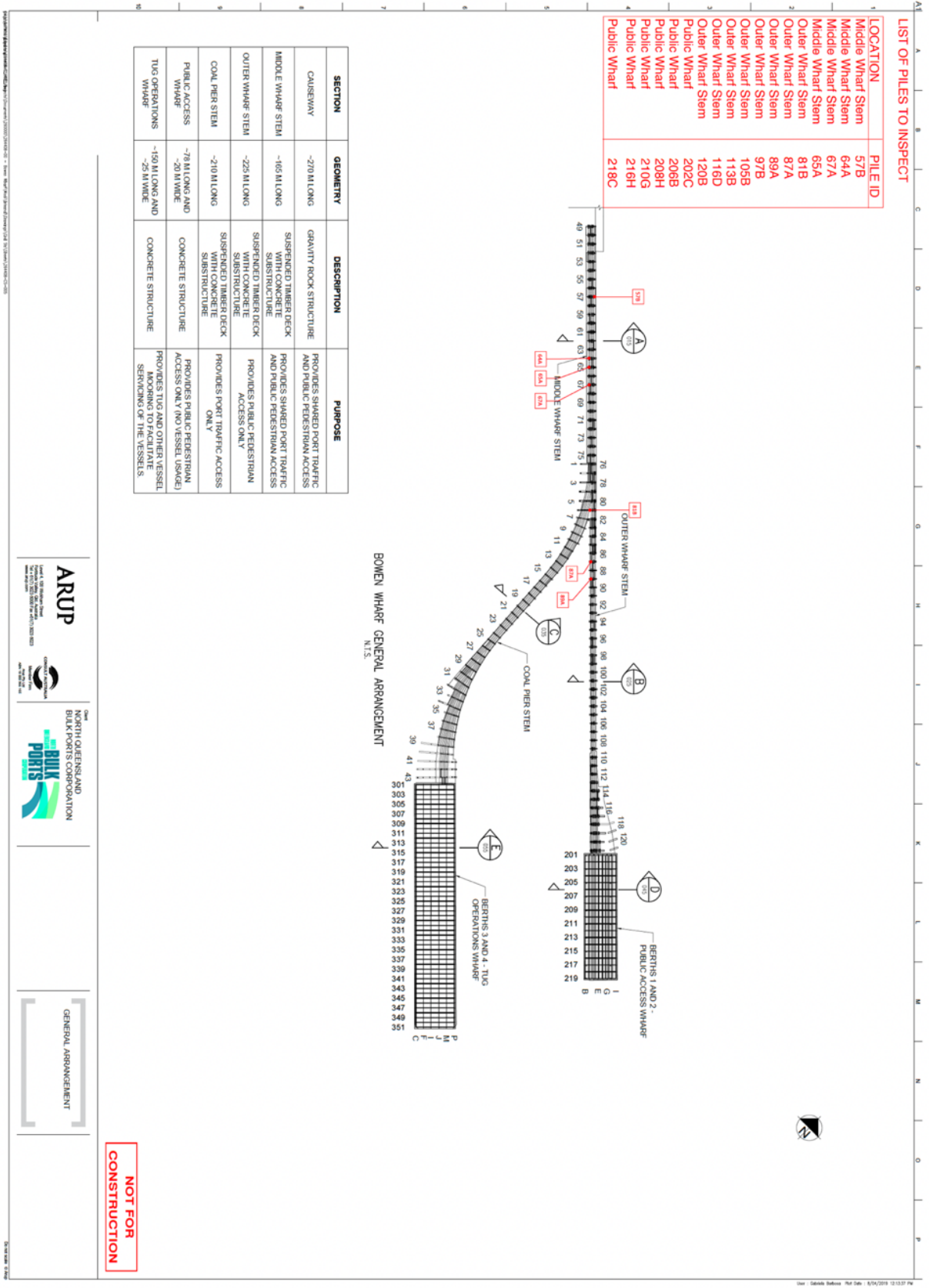
5.2 Supervisor/s

The dive crew were supervised by:

- Luke Nelson – Supervisor (ADAS Part 3 Diver and ADAS Part 3 Supervisor Accredited)

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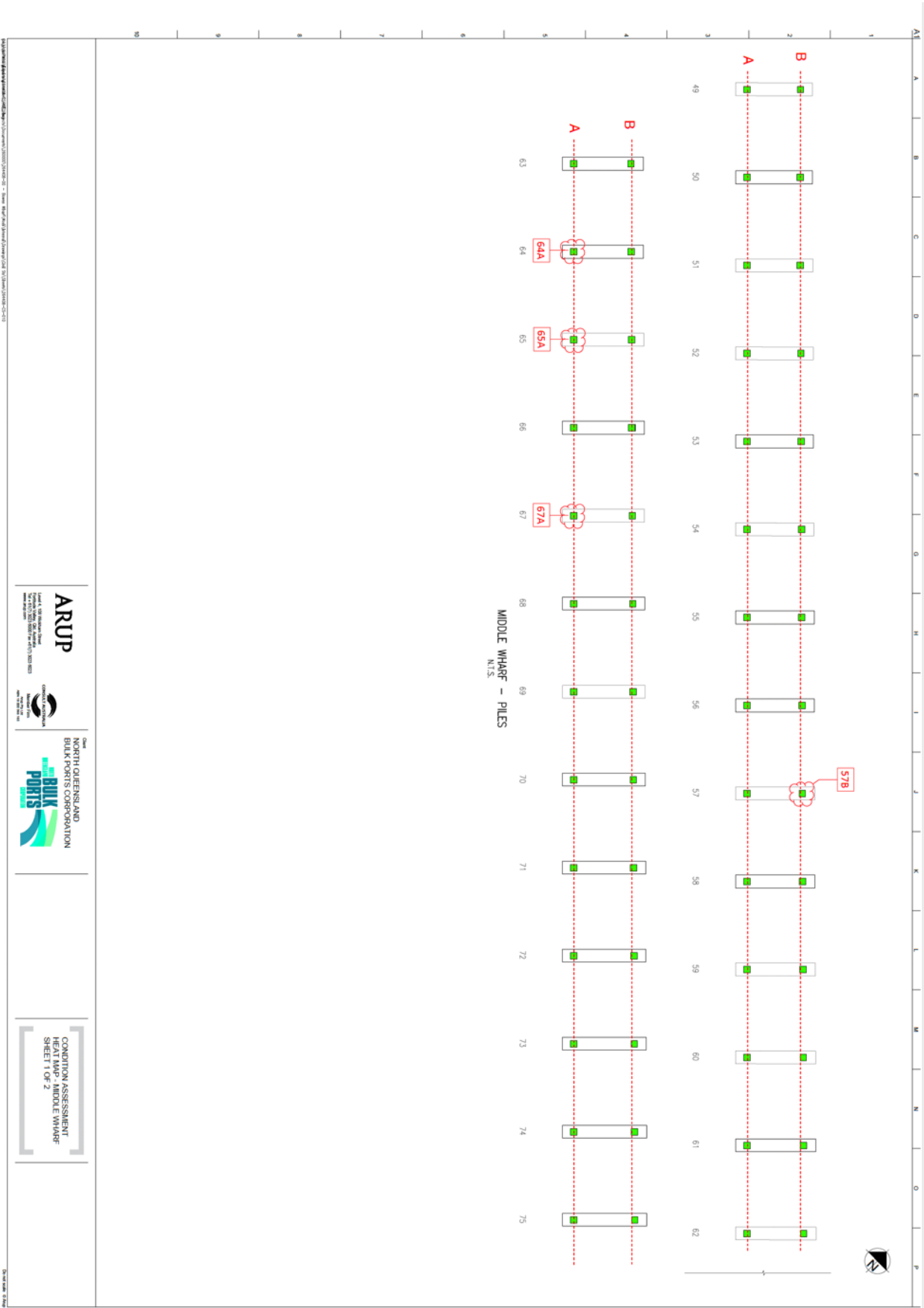
Attachment 1: Inspected Piles



NOT FOR CONSTRUCTION



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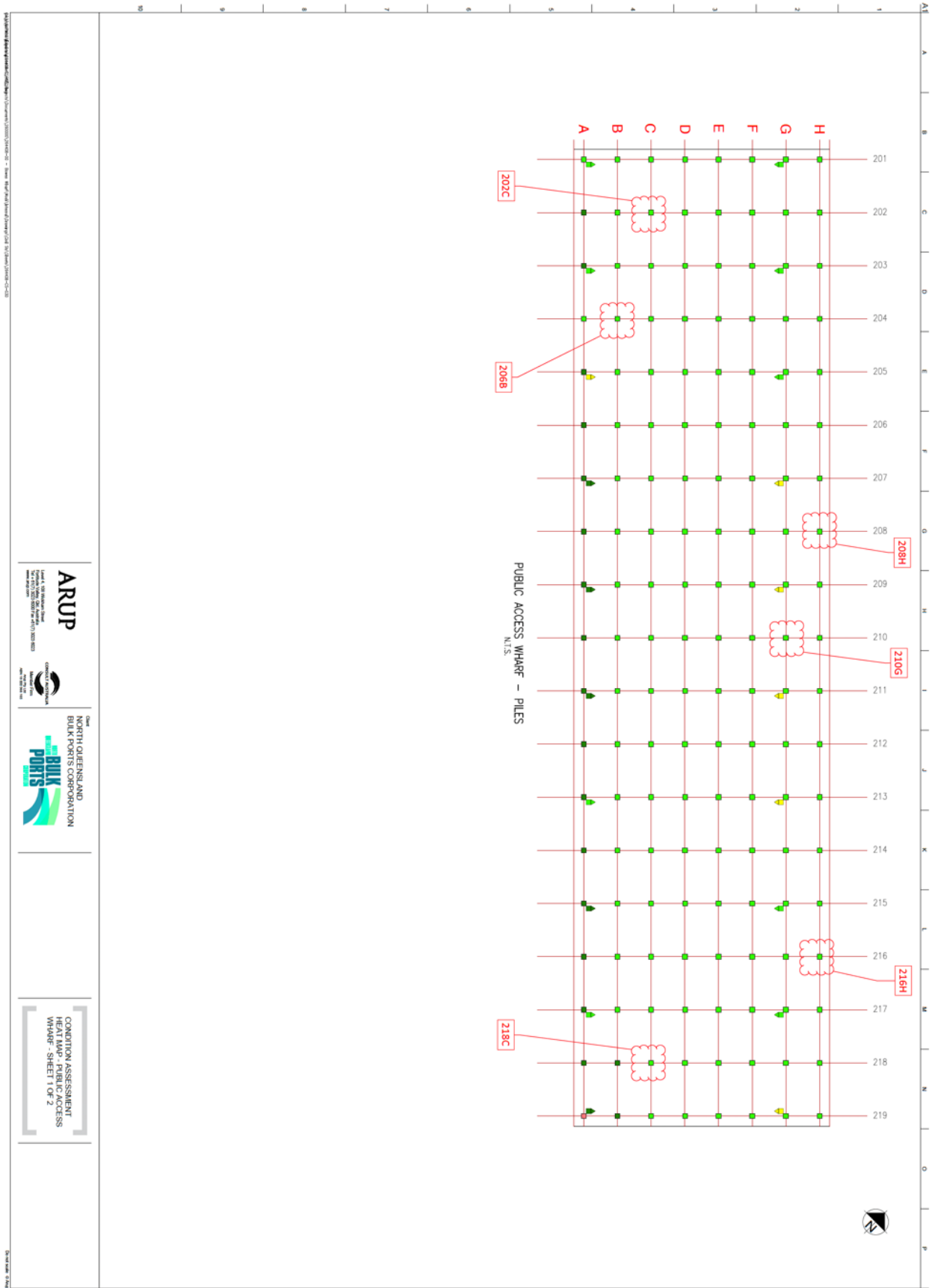
CONDITION ASSESSMENT
HEATMAP - MIDDLE WHARF
SHEET 1 OF 2

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CONDITION ASSESSMENT
HEATING – OUTER WHARF
SHEET 1 OF 2

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Attachment 2: CCTV Video and Photo Catalogue

Table 1 List of CCTV Video Files

File Name	File Type	File Description
57B	MP4	Video Inspection of pile #54B (out of water)
64A	MP4	Video Inspection of pile #64A (out of water)
65A	MP4	Video Inspection of pile #65A (out of water)
67A Pt A	MP4	Video Inspection of pile #67A (out of water) – Face 1 and Face 2
67A Pt B	MP4	Video Inspection of pile #67A (out of water) – Face 3
67A Pt C	MP4	Video Inspection of pile #67A (out of water) – Face 4
85A	MP4	Video Inspection of pile #85A (out of water)
97B Pt A	AVI	Cleaning and preparation of pile #97B for inspection
97B Pt B	AVI	Video Inspection of pile #97B (under water)
105B Pt A	AVI	Cleaning and preparation of pile #105B for inspection
105B Pt B	AVI	Video Inspection of pile #105B (under water)
113B Pt A	AVI	Cleaning and preparation of pile #113B for inspection
113B Pt B	AVI	Video Inspection of pile #113B (under water)
116D Pt A	AVI	Cleaning and preparation of pile #116D for inspection
116D Pt B	AVI	Video Inspection of pile #116D (under water)
120B Pt A	AVI	Cleaning and preparation of pile #120B for inspection
120B Pt B	AVI	Video Inspection of pile #120B (under water)
202C	AVI	Video Inspection of pile #202C (under water)
206B	AVI	Video Inspection of pile #206B (under water)
208H Pt A	AVI	Video Inspection of pile #208H (under water)
208H Pt B	AVI	Video Inspection of pile #208H (under water) continued
210G	AVI	Video Inspection of pile #210G (under water)
216H	AVI	Video Inspection of pile #216H (under water)
218C	AVI	Video Inspection of pile #218C (under water)

Table 2 List of Photo Files

File Name	File Description
GOPR5521.JPG	Pile 57B - headstock
GOPR5522.JPG	Pile 57B - Face 1
GOPR5523.JPG	Pile 57B - Face 2
GOPR5524.JPG	Pile 57B - Face 3
GOPR5525.JPG	Pile 57B - Face 4
GOPR5501.JPG	Pile 64A - headstock
GOPR5502.JPG	Pile 64A - Face 1
GOPR5503.JPG	Pile 64A - Face 2
GOPR5504.JPG	Pile 64A - Face 3
GOPR5505.JPG	Pile 64A - Face 4
GOPR5507.JPG	Pile 65A - headstock
GOPR5508.JPG	Pile 65A - Face 1

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GOPR5509.JPG	Pile 65A - Face 2
GOPR5510.JPG	Pile 65A - Face 3
GOPR5511.JPG	Pile 65A - Face 4
GOPR5513.JPG	Pile 67A - headstock
GOPR5514.JPG	Pile 67A - Face 1
GOPR5515.JPG	Pile 67A - Face 2
GOPR5516.JPG	Pile 67A - Face 3
GOPR5517.JPG	Pile 67A - Face 4
GOPR5528.JPG	Pile 85A - Face 1
GOPR5529.JPG	Pile 85A - Face 2
GOPR5531.JPG	Pile 85A - Face 3
GOPR5532.JPG	Pile 85A - Face 4
GOPR5492.JPG	Pile 97B – Top Face 1
GOPR5493.JPG	Pile 97B – Top Face 1
GOPR5494.JPG	Pile 97B – Top Face 2
GOPR5495.JPG	Pile 97B – Top Face 3
GOPR5496.JPG	Pile 97B – Top Face 4
GOPR5497.JPG	Pile 97B – Bottom Face 1
GOPR5498.JPG	Pile 97B – Bottom Face 2
GOPR5499.JPG	Pile 97B – Bottom Face 3
GOPR5500.JPG	Pile 97B – Bottom Face 4
GOPR5483.JPG	Pile 105B – Top Face 1
GOPR5484.JPG	Pile 105B – Top Face 2
GOPR5485.JPG	Pile 105B – Top Face 3
GOPR5486.JPG	Pile 105B – Top Face 4
GOPR5487.JPG	Pile 105B – Bottom Face 1
GOPR5488.JPG	Pile 105B – Bottom Face 2
GOPR5489.JPG	Pile 105B – Bottom Face 3
GOPR5490.JPG	Pile 105B – Bottom Face 4
GOPR5475.JPG	Pile 113B- Bottom Face 1
GOPR5476.JPG	Pile 113B- Bottom Face 2
GOPR5477.JPG	Pile 113B- Bottom Face 3
GOPR5478.JPG	Pile 113B- Bottom Face 4
GOPR5479.JPG	Pile 113B- Top Face 1
GOPR5480.JPG	Pile 113B- Top Face 2
GOPR5481.JPG	Pile 113B- Top Face 3
GOPR5482.JPG	Pile 113B- Top Face 4
GOPR5465.JPG	Pile 116D – Top Face 1
GOPR5466.JPG	Pile 116D – Top Face 4
GOPR5467.JPG	Pile 116D – Top Face 2 Spalling to left edge and exposed reinforcement bar (staining)
GOPR5468.JPG	Pile 116D – Top Face 3 Spalling to right edge with face 2 and extensive large vertical cracking and material loss
GOPR5469.JPG	Pile 116D – Bottom Face 1
GOPR5470.JPG	Pile 116D – Bottom Face 2
GOPR5471.JPG	Pile 116D – Bottom Face 3
GOPR5472.JPG	Pile 116D – Bottom Face 4

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GOPR5455.JPG	Pile 120B- Bottom Face 1
GOPR5456.JPG	Pile 120B - Bottom Face 2
GOPR5457.JPG	Pile 120B - Bottom Face 3
GOPR5458.JPG	Pile 120B - Bottom Face 4
GOPR5459.JPG	Pile 120B - Top Face 1
GOPR5460.JPG	Pile 120B - Top Face 1
GOPR5461.JPG	Pile 120B - Top Face 2
GOPR5462.JPG	Pile 120B - Top Face 3
GOPR5463.JPG	Pile 120B - Top Face 4
GOPR5434.JPG	Pile 202C
GOPR5435.JPG	Pile 202C
GOPR5436.JPG	Pile 202C
GOPR5437.JPG	Pile 202C
GOPR5438.JPG	Pile 202C
GOPR5439.JPG	Pile 202C
GOPR5440.JPG	Pile 202C large vertical crack at edge of face 3 and 4 with rust staining at bottom
GOPR5441.JPG	Pile 202C large vertical crack at edge of face 3 and 4 with rust staining at bottom
GOPR5442.JPG	Pile 202C
GOPR5443.JPG	Pile 202C
GOPR5444.JPG	Pile 202C
GOPR5445.JPG	Pile 202C
GOPR5446.JPG	Pile 202C
GOPR5418.JPG	Pile 206B – Top Face 1
GOPR5419.JPG	Pile 206B – Top Face 1
GOPR5420.JPG	Pile 206B – Top Face 1
GOPR5421.JPG	Pile 206B – Top Face 2
GOPR5422.JPG	Pile 206B – Top Face 3
GOPR5423.JPG	Pile 206B – Top Face 4
GOPR5424.JPG	Pile 206B – Top Face 4
GOPR5425.JPG	Pile 206B – Top Face 4
GOPR5426.JPG	Pile 206B – Bottom
GOPR5427.JPG	Pile 206B – Bottom
GOPR5428.JPG	Pile 206B – Bottom
GOPR5429.JPG	Pile 206B – Bottom
GOPR5400.JPG	Pile 208H – Top Face 1
GOPR5401.JPG	Pile 208H – Top Face 1
GOPR5402.JPG	Pile 208H – Top Face 2
GOPR5403.JPG	Pile 208H – Top Face 3
GOPR5404.JPG	Pile 208H – Top Face 4
GOPR5405.JPG	Pile 208H
GOPR5406.JPG	Pile 208H
GOPR5407.JPG	Pile 208H
GOPR5408.JPG	Pile 208H
GOPR5410.JPG	Pile 208H – Bottom Face 1
GOPR5411.JPG	Pile 208H – Bottom Face 1
GOPR5412.JPG	Pile 208H – Bottom Face 2

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GOPR5413.JPG	Pile 208H – Bottom Face 2
GOPR5414.JPG	Pile 208H – Bottom Face 3
GOPR5415.JPG	Pile 208H – Bottom Face 3
GOPR5416.JPG	Pile 208H – Bottom Face 4
GOPR5417.JPG	Pile 208H – Bottom Face 4
GOPR5384.JPG	Pile 210G – Top Face 1
GOPR5385.JPG	Pile 210G – Top Face 2
GOPR5386.JPG	Pile 210G – Top Face 3
GOPR5387.JPG	Pile 210G – Top Face 4
GOPR5388.JPG	Pile 210G
GOPR5389.JPG	Pile 210G
GOPR5390.JPG	Pile 210G
GOPR5391.JPG	Pile 210G
GOPR5392.JPG	Pile 210G
GOPR5393.JPG	Pile 210G – Bottom Face 1
GOPR5394.JPG	Pile 210G – Bottom Face 1
GOPR5395.JPG	Pile 210G – Bottom Face 1
GOPR5396.JPG	Pile 210G – Bottom Face 2
GOPR5397.JPG	Pile 210G – Bottom Face 3
GOPR5398.JPG	Pile 210G – Bottom Face 3
GOPR5399.JPG	Pile 210G – Bottom Face 4
GOPR5365.JPG	Pile 216H – Top Face 1
GOPR5366.JPG	Pile 216H – Top Face 1
GOPR5367.JPG	Pile 216H – Top Face 1
GOPR5368.JPG	Pile 216H – Top Face 2
GOPR5369.JPG	Pile 216H – Top Face 3
GOPR5370.JPG	Pile 216H – Top Face 3
GOPR5371.JPG	Pile 216H – Top Face 4
GOPR5373.JPG	Pile 216H
GOPR5374.JPG	Pile 216H
GOPR5375.JPG	Pile 216H – Bottom Face 1
GOPR5376.JPG	Pile 216H – Bottom Face 2
GOPR5377.JPG	Pile 216H – Bottom Face 2
GOPR5378.JPG	Pile 216H – Bottom Face 3
GOPR5379.JPG	Pile 216H – Bottom Face 3
GOPR5380.JPG	Pile 216H – Bottom Face 4
GOPR5381.JPG	Pile 216H – Bottom Face 4
GOPR5348.JPG	Pile 218C – Top Face 1
GOPR5349.JPG	Pile 218C – Top Face 2
GOPR5350.JPG	Pile 218C – Top Face 2
GOPR5351.JPG	Pile 218C – Top Face 3
GOPR5352.JPG	Pile 218C – Top Face 3
GOPR5353.JPG	Pile 218C – Top Face 3
GOPR5354.JPG	Pile 218C – Top Face 4
GOPR5355.JPG	Pile 218C
GOPR5356.JPG	Pile 218C
GOPR5357.JPG	Pile 218C

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GOPR5358.JPG	Pile 218C – Bottom Face 1
GOPR5359.JPG	Pile 218C – Bottom Face 1
GOPR5363.JPG	Pile 218C – Bottom Face 2
GOPR5364.JPG	Pile 218C – Bottom Face 2