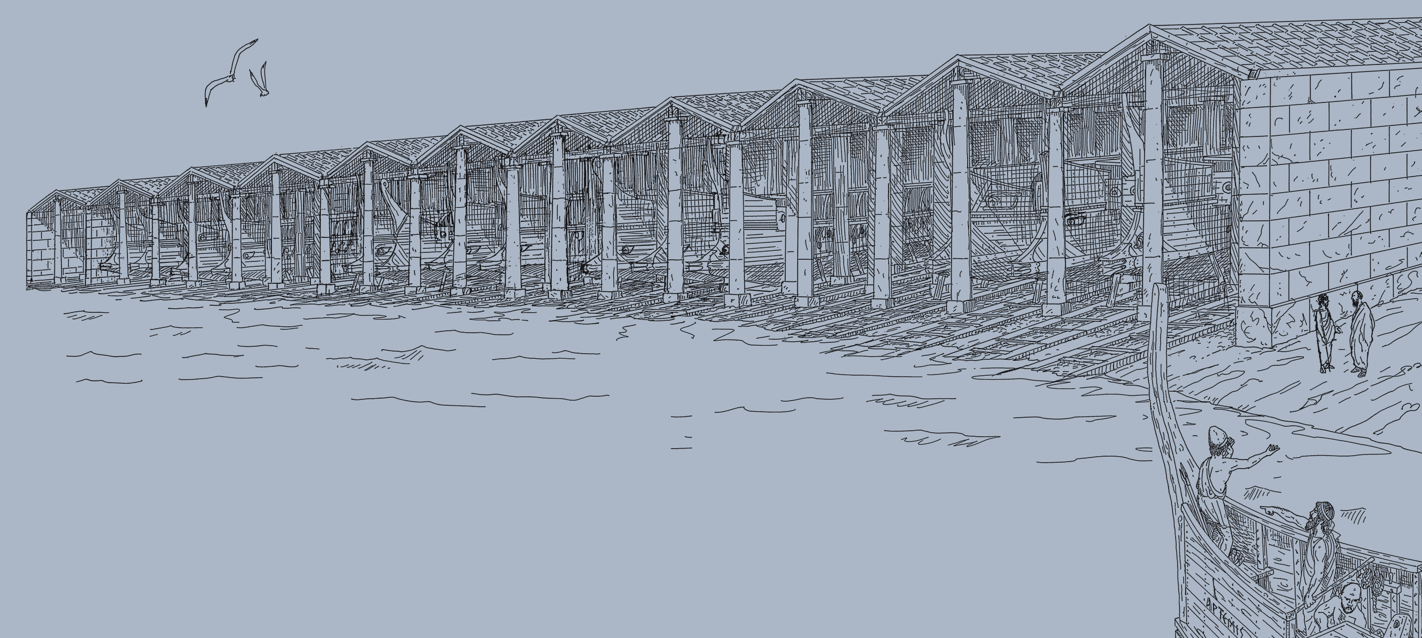
The Ancient Harbours of the Piraeus

Volume II. Zea Harbour: the Group 1 and 2 Shipsheds and Slipways – Architecture, Topography and Finds

Bjørn Lovén & Ioannis Sapountzis



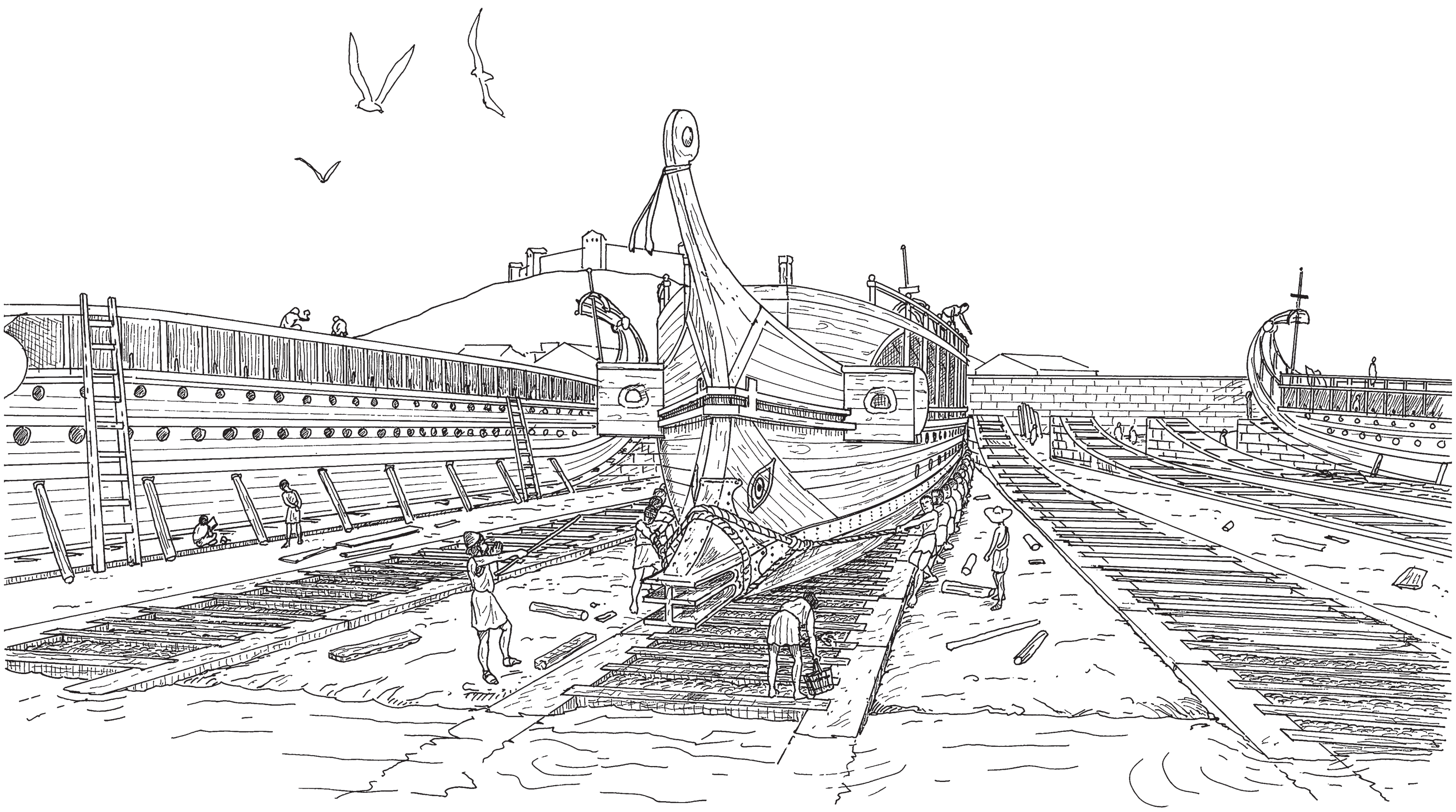
Monographs of the Danish Institute at Athens, Volume 15,3

The Ancient Harbours of the Piraeus, Volume II

ISBN 978-87-7184-802-1
9 788771 848021

The Ancient Harbours of the Piraeus

Volume II. Zea Harbour: the Group 1 and 2 Shipsheds and Slipways – Architecture, Topography and Finds



The Ancient Harbours of the Piraeus

Volume II. Zea Harbour: the Group 1 and 2 Shipsheds and Slipways – Architecture, Topography and Finds

Bjørn Lovén & Ioannis Sapountzis

Monographs of the Danish Institute at Athens
Volume 15,3

Bjørn Lovén & Ioannis Sapountzis
Volume II. Zea Harbour: the Group 1 and 2 Shipsheds and Slipways – Architecture, Topography and Finds

This book is Volume 15,3 in the series Monographs of the Danish Institute at Athens
Volume editors: Dan Davis, Athena Trakadas, Rebecca Ingram & Stefanie Kennell
Series editor: Kristina Winther-Jacobsen
Book design & DTP: Benoit van Santvoort

Printed in Denmark by Narayana Press
Printed on acid-free paper

ISBN 978-87-7184-802-1
ISSN 1397-1433

Distributed by Aarhus University Press
Finlandsgade 29
DK-8200 Aarhus N
www.unipress.dk

Oxbow Books Ltd
The Old Music Hall,
106-108 Cowley Road
Oxford, OX1 1JE
UK
www.oxbowbooks.com

ISD
70 Enterprise Drive
Bristol, CT 06010
USA
www.isdistribution.com

Publication financed by The Carlsberg Foundation

Cover: artistic reconstruction of Group 1 at Zea Harbour by Yiannis Nakas
Inside cover: artistic reconstruction of Group 2 at Zea Harbour by Yiannis Nakas

Contents, Volume II

Preface

"Archaeology is a team sport"

This study presents the results of eight years of Greek-Danish collaboration during the years 2003–2005, 2007–2010, and 2012 primarily at Zea Harbour in the Piraeus. The fieldwork was completed by the Zea Harbour Project (ZHP) in collaboration with and under the auspices of the Ephorate of Underwater Antiquities, the Ephorate of West Attica, Piraeus and Islands, and the Danish Institute at Athens (DIA). I wish to express my gratitude for our fruitful collaboration.

I want to single out Dr. Dimitris Kourkoumelis, our principal supervisor from the Ephorate of Underwater Antiquities, for his friendship, integrity, and love for Greece's submerged past, which have made him a cornerstone not only of the ZHP's success specifically, but of the success of underwater archaeology in Greece overall. I particularly wish to thank former Ephors of the Ephorate of Underwater Antiquities Dr. Katerina Dellaporta and Dr. Angeliki Simosi, as well as the present Ephor, Dr. Paraskevi Kalamara. In addition, I wish to thank Ephor Stella Chryssoulaki, Ephorate of West Attica, Piraeus and Islands, DIA director Dr. Kristina Winther-Jacobsen, former DIA directors Dr. Rune Frederiksen, Dr. Erik Hallager, and Dr. Jørgen Mejer (†) for their assistance, as well as the ever-helpful Hanna Lassen and Lone Gad (former secretary and former accountant of the DIA respectively), and the present secretary Niki Bouras. Their support has been invaluable.

The first manuscript of this volume was initially completed in late 2013. Around the same time, David Blackman and Boris Rankov published *Shipsheds of the Ancient Mediterranean* (2013). This publication, based on the results of the research project "Shipsheds in the Ancient Mediterranean," contains an extremely problematic study of the architecture and topography of the shipsheds in the Piraeus conducted by Rankov that is supplemented by architectural reconstructions by Jari Pakkanen (Chapter 6.4, pp. 155–172). Please read it and judge for yourself. I had been a part of the "Shipshed Project" since 2003 but left it in 2006 due to serious disagreements on leadership, agreements and intellectual property issues. I had simply had enough. I shelved the manuscript of Volume II and immersed myself in our new research project at Lechaion, the main harbour of ancient Corinth, until Professor Flemming Besenbacher, director of the Carlsberg Foundation, motivated me to apply myself and get the publication done. The substantial results that our team obtained, under perhaps the harshest conditions in the history of Classical and underwater archaeology, would never have been published in the monograph form they deserve had Professor Besenbacher not mentored me so robustly. In fact, the fieldwork in the Piraeus would never have been undertaken in the first place had it not been for the continued support and funding of the Carlsberg Foundation, our main sponsor since 2004.

Other people have made key contributions to the success of the ZHP. Professor Vincent Gabrielsen of the University of Copenhagen has also been a mentor to me, providing vital advice in challenging situations. Dr. John Hale of the University of Louisville has been a great source of friendly guidance; his support during the period that led up to my parting of the ways with the Shipshed Project was indispensable. Richard C. Anderson (former architect to the American School's Agora Excavations) has been a great teacher to our survey team as well as to me personally, greatly increasing the precision of our work over the years as a consultant in the field.

Mr. Kopitsas, the director of Marina Zeas A/S, and his staff have assisted us in many ways during our field work at Zea, and our collaboration has been excellent. The Port Police of the Piraeus, especially the Zea Harbour Port Authorities, have been very helpful. The Nautikos Athlitikos Syllogos (NAS), the Olympiakos Sailing Club, and the Istioploikos Omilos (Hellenic Yacht Club) have kindly assisted us in our work at Mikrolimano (ancient Mounichia).

Also deserving of special mention are Interspiro AB, who developed our essential diving AGA mask for women, and Viking (Trelleborg AB), who donated several diving suits for work in contaminated environments.

Numerous people have worked on the ZHP over the years, a dedicated and hardworking team that produced all the data presented in this study. The core team merits special commendation: Mette Kjær Schaldemose, Ioannis Triantafillidis, Ioannis Sapountzis, Panagiotis Athanasopoulos, Sigrid Rasdal Eliassen, Dr. Niels Bargfeldt, Brian Klejn-Christensen, Mette Arenfeldt, Mads Møller Nielsen, Konastantina Vafiadou Ioannis Nakas, Vassilis Tsiairis, Anne Hooton, Karen Lovén, Dr. Eva Mortensen, Dr. Chryssanthi Papadopoulou, Dr. Dan Davis, and Dr. Matthew McCallum.

Ms. Sophia Michalopoulou kindly allowed me to refer to data from her 2003 rescue excavations on the eastern side of Zea Harbour, which are very useful for understanding Zea's topography. I also wish to thank Dr. William Murray for his constructive input on the chronology of the seven monumental unroofed slipways discovered on the south-eastern side of Zea. Dr. Paul Reynolds most kindly commented on Ioannis Sapountzis' ceramic research, presented in Chapters 3 and 5. All Greek publications were translated in detail by Panagiotis Athanasopoulos; he and Stefanie Kennell translated the Greek passages quoted in this volume. Dr. Steffen Jørgensen has helped me gain a better understanding of several important ancient sources related to the Piraeus.

Finally, I am indebted to the editors of this volume – Dr. Dan Davis, Dr. Athena Trakadas, and Dr. Rebecca Ingram (2013 version), and Dr. Stefanie Kennell (2018 version) – who undertook the task of meticulously correcting the text, and to the three anonymous peer reviewers who also made valuable comments. Benoît van Santvoort designed the volume.

Needless to say, any shortcomings are entirely mine.

Bjørn Lovén
Between Sikinos and Sifnos

The book is dedicated to the memory of

Charles William Davenport Pochin (†)

Chapter 6
New and Updated Analyses and Interpretations of the Topography of Zea Harbour, Including Slipway and Shipshed Architecture

Bjørn Lovén

As major areas of the ancient shorelines of Zea and Mounichia have been destroyed by intrusive modern dredging, it is incumbent upon any scientific investigation to reconstruct the ancient waterfront topography using all of the available evidence. This evidence includes relative sea level change, the arrangement and position of the shipsheds and unroofed slipways, and the inclination of their individual architectural elements. By taking these three factors into account it is possible to attempt a reconstruction of the total lengths of the slipways and shipsheds.

(Lovén 2011: 147)

6.1. Introduction

Since the publication of the Zea Harbour Project's first volume (*The Ancient Harbours of the Piraeus* I.1–2) in 2011, work by the project has resulted in important new information coming to light. As has been made clear in the previous pages, these data allow for a better understanding of the layout and positions of the Athenian shipsheds and slipways through several usage phases. Drawing on new results from the ZHP's excavations, we present in this chapter the conclusions based on this evidence concerning the topography of Zea Harbour and the architectural characteristics of its shipsheds and slipways. An additional aim of this chapter is to reaffirm the validity of the project's methodology and published results in the light of recent concerted criticism published in *Shipsheds of the Ancient Mediterranean* (2013) by David Blackman, Boris Rankov, and Jari Pakkanen.[1]

6.2. The Relative Minimum Sea Level Change at Zea and Mounichia

As made clear in Volume I (and at the head of this chapter), an understanding of relative sea level change since antiquity is fundamental to any harbour study, especially when dealing with ancient shipsheds and unroofed slipways.[2] These structures were constructed at

1. Blackman & Rankov 2013: esp. 420–488. See below, pp. 155–173
2. The term *relative* here means that the change may include general rise in sea level over millennia and local tectonic and eustatic effects, among other factors. All measurements surveyed during the ZHP are correlated to the Datum Zero of Ε.Γ.Σ.Α. 87 (87DZ).

the very transition between land and sea. Even slight variations in sea level will affect them in various ways depending on their inclination.

Since the publication of Volume I (2011), important evidence for relative sea level change was found during the 2011 and 2012 seasons at both Zea and Mounichia Harbour (modern Mikrolimano).

6.2.1. New Evidence for Sea Level Change at Zea Harbour

The very large Quarry 22 on the south-western side of Zea Harbour (Area 4, Figs. 2.1, 6.1–6.2) remains one of the most important indicators for the minimum sea level change in the Piraeus (see below). The quarry is probably related to the construction of the nearby 5th- and 4th-century BC fortifications, and parts of it are incorporated into the fortification wall (Fig. 6.1). Quarry 22, traced for 73.20 m along the shoreline, is 21.31 m wide. On land, the upper part of the quarry rises to +3.59 m; in the sea the lowest areas were recorded in eight places, at Q22:1 (-1.92 m), Q22:2 (-1.90 m), Q22:3 (-2.05 m), Q22:4 (-1.84 m), Q22:5 (-1.72 m), Q22:6 (-1.98 m), Q22:7 (-1.70 m), and Q22:8 (-1.82 m) (Figs. 6.1–6.2).[3]

As a result of this research, the updated lower limit of the range of minimum relative sea level change (-2.05 m to -2.25 m) in the Piraeus is now set at -2.05 m on the evidence of the quarry cutting Q22:3 (see below). It is moreover supported by the direct evidence of quarry cuttings Q22:1 (-1.92 m), Q22:2 (-1.90 m), Q22:4 (-1.84 m), Q22:6 (-1.98 m), and Q22:8 (-1.82 m).

During the 2012 excavations, the well-preserved, fully submerged foundations of Slipways 36–42 were traced from +0.01 m m to -1.77 m over a total distance of 42.76 m (Pls. 4.1, 4.8c, p. 112). After Slipway 42 went out of use, its south-western open-passage was quarried for building material down to a depth of -1.42 m (Quarry 9, Pl. 2.13, Appendix 1, p. 194). This quarrying demonstrates that the area, together with a 34.09 m long stretch of rock-cut foundations for the slipways, did lie above mean sea level when it was exploited in antiquity (Pls. 2.2, 2.13, 4.1).

The foundation course of side-wall W29(?)/30(?) was laid at -1.73 m to -1.76 m directly on a foundation of sandy silt containing small quantities (*ca* 20%) of small- to medium-sized (0.05 to 0.10 m) subangular to angular limestone fragments (Trench 1–2008, Locus 4, Layer 1; Pl. 2.10g; see p. 200). Layer 1 continues to a depth of -1.92 m to -1.93 m (Pl. 2.10g) and towards the bottom there is a higher concentration (*ca* 40%) of small- to medium-sized limestone fragments (0.05 to 0.10 m). Architects of the 4th century BC are very unlikely to have constructed sections of a massive in-clined wall *ca* 5.4-m high, *ca* 0.95 m wide and 80.02 m to 82.49 m in length[4] in the sea on sandy foundations because of the dangers of erosion and liquefaction. Further, if Layer 1 had been constructed in the sea, the limestone fragments would have been deposited towards the bottom of the layer and not throughout Layer 1, as is the case with Layer 1 (Pl. 2.10g). The first course of blocks on the northern side of Structure 1 in Area 2 stands in a well-defined foundation trench dug into the natural clay at a maximum depth of -2.16 m (Pls. 2.3, 2.10f; p. 23).

6.2.2. New Evidence for Sea Level Change at Mounichia Harbour

In modern Mikrolimano the datum zero was hitherto not precisely defined on available maps of the area. In order to establish the same accurate 87DZ datum[5] used at Zea Harbour, a digital three-tripod traversing survey from Zea to Mikrolimano was conducted not once but twice to ensure precision.[6] The 87DZ datum now established at Mikrolimano allows direct compari-son between the two harbours of elevation values for ancient structures.

The area surrounding Zea and Mikrolimano Harbours, and the Piraeus in general, is relatively stable tectonically, with very few major earthquakes recorded

3. Quarry 22, which received its designation after the publication of Volume I, is not included in Appendix 1, as it will be published in greater detail in Volume III.

4. Estimated height based on the reconstructed Phase 3 column shaft height (IA: 2.16 m): 5.37 m (Lovén 2011: 163–165).

5. Ε.Γ.Σ.Α. 87 Datum Zero. Datum zero of the Greek Geodetic Reference System (G.G.R.S. 1987).

6. Digital three-tripod traversing survey, planned and conducted by Richard C. Anderson, former architect of the American School of Classical Studies at Athens Agora Excavations.

during the last two thousand years.[7] Since the Zea and Mounichia harbours belong to the same morphostructural, non-faulted geological unit (Neogene carbonate rock context), which is stable at the Holocene scale, that the harbours of Zea and Mikrolimano underwent different degrees of subsidence and uplift is improbable. The two harbours uplifted and subsided in the same sequences over geological time.[8]

Evidence of sea level change was found in the preserved remains of Tower M-T3, located roughly in the middle of the southern fortified mole of the harbour fortifications in Mounichia (Fig. 6.3). The foundations of the late Classical to Hellenistic building phase of this tower contain the deepest submerged rock-cut feature found in the Piraeus to date. The feature, preserved in an area 1.94 x 0.47 m, presently lies at -2.25 m.[9]

Although improbable, it cannot be completely ruled out that this rock-cut feature was constructed either underwater, inside a cofferdam, or at low tide (see p. 156). As a result, the minimum relative sea level change in the Piraeus since the Classical/early Hellenistic periods has been established as a range between -2.05 m, a solid benchmark documented in Quarry 22 (see above), and -2.25 m, the rock-cut foundations in Tower M-T3. This range is supported by evidence found within and just above this depth range (see below, and above).

The minimum sea level change of -2.05 m to -2.25 m is close to the *ca* -2.30 m relative sea level change estimated in the Attica region since 500 BC based on both geological and archaeological data.[10] This range, now documented at Zea and Mounichia Harbours, is equally important for understanding the architecture and topography of the slipways and shipsheds at Zea Harbour under discussion in this present volume. It affects the length reconstructions previously presented in Volume I of this series, which discussed Area 1 (northern half of Group 1) (see pp. 173–176).

Shipsheds 1 and 2 in Group 1 in the northern side of Mounichia Harbour extend for a distance of 23.56 to 33.13 m from the modern quay and to a depth of -1.95 m (Fig. 6.3, Pl. 6.1). Note that the modern harbour front itself is built *ca* 11 m into the sea at the position of side-wall W1; Shipshed 1 therefore extends about 44 m into the sea from the actual shoreline to the last column base laid on foundation fill at a depth of -1.95 m (column base top surface -1.56 m).[11]

Excavations in the colonnade dividing Shipsheds 1 and 2 revealed that this colonnade rests on foundation fill. A worked piece of wood (0.42 x 0.13 x 0.08 m) was found in the foundations of the colonnade dividing Shipsheds 1 and 2, recorded at a depth of -1.90 m in the top surface of the foundation fill 31.77 m distant from the modern quay. This foundation fill was probably laid on dry land, as the wood would probably have floated away if deposited under water or in the surf zone.

In 2012, excavations in the ramp area of Shipshed 1 revealed a tile roof collapse lying directly above a flat bedrock area at a depth ranging from -1.99 m to -2.07 m. The tile deposit offers a *terminus ante quem* of 325–300 BC. The vast number of tiles in the roof collapse extends as far as 38.27 m from the modern quay. This roof collapse indicates that the superstructure of Shipshed 1 continued into this area. More importantly, the debris from the roof collapse was deposited at a depth of -1.99 m to -2.07 m. The two blocks of the column base furthest seaward in the colonnade dividing Shipsheds 1 and 2 are located 4.68 m behind the furthest extent of the roof collapse, placed on foundation fill at -1.95 m (column base top surface -1.56 m), which proves that it is the base of a column (or pier), either fully or partly exposed at the shipsheds' floor level, not a colonnade foundation block within the building's foundations (Pl. 6.1). This identification is also corroborated by the minimum sea level change benchmark found in Quarry 22 at -2.05 m (Fig. 6.2, see above).

On the south-west side of Mounichia (M-G7), two similar adjacent blocks for a column (or pier) stand on a foundation fill at -2.31 m. The top surface is at -1.75 m.[12] This colonnade feature is located perpendicular

7. Goiran, Pavlopoulos, Fouache, Triantaphyllou, & Roland Etienne 2011.
8. Foumelis, Fountoulis, Papanikolaou & Papanikolaou 2013: 1–9; Apostolopoulos, Goiran, Pavlopoulos, Fouache 2014: 412-421, Mourtzas & Kolaiti 2013: 411-425. Dr. J.P. Goiran & Dr. A. Chabrol, pers. comm. 2018. The distance from the south-western side of Zea to the north-eastern side of Mounichia is 1,405 m.
9. Tower M-T3 will be published in Vol. III of this series. Another possible worked surface in bedrock was found in the foundations of Tower M-T3 at a present depth of -2.50 m, but it is not clear if this feature was man-made.
10. Poulos, Ghionis & Maroukian 2009: 14, fig. 4a.
11. Shipsheds 1 and 2 will be fully published in Vol. III of this series.
12. The colonnade foundation will be fully published in Vol. III of this series.

to the fortification wall at a distance of about 40 m (extrapolated) from the inside of the fortified mole.

6.3. The Position of Slipways and Shipsheds on the Shoreline at Zea and Mounichia

Now that the relative sea level change in the Piraeus between the late 6th and early 3rd centuries BC has been established at -2.05 m to -2.25 m, the new direct evidence for the landward and seaward delineations of slipways and shipsheds in Zea and Mounichia remains to be discussed. These data situate the buildings in the three-dimensional space of the ancient harbour front. Relevant evidence presented in Volume I will be restated here to make the argument as clear and transparent as possible.

6.3.1. Direct Evidence for the Position of Slipways and Shipsheds on the Shoreline at Zea Harbour

On the eastern (Group 1) and south-eastern (Group 2) sides of Zea, three landward delineations have been identified, either precisely, as in the case of the nine Phase 3 and two Phase 4 shipsheds (Position 1), or within a range of some metres, as in the case of the six Phase 1 slipways and the seven Phase 5 slipways (Position 2; Pls. 2.2, 2.16). The Phase 5 slipways also provide important evidence for the seaward extent of the slipways and shipsheds at Zea (Position 3; Pl. 2.2):

Zea, Group 1, Phase 3 Shipsheds 16–24(Φ), Phase 4 Shipshed 26, Dragátsis & Dörpfeld 1885, Zea Harbour Project 2001–2006: The well-defined landward delineation of these eleven shipsheds is identified at a distance of 39.22–40.06 m from the modern harbour front (Position 1; Pl. 2.16). In Shipsheds 16–18(χ), the bottoms of the rock-cut foundations of the back-wall are located at +4.11 m to +4.37 m. The easternmost foundations of side-wall W16/26(λ) are located at +4.37 m. The top surfaces of the first column bases in the narrowly spaced (2.16 m) colonnades C17/18:7(δ) and C23/24:3(Σ) are situated at +4.08 m and +4.07 m respectively, while those of the more widely spaced (3.38–3.39 m) colonnades C16/17:2(θ) and C20/21:2(H) at +4.07 m +4.08 m respectively.[13]

Zea, Group 1, Phase 1 Slipways 1–6, Zea Harbour Project 2001–2006: The landward (upper) ends of the Phase 1 slipways in Group 1 at Zea are most probably delimited by the Phase 3 rock-cut colonnade foundation trench C16/17:6 at a distance of 8.14 m east of the modern quay, in other words 31.82 m from the Phase 3 back-wall at an elevation ranging from +0.11 to +0.13 m (Position 2; Pl. 2.16).[14] This measurement is based on evidence indicating that Phase 1 structures were removed by later building phases. The first actual physical trace of Phase 1 found by the ZHP is a rock-cut slot for a transverse timber (SW5:R2, -0.41 m) located at a distance of 40.05 m from the Phase 3 back-wall.

Zea, Group 2, Phase 5 Slipways 36–42, Zea Harbour Project 2012: The landward (upper) ends of these slipways have been either removed by quarrying or covered by modern structures; thus, they cannot be identified (Position 2; Pls. 2.2, 4.1–4.4). The change in gradient of the ramp foundations of Slipway 36 at elevation -0.71 m is interpreted as the transition between the keel-supporting ramp structure (1:25.1/2.3°) and the stern-supporting ramp structure 1:6.9 (8.2°) (Pl. 4.5a). The straight keel of the warship would most probably have rested seaward of this point, whereas the upward curving stern of the warship would have been landward of it.

The fully submerged foundations of the keel-supporting ramp section have been traced for a total length of 37.87 m, at a depth of -0.71 m to -1.77 m maximum (Position 3; Pls. 2.2, 4.8, 4.10b). This distance represents the furthest that any of the slipways and shipsheds at Zea Harbour extended into the sea.

6.3.2. Direct Evidence for the Position of Shipsheds on the Shoreline at Mounichia Harbour

Along the northern (Group 1) and north-eastern (Group 2) sides of Mounichia, one landward delineation can be estimated with reasonable precision and another positively identified, while in Group 1 important evidence for the seaward extent of the shipsheds has been found.

13. Lovén & Schaldemose 2011: 87, 89, 97–98, figs. 173, 174a, 176b; pls. 6, 8a-c.
14. Lovén 2011: 151, pls. 12, 43.

Mounichia, Group 1, Shipsheds 1–2; Zea Harbour Project 2010–2012: In photos of the northern side of the harbour taken in the late 1800s and early 1900s before this area was heavily developed, the foot of the steep limestone hill of Kastella evidently extended almost down to the shoreline (Fig. 6.4). The harbour landscape has changed extensively since then; a quay area with a restaurant and café was built 11–13 m into the sea, on top of Shipsheds 1 and 2 (Fig. 6.3, Pl. 6.1). Further areas of this hill were removed to build houses and to widen the small dirt road into the present-day Akti Koumoundourou, now about 12–13 m wide including both pavements.

Akti Koumoundourou 4, the house on the shore in the centre of this photo (Fig. 6.4), still stands today, thereby permitting photogrammetric analysis of the adjacent landscape (Fig. 6.3, Pl. 6.1). The ground plan of the house measures 10.9 x 21.6 m.[15] Its foundation was evidently cut into the bedrock, while its façade, which aligns with the foot of the cliff in the photo (Fig. 6.4), is estimated to have been 11–12 m distant from the shoreline. Shipsheds 1 and 2 could not have extended beyond the margins of Kastella Hill, which means that their maximum extent was about 22 m from the point where the colonnade dividing Shipsheds 1 and 2 disappears under the modern quay (Pl. 6.1).[16] As much as about 12 m of this colonnade could still be submerged, from which point they could roughly continue for another 10 m to the foot of the hill; the colonnade dividing these two shipsheds is estimated to have extended about 52 m from the column base furthest seaward to the foot of the hill. Between the shipsheds and the foot of Kastella Hill was likely a passage or road that reduced their length by a few metres.

The western side-wall of Shipshed 1 and the colonnade dividing Shipsheds 1 and 2 represent the shipsheds identified in the Piraeus that extend furthest into the sea from the estimated shoreline at a maximum of about 44 m (Position 3, from the modern quay: maximum 33.13 m, Pl. 6.1).

Mounichia, Group 2, Shipsheds, Petritaki 1997, 1999 and 2006; Zea Harbour Project 2012: Excavations of the plot Akti Koumoundourou 22 revealed the back-wall of four securely identified shipsheds on the north-western side of the harbour *ca* 44.40 m distant from the modern quay (Fig. 6.3, Position 1).[17] In the same area ZHP found four column drums, reused in the ramp foundations that extend 15.96 m from the modern quay at -1.73 m. Above these foundations would have been another course of blocks.[18]

Summary

Thirteen slipways and two shipsheds, all securely identified, have been excavated at three locations near the 2006–2012 shorelines of Zea and Mounichia (Position 2). At Zea, the landward ends of the keel-supporting ramp sections have been established on the modern shoreline or in the sea nearby at elevations between +0.11 and +0.13 m (Phase 1 Slipways 1–6, Group 1) and -0.71 m (Phase 5 Slipways 36–42, Group 2, Pls. 2.2, 2.15, 4.1–4.2, 4.5).[19] The Phase 5 foundations in all probability accommodated a built ramp structure, and as a result are preserved to an elevation lower than that of Phase 1, where the transverse ramp timbers are estimated to have been located 0.07 m above the surface of the ramp foundations.[20] The landward limit of Shipsheds 1–2 in Group 1 at Mounichia is situated somewhere between the distance from the estimated shoreline to the foot of Kastella Hill (7–15 m), or in the area bounded by the estimated shoreline and the seaward edge of the modern quay (11–13 m wide, Pl. 6.1).

6.3.3. Possible Slipways and Shipsheds with a Landward Delimitation on or near the 1872–1881 Shoreline

At both Zea and Mounichia, several other shipsheds (or, less likely, unroofed slipways), identified and possible, provide corroborating evidence and strongly indicate the existence of single units with a landward limit near the 1872–1881 shoreline (Position 2):

15. Scaled off the official map of the harbour.
16. Measured from the point where Colonnade C2/3 disappears under the modern quay.
17. Petritaki 2011: 443–444.
18. The structure will be published in detail in Vol. III of this series.
19. Lovén 2011: 158–159, pls. 3, 11–12, 43.
20. Lovén 2011: 69, pl. 12.

Mounichia, Group 1, Graser 1872: To the east of the securely identified Shipsheds 1 and 2, next to the northern fortified mole, Graser estimated the length of a submerged inclined structure that he identified as part of a shipshed at *ca* 148 feet (*ca* 45.11 m, Fig. 6.3).[21] This distance is very close to the 44 m estimated by the ZHP as the maximum seaward extent of Shipsheds 1–2 in this group (Pl. 6.1).

Mounichia, Group 2, von Alten 1876/77, 1881: von Alten documented the remains of a back-wall directly on the shoreline and traced seven possible shipsheds into the sea for roughly 22 m (Fig. 6.3).[22]

Zea, Group 3, von Alten 1876/77: von Alten recorded possible shipsheds in the sea in Group 3, including what appears to be their back-wall (Figs. 2.2, 4.10).

Zea, Group 4, Graser 1872: On the beach, Graser found some remnants of a possible back-wall, part projecting a foot out of the water, the rest submerged. Perpendicular to this wall and stretching into the sea were ten structures (*Wangen*), which Graser identified as four shipsheds (Fig. 2.2).[23]

Zea, Group 4, von Alten 1876/77: von Alten's map of this area shows two parallel structures, partly in the sea and partly on shore. From the furthest seaward of these two structures, four perpendicular structure lines, noted as shipsheds, stretch into the harbour basin (Fig. 4.10).

6.3.4. Identified shipsheds delimited 37+ m inland from the 1885–2006 shorelines

The ZHP has identified 17 shipsheds at three locations 37.54 m to 60.8 m distant from the 1885, 1973, and 2006 shorelines of Zea and Mounichia (Position 1).

On Dörpfeld's 1885 plan of Zea, the landward limit of the identified Shipsheds 16–24 and 26–27 in Group 1 is located 37.54–39.70 m from the outside of the back-wall (Pl. 2.16).[24] The distance from the outside of the back-wall to the 2006 shoreline, as defined by the quay constructed in the 1960s, is 39.22–40.06 m. Alexandri found evidence for two shipsheds at a distance of 60.8 m from the modern shoreline in Group 5. The shipsheds continue into the unexcavated area on the north-east (Fig. 4.13, Pl. 2.17). Near the north-eastern pavement of Akti Moutsopoulou the rock-cut ramp foundations of Shipshed 53 is at +0.23 m. With the rock-cut foundations of Shipshed 17(η)'s ramp structure (S17:R4) at +3.06 m next to the eastern pavement of Akti Moutsopoulou, the actual shoreline in front of Shipshed 53 can be reasonably assumed to have been located much further landward and the modern quay in front of Alexandri's excavation have been built into the sea for an unknown, but considerable, distance.[25]

In Mounichia, Petritaki excavated the back-wall of four identified shipsheds at a distance of *ca* 44.40 m from the modern shoreline in Group 2 (Fig. 6.3).[26] As in Group 1 at Mounichia, the modern quay area is probably built into the sea, but how far is unknown (see above).

Slipways and shipsheds, possible and identified, delimited 36+ meters inland from the 1872–1881 shorelines

Both at Zea and Mounichia, several possible shipsheds provide corroborating evidence that strongly indicates the existence of shipsheds with a landward limit 36.7– *ca* 60 m away from the 1892–1900 shorelines (Position 1).

Zea, Group 1, Dragátsis 1899: Dragátsis excavated the back-wall of an unknown number of shipsheds in the southern part of Group 1 at Zea located about 38 m from the 2012 shoreline (pp. 26–28, Pl. 2.16).[27]

Zea, Group 4, Dragátsis 1892: Dragátsis recorded three features that he identified as parts of shipsheds with a maximum distance of 36.7 m from the 1892 shoreline (Fig. 2.2).[28]

21. Graser 1872: 40–41. See Lovén & Schaldemose 2011.
22. Von Alten 1881: figs. 5, 7–8; Lovén 2011: 47–48, Figs. 25, 29–30.
23. Graser 1872: 50; Lovén 2011: 40.
24. Scaled off Dragátsis & Dörpfeld 1885: pl. 2; margin of precision 0.05 m (Lovén 2011: 76–79, pl. 17).
25. Alexandri 1979a: 151, figs. 34–35; Lovén 2011: 42, fig. 19–20. The highest point on the bottom of the ramp foundations is scaled off Alexandri 1973, fig. 35, section A–A, assuming that the level of the 1973 pavement is the same (+3.06 m) as the 2010 pavement.
26. Petritaki 2011: 443-444.
27. Dragátsis 1899: 38.
28. Dragátsis 1892: 22–23, pl. A; Lovén 2011: 42, fig. 18.

Mounichia, Group 3, Angelopoulos 1898; Dragátsis 1899–1900: Angelopoulos and Dragátsis excavated a 62.3 m long shipshed back-wall located 60 m from the 1899 shoreline, along with several colonnade foundations (Fig. 6.3).[29] Part of this back-wall is still visible today about 60 m from the sea. During the construction of the houses in front of this back-wall, a local fisherman known only by his first name, Panagiotis, saw several column bases stepped towards the sea and interestingly, considered them to be ancient shipsheds.[30]

6.3.5. Two Case Studies: Direct Evidence

The above data situate the upper (landward) limits of identified slipways and shipsheds in Zea and Mounichia at two distinctly different locations on the modern shoreline (Positions 1–2). In addition, the lower parts of identified slipways and shipsheds are located relatively far seaward (Position 3). At Position 1, 17 securely identified shipsheds are located over 38 m from the modern shoreline. At Position 2, 13 slipways and 2 shipsheds, all securely identified, have their upper ends either on or near the modern shoreline. At Position 3, two identified shipsheds and seven slipways extend about 44 m and 42.76 m into the sea respectively; their maximum seaward extent defines this position. Positions 1–3 are all supported by copious direct and indirect evidence (see above). The analysis of the slipway and shipshed shoreline positions concludes with two case studies. Case Study 1 compares the ramp positions of Slipways 36–42 (Group 2) with those of the Phase 3 shipsheds in the northern half of Group 1; also included are relevant data from the Phase 1 slipway ramps identified in parts of the same area as Phase 3 (Pl. 2.16). Case Study 2 compares the colonnade positions of the Phase 3 shipsheds at Zea (Group 1) and the Phase 3 shipsheds at Mounichia (Group 1).

Case Study 1 – Comparison of the Ramp Positions of the Phase 3 Shipsheds and the Phase 5 Slipways at Zea

The Phase 3 shipsheds are dated *terminus ante quem* 375–350 BC, while the Phase 5 slipways probably date toward the end of the period between the early 5th and the late 4th century BC based on historical sources and their relation to Structure 1, which occupies the wedge-shaped area dividing these slipways from the Phase 3a shipsheds (likewise sometime later in the 4th century BC) (see pp. 188–189).[31] The Phase 3 and Phase 3a shipsheds and the Phase 5 slipways were very likely in use at the same time. Furthermore, as discussed in Chapter 2.4, we have strong evidence for the existence of a back-wall at roughly the same position as the Phase 3 back-wall in the southernmost part of Group 1 (pp. 26–28, Pl. 2.16). When Slipway 36 is extended to the preserved lower end of Slipway 42, it clearly encroaches on the reconstructed seaward end of Shipshed 34 (Pl. 2.15). The back-wall may have extended into the area behind Shipshed 34; if so, the shoreline distance between the compared structures would be reduced to zero. The minimum shoreline distance between the ramp structure of Phase 5 Slipway 37 and the ramp of Phase 3 Shipshed 23 used in this case study is 87.95 m (Pl. 2.16).

The Phase 3 ramp foundation furthest seaward has been identified in Shipshed 23(Π) at an elevation of -0.96 m (S23:R2, 54.57 m from the rear of the back-wall; Pl. 2.16).[32] From the point where the bottom surface of the ramp foundations of Slipway 37 has an elevation of -0.96 m to the point in the ramp foundations of Slipway 42 are preserved furthest seaward (at a depth of -1.77 m), the distance is 28.02 m (Pls. 2.2, 4.8a, 2.16), which demonstrates that the ramp foundations of the Phase 5 slipways are preserved further into the sea and deeper (by 0.81 m) than the Phase 3 ramp foundations of Shipshed 23(Π). The preserved seaward (lower) end of Slipway 42 would have been above the mean sea level at +0.28 m to +0.48 m when calibrated to the minimum relative sea level change of -2.05 to -2.25 m. Consequently, in the 4th century BC, the outside of the Phase 3 back-wall (+4.11 m to +4.37 m) was situated 54.57 m from the far (furthest seaward) end of its ramp foundations (S23:R2) at -0.96 m. The distance from the point where the ramp foundation of Slipway 37 is at -0.96 m to the furthest seaward extent

29. Dragátsis 1899: 37–39; 1900: 35–36; Angelopoulos 1899: 39–41; Lovén 2011: 49.
30. Pers. comm. 2012.
31. Lovén 2011: 173.
32. Lovén 2011: 132, fig. 172, 214, 216b, pls.16, 36a.

of Slipway 42 at -1.77 m is 28.02 m, giving a total distance of 82.59 m between the Phase 3 back-wall and the preserved lower end of the Phase 5 slipways. The gentler incline of the Phase 5 ramps (range 1:28.7/2.0° to 1:25.1/2.3°) would of course place them further seaward than the slope of their Phase 3 predecessors (range: 1:12.8/4.5° to 1:11.9/4.8°).

Roughly midway between these two points is the landward end of Slipway 36's keel-supporting ramp foundation, located 37.87 m from the preserved lower end of Slipway 42's ramp foundations at an elevation of -0.71 m (Pls. 2.2, 4.8a), that is, 47.83 m from the Phase 3 back-wall. In Phase 1, the furthest preserved landward rock-cut slot for a transverse timber (SW5:R2, -0.41 m) is located 40.05 m away from the Phase 3 back-wall. The upper ends of the Phase 1 slipways, however, most likely end at a distance of 31.82 m from the outside of the Phase 3 back-wall at elevations of +0.11 and +0.13 (Pl. 2.16).[33]

Comparison of the direct evidence of the Phase 3 shipshed ramps with those of the Phase 1 and Phase 5 slipways, demonstrates that the keel-supporting ramp foundations of unroofed single-unit slipways did exist and had a landward limit near the modern shoreline (present-day mean sea level) in the depth interval between +0.13 m and -0.71 m. In the case of the Phase 5 slipways, the physical remains of the keel-supporting ramp foundations have been traced 37.87 m into the sea to a depth of -1.77 m, indicating that the sternward end of the straight keel of a warship rested near and seaward of this point. The Phase 5 slipways, as stressed above, were most probably in active use at the same time as the Phase 3 shipsheds.

The rear of the Phase 3 back-wall and the upper end of the Phase 3 ramp foundations in Shipshed 17(η) (S17:R5) are located further inland (47.83 m and 45.67 m respectively) than the landward end of the Phase 5 keel-supporting ramp foundations (-0.71 m) at +4.11 m to +4.37 m and +4.11 m. Given the location of the existing physical remains of the Phase 5 slipways and Phase 3 shipsheds, this proves beyond any doubt that Phase 5 consisted of single-unit slipways, while that the Phase 3 shipsheds were double-unit structures designed to house two warships, one behind the other.

Case Study 2 – Comparison of the Colonnade Positions of the Phase 3 Shipsheds at Zea and the Phase 3 Shipsheds at Mounichia

In the Phase 3 shipsheds at Zea, the colonnade foundations furthest seaward are preserved in the colonnade that divides Shipsheds 23(Π) and 24(Φ) (C23/24:10) at a depth of -0.96 m (*terminus post quem* 375–350 BC, Fig. 6.7, Pl. 2.16).[34] In the colonnade dividing Shipsheds 1 and 2 in Group 1 at Mounichia (first building phase: *terminus post quem* 520–480; in active use until 325–300 BC at the latest), the last identified column base stands at a depth of -1.95 m (Fig. 6.3, Pl. 6.1); a similar colonnade feature was found in Mounichia Group 7 standing at -2.31 m (see above). This shows that identified shipshed colonnades extended to a depth of -1.95 m, in other words 0.99 m deeper than the Phase 3 column base foundation feature C23/24:10 at Zea (-0.96 m).

The distance between the outside of the back-wall and the centre of column position 26 is 58.31 m.[35] By extrapolating the Phase 3 colonnade foundations from this point to a depth -1.95 m, the colonnade foundations would have extended to 70.95 m (range: 70.50 m to 71.39 m).[36]

This is supported by direct evidence from Mounichia, where Petritaki excavated a shipshed back-wall *ca* 44.40 m landward from the modern quay in Group 2, and ZHP's identified Shipsheds 1–2, which extend 23.56 to 33.13 m into the sea from the modern quay in Group 1 (Fig. 6.3, Pl. 6.1). Petritaki and ZHP's fieldwork at Mounichia show that shipshed structures can be traced over a maximum distance of approximately 78 m when their positions relative to the modern quay are compared. Note also that von Alten found a back-wall belonging to possible shipsheds along the 1881 shoreline in front of where Petritaki would eventually excavate.[37]

33. Lovén 2011: 151, fig. 200, pls.12, 43.
34. Lovén & Schaldemose 2011: fig. 216a, pl. 24.
35. (2.16 m x 25) + 0.63 m + 3.68 m = 58.31 m.
36. Lower range (based on a gradient of 1:12.8/4.5°): 58.31 m + (0.99 m x 12.8) + 0.41 m (half an average 0.81-m long column base) = 71.39 m. Higher range (based on 1:11.9/4.8° gradient): 58.31 m + (0.99 m x 11.9) + 0.41 m (half an average 0.81-m- long column base) = 70.50 m. Mid-range: 70.95 m.
37. See Lovén & Schaldemose 2011: figs. 21, 29–30.

Strong indications of single-unit and double-unit slipways and shipsheds on the same shoreline are also present in Group 4 at Zea, based on the evidence provided by Dragátsis (1892, double-unit), Graser (1872, single-unit), and von Alten (1876/77, single-unit) (Figs. 2.2, 4.10; see above). In Group 5 Zea, Graser (1872) records submerged remains running *ca* 18.3–27.4 m into the sea. On the same shoreline, Alexandri (1973) excavated shipsheds 60.8 m distant from the modern quay. Note that this quay is built several meters into the sea (Pl. 2.17, see p. 152).[38] Furthermore, good evidence exists for single-unit shipsheds (or less likely slipways) in Group 3 at Zea (von Alten 1876/77, Fig. 4.10) and double-unit shipsheds in Group 3 at Mounichia (Angelopoulos 1898; Dragátsis 1899–1900, Fig. 6.3).

Summary

Based on all the available evidence, it can now be stated with confidence that the minimum relative sea level change was between -2.05 m and -2.25 m. Also, thirteen identified slipways and two identified shipsheds have been delimited near the 2006 and 2012 shorelines (Position 2) at Zea and Mounichia, in two instances extending 42.76 m and about 44 m into the sea to a depth of -1.77 m and -1.95 m (Position 3). Seventeen identified shipsheds have been delimited or found extending inland for a distance of 37.54 m, 60.8 m (it is stressed that the modern quay in this area is built several meters into the sea) and *ca* 44.40 m from the 1885, 1973, and 2006 shorelines (Position 1) respectively. Finally, direct evidence has been laid out in Case Studies 1 and 2 for the Phase 3 shipsheds and Phase 5 slipways' positions on the 4th-century-BC shoreline along the eastern and south-eastern sides of Zea Harbour (Positions 1–3; Pls. 2.2, 2.16).

The progress gained from these conclusions can only be achieved through exploiting all sources of information on the shipsheds, both current and historical. The relevant sections of a recent publication on Mediterranean shipsheds exhibit the failings inherent in studies that neglect to consider carefully all the possible evidence.

6.4. Answering the Challenges of Shipsheds of the Ancient Mediterranean (2013)

6.4.1. Sea Level Change

In his entry on the Piraeus in the catalogue section of *Shipsheds of the Ancient Mediterranean*, Boris Rankov strongly argues against the -1.90 m minimum sea level change benchmark presented in Volume I, which he characterizes as "questionable", "inconclusive", and an "estimate."[39] But his use of the evidence for relative sea level change is problematic. Among other things, he states, "It is clear from the underwater remains in Zea and Munychia that there has been a rise in relative sea level in the harbours since Classical antiquity. The extent of this has, however, been a matter of debate since the nineteenth century and estimates have ranged from *c.* 1.5 m to *c.* 3.5 m; at present, the evidence remains inconclusive."[40] On the contrary, as has been made clear, the evidence of relative sea level change is not inconclusive, nor is the critical benchmark of -1.90 m questionable or based on an estimate. All evidence indicates its reliability in computing sea level change in this area.

The core of Rankov's criticism lies in his view that the ZHP erroneously assumed "that all the man-made features recorded were originally worked out of the water and above ancient sea level which moreover, is implicitly ancient *mean* sea level, but this assumption is far from secure." Rankov then goes on to argue that, during low tide, some "foundations could have been laid in the dry at a (Classical Period) depth of -0.50 m; such foundations now measured at (say) -1.90 m would imply a rise in mean sea level of only *c.* 1.40 m."[41]

38. Lovén 2011: 43–45.
39. Lovén 2011: 147–148; Blackman & Rankov 2013: 423 with n. 34, 456–457.
40. Blackman & Rankov 2013: 423, n. 24.
41. Blackman & Rankov 2013: 456. To judge from twelve years of fieldwork and eight years of living by the harbour front at Zea Harbour, it is clear that extreme low tide (0.40–0.60 m) only occurs for a few days every year in the Piraeus. The ancient builders are highly unlikely to have planned major building programmes such as the construction of shipsheds and slipways on the unpredictable availability of large areas of drained seabed for a few days each year.

The benchmark for minimum sea level change in Volume I, however, was based primarily on the -1.90 m depth of quarry cutting Q22:2 in Area 4 at Zea (Figs. 2.1, 6.1–6.2), and on supporting direct and indirect evidence.[42]

Rankov also argues that the ancients were capable of underwater construction.[43] Ancient builders before and during this period did in fact construct breakwaters, moles, and fortified moles in the sea. They could and did off-load natural, uncut stones into the sea to construct breakwaters and mole foundations. They could and did place huge, rough cut blocks on top of such foundations to create moles, even fortified moles. These were normally above sea level, but in some instances were created underwater when their placement did not require great accuracy. But there is no evidence, nor does common sense dictate, that they attempted to construct with precision, often on a precise inclination, rock-cut or built foundations for ramps, colonnades and other structures in the sea under water.

Rankov suggests that cofferdams may have been used in the 429/28 BC construction of the fortified moles that closed off and protected the harbour entrances in Kantharos, Zea and Mounichia.[44] It is improbable, however, that hundreds of meters of fortified moles were constructed in the open sea using cofferdams. For example, in the harbour fortifications at Mounichia the deepest foundations of the northern Tower M-T1 were located at -5.71 m (Fig. 6.3). Using Rankov's hypothetical relative sea level change of -1.16 m,[45] the ancients were apparently able to place cofferdams in 4.55 m of water in the open sea, in an area often exposed to strong southerly winds. This is more than improbable. The pressure exerted by the sea on cofferdam walls would have been enormous; the effort to construct them would in fact have been on the same monumental scale as the fortified moles themselves. At this depth, towers and fortification walls were constructed using cranes, not cofferdams. Some structures were constructed in the sea, but to what extent the ancients were capable of precise and extensive underwater work is unknown.

Rankov also mentions that liquefaction can cause the sinkage of heavy structures like moles.[46] According to Minos-Minopoulos and his colleagues, "Liquefaction is the transformation of cohesionless, saturated, loosely packed sediments from a solid to a liquid state as a result of increased pore pressure and reduced shear stress, leading to ground failures due to hydraulic fracturing."[47] Sinkage caused by liquefaction is related to buildings standing on saturated or partly saturated sediments, particularly sandy sediments. Sinkage caused by liquefaction does not occur in buildings standing directly on bedrock, as reported for Tower M-T3 (see above), or quarries cut into the very bedrock, like Quarry 22 (Figs. 6.1–6.2). Rankov's attempt to employ liquefaction as an explanation for the depth of Tower M-T3, whose rock-cut foundation trench is cut into bedrock, not silt, simply cannot stand.[48] On the contrary, the rock-cut feature in Tower M-T3 remains important for understanding the relative sea level change, as already discussed in detail (see, pp. 147–155).

Here it should be emphasized that the -1.90 m minimum relative sea level change is based on a depth measurement from the bottom of a quarry cutting (Q22:2; Fig. 6.2). It is a man-made feature created by extracting a block, not the foundations of a built structure. In Volume I, the minimum sea level change of -1.90 m that was posited is supported by direct evidence from how deep and how far built structures extend into the sea, but the "-1.90 m" is based on the depth of a quarry cutting, which is why the minimum relative sea level change is not presented as a range.[49] In his argument, Rankov unaccountably characterizes a quarry cutting as the foundations of a built structure. In this and other instances he shows signs of approaching the problem with preconceived notions of how to reconstruct the Phase 3 shipsheds.[50]

That a submerged manmade feature in a building or other structure was constructed either underwater, at low tide, or using cofferdams might be argued, even if unconvincingly. Nevertheless, evidence

42. Lovén 2011: 147–154.
43. Blackman & Rankov 2013: 456–457.
44. Blackman & Rankov 2013: 457.
45. Blackman & Rankov 2013: 474.
46. Blackman & Rankov 2013: 457 & n. 220.
47. Minos-Minopoulos *et al.* 2015: 76.
48. Lovén 2011: 148.
49. Lovén 2011: 147–154.
50. Blackman & Rankov 2013: 456.

of submerged quarries, such as Quarry 22 (-2.05 m, Figs. 6.1–6.2, see p. 148), evidently related to the extraction of building material remains one of the most important benchmarks for relative sea level change. It is simply inconceivable that builders would exert great energy and time quarrying blocks in the sea or in a surf zone when plenty of bedrock was available to quarry on land nearby. To suggest otherwise is to ignore the mastery and sophistication achieved by Greek builders during the Classical period.

6.4.2. The Phase 3 Shipsheds

Rankov's discussion of the double shipsheds features a complete absence of references to the evidence of slipways and shipsheds, identified and possible, delimited near the modern shoreline at Position 2.[51]

Rankov also passes over the evidence for the slipway and shipshed structures that are preserved further into the sea (Position 3) and deeper than the foundations (-0.91 m) of his 56.06 m/57.60-m-long reconstruction of the Phase 3 superstructure at Zea (see above).[52] In order to preserve the notion that no slipway or shipshed structure extended further the foundations of his reconstructed superstructure, Rankov sows doubt on the "-1.90 m" minimum sea level change benchmark presented in Volume 1.[53] However, as has been shown, the evidence for this change is solid and irrefutable.

At Position 1, 37+ m inland, Rankov does not discuss the shipshed back-wall excavated by Dragátsis (1899) in the southern part of Group 1 at Zea (about 38 m from the modern shoreline). Furthermore, he does not discuss the possible shipshed remains excavated by Dragátsis (1892) in Group 4 *ca* 36.7 m distant from the 1892 shoreline or the shipsheds found by Alexandri (1973) at a distance of 60.8 m from the modern shoreline. Rankov postulates that only the sections of the back-wall excavated by Dragátsis and Dörpfeld (1885) at Zea and Petritaki (1997, 1999 & 2006), and perhaps the section excavated by Angelopoulos & Dragátsis (1899–1900) in Mounichia, "can be firmly associated to shipsheds".[54]

This is methodologically unsound, as evidence cannot simply be omitted without presenting a viable argument for its exclusion.

Rankov and Pakkanen's reconstruction places the Phase 3 Shipsheds 16–24(Φ) from the back-wall (rock-cut foundations at +4.11 m to +4.37 m) to a reconstructed lower ramp end at -1.16 m. Their 56.06 m/57.60-m-long hypothetical superstructure as measured from the outside of the back-wall terminates in the rock-cut colonnade foundation trenches C23/24:9 (Phase 3, -0.96 m) and C14/15:5 (Phase 2, -0.91 m, Fig. 6.7).[55]

Rankov works with two gradients for the reconstructed length of the colonnade dividing Shipsheds 23(Π) and 24(Φ): one at 1:10.28/1:10.29, based on Dörpfeld's elevations, to which data set a false precision of two significant digits have been added.[56] The other is a "designed gradient" of 1:10.5, which he derives from a hypothetical ratio of a two-foot drop over 21 feet in the 2.16-m-IA colonnade.[57] As will be demonstrated below, this two-foot drop (2 x 0.308 m) cannot be established in the only accessible narrowly spaced 2.16 m IA colonnade C17(η)/18(χ), where three column bases are preserved *in situ* in the basement of Sirangiou 1.[58]

The two gradients Rankov employs place the extrapolated top surface of the colonnades 0.20 m/0.30 m above column position 24 (C23/24:9, Phase 3, -0.96 m) and 0.04 m above and 0.06 m under column position 25 (C14/15:5, Phase 2, -0.91 m) (Table 6.3).[59]

---

51. Lovén 2011: 151–152.
52. Lovén 2011: 151–152; Blackman & Rankov 2013: 465–468. Rankov speculates that that Phase 3 may have reused the "façade" of the Phase 2 shipsheds or that a newly built Phase 3 façade was constructed at the same position as that of Phase 2. This would make the shipsheds *ca* 0.80–1.54 m longer. In the catalogue the length of the Phase 3 superstructure is presented at the maximum length of 57.60 m (p. 480).
53. Lovén 2011: 147–148.
54. Blackman & Rankov 2013: 454 with n. 200.
55. Blackman & Rankov 2013: 468. Rankov speculates that that Phase 3 may have reused the "façade" of the Phase 2 shipsheds or that a newly built Phase 3 façade was constructed at the same position as that of Phase 2. This would make the shipsheds *ca* 0.80–1.54 m longer. In the catalogue the length of the Phase 3 superstructure is presented at the maximum length of 57.60 m (p. 480).
56. Blackman & Rankov 2013: 452–453.
57. Blackman & Rankov 2013: 461–462.
58. Lovén 2011: 104–105, fig. 176b, pls. 6–7.
59. C14/15:5 is reused in Phase 3 and was extended to the west (C23/24:10). See Lovén & Schaldemose 2011: 87, 106, fig. 172, 213–216, pls 4–5, 23–24, 39.

Since there is no space for two Phase 3 column bases of average height (0.49 m) at column positions 24 and 25, these gradients require Rankov and Pakkanen to place a wall in the rock-cut colonnade foundations C23/24:9 and C14/15:5 at the position of column positions 24 and 25. It will be demonstrated below that no direct evidence exists to support this hypothetical wall. On the contrary, the design of the rock-cut Phase 3 colonnade foundations of the preserved spur-wall in the upper of Phase 3 colonnades militates against this interpretation.

Essentially, the only hard data required to refute Rankov and Pakkanen's reconstructed lengths of the Phase 3 shipsheds are the column base (-1.95 m) in the colonnade dividing Shipsheds 1 and 2 at Mounichia, located about 44 m into the sea, the ramp foundation of Slipway 42 (-1.77 m) submerged for 42.76 m, and the updated minimum relative sea level change of -2.05 to -2.25 m. These situate the ancient mean sea level shoreline with certainty between 80.02 m (range: 77.26 m to 82.77 m) to 82.49 m (range: 79.64 m to 85.33 m) from the outside of the Phase 3 back-wall (see pp. 173–175), that is, 23.96 m to 26.43 m further seaward than their reconstruction of the length (56.06/57.60 m) of the Phase 3 colonnade (Pl. 2.18).

The extrapolation adopted here of the lengths of the Phase 3 colonnades in relation to the minimum relative sea level change of -2.05 to -2.25 m is reinforced by the direct evidence of Slipways 36–42 and Shipsheds 1–2, which extend 42.76 m to about 44 m into the sea, to a depth of -1.77 m to -1.95 m (Pls. 2.2, 6.1). Based on the benchmark of the lower range of the minimum relative sea level change of -2.05 m, and the roof collapse found at -1.99 m to -2.07 m in Shipshed 1, it is clear that these structures were located above the mean sea level in the Classical period, that is on land (p. 149). Since *Shipsheds of the Ancient Mediterranean* (2013) will probably be the handbook on ancient naval bases for some time, however, Rankov's interpretation and analysis of the datasets of Dragátsis & Dörpfeld (1885) and of the ZHP (2001–2006) demand a closer look.

Dörpfeld's Data and Rankov's Gradient Calculations

Rankov calculates an average 1:10.28 gradient for the two to three uppermost column bases in the colonnades dividing Shipsheds C16/C17(η), C17(η)/18(χ), C20(π)/C21(Δ) and C23(Π)/24(Φ).[60] He uses "first colonnade" and the letters α, A, and B on Dörpfeld's plan to designate these colonnades,[61] yet both Dragátsis' report and Dörpfeld's plan make it clear that these letters actually designate sections of the back-wall. For example, Dragátsis writes:[62]

> *The excavation was begun from the start of the aforementioned street, in other words, where it meets the beach. First, the soil in front of wall AB was removed and it was apparent that it was erected on the regularly cut bedrock. Side-wall Γ, likewise resting on top of the bedrock, was revealed as projecting from this wall. At a distance of 1.70 [m] from this wall, a square construction Δ was revealed as following the slope of the ground towards the sea, whose narrower side EZ has a length of approximately 3 m and longer side reaches as far as the sea, to a length of 37.29 [m].*

And continues,

> *Likewise, in more recent times wall α was erected in front of the side-wall at point β, on which two bases and shaft of the same sort of column were also set, and a window created for some use of a building constructed there in more recent years.*

Considering that the back-wall is discussed extensively throughout Dragátsis' report, it would appear that Rankov has inexplicably failed to come to grips with its observations.

In his calculation of the slope of the Phase 3 colonnades, Rankov introduces a false precision into

60. Blackman & Rankov 2013: 458.

61. Blackman & Rankov 2013: 447, 452–453.

62. Dragátsis 1885: 64, 66, pl. 2. Ἤρξατο λοιπὸν ἡ σκαφὴ ἀπὸ τῆς ἀρχῆς τῆς προμνημονευθείσης ὁδοῦ, ἐκεῖ δηλ. ὅπου αὕτη συναντᾶται μετὰ τῆς παραλίας. Καί πρῶτον μὲν ἀπεκομίσθησαν τὰ χώματα τὰ πρὸ τοῦ τοίχου AB καὶ ἐφάνη ὅτι ἐβασίζετο οὗτος ἐπὶ τοῦ κανονικῶς τετμημένου βράχου. Ἐπὶ τοῦ τοίχου τούτου ἐφάνη προεξέχουσα ἡ ἐπὶ τοῦ βράχου ὁμοίως στηριζομένη ἀντηρὶς Γ. Εἰς ἀπόστασιν 1,70 ἀπὸ τοῦ τοίχου τούτου ἐφάνη κτίσμα τετραγωνικὸν Δ παρακολουθοῦν τὸ κατακλινὲς τοῦ ἐδάφους πρὸς τὴν θάλασσαν, οὗ ἡ στενωτέρα πλευρὰ EZ ἔχει μῆκος τριῶν που μέτρων, αἱ δὲ μακρότεραι φθάνουσι μέχρι τῆς θαλάσσης εἰς μῆκος 37,29. Εἰς νεωτέρους ὁμοίως χρόνους ἱδρύθη καὶ τοῖχος α πρὸ τῆς κατὰ το β ἀντηρίδος, ἐν ᾧ καὶ δύο βάσεις κίονος εἶνε ἱδρυμέναι καὶ σῶμα τοιούτου καὶ θυρὶς εἶνε ἐσχηματισμένη, εἰς χρῆσιν τίς οἶδε τίνος ἰδιωτικοῦ τῶν νεωτέρων χρόνων ἱδρύματος ἐκεῖ κατασκευασθέντος (Dragátsis 1885: 64). Translation: P. Athanasopoulos/S. Kennell. For Dörpfeld's plan see Lovén & Schaldemose 2011: pl. 17. Note also that side-wall W16/26(λ) is marked with a 'λ' on its right-hand side.

Dörpfeld's dataset by calculating it to four significant digits, two more than the original (Table 6.1). In one instance the gradient is calculated with three significant digits. But the result can only be expressed with two significant digits, for example 1:10 for the gradient calculation of C23(Π)/24(Φ), not 1:10.29.

Rankov	ZHP	Rankov's calculation[63]	Verified calculation
	C16/ C17(η)	1:10.56	1:11
α	C17(η)/ 18(χ)	1:9.82	1:10
A	C20(π) /C21(Δ)	1:10.43	1:11
B	C23(Π)/24(Φ)	1:10.29	1:10

Table 6.1. A Comparison of the Two Gradient Calculations

Rankov's "designed gradient" of 1:10.5

As mentioned above, Rankov bases his "designed gradient" of 1:10.5 on a drop of 2 feet (0.616 m) over 21 feet (6.47 m, three interaxial spacings of seven feet) in the narrowly spaced colonnade (2.16 m). He calculates the drop per interaxis as 20.533 cm, again adding a false precision of two significant numbers. The correct calculation is 20.5 cm. Rankov states that his gradient would be in accord with Dörpfeld's 0.21 m drop per interaxis in colonnade B (C23(Π)/24(Φ)) because Dörpfeld measured to the nearest centimetre,[64] but fails to note that the ZHP's drop per interaxis in colonnade C17(η)/18(χ) is 0.22 m. In Volume I the values were presented to the nearest centimetre because of the X and Y margin of precision of the survey in the sea of +/- 0.005 m.[65] The digital survey of the ZHP on land allows the drop between the three column bases in colonnade C17(η)/18(χ) to be calculated as 0.220 m (range 0.214–0.225 m) with three significant digits (Table 6.2).

The slope of this colonnade was clearly not designed with a foot module of 0.308 m, since the drop between four column positions would be 0.660 m, not 0.615 m. Nor was it designed with a gradient of 1:10.5. Rather, it was constructed at a gradient of 1:9.8.

Rankov also detects this 0.308-m foot module in the Phase 3 back-wall by averaging the wider foundation course (0.63 m, range: 0.62–0.65) and the second course (0.59 m, range: 0.58–0.60).[66] Foundation courses are often wider in Greek architecture than superimposed courses, and this trait is evident in the back-wall, spur-wall(γ), and side-wall W16/26(λ) of the Phase 3 shipsheds.[67] Averaging the foundation course with the second course to detect a foot module of 0.308 m neglects this important characteristic, since there would have been several narrower courses above the second (0.59 m or less), and the back-wall was clearly not constructed with a 0.308-m foot module.

Column base	Spot-height (m)	Height difference (m)
C17/18:7(δ)	+4.081	
C17/18:9(ε)	+3.856	0.225
C17/18:11(ζ)	+3.642	0.214
Average:		0.220

Table 6.2. The top surface inclination of the three uppermost column bases in the colonnade dividing Shipsheds 17(η) and 18(χ)

The foot-module that Rankov attempts to detect in the Phase 2 shipsheds is also very problematic (see p. 171). It is entirely possible, as he proposes, that the individual colonnades in Phase 3 were constructed with spacings between their columns and between the colonnades themselves, which were based on a foot of *ca* 0.308 m in plan view.[68] But a hypothetical "designed gradient" of 1:10.5 must conform to the physical reality of the colonnades, whereas Rankov's "designed gradient" cannot be identified in the only accessible *in situ* 2.16 IA colonnade C17(η)/18(χ) in the Phase 3 shipsheds, which was digitally surveyed to the precision of four significant digits. Accordingly, it must be rejected.

63. Blackman & Rankov 2013: 453.
64. Blackman & Rankov 2013: 453.
65. Lovén 2011: 6; Lovén & Schaldemose 2011: 120–121.
66. Blackman & Rankov 2013: 460 with n. 237, 465; Lovén 2011: 82–83.
67. Lovén 2011: 80–88.
68. Blackman & Rankov 2013: 459–461.

The calibration of ZHP's and Dörpfeld's datum zero

Rankov questions ZHP's 0.07 m calibration of datum zero in relation to Dörpfeld's. Our calibration is based mainly on the uppermost three column bases in the colonnade dividing Shipsheds 17(η) and 18(χ), which are still accessible in the basement of Sirangiou 1.[69] Rankov states, "It therefore seems possible that Dörpfeld did not take actual spot heights on δ, ε and ζ [i.e. the printed spot heights on the section of colonnade dividing Shipsheds 17 and 18] but simply assumed them to be the same as those for the corresponding bases Σ, Τ and Υ in colonnade B [B in reality designates back-wall section B, not the colonnade in Dragátsis' report and on Dörpfeld's plan][70], relying on the evidence elsewhere that the colonnades had been carefully laid out at the same height across the whole group."[71] He did not recognize that the longitudinal section drawn in 1885 was based on numerous "spot heights" measured along a horizontal measuring tape calibrated to the datum zero – all part of the basic field methodology that Dörpfeld practised extremely well. This attempt to question the calibration of ZHP's and Dörpfeld's datum zero is best ignored.

Rankov's length reconstruction of the Phase 3 Colonnades

In the discussion of ZHP's length reconstruction, Rankov only discuss the hypothetical maximum length construction of the Phase 3 shipsheds (88.98 m) and omits to clarify that the length reconstruction is presented as a range of 78.27–88.98 m.[72] The present author did indeed focus on the hypothetical upper end of this range, and used the 39.6-m-length of Coates' Mark II trireme reconstruction, but acknowledged that it is "a rough estimate by scientific ship-reconstruction standards."[73] However, the length reconstruction is still presented as a range. Since the publication of Volume I the ZHP has adopted a more no-nonsense approach to the material remains, so that the reconstructed length range presented here is based on hard data and not on architectural hypothesises (such as the alignment of the columns at the lower end) or guesswork about the length of the ancient trireme (see Chapter 6.5, pp. 173–175).

Rankov's reconstruction of the length of the Phase 3 colonnade would place the top surface of a column base of average height (0.49 m),[74] or the bottom of a wall at -0.86 m (based on Rankov's 2.156 m IA) and at -0.87 m (based on Dörpfeld's 2.16 m IA), when extrapolated to the 25th column position using the 1:10.5 "designed gradient." In contrast, slopes of 1:10.28/1:10.29 would place them at -0.96 m (based on Rankov's 2.156 m IA) and at -0.97 m (based on Dörpfeld's 2.16 m IA). Rankov states that the bottom of the colonnade foundation is at -0.96 m here.[75] He is referring to C23/24:10, an extension of the Phase 2 colonnade foundation C14/15:5. At the 25th column position the rock-cut foundation is at -0.91 m; by the column at position 26 the elevation of C23/24:10 is -0.96 m (Fig. 6.7).[76] Both of Rankov's gradients would place the top of the 26th column base (or – very improbably – the bottom of a wall) at -1.17 m/-1.06 m (based on Rankov's 2.156-m-IA and gradients 1:10.28/1:10.29 & 1:10.5) and at -1.18 m/-1.07 m (based on Dörpfeld's 2.16-m-IA and gradients 1:10.28/1:10.29 & 1:10.5).

However, since these gradients are insupportable (see above), the correct calculation of the gradient of the three first column bases in C23(Π)/24(Φ) is 1:10 based on Dörpfeld's 1885 dataset. Note that the three uppermost column bases in the 2.16-m-IA colonnade C17(η)/18(χ) express a similar gradient of 1:9.8 (see above). These two colonnades, it must be stressed, represent the only direct data for the inclination of the 2.16-m-IA colonnades in Phase 3.

Accordingly, a gradient of 1:10 at column position 24 would place the top surfaces of the column bases in colonnade C23(Π)/24(Φ) as extrapolated at -0.90 m (0.06 m above C23/24:9, Phase 3, -0.96 m) and at -1.11 m at column position 25 (0.20 m under C14/15:5, -0.91 m) (Table 6.3).

69. Lovén 2011: 98–99.

70. See p. 158. Dragátsis 1885: 64, pl. 2. For Dörpfeld's plan see Lovén & Schaldemose 2011: pl. 17. Text in square brackets has been inserted here and in the quoted passages that follow for the sake of clarity.

71. Blackman & Rankov 2013: 453–453 with n. 186.

72. Blackman & Rankov 2013: 454, 457; Lovén 2011: 159, 172–173, table 8.5, table 9.3a.

73. Lovén 2011: 163, 172–173; Morrison, Coates & Rankov 2000: 269.

74. Lovén 2011: 97–98, table 6.15.

75. Blackman & Rankov 2013: 458, with n. 229.

76. Lovén & Schaldemose 2011: 97, 106. Catalogue entry C14/15:5 contains a reference to C23/24:11, it should have read C23/24:10.

Rankov's design gradient (1:10.5)	
Column position 22:	-0.25 m (0.48 m above the damage bedrock surface at -0.72 m)
Column position 23:	-0.46 m (0.40 m above the damage bedrock surface at -0.86 m)
Column position 24:	-0.66 m (0.30 m above rock-cut foundations at -0.96 m)
Column position 25:	-0.87 m (0.04 m above the rock-cut foundation at -0.91 m)
Column position 26:	-1.07 m (0.11 m under the rock-cut foundation at -0.96 m)
Rankov's two digits false precision gradients (1:10.28/10:29)	
Column position 24:	-0.76 m (0.20 m above rock-cut foundations at -0.96 m)
Column position 25:	-0.97 m (0.06 m under the rock-cut foundation at -0.91 m)
The correct gradient calculation (1:10)	
Column position 21:	-0.25 m (0.62 m above the damage bedrock surface at -0.87 m)
Column position 22:	-0.47 m (0.26 m above the damage bedrock surface at -0.73 m)
Column position 23:	-0.68 m (0.18 m above the damage bedrock surface at -0.86 m)
Column position 24:	-0.90 m (0.06 m above rock-cut foundations at -0.96 m)
Column position 25:	-1.11 m (0.20 m under the rock-cut foundation at -0.91 m)
Column position 26:	-1.33 m (0.37 m under the rock-cut foundation at -0.96 m)

Table 6.3. Colonnade dividing Shipsheds 23(Π) & 24(Φ). Top surface column base inclinations extrapolated to various column positions based on Dörpfeld's 1885 dataset: (1) Rankov's designed gradient of 1:10.5, (2) Rankov's two digits false precision gradients, (3) the correct gradient calculation[77]

Calculations such as these, which disregard the established measure of sea level change, inevitably lead to erroneous results. A couple of examples will suffice to demonstrate this. As mentioned above, Rankov and Pakkanen end the 2.16 IA colonnades at the 24th and 25th column position in a hypothetical wall based on a gradient of 1:10.28/1:10.29 with a false precision of two significant digits and on a "designed gradient" of 1:10.5. The superstructure in this reconstruction is 56.06 m/57.60 m.[78]

If their gradients are used, along with the minimum relative sea level change of -1.90 m presented in Volume I, this reconstructed colonnade would be located 8.08 m 10.94 m from the ancient shoreline. Alternatively, if their gradients are used in combination with the updated minimum relative sea level change of -2.05 to -2.25 m, the distance to the sea is calculated to be 9.62 m to 12.51 m, and 11.68 m to 14.61 m (Table 6.4).

In fact, the end of their 56.06 m/57.60 m long reconstruction would actually be located 23.96 m/22.42 m to 26.43 m/24.89 m inland from the classical period mean sea level shoreline (see p. 167).

Rankov states that the Phase 3 double-shipsheds can be discounted, arguing that they would require a sea level rise of just under 4 m. He fails to understand that an extrapolation to this depth, or to a minimum sea level change of -1.90 m as presented in Volume I, would automatically invalidate his reconstruction. Rankov's colonnade reconstruction must end at approximately the

77. Top surface elevation of Phase 3 column base C23/24:3(Σ): +4.07 m (Lovén 2011: 97–99). Dörpfeld's 2.16 m interaxial spacing of colonnade C23(Π)/24(Φ) is used in all calculations. Add 0.01 m to obtain the depth value of Rankov's 2.156 IA.
78. See n. 55.

Extrapolation to -1.90 m based on 1:10.28 gradient: 61.37 m (5.97 m x 10.28) + 0.63 m + 3.68 m	65.68 m
Extrapolation to -1.90 m based on 1:10.5 gradient: 62.69 m (5.97 m x 10.5) + 0.63 m + 3.68 m	67.00 m
Extrapolation to -2.05 m based on 1:10.28 gradient: 62.91 m (6.12 m x 10.28) + 0.63 m + 3.68 m	67.22 m
Extrapolation to -2.05 m based on 1:10.5 gradient: 64.26 m (6.12 m x 10.5) + 0.63 m + 3.68 m	68.57 m
Extrapolation to -2.25 m based on 1:10.28 gradient: 64.97 m (6.32 m x 10.28) + 0.63 m + 3.68 m	69.28 m
Extrapolation to -2.25 m based on 1:10.5 gradient: 66.36 m (6.32 m x 10.5) + 0.63 m + 3.68 m	70.67 m

Table 6.4. Extrapolating (1) Rankov's design gradient of 1:10.5, and (2) Rankov's two digits false precision gradients, to minimum relative sea-level change of -1.90 m presented in Volume I, and to the updated minimum relative sea-level change of -2.05 m to -2.25 m[79]

25th column position; it is highly improbable that the superstructure of the shipsheds ended 8.08 m 10.94 m from the ancient shoreline when his gradients are extrapolated to -1.90 m (Table 6.4). If extrapolated to the ancient shoreline defined by the updated minimum relative sea level change of -2.05 to -2.25 m, the colonnades of Rankov's 56.06 m/57.60 m long shipsheds would end 9.62 m to 12.51 m, and 11.68 m to 14.61 m inland from the Classical period mean sea level shoreline (Table 6.4).

In effect, any evidence of a longer shipshed colonnade situated further seaward and deeper (-0.91 m) than Rankov's reconstruction would also automatically invalidate his argument, since his reconstruction (based his questionable "designed gradient") requires that the colonnades of the Phase 3 shipshed end at column position 25 and the column bases at column positions 24 and 25 be replaced with a wall (see below). The evidence that situates the colonnades further seaward than Rankov's reconstruction is, in contrast, overwhelming (see pp. 148–150, 150–155).

Rankov's Reconstructed "Wall" at the end of the Phase 3 Colonnades

According to Rankov's reconstruction, the Phase 3 shipshed superstructure ends at column position 25. This fails to take the evidence of feature C23/24:10 into account, that colonnade C23(Π)/24(Φ), on which his reconstruction is based, though very damaged, continues further seaward to just beyond the 26th column position, where it was destroyed by intrusive dredging in the 1960s (Fig. 6.7).[80]

Rankov suggests that the evidence of dredging that destroyed the lower ends of Shipsheds 23(Π) and 24(Φ) "is not in fact a dredging cut but the ancient drop-off, either natural or man-made, at the lower end of the shipsheds."[81] He argues that the cut is located further seaward than the remains of the intrusive dredging that destroyed the lower parts of Shipsheds 18(χ) and 19(φ). The dredging that destroyed Shipsheds 23(Π) and 24(Φ), however, was identified by modern machine marks in the bedrock; this dredging clearly continues further landwards in a north-easterly direction where it cuts through parts of Shipsheds 21(Δ) and 22(N) and continues under the modern quay. This dredging cut extends further inland than the dredging in Shipsheds 18(χ) and 19(φ) (Pl. 2.16).[82]

Rankov then uses his erroneous interpretation of the dredging cut as an "ancient drop-off" to justify his reconstruction of the Phase 2 and 3 shipshed superstructures as ending just before this modern feature.

In Area 3, intrusive dredging also destroyed the north-western part of Slipways 36–42 near the modern T–jetty, but at a depth of -1.77 m. Here they have

79. Calculations based on 1) minimum relative sea level change: -1.90 m; 2) top level of Phase 3 column base C23/24(Σ):4, calibrated at +4.07 m (Lovén 2011: 105, table 6.20); 3) average width of 1st course in back-wall (section 2a): 0.63 m (Lovén 2011: 82, table 6.4); and 4) distance from inside Phase 3 back-wall (section 2a) to centre of column base C17/18:7(ϐ): 3.68 m (Dörpfeld 1885: pl. 2; Lovén 2011: 159–161, pl. 6.).

80. Lovén & Schaldemose 2011: 106, figs. 214–216, pl. 16.

81. Blackman & Rankov 2013: 463.

82. Lovén and Schaldemose 2011: figs. 170, 172; 213–216; pl. 16.

been traced fully submerged for a distance of more than 42.76 m (Pl. 4.1). This new evidence provides additional reasons to reject Rankov's interpretation of the intrusive dredging cut that starts at -0.96 m as the lower end of the shipsheds.

Rankov and Pakkanen's Phase 3 superstructure reconstruction requires them to end their colonnade in a wall. Rankov's "designed gradient" calculation allow insufficient space for two column bases at the 24th and 25th column positions between the extrapolated slope of the top surfaces of the column bases and the existing colonnade foundations in the colonnade dividing shipsheds 23(Π) and 24(Φ). In addition, to accommodate this wall in Phase 3, he argues that feature C23/24:9 was an extension of the Phase 2 colonnade that was made for the placement of this new structural element.[83] According to Rankov: "There cannot therefore have been a column base block at this point [column position 25]. This, together with the slight difference in level between the abutting Phase 2 and Phase 3 trenches, suggests that there was something other than a column here probably, a wall or a pier."[84] He continues: "It [C23/24:9] thus resembles other extensions of Phase 2 trenches to accommodate Phase 3 features, but as already noted its level and its termination just short of the centre of the 25th Phase 3 column position strongly suggest that it was dug for a wall rather than a column. The most likely reconstruction of the lower end of the Phase 3 colonnade is therefore of a column at the 23rd column position [51.74 m + 0.41 m (half a 0.81 m-long column base) = 52.15 m] and, then after the usual gap [between two column bases: 2.156 m - 0.81 m = 1.35 m], a wall 2 feet wide and a little over 8 feet long (one interaxial space plus half the width of a column base) [2.156 m + 0.41 m = 2.57 m], connecting the 24th and 25th column positions and mirroring the spur wall at the upper end of the colonnade."[85]

Rankov thinks that the 0.05 m step up between foundation trenches C23/24:9 (-0.96 m) and C14/15:5 (-0.91 m) 0.22 m[86] east of his column position 25, "suggests that there was something other than a column here, probably a wall or a pier."[87] This is not "suggested" at column position 23, however, where he places a column base (51.74 m from the outside of the back-wall), 0.30 m east of the eastern bottom edge of Phase 2 colonnade foundation trench C14/15:4 – yet another example of selectively used data (Fig. 6.7).

The rock-cut Phase 2 colonnade foundations were not extended in Phase 3 in order to fit the centres or the bases of columns. Rather, they were constructed for the stylobate or the column foundation blocks that supported the column bases. Several colonnades provide evidence of the construction of this stylobate, in which the column position itself, defined by the average dimensions of the Phase 3 column base (0.81 m x 0.81 m x 0.49 m), is clearly not related to its foundations.[88] For example:

1) A very well-preserved section of the rock-cut foundations of Phase 3 colonnade C16/17(η) was constructed in four steps by removing the western sides of the earlier Phase 2 foundation trenches and extending them westwards, probably by shaving off the eastern top edge of the adjacent Phase 2 foundation on the west. The centre of column position 13 is located right above the step between C16/17:9 (Phase 3) and C7/8:4 (Phase 2), while the centre of column position 14 is located just west of the step between C7/8:5 and the worked bedrock to the east of it,[89] demonstrating that these three steps must be the foundations of a stylobate section on which column positions 13 and 14 were placed.

2) The western side of Phase 2 colonnade foundation trench C12/13:1 was removed for C21/22:6 and extended westward in order to accommodate column positions 18 and 19 in the Phase 3 colonnade dividing Shipsheds 21(Δ) and 22(N). Two pry marks

83. Blackman & Rankov 2013: 467.
84. Blackman & Rankov 2013: 467.
85. Blackman & Rankov 2013: 467. Rankov does not present the measurements, and here they are inserted in the text to clarify his argument. The data are presented with the correct decimal precision, with the exception of Rankov's 2.156 IA, it gives a length of 56.07 m, 0.01 m longer than Rankov's reconstruction at 56.06 m based on a half column base of 0.405 m with a false precision of one significant digit.
86. Normally the distance is measured to the bottom side of a foundation trench, as that is where an architectural feature would have been placed; the distance should have been 0.31 m.
87. Blackman & Rankov 2013: 467.
88. Lovén 2011: 97–98, table 6.15.
89. Lovén & Schaldemose 2011: pl. 25a.

(C21/22:6a-b) with a north-south push direction are located at the bottom of C21/22:6 just to the east of CP 19, strongly indicating that blocks were pushed into place here as a part of the stylobate that carried CP 18 and CP 19.[90]

3) The eastern side of Phase 2 colonnade foundation trench C13/14:1 was destroyed in Phase 3 and extended west (C22/23:5).[91] Column position 13 in the colonnade dividing the Phase 3 shipsheds 22(N) and 23(Π) is positioned directly over the edges of foundation trenches C13/14:2 and C22/23:5. Five pry marks, C22/23:5a-e, located to the west of column position 13 in the bottom of C22/23:5, demonstrate that construction took place in this area, in all probability for the part of the stylobate that accommodated Phase 3 column positions 12 and 13.

4) In the Phase 3 colonnade that divides Shipsheds 23(Π) and 24(Φ) is a single pry marks (C23/24:8a) in C23/24:8 to the west of column position 19. This strongly indicates that a stylobate section was constructed in this foundation trench, and that pry marks C23/24:8b-d were not simply for placing the foundation blocks for the column base above.[92]

5) In the Phase 3 colonnade dividing Shipsheds 23(Π) and 24(Φ) column position 23 is located above the easternmost edge of the Phase 2 rock-cut foundation trench C14/15:4. A Phase 3 column base could not have been placed at this position without a foundation block laid in C14/15:4 to level the area underneath CP 23 (Fig. 6.7).[93]

As demonstrated above, the pre-existing Phase 2 foundation (C14/15:4) was extended in the same way in several other Phase 3 colonnade foundations. C23/24:9 is clearly a Phase 3 colonnade foundation trench for a stylobate, not the foundations for a wall at the end of the shipsheds (Fig. 6.7). No evidence found in the shipshed superstructures at Zea or Mounichia supports Rankov's reconstruction. On the contrary, the bottom of the rock-cut foundations for spur-wall C17/18(γ):1 at the upper end of the Phase 3 shipsheds is much narrower than C23/24:9 (0.77–0.78 m versus 1.19–1.25 m).[94] The rock-cut Phase 3 foundations for side-wall W16/26(λ) (W16/26:2, 0.94–0.97 m wide) and for the Phase 3 back-wall (BW:1–2, 0.92–1.05 m wide) are also narrower than C23/24:9.[95] Taking this data into account, especially the width of the spur-wall foundations, the foundations of Rankov's hypothetical wall would be expected to be narrower, which is clearly not the case.

6.4.3. The Gradient Range of the Phase 3 Superstructure Revisited

ZHP's calculation of the Phase 3 superstructure inclination is based on the range between the gradient of the second course of side-wall W16/26(λ) (1:12.8/4.5°), representing the minimum inclination, and the reconstructed maximum gradient of colonnade C23(Π)/24(Φ) (1:11.9/4.8°). The reconstruction of the latter is based on the assumption that a column base of average height (0.49 m) was placed in the rock-cut colonnade foundation C23/24:10 at the 26th column position of the colonnade dividing Shipsheds 23(Π) and 24(Φ).[96] In Volume I, it has been demonstrated that the colonnades originally continued further seawards from the intrusive dredging that destroyed the western part of colonnade C23(Π)/24(Φ), and based on the available data, this was and still is, the only reasonable way to reconstruct the maximum inclination of the Phase 3 colonnades.

Rankov also has to challenge the ZHP Phase 3 gradient range – "Even this extrapolation is problematical, because the reconstruction is based on evidence of questionable relevance."[97] – because his gradients and the wall reconstruction that makes the Phase 3 colonnade end at column position 25 (refuted in this volume, see above) are obviously incompatible with positing a column base in the identified colonnade founda-

90. Lovén & Schaldemose 2011: figs. 170, 205a, pls. 13, 16.
91. Lovén & Schaldemose 2011: fig. 171, pls. 13, 16.
92. Lovén & Schaldemose 2011: fig. 171, pls. 13, 16.
93. Lovén & Schaldemose 2011: fig. 172, pls. 13, 16.
94. Lovén & Schaldemose 2011: 86–87, 95, fig. 172, pl. 16.
95. Lovén & Schaldemose 2011: 87, 89, pl. 6.
96. Lovén 2011: 104–108, pl 34d.
97. Blackman & Rankov 2013: 457.

tion C23/24:10 at column position 26. He moreover claims, "The inclinations of successive courses in a side-wall [side-wall W16/26(λ)], however, have no direct correlation with the functional elements of a shipshed."[98] Again, Rankov's assertion is methodologically unsound, as a 49.66 m long side-wall (Pl. 6.2a) carrying the eaves of the roof in Shipsheds 16 and 26 cannot be omitted without demonstrating how it fails to correlate to "the functional elements of a shipshed." No viable argument and no data are presented to support his claim. The following discussion will demonstrate that a section of side-wall W16/26(λ) preserved along the keel-supporting ramp section manifestly correlates to the ramp and northern side-passage of Shipshed 17(η) and the colonnade dividing this shipshed and Shipshed 16 and four other Phase 3 colonnades.

The evidence for the inclination of the keel-supporting ramp section and adjacent side-passages in Phase 3 is limited, and the inclined ramp foundation of Shipshed 17(χ) (S17:R7) together with the level foundations found in Shipshed 23(Π) (S23:R2) represent the only accessible, well documented keel-supporting ramp foundations from Phase 3 (Fig. 6.5a).[99] No reconstruction of the keel-supporting ramp section based on these ramp foundations is attempted, as we have no solid data on the blocks from this part of the ramp.

Located at a distance of 40.04 m to 43.20 m from the rear of the back-wall, the well-preserved S17:R7 is clearly a section of the keel-supporting ramp foundations in Shipshed 17(χ). In 1885 there was a *ca* 5.32 m built ramp structure (S17:R17, now missing) preserved on the southern side of S17:R7.[100] The bottom of S17:R7, 3.16 m long, was constructed on a gradient of 1:13.1 (4.4°) (Fig. 6.5a).[101] The adjacent northern side-passage of Shipshed 17(χ) (S17:NSP2), preserved for a length of 1.59 m, has a gradient of 1:12.8 (4.5°);[102] this side-passage is within the lower range of the ZHP gradient range of 1:12.8 (4.5°) to 1:11.9 (4.8°), and the ramp foundation is a mere 0.1° outside the range.

Both the northern side-passage and the keel-supporting ramp foundations of Shipshed 17(χ) have clear structural relationships to the adjacent raised rock-cut foundations of side-wall W16/26:4 & 6 (Fig. 6.5a).[103] This section of side-wall W16/26(λ) was constructed on an inclination of 1:13.5 (4.2°), which is just 0.3° outside our inclination range for Phase 3. The inclinations of the ramp foundations (1:13.1/4.4°), and the northern side-passage (1:12.8/4.5°) of Shipshed 17(χ) vary by only 0.2° and 0.3° from the inclination of side-wall W16/26(λ) (Fig. 6.5a), part of which (W16/26:6) lies 0.30–0.31 m above the bottom of the ramp foundation S17:R7. Let us remember that the foundation of this side-wall is a raised rock-cut platform in the sea. At this position, the colonnade dividing Shipsheds 16 and 17(χ) (C16/17:9–10) also correlates clearly to side-wall W16/26(λ) and the northern side-passage and ramp foundations of Shipshed 17(χ) (Fig. 6.5a). The correlation strongly indicates that the inclination of the Phase 3 shipsheds is closer to the lower range point of 1:12.8 (4.5°) based on the second course in side-wall W16/26(λ), than to the upper range point of 1:11.9 (4.8°) derived from a reconstructed column base in the identified colonnade feature C23/24:10 (see above). Note that colonnade features in the four colonnades preserved at this position (C17/18:15B, C21/22:6, C22/23:5 and C23/24:6) are also closely associated with W16/26:4 & 6, C16/17:9–10, S17:R7 and S17:NSP2 (Fig. 6.5b).

Interestingly, the gradient of the submerged first course in side-wall W29(?)/30(?) (1:13.7/4.2°, Pl. 2.9a) is almost identical to that of the first course in W16/26:9–11 (1:13.8/4.2°) and its submerged foundations W16/26:4 & 6 (1:13.5/4.2°, Pl. 6.2b). Furthermore, the gradients of the ramp foundations of Shipshed 33 (S33:R1, 1:13.3/4.3° & S33:R2, 1:13.2/4.3°) vary by just 0.1°, whereas its northern side-passage S33:NSP1 is 0.7° steeper, at 1:11.6 (4.9°) (Pl. 2.9d-f). Side-wall W29(?)/30(?) is clearly interrelated with Phase 3, both structurally and chronologically (Pls.

98. Blackman & Rankov 2013: 457.
99. Lovén 2011: 130, 132, 136, 170; Lovén & Schaldemose 2011: 94, 105, figs, 167, 172, 181, 183 (Sec 33), 185a, 214, 216b, 222 (Sec 33a), pls. 15–16.
100. Lovén 2011: 132; Lovén & Schaldemose 2011: 95, pls. 15, 17.
101. In the catalogue (Lovén & Schaldemose 2011: 94) the gradient of S17:R7 is mistakenly listed as 1:12.4 based on two spot-heights; the gradient 1:13.1 (4.4°) based on linear regression is the correct value (see Lovén & Schaldemose 2011: fig. 222, sec 33a).
102. Side-passage feature S17:NSP2 was identified as a side-passage after the publication of Volume I. Lovén & Schaldemose 2011: fig. 181, 183 (Sec 31), 184b (Sec 31), 222 (Sec 31).
103. Lovén & Schaldemose 2011: 221c (Sec 24 sea).

2.16, 6.2b; see pp. 11–12, 22–24, 104–107), and the similar gradients found in the ramp and side-passages of Shipshed 33 indicate that this structure may also have been related somehow to the shipsheds of Phase 3.

At the upper end of the shipsheds, side-wall W16/26(λ) has a clear structural correlation to the column bases in both the widely-spaced (IA: 3.38 m) colonnade dividing Shipsheds 16 and 17(χ), and the narrowly spaced colonnade (IA: 2.16 m) dividing Shipsheds 17(η) and 18(χ) (Fig. 6.6a). The inclination of W16/26:1 1:13.5 (4.2°) and W16/26:12–13 (1:12.8/4.5°), which varies by 0.3°, defines the top of the second course. Above, the reconstructed third course (based on the second course's average height of 0.58 m)[104] connects precisely with the back-wall at the point between the first and second courses (Fig. 6.6a). Note that the average height of the second course in the back-wall is also 0.58 m.[105] Furthermore, side-wall W16/26(λ) also correlates with the back-wall and with the point where the spur-wall in C17/18(γ) connects with the back-wall.

While this correlation between five colonnades, a ramp, a side-passage and side-wall W16/26(λ) was not discussed in Volume I, the data were available. Rankov should consequently have examined that evidence before claiming: "The inclinations of successive courses in a side-wall [side-wall W16/26(λ)], however, have no direct correlation with the functional elements of a shipshed." This claim has now been refuted.

Dörpfeld took three elevations on the keel-supporting ramp sections, one on Shipshed 17(η) and two on Shipshed 21(Δ).[106] The inclination between S21:R3(Δ2) and S21:R7(Δ3) is 1:4.6,[107] and 1:30 between S21:R7(Δ3) and S17:R15(η1).[108]

The morphology of the bedrock in the area of Shipsheds 17(η), 21(Δ) and 23(Π) did not allow the ramp foundations to be constructed on a continuous incline.[109] Instead, the ramp foundations were probably constructed in downward, and even upward, stepped sections, inclined where the morphology of the bedrock allowed, as in two sections (S17:R2–R4, S17:R6–R7) of Shipshed 17(η)'s ramp foundations, or level when it did not, as witness one section (S23:R2) of Shipshed 23(Π)'s ramp foundations.[110] Dörpfeld took one elevation on each individual section of the two ramp structures; since they were probably stepped downwards in sections, these elevations in isolation provide no evidence for the gradient of the keel-supporting ramp section.

Rankov bases his inclinations of the Phase 3 superstructure (now refuted, see pp. 158–159), on the three uppermost column bases along the stern-supporting ramp section, that is the area where the ramp curves up to receive and support the up-curving stern of the warship.[111] To support the validity of this argument he claims:

> *The inclination of successive courses in a side-wall* [side-wall W16/26(λ)]*, however, have no direct correlation with the functional elements of a shipshed* [refuted above]*. There are, on the other hand, compelling practical reasons why the column bases, the side-passages where the hauling teams operated, and the ramps should all have had the same gradient, since if they deviated from each other the column bases would have been at different levels relative to the ground around them (i.e. the side-passages) and, more importantly, the haulage force exerted on the ship through the ropes would have been reduced by their not being parallel to the keel (Chapter 7).*[112]

To support this, Rankov quotes the present author:

> *In all of these, the superstructure foundations (i.e. column bases, piers, and slots for wooden posts) and the side-passages are either just above or at the same elevation as the ramp, and both structures appear to follow the inclination of the keel-supporting ramp structure.*[113]

This holds true for the superstructure along the keel-supporting ramp structure, but evidence from Oiniadai and Zea, and in all probability also from Carthage and probably Mandraki (Rhodes) demonstrates that it is not the case along the steeper, up-curving stern-supporting ramp structure.

104. Lovén 2011: 82–83, table 6.4.
105. Lovén 2011: table 6.6 (p. 87).
106. Lovén 2011: 130–134, pl. 36a.
106. 5.96 m distance between S21:R3(Δ2) +3.17 m to S21:R7(Δ3) +1.86 m divided by their height difference of 1.31 m.
108. 3.62 m distance between S21:R7(Δ3) +1.86 m to S17:R15(η1) +1.68 m divided by their height difference of 0.18 m.
109. Lovén & Schaldemose 2011: pl. 36a.
110. Lovén & Schaldemose 2011: fig. 175, pls. 6, 36a.
111. Lovén 2011: 4, 134–137.
112. Blackman & Rankov 2013: 457.
113. Blackman & Rankov 2013: n. 224 (p. 457); Lovén 2011: 134.

Powell's superstructure reconstruction of the Oiniadai shipsheds, which Lehmann-Hartleben,[114] Rankov,[115] and to some extent Gerding[116] follow, of a roof curving upward above column positions 1 and 2 rests on a misunderstanding of how a vessel would have fitted into the internal space of a shipshed (Fig. 4.16). The ramps curve upward more steeply in this area and were designed to slide under and support the up-curving stern of a warship, so that no extended-height superstructure would have been needed in this area. On the contrary, the column shafts and piers can be shorter than along the keel-supporting ramp section, since a warship's up-curving stern would obviously slide in at a higher elevation than its keel (Fig. 4.16). I argued in Volume I:

Thus it seems most reasonable to infer that the architrave and whole roof ran from the spur-walls at a height of 7.0 m and on a linear inclination similar to that of column positions 3–6 (ave. 1:8.6/6.6°), and that the last two columns were shorter to compensate for the steeper inclination of the stern-supporting ramp section.[117]

Where the morphology permitted, the bedrock was used for the ramp structure, side-passages and colonnade foundations to save labour and resources. This clearly holds true for the Oiniadai shipsheds, which were carved out of a rocky outcrop, and is also evident in the Phase 3 shipsheds, since Dragátsis observes that part of Shipshed 22(N)'s stern-supporting ramp structure is cut out of the bedrock. Dragátsis also report that the back-wall stands on a raised 0.70 m rock-cut foundation.[118]

Furthermore, I will argue that the side-passages and the colonnade foundations along the stern-supporting ramp structure were also constructed at a higher elevation and steeper inclination than compared to the side-passages and colonnades along the keel-supporting ramp structure.

Rankov, on the other hand, challenges the ZHP superstructure design of the Phase 3 shipsheds, and as discussed, argues for a linear colonnade inclination based on the upper two to three column bases, reconstructing the length of the shipsheds at 56.06 m/57.60 m (see above). Compared to the length of the Phase 3 superstructure as reconstructed by the ZHP (80.02 m to 82.49 m), which is strongly supported by Case Studies 1 and 2 and other evidence from both at Zea and Mounichia (see pp. 147–157, 173–175), Rankov and Pakkanen's Phase 3 shipshed reconstruction ends an awkward 23.96 m/22.42 m to 26.43 m/24.89 m short of the ancient shoreline. (Pl. 2.18)

Furthermore, when the gradient is calculated correctly rather than with a false precision of two significant digits (1:10, not 1:10.28/1:10.29), the extrapolation of the top surfaces of the three column bases preserved in C23(Π)/24(Φ) does not permit an average-height column base (0.49 m) at column positions 22 to 26, and in fact requires Rankov and Pakkanen's reconstructed wall at the end of the Phase 3 shipsheds to be 7.29 m long (0.81 m + (3 x 2.16 m), Table 6.3, see above). The Phase 3 shipsheds simply cannot be reconstructed with a "designed gradient" based on half the available evidence (see p. 159). Rankov instead assumes:

This means that ZHP's reconstruction of the overall gradient at 1:12.3 on the basis of the side wall blocks would require a change of gradient between the column bases further down the sheds (i.e. there would have to be a kink). Such a change of gradient, for no obvious practical reason, would be architecturally inexplicable.[119]

First of all, Rankov misleadingly supposes that the mid-point (1:12.3/4.65°) of the ZHP gradient range of 1:12.8 (4.5°) to 1:11.9 (4.8°) is based on "side-wall blocks". Blackman is also mistaken in stating that this gradient is "derived from the side wall of a shed".[120] The lower point of the range (1:12.8/4.5°), is based on the inclination of the second course in side-wall W16/26(λ), preserved in a monumental wall structure that has been traced over 49.66 m (Pl. 6.2a). The first course in this side-wall and the wall's foundations are constructed on similar gradients (variation: 1:13.8/4.2° to 1:11.8/4.9°).[121] The upper point in the inclination

114. Lehmann-Hartleben 1923: 116.
115. Blackman & Rankov 2013: n. 231 (p. 458).
116. Gerding in Blackman & Rankov 2013: 166, 415–416 (see below).
117. Lovén 2011: 163.
118. Dragátsis 1885: 64, 67.
119. Blackman & Rankov 2013: 458 with n. 231.
120. Blackman & Rankov 2013: 133.
121. Lovén & Schaldemose 2011: figs. 220–221.

range (1:11.9/4.8°) is based on the reasonable assumption that there was a column base standing in the identified rock-cut foundation trench C23/24:10 at column position 25 (see above). Rankov goes on to argue:

> *This is in no way comparable to the otherwise unparalleled upper ends of the Oiniadai sheds, where the change in gradient (from 1:8.5 to 1:3.5) and height difference (1.07 m) are much greater and have a ready explanation in the need to swing the roofline upwards so as to reduce the impact of rainwater cascading down the sheer cliff behind the sheds (see Catalogue 15: Oiniadai).*[122]

To counter this assertion, however, several salient observations can be made. To describe the rocky outcrop behind and above the Oiniadai shipsheds a "sheer cliff" is an overstatement.[123] Behind and parallel to the back-wall, Joshua M. Sears documented a *ca* 26.9 m long, 0.50 m wide rock-cut drain that would have been sufficient to carry away the rainwater flowing down from the rocky outcrop above.[124] Rankov omits even to refer to the discussion of the reconstruction of the superstructure at Oiniadai presented in Volume I.[125] Gerding, for his part, is initially very cautious and at the end of his discussion of the Oiniadai superstructure in Chapter 9 states, "The position of the uppermost bases does imply that some irregularity was intended, though."[126] Later in the Oiniadai catalogue, Gerding supports the idea that the inclination of the roof did change, based on the narrower interaxial spacing between the two uppermost columns, which he assumes would allow for a steeper architrave. Both Gerding and Rankov failed to consider the 0.50 m wide, *ca* 26.9 m long rock-cut drain above and behind the back-wall of the shipsheds, a significant oversight since the drain is both mentioned by Sears and clearly visible on Powell's plan, captioned 'GUTTER'.[127] Rankov's hypothesis, – "…and have a ready explanation in the need to swing the roofline upwards so as to reduce the impact of rainwater cascading down the sheer cliff behind the sheds" is thus best ignored.

Against Rankov's claim that the steeper design of the colonnade foundations at the upper ends of the Oiniadai shipsheds is "unparalleled", some relevant parallels can be adduced:

Carthage, Circular Harbour

The stern-supporting ramp section (and the adjacent side-passages) in Shipshed F762, 16 and 13 at Carthage does curve up to receive the warship's stern, although this is not made clear in the published plans and sections, the inclination of the foundations of the pier colonnade foundations in all probability also changes along the stern-supporting ramp section and side-passages, as the latter two define the floor level of the shipsheds.[128]

Mandraki Harbour, Rhodes

At the harbour of Mandraki (Rhodes), the narrow shipsheds AB, BC, and CD were traced for *ca* 14.4 m, while the upper end of the wide shipsheds DE, EF, and FG were traced for *ca* 15.0 m.[129] In Phase II, the inclination of the preserved ramps in narrow shipsheds BC and CD and wide shipshed DE is 1:4:36 (12.9°).[130] The side-passages, wall, and colonnade (1:5/11°)[131] foundations are constructed on roughly the same steep inclination and correlate structurally.[132]

The keel-supporting ramp section of the Mandraki shipsheds remains unexcavated, but was probably constructed on a more gentle gradient, as seen in the ramps at Carthage, Oiniadai, Zea, Kos, Naxos (Sicily), and Kition.[133] Since the colonnades and wall at Man-

122. Blackman & Rankov 2013: n. 231 (p. 458).
123. Blackman & Rankov 2013: fig. B15.3. Image also reproduced on cover.
124. Sears 1904: 232 with n.1; pl. IX. The length of the rock-cut gutter is scaled off pl. IX.
125. Lovén 2011: 163.
126. Gerding in Blackman & Rankov 2013: 166.
127. Gerding in Blackman & Rankov 2013: 410–419. Sears 1904: 232 with n.1; pl. IX (see Lovén & Schaldemose 2011: fig. 44).
128. Hurst 1994: fig. 3.2. (see Lovén & Schaldemose 2011: fig. 38).
129. Traced off Knoblauch's plan (fig. 6) in Blackman *et al.* 1996.
130. Blackman *et al.* 1996: 394.
131. Lovén 2011: 122.
132. Knoblauch's plan (fig. 6) in Blackman *et al.* 1996.
133. Lovén 2011: 65–66, fig. 38, 41 (Carthage); 134–135, figs. 44–46 (Oiniadai); 135, fig. 52c (Kos), 135–137, pl. 36a (Zea), 135 (Kition). Lentini & Blackman with Pakkanen in Blackman & Rankov 2013: 407 with n. 101, n. 102 (Naxos). For Kition see Blackman & Rankov 2013: fig. A8.3 (p. 127). For the slight possibility that the Mandraki ramps continued on the same steep inclination (see Lovén 2011: 65). Blackman and Knoblauch present both alternative interpretations Blackman *et al* 1996: 394ff. and figs. 25–26.

draki correlate structurally with the stern-supporting ramp sections and side-passages, the superstructure foundations were likely constructed on a much lower gradient along the keel-supporting ramp section. At Kition, Kos, and Naxos the published data offers no information on the inclination of the superstructure foundations or how they relate to the ramps and side-passages. A major weakness of many shipshed publications is indeed the lack of detailed longitudinal sections of the ramps, side-passages and colonnades/side-walls that would have made it plain how these structures are interrelated.

Zea Harbour

At Zea, Rankov's Phase 3 superstructure gradients are based on the uppermost two to three column bases alongside the stern-supporting section of the ramp over the following lengths: C16/17(η): 4.22 m, C17(η) /18(χ): 5.22 m, C20(π)/21(Δ): 7.68 m and C23(Π)/24(Φ): 5.22 m. The inclination of side-wall W16/26(λ), in other words its original top surface, has been traced over 44.43 m. As demonstrated above, the section of W16/26(λ) preserved along the keel-supporting ramp section is clearly interrelated with all "functional elements": ramp, side-passage, and colonnade (Fig. 6.5a-b).

When the inclination of these rock-cut foundations of W16/26:4 & 6 (1:13.5/4.2°) is extrapolated landwards, the line defined by linear regression runs almost parallel to the top surface of W16/26:9–11 (1:13.8/4.2°) (Fig. 6.6a, Pl. 6.2a).[134] The average heights of the two types of first course blocks found in the back-wall are 0.71 m and 0.80 m; in spur-wall C17/18(γ) the average height of the two blocks in the first course is 0.87 m.[135] The height difference of 0.77–0.80 m between blocks W16/26:9–11 and the landward extrapolation of W16/26:4 & 6 (Fig. 6.6a) is comparable to the heights of the first courses in the back-wall and spur-wall C17/18(γ). The unexcavated foundation of blocks W16/26: 9–11 is reconstructed at the position of the W16/26:4 & 6 extrapolation (Fig. 6.6a, Pl. 6.2a).[136]

The side-wall W16/26(λ) foundations have two marked upward steps, the first up to W16/26:2 for the second course, and a second step up to W16/26:1 for the third course (Fig. 6.6a, Pl. 6.2a). Note that the top surfaces of the *in situ* column bases in colonnades C16/17(η) and C17(η)/18(χ) are approximately flush with the bottom surface of W16/26:1 and the top surfaces of the second course W16/26:12–14 (height variation: 0.00 m to 0.08 m), demonstrating that the bottom of the third course in W16/26(λ) is at the same level as the top of the column bases (Fig. 6.6a).[137] Side-passages S17:NSP1 and S17:SSP1 are also structurally correlated, showing that the 'floor' level at the upper end of Shipsheds 16–18(χ) is defined by the top of the column bases and the bottom of the third course in W16/26(λ) (Fig. 6.6b). Here at the upper end of the shipsheds the foundations for the steeper up-curving stern-supporting ramp do not correlate directly with the side-wall.[138] However The two upward steps in the foundations of W16/26(λ), however, for an estimated change in total height of *ca* 1.37 m indicate that the superstructure was lower along this section of the stern-supporting ramp.[139] At Oiniadai as well, a marked change in elevation between column positions 1–3 and column positions 4–6 also occurs (Fig. 4.16).

The height difference between the top surface of the column bases in the upper end of the shipsheds and the extrapolated structural line defined by the gradient of W16/26:4 & 6 (the estimated position of the bottom of W16/26:9–11) is 1.38 m to 1.49 m (Fig. 6.5a; Pl. 6.2a), demonstrates that the inclination of the column bases at the upper end had to be steeper at the upper end in order to connect with the elevation of the keel-supporting ramp structure. Along the stern-supporting ramp section, the colonnade foundations and side-passages were clearly constructed at a higher inclination. The two to three uppermost column bases were demonstrably constructed at a steeper inclination compared to the preserved side-wall W16/26(λ), ramp foundation S17:R7, and side-passage S17:NSP1 along the keel-supporting ramp section, thus are obviously

134. Lovén 2011: 87, pl. 34a.
135. Lovén 2011: 83 (table 6.4), 85 (table 6.5)
136. Lovén 2011: 86–87. The space between the side of the rock-cut foundations and blocks W16/26:9–11 was not excavated due to the limited space between them.
137. Lovén 2011: 87, table 6.6.
138. Lovén 2011: 87, pl. 36a.
139. Estimated height of first course 0.79 m (see above) and average height of second course (0.59 m, Lovén 2011: table 6.6, p. 87).

not indicative of the inclination of the superstructure and the keel-supporting ramp structure. This gives another reason to reject Rankov's gradients, based only on the top two to three column bases in Phase 3 (see above, pp. 158–159).

Rankov does not discuss the fact that the inclination of the rock-cut colonnade foundations is 1:9. That the heights of the column bases are adjusted to create an inclination of 1:10 and 1:11 is additional proof that the gradient of the superstructure could have been further adjusted by the height of the column shafts and, if capitals were used, by a slanting abacus, as seen in the Oiniadai shipsheds.[140] Finally, adjusting the gradient in the columns is far easier than constructing column bases on a near-linear inclination.

6.4.4. The Phase 2 Shipsheds

The Chronology of the Phase 2 Shipsheds

In stating, "…although it will be clear that only the *terminus post quem* of Phase 3 is secure," Rankov challenges the chronology of the Phase 2 shipsheds.[141] This challenge is, however, baseless, as the deposit found in the ramp of Phase 3 Shipshed 17 provides a solid *terminus ante quem* of 375–350 BC for Phase 2 as well, since this set of shipsheds was definitely constructed prior to this date range.

Based on historical sources, the 470s to 430s BC was proposed as the most likely time for the construction of the Phase 2 shipsheds, with 404/3 BC as the probable date of their demolition by the Thirty Tyrants.[142] Although the *terminus ante quem* of 375–350 BC represents the only firm chronological fixed point for Phase 2, we should remember that the Athenians had between 350–400 triremes at the beginning of the Peloponnesian War in 431 BC, and these warships had to be housed somewhere.[143]

Phase 2 Colonnade Gradients

Rankov argues, "Lovén finds no evidence for the inclination of the Phase 2 sheds, but fails to take into account the fact the Dörpfeld's plan and section of Colonnade A [A is in reality designating back-wall section A, not the colonnade in Dragátsis' report and on Dörpfeld's plan][144] show that the Phase 2 foundation blocks there were of a standard size and in particular of a standard height, and that they and the foundation cutting A were laid out on a continuous gradient."[145] He then goes on to calculate the gradient of the colonnades at 1:9.65 (5.9°), also arguing for a "designed gradient" of 1:9.75 (5.9°).[146]

This hypothesis can be tested by placing a number of standard (in other words, average-sized) Phase 2 blocks (length 1.16 m; height 0.54 m) in their respective foundation cuttings in the merged sections of the Phase 2 colonnades (Pl. 6.2c).[147] After placing two standard blocks in the rock-cut foundations of column position 9 (C14/15:4) in the colonnade dividing Shipsheds 14 and 15(?) and three blocks at column position 8 in the rock-cut foundation trench C10/11:2, however, extrapolation of Rankov's calculated gradient of 1:9.65 (5.9°) and the "designed gradient" of 1:9.75 (5.9°) to colonnade blocks C11/12:2(?), 4, 6, & 8 makes it quite clear that Rankov's hypothesis does not fit the physical reality of the Phase 2 colonnades (Pl. 6.2c). Both gradients cut through the reconstructed colonnade blocks placed atop C11/12:2(?), 4, 6, 8, & 9 at various heights, which proves that the Phase 2 colonnade blocks were not standardized and so cannot be used to calculate the gradient at 1:9.65 (5.9°). Testing the gradients from C11/12:2(?) towards the west will produce the same results, as well as showing that the colonnade features C11/12: 2(?), 4, 6, 8 & 9 were constructed not on a 1:9.65 (5.9°) or 1:9.75 (5.9°) gradient, but on a slightly gentler gradient of 1:10.4 (5.5°) (Pl. 6.2c). The 1:10.4 (5.5°) gradient does not fit Rankov's standardized block hypothesis either, thereby refuting his gradient hypothesis for the Phase 2 superstructure and any research based on it.[148]

140. Lovén 2011: 104–106, 108, tables 6.20–6.21.
141. Blackman & Rankov 2013: 476.
142. Lovén 2011: 170–171, see also 9–14.
143. Gabrielsen (2008: 47–73) favours the higher end of this range.
144. See p. 158. Dragátsis 1885: 64, pl. 2. For Dörpfeld's plan, see Lovén & Schaldemose 2011: pl. 17.
145. Blackman & Rankov 2013: 450.
146. Blackman & Rankov 2013: 450, 461. Note that Rankov introduces a false precision of one significant digit into the calculated gradient (1:9.65/5.9°).
147. Lovén 2011: 113–114, table 6.22b
148. Note that the 1:10.4 (5.5°) extrapolation ends just 0.04 m below the top surface (-0.71 m) of colonnade block C10/11:3.

Phase 2 Interaxial Spacing

Rankov measures the interaxial spacing of the three identified Phase 2 colonnade blocks on Dörpfeld's section at *ca* 4.00 m and records this interaxial spacing in his catalogue.[149] According to the ZHP's measurements, however the interaxial spacing of the individual colonnades is 3.97 m.[150] Rankov should therefore have tested his interaxial spacing in the physical space of the colonnade foundations. For example, this spacing (4.00 m) would push the west side of a 0.70 m diameter column 0.06 m nearer to the west edge of the *in situ* colonnade foundation block C10/11:3, and move this block 0.11 m out of its foundation trench towards the west (Pl. 6.2c). He suggests that his 4.00 m IA could represent 13 feet, 0.308 m in length, which is unlikely since the spacing is a poor fit with the actual physical remains of Phase 2.[151] The interaxial spacing of the Phase 2 shipsheds must be based on all available evidence, as is the 3.97 m IA calculated by the ZHP. Rankov instead seems to have cherry-picked three colonnade blocks that give him the data to detect an ancient foot.

The Phase 2 back-wall Reconstruction

Although no identifiable or possible traces of the Phase 2 colonnade dividing Shipsheds 11 & 12 east of the rock-cut foundation C11/12:1(?) and block C11/12:2(?) exist, Rankov chooses to use the raised Phase 3 rock-cut foundation for column position 4 (C20/21:11) in the colonnade that divides Phase 3 Shipsheds 20 & 21 as the foundation of the Phase 2 back-wall.[152] This is an identified Phase 3 feature; no data supports its interpretation as the foundations of the Phase 2 back-wall. On Dörpfeld's plan, the feature C20/21:11 is illustrated as a square rock-cut foundation, with no evidence of this feature continuing towards the north and south (Fig. 6.8).[153] Rankov suggests that the Phase 3 ramp removed the Phase 2 wall foundations, but that would not explain why no remains are visible in the side-passage area on each side of C20/21:11.[154]

The bedrock between colonnade features C20/21:11 and C11/12:2(?) moreover does not appear to be worked (Pl. 6.2c). In Phase 3, the floor level in front of the back-wall is a relatively level surface, and the same would be expected in Phase 2, as this area were obviously used as a passageway between the individual shipsheds at the upper end of the complex (Fig. 6.6b).[155] Another observation not discussed by Rankov is the following:

> *The dimensions of feature C11/12:2(?) are similar to the identified Phase 2 blocks, but it does not tie into the 3.97 m interaxial spacing; it is therefore classified as a possible Phase 2 block (at column position 0). There are no visible features east of C11/12:3–4 relating to the 3.97 m interaxial alignment, and Phase 2 did not continue east of C11/12:1(?)–2(?). C11/12:1(?)–2(?) may somehow be related to the back-wall of the Phase 2 shipsheds. Perhaps it is the remains of a spur-wall. It is also possible that a Phase 2 block was moved and re-used in the Phase 3 colonnade when it was built.*[156]

Until this crucial area is re-excavated, C11/12:2(?) is more likely to be a Phase 2 block reused in the foundations of Phase 3; since the Phase 3 block above it clearly has a structural interrelationship with the interaxial spacing of the Phase 3 colonnade, and block C11/12:2(?) does not tie into the Phase 2 interaxial spacing of 3.97 m (Pl. 6.2c). The feature S12:R1 is hereby reclassified as possible ramp feature S12:R1(?), and colonnade features C11/12:3–4 at column position 1 become the first securely identifiable remains of Phase 2.[157]

It would appear that Rankov chose to use this Phase 3 colonnade feature (C20/21:11) as the foundation of his Phase 2 back-wall, because his 44.04 m long Phase 2 reconstruction would otherwise be 3.26 m shorter at 40.76 m to the eastern side of C11/12:2(?).

149. Blackman & Rankov 2013: 481. According to ZHP measurements (Pl. 6.2c) the distance between the three colonnade blocks is 4.04 m and 3.97 m (Lovén 2011: 115, table 6.24).

150. Lovén 2011: 114–116, tables 6.23, 6.24, 6.25; pls. 27–28.

151. Blackman & Rankov 2013: 461.

152. Blackman & Rankov 2013: 450. Rankov doesn't follow the feature designations of the ZHP, and has named C20/21:11 – F. On an aetheric note, see the curious design of the letter designations A to G, that defiles Dörpfeld's beautiful plan (Fig. B16.11) and sections (Fig. B16.12).

153. Dörpfeld 1885: pl. 2. See Lovén & Schaldemose 2011: pl. 17.

154. Blackman & Rankov 2013: 450.

155. Lovén 2011: 157, This passage is called P:1 on figs.173a, 174a-b, 175a-b, 176a; pls. 6–7; and P:2 to P:5 on pls. 6–7, 15–16. See also figs. 67, 69, 92.

156. Lovén 2011: 111.

157. Lovén 2011: 74, 112, 118, pl. 13.

Measured to the first securely identifiable Phase 2 colonnade feature, Rankov's Phase 2 reconstruction is 6.72 m shorter at 37.32 m. Subtracting the width of the back-wall, the internal space for one trireme would be 40.13 m and 36.69 m. How Rankov and Pakkanen could squeeze a 44.04 m long reconstruction into the actual physical distance of 43.55 m between the eastern side of the rock-cut Phase 3 colonnade foundation trench C20/21:11 and the westernmost preserved part of C14/15:5 is incomprehensible. The Phase 2 colonnade feature C14/15:5 is preserved for 1.34 m; since the average length of the fully preserved Phase 2 colonnade foundations is 1.35 m, the missing 0.48 m cannot be accounted for (Fig. 6.7).[158]

As mentioned above, Rankov passed over the discussion of C11/12:1(?)–2(?) as possible remains of an anta. In FIGURE B16.13 Pakkanen extends the Phase 3 rock-cut colonnade feature C20/21:11 towards the south and north although absolutely no data exist to support this reconstruction.[159] Indicating architectural features for which there is no evidence in the same way as features identified from recognizable architectural characteristics, such as the rock-cut foundation trenches and *in situ* foundation blocks in the Phase 2 colonnades, is not proper scientific practice.[160] On the reconstructed plan of the Phase 2 shipsheds, Pakkanen draws the so called back-wall and the hypothetical anta at the lower end of the shipsheds in solid black, in the same manner as the Phase 2 colonnade features identified by the ZHP, and even extends C20/21:11 for a distance of *ca* 2.36 m north and south in solid black,[161] Although this Phase 3 colonnade feature is only 0.84 m wide on Dörpfeld's plan.[162] Rankov goes so far as to suggest that the construction of the Phase 3 back-wall was planned from C20/21:11 as it fits perfectly into the 3.39 m interaxial spacing of the Phase 3 colonnade.[163] That an identified rock-cut Phase 3 colonnade foundation is interrelated with the interaxial spacing of the Phase 3 colonnades should come as no surprise.

The Wall at the Lower End of the Phase 2 Shipsheds

In Phase 3 Rankov and Pakkanen chose to reconstruct the end of the Phase 2 colonnades at column position 11 (column base foundation C14/15:5) with a hypothetical wall.[164] Like the so-called Phase 2 'back-wall' discussed above, this wall is marked on Pakkanen's plan in solid black, which is normally used to indicate an identifiable architectural feature.

No data has been found in the Phase 2 shipsheds that could support this reconstruction which, as in Phase 3, is based on a combination of pure guesswork and inadequate research (see pp. 162–164). As discussed above in detail, C14/15:5 is clearly a Phase 2 column base/block foundation trench that was extended in Phase 3 (C23/24:10) (Fig. 6.7, see pp. 163–164), while the Phase 3 colonnade reconstruction extends 22.82 m to 25.29 m from C14/15:5. Since the Phase 2 shipsheds had to reach about as far as the same ancient shoreline, their length reconstruction of Phase 2 is now invalidated. Rankov and Pakkanen based their reconstruction of the Phase 2 shipsheds, and to some extent the Phase 3 shipsheds, on the ZHP's plans and data without accurately referring to the data they used.[165] The Zea Harbour Project excavated the main part of the Phase 2 shipsheds beneath the sea under some of the harshest and most difficult conditions in the history of archaeology. Both authors are well aware that the submerged Phase 2 shipsheds were identified by the author of this volume, who located the Phase 2 features on Dörpfeld's plan and sections utilizing discoveries made by the ZHP underwater.[166]

Shipsheds of the Ancient Mediterranean (2013) neglects to give the ZHP proper credit in its plans of the Phase 2 and Phase 3 shipsheds, although FIGURE B16.14 contains ZHP data and FIGURE B16.13 is plainly based on ZHP data. The latter, Pakkanen's plan of Phase 2, is the most significant example. Out of 27 identified column positions for Phase 2, FIGURE B16.13 contains 16 column positions excavated and identified by the ZHP and 11 column positions identi-

158. Lovén 2011: 112 with n. 88.
159. Blackman & Rankov 2013: fig. B16.13 (p. 464); Dörpfeld 1885: pl. 2; see Lovén and Schaldemose 2011: pl. 17.
160. Lovén & Schaldemose 2011: pl. 13.
161. Blackman & Rankov 2013: fig. B16.13 (p. 464).
162. Scaled off Dörpfeld 1885, pl 2.
163. Blackman & Rankov 2013: 466.
164. Blackman & Rankov 2013: fig. B16.13. Cf. Lovén & Schaldemose 2011: pl. 13.
165. Blackman & Rankov 2013: fig. B16.13 (p. 464), fig. B16.14 (p. 469).
166. Lovén 2011: 73–75, 109–119. Until 2006, Lovén participated in the research project behind *Shipsheds of the Ancient Mediterranean* (2013); Pakkanen was also Lovén's PhD supervisor.

fied by the ZHP on Dörpfeld's plan and sections on the basis of data found in the sea. These figures mean that 59% of the colonnade data that Pakkanen presents in his Phase 2 plan unquestionably belongs under ZHP copyright, but neither the figure caption nor the figure list makes reference to the ZHP's research using the standard academic phraseology for these sorts of situations, such as "based on" or "after."[167] Furthermore, that the interaxial spacing of the colonnades on Pakkanen's reconstructed 1:400 plan is 3.96 m, closer to the 3.97 m IA calculated by the ZHP than to the 4.00 m interaxial spacing measured by Rankov, should be noted. Finally, Rankov does not provide a proper reference for ZHP's identification of the Phase 2 shipsheds, in fact arguing that Phase 2 was identified by Dörpfeld,[168] which is manifestly not the case because he reconstructed the shipsheds that the ZHP has now identified as those belonging to Phase 3. Dörpfeld did not present a reconstruction of the Phase 2 shipsheds in his plan and sections, nor did Dragátsis mention another earlier shipshed building phase, so the caption of FIGURE B16.13: "Piraeus: reconstructed plan of Phase 2 of the Dragátsis/Dörpfeld shipsheds at Zea (J. Pakkanen)" is problematically misleading. By the same token, FIGURE B16.14, "Piraeus: reconstructed plan of Phase 3 of the Dragátsis/Dörpfeld shipsheds at Zea (J. Pakkanen)," includes data on 11 essential column positions excavated in the sea by the ZHP but omits to give the ZHP proper credit for contributing the data and identifying the building phase. The failure of these scholars to follow accepted citation practice is disappointing, for those 11 column positions are what defines 17.70 m out of the total preserved Phase 3 colonnade length of 59.20 m (equalling 30%).

Summary

The preceding discussion of certain issues in current naval base studies has definitively shown that Rankov and Pakkanen's reconstruction of the Phase 2 and 3 shipsheds is based not on objective analysis of the physical evidence, but rather inaccurate data and misconceived ideas about the architecture of the shipsheds in the Piraeus, and the sea level change since the Classical Period. The resulting catalogue entry, "Piraeus," is thus fatally flawed and should be treated with extreme caution.[169]

6.5. Updating the Reconstructed Length of the Phase 3 Superstructures in Group 1 (Area 1) at Zea Harbour

The updated minimum relative sea level change of -2.05 m to -2.25 m, allows the superstructure length reconstruction of the Phase 3 shipsheds in Group 1 (*terminus post quem* 375–350 BC) to be updated. Previously, the reconstructed length of 77.86 m (range: 75.47–80.85 m) was based on a minimum relative sea level change of -1.90 m;[170] this length can now be extended to allow for the deeper minimum relative sea level change of -2.05 m to -2.25 m. The inclination range for the Phase 3 superstructure remains unchanged at 1:12.8/4.5° to 1:11.9/4.8°. The lower point of this range, 1:12.8/4.5°, is nonetheless the most probable (see above).[171]

The updated superstructure length reconstruction of Phase 3 to the minimum relative sea level change is anchored to the top surface centre of the first column base in the colonnade dividing Shipsheds C17(η)/18(χ). Based on the following data, the Phase 3 shipsheds at Zea Harbour can be securely reconstructed to a length of 80.02 m (range: 77.26–82.77 m) to 82.49 m (range: 79.64–85.33 m; Pls. 2.16, 2.18, Table 6.5):

1) Minimum relative sea level change: -2.05 to -2.25 m (see pp. 147–150).
2) The inclination range of Phase 3 shipsheds: 1:12.8 (4.5°) to 1:11.9 (4.8°) (see pp. 164–170).[172]
3) Top level of Phase 3 column base C17/18:7(δ): +4.08 m.[173]

167. Blackman & Rankov 2013: xv, fig. B16.13 (p. 464). Cf. Lovén & Schaldemose 2011: pl. 13.
168. Blackman & Rankov 2013: 447.
169. Phrasing inspired by John K. Papadopoulos' review of a similarly troubling publication www.bmcreview.org/2016/04/20160438.html. Other misgivings in regard to the methodology, data, and conclusions presented in Blackman & Rankov 2013 will, if necessary, be published elsewhere.
170. Lovén 2011: 147–150, 159–161, 171; pl. 43. Length reconstructions based on the inclination range 1:12.8 ((4.5°) to 1:11.9 (4.8°). Length reconstructions include width of back-wall (0.63 m).
171. For further discussion of the 1:12.8 (4.5°) to 1:11.9 (4.8°) inclination range, see Lovén 2011: 104–108.
172. Lovén 2011: 104–108, pl. 37, 43.
173. Lovén 2011: 98, figs. 176b, 230; pls. 6, 43.

Fig. 2.1 Zea Harbour, designations of Areas 1–9.

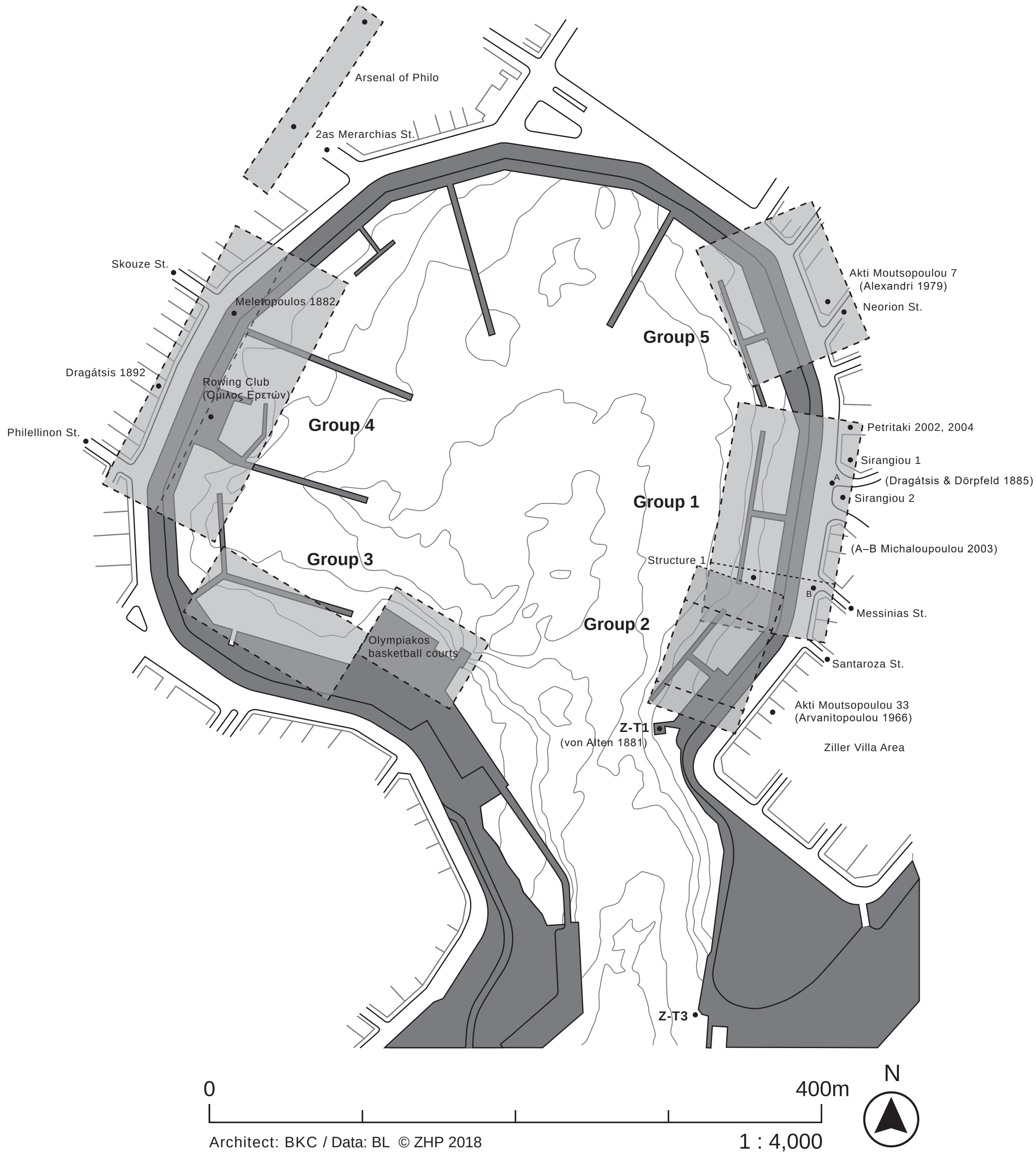


Fig. 2.2 Zea Harbour, topographical reconstruction of Groups 1–5 (*terminus post quem* 330/29 BC).

Fig. 2.9 Zea Harbour, northern, north-eastern (Area 5) and eastern (Areas 1 & 2) sides (L. Heldring 1898).

Fig. 2.10 Zea Harbour, eastern (Areas 1 & 2) and south-eastern (Area 3) sides
(Postcard “39 ΠΕΙΡΑΙΕΥΣ ΟΡΜΟΣ ΚΑΝΑΡ,” probably from the 1930s, unknown photographer).

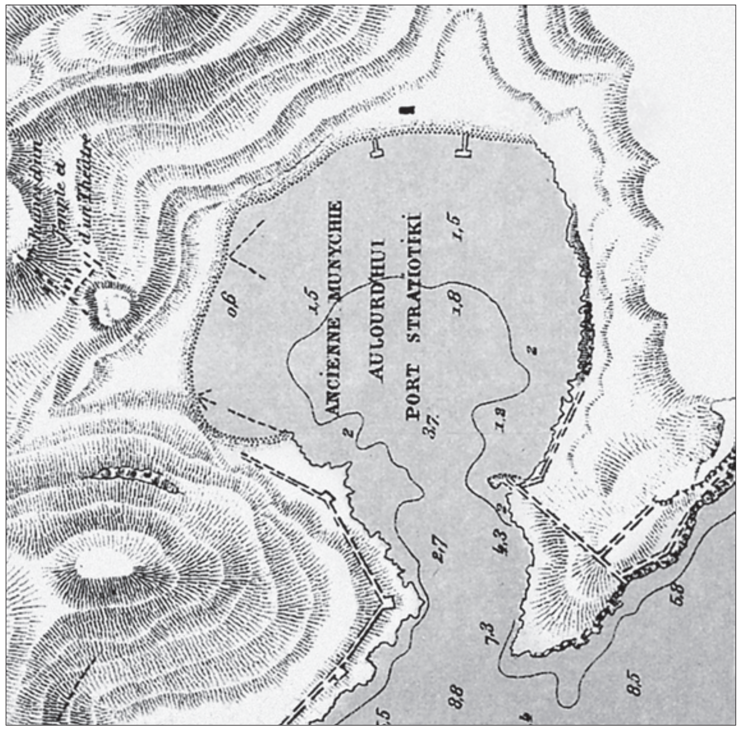


Fig. 4.9 Detail of Zea Harbour (*Le Pirée* (1:10,000), *Atlas des Ports Étrangers*, 3e sér., pl. XV. Paris 1870, re-scaled at 1:8,000).

Fig. 4.10 Detail of Zea Harbour (Curtius & Kaupert 1881: pl. II, von Alten's map *Die Halbinsel Peiraieus* 1876/77, re-scaled at *ca* 1:8,000).

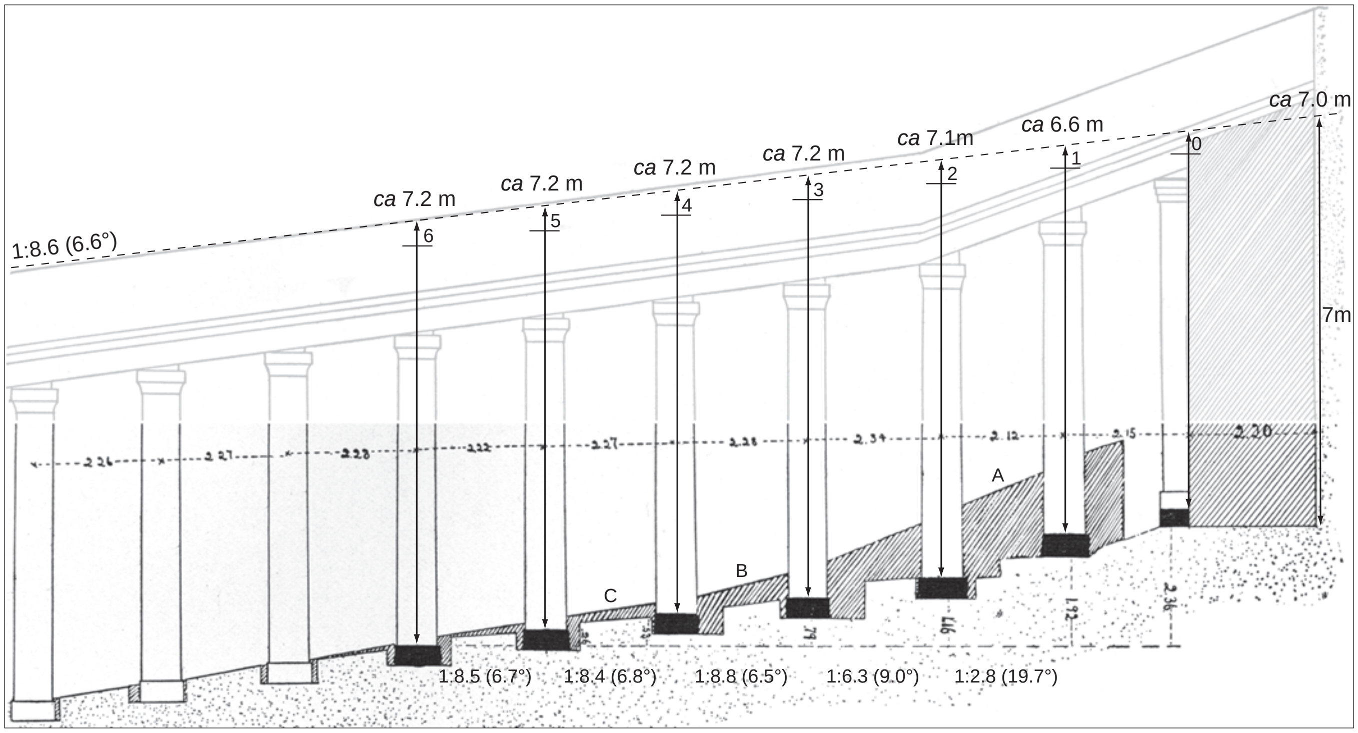


Fig. 4.16 Oiniadai, longitudinal section of colonnade dividing shipsheds 2 and 3, including section of ramp and reconstruction of superstructure (Sears 1904: pl. X, scaled as in the publication).

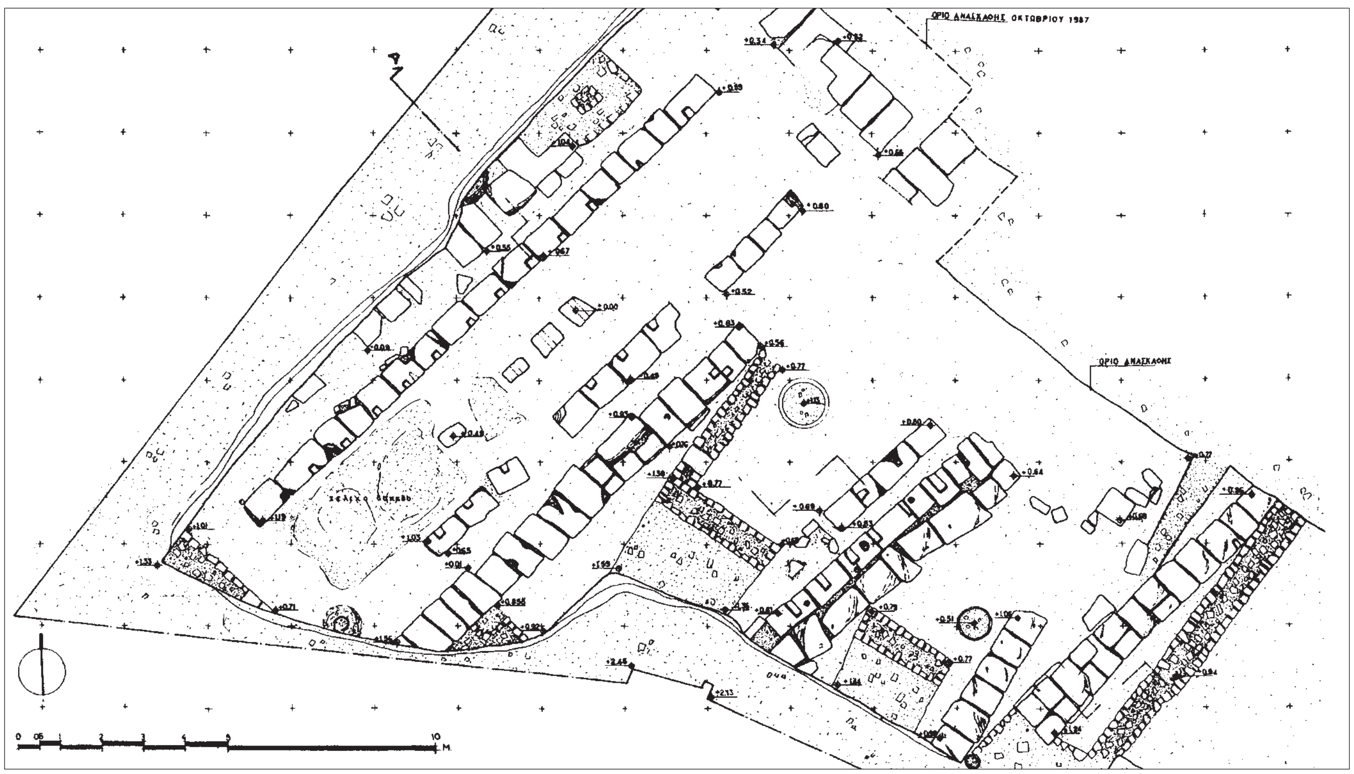
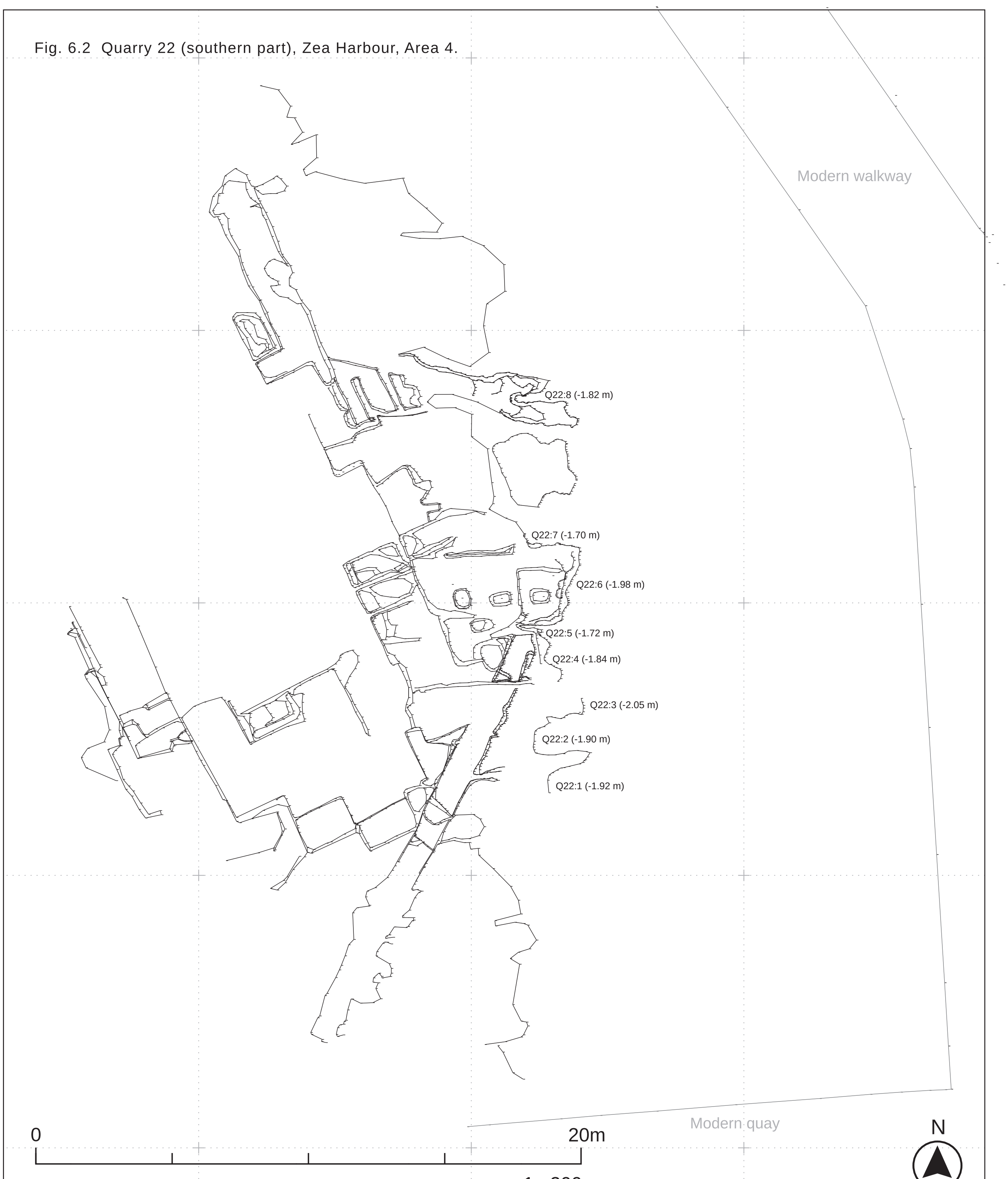


Fig. 4.17 Kos, plan of . 6)

Fig. 6.1 Quarry 22 from the southeast, Zea Harbour, Area 4 (B. Lovén © ZHP 2018).

Fig. 6.2 Quarry 22 (southern part), Zea Harbour, Area 4.



Surveyors: EM, MA, NB, SRE, & YN / Architect: BL © ZHP 2018

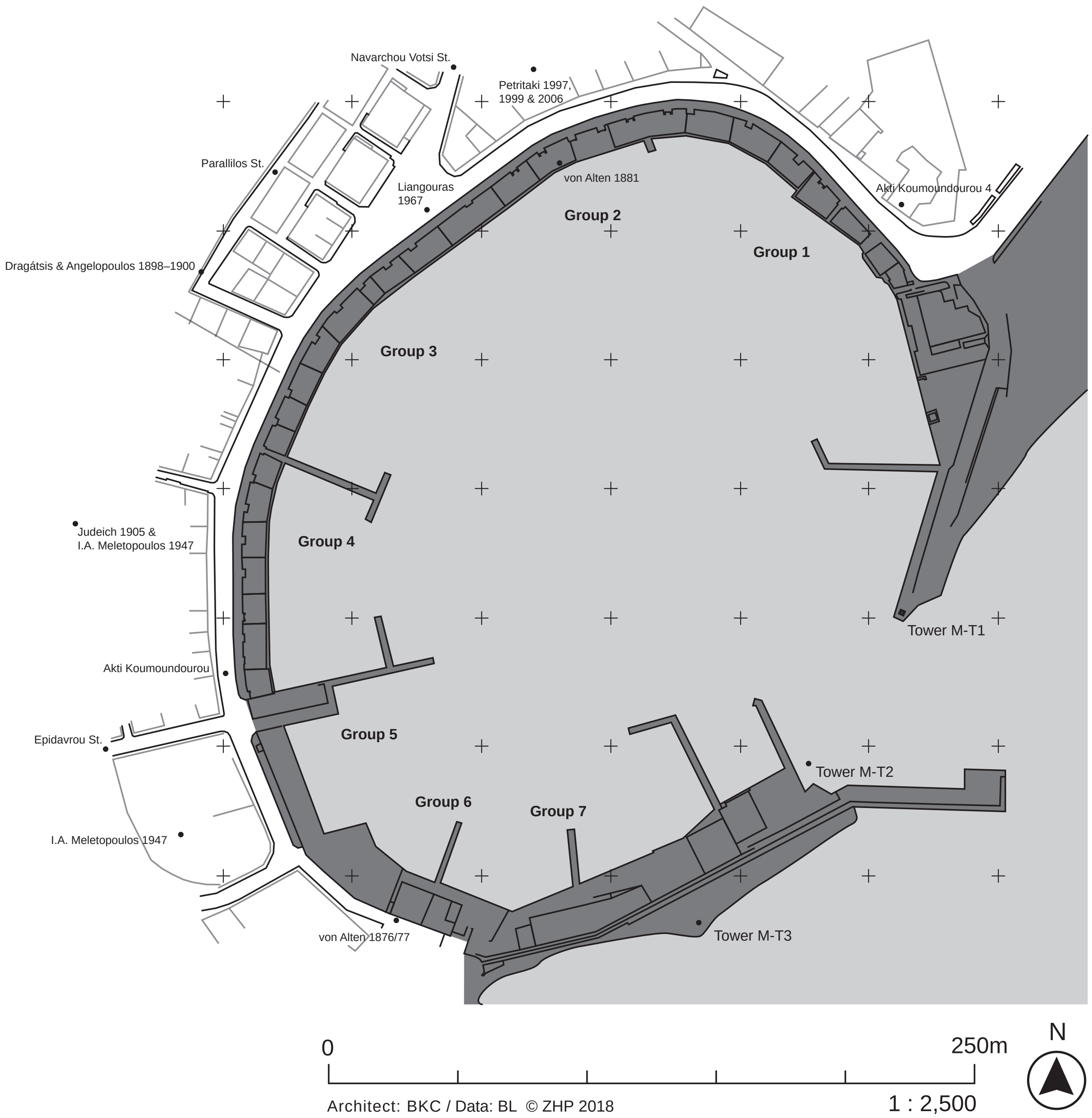
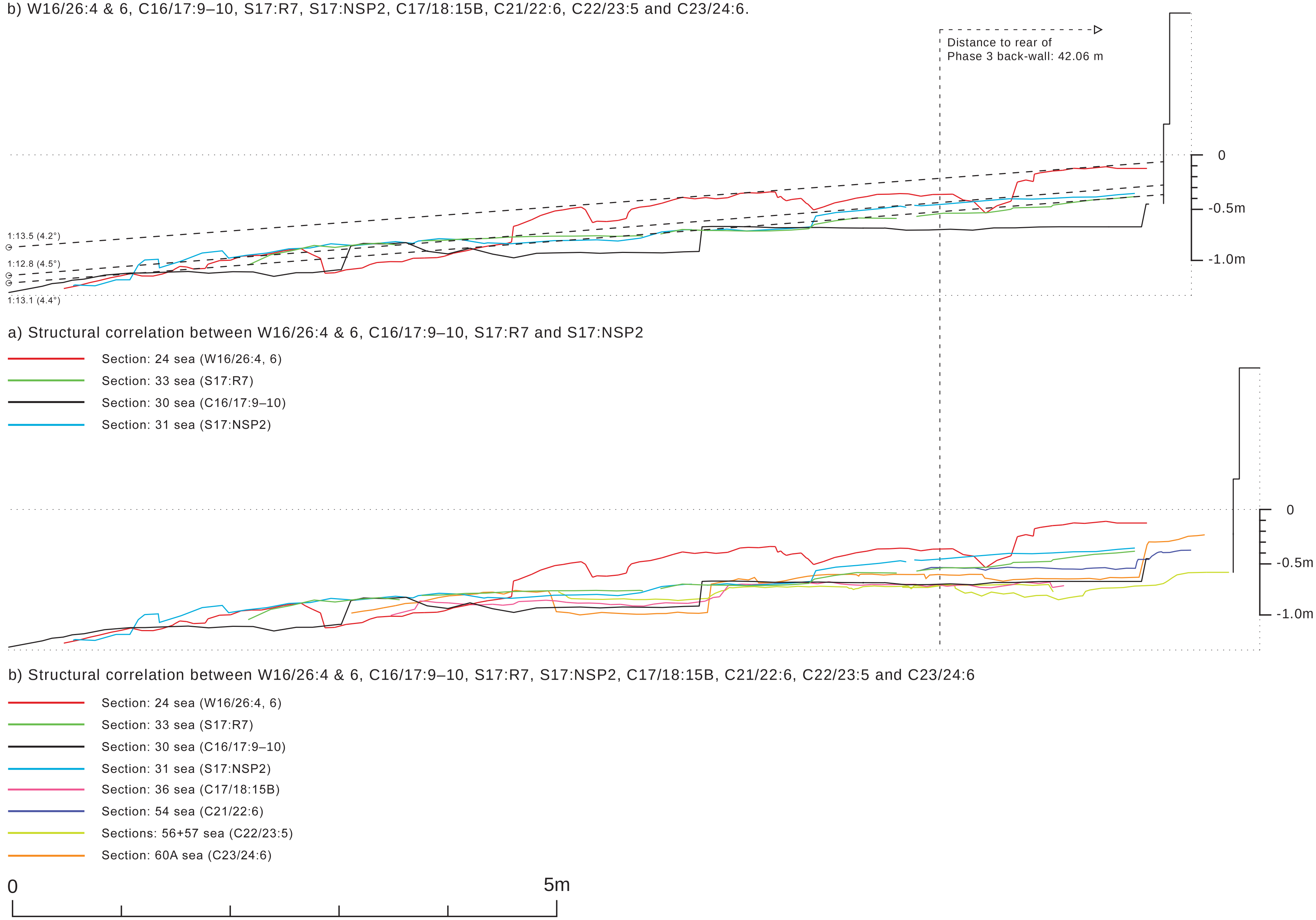


Fig. 6.3 Mounichia Harbour, modern Mikrolimano.

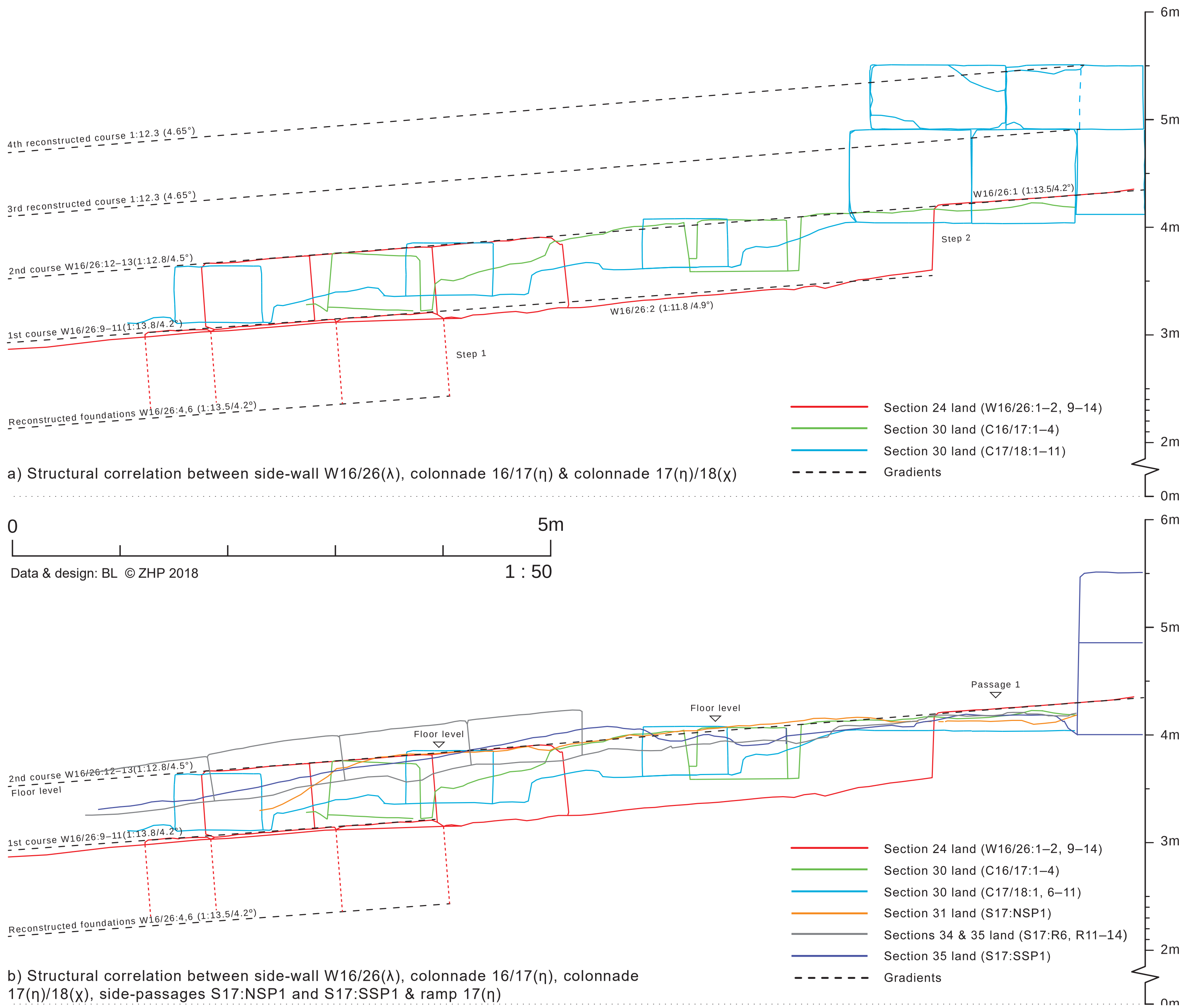
Fig. 6.4 Akti Koumoundourou 4, Mounichia Harbour, M-G1 (1933, unknown photographer).

Fig. 6.5 a) Structural correlation between: a) W16/26:4 & 6, C16/17:9–10, S17:R7 and S17:NSP2, and
b) W16/26:4 & 6, C16/17:9–10, S17:R7, S17:NSP2, C17/18:15B, C21/22:6, C22/23:5 and C23/24:6.



Data & design: BL © ZHP 2018

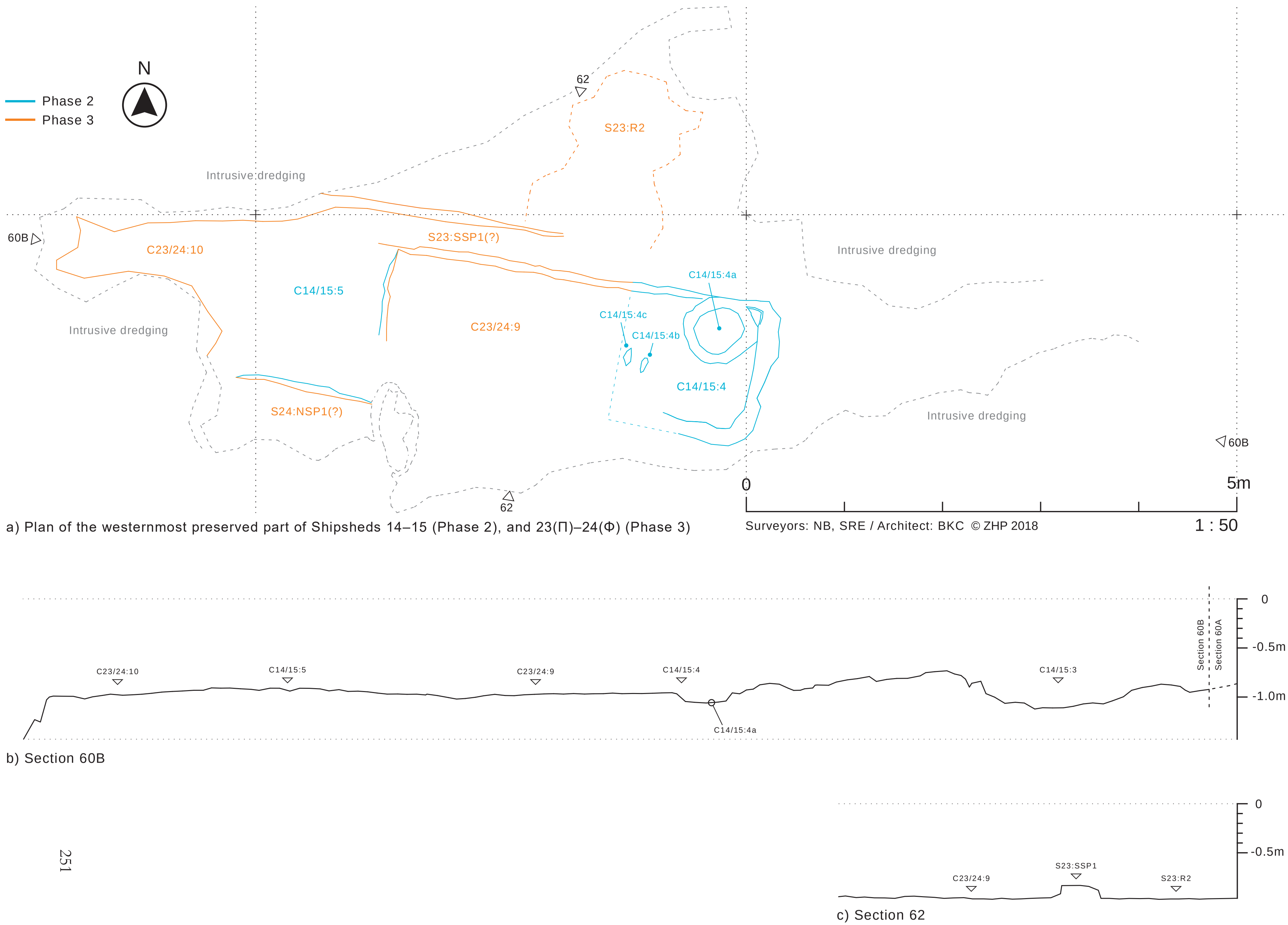
Fig. 6.6 Zea Harbour, Z-G1 (Area 1), Basement of Sirangiou 1, structural correlation between: a) side-wall W16/26(λ), colonnade 16/17(η) & colonnade 17(η)/18(χ), b) Structural correlation between side-wall W16/26(λ), colonnade 16/17(η), colonnade 17(η)/18(χ), side-passages S17:NSP1 and S17:SSP1 & ramp 17(η).



a) Structural correlation between side-wall W16/26(λ), colonnade 16/17(η) & colonnade 17(η)/18(χ)

b) Structural correlation between side-wall W16/26(λ), colonnade 16/17(η), colonnade 17(η)/18(χ), side-passages S17:NSP1 and S17:SSP1 & ramp 17(η)

Fig. 6.7 Zea Harbour, Z-G1 (Area 1): a) plan of the westernmost preserved part of Shipsheds 14–15 (Phase 2) and 23(Π)–24(Φ) (Phase 3); b) Section 60B and c) Section 62.



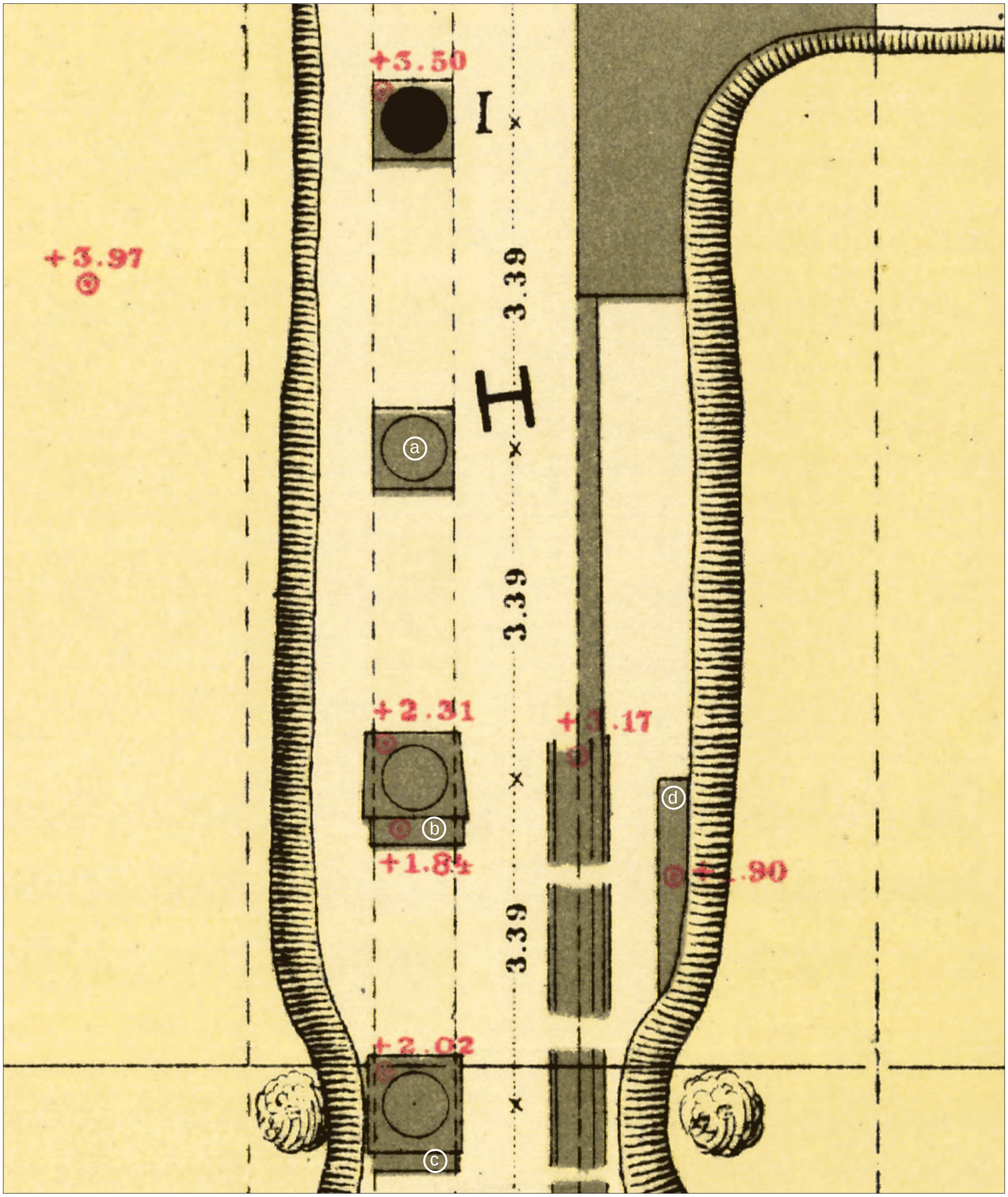
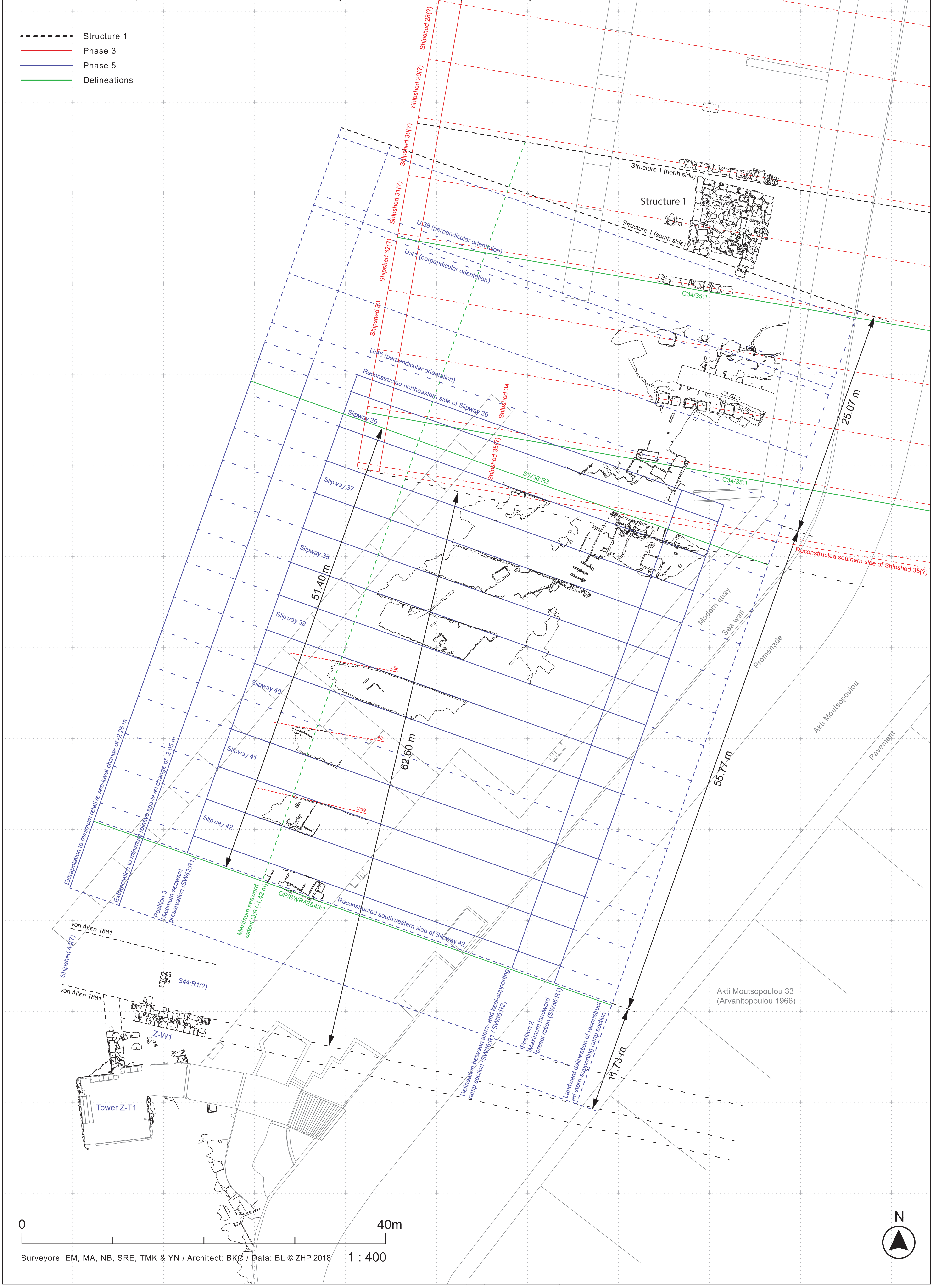


Fig. 6.8 Detail of Dörpfeld 1885, pl. 2, showing (a) Phase 3 colonnade feature C20/21:11; (b) Phase 2 colonnade feature C11/12:2(?); (c) Phase 2 colonnade feature C11/12:4, and (d) Phase 2 ramp feature S12:R1(?).

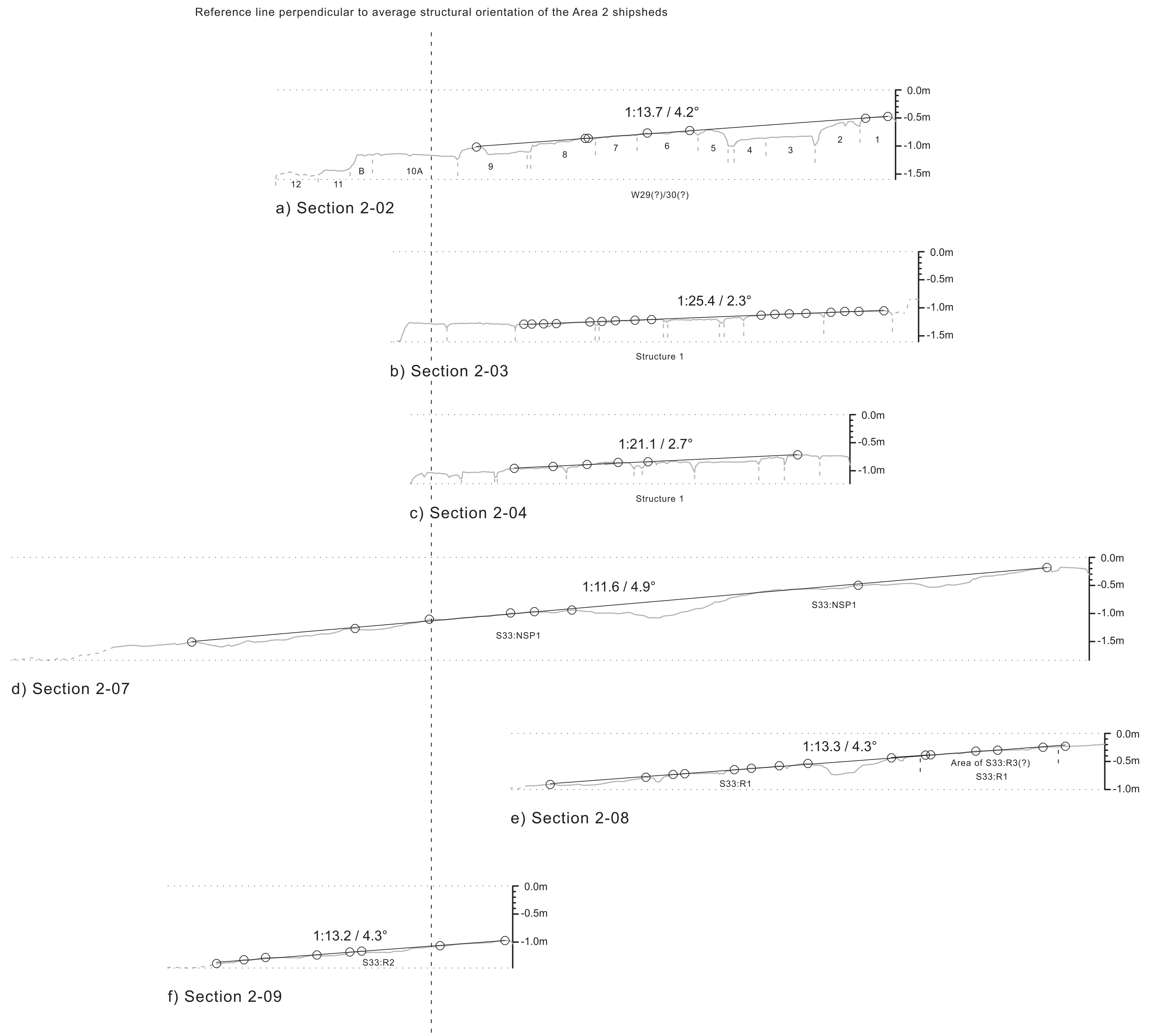
Pl. 2.2 Zea Harbour, Areas 2–3, Reconstruction of Group 2 and the southern part of Group 1



Pl. 2.3 Zea Harbour, Z-G1 (Area 2), Shipsheds 28(?)–32(?)

Surveyors: EM, MA, NB & YN / Architect: BKC © ZHP 2018

Pl. 2.9 Zea Harbour, Z-G1 (Area 2), gradient calculations of 2-02 to 2-04 and 2-07 to 2-09

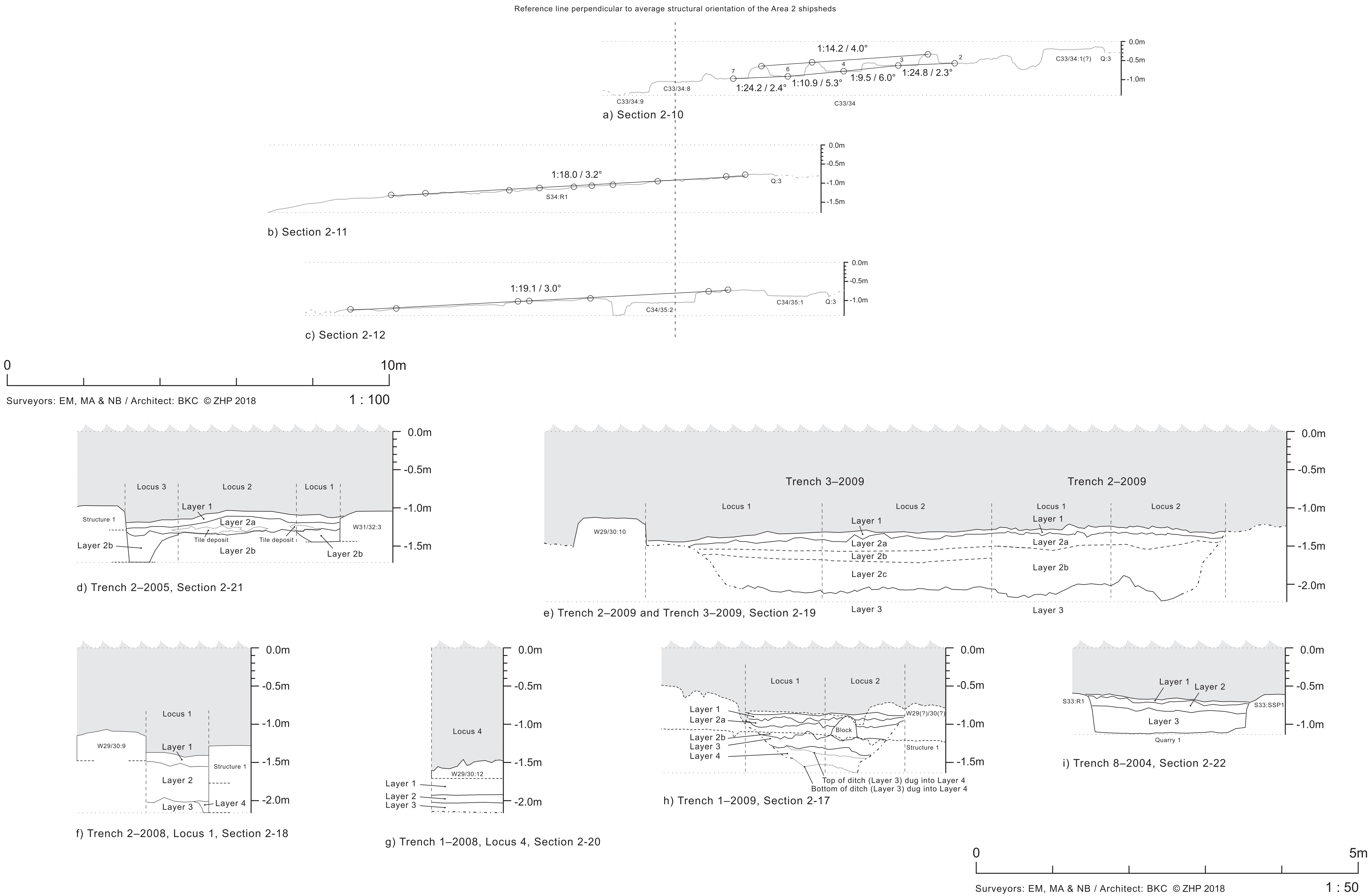


0 10m

Surveyors: EM, MA & NB / Architect: BKC © ZHP 2018

1 : 100

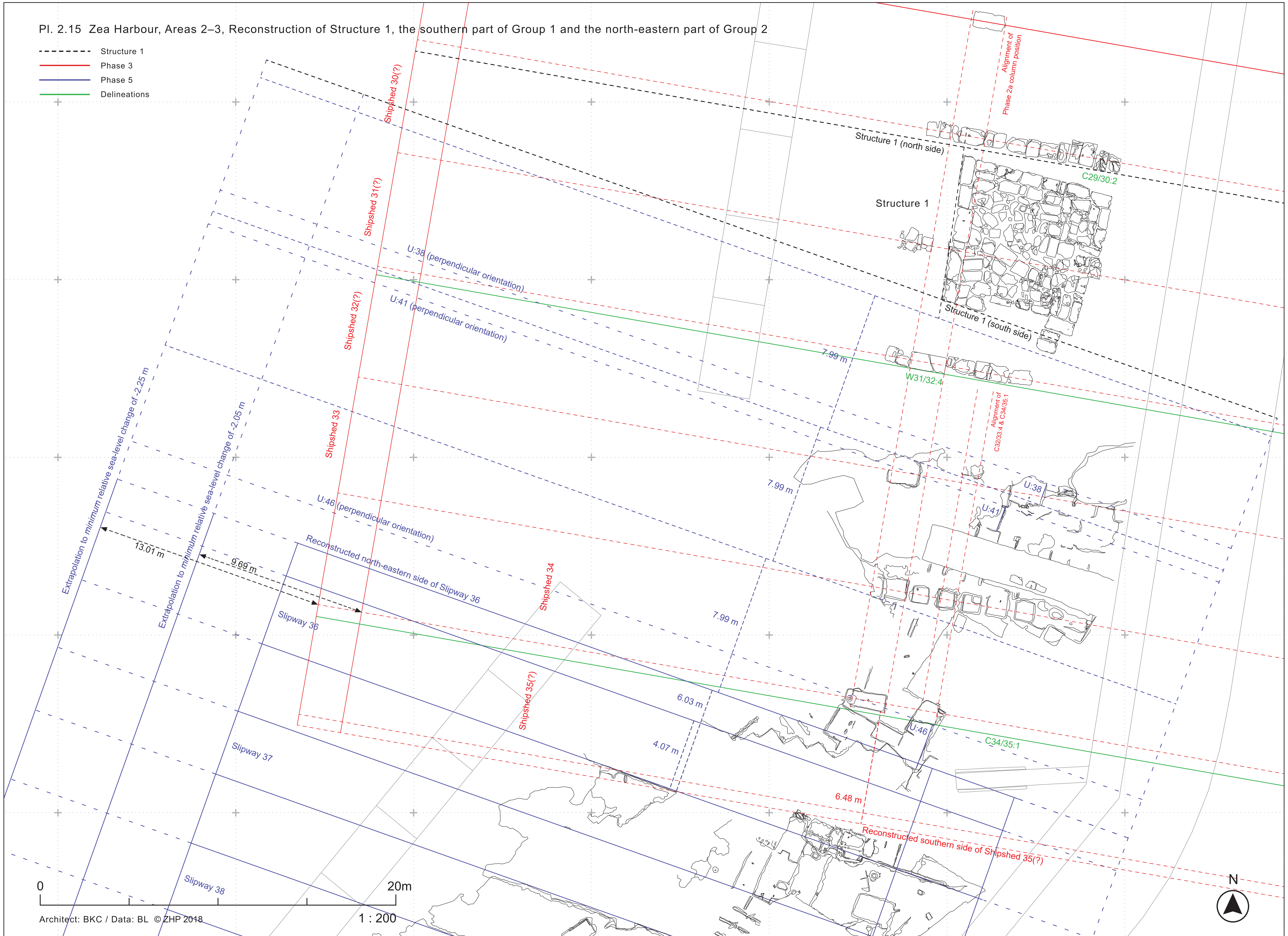
Pl. 2.10 Zea Harbour, Z-G1 (Area 2), a-c) gradient calculations of 2-10 to 2-12; d-f) trench stratigraphy sections 2-17 to 2-22



Pl. 2.13 Zea Harbour, Z-G1 (Area 2), Quarries 1–21

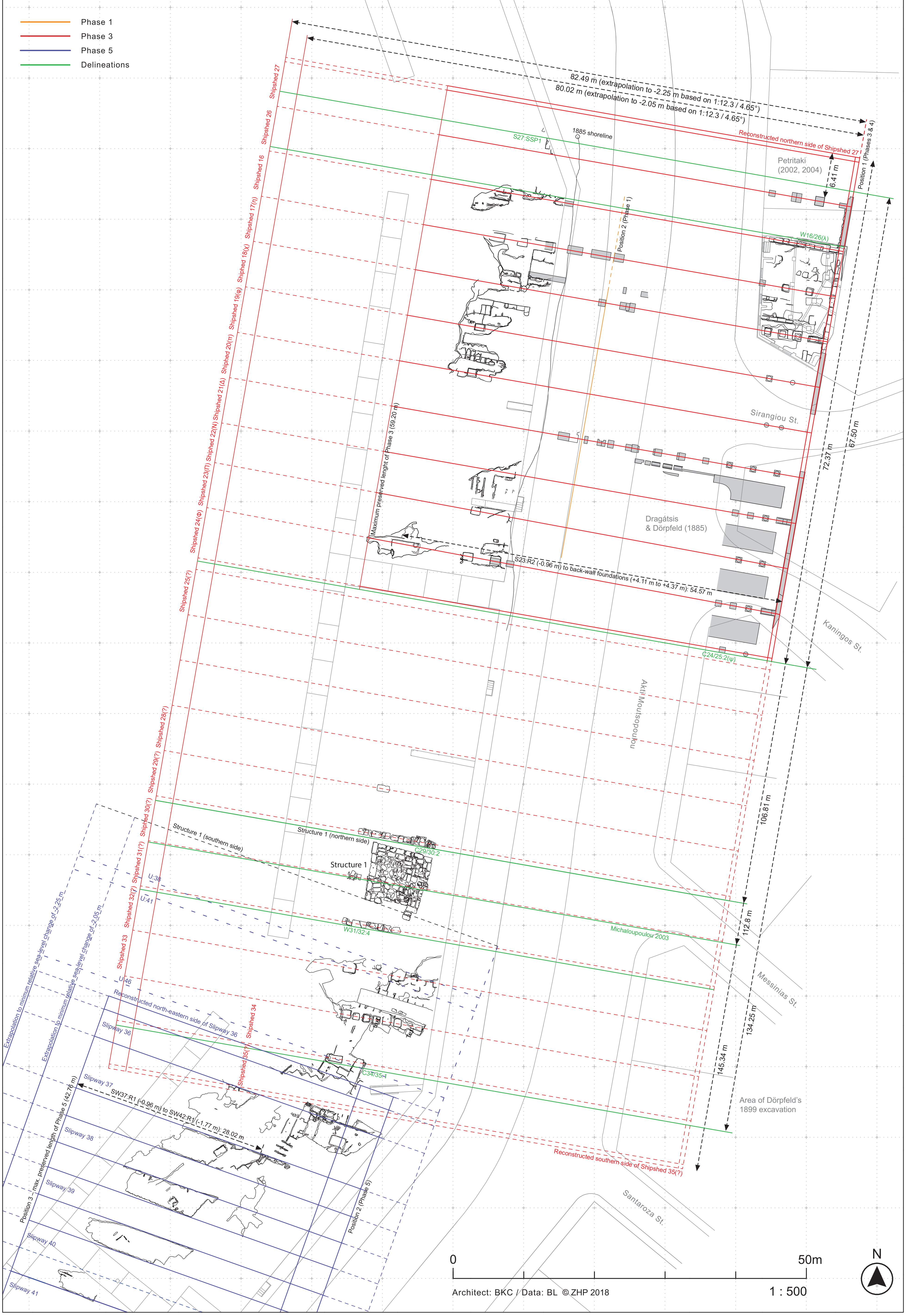
Surveyors: EM, IT, MA, NB & YN / Architect: BKC © ZHP 2018

Pl. 2.15 Zea Harbour, Areas 2–3, Reconstruction of Structure 1, the southern part of Group 1 and the north-eastern part of Group 2

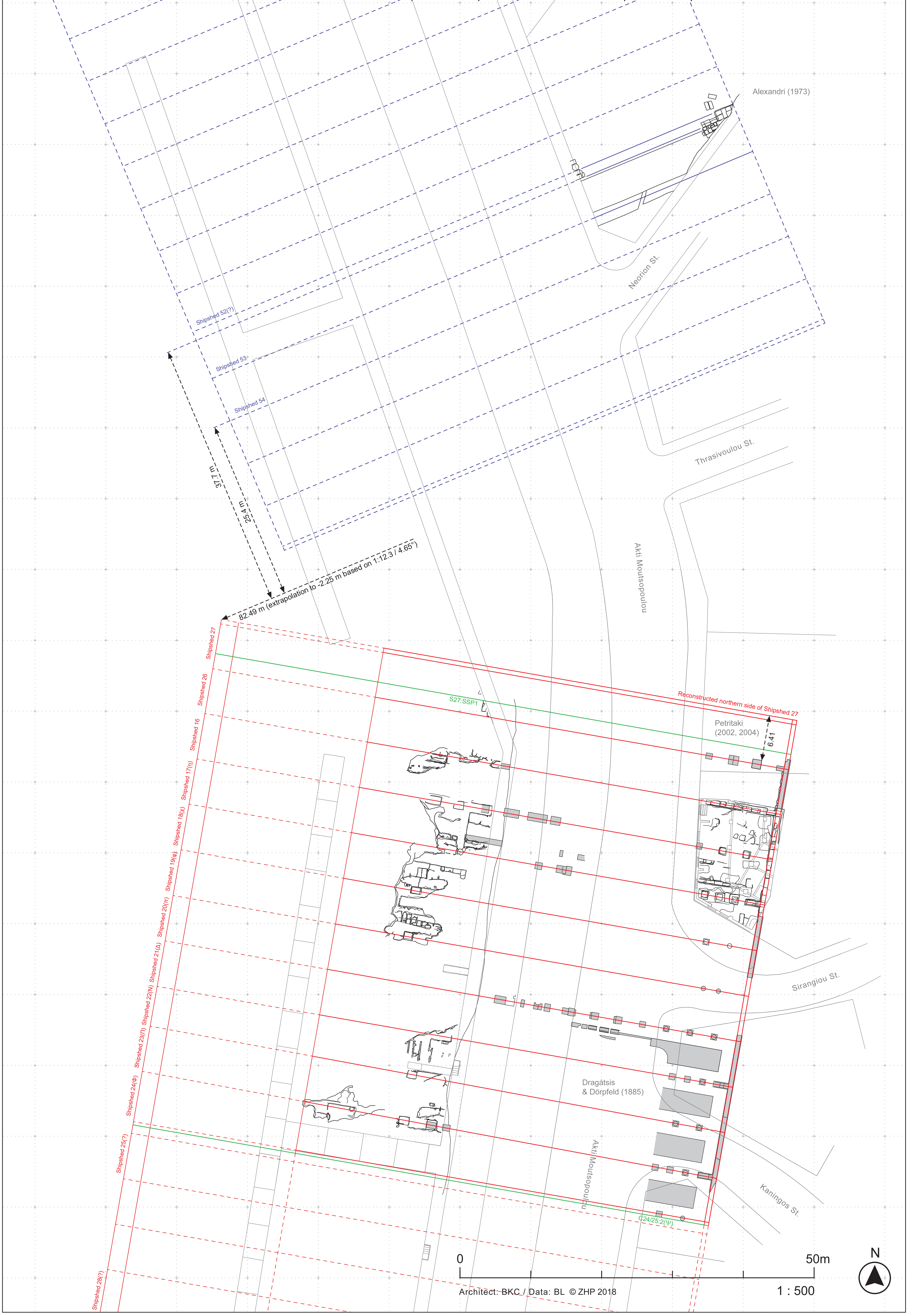


Architect: BKC / Data: BL ©ZHP 2018

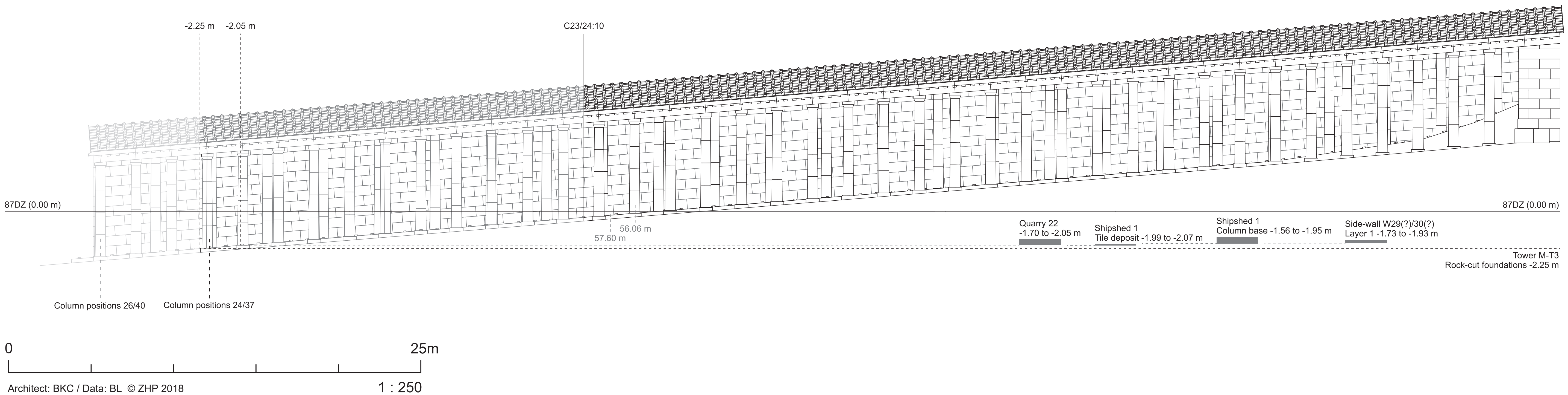
Pl. 2.16 Zea Harbour, Areas 1–2, Reconstruction Group 1 (Phase 3) and the north-eastern part of Group 2 (Phase 5)



Pl. 2.17 Zea Harbour, Areas 1 and 9, Reconstruction of the northern part of Group 1 and the south-eastern part of Group 5

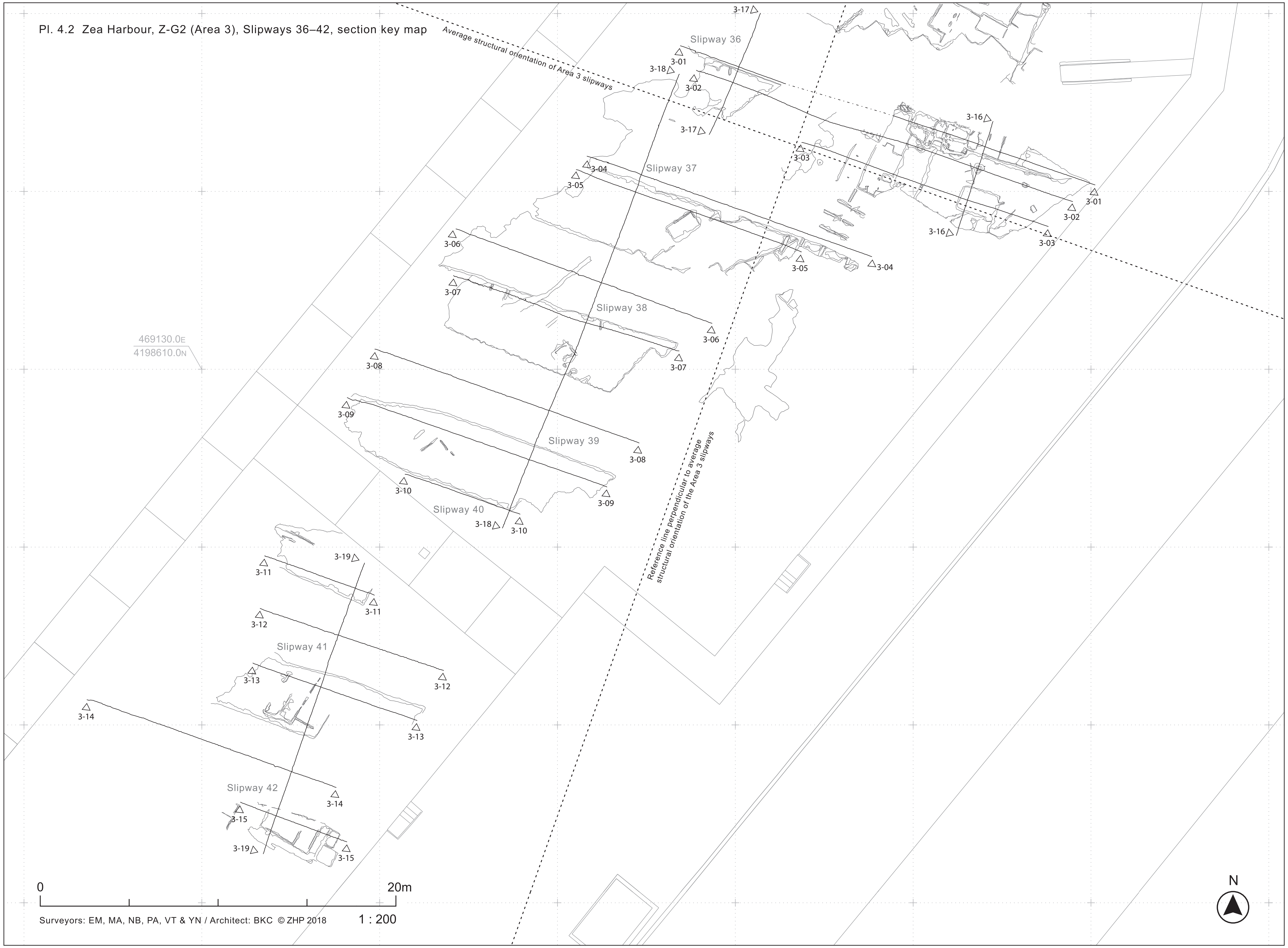


Pl. 2.18 Zea Harbour, reconstruction of the Phase 3 shipsheds



Pl. 4.1 Zea Harbour, Z-G2 (Area 3), Slipways 36–42

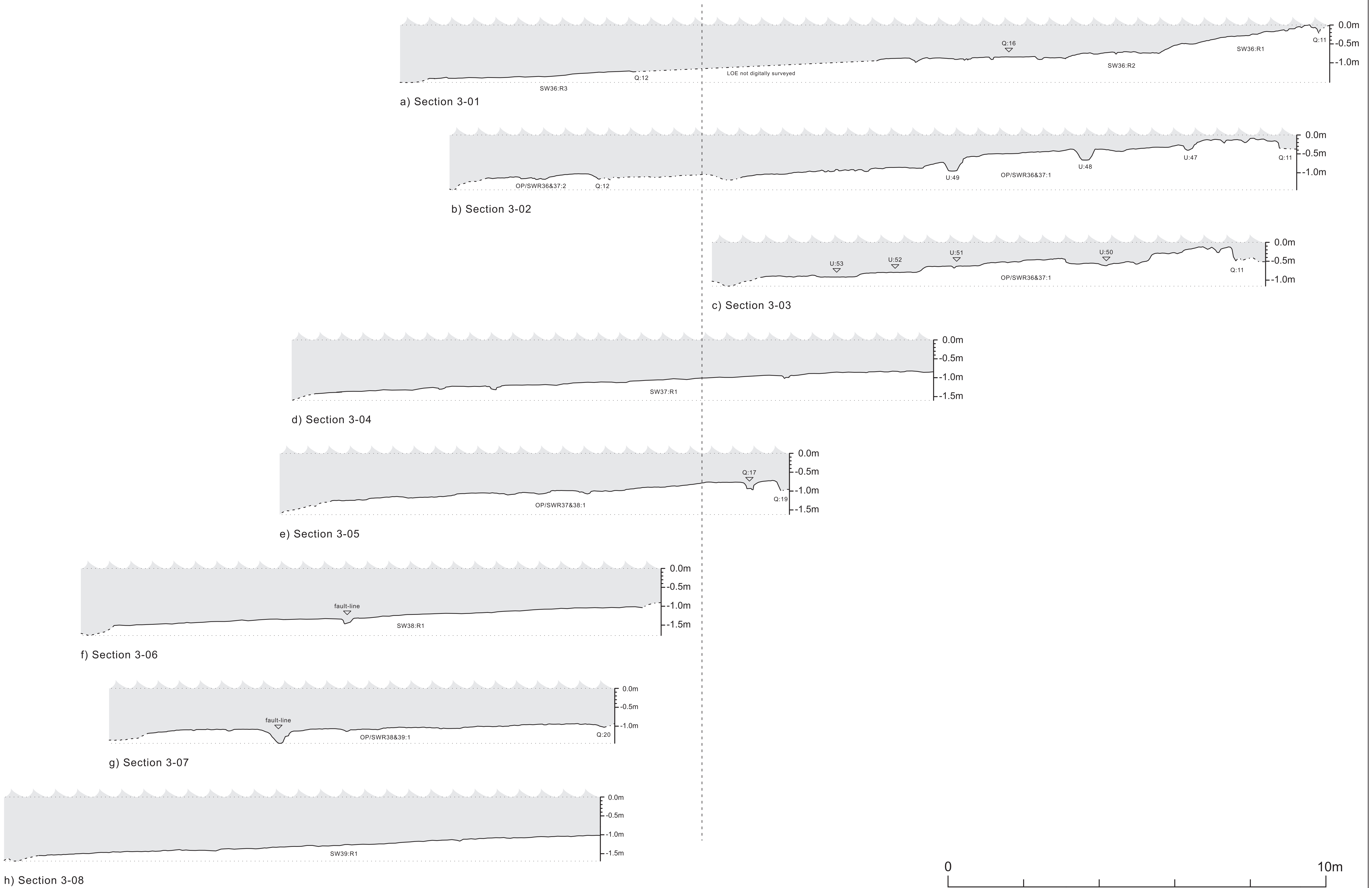
Surveyors: EM, MA, NB & YN / Architect: BKC © ZHP 2018



Pl. 4.2 Zea Harbour, Z-G2 (Area 3), Slipways 36–42, section key map

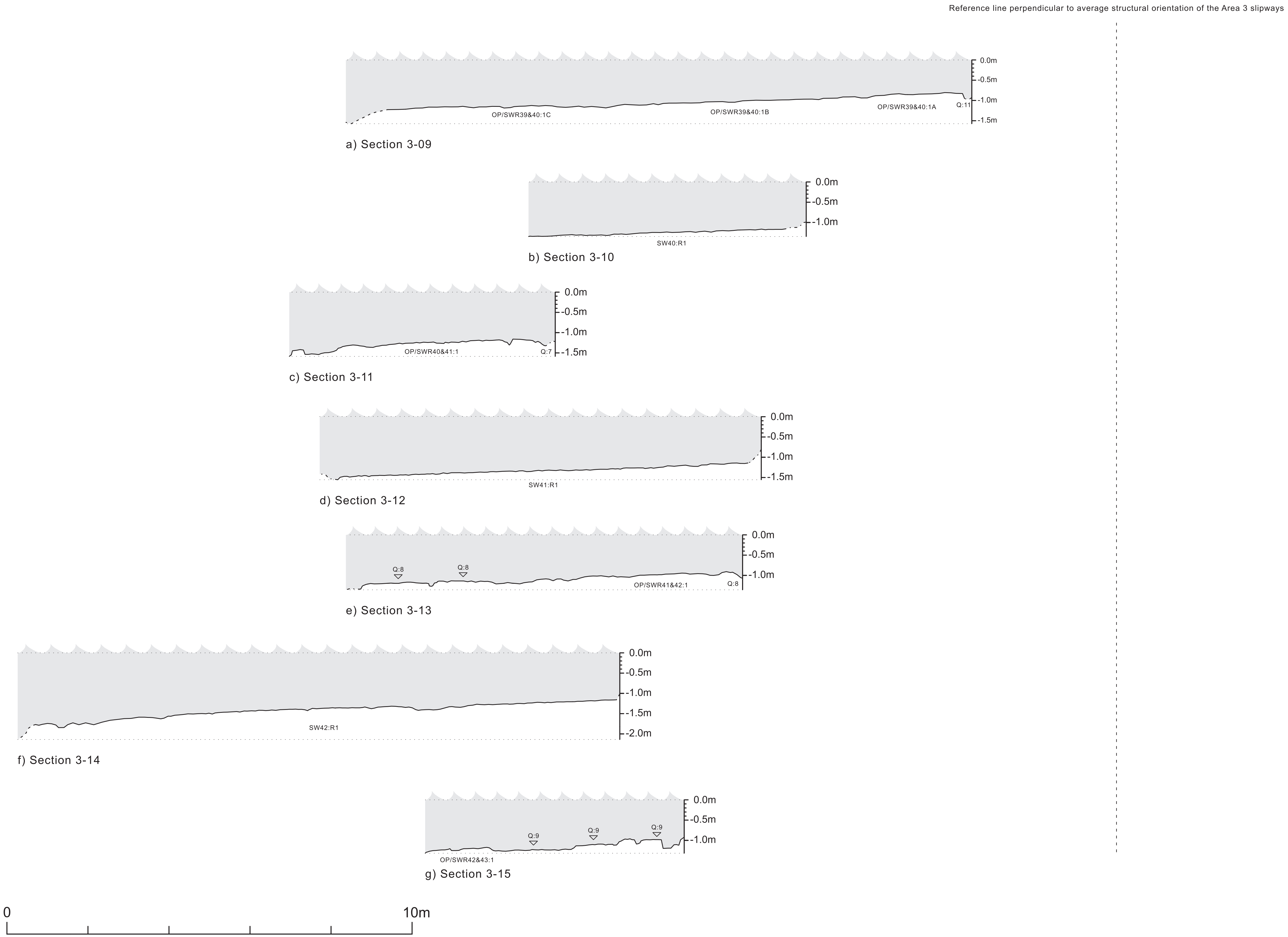
Pl. 4.3 Zea Harbour, Z-G2 (Area 3), Slipways 36–39, longitudinal sections 2-01 to 2-08

Reference line perpendicular to average structural orientation of the Area 3 slipways

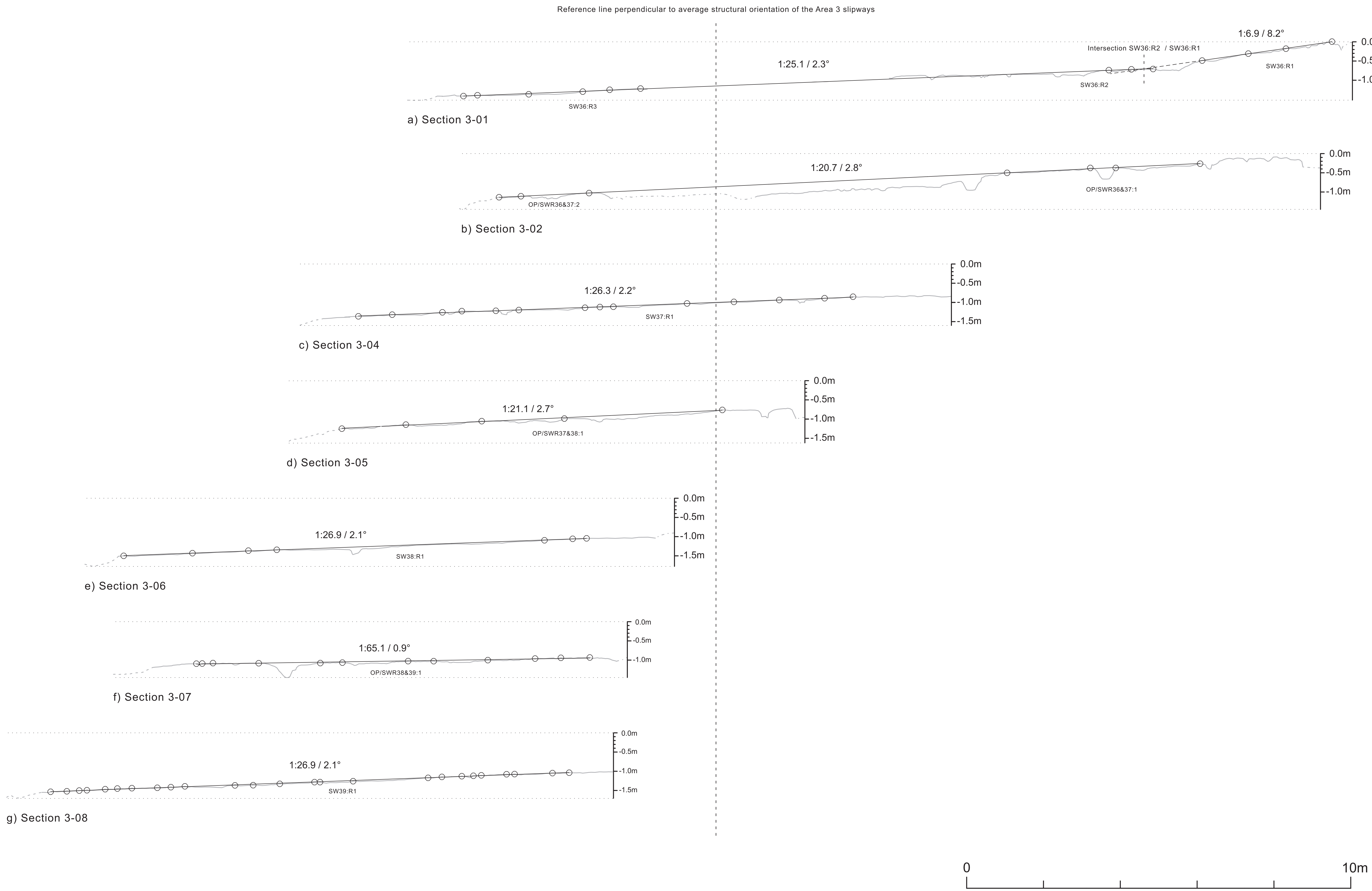


Surveyors: EM, MA, NB, PA, VT & YN / Architect: BKC © ZHP 2018 1 : 100

Pl. 4.4 Zea Harbour, Z-G2 (Area 3), Slipways 40–42, longitudinal sections 2-09 to 2-15

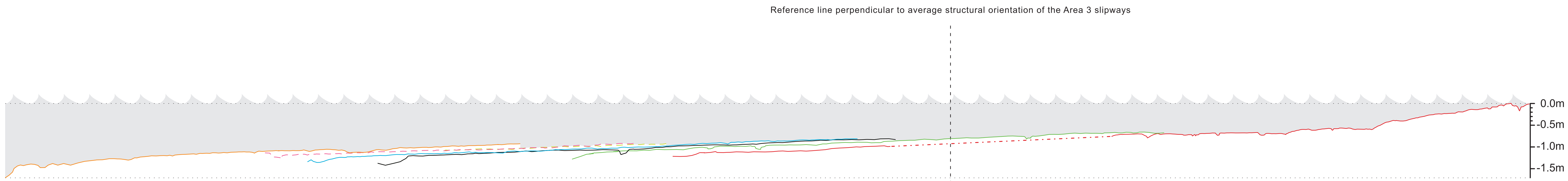


Pl. 4.5 Zea Harbour, Z-G2 (Area 3), gradient calculations of ramps and open-passages of Slipways 36–39. Excluding OP/SWR39&40



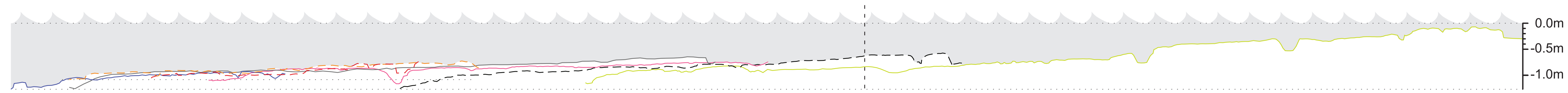
Surveyors: EM, MA, NB, PA, VT & YN / Architect: BKC © ZHP 2018 1 : 100

Pl. 4.8 Zea Harbour, Z-G2 (Area 3), Slipways 36–42, merged sections: a) Ramps of Slipways 36–42; b) Open-passages of Slipways 36–42; c) Ramps and open-passages of Slipways 36–42



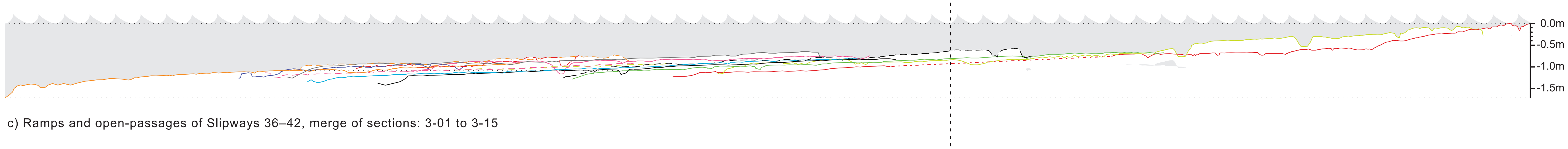
a) Ramps of Slipways 36–42, merge of sections: 3-01, 3-04, 3-06, 3-08, 3-10, 3-12 and 3-14

Section: 3-01 (SW36:R1–R3)
Section: 3-04 (SW37:R1)
Section: 3-06 (SW38:R1)
Section: 3-08 (SW39:R1)
Section: 3-10 (SW40:R1)
Section: 3-12 (SW41:R1)
Section: 3-14 (SW42:R1)



b) Open-passages of Slipways 36–42, merge of sections: 3-02, 3-05, 3-07, 3-09, 3-11, 3-13 and 3-15

Section: 3-02 (OP/SWR36&37:1–2)
Section: 3-05 (OP/SWR37&38:1)
Section: 3-07 (OP/SWR38&39:1)
Section: 3-09 (OP/SWR39&40:1)
Section: 3-11 (OP/SWR40&41:1)
Section: 3-13 (OP/SWR41&42:1)
Section: 3-15 (OP/SWR42&43:1)

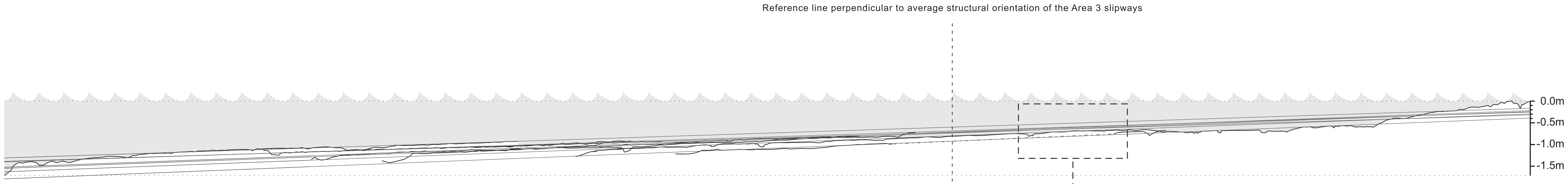


c) Ramps and open-passages of Slipways 36–42, merge of sections: 3-01 to 3-15

0 12.5m

Surveyors: EM, MA, NB, PA, VT & YN / Architect: BKC © ZHP 2018 1 : 125

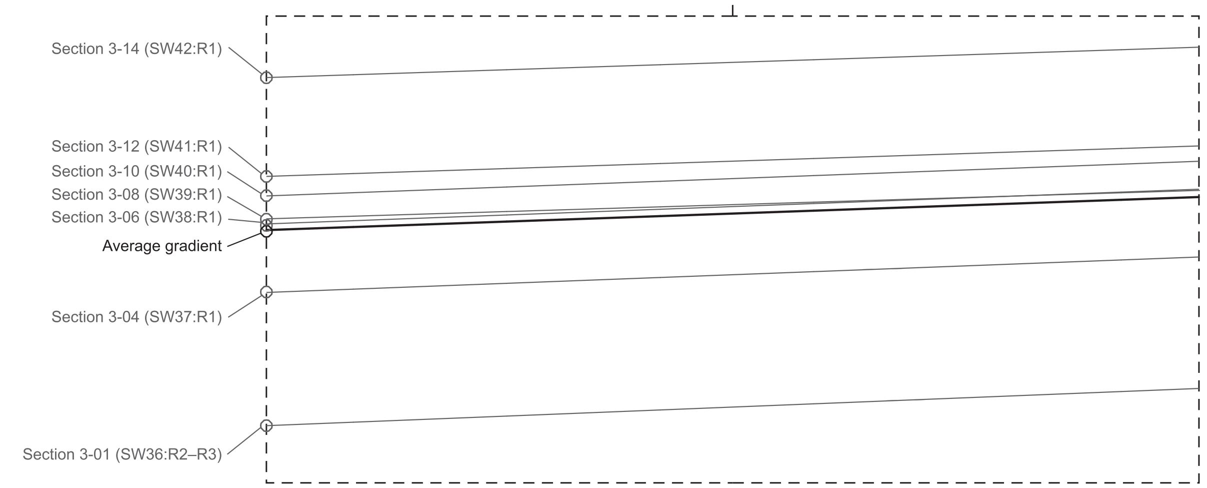
Pl. 4.10 Zea Harbour, Z-G2 (Area 3), extrapolation of Slipways 36–42 to minimum relative sea-level change of -2.05 to -2.25 m

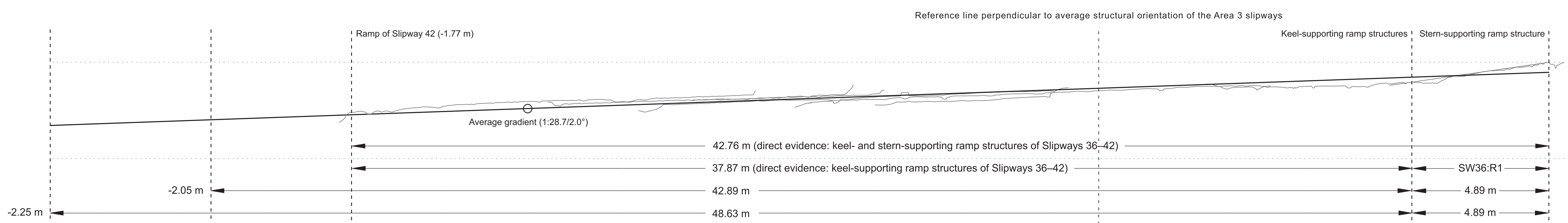


a) Ramps of Slipways 36–42, merge of sections: 3-01, 3-04, 3-06, 3-08, 3-10, 3-12 and 3-14

0 — 12.5m

Architect: BKC / Data: BL © ZHP 2018 1 : 125





b) Ramp structures of Slipway 36–42: extratrapolation to the minimum relative sea-level change of -2.05 to -2.25 m

0 — 15m

Architect: BKC / Data: BL © ZHP 2018 1 : 150

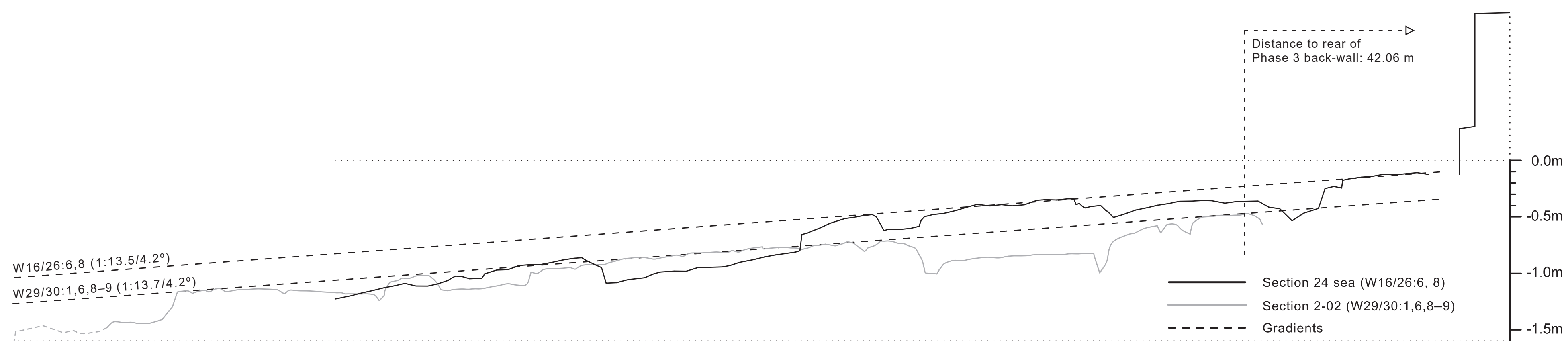
Pl. 6.1 Mounichia Harbour, M-G1, Shipsheds 1–2
Position 2
Estimated foot of the Kastella Hill
Akti Koumoundourou
Quay area
Akti Koumoundourou 4
Side-wall W1
Shipshed 1
Shipshed 2
Position 3
0
20m
N
Surveyors: MA & YN / Architect: BKC / Data: BL © ZHP 2018
1 : 200

Pl. 6.2 Zea Harbour, Z-G1(Area 1): a) Structural correlation between the sea- and landward sections of side-wall W16/26(λ); b) Structural correlation between side-wall W16/26(λ) and side-wall 29(?)/30(?); and c) Testing Rankov's Phase 2 gradient 1:9.65 (5.9°)

a) Structural correlation between the sea- and landward sections of side-wall W16/26(λ)

0 20m

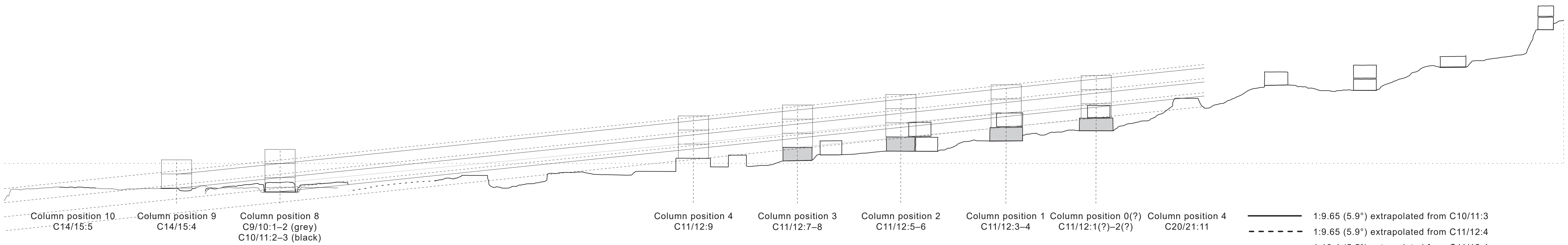
Surveyor: NB & SRE / Architect: BKC / Data: BL © ZHP 2018 1 : 200



b) Structural correlation between side-wall W16/26(λ) and side-wall 29(?)/30(?)

0 5m

Surveyors: EM, MA, NB & SRE / Architect: BKC / Data: BL © ZHP 2018 1 : 50



C) Testing Rankov's Phase 2 gradient 1:9.65 (5.9°)

0 15m

Architects: WD & BKC / Data: BL © ZHP 2018 1 : 150