Work Area: SMM
Work Type: I&M
Originator Company: GEOCISA UK

C435
Farringdon Main Station

CRL Lead reviewer: [redacted]
CRL Reviewer:

Monitoring Close-Out Report:
Automated Total Station ATS 05 and 3D Targets read by ATS 05.

CRL Document Number: C435-BFK-C2-RGN-M123-51640

Supplier Document Number: N/A

Contract MDL reference C13.012

1. Contractor Document Submittal History:

Revision:	Date:	Prepared by:	Checked by:	Approved by:	Reason for Issue:
1.0	07-04-2016	[redacted]			For acceptance
2.0	24-05-2016				For acceptance

2a. Stakeholder Review Required? YES ☐ NO ☒

Stakeholder submission required: LU ☐ RfL ☐ NR ☐ LO ☐ DLR ☐ Other: _____

Purpose of submission: For no objection ☐ For information ☐

This document has been reviewed by the following individual for coordination, compliance, integration and acceptance and is acceptable for transmission to the above stakeholder for the above stated purpose.

Sign: _____ Role: _____ Name: _____ Date: _____

Sign: _____ Role: _____ Name: _____ Date: _____

2b. Review by Stakeholder (if required):

Stakeholder Organisation	Job Title	Name	Signature	Date	Acceptance
					☐
					☐
	[redacted]				☐

compliance with their contractual obligations and does not constitute
ds or materials developed or selected by the designer/supplier.

15/10/2016

3. Acceptance by *Crossrail:*

Contents

A. INTRODUCTION

In line with the C122 – M&W Specification KX10 – Instrumentation & Monitoring C122-OVE-Z4-RSP-CR001-00007, this close out report aims to address the following points in relation to the instrumentation defined in Section B.

- Identify movements observed by the relevant instruments;
- Relate these movements to construction activities, where applicable.
- Identify trigger breaches that may have occurred.
- Demonstrate that the rate of change of the data is either in line with the required rate or such that residual risks are minimal.
- Identify any such residual risks should there be considered to be any.

Based on the above points, this close out reports will provide justification for the decommissioning of the instruments.

B. INSTRUMENTS

B.1 Description of the Instruments

This Close-Out Report relates to the prisms read by ATS05. See Table 1 below for the details of the prisms read by ATS05 and AT05.

ATS 20 CODE	LOCATION	COORDINATES	
		X (m)	Y (m)
C435-AT00005	40-42 Charterhouse Street	82239.61	36576.77

PRISM CODE	LOCATION	Easting (m)	Northing (m)	Elevation (mATD)
C435-RP00501	99-103 CHARTERHOUSE	82205.5079	36544.1485	119.0258
C435-RP00502	99-103 CHARTERHOUSE	82205.6716	36544.3734	130.2439
C435-RP00503	99-103 CHARTERHOUSE	82211.2550	36552.7309	118.7781
C435-RP00504	99-103 CHARTERHOUSE	82211.3420	36552.8285	130.21
C435-RP00505	99-103 CHARTERHOUSE	82216.9322	36561.1833	120.7571
C435-RP00506	99-103 CHARTERHOUSE	82217.2787	36561.6471	129.5262
C435-RP00507	105 CHARTERHOUSE STREET	82217.3861	36561.8622	121.2974
C435-RP00508	105 CHARTERHOUSE STREET	82217.5022	36561.9480	129.5473
C435-RP00509	105 CHARTERHOUSE STREET	82220.4521	36566.5687	121.1786
C435-RP00510	105 CHARTERHOUSE STREET	82220.2456	36566.2290	129.6174
C435-RP00511	107 CHARTERHOUSE STREET	82220.9139	36567.3109	120.2243
C435-RP00512	107 CHARTERHOUSE STREET	82220.9003	36567.2349	131.3571
C435-RP00513	107 CHARTERHOUSE STREET	82223.9398	36572.5247	119.9602
C435-RP00514	107 CHARTERHOUSE STREET	82223.9043	36572.4170	131.5797
C435-RP00515	109-113 CHARTERHOUSE STREET	82224.6302	36573.5885	121.8345
C435-RP00516	109-113 CHARTERHOUSE STREET	82224.7502	36573.7807	128.0675
C435-RP00517	109-113 CHARTERHOUSE STREET	82228.2461	36579.5026	121.8779
C435-RP00518	109-113 CHARTERHOUSE STREET	82228.2374	36579.4606	129.7915
C435-RP00519	115 CHARTERHOUSE STREET	82231.0939	36584.1959	122.0074

PRISM CODE	LOCATION	Easting (m)	Northing (m)	Elevation (mATD)
C435-RP00520	115 CHARTERHOUSE STREET	82231.1131	36584.2297	127.6584
C435-RP00523	115 CHARTERHOUSE STREET	82234.1773	36589.2352	121.8149
C435-RP00524	115 CHARTERHOUSE STREET	82234.1482	36589.3759	129.1884
C435-RP00525	99-103 CHARTERHOUSE STREET	82206.102	36566.148	136.5282
C435-RP00526	99-103 CHARTERHOUSE STREET	82209.056	36563.878	136.5505
C435-RP00527	99-103 CHARTERHOUSE STREET	82211.929	36561.89	136.5362
C435-RP00528	107 CHARTERHOUSE STREET	82215.946	36570.77	133.3813
C435-RP00529	105 CHARTERHOUSE STREET	82219.2	36568.199	132.4018
C435-RP00530	107 CHARTERHOUSE STREET	82220.581	36575.309	133.3736
C435-RP00531	109-113 CHARTERHOUSE STREET	82222.523	36573.865	132.1596
C435-RP00532	38 CHARTERHOUSE STREET	82235.718	36571.09	130.305
C435-RP00533	38 CHARTERHOUSE STREET	82231.844	36565.067	130.3039
C435-RP00534	38 CHARTERHOUSE STREET	82226.975	36557.202	130.3095

Table 1: Details of the prisms read by ATS05.

These prisms read by ATS 05 and the ATS 05 itself is shown in the following documents:

Drawings:

- C435-BFK-C2-DWG-M123-50045. 3D Targets installed for Farringdon Station.

Installation Reports:

- C435-BFK-C2-RGN-M123-50010 Installation Report: Automated Total Station Installation at 40 to 42 Charterhouse Street (ATS 05)
- C435-BFK-C2-RGN-M123-50057 Installation Report of 3D Targets read by ATS 05
- C435-BFK-C2-RGN-M123-50064 Installation Report of 3D Targets installed on Roof
- C430-LOS-C-RGN-M123-50018 Installation Report – Asset Protection Outside Site Boundaries – ETH

B.2 Location of the Instruments

Prisms associated with ATS05 are located on the plan below highlighted in yellow.

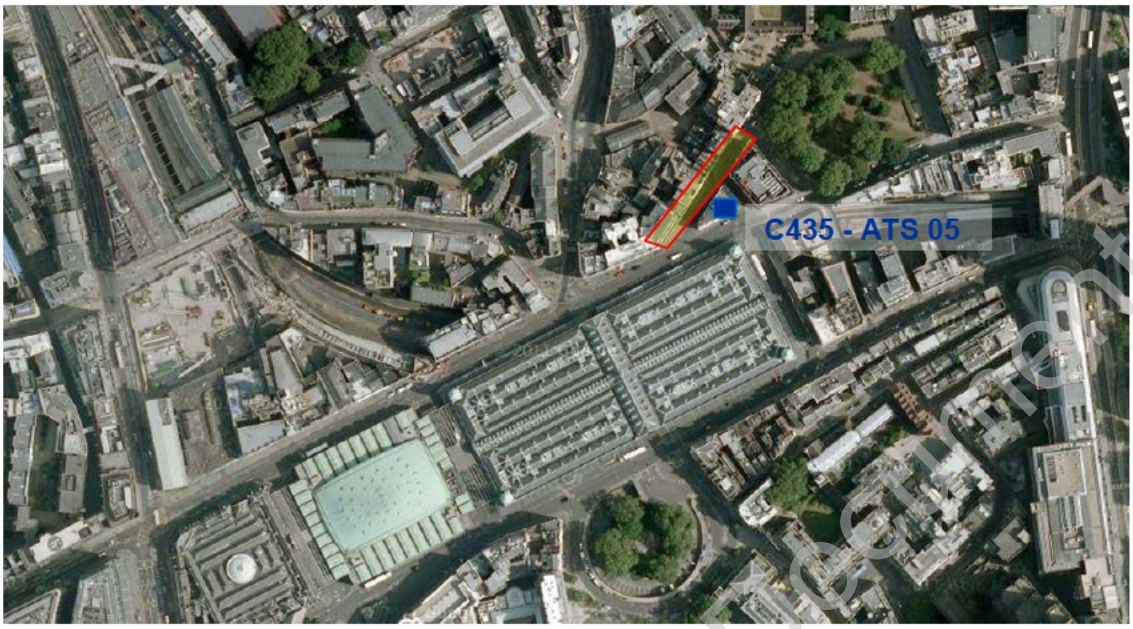


Figure 1 – Plan showing the Location of prisms read by ATS05

C. MOVEMENTS

C.1 Movements Resulting from Construction Activities

C.1.1 Relevant Crossrail (BFK) Works

The construction activities associated with these instruments are related to Crossrail tunnelling works. See below Table 2 for dates.

ACTIVITY	START DATE	END DATE
Moorgate Spur Shaft No. 2 TAM Installation	01/05/2013	16/07/2013
Moorgate Spur Shaft No. 2 Pre-Treatment works	29/07/2013	02/09/2013
WB TBM passage	30/09/2013	07/10/2013
SCL-PTW enlargement	24/07/2014	06/10/2014
EB TBM passage	16/01/2014	23/01/2014
SCL-PTE enlargement	17/08/2014	18/01/2015
SCL-RTE2	18/10/2014	11/11/2014
SCL-CP6	12/11/2104	22/11/2014
SCL-CP7	23/02/2015	26/02/2015
SCL-CH2E	15/01/2015	05/03/2015
SCL-CH2 Phase2	15/05/2015	28/05/2015
SCL-ES2	04/06/2015	21/09/2015
ETH-Excavation works	26/04/2013	29/08/2014

Table 2 –Construction activities

C.1.2 Resulting Movements

- 99-103 Charterhouse Street:

Monitoring data for these prisms is shown in Appendix B.

- WB TBM caused 3mm maximum of settlement on 30-09-2013
- Compensation grouting caused 3-4mm maximum of heave from 22-11-2013 to 08-01-2014.
- EB TBM caused 4-5mm of settlement on 16-01-2014.
- Compensation grouting caused 8mm maximum of heave from 02-07-2014 to 01-08-2014.
- Ground treatment caused 14-15mm of heave in October 2014
- PTE and CP6 construction caused 16-18mm of settlement from 17-08-2014 to 18-01-2015.
- CH2 caused 8-10mm of settlement maximum from 15-01-2015 to 28-05-2015.
- Maximum Lateral displacement was -18mm
- Maximum Transversal displacement was 18mm
- Maximum settlement at the end of the works was -28mm

- 105-107 Charterhouse Street:

Monitoring data for these prisms is shown in Appendix B.

- TAM's drilling from Moorgate Shaft 2 caused 2mm of heave from 01-05-2013 to 16-07-2013.
- Compensation grouting carried out from 03-11-2013 to 03-01-2014 caused maximum 3-4mm of heave.
- EB TBM caused 2mm of settlement on 16-01-2014.
- Compensation grouting caused 6mm of heave from 24-06-2014 to 06-08-2014.
- Ground treatment caused 10-12mm of heave in October and November 2014.
- PTE and CP6 works caused 16-18mm of settlement between 17-08-014 and 22-11-2014.
- CH2 construction works caused 8-10mm of settlement from 15-01-2015 to 28-05-2015.
- Maximum Lateral displacement was -12mm
- Maximum Transversal displacement was 12mm
- Maximum settlement at the end of the works was -20mm

- 109-113 Charterhouse Street:

Monitoring data for these prisms is shown in Appendix B.

- EB TBM caused maximum 2-3mm of settlement on 16-01-2014.
- Compensation Grouting from Moorgate Shaft 2 caused 4-5mm of heave from 01-07-2014 to 03-09-2014.
- Ground treatment caused 12-14mm of heave in October and November 2014.
- PTE and CP6 caused 14-16mm of settlement from 17-08-2014 to 22-11-2014.
- CH2 caused 2-3mm maximum of settlement from 15-01-2015 to 05-03-2015.
- Maximum Lateral displacement was 8mm
- Maximum Transversal displacement was 16mm
- Maximum settlement at the end of the works was -8mm

- 115 Charterhouse Street:

Monitoring data for these prisms is shown in Appendix B.

- EB TBM caused 2-3mm maximum of settlement on 16-01-2014.
- Compensation grouting caused 3-4mm of heave from 24-06-2014 to 29-08-2014.
- Ground treatment caused 9mm maximum of heave in October and November 2014.
- PTE and CP6 works caused 8-10mm of settlement from 17-08-2014 to 22-11-2014.
- CH2 caused maximum 2-3mm of settlement from 15-05-2015 to 28-05-2015.
- Maximum Lateral displacement was 8mm
- Maximum Transversal displacement was 12mm
- Maximum settlement at the end of the works was -10mm

- 38 Charterhouse St.

Monitoring data for these prisms is shown in Appendix B. These prisms were installed by C430 to be read manually. C435 change the orientation for these prisms to be read automatically on 19-12-2014. For this reason the history of the movements for theses prisms start on 19-12-204.

- PTE enlargement works caused maximum 4mm from 20-12-2014 to 13-01-2015.
- Compensation grouting from Moorgate Shaft 2 caused maximum 8mm of heave between 10-01-2015 and 16-01-2015.
- CP7 construction caused 2-3mm of settlement from 23-02-2015 to 27-02-2015.
- CH2 works caused maximum 4-5mm of settlement from 05-03-2015 to 28-05-2015.
- Maximum Lateral displacement was 10mm
- Maximum Transversal displacement was 16mm
- Maximum settlement at the end of the works was -26m

C.2 Trigger Breaches

The Instrumentation and Monitoring Plan: Farringdon Station Ground Movement and Asset Protection C122-OVE-C2-RGN-M123-50013 outlines the triggers associated with the devices.

In this case, buildings are in Moorgate Spur Shafts No.2. ZoI, so the trigger values associated to this building are:

- DEFAULT ALERT (in any direction): 10mm

No triggers breached. The Table 3 below shows the 10mm default alerts breached:

MONITORING GROUP (Location)	POINT ID	TYPE	DIRECTION	DATE OF LAST READING	LAST READING VALUE (mm)	TRIGGER LEVEL	
						WORST HISTORICAL STATUS	CURRENT STATUS
99-103 CHARTERHOUSE	C435-RP00501	AUTOMATIC RP	Settlement	07/03/2016 08:00	-28.6	Default Alert	Default Alert
	C435-RP00502	AUTOMATIC RP	Settlement	07/03/2016 08:00	-29.2	Default Alert	Default Alert
	C435-RP00503	AUTOMATIC RP	Settlement	07/03/2016 10:00	-25.2	Default Alert	Default Alert
	C435-RP00504	AUTOMATIC RP	Settlement	07/03/2016 08:00	-27.6	Default Alert	Default Alert
	C435-RP00505	AUTOMATIC RP	Settlement	07/03/2016 08:00	-20.1	Default Alert	Default Alert
	C435-RP00506	AUTOMATIC RP	Settlement	07/03/2016 08:00	-17.6	Default Alert	Default Alert
105 CHARTERHOUSE STREET	C435-RP00507	AUTOMATIC RP	Settlement	07/03/2016 08:00	-19.2	Default Alert	Default Alert
	C435-RP00508	AUTOMATIC RP	Settlement	07/03/2016 08:00	-20.6	Default Alert	Default Alert
	C435-RP00509	AUTOMATIC RP	Settlement	07/03/2016 08:00	-12.8	Default Alert	Default Alert
	C435-RP00510	AUTOMATIC RP	Settlement	07/03/2016 08:00	-15.2	Default Alert	Default Alert
107 CHARTERHOUSE STREET	C435-RP00511	AUTOMATIC RP	Settlement	07/03/2016 08:00	-13	Default Alert	Default Alert
	C435-RP00512	AUTOMATIC RP	Settlement	07/03/2016 08:00	-14	Default Alert	Default Alert
	C435-RP00513	AUTOMATIC RP	Settlement	07/03/2016 08:00	-9.2	Default Alert	Clear
	C435-RP00514	AUTOMATIC RP	Settlement	07/03/2016 08:00	-12	Default Alert	Default Alert
109-113 CHARTERHOUSE STREET	C435-RP00515	AUTOMATIC RP	Settlement	07/03/2016 08:00	-10	Default Alert	Default Alert
	C435-RP00516	AUTOMATIC RP	Settlement	07/03/2016 08:00	-10.5	Default Alert	Default Alert
	C435-RP00517	AUTOMATIC RP	Settlement	07/03/2016 10:00	-7.9	Default Alert	Clear
	C435-RP00518	AUTOMATIC RP	Settlement	07/03/2016 10:00	-9.3	Default Alert	Clear
115 CHARTERHOUSE STREET	C435-RP00519	AUTOMATIC RP	Settlement	07/03/2016 10:00	-7.6	Clear	Clear
	C435-RP00520	AUTOMATIC RP	Settlement	07/03/2016 10:00	-7.1	Clear	Clear
	C435-RP00523	AUTOMATIC RP	Settlement	07/03/2016 10:00	-5.2	Clear	Clear
	C435-RP00524	AUTOMATIC RP	Settlement	07/03/2016 10:00	-5.6	Clear	Clear
99 CHARTERHOUSE STREET	C435-RP00525	AUTOMATIC RP	Settlement	07/03/2016 10:00	-21.4	Default Alert	Default Alert
	C435-RP00526	AUTOMATIC RP	Settlement	07/03/2016 10:00	-22.7	Default Alert	Default Alert
	C435-RP00527	AUTOMATIC RP	Settlement	07/03/2016 10:00	-23.9	Default Alert	Default Alert
105 CHARTERHOUSE STREET	C435-RP00528	AUTOMATIC RP	Settlement	07/03/2016 10:00	-11.5	Default Alert	Default Alert
	C435-RP00529	AUTOMATIC RP	Settlement	07/03/2016 10:00	-12.2	Default Alert	Default Alert
107 CHARTERHOUSE STREET	C435-RP00530	AUTOMATIC RP	Settlement	07/03/2016 10:00	-8.2	Default Alert	Clear
	C435-RP00531	AUTOMATIC RP	Settlement	07/03/2016 10:00	-7.2	Default Alert	Clear
38 CHARTERHOUSE STREET	C435-RP00532	AUTOMATIC RP	Settlement	07/03/2016 10:00	-13.7	Default Alert	Default Alert
	C435-RP00533	AUTOMATIC RP	Settlement	07/03/2016 10:00	-12.6	Default Alert	Default Alert
	C435-RP00534	AUTOMATIC RP	Settlement	07/03/2016 10:00	-18.2	Default Alert	Default Alert

Table 3 – Triggers breached by the prisms read by ATS05.

C.3 Significant issues with the Instrumentation

Prisms C435-RP00532, C435-RP00533 and C435-RP00534 where installed on the 38 Charterhouse Street facade by C430 and read manually with the codes C430-RP24021, C430-RP24022 and C430-RP24023 before they were faced to ATS05 and start to be read automatically from 19/12/2014.

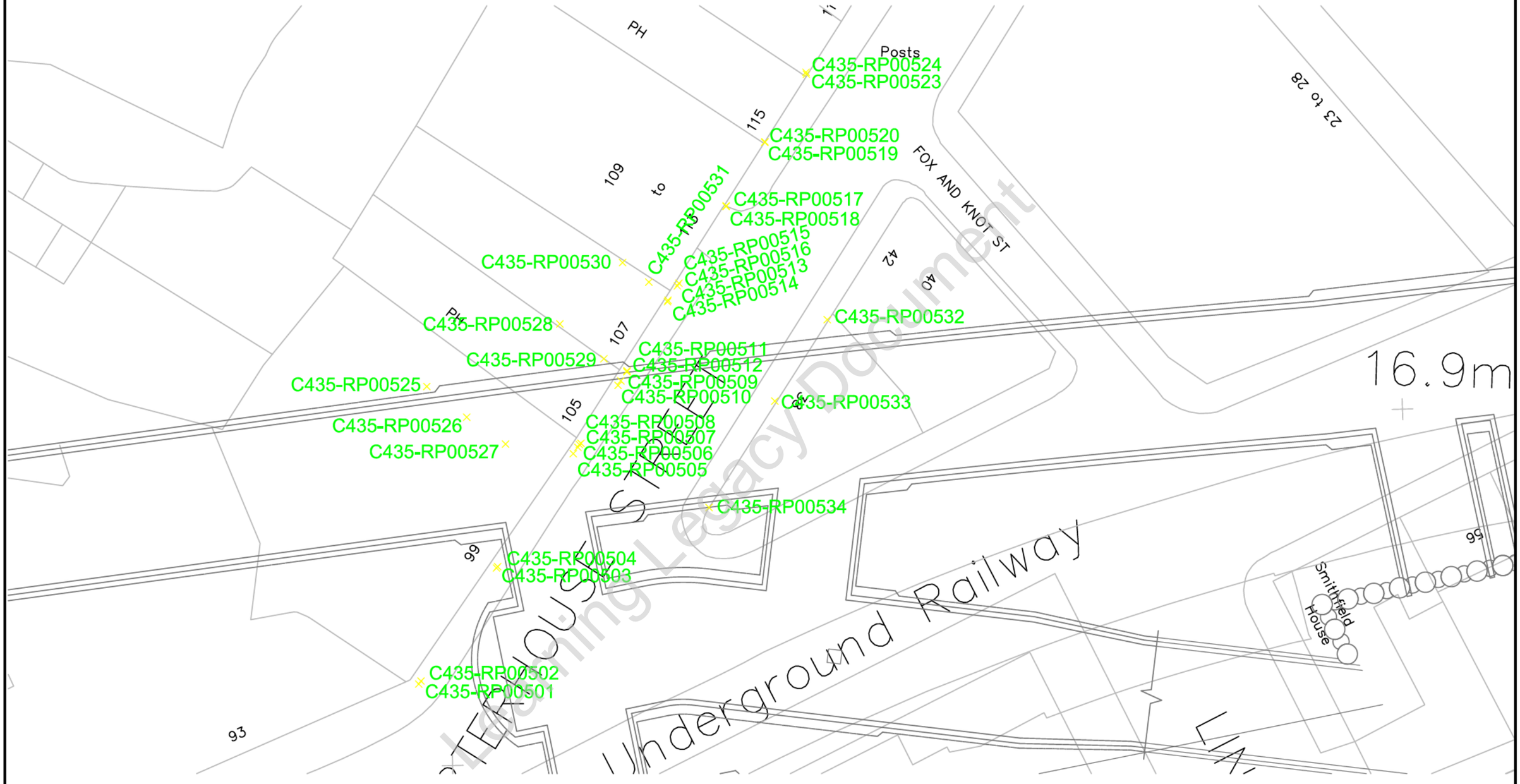
C.4 Residual Risks

As per C435-PMI-00549 the Long Term Monitoring has been ceased by Contract C435 in this area. The last measurement carried out by C435 for these instruments was undertaken on 07-03-2016. Long term monitoring will be continued by Crossrail to review long term stability.

D. CONCLUSIONS

No triggers breached, monitoring stable. No residual risks remain. Long term monitoring to be completed by Crossrail.

APPENDIX A: DRAWINGS



Rev.	Date	Descrlptlon	By	Chkd	App	Auth

Notes:

Crossrail

BFK Bam | Ferrovial | Kier

GEOCISA

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Contract : BORED TUNNELS (ALIGMENT AND TRACK)

Orlglnator : OVE ARUP & PARTNERS LIMITED

Location : CROSSRAIL GENERAL

Title :

By : [redacted]

Chk

App

Scale : @ A3

Drg No : C435-BFK-C2-DWG-M123-50045-PRISMS

Rev :

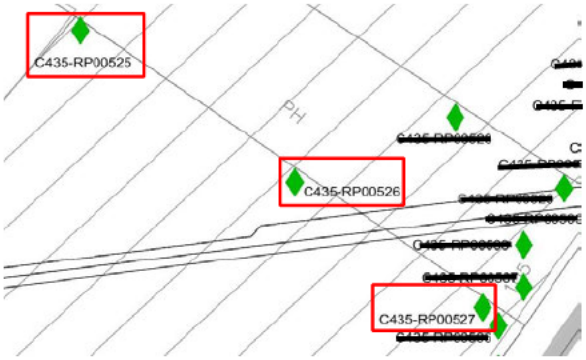
Sult :

Auth : GEOCISA

Pby

APPENDIX B: GRAPHS

REPORT	Automatic Prisms
AREA	Farringdon Station
DEVICE	3D Target



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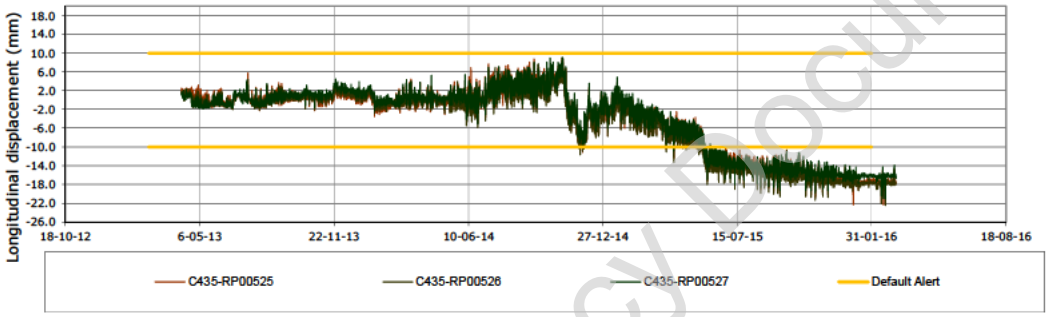

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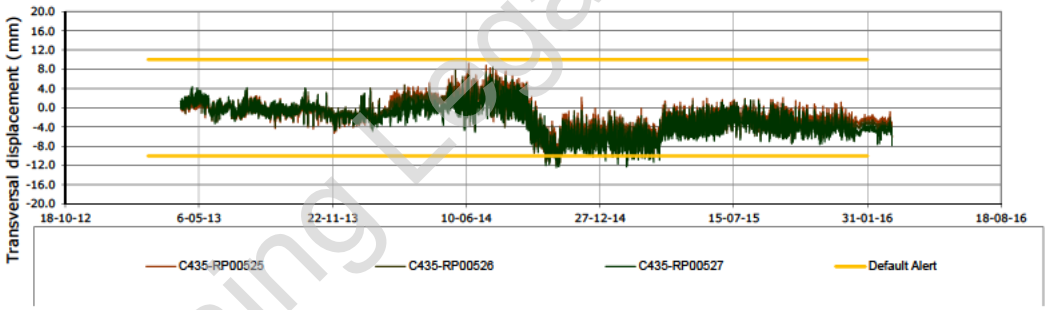

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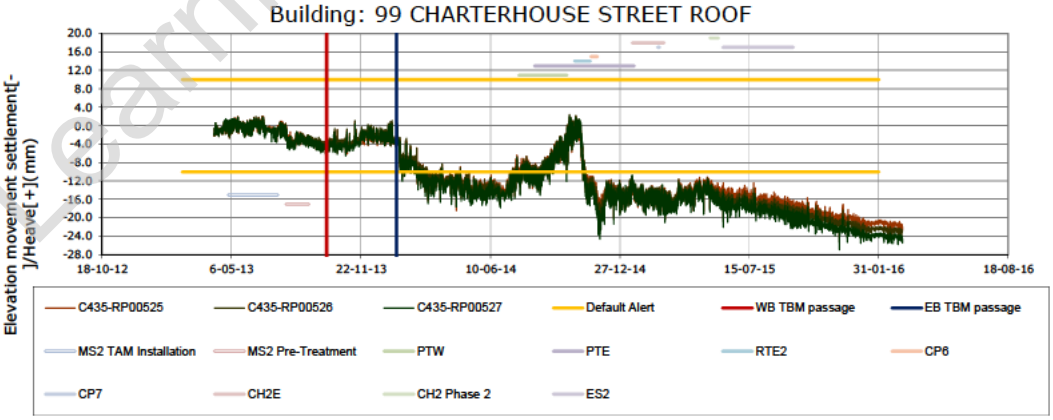
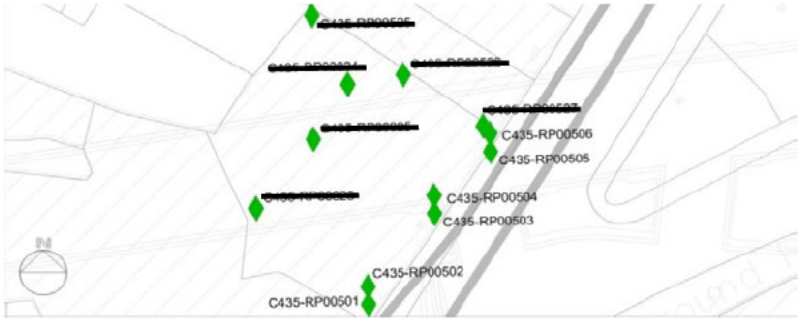
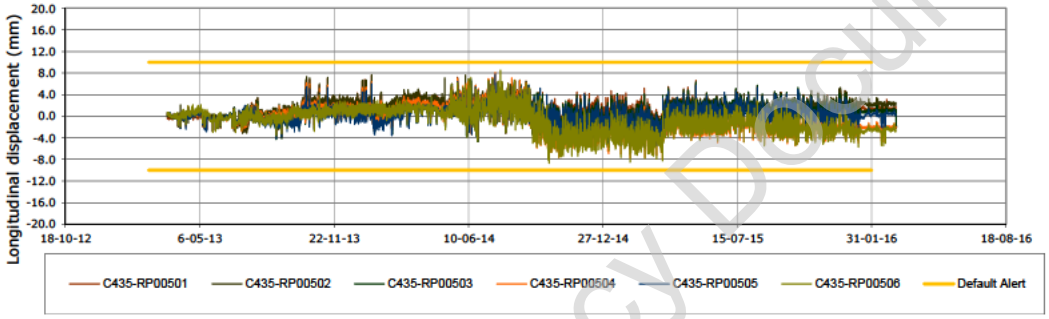


REMARKS

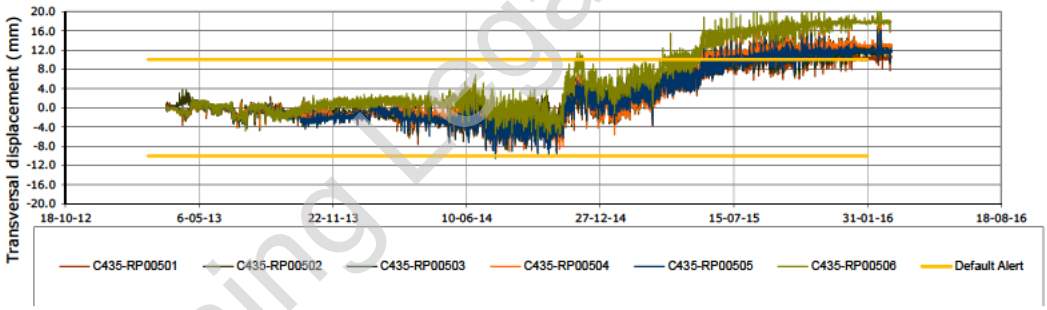
REPORT	Automatic Prisms
AREA	Farringdon Station
DEVICE	3D Target



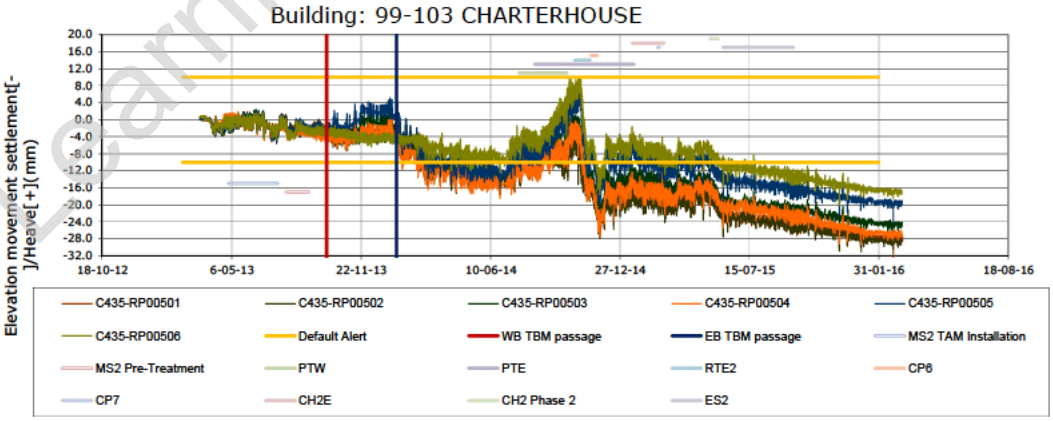
Building: 99-103 CHARTERHOUSE



Building: 99-103 CHARTERHOUSE

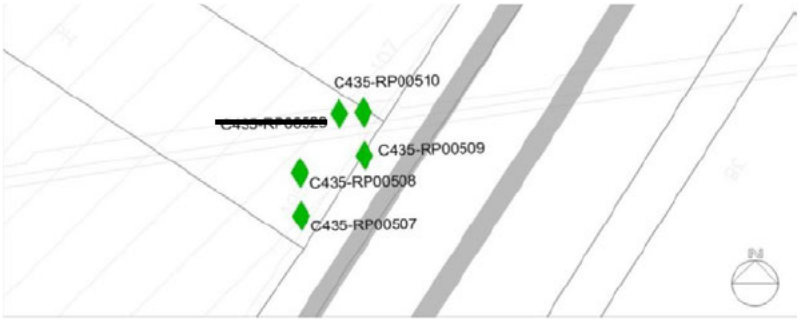


Building: 99-103 CHARTERHOUSE



REMARKS

REPORT	Automatic Prisms
AREA	Farringdon Station
DEVICE	3D Target



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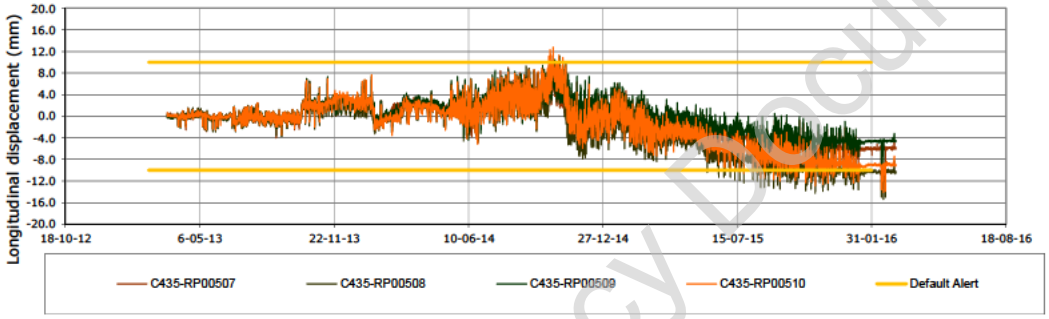
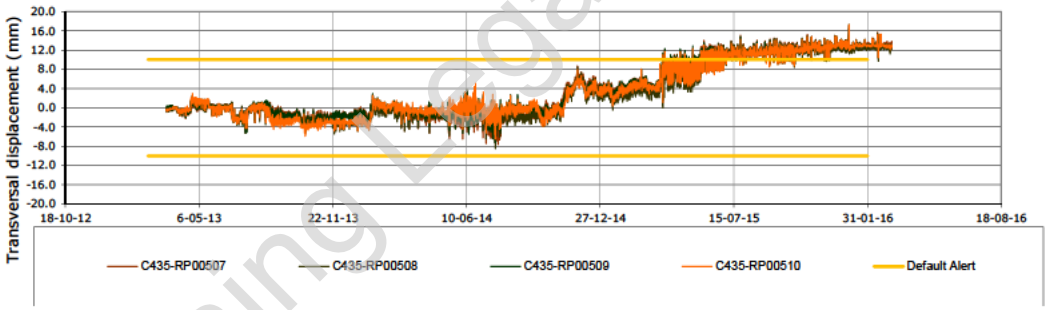
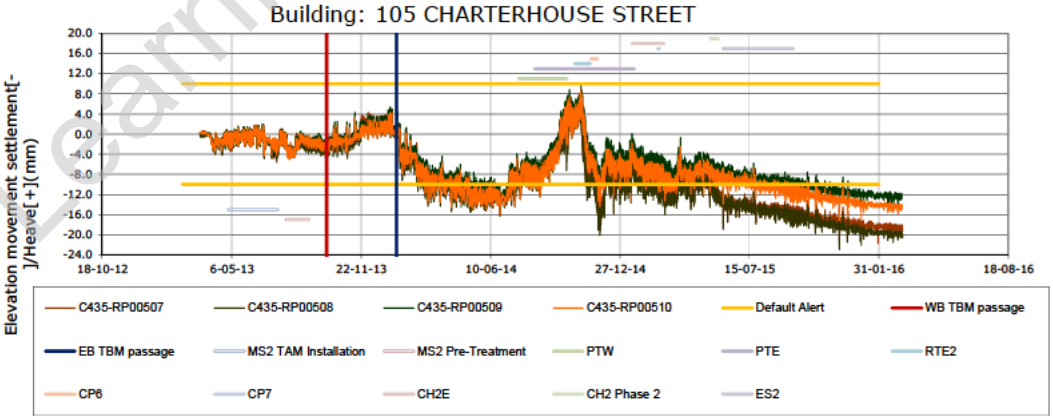


Building: 105 CHARTERHOUSE STREET

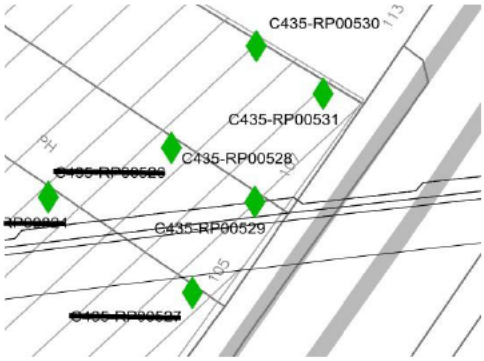


Building: 105 CHARTERHOUSE STREET

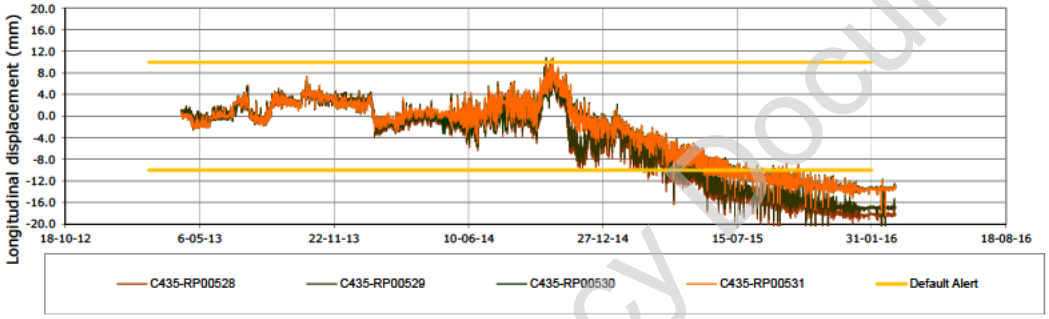


REMARKS

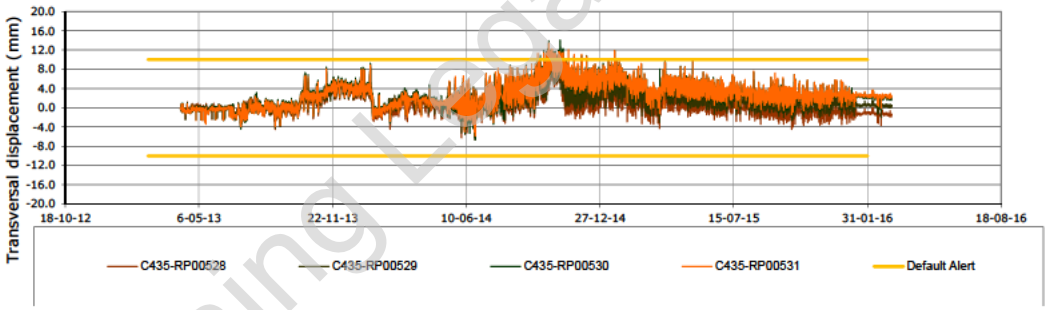
REPORT	Automatic Prisms
AREA	Farringdon Station
DEVICE	3D Target



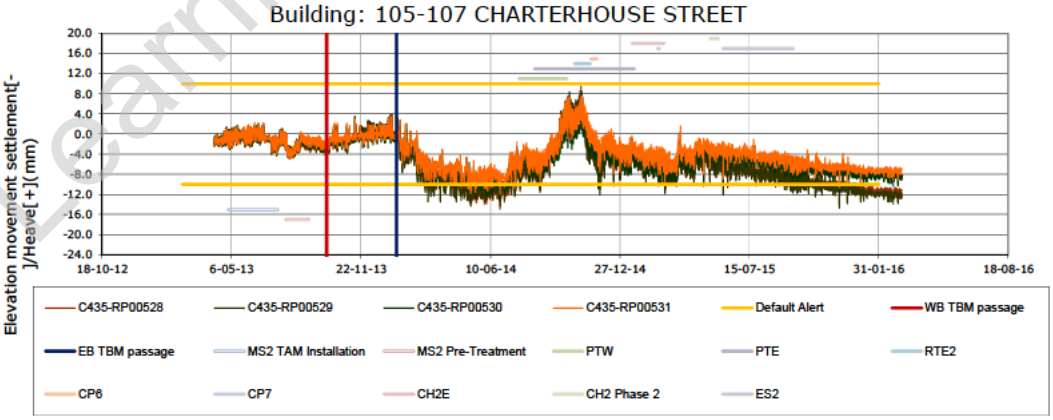
Building: 105-107 CHARTERHOUSE STREET



Building: 105-107 CHARTERHOUSE STREET

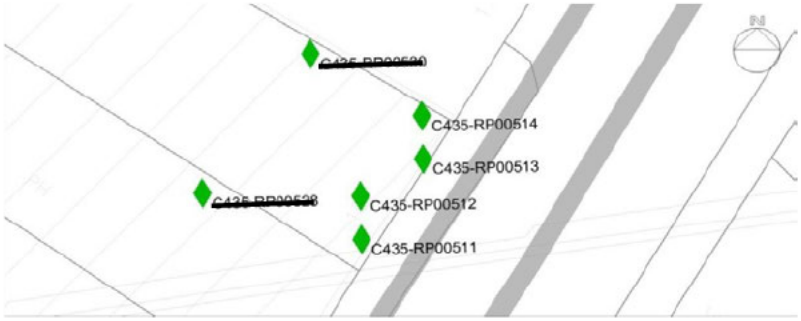


Building: 105-107 CHARTERHOUSE STREET

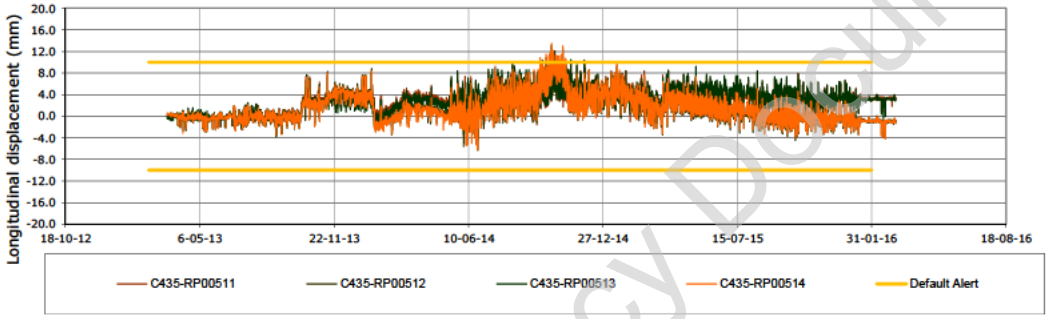


REMARKS

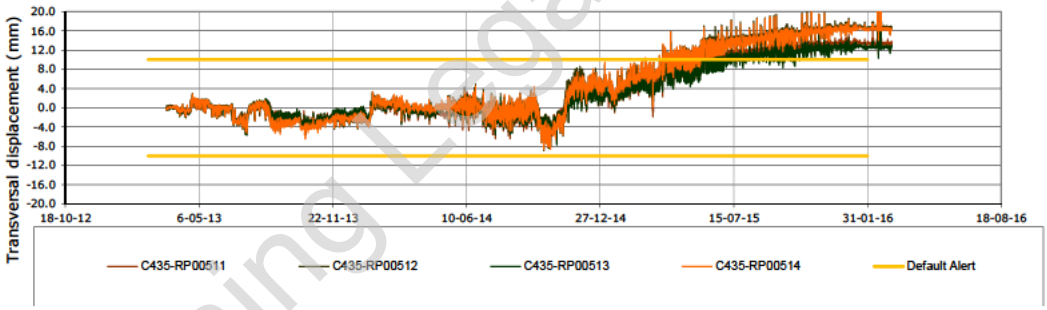
REPORT	Automatic Prisms
AREA	Farringdon Station
DEVICE	3D Target



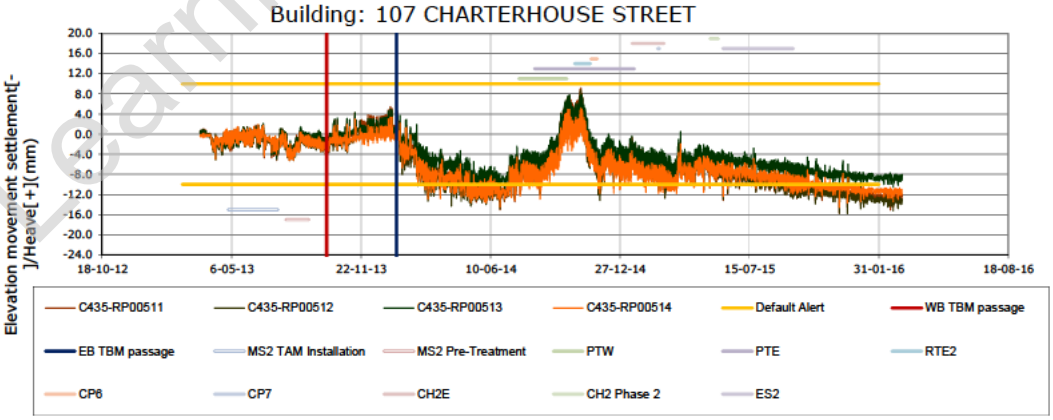
Building: 107 CHARTERHOUSE STREET



Building: 107 CHARTERHOUSE STREET

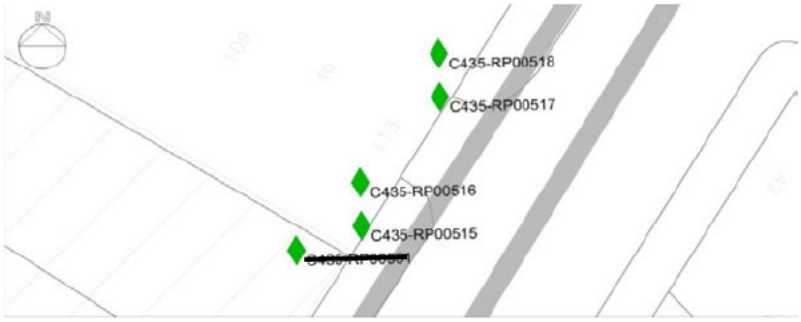


Building: 107 CHARTERHOUSE STREET

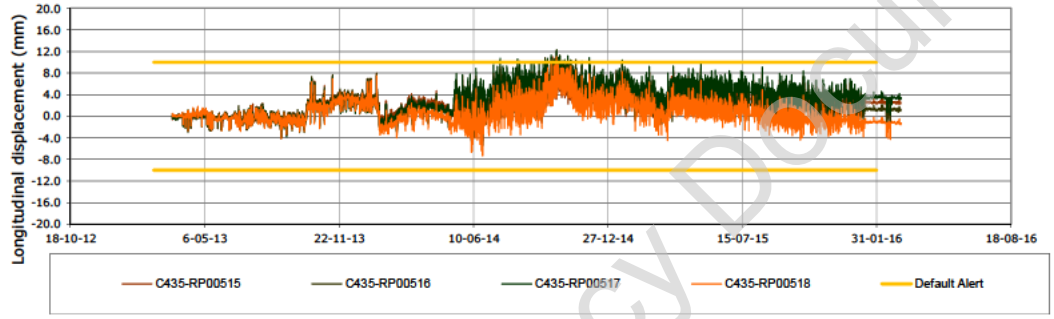


REMARKS

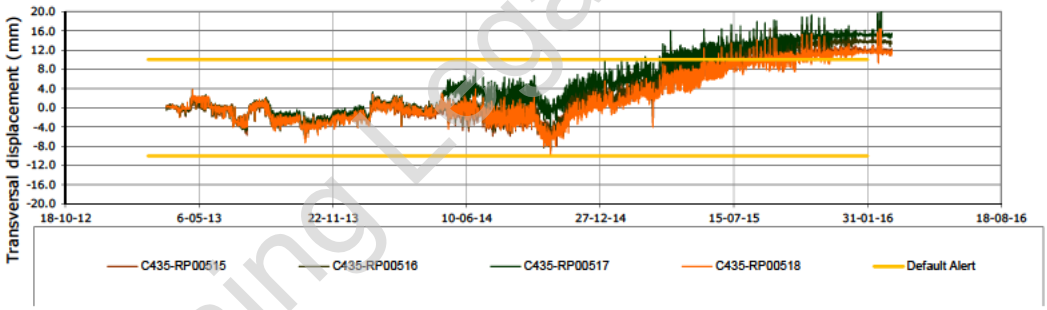
REPORT	Automatic Prisms
AREA	Farringdon Station
DEVICE	3D Target



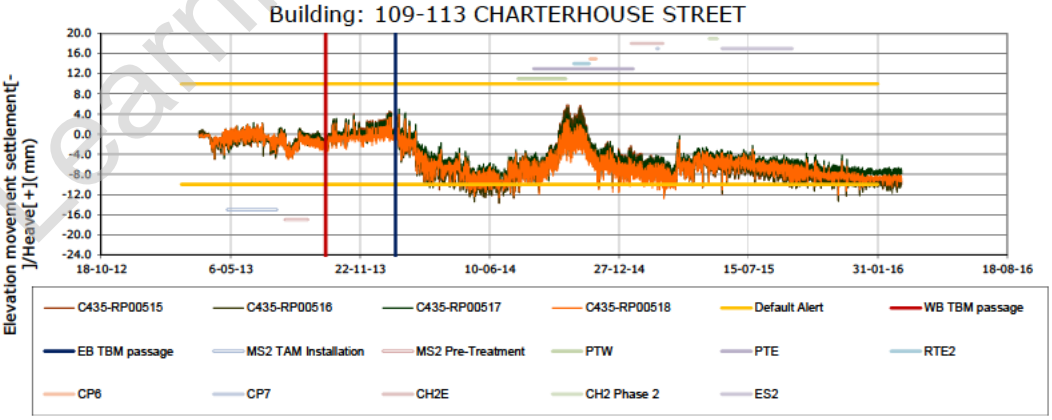
Building: 109-113 CHARTERHOUSE STREET



Building: 109-113 CHARTERHOUSE STREET

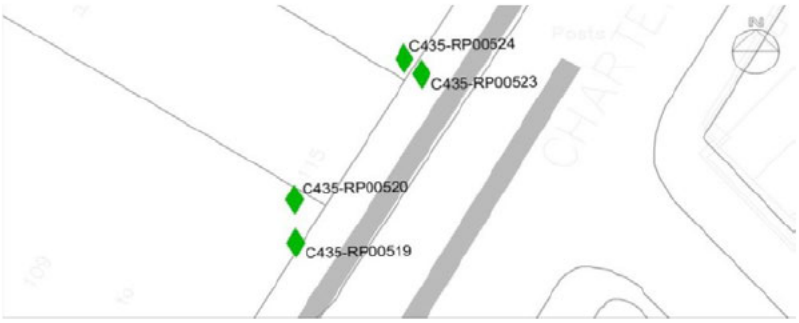


Building: 109-113 CHARTERHOUSE STREET

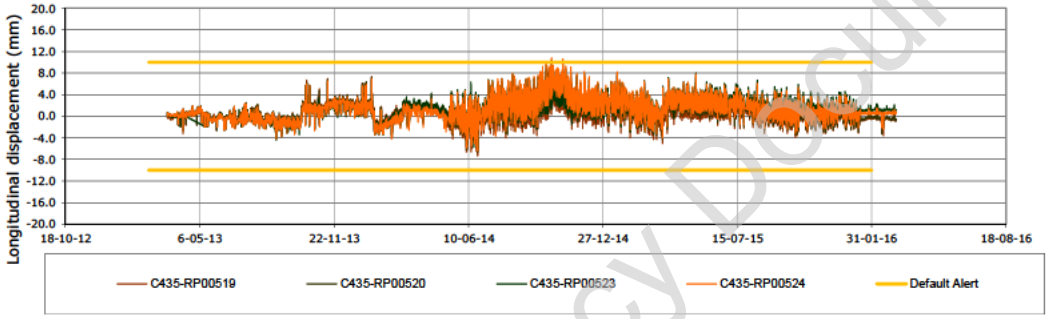


REMARKS

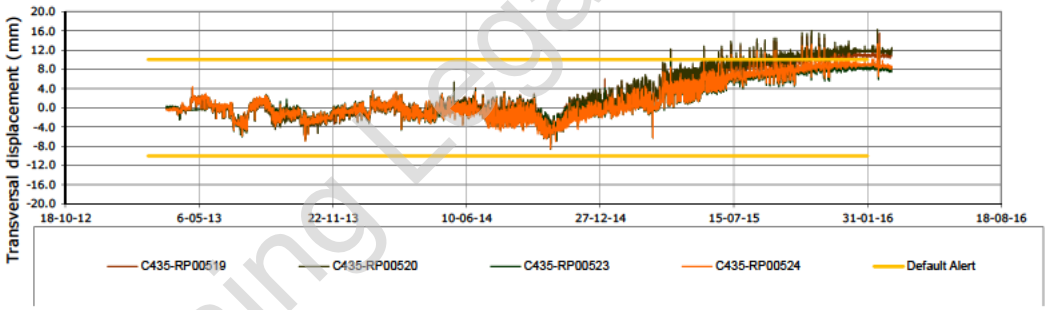
REPORT	Automatic Prisms
AREA	Farringdon Station
DEVICE	3D Target



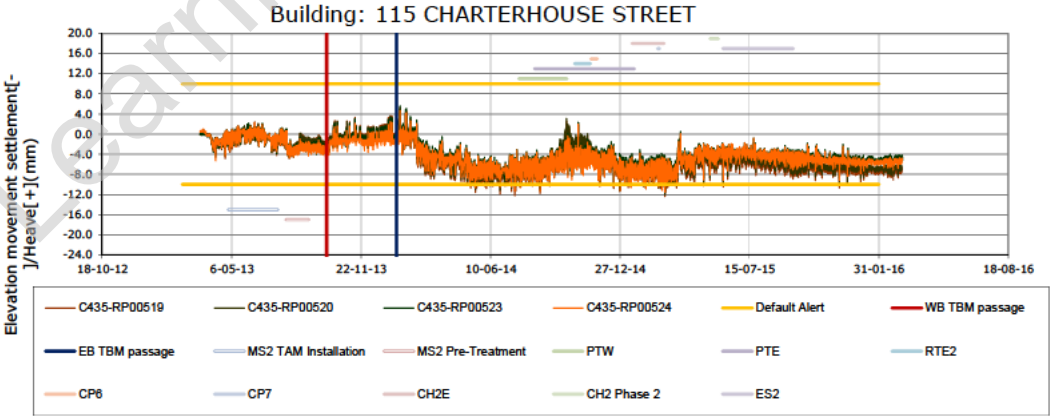
Building: 115 CHARTERHOUSE STREET



Building: 115 CHARTERHOUSE STREET

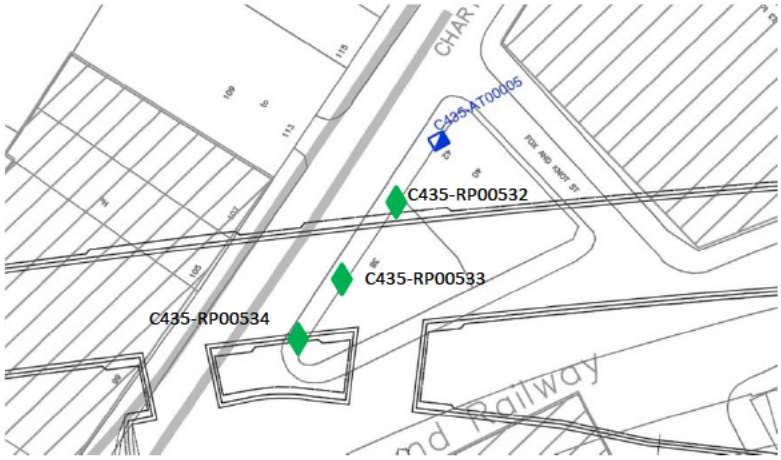


Building: 115 CHARTERHOUSE STREET

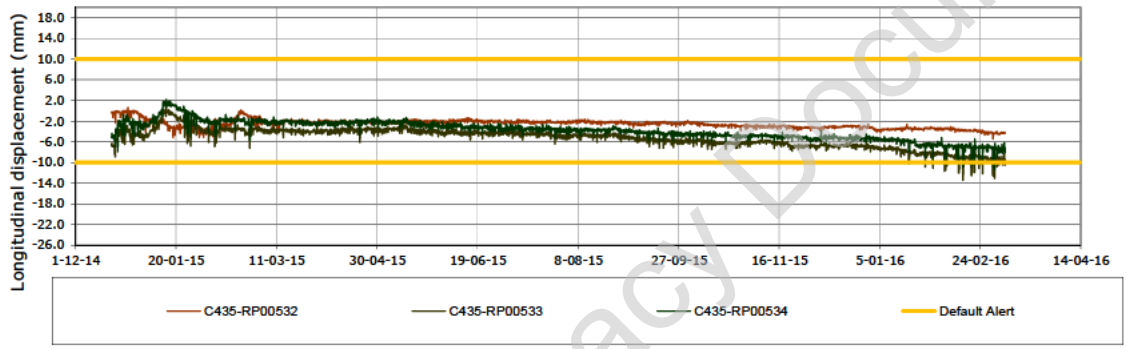


REMARKS

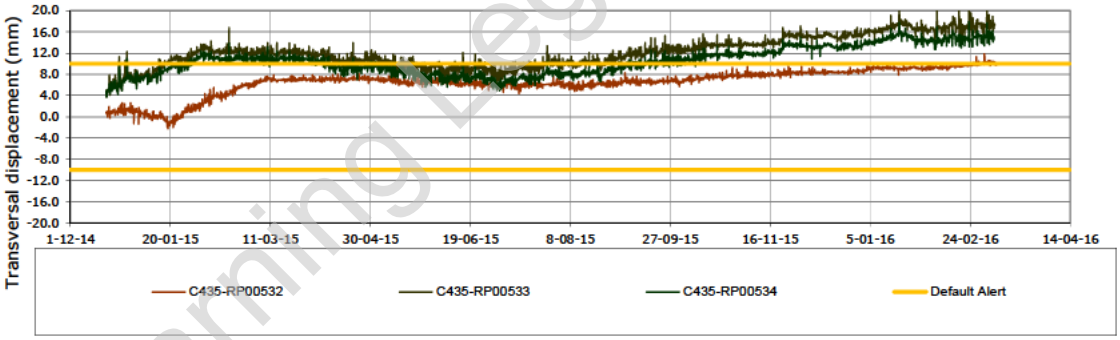
REPORT Automatic Prisms
AREA Farringdon Station
DEVICE 3D Target



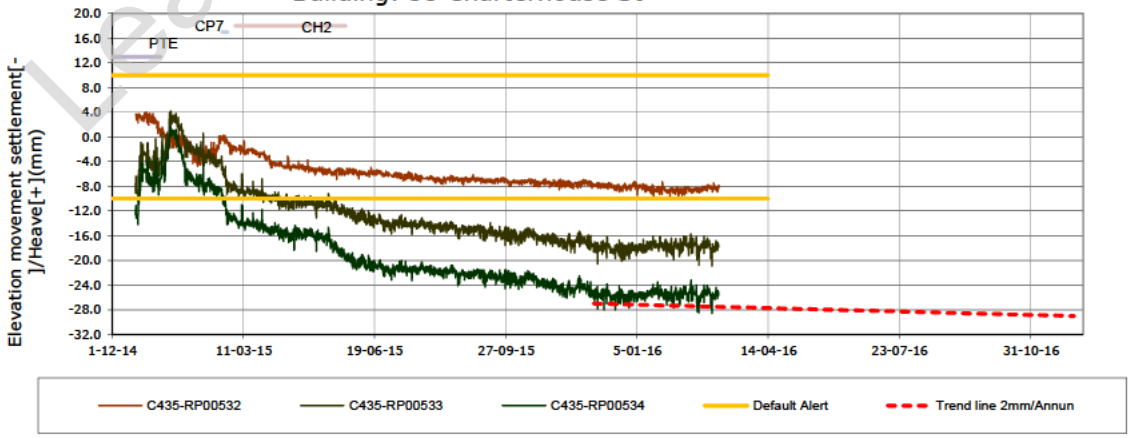
Building: 38 Charterhouse St



Building: 38 Charterhouse St



Building: 38 Charterhouse St



REMARKS

APPENDIX C: GLOSSARY

- ATS — Automatic Total Station.
- ETH — Eastern Ticket Hall.
- WB — Westbound.
- TBM — Tunnel Boring Machine.
- EB — Eastbound.
- PTW — Platform Tunnel West
- PTE — Platform Tunnel East
- CP — Cross passages.
- CH — Concourse Hall.
- VA — Ventilation Adit
- STE — Stub Tunnel East.
- STW — Stub Tunnel West.
- RTE — Running Tunnel East.
- ES — Escalator Shaft.
- CHS — Charterhouse Street.
- ZoI — Zone of Influence.
- TaM — Tube a Manchette.