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

C435
Farringdon Main Station

CRL Lead reviewer: [redacted]
CRL Reviewer: [redacted]

Monitoring Close-Out Report:
Section C and H

CRL Document Number: C435-BFK-C2-RGN-M123-51626

Supplier Document Number: N/A

Contract MDL reference C14.022

1. Contractor Document Submittal History:

Revision:	Date:	Prepared by:	Checked by:	Approved by:	Reason for Issue:
1.0	16-12-2015	[redacted]			For acceptance
2.0	22-02-2016				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
					☐
					☐
					☐

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

3. Acceptance by *Crossrail*:

[redacted]eer
09/03/2016

CRL RESTRICTED

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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 2.

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 the monitoring devices installed on Section C. See table 1 bellow with the details for the devices.

Sensor	Location	Northing	Estaing	Elevation
C435-IM00003	The Partners	82067.973	36528.732	114.786
C435-XR11000	The Partners	82072.81	36529.733	114.39
C435-IM00004	Greenhill's Rent	82089.645	36514.864	114.8003
C435-XR14000	Greenhill's Rent	82089.626	36512.831	114.345
C435-XR12000	Greenhill's Rent	82096.719	36535.095	114.3437

Table 1: Details of the devices installed on Section C and H

The monitoring devices installed on The Partners are shown in the following documents:

Drawings:

- C122-OVE-C2-DDA-CR001_Z-31531

Installation Reports:

- C435-BFK-C-RGN-M123-50042
- C435-BFK-C-RGN-M123-50049
- C435-BFK-C-RGN-M123-50934
- C435-BFK-C-RGN-M123-50989
- C435-BFK-C-RGN-M123-50981

B.2 Location of the Instruments

The in ground devices are installed on the car park are for The Partners

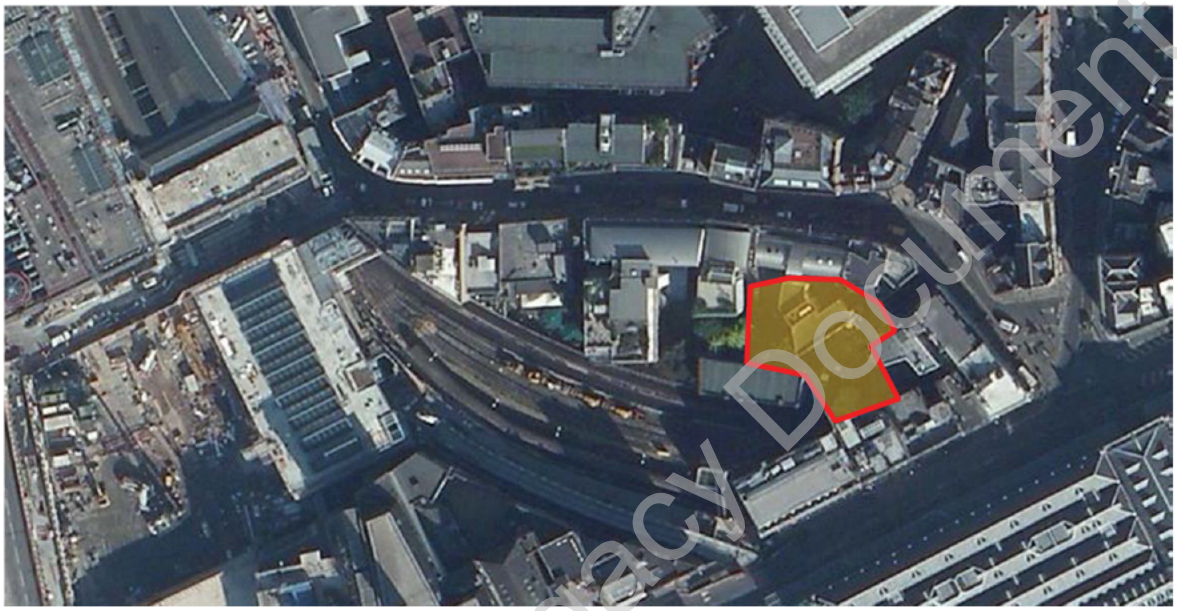


Figure 1 – Map showing the Location for the device on Section C and H

C. MOVIMENTS

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 tunneling works. In all cases, these comprise of the passage of a TBM (C300), platform tunnel enlargement and cross passengers tunnel. The devices are outside for the Compensation Grouting Area from Shaft 3

The in ground devices were affected by the following works:

Activity	Start Date	End Date
WB TBM passage	28-09-2013	30-09-2013
EB TBM passage	12-01-2014	14-01-2014
PTE enlargement	13-07-2014	20-07-2014
PTW enlargement	28-06-2014	22-07-2014

C.1.2 Resulting Movements

- **Extensometer XR11000.**

The monitoring data for the extensometer at street level located at 12m from the axis of the EB TBM (C435-XR11000) is shown in Appendix B.

The passage of the EB TBM is shown to have caused a maximum settlement of 10mm, recorded on the extensometer rod at 34m below street level. After TBM, the extensometer shows a trend of movement, adding another 2mm. During the PTE construction works, the extensometer show a maximum settlement of 28mm more, recorded on the extensometer rod at 34m below street level. During two months after the completion for PTE, the extensometer shows a small trend of movements.

After these works, maximum settlement captured on this extensometer was 42mm record at 34m below street level.

- **Inclinometer IM00003.**

The monitoring data for the manual inclinometer located at 12m from the axis of the EB TBM is show in Appendix B.

As usual the movements captured during TBM passage are minimums. This is caused because the TBM cross the area very quickly, and tunnel section is done at the same time. In this case the maximum horizontal movement captured by the inclinometer is around 2-3mm into the tunnel at the bottom level of the tunnel in A+ direction. In B+ direction the inclinometer didn't show significant movements.

During the PTE construction, the inclinometer showed the maximum movements. The inclinometer was inside the influence area for the construction around one month, capturing the movement as soon as the inclinometer was inside the PTE influence area. During this period, the maximum movement showed by the inclinometer on A+ direction was 8-9mm into the tunnel at the axis level for PTE. The movement on B- direction looks like a kink, but the trend for the movement is slowly and the direction of the movement is the correct because the inclinometer was moving to the tunnel. So, for this reason, the movement on B- is real, in this case, the maximum on this direction was 6-7mm.

Once the inclinometer was outside the influence area for PTE, the movements captured showed stable conditions. Also, in the last readings the trend of the movements showing how the inclinometer moves to the original position, in both directions.

At the end, the maximum movement captured by this inclinometer was caused by the PTE construction was 7-8mm at the tunnel axis level.

- **Inclinometer IM00004.**

The monitoring data for the manual inclinometer installed at 11m from the axis of the WB TBM is show in Appendix B.

The first graph for this inclinometer is showing the movements before and after the TBM. As is usual, the inclinometers didn't capture significant movements caused by the TBM. The reason for this is the construction method. The maximum movement is 2-3mm.

During the PTW construction works is when the inclinometer captured the maximum movements. In this case the maximum horizontal movement was 10mm on A+ into the tunnel. As is usual, the inclinometer showed the maximum movements on the tunnel axis level. As the graphs show, the two readings that show the maximum movements match with the dates when the PTW cross the location for the inclinometer. After PTW cross the inclinometer, the readings show stables.

Once the inclinometer was outside the influence area for PTW, the horizontal movements showed stable conditions.

- **Extensometer XR14000.**

The result for the monitoring data for the extensometer XR14000 is shows in Appendix B.

The extensometer was installed at street level at 9m from the axis of the WB axis tunnel. This extensometer was affected by WB TBM, PTW enlargement and some grouting episode from Shaft 3. Before the extensometer was inside for the influence area for WB TBM, some grouting episode was carried out from shaft 3. This grouting caused 2-3mm maximum heave. During the TBM passage, the deeper anchor (34m below street level) for he extensometer captured 4mm maximum of settlement. Significant residual settlement was captured by the extensometer after the TBM, adding 10mm more.

Before the extensometer was affected by PTW works, some grouting episodes were carried out, caused 4-5mm heave in the anchors above the TAM's level. When the extensometer was affected by the PTW, the maximum settlement was -32mm at 34m below the street level. After the PTW some residual settlement was captured, adding 4-5mm more, until April 2015. From this date, the extensometer is showing stable conditions.

In total, the maximum settlement captured by his extensometer was -38mm at 34m below street level.

- **Extensometer XR12000.**

The monitoring data for the extensometer XR12000 is show in Appendix B.

The extensometer XR12000 was installed at the street level at 10m from the EB TBM axis. He deeper anchor is at 34m below the street level.

The extensometer was affected mainly by EB TBM and PTE works, although the extensometer is so far for the CP4 cross passenger (25m) some movement was captured by the extensometer.

During the TBM works, he movements caused in the extensometer was 3-4mm settlement. After this work, small trend in the movements caused another 3mm more.

During the PTE is when the extensometer showed the maximum movements, around 35mm settlement, captured in the deeper anchor. After this period, the trend for he movements was small, adding only 1-2mm more.

During the CP4 and PTE connection, he extensometer was affected, showing another 8 mm more in settlement, until December 2014. From this date the extensometer shows stable conditions.

C.2 Trigger Breaches

The Instrumentation and Monitoring Plan: Farringdon Station Ground Movement and Asset Protection C122-OVE-C2-RGN-M123-50013 in section 6.1, no triggers are applicable for in-ground monitoring.

C.3 Significant Issues with the Instrumentation

No issues with these devices.

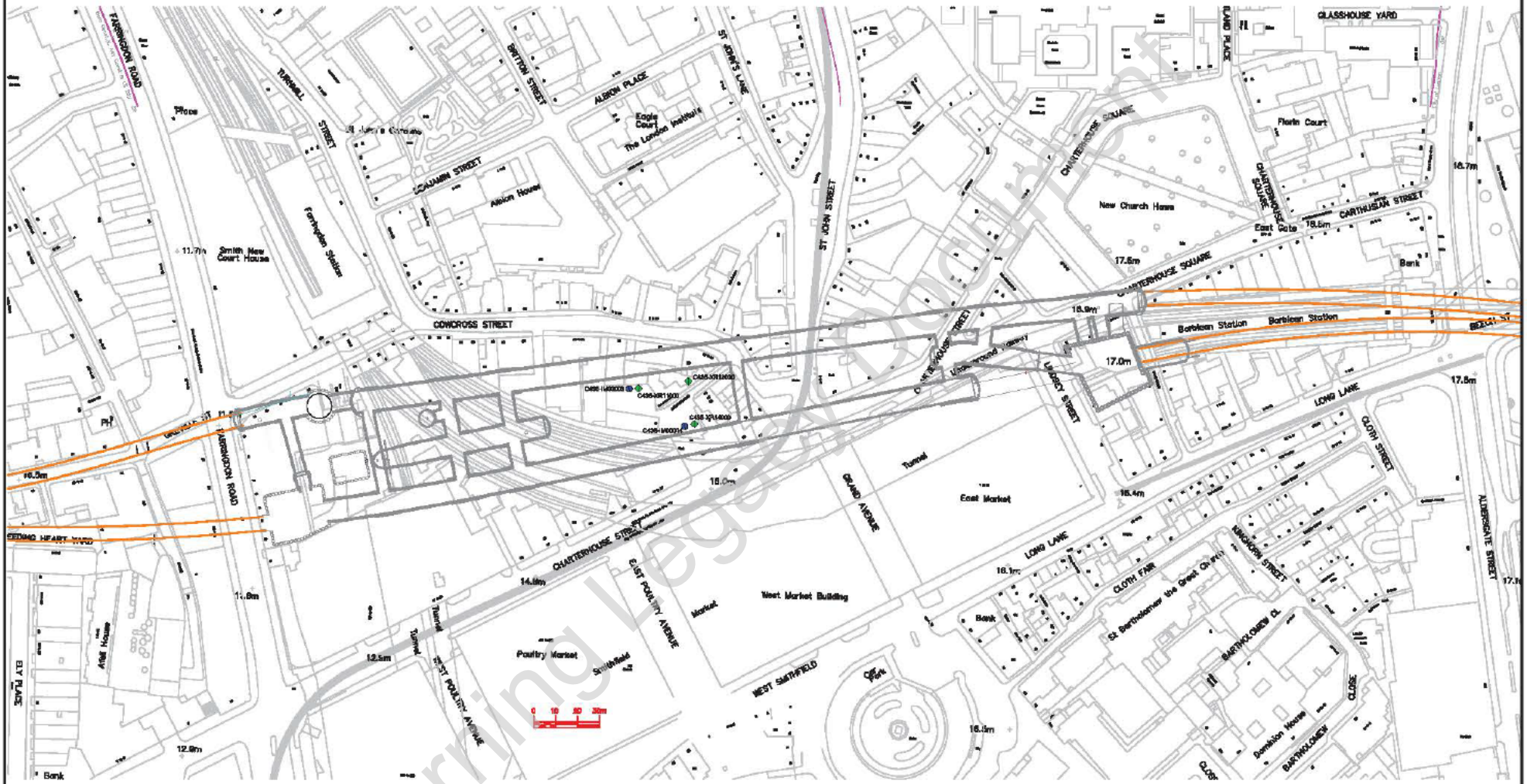
C.4 Residual Risks

The rates of residual settlement for the extensometer have been determined and in all cases these rates are less than 2mm/year. No rates for the horizontal movements are applicable.

D. CONCLUSIONS

Following the EB and WB TBM passage, of the SCL enlargement of PTE and PTW, the measured settlement on the extensometers and horizontal movements on the inclinometers show stable conditions, therefore these devices are considered stabilized.

APPENDIX A: DRAWINGS



Rev.	Date	Description	By	Chkd	App	Auth

Notes:

Crossrail

BFK Bam Ferrovial Kier

GEOCISA

C/ Los Llanos de Jerez 10-12
28823- MADRID
www.geocisa.com

Contract :	BORED TUNNELS (ALIGMENT AND TRACK)
Originator :	OVE ARUP & PARTNERS LIMITED
Location :	CROSSRAIL GENERAL
Title :	In-ground device installed on Section C and H
Scale :	@ A3
Drg No :	C435-BFK-C2-DWG-M123-50011
Rev :	
Built :	
By :	
Chk :	
App :	
Auth :	GEOCISA

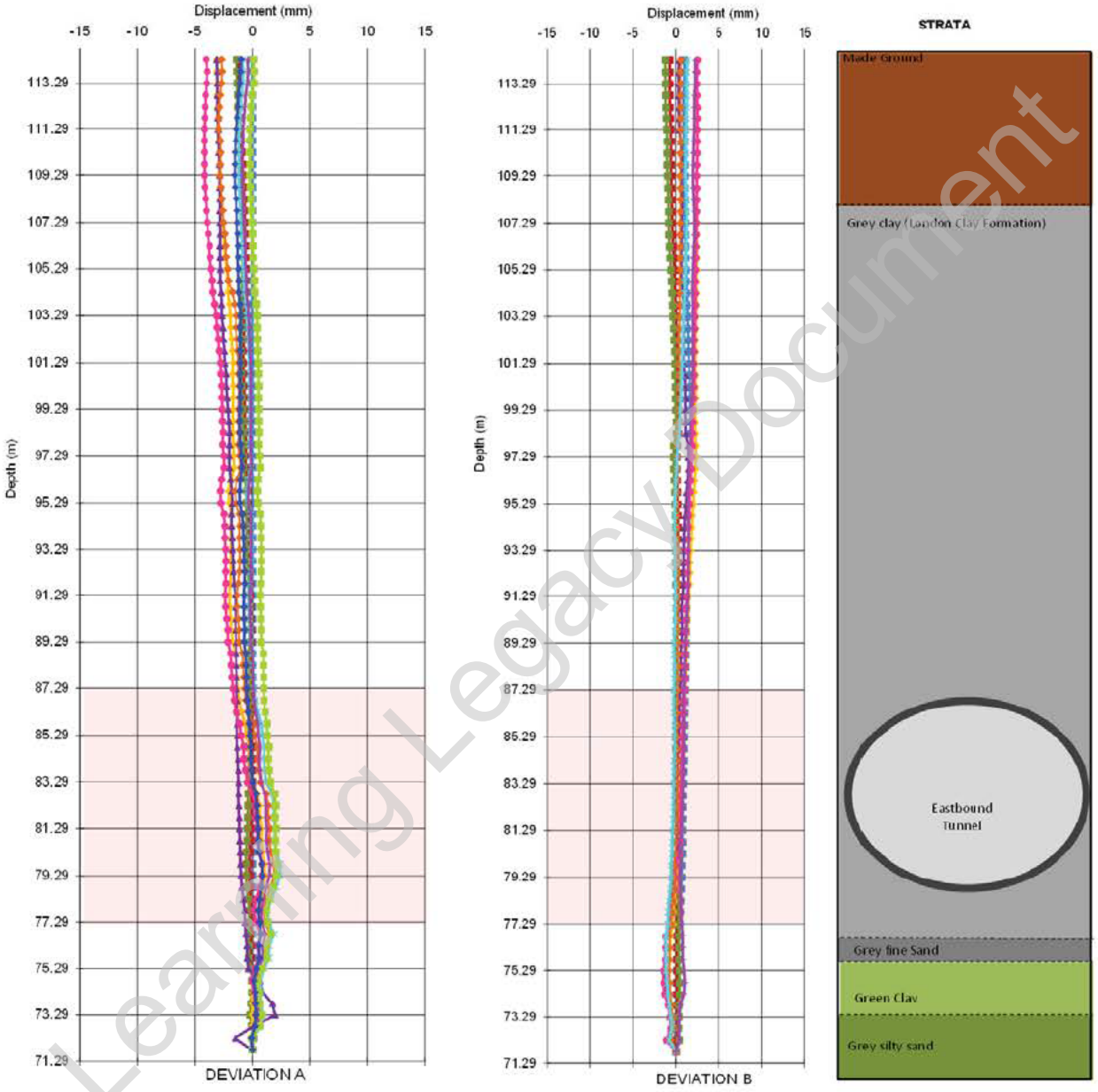
$Plot$

APPENDIX B: GRAPHS

C435 FARRINGDON STATION

GEOCISA UK

REPORT: Manual Inclinometer
LOCATION: The Partners
DEVICE: Inclinometer C435-IM00003
Before and After TBM



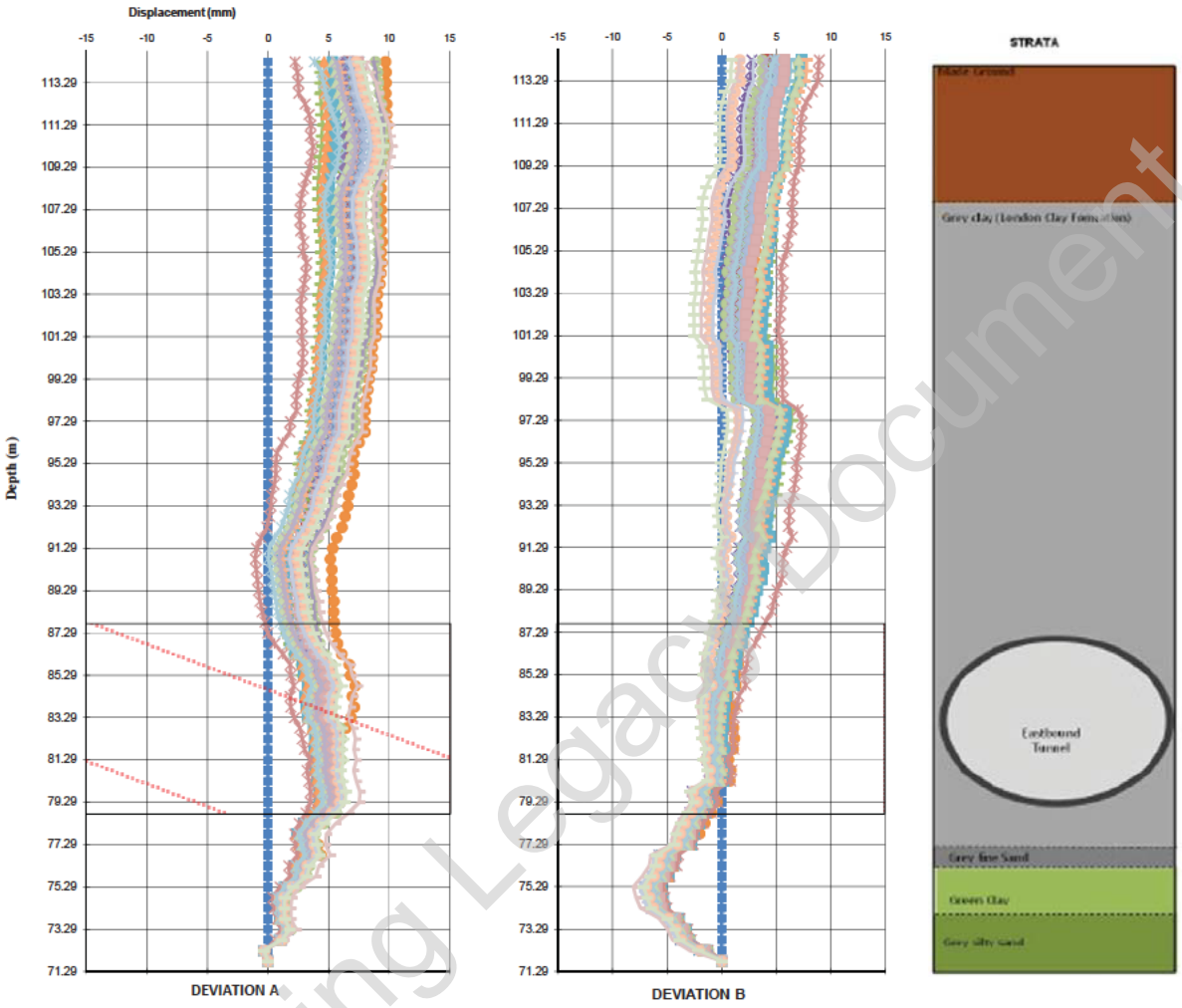
MEASURING DATES

13/03/2013 Baseline	10/08/2013	16/09/2013	02/12/2013
07/01/2014	12/01/2014	13/01/2014	14/01/2014
15/01/2014	16/01/2014	20/01/2014	

REMARKS:

TBM cross the area where the inclinometer is install on 12-01-2014

REPORT: MANUAL INCLINOMETER
LOCATION: BACKYARD-THE PARTNERS
DEVICE: Inclinometer C430-IM00003
During PTE Construction



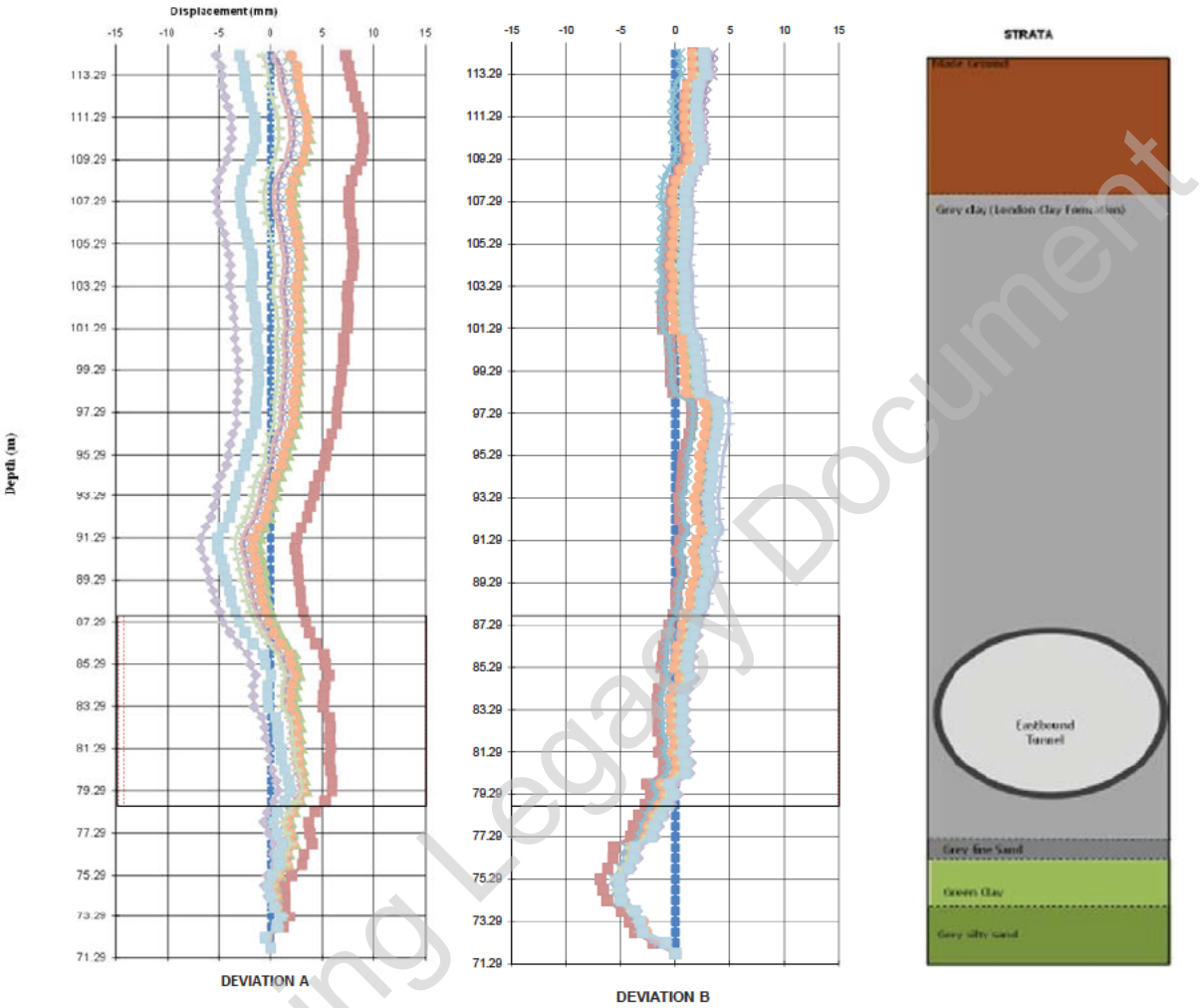
MEASURING DATES

13/03/2013 Baseline	01/07/2014	02/07/2014
03/07/2014	04/07/2014	05/07/2014
06/07/2014	07/07/2014	08/07/2014
09/07/2014	10/07/2014	11/07/2014
12/07/2014	13/07/2014	14/07/2014
15/07/2014	16/07/2014	17/07/2014
18/07/2014	21/07/2014	22/07/2014
23/07/2014	24/07/2014	25/07/2014
29/07/2014	30/07/2014	31/07/2014

REMARKS:

The inclinomer was inside the influence area for PTE constructuion from 08-07-2014 to 25-07-2014

REPORT: MANUAL INCLINOMETER
LOCATION: BACKYARD-THE PARTNERS
DEVICE: Inclinometer C430-IM00003
Last Readings

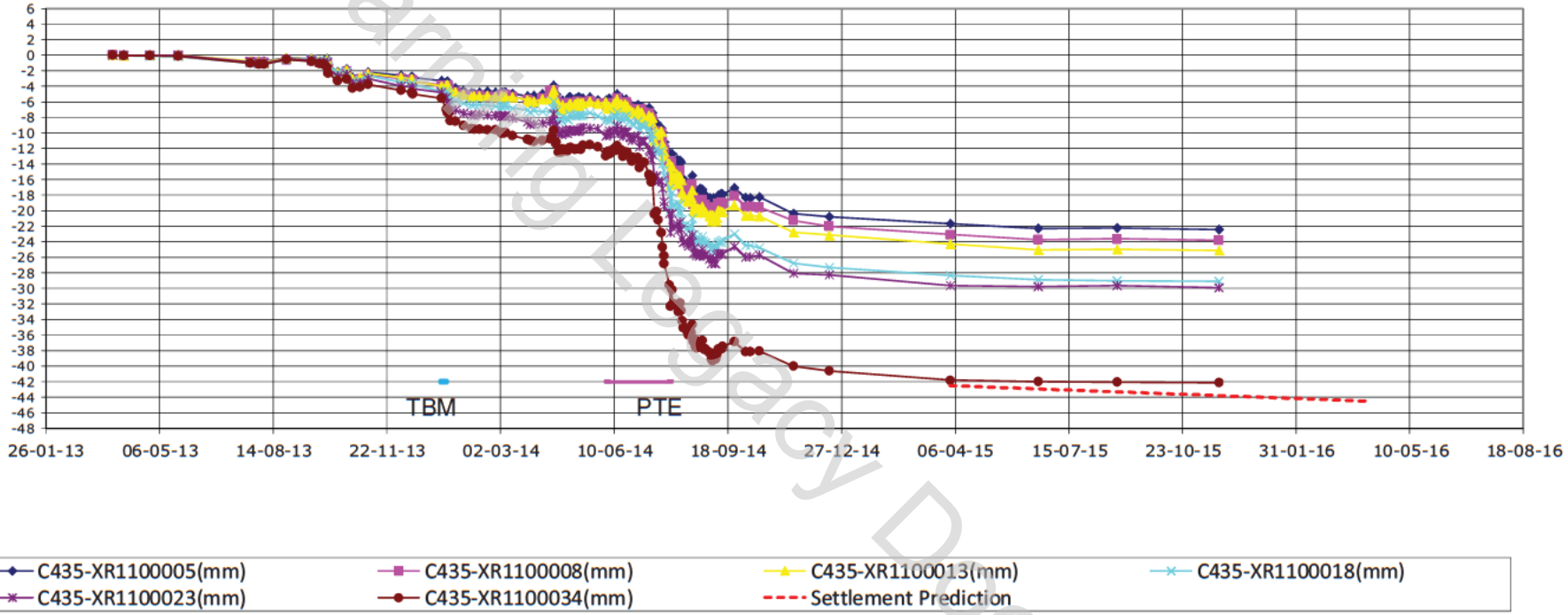


MEASURING DATES

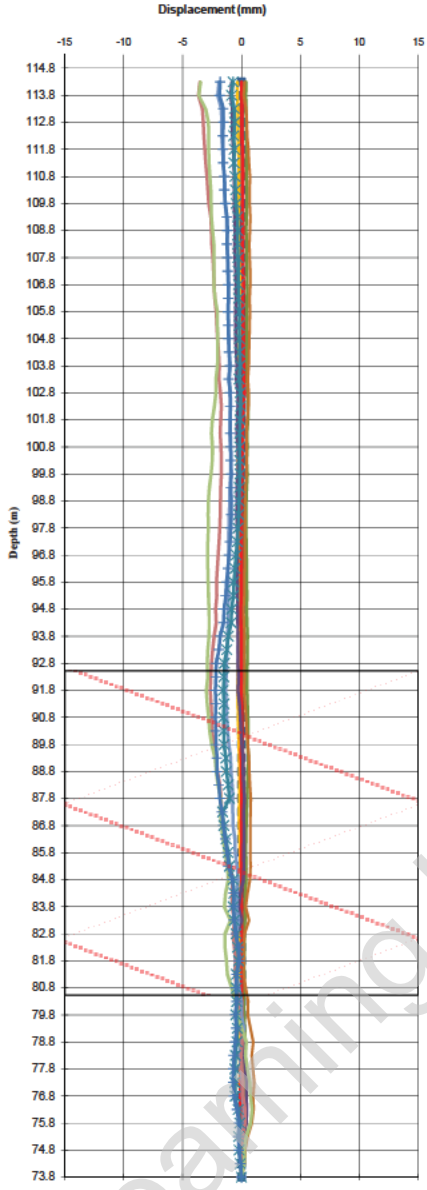
13/03/2013 Baseline
25/07/2014
25/08/2014
24/09/2014
08/10/2014
15/10/2014
12/11/2014
15/01/2015
18/02/2015
09/06/2015
08/09/2015

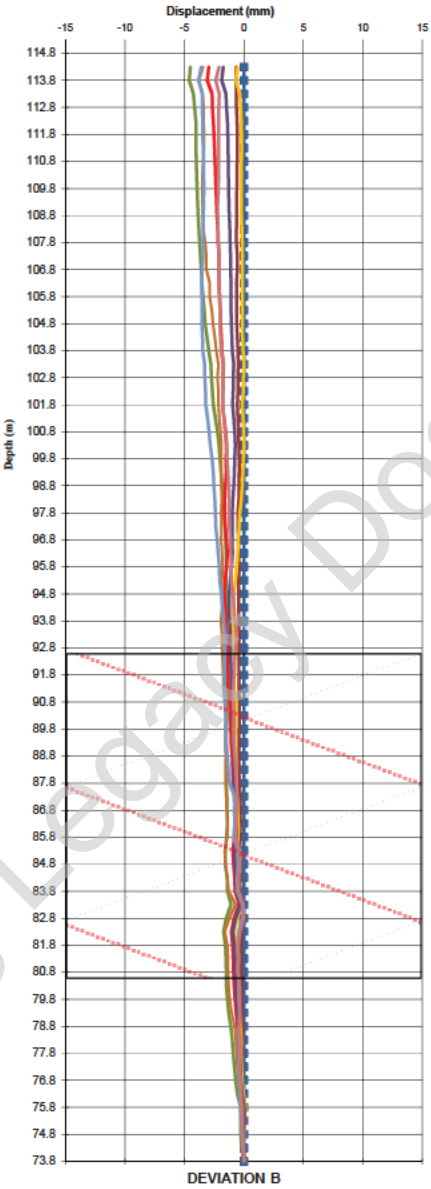
REMARKS:

TBM cross the inclinometer location on 12-01-2014
The inclinometer was inside the influence area for PTE from 08-07-2014 to 25-07-2014

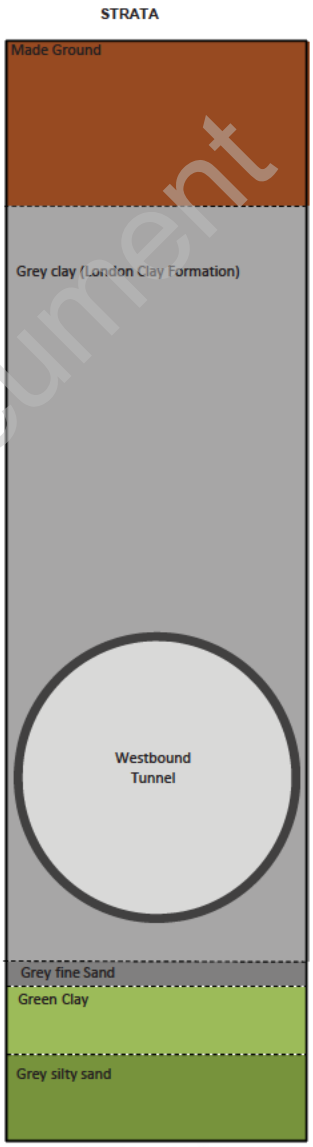


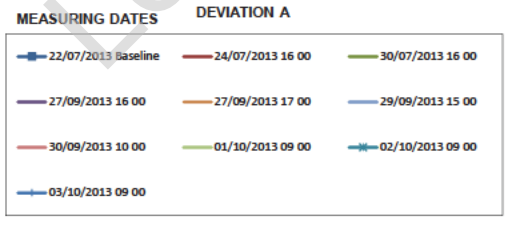
REPORT: MANUAL INCLINOMETER
LOCATION: GRENNHILL'S RENT
DEVICE: Inclinometer C435-IM00004
Before and After TBM

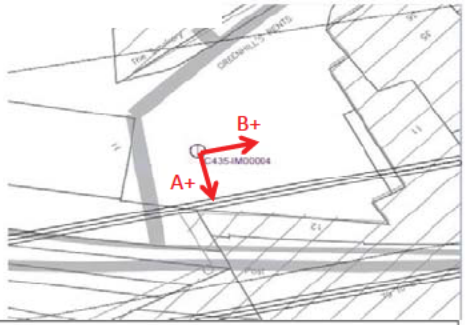




DEVIATION B





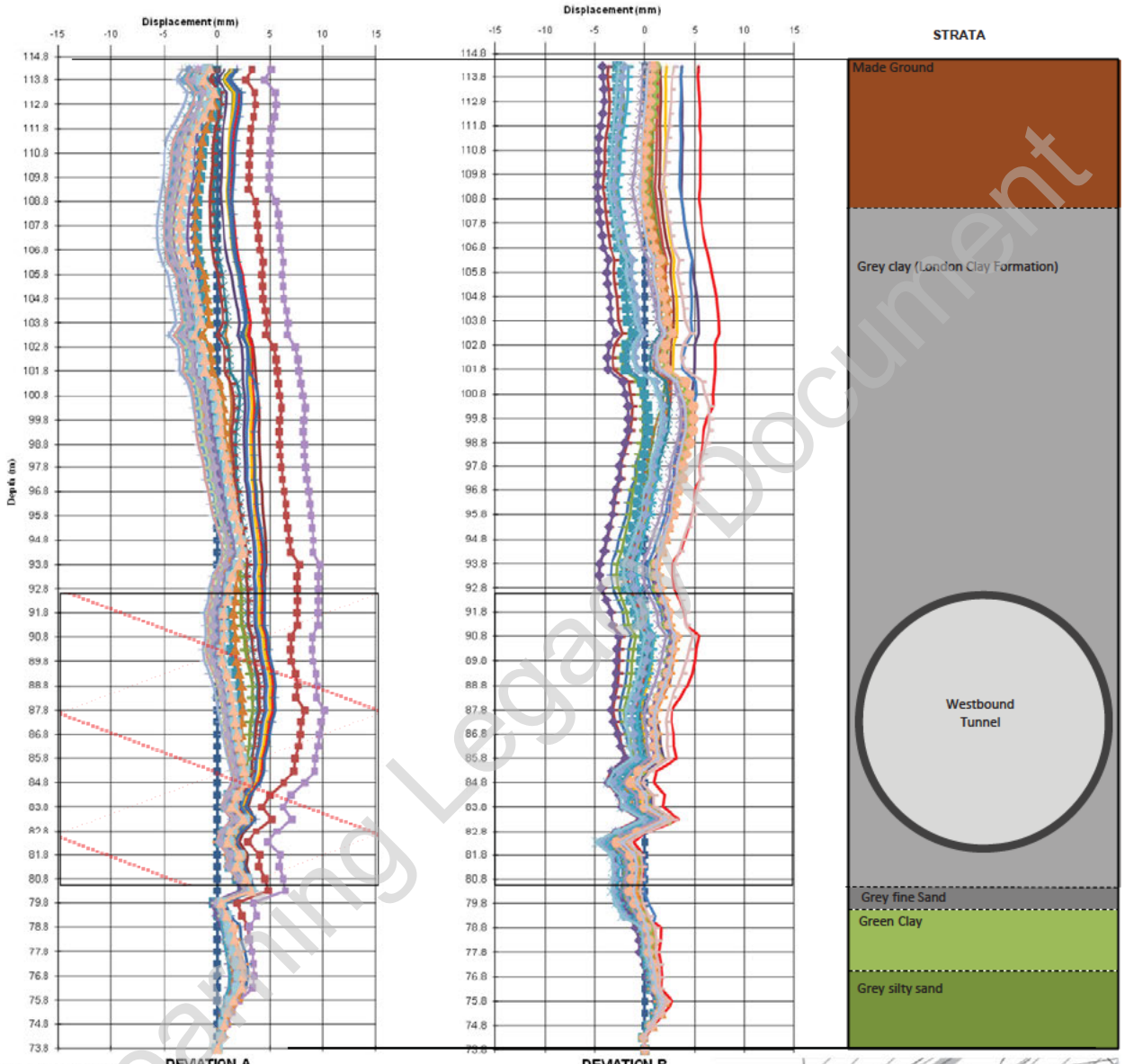


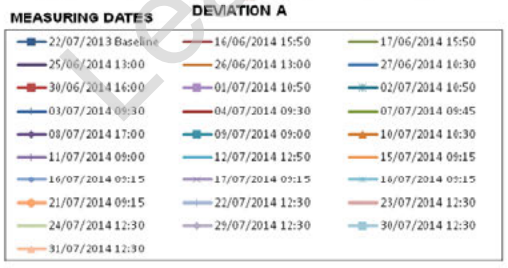
REMARKS:

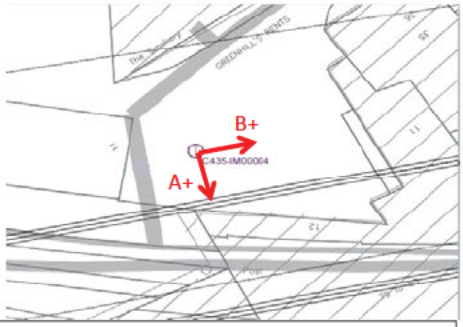
The inclinometer was inside influence area for WB TBM from 29-09-2013

C435 FARRINGDON STATION

REPORT: MANUAL INCLINOMETER
LOCATION: GRENNHILL'S RENT
DEVICE: Inclinometer C435-IM00004
During PTW



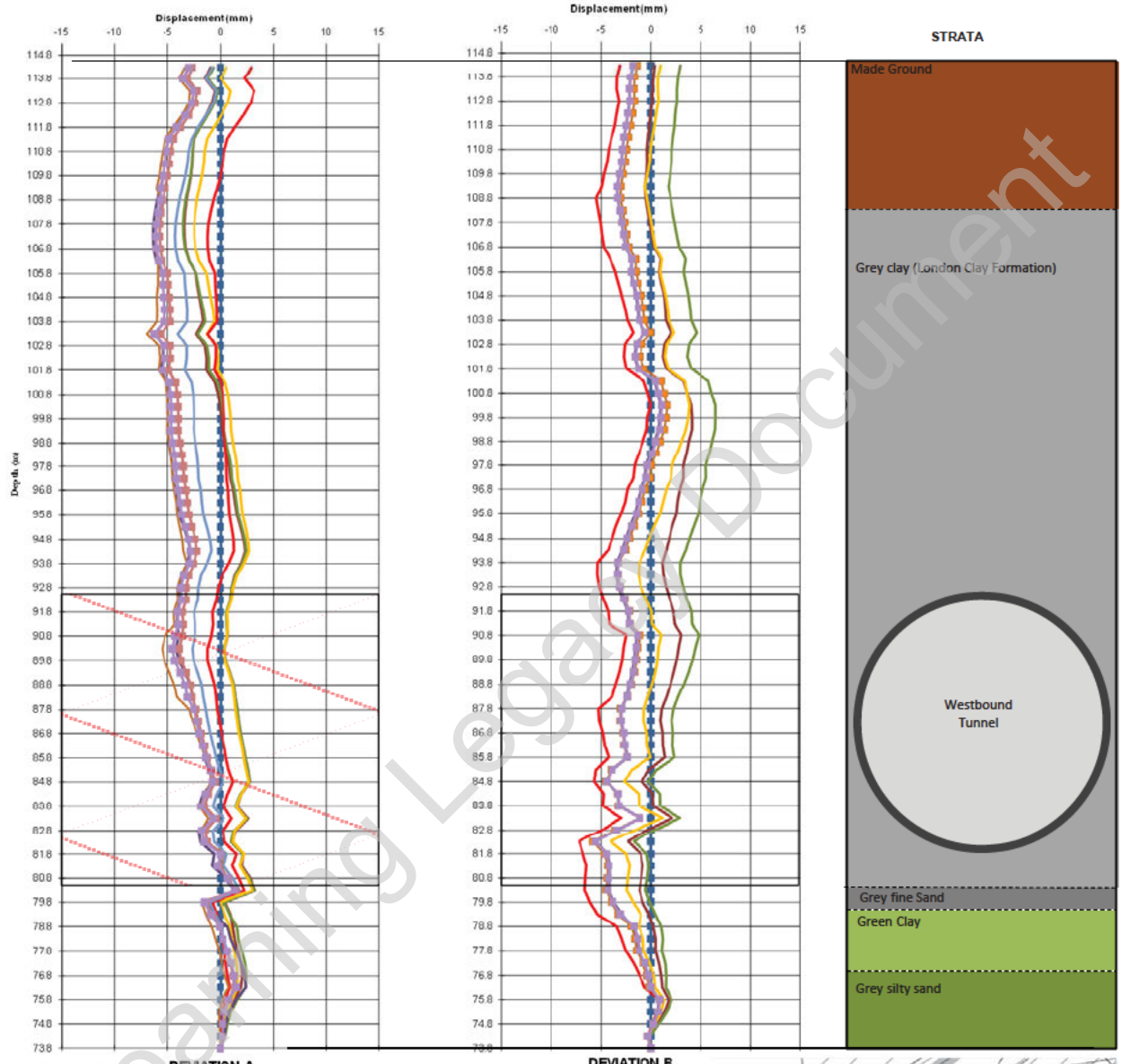


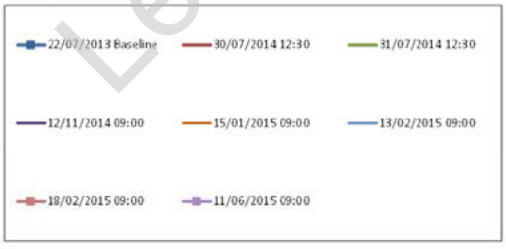


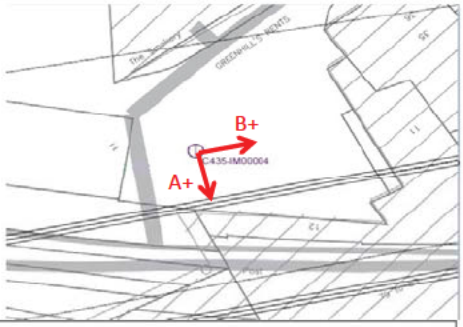
REMARKS:

The inclinometer was inside influence area for PTW from 30-06-2014 to 22-07-2014

REPORT: MANUAL INCLINOMETER
LOCATION: GRENNHILL'S RENT
DEVICE: Inclinometer C435-IM00004
Last Readings







REMARKS:

TBM cross the inclinometer location on 29-09-2013
The inclinometer was inside influence area for PTW from 30-06-2014 to 22-07-2014