C305– Eastern Running Tunnels

Close Out Report for SGS-PML-LU28 District Line and LU29 Campbell Road LU Substation at Eleanor St. Shaft

CRL Document Number: C305-DSJ-C2-RGN-CRG03-50408

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Contract MDL reference C08.079

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Stakeholder submission required: LU ☑ RIL ☐ 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: [redacted] Role: [redacted] Name: [redacted] Date: 22/6/16

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

2b. Review by Stakeholder (if required):

Stakeholder Organisation	Job Title	Name	Signature	Date	Acceptance
					☐

3. Acceptance by *Crossrail*:

	Crossrail Review and Acceptance Decal	
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Reviewed/Accepted by (signature): [redacted] Print Name: [redacted] Position: [redacted] Date: 23/06/16

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GEOCISA UK

C305-CLOUT-20160419

Close Out Report for SGS-PML-LU28 District Line and LU29 Campbell Road LU Substation at Eleanor St. Shaft

C305 Crossrail Eastern Running Tunnels

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CONTENTS

1. CLOSE OUT REPORT PURPOSE

The purpose of this Close Out Report is to summarise the monitoring data related to the C305 construction activities recorded by the C704 monitoring system on the LU28 District Line Viaduct and LU29 Campbell Road LU Substation. This report incorporates the existing C704 decommissioning agreement for these assets (C704 Instrumentation Decommissioning Agreement LU/28 and LU/29 Campbell Road LU Substation at Eleanor Street Shaft - C704-XRL-C-AAG-CR094_SH007-50002) whereby the C704 monitoring system shows the settlement to be at an acceptably small rate and can now be decommissioned.

To provide a summary of the effects of C305 construction activities on the assets, the C305 manual verification readings have been reviewed alongside the C704 automatic monitoring system for completeness. This report has been produced to close out the requirement for C305 monitoring reviews in connection with these assets.

2. LOCATION OF THE WORKS

The instrumentation included within this report is located on Drive Z between Pudding Mill Lane and Stepney Green Site and intersects the Crossrail route at reference chainage from 82600 to 82700. The District Line Viaduct (LU/28) runs approximately in east-west direction and broadly perpendicular to the Crossrail tunnel's alignment. This brick built arched viaduct connects Bow Road and Bromley by Bow and forms part of the D129A LU assets.

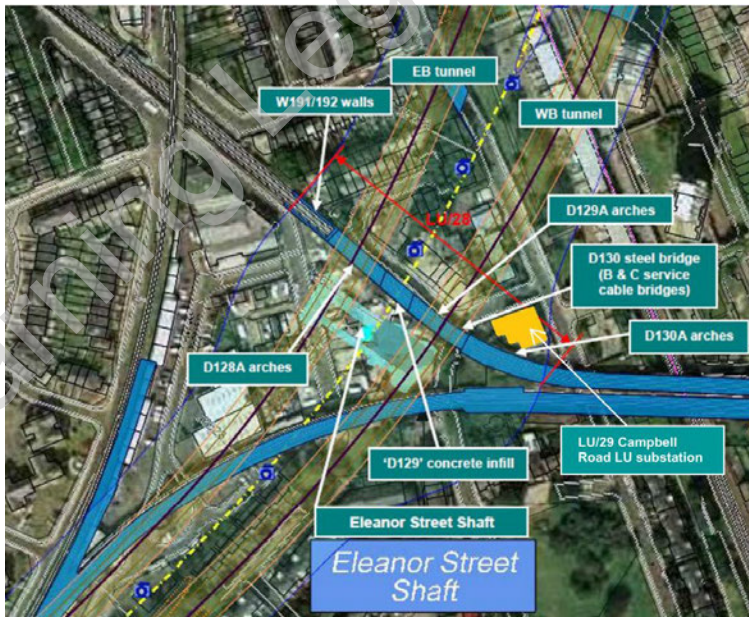


Figure 1 Location plan for the interface between LU district Line viaduct LU28 and Crossrail elements

The Campbell Road LU Substation LU/29 is located beside the LU/28 Viaduct, approximately 20m east of the Crossrail tunnels at chainage 82650. This asset was not monitored by C704.

3. DOCUMENTATION SUMMARY

CROSSRAIL NUMBER	DOCUMENT NAME	REASON FOR ISSUE
C701-ITM-O1-GMS-CR094_SH007-50001	C701 Method Statement for LU/28 & LU/29	Method of Statement
C701-ITM-C-RGN-CR094_SH007-50002	C701 Installation Report for LU/28 & LU/29	Installation Report
C122-OVE-C2-ASM-CR094_WS109-50002	C122 Assessment Report for LU/28	Asset Report
C122-OVE-C2-RAN-D044-00001	C122 Assessment Report for LU/29	Asset Report
C122-OVE-C2-RGN-CR001-50024	C122 I&M Plan for LU/28 & LU/29	I&M Plan
C122-OVE-C2-DDA-CR001_Z-31136	C122 I&M Drawing	Drawing
C122-OVE-C2-DDB-CR001_Z-32018	C122 I&M Drawing	Drawing
C122-OVE-C2-RGN-CRG01-50095	LU/28 District Line Viaduct at Eleanor St shaft	Baseline Report
C305-DSJ-C2-RGN-CRG03-50379	I&M Installation report for Sockets, Levelling Points & Prisms from Pudding Mill Lane to Stepney Green (Drive Z)	Installation Report
C704-XRL-C-AAG-CR094_SH007-50002	LU/28 District Line and LU/29 Campbell Road LU Substation at Eleanor Street Shaft	Decommissioning Agreement

4. SUMMARY OF INSTRUMENTATION

The instruments covered in this report are listed below:

- 94 No. Prisms installed on the District Line Viaduct structure. See Appendix A.
- 34 No. BRE levelling sockets for manual monitoring installed on the Viaduct. See Appendix A.
- 280 No. Level markings on the running rails by C305. See Appendix B.
- 4 No. BRE levelling sockets for manual monitoring installed on the LU/29 Campbell Road LU Substation by C305 (see Installation Report: C305-DSJ-C2-RGN-CRG03-50379)
- 3 No. prisms installed on the LU/29 Campbell Road LU Substation by C305 (see Installation Report: C305-DSJ-C2-RGN-CRG03-50379)

5. C305 CONSTRUCTION ACTIVITIES

The CRL works that have affected the assets are dated below:

C305 Construction activity	Start	End
Drive Z Eastbound (EB) Tunnel Boring Machine (TBM) Passage	22-Oct-13 Ring #465	29-Oct-13 Ring #525
Drive Z Westbound (WB) Tunnel Boring Machine (TBM) Passage	10-Apr-14 Ring #475	15-Apr-14 Ring #540
Construction activity by Others	**Start**	**End**
Construction of temporary shaft	Jul-13	Sep-13
Construction of main shaft	Jul-14	Nov-14
Construction of the Sprayed Concrete Lining tunnels	Sep-13	Apr-15
Dewatering associated with the Eleanor Street Shaft	Jul-13	Oct-15
Piling associated with ESS Headhouse	Aug-15	Sep-15

6. SUMMARY OF C704 DATA

The summary of the C704 data can be found in the decommissioning agreement, in appendix C attached to this report, where a detailed explanation of the movements related to the Crossrail construction activities is provided. The arrangement of the different arrays analysed are below:

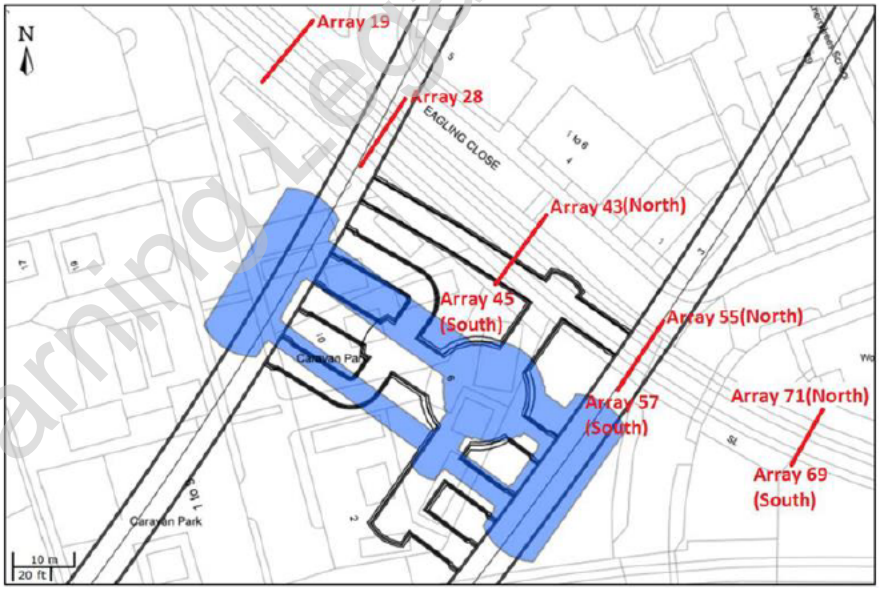


Figure 2. Arrangement of the arrays analysed

All the arrays are located within the 5mm contour line settlement.

C704 Prisms

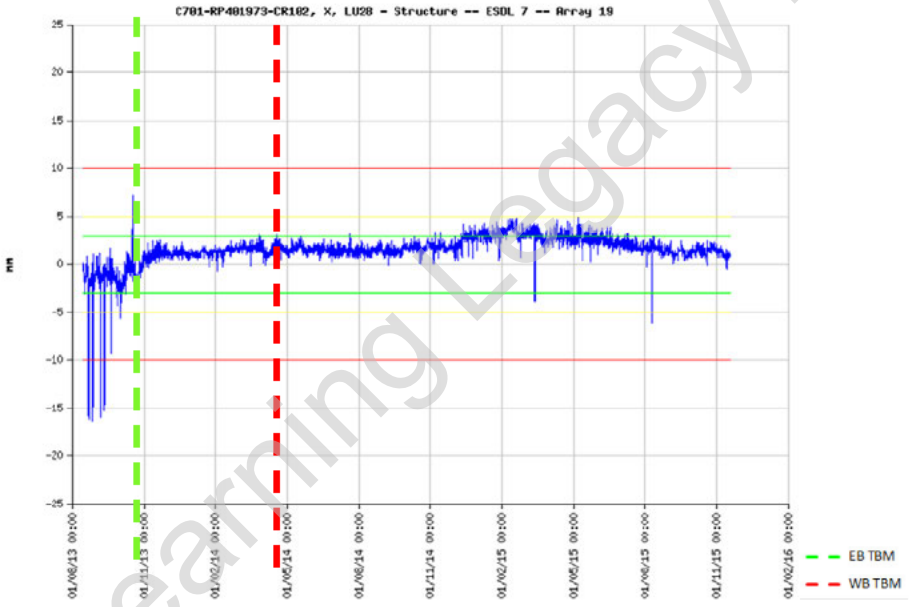
The following graphs represent monitoring data recorded by the C704 monitoring system and were downloaded from UCIMS.

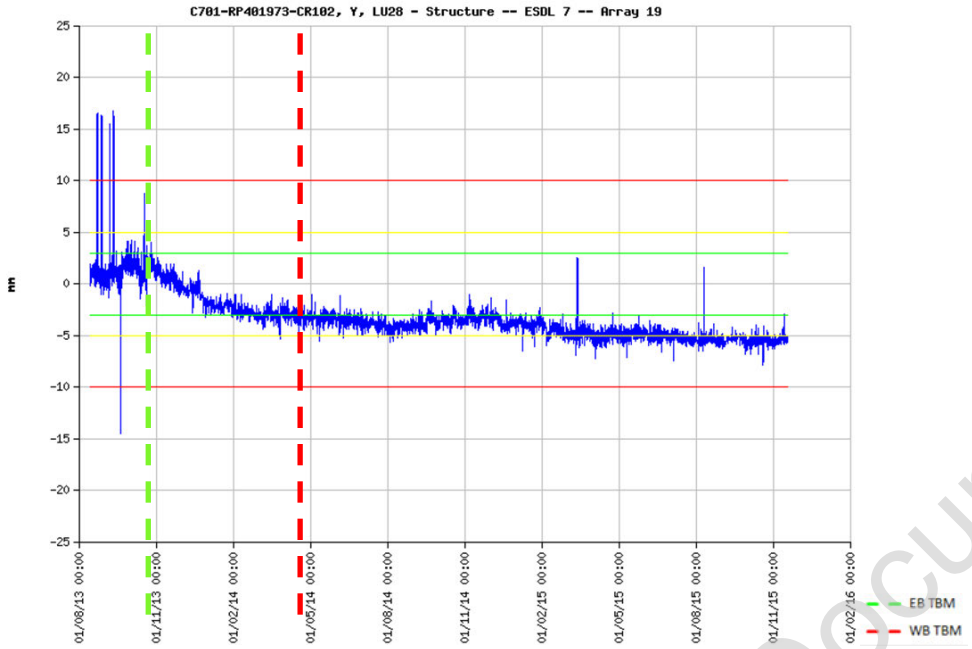
Note:

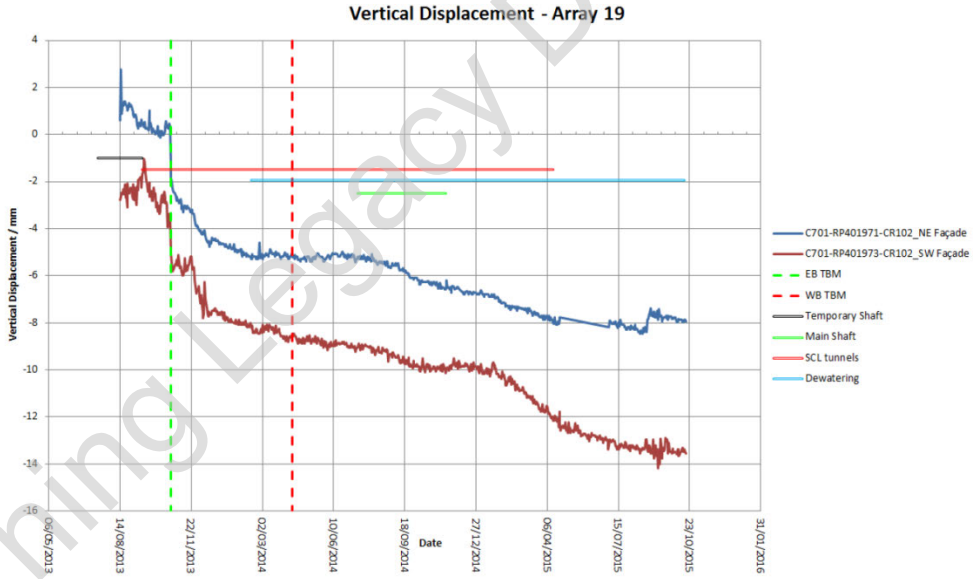
See below settlement trigger values specified in the I&M plan C122-OVE-C2-RGN-CR001-50024 Rev 4.0

	Green (mm)	Amber (mm)	Red (mm)
Retaining walls	15	20	25
Viaduct (D129A)	40	50	65
Viaduct (D130A)	5	10	15
Service Bridges	5	10	15
Substation	5	10	15

Array 19- C701-RP401973





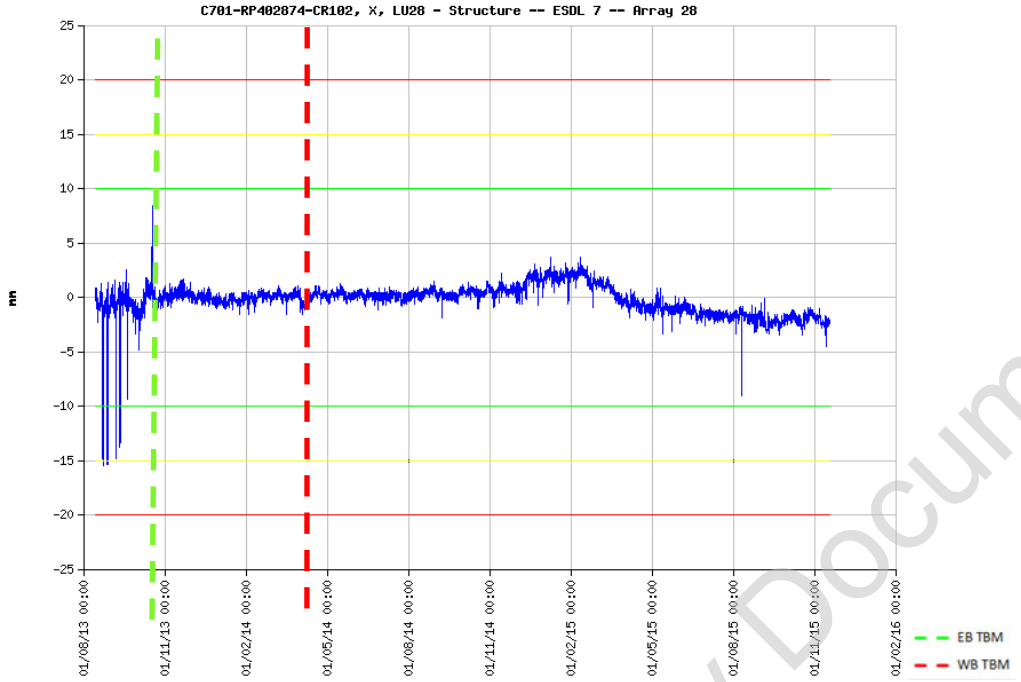


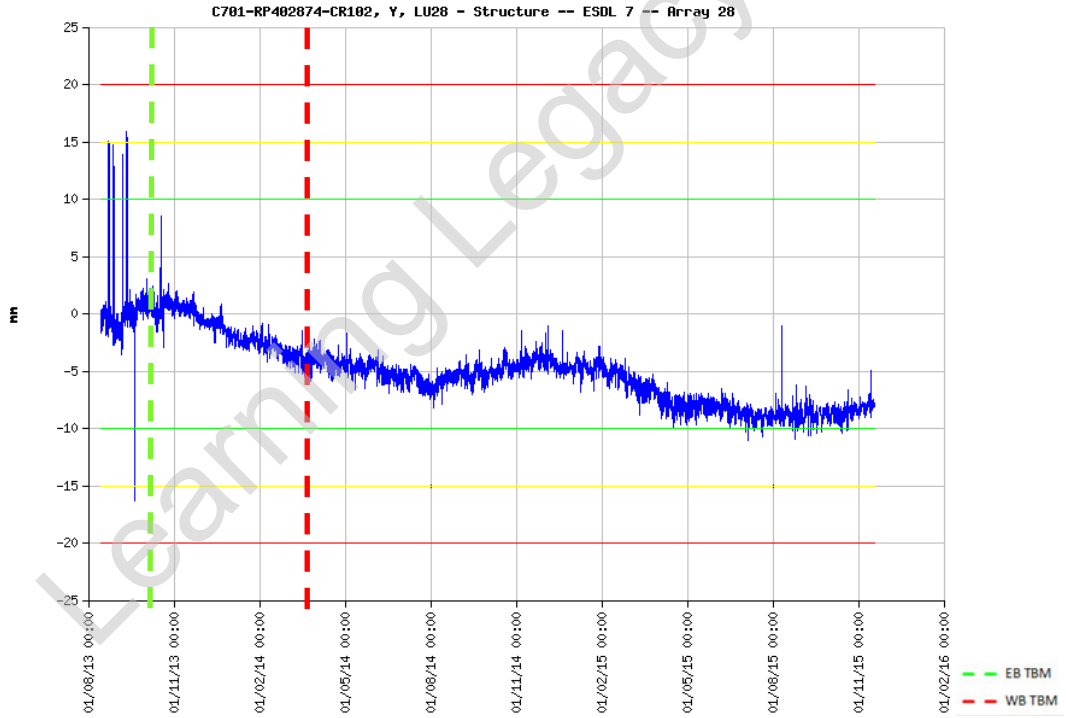
The X axis shows a maximum movement of 4.7 mm after the Westbound TBM transit.

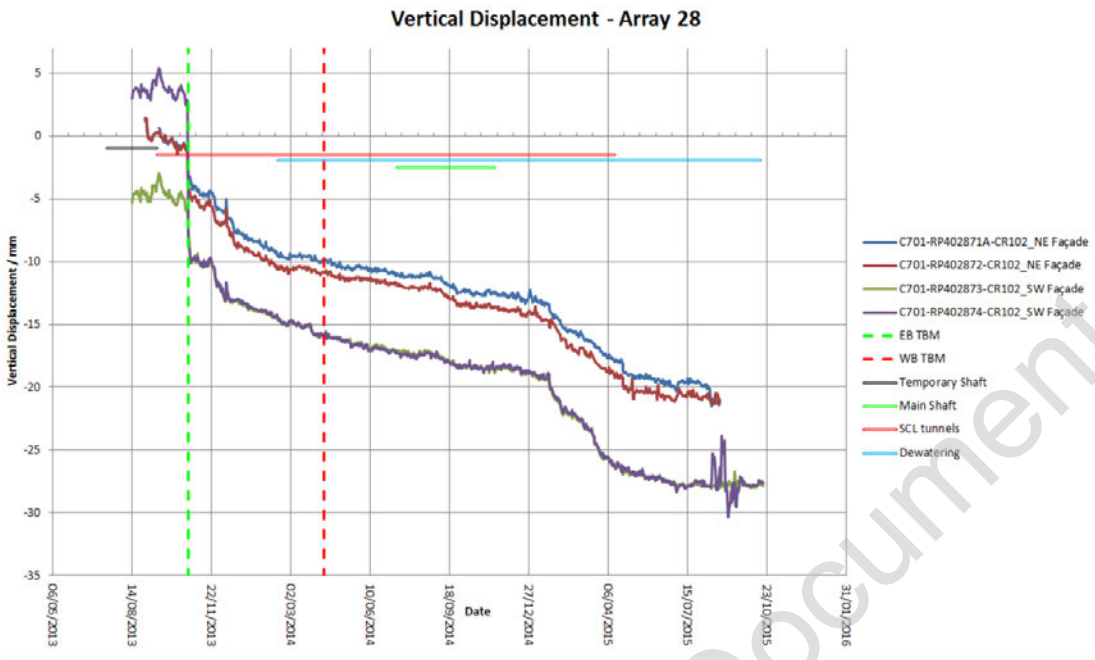
The Y axis shows a maximum movement of -7 mm after the Westbound TBM transit. Amber trigger values have been reached.

The Z axis shows a maximum movement of -6mm after the Eastbound TBM transit and a maximum movement of –10 mm after the westbound TBM transit.

Array 28- C701-RP402874





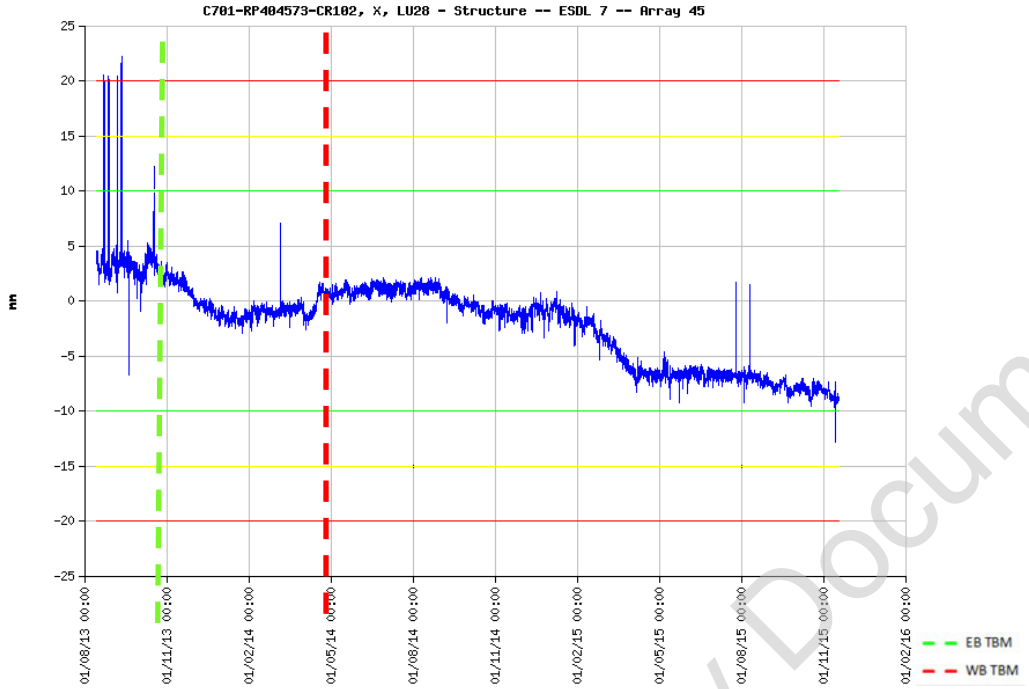


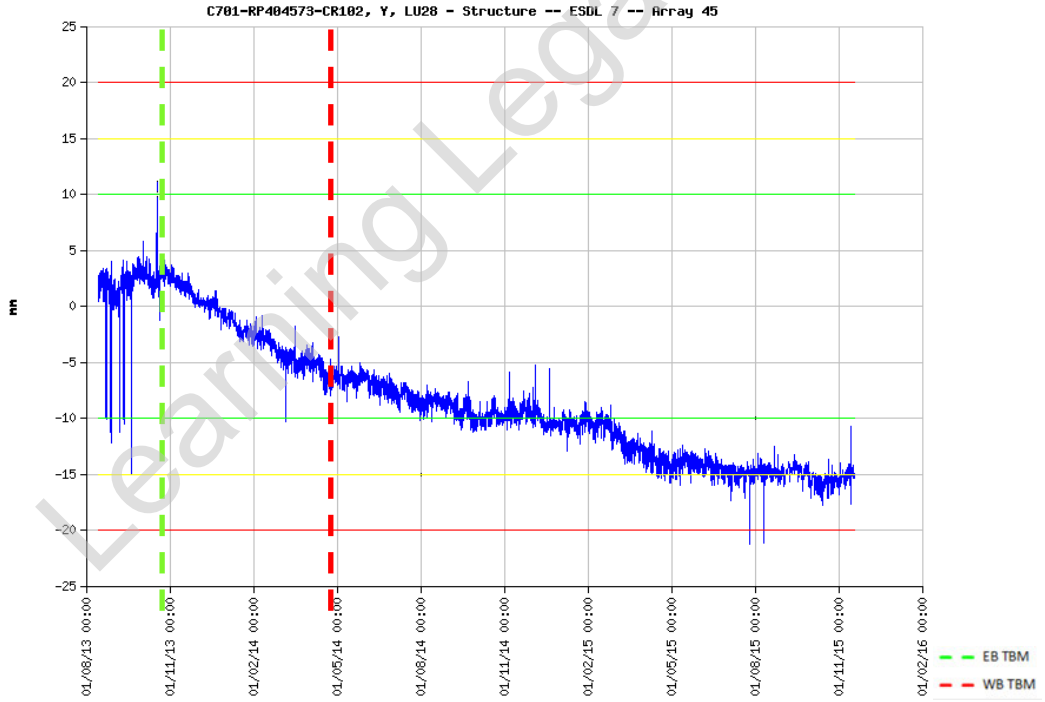
The X axis shows a maximum movement of 3 mm after the Westbound TBM transit.

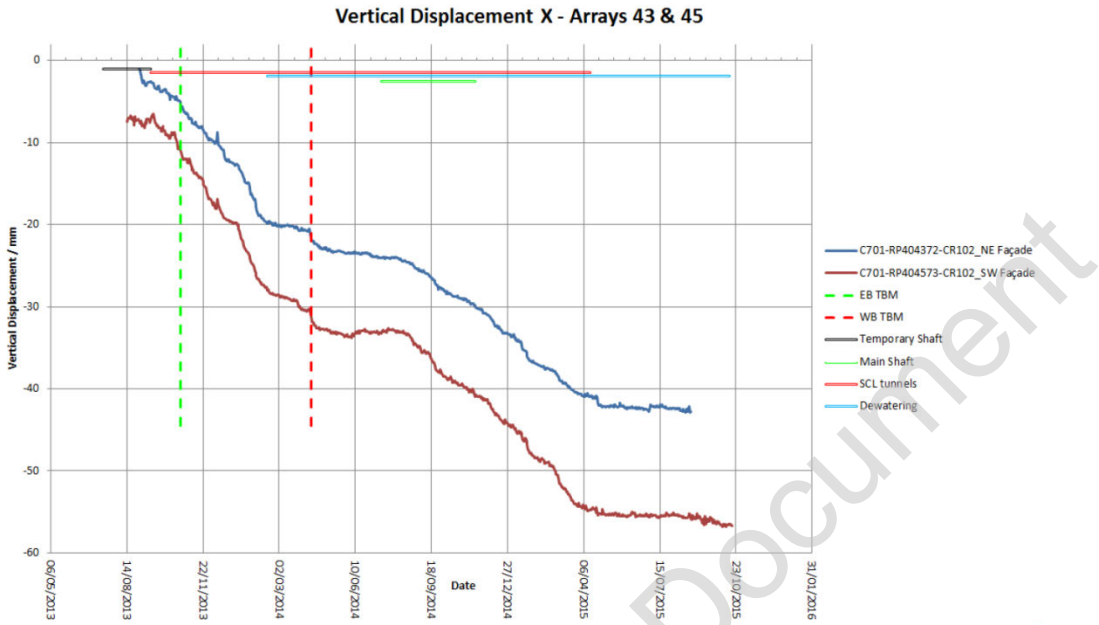
The Y axis shows a maximum movement of -11 mm after the Westbound TBM transit. Green trigger values have been reached.

The Z axis shows a maximum movement of -10mm after the Eastbound TBM transit and a maximum movement of –17 mm after the westbound TBM transit.

Arrays 43(North) & 45 (South) - C701-RP404573





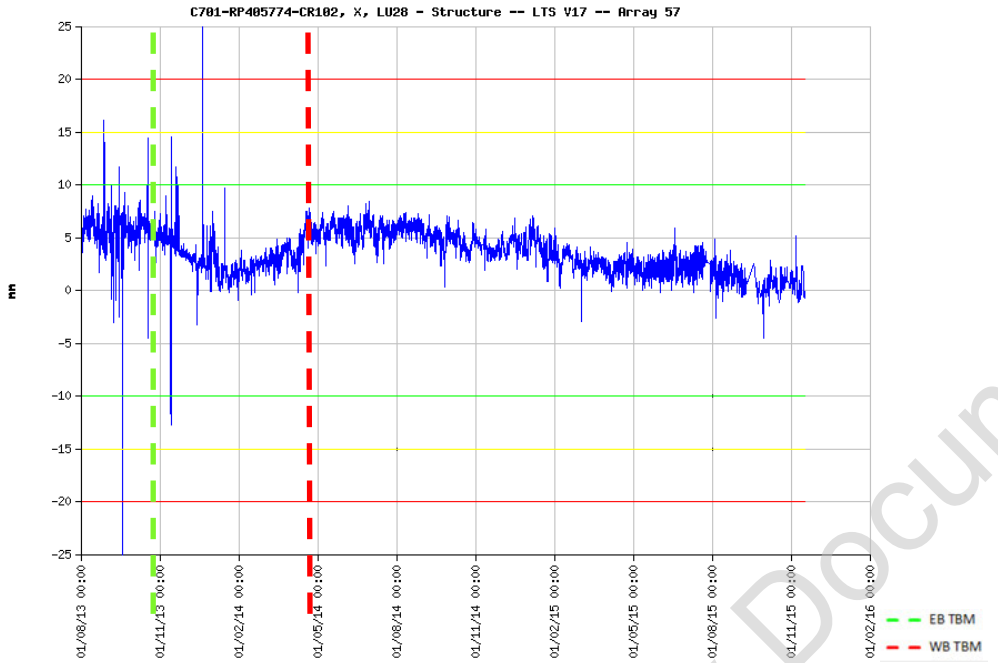


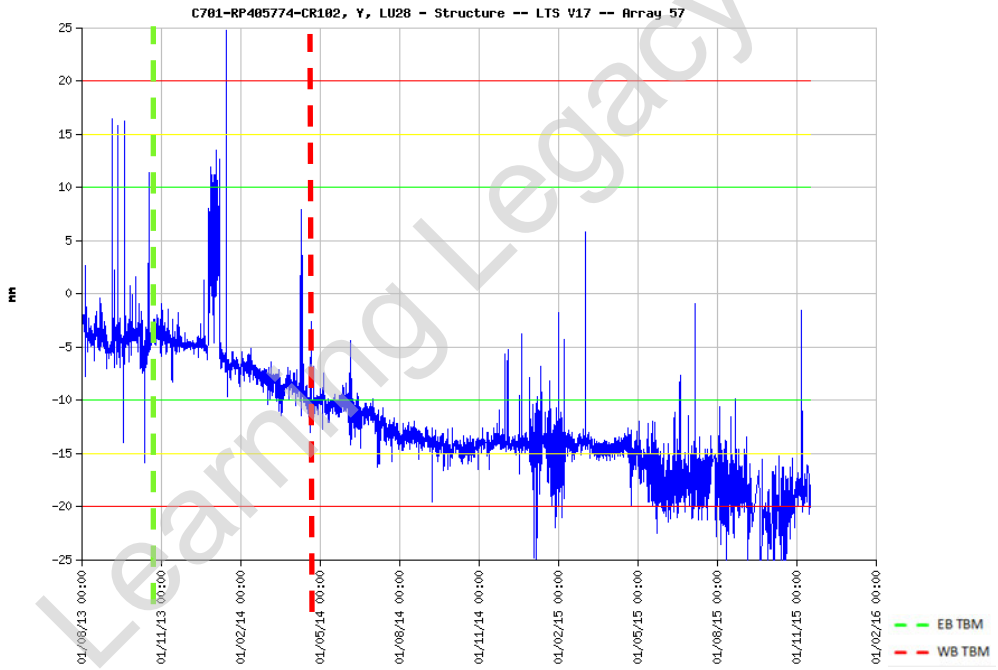
The X axis shows a maximum movement of -9 mm after the Westbound TBM transit. Green trigger values have been reached.

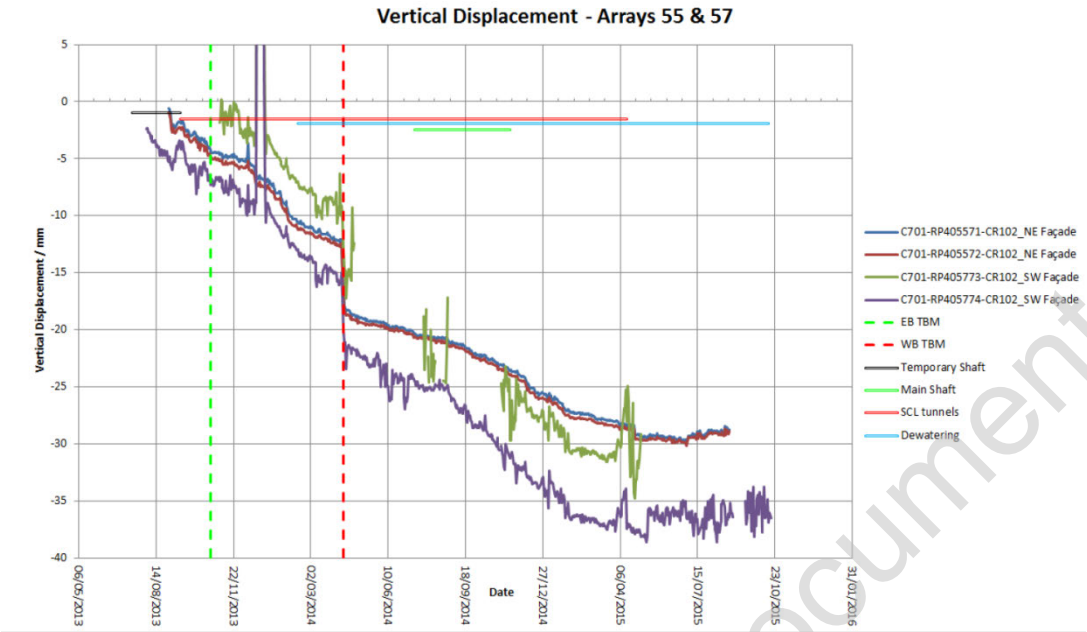
The Y axis shows a maximum movement of -17 mm after the Westbound TBM transit. Amber trigger values have been reached.

The Z axis shows a maximum movement of -12mm after the Eastbound TBM transit and a maximum movement of –33 mm after the westbound TBM transit. Amber trigger values have been reached (50 mm settlement).

Arrays 55 (North) & 57 (South) - C701-RP405774





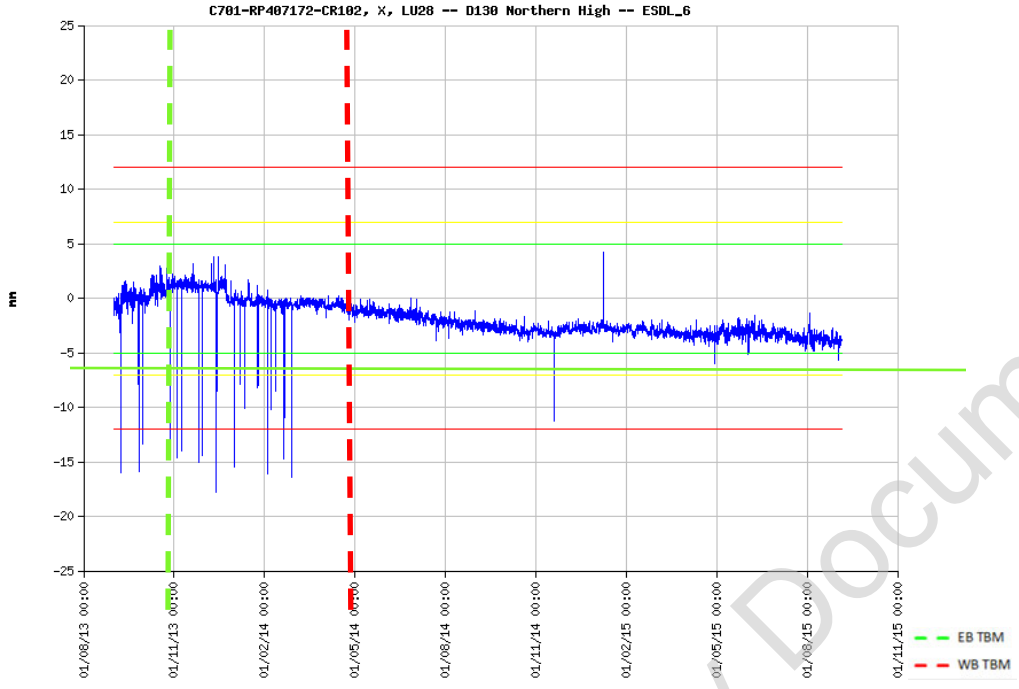


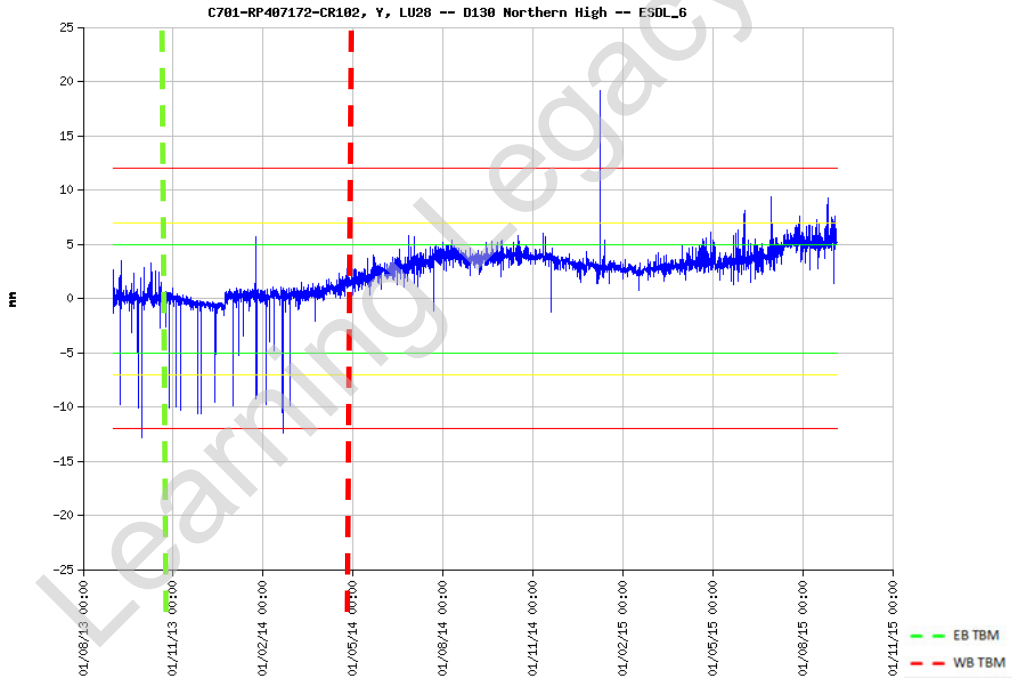
The X axis shows a maximum movement of 8 mm after the Westbound TBM transit.

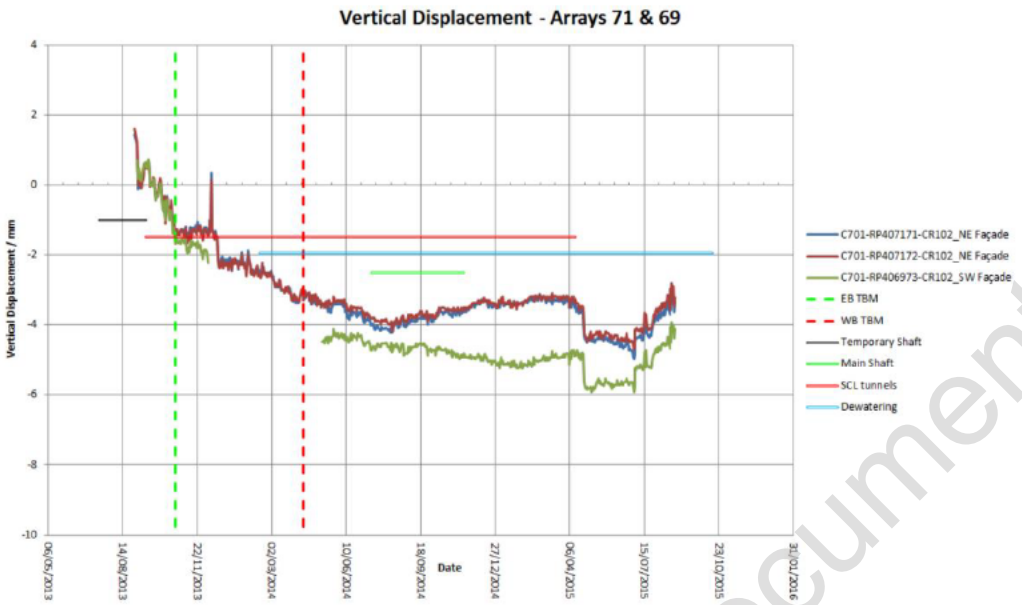
The Y axis shows a maximum movement of -25 mm after the Westbound TBM transit. Red trigger values have been reached.

The Z axis shows a maximum movement of -7 mm after the Eastbound TBM transit and a maximum movement of –25 mm after the westbound TBM transit.

Arrays 71 (North) & 69 (South) - C701-RP407172







The X axis shows a maximum movement of -4 mm after the Westbound TBM transit.

The Y axis shows a maximum movement of 7 mm after the Westbound TBM transit. Amber trigger values have been reached.

The Z axis shows a maximum movement of -1.5 mm after the Eastbound TBM transit and a maximum movement of –3.5 mm after the westbound TBM transit. Green trigger values have been reached (5mm Settlement)

The following table summarizes the maximum settlement for the different arrays:

Array	Activity						Max movement		
	TBMs								
	EB TBM Passage (mm)	WB TBM Passage (mm)	Max X EB TBM Passage (mm)	Max X WB TBM passage (mm)	Max Y EB TBM passage (mm)	Max Y WB TBM passage (mm)	Max settlement recorded (mm)	Max X movement recorded (mm)	Max Y movement recorded (mm)
19	-3.5	-2	2	1	2	1	-13.5	5	-5
28	-5	-2	0	0	-2	0	-27.5	-3	-9
43-45	-2	-3	2	2	-1	-1	-56	-8	-15
55-57	-2	-6	-1	2	-1	-1	-37	4	-20
71-69	-2	-1	1	0	0	1	-4.5	-4	7

The arrays located above the tunnel alignment showed the largest settlement. The array 43 (North) – 45 (South), located equidistant between the EB and WB alignment, registered the largest settlement with up to -56mm settlement. This array was also affected by temporary works, the construction of the main shaft at Eleanor Street, the SCL tunnel works and dewatering. This settlement effect on the assets has been confirmed by the LU track manual levelling, undertaken by C305 (see section 7 below).

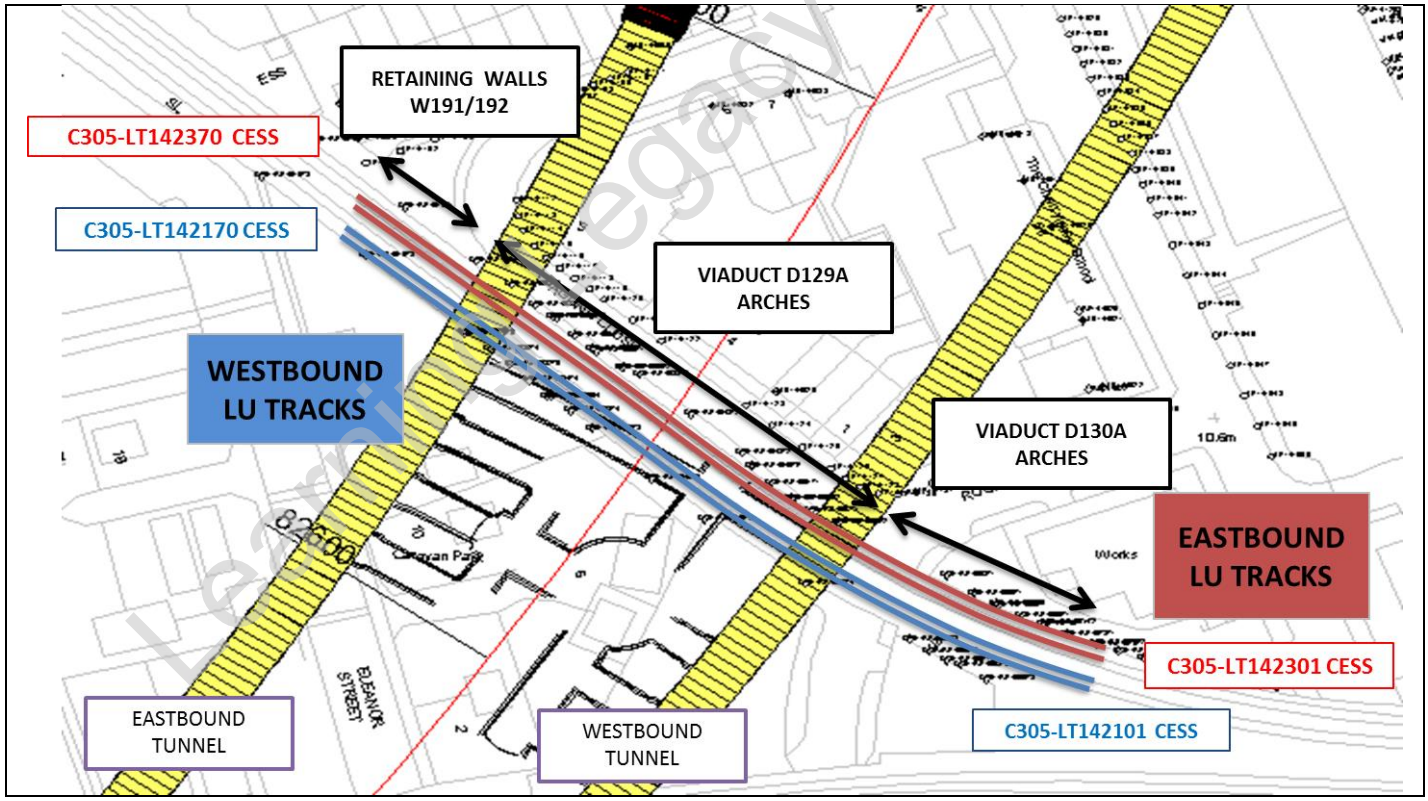
7. C305 MANUAL VERIFICATION READINGS

During the passage of the TBMs manual readings were taken to verify the data recorded by the C704 monitoring system. This was of added importance for monitoring of the track where the repeatability of the readings from the prisms was less reliable and generally had greater survey noise. This was considered a consequence of vibrations from train movements, physical impact from people working on the tracks and dirt accumulating on the prisms which required regular cleaning.

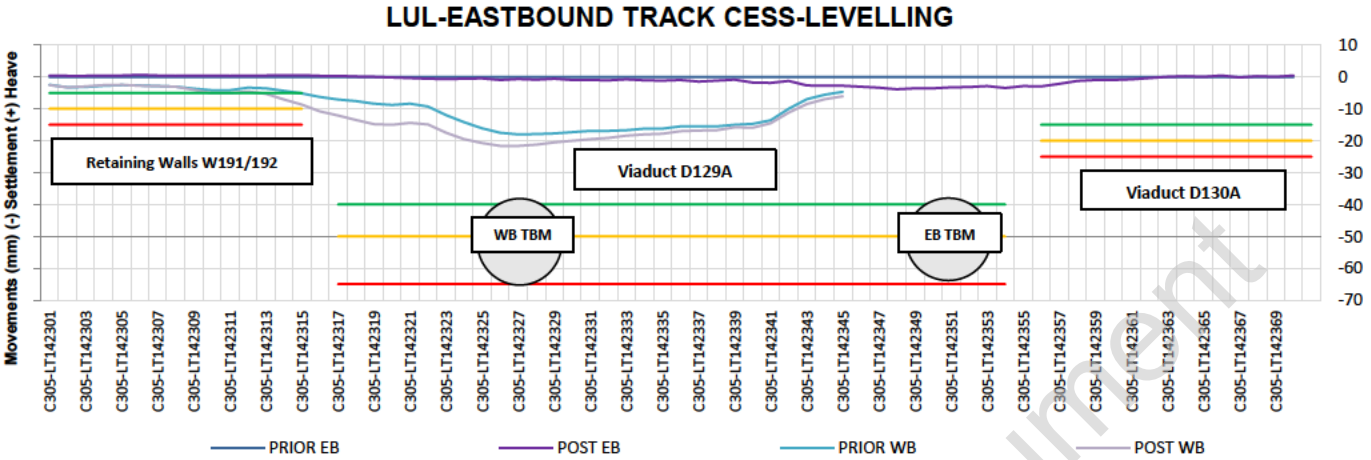
For clarification; the manual track levelling has been summarized as follows:

a) Pre-eastbound TBM
b) Post-eastbound TBM
c) Pre-westbound TBM
d) Post-westbound TBM

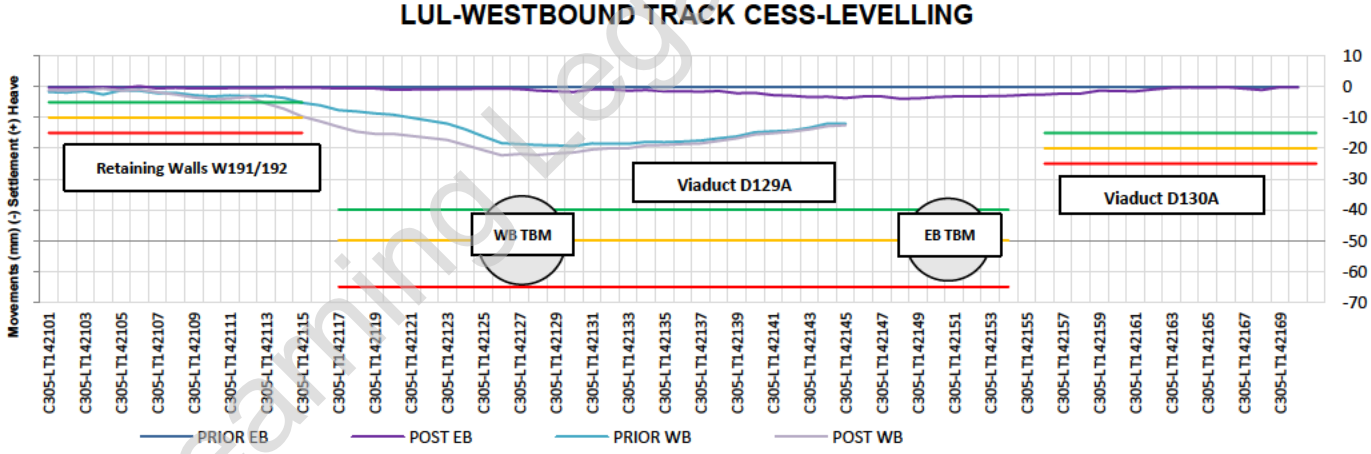
The arrangement of the track levelling marks can be seen below:



LU tracks Track Levelling Settlement



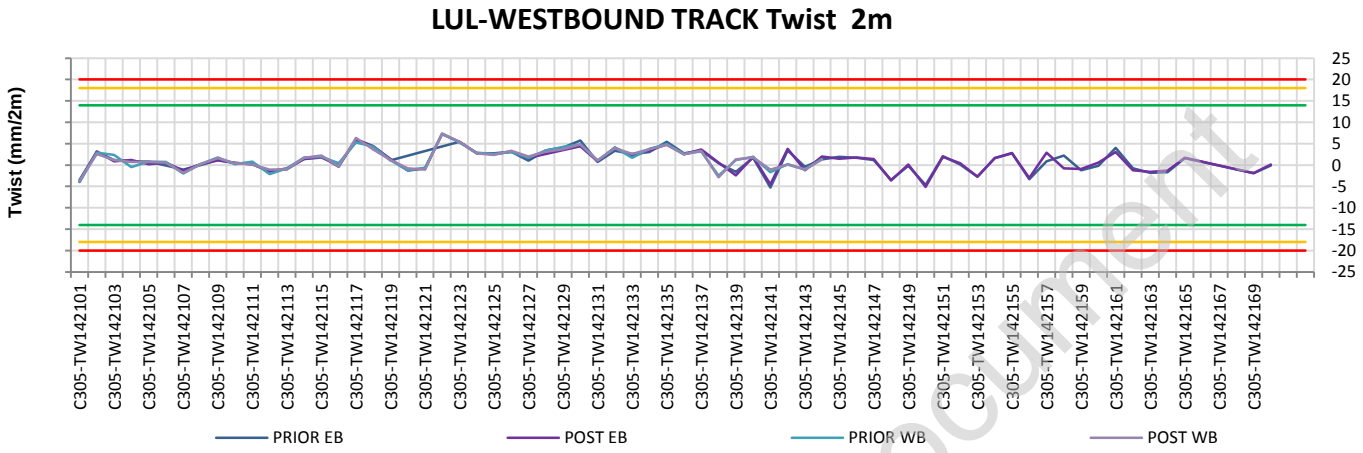
After eastbound TBM transit, the track levelling survey shows up to -3.5 mm settlement. Due to the effect of Eleanor Street Shaft works, a maximum settlement of -18 mm was recorded before westbound TBM transit. After westbound TBM transit, the cumulated maximum settlement noted in the area was -21.6 mm just above the westbound tunnel alignment. Green trigger was reached at Retaining Walls area (C305-LT142313 to C305-LT142315), the trigger values are specified in the C122 I&M Plan C122-OVE-C2-RGN-CR001-50024 Rev 4.0.

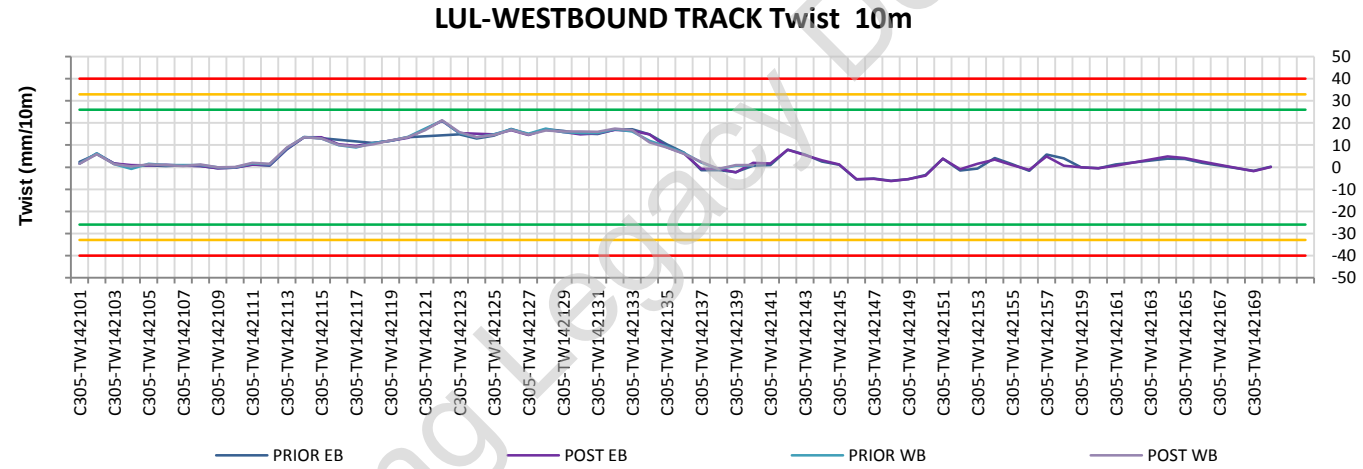


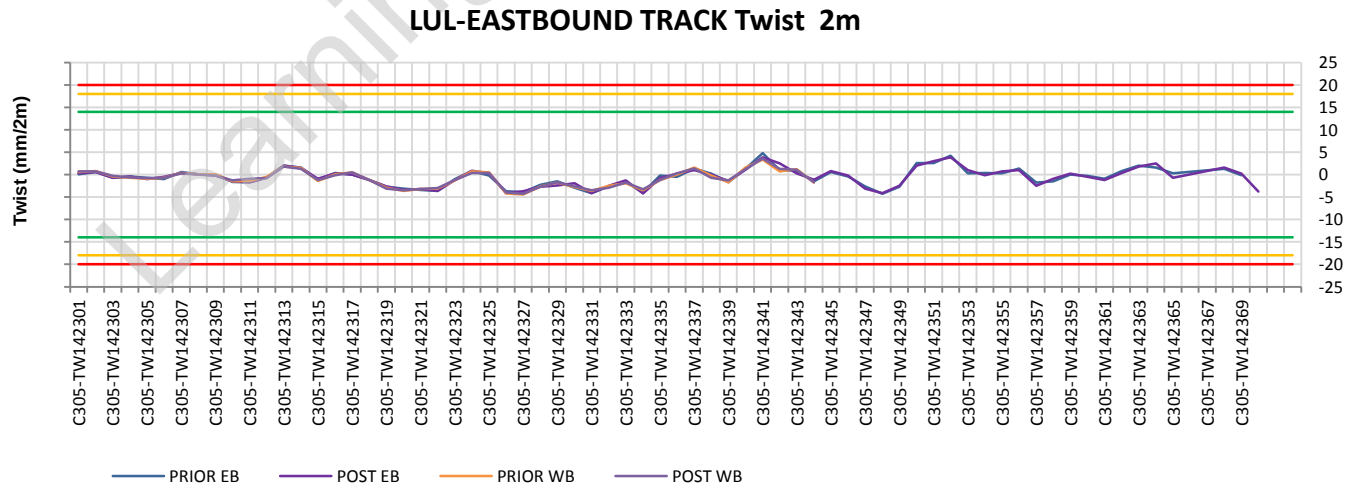
After eastbound TBM transit, the track levelling survey shows up to -3.8 mm settlement. Due to the effect of Eleanor Street Shaft works, a maximum settlement of -18.7 mm was recorded before westbound TBM transit. After westbound TBM transit, the cumulated maximum settlement noted in the area was -22.3 mm just above the westbound tunnel alignment. Green trigger was reached at Retaining Walls area (C305-LT142113 to C305-LT142115), the trigger values are specified in the C122 I&M Plan C122-OVE-C2-RGN-CR001-50024 Rev 4.0.

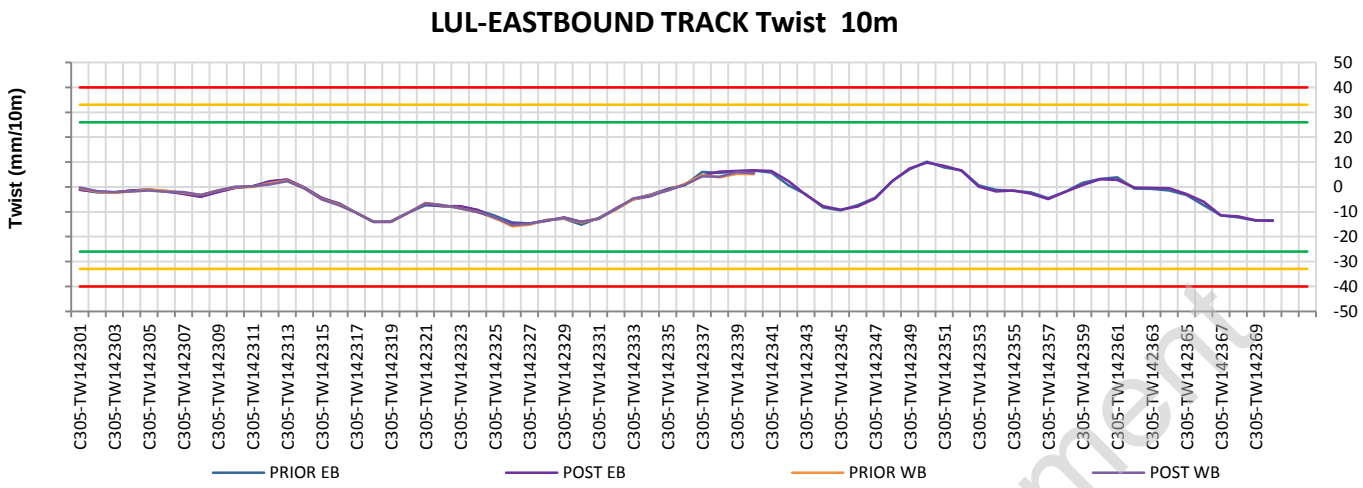
LU tracks Track Levelling Twist.

No significant changes were detected, see graphs below. All movements were within the trigger values specified in the C122 I&M Plan C122-OVE-C2-RGN-CR001-50024 Rev 4.0



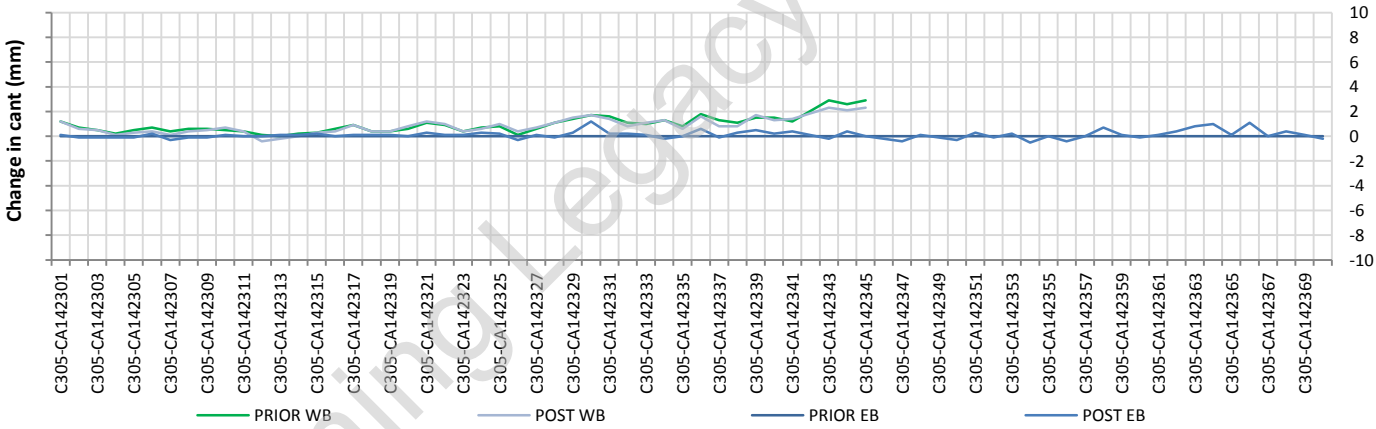


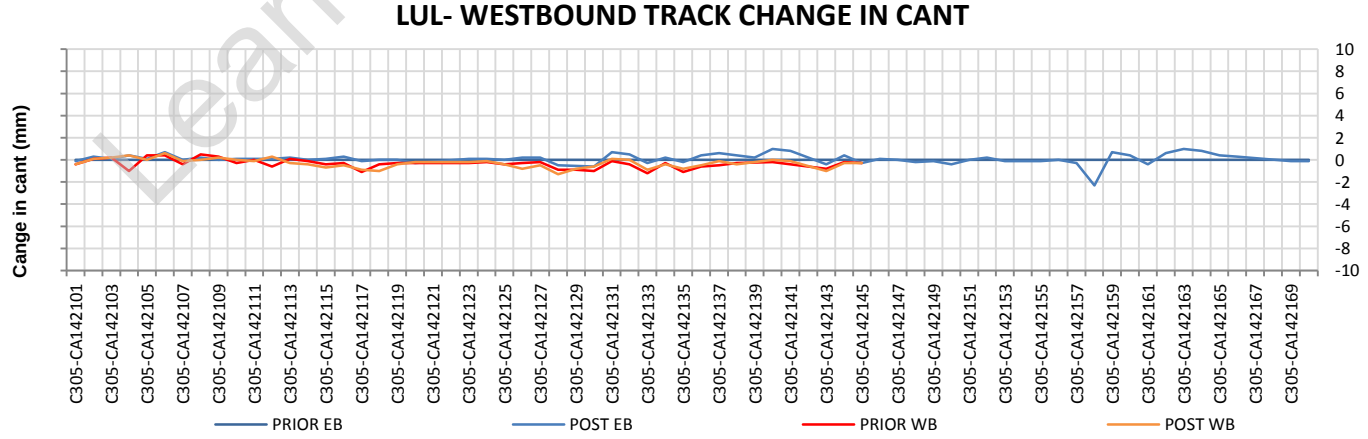




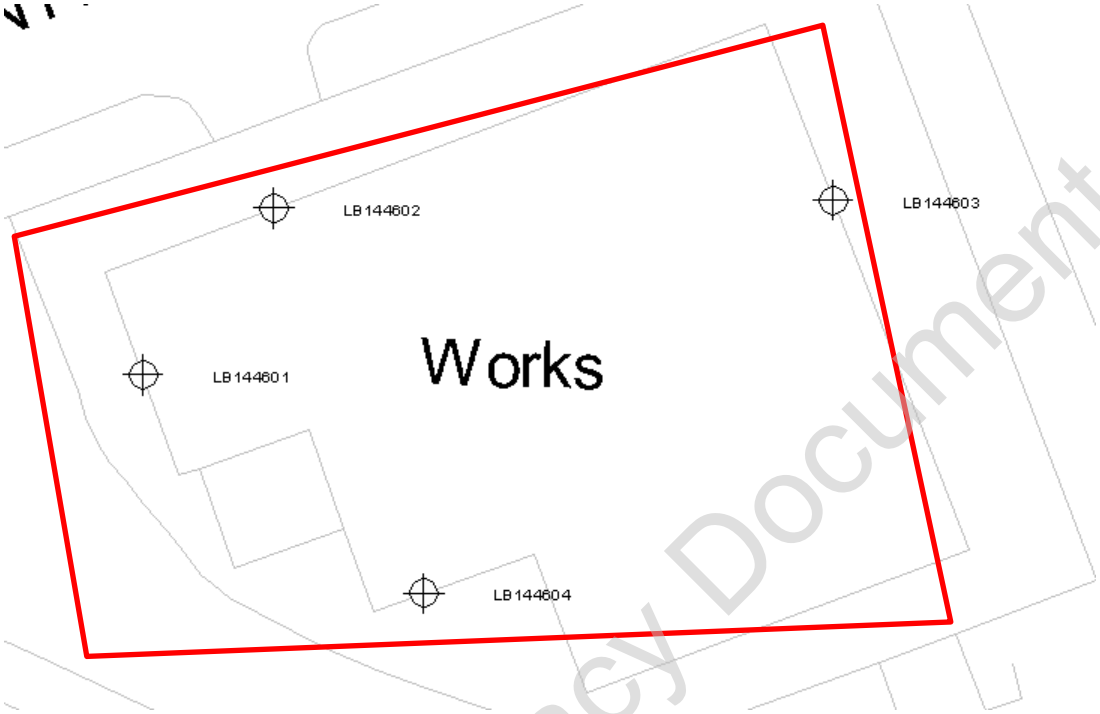
LU tracks Track Levelling Change in Cant.

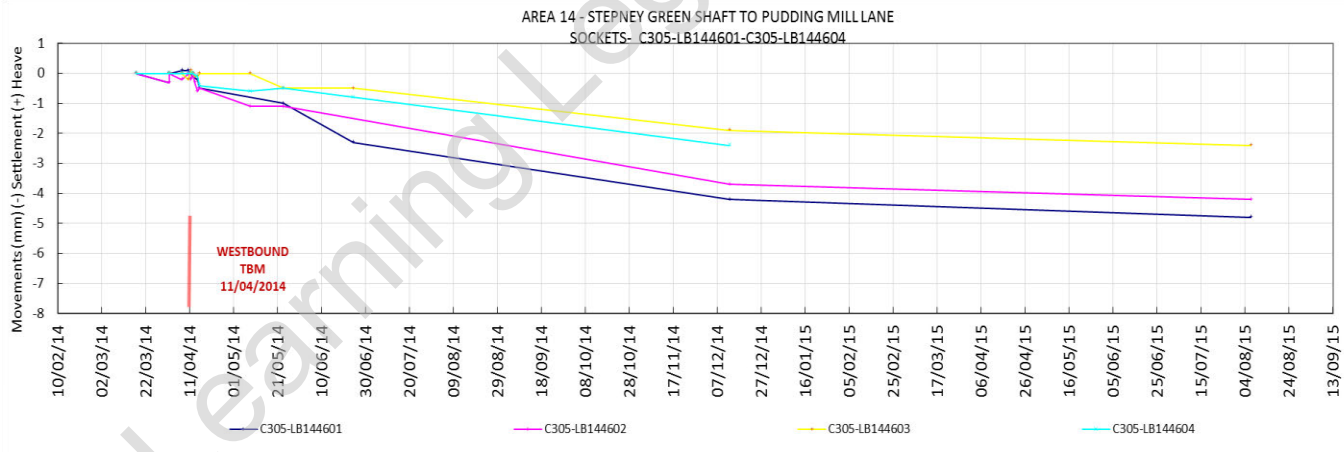
No significant changes were detected, see graphs below:





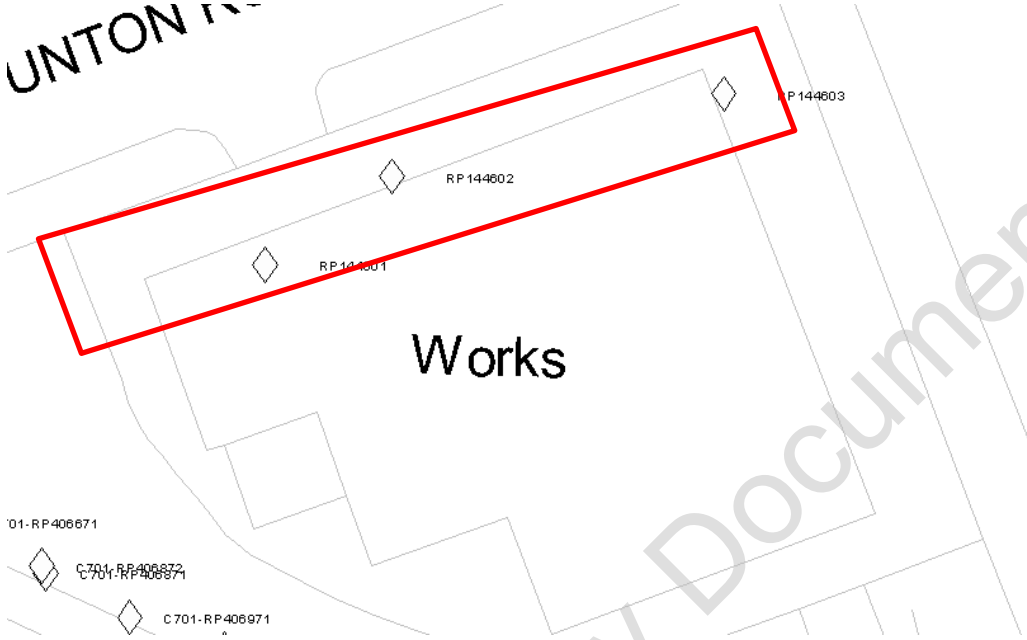
Sockets on LU/29 Campbell Road LU Substation: C305-LB144601 - C305-LB144604

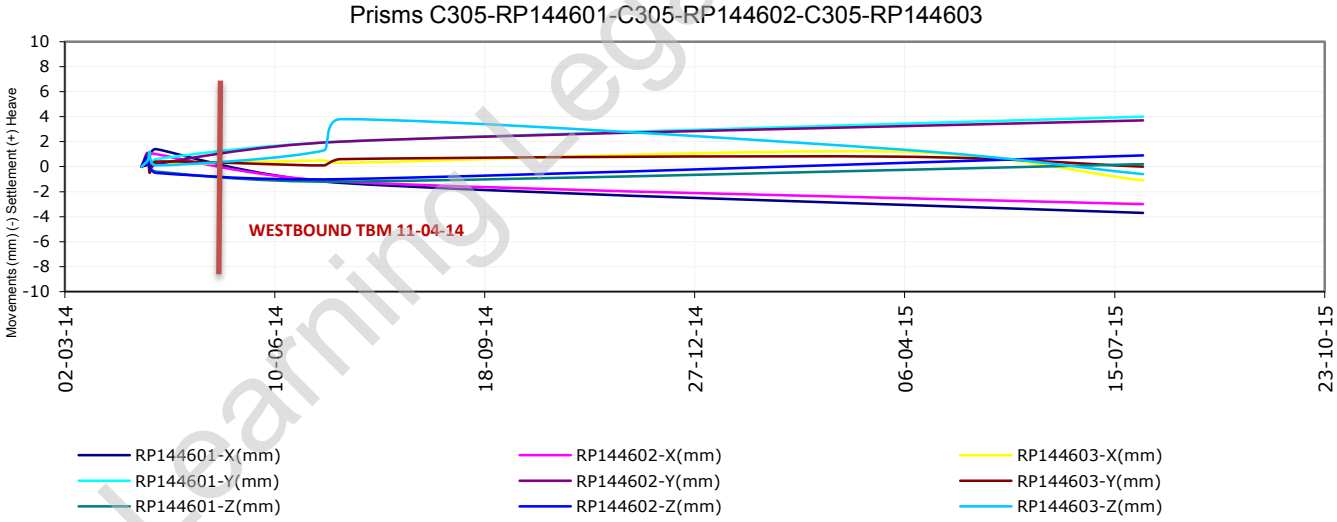




A total maximum settlement of approximately -1mm was recorded after the WB TBM and a total maximum settlement of -4.8mm was recorded by August 2015

Prisms on LU/29 Campbell Road LU Substation: C305-RP144601 - C305-RP1446003





8. SUMMARY

This review of both the C305 manual verification data and the C704 automatic system data concludes that the impact of the C305 works was within the predictions as per the trigger values specified in the C122 I&M Plan C122-OVE-C2-RGN-CR001-50024 Rev 4.0 .

The assessment concluded in the C704 Instrumentation Decommissioning Agreement (LU/28 District Line and LU/29 Campbell Road LU Substation at Eleanor Street Shaft C704-XRL-C-AAG-CR094_SH007-50002) that long term ground movements have reached an acceptably small rate, and proposes to decommission the automatic system and that manual monitoring should cease (attached as appendix A in this document).

APPENDIX A: DECOMMISSIONING AGREEMENT

Crossrail Delivery – Contract C704

C704 Instrumentation Decommissioning Agreement LU/28 District Line and LU/29 Campbell Road LU Substation at Eleanor Street Shaft

Document Number: C704-XRL-C-AAG-CR094_SH007-50002

Document History:

Revision	Date:	Prepared by:	Checked by:	Approved by:	Reason for Issue
1.0	07-10-15	Simon Nevard	Javier Gonzalez Marti	Mike Groves	First Issue
Formal Acceptance by Chief Engineers Group (CEG)				**Accepted by:**	
				Mike Black	

Contents

1 Purpose

Following detailed assessment of the impact of CRL works on the individual assets by C122 and as part of CRL's resulting risk management strategy, a comprehensive Instrumentation & Monitoring (I&M) system has been installed by C701 to monitor London Underground assets in the vicinity of the Crossrail Eleanor Street Shaft. The objective of the monitoring regime has been that of automatically monitoring the effects of the excavation-induced movements caused by Crossrail works on the Asset under consideration.

The C701 I&M automatic system was installed after the start of ESS excavation. Baseline values were applied to the data on 23/10/2013 based on manual monitoring data, which started recording before the start of CRL construction activities. Currently C704 provide monitoring data from the system to UCIMS.

The latest CRL works that affected the Asset were the C360 SCL tunnelling works (excavation and primary lining) which were finished by mid-April 2015 and dewatering, which was switched off in mid October2015.

This document aims to provide a basis on which all relevant parties can agree on to cease the automatic monitoring of the Asset.

Given its purpose, the document has been intentionally drafted by C704 as a high level reference summary to be used by decision makers and not as a detailed technical report. Comments have been provided on the quality and the reliability of the data collected, but any engineering considerations with regards to the impact induced by Crossrail works on the Asset and to stability of post-construction monitoring data will be provided by Crossrail in separate documents.

2 Scope

This document covers the extent of the District Line viaduct (LU/28) and Campbell Road LU Substation (LU/29) located in the zone of influence of Crossrail works at the Eleanor Street Shaft.

The scope of the installation is defined by I&M drawings C122-OVE-C2-DDA-CR001_Z-31136 and C122-OVE-C2-DDB-CR001_Z-32018 (see Appendix A). Note that the LU/28 viaduct structure was monitored by C701/C704 with LU/29 (Campbell Road substation) having a C701 ATS installed on it. LU/29 was monitored by C305.

LU/28 includes the structures on the District Line between:

Eastbound - D044/DEB/0260 and D044/DEB/0430

Westbound – D044/DWB/0580 and D044/DWB/0410

The extent of the District Line within the zone of influence of the Crossrail works is shown on Figure 1.

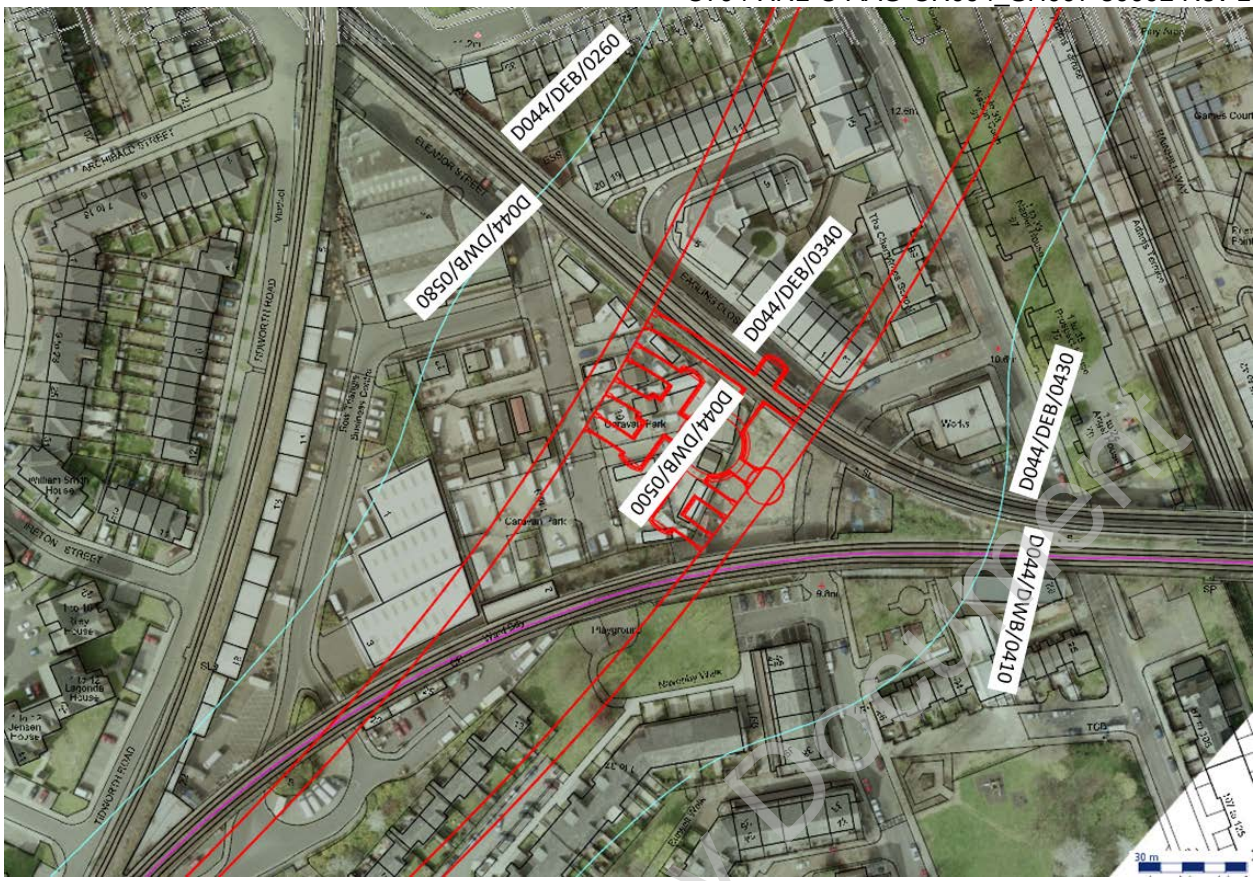


Figure 1 – District Line chainage and location of Crossrail works

3 Definitions

Asset	Specific LU interface covered by this document (LU/28 and LU/29). C701/4 only monitored LU/28 however LU/29 has an ATS installed on it. This interface includes the assets listed in C122 I&M Plan (C122-OVE-C2-RGN-CR001-50024).
CRL	Crossrail.
C122	CRL Contract that assessed excavation-induced ground movements and acts as Designer of C701/C704 I&M systems.
C701	CRL Contract responsible for the installation/maintenance of the automatic I&M system in LU/28 & LU/29.
C704	CRL Contract responsible for the maintenance and the decommissioning of the automatic I&M system in LU/28 & LU/29. Power isolation between power source and the Power and Communications Enclosure will be carried out by LUL.
C305	CRL Contract responsible for the construction of the Drive Z TBM running tunnels

C360	CRL Contract responsible for the construction of the Eleanor Street shaft and associated adits.
I&M	Instrumentation & Monitoring.
LUL	London Underground Limited.
Predicted zone of influence of Crossrail works	Area located within the predicted 1mm greenfield ground surface settlement contour associated with Crossrail works.
Relevant parties	Parties requested to formally agree decommissioning of the automatic I&M system presented in this document: - *London Underground Limited (LUL)*; - *CRL Chief Engineers Group (CEG)*.

4 The Asset: District Line viaduct at Bow Road to Bromley-by-Bow (LU/28) and Campbell Road LU Substation (LU/29)

The following sections comprise a brief description of the District Line viaduct in the vicinity of the Eleanor Street Shaft and present the Crossrail works that have affected this asset.

Further details are included in *C122 Assessment Report: Assessment of Ground Movement Effects on LU/28 District Line Viaduct between Bow Road and Bromley-by Bow due to the Construction of Eleanor Street Shaft and Temporary Shaft* (C122-OVE-C2-ASM-CR094_WS109-50002 Rev 1.0).

4.1 Asset Description

Figure 2 below shows the assets to be monitored under the LU/28 and LU/29 interface. A comprehensive list of these assets is included in *Instrumentation and Monitoring Plan: LU/28 District Line Viaduct Bow road to Bromley-by-Bow and LU/29 Campbell Road LU substation (C122-OVE-C2-RGN-CR001-50024)*.

The methodology used to assess the predicted impact of Crossrail works on the District Line Viaduct and a summary of the results of these assessments are presented in *C122 Assessment Report: Assessment of Ground Movement Effects on LU/28 District Line Viaduct between Bow Road and Bromley-by Bow due to the Construction of Eleanor Street Shaft and Temporary Shaft (C122-OVE-C2-ASM-CR094_WS109-50002) and Assessment of Ground Movement Effects: LU/29 Campbell Road LU substation (C122-OVE-C2-RAN-D044-00001).*

Figure 2 - Location plan for the interface between LU District Line viaduct (LU/28) and Crossrail elements

4.2 Crossrail Works with the potential to affect the Asset

The construction of Crossrail running tunnels (part of the C305 Running Tunnel Contract, Drive Z, from Pudding Mill lane and Stepney Green Shaft) and the construction of the Eleanor Street Shaft and adits were identified by C122 as the construction works with the potential of affecting the Asset. The Crossrail eastbound (EB) and westbound (WB) running tunnels pass below the District Line Viaduct.

The Eleanor Street Shaft and adjoining SCL tunnels are located to the southwest of and below the District Line Viaduct.

5 C701/C704 I&M System in LU/28 & LU/29

The automatic I&M system to be installed in the asset under consideration was specified on drawings C122-OVE-C2-DDA-CR001_Z-31136 and C122-OVE-C2-DDB-CR001_Z-32018, see Appendix A.

Monitoring frequencies and trigger values were specified in *Instrumentation and Monitoring Plan: LU/28 District Line Viaduct Bow road to Bromley-by-Bow and LU/29 Campbell Road LU substation (C122-OVE-C2-RGN-CR001-50024).*

The installation of this system in LU/28 and LU/29 has been carried out by C701. LU/29 was not monitored by C701 however an ATS was fixed to the structure.

As described in detail in C701-ITM-C-RGN-CR094_SH007-50002 (C701 Installation Report for the monitoring system at LU District Line at Eleanor Street Shaft), the I&M system comprises the following:

- 2 No. RTS (ATS ESDL_5 and ESDL_7) and associated brackets fixed to the external District Line Viaduct.

- 1 No. RTS (ATS ESDL_6) and the associated brackets fixed to the Campbell Road Substation.
- A total of 94 No. prisms have been fixed to the District Line Viaduct structure.
- Datalogger boxes (5 No.). The associated data-logging equipment has been fixed to the viaduct walls within 15m of the relevant ATS.
- Transformer enclosure (1 No.) fixed to the Campbell Road Substation wall.
- 34 No. BRE bolts for manual monitoring of the viaduct have also been installed, see Appendix D for location plan.

As-built drawings are available in Appendix B.

Further details are included in C701-ITM-O1-GMS-CR094_SH007-50001 Rev 3.0 (C701 Method Statement for LU/28 and LU/29).

6 Monitoring Results vs. CRL Construction Works

The present document has been intentionally drafted by C704 as a high level reference summary to be used by decision makers and not as a detailed technical report. It is not the purpose of this document to analyse in detail the construction monitoring results for all monitored parameters, compare these results with associated trigger values and provide engineering considerations with regards to the impact induced by Crossrail works on the Asset will be provided by the Main Contractor in separate documents.

A brief summary of current trends for LU/28 is included in Appendix C. Monitoring results for arrays 19, 28, 43, 55, 71 are presented (see Appendix C for array locations). Arrays 28 and 55 are directly above the Crossrail tunnels.

The CRL works that have affected the Asset are dated:

- Construction of temporary shaft: July 2013 to September 2013
- Construction of main shaft: July 2014 to November 2014
- Construction of the SCL tunnels: September 2013 to April 2014, November 2014 to April 2015.
- Drive Z Eastbound TBM Passage: October 2013.
- Drive Z Westbound TBM Passage: April 2014
- Dewatering associated with the Eleanor Street Shaft: July 2013 to October 2015.
- Piling associated with ESS headhouse: August 2015 to September 2015.

The construction monitoring settlement data recorded by the automatic system indicate a clear correlation with the two TBM drives (see graphs in Appendix C). The impact of the excavation of the Eleanor Street shaft can also be observed.

The post-construction data indicates a general stabilisation, with less than 1.25mm of settlement for the majority of the monitored area between May and August 2015, which is of similar magnitude to the accuracy of the monitoring system. Data suggests settlement of less than 2.5mm over this period of time in some areas (see contour plots), however data seems to have since stabilised across the site, with settlement less than 1.25mm since late April 2015.

The data recorded from the automatic system during both construction and closeout monitoring regimes are considered reliable. Non construction-related variations are within the expected repeatability for this kind of system. The slight heave observed around array 71 since July 2015 (see Appendix C) is due to network instability (slow, small movement of reference C701-RP2COM12-CR102) and should be disregarded and considered as stable.

7 Assessment of Closeout Trends

Excavation of the Eleanor Street shaft and its adits was completed by C360 in April 2015. Dewatering is the last CRL reated works with the potential to affect, this is due to continue into October 2015. The post-dewatering monitoring will start at this point and the total time period of moniroting required is dependet on recovery speed.

As highlighted in Section 6, almost no movement has been recorded since 26/04/2015. Current closeout trends suggest a general stabilisation across the monitored area with very limited residual (post-construction) variations that are within the accuracy of the monitoring system. Trends since 26/04/2015 are lower than the 2mm/year criterion defined by C122 as the trigger for decommissioning (see graphs in Appendix C).

Taking the above in to consideration it is recommended that the automated monitoring of LU/28 provided by C704 can cease. Beyond this it is proposed that manual monitoring of the prisms installed on the viaduct to be carried out at weekly intervals until one month after the dewatering has been switched off followed by 2 monthly surveys to demonstrate stable conditions.

Should measurement of longer term movements still be required, the manual monitoring can continue at quarterly intervals. In addition, INSAR Satellite technology along the route can be used to provide further assessment of the long term settlement. At the moment CRL is processing the data every three months, using two or more images per month (a total of 6 or more images every three months period). The INSAR data will be presented by CRL, and they will present it to the Asset Owner in the form of “hitmaps” (or contour plots). It should also be noted that the C360 contractor will be undertaking longer term monitoring of this asset to monitor the effects of the dewatering.

8 Reference Documents

- C701-ITM-O1-GMS-CR094_SH007-50001 (C701 Method Statement for LU/28 & LU/29)
- C701-ITM-C-RGN-CR094_SH007-50002 (C701 Installation Report for LU/28 & LU/29)
- C122-OVE-C2-ASM-CR094_WS109-50002 (C122 Assessment Report for LU/28)
- C122-OVE-C2-RAN-D044-00001 (C122 Assessment Report for LU/29)
- C122-OVE-C2-RGN-CR001-50024 (C122 I&M Plan for LU/28 & LU/29)
- C122-OVE-C2-DDA-CR001_Z-31136 (C122 I&M Drawing)
- C122-OVE-C2-DDB-CR001_Z-32018 (C122 I&M Drawing)

9 Appendices

Appendix A – I&M Drawings C122-OVE-C2-DDA-CR001_Z-31136 & C122-OVE-C2-DDB-CR001_Z-32018

Appendix B – I&M As-Built Drawing C701-ITM-C-RGN-CR094_SH007-50002

Appendix C – Summary of monitoring results for LU/28

Appendix D – Manual monitoring locations

APPENDIX A – I&M Drawings

NR Mainline: Fenchurch St. - West Ham London, Tilbury and Southend Viaduct Viaduct real time/data logged monitoring (e.g. 3D geodetic prism) is installed, monitored and reported by C701. Precise levelling points on rails are installed by C701. C305/ C360 to undertake manual viaduct and track monitoring during TBM Passage or nearby SCL construction. Refer to elevation G and section G1 on Drg No. C122-OVE-C2-DDB-CR001_Z-32018

District Line Viaduct Viaduct realtime monitoring (i.e 3D Geodetic prism) is Installed, monitored and reported by C701. Precise levelling points on rails are installed and baselined by C701. C305/ C360 to undertake manual viaduct and track monitoring during TBM passage or nearby SCL construction. Refer to elevation G and section G1 on Drg No. C122-OVE-C2-DDB-CR001_Z-32018

Eleanor Street Shaft

I & M by Shaft Contractor Details to be confirmed

DLR Bow Church Tunnel Automated total stations and 3D geodetic prism installation and monitoring by C305. C305 to also undertake manual track monitoring during TBM passage or nearby SCL construction. Refer to section Q on Drg No. C122-OVE-C2-DDB-CR001_Z-32021

Safety Health and Environmental Information:

1. C122 Design Team consider, that over and above the general C701 specific hazards and risks identified in the General Notes Drawing (cited in item 3 below), there are no location-specific hazards and risks additional to those normally associated with the work covered by this drawing which a competent contractor would not be readily aware of.

2. For SHE information relevant to all C701 I&M works see:CDM Risk Register: C122-OVE-N3-LRG-CRG02-00001.

3. All location-specific drawings should be read in conjunction with the SHE content of General Notes Drawing No C122-OVE-C2-DDJ-CR001_Z-31002.

4. These notes are based on experienced and competent contractors carrying out the works using an approved safe method of working.

Legend

Parties Responsible for the installation of the I & M
- C701
- Others

General
- Tunnel Alignment
- Track shoe monitoring at 2m centres Shading omitted from plans of tube tunnels for clarity
- Track shoe monitoring at 3m centres Shading omitted from plans of tube tunnels for clarity

Settlement Contours
- 1mm Settlement Contour
- 10mm Settlement Contour

Existing Structures
- Bored Tunnels
- Cut & Cover Tunnels
- Structures with I & M Commitments
- Mains Sewer (greater than 1.5mØ)

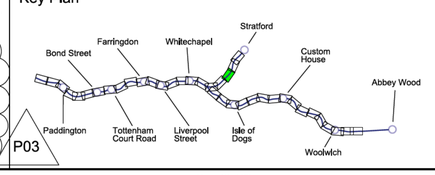
Instruments and Monitors
- Automated Total Station
- Basset Convergence System
- Electrolevel Beams
- Extensometer - Rod
- Inclinometer
- Inclinometer - Electrolevels
- Piezometer - Vibrating Wire
- 3D Geodetic Prisms
- Sockets - BRE Type - Structure
- Studs - Precise Ground Levelling
- Sparse Monitoring Point
- Monitoring Transect in Tunnels
- Deep Datum

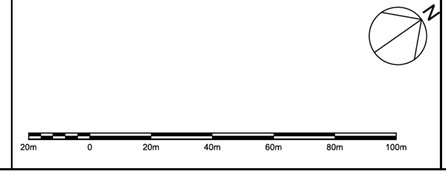
Rev.	Date	Descrlption	By	Chkd	App	Auth
P01	25/11/2010	Issued for Information	JG	RB	RM	—
P02	14/10/2011	Minimum requirement for Instrumentation and Monitoring	AR	JA	SR	—
C01	09/11/2011	Issued as Fit for construction	AR	JA	SR	IT
P03	24/05/2012	Revised to reflect access Issues	GK	DW	RM	-

Notes

1. For Instrumentation & Monitoring general notes, schedule and monitoring frequency, refer to Drg Nos. C122-OVE-DDJ-CR001_Z-31002 and C122-OVE-DDJ-CR001_Z-31007.
2. The Instrumentation on the L.T.S. viaduct shall be developed to deal with restriction on access and visibility based on a scheme for each viaduct face. The Instrumentation layout are as follows
   - i) Original scheme
   - ii) Alternative scheme with a prism on the inside face of parapet, and a BRE socket on the external face of the viaduct, see drawing C122-OVE-C2-DDB-CR001_Z-32018.
   - iii) Combined scheme with the original layout but with alternative layouts where access/ visibility cannot resolved.

Key Plan





Crossrail Limited
25 Canada Square
Canary Wharf
London
E14 5LQ
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www.crossrail.co.uk

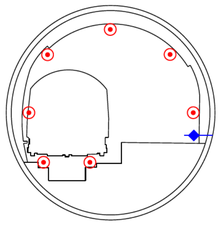
Contract: Bored Tunnels (Alignment and Track)
Originator: Ove Arup & Partners Limited
Location: Crossrail General
Title: Instrumentation & Monitoring Combined I & M Routewide Plan Sheet 36 of 38 C701
By: G.KAVANAGH
Chk: D.WILSON
App: R.MCCRAE
Auth: —
Scale: 1:1000@ A1
Drawing and CAD file No: C122-OVE-C2-DDA-CR001_Z-31136
Rev: P03
Suitability: S4

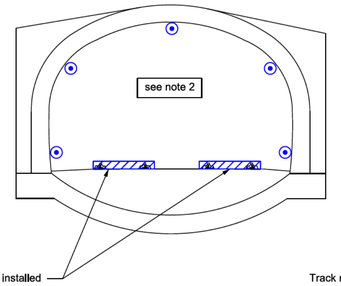
RESTRICTED

Fit for authorisation

Copy Approved for Design - Created: 24-MAY-2012

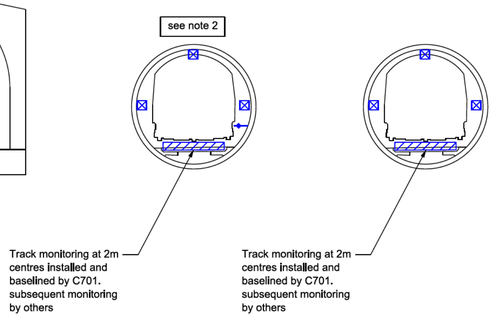
Transects at 10m centres. Track monitoring at 2m centres for LU and 3m centres for NR tracks





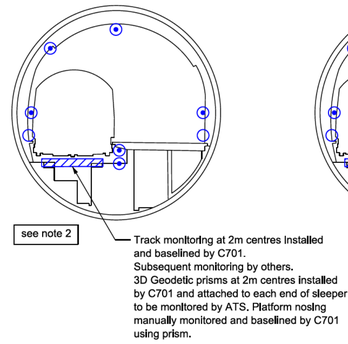
Section A - A
Indicative Cross-Section of LU / TCR Transects

Section B - B
Indicative Cross-Section of cut & cover tunnel

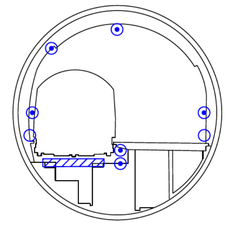


Section C - C
Indicative Cross-Section of LU running tunnel Central, Victoria, Bakerloo, Northern, Jubilee & Piccadilly lines
Electrolevels to be continuous and extend between extents of transects (except in station tunnels)

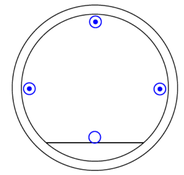
Section C1 - C1
Indicative Cross-Section of LU running tunnel Central Line at Pudding Mill Lane



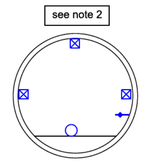
Section D - D
Indicative Cross-Section of LU platform tunnel Central, Northern and Piccadilly lines



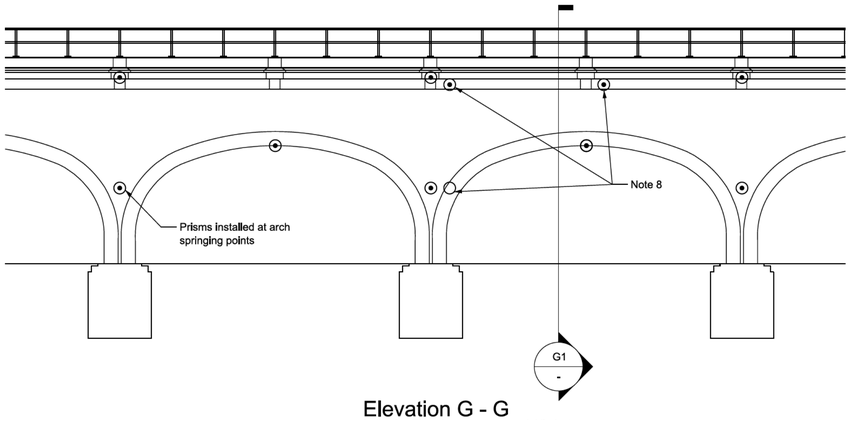
Section D1
Indicative Cross-Section of Northern Line platforms for Moorgate Station



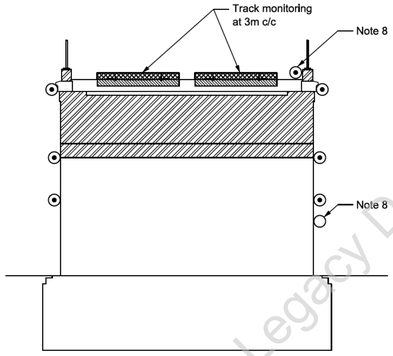
Section E - E
Indicative Cross-Section of BT Statutory Authority Service tunnel, Post Office tunnel and general cable tunnels



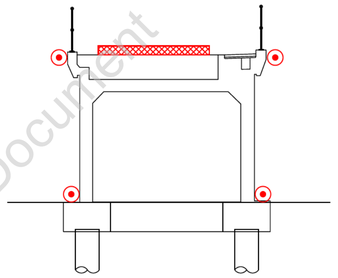
Section F - F
Cross passages



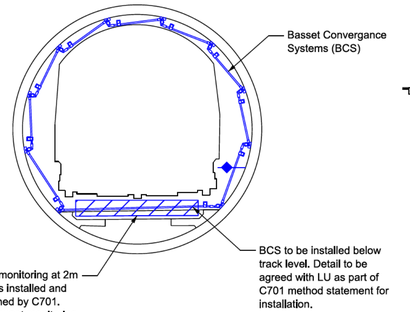
Elevation G - G
Indicative Elevation, masonary arch Viaducts
-DLR Limehouse Viaduct. (by others)
-NR Tilbury & southened Viaduct (by C701)
-LU District Line Viaduct- Bow Road to Bromley by Bow (by C701)



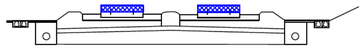
Section G1
Indicative Elevation, masonary arch Viaducts
-DLR Limehouse Viaduct. (by others)
-NR Tilbury & southened Viaduct (by C701)
-LU District Line Viaduct- Bow Road to Bromley by Bow (by C701)



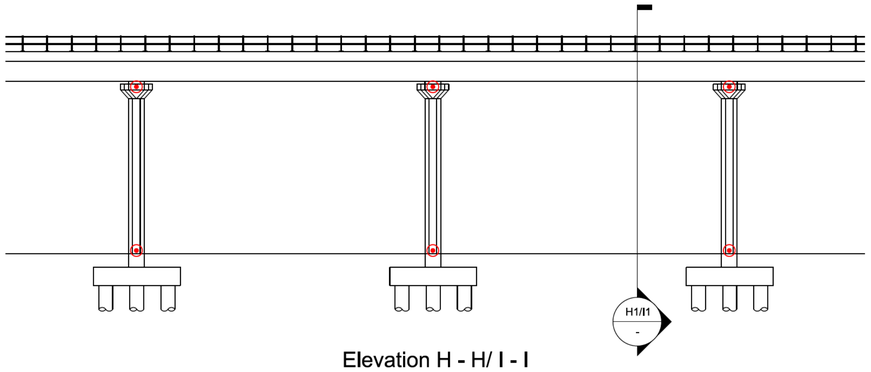
Section J - J
Indicative Cross - Section of DLR Piled Abutments



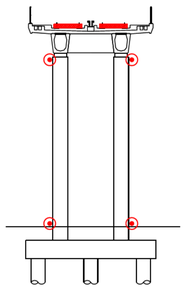
Section K - K
Indicative Cross-Section of LU running tunnel Central, Victoria, Bakerloo, Northern, Jubilee & Piccadilly lines at Basset convergance system location.



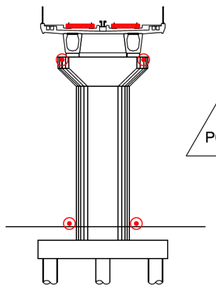
Section L - L
Indicative Cross Section of DLR at grade



Elevation H - H/ I - I
Indicative Elevation, DLR RC Piled Viaduct
H- Double RC Columns
I- Single RC Column

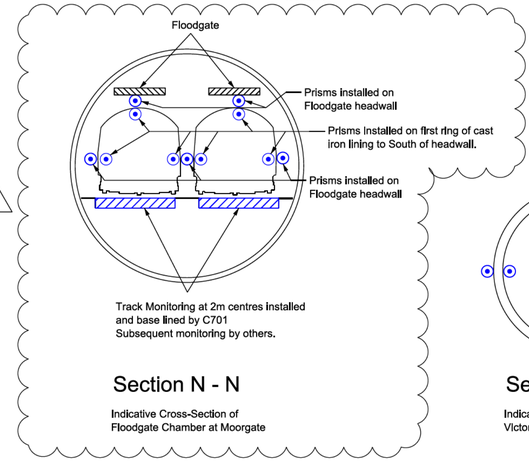


Section H1
Indicative Section, DLR RC Piled Viaduct Double RC Columns

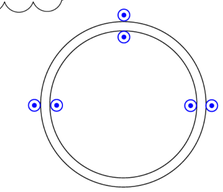


Section I1
Indicative Section, DLR RC Piled Viaduct Single RC Pier

P05



Section N - N
Indicative Cross-Section of Floodgate Chamber at Moorgate



Section M - M
Indicative Cross-Section of Victoria Line headwall transect

Legend
- Installed and monitored By C701
- By Others
- 3D Geodetic Prism (Transects @ 10m c/c)
- Sockets - BRE Type - Structure (Transects @ 10m c/c)
- Track shoe monitoring at 2m centres
- Track shoe monitoring at 3m centres
- Electrolevel Beam
- Retro reflective target

Rev.	Date	Description	By	Chkd	App	Auth
P01	03/11/2010	First Issue	JG	RB	RM	
P02	25/11/2010	—	JG	RB	RM	
P03	21/10/2011	Minimum requirement for Instrumentation and Monitoring	AR	JA	SR	
C01	09/11/2011	Issued as Fit for construction	AR	JA	SR	IT
P04	24/05/2012	Revised to reflect access issues	GK	DW	RM	-
C02	04/10/2012	Issued as Fit for construction	GK	DW	RM	MA
P05	07/12/2012	Issued as Fit for construction	GK	JA	RM	-

Notes
1. This drawing is to be read in conjunction with drawing numbers C122-OVE-C2-DDA-CR001_Z-31101 to 31138 inc.
2. Prisms, BRE sockets electrolevels and retro reflective targets are installed and baselined by C701. Precise track monitoring installed and baselined by C701. Others to carry out subsequent manual monitoring (precise levelling) of tunnel / station transects and track.
3. Locations of instrumentation are indicative only and subject to confirmation on site by Contractor following verification of location of utilities, obstructions and access.
4. Prisms, Retro reflective targets to be installed in positions to satisfaction of LU and NR and to avoid risk of reflectance and potential to affect Tube drivers.
5. Positions of ATS to be selected by C701 and proposed for acceptance of Project Manager.
6. Generic principles of monitoring identified in sections B-B and C-C. Cross sections vary along alignment from Farringdon to Liverpool St and exact configuration should be agreed between C701 and Project Manager. In some instances section B-B of C122-OVE-C2-DDB-CR001_Z-32018 may be more appropriate.
7. Platform nosing to be marked at 2.00m c/c (LU) or 3.0m c/c (NR) over specified length (in line with the precise levelling points) to show positions for platform train interface surveys.
8. The instruments shown are to be installed as an alternative to the orginal scheme. The alternative scheme consists of a prism on the inside face of the parapet, to be monitored with track ATS, and a BRE socket on the external face at each arch support if access is available.

Crossrail Limited
25 Canada Square
Canary Wharf
London
E14 5LQ
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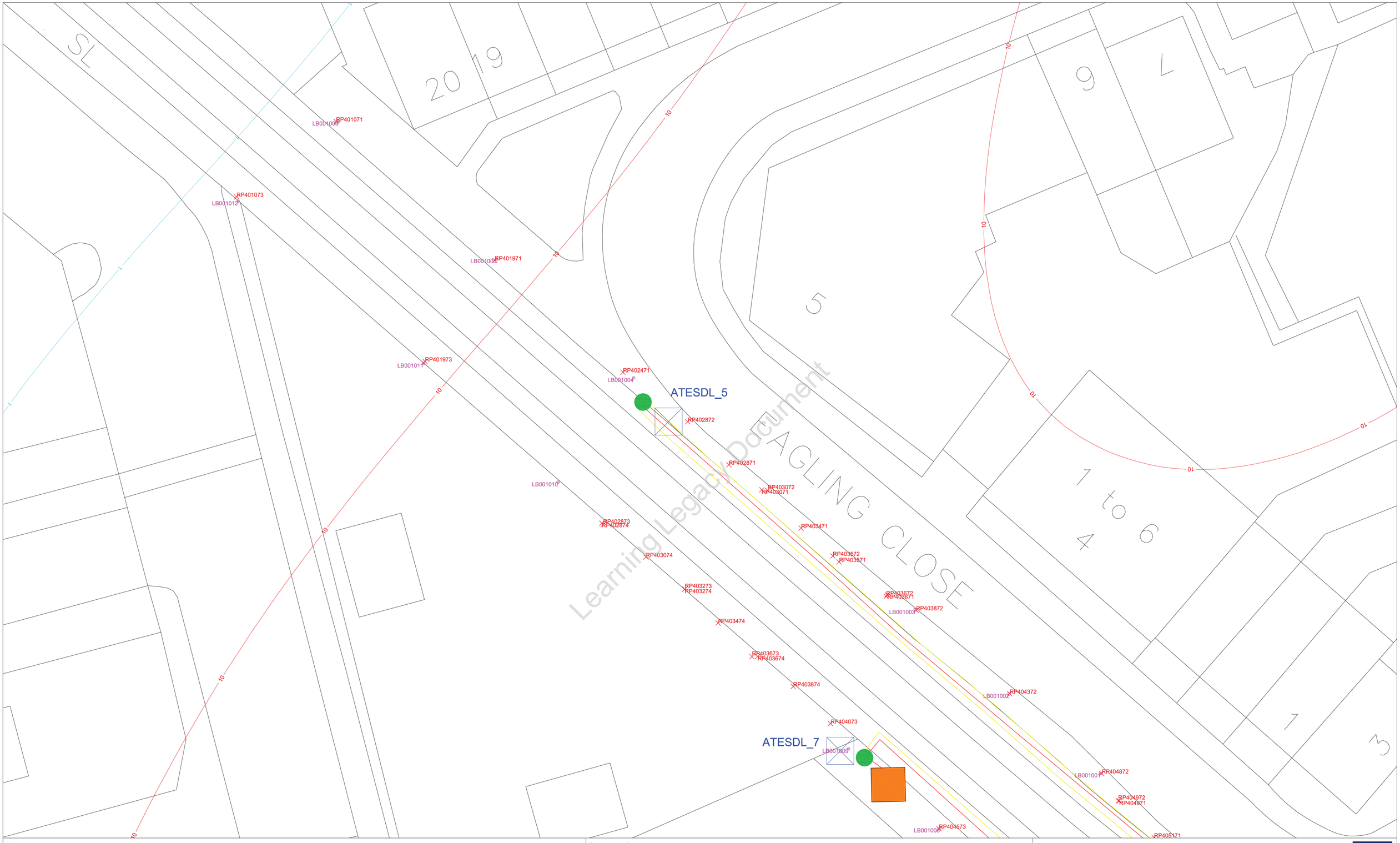
www.crossrail.co.uk

Contract: Bored Tunnels (Alignment and Track)
Originator: Ove Arup & Partners Limited
Location: Crossrail General
Title: Instrumentation and Monitoring
Combined I & M for Asset Protection
Indicative Cross-Sections
C701
By: G.KAVANAGH
Chk: J.APTED
App: R.MCCRAE
Auth: —
Scale: NTS@ A1
Drawing and CAD file No: C122-OVE-C2-DDB-CR001_Z-32018
Rev: P05
Suitability: S4

Fit for authorisation
RESTRICTED
Copy Approved for Design - Created: 12-DEC-2012

APPENDIX B – I&M As-Built Drawings



Notes

1 - Note 1

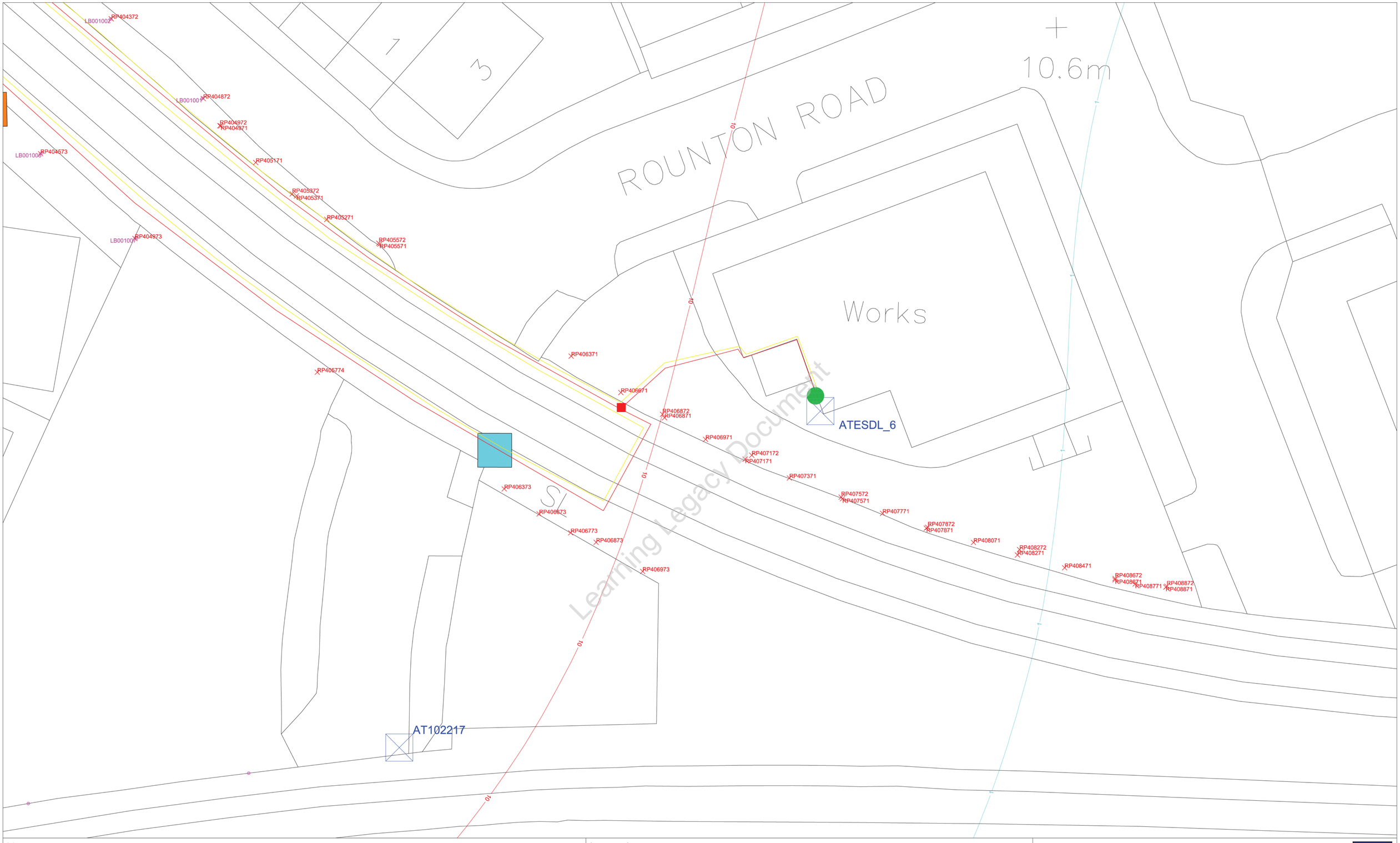
Legend

- Robotic Total Station
- 3D Geodetic Prism
- BRE Level Monitoring Point
- Itmsoil installed power enclosure
- Itmsoil installed power junction box
- Itmsoil installed communications enclosure
- Itmsoil installed data logger enclosure
- 45V ELV 3 Core 4mm² SWA Power Cable
- 3 x 2 x 0.22mm² LSZH Communications Cable

itmsoil
itmsoil
UCKFIELD EAST SUSSEX TN22 1QL ENGLAND
Tel: +44(0)1825 765044
Fax: +44(0)1825 761740

Crossrail

Drawn	CK	Title	C701 - District Line at Eleanor Street As Built Drawing	
Checked	BO			
Date	04-09-13	Paper	Drawing No.	Sheet
Rev	01	A1	C701-ITM-ESDL-ASB-001	01
Scale	1:125	Job Number	228-005	



Notes

1 - Note 1

Legend

- Robotic Total Station
- 3D Geodetic Prism
- BRE Level Monitoring Point
- Itmsoil installed power enclosure
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Crossrail

Drawn	CK	Title	C701 - District Line at Eleanor Street As Built Drawing	
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Rev	01	A1	C701-ITM-ESDL-ASB-001	02
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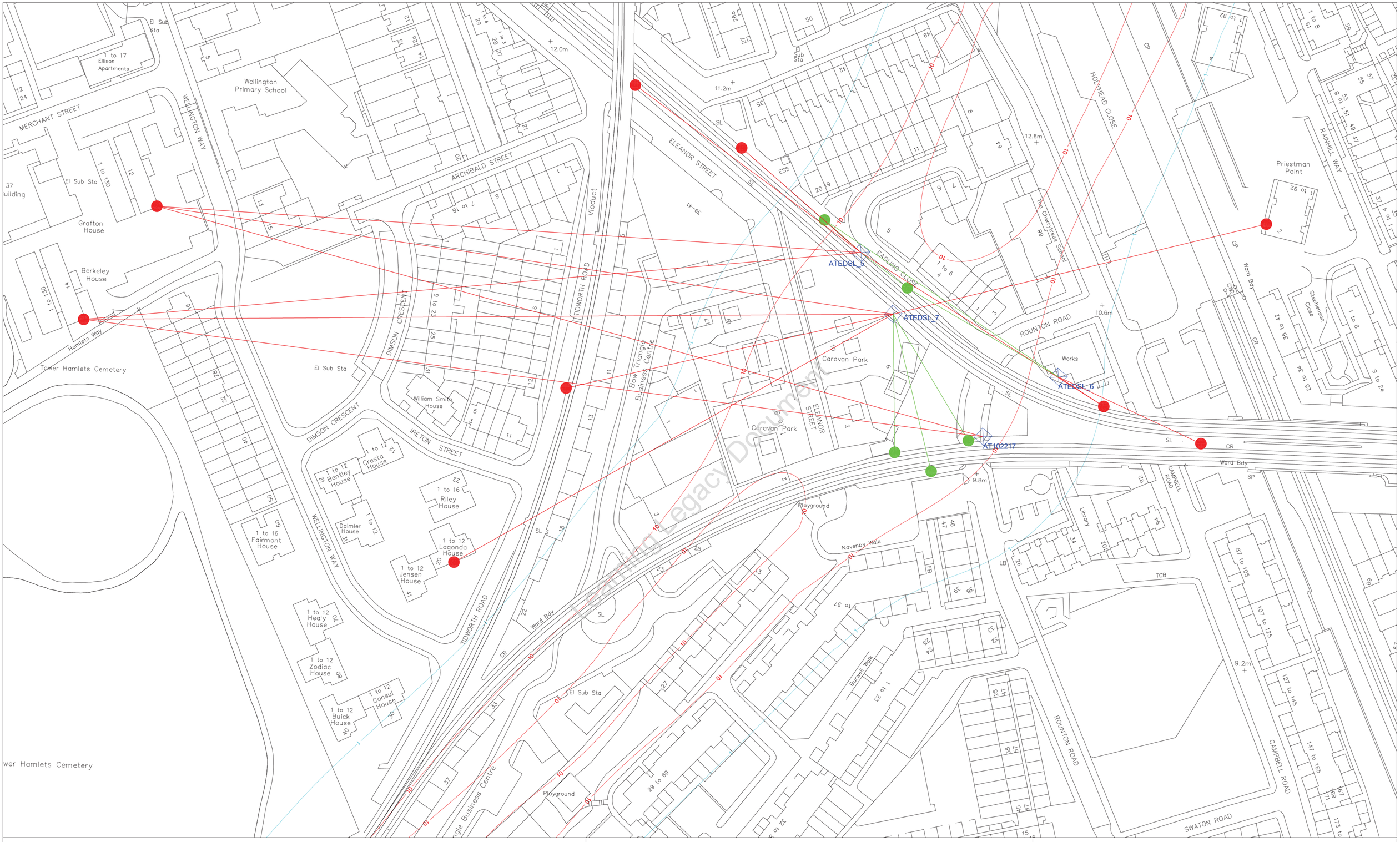

Notes

1 - Note 1

Legend

- Robotic Total Station
- Reference Prism
- Common Prism

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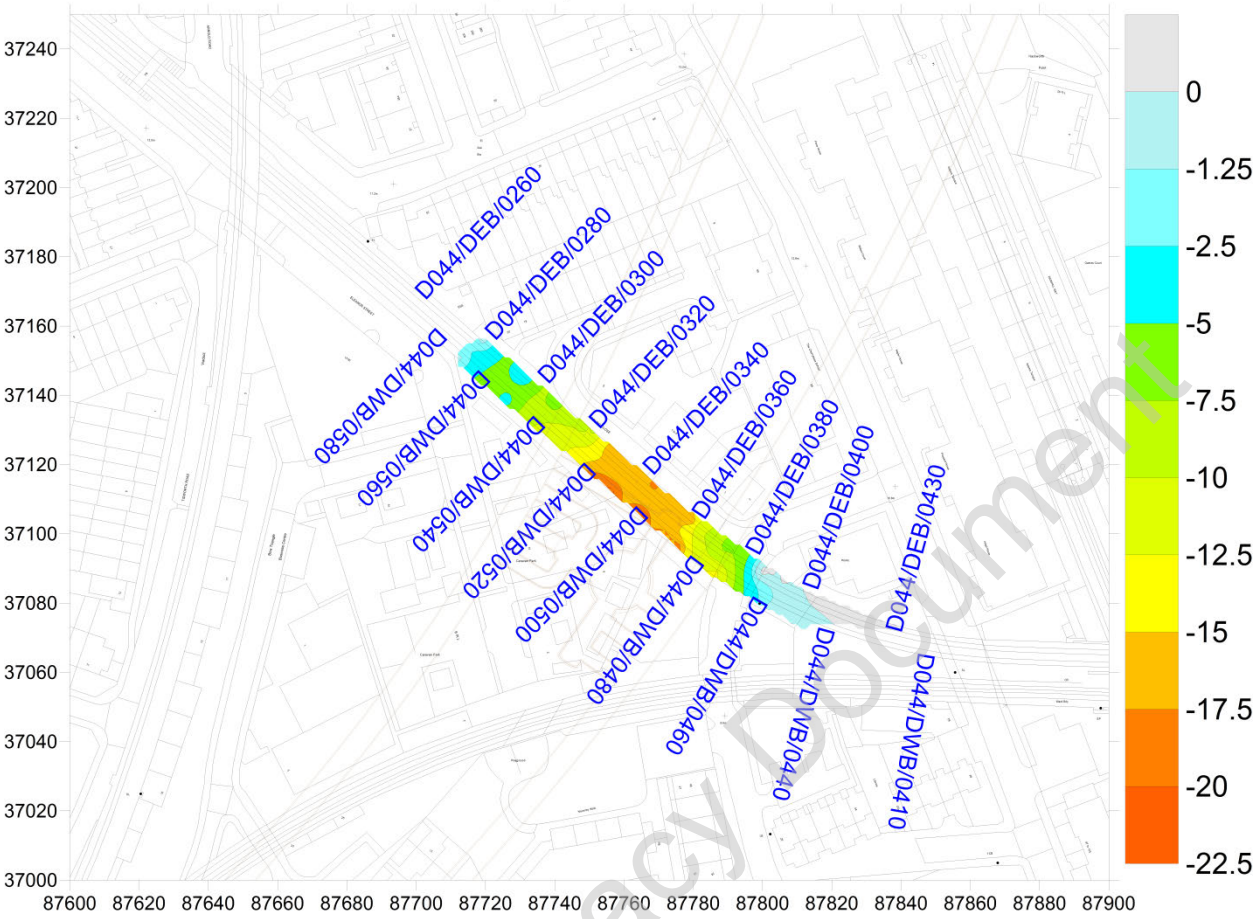
Drawn	CK	Title	C701 - District Line at Eleanor Street Network Drawing
Checked	BO		
Date	30-09-13	Paper: A1	Drawing No.: C701-ITM-ESDL-NET-001
Rev	01		Sheet: 03
Scale		Job Number	228-005

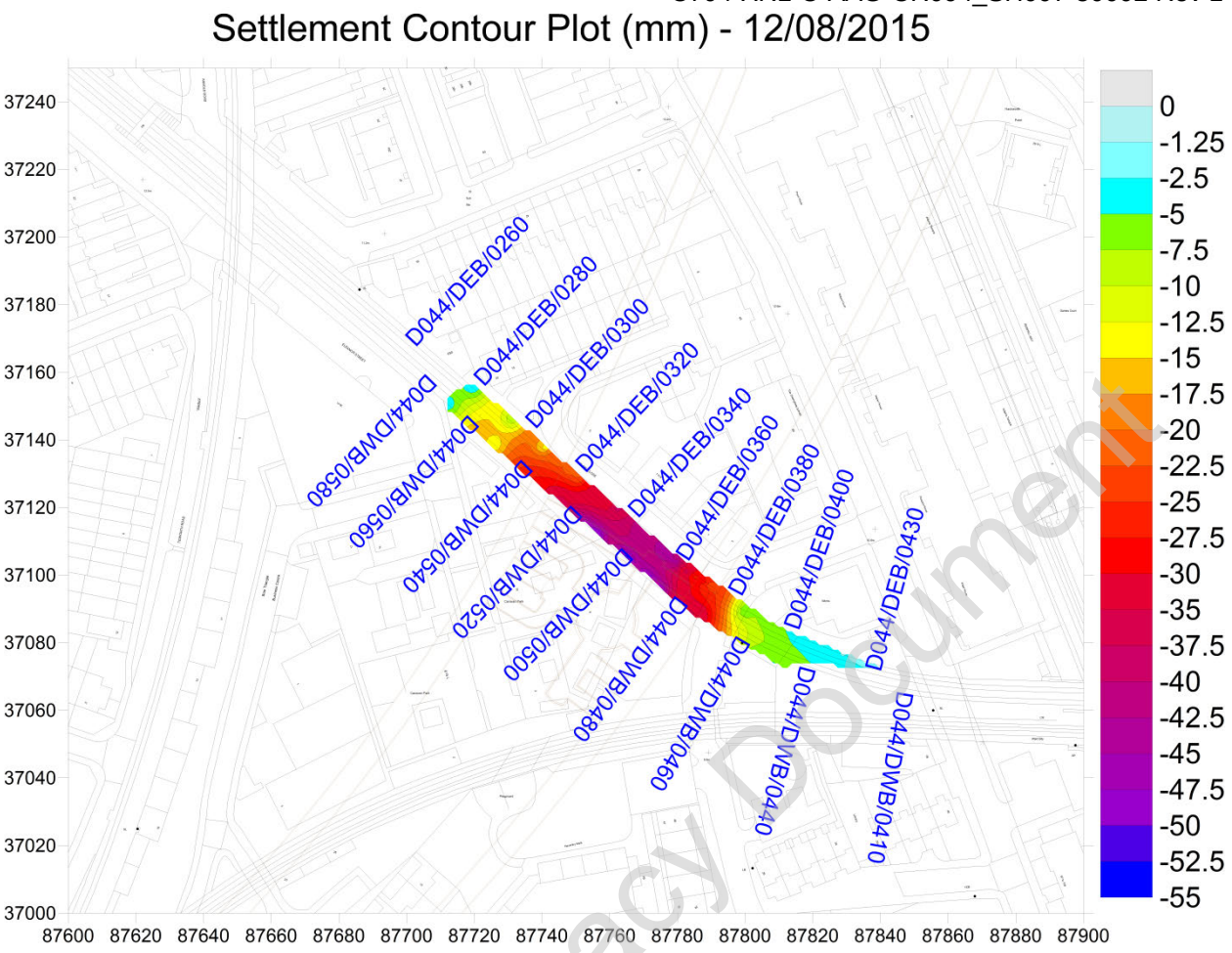
APPENDIX C – Summary of Monitoring Results

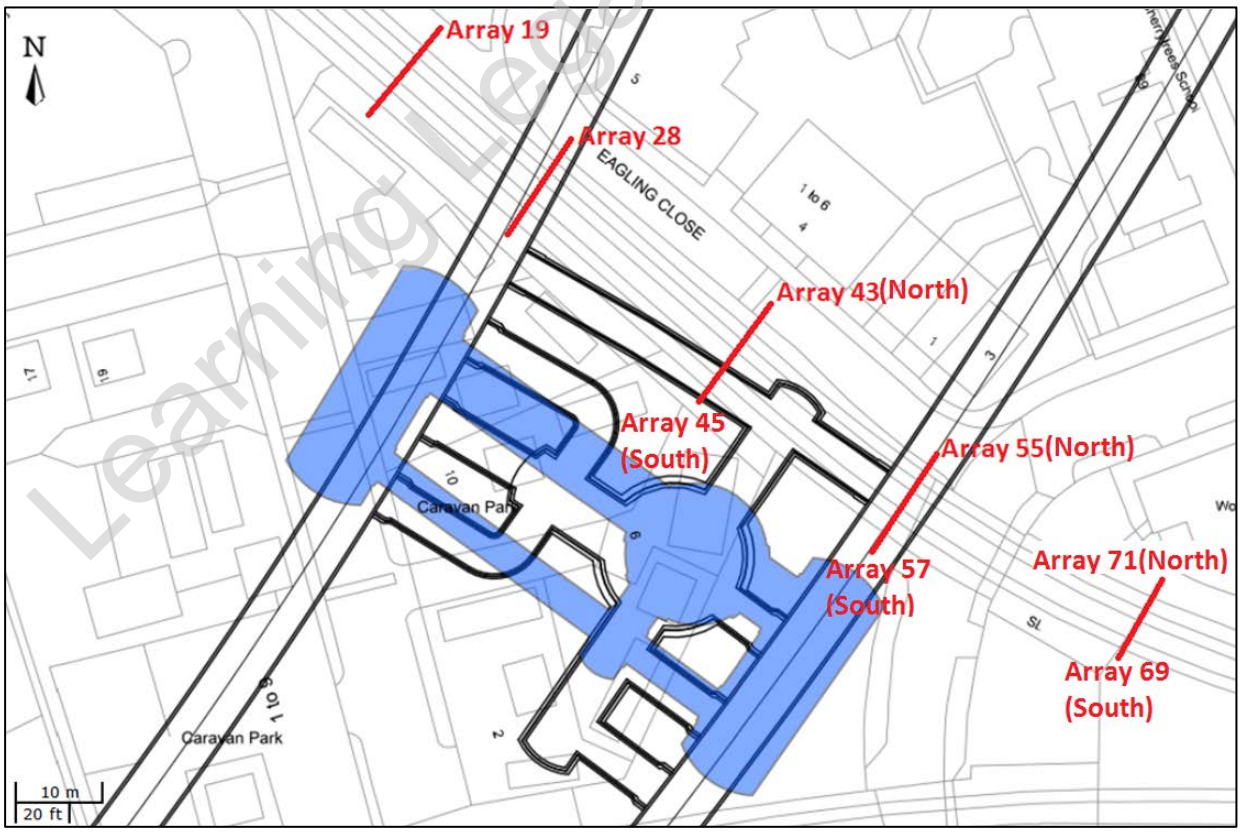
Differential Movement Z (mm) from 12/05/2015 to 12/08/2015

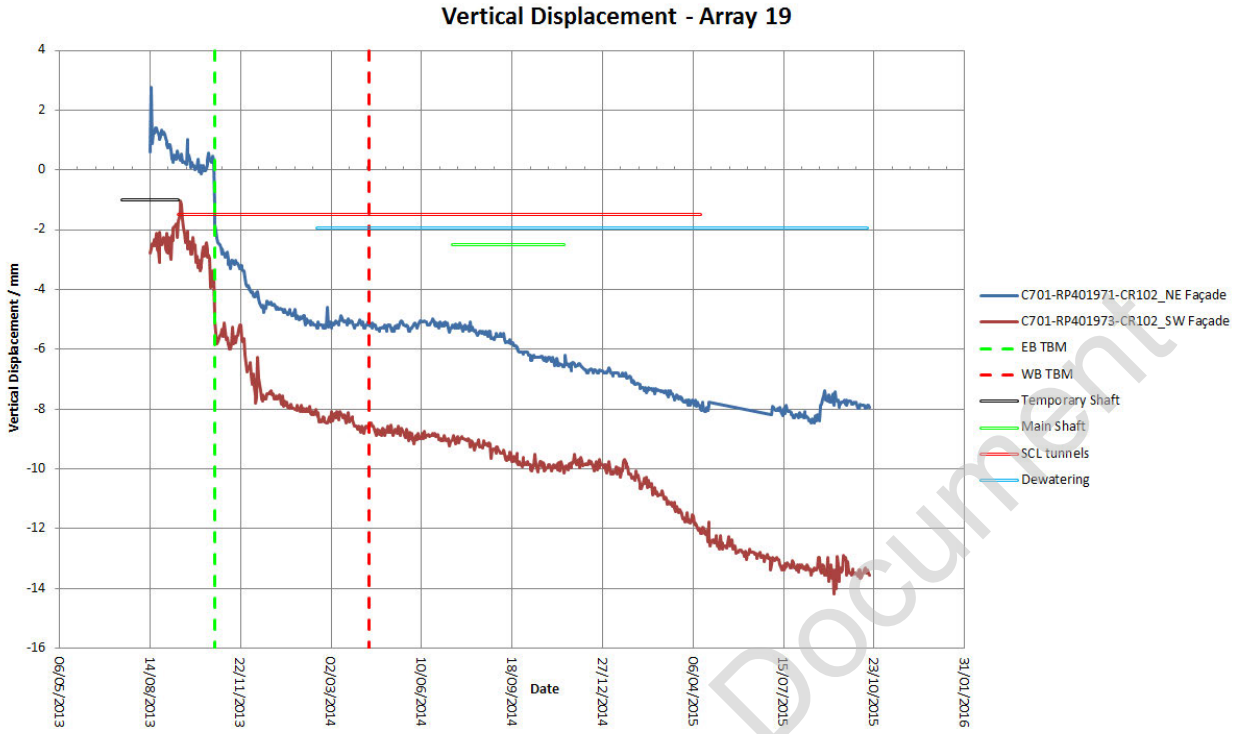
Differential Movement Z (mm) from 12/02/2015 to 12/08/2015

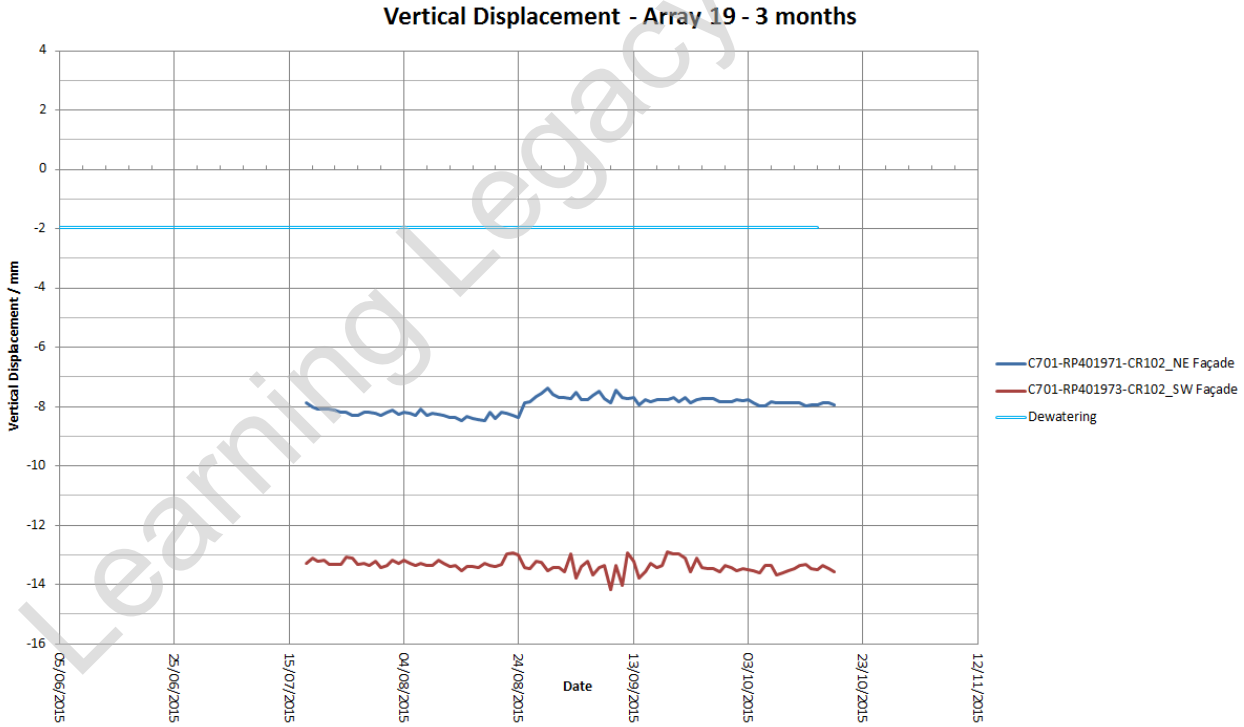
Differential Movement Z (mm) from 12/08/2014 to 12/08/2015

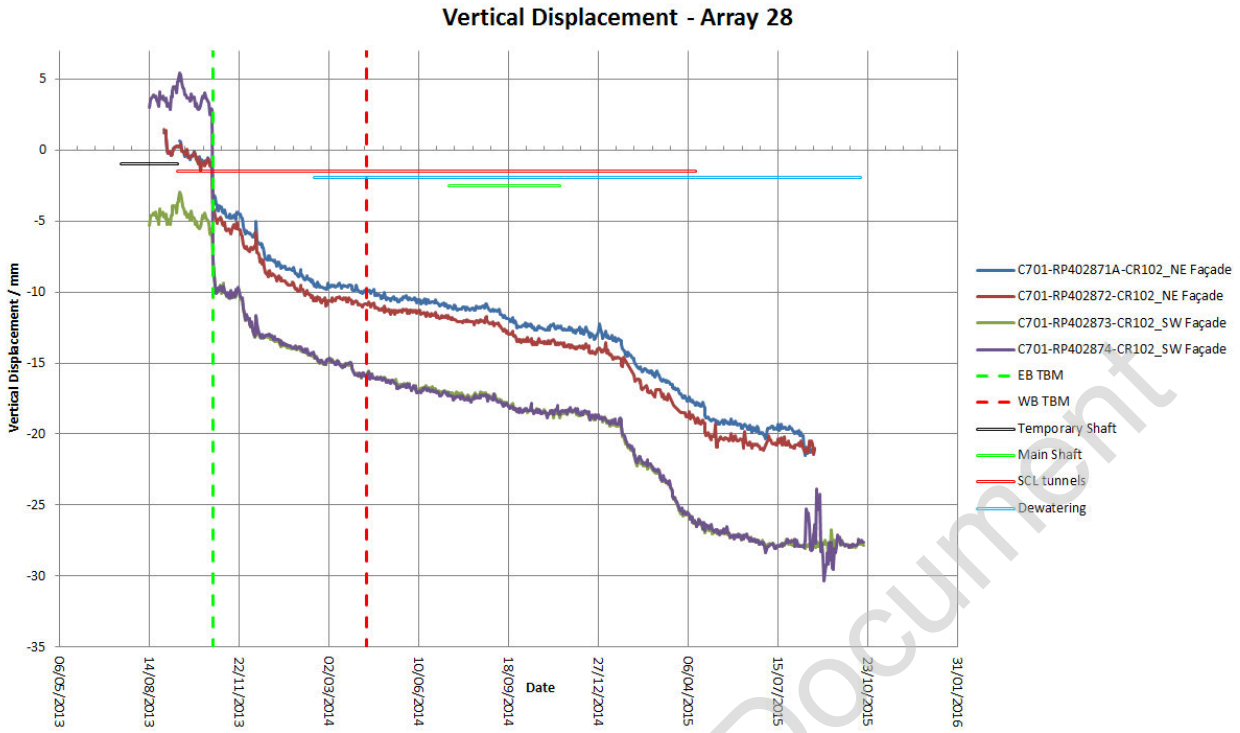


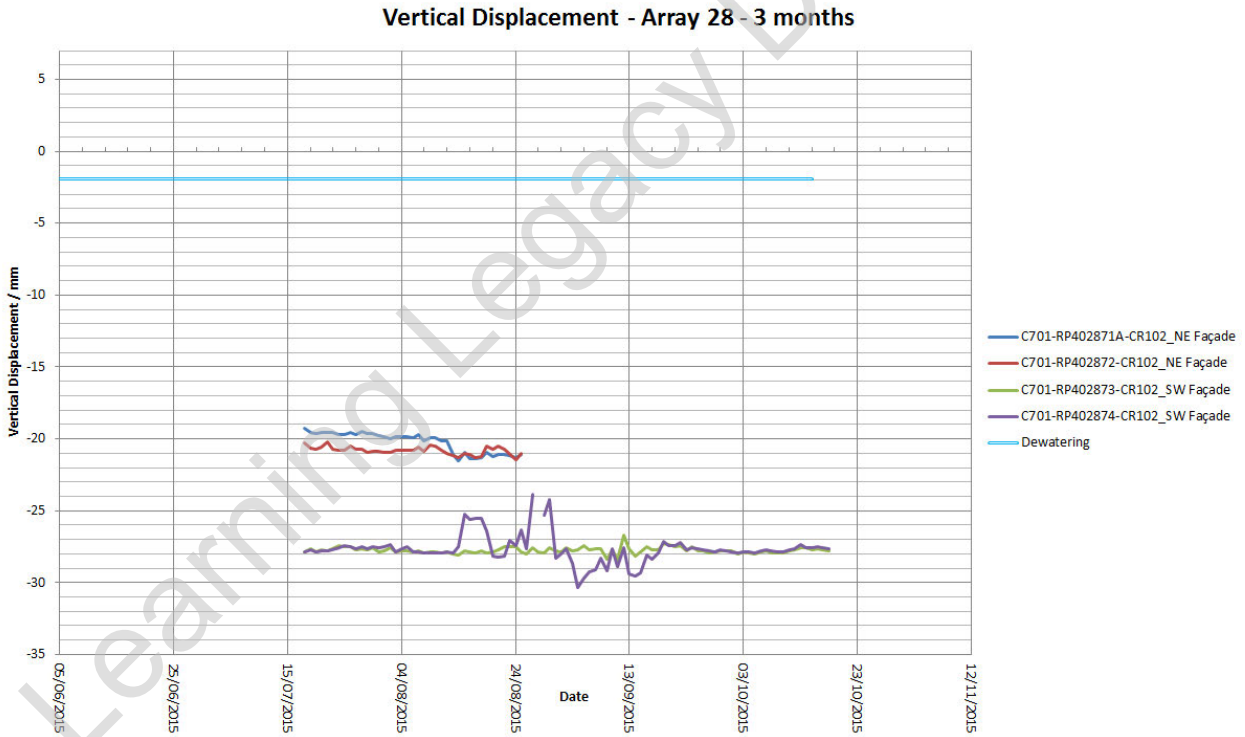


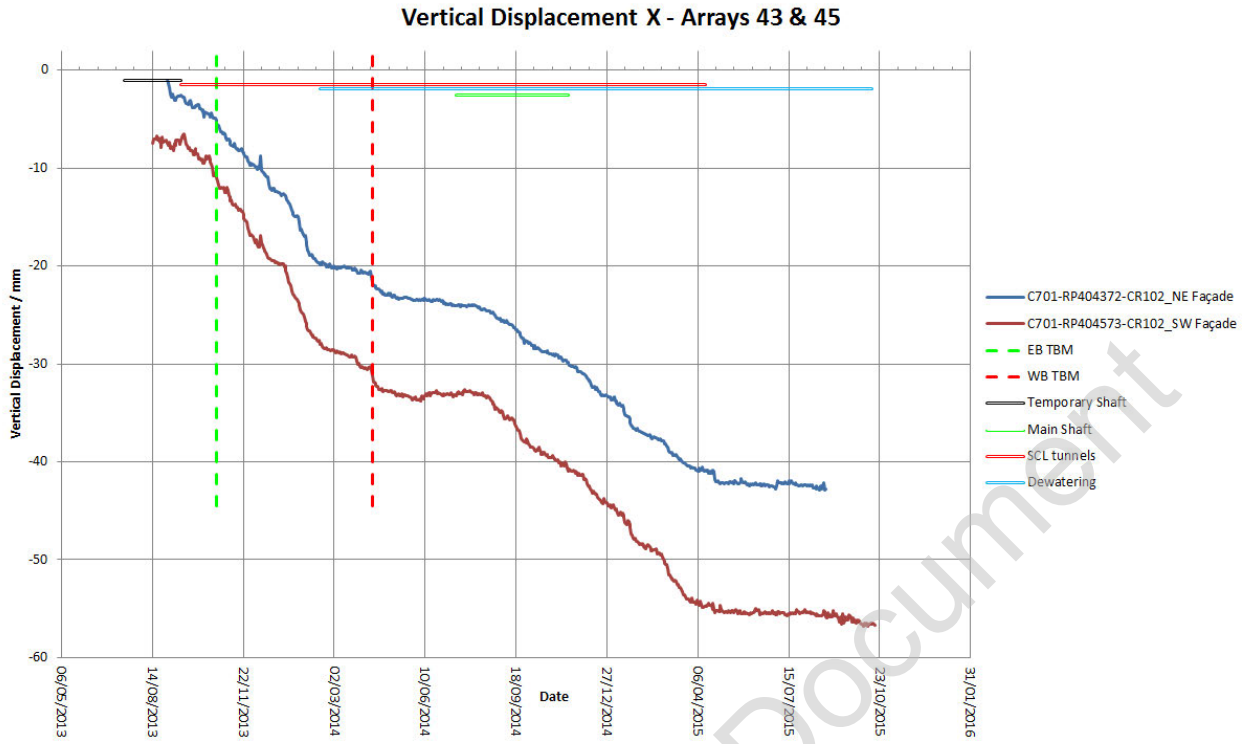


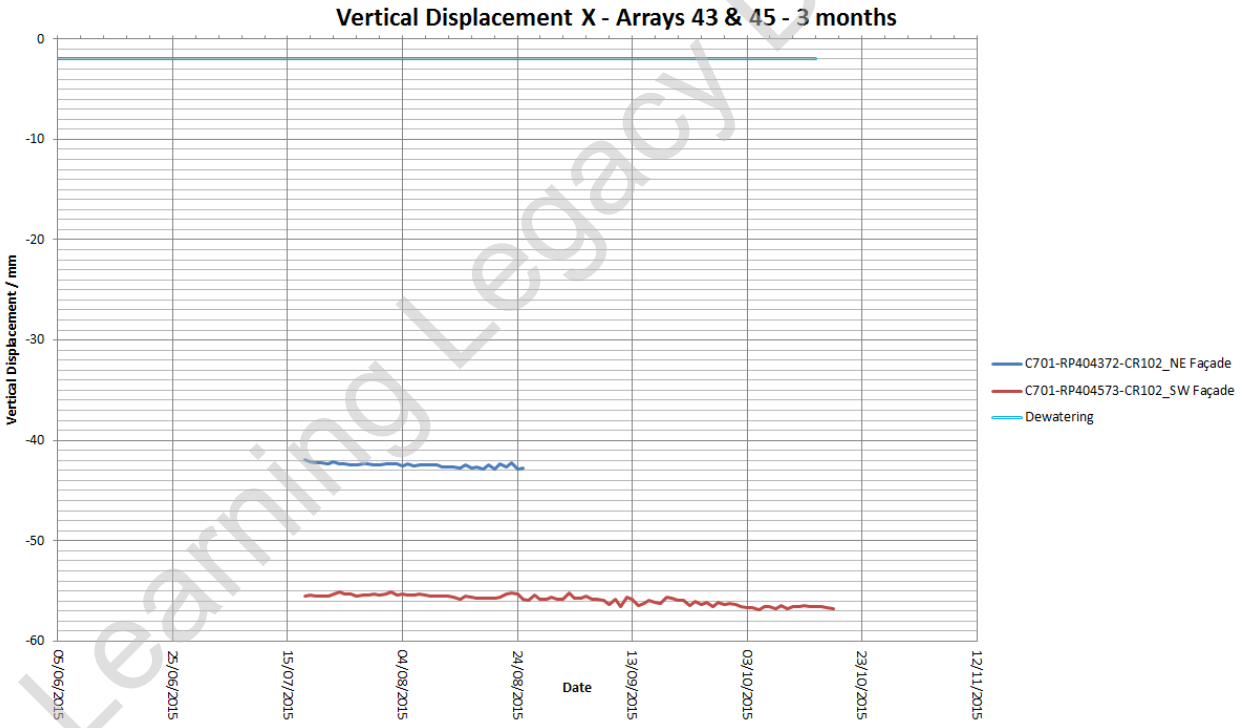


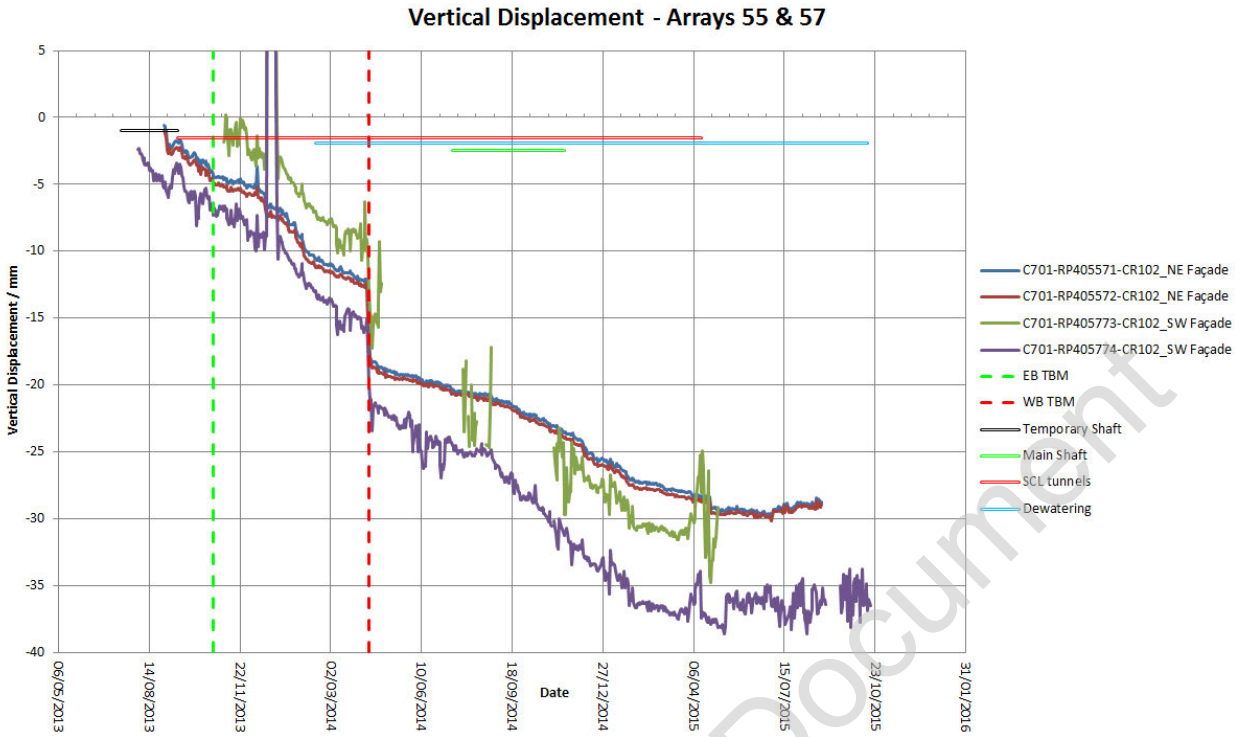


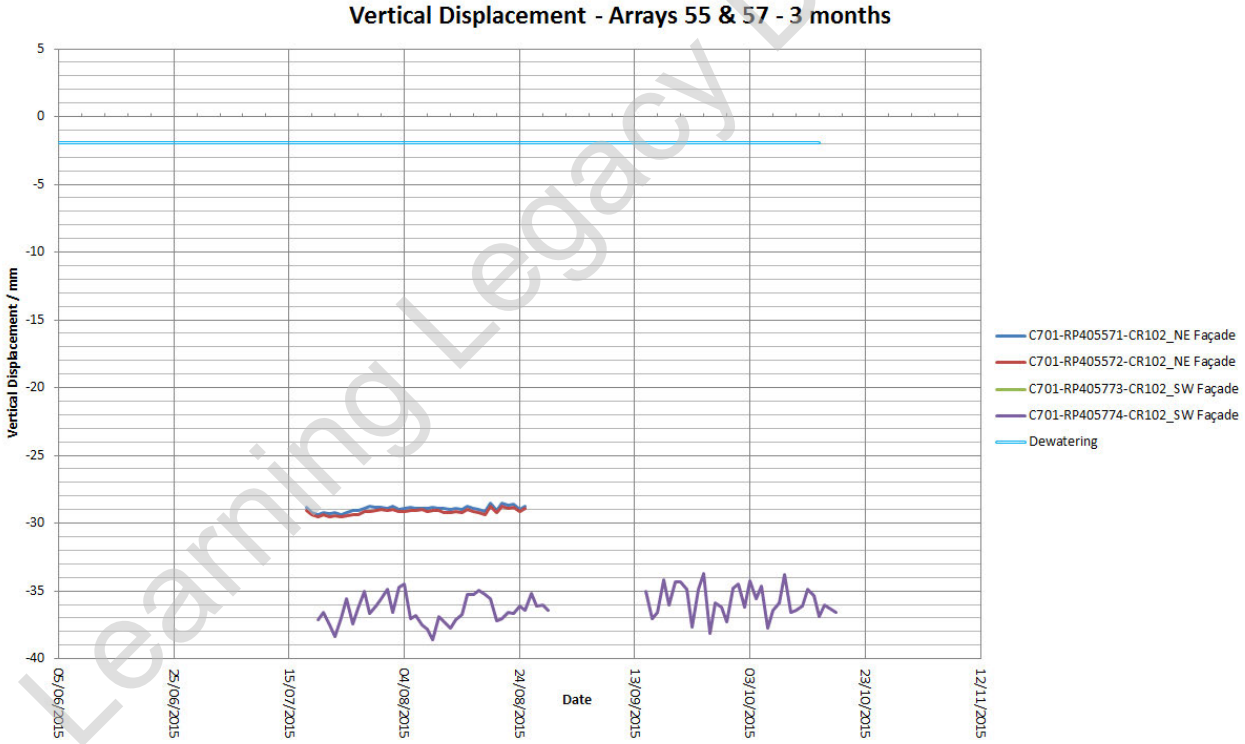


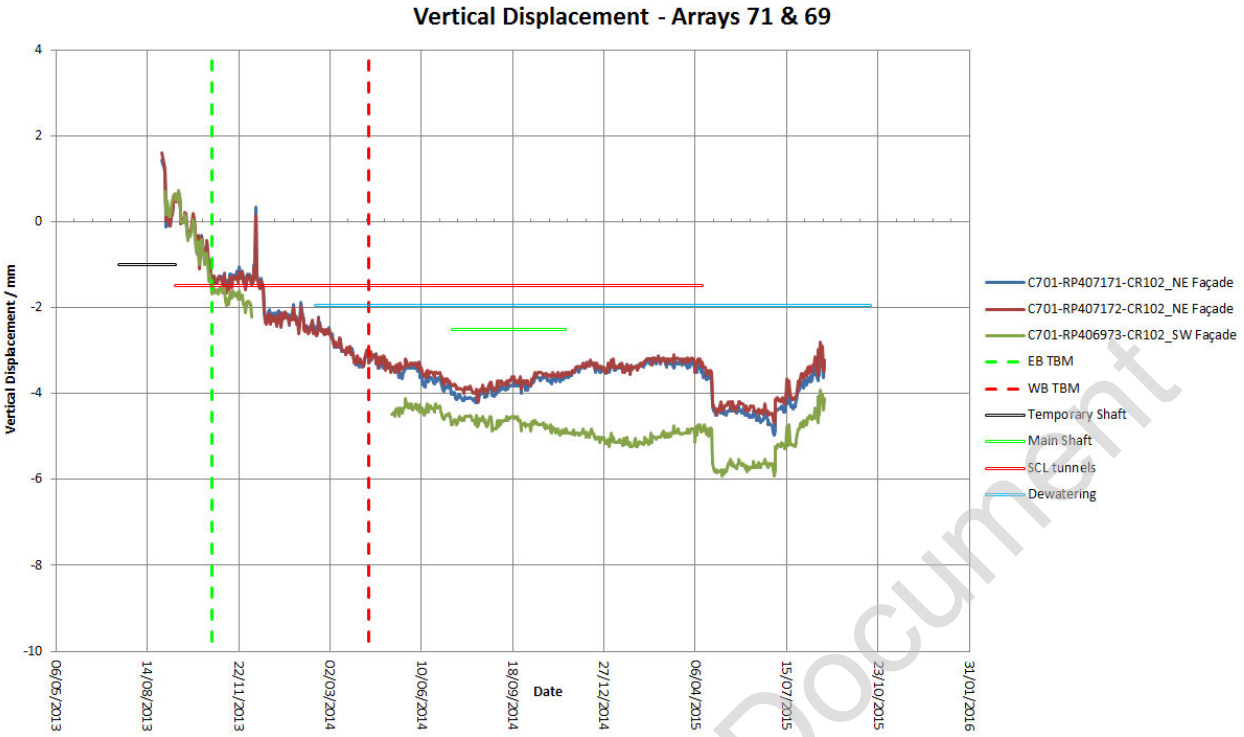


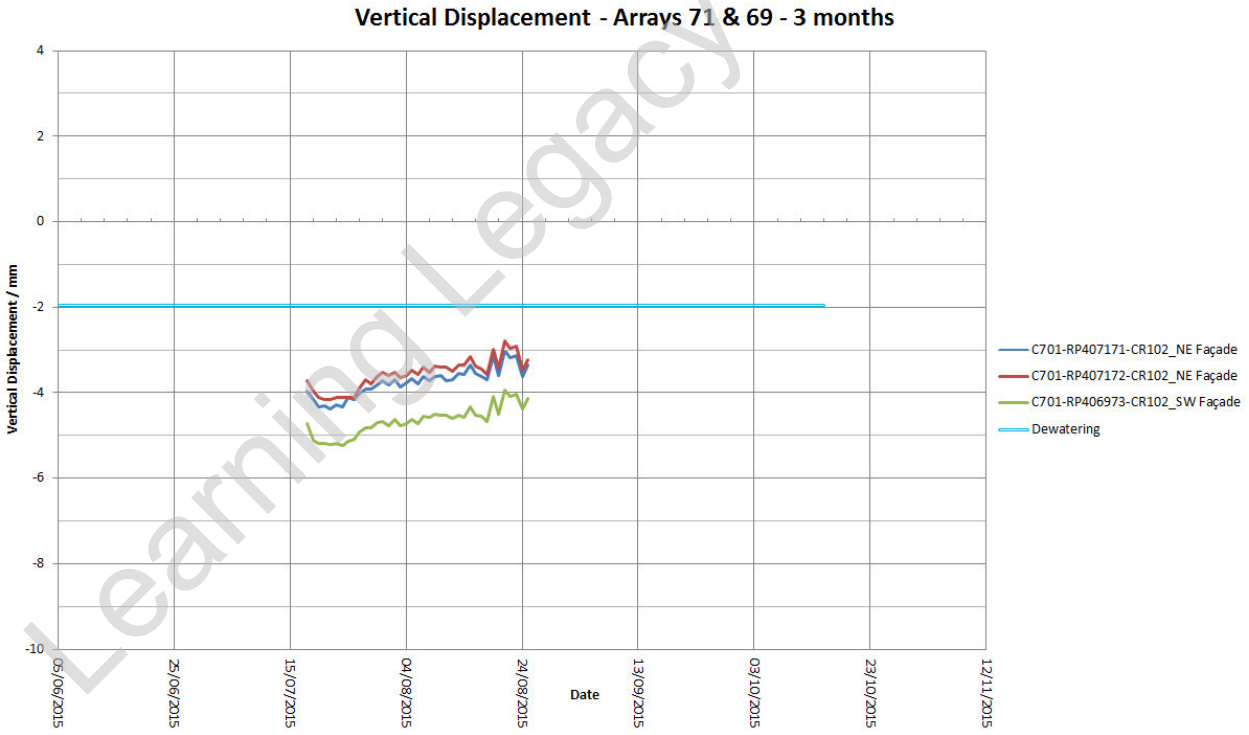


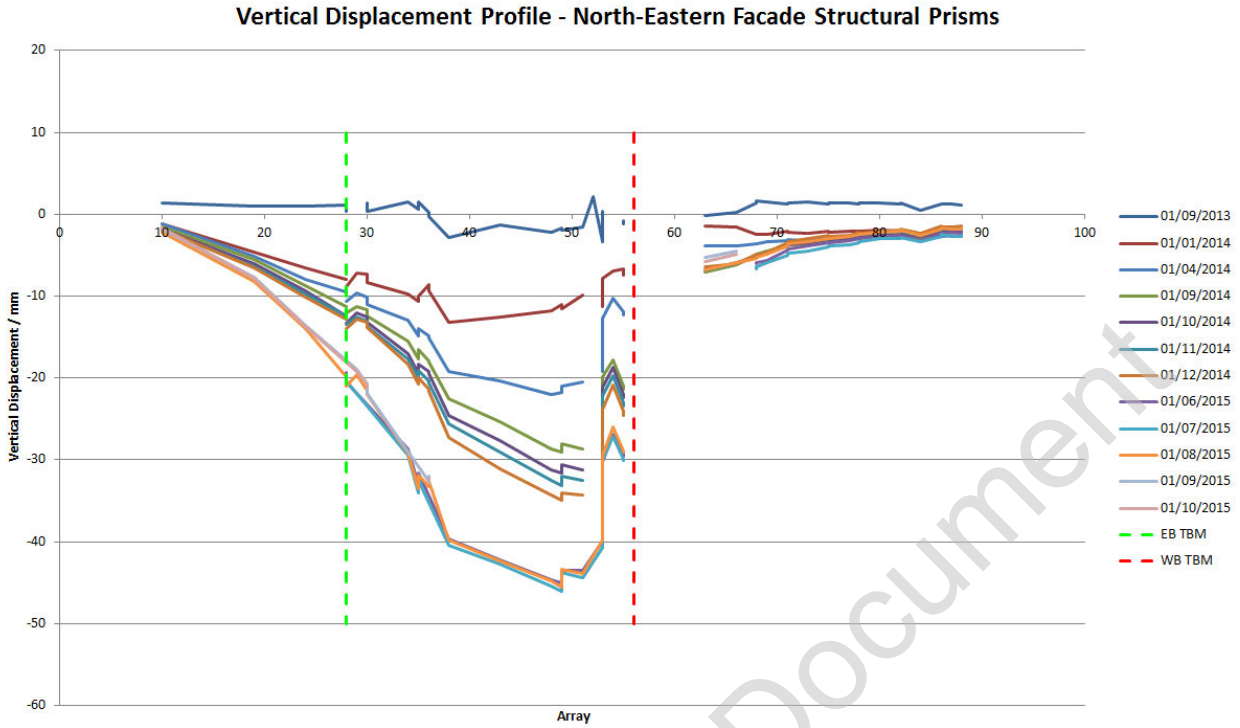


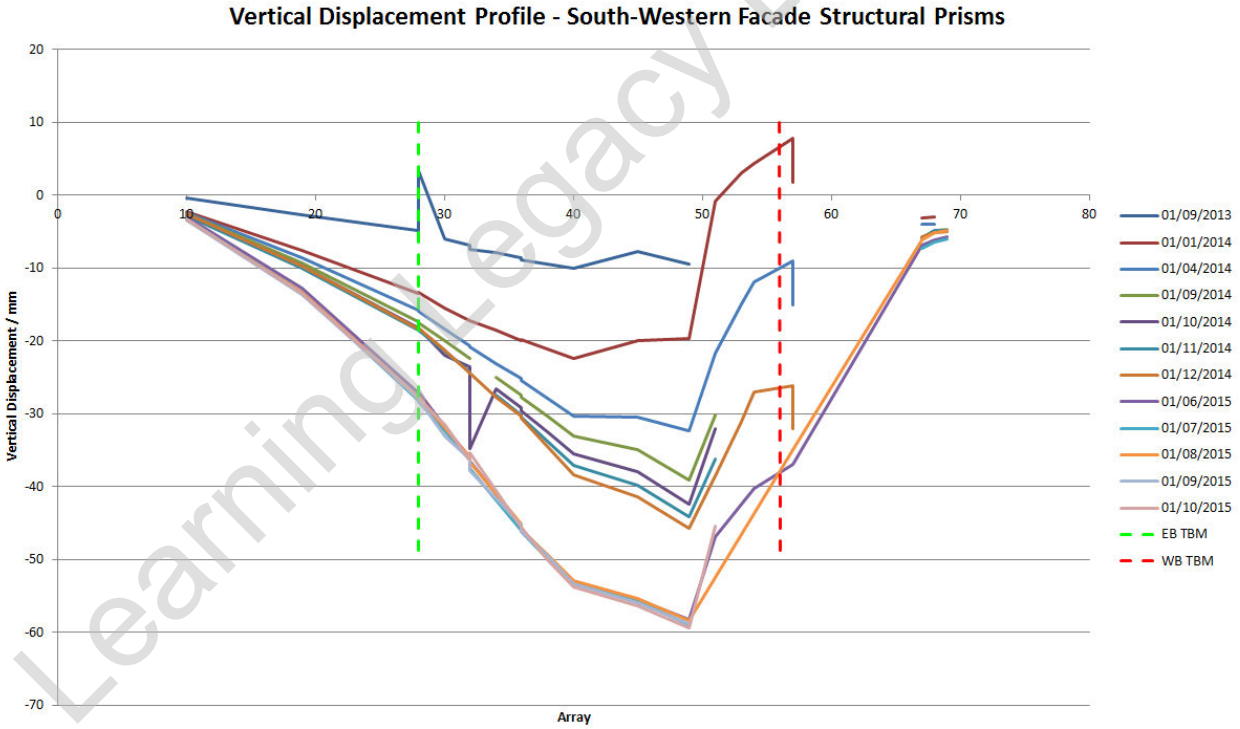










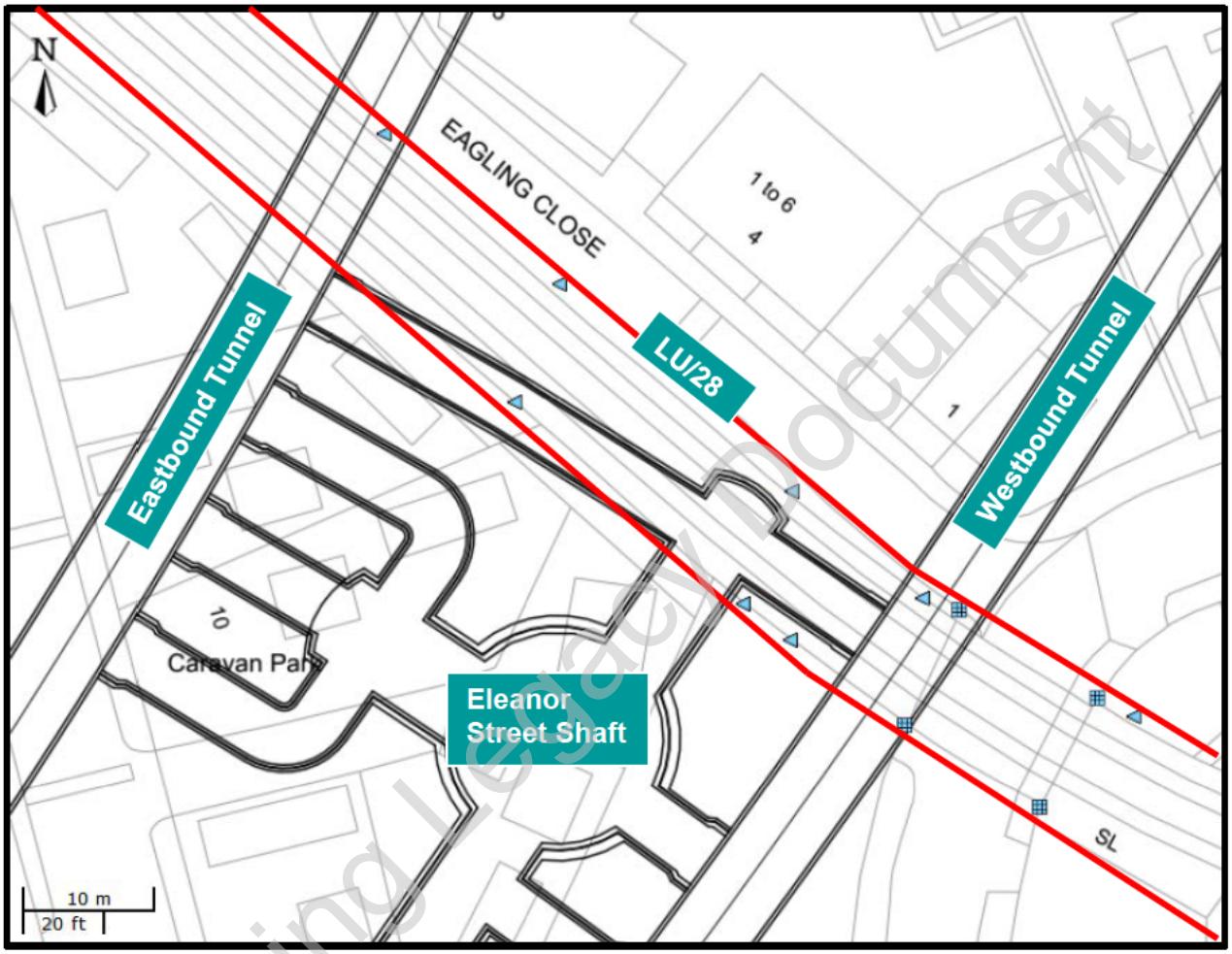


APPENDIX D – Manual Monitoring Locations

Proposed BRE sockets to be manually monitored during close out monitoring phase:

North-Eastern Façade			South-Western Façade		
Name	**E**	**N**	**Name**	**E**	**N**
C701-LB001005-CR102	87731.158	37146.213	C701-LB001011-CR102	87725.781	37138.535
C701-LB001004-CR102	87741.234	37137.476	C701-LB001010-CR102	87735.678	37129.813
C701-LB402871-CR102	87745.571	37133.422	C701-LB404074-CR102	87755.604	37112.743
C701-LB403771-CR102	87759.224	37121.798	C701-LB001009-CR102	87757.028	37110.218
C701-LB001003-CR102	87761.931	37120.432	C701-LB001008-CR102	87763.750	37104.385
C701-LB001002-CR102	87768.847	37114.256	C701-LB001007-CR102	87770.722	37098.125
C701-LB001001-CR102	87775.573	37108.427	C701-LB405074-CR102	87773.414	37097.074
C701-LB405071-CR102	87777.146	37105.729	C701-LB405374-CR102	87776.961	37094.261
C701-LB405571-CR102	87787.132	37097.603	C701-LB405885-CR102	87785.750	37087.734
C701-LB405881-CR102	87789.972	37096.688	C701-LB405886-CR102	87786.050	37088.340
C701-LB405882-CR102	87789.364	37097.145	C701-LB405887-CR102	87785.740	37087.718
C701-LB405883-CR102	87789.647	37096.870	C701-LB405888-CR102	87786.046	37088.359
C701-LB405884-CR102	87789.122	37097.262	C701-LB406285-CR102	87796.244	37081.461
C701-LB406281-CR102	87800.643	37089.900	C701-LB406286-CR102	87795.834	37080.626
C701-LB406282-CR102	87799.985	37088.978	C701-LB406287-CR102	87796.339	37081.577
C701-LB406283-CR102	87800.683	37089.963	C701-LB406288-CR102	87795.861	37080.624
C701-LB406284-CR102	87800.049	37089.087	C701-LB406374-CR102	87796.022	37080.940
C701-LB406471-CR102	87803.445	37088.467			

Location of BRE sockets to be manually monitored during close out monitoring phase:



APPENDIX B: LEVELLING MARKS

1. Levelling Mark Located on the Rails.

For location purposes the coordinates of theC305 levelling marks, located within the LU28/ LU29 monitoring area covered by this close out report, is presented below.

Sensor type	ID		Sensor Location GPS Readings(m)		
			Easting X (m)	Northing Y (m)	Elevation Z (mATD)
Levelling mark	C305-LT142301		87820.488	37077.657	115.89
Levelling mark	C305-LT142302		87818.636	37078.39	115.889
Levelling mark	C305-LT142303		87816.782	37079.154	115.891
Levelling mark	C305-LT142304		87814.94	37079 944	115.895
Levelling mark	C305-LT142305		87813.124	37080.748	115.891
Levelling mark	C305-LT142306		87811.307	37081 576	115.888
Levelling mark	C305-LT142307		87809.502	37082.43	115.885
Levelling mark	C305-LT142308		87807.713	37083 309	115.884
Levelling mark	C305-LT142309		87805.938	37084 205	115.882
Levelling mark	C305-LT142310		87804.17	37085.133	115.878
Levelling mark	C305-LT142311		87802.411	37086.09	115.874
Levelling mark	C305-LT142312		87800.669	37087 068	115.872
Levelling mark	C305-LT142313		87798.934	37088.06	115.871
Levelling mark	C305-LT142314		87797.212	37089 079	115.869
Levelling mark	C305-LT142315		87795.503	37090.124	115.868
Levelling mark	C305-LT142316		87793.812	37091.186	115.87
Levelling mark	C305-LT142317		87792.129	37092 277	115.868
Levelling mark	C305-LT142318		87790.463	37093.39	115.868
Levelling mark	C305-LT142319		87788.809	37094 525	115.872
Levelling mark	C305-LT142320		87787.173	37095.685	115.876
Levelling mark	C305-LT142321		87785.555	37096 848	115.876
Levelling mark	C305-LT142322		87783.949	37098 042	115.876
Levelling mark	C305-LT142323		87782.365	37099 251	115.874
Levelling mark	C305-LT142324		87780.795	37100.475	115.865
Levelling mark	C305-LT142325		87779.226	37101.719	115.851
Levelling mark	C305-LT142326		87777.672	37102 982	115.829
Levelling mark	C305-LT142327		87776.126	37104.25	115.808
Levelling mark	C305-LT142328		87774.584	37105 529	115.789
Levelling mark	C305-LT142329		87773.058	37106 812	115.763
Levelling mark	C305-LT142330		87771.531	37108.119	115.735
Levelling mark	C305-LT142331		87770.016	37109.425	115.707
Levelling mark	C305-LT142332		87768.501	37110.721	115.676
Levelling mark	C305-LT142333		87766.989	37112 032	115.642
Levelling mark	C305-LT142334		87765.484	37113 347	115.604
Levelling mark	C305-LT142335		87763.98	37114.662	115.568
Levelling mark	C305-LT142336		87762.473	37115 979	115.53
Levelling mark	C305-LT142337		87760.965	37117 286	115.487
Levelling mark	C305-LT142338		87759.455	37118.6	115.44
Levelling mark	C305-LT142339		87757.942	37119 917	115.394
Levelling mark	C305-LT142340		87756.438	37121 233	115.349
Levelling mark	C305-LT142341		87754.935	37122 544	115.299
Levelling mark	C305-LT142342		87753.43	37123 855	115.242
Levelling mark	C305-LT142343		87751.919	37125.166	115.183
Levelling mark	C305-LT142344		87750.411	37126.477	115.129
Levelling mark	C305-LT142345		87748.903	37127.79	115.078
Levelling mark	C305-LT142346		87747.399	37129.101	115.028
Levelling mark	C305-LT142347		87745.893	37130.416	114.975
Levelling mark	C305-LT142348		87744.395	37131.721	114.924
Levelling mark	C305-LT142349		87742.889	37133 036	114.879
Levelling mark	C305-LT142350		87741.385	37134 344	114.829
Levelling mark	C305-LT142351		87739.882	37135.655	114.772
Levelling mark	C305-LT142352		87738.379	37136 966	114.718
Levelling mark	C305-LT142353		87736.872	37138 279	114.665
Levelling mark	C305-LT142354		87735.369	37139.59	114.615
Levelling mark	C305-LT142355		87733.863	37140 898	114.564
Levelling mark	C305-LT142356		87732.361	37142 212	114.513
Levelling mark	C305-LT142357		87730.855	37143 523	114.461
Levelling mark	C305-LT142358		87729.35	37144 832	114.412
Levelling mark	C305-LT142359		87727.846	37146.142	114.362
Levelling mark	C305-LT142360		87726.341	37147.455	114.31
Levelling mark	C305-LT142361		87724.837	37148.766	114.26
Levelling mark	C305-LT142362		87723.337	37150 071	114.21
Levelling mark	C305-LT142363		87721.833	37151 383	114.158
Levelling mark	C305-LT142364		87720.327	37152.691	114.105
Levelling mark	C305-LT142365		87718.817	37154 006	114.052
Levelling mark	C305-LT142366		87717.314	37155 314	114.002
Levelling mark	C305-LT142367		87715.808	37156.623	113.954
Levelling mark	C305-LT142368		87714.303	37157 928	113.903
Levelling mark	C305-LT142369		87712.8	37159 234	113.852
Levelling mark	C305-LT142370		87711.289	37160 537	113 8

Sensor type	ID		Sensor Location GPS Readings(m)		
			Easting X (m)	Northing Y (m)	Elevation Z (mATD)
Levelling mark	C305-LT142401		87819.828	37076 381	115.94
Levelling mark	C305-LT142402		87817.969	37077.115	115.938
Levelling mark	C305-LT142403		87816.136	37077 872	115.941
Levelling mark	C305-LT142404		87814.311	37078.658	115.942
Levelling mark	C305-LT142405		87812.494	37079.462	115.938
Levelling mark	C305-LT142406		87810.67	37080 293	115.934
Levelling mark	C305-LT142407		87808.872	37081.148	115.931
Levelling mark	C305-LT142408		87807.077	37082.02	115.931
Levelling mark	C305-LT142409		87805.299	37082 921	115.93
Levelling mark	C305-LT142410		87803.54	37083 845	115.928
Levelling mark	C305-LT142411		87801.783	37084.799	115.923
Levelling mark	C305-LT142412		87800.041	37085.771	115.919
Levelling mark	C305-LT142413		87798.31	37086.767	115.917
Levelling mark	C305-LT142414		87796.598	37087.776	115.917
Levelling mark	C305-LT142415		87794.894	37088 819	115.916
Levelling mark	C305-LT142416		87793.2	37089 879	115.915
Levelling mark	C305-LT142417		87791.521	37090 961	115.914
Levelling mark	C305-LT142418		87789.854	37092 073	115.915
Levelling mark	C305-LT142419		87788.201	37093 204	115.918
Levelling mark	C305-LT142420		87786.569	37094 349	115.919
Levelling mark	C305-LT142421		87784.953	37095 515	115.919
Levelling mark	C305-LT142422		87783.345	37096.707	115.917
Levelling mark	C305-LT142423		87781.754	37097 917	115.91
Levelling mark	C305-LT142424		87780.182	37099.139	115.901
Levelling mark	C305-LT142425		87778.618	37100 382	115.886
Levelling mark	C305-LT142426		87777.069	37101.634	115.864
Levelling mark	C305-LT142427		87775.514	37102 903	115.841
Levelling mark	C305-LT142428		87773.977	37104.172	115.817
Levelling mark	C305-LT142429		87772.452	37105.455	115.787
Levelling mark	C305-LT142430		87770.924	37106.755	115.756
Levelling mark	C305-LT142431		87769.402	37108 058	115.726
Levelling mark	C305-LT142432		87767.885	37109 356	115.693
Levelling mark	C305-LT142433		87766.373	37110.666	115.656
Levelling mark	C305-LT142434		87764.868	37111 979	115.618
Levelling mark	C305-LT142435		87763.368	37113 292	115.579
Levelling mark	C305-LT142436		87761.865	37114.607	115.537
Levelling mark	C305-LT142437		87760.354	37115 922	115.495
Levelling mark	C305-LT142438		87758.851	37117 229	115.45
Levelling mark	C305-LT142439		87757.355	37118 532	115.404
Levelling mark	C305-LT142440		87755.855	37119.84	115.357
Levelling mark	C305-LT142441		87754.359	37121.148	115.309
Levelling mark	C305-LT142442		87752.868	37122.446	115.257
Levelling mark	C305-LT142443		87751.369	37123.753	115.199
Levelling mark	C305-LT142444		87749.872	37125 055	115.143
Levelling mark	C305-LT142445		87748.371	37126 363	115.09
Levelling mark	C305-LT142446		87746.859	37127.674	115.042
Levelling mark	C305-LT142447		87745.359	37128 983	114.989
Levelling mark	C305-LT142448		87743.858	37130 288	114.936
Levelling mark	C305-LT142449		87742.377	37131.59	114.885
Levelling mark	C305-LT142450		87740.869	37132 896	114.834
Levelling mark	C305-LT142451		87739.368	37134 207	114.78
Levelling mark	C305-LT142452		87737.866	37135 519	114.729
Levelling mark	C305-LT142453		87736.363	37136 827	114.68
Levelling mark	C305-LT142454		87734.857	37138.138	114.63
Levelling mark	C305-LT142455		87733.353	37139.45	114.58
Levelling mark	C305-LT142456		87731.848	37140.76	114.529
Levelling mark	C305-LT142457		87730.344	37142 073	114.477
Levelling mark	C305-LT142458		87728.838	37143 381	114.427
Levelling mark	C305-LT142459		87727.331	37144.694	114.375
Levelling mark	C305-LT142460		87725.828	37146	114.325
Levelling mark	C305-LT142461		87724.327	37147 314	114.273
Levelling mark	C305-LT142462		87722.817	37148.629	114.222
Levelling mark	C305-LT142463		87721.308	37149 946	114.171
Levelling mark	C305-LT142464		87719.802	37151 254	114.12
Levelling mark	C305-LT142465		87718.294	37152 567	114.069
Levelling mark	C305-LT142466		87716.782	37153 882	114.019
Levelling mark	C305-LT142467		87715.274	37155.19	113.967
Levelling mark	C305-LT142468		87713.769	37156.497	113.917
Levelling mark	C305-LT142469		87712.255	37157 814	113.866
Levelling mark	C305-LT142470		87710.749	37159.116	113.817

Sensor type	ID		Sensor Location GPS Readings(m)		
			Easting X (m)	Northing Y (m)	Elevation Z (mATD)
Levelling mark	C305-LT142101		87818.025	37073.113	115.916
Levelling mark	C305-LT142102		87816.15	37073.86	115.919
Levelling mark	C305-LT142103		87814.304	37074.631	115.926
Levelling mark	C305-LT142104		87812.461	37075.429	115.929
Levelling mark	C305-LT142105		87810.622	37076.25	115.93
Levelling mark	C305-LT142106		87808.817	37077 085	115.933
Levelling mark	C305-LT142107		87807.018	37077 949	115.936
Levelling mark	C305-LT142108		87805.224	37078 836	115.938
Levelling mark	C305-LT142109		87803.44	37079.753	115.941
Levelling mark	C305-LT142110		87801.662	37080.697	115.945
Levelling mark	C305-LT142111		87799.937	37081.639	115.955
Levelling mark	C305-LT142112		87798.131	37082.662	115.96
Levelling mark	C305-LT142113		87796.37	37083.693	115.965
Levelling mark	C305-LT142114		87794.673	37084.714	115.97
Levelling mark	C305-LT142115		87792.974	37085.767	115.973
Levelling mark	C305-LT142116		87791.151	37086 917	115.975
Levelling mark	C305-LT142117		87789.452	37088 024	115.972
Levelling mark	C305-LT142118		87787.678	37089 229	115.977
Levelling mark	C305-LT142119		87786.015	37090 389	115.976
Levelling mark	C305-LT142120		87784.351	37091 571	115.967
Levelling mark	C305-LT142121		87782.708	37092.757	115.959
Levelling mark	C305-LT142122		87781.177	37093.88	115.949
Levelling mark	C305-LT142123		87779.506	37095.149	115.938
Levelling mark	C305-LT142124		87777.86	37096.409	115.927
Levelling mark	C305-LT142125		87776.283	37097.638	115.909
Levelling mark	C305-LT142126		87774.686	37098 905	115.89
Levelling mark	C305-LT142127		87773.098	37100.188	115.871
Levelling mark	C305-LT142128		87771.557	37101.443	115.849
Levelling mark	C305-LT142129		87770.024	37102.715	115.818
Levelling mark	C305-LT142130		87768.5	37103 983	115.789
Levelling mark	C305-LT142131		87766.866	37105 363	115.753
Levelling mark	C305-LT142132		87765.388	37106.618	115.719
Levelling mark	C305-LT142133		87763.812	37107 971	115.683
Levelling mark	C305-LT142134		87762.286	37109 288	115.643
Levelling mark	C305-LT142135		87760.792	37110 583	115.601
Levelling mark	C305-LT142136		87759.262	37111 918	115.556
Levelling mark	C305-LT142137		87757.83	37113.171	115.511
Levelling mark	C305-LT142138		87756.31	37114 502	115.46
Levelling mark	C305-LT142139		87754.835	37115.797	115.41
Levelling mark	C305-LT142140		87753.381	37117 074	115.362
Levelling mark	C305-LT142141		87751.893	37118 373	115.312
Levelling mark	C305-LT142142		87750.338	37119.73	115.258
Levelling mark	C305-LT142143		87748.793	37121 083	115.205
Levelling mark	C305-LT142144		87747.302	37122 391	115.154
Levelling mark	C305-LT142145		87745.755	37123.749	115.102
Levelling mark	C305-LT142146		87744.211	37125.104	115.05
Levelling mark	C305-LT142147		87742.731	37126 399	115.002
Levelling mark	C305-LT142148		87741.205	37127.741	114.951
Levelling mark	C305-LT142149		87739.753	37129 013	114 9
Levelling mark	C305-LT142150		87738.208	37130 371	114.843
Levelling mark	C305-LT142151		87736.716	37131.676	114.792
Levelling mark	C305-LT142152		87735.281	37132 932	114.741
Levelling mark	C305-LT142153		87733.707	37134 311	114.686
Levelling mark	C305-LT142154		87732.234	37135.603	114.636
Levelling mark	C305-LT142155		87730.713	37136 935	114.584
Levelling mark	C305-LT142156		87729.217	37138 246	114.532
Levelling mark	C305-LT142157		87727.804	37139.488	114.483
Levelling mark	C305-LT142158		87726.157	37140 933	114.428
Levelling mark	C305-LT142159		87724.657	37142 245	114.376
Levelling mark	C305-LT142160		87723.156	37143 558	114.325
Levelling mark	C305-LT142161		87721.647	37144.88	114.273
Levelling mark	C305-LT142162		87720.062	37146 265	114.218
Levelling mark	C305-LT142163		87718.619	37147.53	114.169
Levelling mark	C305-LT142164		87717.088	37148 871	114.118
Levelling mark	C305-LT142165		87715.57	37150.199	114.067
Levelling mark	C305-LT142166		87714.049	37151 533	114.014
Levelling mark	C305-LT142167		87712.6	37152.798	113.963
Levelling mark	C305-LT142168		87711.064	37154.137	113.911
Levelling mark	C305-LT142169		87709.526	37155.481	113.858
Levelling mark	C305-LT142170		87708.075	37156.743	113.81

Sensor type	ID		Sensor Location GPS Readings(m)		
			Easting X (m)	Northing Y (m)	Elevation Z (mATD)
Levelling mark	C305-LT142201		87818.792	37074 349	115.844
Levelling mark	C305-LT142202		87816.909	37075 091	115.844
Levelling mark	C305-LT142203		87815.027	37075 882	115.854
Levelling mark	C305-LT142204		87813.163	37076.684	115.858
Levelling mark	C305-LT142205		87811.334	37077 504	115.862
Levelling mark	C305-LT142206		87809.491	37078.35	115.863
Levelling mark	C305-LT142207		87807.675	37079 219	115.866
Levelling mark	C305-LT142208		87805.835	37080.13	115.867
Levelling mark	C305-LT142209		87804.044	37081 055	115.871
Levelling mark	C305-LT142210		87802.269	37081 994	115.876
Levelling mark	C305-LT142211		87800.493	37082 965	115.887
Levelling mark	C305-LT142212		87798.785	37083.93	115.891
Levelling mark	C305-LT142213		87797.068	37084 941	115.895
Levelling mark	C305-LT142214		87795.382	37085 959	115 9
Levelling mark	C305-LT142215		87793.635	37087 033	115.904
Levelling mark	C305-LT142216		87791.909	37088.127	115.907
Levelling mark	C305-LT142217		87790.194	37089 246	115.906
Levelling mark	C305-LT142218		87788.463	37090.426	115.915
Levelling mark	C305-LT142219		87786.785	37091 598	115.918
Levelling mark	C305-LT142220		87785.142	37092.759	115.912
Levelling mark	C305-LT142221		87783.534	37093 927	115.903
Levelling mark	C305-LT142222		87781.939	37095 097	115.893
Levelling mark	C305-LT142223		87780.309	37096 326	115.887
Levelling mark	C305-LT142224		87778.673	37097 585	115.881
Levelling mark	C305-LT142225		87777.139	37098.783	115.867
Levelling mark	C305-LT142226		87775.539	37100 047	115.85
Levelling mark	C305-LT142227		87774.016	37101 277	115.834
Levelling mark	C305-LT142228		87772.41	37102 591	115.813
Levelling mark	C305-LT142229		87770.867	37103 865	115.787
Levelling mark	C305-LT142230		87769.363	37105.122	115.759
Levelling mark	C305-LT142231		87767.787	37106.451	115.73
Levelling mark	C305-LT142232		87766.262	37107.751	115.698
Levelling mark	C305-LT142233		87764.767	37109 029	115.664
Levelling mark	C305-LT142234		87763.215	37110 367	115.626
Levelling mark	C305-LT142235		87761.72	37111.662	115.588
Levelling mark	C305-LT142236		87760.22	37112 963	115.547
Levelling mark	C305-LT142237		87758.747	37114 255	115.505
Levelling mark	C305-LT142238		87757.234	37115 592	115.46
Levelling mark	C305-LT142239		87755.746	37116 891	115.41
Levelling mark	C305-LT142240		87754.227	37118 221	115.359
Levelling mark	C305-LT142241		87752.781	37119.479	115.31
Levelling mark	C305-LT142242		87751.19	37120.88	115.252
Levelling mark	C305-LT142243		87749.666	37122 213	115.199
Levelling mark	C305-LT142244		87748.191	37123 509	115.148
Levelling mark	C305-LT142245		87746.653	37124.86	115.097
Levelling mark	C305-LT142246		87745.151	37126.176	115.048
Levelling mark	C305-LT142247		87743.675	37127.467	115.002
Levelling mark	C305-LT142248		87742.17	37128.788	114.952
Levelling mark	C305-LT142249		87740.686	37130 088	114.897
Levelling mark	C305-LT142250		87739.221	37131 375	114.842
Levelling mark	C305-LT142251		87737.604	37132.797	114.784
Levelling mark	C305-LT142252		87736.18	37134.04	114.735
Levelling mark	C305-LT142253		87734.604	37135.424	114.68
Levelling mark	C305-LT142254		87733.091	37136.746	114.628
Levelling mark	C305-LT142255		87731.618	37138 039	114.579
Levelling mark	C305-LT142256		87730.124	37139 348	114.528
Levelling mark	C305-LT142257		87728.631	37140.655	114.477
Levelling mark	C305-LT142258		87727.099	37141 997	114.424
Levelling mark	C305-LT142259		87725.612	37143 302	114.373
Levelling mark	C305-LT142260		87724.075	37144.645	114.32
Levelling mark	C305-LT142261		87722.558	37145 971	114.268
Levelling mark	C305-LT142262		87721.036	37147 306	114.217
Levelling mark	C305-LT142263		87719.575	37148 585	114.167
Levelling mark	C305-LT142264		87718.001	37149 963	114.114
Levelling mark	C305-LT142265		87716.504	37151 277	114.063
Levelling mark	C305-LT142266		87715.024	37152 572	114.012
Levelling mark	C305-LT142267		87713.565	37153 842	113.961
Levelling mark	C305-LT142268		87712.095	37155.123	113.912
Levelling mark	C305-LT142269		87710.502	37156 512	113.858
Levelling mark	C305-LT142270		87709.033	37157.796	113.81