

		<b>C310 THAMES TUNNEL REPORT</b>		
EMPLOYER	CROSSRAIL	eB NO	C310-HTM-C-RGN-CR148-50035	Rev 2.0
TITLE	Monitoring Close-Out Report for North Kent Line (NKL)			

ORIGINATOR COMPANY NAME	Hochtief Murphy JV
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CMDL: C09.006

REVISION	DOCUMENT APPROVAL / REVISION RECORD DETAILS	DATE
1.0	Issued for CRL Acceptance	11/05/2015
2.0	DRS Comments Addressed	01/06/2015

Stakeholder (Network Rail) review required? Yes: X No ...

This document has been reviewed by ..... in the capacity of ..... for coordination, compliance, integration, and acceptance as a safe system of work, output, control, sequence. This document is acceptable for transmittal to ..... for no objection to the works being executed as described.

Sign: \_\_\_\_\_ Name: \_\_\_\_\_ Date: \_\_\_\_\_


Review by Stakeholder (if required):

Stakeholder organization	Job Title	Name	Signature	Date	Acceptance
NETWORK RAIL				29/07/15	YES

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<b>PREPARED BY: HMJV Monitoring Manager</b> Print: _____ Sign: _____ Date: 01-06-2015	<b>REVIEWED BY: HMJV Technical and Risk Manager</b> Print: _____ Sign: _____ Date: 01-06-2015
<b>REVIEWED BY: HMJV Temp Works &amp; Design Manager</b> Print: _____ Sign: _____ Date: 01-06-15	<b>APPROVED BY: HMJV Project Director</b> Print: _____ Sign: _____ Date: 01-06-2015

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TITLE	<b>Monitoring Close-Out Report for North Kent Line (NKL)</b>				

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## 1.0 INTRODUCTION

The purpose of this report is to summarise the monitoring data related to the Network Rail North Kent Line (NR24), running adjacent to the Plumstead Portal construction activities. In addition this data is utilised to demonstrate that no further ground movements due to the nature of ongoing and further C310 works would be expected to impact the Network Rail assets.

The instrumentation used to monitor any potential movements of the North Kent Line are:

- Shape Accelerator Array (SAA) on the south diaphragm wall panels of the portal, monitoring deflections of the retaining walls,
- Precise levelling studs on the Network Rail Asset Protection Barrier (APB) posts as an earlier indicator, monitoring vertical movements; and
- 3D geodetic prism monitoring of the Network Rail lines, monitoring horizontal and vertical movement and forming subsequently the base to calculate cant and twist values of the up and down line tracks (installation by C701/C704 and monitoring data processing by C701/C704) .
- [Track trolley monitoring on NKL Up and Down lines between NR chainage 10m 88y – 10m 1407y](#)

The asset settlement data is presented in relation to the construction activities causing potential ground movements carried out by HMJV.

This forms the basis for which the associated monitoring is to be ceased.

The content of the report complies with the requirements as per C122 – M&W Specification KX10 – Instrumentation & Monitoring C122-OVE-Z4-RSP-CR001-00007 Rev.7.0.

## 2.0 REFERENCE DOCUMENTS

MPCGM C310-HTM-Z-STP-CR148-50058 Rev.14.0

*HMJV I&M Drawings:*

C310-HTM-C-DWG-CR148\_PT005-50010 Rev. 8.0

*M&W Specification KX10 – Instrumentation & Monitoring;*


C122-OVE-Z4-RSP-CR001-00007 Rev. 7.0

Final Report of Manual and Automated Inclinator (Shape Accelerator Array – SAA) in Plumstead Portal;  
C310-HTM-C-RGN-CR148-50028

Ground Movement Summary Report; C310 – Plumstead Portal;  
C122-OVE-C2-RGN-CR148\_PT005-50010 Rev 2.0

C704 Instrumentation Decommissioning Agreement; Plumstead – Phase 1, Network Rail, North Kent Line NR/24;

C704-XRL-C-AAG-CR148\_PT005-50001

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### 3.0 CONSTRUCTION AND MONITORING ACTIVITIES

All construction activities associated with potential ground movements of the Network Rail North Kent Line asset have been complete.

The monitoring associated with the Network Rail asset and the current status is the following:

- Shape Accelerator Array (SAA) – Diaphragm Wall monitoring – Ceased.
- Network Rail Asset Protection Barrier (APB) – Final levelling run was carried out on 14/05/15. APB posts completely removed on 16/05/2015
- C704 Track monitoring – 3No. Automatic Total Station (ATS) 1, 2 and 3 with associated track mounted prisms and reference points
- Final track trolley run on NKL Up and Down lines was carried out on 17/05/15

### 4.0 REVIEW OF MONITORING

The trigger values for all monitoring were set in accordance to Doc. No. C122-OVE-C2-RGN-CR146\_ST004-50001 and C310-HTM-Z-STP-CR148-50058. The following is a summary of the monitoring related to the Network Rail North Kent Line Up and Down lines:

#### Phase 1 – Construction of Plumstead Portal (to substantial completion – Sept 2011 – Dec 2012)

##### Network Rail Up and Down Lines

- Up to 10mm settlement in the vicinity of the headhouse area arising from deep excavation on the NKL down line. Up to 15mm settlement at the eastern end of the portal due to installation of temporary sheet piles. No track trigger values were exceeded during this period. Refer to “Ground Movement Summary Report; C310 – Plumstead Portal” (C122-OVE-C2-RGN-CR148\_PT005-50010) for more details.
- Asset Protection Barrier (APB) – readings are between -14mm and -10mm. The green trigger was exceeded but with no effect onto the NKL tracks. Data were reviewed in daily SRG and no further trend is observed since December 2012. Refer to Appenix 2 for data table.

##### Track Trolley Monitoring

- No discernible deformation was detected during this period and no trigger values were exceeded.

##### Diaphragm Wall Deflection


- Shape Accelerator Array (SAA) - Appendix 01 shows the last readings of the retaining wall adjacent to the track. The green trigger value is 43mm. A maximum deflection of 25.4mm was recorded, no trigger value was exceeded.

#### Phase 2 – Construction of Plumstead Portal roof-slab and Headhouse (to completion, Nov 2014 – May 2015)

The construction works at Plumstead Portal resumed in October 2014 upon significant completion of the tunnel constructions works.

##### Network Rail Up and Down Lines

- The NKL Up and Down lines were tamped in October and Decemebr 2014 as part of the NR’s scheduled renewals programme. This effectively returned the track to the “initial condition” and re-baselined the NKL monitoring. No discernible movement has been observed between November 2014 and May 2015.

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In general, not track movement arising from the Crossrail works were observed. Some settlement with time was observed but this was directly related to the track settling after tamping. No trigger values were exceeded.

Accordingly, no long term movement trends associated. The observed settlement rate is equal to or less than 2.0mm per annum and meets the decommissioning criteria.

Refer to report "C704 Instrumentation and Monitoring – Decommissioning Agreement Plumstead – Phase 1, network Rail, North Kent Line NR/24" (C704-XRL-C-AAG-CR148\_PT005-50001) for more details.

#### Track Trolley Monitoring

- No discernible track deformation was detected during this period and no trigger values were exceeded.

## 5.0 CONCLUSION

#### Construction of Plumstead Portal (up to Dec 2012)

Up to 15mm of track settlement was observed, arising from the construction of Plumstead Portal on the Up and Down NKL lines. Notwithstanding, no settlement or track deformation trigger values were exceeded during this period.

#### Construction of Plumstead Portal (Nov 2014 onwards)

The NR NKL Down Line was tamped twice between October and December 2014. This effectively returned the track to its initial condition.

No discernible movement or trends arising from the Crossrail works were detected during this period.

Based on the monitoring data and observations, the impact of the Crossrail works on NKL line is considered to be low – negligible.


As such, in view of the monitoring and observations to date in conjunction with the current phase of construction, it is considered that there are no further residual risks on the NR assets arising from the Crossrail works.

All monitoring data display an acceptably small rate of change (i.e. within the accuracies of the respective instruments) and satisfies the decommissioning requirements.

Based on this HMJV propose the cessation of monitoring of the NKL lines.

Construction works at Plumstead Portal have been completed and there is no further construction activity which will give rise to ground movements. Additionally, there is no further site activity, e.g. heavy plant movement and heavy crane lifts or operation which may potentially impact on the NKL.


HMJV proposes the cessation of the remaining Network Rail North Kent Line automated track monitoring and continue with manual quarterly readings as proposed by C704 (manual quarterly monitoring to be carried out by others).

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## 6.0 APPENDICES

- Appendix 01 SAA Monitoring data – Extract from C310-HTM-C-RGN-CR148-50028
- Appendix 02 APB Levelling Data
- Appendix 03 C704 report “C704 Instrumentation and Monitoring – Decommissioning Agreement Plumstead – Phase 1, Network Rail, North Kent Line NR/24” (C704-XRL-C-AAG-CR148\_PT005-50001)
- Appendix 04 C122 report “Ground Movement Summary Report; C310 – Plumstead Portal” (C122-OVE-C2-RGN-CR148\_PT005-50010).

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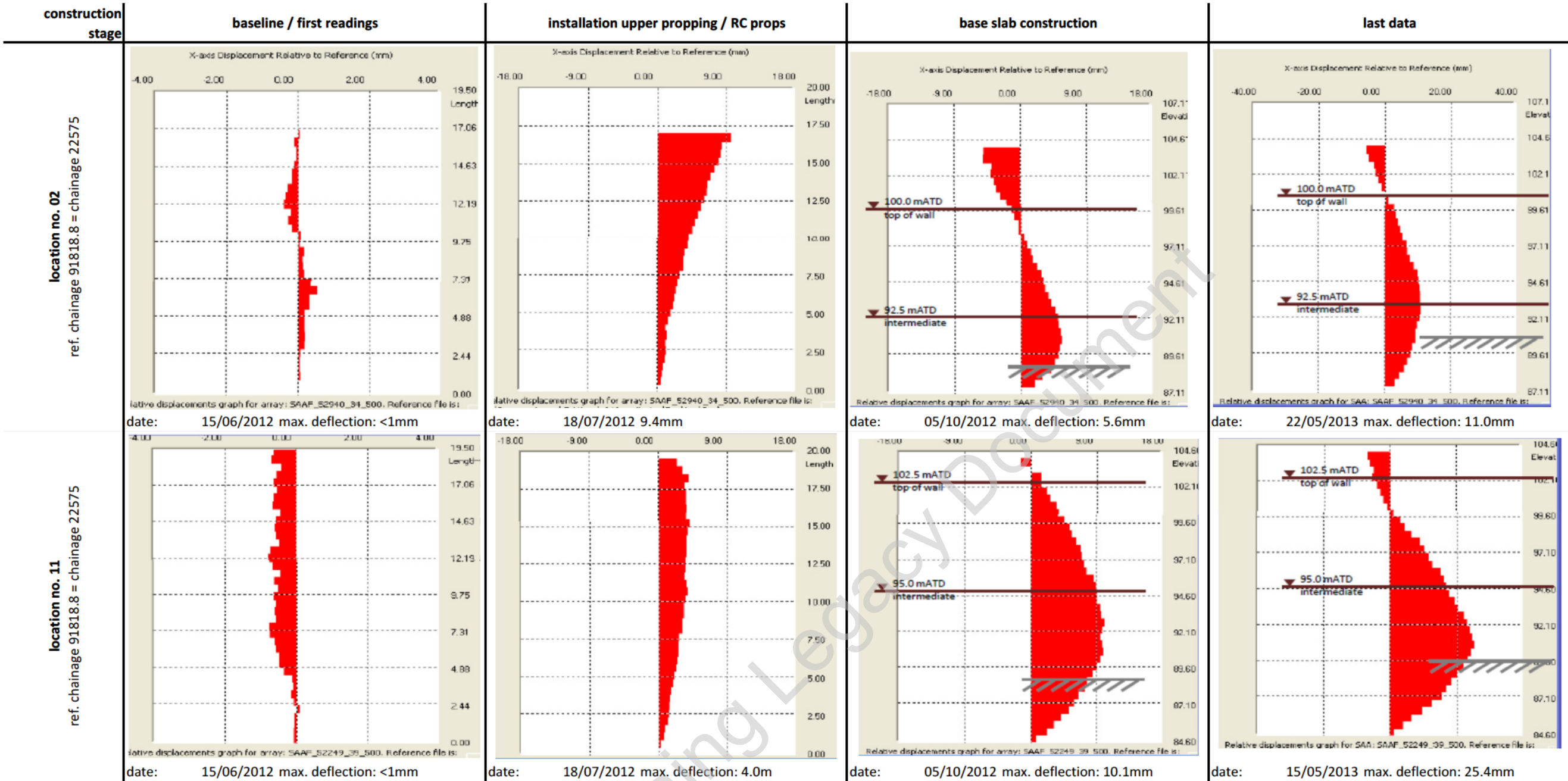
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**APPENDIX 01**

SAA Monitoring data – Extract from C310-HTM-C-RGN-CR148-50028

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**legend**

	current excavation level
	final diaphragm wall cut of level: North wall: 100.0mATD South wall: 102.5mATD
	intermediate North wall: 92.5mATD South wall: 95.0mATD

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**APPENDIX 02**  
 APB Levelling Data

Learning Legacy Document

monitoring table



monitoring table



project: C310 Thames Tunnel

Joint Venture


project: C310 Thames Tunnel

Joint Venture

structure: asset protection barrier posts - rebaseline CFA pile area

structure: asset protection barrier posts - rebaseline CFA pile area

	No. of reading	baseline	289. following			290. following			291. following			292. following			293. following			294. following			295. following			296. following			297. following					
	date	23/08/2011 19/03/2012	12/02/2015			19/02/2015			24/02/2015			25/02/2015			27/02/2015			02/03/2015			04/03/2015			19/03/2015			09/04/2015					
	Point No.	elevation	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline	elevation	deviation from last/ baseline		
CFA piles	(3004 00)56	103 521																														
	(3004 00)59	103.462																														
	(3004 00)62	103.447																														
	(3004 00)65	103 531																														
	(3004 00)68	103 540																														
secant piles (marmadon sewer no. 89)	(3004 00)71	103 567																														
	(3004 00)74	103 676																														
	(3004 00)77	103 714																														
	(3004 00)80	103 794																														
	(3004 00)83	103 746																														
	(3004 00)86	103 859																														
	(3004 00)89	103 958																														
	(3004 00)92	104.117																														
	(3004 00)95	104.117																														
	(3004 00)98	104.123																														
	(3004 0)101	104 014																														
	(3004 0)104	104 028																														
	(3004 0)107	104 061																														
	(3004 0)110	104 035	104.031	0	-4	104.031	0	-4	104.030	-1	-5	104.030	0	-5	104.031	0	-5	104.030	0	-5	104.031	0	-5	104.030	0	-5	104.029	-1	-6			
	(3004 0)113	104.123	104.119	0	-5	104.118	0	-5	104.118	0	-5	104.118	0	-6	104.118	0	-5	104.118	1	-5	104.118	0	-5	104.117	-2	-7						
	(3004 0)116	104.133	104.121	-1	-12	104.121	0	-11	104.120	-1	-13	104.120	0	-13	104.121	1	-12	104.121	0	-12	104.121	0	-11	104.120	-1	-13						
	(3004 0)119	104.121	104.115	-1	-6	104.116	1	-5	104.115	-1	-6	104.115	0	-7	104.115	1	-6	104.116	0	-6	104.116	0	-5	104.115	-1	-6						
	(3004 0)122	104.190	104.183	0	-7	104.183	0	-7	104.182	-1	-8	104.182	0	-8	104.183	0	-8	104.183	0	-7	104.183	0	-7	104.180	-3	-10						
	(3004 0)125	104 220	104.213	0	-7	104 213	0	-7	104.212	-1	-8	104.212	0	-8	104.212	1	-8	104.213	0	-7	104 213	1	-7	104.210	-4	-10						
	(3004 0)128	104 286	104.278	-1	-8	104 279	0	-8	104.278	-1	-8	104.277	-1	-9	104.278	1	-8	104.278	0	-8	104 279	1	-7	104.275	-5	-12						
(3004 0)131	104 304	104.298	0	-5	104 299	1	-5	104.298	-1	-6	104.298	0	-6	104.298	0	-6	104.298	1	-5	104 299	1	-4	104.297	-3	-7							
(3004 0)134	104 349	104.343	-1	-6	104 344	1	-5	104.343	-1	-6	104.342	-1	-7	104 343	1	-6	104.343	0	-6	104 344	1	-5	104.341	-3	-8							
(3004 0)137	104 369	104.361	0	-8	104 362	1	-7	104.361	-1	-8	104.360	-1	-9	104 361	1	-8	104.361	0	-8	104 362	1	-7	104.358	-4	-11	Not Acce	-	-				
(3004 0)140	104 380	104.372	-1	-8	104 373	1	-7	104.372	-1	-8	104.372	0	-8	104 372	0	-8	104.372	0	-8	104 373	1	-7	104.372	-1	-8	104.375	2	-5				
(3004 0)143	104.405	104.396	-1	-9	104 397	0	-9	104.397	0	-8	104.396	-1	-9	104 397	1	-8	104.397	0	-8	104 398	1	-8	104.397	-1	-8	104.399	2	-6				
(3004 0)146	104.417	104.407	1	-10	104.406	-1	-11	104.407	1	-10	104.407	0	-10	104.407	0	-10	104.407	1	-10	104.408	1	-9	104.407	-1	-10	104.409	1	-8				
(3004 0)149	104.439	104.428	1	-11	104.428	1	-11	104.428	0	-11	104.428	0	-12	104.428	0	-12	104.428	0	-12	104.429	1	-11	104.427	-2	-12	104.430	1	-9				
(3004 0)152	104 515	104.503	1	-12	104 503	-1	-12	104.502	-1	-13	104.502	0	-12	104 502	0	-12	104.503	1	-12	104 504	1	-11	104.502	-2	-13	104.505	1	-10				
(3004 0)155	104 573	104.564	2	-9	104 562	-1	-10	104.562	0	-11	104.562	0	-11	104 562	0	-11	104.562	1	-10	104 562	0	-11	104.561	-1	-12	104.564	2	-9				
(3004 0)158	104 649	104.636	1	-13	104 635	-1	-14	104.635	0	-14	104.636	0	-13	104 636	0	-13	104.636	0	-13	104 635	-1	-14	104.635	0	-14	104.637	1	-12				
(3004 0)161	104 666	104.658	2	-8	104 655	-3	-11	104.656	1	-10	104.656	0	-9	104 656	0	-10	104.656	0	-9	104 656	0	-9	104.656	-1	-10	Not Acce	-	-				
(3004 0)164	104 669	104.664	2	-5	104 662	-2	-7	104.662	0	-7	104.662	0	-7	104 662	0	-7	104.663	1	-6	104 663	0	-6	104.663	0	-6	Not Acce	-	-				
(3004 0)166	104 739																															

 <b>HOCHTIEF MURPHY</b> Joint Venture		<b>C310 THAMES TUNNEL          REPORT</b>			
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**APPENDIX 03**

C704 report "C704 Instrumentation and Monitoring – Decommissioning Agreement Plumstead – Phase 1, Network Rail, North Kent Line NR/24" (C704-XRL-C-AAG-CR148\_PT005-50001)

Learning Legacy Document



# Crossrail Delivery – Contract C704

## C704 Instrumentation Decommissioning Agreement Plumstead – Phase 1, Network Rail, North Kent Line NR/24

Document Number: C704-XRL-C-AAG-CR148\_PT005-50001

### Document History:

Revision	Date:	Prepared by:	Checked by:	Approved by:	Reason for Issue
1.0	16-04-2015	[REDACTED]	[REDACTED]	[REDACTED]	First Issue
		[REDACTED]	[REDACTED]	[REDACTED]	

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## **1 Definitions**

<b>Asset</b>	Specific Network Rail interface covered by this document (NKL).
<b>ELR NKL CRL</b>	Engineers Line Reference; North Kent Line Crossrail.
<b>C122</b>	CRL Contract that assessed excavation-induced ground movements and acts as Designer of C701/C704 I&M systems. C122 advises on residual risk to the Asset associated with long term movements/deformations, based on current trends.
<b>C310</b>	CRL Main Works Contractor (Hochtief Murphy Joint Venture)
<b>TBM</b>	Tunnel Boring Machine
<b>C701</b>	CRL Contract responsible for the installation/maintenance of the automatic I&M system on NR/24
<b>UCIMS</b>	Underground Construction Information Management System
<b>C704</b>	CRL Contract responsible for the maintenance/decommissioning of C701 automatic I&M system on NR/24.
<b>I&amp;M</b>	Instrumentation & Monitoring.
<b>NR</b>	Network Rail.
<b>ZOI</b>	Zone of Influence
<b>Predicted zone of influence of Crossrail works</b>	Area located within the predicted 1mm greenfield ground surface settlement contour associated with Crossrail works.
<b>Relevant parties</b>	Parties requested to formally agree decommissioning of the automatic I&M system presented in this document: <ul style="list-style-type: none"><li>- <i>Network Rail (NR)</i>;</li></ul>
<b>ATS</b>	Automatic Total Station

## **2 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 on the Network Rail North Kent Line (NR24). The objective of the monitoring regime has been that of automatically monitoring the effects of the movements caused by Crossrail works (TBM passage and Construction of Plumstead Portal) adjacent to the Asset.

The C701 I&M automatic system has been installed in advance of CRL construction activities to record necessary background monitoring data. Currently C704 provide monitoring data from the system to UCIMS.

This document aims to provide a basis on which all relevant parties can agree on C704 ceasing automated monitoring of the Asset that can now be demonstrated to be stable with no further settlement anticipated.

## **3 Scope**

Given its purpose, this document has been produced 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 the residual risk (associated with long term movements/deformations) to the Asset will be provided by Crossrail in a close-out report.

The extent of the asset that this decommissioning agreement refers to runs from approximately 10m/10ch to 10m46ch/CRL Chainage 91750 to 92320. The monitoring in question comprises the Phase 1 installation as detailed in C701-ITM-C-RGN-CR148\_PT005-5001. It should be noted that 1no. ATS (ATS6) was removed during the decommissioning of the Phase 2 installation (C704-XRL-C-RGN-CR148\_PT005-50001). Furthermore ATS 4 and 5 have also been removed previously on the 23<sup>rd</sup> December 2014 following agreement with C310 and Network Rail. The remaining monitoring equipment is shown in Appendix B and can be summarised as:

- 3no. Automatic Total Stations (ATS1,2 and 3)
- Approx 350no. track mounted prisms
- Associated reference prisms

## **4 The Asset: North Kent Line (NKL), NR/24**

### **4.1 Asset Description**

The Asset is described in the Assessment of Ground Movement Effects (C122-OVE-C2-RGN-CR148\_PT005-50004) and consists of the Up and Down line of the North Kent Line (ELR:NKL) which runs approximately in the east – west direction and broadly parallel with the Crossrail alignment adjacent to Plumstead Portal.

### **4.2 Crossrail Works affecting the Asset**

The CRL works included Portal Construction and the twin TBM running tunnels exiting at the western end of the portal site and monitored by the Phase 2 installation. Upon completion of the tunnel drives the head house structure was completed.



The latest and last CRL work that had the potential to affect the Asset was the de-stressing of ground anchors and removal of propping in the headwall area of the launch chamber carried out between the 24<sup>th</sup> and 27<sup>th</sup> of February 2015. Subsequent to this there have been other works that were not assessed as having the potential to cause ground movements. All recent works carried out in this headwall area are listed below:

- Excavation of attenuation tank – 18th November 2014
- Retaining wall east excavation – 24th November 2014
- Head shunt excavation – 12th February 2015
- Prop removal in head house area – 24/27th February 2015
- Ground anchor de-stressing – 24/27th February 2015
- Retaining wall west excavation – 2nd March 2015
- Extension slab excavation – 2nd March 2015
- Removal of asset protection barrier posts 55-98 – 7/8th March
- Removal of asset protection barrier posts 99-140 – 20th/21st March

Works with the potential to impact the railway could be considered as essentially complete.

## **5 Predicted impact of CRL Works on the Asset**

The methodology used to assess the predicted impact of Crossrail works on the Network Rail Asset (NR/24) and a summary of the results of this assessment are presented in C122 Assessment of Ground Movement Effects on Network Rail Assets (NR/22 and NR/24) – North Kent Line at Plumstead Goods Yard C122-OVE-C2-RGN-CR148\_PT005-50004.

## **6 I&M Systems in NR/24**

### **6.1 C704 systems**

The automatic I&M system installed on the asset under consideration was specified on drawing C122-OVE-C2-DDA-CR001\_Z-31134.

Monitoring frequencies and trigger values were specified in *Design Consultant Framework Contract C122 – Bored Tunnels: Instrumentation & Monitoring Plan for Network Rail Assets NR/22 to NR/25, Plumstead C122-OVE-C2-RGN-CR148\_PT005-50006*.

The installation of this system on NR/24 was carried out by C701 and is described in detail in C701-ITM-C-RGN-CR148\_PT005-50001 (C701 Installation Report for NR/24). In summary the full system comprised the following:

- Track monitoring at 3.0m centres by means of geodetic prisms fixed to the foot of the rail and read by ATS.
- 6no. Leica ATS with associated power and telecoms cable
- Associated reference prisms.

Partial decommissioning of this system together with Plumstead Phase 2 has already been carried out. Please see the partial decommissioning report for details C704-XRL-C-RGN-CR148\_PT005-50001. As part of this work, ATS6 and its respective prisms were removed.

Following agreement with C310 and Network Rail, 2 additional instruments (ATS 4 and 5) and their respective prisms were removed on the 23<sup>rd</sup> of December 2014, reducing the system further in the East.

The remaining instrumentation closest to the headwall and which is the focus of this decommissioning agreement is shown in Appendix B.

## **6.2 Systems installed by others**

Not considered in this report.

## **7 Monitoring Results vs. CRL Construction Works**

*Design Consultant Framework Contract C122 – Bored Tunnels: Instrumentation & Monitoring Plan for Network Rail Assets NR/22 to NR/25, Plumstead C122-OVE-C2-RGN-CR148\_PT005-50006* presents trigger values for the following purposes:

- Asset protection;
- Construction control;
- Track Geometry and Track Clearance.

As discussed in section 4.2, the latest and last CRL work with the potential to affect the Asset was the de-stressing of ground anchors and removal of propping in the headwall area of the launch chamber carried out between the 24<sup>th</sup> and 27<sup>th</sup> of February 2015. Other works undertaken in the head house area as listed in section 4.2 have also been assessed in this report (see Appendix C).

The monitoring data recorded by the automatic systems (Geodetic prisms and ATS) show that no significant movements occurred as a result of the recent works undertaken in the head house area. (see graphs in Appendix C). It could be argued that the head shunt excavation and prop removal/ ground anchor de-stressing had a slight influence on the track monitoring but the movements in question are very small and within the monitoring accuracy of the system (+/- 1mm).

The heave and subsequent settlement of the track prisms that is observed in the Down line is attributed to the rail tamps on the 19<sup>th</sup> of October and 21<sup>st</sup> of December 2014. This can be corroborated by checking a prism from the same array on the Up line over the same period. Since no movements are recorded in the Up line at the time of the movements observed on the down line the heave can only be attributed to rail works as opposed to works occurring on the CRL work site.

The data recorded from the automatic system during both construction and closeout monitoring regimes are considered reliable and non-construction related variations are within the expected repeatability for this kind of system.

## **8 Assessment of Closeout Trends**

C122 Instrumentation and Monitoring, Combined I & M Schedule C310, C122-OVE-C2-DDJ-CR001\_Z-30003 stipulates that monitoring should continue for 3 months post the last construction event with the potential to cause ground movements. Beyond these 3 months, the monitoring frequency should be reduced to quarterly until settlement rate is equal to or less than 2mm per annum.

Current closeout trends highlight a general stabilization with very limited residual (post-construction) movement over the last 2-3 months. The only movement observed in the last 3 months has been the settlement of the ballast following rail tamping in December 2014. An analysis of monthly contour plots in this area shows that from February to April there have been

**C704 Instrumentation and Monitoring –Decommissioning Agreement  
Plumstead – Phase 1, Network Rail, North Kent Line NR/24**

**C704-XRL-C-AAG-CR148\_PT005-50001 Rev 1.0**

no discernible movements on either of the Up or Down tracks. Contour plots for the last three months in the affected area are given in Appendix C.

Based on above, it is proposed to decommission the automatic I&M system currently installed on NR/24 over the defined area as described in Section 6.1 and shown in Appendix B. Furthermore, it is also proposed that further quarterly readings of the track by manual means or other methods are not required.

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## **9 Reference Documents**

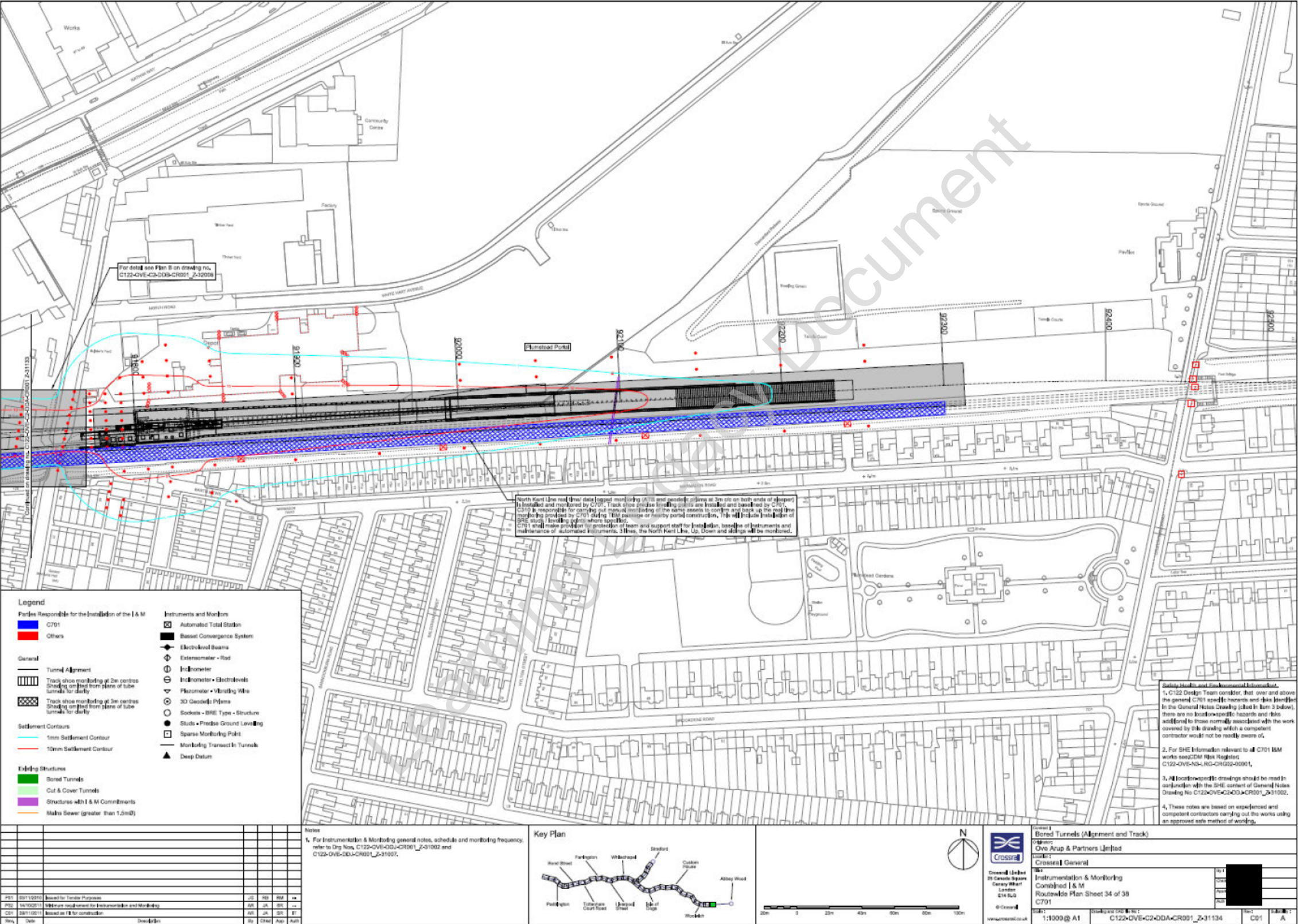
C701-ITM-C-RGN-CR148_PT005-50001	C701 Installation Report for NR/14
C704-XRL-C-RGN-CR148_PT005-50001	Partial decommissioning report, Plumstead North Kent Line
C122-OVE-C2-RGN-CR148_PT005-50006	Instrumentation & Monitoring Plan for Network Rail Assets NR/22 to NR/25, Plumstead
C122-OVE-C2-DDA-CR001_Z-31134	I&M drawing
C122-OVE-C2-RGN-CR148_PT005-50004	Assessment of Ground Movement Effects on Network Rail Assets (NR/22 and NR/24) – North Kent Line at Plumstead Good Yard
C122-OVE-C2-DDJ-CR001_Z-30003	Instrumentation and Monitoring, Combined I & M Schedule C310

## **10 Appendices**

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## **APPENDIX A - I&M Drawings**

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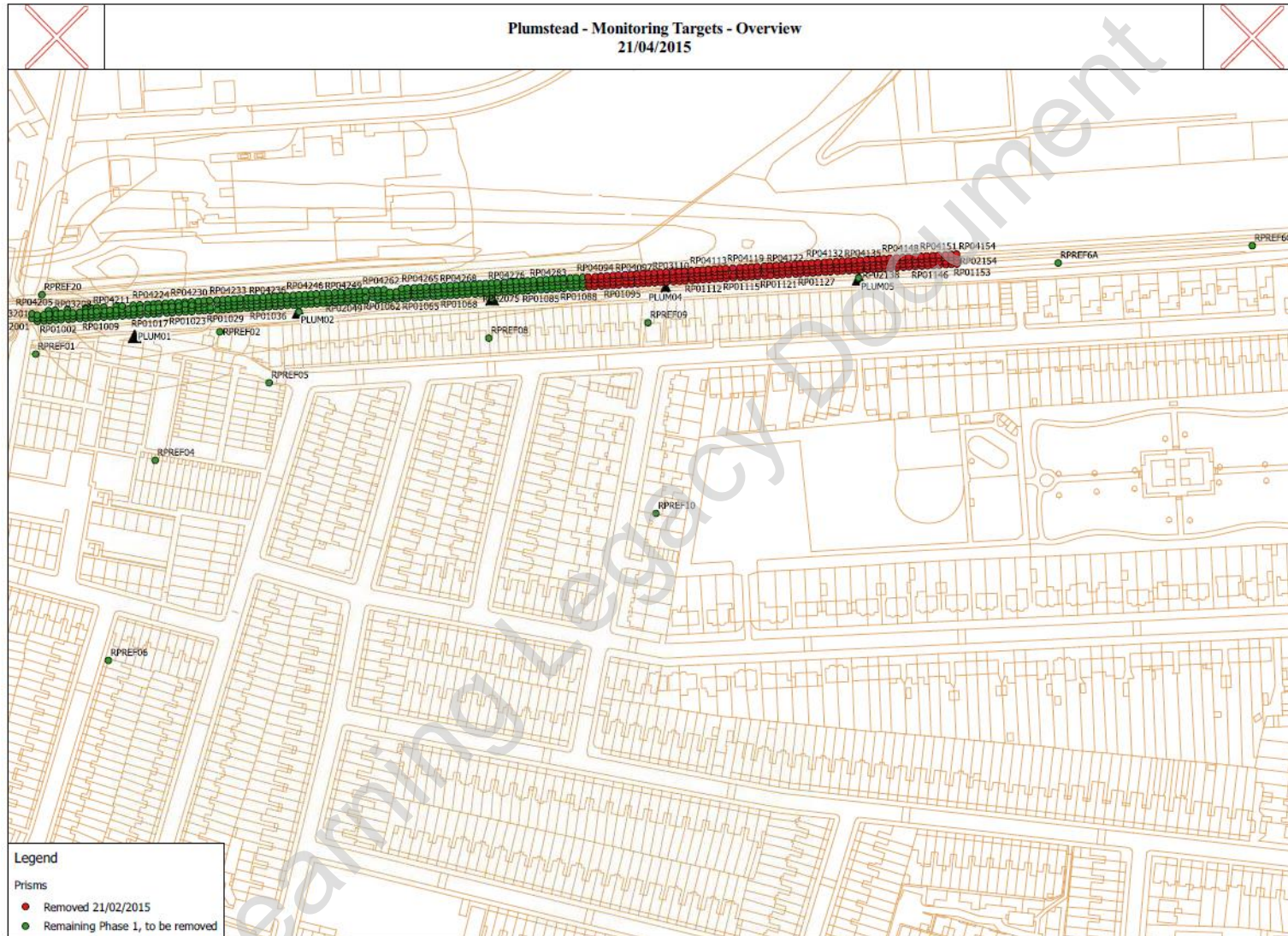
## **APPENDIX B – Location Plan**

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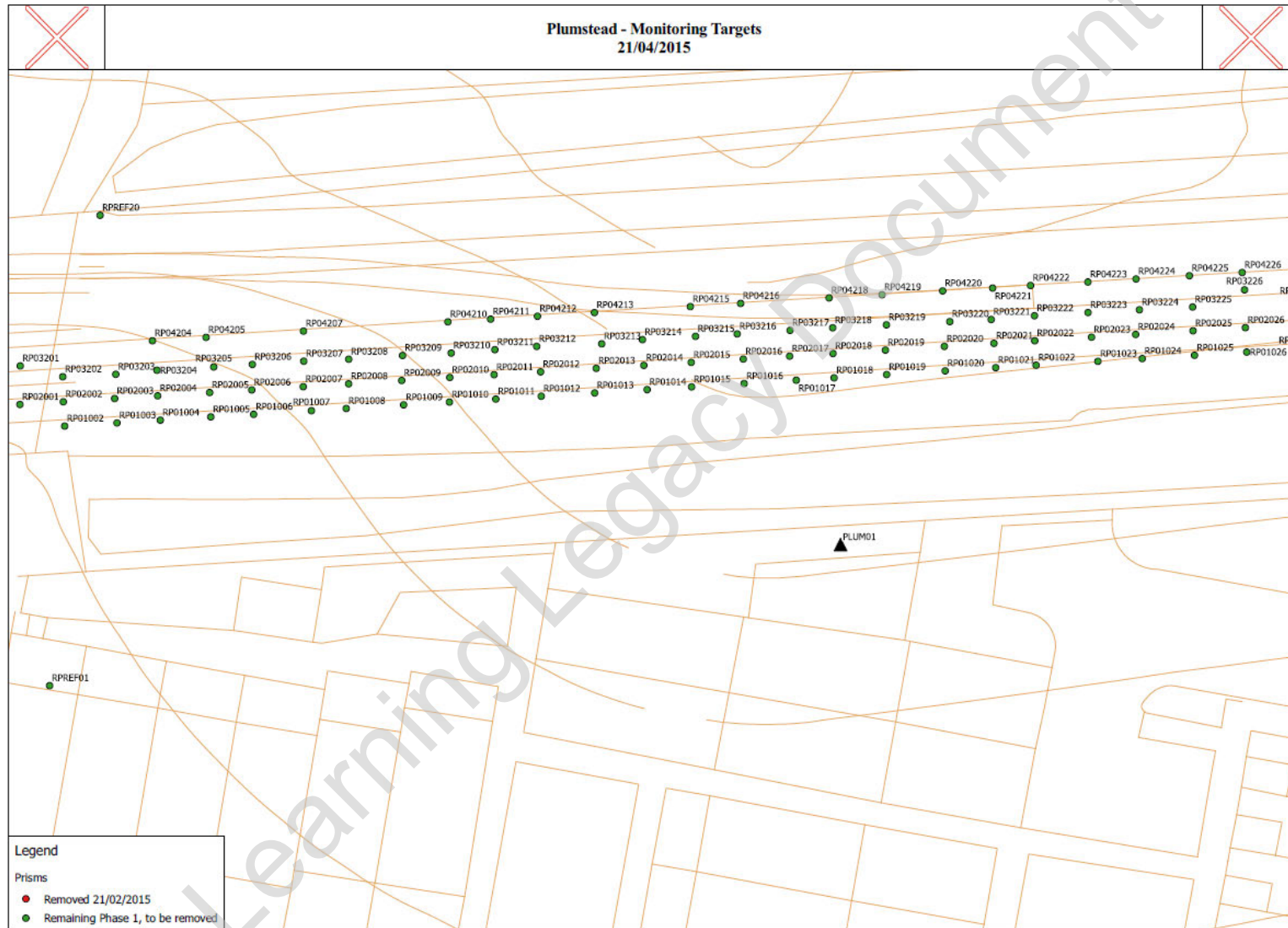
**C704 Instrumentation and Monitoring –Decommissioning Agreement  
Plumstead – Phase 1, Network Rail, North Kent Line NR/24**

**C704-XRL-C-AAG-CR148\_PT005-50001 Rev 1.0**



**C704 Instrumentation and Monitoring –Decommissioning Agreement  
Plumstead – Phase 1, Network Rail, North Kent Line NR/24**

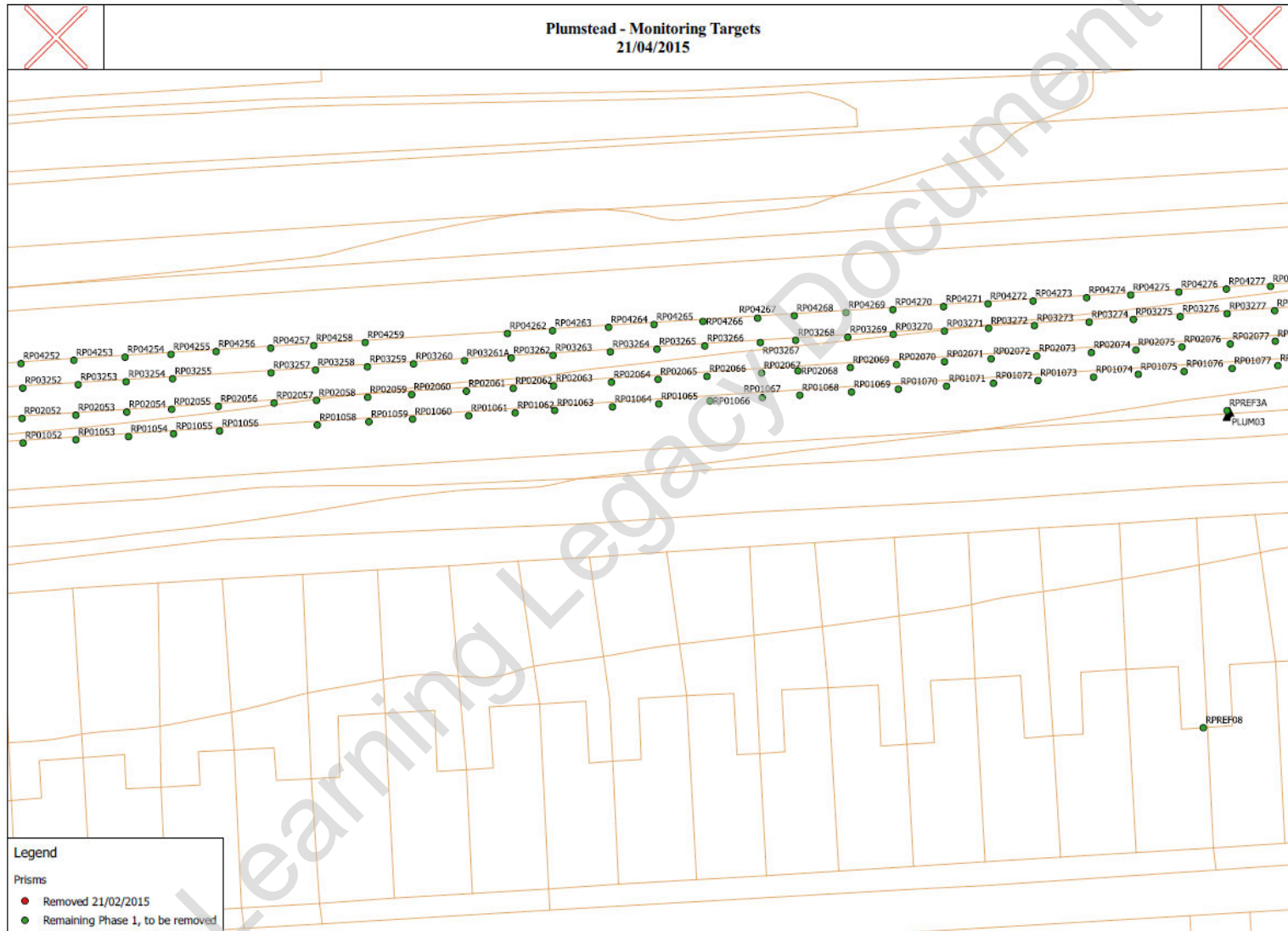
**C704-XRL-C-AAG-CR148\_PT005-50001 Rev 1.0**





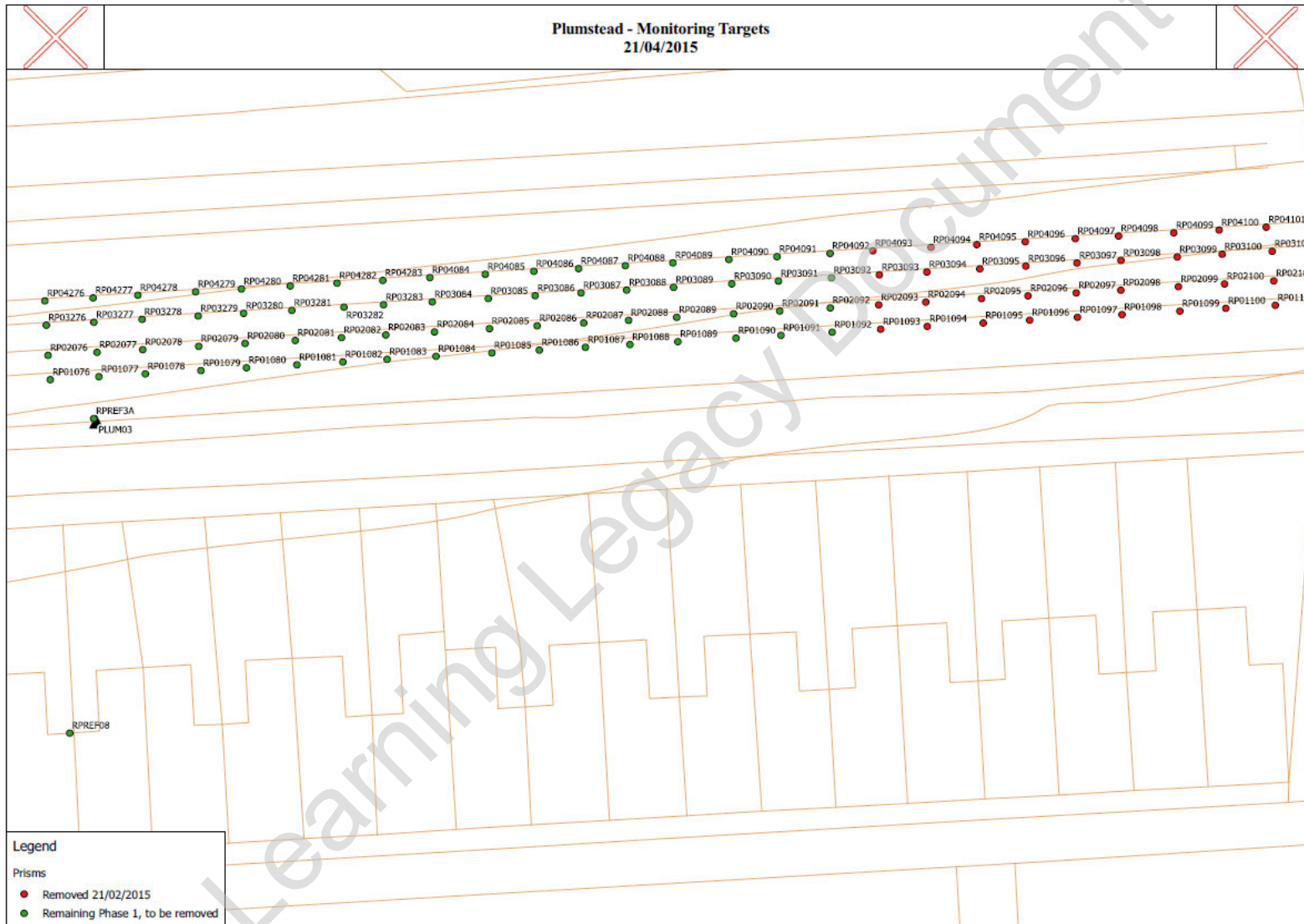
**C704 Instrumentation and Monitoring –Decommissioning Agreement  
Plumstead – Phase 1, Network Rail, North Kent Line NR/24**

**C704-XRL-C-AAG-CR148\_PT005-50001 Rev 1.0**



C704 Instrumentation and Monitoring –Decommissioning Agreement  
Plumstead – Phase 1, Network Rail, North Kent Line NR/24

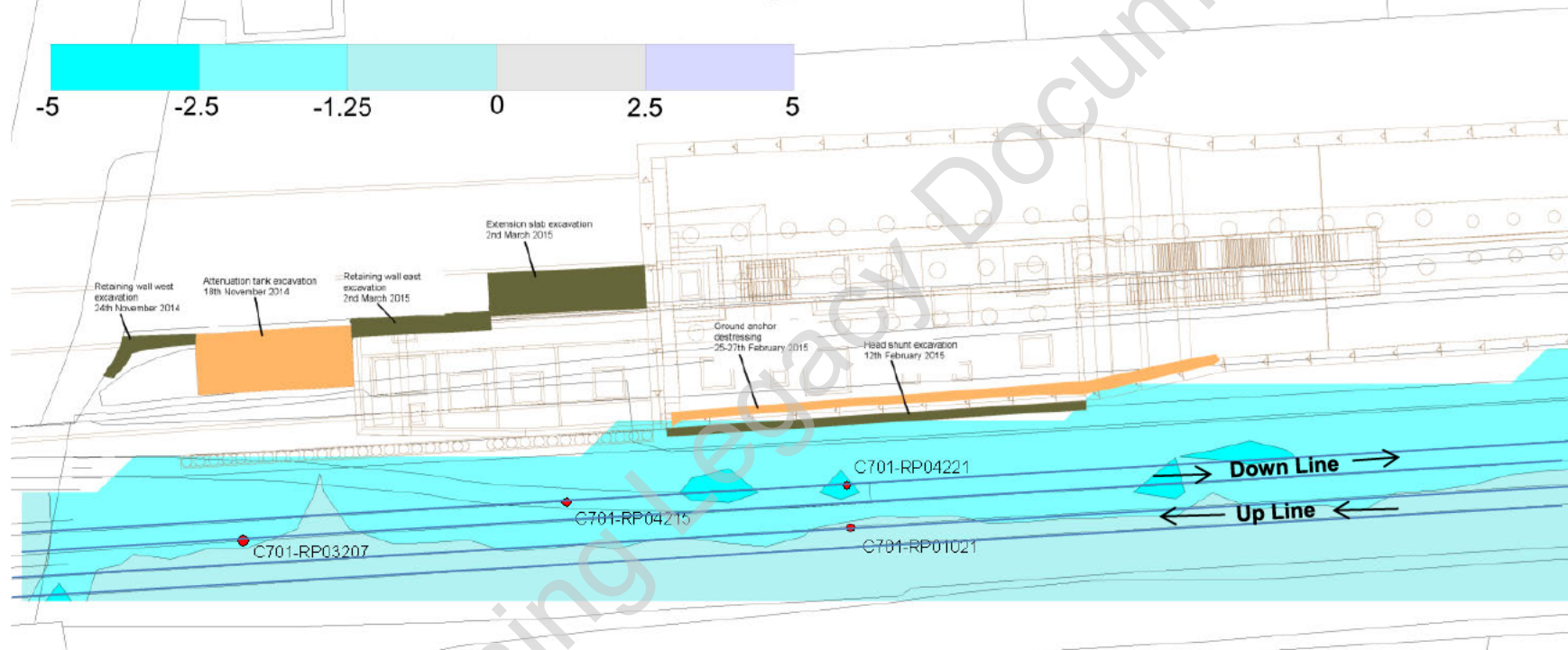
C704-XRL-C-AAG-CR148\_PT005-50001 Rev 1.0



## **APPENDIX C - Summary of monitoring results for NR/24**

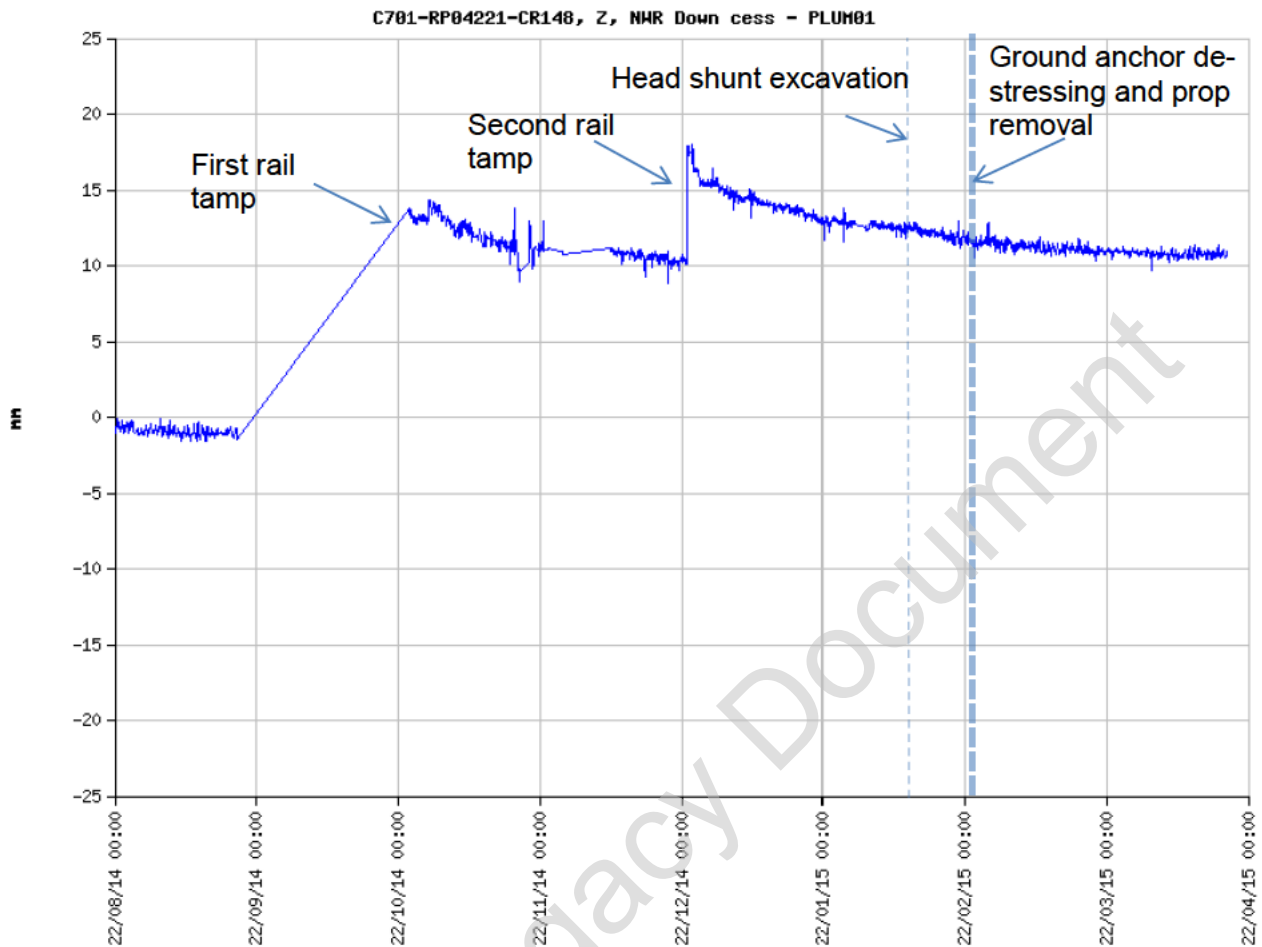
1. Contour map of settlement observed between January and April 2015 with construction activity locations
2. Time plot of Down line prism near prop removal showing no effect of CRL works but showing effect of rail tamping
3. Time plot of Up line prism near prop removal showing no effect of CRL works or rail tamping
4. Time plot of prism near attenuation tank showing no effect of CRL works
5. Time plot of prism near extension slab showing no effect of CRL works
6. Time plot of prism near asset protection barrier post showing no response to removal
7. Site contour plots
  - a. January to April 2015
  - b. January to February 2015
  - c. February to March 2015
  - d. March to April 2015

## Differential movement in Z (mm) observed in automated track monitoring January to April 2015 - Headwall area



- Contour plot showing locations and dates of recent C310 CRL construction works and approximate locations of specific sensors in following report.
- Plot shows that there is negligible movement (0 to 1.25mm settlement) over this time period related to CRL works.
- Darker blue areas show the settlement of the rail in response to a rail tamp at the end of 2014 as shown in the time plots below.

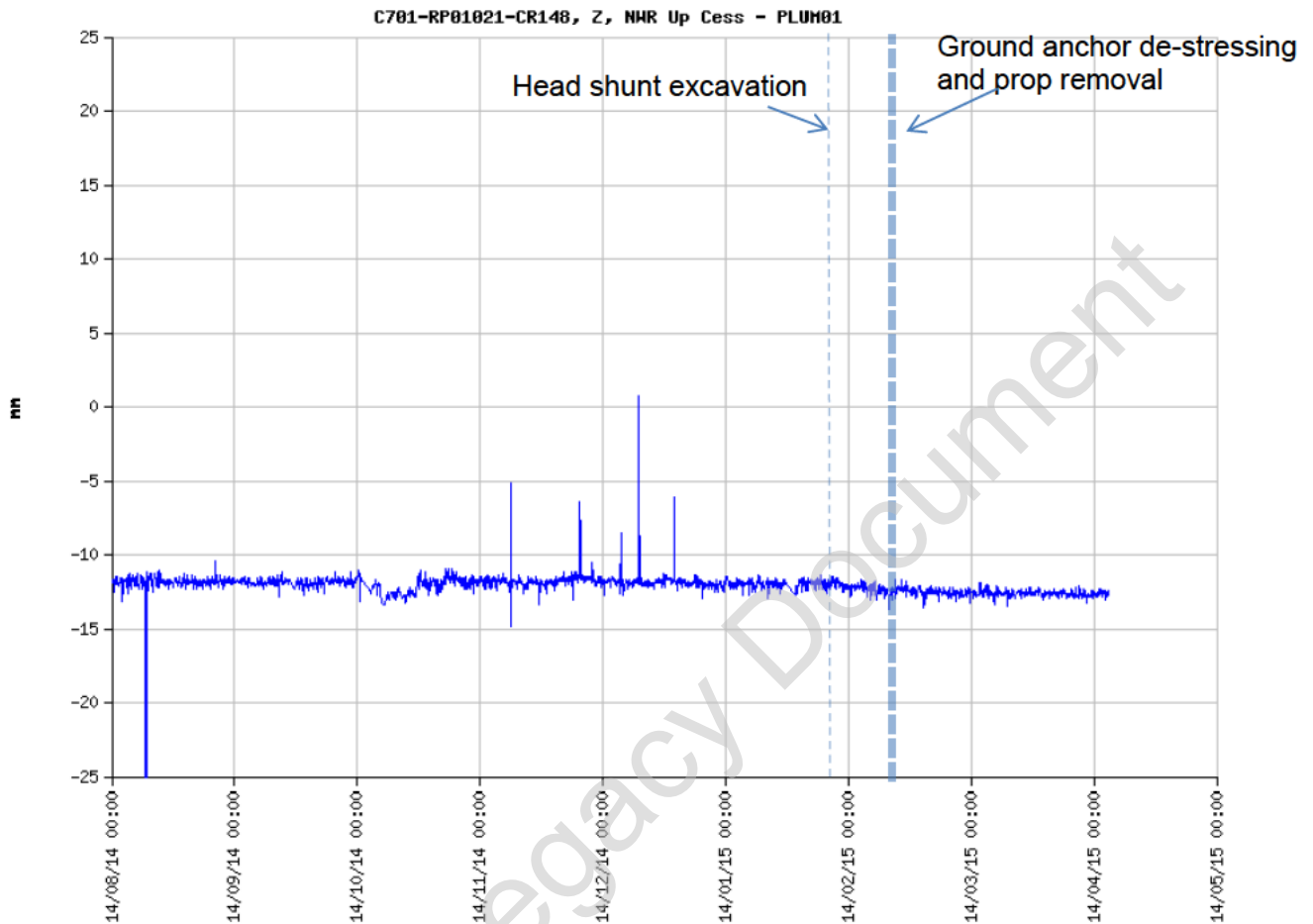
**Prop removal/ground anchor de-stressing/head shunt excavation (Down Line)**



- Prism located on Down line cess rail, close to location of the head shunt excavation and prop removal/ground anchor de-stressing
- Down line track replaced in August 2014. Prisms installed and baselined following this.
- Prism shows clearly the two steps and subsequent settlement caused by the rail works on the possessions of the 19<sup>th</sup> October and 21<sup>st</sup> December 2014
- Slight possibility of a further trend discernable around the 12<sup>th</sup> of February that could be related to the head shunt excavation. This is very small however and is within the monitoring accuracy. This potential settlement has ceased and the overall trend is still due to the rail works and not related to CRL works. Also current trends indicate all movements have stabilised.
- Slight possibility of a further trend discernable related to the removal of the props and de-stressing of ground anchors on the 24-27<sup>th</sup> of February. This is very small however and is within the monitoring accuracy. This potential settlement has ceased and the overall trend is still due to the rail works and not related to CRL works. Also current trends indicate all movements have stabilised

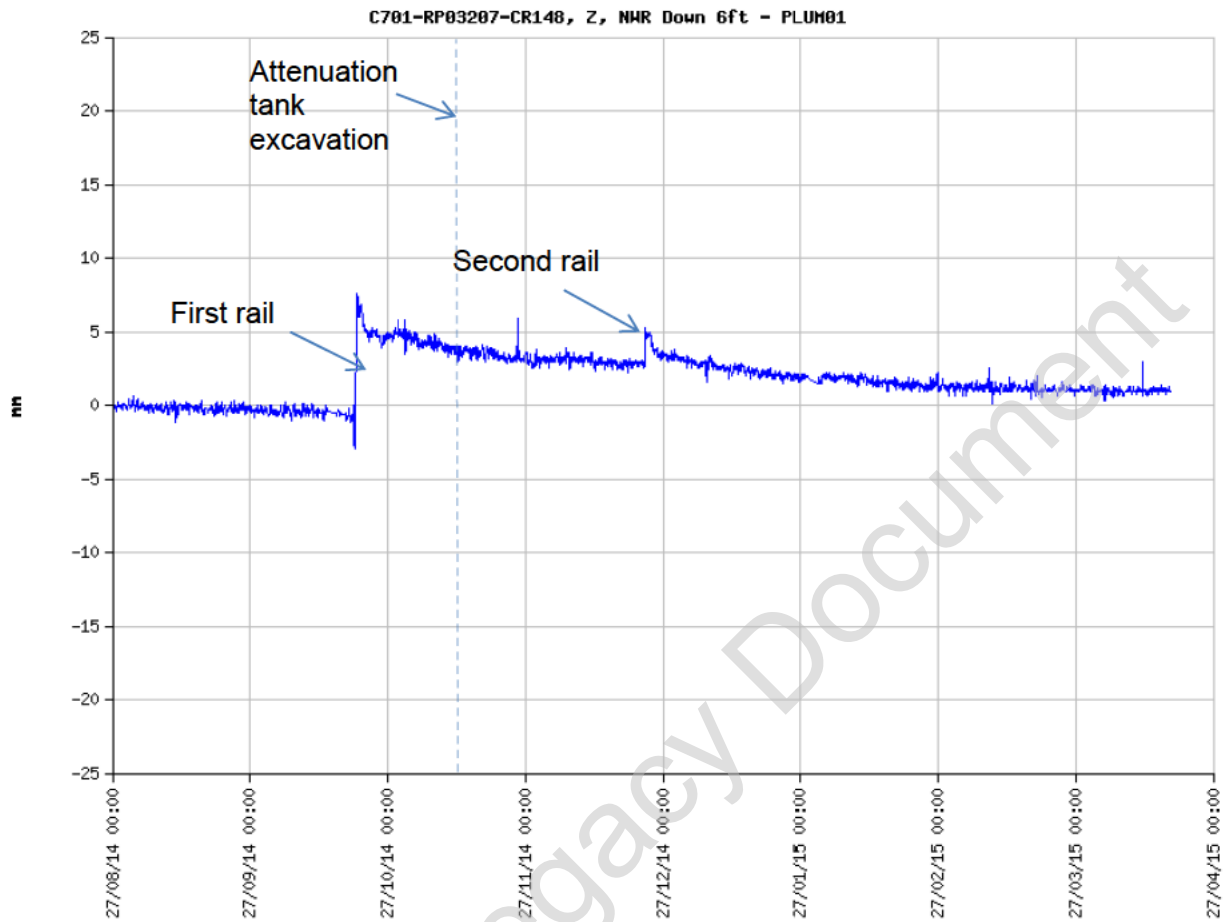


**Prop removal/ground anchor de-stressing/head shunt excavation (Up Line)**



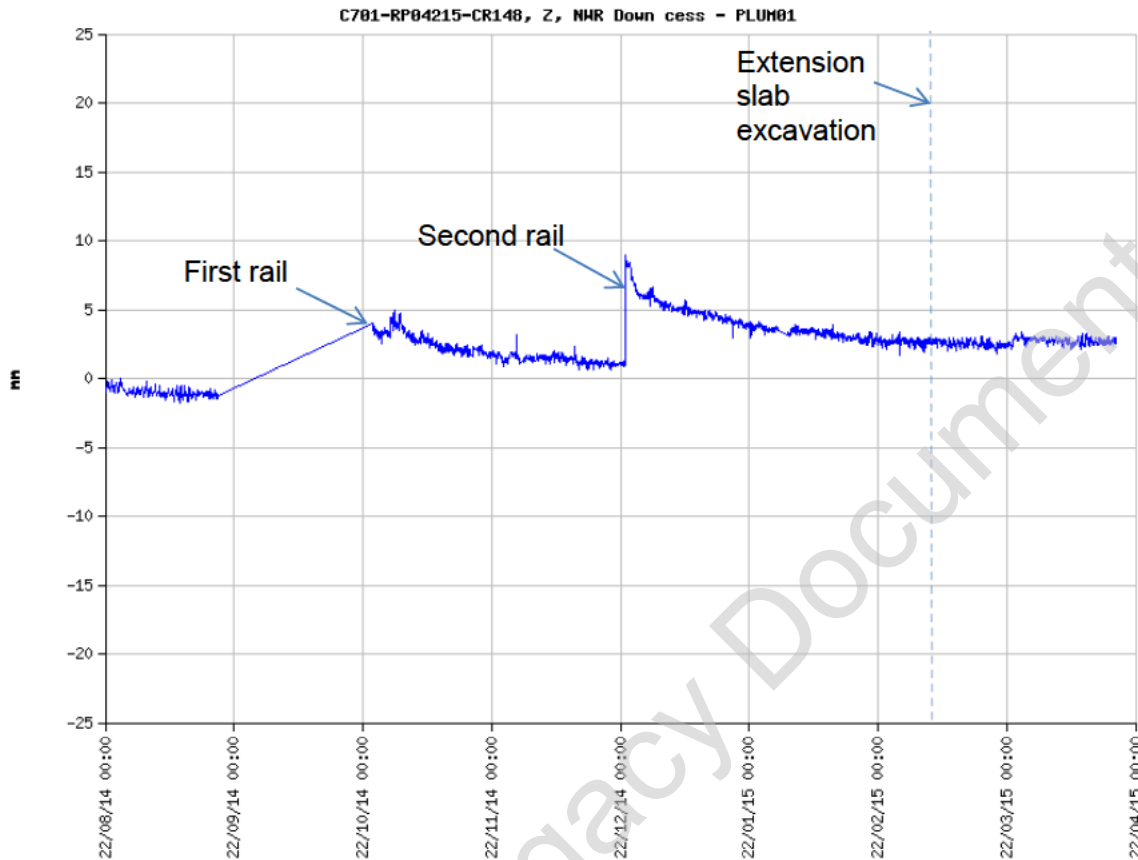
- Prism located on Up line cess rail adjacent to RP04221 on previous page, close to location of the head shunt excavation and prop removal/ground anchor de-stressing
- Prism starting at -12mm as the Up Line was not replaced when along with the Down in August. Settlement to date is a reflection of earlier works. This will be addressed in the contractor's close out report.
- Prism shows no discernable trend compared to the down line on the same array indicating that the movements observed are due to the track works and not CRL related works. If the settlement observed on the down line were due to CRL construction activity these movements would be visible on the up line also.
- Slight possibility of a trend discernable around the 12<sup>th</sup> of February that could be related to the head shunt excavation. This is very small however and is within the monitoring accuracy. Current trends indicate all movements have stabilised.
- Slight possibility of a further trend discernable related to the removal of the props and de-stressing of ground anchors on the 24-27<sup>th</sup> of February. This is very small however and is within the monitoring accuracy. This potential settlement has ceased and the overall trend is still due to the rail works and not related to CRL works. Also current trends indicate all movements have stabilised

### Attenuation tank removal



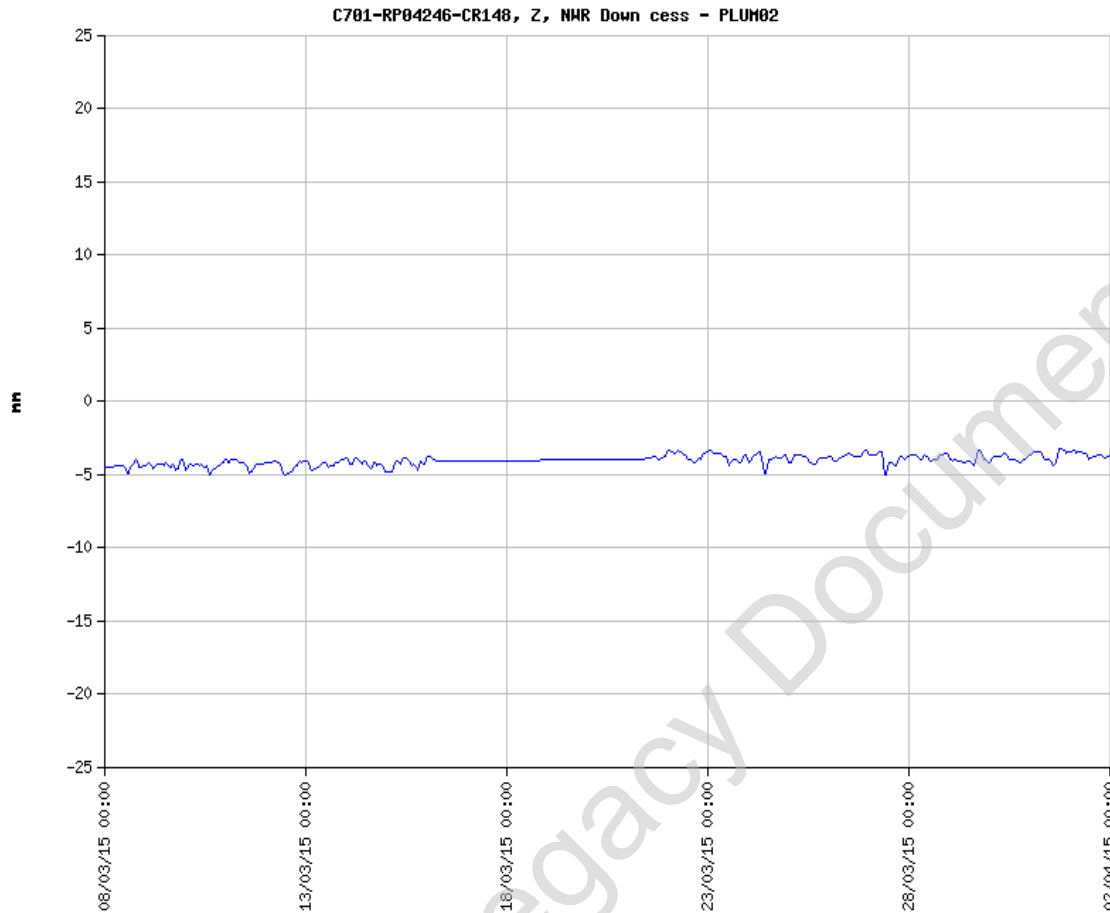
- Prism located on Down line 6ft rail, close to location of the attenuation tank excavation.
- Prism shows clearly the two steps and subsequent settlement caused by the rail works on the possessions of the 19<sup>th</sup> October and 21<sup>st</sup> December 2014
- Current trends indicate all movements have stabilised.
- The excavation of the attenuation tank on the 18<sup>h</sup> of November does not seem to have affected the track.

### Extension slab excavation



- Prism located on Down line cess rail, close to location of the extension slab excavation.
- Prism shows clearly the two steps and subsequent settlement caused by the rail works on the possessions of the 19<sup>th</sup> October and 21<sup>st</sup> December 2014
- Current trends indicate all movements have stabilised
- The excavation of the extension slab on the 2<sup>nd</sup> of March does not seem to have affected the track

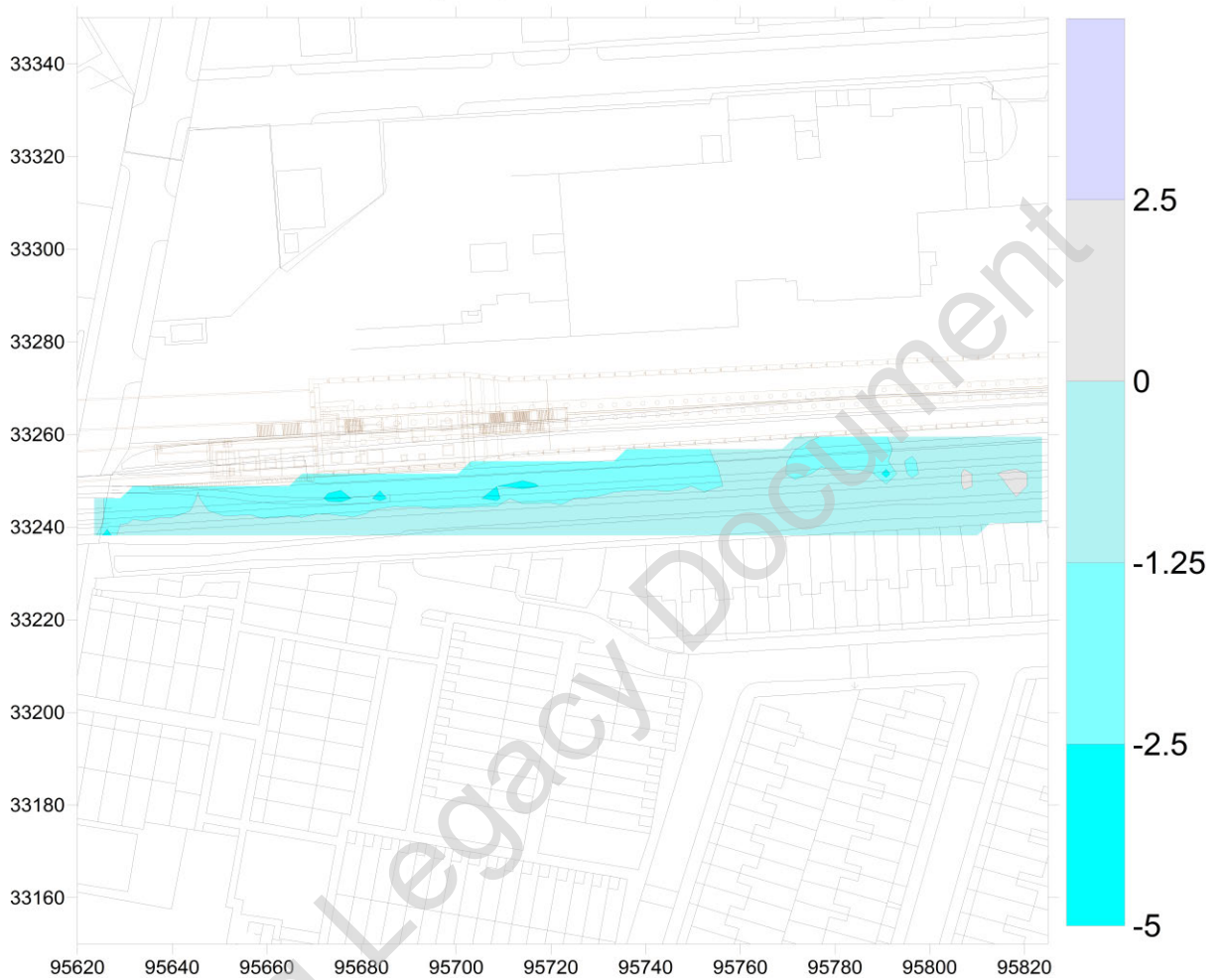
**Asset protection barrier post removal**



- Prism located on Down line cess rail, close to location of asset protection barrier post removal works.
- The works were carried out on the weekend of the 21st/22nd march 2015.
- The data shows that the tracks did not move in response to these works.

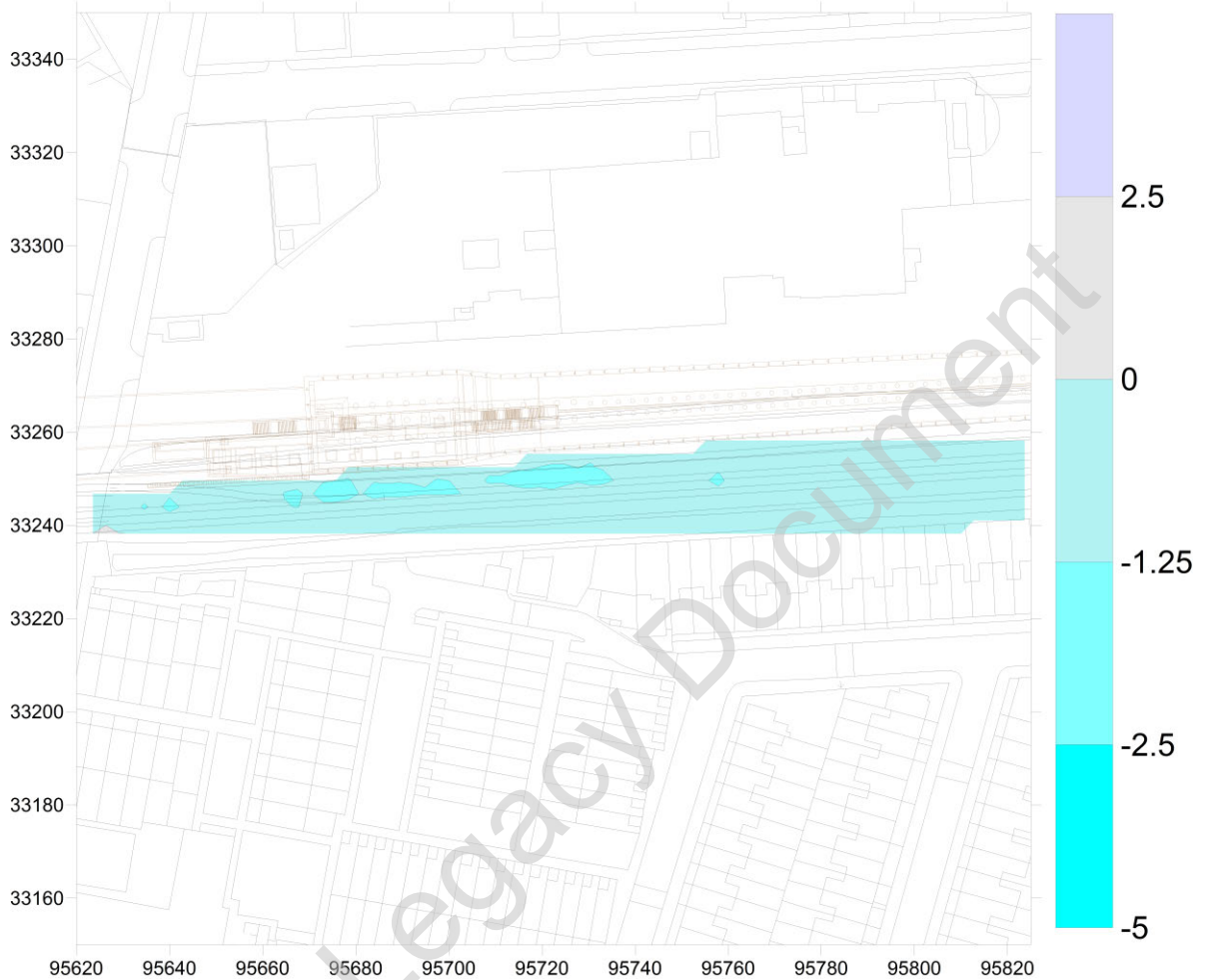
**Site contour plans**

Differential Movement Z (mm) from January 2015 to April 2015



- Daily median of settlement recorded between January and April 2015
- Shows the residual settlement of the down line only in response to the rail tamp

Differential Movement Z (mm) from January 2015 to February 2015



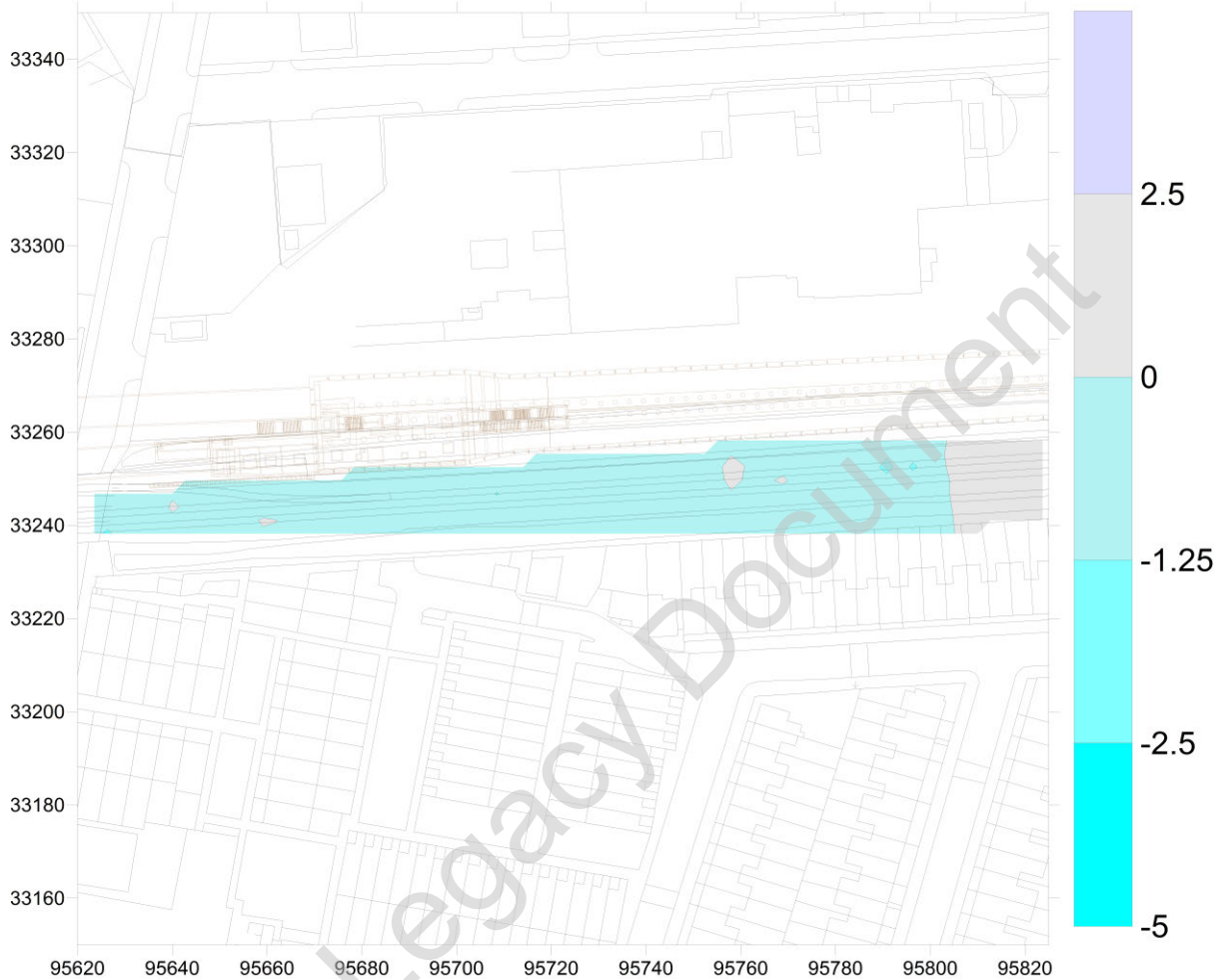
- Daily median of settlement recorded between January and February 2015
- Slight settlement in down line observed
- Movement still related to tamp in December 2012

**Differential Movement Z (mm) from February 2015 to March 2015**




- Daily median of settlement recorded between February and March 2015
- Any movements observed within the monitoring accuracy of the system (+/- 2mm)

**Differential Movement Z (mm) from March 2015 to April 2015**



- Daily median of settlement recorded between March and April 2015
- Any movements observed within the monitoring accuracy of the system (+/- 2mm)



 <b>HOCHTIEF MURPHY</b> Joint Venture		<b>C310 THAMES TUNNEL</b> <b>REPORT</b>			
EMPLOYER	CROSSRAIL	eB NO	C310-HTM-C-RGN-CR148-50035	Rev	2.0
TITLE	Monitoring Close-Out Report for North Kent Line (NKL)				

**APPENDIX 04**

C122 report "Ground Movement Summary Report; C310 – Plumstead Portal"

(C122-OVE-C2-RGN-CR148\_PT005-50010)

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DESIGN CONSULTANT FRAMEWORK  
CONTRACT C122 – BORED TUNNELS

Ground Movement summary report –  
Plumstead Portal

Document Number: C122-OVE-C2-RGN-CR148\_PT005-50010

Document History:

Revision:	Date:	Prepared by:	Checked by:	Authorised by:	Reason for Issue:
1.0	10/10/2013				For Approval

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Project title	C122 Bored Tunnels	Job number
Document title	Ground Movement summary report –Plumstead portal	File reference
Document ref	C122-OVE-C2-RGN-CR148_PT005-50010	

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		Name	[Redacted]		
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		Filename			
		Description			
		Prepared by	Checked by	Approved by	
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## 1 Introduction

### 1.1 Scope

This report summarises the observed ground movements arising from the Crossrail works at Plumstead. In addition this report compares calculated/predicted ground movements against movements monitored during construction. The construction of Plumstead Portal was substantially completed in November 2012. The measured values in this report were taken at the end of December 2012 after completion of the base slab construction at Plumstead Portal where approximately 90% of predicted ground movements have occurred (Based on the Report "Ground Movement Prediction Report" (Document ref. no.: C156-CSY-C2-RGN-CR148\_PT005-00009)).

All the data used herein is available in the UCIMS under Contract C310 Plumstead Portal.

### 1.2 Third Party Assets

Third Party Assets within the zone of influence of Plumstead Portal are summarised in the table below:

C122 ref	Description	Asset Type	Damage Assessment Report Ref.	Source of Ground Movement
C122 17146 C122 17148	White Hart Avenue Depot	Listed building	C122-OVE-C2-RGN-CR148_PT005-00004 rev02	Deep excavation
NR/22 NR/24	North Kent Line at Plumstead Goods Yard North Kent Line next to Plumstead Portal	Railway	C122-OVE-C2-RGN-CR148_PT005-50004	Deep excavation

## 2 Ground Movement Prediction and Damage Assessment

### 2.1 Standards Used

The following standards have been used by C122 for the calculation of ground movements:

- Crossrail Civil Engineering Design Standard (CEDs) part 7, Ground Movement Prediction, Document number CR-STD-303-7 (CEDs 7); and
- Crossrail Civil Engineering Design Standard (CEDs) part 8, Assessment of Existing Structures and Mitigation Design, Document number CR-STD-303-8 (CEDs 8)

### 2.2 Ground Movement Modelling

The assessment of ground movements arising from the excavation at Plumstead Portal is based on the methods set out in the following reports, Settlement Estimation Procedure: Phase 3 Methodology for Box Excavations (Document Ref. No. 1D0101-G0G00-01019) and Settlement Estimation Procedure: Box Excavations & Shafts, (Document Ref. No. 1D0101-G0G00-01004). The total or 'final' magnitude of ground movements (maximum) is obtained by combining all the sources of ground movements from the various construction stages (where applicable).

Ground movements due to construction of the diaphragm wall have been based on ground movement curves in CIRIA Report C580 Embedded Retaining Walls – Guidance for Economic Design.

The predicted settlement contours due to the construction of the portal are indicated in drawing "Settlement Contours Final Stage Routewide Plan Sheet 34 of 38 C310" C122-OVE-C2-DDA-CR001\_Z-21334.

Maximum depth of excavation was 14.3 m. The portal was constructed using a series of 1000 mm thick diaphragm walls and 750 mm secant pile walls.

### 3 Instrumentation and Monitoring

#### 3.1 Network Rail North Kent Line

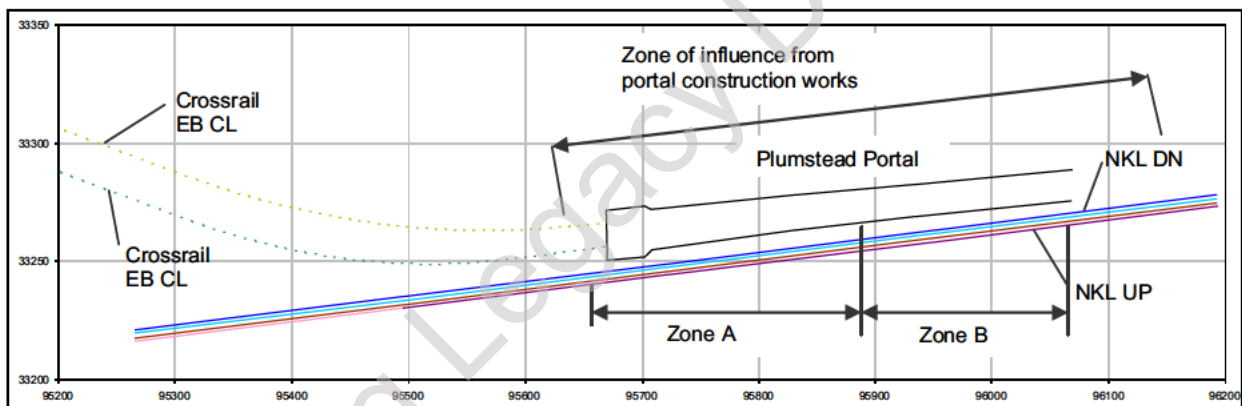
The assessment considered approximately 800m of the Up and Down North Kent Line tracks which are assessed to be within the Crossrail works influence zone. Instrumentation used for these assets comprised 3D prisms positioned every 3m along all 4 rails, monitored by an ATS remote monitoring system.

Figure 1 indicates the general arrangement of all 4 rails and the zone of influence of the Plumstead Portal construction works.

All 4 rails were assessed and are termed as follows in the presentation of the results;

- DN N - North Kent Line Down Line Near Rail
- DN F - North Kent Line Down Line Far Rail
- UP N - North Kent Line Up Line Near Rail
- UP F - North Kent Line Up Line Far Rail

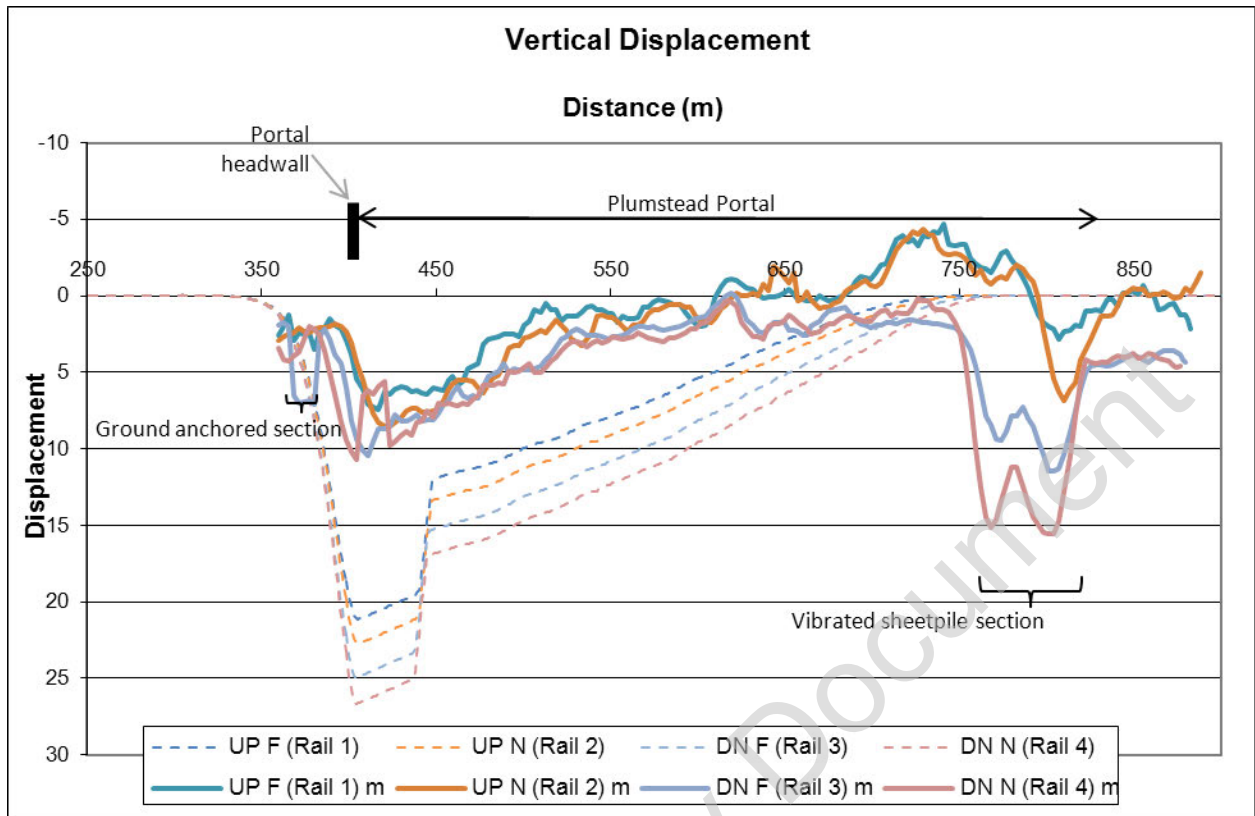
'Near' and 'Far' is in reference to distance from the Crossrail works.



**Figure 1 – General arrangement of the NKL Up and Down lines, Crossrail works and zone of influence of the portal construction works. Zone A and Zone B indicate the extent of diaphragm wall construction and secant pile wall construction respectively.**

The predicted movements given in Figure 2 represent the maximum calculated movements (dashed lines), including the effects of wall installation. Measured displacements of the rails, as of December 2012 (continuous lines), were taken after substantial completion of Plumstead Portal but before the launch of the westbound TBM drive.





**Figure 2 - Calculated 'greenfield' vertical displacements and measured vertical displacements of NKL rails due to construction of Plumstead Portal**

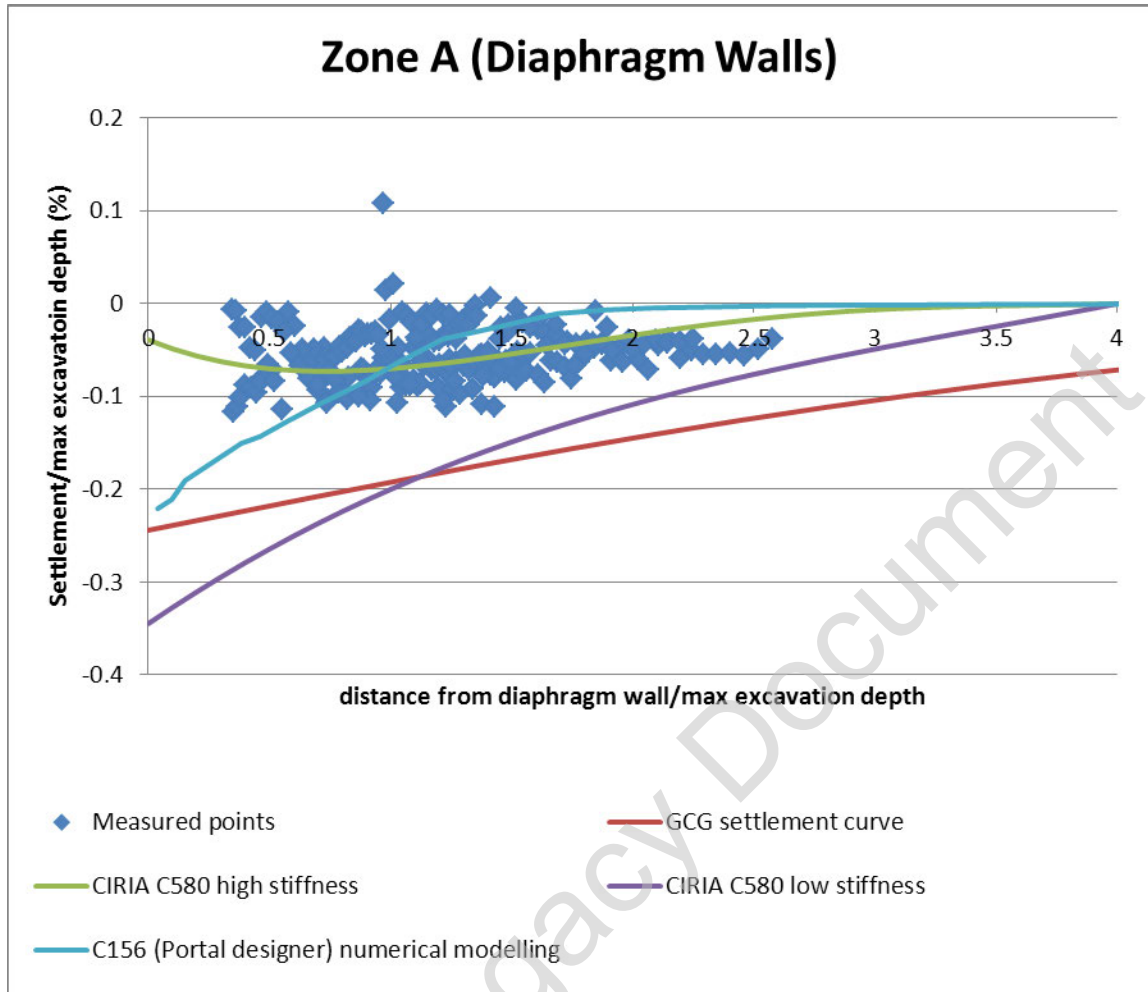
Suffix 'm' is in reference to monitored movements (December 2012). Trend lines for a 5 point rolling average have been indicated.

### 3.2 Ground Movement

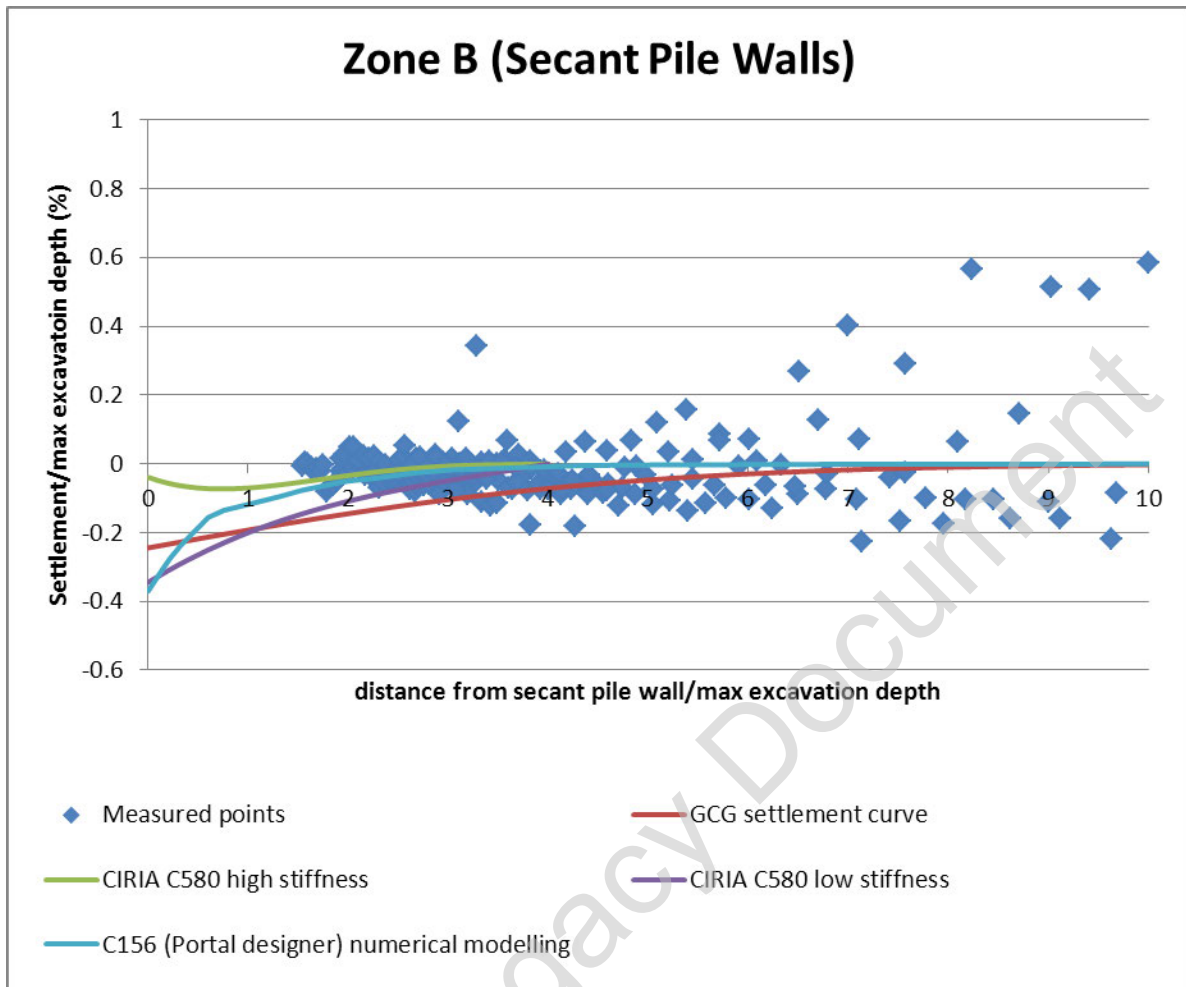
The recorded ground movement from December 2012 to the south of Plumstead Portal are in figures 3 and 4. These are taken from surface studs monitored using a precise levelling.

The figures present settlement normalised by depth of excavation for all the monitored points behind the diaphragm walls and secant pile walls. Actual ground movement values and an extract from the I&M drawing showing the general layout of the instrumentation are shown in Appendix C. Other curves giving predicted deflection are shown for comparison. Shapes of the trend lines in Figure 3 and 4 best fits CIRIA C580 high stiffness curve.

Refer to Figure 1 for Locations of Zones A and B.



**Figure 3 – Plot showing settlements along south diaphragm wall of Plumstead Portal normalised by depth of excavation and comparison against various ground movement curves. The extent of Zone A is shown on Figure 1.**



**Figure 4 - Plot showing settlements along south secant pile wall of Plumstead Portal normalised by depth of excavation and comparison against various ground movement curves. The extent of Zone B is shown on Figure 1.**

Sections A and B are show the following:

- Settlements of points measured behind the south diaphragm wall (A) and secant pile walls (B) of the Plumstead Portal,
- CIRIA C580 (low and high stiffness),
- Plumstead Portal designer's calculations made in PLAXIS (based on "Ground Movement Prediction Report" document ref. no. C156-CSY-C2-RGN-CR148\_PT005-00009 rev. 2.0),
- Geotechnical Consulting Group (based on "Settlement estimation procedure: Phase 3 Methodology for box excavations" document ref. no. 1D0101-G0G00-01019 rev. B).

### 3.3 Diaphragm Wall Deflections

In general the embedded wall deflections were lower than predicted. Measurements were taken on November 2012, using Shape Accel Arrays (SAA) installed in diaphragm walls. The highest values (maximum 14 mm) occurred in the headwall area, where the deepest excavation (14.3m) was (SAA 1, 2, 3, 10, 11, 12). A comparison of actual and predicted wall deflections is provided in Appendix A.

### 3.4 White Hart Avenue Depot

The damage assessment also considered White Hart Avenue Depot which was assessed to be within the Crossrail works influence zone. Instrumentation used for monitoring the assets were hydrostatic levelling cells together with tilt meters. Figures 5 and 6 below, present details of the measured and predicted settlement.

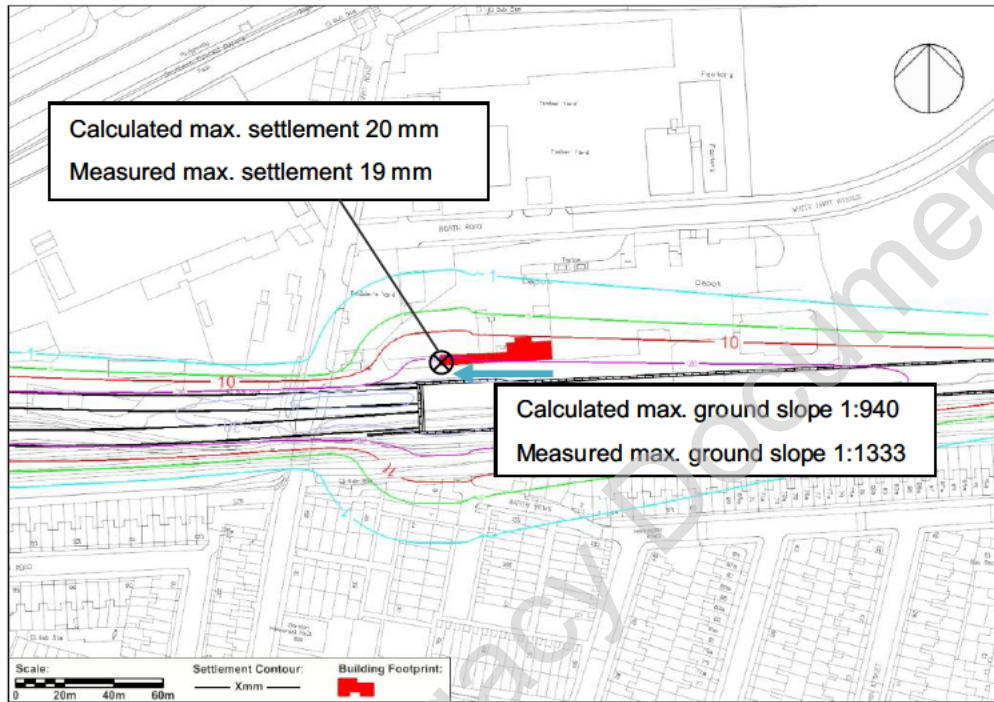


Figure 5 – Front ramp settlement contours (C122\_17146)

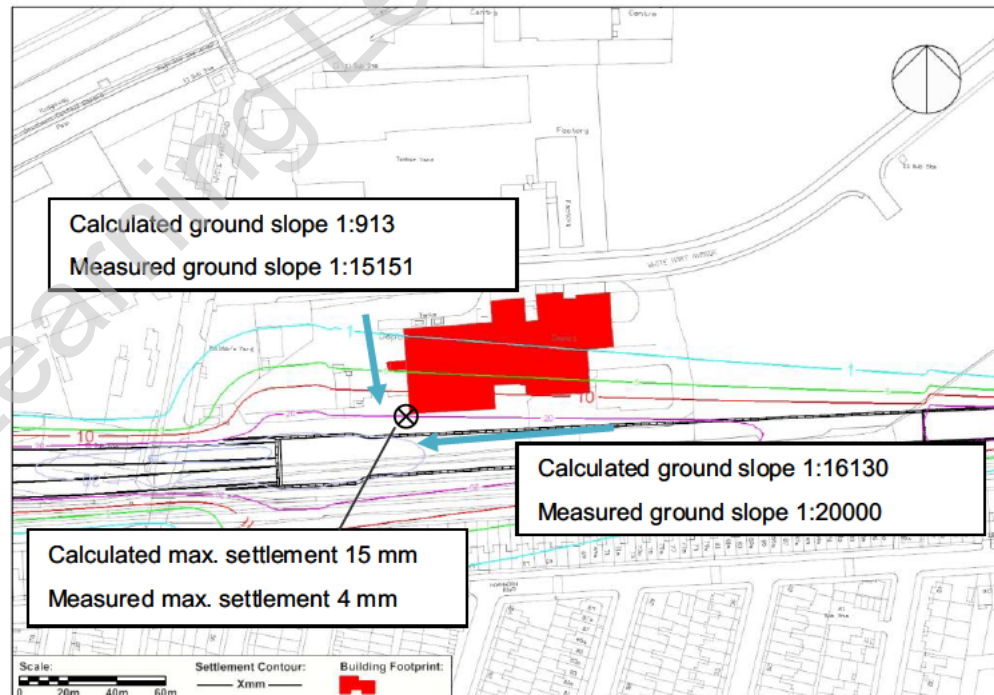


Figure 6 – Main building settlement contours (C122\_17146)

A comparison of the calculated movements (see Section 1.2) for White Hart Avenue Depot and values monitored during construction are as follows:

White Hart Avenue Depot front ramp - Maximum calculated settlement was 20 mm, while maximum measured settlement was 19 mm. Maximum calculated ground slope was 1:940 and measured was 1:3300 (parallel to excavation).

White Hart Avenue Depot main building - Maximum calculated settlement was 15 mm, while maximum measured settlement was 4 mm. Maximum calculated ground slope was 1:913 and measured was 1:15100 (perpendicular to excavation).

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## 4 Conclusion

In general the monitored ground movements arising from the construction of Plumstead Portal were lower than predicted/calculated.

The overall movement trends are consistent with that predicted although lower in magnitude.

On average, the monitored movements of the NKL are approximately 40% of the calculated values. In general, the monitored movements of White Hart Depot are approximately 25% of the calculated values.

Similar trend was observed for the diaphragm and secant pile walls for which actual movements were lower than predicted.

One particular section of White Hart Depot ramp displayed settlements which were anomalous to the overall settlement trend of the building. Approximately 95% of the predicted displacement was observed at this location. This out of trend settlement was thought to be related to dewatering and consolidation of compressible layers below the building. This was mitigated by the installation of additional recharge walls in the vicinity. Ground movements have subsequently stabilised.

## Appendix A – Plumstead Portal Walls, Comparison of Monitored and Predicted Movements

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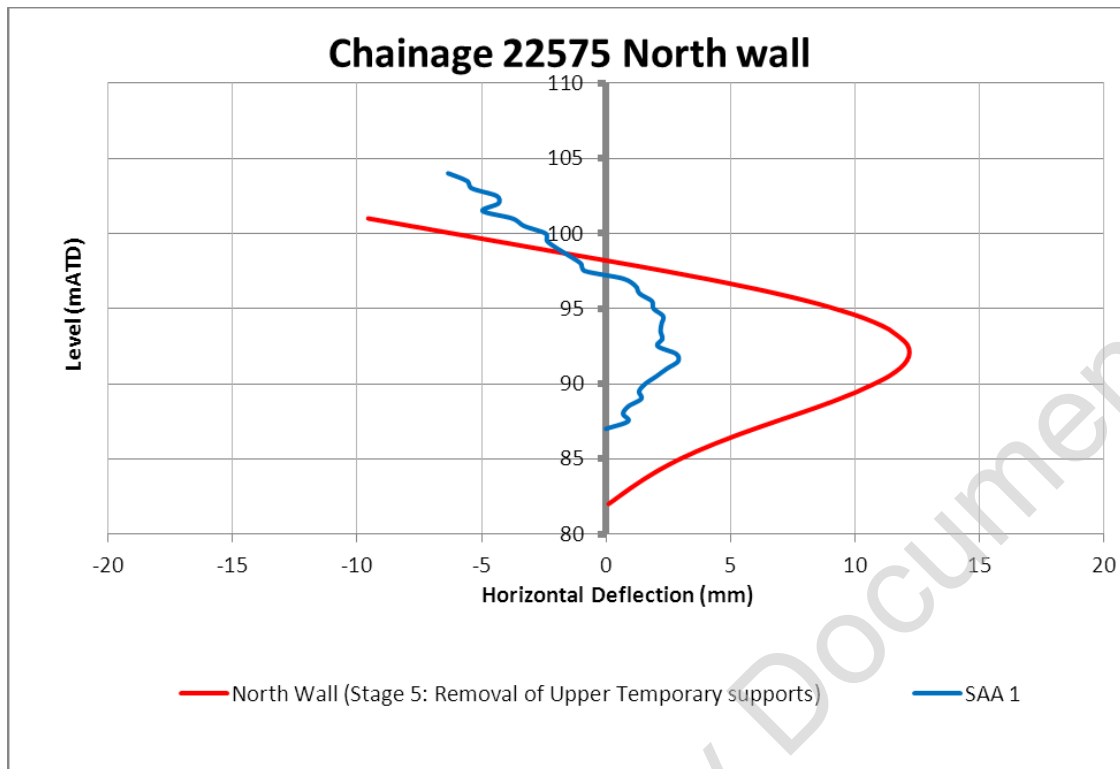


Figure 7 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22575 for SAA 1.

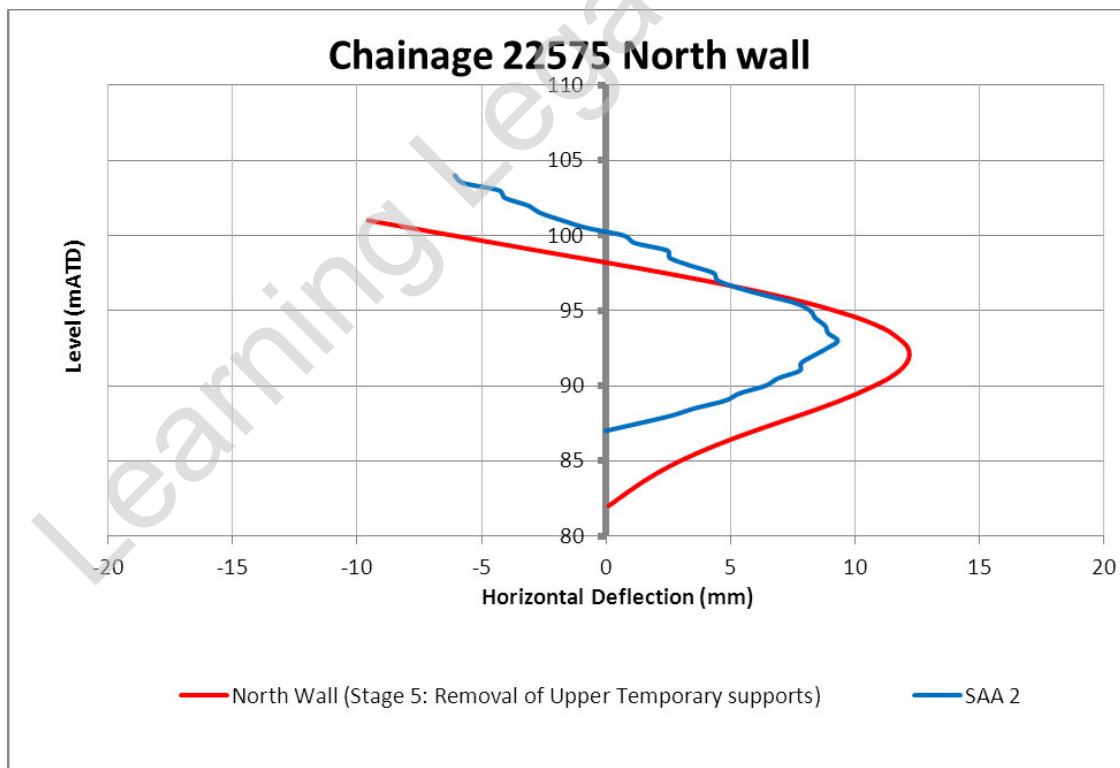
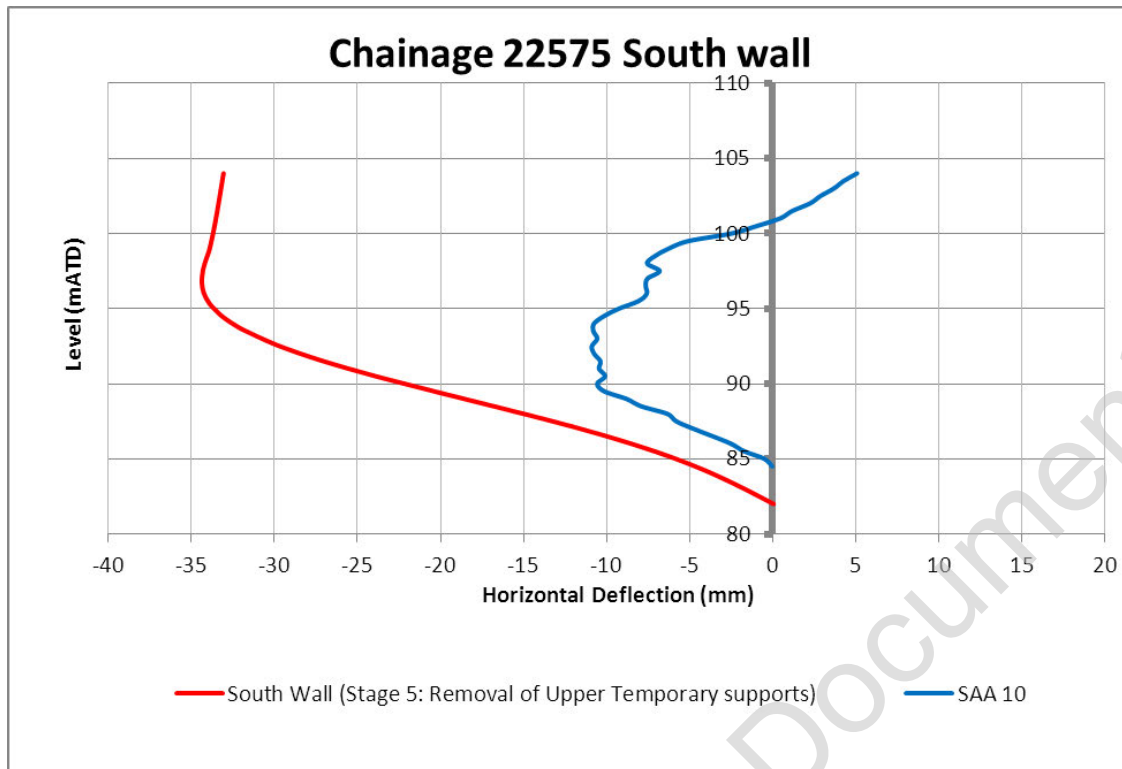
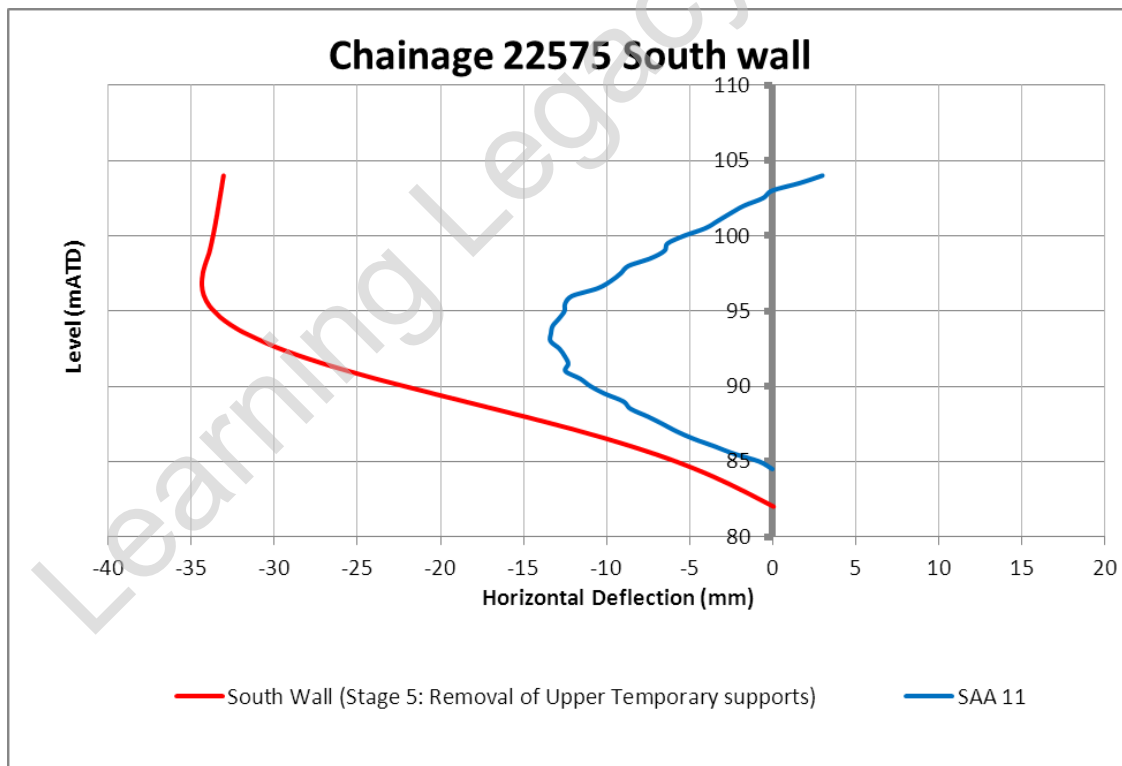


Figure 8 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22575 for SAA 2.





**Figure 9 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22575 for SAA 10.**



**Figure 10 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22575 for SAA 11.**

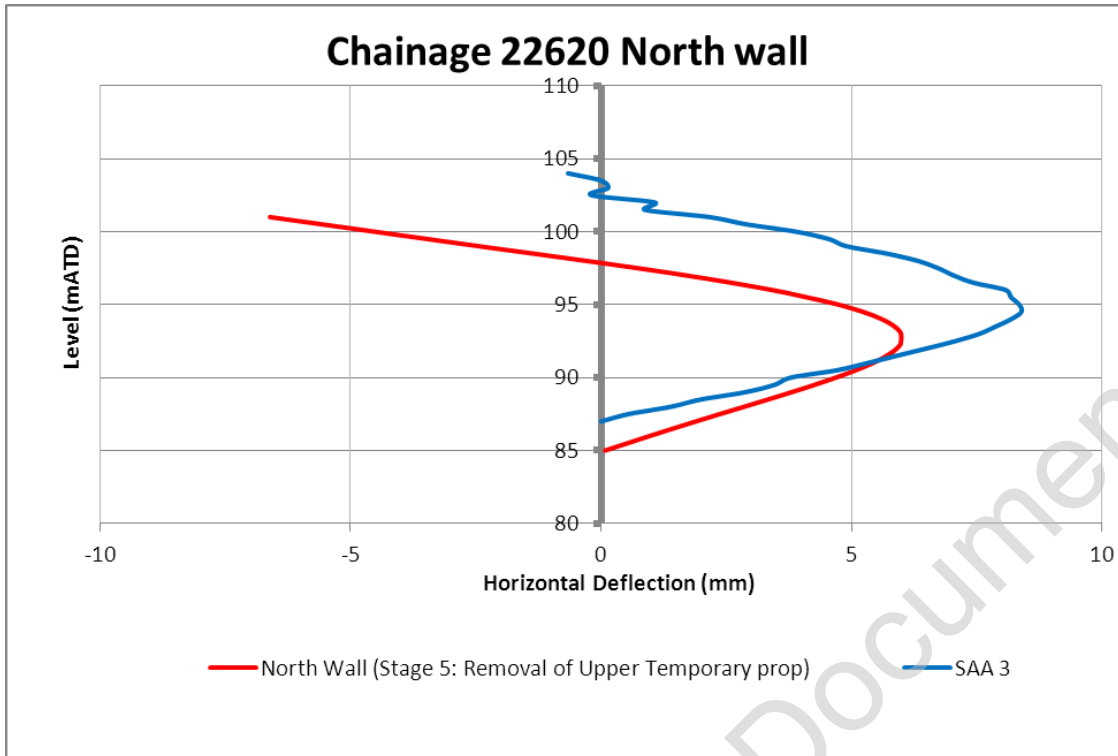


Figure 11 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22620 for SAA 3.

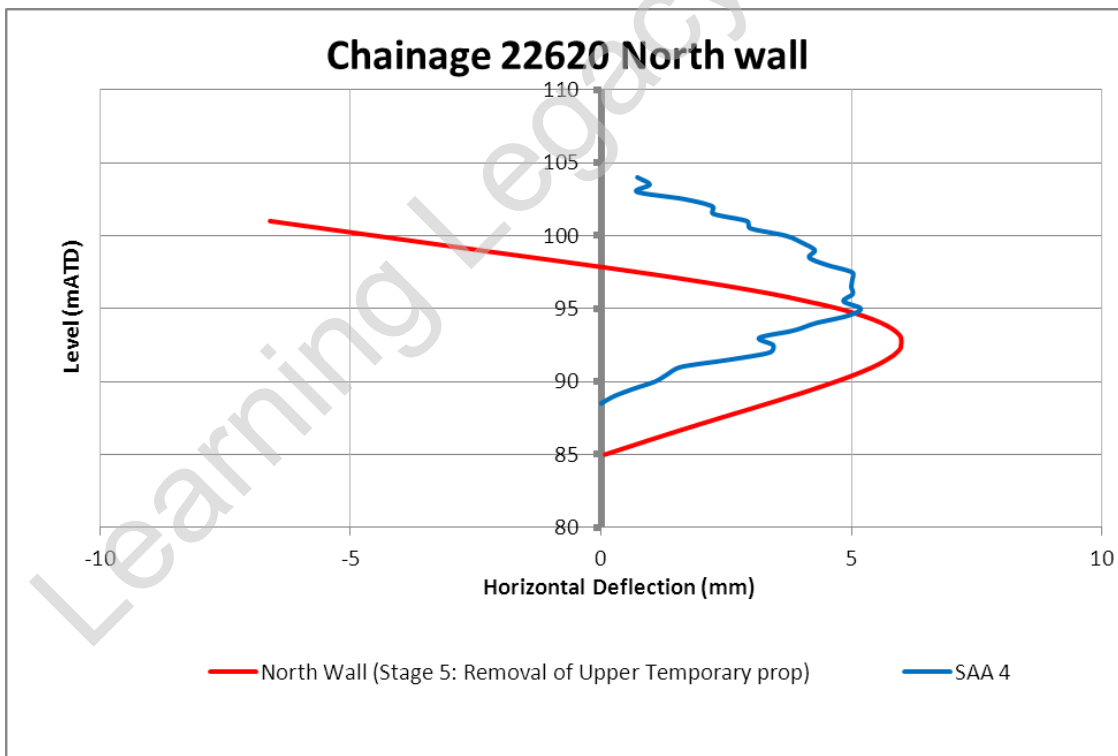


Figure 12 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22620 for SAA 4.

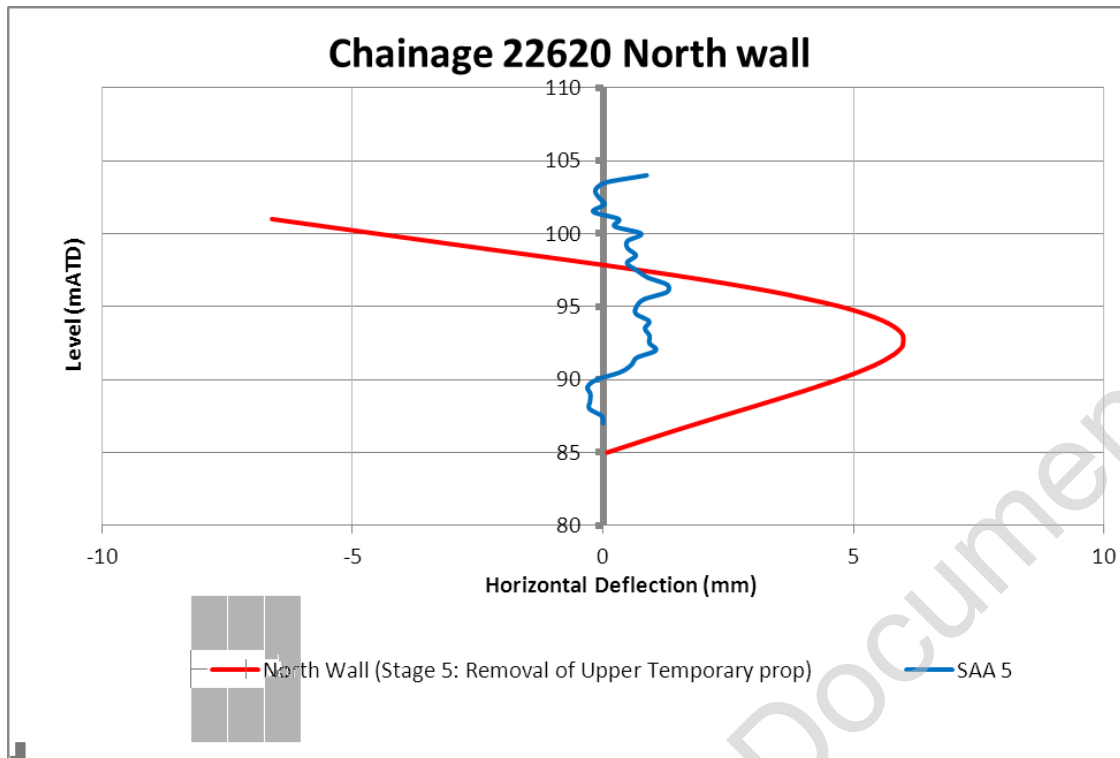


Figure 13 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22620 for SAA 5.

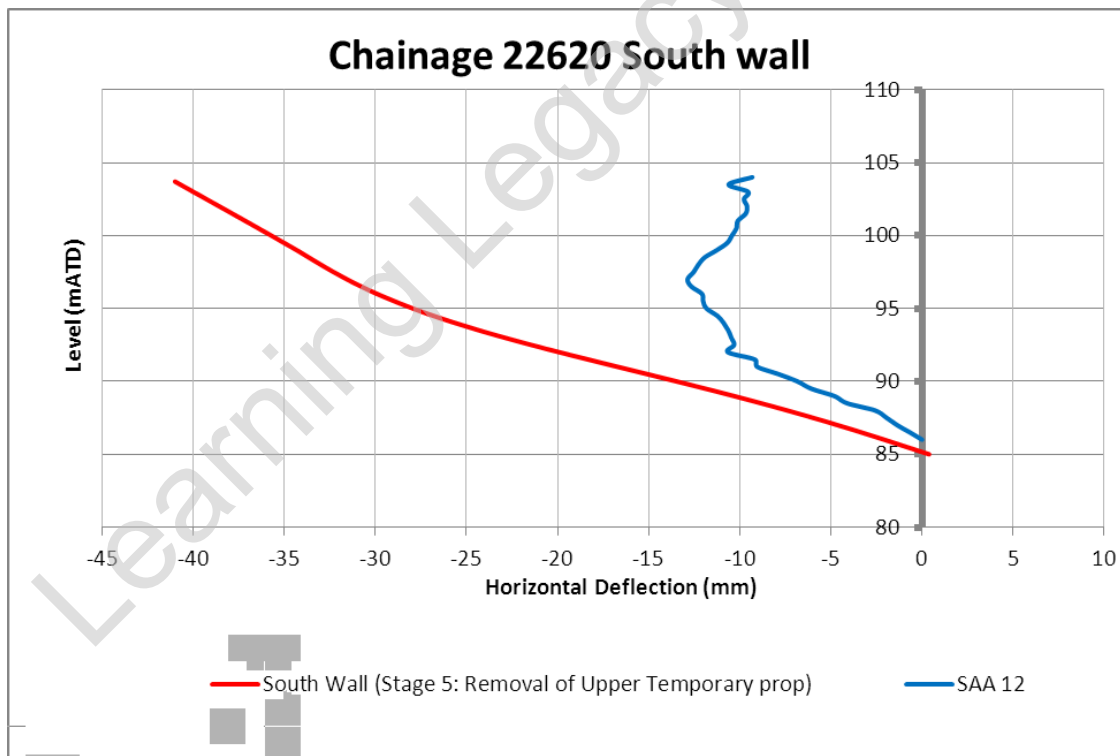


Figure 14 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22620 for SAA 12.

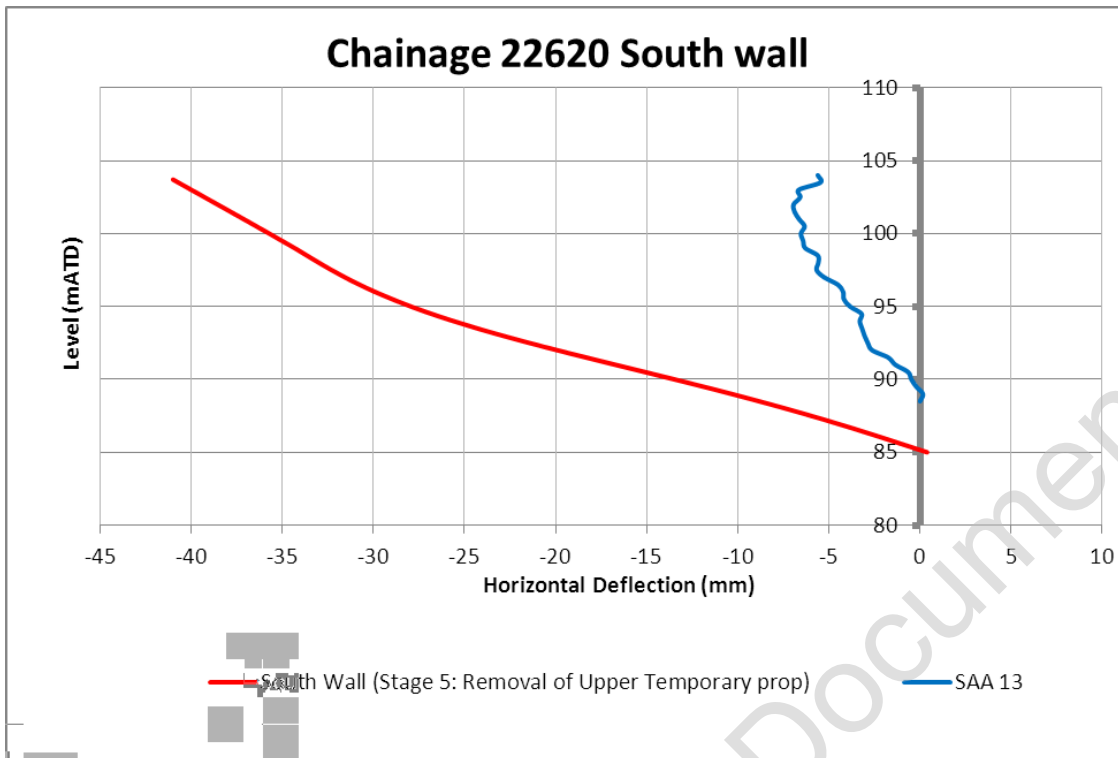


Figure 15 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22620 for SAA 13.

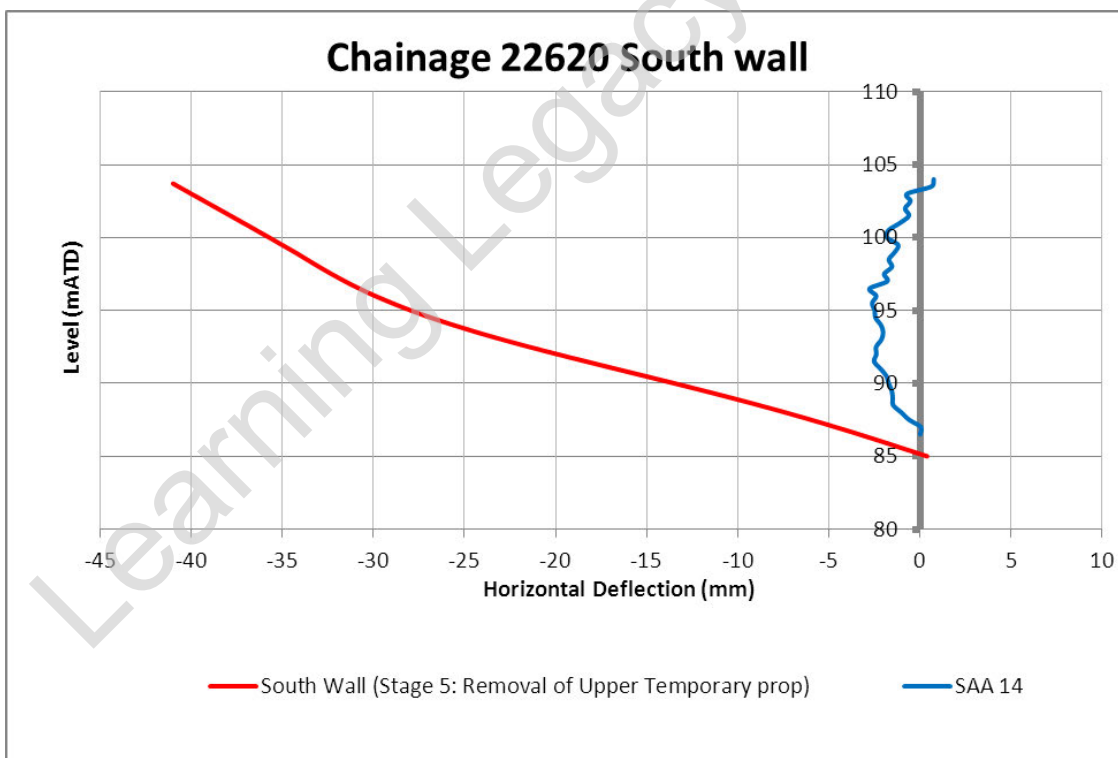


Figure 16 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22620 for SAA 14.

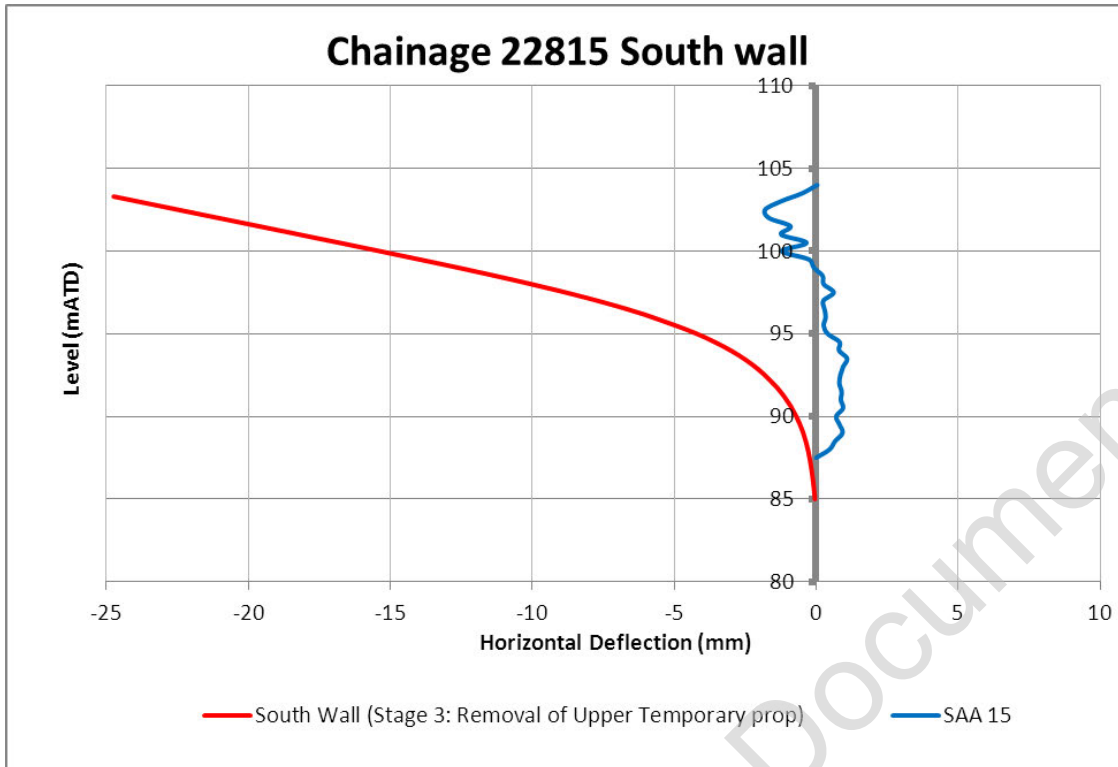


Figure 17 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22815 for SAA 15.

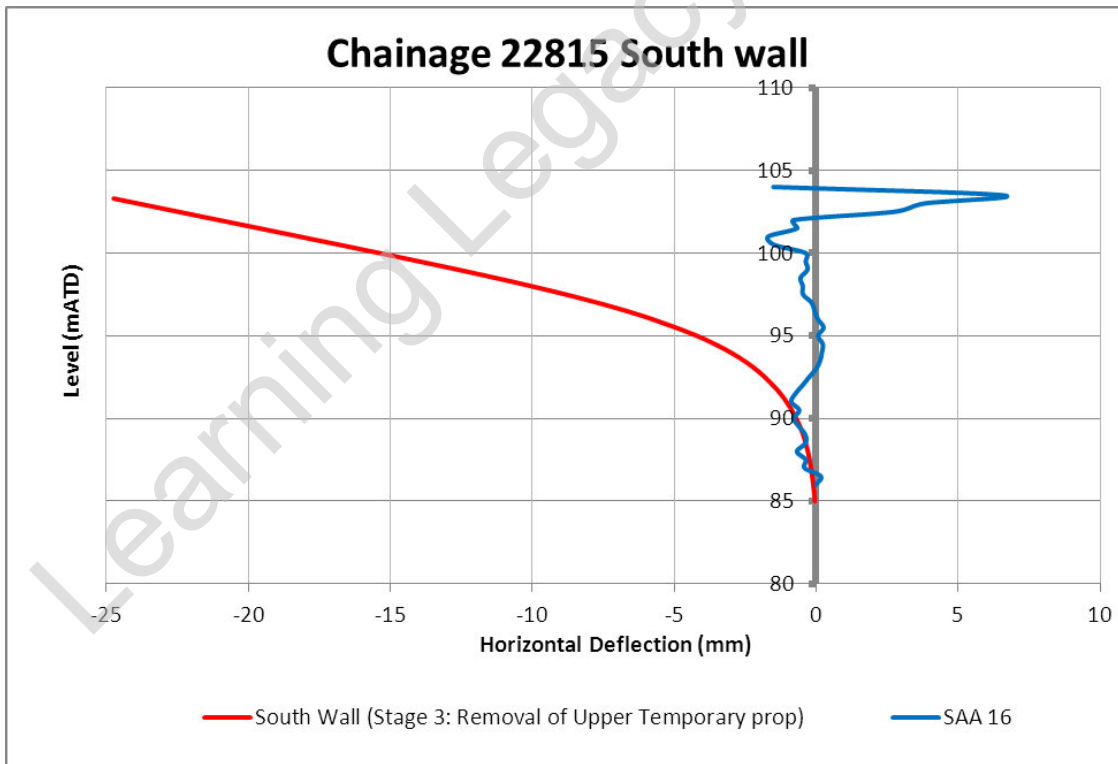


Figure 18 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22815 for SAA 16.

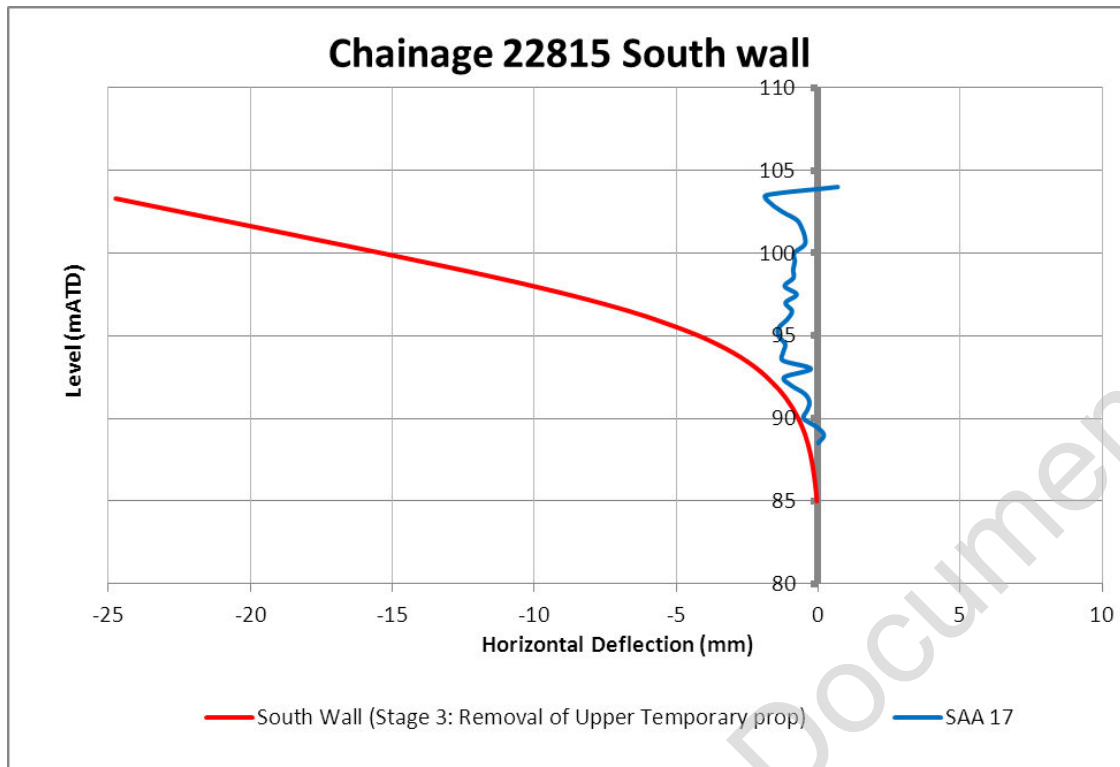


Figure 19 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22815 for SAA 17.

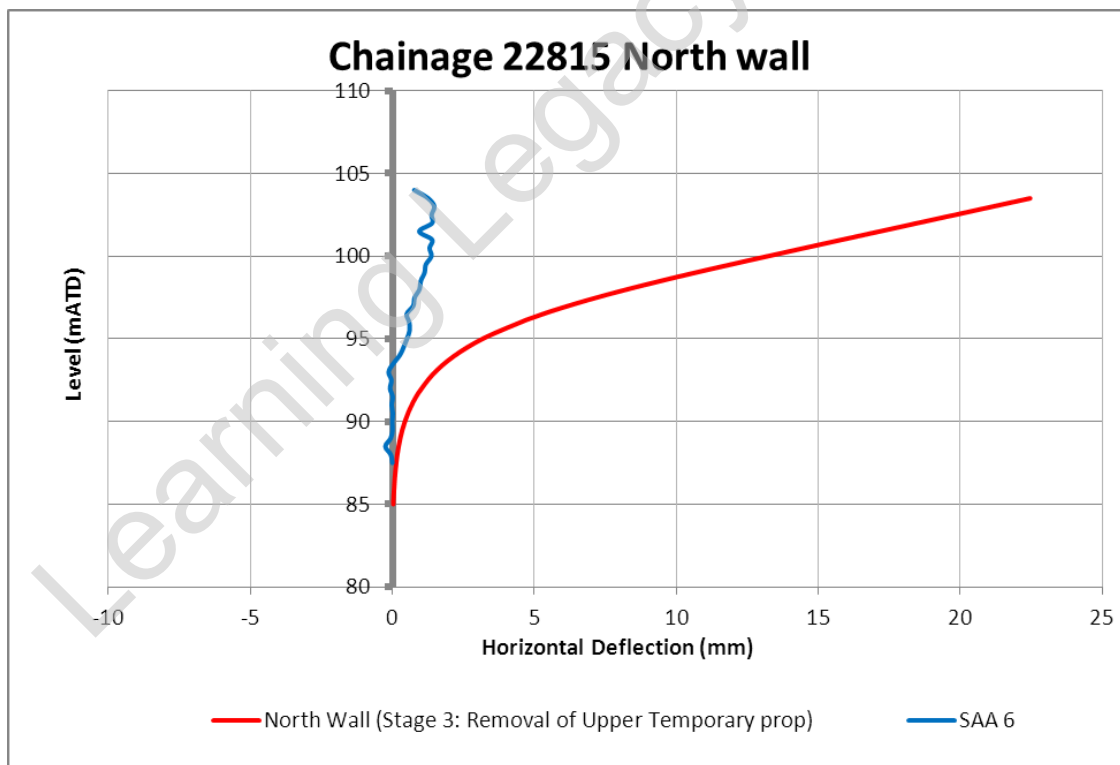


Figure 20 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22815 for SAA 6.

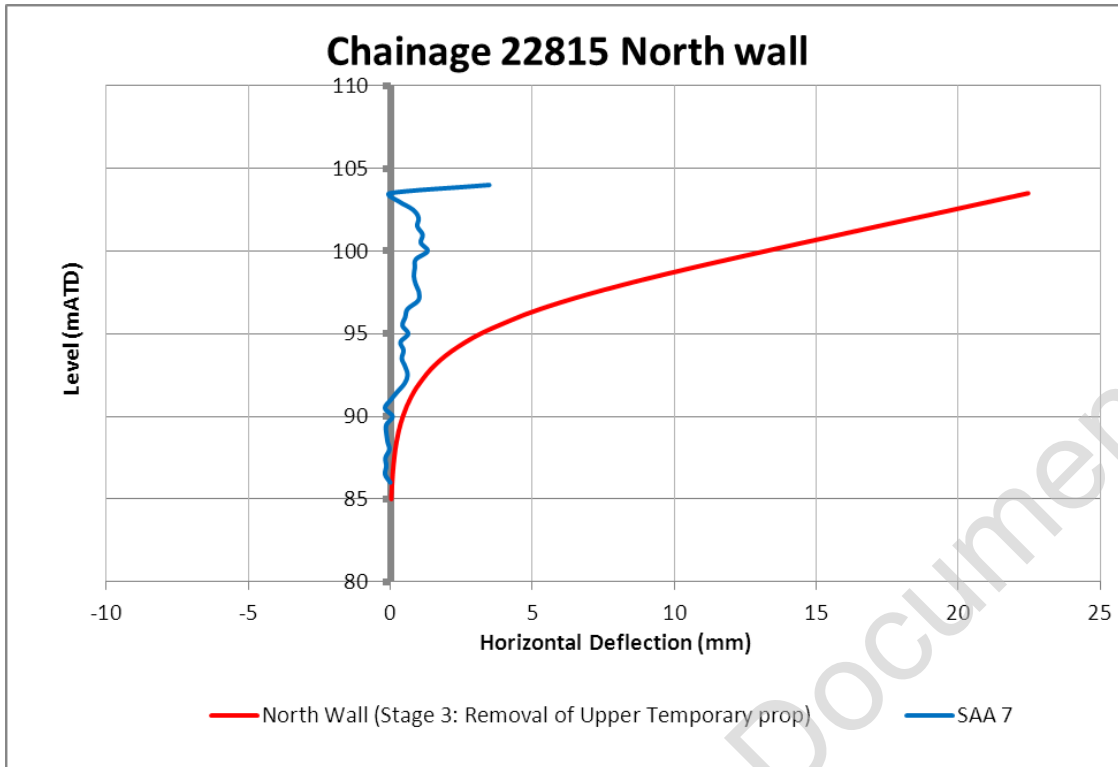


Figure 21 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22815 for SAA 7.

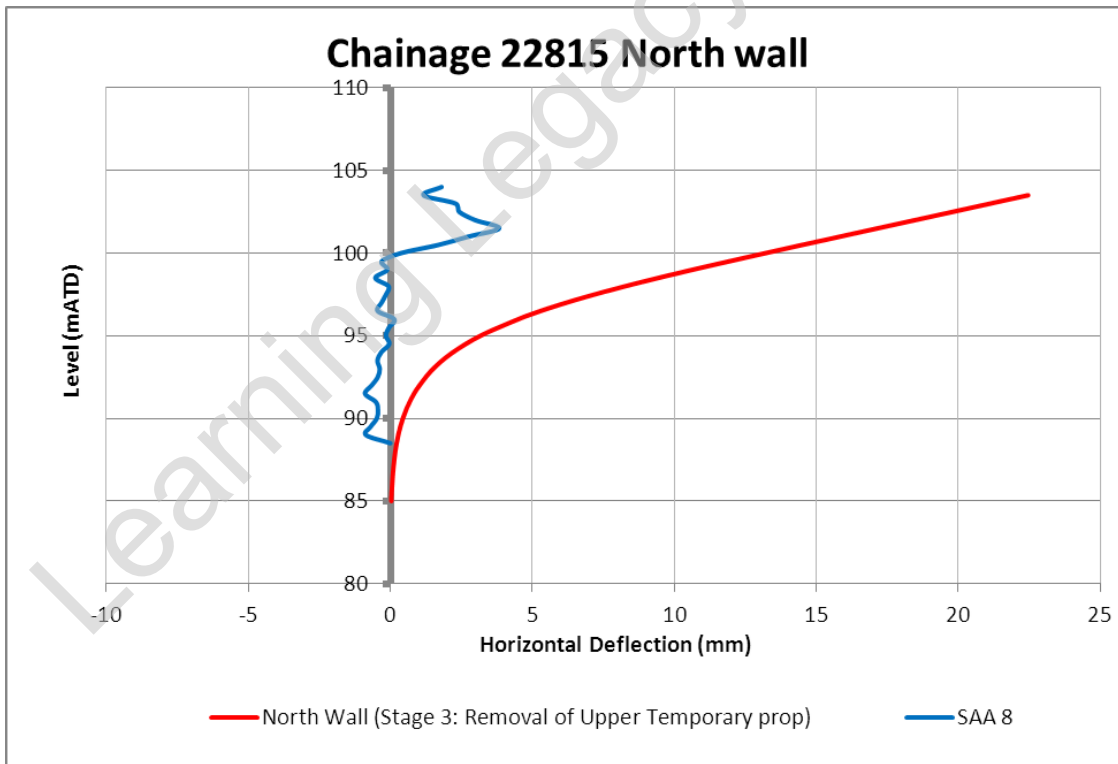


Figure 22 - Plot showing comparison between predicted and monitored diaphragm wall deflections at Chainage 22815 for SAA 8.

## Appendix B – Plumstead Portal settlement behind diaphragm and secant pile walls

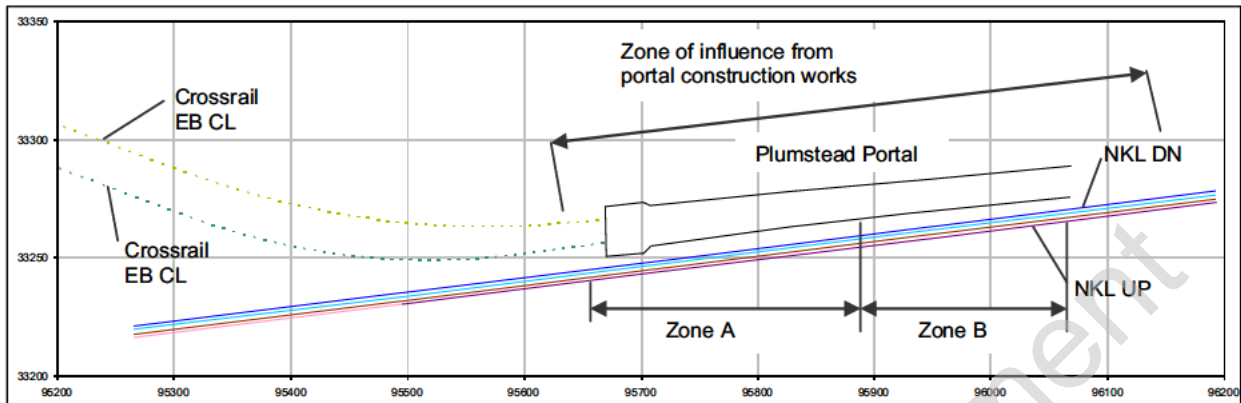


Figure 23 – General arrangement of the NKL Up and Down lines, Crossrail works and zone of influence of the portal construction works. Zone A and Zone B indicate the extent of diaphragm wall construction and secant pile wall construction respectively.

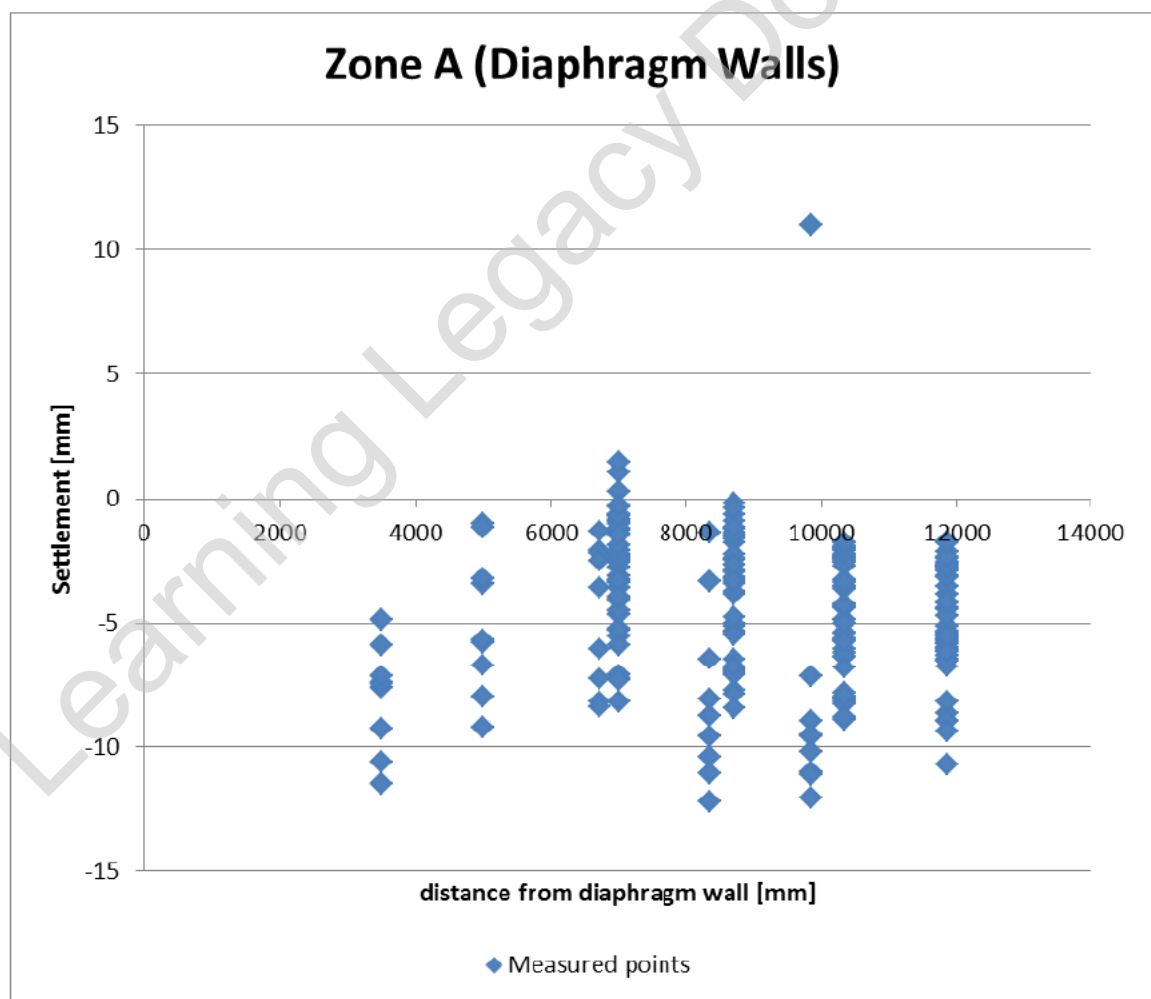


Figure 24 – Plot showing settlements along south diaphragm wall of Plumstead Portal



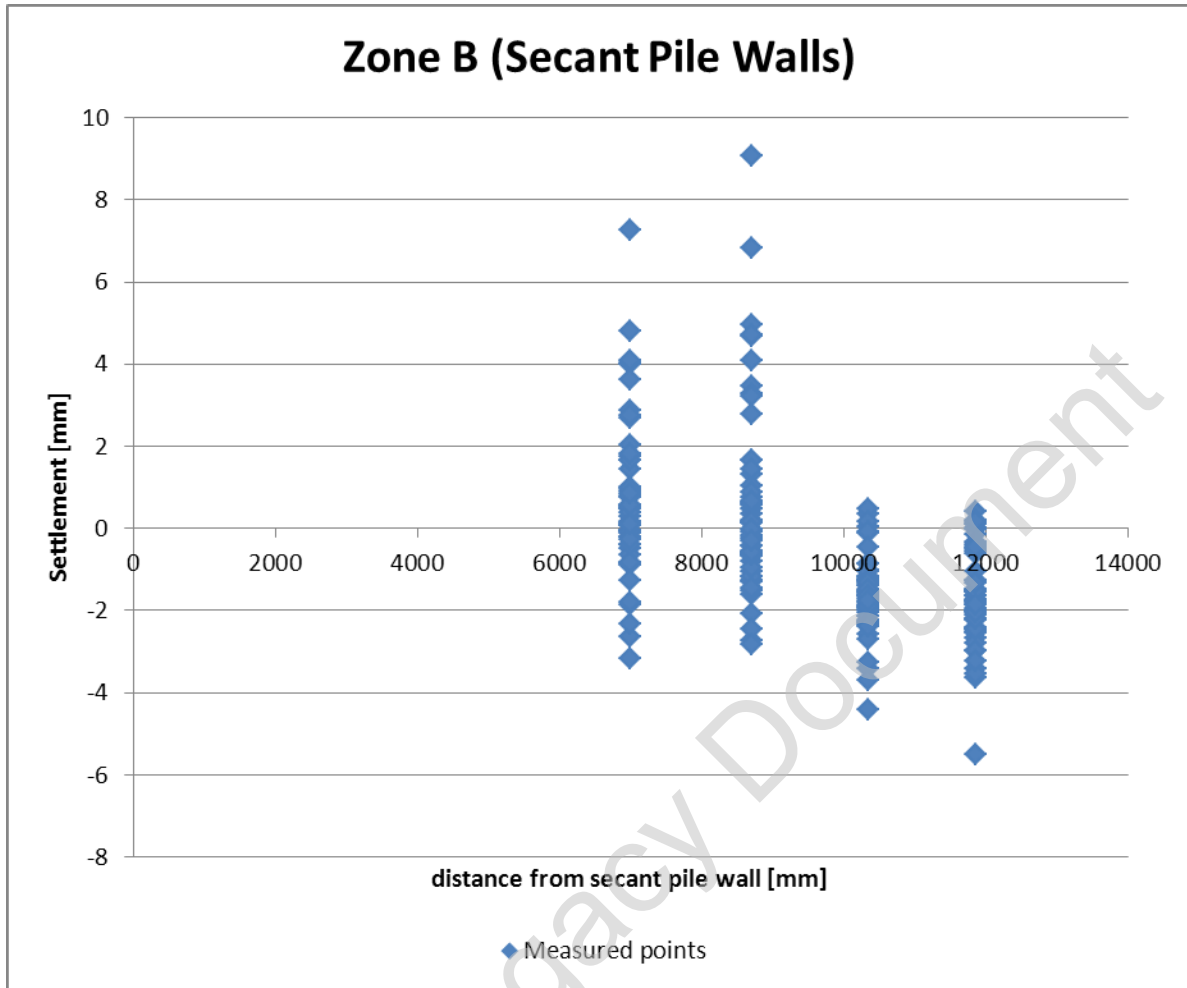
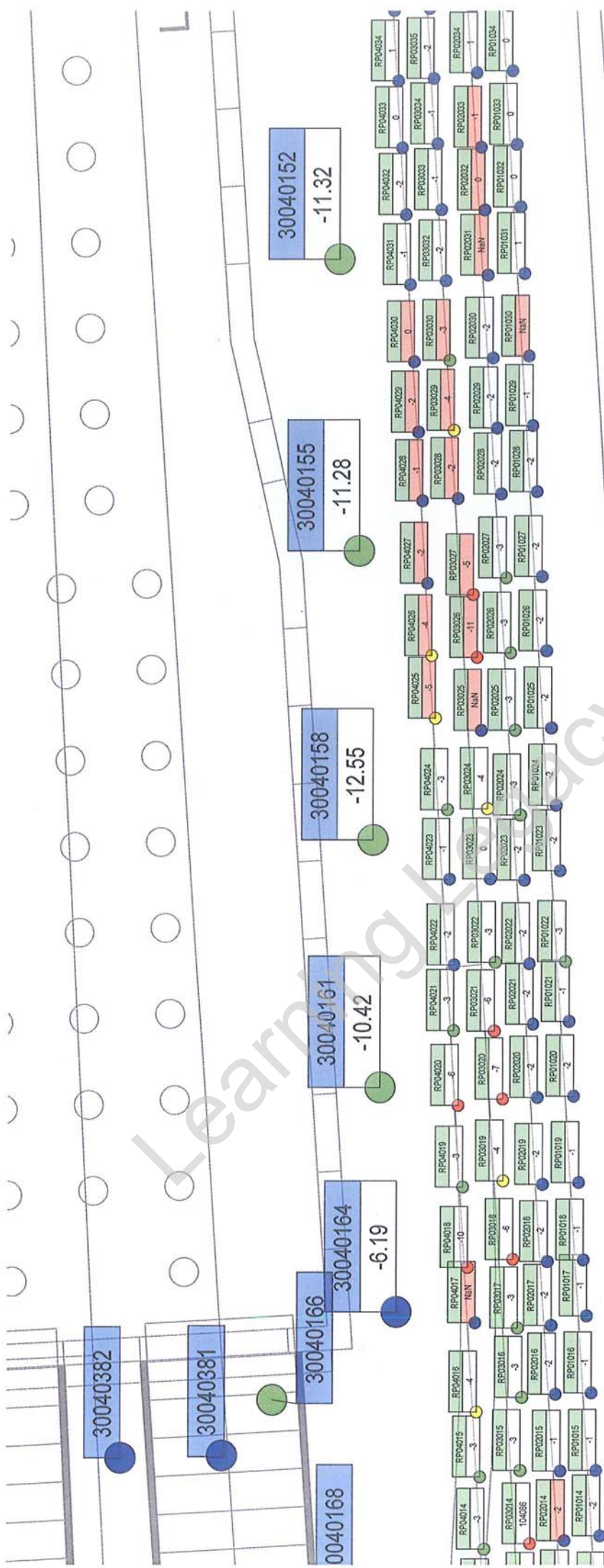


Figure 25 - Plot showing settlements along south secant pile wall of Plumstead Portal

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**Appendix C – Plumstead Portal monitoring arrangement and settlements behind diaphragm and secant pile walls**

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RP04014	RP04015	RP04016	RP04017	RP04018	RP04019	RP04020	RP04021	RP04022	RP04023	RP04024	RP04025	RP04026	RP04027	RP04028	RP04029	RP04030	RP04031	RP04032	RP04033	RP04034
-3	-3	-4	NAN	-10	-3	-6	-3	-2	-1	-3	-5	-4	-2	-2	-2	0	-1	-2	0	1
RP03014	RP03015	RP03016	RP03017	RP03018	RP03019	RP03020	RP03021	RP03022	RP03023	RP03024	RP03025	RP03026	RP03027	RP03028	RP03029	RP03030	RP03031	RP03032	RP03033	RP03034
10486	-3	-3	-3	-5	-4	-7	-6	-3	0	-4	NAN	-11	-5	-3	-4	-3	NAN	-2	-1	-2
RP01014	RP01015	RP01016	RP01017	RP01018	RP01019	RP01020	RP01021	RP01022	RP01023	RP01024	RP01025	RP01026	RP01027	RP01028	RP01029	RP01030	RP01031	RP01032	RP01033	RP01034
-2	-1	-1	-1	-1	-1	-2	-1	-3	-2	-2	-2	-2	-2	-2	-1	-2	1	0	0	0

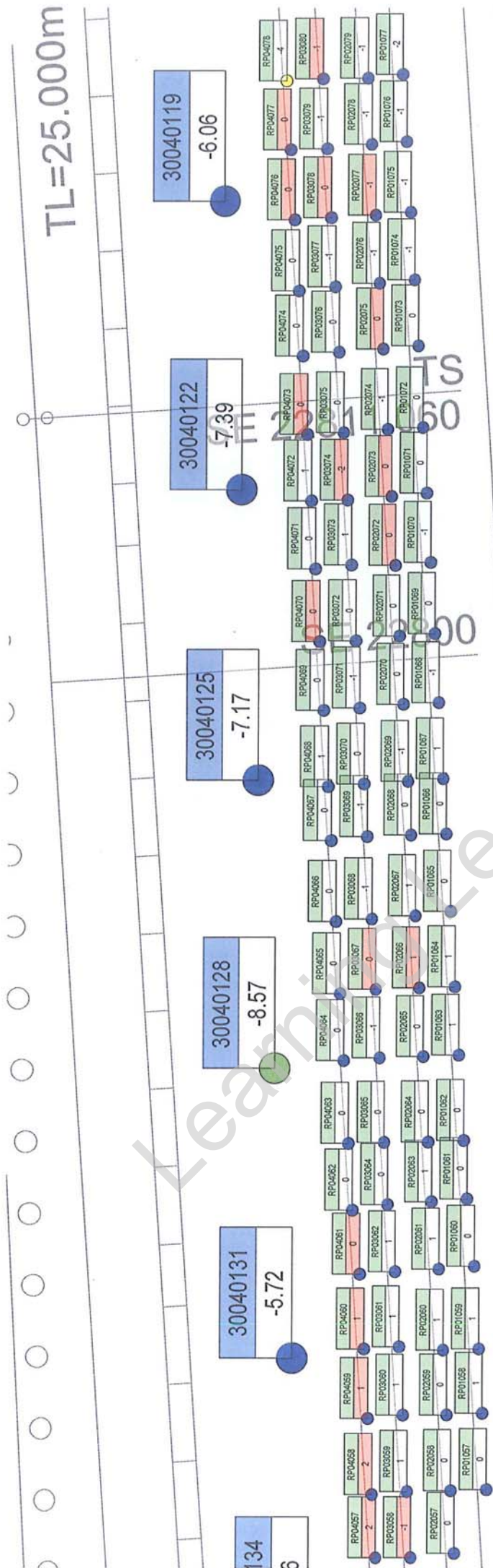
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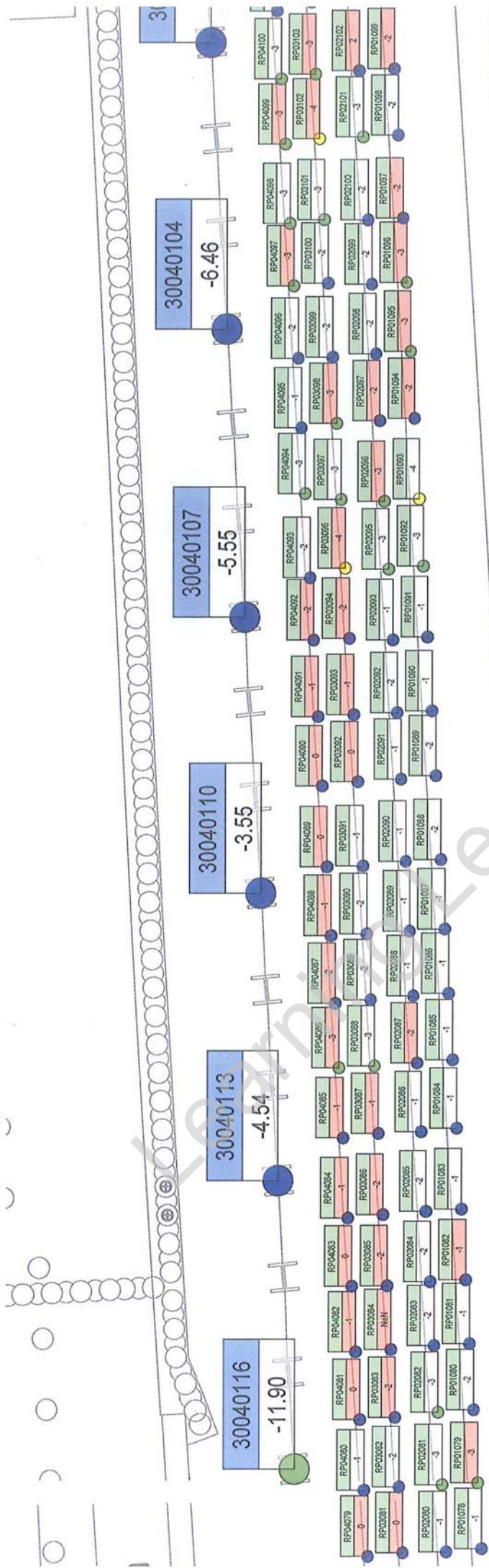


Learning Legacy Document

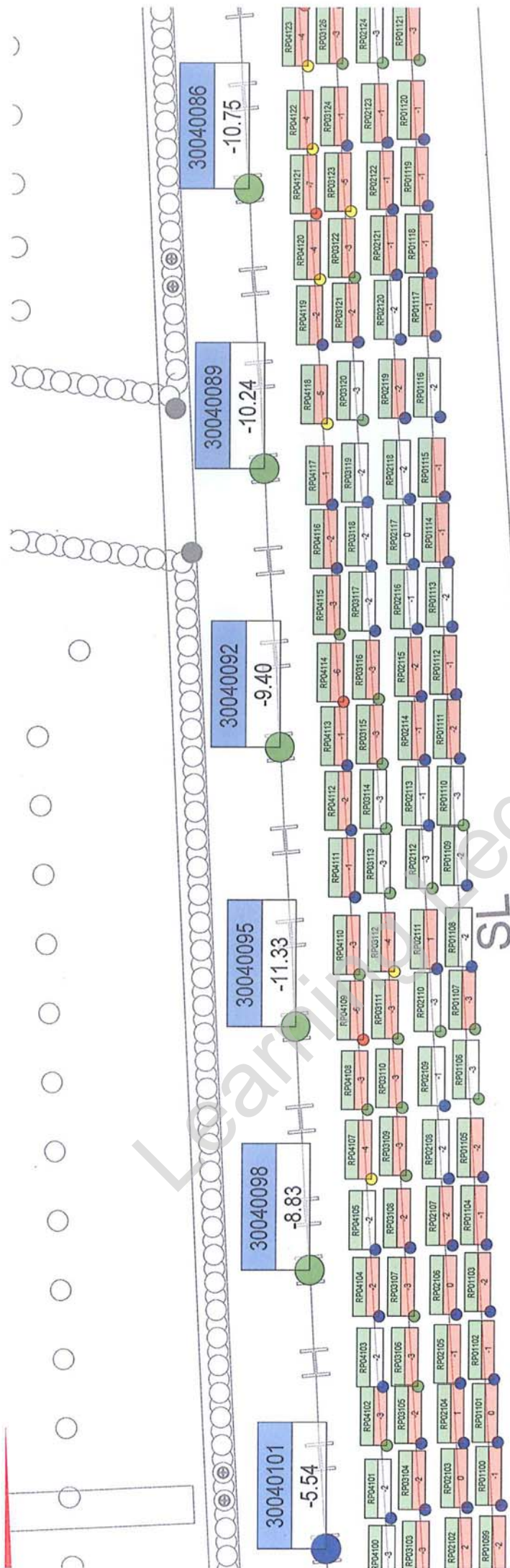
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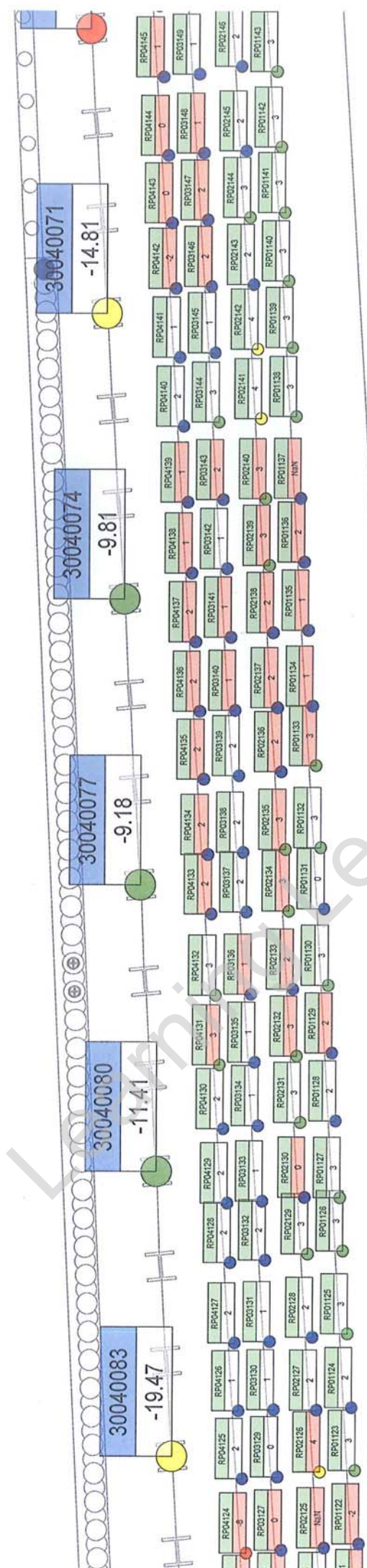
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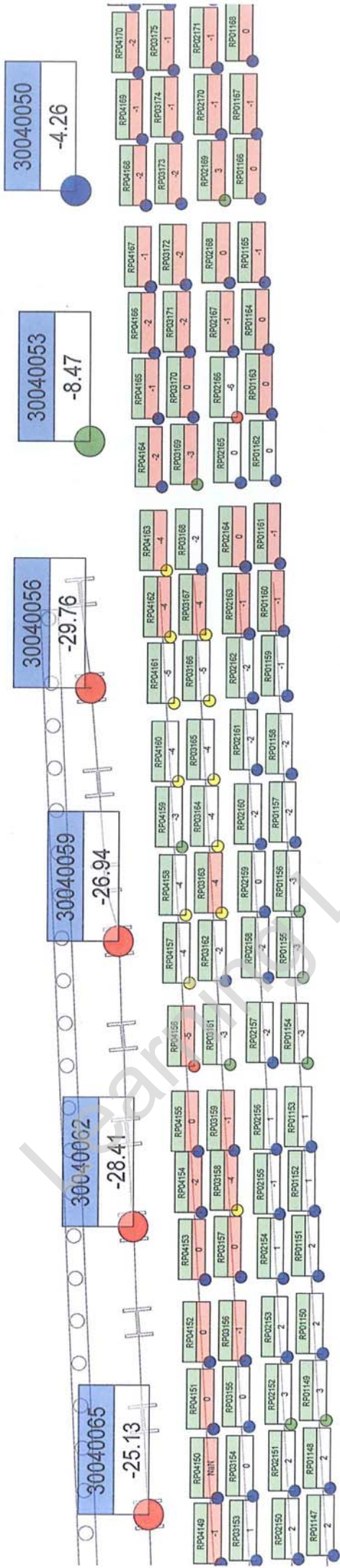


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