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Work Type: I&M
Originator Company: GEOCISA

C435 Farringdon Main Station

CRL Lead reviewer: [REDACTED]
CRL Reviewer: [REDACTED]

Monitoring Close-Out Report: Automated Total Station ATS12 and 3D Targets read by ATS12.

CRL Document Number: C435-BFK-C2-RGN-M123-51612

Supplier Document Number: N/A

Contract MDL reference C13.012

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

Purpose of submission: For no objection For information

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

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

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

2b. Review by Stakeholder (if required):

Stakeholder Organisation	Job Title	Name <small>compliance with their contractual obligations and does not constitute designs or materials developed or selected by the designer/supplier.</small>	Signature	Date	Acceptance
	[REDACTED]				<input type="checkbox"/>
					<input type="checkbox"/>
					<input type="checkbox"/>

3. Acceptance by Crossrail:

Contents

A.	INTRODUCTION	3
B.	INSTRUMENTS	3
B.1	DESCRIPTION OF THE INSTRUMENTS	3
B.2	LOCATION OF THE INSTRUMENTS	5
C.	MOVEMENTS	5
C.1	MOVEMENTS RESULTING FROM CONSTRUCTION ACTIVITIES	5
C.1.1	Relevant Crossrail (BFK) Works	5
C.1.2	Resulting Movements	6
C.2	TRIGGER BREACHES	7
C.3	SIGNIFICANT ISSUES WITH THE INSTRUMENTATION	8
C.4	RESIDUAL RISKS	8
D.	CONCLUSIONS	8
APPENDIX A: DRAWINGS.		
APPENDIX B: GRAPHS.		

Learning Legacy Document

A. INTRODUCTION

In line with the C122 – M&W Specification KX10 – Instrumentation & Monitoring C122-OVE-Z4-RSP-CR001-00007, this Close-Out Report aims to address the following points in relation to the instrumentation defined in Section 2.

Identify movements observed by the relevant instruments;

Relate these movements to construction activities, where applicable;

Identify trigger breaches that may have occurred;

Demonstrate that the rate of change of the data is either in line with the required rate or such that residual risks are minimal;

Identify any such residual risks should there be considered to be any.

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

B. INSTRUMENTS

B.1 Description of the Instruments

This Close-Out Report relates the prisms read by ATS12, most of the installed on Cowcross St. See table 1 below with the details for the prisms.

Sensor	Location	Northing	Easting	Elevation
C435-RP01201	70-77 COWCROSS ST	82059.66	36554.6	129.8233
C435-RP01202	70-77 COWCROSS ST	82051.29	36554.76	129.8053
C435-RP01203	70-77 COWCROSS ST	82043.2	36554.95	129.7993
C435-RP01204	70-77 COWCROSS ST	82030.8	36555.19	129.7999
C435-RP01205	70-77 COWCROSS ST	82059.59	36554.61	119.9731
C435-RP01206	70-77 COWCROSS ST	82051.33	36554.78	119.9485
C435-RP01207	70-77 COWCROSS ST	82043.24	36554.96	119.9345
C435-RP01208	70-77 COWCROSS ST	82030.83	36555.23	119.9248
C435-RP01209	67-69 COWCROSS ST	82010.13	36553.83	116.9619
C435-RP01210	67-69 COWCROSS ST	82009.77	36553.82	125.6804
C435-RP01211	67-69 COWCROSS ST	82018.95	36554.38	116.7418
C435-RP01212	67-69 COWCROSS ST	82019.02	36554.4	125.5832
C435-RP01213	67-69 COWCROSS ST	82025.27	36554.9	116.9797
C435-RP01214	67-69 COWCROSS ST	82025.33	36554.92	125.7418
C435-RP01215	67-69 COWCROSS ST	82025.56	36554.8	117.244
C435-RP01216	67-69 COWCROSS ST	82025.57	36554.65	125.4309
C435-RP01223	85 COWCROSS ST	82073.77	36552.71	118.3946
C435-RP01224	85 COWCROSS ST	82073.39	36552.75	124.4179
C435-RP01225	85 COWCROSS ST	82082.15	36551.62	118.8349
C435-RP01226	85 COWCROSS ST	82082.87	36551.39	125.7497

C435-RP01227	85 COWCROSS ST	82090.19	36550.45	125.5753
C435-RP01228	85 COWCROSS ST	82090.65	36550.51	119.2522
C435-RP01229	85 COWCROSS ST	82095.67	36549.86	119.4996
C435-RP01230	85 COWCROSS ST	82095.48	36549.75	125.7263
C435-RP01231	78 COWCROSS ST	82060.38	36554.41	118.7311
C435-RP01232	78 COWCROSS ST	82060.37	36554.19	129.9448
C435-RP01233	78 COWCROSS ST	82066.26	36553.62	118.7166
C435-RP01234	78 COWCROSS ST	82066.58	36553.36	129.9412
C435-RP01235	78 COWCROSS ST	82072.65	36552.83	118.723
C435-RP01236	78 COWCROSS ST	82072.67	36552.61	130.423
C435-RP01247	64-66 COWCROSS ST	82008.96	36554	117.2539
C435-RP01248	64-66 COWCROSS ST	82000.71	36553.8	117.0418
C435-RP01249	64-66 COWCROSS ST	82000.26	36552.22	130.8893
C435-RP01250	64-66 COWCROSS ST	81988.86	36553.63	118.3123
C435-RP01251	61-63 COWCROSS ST	81988.31	36555.24	118.5331
C435-RP01252	61-63 COWCROSS ST	81982.35	36555.26	118.6121
C435-RP01253	61-63 COWCROSS ST	81978.35	36555.3	118.6184
C435-RP01254	61-63 COWCROSS ST	81972.83	36555.31	118.4794
C435-RP01255	61-63 COWCROSS ST	81988.35	36555.08	130.4465
C435-RP01256	61-63 COWCROSS ST	81982.32	36555.12	130.1923
C435-RP01257	61-63 COWCROSS ST	81977.11	36555.08	129.9031
C435-RP01258	61-63 COWCROSS ST	81974.46	36555.04	129.9235
C435-RP01259	64-66 COWCROSS St	82000.45	36545.8	130.8885
C435-RP01260	64-66 COWCROSS St	82000.35	36549.17	130.8873
C435-RP01261	64-66 COWCROSS St	82000.26	36552.23	130.8932

Table 1: Details of the prisms read byATS12 on Cowcross St

The prisms reading by ATS12 installed on Cowcross St are shown in the following documents:

Drawings:

- C435-BFK-C2-RGN-M123-50060-IR-RP-ATS12

Installation Reports:

- C435-BFK-C2-RGN-M123-50060: 3D Targets read by ATS12
- C435-BFK-C2-RGN-M123-50004: Automated Total Station ATS12

B.2 Location of the Instruments

The instruments described in Section k are located in Cowcross St. Sockets, Studs and Prisms are installed on the pavement and on the buildings along Cowcross St. The sockets are installed on the bottom on the buildings. The prisms are installed in two levels on the façade of the buildings. In the Appendix A is included the drawing with the location of instruments. See Figure 1 below with location for the device installed on Cowcross St.

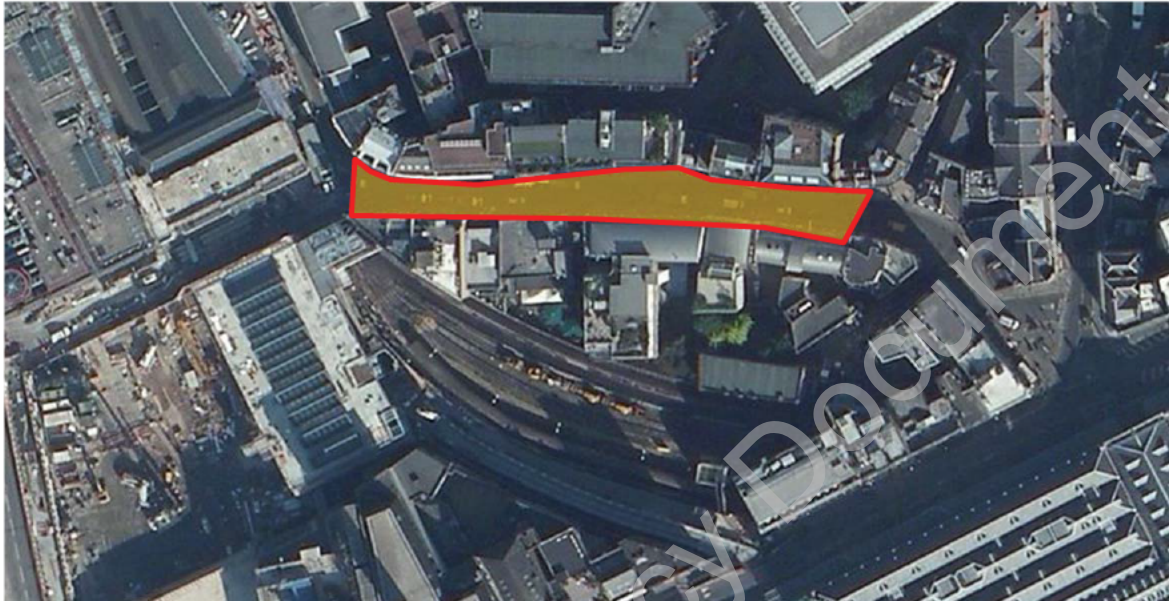


Figure 1 – Map showing the Location for the device on Cowcross St

C. MOVEMENTS

C.1 Movements Resulting from Construction Activities

C.1.1 Relevant Crossrail (BFK) Works

The construction activities associated with these instruments are related to Crossrail tunneling works. In all cases, these comprise of the passage of a TBM (C300), platform tunnel enlargement and cross passengers tunnel. Also some areas for the prisms read by ATS 12 for were been affected by different compensation grouting episode from Butchers Ramp shaft.

Both EB TBM and PTE enlargement are mainly parallel to Cowcross St, especially the western. Just at the end to Cowcross St (Charterhouse St Junction), TBM and PTE cross Cowcross St.

Prisms from ATS12 on Cowcross St were affected by CP2a and Cp3a cross passengers. CP2a and CP3a are so far for the St.

This geometry is the reason why the device installed on the western for the St show less movement than the sensor installed on the eastern.

Activity	Start Date	End Date
EB TBM passage	08/01/2014	16/01/2014
PTE enlargement	15/05/2014	02/09/2014
CP3a	24/05/2014	28/08/2014
CP2a	06/09/2014	14/09/2014

C.1.2 Resulting Movements

To analyse the result for the prisms will be separate on three sections.

- The first one is from 61 Cowcross St to 67 Cowcross St (The fence).
- The second group is from 70-77 Cowcross St to 78 Cowcross St.
- The third group includes all 85 Cowcross St.

- GROUP 1:

The monitoring data for the first group for the prisms installed on Cowcross St is presented in Appendix B.1

The buildings where the prisms are installed were affected by EB TBM, PTE enlargement, CP3a and CP2a. Although some movement has been recorded by these devices, it has been less than the expected in comparison with the movement recorded in Groups 2 and 3 showing buildings located closer and even above the PTE axis and where the settlement has been bigger.

During EB TBM, the maximum movement was around 2mm settlement on the prisms. After this work, some grouting episode was carried out to improve and to mitigate the movements for the next work, PTE enlargement. The maximum heave on these prisms was 4mm heave.

During PTE enlargement, no significant movements were observed on the buildings.

Is when the CP3a construction was carried out, when the movements were more significant. Some prisms showed in this phase around 4mm of settlement.

During CP2a construction, the prisms didn't show any significant movement.

In this area the prisms show stable conditions, the rate for the movements is less than 2mm/year, from 11-12-2014.

- GROUP 2:

The result, for the second group of the prisms installed on Cowcross St is presented in Appendix B.1 as well.

In this group of prisms the movements observed are much bigger because the tunnels are closer to these buildings.

During TBM passage, the maximum settlements on these prisms are around 2-3mm. After TBM, during June and July, some compensation grouting from Butcher's Ramp was carried out. The prisms affected for the grouting episode showed 4mm as maximum heave.

The PTE enlargement caused a big settlement in this group of prisms. In this phase of the construction, prisms showed maximum 16mm settlement. After PTE cross passage all these buildings showed a residual settlement until January 2015. From this date on, the prisms show stable conditions being flat the trend of movement. This means the ratio of movements is less than 2mm/year.

- GROUP 3:

The results for this last group of prisms are shown in the same appendix.

As is reasonable, the prisms on this building show the biggest settlement. All of them are located above the tunnel.

During the TBM passage, the prisms showed maximum 5mm settlement. After TBM, all prisms showed very stable conditions.

The works carried out for the PTE Enlargement construction caused the biggest movement for these prisms read by ATS12.

In particular, the maximum settlement observed has been of 26mm on prisms C435-RP01229 and C435-RP01230, both of them installed on the same vertical of the building. These prisms are the ones installed above the tunnel.

Although this building is located far from the CP4 cross passage, it is inside the zone of influence, showing these prisms a maximum settlement of 2mm affected by this excavation works.

During the three months after the CP4 excavation, these prisms showed a residual settlement, showing stable conditions from December 2014.

From this date on, the ratio for the movements is less than 2mm/year.

C.2 Trigger Breaches

The Instrumentation and Monitoring Plan: Farringdon Station Ground Movement and Asset Protection C122-OVE-C2-RGN-M123-50013 outlines the triggers associated with the works. Green trigger (-24mm) was breached by three prisms. Green trigger is less (80%) that the predicted movement. After breach the green trigger, the prisms show stable conditions.

POINT ID	TYPE	DIRECTION	DATE OF LAST READING	LAST READING VALUE (mm)	TRIGGER LEVEL	
					WORST HISTORICAL STATUS	CURRENT STATUS
C435-RP01201Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-13.1	Default Alert	Default Alert
C435-RP01202Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-8.9	Clear	Clear
C435-RP01203Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-5.9	Clear	Clear
C435-RP01204Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-3.4	Clear	Clear
C435-RP01205Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-12	Clear	Clear
C435-RP01206Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-8	Clear	Clear
C435-RP01207Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-4.9	Clear	Clear
C435-RP01208Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-1.8	Clear	Clear
C435-RP01209Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	1	Clear	Clear
C435-RP01210Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	1.8	Clear	Clear
C435-RP01211Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	4	Clear	Clear
C435-RP01212Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	3	Clear	Clear
C435-RP01213Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	4.6	Clear	Clear
C435-RP01214Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	4.8	Clear	Clear
C435-RP01215Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-1.7	Clear	Clear
C435-RP01216Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-0.6	Clear	Clear
C435-RP01223Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-15.4	Clear	Default Alert
C435-RP01224Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-17.1	Default Alert	Clear
C435-RP01225Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-22.4	Clear	Default Alert
C435-RP01226Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-21.9	Clear	Default Alert
C435-RP01227Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-23.9	Default Alert	Default Alert
C435-RP01228Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-25.2	Green	Default Alert
C435-RP01229Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-27.1	Green	Default Alert
C435-RP01230Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-26.8	Green	Default Alert
C435-RP01231Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-11.7	Clear	Default Alert
C435-RP01232Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-13.1	Clear	Default Alert
C435-RP01233Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-12.2	Default Alert	Default Alert
C435-RP01234Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-14.2	Default Alert	Default Alert
C435-RP01235Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-15.2	Clear	Default Alert
C435-RP01236Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-17.3	Clear	Default Alert
C435-RP01247Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	3.5	Clear	Clear
C435-RP01248Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	4	Clear	Clear
C435-RP01249Z	AUTOMATIC RP	Settlement	30/01/2014 07:00	0.9	Clear	Clear
C435-RP01250Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	0.8	Clear	Clear
C435-RP01251Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	2.8	Clear	Clear
C435-RP01252Z	AUTOMATIC RP	Settlement	21/07/2015 08:00	0.6	Clear	Clear
C435-RP01253Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	0.1	Clear	Clear
C435-RP01254Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	-1	Clear	Clear
C435-RP01255Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	2.1	Clear	Clear
C435-RP01256Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	-0.2	Clear	Clear
C435-RP01257Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	-1.1	Clear	Clear
C435-RP01258Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	-0.7	Clear	Clear
C435-RP01259Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-8.9	Clear	Clear
C435-RP01260Z	AUTOMATIC RP	Settlement	18/09/2015 09:00	-4.5	Clear	Clear
C435-RP01261Z	AUTOMATIC RP	Settlement	18/09/2015 08:00	-0.6	Clear	Clear

C.3 Significant Issues with the Instrumentation

No issues with these devices.

C.4 Residual Risks

The rates of residual settlement for the prisms have been determined and in all cases these rates are less than 2mm/year.

D. CONCLUSIONS

Following the EB TBM passage, of the SCL enlargement of PTE CP2a and CP3a, the maximum measured settlement on the prisms remain less than the expected.

At the moment, this area monitored by these prisms should be in a Long Term basis with readings every three months, but per C435-PMI-00549 Long Term has being ceased in this area, being the last measure carried out for these devices on 21/07/2015.

Learning Legacy Document

APPENDIX A: DRAWINGS

Learning Legacy Document



Contract: C435 IRR FARRINGTON
Originator: GEOSIBA
Location: CROSSBURN CENTRAL
Title: 3D PRIMS ATSS12

Contract: C435 BFK C2 RGN M423 50060 IRRP-ATS12

Scale: @ A3

Notes:

Rev.	Date	Description	By	Chkd	App	Auth
1	20-05-2013					

By: [Redacted]
CHK: [Redacted]
App: [Redacted]
Auth: [Redacted]

Scale: @ A3
Rev: [Redacted]
Suit: [Redacted]

Contract: C435 IRR FARRINGTON
Originator: GEOSIBA
Location: CROSSBURN CENTRAL
Title: 3D PRIMS ATSS12

Contract: C435 BFK C2 RGN M423 50060 IRRP-ATS12

Scale: @ A3

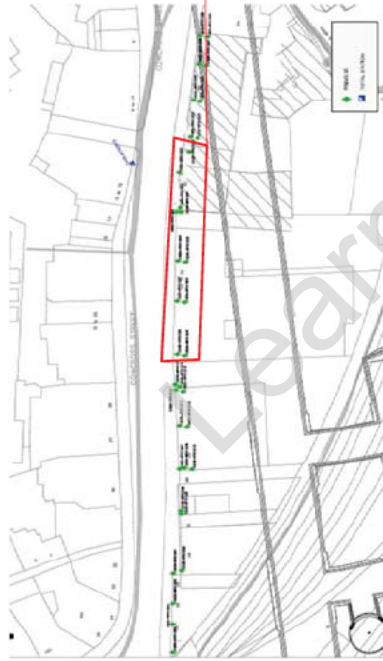
Notes:

Logo: GEOSIBA UK
 17 Los Linceos de Jerez 10-12
 28023-MAJURO
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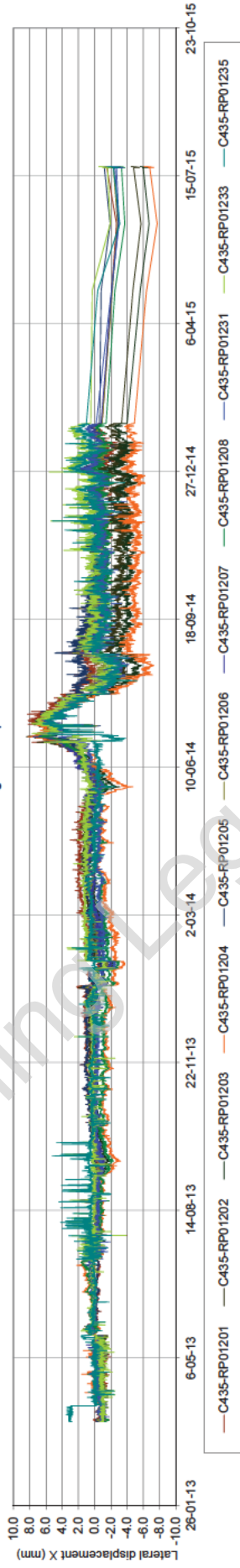
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 BENTLEY SYSTEMS

APPENDIX B: GRAPHS

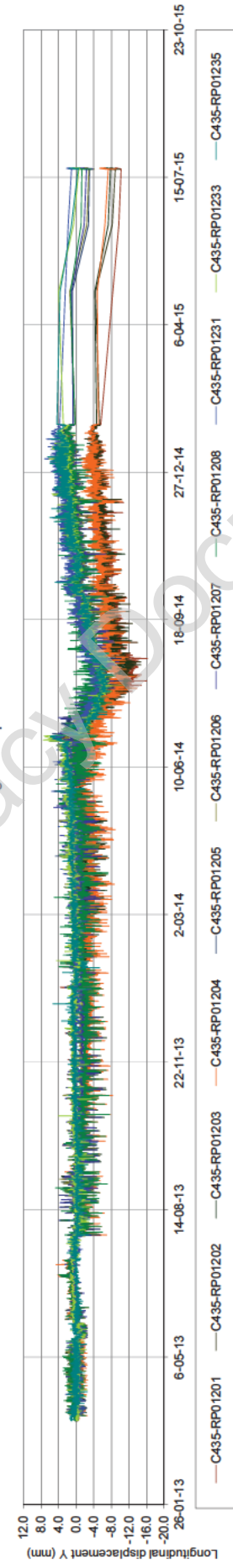
Learning Legacy Document



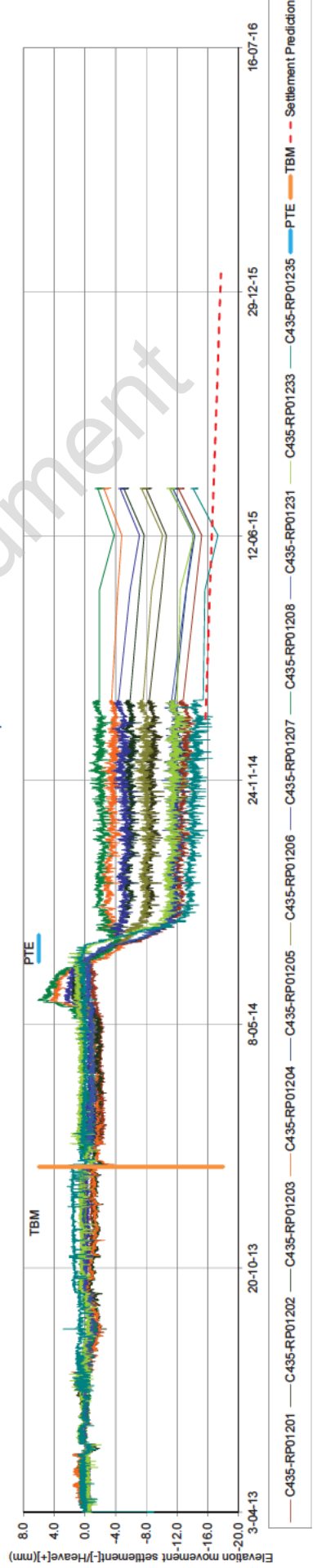
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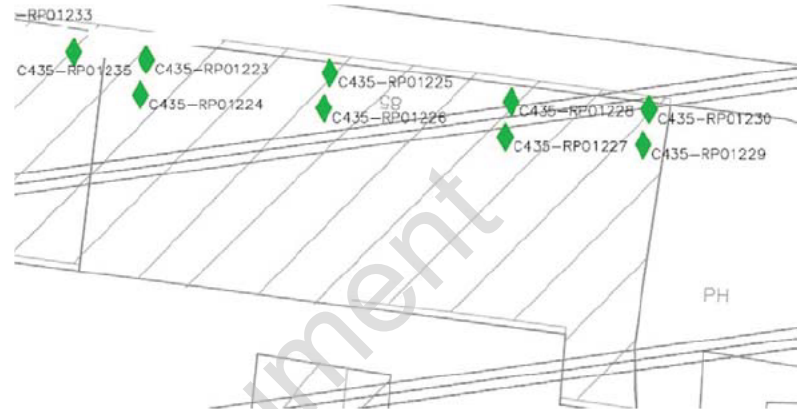


Northing Y Group 2

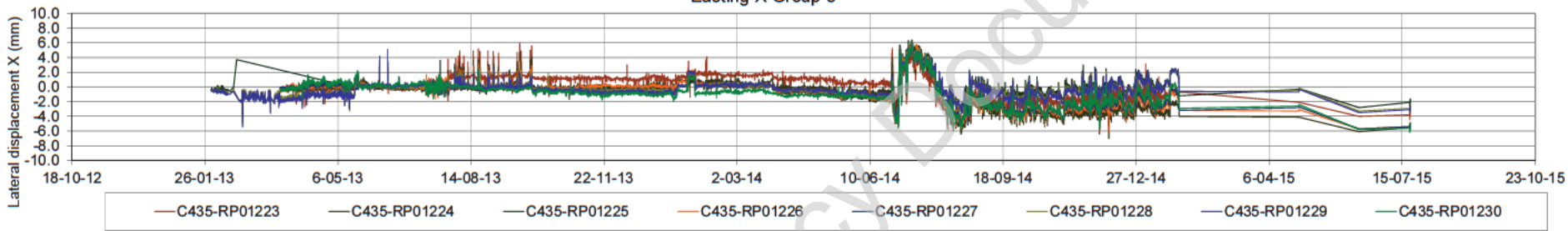


Elevation Z Group 2

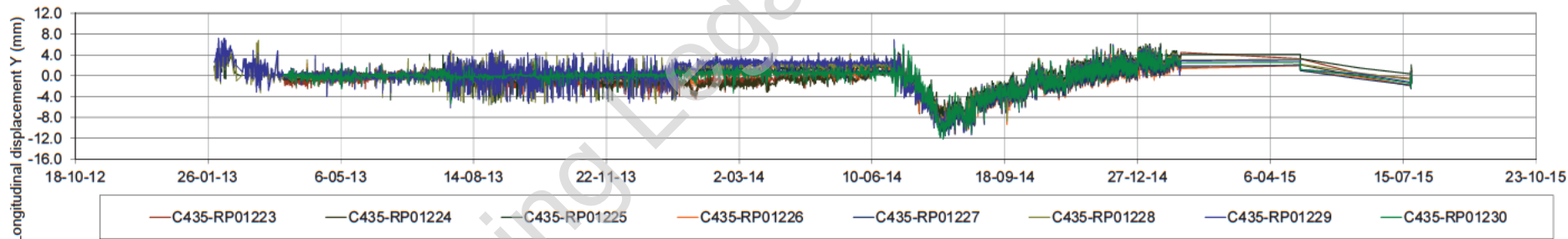




Easting X Group 3



Northing Y Group 3



Elevation Z Group 3

