



C510 – Whitechapel and Liverpool Street Station Tunnels

Instrumentation and Monitoring Close Out Report Block 15 Liverpool Street

CRL Document Number: C510-BBM-C2-RGN-C101-50231

Supplier Document Number: N/A

Contract MDL reference: C13.014

1. Contractor Document Submittal History:

Revision:	Date:	Prepared by:	Checked by:	Approved by:	Reason for Issue:
1.0	08/02/2017	[Redacted]	[Redacted]	[Redacted]	For Acceptance

2a. Stakeholder Review Required?

YES NO

Stakeholder submission required: LU RfL Purpose of submission: For no objection
 NR LO For information
 DLR Other: _____

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

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

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

2b. Review by Stakeholder (if required):

Stakeholder Organisation	Job Title	Name	Signature	Date	Acceptance
					<input type="checkbox"/>
					<input type="checkbox"/>

3. Acceptance by Crossrail:

Crossrail Review and Acceptance Decal	
	This decal is to be used for submitted documents requiring acceptance by Crossrail.
<input checked="" type="checkbox"/>	Code 1. Accepted. Work May Proceed
<input type="checkbox"/>	Code 2. Not Accepted. Revise and resubmit. Work may proceed subject to incorporation of changes indicated
<input type="checkbox"/>	Code 3. Not Accepted. Revise and resubmit. Work may not proceed
<input type="checkbox"/>	Code 4. Reserved for information only. Receipt is not required
[Redacted]	Date: 06/03/17
Acceptance by Crossrail does not relieve the designer/supplier from full compliance with their contractual obligations and does not constitute Crossrail approval of design, details, calculations, analyses, test methods or materials developed or selected by the designer/supplier.	

Document Revision History		
Revision	Date	Purpose
1.0	08/02/2017	For approval

TABLE OF CONTENTS

1	Purpose of Close out Report	3
2	Scope of Monitoring Assessment for Close Out	4
3	Close Out Report Block Description and Location Plan	5
3.1	Block 15 Location	5
3.2	Block 15 Description.....	6
4	Construction Programme Influencing Block 15	7
4.1.1	Tunnel Advances Affecting Block 15	9
5	Monitoring Assessment of Block 15	10
5.1	Time Graphs Monitoring Full History and Construction Durations	10
5.2	Decommissioning Status Tracker	13
5.3	Supplementary Evidence for Decommissioning.....	16
5.4	Monitoring sensor Location Plan and Decommissioning Status	19
6	Decommissioning Recommendations	22

Tables and Figures

<i>Figure 1-</i>	<i>Liverpool St General Location Plan - including Block 15 monitoring area</i>	<i>5</i>
<i>Figure 2 -</i>	<i>Block 15 ZOI Constructions.....</i>	<i>8</i>
<i>Figure 3-</i>	<i>LP Monitoring Sensor Settlement Status and Location Plan.....</i>	<i>20</i>
<i>Figure 4-</i>	<i>RP Monitoring Sensor Settlement Status and Location Plan</i>	<i>21</i>
<i>Graph 1-</i>	<i>All Block 15 Road Studs (LP) Manual Monitoring History in Relation to Construction</i>	<i>11</i>
<i>Graph 2 -</i>	<i>All Block 15 Geodetic Prisms (RP) Manual Monitoring History in Relation to Construction.....</i>	<i>12</i>
<i>Graph 3-</i>	<i>44 Moorfields House monitoring data prior to adjustment.....</i>	<i>16</i>
<i>Graph 4-</i>	<i>44 Moorfields House adjusted monitoring data</i>	<i>16</i>
<i>Graph 5-</i>	<i>Movement of C510-RP11506 and adjacent monitoring sensors</i>	<i>18</i>
<i>Table 1-</i>	<i>Tunnel Advances Affecting Block 15.....</i>	<i>9</i>
<i>Table 2 -</i>	<i>Decommissioning Tracker.....</i>	<i>15</i>

1 Purpose of Close out Report

Materials and Workmanship Specification - Instrumentation and Monitoring (C122-OVE-Z4-RSP-CR001-00007), section KX10.2114 specifies the requirement for a close out report prior to the decommissioning of monitoring sensors and instruments. It is therefore, the purpose of this close out report to gain acceptance to decommission identified monitoring sensors in Block 15 of Crossrails's C510 Liverpool St. Acceptance to decommission sensors will result in ceasing measurements, stopping the reporting and removing sensors.

To gain approval to decommission instrumentation and monitoring, the monitoring data will be analysed to demonstrate settlement does not breach specified rates after the minimum monitoring period is complete.

N.B. Monitoring sensors refers to all monitoring points; which includes BREs, road studs, extensometers, inclinometers, tilt meters, crack meters, retros (survey stickers) and prisms. Please note this is not an exhaustive list and does not include monitoring systems/equipment, such as communication boxes.

2 Scope of Monitoring Assessment for Close Out

Specification KX10.4103 of document C122-OVE-Z4-RSP-CR001-00007 states that to establish approval for decommissioning, the contractor is to produce a close out report which summarises the observations in correlation with the construction activities. The report is to demonstrate monitoring has reached acceptable settlement rates; whether to the specified rate, or where no rate is specified trigger values are evaluated against potential residual risks. I&M schedule C122-OVE-C2-DDJ-CR001-Z-31511 specifies the acceptable settlement rates with the requirements to monitor at different construction phases, and duration for completion. To summarise the I&M schedule states that the manual monitoring decommissioning specified rate is 2mm per year, following 16 months post construction monitoring (4 months step down and quarterly measurements for a minimum of 12 months long term monitoring). The I&M schedule does not identify the need for long term automated monitoring or specify a settlement rate requirement, it only states that monitoring must continue for 6 months post construction. At the 6 month juncture, agreement must be sought from the project manager to decommission automated monitoring programmes through a close out report or agreeing to cease the works with the project manager. In most cases decommissioning will be possible, as the residual risk will be captured through the remaining long term manual monitoring.

Contrary to the Specification for Instrumentation and Monitoring (C122-OVE-Z4-RSP-CR001-00007), the Project Managers Instruction (PMI) C510-PMI-01102 replaces long term monitoring with satellite interferometry (InSAR) for the areas agreed by the project manager. If long term monitoring responsibilities are removed from BBMV and covered by satellite interferometry, the specified settlement criteria may not be met by BBMV. If this occurs, reference to the agreement will be provided to state BBMV are no longer responsible for the sensors and consequently decommissioning acceptance will be proposed.

In some cases it may be agreed with the project manager to cease monitoring prior to meeting the specified rates. The close out report will be revised to incorporate these agreements prior to decommissioning. Due to multiple influencers and large construction monitoring zones, it may be prudent to submit successive document revisions for close out reports, where the specification is not met or the minimum post construction monitoring has not been achieved.

3 Close Out Report Block Description and Location Plan

3.1 Block 15 Location

Figure 1 shows the Liverpool St general location plan, C510 tunnel construction and where Block 15 is situated. Detailed location plans can be found within the installation reports and photomontages as listed in Section 3.2. Each monitoring sensor's location is shown within the assessment plans (Section 5.4).

Thames Water Critical Assets include the Goswell Street Sewer North Branch Diversion and Ropemaker Street Sewer both located on Ropemaker St within close proximity to Block 15. Other utilities include gas a water mains along Moorfields and Ropemaker St. Location and details of this asset can be found in Instrumentation and Monitoring Plan: Liverpool Street Station Ground Movement and Asset Protection C122-OVE-C2-RGN-C101-50013 or the relevant C122 prepared Damage Assessment Reports.

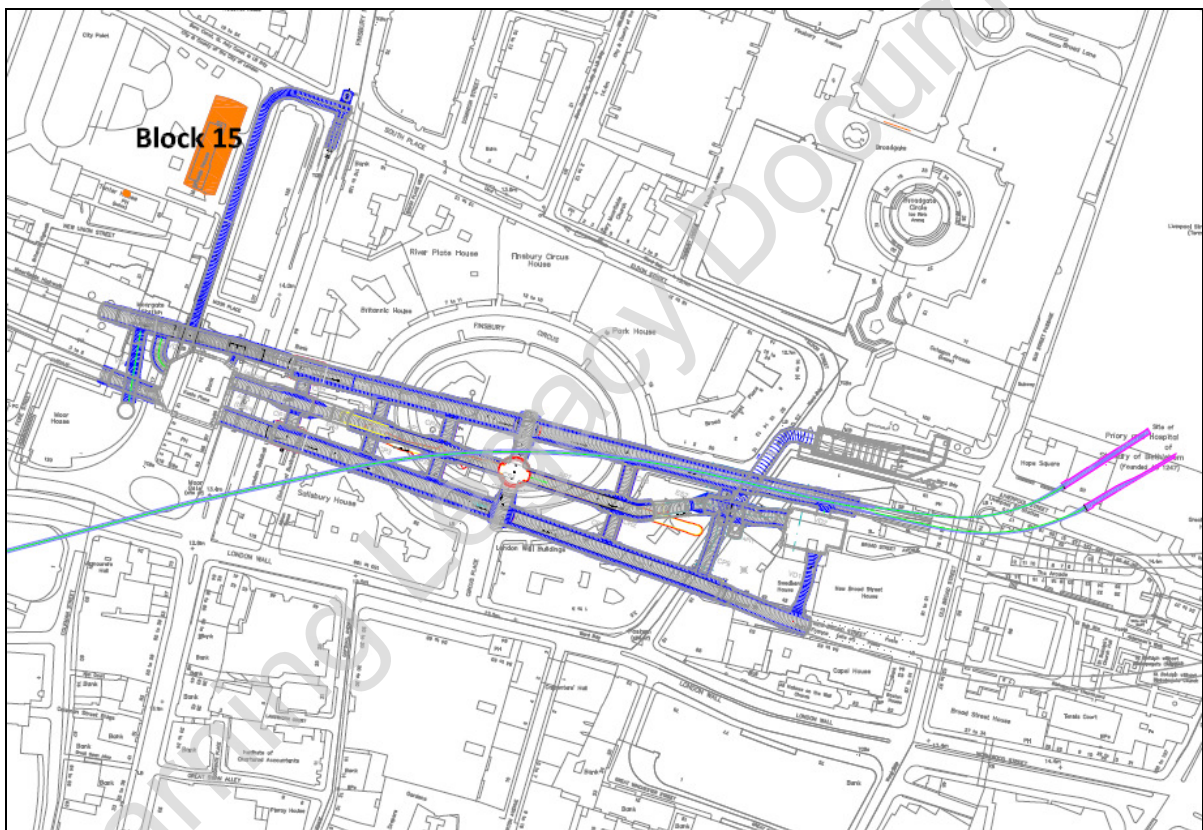


Figure 1- Liverpool St General Location Plan - including Block 15 monitoring area

3.2 Block 15 Description

Block 15 is located between Ropemaker St and New Union St. The Block occupies 44 Moorfields House. Block 15 contains the following types of monitoring sensors:

- Road Studs (LP) - manual monitoring
- Building Prism monitoring (RP) – automated monitoring

Each monitoring assets details are listed within the Decommissioning Status Tracker (*Table 2*) and further relevant information can be sourced from the installation reports.

Block 15 Installation Report References:

- Monitoring Installation Report LIV-LP35 – Liverpool Street
CRL Document Number: C510-BBM-C2-RGN-C101-50168
- Installation Report- Tenter House- Block 15, Liverpool Street
CRL Document Number: C510-BBM-C2-RGN-C101-50014

The Settlement Contour Drawing (C122-OVE-C2-DDA-CR001_Z-21313) predicts the Block 15 area to experience approximately 1-10mm of settlement.

4 Construction Programme Influencing Block 15

Extent of Influence (EOI) monitoring areas were established to record ground movements in relation to Crossrail construction. The EOI purpose is to ensure all assets and areas are adequately monitored for movement during construction, this is achieved by controlling when and how often monitoring occurs. The Asset Protection Instrument and Monitoring (I&M) Schedules (C122 –OVE-C2-DDJ-CR001_Z-31511) states the extent of influence (EOI) of an active tunnel is 2 x depth from the active tunnel face. The EOI is used to determine when monitoring sensors are no longer influenced by construction and can be considered for decommissioning.

The original specification received amendments to manual monitoring frequency within the EOI through several PMIs, with the latest PMI (C510-PMI-01103) establishing an Active ZOI (Zone of Influence) as 2 x tunnel diameter from the active tunnel face projected to the surface. The Active ZOI changed the rates of monitoring frequency, it did not replace EOI. The EOI is used to determine when a monitoring sensor is eligible for decommissioning. Whereas, active ZOI is used to analyse manual monitoring movement against construction.

To identify the tunnels that had the potential to significantly affect Block 15, a ZOI area was established by giving each monitoring sensor a radius of 2.0 x tunnel diameter. This area was then used to determine all the mining advances that occurred within its boundary, *Figure 2* shows the ZOI boundary (orange outline) and the tunnel constructions. As the only C510 construction within the Block 15 ZOI is the AP6 Enlargement, the initial and final EOI construction will also be referenced to assist in the analysis of the monitoring data. Tunnel advance start and finish dates will be used in assessment of the monitoring data.

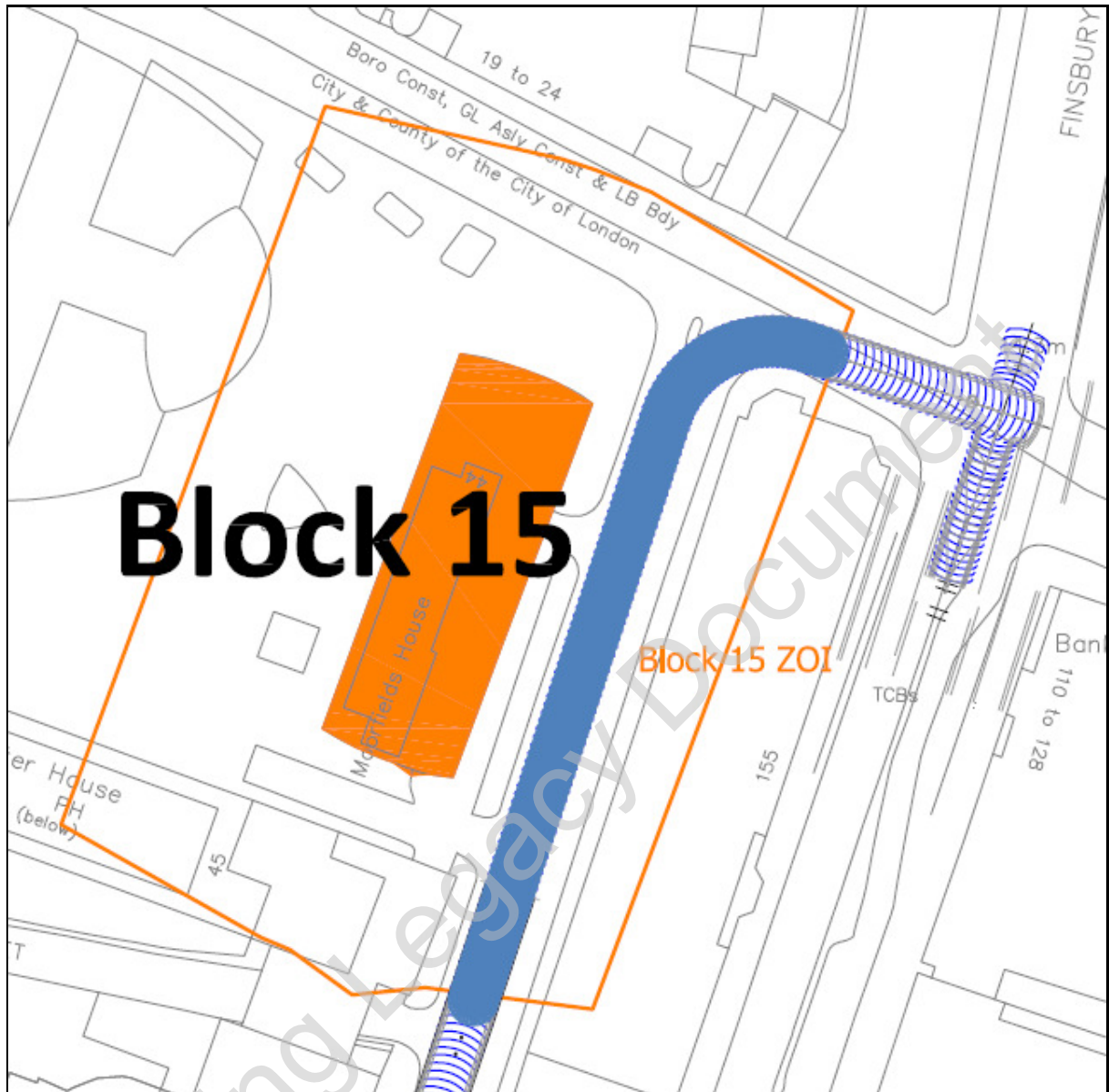


Figure 2 - Block 15 ZOI Constructions

Figure 2 shows the C510 works within the ZOI for Block 15. The construction advances within the ZOI that have the potential to affect Block 15 are listed and summarised in *Table 1*. Further evidence for construction dates can be seen in *Table 2*, which lists the latest tunnel advances for each point.

The last completed C510 construction which had the potential to affect Block 15 within the ZOI was AP6, which was completed in May 2015. As there is no further C510 construction that has the potential to influence Block 15 it is proposed to decommission all monitoring sensors.

4.1.1 Tunnel Advances Affecting Block 15

The information presented in *Table 1* is used in the monitoring graph (Section 5.1), to show the ground movements in relation to construction.

TUNNEL ADVANCES STARTS & ENDS FOR GRAPHS							
Tunnel Code	Tunnel Reference	Primary Layer Type	Start Date	End Date	Start Advance	End Advance	Zone
PRM Lift-Enlargement	PRM Lift	Enlargement	09/08/2015	09/10/2015	1	100	EOI
AP6-1-Enlargement	AP6-1	Enlargement	26/06/2014	06/05/2015	45	145	ZOI
LCE-Pilot	LCE	Pilot	10/08/2013	12/09/2013	15	93	EOI

Table 1- Tunnel Advances Affecting Block 15

Heading Index:

AP – Access Passage

CH - Chamber

CP - Cross Passage

ES – Escalator

GAD – Grout Adit

LCE - Launch Chamber East

LCW – Launch Chamber West

PTE – Platform Tunnel East

PTW – Platform Tunnel West

RCE – Reception Chamber East

RCW – Reception Chamber West

TBM – Tunnel Boring Machine

VD – Ventilation Drive

5 Monitoring Assessment of Block 15

Evidence for decommissioning each monitoring sensor is shown through a graph, table (*Table 2*) and a plan. Each element of assessment compliments the other and is used together to determine acceptance of decommissioning. *Table 2* highlights the monitoring sensors to be considered for decommissioning and provides the supporting evidence for the decision. In some cases supplementary evidence is required to prove stability or provide reasoning for decommissioning.

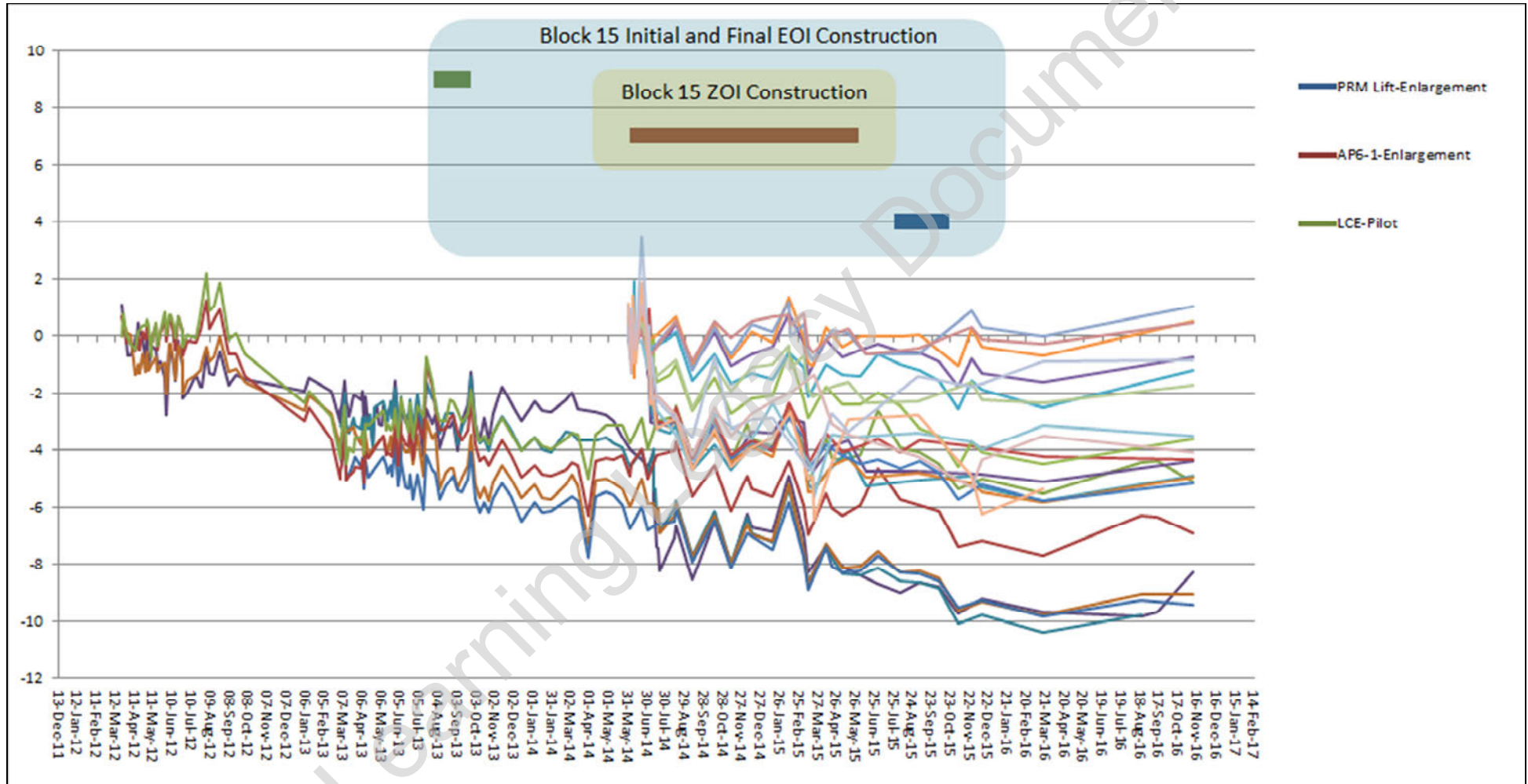
5.1 Time Graphs Monitoring Full History and Construction Durations

To assess the movement of Block 15 monitoring sensors; each monitoring sensor data type is displayed in a line graph, with a gantt chart (bar) representing the construction identified in Section 4:

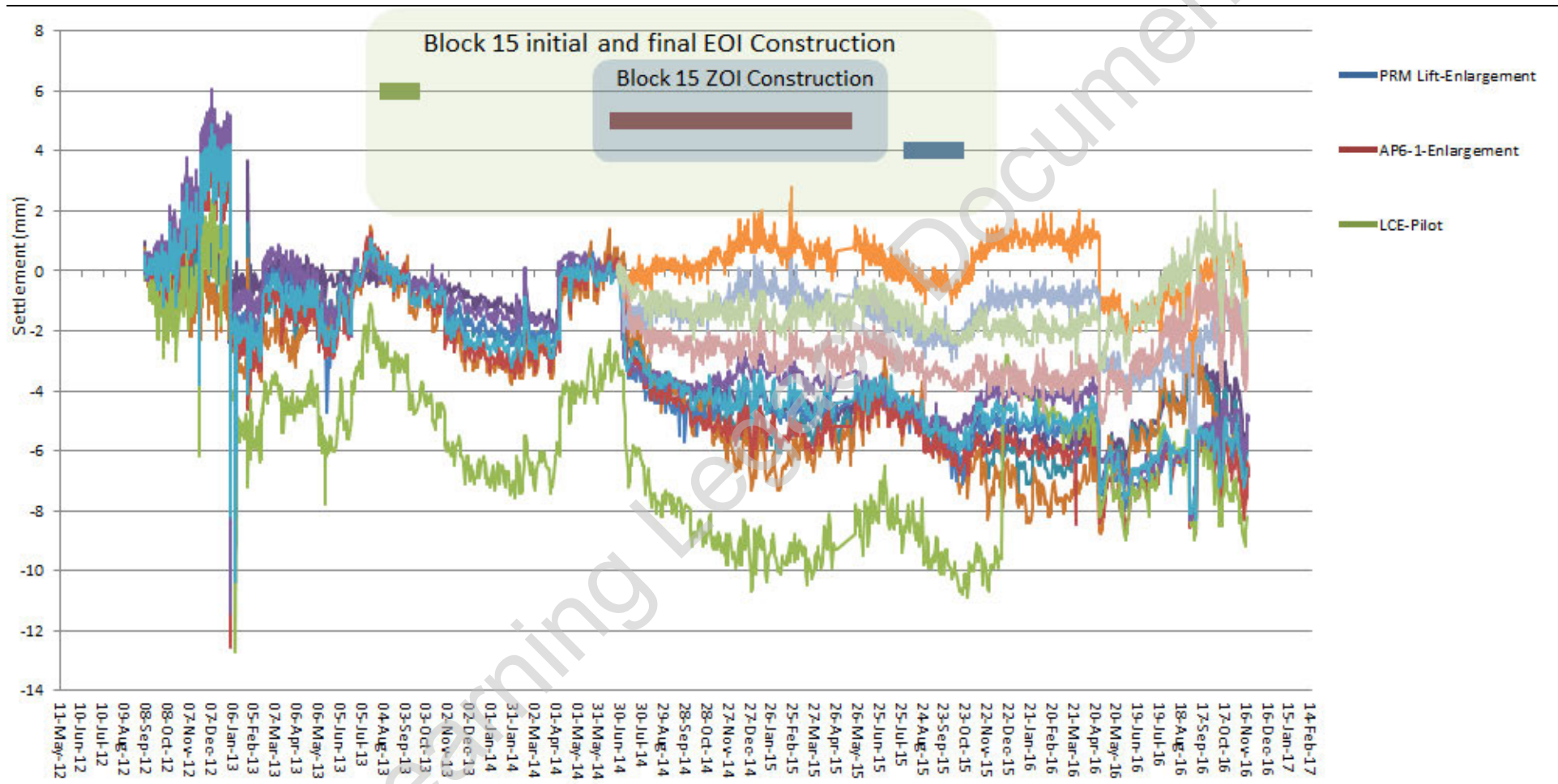
- *Graph 1* –All Block 15 Road Studs (LP) Manual Monitoring History in Relation to Construction
- *Graph 2* –All Block 15 Geodetic Prisms (RP) Manual Monitoring History in Relation to Construction

Learning Legacy Document

Graph 1- All Block 15 Road Studs (LP) Manual Monitoring History in Relation to Construction



Graph 2 - All Block 15 Geodetic Prisms (RP) Manual Monitoring History in Relation to Construction



5.2 Block 15 Decommissioning Status Tracker

The decommissioning tracker identifies (*Table 2*) each monitoring sensor and provides the critical information to enable decommissioning assessment for each sensor. The initial fields shown in the tracker are descriptors of the monitoring sensor, whilst the remaining fields are the assessment for decommissioning. The purpose of the tracker is to provide Crossrail reviewers with sufficient information in conjunction with construction movement graphs and plots, to accept BBMV's proposal to decommission sensors on an individual basis.

Detailed explanation of the tracker column headers:

Tracker Column Header – Last Construction Date and Traffic Lights

For each sensor the EOI parameter is used to determine the last completed construction advance that had the potential to cause settlement. All construction tunnel advances that had the potential to affect a sensor through its EOI are listed for each sensor, from the list the latest advance is used as a construction completion indicator. A traffic light system is used to highlight when a sensor has surpassed defined monitoring time frames; 4 months (120 days), 6 months (180 days) and 16 months (480 days).

N.B. Each monitoring sensor's last affecting primary construction heading and advance number's completion date has been listed within the Decommissioning Status Tracker. The last construction heading listed, is not the closest to the monitoring sensor, but the last completed within the 2 x diameter radius.

Tracker Column Header – 120, 180 & 365 Days Average Settlement Trend

There are three average settlement trends, which tie into the defined monitoring time frames; 120, 180 and 365 days. The calculation used to determine the trend is the same for all three periods. It is a slope calculation (explained below) of the defined period, multiplied over one year. The trend is calculated from the latest reading and includes all readings within the defined period, which is averaged and then multiplied over 1 year. If there is no initial reading for the time frame date, the calculation will continue back to include the next available date. This is an important consideration when assessing the trend and to assist the reviewers, the time frame used within the calculation is included within the decommissioning tracker status table. Defined monitoring time frames:

- The 120 day average rate is used to show the completion of manual monitoring step down period, this is the minimum period of monitoring prior to InSAR taking monitoring responsibility.
- The 180 day average rate is the minimum monitoring period after construction for automated sensors.
- The 365 day average trend is a calculation to determine annual settlement rates using measurements taken across a full year. This measurement period is therefore the desired duration to be used to assess whether long term settlement meets the 2mm per annum specification.

Slope calculation Settlement Trend:

Description – The settlement trend calculates the slope of the linear regression line through data points in known_y's and known_x's. The slope is the vertical distance divided by the horizontal distance between any two points on the line, which is the rate of change along the regression line.

Calculation

$$b = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sum (x - \bar{x})^2}$$

Example - If the calculated trend for a 6 month period is 1.5mm, it is multiplied into 365 days, to equal a projected settlement trend of 3mm over 1 year.

Tracker Column Header – ERP Ceased date

ERP and CTC meetings have identified project efficiencies, by ceasing manual monitoring programmes early, or prior to reaching 2mm/yr. InSAR may have taken responsibility of monitoring or the perceived risk may be low enough to warrant ceasing the monitoring. In these situations the cease date is provided, along with a comment explaining the reasoning. Monitoring that has been ceased still requires approval to decommission and will be identified within the decommissioning status tracker as proposed to decommission.

Tracker Column Header – Decommissioning Status

The status is the decommissioning situation for each sensor within Block 15. The different statuses are as follows:

- Outstanding - Monitoring sensor has not met the close out requirements and approval to decommission will be sought in subsequent revisions of this close out report.
- Proposed - the sensor is proposed to be decommissioned. Crossrail to accept the sensor can be decommissioned.
- Agreed – Agreed to decommission through previous revision of the close out report. No further reporting or monitoring has taken place.
- Complete - Monitoring sensor has been removed and evidence gathered during decommissioning.

N.B. When monitoring sensors have not met the requirements, it may still be appropriate to decommission. In this scenario supplementary evidence will be provided to explain the reasoning for decommissioning.

Table 2 - Block 07 Decommissioning Status Tracker RP

08/02/2017

< 2.0 mm GREEN < 3.5 mm AMBER > 3.5 mm RED

19/12/2016

C510 Sensor Name	Block	Section	Int / Ext	Measurement Type	Sensor Type	Sensor Description	Asset/Location	EOI Last Primary Layer Construction	Last Construction Date	Latest Surveyed Date	AVERAGE SETTLEMENT TREND						General Comment	Decommissioning Status
											120 Days	120 Day Calculation Period	180 Days	180 Day Calculation Period	365 Days	365 Day Calculation Period		
C510-RP11501	Block 115	N/A	External	Unknown	RP	3D Geodetic prism	44 Moorfields	LIV_AP6-1_Enlargement_Adv-145	06/05/2015	05/06/2016	4.87	120	2.25	181	-0.87	366	C510-RFI-001014- 44 Moorfields House= Crossrail confirms InSAR can replace automated long term monitoring.	Proposed
C510-RP11502	Block 115	N/A	External	Unknown	RP	3D Geodetic prism	44 Moorfields	LIV_AP6-1_Enlargement_Adv-145	06/05/2015	05/06/2016	5.64	120	2.57	181	-1.70	366	C510-RFI-001014- 44 Moorfields House= Crossrail confirms InSAR can replace automated long term monitoring.	Proposed
C510-RP11503	Block 115	N/A	External	Unknown	RP	3D Geodetic prism	44 Moorfields	LIV_AP6-1_Enlargement_Adv-145	06/05/2015	05/06/2016	8.92	121	4.19	181	-2.33	365	C510-RFI-001014- 44 Moorfields House= Crossrail confirms InSAR can replace automated long term monitoring.	Proposed
C510-RP11504	Block 115	N/A	External	Unknown	RP	3D Geodetic prism	44 Moorfields	LIV_AP6-1_Enlargement_Adv-119	10/07/2014	05/06/2016	0.49	121	0.00	181	-0.17	365	C510-RFI-001014- 44 Moorfields House= Crossrail confirms InSAR can replace automated long term monitoring.	Proposed
C510-RP11505	Block 115	N/A	External	Unknown	RP	3D Geodetic prism	44 Moorfields	LIV_AP6-1_Enlargement_Adv-119	10/07/2014	05/06/2016	-1.60	121	-1.22	181	-1.45	365	C510-RFI-001014- 44 Moorfields House= Crossrail confirms InSAR can replace automated long term monitoring.	Proposed
C510-RP11506	Block 115	N/A	External	Unknown	RP	3D Geodetic prism	44 Moorfields	LIV_AP6-1_Enlargement_Adv-119	10/07/2014	05/06/2016	-11.71	120	-9.41	181	-5.93	365	C510-RFI-001014- 44 Moorfields House= Crossrail confirms InSAR can replace automated long term monitoring.	Proposed
C510-RP11507	Block 115	N/A	External	Unknown	RP	3D Geodetic prism	44 Moorfields	LIV_AP6-1_Enlargement_Adv-96	06/07/2014	05/06/2016	-1.68	121	-0.86	181	0.42	366	C510-RFI-001014- 44 Moorfields House= Crossrail confirms InSAR can replace automated long term monitoring.	Proposed
C510-RP11508	Block 115	N/A	External	Unknown	RP	3D Geodetic prism	44 Moorfields	LIV_AP6-1_Enlargement_Adv-96	06/07/2014	05/06/2016	0.07	121	-0.41	181	-0.55	365	C510-RFI-001014- 44 Moorfields House= Crossrail confirms InSAR can replace automated long term monitoring.	Proposed
C510-RP11551	Block 115	N/A	External	Unknown	RP	3D Geodetic prism	Moorfields House	LIV_AP6-1_Enlargement_Adv-137	13/07/2014	05/06/2016	-3.93	120	-1.96	180	1.05	365	C510-RFI-001014- 44 Moorfields House= Crossrail confirms InSAR can replace automated long term monitoring.	Proposed
C510-RP11552	Block 115	N/A	External	Unknown	RP	3D Geodetic prism	Moorfields House	LIV_AP6-1_Enlargement_Adv-129	12/07/2014	05/06/2016	-2.63	120	-1.17	180	-1.14	365	C510-RFI-001014- 44 Moorfields House= Crossrail confirms InSAR can replace automated long term monitoring.	Proposed
C510-RP11553	Block 115	N/A	External	Unknown	RP	3D Geodetic prism	Moorfields House	LIV_AP6-1_Enlargement_Adv-129	12/07/2014	05/06/2016	3.69	120	1.97	180	-0.40	365	C510-RFI-001014- 44 Moorfields House= Crossrail confirms InSAR can replace automated long term monitoring.	Proposed
C510-RP11554	Block 115	N/A	External	Unknown	RP	3D Geodetic prism	Moorfields House	LIV_AP6-1_Enlargement_Adv-129	12/07/2014	05/06/2016	4.18	120	2.34	180	-0.07	365	C510-RFI-001014- 44 Moorfields House= Crossrail confirms InSAR can replace automated long term monitoring.	Proposed
C510-LP13501	Block 115	S11501	External	Manual	LP	Road Stud	Ropemaker St	LIV_AP6-1_Enlargement_Adv-149	08/05/2015	08/11/2016	1.51	237	1.51	237	0.54	371	Met 2mm per annum specification	Proposed
C510-LP13502	Block 115	S11501	External	Manual	LP	Road Stud	Ropemaker St	LIV_AP6-1_Enlargement_Adv-144	05/05/2015	18/08/2016	1.48	155	0.13	250	-1.36	380	Met 2mm per annum specification	Proposed
C510-LP13503	Block 115	S11501	External	Manual	LP	Road Stud	Ropemaker St	LIV_AP6-1_Enlargement_Adv-138	13/07/2014	08/11/2016	1.27	237	1.27	237	0.58	371	Met 2mm per annum specification	Proposed
C510-LP13504	Block 115	S11501	External	Manual	LP	Road Stud	Ropemaker St	LIV_AP6-1_Enlargement_Adv-131	12/07/2014	08/11/2016	0.73	237	0.73	237	0.13	371	Met 2mm per annum specification	Proposed
C510-LP13505	Block 115	S11501	External	Manual	LP	Road Stud	Ropemaker St	LIV_AP6-1_Enlargement_Adv-131	12/07/2014	08/11/2016	1.64	237	1.64	237	0.93	371	Met 2mm per annum specification	Proposed
C510-LP13506	Block 115	S11501	External	Manual	LP	Road Stud	Ropemaker St	LIV_AP6-1_Enlargement_Adv-131	12/07/2014	08/11/2016	1.17	237	1.17	237	0.66	371	Met 2mm per annum specification	Proposed
C510-LP13507	Block 115	S11502	External	Manual	LP	Road Stud	Moorfields	LIV_AP6-1_Enlargement_Adv-96	06/07/2014	08/11/2016	1.13	237	1.13	237	0.35	433	Met 2mm per annum specification	Proposed
C510-LP13508	Block 115	S11502	External	Manual	LP	Road Stud	Moorfields	LIV_AP6-1_Enlargement_Adv-108	08/07/2014	08/11/2016	1.30	237	1.30	237	0.04	433	Met 2mm per annum specification	Proposed
C510-LP13509	Block 115	S11502	External	Manual	LP	Road Stud	Moorfields	LIV_AP6-1_Enlargement_Adv-119	10/07/2014	08/11/2016	1.43	237	1.43	237	-0.01	433	Met 2mm per annum specification	Proposed
C510-LP13510	Block 115	S11502	External	Manual	LP	Road Stud	Moorfields	LIV_AP6-1_Enlargement_Adv-131	12/07/2014	08/11/2016	0.98	237	0.98	237	0.40	371	Met 2mm per annum specification	Proposed
C510-LP13511	Block 115	S11502	External	Manual	LP	Road Stud	Moorfields	LIV_AP6-1_Enlargement_Adv-142	14/07/2014	08/11/2016	-0.14	234	-0.14	234	-0.57	431	Met 2mm per annum specification	Proposed
C510-LP13512	Block 115	S11502	External	Manual	LP	Road Stud	Moorfields	LIV_AP6-1_Enlargement_Adv-136	13/07/2014	08/11/2016	1.35	237	1.35	237	0.54	371	Met 2mm per annum specification	Proposed
C510-LP13513	Block 115	S11502;S11503	External	Manual	LP	Road Stud	Moorfields	LIV_AP6-1_Enlargement_Adv-127	11/07/2014	08/11/2016	1.40	237	1.40	237	0.61	371	Met 2mm per annum specification	Proposed
C510-LP13514	Block 115	S11503	External	Manual	LP	Road Stud	Moorfields House	LIV_AP6-1_Enlargement_Adv-117	10/07/2014	08/11/2016	2.01	237	2.01	237	0.82	371	Met 2mm per annum specification	Proposed
C510-LP13515	Block 115	S11503	External	Manual	LP	Road Stud	Moorfields House	LIV_AP6-1_Enlargement_Adv-104	07/07/2014	08/11/2016	1.84	237	1.84	237	0.92	371	Met 2mm per annum specification	Proposed
C510-LP13516	Block 115	S11503	External	Manual	LP	Road Stud	Moorfields House	LIV_AP6-1_Enlargement_Adv-93	06/07/2014	08/11/2016	1.60	237	1.60	237	0.96	433	Met 2mm per annum specification	Proposed
C510-LP13517	Block 115	S11503	External	Manual	LP	Road Stud	Moorfields House	LIV_AP6-1_Enlargement_Adv-79	03/07/2014	08/11/2016	1.18	237	1.18	237	0.56	433	Met 2mm per annum specification	Proposed
C510-LP13518	Block 115	S11503	External	Manual	LP	Road Stud	Moorfields House	LIV_AP6-1_Enlargement_Adv-89	04/07/2014	08/11/2016	0.96	237	0.96	237	0.34	433	Met 2mm per annum specification	Proposed
C510-LP13519	Block 115	S11504	External	Manual	LP	Road Stud	Moorfields	LIV_AP6-1_Enlargement_Adv-96	06/07/2014	09/11/2016	-0.57	238	-0.57	238	0.14	434	Met 2mm per annum specification	Proposed
C510-LP13520	Block 115	S11504	External	Manual	LP	Road Stud	Moorfields	LIV_AP6-1_Enlargement_Adv-108	08/07/2014	16/03/2016	-4.78	196	-4.78	196	-0.43	371	Met 2mm per annum specification	Proposed
C510-LP13521	Block 115	S11504	External	Manual	LP	Road Stud	Moorfields	LIV_AP6-1_Enlargement_Adv-108	08/07/2014	09/11/2016	0.03	238	0.03	238	0.69	434	Met 2mm per annum specification	Proposed
C510-LP13522	Block 115	S11504	External	Manual	LP	Road Stud	Moorfields	LIV_AP6-1_Enlargement_Adv-111	09/07/2014	09/11/2016	-0.88	238	-0.88	238	0.55	434	Met 2mm per annum specification	Proposed

Learning Legacy

5.3 Supplementary Evidence for Decommissioning

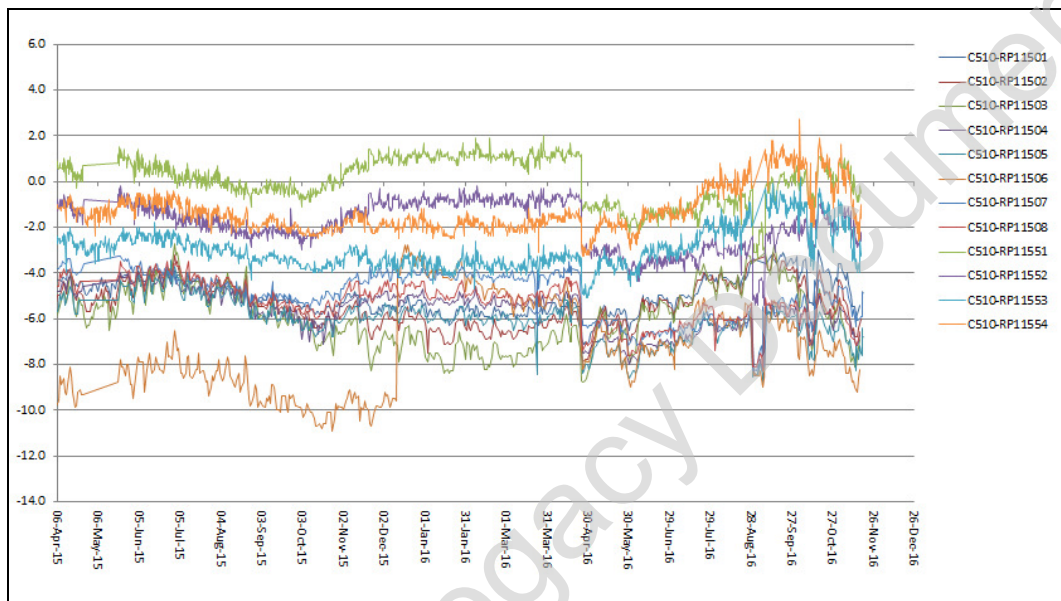
In some cases supplementary evidence will be provided to support the decommissioning evidence.

3d Geodetic Prism Monitoring Adjustment- 44 Moorfields House

Includes: C510-RP11501-08 and C510-RP11551-54

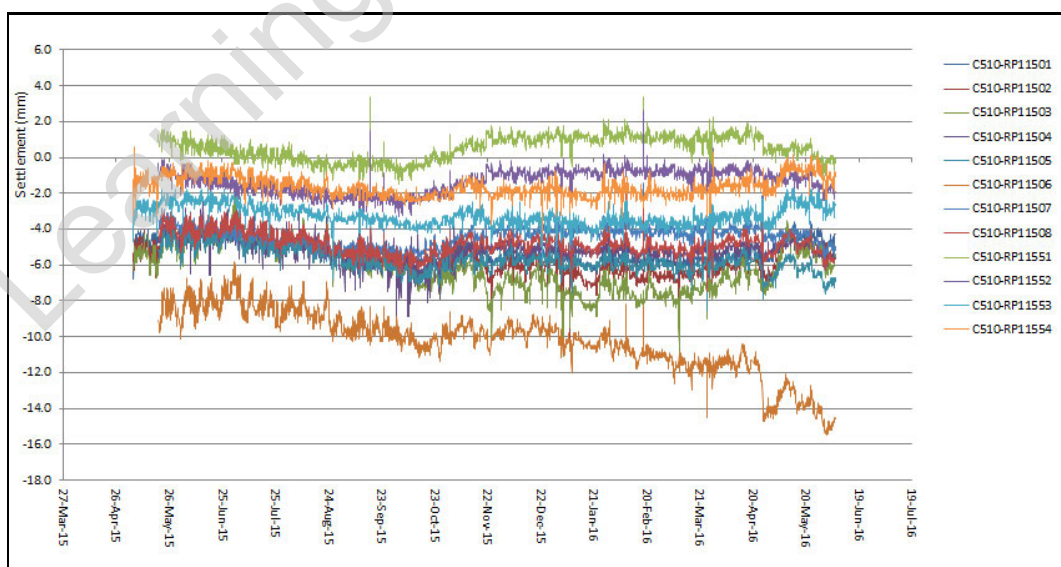
Graph 3 shows the 44 Moorfields House prism monitoring data. There are steps in the data that do not relate to any construction and appear to be either monitoring errors or network adjustments.

Graph 3- 44 Moorfields House monitoring data prior to adjustment



Adjustments have been made to remove anomalies from the data set. Graph 4 shows the adjusted data that will be used in the assessment of the 44 Moorfields House settlement.

Graph 4- 44 Moorfields House adjusted monitoring data



3d Geodetic Prism Monitoring assessment period- 44 Moorfields House

Includes: C510-RP11501-08 and C510-RP11551-54

Reasons to propose decommissioning

C510-RFI-001014 states: 44 Moorfields House (MDC_00493)- As the prisms are the only monitoring actually on the building, then the 2mm/year criteria should apply which we understand has been met. Insar coverage appears reasonable.

The latest automated monitoring data for 44 Moorfields house is unreliable. To assess the settlement, the monitoring data will be referenced over 12 months from the last C510 construction which was the AP6 Enlargement on the 5th of May 2015. This is the preferred assessment period in this case as the monitoring data from July 2016 onwards is unreliable. *Graph 5* shows the monitoring trends over 12 months for all prisms located on 44 Moorfields House, the same data will be used to calculate monitoring trends in the decommissioning tracker.

When calculated over 12 months post construction, most prisms on 44 Moorfields House meet the 2mm a year that was desired in RFI C510-RFI001014. As the road studs around 44 Moorfields House have all met specification and have shown very minimal settlement over the past 12 months, it appears reasonable for Insar to take over responsibility for the remaining long term monitoring of 44 Moorfields House.

Learning Legacy Document

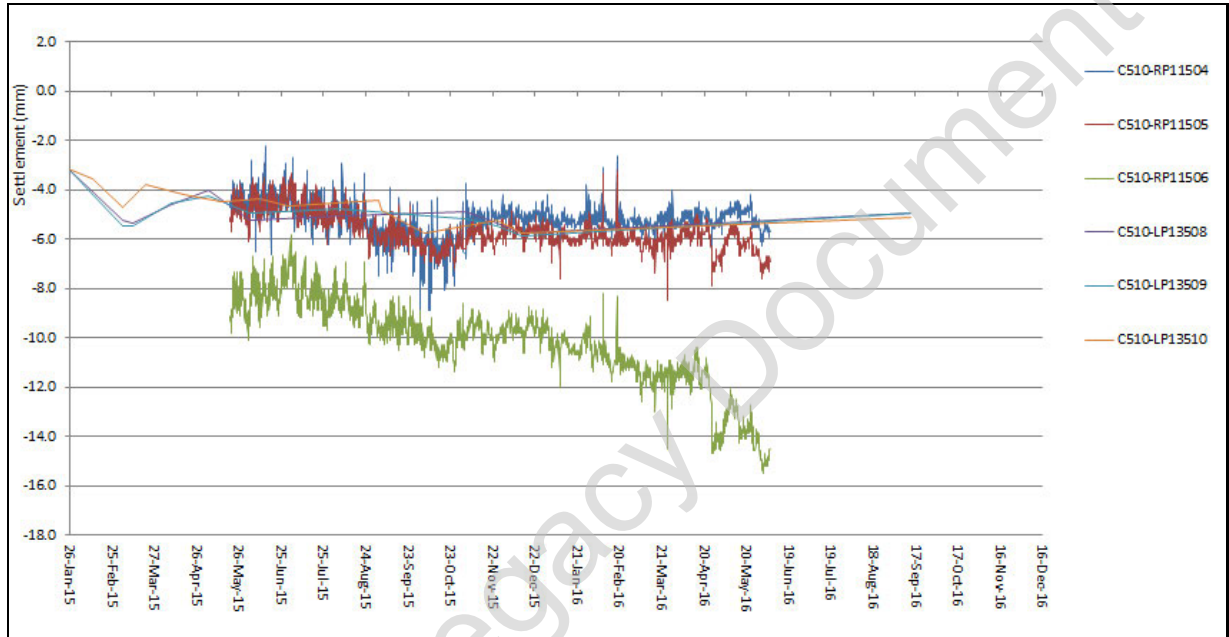
3d Geodetic Prism Monitoring (RP) Automated Monitoring

Includes: C510-RP11506

Reasons to propose decommissioning

C510-RP11506 has not met the desired 2mm per annum that was specified in RFI C510-RFI001014. The RP11506 results are anomalous when investigating the trends against the rest of the block. Investigations show that adjacent sensors have shown minimal movement. *Graph 6* displays the monitoring prisms directly below LP11506 and the road studs below the prisms in the footpath.

Graph 5- Movement of C510-RP11506 and adjacent monitoring sensors



As C510-RP11506 results are not consistent with the adjacent sensors settlement trends, it is evident that the additional settlement the prism experienced was due to monitoring discrepancies. For these reasons it is proposed to agree decommissioning of C510-LP11506 and for Insar to take over long term monitoring responsibilities of 44 Moorfields House.

(From General Document Template ref: BBMV-Form-S9-04 rev 5.0)

5.4 Monitoring sensor Location Plan and Decommissioning Status

The following plots provide a visual representation of all Block 15 monitoring sensors with a colour circle that defines its settlement status. A green circle represents when a trend is below 2mm/yr and the larger the circle the greater the trend period. When a trend has not been met, a small red circle will represent the monitoring sensor.

- *Figure 3* - LP Monitoring Sensor Settlement Status and Location Plan
- *Figure 4* – RP Monitoring Sensor Settlement Status and Location Plan

Learning Legacy Document

Figure 3- LP Monitoring Sensor Decommissioning Status and Location Plan

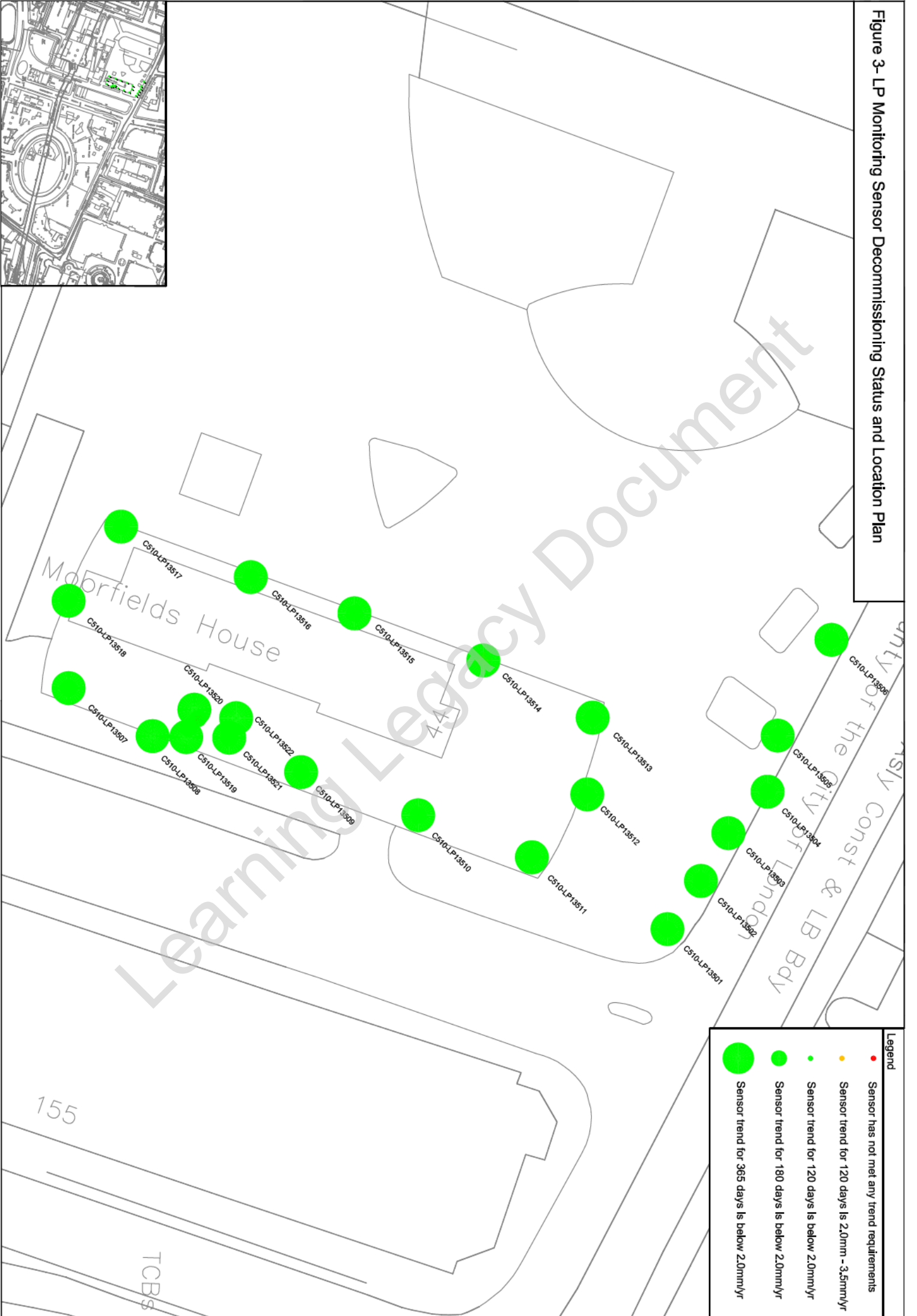
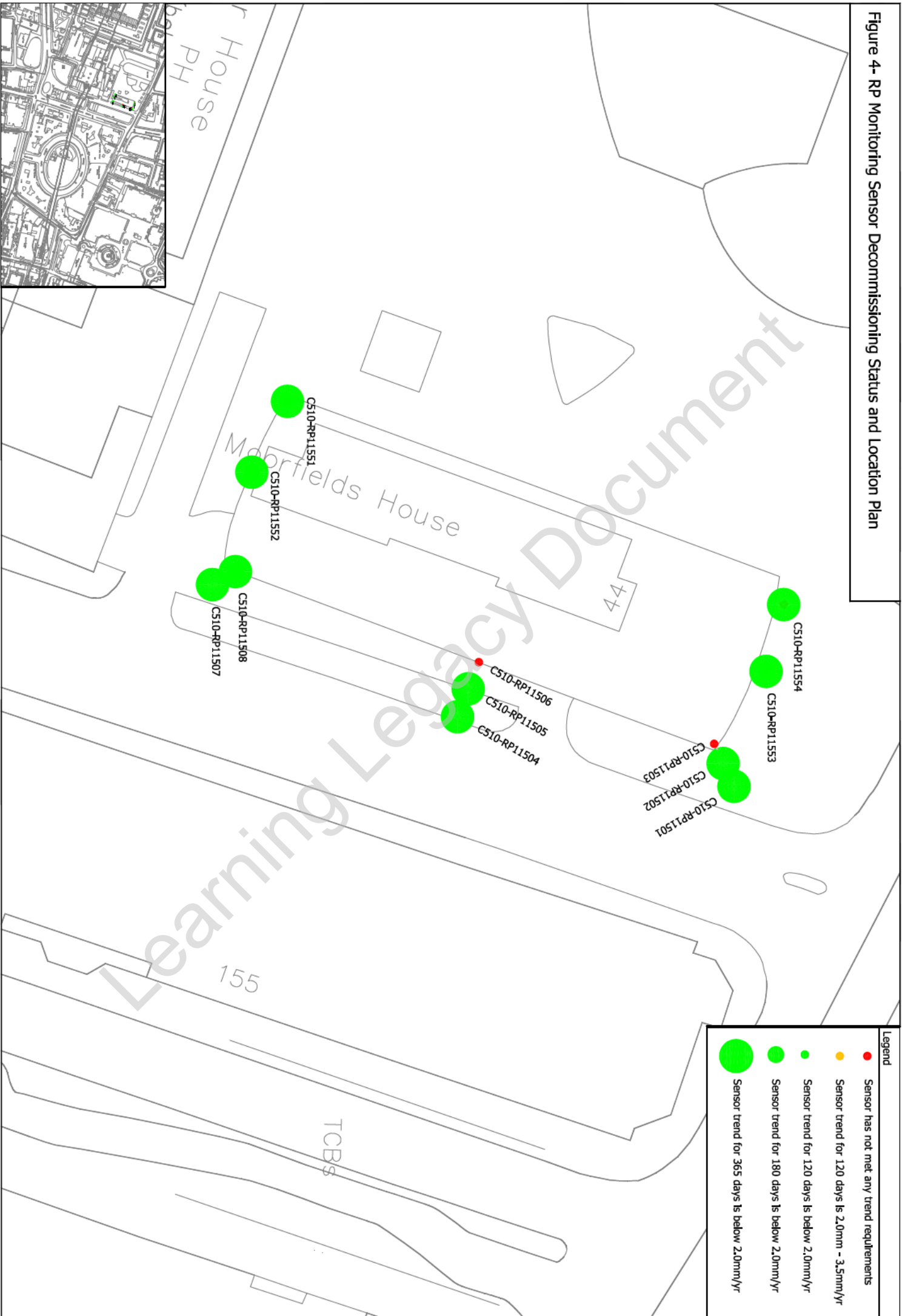


Figure 4- RP Monitoring Sensor Decommissioning Status and Location Plan



6 Decommissioning Recommendations

Through the monitoring assessment process in Section 5, it is purposed that all Block 15 sensors are to be decommissioned and for InSAR to assume responsibility of long term monitoring for 44 Moorfields House. *Table 2* Decommissioning Tracker lists all Block 15 monitoring sensor's decommissioning status and the supporting evidence. 3d Geodetic Prism C510-RP11506 has not met the desired trends specified in RFI C510-RP11506, reasons for this have been provided in Section 5.3 Supplementary Evidence.

N.B. When required, decommissioning and re-instatement evidence will be collected during the removal of monitoring sensors, which will be included within the final report.

Learning Legacy Document