C510 – Whitechapel and Liverpool Street Station Tunnels

Instrumentation and Monitoring Close Out Report
Block 26 Liverpool Street

CRL Document Number: C510-BBM-C2-RGN-C101-50223

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	06/10/2016	[redacted]			For Acceptance

2a. Stakeholder Review Required? YES ☐ NO ☐

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

Purpose of submission: For no objection ☐ For information ☐

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

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

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

2b. Review by Stakeholder (if required):

Stakeholder Organisation	Job Title	Name	Signature	Date	Acceptance
					☐
					☐

3. Acceptance by *Crossrail:*

***Crossrail* Review and Acceptance Decal**

This decal is to be used for submitted documents requiring acceptance by *Crossrail*.

☑	Code 1.	Accepted. Work May Proceed
☐	Code 2.	Not Accepted. Revise and resubmit. Work may proceed subject to incorporation of changes indicated
☐	Code 3.	Not Accepted. Revise and resubmit. Work may not proceed
☐	Code 4.	Received for information only. Resubmission 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	06/10/2016	For approval

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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 26 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 26 Location

Figure 1 shows the Liverpool St general location plan, C510 tunnel construction and where Block 26 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 assets are located on Old Broad St and Liverpool St within Block 26, including 8in and 16in CI water mains (Critical Assets) and brick sewers. National Grid Gas assets include plastic mains along Old Broad St, a steel main along The Arcade and a ductile iron main along Liverpool Street. The location and details of these assets 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.

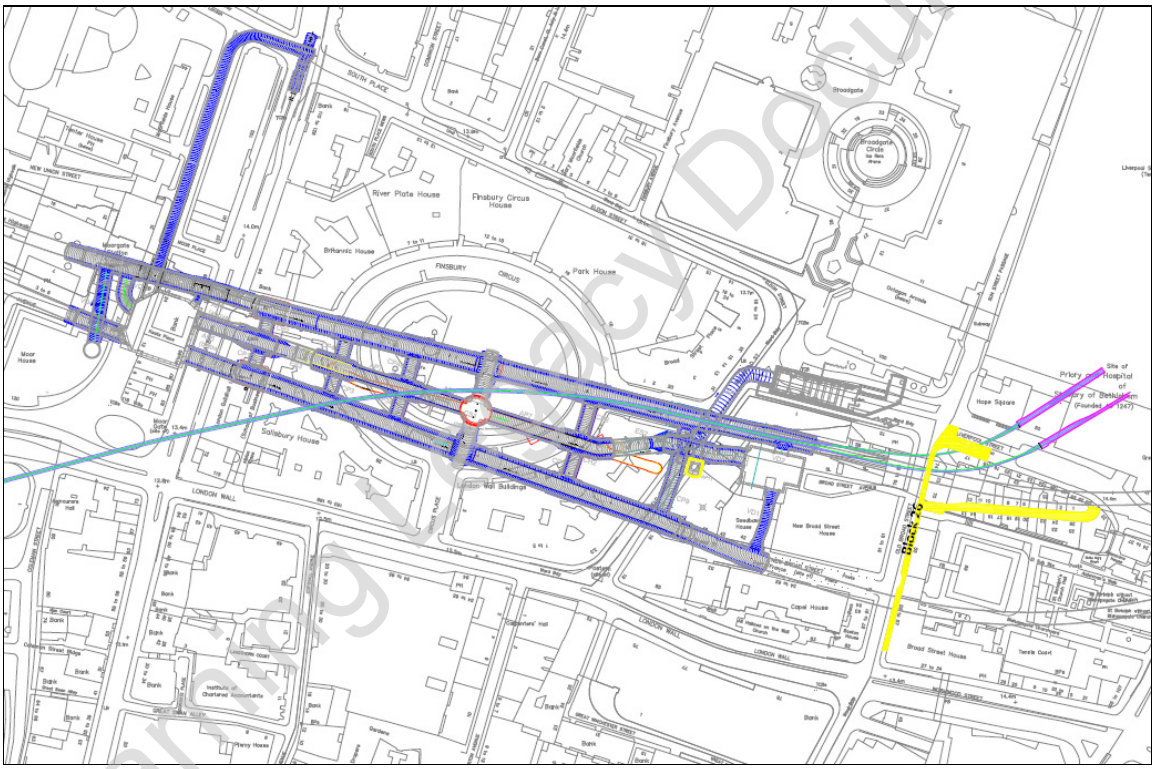


***Figure 1*- Liverpool St General Location Plan - including Block 26 monitoring area**

3.2 Block 26 Description

Block 26 is located between Wormwood St and Liverpool St. The block occupies Old Broad St, The Arcade and a small area of Liverpool St (adjacent to Liverpool St station entrance). Crossrail's Eastbound and Westbound TBM constructions intersect the ZOI. Block 26 contains the following types of monitoring sensors:

- Road Studs (LP) - manual 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 26 Installation Report References:

- Monitoring Installation Report LIV-LP-26- Old Broad Street
  CRL Document Number: C510-BBM-C2-RGN-C101-50165

The Settlement Contour Drawing (C122-OVE-C2-DDA-CR001_Z-21313) predicts the Block 26 area to experience approximately 5-30mm of settlement.

4 Construction Programme Influencing Block 26

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 26, 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 this area (yellow outline) and the tunnel constructions. Tunnel advances start and finish dates will be used in assessment of the monitoring data.

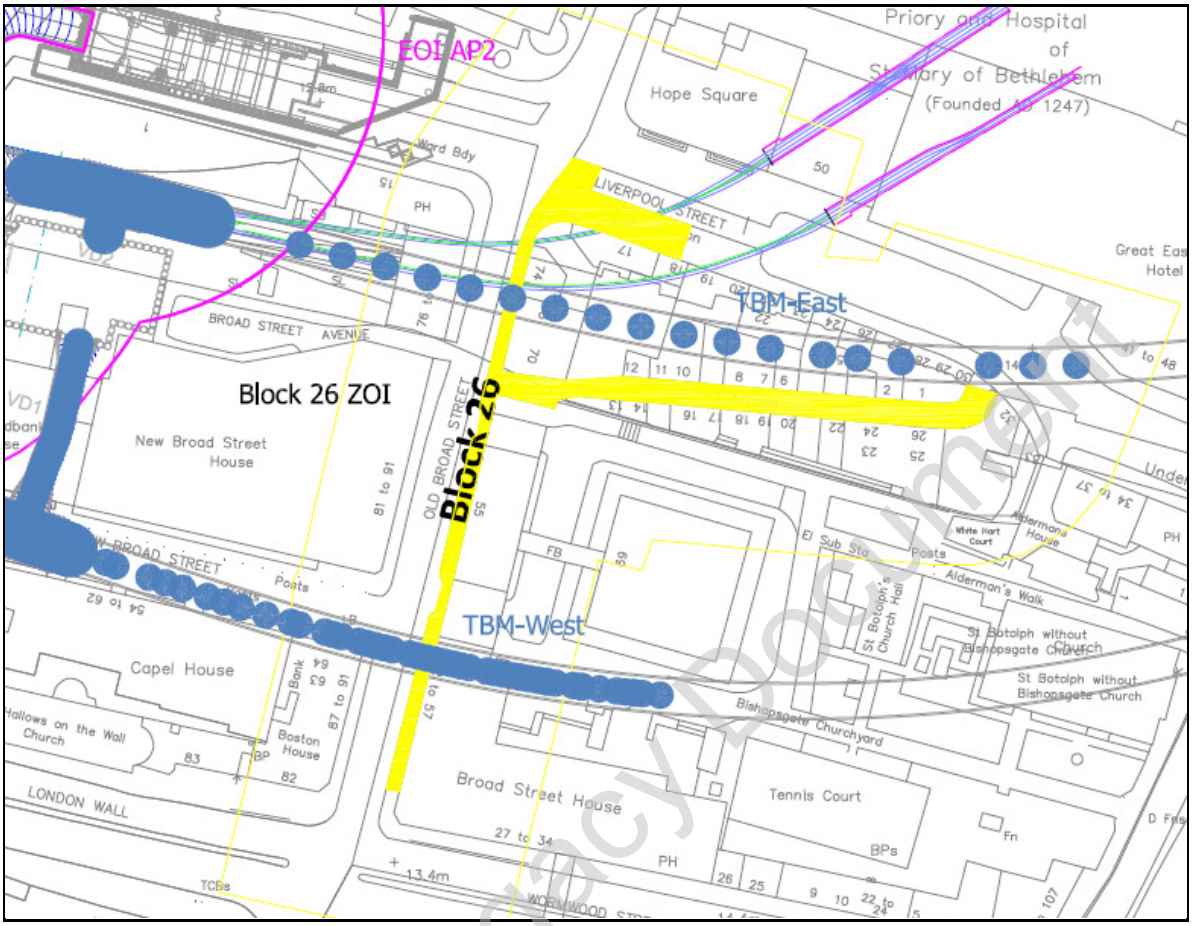


***Figure 2* - Block 26 Active ZOI Constructions**

N.B. AP2 EOI is represented in *Figure 2* to display that the ZOI for Block 26 is not affected by the last AP2 construction.

Figure 2 shows that no C510 works are within 2 x tunnel diameter of Block 26 (active ZOI). Therefore, to assist the monitoring analysis of Block 26, the EOI of construction will be referenced against settlement. The construction advances within the EOI that have the potential to affect Block 26 are listed and summarised in *Table 1.*

The last completed C510 construction which had the potential to affect Block 26 within its EOI was the VD1 Enlargement, which was completed on the 8th of June 2014. As there is no further Crossrail construction that has the potential to affect Block 26 and the last advance within the ZOI has surpassed 16 months, the entire Block 26 can be assessed for decommissioning.

The C305 Eastbound and Westbound TBM construction had the potential to influence Block 26, and is included within the table and the graph to assess the monitoring data. Further evidence for construction dates can be seen in *Table 2*, which lists the latest tunnel advances for each point.

N.B. It should be noted that C502 and C503 works may have affected Block 26. Reference should be made to C502 and C503 close out reports for construction dates.

4.1.1 Tunnel Advances Affecting Block 26

The information presented in *Table 1* is used in the monitoring graph (Section 5.1), to show the ground movements in relation to construction. As no C510 construction's active ZOI affects Block 26, C510 construction's EOI has been used.

TUNNEL ADVANCES STARTS & ENDS FOR GRAPHS									
No. Start	No. End	Tunnel Code	Tunnel Reference	Primary Layer Type	Start Date	End Date	Start Advance	End Advance	Zone
1	1	TBM-West-RC-Pilot	TBM-West-RC	Pilot	03/03/2015	12/03/2015	3941	4008	C305
2	2	TBM-East-RC-Pilot	TBM-East-RC	Pilot	22/01/2015	31/01/2015	3805	3909	C305
3	3	VD1-Enlargement	VD1	Enlargement	28/05/2014	08/06/2014	3	41	EOI
4	4	VD2-Enlargement	VD2	Enlargement	17/05/2014	17/05/2014	2	3	EOI
5	5	RCW-Enlargement	RCW	Enlargement	28/04/2014	07/05/2014	38	71	EOI
6	6	RCE-Enlargement	RCE	Enlargement	15/02/2014	05/03/2014	35	86	EOI
7	7	RCW-Pilot	RCW	Pilot	25/10/2013	28/10/2013	22	42	EOI
8	8	RCE-Pilot	RCE	Pilot	17/09/2013	26/09/2013	20	51	EOI

***Table 1*- Tunnel Advances Affecting Block 26**

N.B. The advance number for TBM headings, is the advance ring number.

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 26

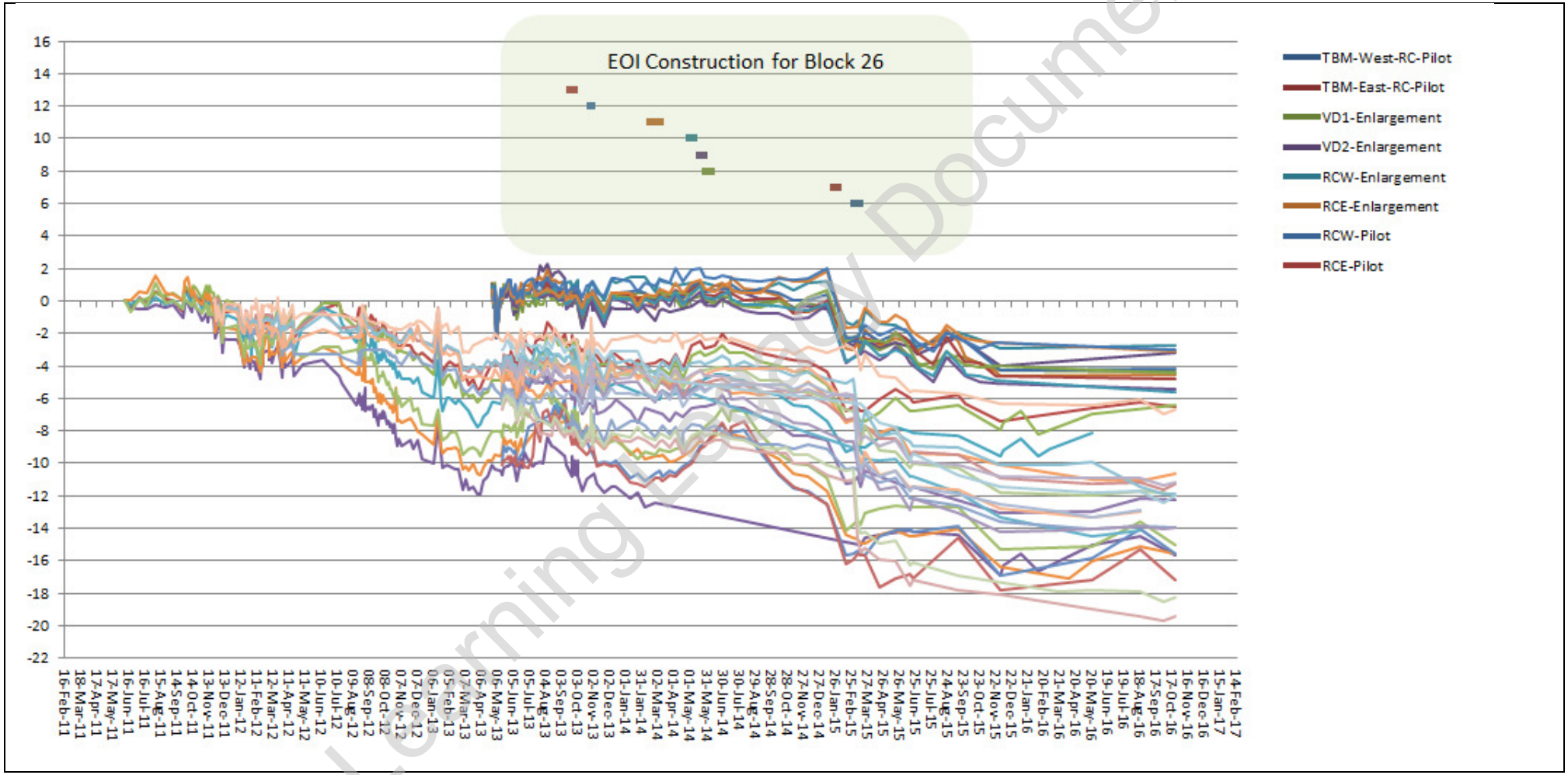
Evidence for decommissioning each monitoring sensor is shown through a graph, table (*Table 2*) and a plan. Each element of assessment compliments the other and is used together to determine acceptance of decommissioning. *Table 2* highlights the monitoring sensors to be considered for decommissioning 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 26 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 26 Road Studs (LP) Manual Monitoring History in Relation to Construction

***Graph 1*- All Block 26 Road Studs (LP) Manual Monitoring History in Relation to Construction**



5.2 Block 26 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 latest 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 26. 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 26 Decommissioning Status Tracker

21/10/2016

21/10/2016

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

AVERAGE SETTLEMENT TREND

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	120 day	120 Days	120 Day Calculation Period	180 day	180 Days	180 Day Calculation Period	460 day	365 Days	365 Day Calculation Period	Ceased Date	General Comment	Decommissioning Status
C510-LP12601	Block 26	S10601	External	Manual	LP	Road Stud	Arcade	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		-0.32	327		-0.01	327		-0.59	405	10/03/2016	ERP Ceased 10/03/2016	Proposed
C510-LP12602	Block 26	S10601	External	Manual	LP	Road Stud	Arcade	LIV_TBM-West-RC_Pilot_Adv-4001	08/03/2015	21/10/2016		-0.82	327		0.88	327		-0.39	405	10/03/2016	ERP Ceased 10/03/2016	Proposed
C510-LP12603	Block 26	S10601	External	Manual	LP	Road Stud	Arcade	LIV_TBM-West-RC_Pilot_Adv-3996	07/03/2015	21/10/2016		-0.51	327		0.20	327		-0.45	405	10/03/2016	ERP Ceased 10/03/2016	Proposed
C510-LP12604	Block 26	S10601	External	Manual	LP	Road Stud	Arcade	LIV_TBM-West-RC_Pilot_Adv-3989	07/03/2015	21/10/2016		-0.43	327		0.05	327		-0.55	391	10/03/2016	ERP Ceased 10/03/2016	Proposed
C510-LP12605	Block 26	S10601	External	Manual	LP	Road Stud	Arcade	LIV_TBM-West-RC_Pilot_Adv-3983	07/03/2015	21/10/2016		0.26	327		0.12	327		-1.30	405	10/03/2016	ERP Ceased 10/03/2016	Proposed
C510-LP12606	Block 26	S10601	External	Manual	LP	Road Stud	Arcade	LIV_TBM-West-RC_Pilot_Adv-3975	06/03/2015	21/10/2016		1.27	334		-0.23	334		-0.86	391	10/03/2016	ERP Ceased 10/03/2016	Proposed
C510-LP12607	Block 26	S10601	External	Manual	LP	Road Stud	Arcade	LIV_TBM-West-RC_Pilot_Adv-3970	06/03/2015	21/10/2016		-1.40	334		-0.52	334		-0.48	391	10/03/2016	ERP Ceased 10/03/2016	Proposed
C510-LP12608	Block 26	S10601	External	Manual	LP	Road Stud	Arcade	LIV_TBM-West-RC_Pilot_Adv-3963	05/03/2015	21/10/2016		2.12	334		-0.32	334		-0.54	391	10/03/2016	ERP Ceased 10/03/2016	Proposed
C510-LP12609	Block 26	S10601	External	Manual	LP	Road Stud	Arcade	LIV_TBM-West-RC_Pilot_Adv-3957	05/03/2015	21/10/2016		1.22	334		-0.82	334		-1.02	391	10/03/2016	ERP Ceased 10/03/2016	Proposed
C510-LP12610	Block 26	S10601	External	Manual	LP	Road Stud	Arcade	LIV_TBM-West-RC_Pilot_Adv-3951	05/03/2015	21/10/2016		1.05	334		-0.51	334		-0.62	391	10/03/2016	ERP Ceased 10/03/2016	Proposed
C510-LP12611	Block 26	S10601	External	Manual	LP	Road Stud	Arcade	LIV_TBM-West-RC_Pilot_Adv-3948	04/03/2015	21/10/2016		0.49	334		-0.43	334		-0.33	391	10/03/2016	ERP Ceased 10/03/2016	Proposed
C510-LP12612	Block 26	S10602	External	Manual	LP	Road Stud	Liverpool St	LIV_TBM-West-RC_Pilot_Adv-3970	06/03/2015	21/10/2016		0.51	155		1.15	327		0.37	391	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12613	Block 26	S10602	External	Manual	LP	Road Stud	Liverpool St	LIV_TBM-West-RC_Pilot_Adv-3974	06/03/2015	21/10/2016		1.90	155		2.12	233		0.45	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12614	Block 26	S10603	External	Manual	LP	Road Stud	Liverpool St	LIV_TBM-East-RC_Pilot_Adv-3909	31/01/2015	21/10/2016		-1.31	155		1.61	255		0.56	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12615	Block 26	S10602	External	Manual	LP	Road Stud	Liverpool St	LIV_TBM-West-RC_Pilot_Adv-3980	06/03/2015	19/05/2016		0.71	133		0.38	250		-1.05	368	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12616	Block 26	S10603	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-3993	07/03/2015	21/10/2016		0.12	155		2.84	199		-0.51	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12617	Block 26	S10603	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4001	08/03/2015	21/10/2016		-0.37	155		2.27	327		0.06	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12618	Block 26	S10603	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4004	10/03/2015	21/10/2016		0.21	155		1.52	327		-0.73	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12619	Block 26	S10603	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		0.03	155		0.93	327		-0.89	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12620	Block 26	S10603	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		-4.97	155		1.10	327		-0.38	488	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12621	Block 26	S10603	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	17/08/2016		-0.38	262		-1.31	262		-3.02	423	20/09/2016	ERP Ceased 20/09/2016 + Supplementary Evidence	Proposed
C510-LP12622	Block 26	S10603	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		0.35	155		-0.80	327		-1.22	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12623	Block 26	S10603	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		-1.33	155		-0.38	327		-1.04	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12624	Block 26	S10603;S10604	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		-1.43	155		-0.58	327		-1.40	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12625	Block 26	S10603;S10604	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		-0.83	155		-0.03	327		-0.99	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12626	Block 26	S10604	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		-0.92	155		0.19	216		-0.41	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12627	Block 26	S10604	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		-1.02	155		-3.70	216		-2.45	405	20/09/2016	ERP Ceased 20/09/2016+ Supplementary Evidence	Proposed
C510-LP12628	Block 26	S10604	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	17/08/2016		-0.38	262		-0.38	262		-1.58	423	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12629	Block 26	S10604	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	17/08/2016		0.35	151		-0.67	262		-1.50	423	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12630	Block 26	S10604	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		-1.90	155		-1.67	327		-1.67	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12631	Block 26	S10604	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		-1.72	155		-0.90	216		-1.23	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12632	Block 26	S10604	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		-1.07	155		-0.47	327		-0.81	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12633	Block 26	S10604	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		-1.47	155		-0.82	327		-1.14	405	20/09/2016	ERP Ceased 20/09/2016	Proposed
C510-LP12634	Block 26	S10604	External	Manual	LP	Road Stud	Old Broad St	LIV_TBM-West-RC_Pilot_Adv-4008	12/03/2015	21/10/2016		-1.15	155		-0.46	327		-0.72	405	20/09/2016	ERP Ceased 20/09/2016	Proposed

5.3 Supplementary Evidence for Decommissioning

If the decommissioning specifications for the monitoring sensors have not been met and they are proposed for decommissioning, evidence / reasoning is provided.

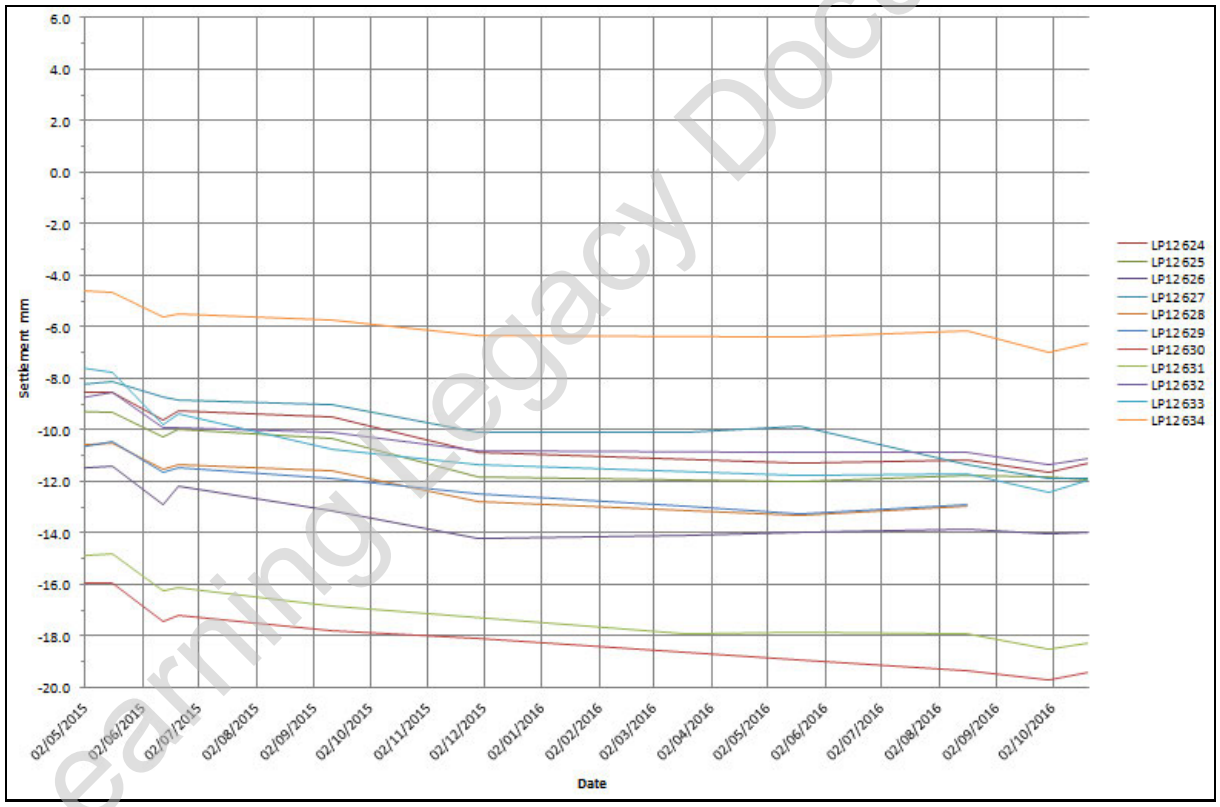
Section 4 Road Studs (LP) Manual Monitoring (Old Broad St)

Includes: C510-LP12627

Reasons to propose decommissioning

C510-LP12627 has not met the 2mm per annum specification identified in Section 2. *Graph 2* displays that Section 4 sensors have displayed steady trends since May 17th 2015. It is likely that the additional 0.45mm of movement outside of specification that C510-LP12627 experienced was due to local factors; in particular LP12627 is located on the pavement close to an access road.

Graph 2 **- C510-LP12627 Supplementary Evidence**



All adjacent sensors have met the specification identified in section 2. As there is no current or future construction within the EOI for sensor C510-LP12627 and the 120 day trend is less than 2mm, it is proposed that C510-LP12627 be agreed for decommissioning.

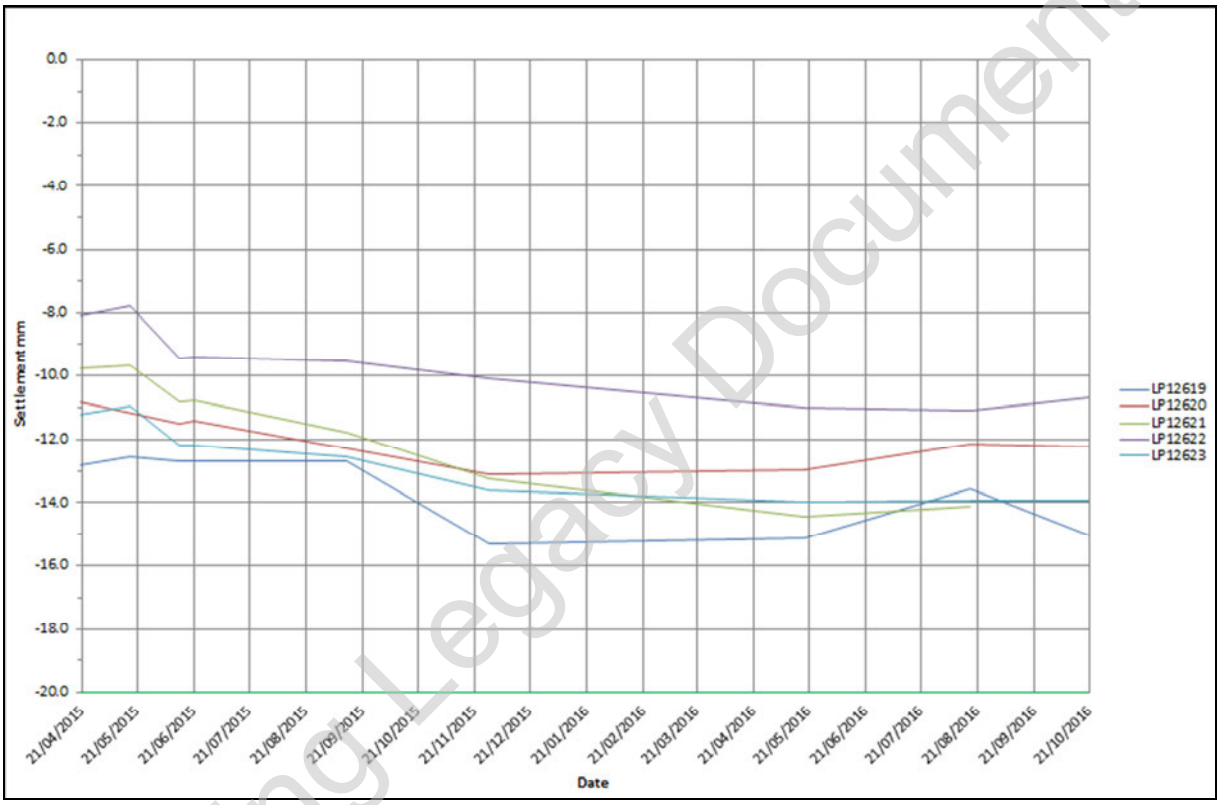
Section 3 Road Studs (LP) Manual Monitoring (Old Broad St)

Includes: C510-LP12621

Reasons to propose decommissioning

C510-LP12621 has not met the 2mm per annum specification identified in Section 2. *Graph 3* displays that C510-LP12621 and adjacent sensors have displayed similar trends. It is likely that the additional movement that C510-LP12621 experienced was due to local factors.

***Graph 3* - C510-LP12621 Supplementary Evidence**



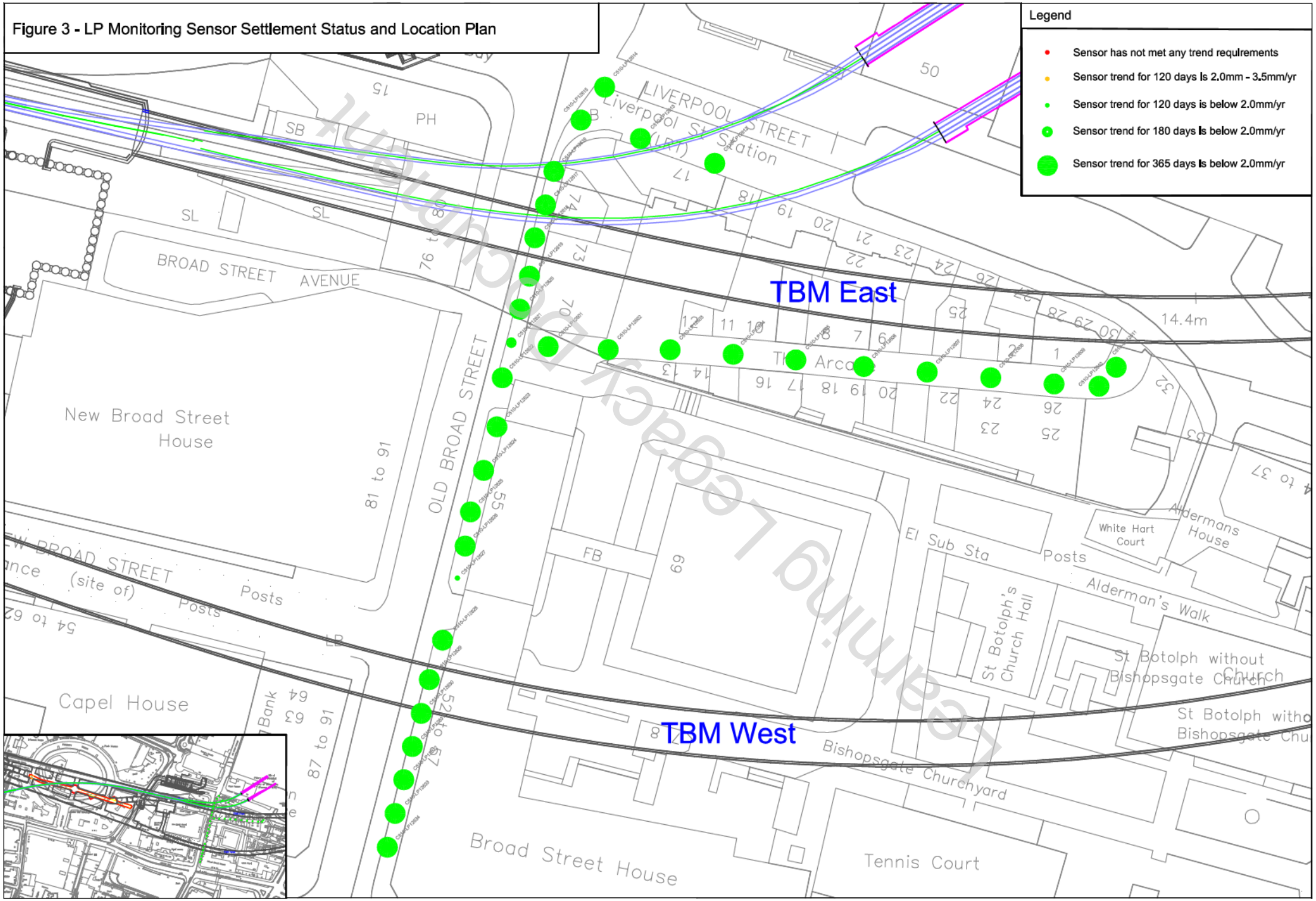
All adjacent sensors have met the specification identified in section 2. As there is no current or future construction within the EOI for sensor C510-LP12621, and the settlement value for both the 120 and 180 day trends is less than 2mm, it is proposed to decommission.

5.4 Monitoring sensor Location Plan and Decommissioning Status

The following plots provide a visual representation of all Block 26 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. There is one plan for Block 26 LP monitoring sensors.

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

Figure 3 - LP Monitoring Sensor Settlement Status and Location Plan



6 Decommissioning Recommendations

Through the monitoring assessment process in Section 5, it is purposed that all Block 26 sensors are to be decommissioned. *Table 2*- Decommissioning Tracker lists all Block 26 monitoring sensor's decommissioning status and the supporting evidence. Section 3 road stud C510-LP12621 and Section 4 road stud C510-LP12627 have not met the specification identified in Section 2, evidence and reasons for this are provided in Section 5.3 Supplementary Evidence. Monitoring ceased as part of ERP meetings on the 10th of March (Section 1) and the 20th of September 2016 (Sections 2, 3 and 4).

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.