



# C510 – Whitechapel and Liverpool Street Station Tunnels

# Instrumentation and Monitoring Close Out Report Post Office Tunnel Liverpool Street

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## 1 Purpose of Close out Report

KX10.2114 in C122-OVE-Z4-RSP-CR001-00007 Materials and Workmanship Specification I&M 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 Post Office Tunnel 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.

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 **Description and Location Plan**

#### 3.1 Post office tunnel Location

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

Post Office running tunnels are located within the vicinity of London Liverpool Street and Moorgate underground station and the tunnels are highlighted in red. The location and details of these assets can be found in Instrumentation and Monitoring Plan: C122-OVE-C2-RAN-C101-00024 or the relevant C122 prepared Damage Assessment Reports.



Figure 1 - Liverpool St General Location Plan



## 3.2 Post office Tunnel Description

The Post Office tunnel is located CRL Liverpool Street underground station and is adjacent C510 tunnel construction work. Approximately 400m of Office tunnel overlaps C510 tunnel construction work as the tunnels generally head in an east-west direction. Further detail of the construction programmes can be found in Section 4. Post Office tunnel contains the following types of monitoring sensors:

- Prisms (RP) automated monitoring
- Road Studs (LP) manual monitoring

Monitoring asset details are listed within the Decommissioning Status Tracker (Table 2) and further relevant information can be sourced from the installation reports.

Post Office tunnel Installation Report References:

- Assessment of ground movement effects on post office tunnel at Liverpool street station CRL Document Number: C122-OVE-C2-RAN-C101-00016
- Instrumentation and Monitoring Plan Post Office Tunnel at Liverpool Street

CRL Document Number: C122-OVE-C2-RAN-C101-50024

- Procedure for Numbering of Instrumentation and Transfer of Monitoring Data
   CRL Document Number: CRL1-XRL-Z-GPD-CR001-00002
- Monitoring Installation of ATS system in the Post Office Tunnels, Liverpool Street
   CRL Document Number: C510-BBM-C-GMS-C101-50004.
- Monitoring Installation Report Post Office Tunnels (POT), Liverpool Street
   CRL Document Number: C510-BBM-C2-RGN-C101-50070.

The Settlement Contour Drawing (C122-OVE-C2-DDA-CR001\_Z-21313) predicts the post office tunnel area to experience approximately 0 - 130mm of settlement.



# 4 Construction Programme Influencing Post office tunnel

Extent of Influence (EOI) monitoring areas were established to record ground movements in relation to C510 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 Post office tunnel, 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 area (purple outline) and the tunnels. Start and finish dates of tunnel constructions will be used in the assessment of the monitoring data.



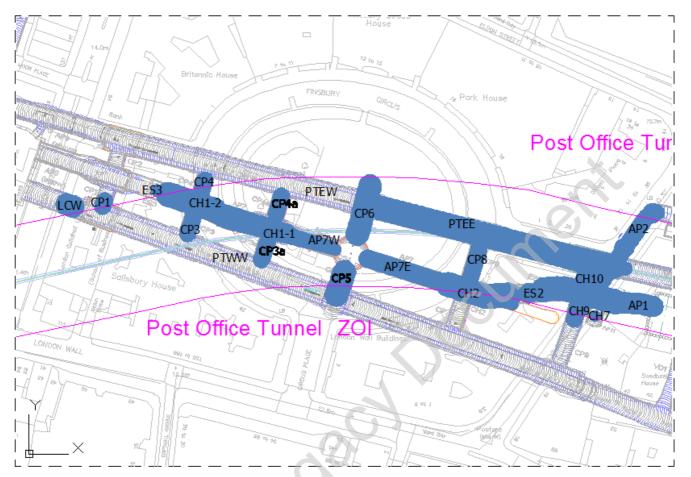


Figure 2 - Post office tunnel and C510 Construction

Post Office tunnel Active ZOI Construction shows C510 construction works that are within 2 x tunnel diameter of Post Office tunnel (active ZOI) and these construction works are shown in Figure 2. Therefore, to assist the monitoring analysis of the Post office tunnel, the ZOI construction work will be referenced against sensor settlement. The construction advances ZOI that have the potential to affect Post Office tunnel are listed and summarised in Table 1.

The last completed SCL advance, which had the potential to affect the Post Office tunnel through its ZOI, is ES3 Enlargement top heading uphill advance 1 and invert downhill advance 38, which was completed on 20/02/2017. Even though the post office tunnel is in the EOI of ES3, the construction work of ES3 had no discernible effect on the post office tunnel within the influence zone; further evidence for this can be found in section 5.2 supplementary evidence.

The entire Post Office tunnel can be assessed for decommissioning. Further evidence for construction dates can be seen in the decommissioning tracker Table 2 , which lists the last tunnel advances within a 25m radius for each point.



## 4.1.1 Tunnel Advances Affecting Post office tunnel

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

TUNNEL ADVANCE START & END FOR GRAPHS											
Tunnel Code	Tunnel Reference		Start Date	End Date	Start Advance	End Advance	Zo				
ES3-Enlargement	ES3	Enlargement	15/02/2017	20/02/2017	1	38	ZC				
ES2-Enlargement	ES2	Enlargement	28/10/2016	20/11/2016	7	45	ZC				
CH3-Enlargement	CH3	Enlargement	21/08/2016	28/08/2016	1	11	20				
AP11-Enlargement	AP11	Enlargement	06/08/2016	11/08/2016	7	18	20				
AP12-Enlargement	AP12	Enlargement	04/08/2016	04/08/2016	2	2	20				
AP2-Enlargement	AP2	Enlargement	21/06/2016	28/06/2016	1	37/2	20				
ES3-Pilot	ES3	Pilot	24/06/2016	09/08/2016	1	9	20				
AP2-Pilot	AP2	Pilot	25/04/2016	25/05/2016	1	57	Z				
ES2-Pilot	ES2	Pilot	31/10/2015	24/04/2016	6	45	ZC				
PRM Lift-Enlargement	PRM Lift	Enlargement	09/08/2015	09/10/2015	1	100	Z				
AP10b-Enlargement	AP10b	Enlargement	21/07/2015	31/07/2015	1	19	Z				
AP10a-Enlargement	AP10a	Enlargement	14/07/2015	20/07/2015	1	10	20				
TBM-East-RC-Pilot	TBM-East-RC	Pilot	23/01/2015	31/01/2015	3830	3909	Z				
CP4-Enlargement	CP4	Enlargement	27/09/2014	03/10/2014	3	9	20				
CP10-Enlargement	CP10	Enlargement	15/08/2014	17/08/2014	3	7	20				
CP9-Enlargement	CP9	Enlargement	08/08/2014	11/08/2014	3	10	20				
CP9-Pilot	CP9	Pilot	17/07/2014	18/07/2014	3	8	20				
CP10-Pilot	CP10	Pilot	15/07/2014	16/07/2014	3	6	20				
AP6-1-Enlargement	AP6-1	Enlargement	12/07/2014	18/05/2015	129	172	Z				
CP1-Enlargement	CP1	Enlargement	26/06/2014	28/06/2014	8	13	20				
VD1-Enlargement	VD1	Enlargement	08/06/2014	08/06/2014	41	41	Z				
CP1-Pilot	CP1	Pilot	07/06/2014	07/06/2014	9	9	20				
CP3a-Enlargement	CP3a	Enlargement	24/05/2014	31/05/2014	3	end face	20				
VD2-Enlargement	VD2	Enlargement	17/05/2014	17/05/2014	2	3	20				
CP4-Pilot	CP4	Pilot	07/05/2014	09/05/2014	2	7	Z				
CP3-Enlargement	CP3	Enlargement	01/05/2014	06/05/2014	3	15	20				
CP3-Pilot	CP3	Pilot	29/04/2014	01/05/2014	3	10	20				
CP8-Enlargement	CP8	Enlargement	14/04/2014	26/04/2014	3	END FACE	Z				
CP4a-Enlargement	CP4a	Enlargement	13/04/2014	16/09/2014	3	13	Z				
CP8-Pilot	CP8	Pilot	07/04/2014	12/04/2014	2	END FACE	20				
LCWb-Enlargement	LCWb	Enlargement	25/02/2014	26/02/2014	1	5	20				
RCE-Enlargement	RCE	Enlargement	31/01/2014	05/03/2014	1	86	Z				
CP4a-Pilot	CP4a	Pilot	14/01/2014	19/01/2014	2	12	Z				
CP3a-Pilot	CP3a	Pilot	10/01/2014	14/01/2014	2	end face	Z				
PTE-East-Enlargement	PTE-East	Enlargement	22/10/2013	30/01/2014	4	168	Z				
TE-West-Enlargement	PTE-West	Enlargement	07/10/2013	01/12/2013	4	83	20				
RCE-Pilot	RCE	Pilot	09/09/2013	26/09/2013	1	51	Z				
TW-West-Enlargement	PTW-West	Enlargement	18/08/2013	24/02/2014	4	182	Z				
AP1a-Enlargement	AP1a	Enlargement	04/08/2013	14/08/2013	53	80	Z				
AP1b-Enlargement	AP1b	Enlargement	13/07/2013	04/08/2013	1	52	Z				
PTE-East-Pilot	PTE-East	Pilot	23/06/2013	09/09/2013	1	121	Z				
PTE-West-Pilot	PTE-West	Pilot	05/06/2013	16/06/2013	2	52	Z				
PTW-West-Pilot	PTW-West	Pilot	04/06/2013	19/10/2013	9	125	Z				
AP1a-Pilot	AP1a	Pilot	19/05/2013	07/06/2013	125	142	Z				
CH1-Enlargement	CH1	Enlargement	16/05/2013	26/05/2013	49	83	Z				
ES3/CH5-Pilot	ES3/CH5	Pilot	23/04/2013	24/04/2013	84	89	Z				
CH2-Enlargement	CH2	Enlargement	11/04/2013	01/05/2013	3	49	Z				
AP1b-Pilot	AP1b	Pilot	27/03/2013	18/05/2013	89	124	Z				
ES2-Initial-Pilot	ES2-Initial	Pilot	19/03/2013	26/03/2013	74	88	Z				
CH1-Pilot	CH1	Pilot	09/03/2013	22/04/2013	61	83	Z				
AP7 East-Enlargement	AP7 East	Enlargement	02/03/2013	10/04/2013	1	41	Z				
P7 West-Enlargement	AP7 West	Enlargement	16/02/2013	26/05/2013	1	83	Z				
CH2-Pilot	CH2	Pilot	14/02/2013	18/03/2013	43	73	Z				
CP6-Enlargement	CP6	Enlargement	19/01/2013	31/01/2013	1	37	2				
CP5-Enlargement	CP5	Enlargement	08/12/2012	08/01/2013	1	20	Z				
CP6-Pilot	CP6	Pilot	16/11/2012	08/12/2012	1	28	Z				
CP5-Pilot	CP5	Pilot	10/11/2012	12/11/2012	1	14	Z				
AP7 West-Pilot	AP7 West	Pilot	03/11/2012	09/03/2013	2	60	Z				
AP7 East-Pilot	AP7 East	Pilot	21/10/2012	14/02/2013	2	42	Z				
GAD2-Pilot	GAD2	Pilot	10/02/2012	04/03/2012	1	73	Z				
	GAD1	Pilot	19/01/2012	07/02/2012		75					

**Table 1 - Tunnel Advances Affecting Post office tunnel** 



## **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 Post office tunnel

Evidence for decommissioning each monitoring sensor is shown through graphs, tables (Table 2 & 3) and plans. Each element of assessment compliments the other and is used together to determine acceptance of decommissioning. Table 2 representing (RP) and Table 3 representing (LP) - Post office tunnel Decommissioning Status Tracker 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

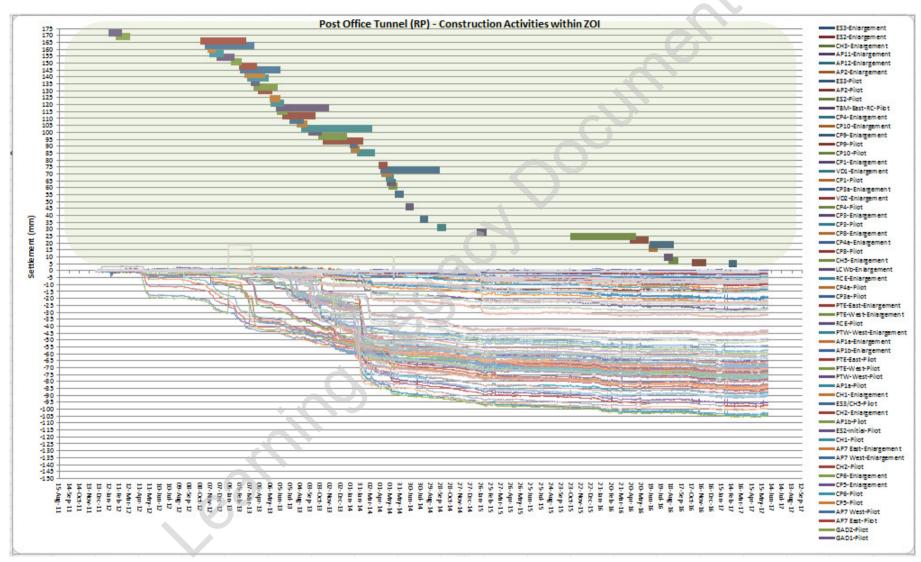
To assess the movement of Post office tunnel monitoring sensors; each monitoring sensor data type is displayed in a line graph, with a Gantt chart (bar) representing the construction identified in Section 4:

- Graph 1- All Post office tunnel Geodetic Prisms (RP) Automated Monitoring History in Relation to Construction
- Graph 2 All Post office tunnel (LP) Manual Monitoring History in Relation to Construction



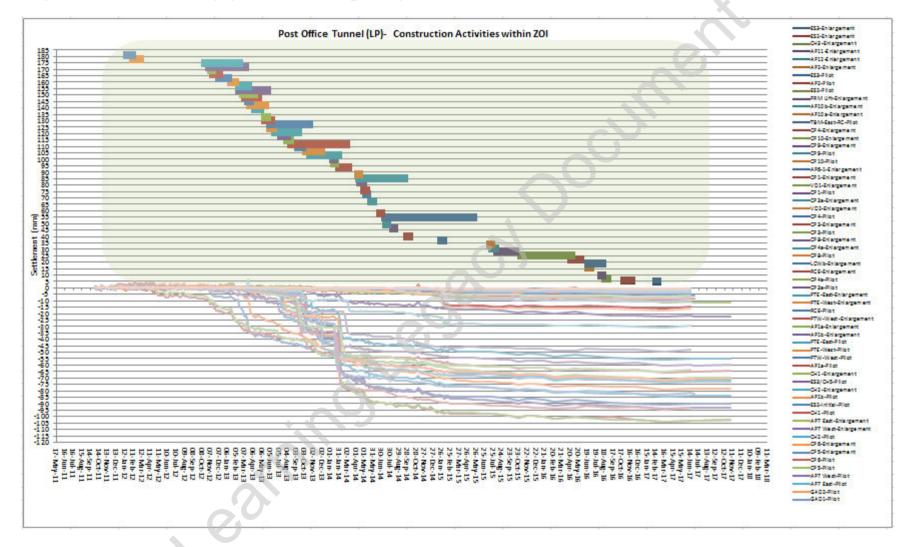


Graph 1- All Post office tunnel Geodetic Prisms (RP) Automated Monitoring History in Relation to Construction





Graph 2 - All Post office tunnel (LP) Manual Monitoring History in Relation to Construction







#### 5.2 Post office tunnel 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 a 50m radius.

If any Post office tunnel sensors are not within a distance of 2 x depth of any tunnel advance location, the last completed construction within a 50m radius that had the potential to affect Post office tunnel is used as a reference.

#### Tracker Column Header – 120, 180, 270 & 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 270 day average rate is the minimum monitoring period after construction for automated sensors.
- The 365 day average trend is the desired period to be used if the long term monitoring has been completed for decommissioning evidence. The specification states that if the trend is below 2mm/yr, then the sensor is eligible for decommissioning.



#### **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

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

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 Post office tunnel. 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 - Post Office Tunnel Decommissioning Status Tracker RP 06/07/2017

06/07/2017

< 2.0 mm GREEN > 3.5 mm RED AVERAGE SETTLEMENT TREND

MATCH No Sensor Latest Measuremen ecommission S10 Sensor No Rlock Section Int / Evt Accet/I ocation 70LL ast Primary Layer Construction Construction 120 Days Calculation 180 Days Calculation 365 Days Calculation General Comment Type Туре Description Surveyed Da Status Date Period Period Period C510\_RP84701 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV TBM-East-RC Pilot Adv-3909 31/01/2015 02/06/2017 120 1.97 180 -0.29 365 2mm/year Specification met C510-RP84702 N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV TBM-East-RC Pilot Adv-3909 31/01/2015 02/06/2017 120 180 2mm/year Specification met N/A N/A 180 C510-RP84703 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV TBM-East-RC Pilot Adv-3909 31/01/2015 02/06/2017 120 2mm/year Specification met RP 3D Geodetic prism Post Office Tunnel LIV TRM-East-RC Pilot Adv-3909 02/06/2017 180 POT N/A 120 N/A 365 C510\_RP84704 Internal Automated 31/01/2015 0.01 2mm/year Specification met C510-RP84705 RP NI/A POT N/A Internal Automated 3D Geodetic prism Post Office Tunnel LIV TBM-Fast-RC Pilot Adv-3909 31/01/2015 02/06/2017 120 180 0.00 2mm/year Specification met POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV\_TBM-East-RC\_Pilot\_Adv-3895 02/06/2017 120 180 -1.06 365 2mm/year Specification met 3D Geodetic prism Post Office Tunnel 02/06/2017 C510-RP84902 N/A Internal Automated LIV TBM-East-RC Pilot Adv-3895 27/01/2015 120 181 0.15 2mm/year Specification met DР 181 N/A 3D Geodetic prism Post Office Tunnel LIV TRM-Fast-RC Pilot Adv-3895 0.99 0.65 C510-RP84903 Internal Automated 27/01/2015 02/06/2017 120 -1.09 2mm/year Specification met C510-RP85103 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV TRM-East-RC Pilot Adv-3885 26/01/2015 02/06/2017 120 -0.15 181 -0.80 366 2mm/year Specification met 181 N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV\_CP1\_Enlargement\_Adv-13 02/06/2017 120 2mm/year Specification met 181 N/A Automated RP 3D Geodetic prism Post Office Tunnel 02/06/2017 120 0.06 366 2mm/year Specification met C510-RP90102 Internal LIV CP1 Enlargement Adv-13 C510-RP90103 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV LCWb Enlargement Adv-2 25/02/2014 02/06/2017 120 0.76 181 366 2mm/year Specification met C510-RP90301 N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV LCWb Enlargement Adv-5 02/06/2017 120 181 2mm/year Specification met RP 181 C510-RP90302 POT N/A Internal Automated 3D Geodetic prism Post Office Tunnel LIV\_CP1\_Enlargement\_Adv-13 02/06/2017 120 0.41 -1.25 366 2mm/year Specification met 02/06/2017 POT N/A Automated 3D Geodetic prism Post Office Tunnel LIV CP1 Enlargement Adv-13 28/06/2014 181 C510-RP90303 Internal 120 366 2mm/year Specification met RP 3D Geodetic prism Post Office Tunnel C510-RP90501 N/A Internal Automated LIV CP1 Enlargement Adv-13 28/06/2014 02/06/2017 120 181 2mm/year Specification met 181 C510-RP90502 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV CP1 Enlargement Adv-13 28/06/2014 02/06/2017 120 0.37 -0.61 366 2mm/year Specification met N/A 3D Geodetic prism Post Office Tunnel LIV\_CP1\_Enlargement\_Adv-13 28/06/2014 02/06/2017 120 181 C510-RP90503 Internal Automated 2mm/year Specification met 181 -0.72 3D Geodetic prism Post Office Tunnel C510-RP90701 N/A Internal Automated LIV CP1 Enlargement Adv-13 02/06/2017 120 0.81 366 2mm/year Specification met C510-RP90702 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV\_CP1\_Enlargement\_Adv-13 28/06/2014 02/06/2017 1.61 120 181 366 2mm/year Specification met 120 181 C510-RP90703 N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV\_LCWb\_Enlargement\_Adv-2 02/06/2017 2mm/year Specification met RP N/A Automated 3D Geodetic prism Post Office Tunnel 02/06/2017 120 0.96 180 365 2mm/year Specification met C510-RP90901 Internal LIV LCWb Enlargement Adv-5 RP POT N/A 3D Geodetic prism Post Office Tunnel 28/06/2014 02/06/2017 C510\_RPQ0Q02 Internal Automated LIV CP1 Enlargement Adv-13 120 180 2mm/year Specification met C510-RP90903 N/A Internal Automated DD 3D Geodetic prism Post Office Tunnel 02/06/2017 120 180 2mm/year Specification met 180 C510-RP91101 POT N/A Internal Automated PP 3D Geodetic prism Post Office Tunnel LIV\_CP1\_Enlargement\_Adv-13 02/06/2017 120 -1 02 2mm/year Specification met N/A 28/06/2014 02/06/2017 POT Automated 3D Geodetic prism Post Office Tunnel LIV CP1 Enlargement Adv-13 C510-RP91102 Internal 120 180 2mm/year Specification met 0.73 C510-RP91103 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV CP1 Enlargement Adv-13 28/06/2014 02/06/2017 120 180 2mm/year Specification met C510-RP91301 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV LCWb Enlargement Adv-2 25/02/2014 02/06/2017 N/A 120 0.93 180 -1.61 365 2mm/year Specification met Internal C510-RP91302 N/A Automated 3D Geodetic prism Post Office Tunnel LIV\_LCWb\_Enlargement\_Adv-5 02/06/2017 120 180 2mm/year Specification met N/A 3D Geodetic prism Post Office Tunnel 02/06/2017 120 -1 28 C510-RP91303 LIV CP1 Enlargement Adv-13 180 Internal Automated 2mm/year Specification met C510\_RP01501 POT N/A Internal Automated P.P. 3D Geodetic prism Post Office Tunnel LIV\_CP1\_Enlargement\_Adv-13 28/06/2014 02/06/2017 1 08 120 0.39 180 -1.68 365 2mm/year Specification met C510-RP91502 POT N/A Internal Automated DD 3D Geodetic prism Post Office Tunnel 28/06/2014 02/06/2017 120 180 2mm/year Specification met DР -1.22 Internal Automated 3D Geodetic prism Post Office Tunnel 120 180 C510-RP91503 LIV LCWb Enlargement Adv-2 2mm/year Specification met N/A RP C510-RP91504 POT Internal Automated 3D Geodetic prism Post Office Tunnel LIV\_LCWb\_Enlargement\_Adv-5 26/02/2014 02/06/2017 120 180 -0.83 -2.25 2mm/year Specification met C510-RP91701 N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel 02/06/2017 120 180 LIV\_CP1\_Enlargement\_Adv-13 28/06/2014 6 month post Construction me POT N/A PP 3D Geodetic prism Post Office Tunnel 02/06/2017 180 -1.92 Internal Automated LIV CP1 Enlargement Adv-13 28/06/201/ 120 365 2mm/year Specification met C510-RP91703 N/A Internal Automated 3D Geodetic prism Post Office Tunnel LIV CP1 Enlargement Adv-13 28/06/2014 02/06/2017 120 180 2mm/year Specification met -1.77 365 C510-RP91704 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV CP1 Enlargement Adv-13 28/06/2014 02/06/2017 120 180 2mm/year Specification met 180 C510-RP91705 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV\_CP1\_Enlargement\_Adv-13 28/06/2014 02/06/2017 N/A 120 1.98 -1.66 365 2mm/year Specification met N/A Internal Automated 3D Geodetic prism Post Office Tunnel LIV ES3 Elargement Uphill Adv-10 02/06/2017 180 120 6 month post Construction me 120 C510-RP91902 POT N/A RP 3D Geodetic prism Post Office Tunnel LIV\_ES3\_Elargement\_Uphill\_Adv-10 18/03/2017 02/06/2017 180 6 month post Construction me Internal Automated 180 -1.3 C510-RP91903 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV ES3 Elargement Uphill Adv-10 18/03/2017 02/06/2017 120 0.36 365 2mm/year Specification met C510-RP91904 POT N/A Internal Automated DD 3D Geodetic prism Post Office Tunnel LIV\_ES3\_Elargement\_Uphill\_Adv-10 19/02/2017 02/06/2017 120 180 6 month post Construction me Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV\_ES3\_Elargement\_Uphill\_Adv-10 02/06/2017 120 180 C510-RP91905 6 month post Construction met N/A RP 3D Geodetic prism Post Office Tunnel 02/06/2017 180 C510-RP92101 POT Internal Automated LIV\_CP4\_Enlargement\_Adv-9 03/10/2014 1.01 120 0.06 365 6 month post Construction me C510-RP92102 N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV CP4 Enlargement Adv-10 03/10/2014 02/06/2017 120 180 6 month post Construction me POT N/A Automated RP 3D Geodetic prism Post Office Tunnel 120 180 -2.87 365 Internal LIV CP4 Enlargement Adv-8 02/06/2017 6 month post Construction met C510-RP92104 POT N/A 3D Geodetic prism Post Office Tunnel LIV CP4 Enlargement Adv-10 03/10/2014 02/06/2017 120 180 month post Construction me Internal Automated 2.96 1 41 120 0.43 180 365 RP C510-RP92105 POT N/A Internal Automated 3D Geodetic prism Post Office Tunnel LIV CP4 Enlargement Adv-8 02/10/2014 02/06/2017 6 month post Construction me C510-RP92301 TOG N/A Internal Automated DD. 3D Geodetic prism Post Office Tunnel LIV\_CP4a\_Enlargement\_Adv-13 16/00/2014 02/06/2017 0.87 120 -0.12180 -3.16 365 6 month post Construction met C510-RP92302 N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV CP4a Enlargement Adv-13 16/09/2014 02/06/2017 180 month post Construction me RP 3D Geodetic prism Post Office Tunnel 120 180 POT N/A Internal Automated 16/09/2014 02/06/2017 6 month post Construction met C510-RP92303 LIV\_CP4a\_Enlargement\_Adv-13 RP C510-RP92304 POT N/A Internal Automated 3D Geodetic prism Post Office Tunnel LIV CP4a Enlargement Adv-13 16/09/2014 02/06/2017 1 41 120 0.35 180 -2.90 365 6 month post Construction met C510-RP92305 N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV\_CP4a\_Enlargement\_Adv-13 16/09/2014 02/06/2017 120 180 6 month post Construction me POT N/A RP Internal Automated 3D Geodetic prism Post Office Tunnel LIV\_CP4a\_Enlargement\_Adv-13 120 0 6 month post Construction met C510-RP92432 N/A RP 3D Geodetic prism Post Office Tunnel 16/09/2014 02/06/2017 120 180 2.92 365 POT Internal Automated LIV CP4a Enlargement Adv-13 0.82 6 month post Construction me 180 RP C510-RP92433 N/A Internal Automated 3D Geodetic prism Post Office Tunnel LIV\_CP4a\_Enlargement\_Adv-13 16/09/2014 21/03/2013 120 N/A 365 Not Applicable 180 POT N/A Automated DD. 3D Geodetic prism Post Office Tunnel LIV\_CP4a\_Enlargement\_Adv-13 16/09/2014 02/06/2017 120 3.35 365 Internal 6 month post Construction me C510-RP92502 N/A 3D Geodetic prism Post Office Tunnel LIV CP4a Enlargement Adv-13 16/09/2014 02/06/2017 120 180 Internal Automated 6 month post Construction me 180 -3.17 POT N/A RP 3D Geodetic prism Post Office Tunnel 1.14 0.11 365 C510-RP92503 Internal Automated LIV CP4a Enlargement Adv-13 16/09/2014 02/06/2017 120 6 month post Construction me C510-RP92504 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV\_CP4a\_Enlargement\_Adv-13 16/09/2014 02/06/2017 120 0.45 180 2.99 365 6 month post Construction met RP 180 N/A Internal Automated 3D Geodetic prism Post Office Tunnel LIV\_CP4a\_Enlargement\_Adv-13 16/09/2014 02/06/2017 6 month post Construction me -2.90 180 POT N/A Internal Automated 3D Geodetic prism Post Office Tunnel LIV\_PTE-West\_Enlargement\_Adv-44 22/11/2013 02/06/2017 120 6 month post Construction met RP 3D Geodetic prism Post Office Tunnel LIV\_PTE-West\_Enlargement\_Adv-46 180 C510-RP92702 POT N/A Internal Automated 23/11/2013 02/06/2017 120 -3.01 365 6 month post Construction me 180 C510-RP92703 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV\_PTE-West\_Enlargement\_Adv-43 22/11/2013 02/06/2017 120 365 6 month post Construction me RP 180 3.25 365 POT N/A Internal Automated 3D Geodetic prism Post Office Tunnel LIV\_PTE-East\_Enlargement\_Adv-55 120 6 month post Construction met RP 3D Geodetic prism Post Office Tunnel LIV\_PTE-East\_Enlargement\_Adv-55 -2.94 -3.13 C510-RP92902 POT N/A Internal Automated 18/11/2013 02/06/2017 120 1.02 180 365 6 month post Construction me 180 RP 3D Geodetic prism Post Office Tunnel LIV\_PTE-East\_Enlargement\_Adv-55 02/06/2017 365 C510-RP92903 POT N/A Internal Automated 18/11/2013 120 0.46 6 month post Construction me C510-RP92904 POT N/A Internal Automated RP 3D Geodetic prism Post Office Tunnel LIV\_PTE-East\_Enlargement\_Adv-55 18/11/2013 28/06/2015 120 192 401 Not Applicable

0540 PP00005	DOT	ALIA	Internal	Automoted	DD	2D O . dati anima Dad Office Towns	LIV DTC Cod Colombia Adv CC 40/4/004	44/00/0044	N/A	100	NI/A	100	NI/A	2CE Not Applicable	
C510-RP92905 C510-RP93101	POT	N/A N/A	Internal	Automated Automated	RP RP	3D Geodetic prism Post Office Tunnel 3D Geodetic prism Post Office Tunnel	LIV_PTE-East_Enlargement_Adv-55 18/11/2013 LIV_CP8_Enlargement_Adv-END_FACE 26/04/2014	14/09/2014		120 120	0.18	180	N/A -3.31	365 Not Applicable Pro 365 6 month post Construction met Pro	roposed
C510-RP93102	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_CP8_Enlargement_Adv-END FACE 26/04/2014		1.55	120		180		365 6 month post Construction met Pro	ronosed
C510-RP93103	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_CP8_Enlargement_Adv-END FACE 26/04/2014	02/06/2017	0.97	120	-0.05	180			roposed
C510-RP93104	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV CP8 Enlargement Adv-END FACE 26/04/2014	02/06/2017		120	0.95	180			roposed
C510-RP93105	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_CP8_Enlargement_Adv-END FACE 26/04/2014	02/06/2017	1.14	120	0.12	180	-0.91	365 2mm/year Specification met Pro	roposed
C510-RP93301	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Safe_Stop_Adv-10 24/11/2010	02/06/2017		120	0.11	180		365 6 month post Construction met Pro	roposed
C510-RP93302	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Safe_Stop_Adv-7 20/11/2016	02/06/2017		120	1.08	180		365 6 month post Construction met Pro	roposed
C510-RP93303	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Safe_Stop_Adv-10 24/11/2016	02/06/2017		120	-0.09	180		555	roposed
C510-RP93304 C510-RP93305	POT	N/A N/A	Internal	Automated Automated	RP RP	3D Geodetic prism Post Office Tunnel 3D Geodetic prism Post Office Tunnel	LIV_ES2_Safe_Stop_Adv-7 20/11/2010 LIV_ES2_Safe_Stop_Adv-10 24/11/2010	02/06/2017	14//	120 120	1.01	180	-2.50 -3.26	occ Cincin poor Conduction met	roposed
C510-RP93501	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Safe_Stop_Adv-10 24/11/2016	02/06/2017		120	-0.43	180		365 6 month post Construction met Pro 365 6 month post Construction met Pro	roposed
C510-RP93502	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Safe_Stop_Adv-10 24/11/2010	24/01/2017		120	0.87	180			roposed
C510-RP93503	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Safe_Stop_Adv-10 24/11/2016		1.30	120	0.97	189	-2.90	365 6 month post Construction met Pro	roposed
C510-RP93504	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Safe_Stop_Adv-10 24/11/2016	02/06/2017	N/A	120	1.19	189	<b>-3</b> .51	365 6 month post Construction met Pro	roposed
C510-RP93505	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Safe_Stop_Adv-10 24/11/2016		1.81	120	0.70	189	3.98	365 6 month post Construction met Pro	roposed
C510-RP93701	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Invert_Adv-8 07/11/2016		N/A	120		180		365 6 month post Construction met Pro	roposed
C510-RP93702	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Invert_Adv-8 07/11/2016		N/A	120			-3.19		roposed
C510-RP93703	POT	N/A	Internal	Automated	RP RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Invert_Adv-8 07/11/2016			120	1.81	180	-3.42		roposed
C510-RP93704 C510-RP93705	POT	N/A N/A	Internal	Automated Automated	RP RP	3D Geodetic prism Post Office Tunnel 3D Geodetic prism Post Office Tunnel	LIV_ES2_Invert_Adv-8 07/11/2016 LIV_ES2_Invert_Adv-8 07/11/2016			120 120	1.88 1.78	189			roposed roposed
C510-RP93901	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Invert_Adv-8 07/11/2010			120	1.45	180	-2.12	365 6 month post Construction met Pro	roposed
C510-RP93902	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Invert_Adv-8 07/11/2010	02/06/2017	N/A	120	N/A	180	-1.71		roposed
C510-RP93903	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Invert_Adv-8 07/11/2016			120	-5.22	180			roposed
C510-RP93903	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Invert_Adv-8 07/11/2016	02/06/2017	N/A	120	1.51	180	0.98		roposed
C510-RP93904	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Invert_Adv-8 07/11/2016		N/A	120	N/A	189	-1.70		roposed
C510-RP93905	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_ES2_Invert_Adv-8 07/11/2016	02/06/2017	N/A	120	N/A	189	1.00		roposed
C510-RP94101	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_AP11_Enlargement_Adv-7 06/08/2016	02/06/2017		120		180	-2.42	140t Applicable	roposed roposed
C510-RP94102 C510-RP94103	POT	N/A N/A	Internal	Automated Automated	RP RP	3D Geodetic prism Post Office Tunnel 3D Geodetic prism Post Office Tunnel	LIV_AP11_Enlargement_Adv-7 06/08/2010 LIV AP11_Enlargement_Adv-7 06/08/2010	02/06/2017	N/A N/A	120 120	N/A	180	-1.68 1.29	coc ziminyour opcomodion met	roposed
C510-RP94103	POT	N/A	Internal	Automated	RP	3D Geodetic prismi Post Office Tunnel	LIV AP11 Enlargement Adv-7 06/08/2016		N/A	536	N/A		N/A		roposed
C510-RP94105	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_AP11_Enlargement_Adv-7 06/08/2019	02/06/2017		120	N/A	180			roposed
C510-RP94301	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2019	02/06/2017		120	N/A	180			roposed
C510-RP94302	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_AP2_Enlargement_Adv-8 25/06/2016	02/06/2017	N/A	120		180			roposed
C510-RP94303	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2019	02/06/2017	N/A	120	N/A	180	0.10		roposed
C510-RP94304	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_AP2_Enlargement_Adv-8 25/06/2010		N/A	120	N/A	180	-1.11	The second secon	roposed
C510-RP94305	POT	N/A	Internal	Automated	RP RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2019			120	N/A	180			roposed
C510-RP94501 C510-RP94502	POT	N/A N/A	Internal	Automated Automated	RP RP	3D Geodetic prism Post Office Tunnel 3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2019 LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2019	02/06/2017	N/A N/A	120 120	N/A N/A	180	-0.63 -0.70		roposed roposed
C510-RP94502	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV TBM-East-RC Pilot Adv-3909 31/01/2019	02/06/2017		120	N/A		0.50		roposed
C510-RP94504	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV TBM-East-RC Pilot Adv-3909 31/01/2019	02/06/2017		120	N/A	180			roposed
C510-RP94505	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2019		N/A	120	N/A	180	-0.37		roposed
C510-RP94601	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2015	02/06/2017		120	N/A	180	-0.47	365 2mm/year Specification met Pro	roposed
C510-RP94602	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2019	02/06/2017		120			-0.48		roposed
C510-RP94603	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2019	02/06/2017		120		180		The second secon	roposed
C510-RP94701	POT	N/A	Internal	Automated	RP RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3909 31/01/201	02/06/2017	N/A N/A	120	N/A N/A		1.56		roposed
C510-RP94702 C510-RP94703	POT	N/A N/A	Internal	Automated Automated	RP RP	3D Geodetic prism Post Office Tunnel 3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2019 LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2019	02/06/2017	N/A N/A	120 120	N/A N/A	180	0.00		roposed roposed
C510-RP94703	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2019	02/06/2017		120	N/A	180	0.00		roposed
C510-RP94705	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3909 31/01/2019			120	N/A		0.35		roposed
C510-RP94901	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3895 27/01/2019	02/06/2017		120		181			roposed
C510-RP94902	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3895 27/01/201	02/06/2017		120		181		coo zimiiyodi oposiiiodiisii iiiot	roposed
C510-RP94903	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3895 27/01/2019	4	N/A	120	N/A	181	0.12	The second secon	roposed
C510-RP95101	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3885 26/01/2019	02/06/2017	1.29	120	0.95	181	0.12	and a second and a second and a second	roposed
C510-RP95102 C510-RP95103	POT	N/A N/A	Internal	Automated Automated	RP RP	3D Geodetic prism Post Office Tunnel 3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3885 26/01/2019 LIV_TBM-East-RC_Pilot_Adv-3885 26/01/2019	02/06/2017		120 120	1.17		0.22		roposed
C510-RP95103 C510-RP95301	POT	N/A N/A	Internal	Automated	RP RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3883 26/01/2019 LIV_TBM-East-RC_Pilot_Adv-3870 26/01/2019			120	0.94		0.21		roposed roposed
C510-RP95301	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV TBM-East-RC Pilot Adv-3870 26/01/2019	02/06/2017		120	0.98	181			roposed
C510-RP95303	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3870 26/01/2019	02/06/2017		120		181			roposed
C510-RP95501	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3860 25/01/2019	02/06/2017	1.80	120	1.35	181	-0.15		roposed
C510-RP95502	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3860 25/01/2019	02/06/2017	1.15	120	0.86	181			roposed
C510-RP95503	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3860 25/01/2019		1.71	120	1.27	181			roposed
C510-RP95701	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3840 24/01/2019	02/06/2017	0.00	120	0.63		-0.17		roposed
C510-RP95702 C510-RP95703	POT	N/A N/A	Internal	Automated Automated	RP RP	3D Geodetic prism Post Office Tunnel 3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3835 24/01/2019 LIV_TBM-East-RC_Pilot_Adv-3840 24/01/2019	02/06/2017	0.87	120 120	0.56	181			roposed roposed
C510-RP95703 C510-RP95901	POT	N/A N/A	Internal	Automated	RP RP	3D Geodetic prism Post Office Tunnel 3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3840 24/01/2019 LIV_TBM-East-RC_Pilot_Adv-3840 24/01/2019	02/06/2017	0.95	120	0.63	181			roposed roposed
C510-RP95901 C510-RP95902	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3840 24/01/2019	02/06/2017	0.37	120	0.26	181	0.10	The second secon	roposed
C510-RP95903	POT	N/A	Internal	Automated	RP	3D Geodetic prism Post Office Tunnel	LIV_TBM-East-RC_Pilot_Adv-3840			120	0.30	.0.	-0.04	365 2mm/year Specification met Pro	roposed
											_			.,	

Table 3 - Post Office Tunnel Decommissioning Status Tracker LP

10/11/2017

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

AVERAGE SETTLEMENT TREND

10/11/2017 MATCH No:

MATCH No:																		
C510 Sensor Name	Block	Section	Int / Ext	Measurement Type	Sensor Type	Sensor Description	Asset/Location	ZOI Last Primary Layer Construction	Last Construction Date	Latest & Surveyed Date	180 Days	180 Day Calculation Period	270Days	270 Day Calculation Period	365 Days	365 Day Calculation Period	General Comment	Decommissionin g Status
C510-LP84709	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10a_Enlargement_Adv-1	26/01/2015	15/06/2017	1.13	188	0.05	273	-0.75	366	2mm/year Specification met	Proposed
C510-LP84909	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10a_Enlargement_Adv-10	26/01/2015	15/06/2017	0.72	188	-0.17	273	-0.73	366	2mm/year Specification met	Proposed
C510-LP85109	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10a_Enlargement_Adv-2	26/01/2015	15/06/2017	-0.51	188	-0.31	273	-0.76	366	2mm/year Specification met	Proposed
C510-LP85309	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV AP10a Enlargement Adv-3	26/01/2015	15/06/2017	0.30	188	-0.04	273	-0.59	366	2mm/year Specification met	Proposed
C510-LP85509	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV AP10a Enlargement Adv-5	27/01/2015	15/06/2017	0.61	188	0.22	273	-0.38	366	2mm/year Specification met	Proposed
C510-LP85709	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10a_Enlargement_Adv-6	31/01/2015	15/06/2017	0.46	188	0.13	273	0.51	366	2mm/year Specification met	Proposed
C510-LP90109	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10a_Enlargement_Adv-7	31/01/2015	15/06/2017	2.06	188	1.80	273	0.98	366	2mm/year Specification met	Proposed
C510-LP90309	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10a_Enlargement_Adv-8	31/01/2015	15/06/2017	-1.88	188	0.68	273	0.21	366	2mm/year Specification met	Proposed
C510-LP90509	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10a_Enlargement_Adv-9	31/01/2015	15/06/2017	1.68	188	1.56	273	0.50	366	2mm/year Specification met	Proposed
C510-LP90709	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-1	31/01/2015	15/06/2017	-1.94	188	0.68	273	0.31	366	2mm/year Specification met	Proposed
C510-LP90909	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-10	31/01/2015	15/06/2017	1.57	188	1.29	273	0.10	366	2mm/year Specification met	Proposed
C510-LP91109	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-11	31/01/2015	27/06/2017	-2.04	200	-0.37	285	-0.60	378	2mm/year Specification met	Proposed
C510-LP91309	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-12	09/10/2015	27/06/2017	0.52	200	-0.12	285	-0.99	378	2mm/year Specification met	Proposed
C510-LP91509	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-13	09/10/2015	31/10/2017	0.41	228	-1.55	326	-0.83	411	2mm/year Specification met	Proposed
C510-LP91709	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-14	09/10/2015	31/10/2017	0.55	228	-0.40	326	-0.71	411	2mm/year Specification met	Proposed
C510-LP91859	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-15	26/02/2014	31/10/2017	1.35	228	0.09	326	-0.71	411	2mm/year Specification met	Proposed
C510-LP91909	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-16	28/06/2014	31/10/2017	0.25	228	-1.86	326	-1.47	411	2mm/year Specification met	Proposed
C510-LP91959	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-17	18/03/2017	31/10/2017	1.79	228	0.46	326	-0.48	411	2mm/year Specification met	Proposed
C510-LP92009	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-18	18/03/2017	31/10/2017	2.13	228	0.50	326	-1.75	411	2mm/year Specification met	Proposed
C510-LP92059	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-19	18/03/2017	31/10/2017	1.83	228	0.35	326	-0.47	411	2mm/year Specification met	Proposed
C510-LP92109	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-2	18/03/2017	31/10/2017	41.32	228	-0.17	326	-0.85	411	2mm/year Specification met	Proposed
C510-LP92159	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-3	15/03/2017	31/10/2017	1.70	228	-0.61	326	-1.08	411	2mm/year Specification met	Proposed
C510-LP92309	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-5	03/10/2014	31/10/2017	0.89	228	-1.52	326	-1.52	411	2mm/year Specification met	Proposed
C510-LP92509	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-6	03/10/2014	31/10/2017	1.34	228	-0.19	326	-0.94	411	2mm/year Specification met	Proposed
C510-LP92709	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-7	16/09/2014	31/10/2017	1.83	228	-0.70	326	-0.80	411	2mm/year Specification met	Proposed
C510-LP92909	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-8	16/09/2014	31/10/2017	1.98	228	0.26	326	-0.47	411	2mm/year Specification met	Proposed
C510-LP93109	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP10b_Enlargement_Adv-9	22/11/2013	31/10/2017	1.30	228	-1.19	326	-1.27	411	2mm/year Specification met	Proposed
C510-LP93309	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP11_Enlargement_Adv-18	17/11/2013	31/10/2017	1.25	228	-0.08	326	-0.87	411	2mm/year Specification met	Proposed
C510-LP93509	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP11_Enlargement_Adv-7	26/04/2014	27/06/2017	-1.75	200	-2.00	285	-2.44	378	2mm Specification met over 9 months	Proposed
C510-LP93709	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP12_Enlargement_Adv-2	24/11/2016	27/06/2017	0.57	200	-1.02	285	-1.96	378	2mm/year Specification met	Proposed
C510-LP93909	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP1a_Enlargement_Adv-53	24/11/2016	15/06/2017	-0.48	188	-0.52	273	-1.29	366	2mm/year Specification met	Proposed
C510-LP94109	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP1a_Enlargement_Adv-55	07/11/2016	15/06/2017	1.26	188	-0.30	273	-1.37	366	2mm/year Specification met	Proposed
C510-LP94309	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP1a_Enlargement_Adv-56	07/11/2016	15/06/2017	-0.12	188	-0.41	273	-0.95	366	2mm/year Specification met	Proposed
C510-LP94509	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP1a_Enlargement_Adv-58	06/08/2016	15/06/2017	1.30	188	-0.04	273	-0.80	366	2mm/year Specification met	Proposed
C510-LP94709	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP1a_Enlargement_Adv-59	31/01/2015	15/06/2017	1.24	188	0.27	273	-0.47	366	2mm/year Specification met	Proposed
C510-LP94909	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP1a_Enlargement_Adv-61	31/01/2015	15/06/2017	1.12	188	0.08	273	-0.48	366	2mm/year Specification met	Proposed
C510-LP95109	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP1a_Enlargement_Adv-62	31/01/2015	15/06/2017	1.02	188	0.21	273	-0.25	366	2mm/year Specification met	Proposed
C510-LP95309	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP1a_Enlargement_Adv-64	27/01/2015	15/06/2017	0.59	188	0.02	273	-0.27	366	2mm/year Specification met	Proposed
C510-LP95509	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP1a_Enlargement_Adv-65	26/01/2015	15/06/2017	0.57	188	-0.08	273	-0.28	366	2mm/year Specification met	Proposed
C510-LP95709	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP1a_Enlargement_Adv-67	26/01/2015	15/06/2017	0.00	188	-0.12	273	0.04	366	2mm/year Specification met	Proposed
C510-LP95909	POT	SPOT01	Internal	Manual	LP	Road Stud	Post Office Tunnel	LIV_AP1a_Enlargement_Adv-68	25/01/2015	15/06/2017	0.11	188	0.18	273	0.00	366	2mm/year Specification met	Proposed
		•								<u> </u>							•	



#### 5.3 Supplementary Evidence for Decommissioning

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

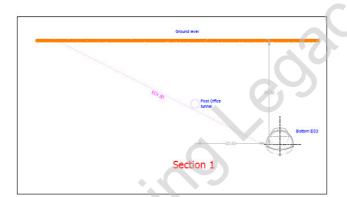
#### **Geodetic Prisms (RP) Automated Monitoring**

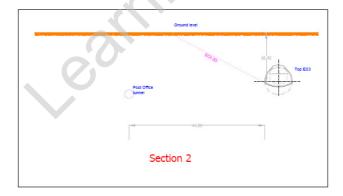
In General - There are no long term monitoring requirements for the automated monitoring, as detailed in I&M Schedule. Therefore, provided there are no particular discrepancies between the automated and manual monitoring, agreement to decommission the manual monitoring will generally apply to the automated monitoring.

Figure 3- shows the position of post office tunnel in relation to ES3, section 1 illustrates where post office tunnel is within the EOI of ES3 at the bottom of the tunnel while section 2 illustrates where post office tunnel is outside EOI at the top of tunnel of ES3.

Despite the fact that section 1 Post Office tunnels are within the EOI of ES3, there are no discernible effects of movement from ES3 to the post office tunnel. Because, The X, Y & Z Movement shows stability around ES3 before the starting of construction in mid-February 2017, during and after finishing of the construction in 20 of February 2017. These trends can be seen in Figure 4.

Note that, in Figure 4 on X, Y & Z Movement between 29/04/2017 and 10/05/2017 the system was down, there were no data recorded. The step in the data was not due to physical movement of the tunnel, it was an offset applied after the system was re-running.





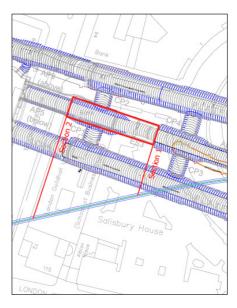
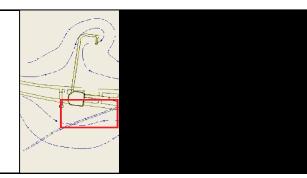


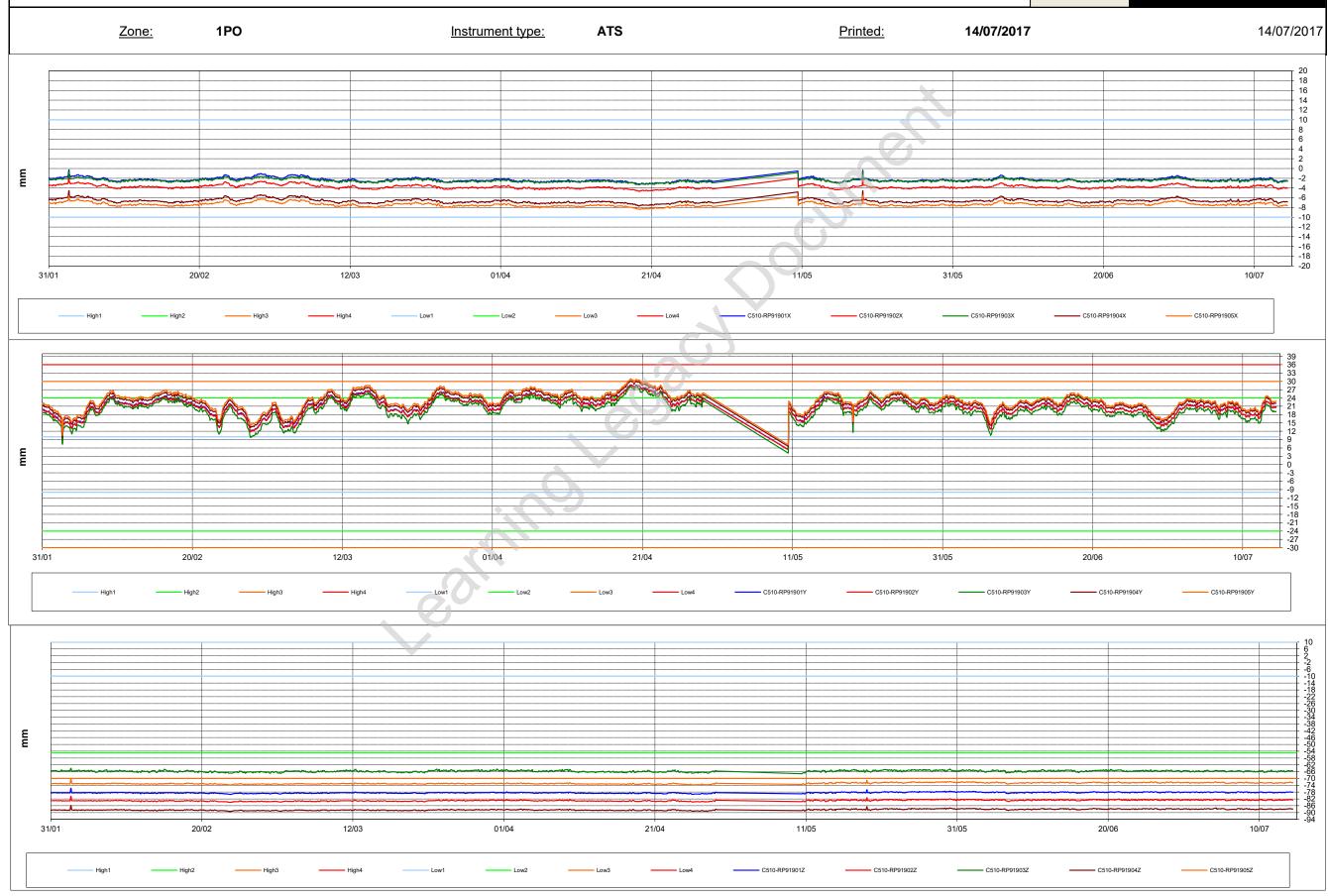
Figure 3- The position of post office tunnel in relation to ES3 sectional Plan

Figure 4 - The Post Office tunnel X, Y and Z movement within the zone of ES3 shown below



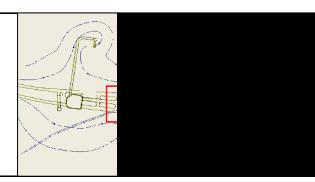
## Crossrail C510 - Soldata Structural Monitoring Lis - POT T09S110-S190\_2 X,Y and Z movements

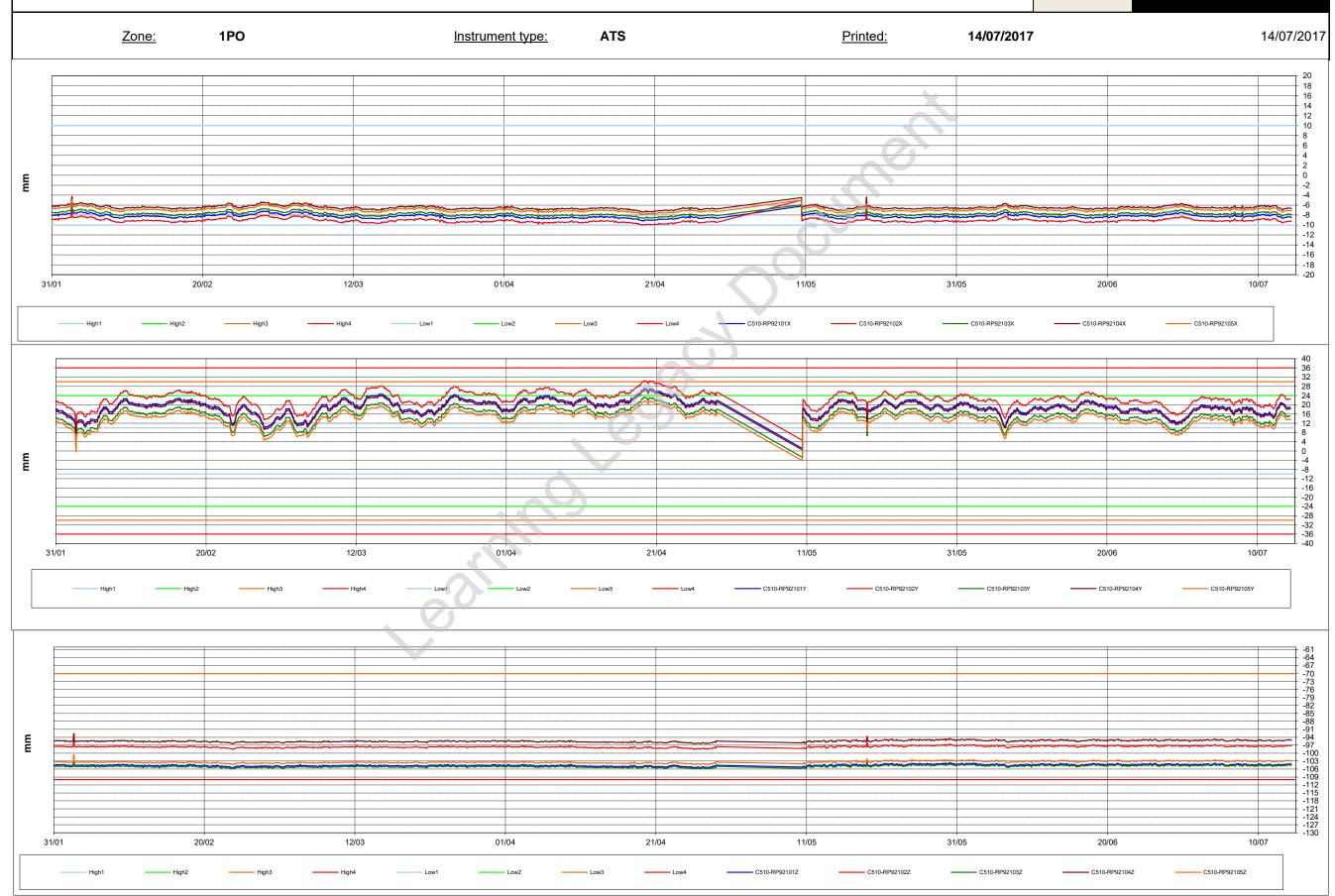






# Crossrail C510 - Soldata Structural Monitoring Liverpool Street - POT T09S210-S290\_1 X,Y and Z movements



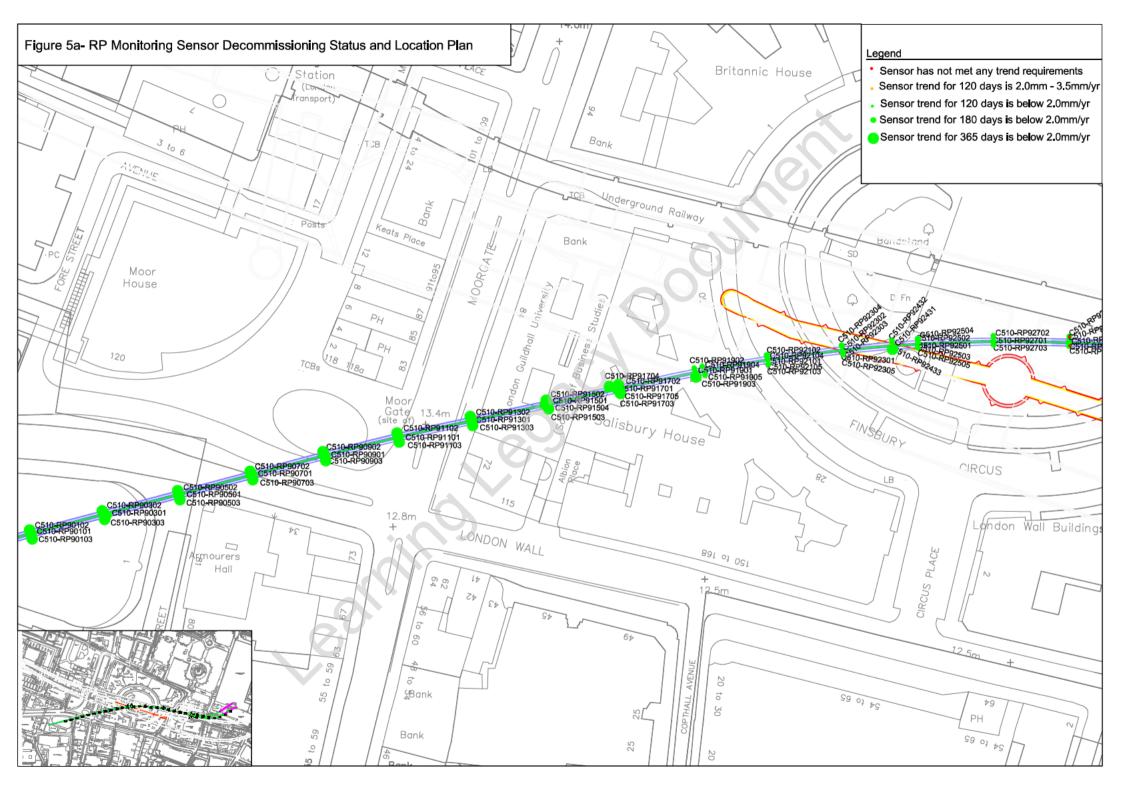


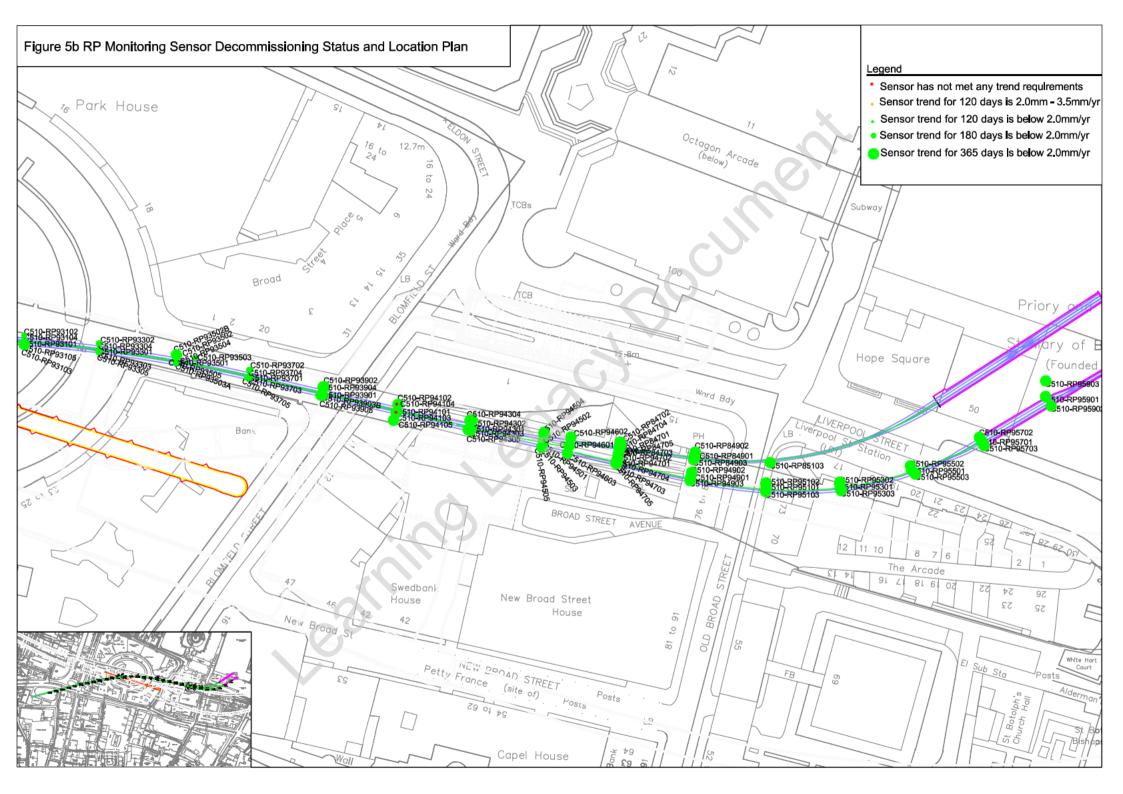


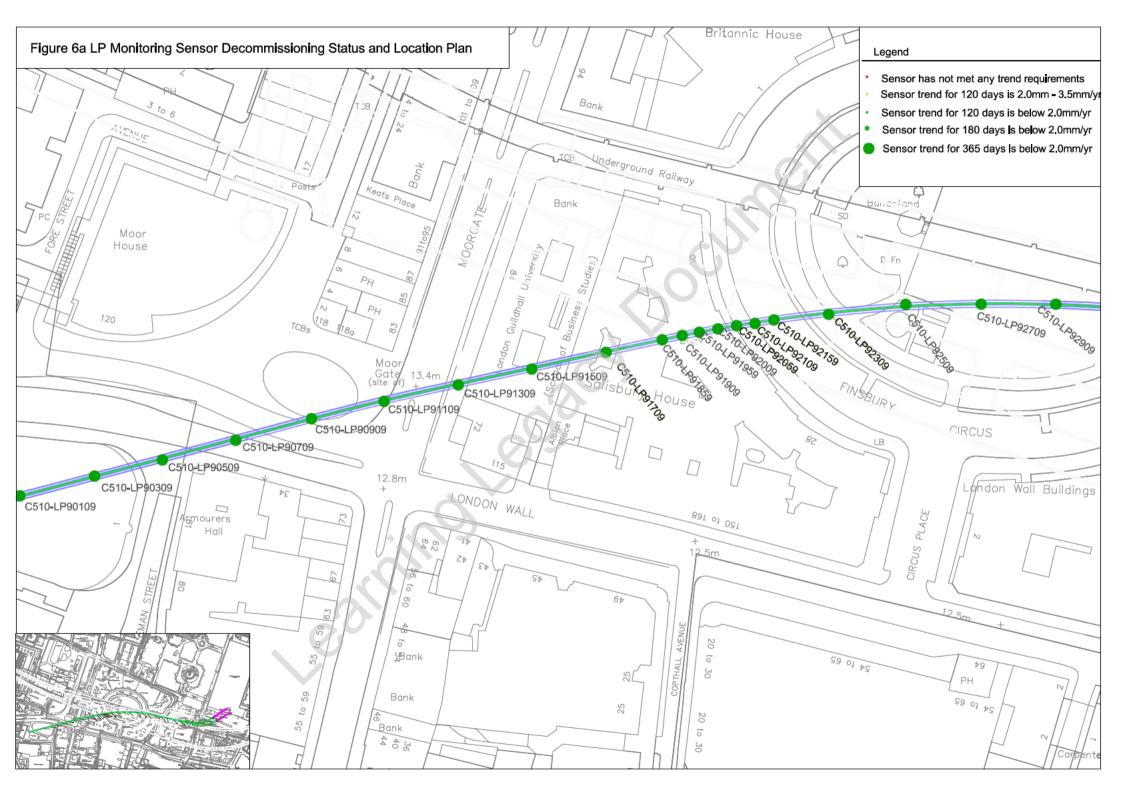
## 5.4 Monitoring sensor Location Plan and Decommissioning Status

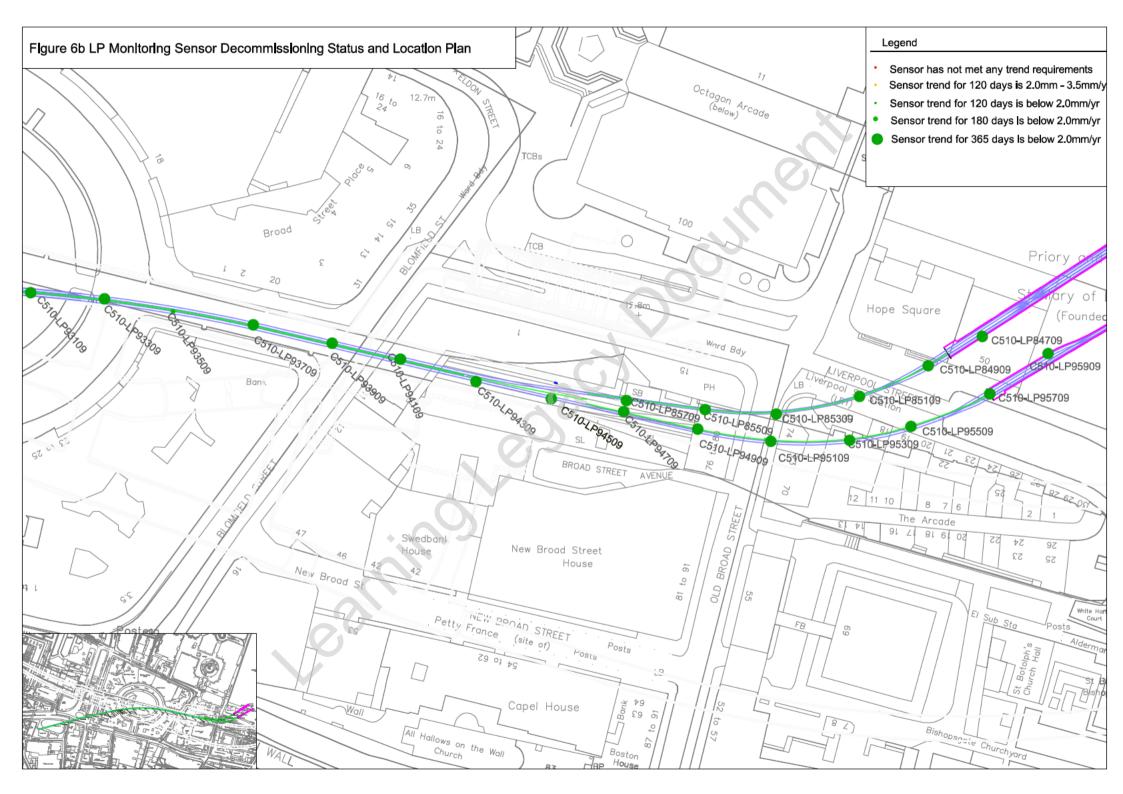
The following plots provide a visual representation of all Post office tunnel monitoring sensors with a colour circle that defines its settlement status. A green circle represents when a trend is below 2mm/yr and the larger the circle the greater the trend period. When a trend has not been met, a small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

- Figure 5a & 5b RP Monitoring Sensor Settlement Status and Location Plan
- Figure 6a & 6b LP Monitoring Sensor Settlement Status and Location Plan











## **6** Decommissioning Recommendations

Through the monitoring assessment process in Section 5, it is purposed that all automated monitoring sensors in post office tunnel sensors are to be decommissioned. Also, all manual monitoring sensors road studs (LP) in post office tunnel have met the monitoring specification of less or equal to 2mm/year.

All manual monitoring sensors met the monitoring specification over the period of a year, except for one sensor over the period of 9 months. Table 2 & 3 Decommissioning Tracker lists all post office tunnel monitoring sensors decommissioning status and the supporting 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.