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|---------------------------------------|
| <b>Work Area:</b><br>SMM              |
| <b>Work Type:</b><br>I&M              |
| <b>Originator Company:</b><br>GEOCISA |

# C435 Farringdon Main Station

|   |
|---|
| <b>CRL Lead reviewer:</b><br>[Redacted] |
| <b>CRL Reviewer:</b><br>[Redacted]      |

## Monitoring Close-Out Report:

### In-ground Monitoring Section B and Internal Monitoring installed on 66 Cowcross St.

**CRL Document Number: C435-BFK-C2-RGN-M123-51605**

**Supplier Document Number: N/A**

**Contract MDL reference C03.035**

#### 1. Contractor Document Submittal History:

| Revision: | Date:      | Prepared by: | Checked by: | Approved by: | Reason for Issue: |
|-----------|------------|--------------|-------------|--------------|-------------------|
| 1.0       | 15-06-2015 | [Redacted]   | [Redacted]  | [Redacted]   | For acceptance    |
| 2.0       | 03-08-2015 | [Redacted]   | [Redacted]  | [Redacted]   |                   |
|           |            |              |             |              |                   |

#### 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"/> |
|                          |           |      |           |      | <input type="checkbox"/> |

#### 3. Acceptance by Crossrail:

27/08/2015

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## A. INTRODUCTION

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

Identify movements observed by the relevant instruments;

Relate these movements to construction activities, where applicable;

Identify trigger breaches that may have occurred;

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

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

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

## B. INSTRUMENTS

### B.1 Description of the Instruments

This Close-Out Report relates the In-ground Monitoring Section B, consisting one extensometer located in the Cowcross St. The internal monitoring installed on 66 Cowcross St consisting in sockets installed on walls and biaxial tiltmeters installed on the same walls. A list of the sensors are in the table 1 and 2.

| Instrument          | Depth (m)         | Northing's (m) | Easting's (m) | Elevation (m) | Description         |
|---------------------|-------------------|----------------|---------------|---------------|---------------------|
| C435-XR07000        | 19                | 81999.8742     | 36558.8690    | 112.6335      | Manual extensometer |
| C435-TB00701<br>A/B | Basement<br>Level | 82000.9478     | 36552.9813    | 112.1025      | Biaxial Tiltmeter   |
| C435-TB00702<br>A/B | Basement<br>Level | 82001.8719     | 36536.7626    | 111.9363      | Biaxial Tiltmeter   |

Table 1: Details In-Ground monitoring devices Section B.

| Instrument   | Depth (m)         | Northing's (m) | Easting's (m) | Elevation (m) |
|--------------|-------------------|----------------|---------------|---------------|
| C435-LB13962 | Basement<br>Level | 82007.386      | 36553.381     | 114.7827      |
| C435-LB13963 | Basement<br>Level | 82005.583      | 36542.738     | 114.6971      |
| C435-LB13964 | Basement<br>Level | 82000.858      | 36553.027     | 112.106       |
| C435-LB13965 | Basement<br>Level | 82001.185      | 36548.196     | 112.0816      |
| C435-LB13966 | Basement<br>Level | 82001.459      | 36542.547     | 111.8873      |
| C435-LB13967 | Basement<br>Level | 82001.677      | 36536.833     | 111.9652      |
| C435-LB13968 | Basement<br>Level | 82009.489      | 36537.079     | 111.9981      |
| C435-LB13969 | Basement<br>Level | 82009.325      | 36540.599     | 111.873       |

Table 2: Details of the sockets installed on the basement.

The tiltmeters, sockets and extensometer installed on the Section B are shown in the following documents:

Drawings:

- C122-OVE-C2-DDA-CR001\_Z-31531
- C122-OVE-C2-DDA-CR001\_Z-31404

Installation Reports:

- C435-BFK-C-GMS-M123-50204
- C435-BFK-C2-RGN-M123-50997
- C435-BFKC2-RGN-M123-50047
- C122-OVE-T1-GMS-M123-50005

## B.2 Location of the Instruments

The instruments described in Section B are located in Cowcross St. The internal monitoring is installed in the basement on 66 Cowcross St. In the Appendix A is included the drawing with the location of instruments. See Figure 1 below with location Section B.

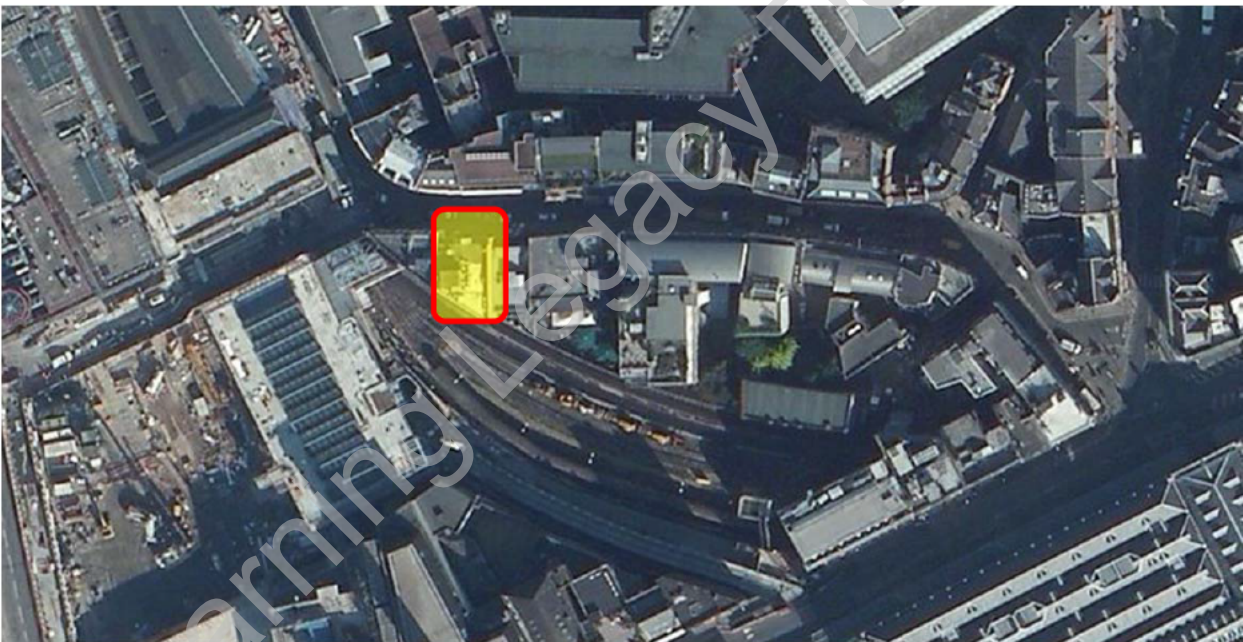


Figure 1 – Map showing the Location of Section A.



## C. MOVEMENTS

### C.1 Movements Resulting from Construction Activities

#### C.1.1 Relevant Crossrail (BFK) Works

The construction activities associated with these instruments are related to Crossrail tunneling works. In all cases, these comprise of the passage of a TBM (C300) and a platform tunnel enlargement.

| Activity        | Start Date | End Date   |
|-----------------|------------|------------|
| EB TBM passage  | 09/01/2014 | 10/01/2014 |
| PTE enlargement | 04/06/2014 | 09/06/2014 |
| CP3a            | 27/08/2014 | 29/08/2014 |
| CP2a            | 06/09/2014 | 18/09/2014 |

#### C.1.2 Resulting Movements

The monitoring data for the extensometer at street level located at 27m from the axis of the EB TBM (C435-XR07000) is shown in Appendix B. The passage of the EB TBM is shown to have caused a maximum settlement of 5mm, recorded on the extensometer rod at 14m below street level. During the enlargement of PTE the extensometer show a maximum settlement of 9mm, recorded on the extensometer rod at 14m below street level. During CP3a and CP2a construction, no significant settlement was observed on the extensometer.

The monitoring data for the tiltmeters located on the basement for the building (C435-XR00701 and C435-XR00702) is presented in Appendix B. The results obtained from these instruments do not show any conclusive movements from construction.

Sockets installed on walls in the basement for the building is presenting in Appendix B. These sockets show the settlement caused by the different works carried out.

During the TBM, the sockets show 8.5mm maximum of settlement. The socket that shows the maximum settlement is located in the western wall, and is the first socket that was affected by TBM. After the TBM, some grouting episode was carried out. These episodes have produce maximum 4mm maximum after TBM.

During the PTE enlargement, the sockets show another 15mm settlement. The maximum movement during this construction phase was 23.7mm. When the sockets were outside for the influence area for PTE enlargement, these sockets show stable conditions, but with a residual settlement.

CP3a tunnel construction was made in two different stages. During the first stage, sockets didn't show significant movement. Second stage for CP3a construction produced another 4mm settlement. In this period, green trigger (-24mm) was breached by two sockets, the sockets closer to CP3a.

Once the last construction phase was completed, sockets shows very stable conditions, and the trend line for these sockets is horizontal, that's mean that the settlement on this building is slowed to below the rate of 2mm/year.

## C.2 Trigger Breaches

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

| Point ID     | Date of Reading     | Reading Value | Trigger Breached | Affected by            | Remarks        |
|--------------|---------------------|---------------|------------------|------------------------|----------------|
| C435-LB13967 | 17/07/2014<br>12:00 | -24.9         | GREEN            | SCL-PTE<br>Enlargement | Keeps in GREEN |
| C435-LB13968 | 27/03/2015<br>14:00 | -24.3         | GREEN            | SCL-PTE<br>Enlargement | Keeps in GREEN |

## C.3 Significant Issues with the Instrumentation

No issues with these devices. During the period between December 2014 and March 2015, the socket use like a reference was covered by boxes. When the reference points is covered, is not possible take reading for the rest of the sockets.

## C.4 Residual Risks

The rates of residual settlement for the extensometer, sockets and horizontal movement for the tiltmeters have been determined and in all cases these rates are less than 2mm/year.

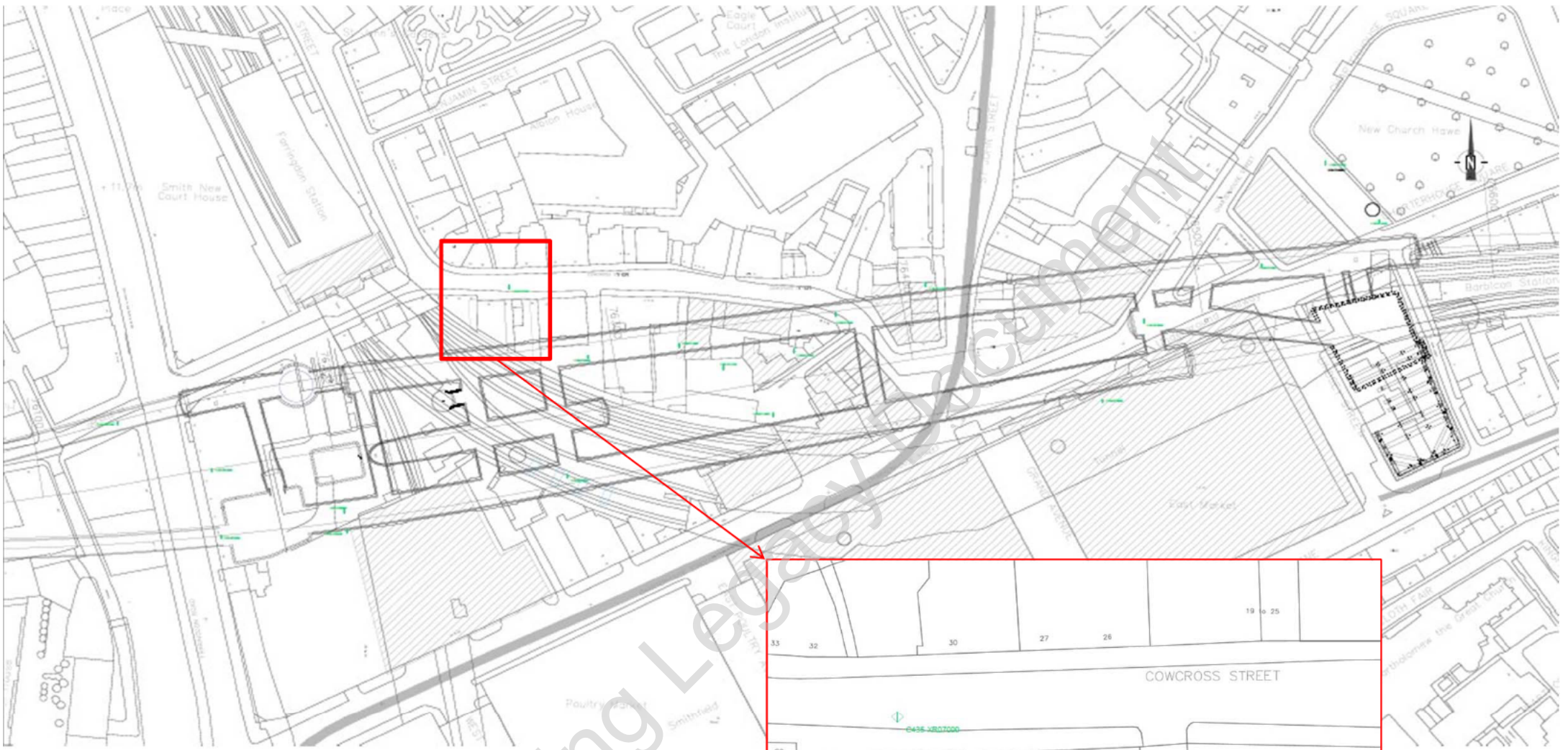
## D. CONCLUSIONS

Following the EB TBM passage, of the SCL enlargement of PTE and CP3a, the maximum measured settlement in the extensometer, internal sockets and horizontal displacement in the tiltmeters remain less than the expected.

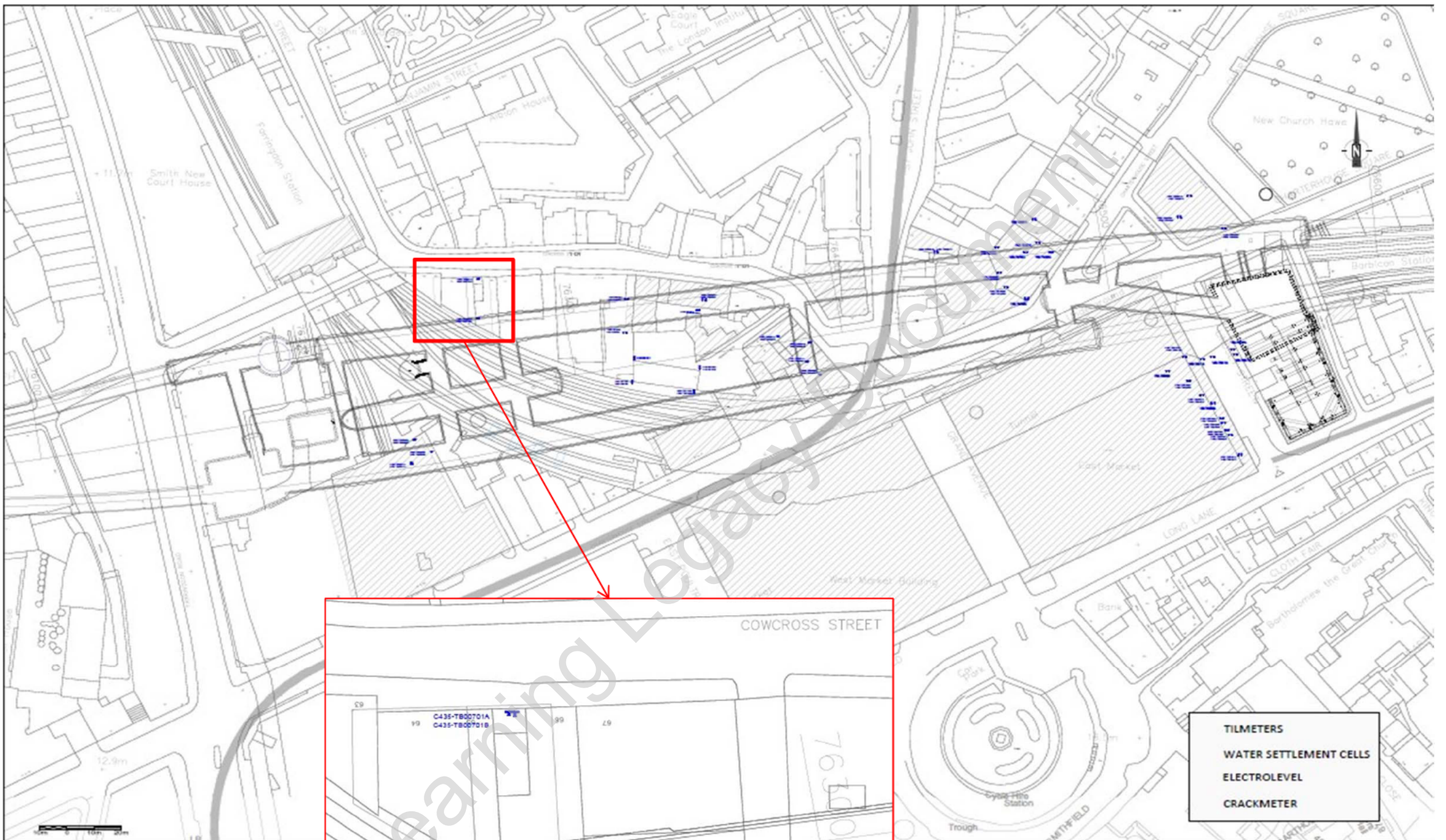
After the works, all devices do not show any significant movement, therefore these devices are considered stabilized.

APPENDIX A: DRAWINGS

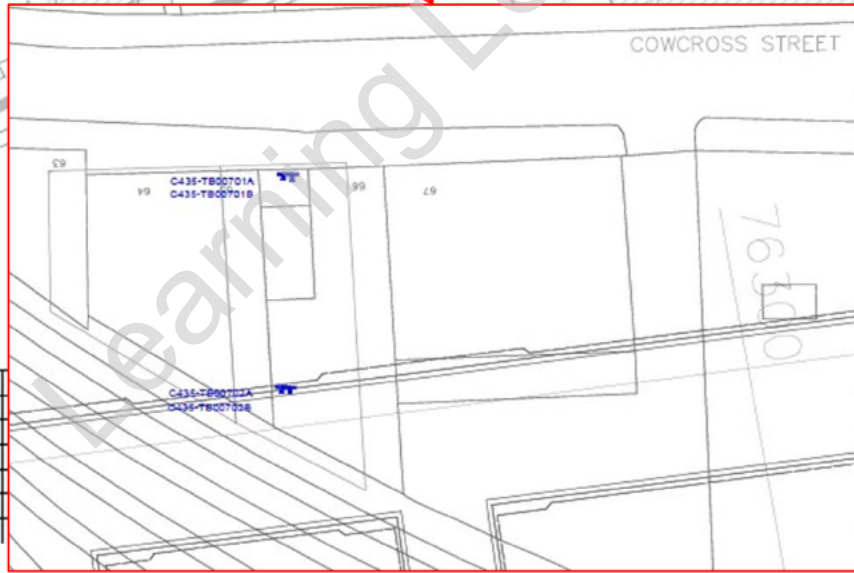
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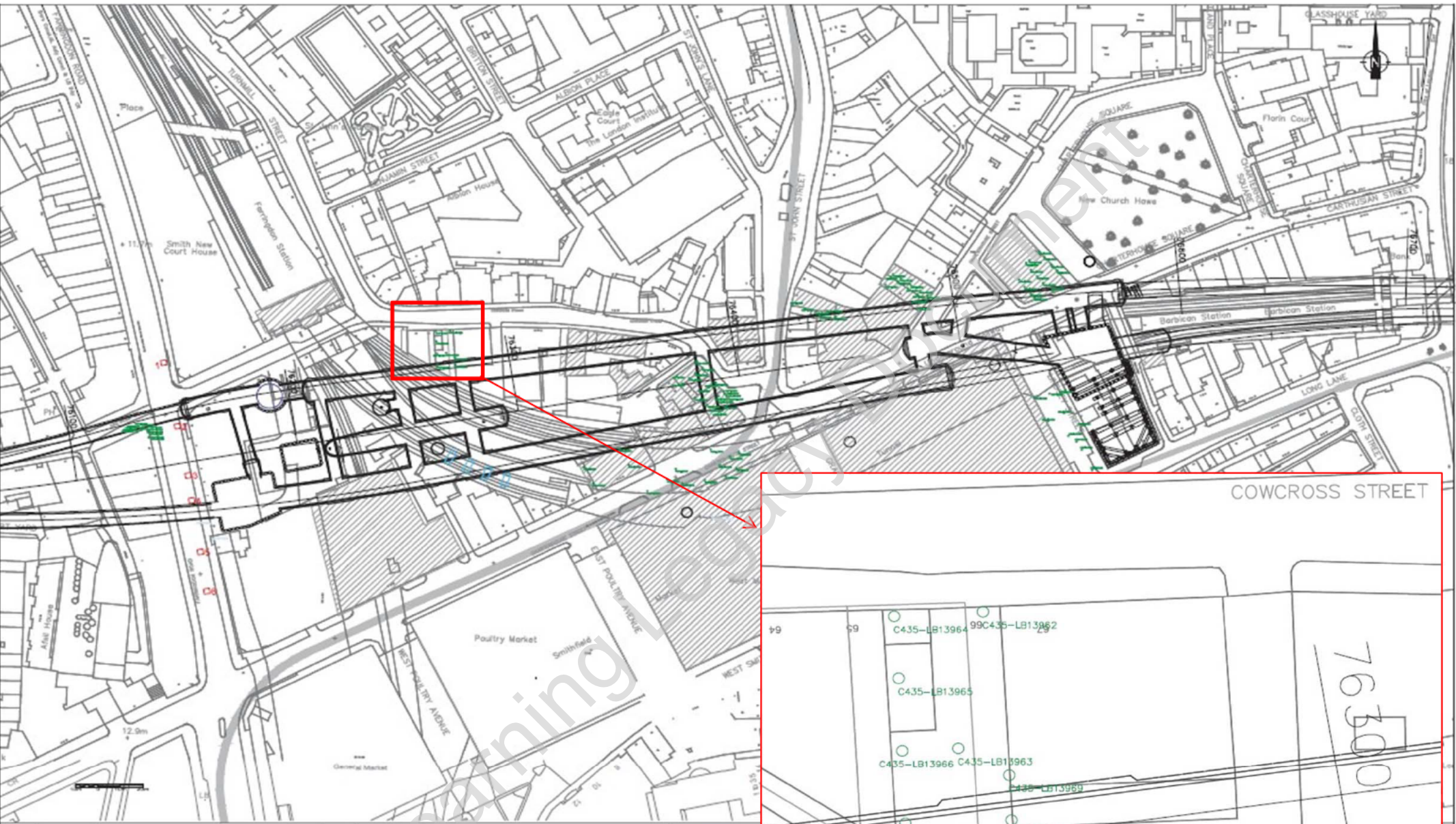


| Rev. | Date       | Description | By |
|------|------------|-------------|----|
| 1    | 15-11-2013 |             |    |



|   |                            |
|---|----------------------------|
| Project:  | C435 FARRINGTON STATION    |
| Client:   | GEOSISA                    |
| Contract:   | CROSSRAIL GENERAL          |
| C435 INSTRUMENTATION AND MONITORING - INTERNAL AND EXTERNAL BUILDING MONITORING APPARATUS |                            |
| Doc No:   | C435-BFK-C2-DWG-M123-50010 |
| Rev:  |                            |
| Out:  |                            |
| By:   | -                          |
| Chk:  | -                          |
| App:  | -                          |
| Auth:   | <b>GEOSISA</b>             |

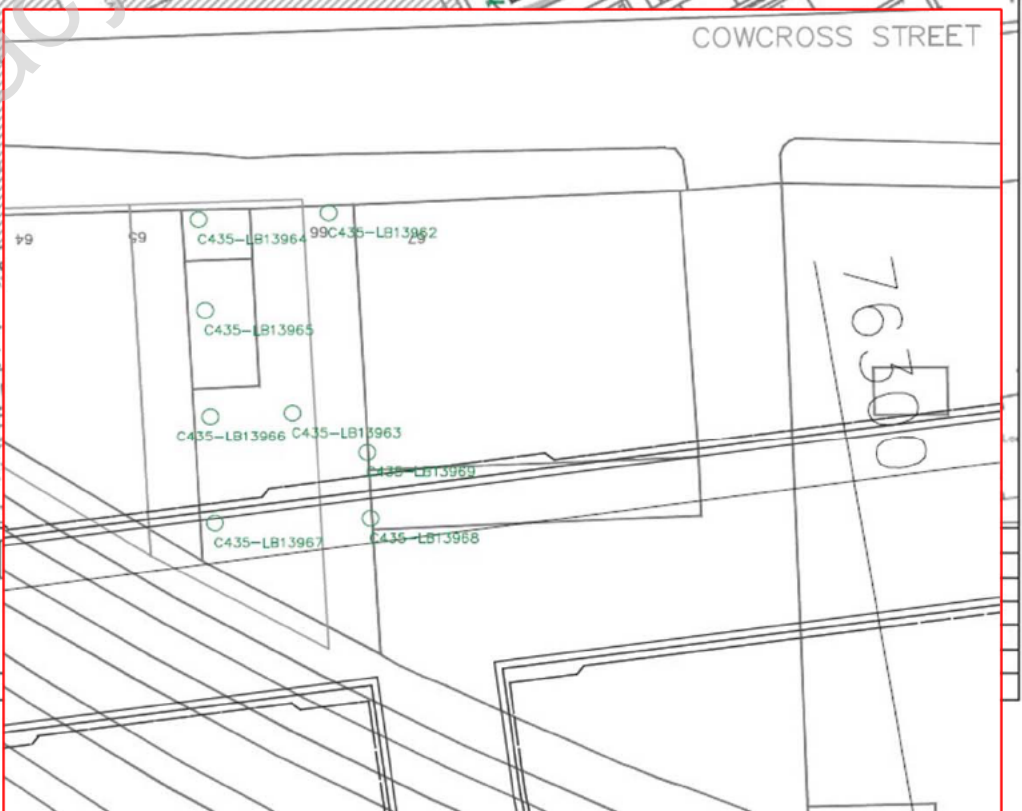




| Rev. | Date       | Description | By | Chkd | App | Auth |
|------|------------|-------------|----|------|-----|------|
| 1    | 15-11-2013 |             |    |      |     |      |

Notes:

Scale :



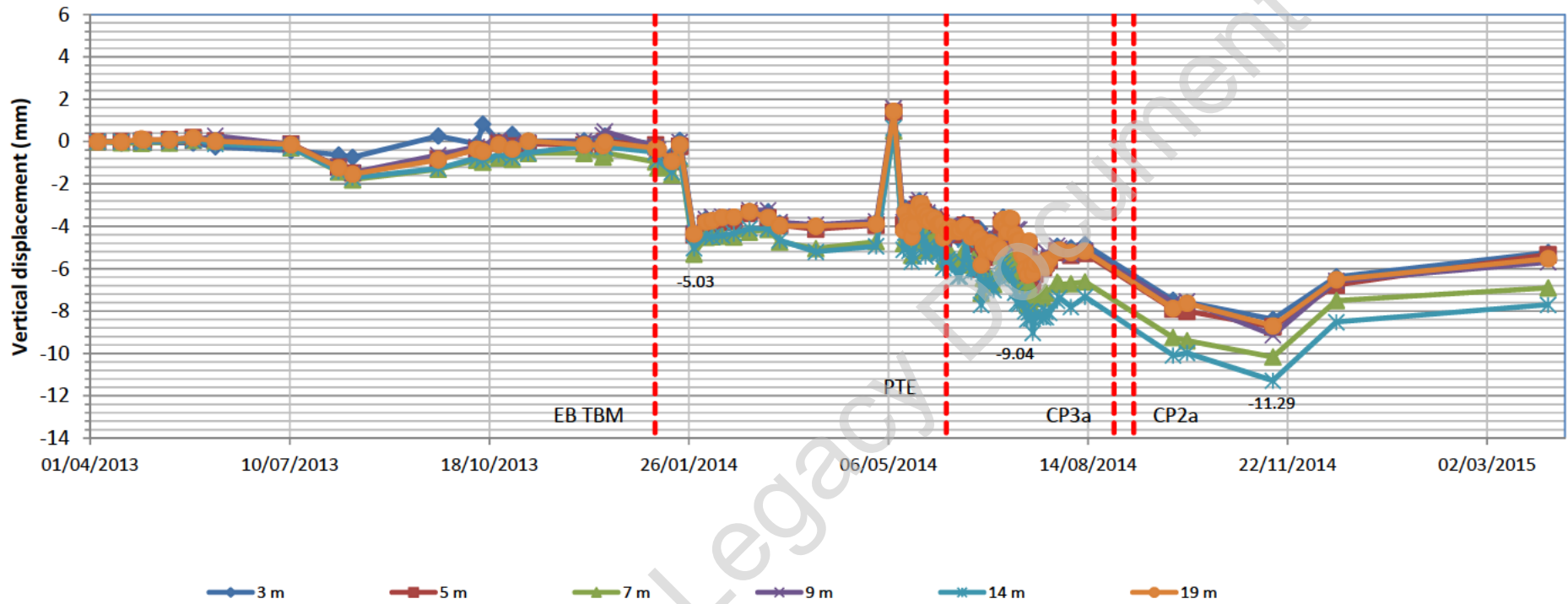
APPENDIX B: GRAPHS

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REPORT:  
AREA:  
DEVICE:

In-ground monitoring  
Cowcross Street  
Extensometer

Extensometer C435-XR07000



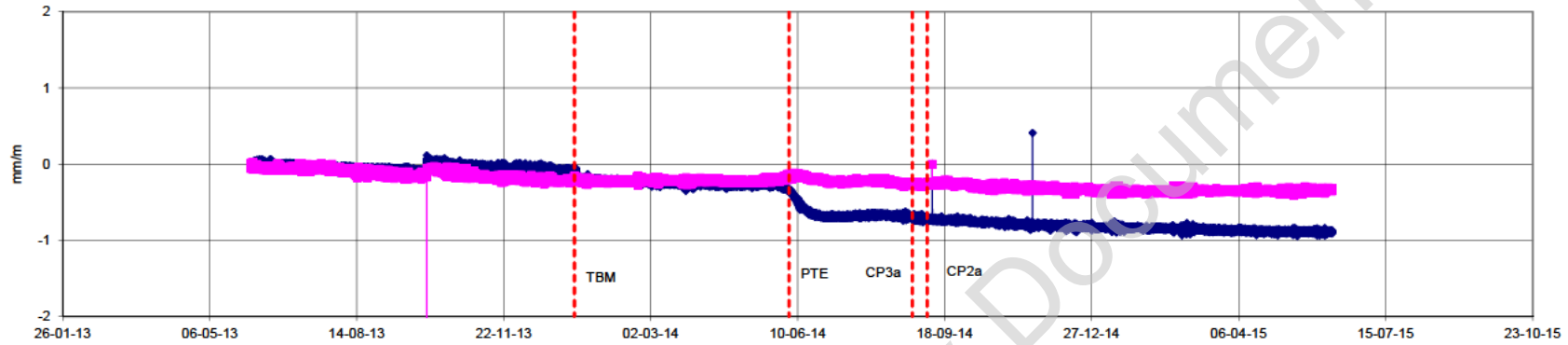
REMARKS: The first reading 14m and 9m are mistakes rebase line required. Three readings taken between 25-09-2014 and 14-11-2014 show bad readings. Some grouting episode was carried out on this period.



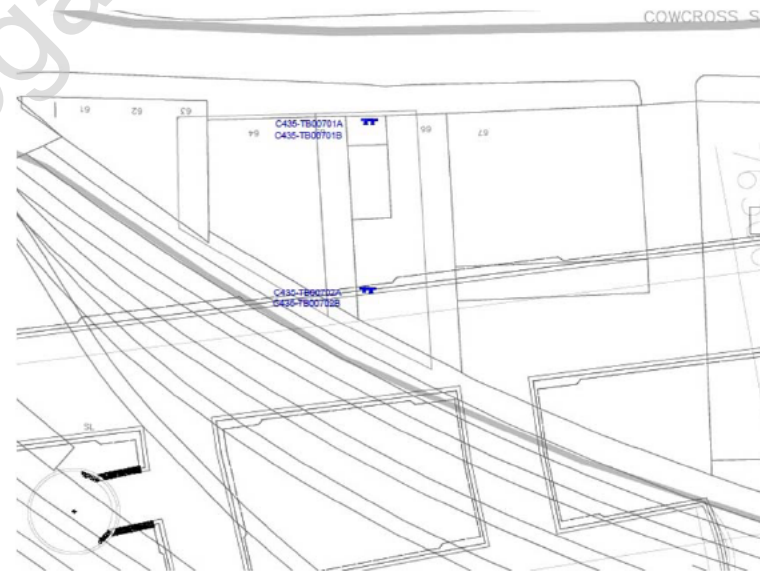




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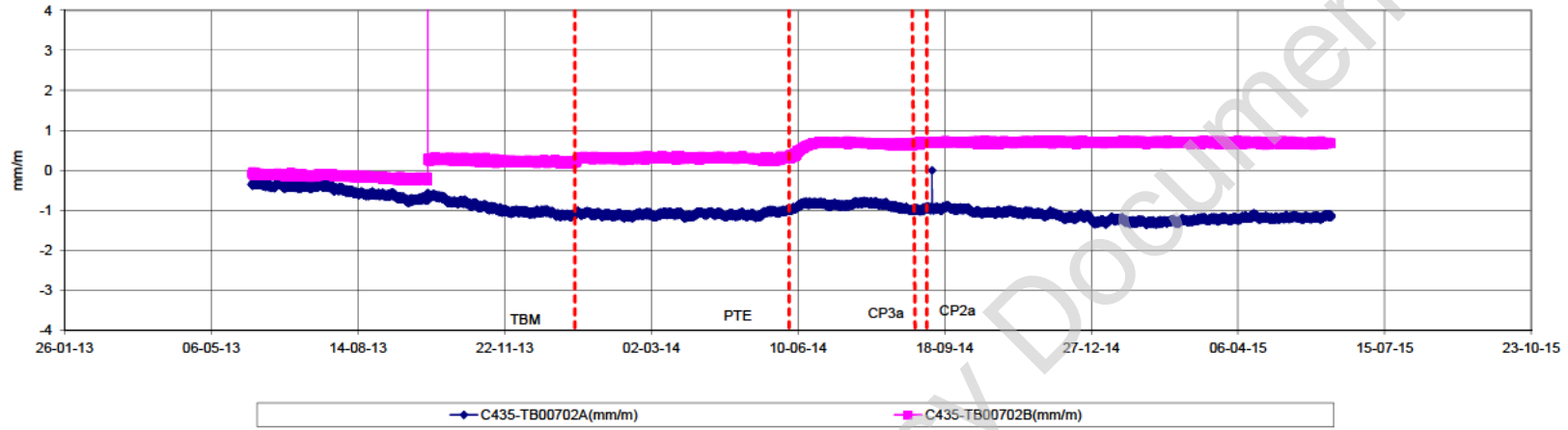


REMARKS:

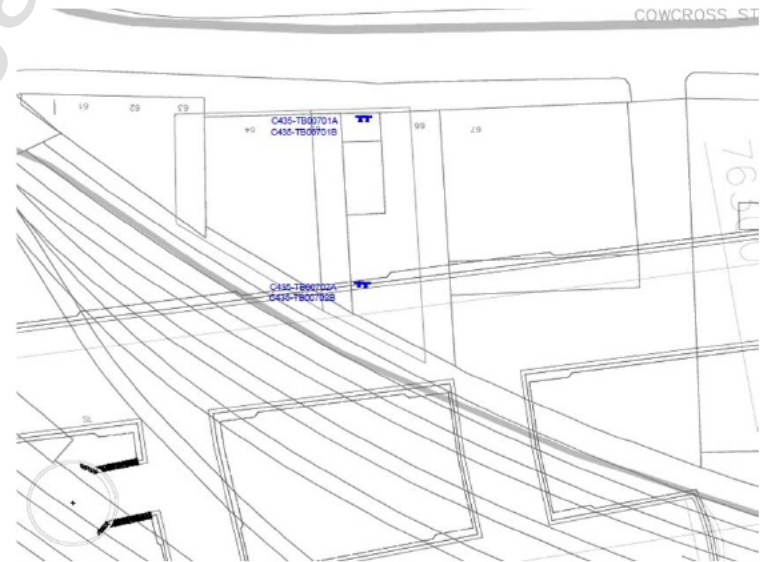


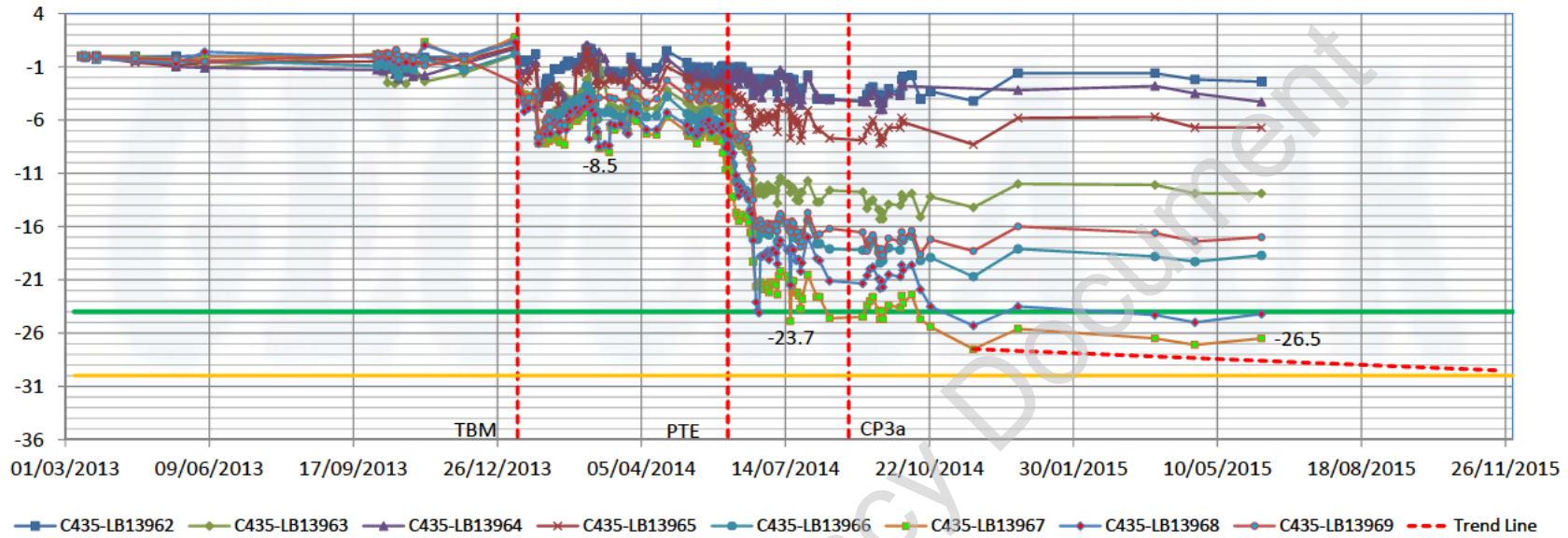


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REMARKS:





**REMARKS:**No access to the reference point between December 2014 and April 2015. This point was covered by boxes.

