



C305– Eastern Running Tunnels

Close out report for DLR Royal Victoria Station to VDP

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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
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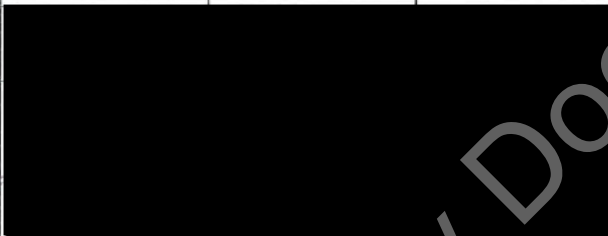
3. Acceptance by Crossrail:

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Close out report for DLR Royal Victoria Station to VDP**C305 Crossrail Eastern Running Tunnels**

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1. CLOSE OUT REPORT PURPOSE

As stated in the specification: C122-OVE-Z4-RSP-CR001-00007 Rev 7.0, the purpose of this close-out report is to summarise the data from the instrumentation included in this document and to relate the recorded movements to the construction activities which produce any observed changes. For construction activities it is intended excavation of the C305 twin bored tunnels; impacts from cross passage excavation or from other CRL contracts are not included in this report.

The long term readings have been used to demonstrate that the subsequent movement has reached an acceptably stable rate within the accuracy of the system in order to decommission and/or that works are no longer impacting the area concerned.

As stated in the specifications the settlement rate of 2 mm/yr has been defined. Where this is not achieved this report seeks agreement from all parties that the rate is acceptably low enough to cease monitoring and decommission.

2. LOCATION OF THE WORKS

The instrumentation included within this report is situated on the section of Drive G between 50 meters east of the headwall at Victoria Dock Portal and to a point 20 meters west of the western end of the Royal Victoria DLR station platform:

- DLR track and platform. The sidings are not included
- Royal Victoria station asset monitoring (structure)
- C305 monitoring (DLR manual levelling tracks and Royal Victoria Station)

3. DOCUMENTATION SUMMARY

CROSSRAIL NUMBER	DOCUMENT NAME	REASON FOR ISSUE	TYPE AND NUMBER OF INSTRUMENTATION INSTALLED
C701-ITM-C-RGN-CR144-50002	C701 – Canning Town to Royal Victoria DLR Running Rail and Structural Monitoring (Phase 1a&3) Robotic Total Station & 3D Prism Installation Report	Installation report	13 Robotic Total Stations (RTS)
			1212 Geodetic prisms
C701-ITM-C-RGN-CR145_WS157-50003	C701 –Victoria Dock Portal DLR Running Rail and Structural Monitoring (Phase 2) Robotic Total Station & 3D Prism Installation Report	Installation report	6 Robotic Total Stations (RTS)
			573 Geodetic prisms
C704-SOL-C2-RGN-CR144-50003 Rev 3.0	C704 Installation Report (Lift Shaft Prisms)	Installation report	-
C305-DSJ-C2-RGN-CRG03-50294	I&M Installation Report for socket, 3D Prisms, Retro Targets & Tiltmeters (Drive G)	Installation report	-

4. SUMMARY OF INSTALLED INSTRUMENTATION

The total number of instruments installed, as per documents listed in section above was:

- 534 - 3D Prisms
- 12 - Tiltmeters
- 9 - Sockets

All the prisms from the C701 were installed in October 2013 whereas the C305 instrumentation was installed in two different dates, September 2013 for the sockets, and June 2014 for prisms and tiltmeters. This data have been gathered from the C704 and the C305 system.

The instruments related to the C704 system (starting June 2014) keep the number scheme from C701.

- ROYAL VICTORIA STATION PLATFORM - SOUTHERN AND NORTHERN PLATFORM
 - PRISMS

SOUTHERN PLATFORM	NORTHERN PLATFORM	CHAINAGE DLR
C701-RP515921	C701-RP515922	-
C701-RP516121	C701-RP516122	-
C701-RP516321	C701-RP516322	8580
C701-RP516621	C701-RP516622	-
C701-RP517021	C701-RP517022	-
C701-RP517321	C701-RP517322	8610
C701-RP517621	C701-RP517622	-
C701-RP518021	C701-RP517922	8630
C701-RP518321	C701-RP518322	-
C701-RP518721	C701-RP518722	-

- DLR - POPLAR BECKTON
 - PRISMS

POP BEC DOWN LEFT	POP BEC DOWN RIGHT	POP BEC UP RIGHT	POP BEC UP LEFT	CHAINAGE DLR
C701-RP515114	C701-RP515113	C701-RP515112	C701-RP515111	-
C701-RP515214	C701-RP515213	C701-RP515212	C701-RP515211	-
C701-RP515314	C701-RP515313	C701-RP515312	C701-RP515311	8550
C701-RP515414	C701-RP515413	C701-RP515412	C701-RP515411	-
C701-RP515514	C701-RP515513	C701-RP515512	C701-RP515511	-
C701-RP515614	C701-RP515613	C701-RP515612	C701-RP515611	-
C701-RP515714	C701-RP515713	C701-RP515712	C701-RP515711	-
C701-RP515814	C701-RP515813	C701-RP515812	C701-RP515811	-
C701-RP515914	C701-RP515913	C701-RP515912	C701-RP515911	8570
C701-RP516014	C701-RP516013	C701-RP516012	C701-RP516011	-
C701-RP516114	C701-RP516113	C701-RP516112	C701-RP516111	-
C701-RP516214	C701-RP516213	C701-RP516212	C701-RP516211	-
C701-RP516314	C701-RP516313	C701-RP516312	C701-RP516311	-

POP BEC DOWN LEFT	POP BEC DOWN RIGHT	POP BEC UP RIGHT	POP BEC UP LEFT	CHAINAGE DLR
C701-RP516414	C701-RP516413	C701-RP516412	C701-RP516411	-
C701-RP516514	C701-RP516513	C701-RP516512	C701-RP516511	-
C701-RP516614	C701-RP516613	C701-RP516612	C701-RP516611	8590
C701-RP516714	C701-RP516713	C701-RP516712	C701-RP516711	-
C701-RP516814	C701-RP516813	C701-RP516812	C701-RP516811	-
C701-RP516914	C701-RP516913	C701-RP516912	C701-RP516911	-
C701-RP517014	C701-RP517013	C701-RP517012	C701-RP517011	-
C701-RP517114	C701-RP517113	C701-RP517112	C701-RP517111	-
C701-RP517214	C701-RP517213	C701-RP517212	C701-RP517211	8610
C701-RP517314	C701-RP517313	C701-RP517312	C701-RP517311	-
C701-RP517414	C701-RP517413	C701-RP517412	C701-RP517411	-
C701-RP517514	C701-RP517513	C701-RP517512	C701-RP517511	-
C701-RP517614	C701-RP517613	C701-RP517612	C701-RP517611	-
C701-RP517714	C701-RP517713	C701-RP517712	C701-RP517711	-
C701-RP517814	C701-RP517813	C701-RP517812	C701-RP517811	-
C701-RP517914	C701-RP517913	C701-RP517912	C701-RP517911	8630
C701-RP518014	C701-RP518013	C701-RP518012	C701-RP518011	-
C701-RP518114	C701-RP518113	C701-RP518112	C701-RP518111	-
C701-RP518214	C701-RP518213	C701-RP518212	C701-RP518211	-
C701-RP518314	C701-RP518313	C701-RP518312	C701-RP518311	-
C701-RP518414	C701-RP518413	C701-RP518412	C701-RP518411	-
C701-RP518514	C701-RP518513	C701-RP518512	C701-RP518511	8650
C701-RP518614	C701-RP518613	C701-RP518612	C701-RP518611	-
C701-RP518714	C701-RP518713	C701-RP518712	C701-RP518711	-
C701-RP518814	C701-RP518813	C701-RP518812	C701-RP518811	-
C701-RP518914	C701-RP518913	C701-RP518912	C701-RP518911	-
C701-RP519014	C701-RP519013	C701-RP519012	C701-RP519011	-
C701-RP519114	C701-RP519113	C701-RP519112	C701-RP519111	-
C701-RP519214	C701-RP519213	C701-RP519212	C701-RP519211	8670
C701-RP519314	C701-RP519313	C701-RP519312	C701-RP519311	-
C701-RP519414	C701-RP519413	C701-RP519412	C701-RP519411	-
C701-RP519514	C701-RP519513	C701-RP519512	C701-RP519511	-
C701-RP519614	C701-RP519613	C701-RP519612	C701-RP519611	-
C701-RP519714	C701-RP519713	C701-RP519712	C701-RP519711	-
-	C701-RP519813	C701-RP519812	C701-RP519811	-
-	C701-RP519913	C701-RP519912	C701-RP519911	-
C701-RP520014	C701-RP520013	C701-RP520012	C701-RP520011	-
C701-RP520114	C701-RP520113	C701-RP520112	C701-RP520111	-

- DLR - VICTORIA DOCK PORTAL
 - PRISMS

VDP DOWN LEFT	VDP DOWN RIGHT	VDP UP RIGHT	VDP UP LEFT	CHAINAGE DLR
-	C701-RP800113	C701-RP800112	C701-RP800111	-
C701-RP800214	C701-RP800213	C701-RP800212	C701-RP800211	-
C701-RP800314	C701-RP800313	C701-RP800312	C701-RP800311	8710
C701-RP800414	C701-RP800413	C701-RP800412	C701-RP800411	-
C701-RP800514	C701-RP800513	C701-RP800512	C701-RP800511	-
C701-RP800614	C701-RP800613	C701-RP800612	C701-RP800611	-
C701-RP800714	C701-RP800713	C701-RP800712	C701-RP800711	-
C701-RP800814	C701-RP800813	C701-RP800812	C701-RP800811	-

VDP DOWN LEFT	VDP DOWN RIGHT	VDP UP RIGHT	VDP UP LEFT	CHAINAGE DLR
C701-RP800914	C701-RP800913	C701-RP800912	C701-RP800911	8730
C701-RP801014	C701-RP801013	C701-RP801012	C701-RP801011	-
C701-RP801114	C701-RP801113	C701-RP801112	C701-RP801111	-
C701-RP801214	C701-RP801213	C701-RP801212	C701-RP801211	-
C701-RP801314	C701-RP801313	C701-RP801312	C701-RP801311	-
C701-RP801414	C701-RP801413	C701-RP801412	C701-RP801411	-
C701-RP801514	C701-RP801513	C701-RP801512	C701-RP801511	-
C701-RP801614	C701-RP801613	C701-RP801612	C701-RP801611	8750
C701-RP801714	C701-RP801713	C701-RP801712	C701-RP801711	-
C701-RP801814	-	C701-RP801812	C701-RP801811	-
C701-RP801914	-	C701-RP801912	C701-RP801911	-
C701-RP802014	C701-RP802013	C701-RP802012	C701-RP802011	-
C701-RP802114	C701-RP802113	C701-RP802112	C701-RP802111	-
C701-RP802214	C701-RP802213	C701-RP802212	C701-RP802211	-
C701-RP802314	C701-RP802313	C701-RP802312	C701-RP802311	8770
C701-RP802414	C701-RP802413	C701-RP802412	C701-RP802411	-
C701-RP802514	C701-RP802513	C701-RP802512	C701-RP802511	-
C701-RP802614	C701-RP802613	C701-RP802612	C701-RP802611	-
C701-RP802714	C701-RP802713	C701-RP802712	C701-RP802711	-
C701-RP802814	C701-RP802813	C701-RP802812	C701-RP802811	-
C701-RP802914	C701-RP802913	C701-RP802912	C701-RP802911	-
C701-RP803014	C701-RP803013	C701-RP803012	C701-RP803011	8790
C701-RP803114	C701-RP803113	C701-RP803112	C701-RP803111	-
C701-RP803214	C701-RP803213	C701-RP803212	C701-RP803211	-
C701-RP803314	C701-RP803313	C701-RP803312	C701-RP803311	-
C701-RP803414	C701-RP803413	C701-RP803412	C701-RP803411	-
C701-RP803514	C701-RP803513	C701-RP803512	C701-RP803511	-
C701-RP803614	C701-RP803613	C701-RP803612	C701-RP803611	-
C701-RP803714	C701-RP803713	C701-RP803712	C701-RP803711	8810
C701-RP803814	C701-RP803813	C701-RP803812	C701-RP803811	-
C701-RP803914	C701-RP803913	C701-RP803912	C701-RP803911	-
C701-RP804014	C701-RP804013	C701-RP804012	C701-RP804011	-
C701-RP804114	-	C701-RP804112	C701-RP804111	-
C701-RP804214	C701-RP804213	C701-RP804212	C701-RP804211	-
C701-RP804314	C701-RP804313	C701-RP804312	C701-RP804311	-
C701-RP804414	C701-RP804413	C701-RP804412	C701-RP804411	8830
C701-RP804514	-	C701-RP804512	C701-RP804511	-
C701-RP804614	-	C701-RP804612	C701-RP804611	-
C701-RP804714	C701-RP804713	C701-RP804712	C701-RP804711	-
C701-RP804814	C701-RP804813	C701-RP804812	C701-RP804811	-
C701-RP804914	C701-RP804913	C701-RP804912	C701-RP804911	-
C701-RP805014	C701-RP805013	C701-RP805012	C701-RP805011	8850
C701-RP805114	C701-RP805113	C701-RP805112	C701-RP805111	-
C701-RP805214	C701-RP805213	C701-RP805212	C701-RP805211	-
C701-RP805314	C701-RP805313	C701-RP805312	C701-RP805311	-
C701-RP805414	C701-RP805413	C701-RP805412	C701-RP805411	-
C701-RP805514	C701-RP805513	C701-RP805512	C701-RP805511	-
C701-RP805614	C701-RP805613	C701-RP805612	C701-RP805611	8890
C701-RP805714	C701-RP805713	C701-RP805712	C701-RP805711	-
C701-RP805814	C701-RP805813	C701-RP805812	C701-RP805811	-
C701-RP805914	C701-RP805913	C701-RP805912	C701-RP805911	-
C701-RP806014	C701-RP806013	C701-RP806012	C701-RP806011	-
C701-RP806114	C701-RP806113	C701-RP806112	C701-RP806111	-

VDP DOWN LEFT	VDP DOWN RIGHT	VDP UP RIGHT	VDP UP LEFT	CHAINAGE DLR
C701-RP806214	C701-RP806213	C701-RP806212	C701-RP806211	-
C701-RP806314	-	-	-	-

- ROYAL VICTORIA DLR STATION (C701)
 - PRISMS

AREA	ORIENTATION	COLUMN LOW/HIGH	SENSOR
SOUTH LIFT	NE	COLUMN LOW	C701-RP900122
SOUTH LIFT	NE	COLUMN HIGH	C701-RP900112
SOUTH LIFT	SW	COLUMN LOW	C701-RP900121
SOUTH LIFT	SW	COLUMN HIGH	C701-RP900111
NORTH LIFT	NE	COLUMN LOW	C701-RP900127
NORTH LIFT	NE	COLUMN HIGH	C701-RP900117
NORTH LIFT	SE	COLUMN LOW	C701-RP900126
NORTH LIFT	SE	COLUMN HIGH	C701-RP900116
NORTH LIFT	SW	COLUMN LOW	C701-RP900128
NORTH LIFT	SW	COLUMN HIGH	C701-RP900118
MID LIFT	S	COLUMN LOW	C701-RP900424
MID LIFT	S	COLUMN HIGH	C701-RP900414
MID LIFT	N	COLUMN LOW	C701-RP900425
MID LIFT	N	COLUMN HIGH	C701-RP900415
HIGH LEVEL CONCOURSE (HLC)	SE	COLUMN LOW	C701-RP900523
HIGH LEVEL CONCOURSE (HLC)	SE	COLUMN HIGH	C701-RP900513
HIGH LEVEL CONCOURSE (HLC)	NE	COLUMN LOW	C701-RP900525
HIGH LEVEL CONCOURSE (HLC)	NE	COLUMN HIGH	C701-RP900515
HIGH LEVEL CONCOURSE (HLC)	SW	COLUMN LOW	C701-RP900623
HIGH LEVEL CONCOURSE (HLC)	SW	COLUMN HIGH	C701-RP900613
HIGH LEVEL CONCOURSE (HLC)	NW	COLUMN LOW	C701-RP900625
HIGH LEVEL CONCOURSE (HLC)	NW	COLUMN HIGH	C701-RP900615
FOOT BRIDGE (FB)	NW	COLUMN LOW	C701-RP900326
FOOT BRIDGE (FB)	NW	COLUMN HIGH	C701-RP900316
FOOT BRIDGE (FB)	NE	COLUMN LOW	C701-RP900227
FOOT BRIDGE (FB)	NE	COLUMN HIGH	C701-RP900217
FOOT BRIDGE MID (FB MID)	S	COLUMN LOW	C701-RP900323
FOOT BRIDGE MID (FB MID)	S	COLUMN HIGH	C701-RP900313
FOOT BRIDGE MID (FB MID)	N	COLUMN LOW	C701-RP900324
FOOT BRIDGE MID (FB MID)	N	COLUMN HIGH	C701-RP900314
FOOT BRIDGE (FB)	SW	COLUMN LOW	C701-RP900322
FOOT BRIDGE (FB)	SW	COLUMN HIGH	C701-RP900312
FOOT BRIDGE (FB)	SE	COLUMN LOW	C701-RP900222
FOOT BRIDGE (FB)	SE	COLUMN HIGH	C701-RP900212

- ROYAL VICTORIA DLR STATION (C305)
 - PRISMS

LOCATION	SENSOR	LOCATION	SENSOR
STAIRS NORTH	C305-RP015110	FOOT BRIDGE	C305-RP015310
	C305-RP015115		C305-RP015315
	C305-RP015120		C305-RP015320
	C305-RP015125		C305-RP015325
	C305-RP015130		C305-RP015330
	C305-RP015135		C305-RP015335
LIFT SOUTH	C305-RP015510	LIFT NORTH	C305-RR015210
	C305-RP015520		C305-RR015220
LIFT CENTRAL	C305-RR015610	STAIRS CENTRAL	C305-RP015810
	C305-RR015620		C305-RP015820
HIGH LEVEL CONCOURSE	C305-RP015710		C305-RP015825
	C305-RP015715		C305-RP015830
	C305-RP015720	C305-RP015835	
	C305-RP015725	STAIRS SOUTH	C305-RP015920
	C305-RP015730		C305-RP015925
	C305-RP015735		C305-RP015930
	C305-RP015740		C305-RP015935
C305-RP015745	TOP ENDING "5" / BOTTOM ENDING "0"		

- SOCKETS

LOCATION	RELEVANT STRUCTURES	SENSOR
LB SOUTH - CANNING SIDE	SOUTH STAIRS	C305-LB011110
		C305-LB011120
		C305-LB011130
LB CENTRAL - CANNING SIDE	COLUMN OF FB MID COLUMN OF HLC COLUMN OF MID STAIRS	C305-LB011210
		C305-LB011220
		C305-LB011230
LB NORTH - CANNING SIDE	NORTH STAIRS	C305-LB011310
		C305-LB011320
		C305-LB011330

- TILTMETERS

LOCATION	SENSOR	LOCATION	SENSOR
LIFT NORTH	C305-TU010101	LIFT SOUTH	C305-TU010301
	C305-TU010102		C305-TU010302
	C305-TU010103		C305-TU010303
	C305-TU010104		C305-TU010304
LIFT CENTRAL	C305-TU010201		
	C305-TU010202		
	C305-TU010203		
	C305-TU010204		

5. CONSTRUCTION ACTIVITY

TBM passage

DRIVE Y	RINGS	PROJECT CHAINAGE	DATES
Eastbound	361 – 518	85518 - 85800	12/10/2014 to 19/10/2014
Westbound	368 – 523		02/08/2014 to 11/08/2014

No stoppage periods.

The period of TBM passage is related to the rings located close to the instrumentation included in this close out report.

Ground treatment:

Micro piling	24/10/2013 to 20/01/2014
Trial grouting	12/12/2013 to 20/01/2014
Vertical TAM drilling	02/12/2013 to 12/02/2014
Vertical TAM grouting	20/01/2014 to 15/07/2014
Soil mixing	17/04/2014 to 14/05/2014
Sub-horizontal TAM drilling	22/04/2014 to 04/07/2014
Sub-horizontal TAM grouting	12/05/2014 to 17/07/2014
EB eye ground treatment	01/10/2014 to 14/10/2014

Construction activities at DLR Royal Victoria Station:

ROV separation works	31/05/2014 to 01/06/2015
ROV cross bracing	28/07/2014 to 02/08/2014 (approximately)
North Platform coper adjustment	July 2014

6. METHODOLOGY

To determine the settlement rate the following methodology has been used. A Linear Regression has been applied for a defined period using long term readings after TBM construction. This uses the following formula.

$$b = \frac{\sum_{i=1}^n (X_i - \bar{X}_i) \cdot (Y_i - \bar{Y}_i)}{\sum_{i=1}^n (X_i - \bar{X}_i)^2}$$

Where:

B =gradient or slope

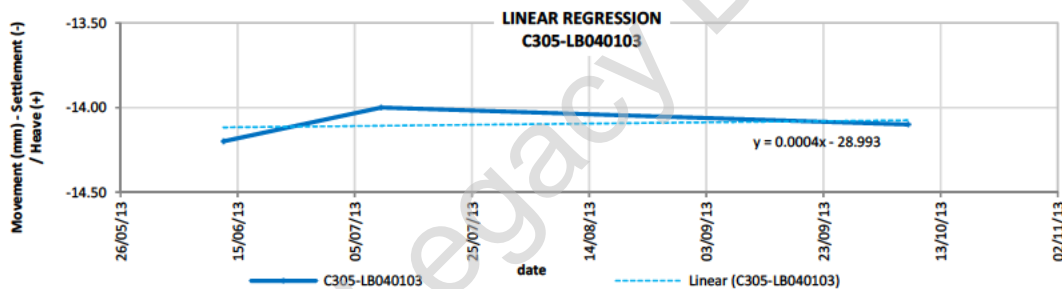
X (independent variable) = date

Y (dependent variable) = vertical movement

From this, the settlement rate per day can be calculated and rate per year determined (negative value is for settlement, positive is for heave). For these values, the percentage at or below 2 mm/yr will be used to determine the trend of the section/area being considered. Also for comparison, values at or below 3mm/year are presented to highlight that the rate is close to achieving the 2 mm/yr. Note the percentages of settlement rate presented in the sections below refer to values rounded to the nearest integer.

One example of this calculation can be seen below for one socket and its projection.

	Registered movement (mm)			RATE mm/year
	12/06/2013	09/07/2013	07/10/2013	
C305-LB040103	-14.20	-14.00	-14.10	0.146



CALCULATION - C305-LB040103

X_i	Y_i	$X_i - \bar{X}_i$	$Y_i - \bar{Y}_i$	$(X_i - \bar{X}_i)^2$	$(X_i - \bar{X}_i) \cdot (Y_i - \bar{Y}_i)$
12/06/2013	-14.2	-47.94	-0.10	2298.67	4.794
09/07/2013	-14	-21.03	0.10	442.17	-2.103
07/10/2013	-14.1	68.97	0.00	4757.17	0.000

\bar{X}_i	41485.53	
\bar{Y}_i	-14.10	
$\sum_{i=1}^n (X_i - \bar{X}_i)^2$	7498.00	(2)
$\sum_{i=1}^n (X_i - \bar{X}_i) \cdot (Y_i - \bar{Y}_i)$	2.692	(1)
m (SLOPE)	(1)/(2)	0.0004
Rate (mm/year)	m * 365	0.146

7. SUMMARY OF THE DATA

During the life of the instrumentation, an enormous amount of data has been gathered. As is necessary to show the data in a highly compressed timeline, the visualization would be unclear, and trends could be hidden. To avoid this, is showed one point per day only, corresponding to the 09:00. If there is no record of a point at that time, it is taken the closest one.

ROYAL VICTORIA STATION - PLATFORM

The graphs included in Appendix 1 summarise the instrumentation data for Royal Victoria Station platform.

The graphs sequence is as follows:

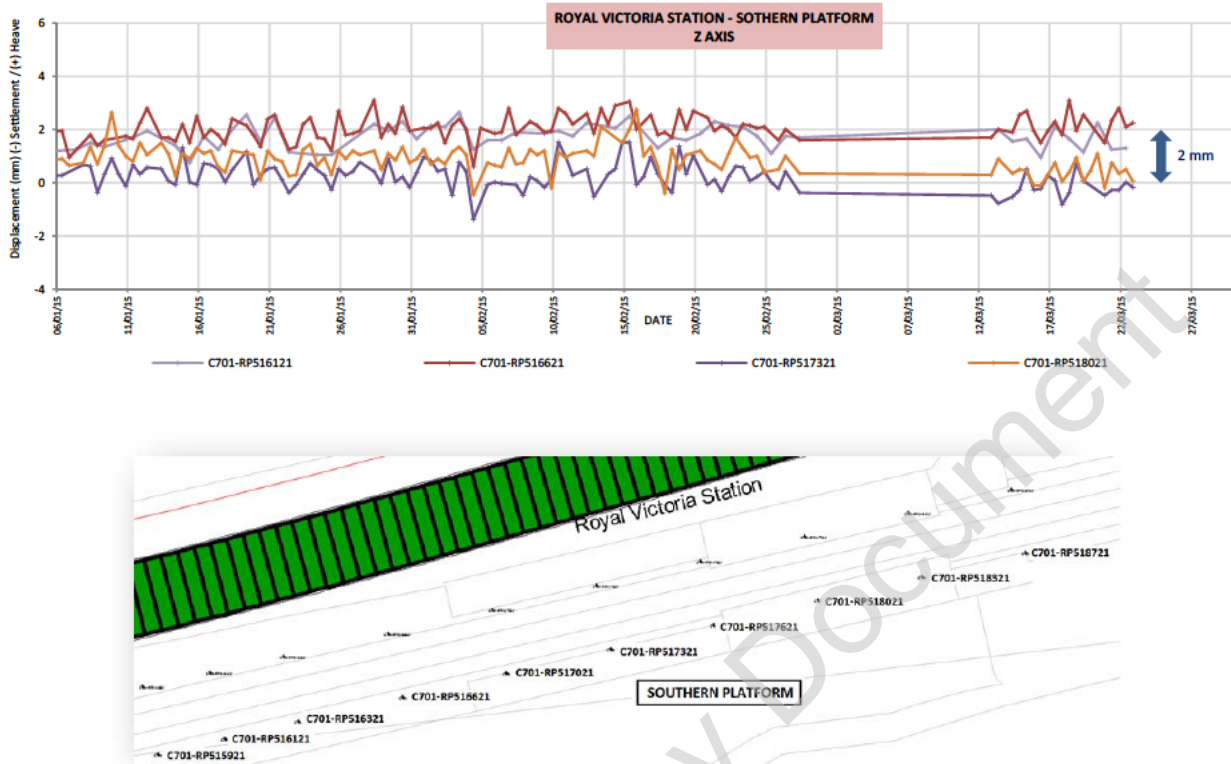
- Time plot in x, y and z, for Southern platform (10 prisms) and time plot in x, y and z for Northern Platform (10 prisms)
- Time plot in z, for each pair of prisms positioned perpendicular to the axis of the DLR track, one located in Southern platform and the second one in Northern platform. The aim of this graph is to show the movement of the platform in the same cross section and on both sides of the DLR track.
- Longitudinal section for the Southern platform and Northern Platform, using monthly readings from June 2014 to March 2015.

Southern Platform:

There is no effect in X and Y axes after the Westbound and Eastbound TBMs passages. A heave of +2 mm is appreciable in Z axis from the Eastbound TBM passage until the beginning of 2015.

The range of movement observed due to the inherent noise in the system can be disregarded. No effect from dewatering is perceptible.

The overall discernible trend in the data shows that settlement has reached steady state following running tunnel construction. This can be seen from the example below that shows the z direction for some of the prisms along the Southern Platform (every 20 meters), from January 2015.



Northern Platform:

Following a review of a platform clearance survey before the tunnelling works, the northern platform was highlighted as potentially having an issue regarding the Platform Train Interface (PTI) a primarily from the WB TBM passage. DLR carried out works before to adjust the coper stones (north platform only) where the PTI was non-compliant and to mitigate the potential effect of the tunnelling works.

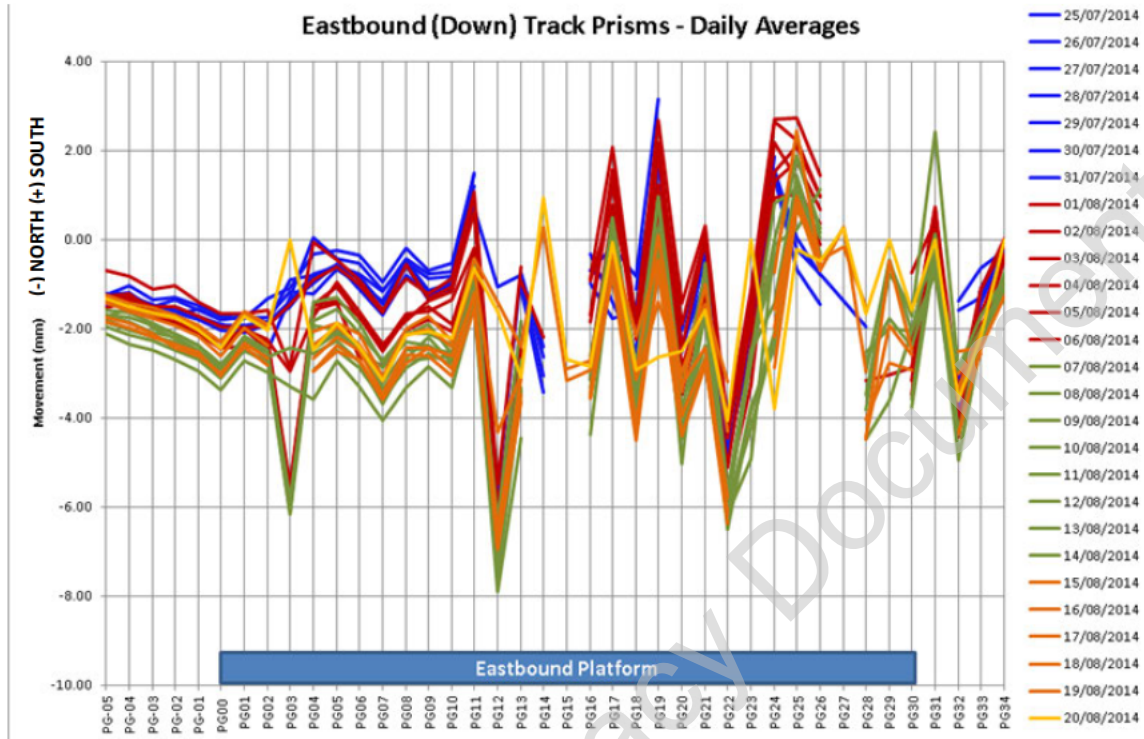
The PTI was monitored during the TBM passage in two ways:

1. C704 prism data to identify trends on the platform edge and the change in cant of the track and therefore potential movement towards the platform.
2. Nightly platform gauge survey's to compare with original survey

C704 Data

In X axis a negative movement of -4mm can be observed in June 2014 and -1 mm after the Eastbound TBM passage. In Y axis there is also a positive movement between +2 and +3 mm after the Westbound TBM passage and +1 mm more after the second TBM (Eastbound), registering a total movement of +4 between June 2014 and January 2015. In Z axis a settlement of -1 mm is observed after Westbound TBM passage and +1 mm heave after the Eastbound.

Looking at the daily averages of the prisms along the length of the platform over the period of the WB passage it shows movement of approx. 1-4mm movement north towards the platform.



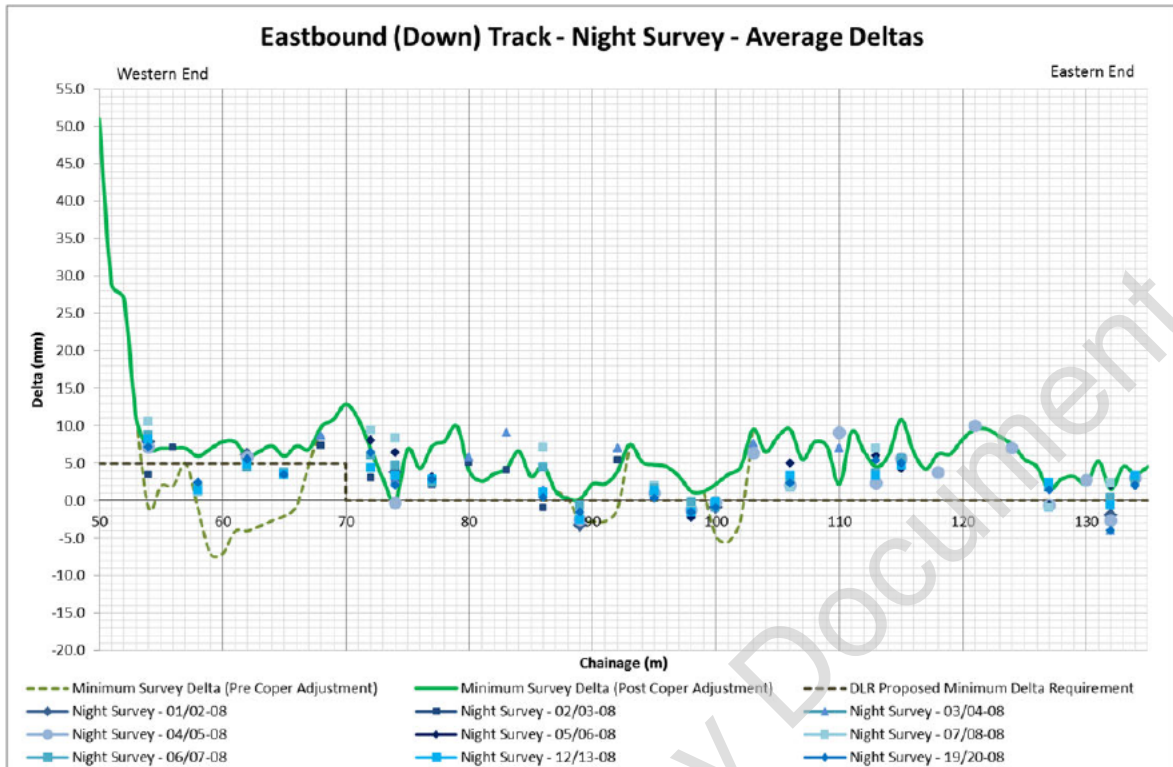
PG	PRISMS	
PG-05	C701-RP515113	C701-RP515114
PG-04	C701-RP515213	C701-RP515214
PG-03	C701-RP515313	C701-RP515314
PG-02	C701-RP515413	C701-RP515414
PG-01	C701-RP515513	C701-RP515514
PG00	C701-RP515613	C701-RP515614
PG01	C701-RP515713	C701-RP515714
PG02	C701-RP515913	C701-RP515914
PG03	C701-RP516013	C701-RP516014
PG04	C701-RP516113	C701-RP516114
PG05	C701-RP516213	C701-RP516214
PG06	C701-RP516313	C701-RP516314
PG07	C701-RP516413	C701-RP516414
PG08	C701-RP516513	C701-RP516514
PG09	C701-RP516613	C701-RP516614
PG10	C701-RP516713	C701-RP516714
PG11	C701-RP516813	C701-RP516814
PG12	C701-RP516913	C701-RP516914
PG13	C701-RP517013	C701-RP517014
PG14	C701-RP517113	C701-RP517114
PG15	C701-RP517213	C701-RP517214
PG16	C701-RP517313	C701-RP517314

PG	PRISMS	
PG17	C701-RP517413	C701-RP517414
PG18	C701-RP517513	C701-RP517514
PG19	C701-RP517613	C701-RP517614
PG20	C701-RP517713	C701-RP517714
PG21	C701-RP517813	C701-RP517814
PG22	C701-RP517913	C701-RP517914
PG23	C701-RP518013	C701-RP518014
PG24	C701-RP518113	C701-RP518114
PG25	C701-RP518213	C701-RP518214
PG26	C701-RP518313	C701-RP518314
PG27	C701-RP518413	C701-RP518414
PG28	C701-RP518513	C701-RP518514
PG29	C701-RP518613	C701-RP518614
PG30	C701-RP518713	C701-RP518714
PG31	C701-RP518813	C701-RP518814
PG32	C701-RP518913	C701-RP518914
PG33	C701-RP519013	C701-RP519014
PG34	C701-RP519113	C701-RP519114

Due the complexity of combining data of different systems, accuracy, geometry and the repeatability of the systems the monitoring data could not be used to directly calculate the PTI. However it does show that there were similar trends on both platform and track.

Manual Platform Gauge Surveys

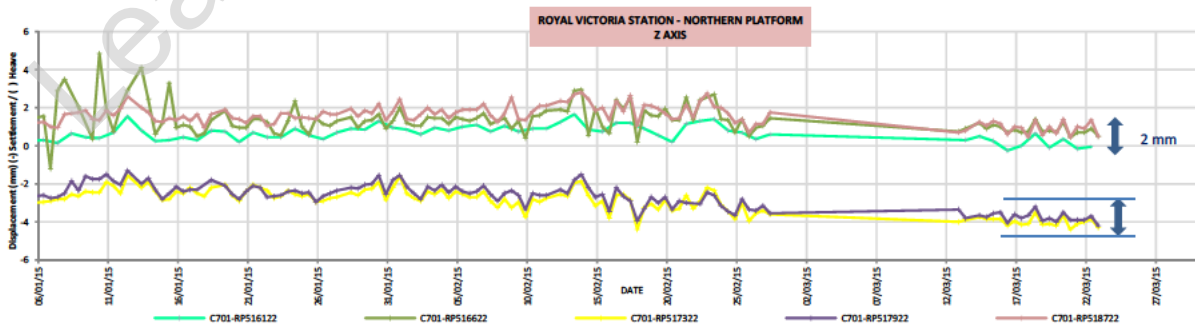
The graph below shows the averages of the 3 readings taken each night during the passage of the Westbound TBM and immediately post passage.

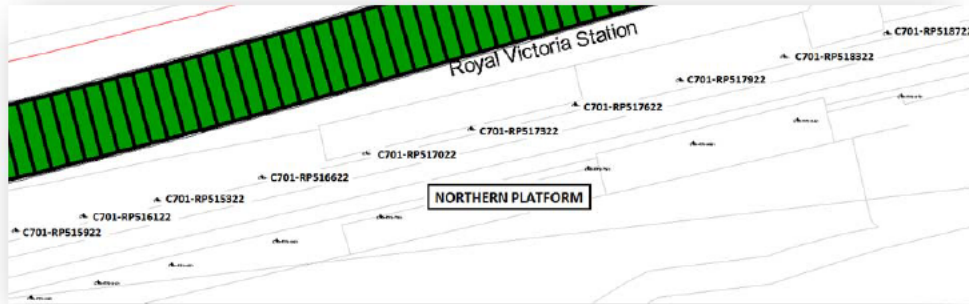


Generally the manual surveys and the C704 data showed similar given the accuracies of the two different systems. The above plots show that the deltas did not exceed the -5mm delta red trigger (once the temporary speed restriction was lifted) and nor did it exceed the worst case position pre-coper adjustments.

There is a range of movement observed due to the inherent noise in the system, which can be disregarded.

The overall discernible trend in the data shows that settlement has reached steady state following running tunnel construction. This can be seen from the example below that shows the z direction for some of the prisms along the Northern Platform (every 20 meters), from January of 2015.





POPLAR BECKTON DLR

The graphs included in Appendix 2 summarise the instrumentation data for Poplar to Beckton tracks at Royal Victoria Station. They comprise measures from June 2014 to March 2015.

There are 202 prisms installed in this area. To avoid the excess of data and difficulty to discern trends in the plots prisms have been taken every 15 meters to represent the behaviour of the tracks.



The picture above and the list below show the cross sections and the prisms in the graphs of Appendix 2:

CROSS SECTION	UP LEFT	UP RIGTH	DOWN RIGHT	DOWN LEFT
1	C701-RP515111	C701-RP515112	C701-RP515113	C701-RP515114
2	C701-RP515511	C701-RP515512	C701-RP515513	C701-RP515514
3	C701-RP515911	C701-RP515912	C701-RP515913	C701-RP515914
4	C701-RP516311	C701-RP516312	C701-RP516313	C701-RP516314
5	C701-RP516711	C701-RP516712	C701-RP516713	C701-RP516714
6	C701-RP517111	C701-RP517112	C701-RP517113	C701-RP517114
7	C701-RP517511	C701-RP517512	C701-RP517513	C701-RP517514
8	C701-RP517911	C701-RP517912	C701-RP517913	C701-RP517914
9	C701-RP518311	C701-RP518312	C701-RP518313	C701-RP518314
10	C701-RP518811	C701-RP518812	C701-RP518813	C701-RP518814
11	C701-RP519211	C701-RP519212	C701-RP519213	C701-RP519214
12	C701-RP519711	C701-RP519712	C701-RP519713	C701-RP519714

The graphs sequence is as follows:

- Time plot in x, y and z, for Poplar Beckton DLR Up Left. C701-RP515111 to C701-RP520111
- Time plot in x, y and z, for Poplar Beckton DLR Up Right. C701-RP515112 to C701-RP520112
- Time plot in x, y and z, for Poplar Beckton DLR Down Right. C701-RP515113 to C701-RP520113
- Time plot in x, y and z, for Poplar Beckton DLR Down Left. C701-RP515114 to C701-RP520114

POP BEC UP LEFT C701-RP515111 TO C701-RP520111:

Forty-nine prisms located in the cess area of the track Poplar Beckton Up are included in this report, from C701-RP515111 to C701-RP520111. The readings are taken by two different Robotic Total Stations (RTS24 and VDP25).

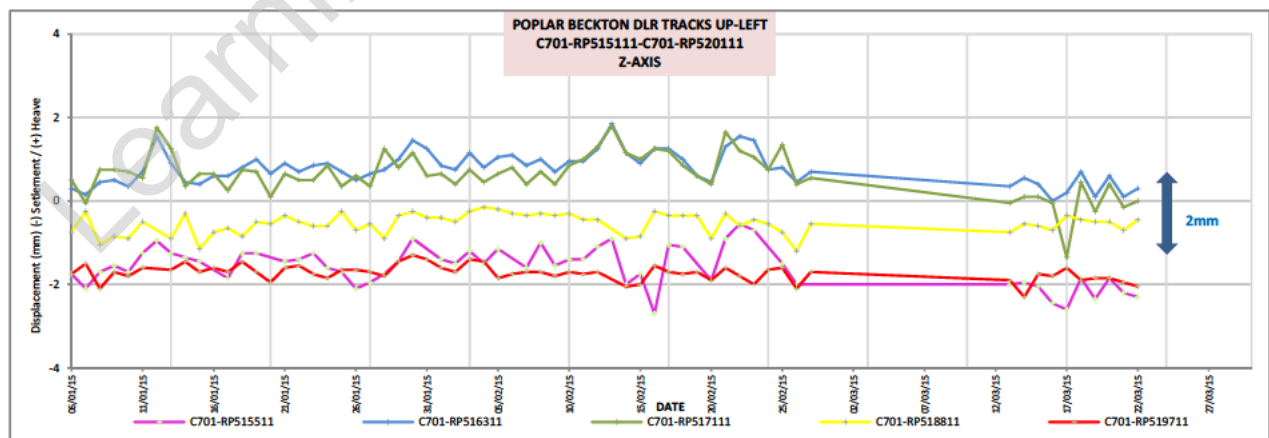
Readings in X axis are spiky and do not show displacements due to the TBMs passages.

Some prisms, such as C701-RP515911, have an unexplained behaviour being out of range.

As in the previous axis, readings in Y are spiky and two different trends for the prisms are appreciable. Some of them have a positive movement of +2mm after the first TBM passage, whereas the rest of the prisms remain stable.

In Z axis no effect is observed due to the TBMs.

There is a range of movement observed due to the inherent noise in the system, which can be disregarded. The overall discernible trend in the data shows that settlement has reached steady state following running tunnel construction. This can be seen from the example below that shows the z direction for some of the prisms along cess area of the track Poplar Beckton Up (every 30 meters), from January of 2015.



POP BEC UP RIGHT C701-RP515112 TO C701-RP520112:

Fifty-one prisms located in the six foot area of the track Poplar Beckton Up are included in this report, from C701-RP515112 to C701-RP520112. The readings are taken by two different Robotic Total Stations (RTS24 and VDP25).

Readings in X axis are spiky and do not show displacements due to the TBMs passages.

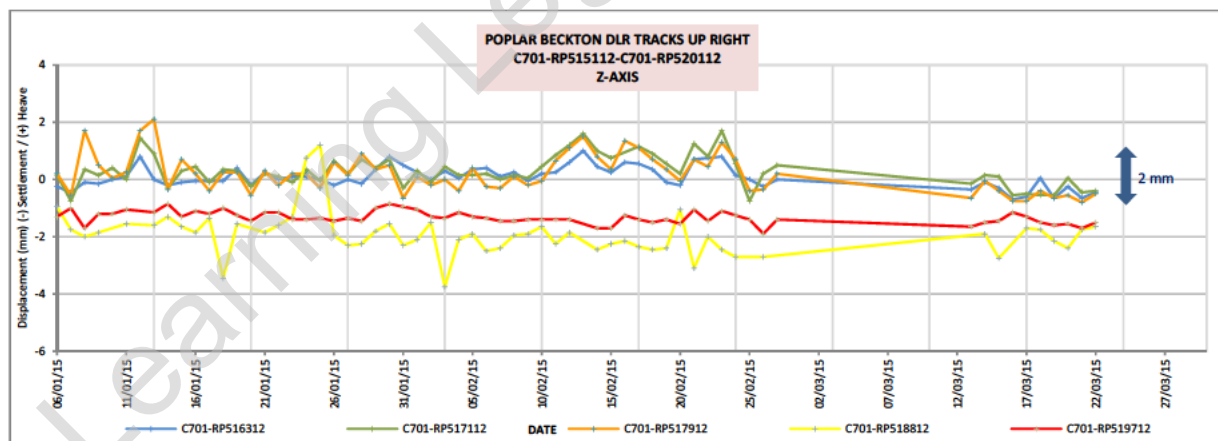
Some prisms, such as C701-RP515912, have an unexplained behaviour being out of range.

As in the previous axis, readings in Y are spiky and two different trends are appreciable. A continuous positive movement can be observed from the first TBM passage to February 2015.

The readings in X and Y axes are stable.

In Z axis there is a -1mm settlement before the Eastbound TBM passage an +1mm heave after it. The readings have a settlement of -1 mm in the last month.

There is a range of movement observed due to the inherent noise in the system, which can be disregarded. The overall discernible trend in the data shows that settlement has reached steady state following running tunnel construction. This can be seen from the example below that shows the z direction for some of the prisms along 6foot area of the track Poplar Beckton Up (every 30 meters), from January of 2015.



POP BEC DOWN RIGHT C701-RP515113 TO C701-RP520113:

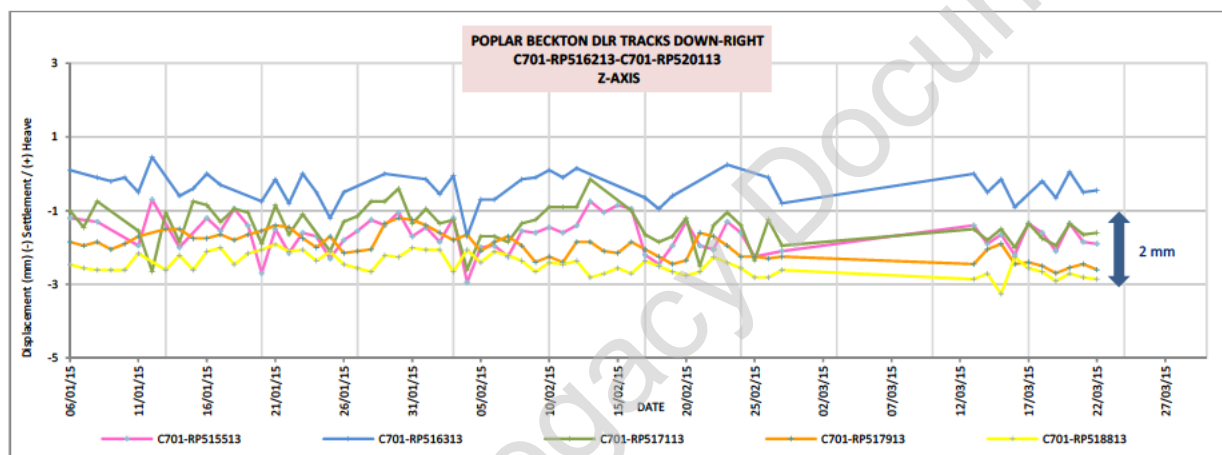
Fifty-one prisms located in the six foot area of the track Poplar Beckton down are included in this report, from C701-RP515113 to C701-RP520113. The readings are taken by two different Robotic Total Stations (RTS23 and VDP25).

Readings in X and Y axes are spiky and do not show displacements due to the TBMs passages.

Some prisms, such as C701-RP518813 and C701-RP515913, have an unexplained behaviour being out of range.

In Z axis there is a -1mm settlement before the Eastbound TBM passage a +1mm heave after it.

There is a range of movement observed due to the inherent noise in the system, which can be disregarded. The overall discernible trend in the data shows that settlement has reached steady state following running tunnel construction. This can be seen from the example below that shows the z direction for some of the prisms along 6foot area of the track Poplar Beckton Down (every 30 meters), from January of 2015.

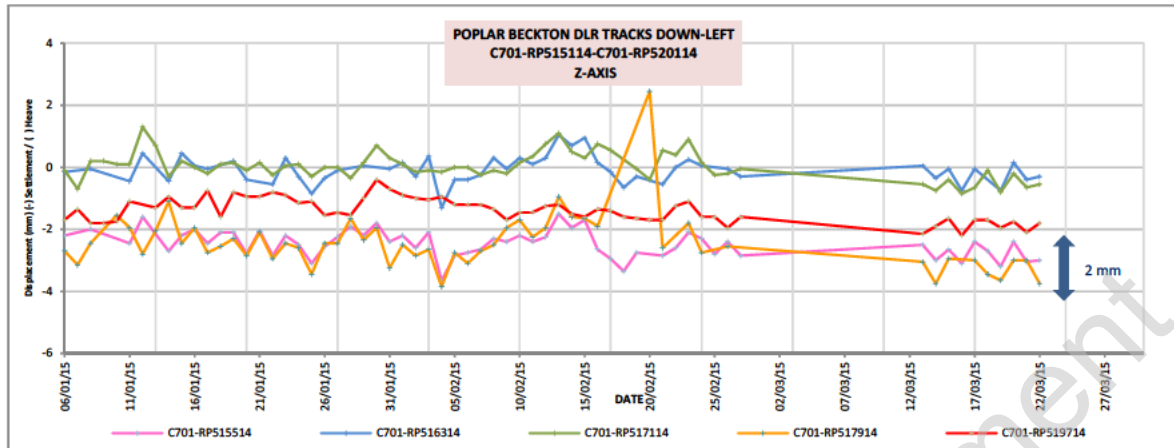


POP BEC DOWN LEFT C701-RP515114 TO C701-RP520114:

Fifty-one prisms located in the cess area of the track Poplar Beckton down are included in this report, from C701-RP515114 to C701-RP520114. The readings are taken by two different Robotic Total Stations (RTS23 and VDP25).

Readings in X and Y axes are spiky and do not show displacements due to the TBMs passages. Some prisms have an unexplained behaviour being out of range.

In Z axis no effect is observed during and post TBMs.



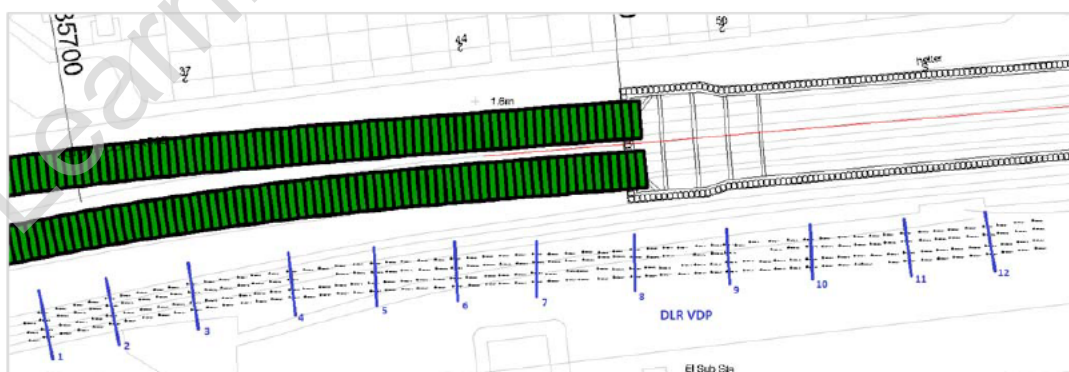
There is a range of movement observed due to the inherent noise in the system, which can be disregarded. The overall discernible trend in the data shows that settlement has reached steady state following running tunnel construction. This can be seen from the example below that shows the z direction for some of the prisms along cess area of the track Poplar Beckton Down (every 30 meters), from January of 2015.

VICTORIA DOCK PORTAL DLR

This section discusses movement during and post TBM passage and the following section (Ground Treatment Area) discusses movement due to works prior to the TBM passage.

The graphs included in Appendix 3 summarise the instrumentation data for Victoria Dock Portal DLR tracks from Royal Victoria Station to Victoria Dock Portal headwall. They comprise measures from June 2014 to March 2015.

There are 243 prisms installed in this area. To avoid the excess of data and difficulty to discern trends in the plots prisms have been taken every 15 meters to represent the behaviour of the tracks.



The picture above and the list below show the cross sections and the prisms in the graphs of Appendix 3:

CROSS SECTION	UP LEFT	UP RIGTH	DOWN RIGHT	DOWN LEFT
1	C701-RP800211	C701-RP800212	C701-RP800213	C701-RP800214
2	C701-RP800611	C701-RP800612	C701-RP800613	C701-RP800614
3	C701-RP801111	C701-RP801112	C701-RP801113	C701-RP801114
4	C701-RP801711	C701-RP801712	C701-RP801713	C701-RP801714
5	C701-RP802111	C701-RP802112	C701-RP802113	C701-RP802114
6	C701-RP802711	C701-RP802712	C701-RP802713	C701-RP802714
7	C701-RP803211	C701-RP803212	C701-RP803213	C701-RP803214
8	C701-RP803811	C701-RP803812	C701-RP803813	C701-RP803814
9	C701-RP804411	C701-RP804412	C701-RP804413	C701-RP804414
10	C701-RP804911	C701-RP804912	C701-RP804913	C701-RP804914
11	C701-RP805511	C701-RP805512	C701-RP805513	C701-RP805514
12	C701-RP806011	C701-RP806012	C701-RP806013	C701-RP806014

The graphs sequence is as follows:

- Time plot in x, y and z, for Victoria Dock Portal DLR Up Left. C701-RP800111 to C701-RP806211
- Time plot in x, y and z, for Victoria Dock Portal DLR Up Right. C701-RP800112 to C701-RP806212
- Time plot in x, y and z, for Victoria Dock Portal DLR Down Right. C701-RP800113 to C701-RP806213
- Time plot in x, y and z, for Victoria Dock Portal DLR Down Left. C701-RP800114 to C701-RP806214

VDP UP LEFT C701-RP800111 TO C701-RP806211:

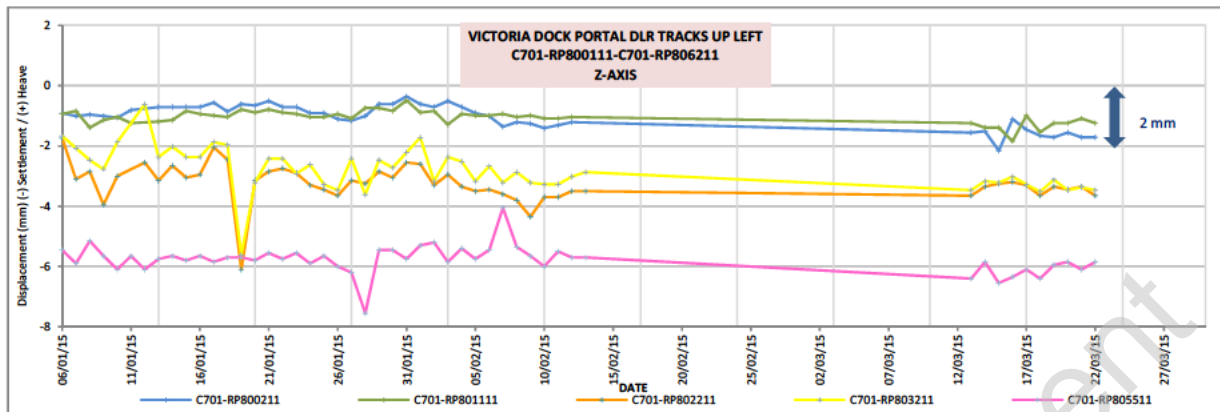
Sixty-three prisms located in the cess area of the track Victoria Dock Portal Up are included in this report, from C701-RP800111 to C701-RP806211.

Readings in X show a negative movement of -2 mm after the Westbound TMB passage. No movement after the second TBM.

The Y axis shows a heave of 2 mm after the Westbound TBM and no effect after the second TBM.

In Z axis no effect is observed due to the TBMs.

There is a range of movement observed due to the inherent noise in the system, which can be disregarded. The overall discernible trend in the data shows that settlement has reached steady state following running tunnel construction. This can be seen from the example below that shows the z direction for some of the prisms along cess area of the track VDP Up (every 30 meters), from January of 2015.



VDP UP RIGHT C701-RP800112 TO C701-RP806212:

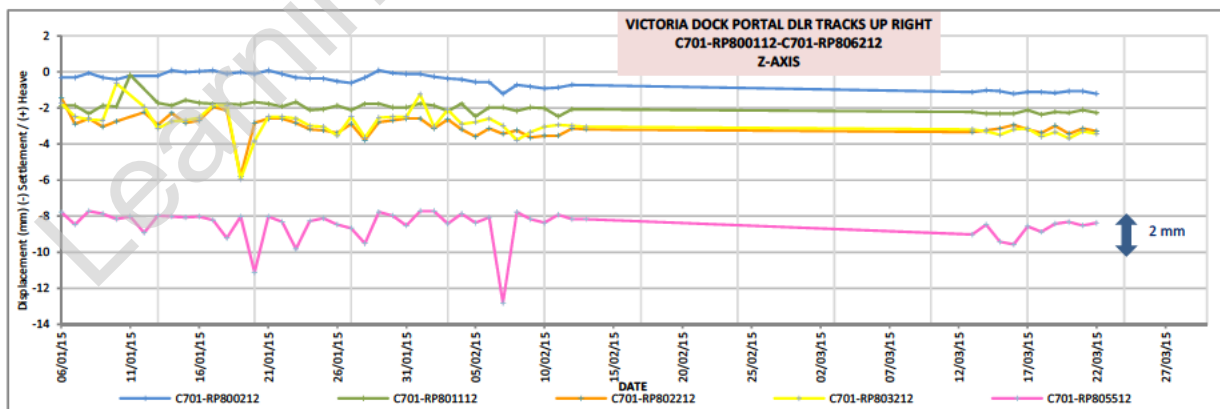
Sixty-three prisms located in the six foot area of the track Victoria Dock Portal Up are included in this report, from C701-RP800112 to C701-RP806212.

Readings in X show a negative movement of -2 mm between the two TMB passages. A movement of -4 mm is observed from November 2014 to February 2015.

The Y axis shows a positive movement of +2 mm after the Westbound TBM and no effect after the second TBM.

In Z axis no effect is observed due to the TBMs.

There is a range of movement observed due to the inherent noise in the system, which can be disregarded. The overall discernible trend in the data shows that settlement has reached steady state following running tunnel construction. This can be seen from the example below that shows the z direction for some of the prisms along 6foot area of the track VDP Up (every 30 meters), from January of 2015.



VDP DOWN RIGHT C701-RP800113 TO C701-RP806213:

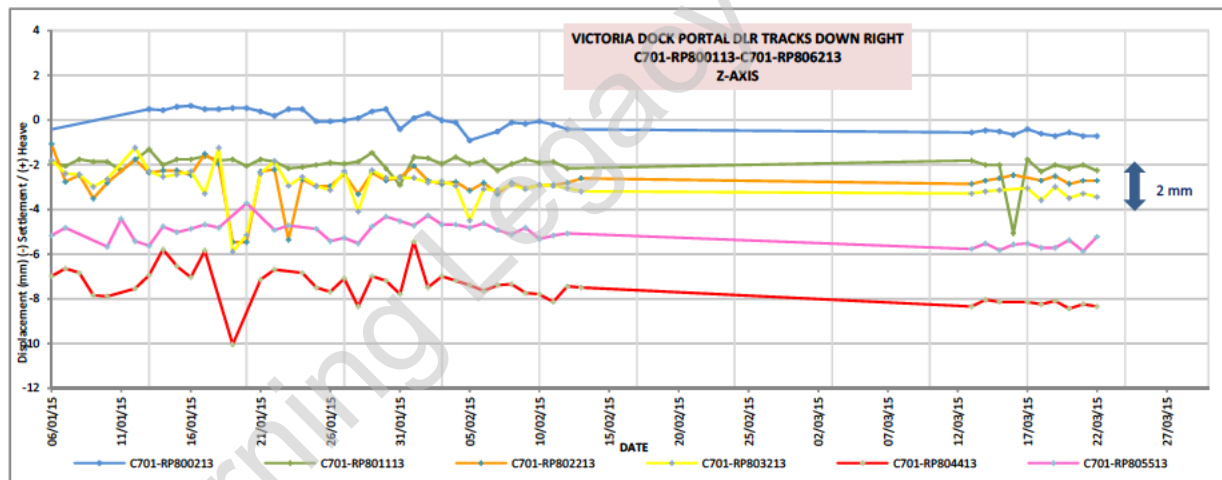
Fifty-eight prisms located in the cess area of the track Victoria Dock Portal Down are included in this report, from C701-RP800113 to C701-RP806213.

Readings in X show a negative movement of -4 mm in some of the prisms after the Westbound TBM passage whereas the rest remains stable. No movement due to second TMB passages. Some prisms have an unexplained behaviour being out of range

The Y axis shows a positive movement of +2 mm after the Westbound TBM and no effect after the second TBM.

In Z axis no effect is observed due to the TBMs.

There is a range of movement observed due to the inherent noise in the system, which can be disregarded. The overall discernible trend in the data shows that settlement has reached steady state following running tunnel construction. This can be seen from the example below that shows the z direction for some of the prisms along 6foot area of the track VDP Down (every 30 meters), from January of 2015.



VDP DOWN LEFT C701-RP800214 TO C701-RP806214:

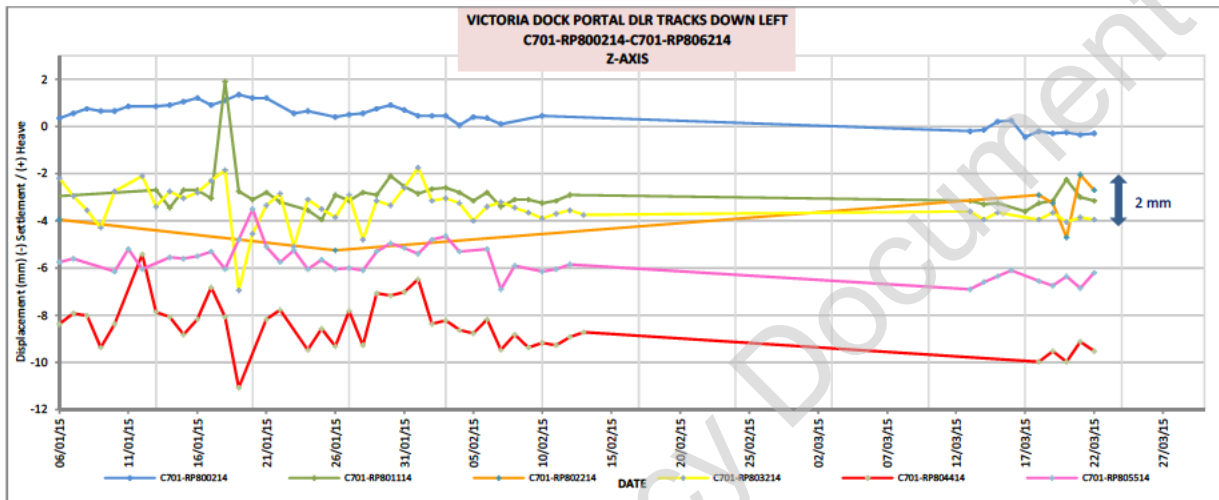
Sixty-two prisms located in the six foot area of the track Victoria Dock Portal Down are included in this report, from C701-RP800214 to C701-RP806214.

Readings in X show a negative movement of -4 mm in some of the prisms after the Westbound TBM passage whereas the rest remains stable. No movement due to second TMB passages. Some prisms have an unexplained behaviour being out of range

The Y axis shows a positive movement of +2 mm after the Westbound TBM and no effect after the second TBM.

In Z axis no effect is observed due to the TBMs.

There is a range of movement observed due to the inherent noise in the system, which can be disregarded. The overall discernible trend in the data shows that settlement has reached steady state following running tunnel construction. This can be seen from the example below that shows the z direction for some of the prisms along cess area of the track VDP Down (every 30 meters), from January of 2015.



GROUND TREATMENT AREA

The area which has received ground treatment is located between Victoria Dock Portal headwall and the beginning of Royal Victoria Station platform. The treatments include micropiling, grouting trial, TAM drilling, grouting and soil mixing. The graphs included in Appendix 4 comprise measures from October 2013 to March 2015.

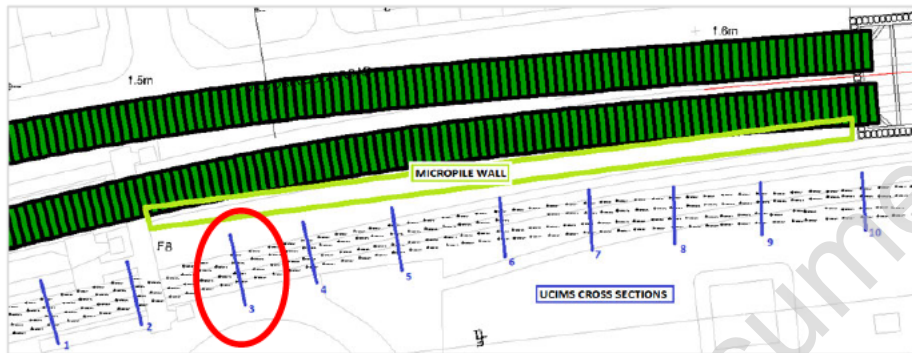
The data for the key activities before June 2014, as the installation of the micropile wall parallel to the DLR tracks, have been gathered from the Underground Construction Information Management System (UCIMS).

Prisms have been taken every 15 meters to represent the behaviour of the during ground treatment works.

The list below contains the prisms whose UCIMS graphs are included in the Appendix 4, as well as a sketch of the location of the cross sections:

	1	3	5	7	9
UP LEFT	C701-RP519211	C701-RP800211	C701-RP801111	C701-RP802211	C701-RP803211
UP RIGHT	C701-RP519212	C701-RP800212	C701-RP801112	C701-RP802212	C701-RP803212
DOWN RIGHT	C701-RP519213	C701-RP800213	C701-RP801113	C701-RP802213	C701-RP803213
DOWN LEFT	C701-RP519214	C701-RP800214	C701-RP801114	C701-RP802214	C701-RP803214

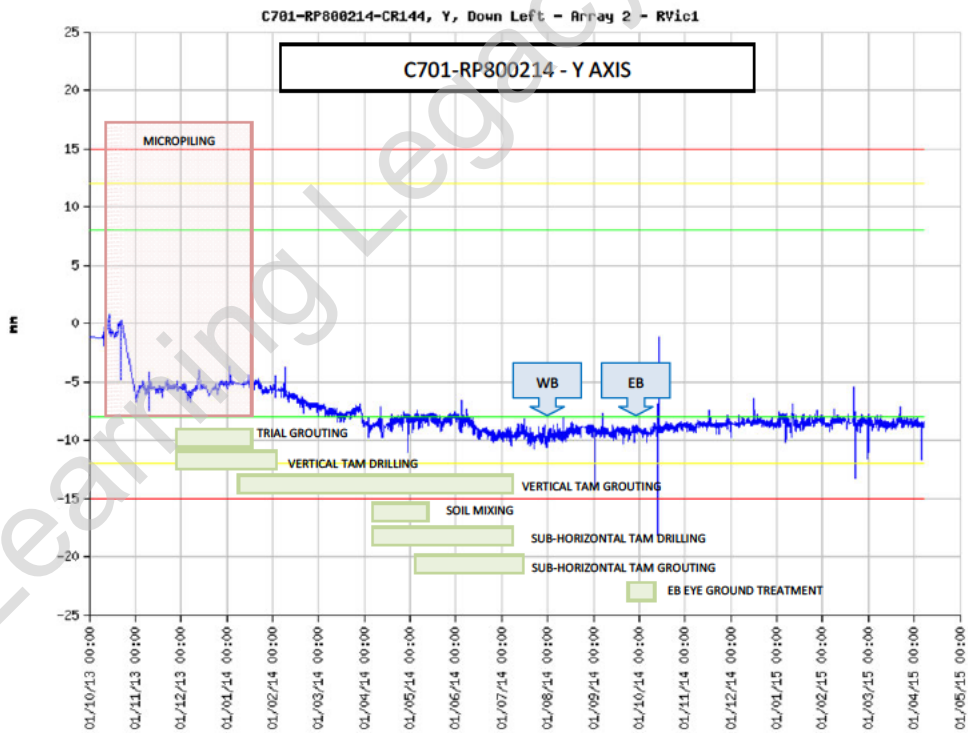
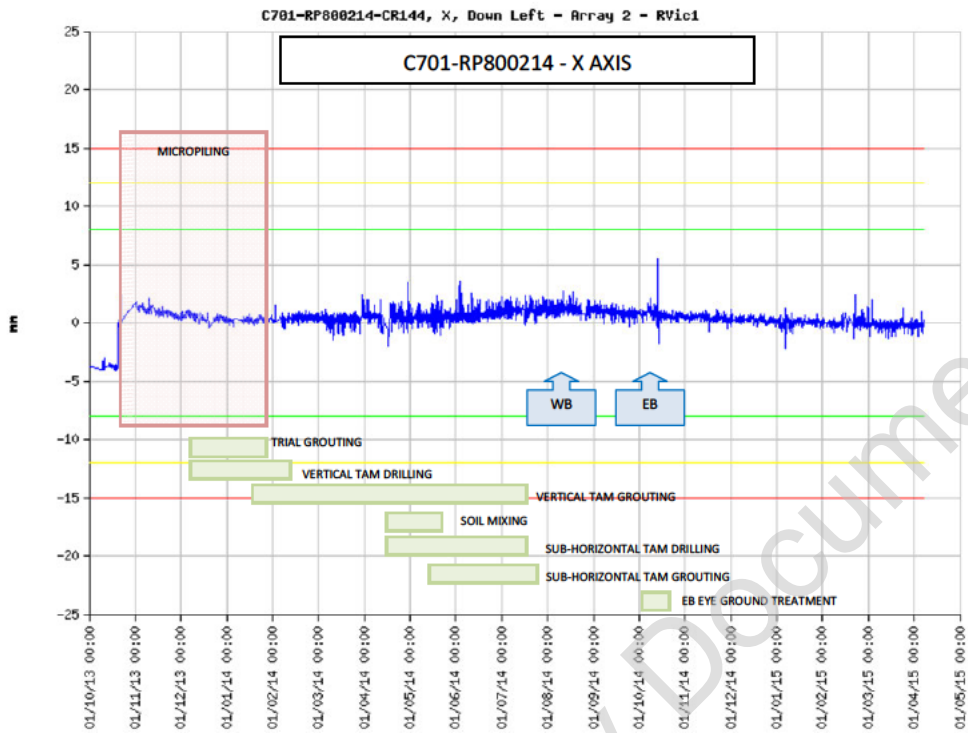
	2	4	6	8	10
UP LEFT	C701-RP519711	C701-RP800611	C701-RP801711	C701-RP802711	C701-RP803811
UP RIGHT	C701-RP519712	C701-RP800612	C701-RP801712	C701-RP802712	C701-RP803812
DOWN RIGHT	C701-RP519713	C701-RP800613	C701-RP801713	C701-RP802713	C701-RP803813
DOWN LEFT	C701-RP519714	C701-RP800614	C701-RP801714	C701-RP802714	C701-RP803814

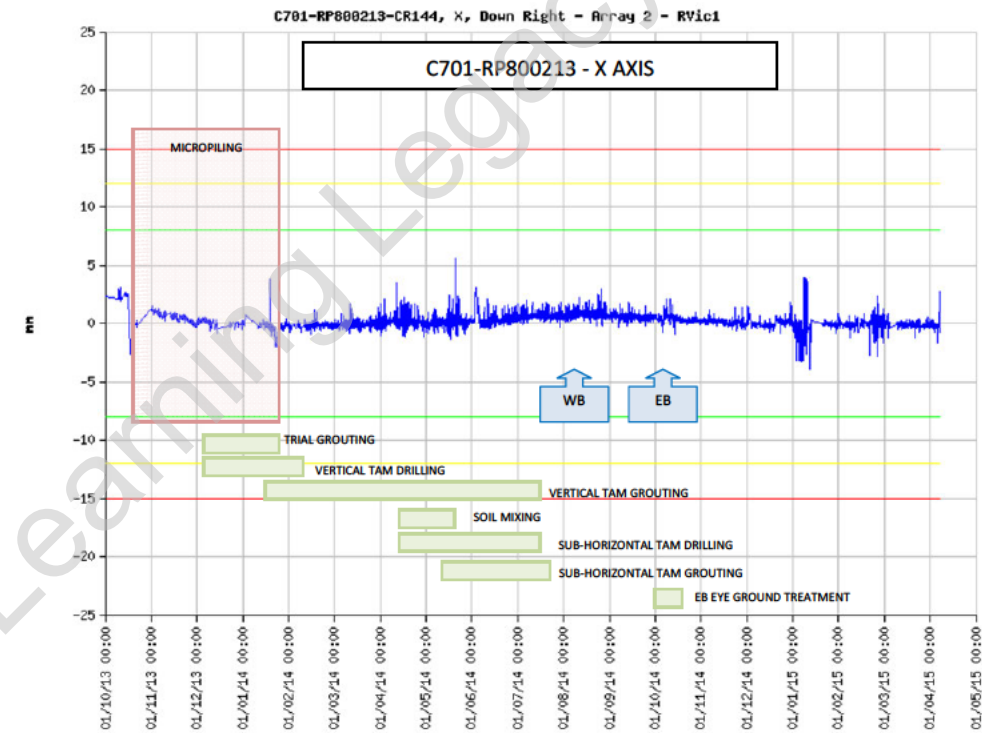
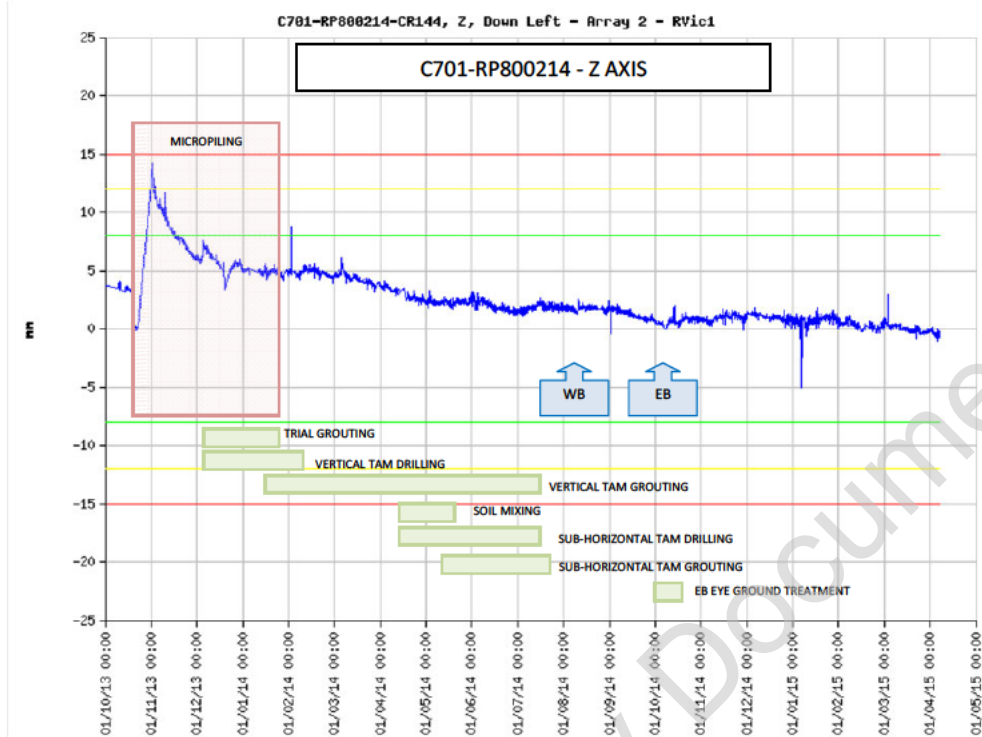


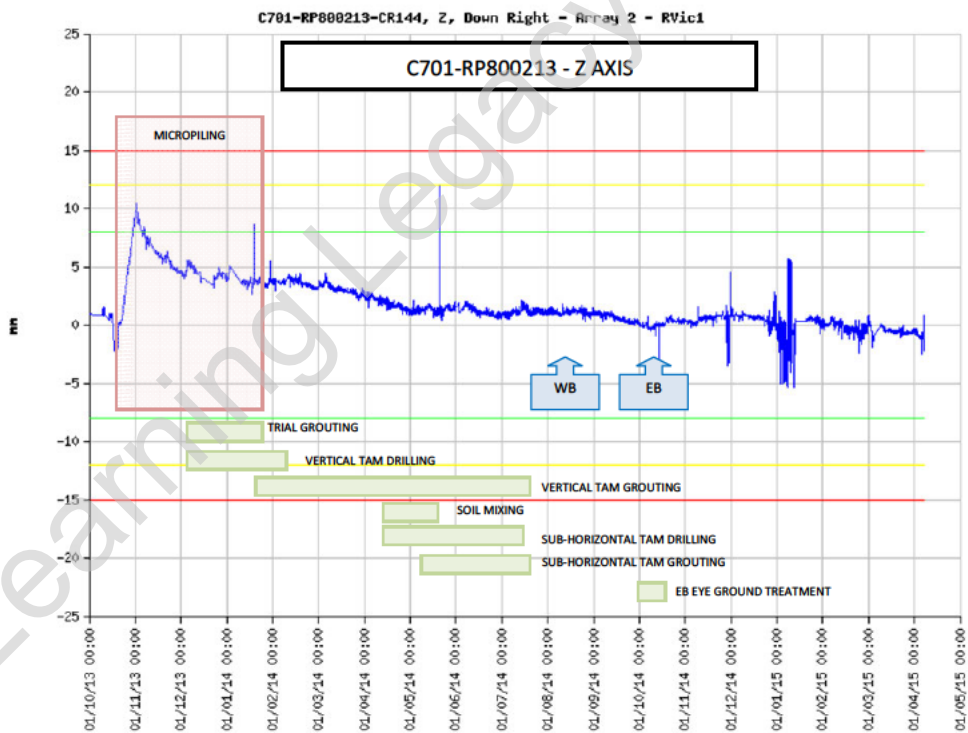
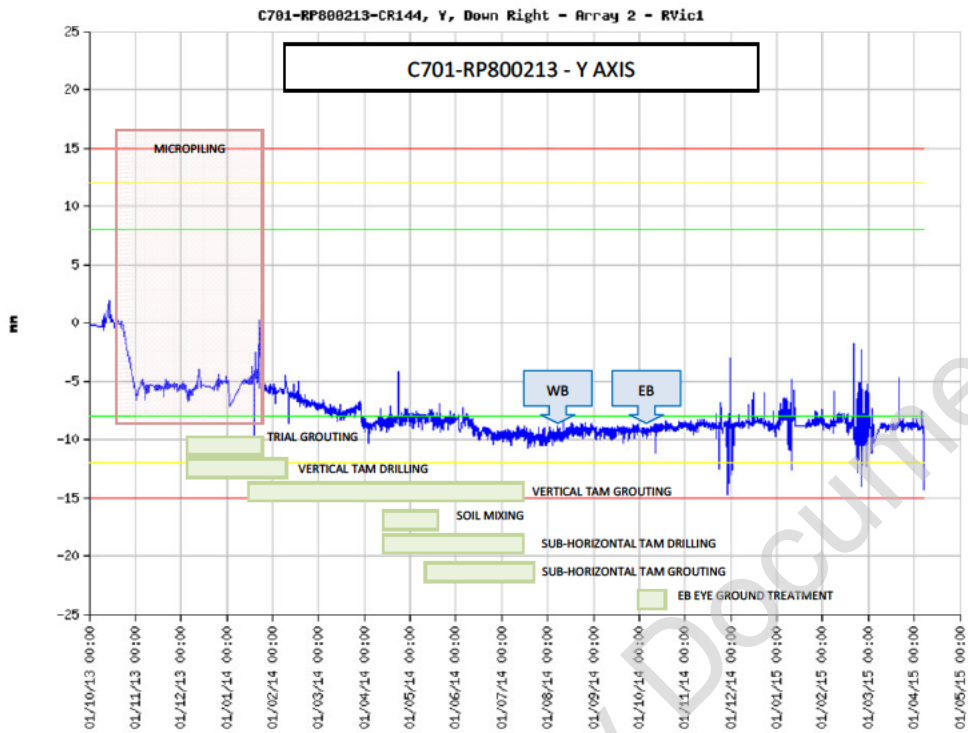
Graphs below show the X, Y and Z direction of the prisms in the cross section 3 (C701-RP800214, C701-RP800213, C701-RP800212 and C701-RP800211), circled in red above.

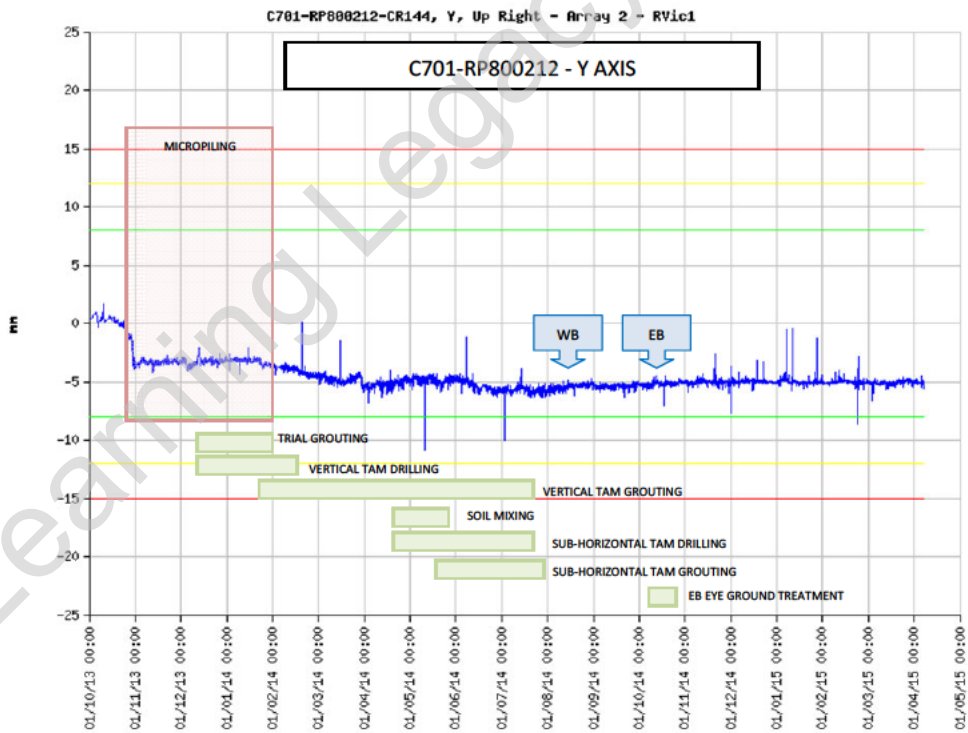
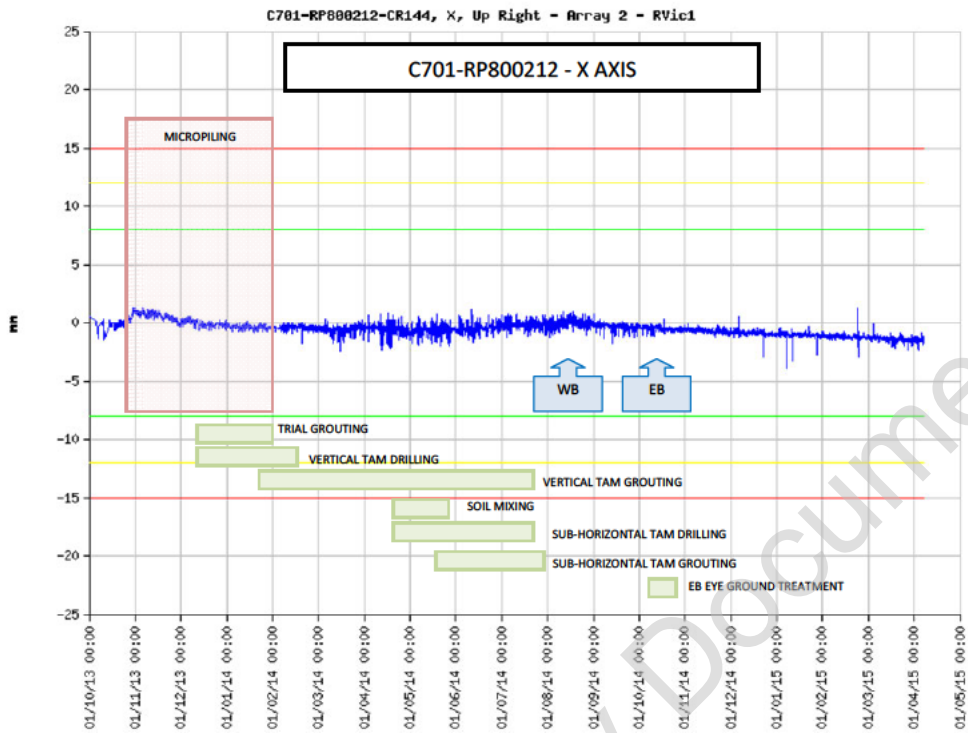
One of the prisms C701-RP800214 (close to the wall) shows a heave of +15 mm reaching the amber threshold in October/November 2013. This heave decreases until +5 mm for the furthest prism in the same cross section. In X axis there is a +5 mm movement at the beginning of the works and no more important movements are seen. In Y axis it is seen a movement of -5 mm due to the micropiling works.

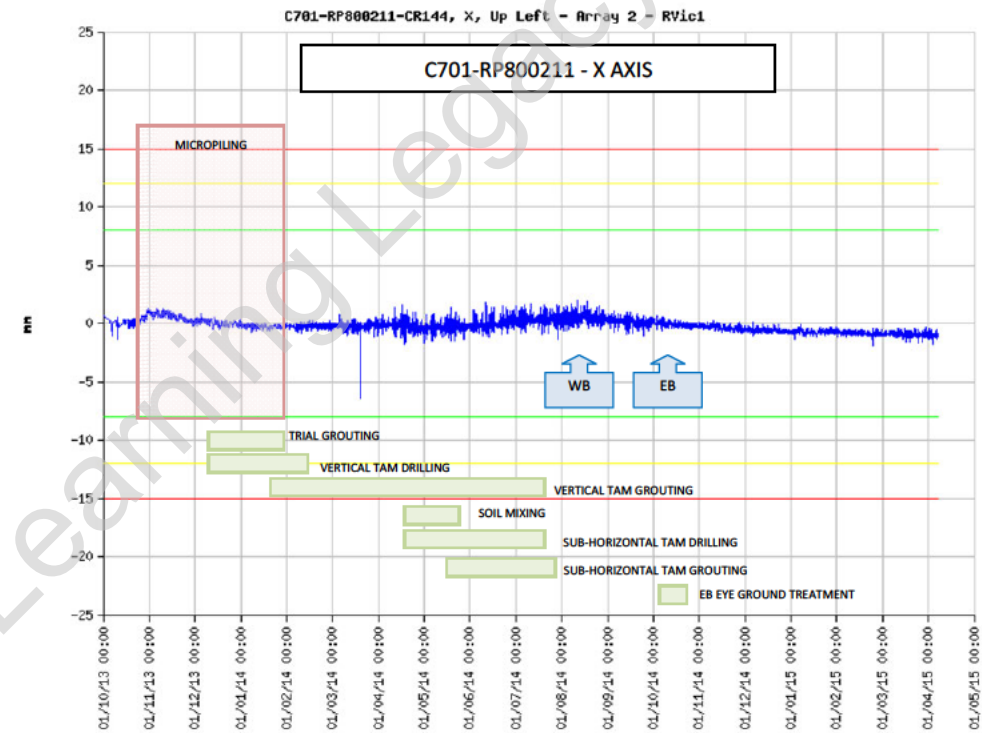
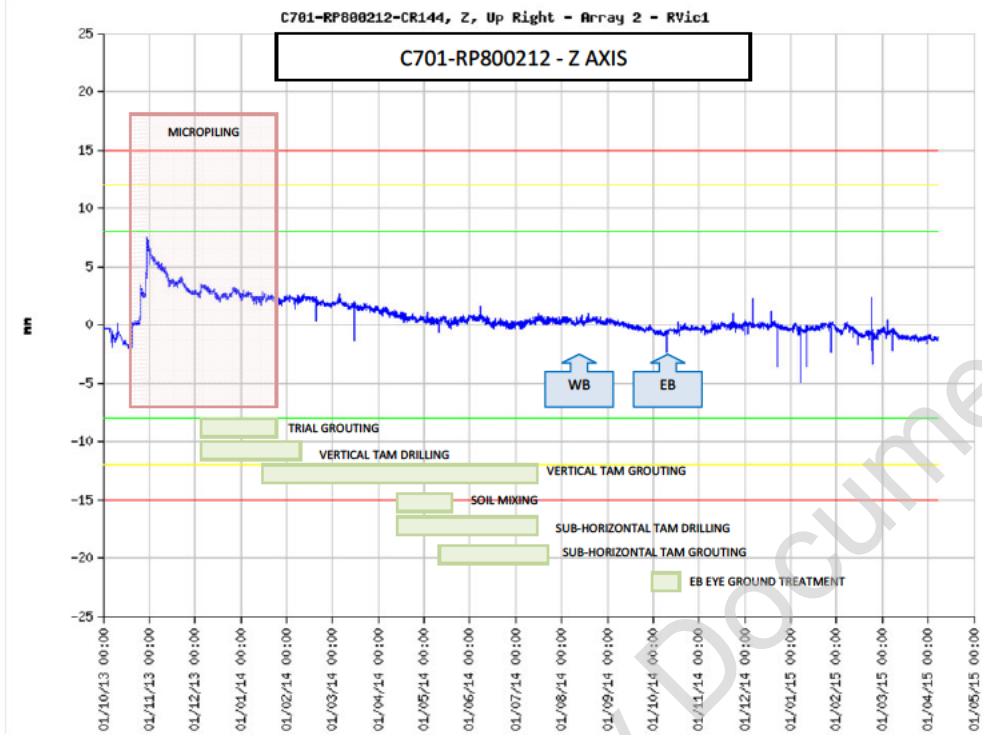
The heave movement and part of the next settle is due to micropiling. As seen in the graphs below, after micropiling there was not much movement, only horizontal, which was potentially due to ground treatment. However there was no corresponding vertical movement. There is also a seasonal trend on the X direction.

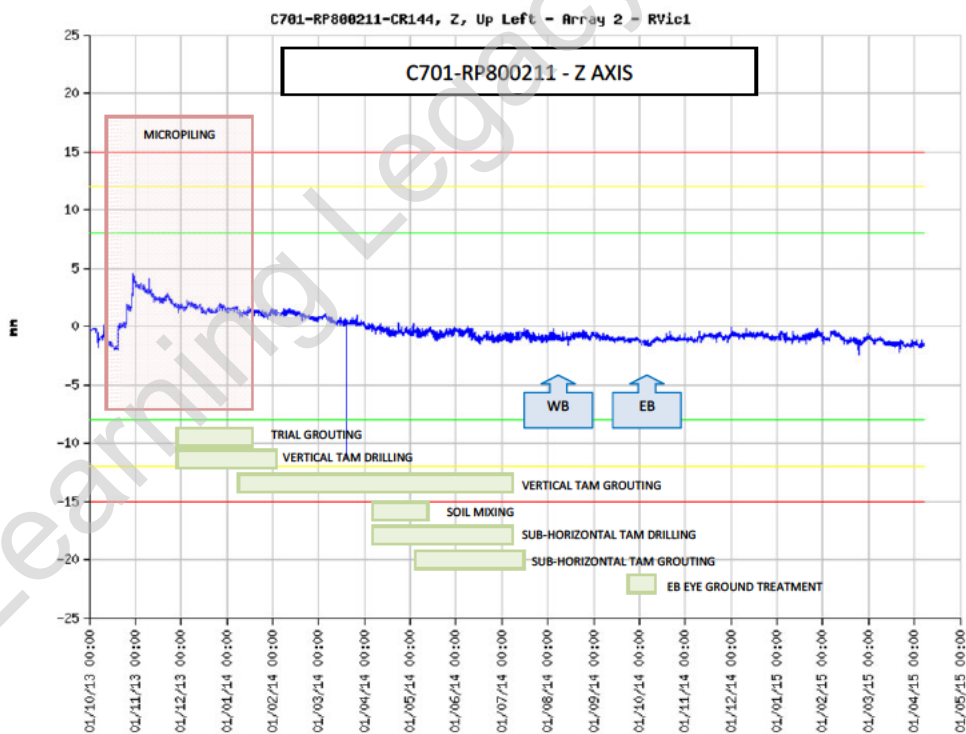
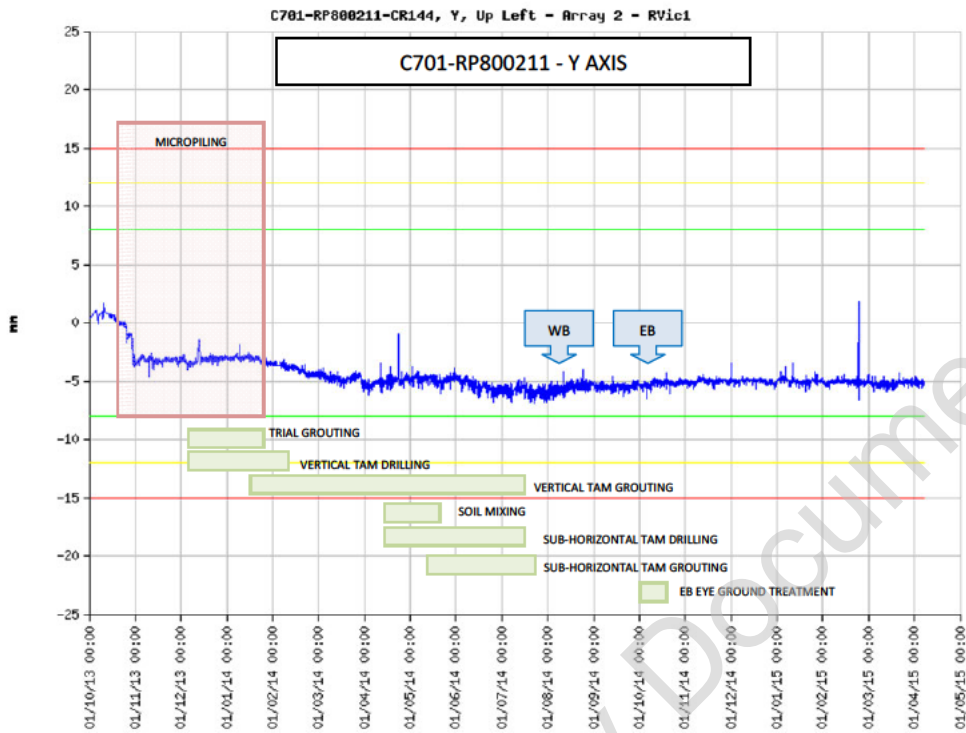












Concerning X axis of the rest of the section, there are small movements (± 1 mm) at the start of the micropiling works, which stop with the end of these (see Appendix 4).

Relating to Y axis in the rest of the section, there are quick movements between -3 and -6 mm, coinciding with the micropiling works. After that, the prisms gather slow negative movements, reaching maximum movements of -11 mm for C701-RP800213 and -6 mm for the rest. After that, the measures keep stable in the given range, as seen in Appendix 4.

The lateral extent of this movement is reduced and it dissipates away from the central point (C701-RP800214) eastwards and westwards. The readings taken from C701-RP519714 and C701-RP800614 show very little movements, as it is shown in Appendix 4.

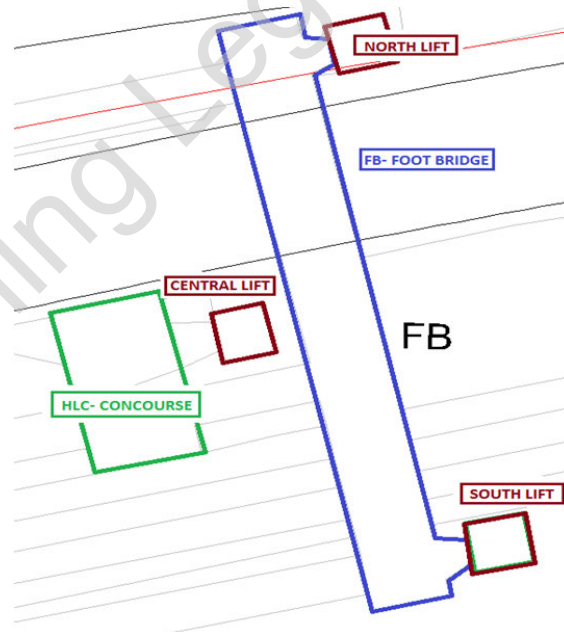
The C701/C704 system has had numerous issues over the duration of the works since installation. Therefore there are movements shown in the data not related to the works that are not explained in this report. As trends have been used to determine the behaviour of movement this does not affect the conclusions drawn in this report.

FOOT BRIDGE STRUCTURE ROYAL VICTORIA STATION (C701)

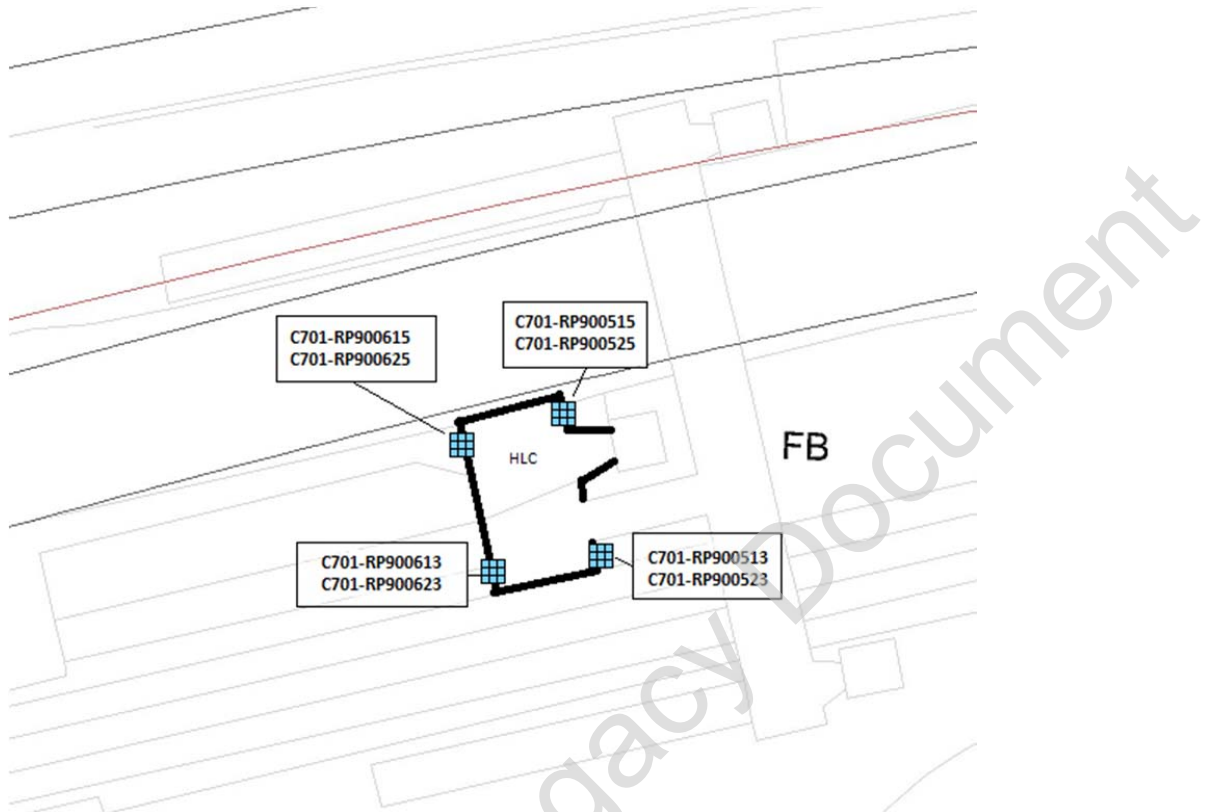
Thirty-three prisms from C701 are located on the foot bridge structure in Royal Victoria Station.

The graphs of the automatic readings for these prisms are included in the Appendix 5, as well as the manual readings taken by the C305 contract as verification.

The sketch below shows the location of the different parts of the structure.



HLC- High Level Concourse:



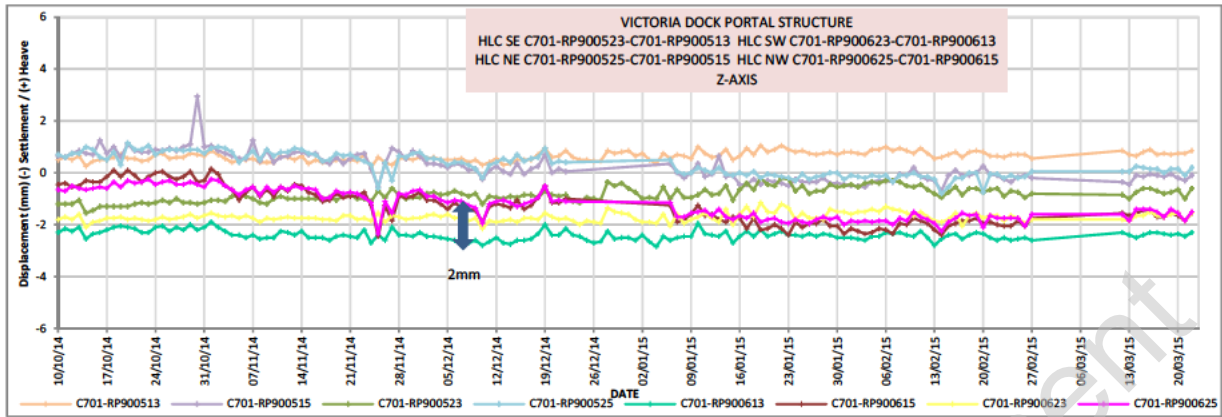
Readings in X show a small movement around ± 1 mm for ground treatment and a negative movement of -1 mm after the Westbound TBM passage and -1mm after the Eastbound.

Readings in Y show a movement for ground treatment of +3/-4 mm, and a positive movement of +1 mm after the Westbound TBM passage and +1mm after the Eastbound

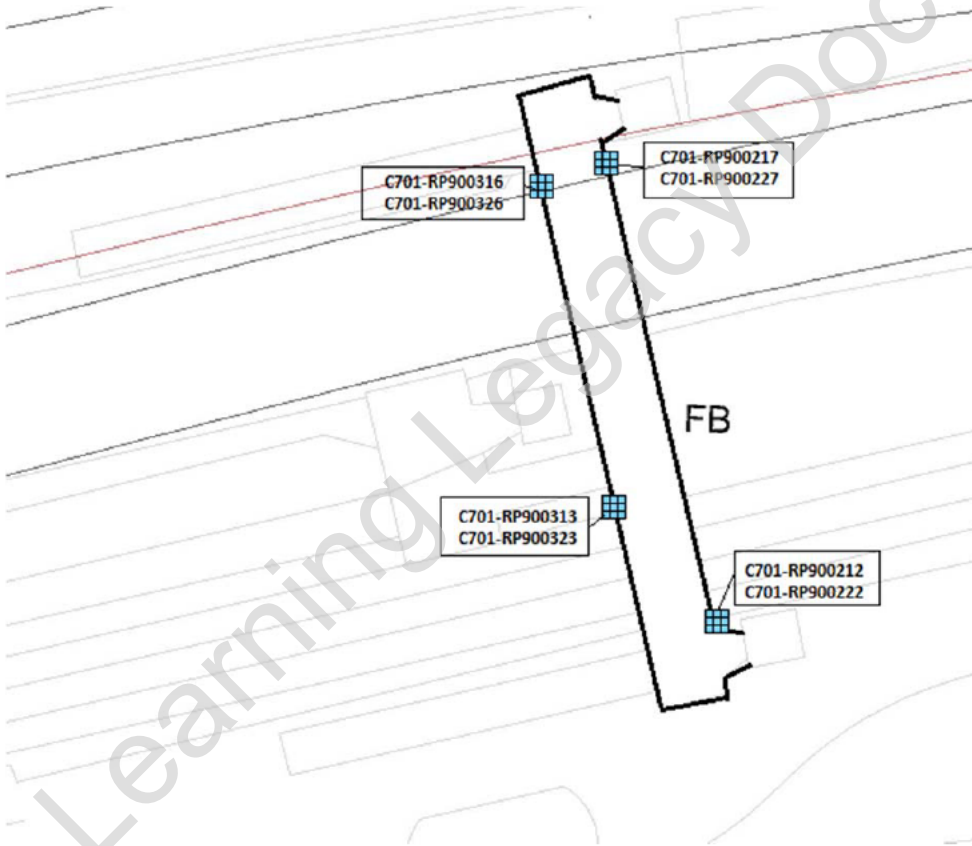
In Z axis a +3 mm heave can be observed after the Westbound TBM passage and no effect after the second TBM.

There are also several spikes in all axes during the ground treatment works among June and July 2014.

The overall discernible trend in the data shows that settlement has reached steady state following running tunnel construction. This can be seen from the example below that shows the z direction for the prisms along concourse, from January of 2015.



Foot bridge:



Readings in X show a seasonal trend and a negative movement of -2 mm after the Eastbound TBM passage until February 2015.

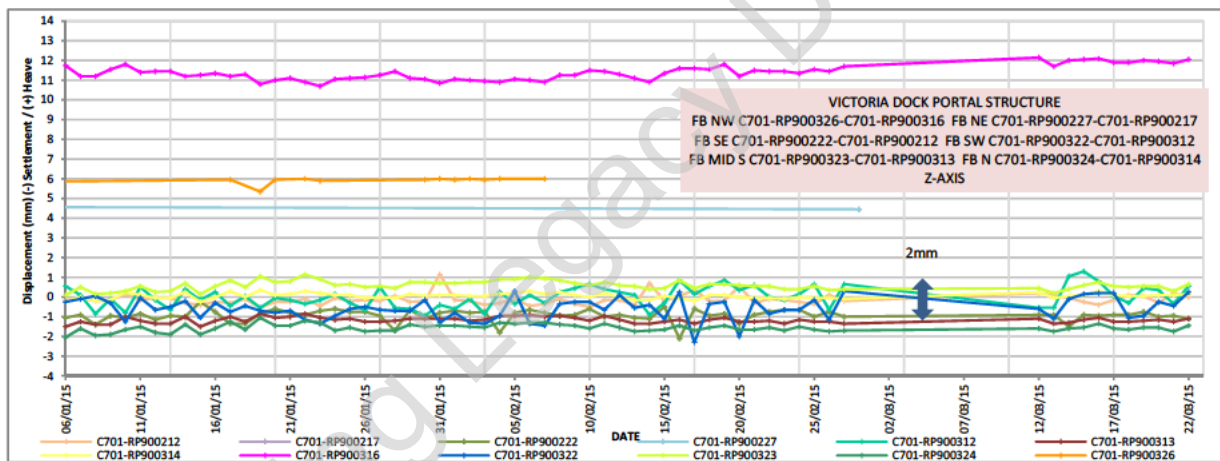
Readings in Y axis show approx. 5-10 mm positive movement at the north end of the footbridge due to ground treatment and 5-10mm after the Westbound TBM passage.

Reaings in Z axis show approx. 5 mm heave during the ground treatment and approx. 10 mm heave at the north end of footbridge after Westbound TBM passage.

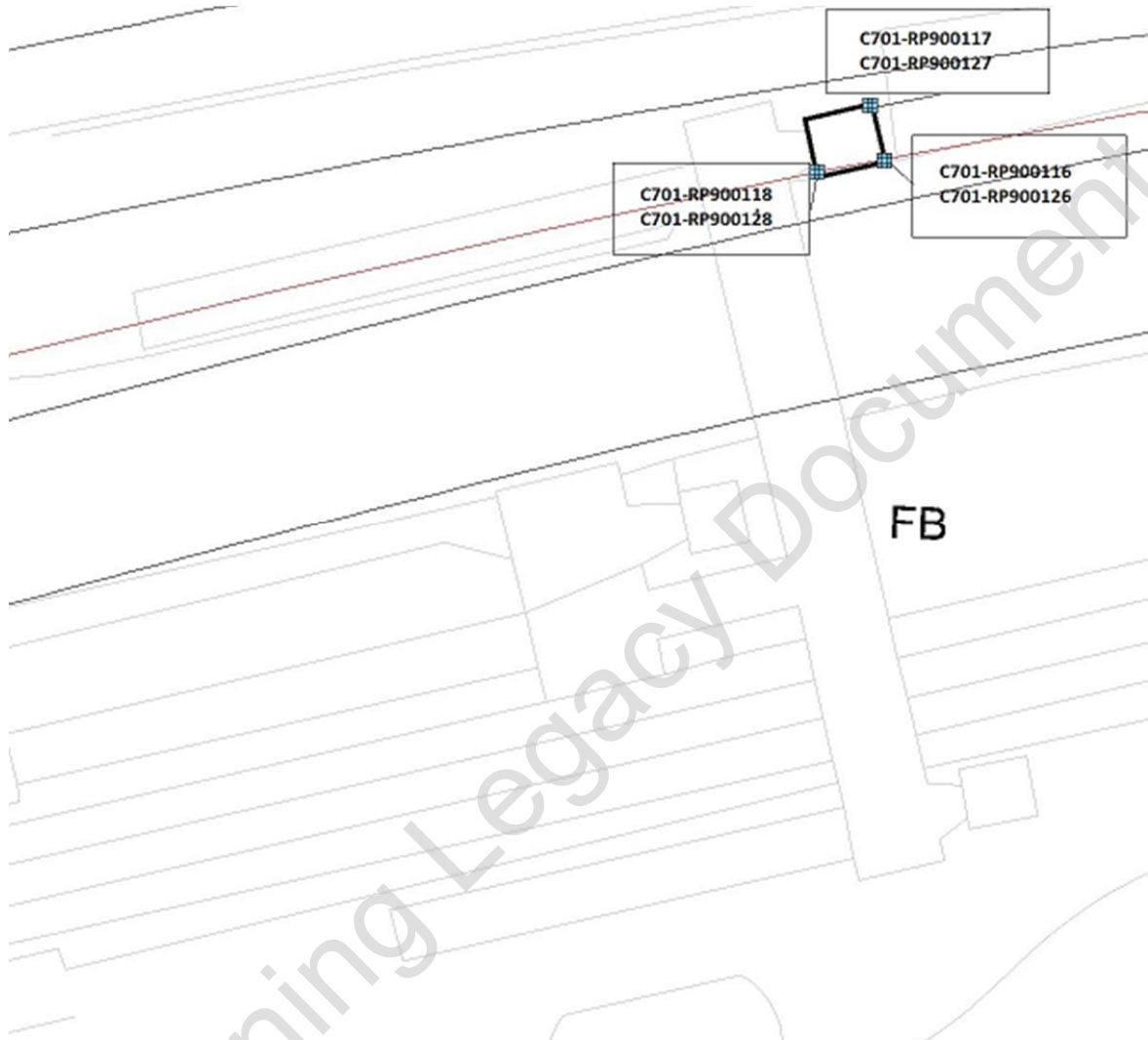
There are several spikes in all the axes during the ground treatment works between June and July 2014.

For a number of prisms monitoring commenced part way through the works and have not been offset due to the difficulty in deriving it.

The overall discernible trend in the data shows that settlement has reached steady state following running tunnel construction. This can be seen from the example below that shows the z direction for the prisms in the foot bridge, from January of 2015.



North lift:



Readings in X show a positive movement of +1 mm after the two TBMs passage. Three of the prisms (C701-RP900117, C701-RP900126 and C701-RP900127) have an accumulated movement of +6mm during the ground treatment works.

Readings in Z axis show a +3mm heave after the Westbound TBM passage and +2 mm heave after the second one.

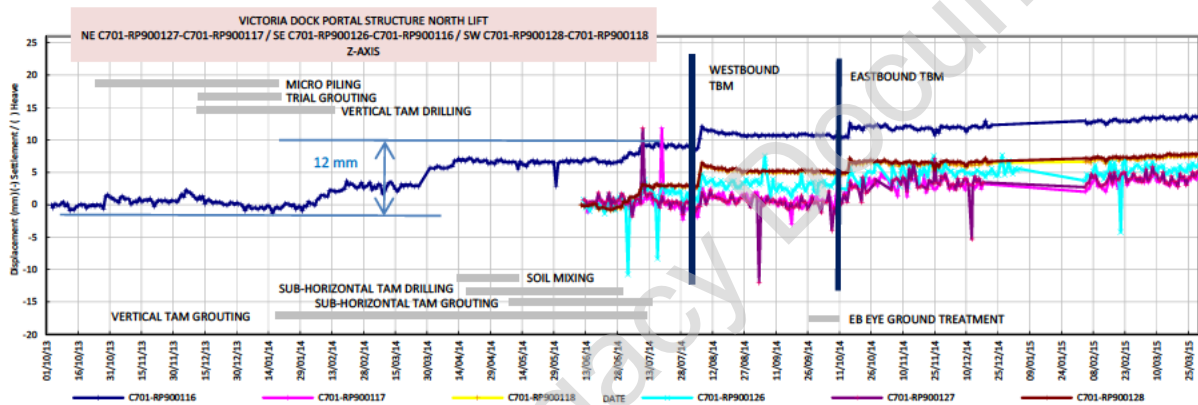
There are several spikes in all the axes during the ground treatment works between June and July 2014.

For a number of prisms monitoring commenced part way through the works and have not been offset due to the difficulty in deriving it.

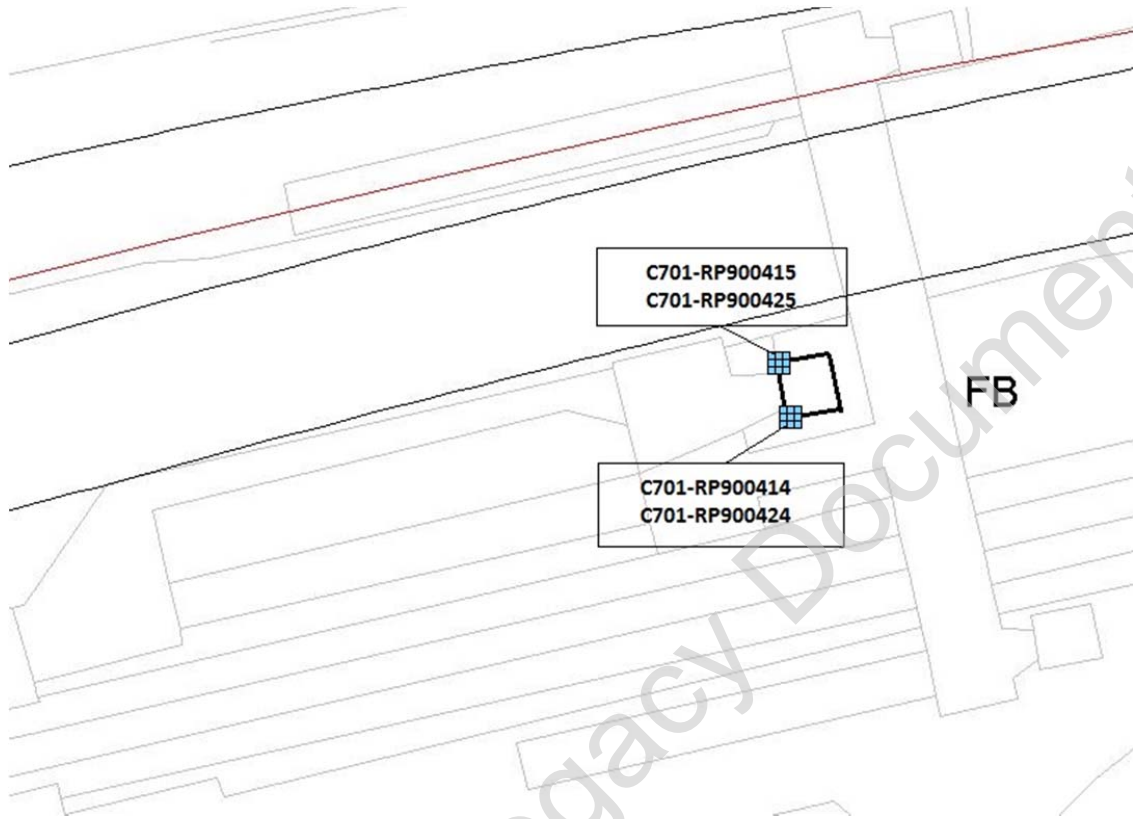
In the graph below a +12 mm heave is perceptible in the prism C701-900116 during the vertical TAM grouting between 20/01/14 and 15/07/14 - see Appendix 5; negative movement in X direction (-8 mm) and positive movement in Y direction (+40 mm).

The North lift shows a displacement NW during the mentioned grouting works. Manual readings of the same prism taken by C305 verify this movement (Appendix 5).

From January of 2015 the discernible trend in the data shows that settlement has reached steady state following running tunnel construction.



Central lift:

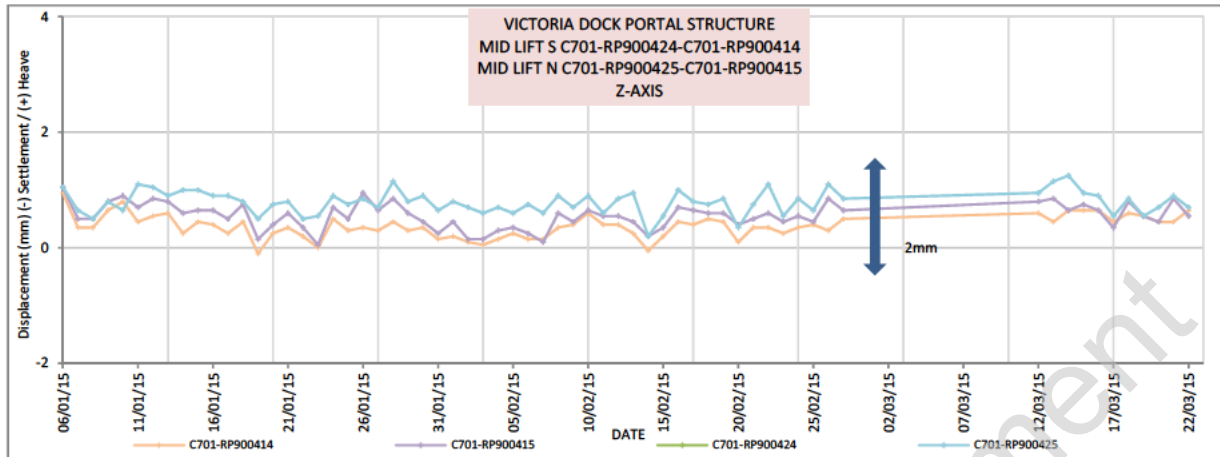


Readings in X show a seasonal trend and a positive movement of +2 mm during the ground treatment works and -1mm after the Westbound TBM passage. No effect for the second TBM.

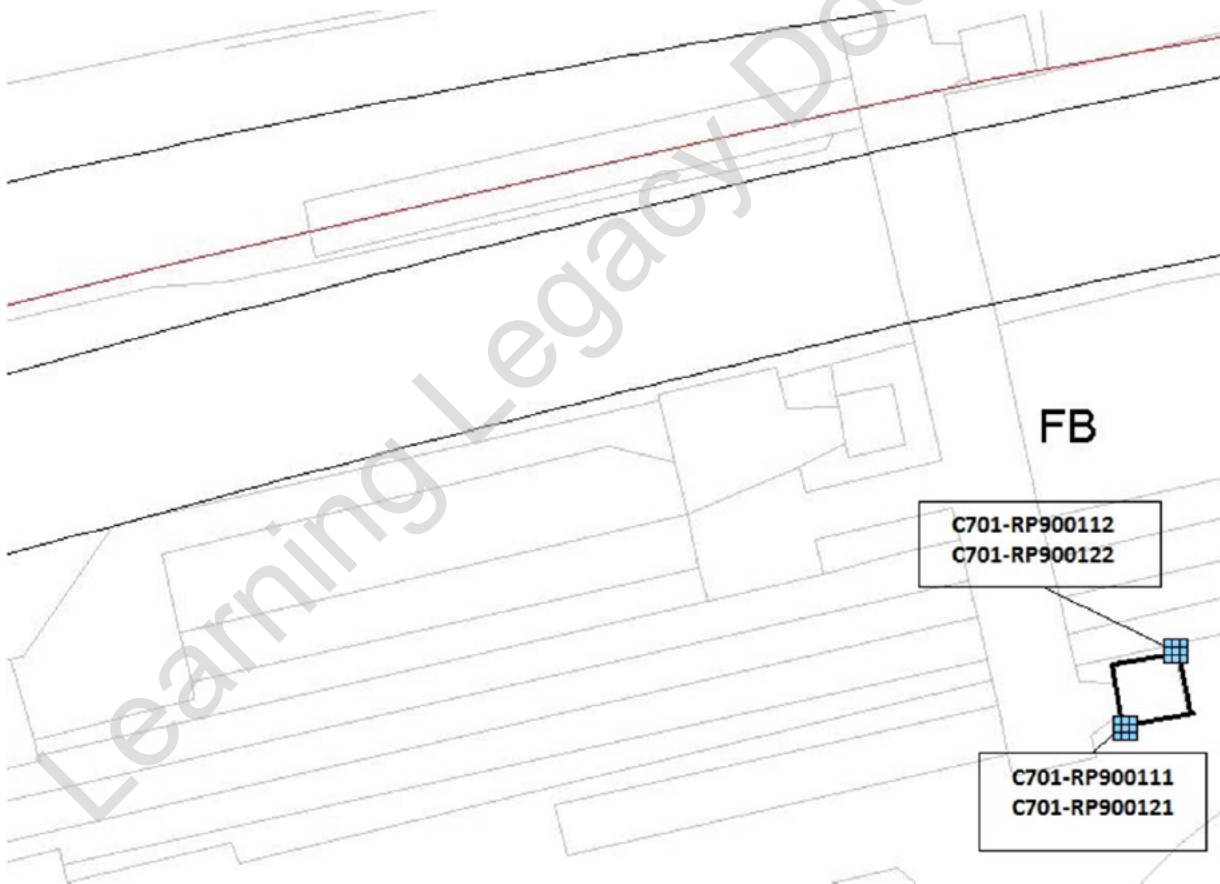
In Y axis there is a negative movement of -3mm during the ground treatment works and +1mm after the Westbound TBM passage.

Readings in Z show a positive movement of +2 mm during the ground treatment works and +1mm after the Westbound TBM passage. No effect for the second TBM.

There are several spikes in all the axes during the ground treatment works between June and July 2014. The noticed settlement rate is nearly zero.



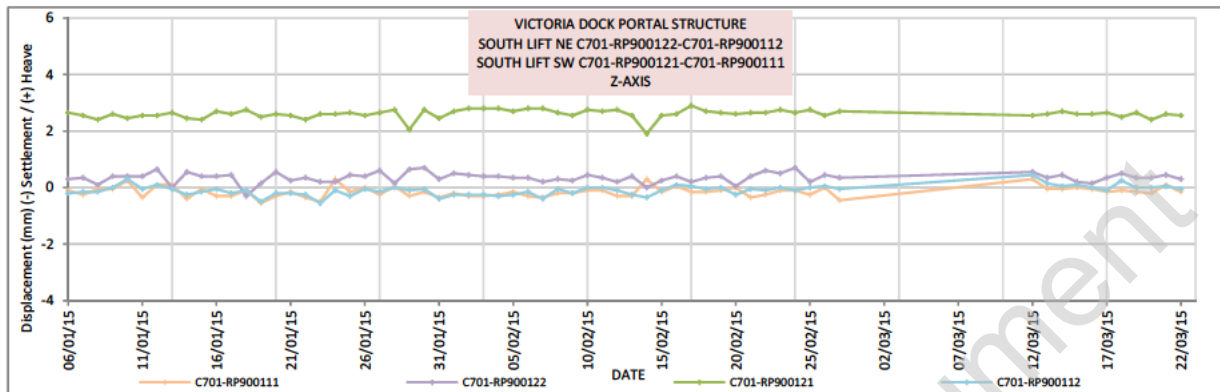
South lift:



No movements are perceptible for the south lift, excepting a -2 mm movement during ground treatments in Y axis.

There are several spikes in all the axes during the ground treatment works between June and July 2014.

From January of 2015 the discernible trend in the data shows steady state following running tunnel construction.



Manual readings:

Some manual readings of the C701 prism in the foot bridge structure have been taken by C305 contract.

These readings verify the automatic readings.

The data covers the period between December 2013 and August 2014 and the works made then: micropiling, trial grouting, Vertical TAM drilling, soil mixing, sub-horizontal TAM drilling, sub-horizontal TAM grouting, vertical TAM grouting and westbound TBM passage.

C305 ROYAL VICTORIA STATION MONITORING

This report includes the instrumentation located in Royal Victoria station and monitored by C305.

See Appendix 6.

SOCKETS C305

The monitoring period covers from the micropiling to the second TBM passage (October 2013 – October 2014).

The readings show a positive displacement with the Westbound TBM passage in the north line. A maximum heave of +9 mm is reached for the socket C305-LB011320, +6 mm for C305-LB011310 and +3mm for C305-LB011330.

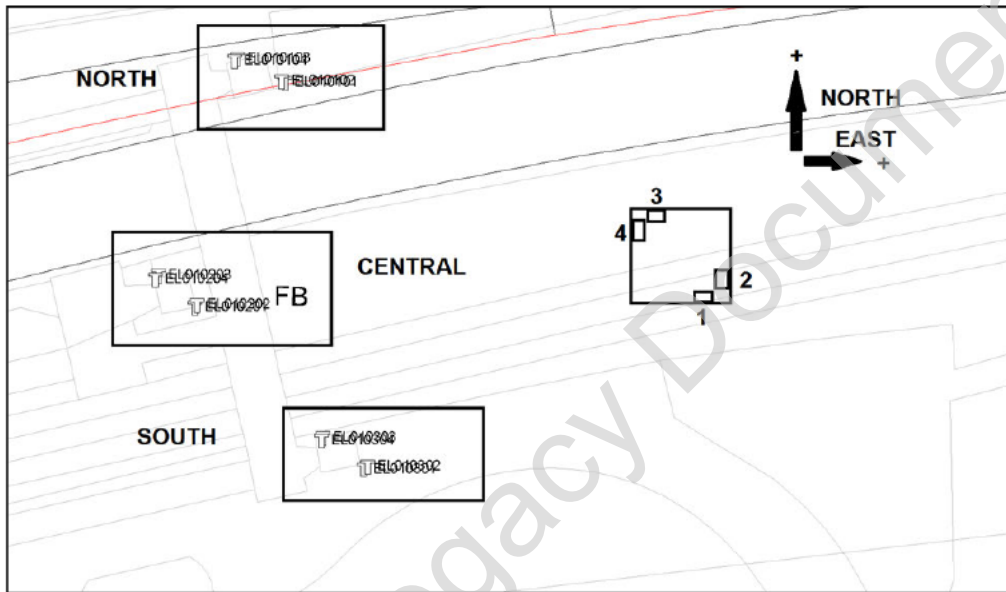
TILTMETERS C305

The graphs below show the readings for the tiltmeters located on the lifts of Royal Victoria Station. They comprise measures from June 2014 to November 2015. The four tiltmeters on each lift were combined to calculate the average displacement in North-South direction and East-West direction. These plus the individual readings are shown below.

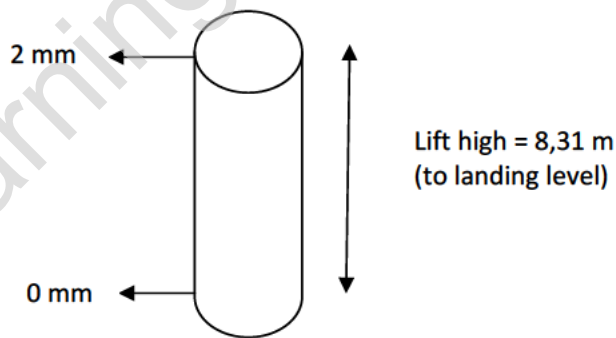
Tiltmeter monitoring commenced part way through the works and has not been offset due to the difficulty in deriving it.

In order to close out the monitoring of the lifts a tilt criteria is illustrated at the bottom of the page, as has been specified by C122 in the document TIS/DIS Royal Victoria Station Remedial Works C122-OVE-S-XST-CR144-50001 Rev 3.0.

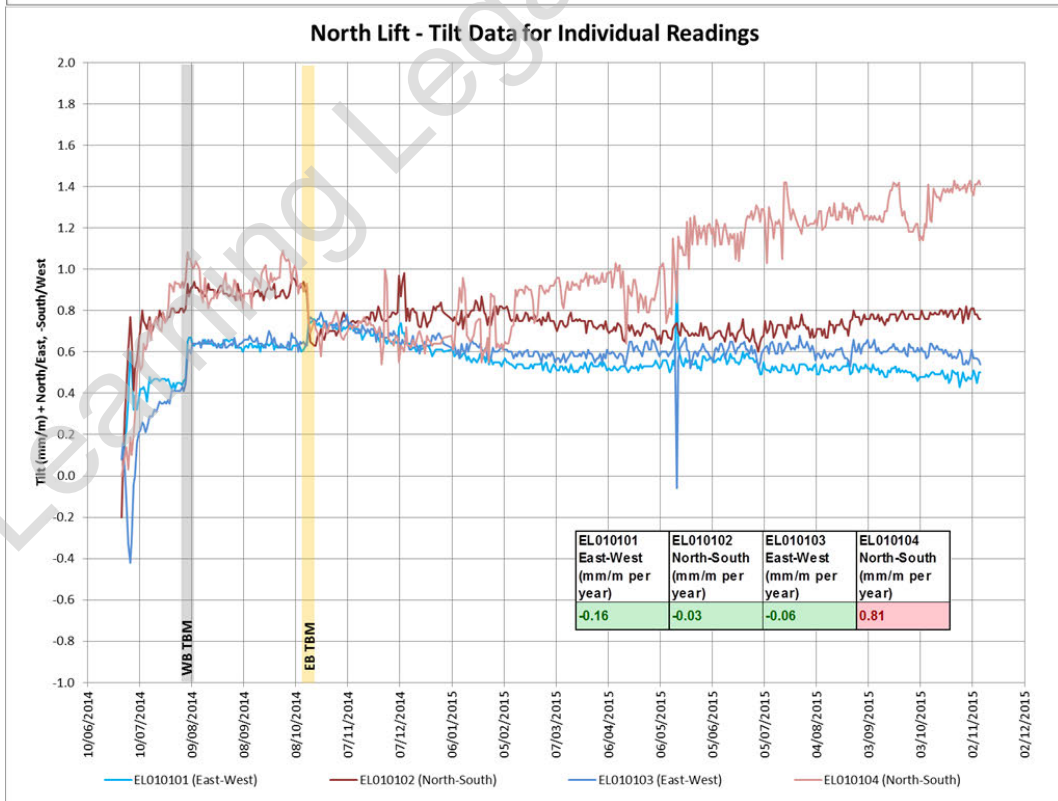
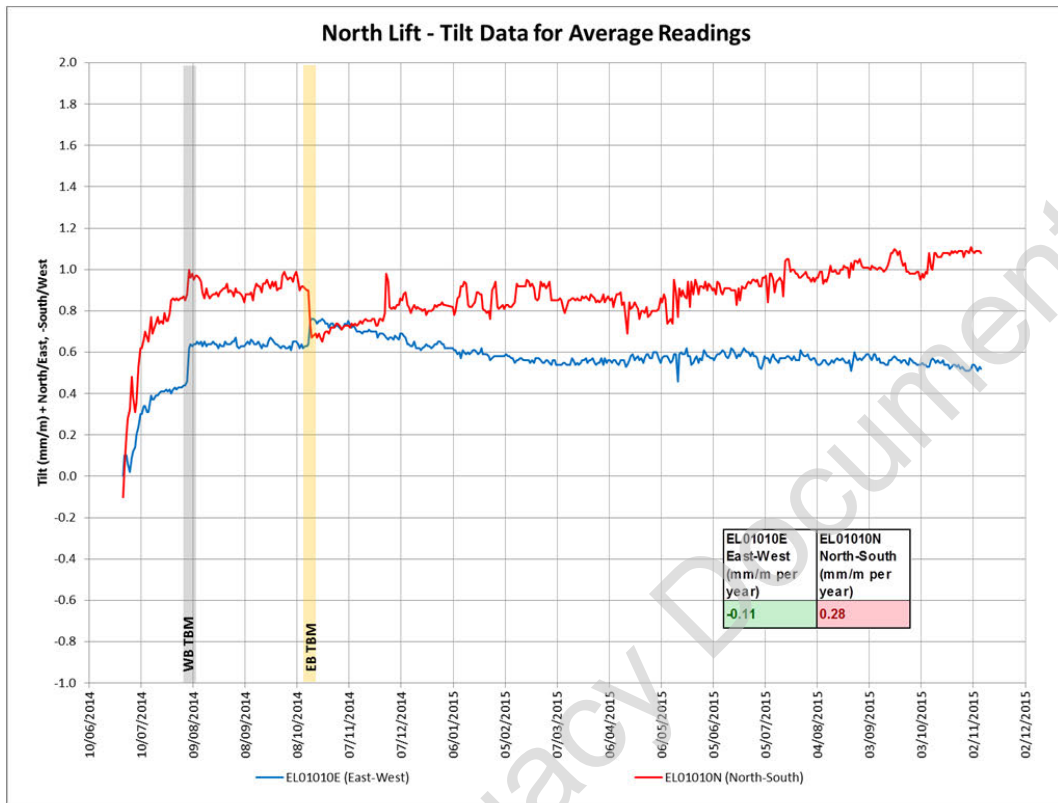
Refer to the drawing below for a map of instruments location.



Tiltmeter criteria: $2 \text{ mm}/8.31 \text{ m} = 0.24\text{mm/m}$ (per year)



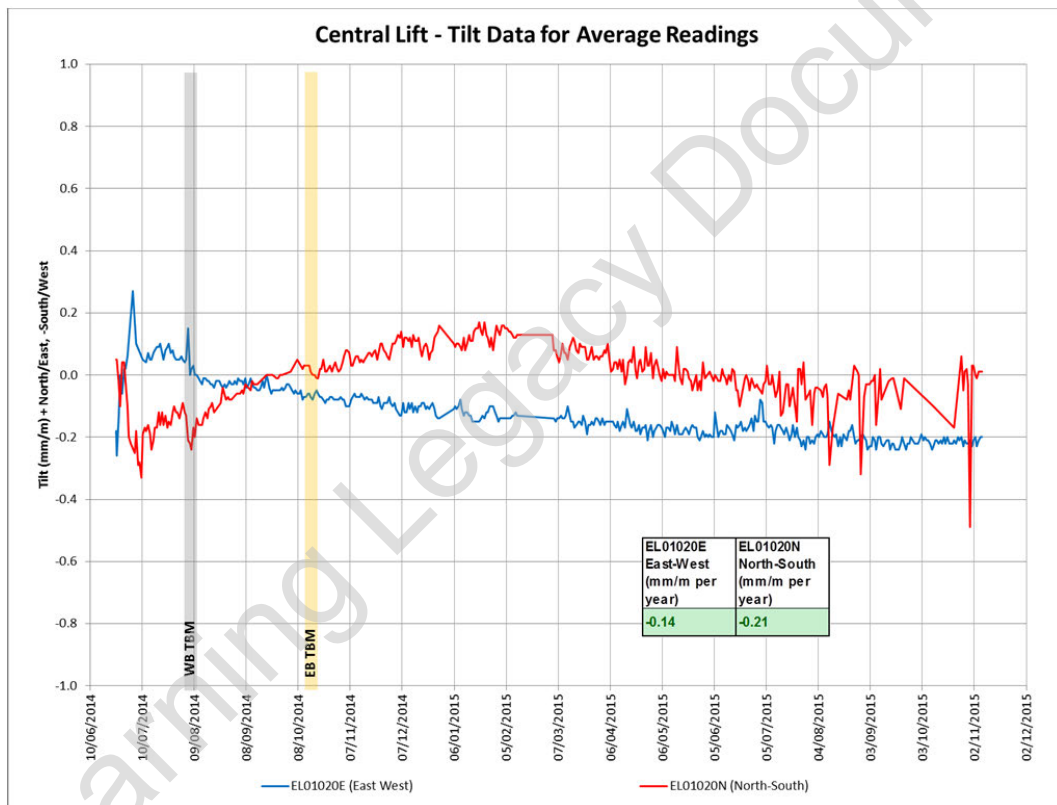
North lift

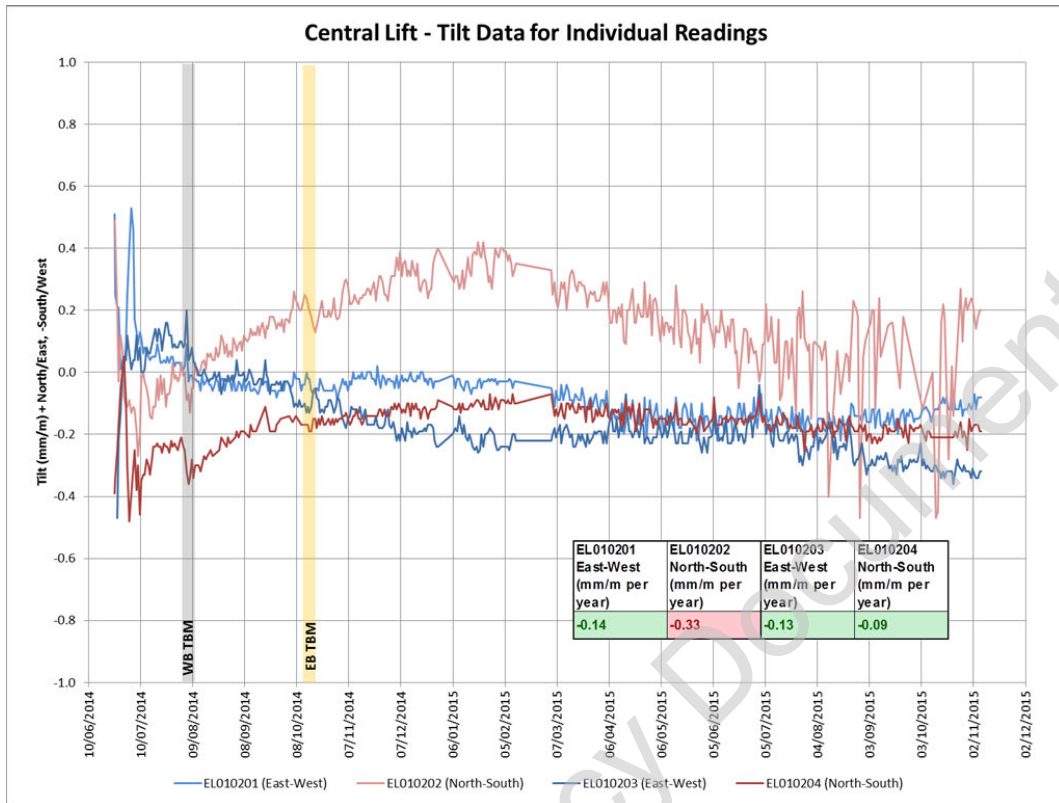


The graph shows a displacement towards NE during the ground treatment works in June and July 2014 and during the Westbound TBM passage, and towards SE (0.5-1 mm/m) after the Eastbound TBM crossing.

Comparing the long term tilt rate over the period of Nov14-Nov15 it can be shown that the average readings East-West are within the tilt criteria but the North-South is not. Looking into the individual tilt readings shows EN10102 and EN10104 with different trends. EN10104 shows a divergent trend to the other three sensors indicating that the sensor is not performing correctly and EN10102 is more reliable. Therefore considering only EN10102 the tilt rate for the North-South direction is also within the tilt criteria.

Central lift

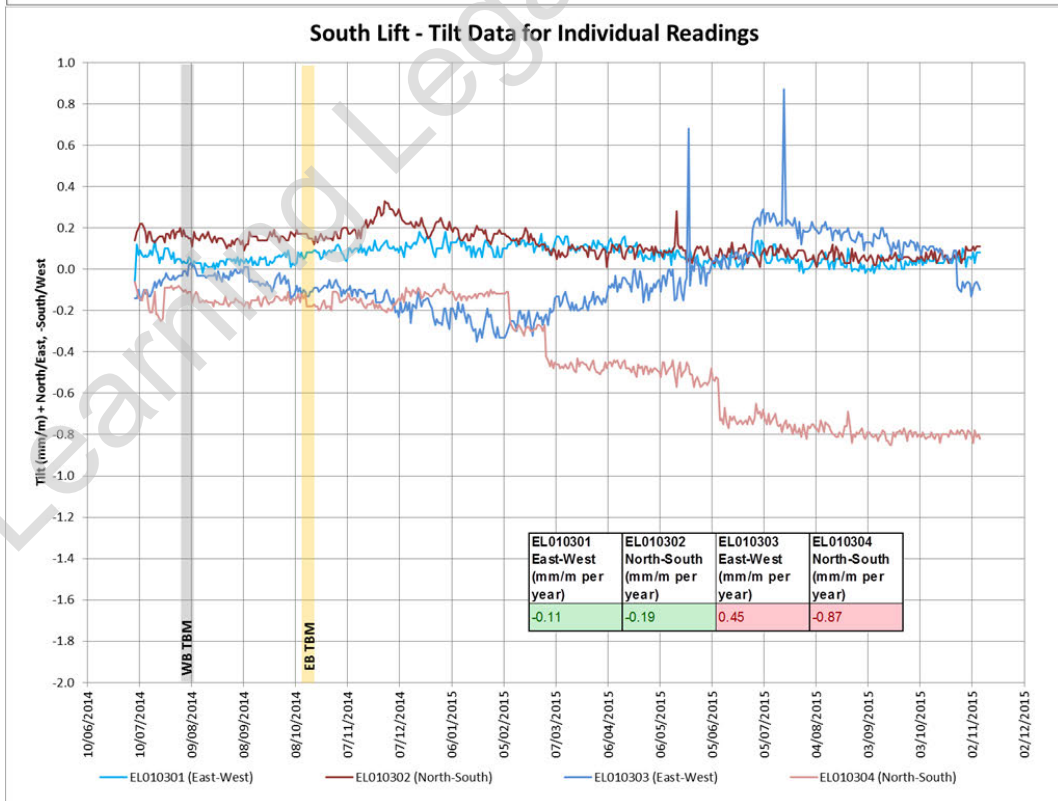
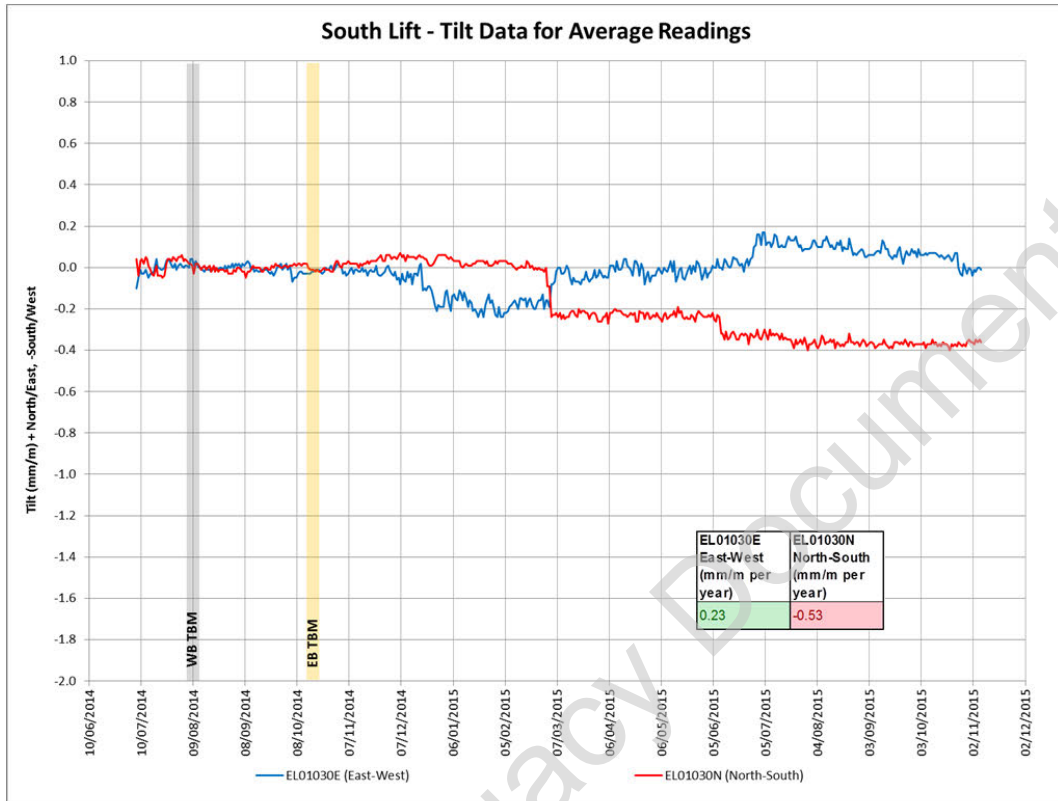




The graph shows a displacement in SE direction during the ground treatment works in June and July 2014 with displacement less than 0.5 mm/m. After the WB TBM this recovers back to almost zero, with the EB TBM causing a slight NW movement of 0.1mm/m.

Comparing the long term tilt rate over the period of Nov14-Nov15, the average readings show that it is within the criteria. Looking at the individual readings shows that EN10202 exceeds the criteria but also shows more erratic behaviour and larger range of movement, which differs from the other sensors and therefore can be disregarded.

South lift



Displacements are not perceptible in this lift during the ground treatment works, or during the TBMs passages.

The tilt rate on average readings over the period of Nov'14-Nov'15 show that East-West direction is just within the criteria, however North-South is not. When looking at the individual readings, EN10301 and EN10304 show trends that are not seen on EN10301 and EN10302. As EN10301 and EN10304 are located on the corner of the lift shaft close to the entrance for the lift at ground level they may have been subject to impact from the general public or other external effects. Considering that there was no discernible movement from both TBM passages and considering EN10301 and EN10302 it can be concluded that the tilt is within the criteria.

The noticed settlement rate is nearly zero.

PRISMS C305

The graphs showed in Appendix 6 comprise measures from June 2014 to December 2014.

- Stairs North: A movement towards NW can be seen in the graph and a heave of +3/4 mm during the ground treatment works. The movement in Z direction is a heave of +4 mm after the Westbound TBM passage.
- Foot bridge: Heave of +10 mm after the Westbound TBM passage and +6 mm after the Eastbound.
- Concourse: Heave of +6 mm after the Westbound TBM passage and +2 mm in some prisms after the second TBM with a shortly recovery after it.
- Stairs South: Heave of +2 mm after the Westbound TBM passage and +2 mm in some prisms after the second TBM with a shortly recovery after it.
- Stairs Central: A small movement towards NE can be seen in the graph and a heave of +2 mm after the Westbound TBM passage.
- Lift South: No movement is perceptible.
- Lift Central: The graph shows a displacement in SE direction during the ground treatment works in June and July 2014. The movement in Z direction is a heave of +4 mm after the Westbound TBM passage.
- North lift: The graph shows a displacement towards NE during the ground treatment works in June and July 2014. The movement in Z direction is a heave of +8 mm after the Westbound TBM passage and +4 mm after the second TBM.

Prisms monitoring commenced part way through the works and has not been offset due to the difficulty in deriving it.

DLR TRACK LEVELLING

The graphs for the DLR track levelling are included in Appendix 7.

POPLAR BECKTON DLR

The length of the levelling track included in this report is as follows:

- POP BEC UP CESS: C305-LT025618 to C305-LT025658
- POP BEC UP 6FOOT: C305-LT025818 to C305-LT025858
- POP BEC DOWN CESS: C305-LT025218 to C305-LT025257
- POP BEC DOWN 6FOOT: C305-LT025418 to C305-LT025457

The track levelling does not show any significant movement due to the TBMs for the up direction. The down direction and the cess line in particular, show a settlement of -2mm in October 2014 with the Eastbound TBM passage.

No changes have been observed in twist from the baseline report, covering between May 2014 and October 2014.

VDP DLR

The measures showed in Appendix 7 contain data from November 2013 to October 2014.

The length of the levelling track included in this report is as follows:

- ROYAL VICTORIA EASTBOUND CESS: C305-LT011001 to C305-LT011058
- ROYAL VICTORIA EASTBOUND 6foot: C305-LT012001 to C305-LT012058
- ROYAL VICTORIA WESTBOUND CESS: C305-LT013001 to C305-LT013058
- ROYAL VICTORIA WESTBOUND 6FOOT: C305-LT014001 to C305-LT014058

The cess part of the Eastbound track is the closest line to the micropile wall. It can be observed in the graph a continuous settlement from November 2013 to May 2014 of -5mm. The same movement can be seen in the rest of the lines, Eastbound and Westbound.

The same trend has been exposed for the C701 prisms in the area of micropile wall (C701-RP800214, C701-RP800213, C701-RP800212 and C701-RP800211) analyse using the UCIMS graphs.

A heave of +5 mm was observed in the area during the construction of micropile wall in October/November 2013 and the subsequent recovery as a settlement.

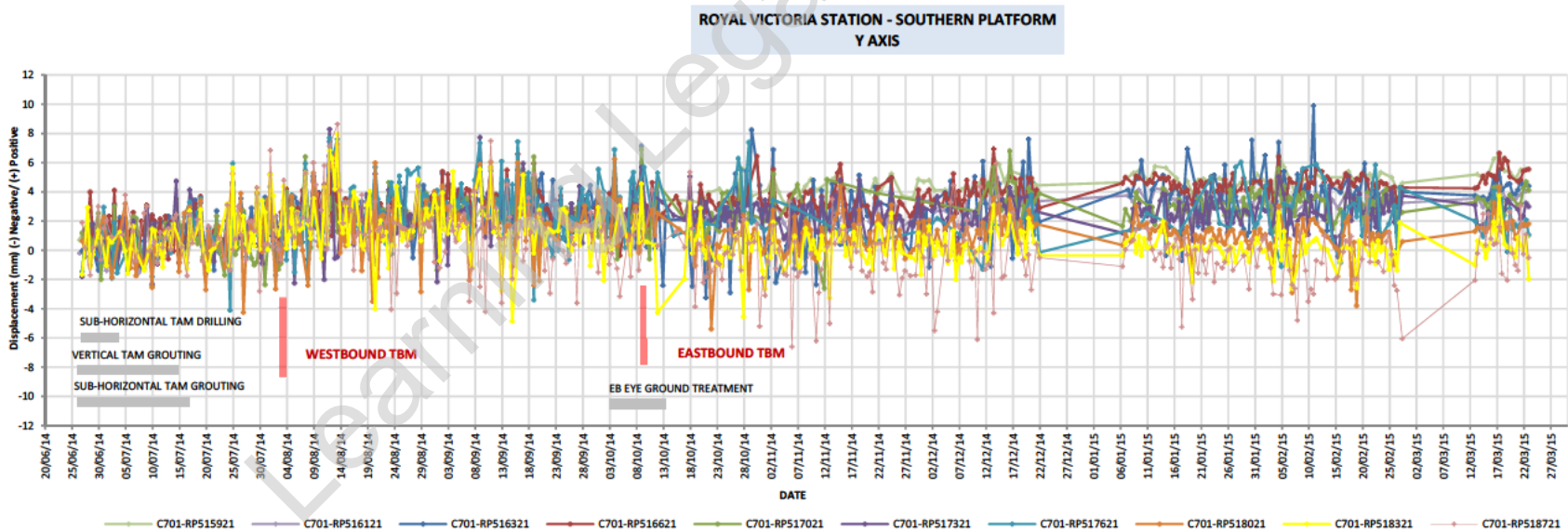
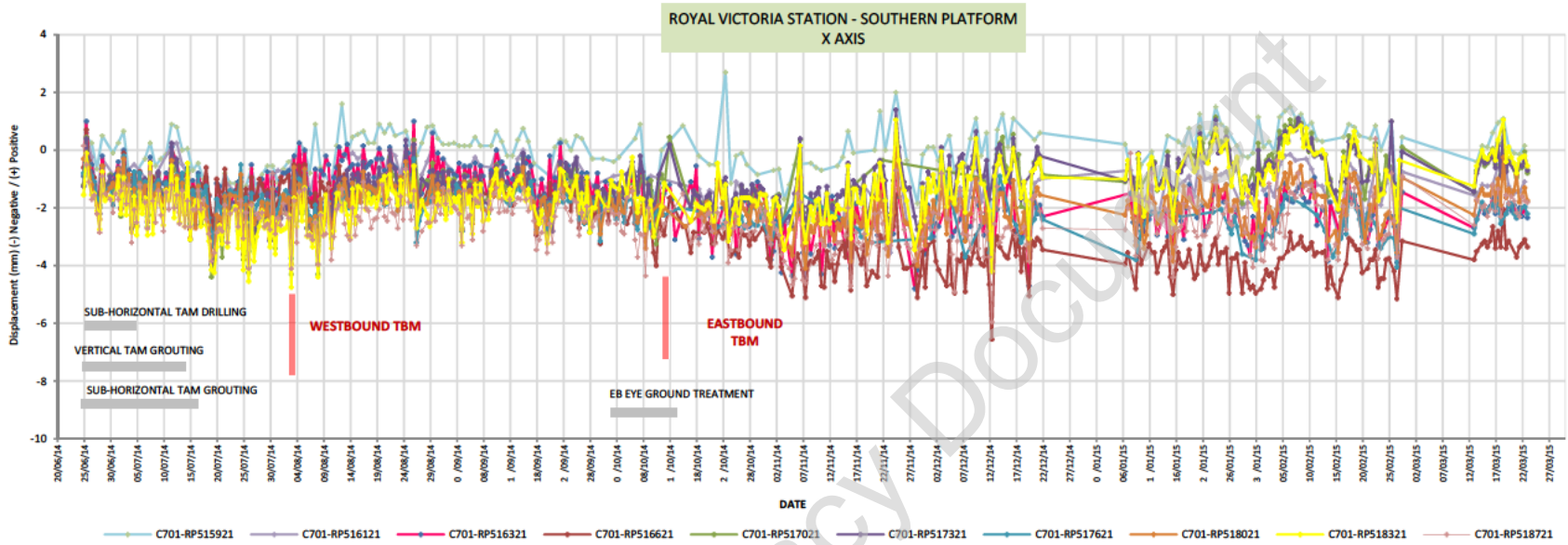
No changes have been observed in twist from the Baseline Monitoring Report for DLR Drive G (C305-XRL-C2-RGN-CR144-50001).

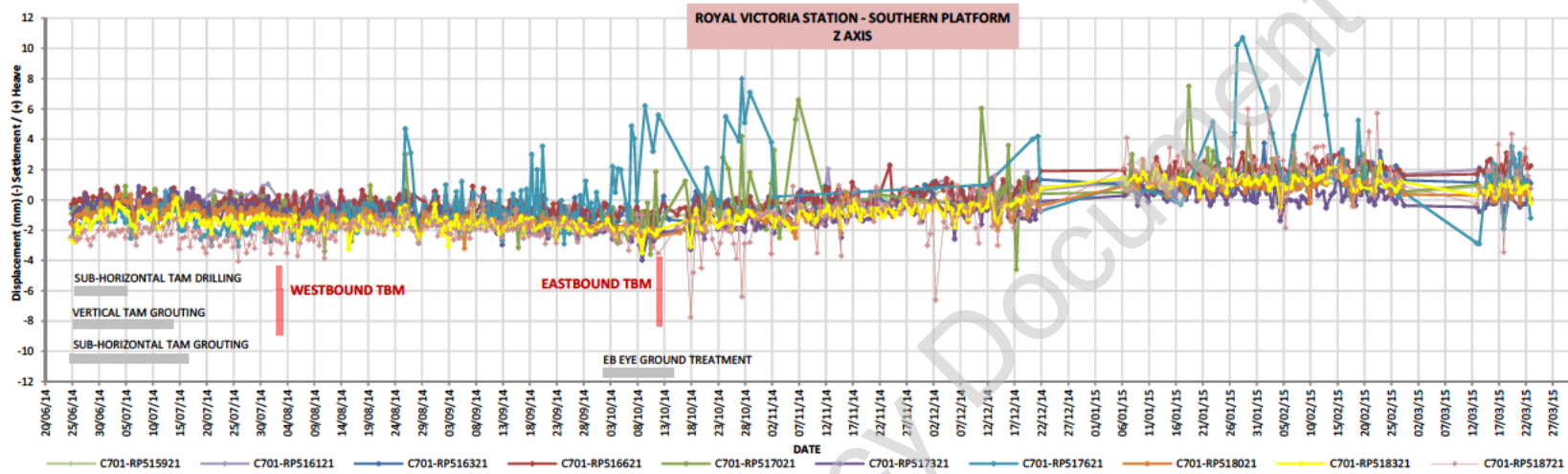
The manual track monitoring commenced after the start of the micro-piling wall construction, and it noticed a settlement (~14mm), which was recorded by the track monitoring as the settlement from a previous heave event.

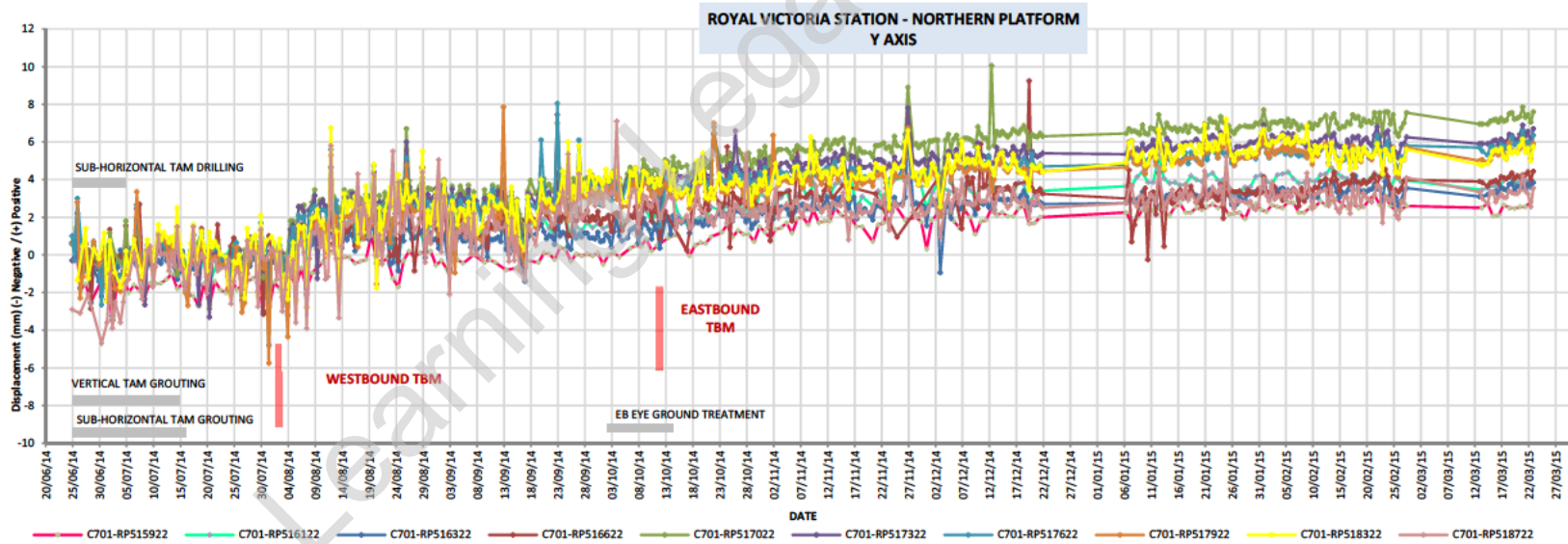
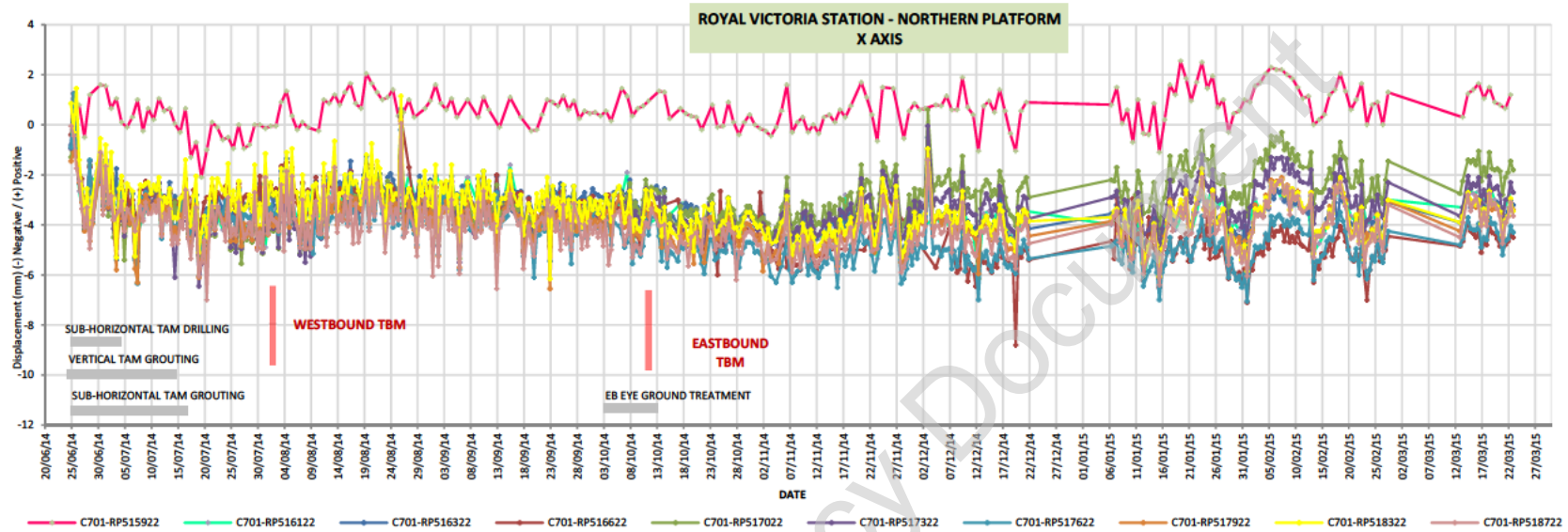
Learning Legacy Document

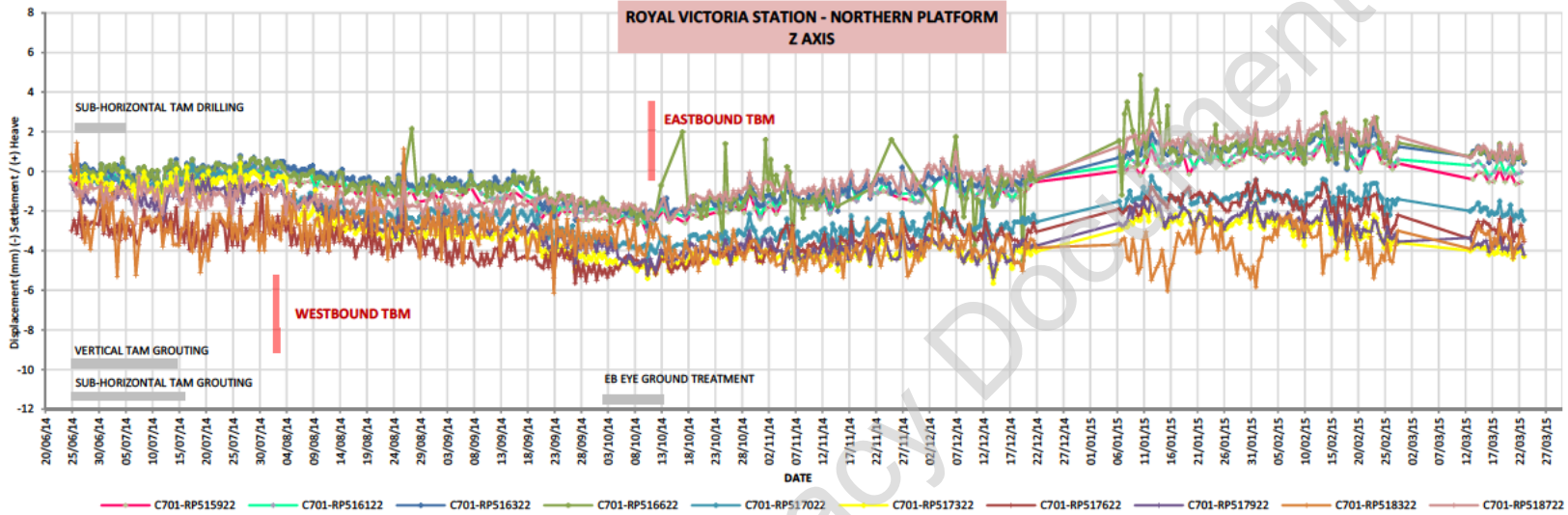
Learning Legacy Document

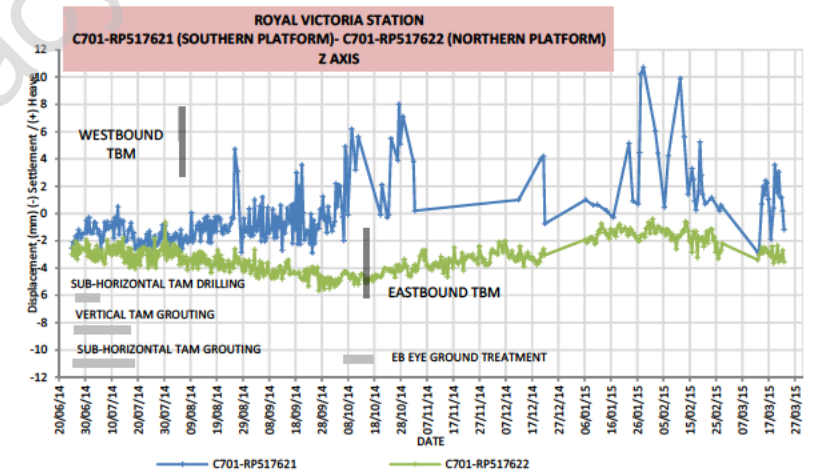
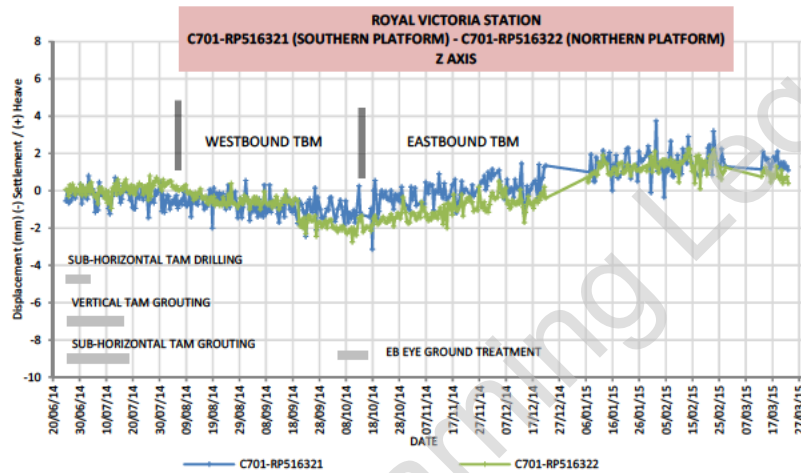
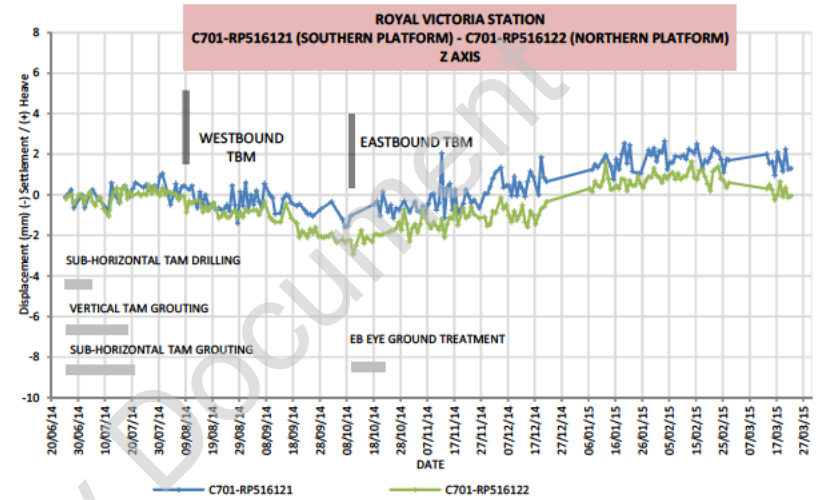
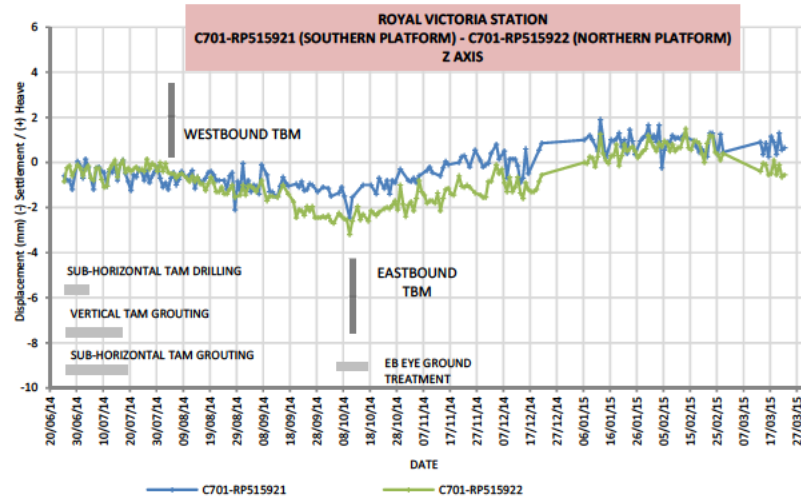
Appendix 1: Royal Victoria Station Platform

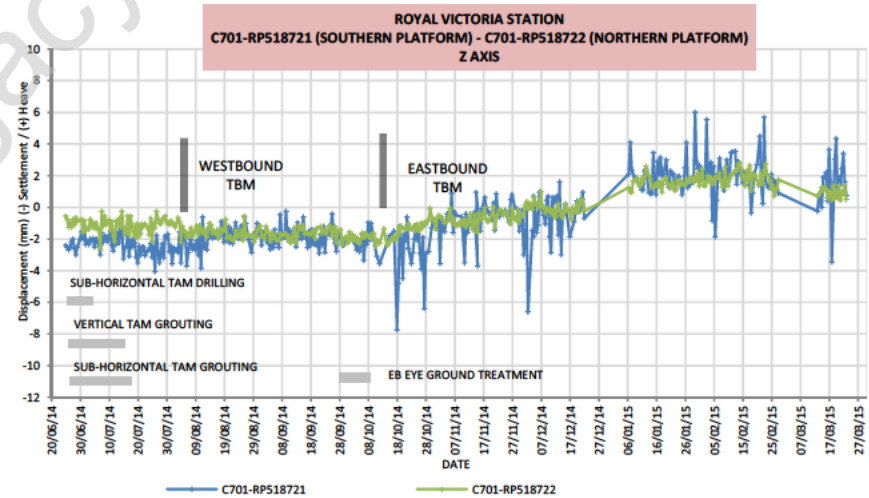
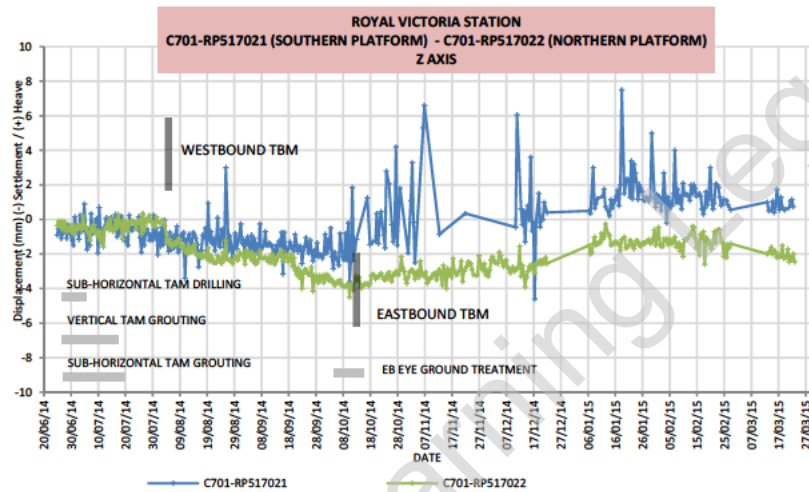
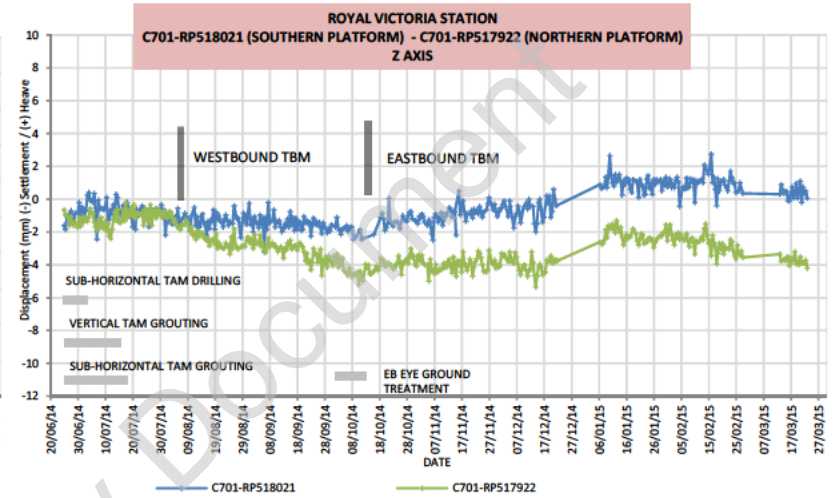
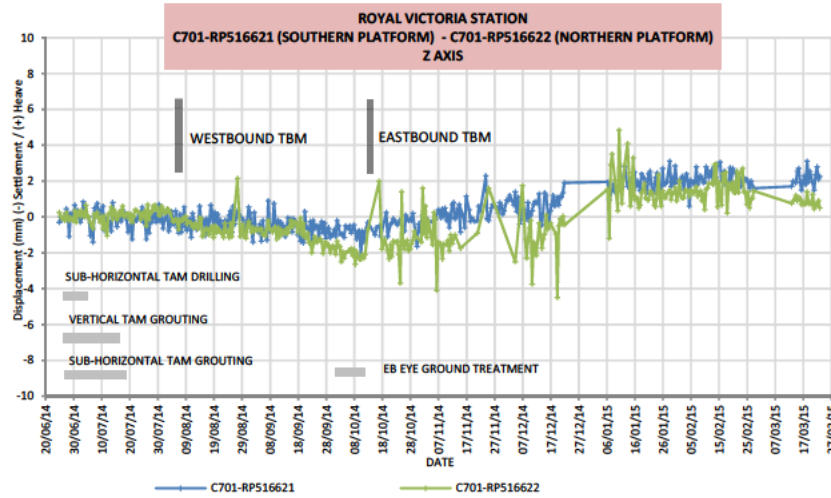


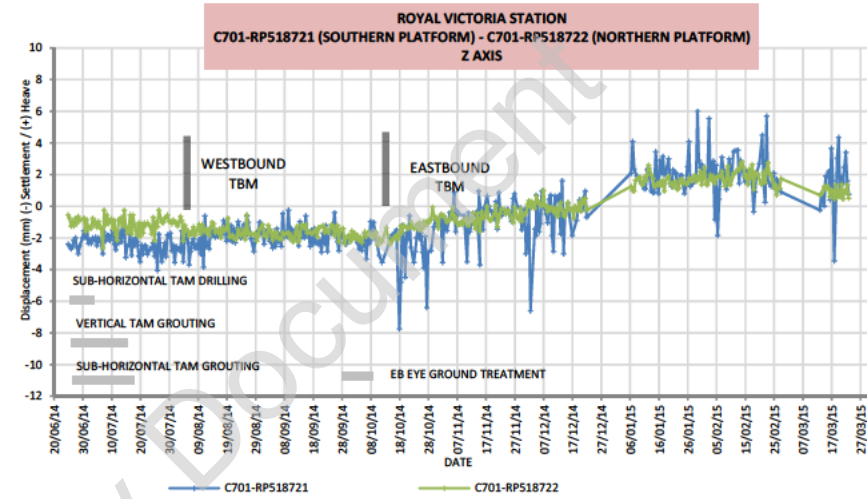
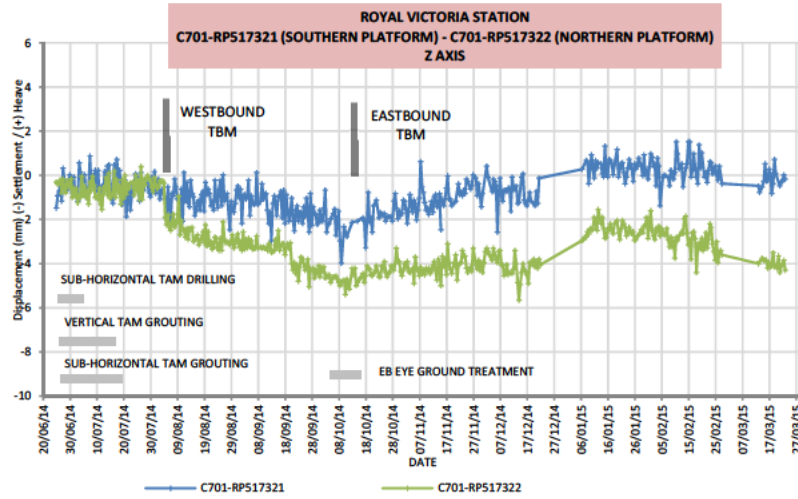








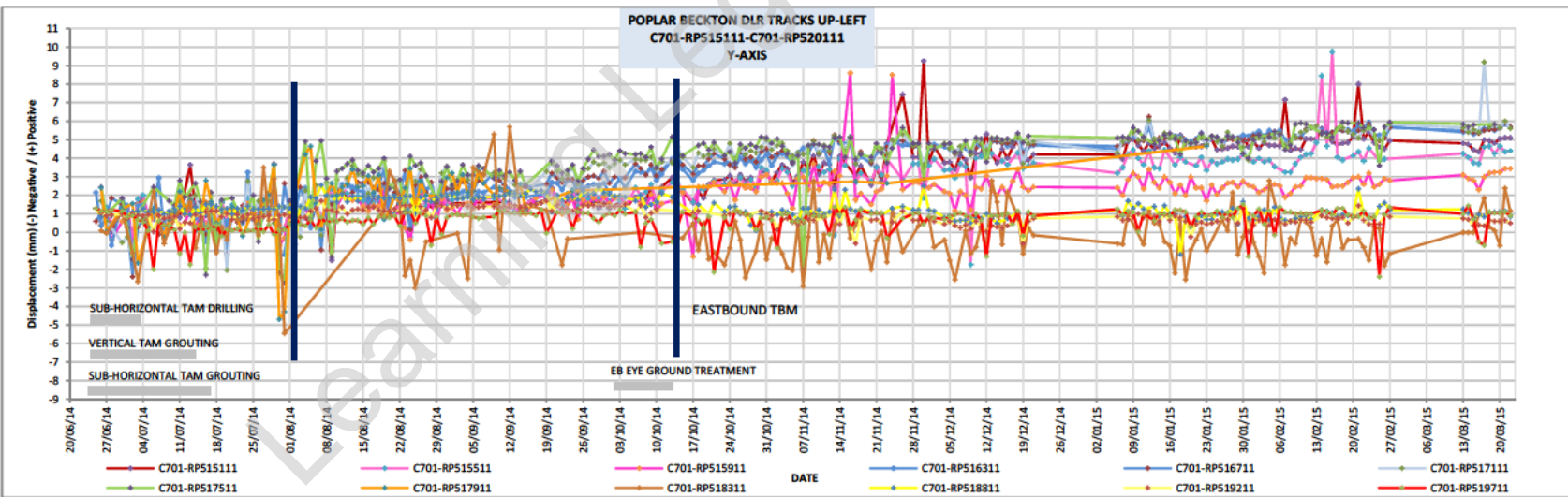
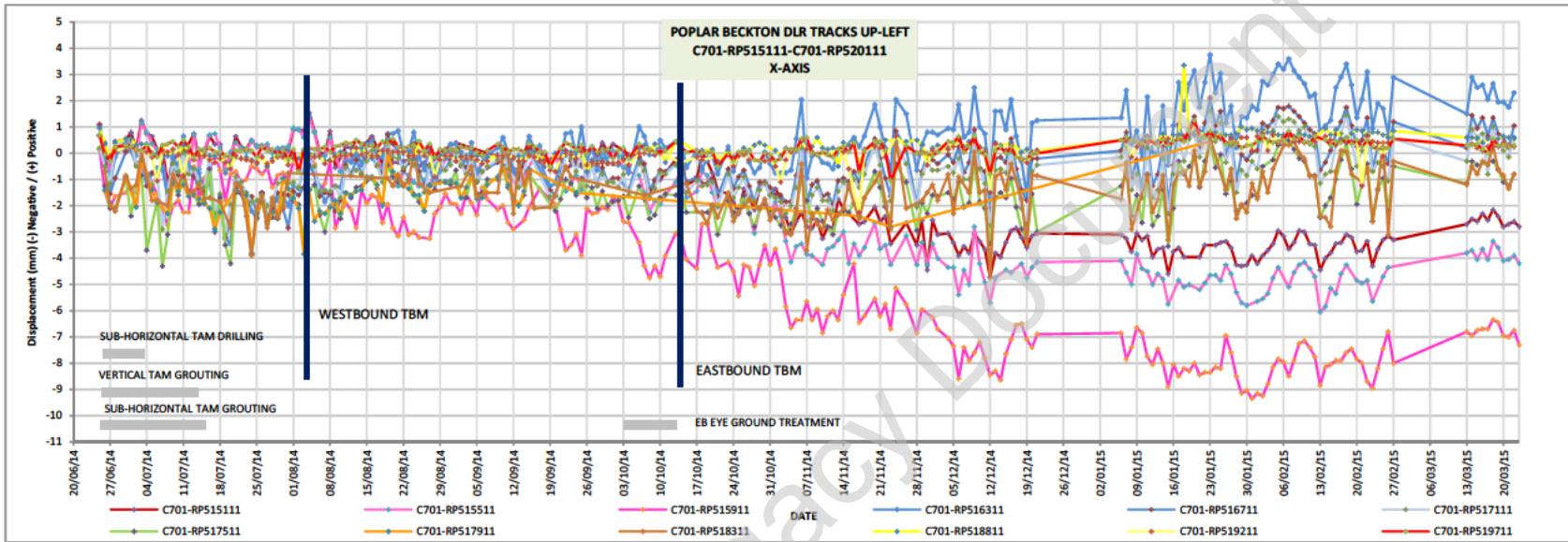


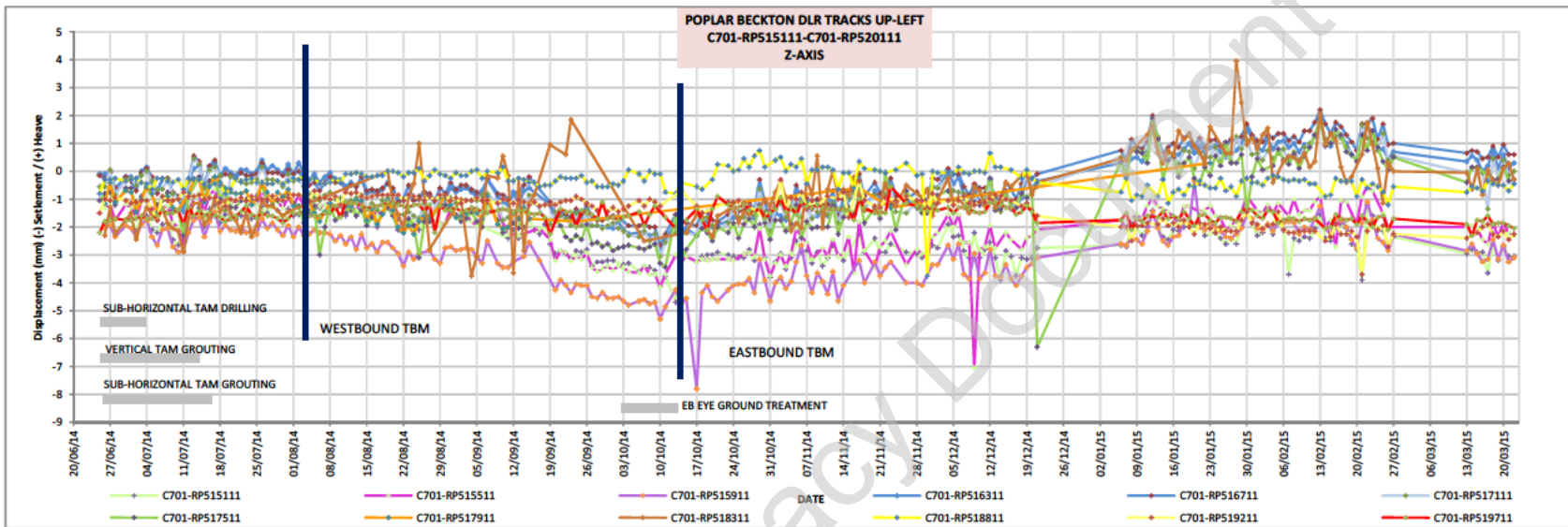


Learning Legacy Document

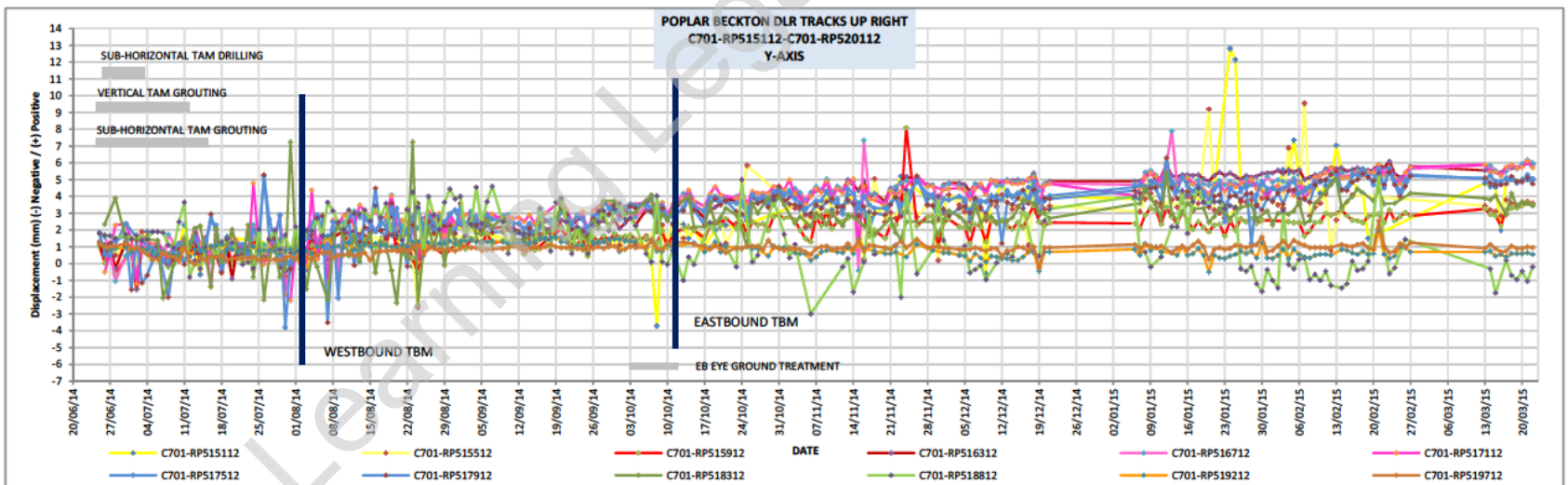
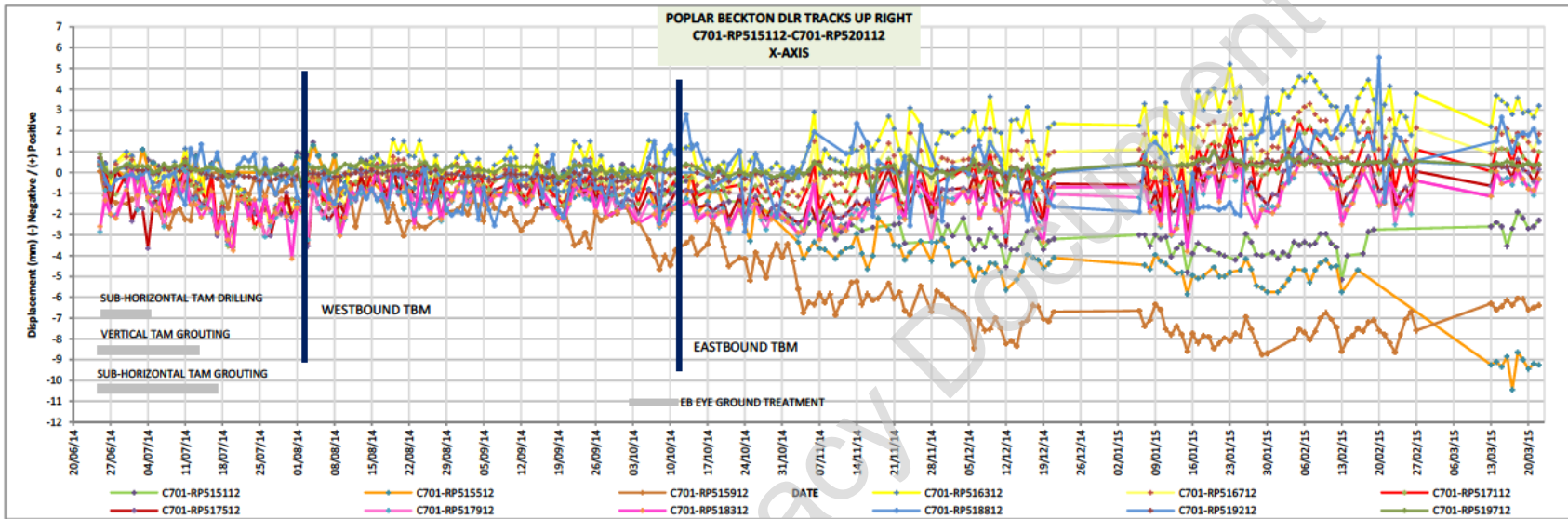
Appendix 2: Poplar to Beckton tracks at Royal Victoria Station

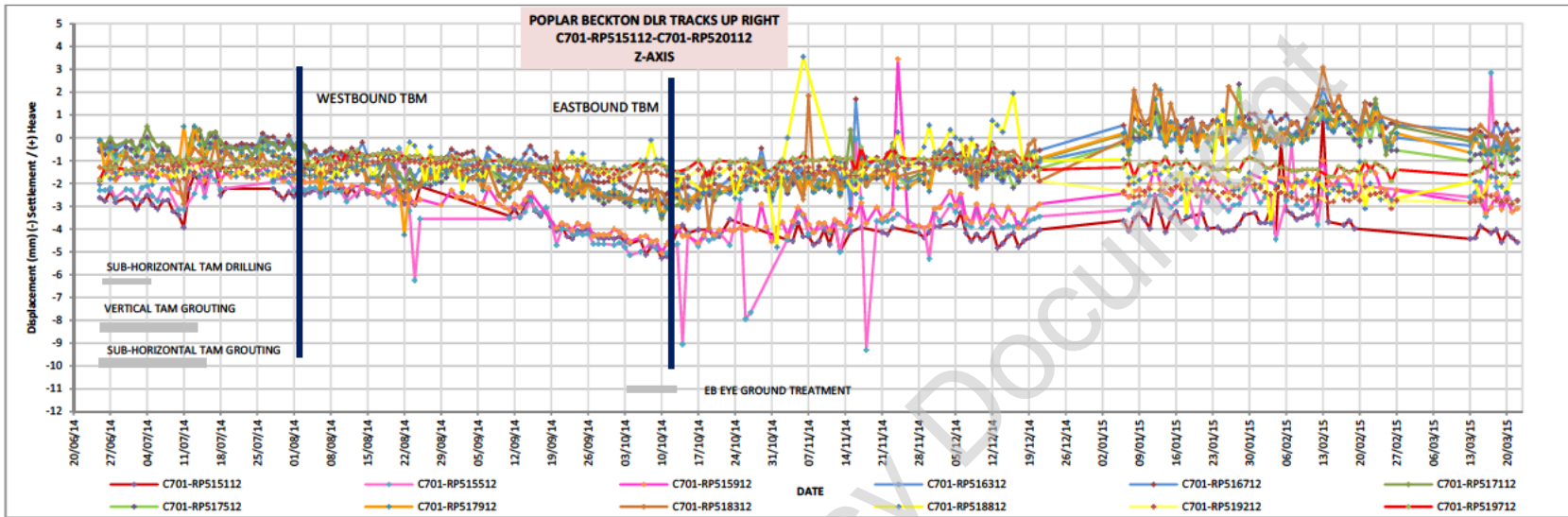
Poplar Beckton DLR Up Left. C701-RP515111 to C701-RP520111



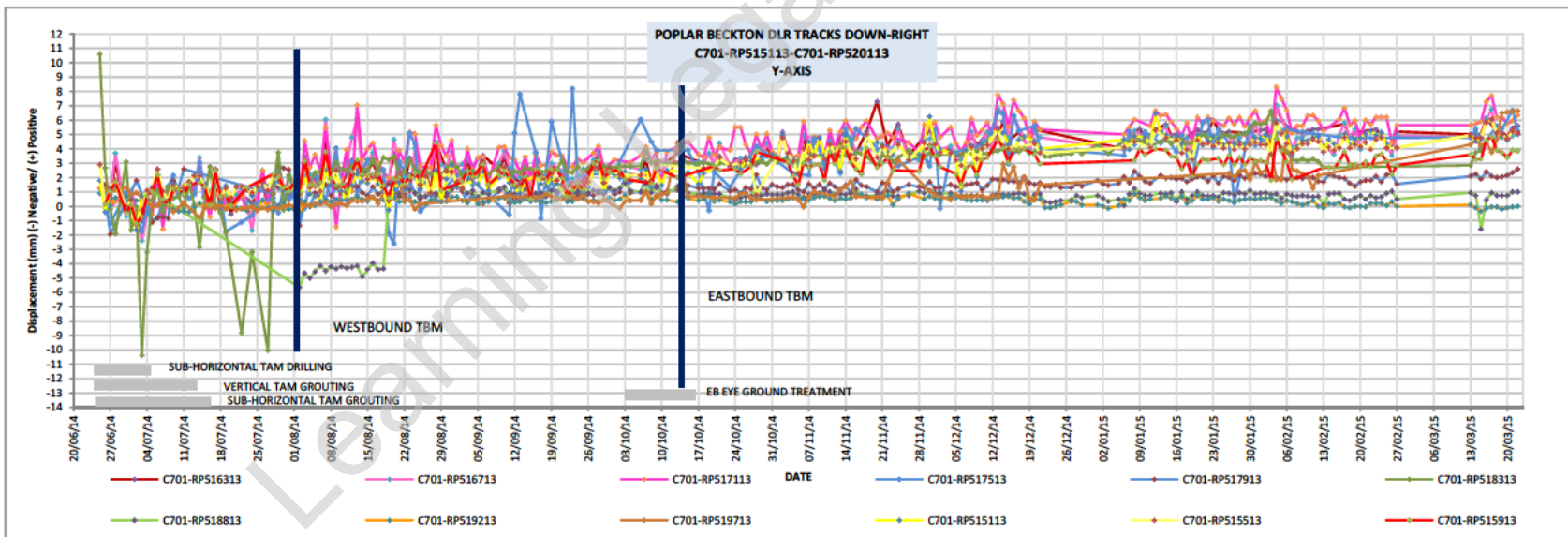
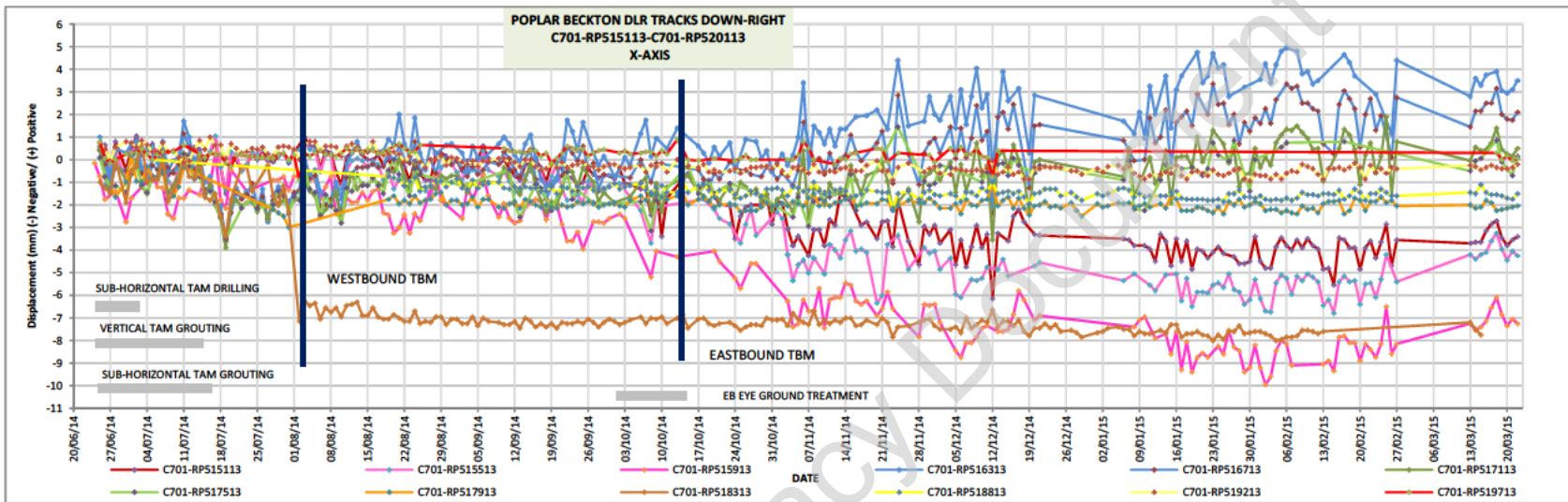


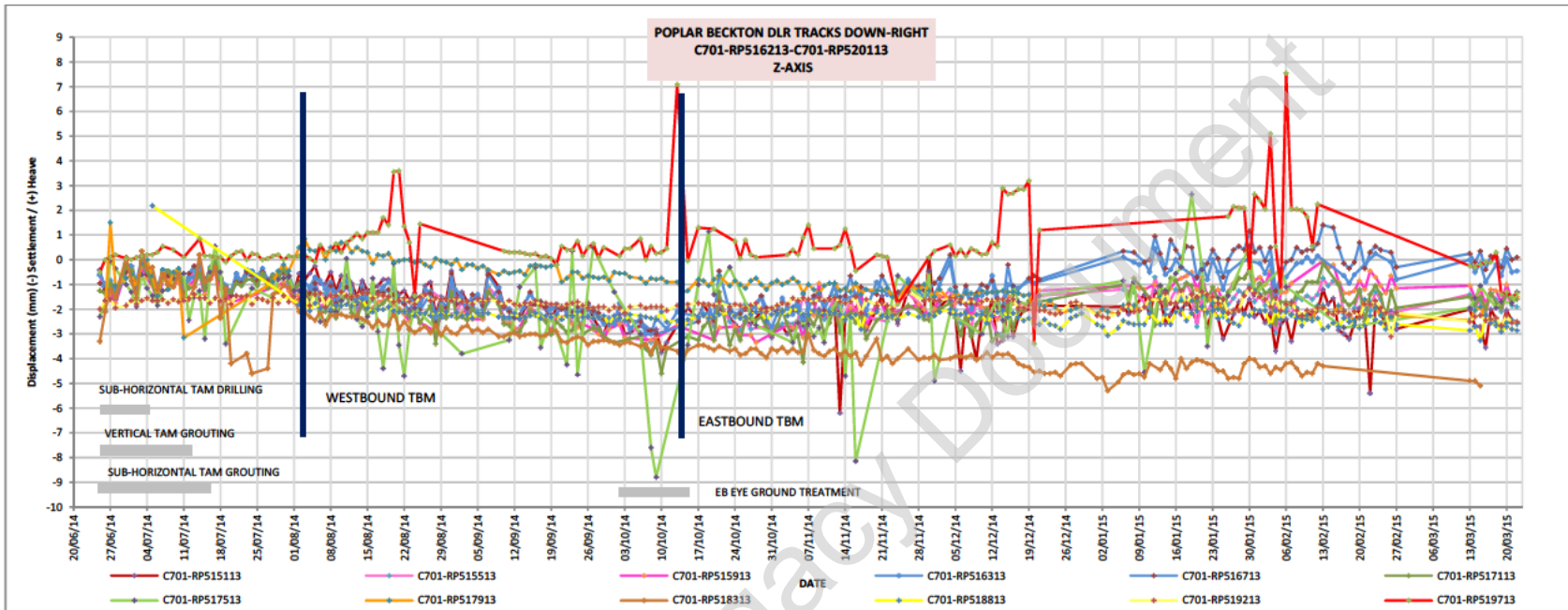
Poplar Beckton DLR Up Right. C701-RP515112 to C701-RP520112



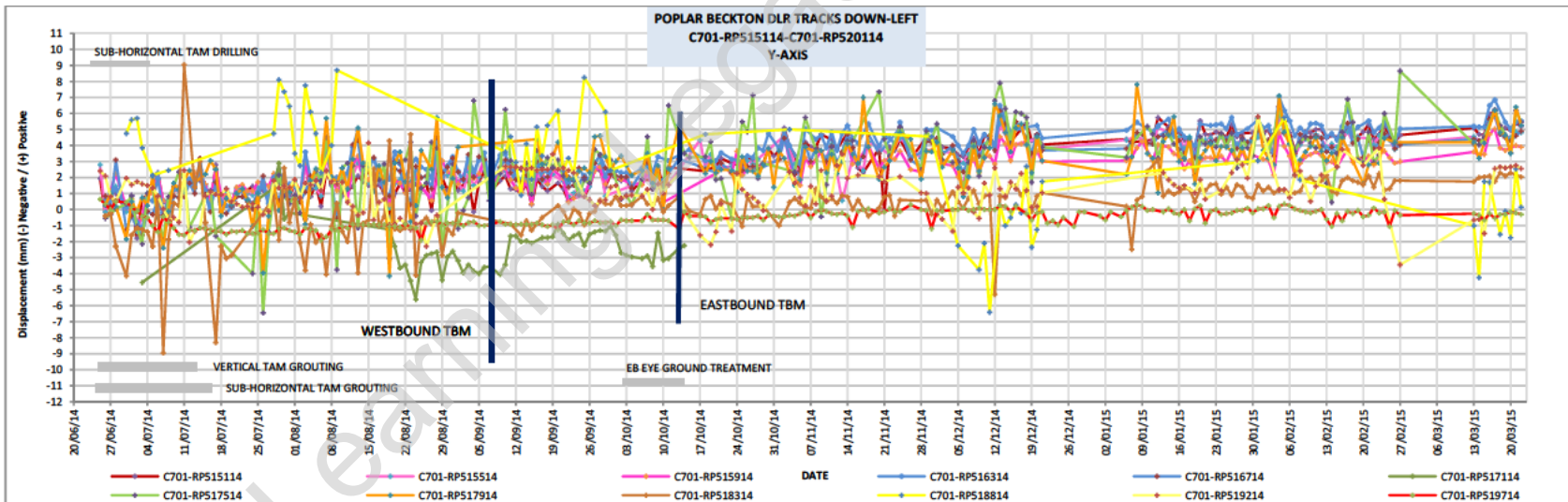
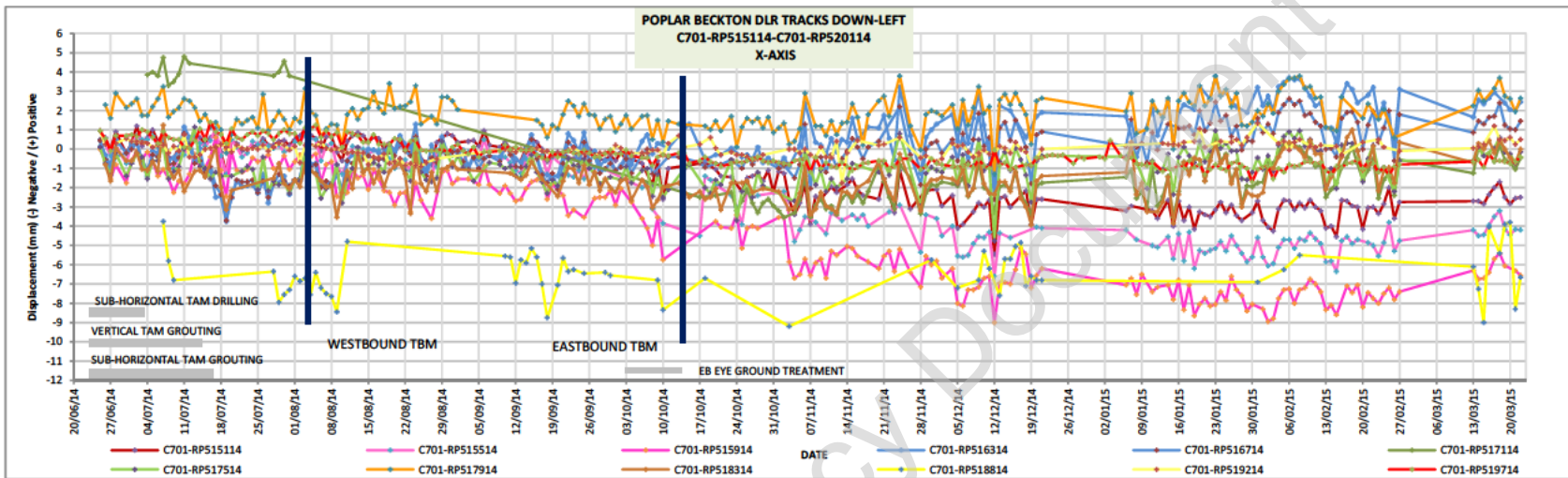


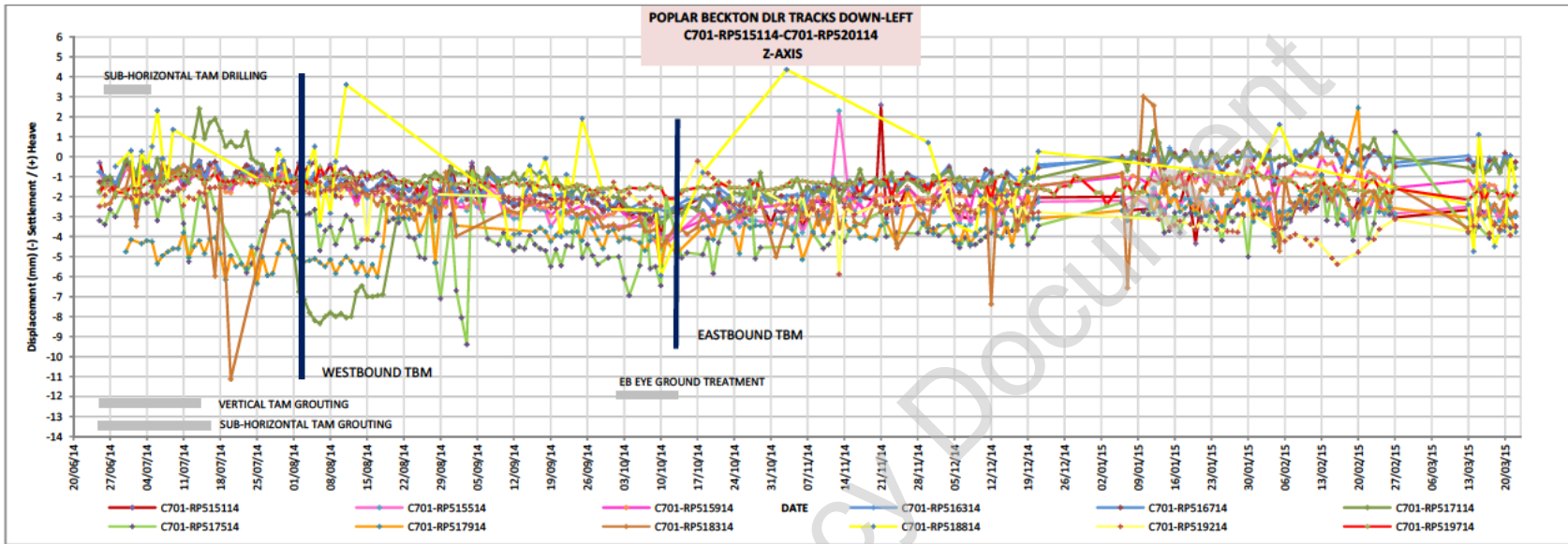
Poplar Beckton DLR Down Right. C701-RP515113 to C701-RP520113





Poplar Beckton DLR Down Left. C701-RP515114 to C701-RP520114



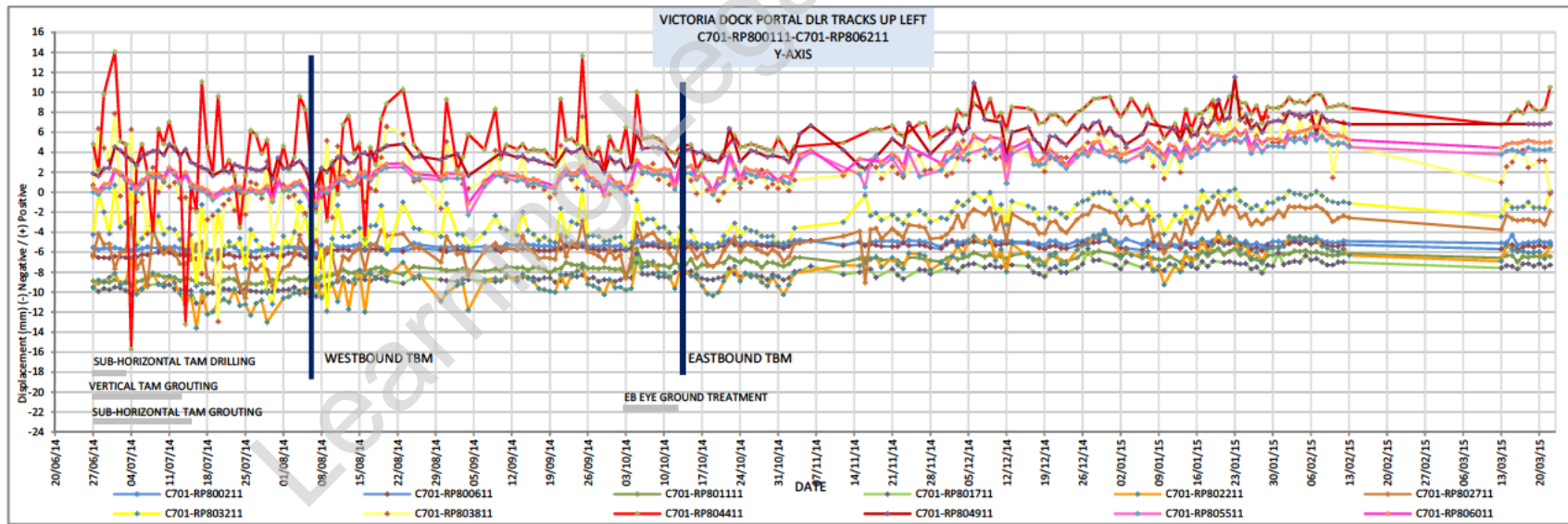
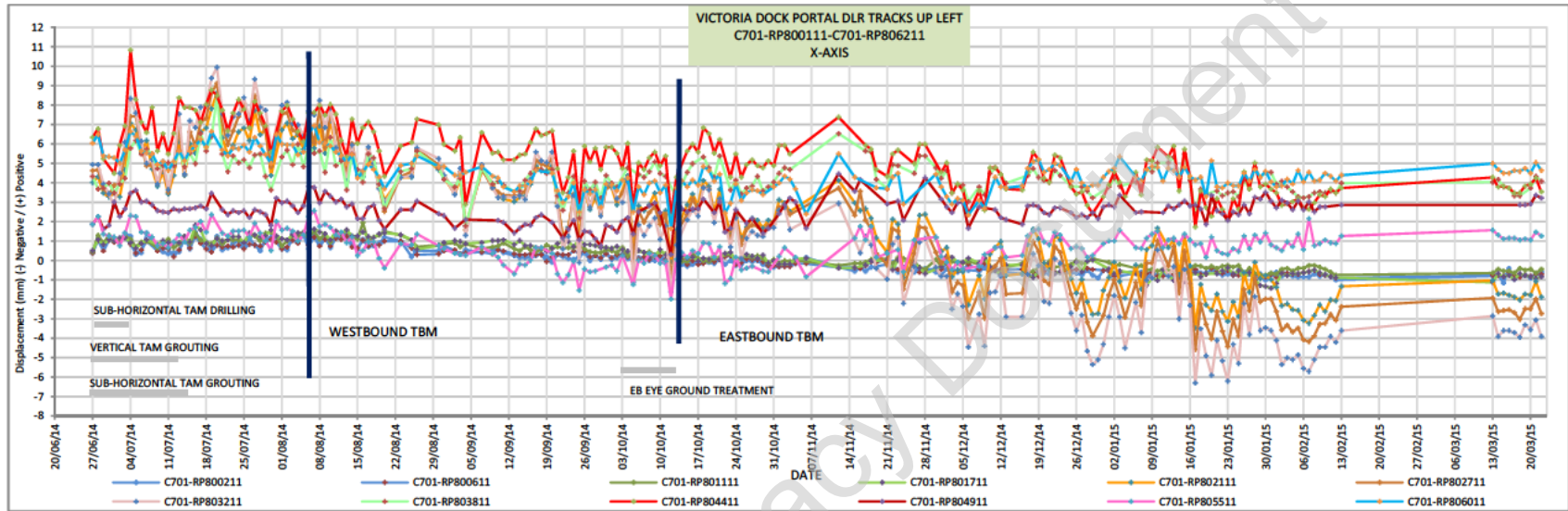


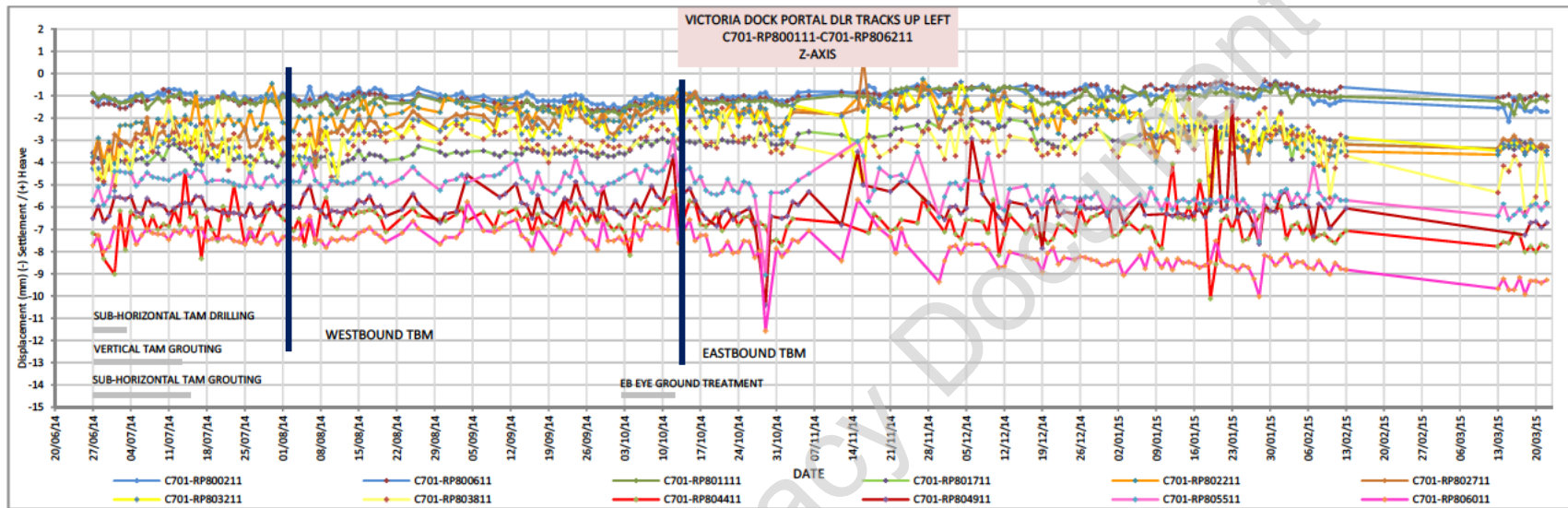
Learning Legacy Document

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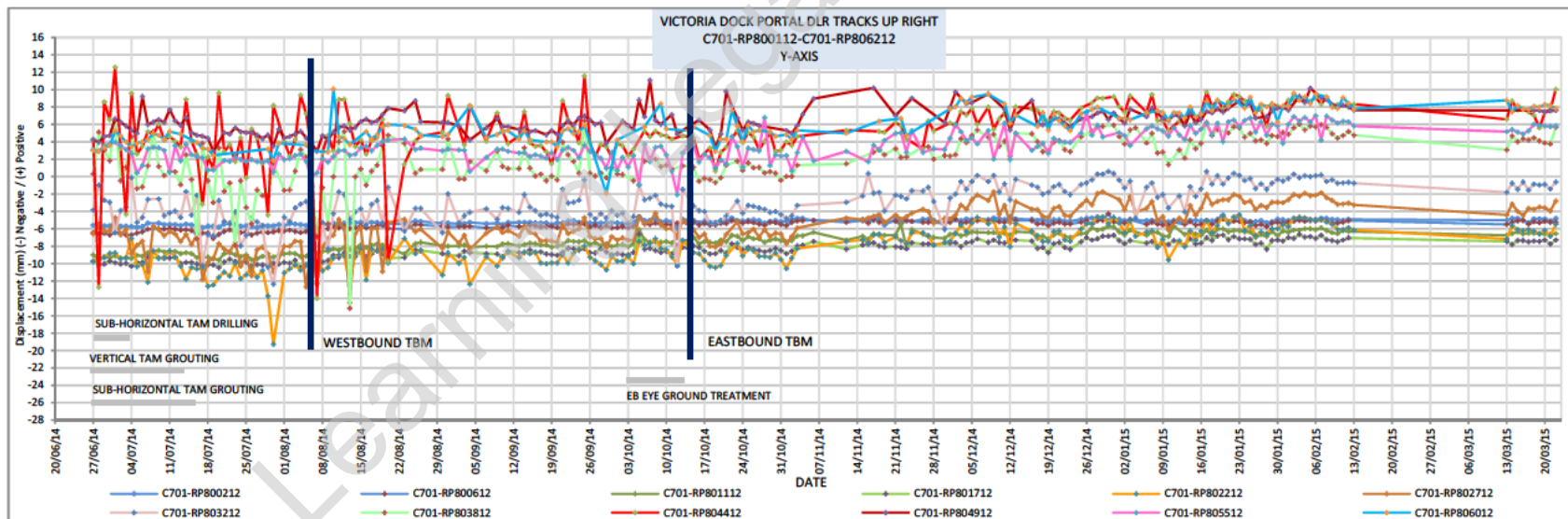
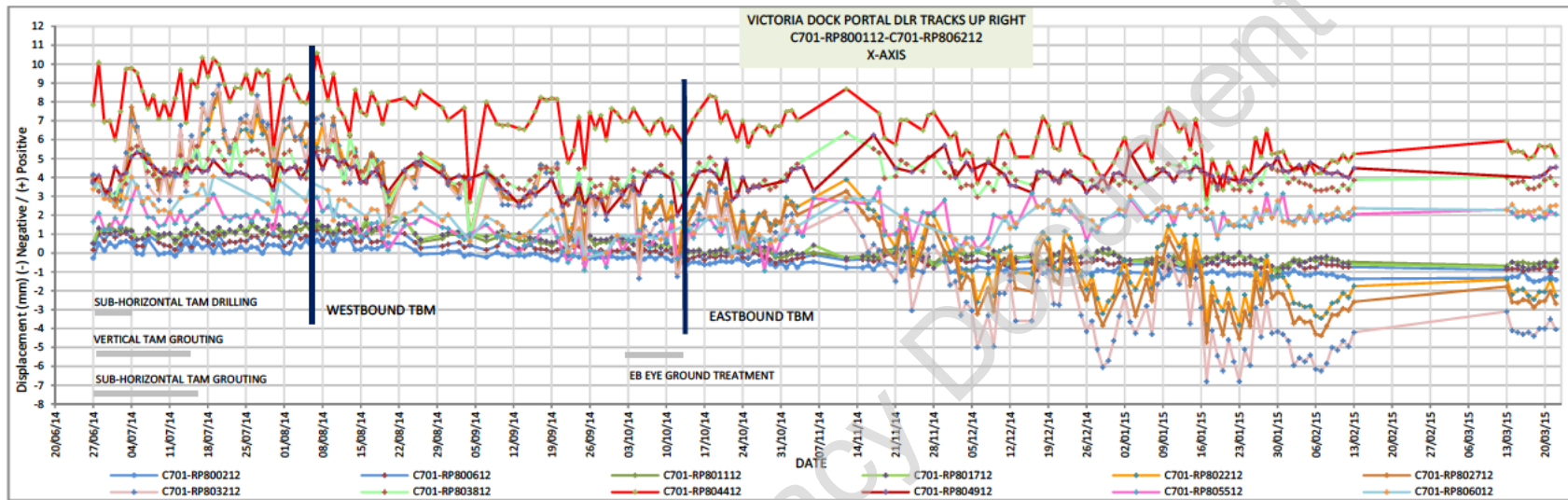
**Appendix 3: Poplar to Beckton tracks from Royal Victoria Station to Victoria
Dock Portal Headwall**

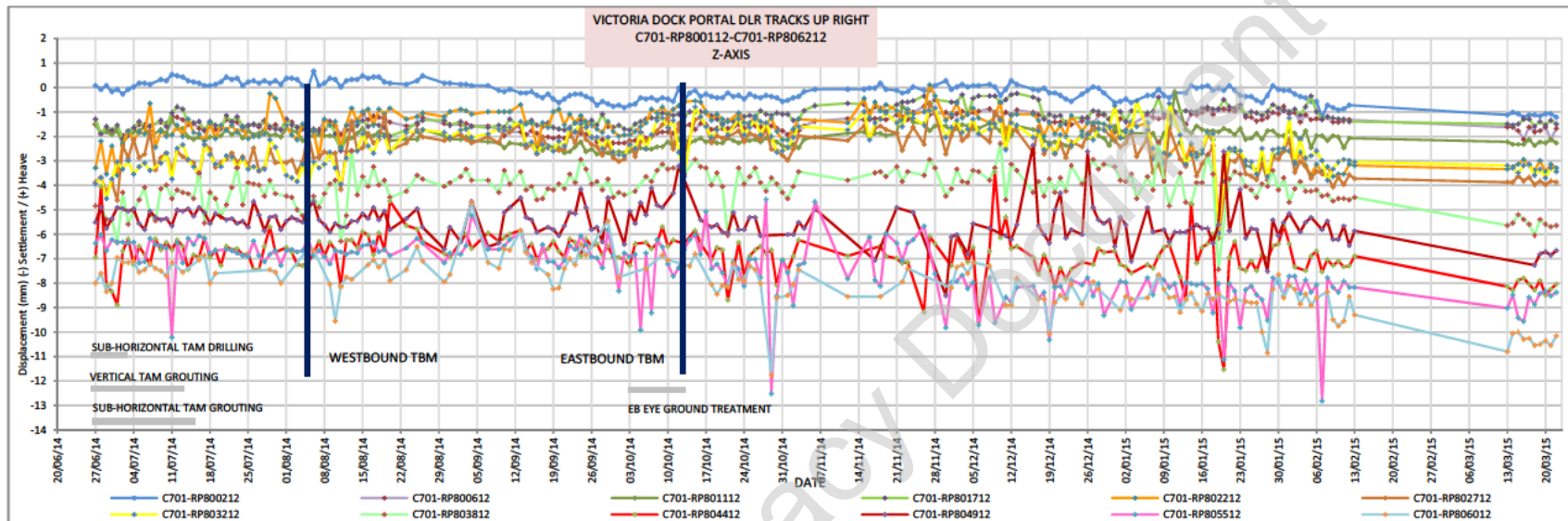
Victoria Dock Portal DLR Up Left. C701-RP800111 to C701-RP806211



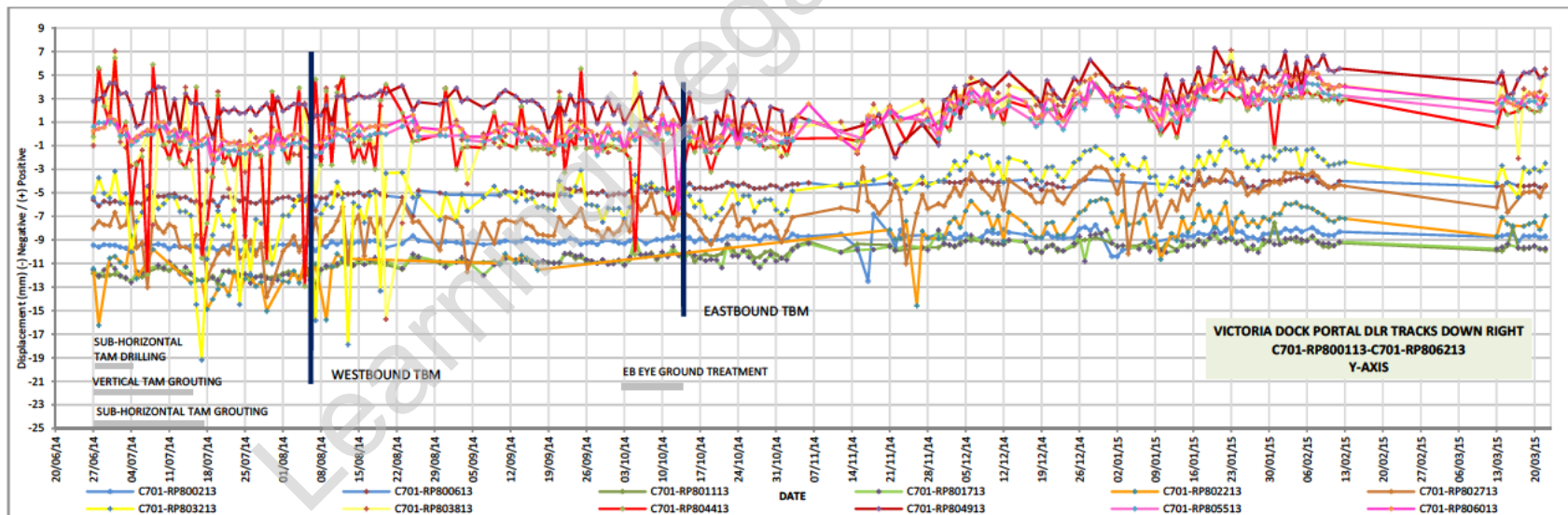
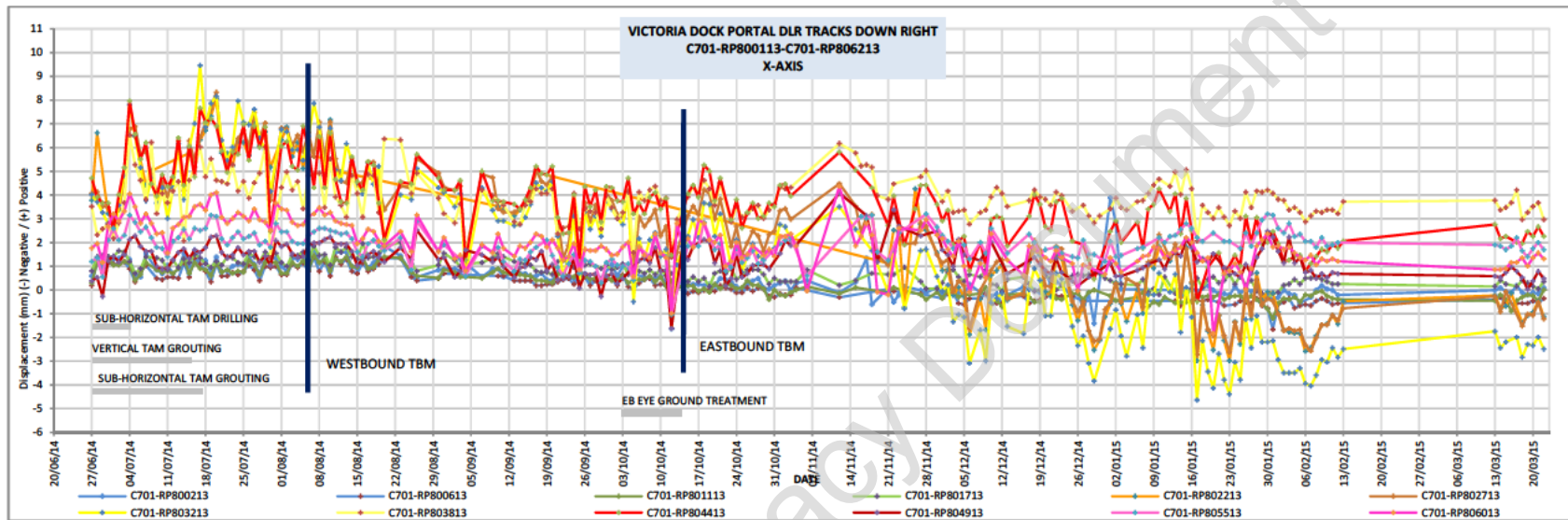


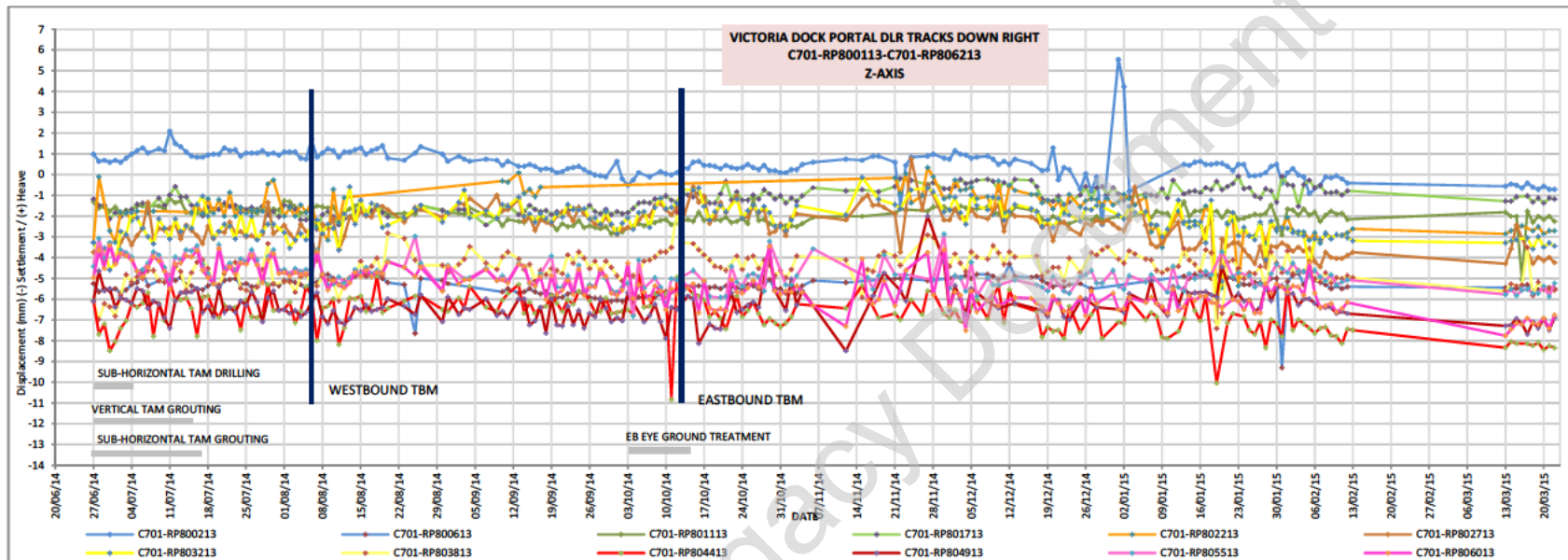
Victoria Dock Portal DLR Right C701-RP800112 to C701-RP806212



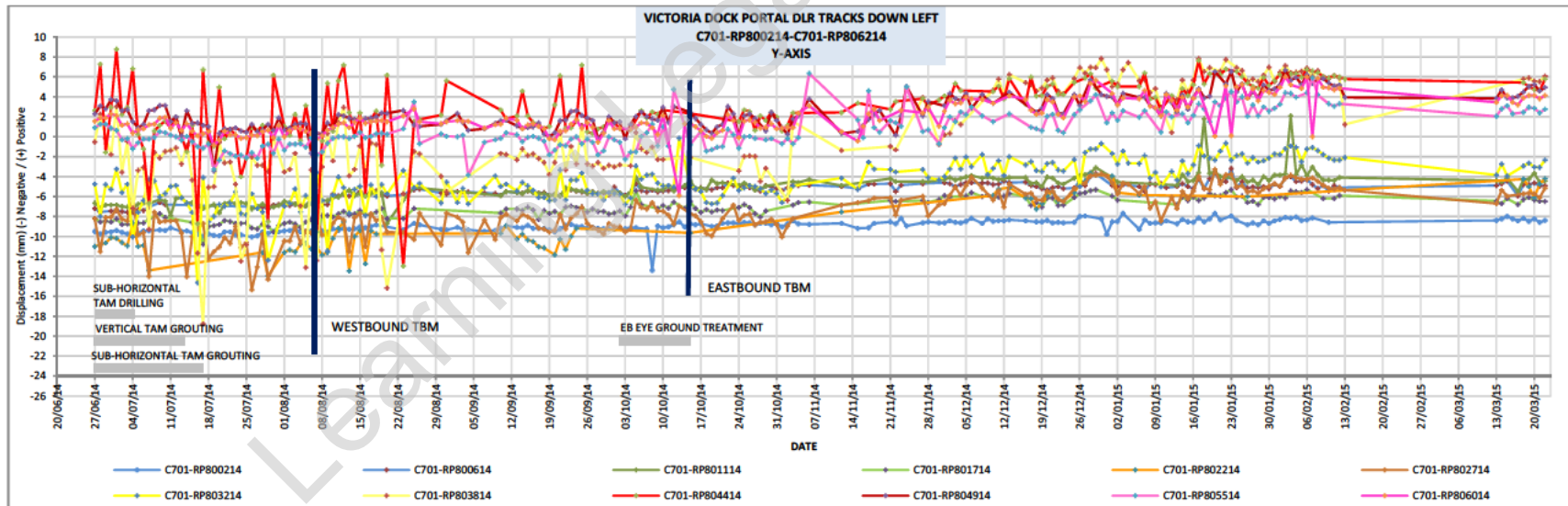
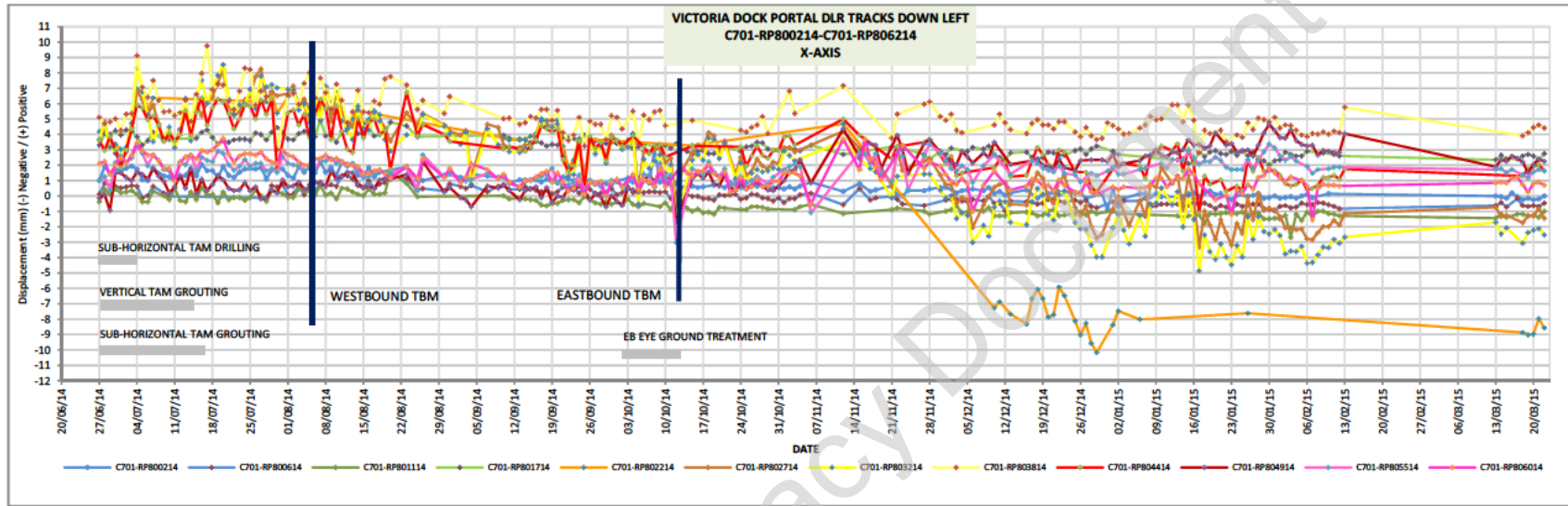


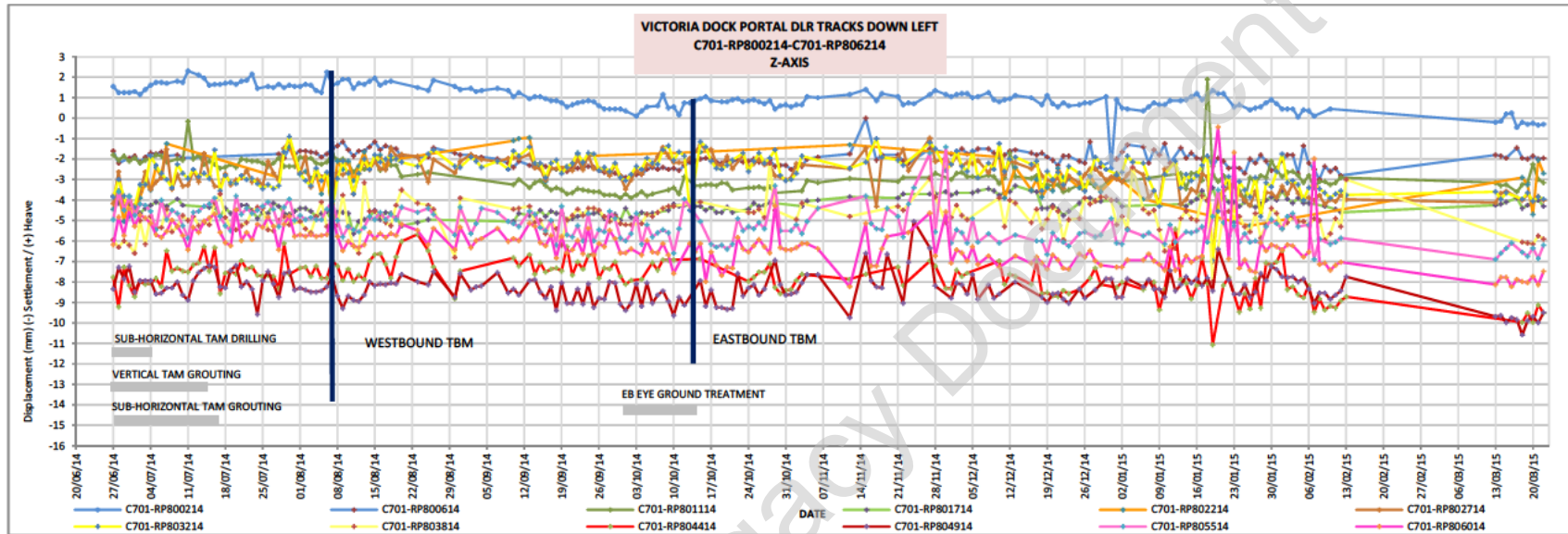
Victoria Dock Portal DLR Down Right C701-RP800113 to C701-RP806213





Victoria Dock Portal DLR Down Left C701-RP800214 to C701-RP806214



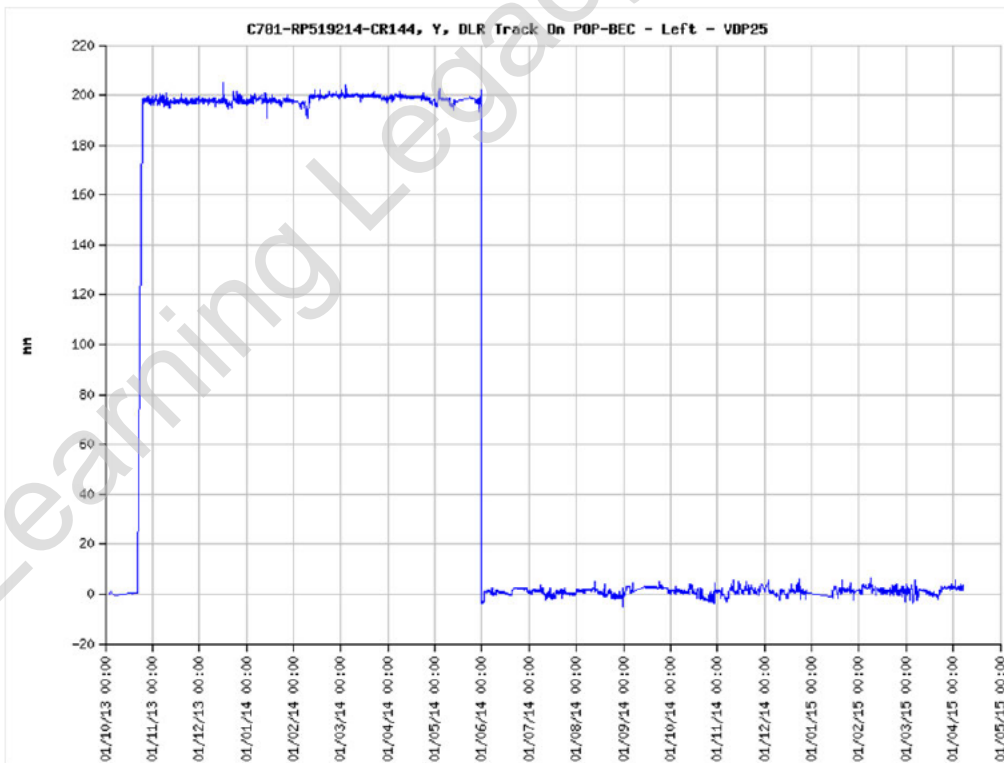
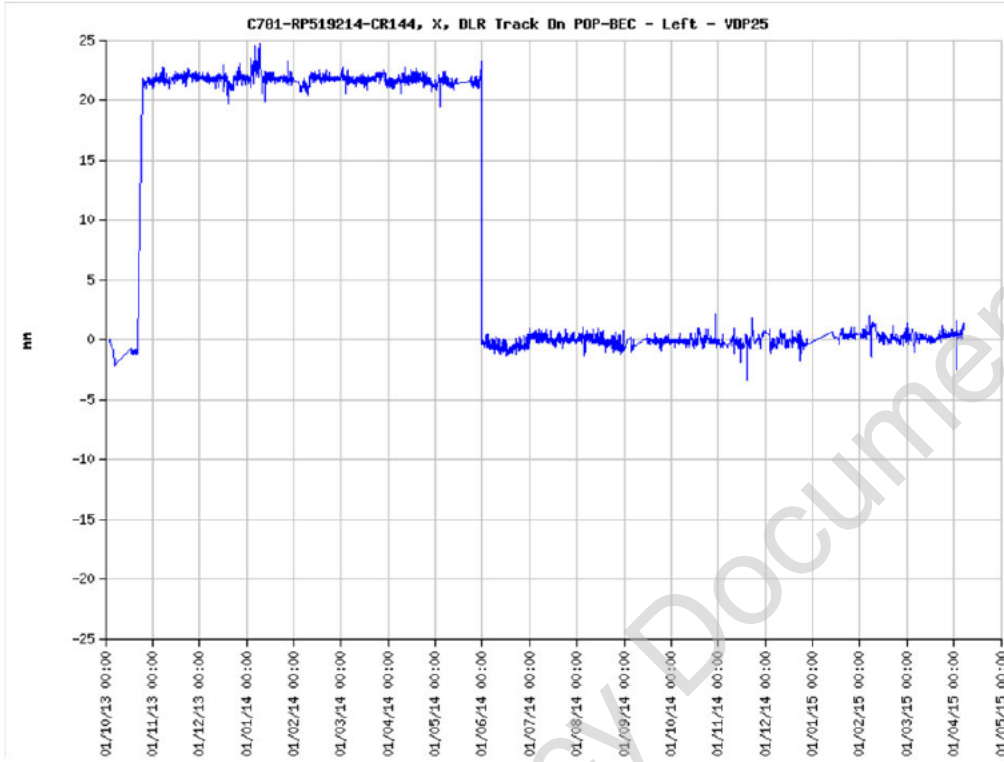


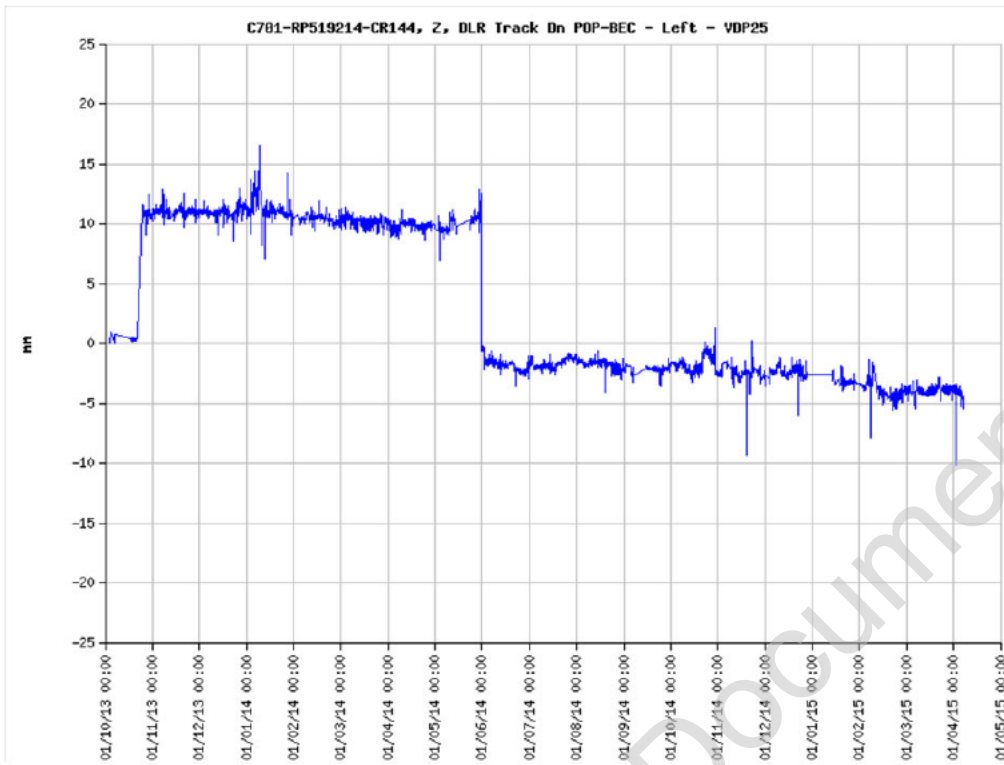
Learning Legacy Document

**Appendix 4: UCIMS GRAPHS: Poplar to Beckton tracks from Royal Victoria
Station to Victoria Dock Portal Headwall**

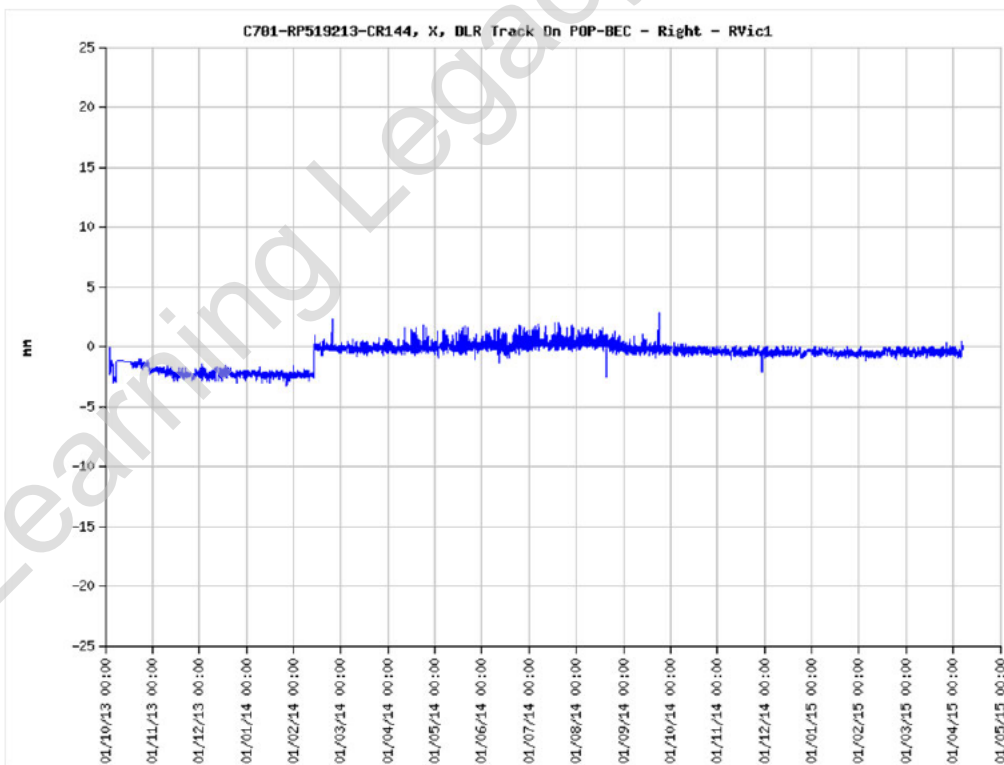
DLR PRISMS MICRO PILING (SOURCE: UCIMS)

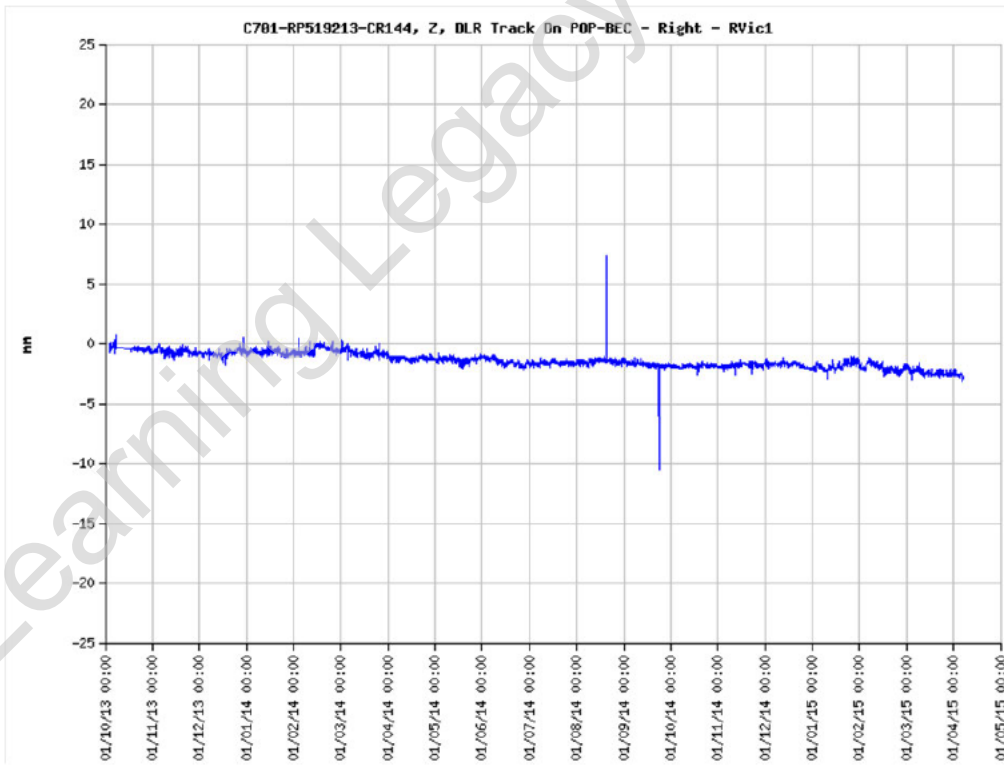
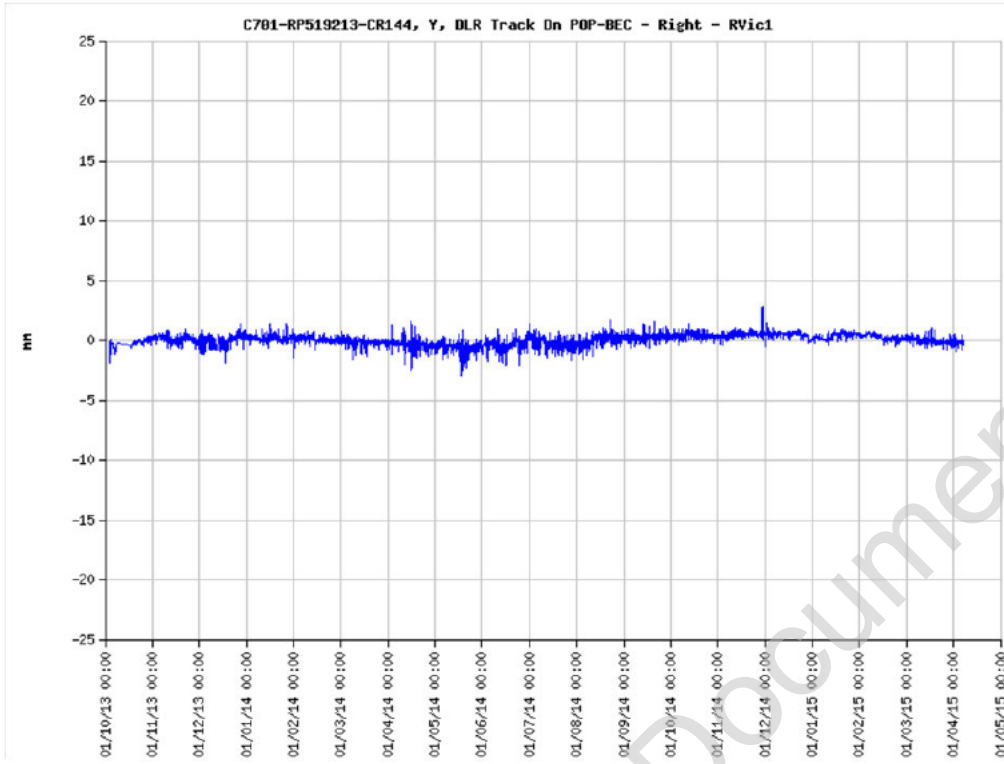
POP BEC C701-RP519214



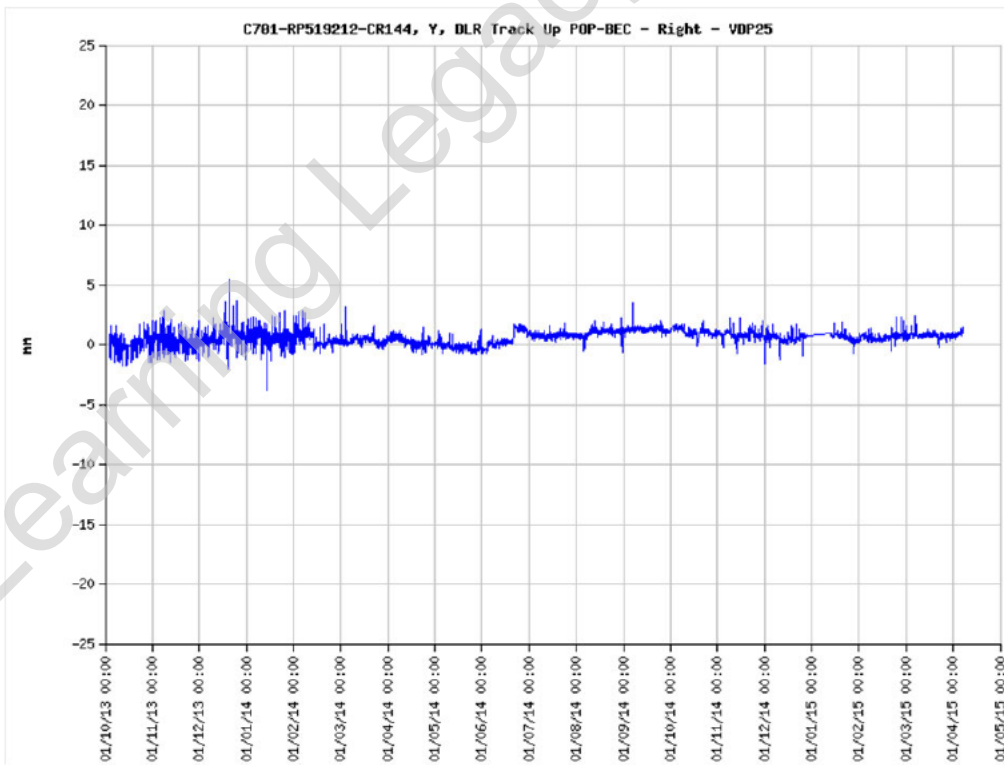
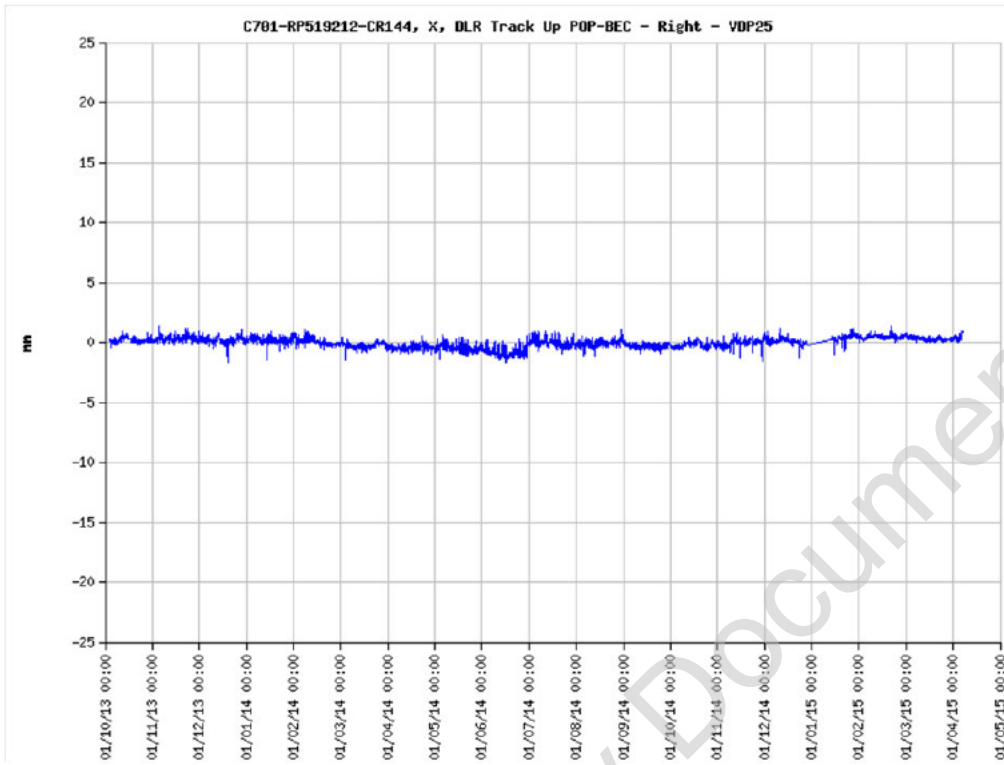


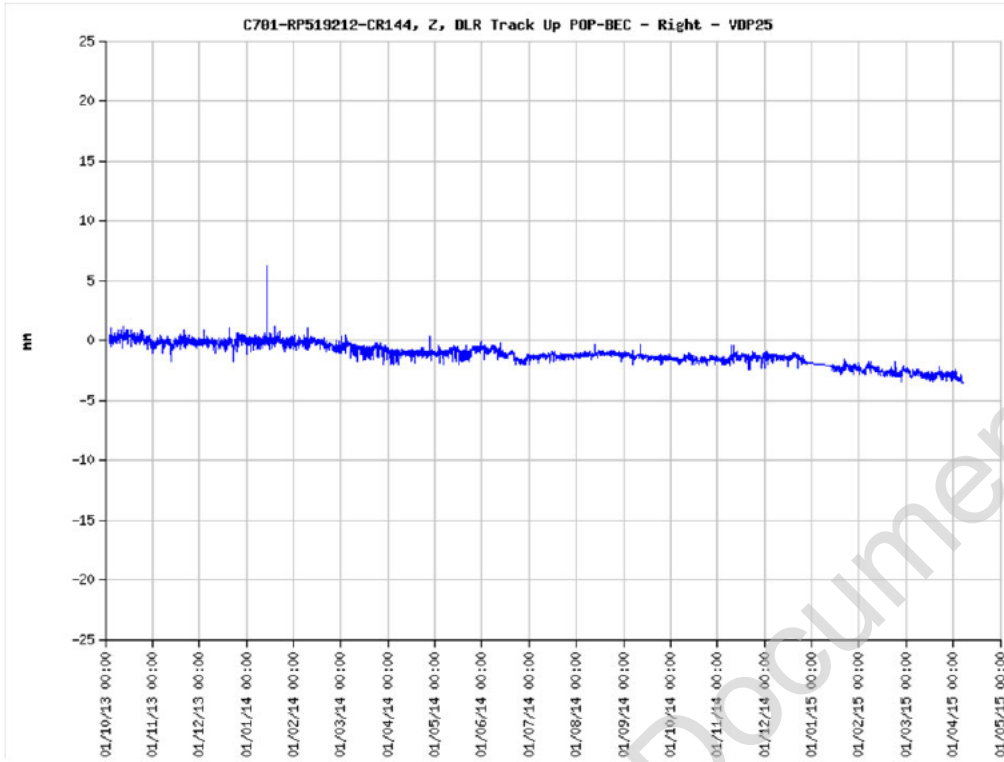
POP BEC C701-RP519213



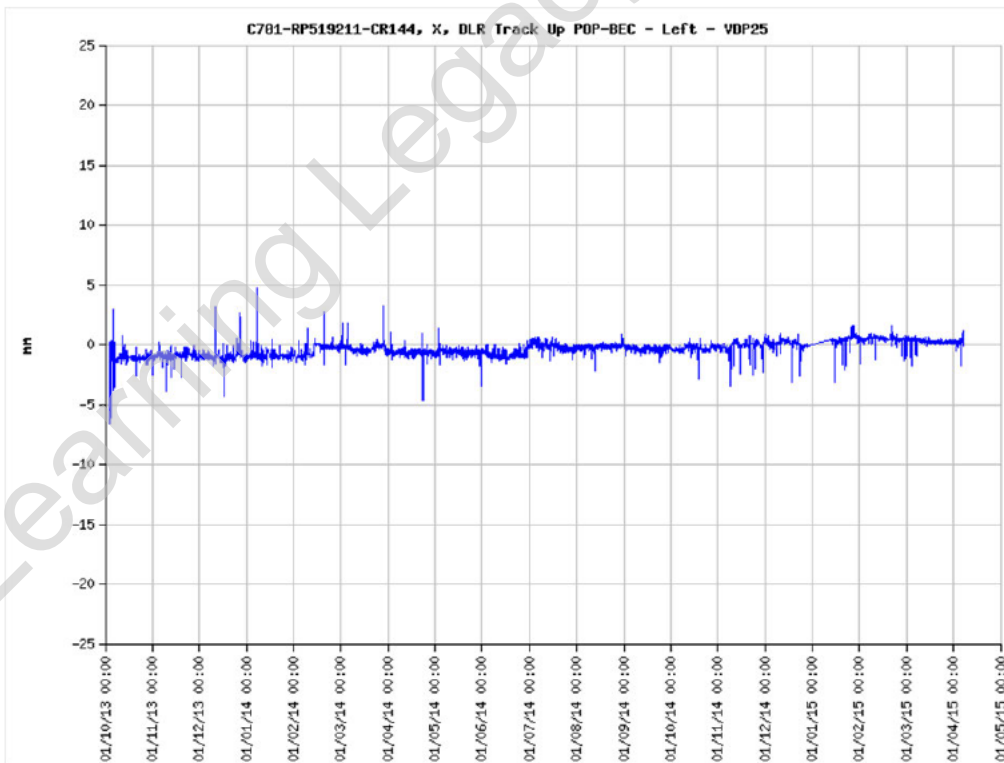


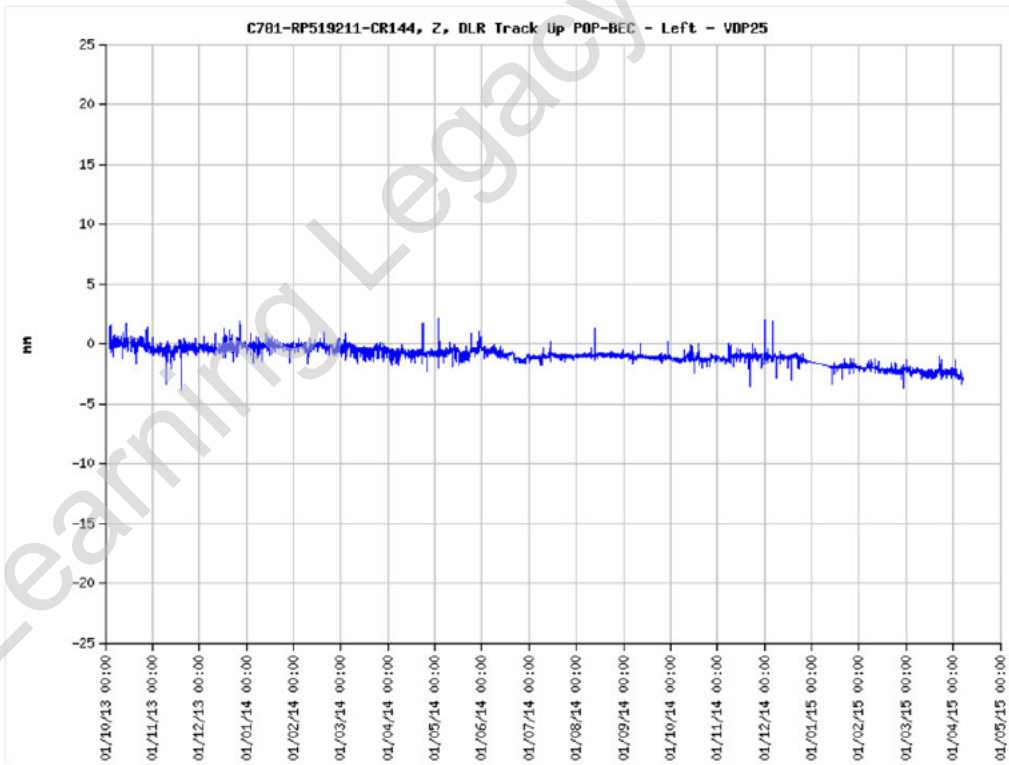
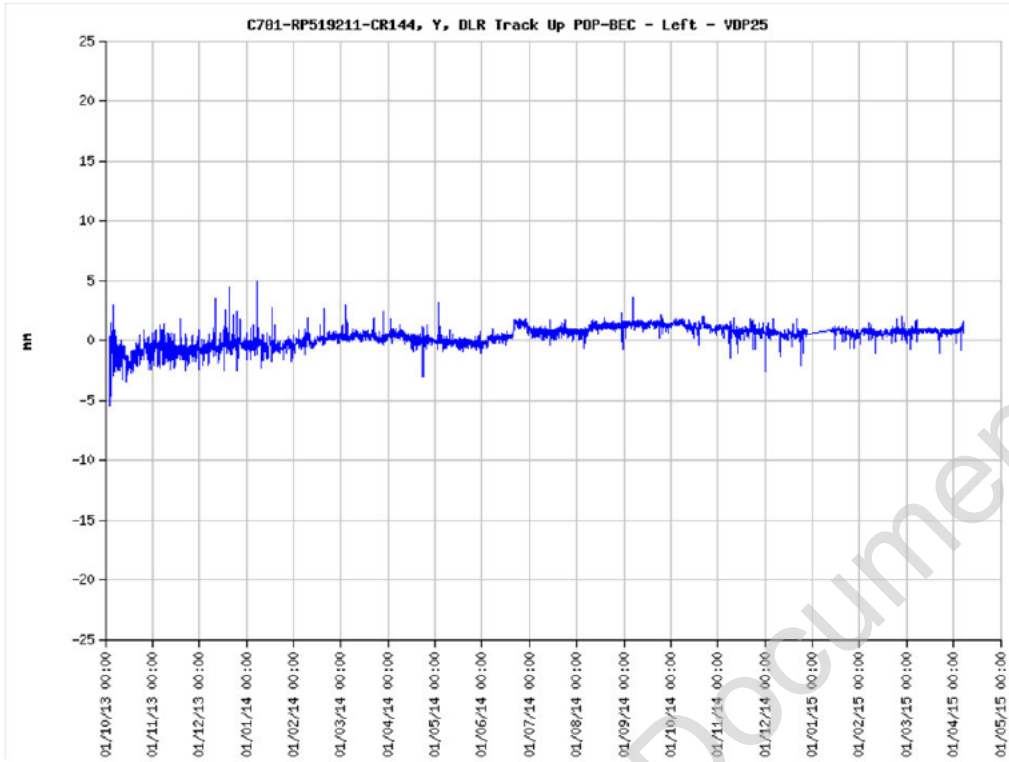
POP BEC C701-RP519212



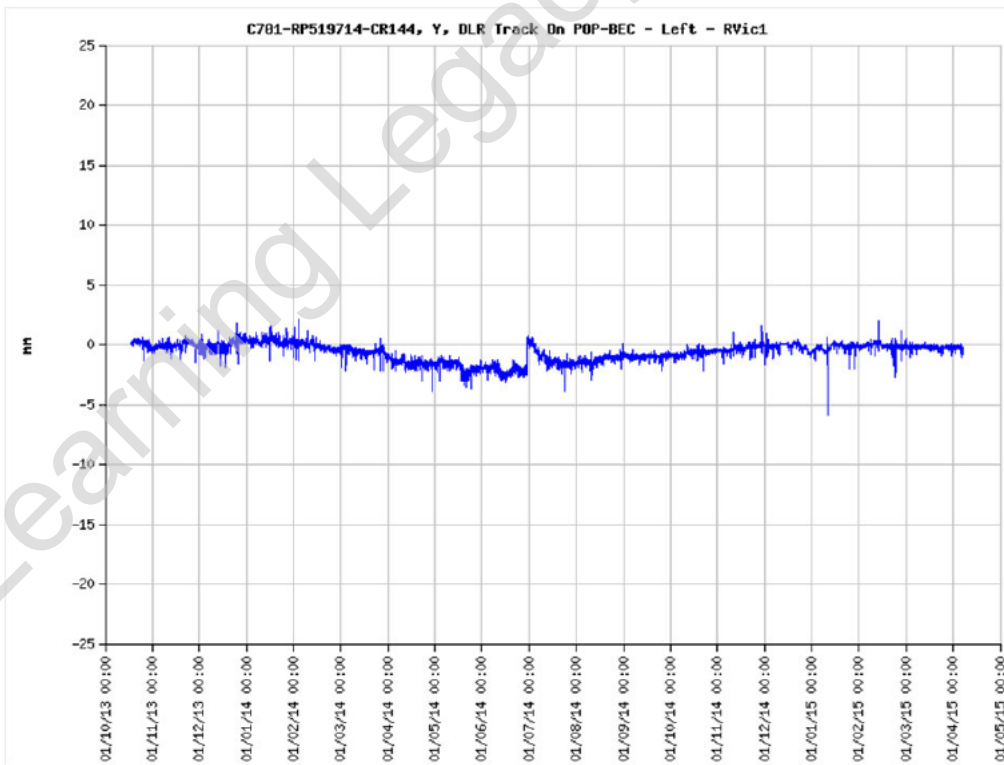
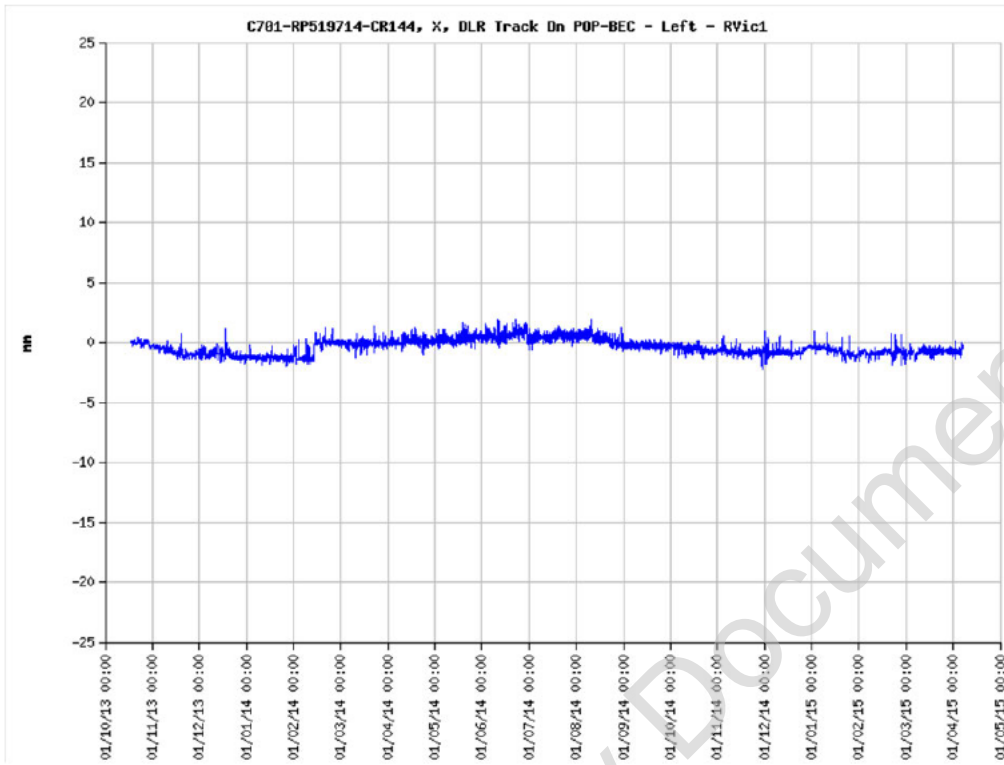


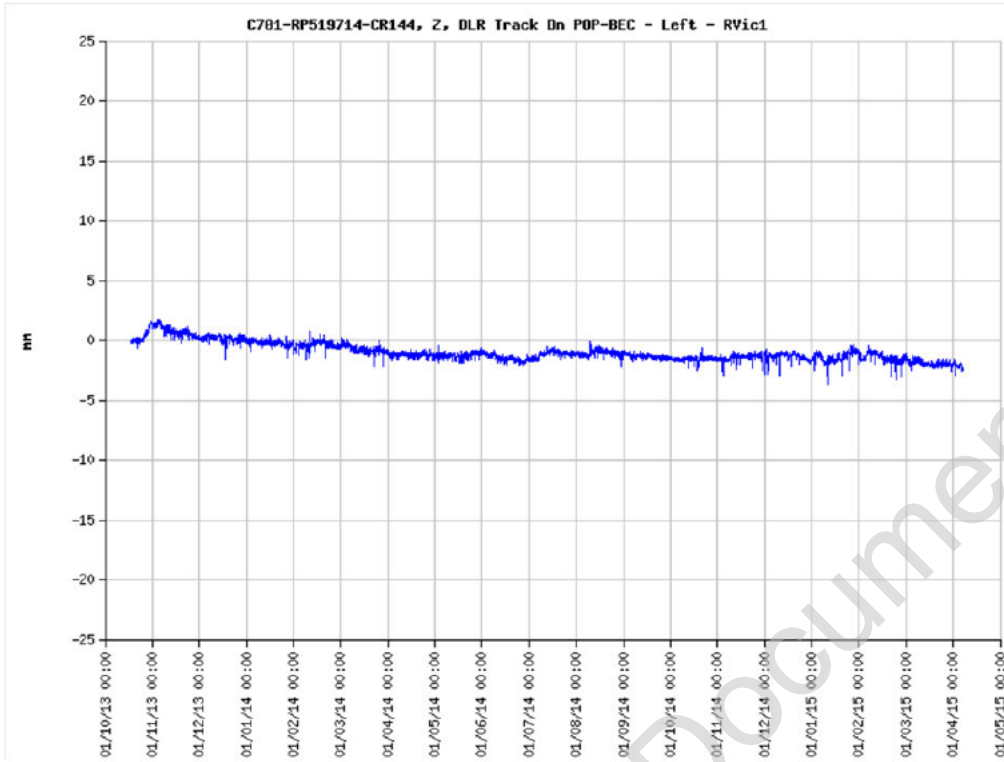
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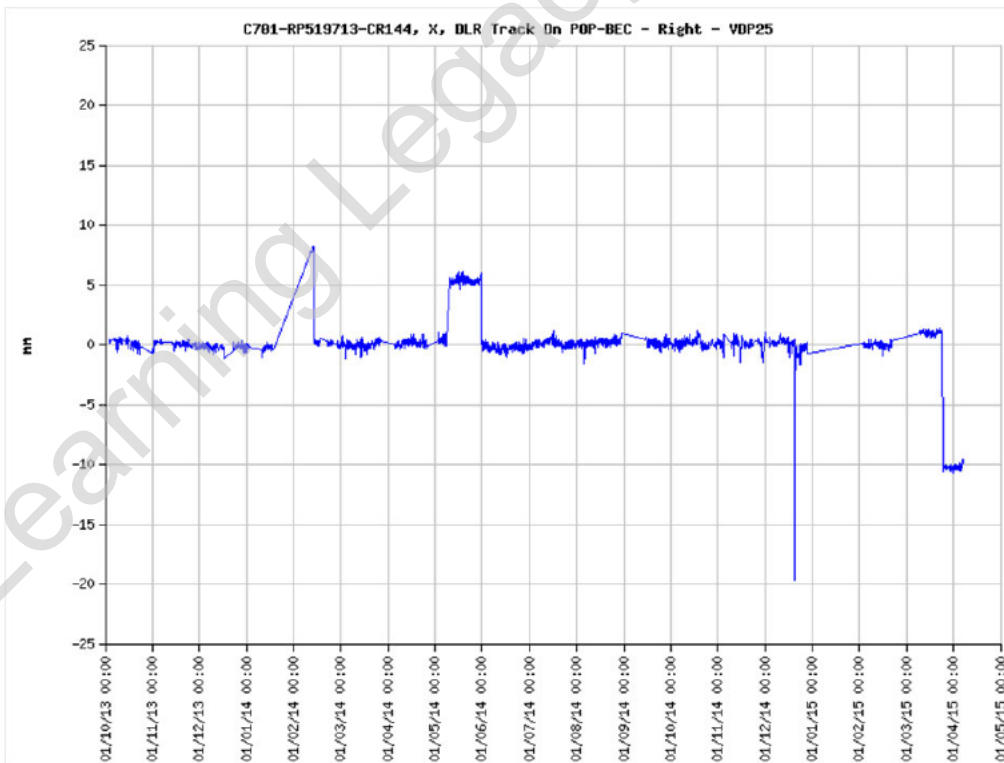


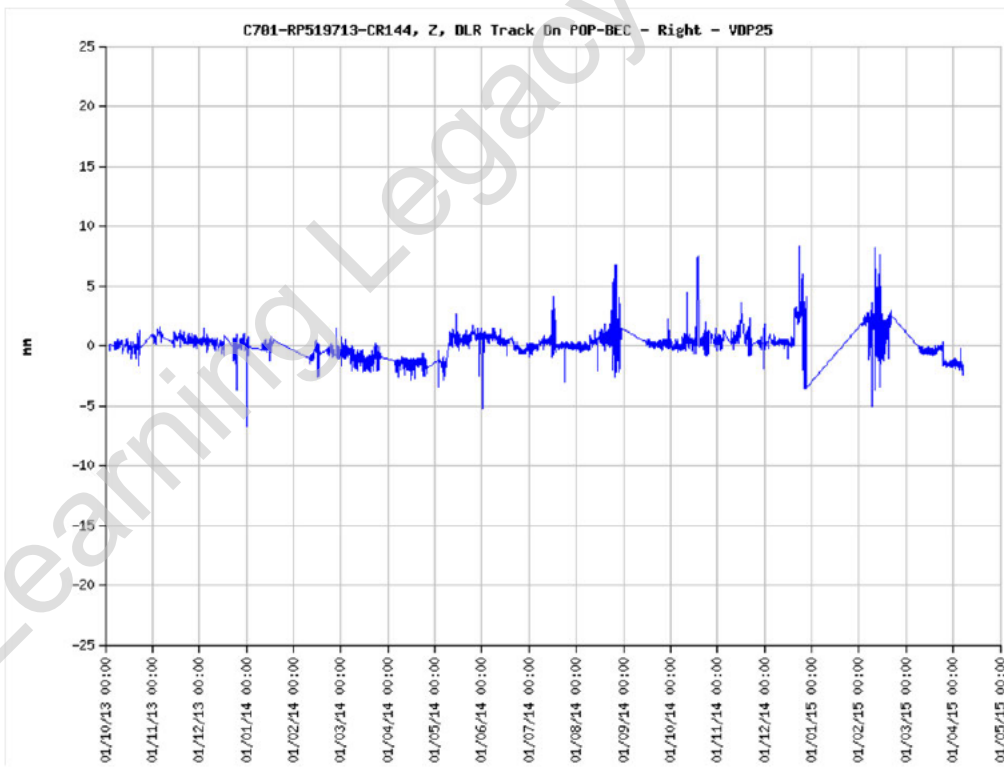
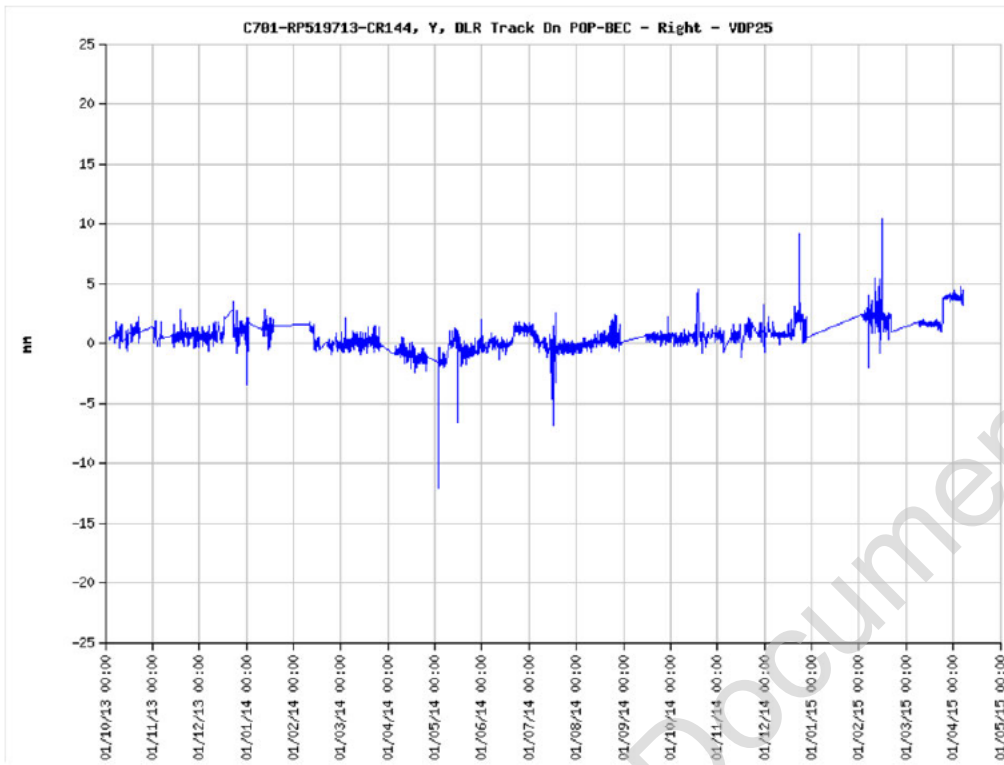
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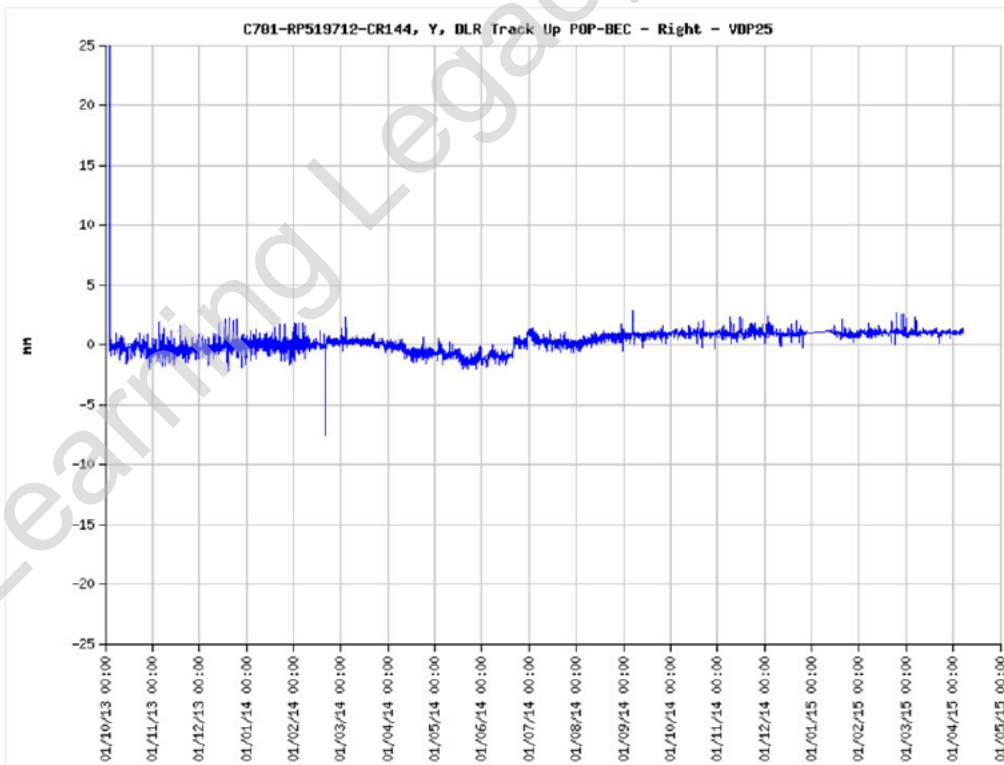
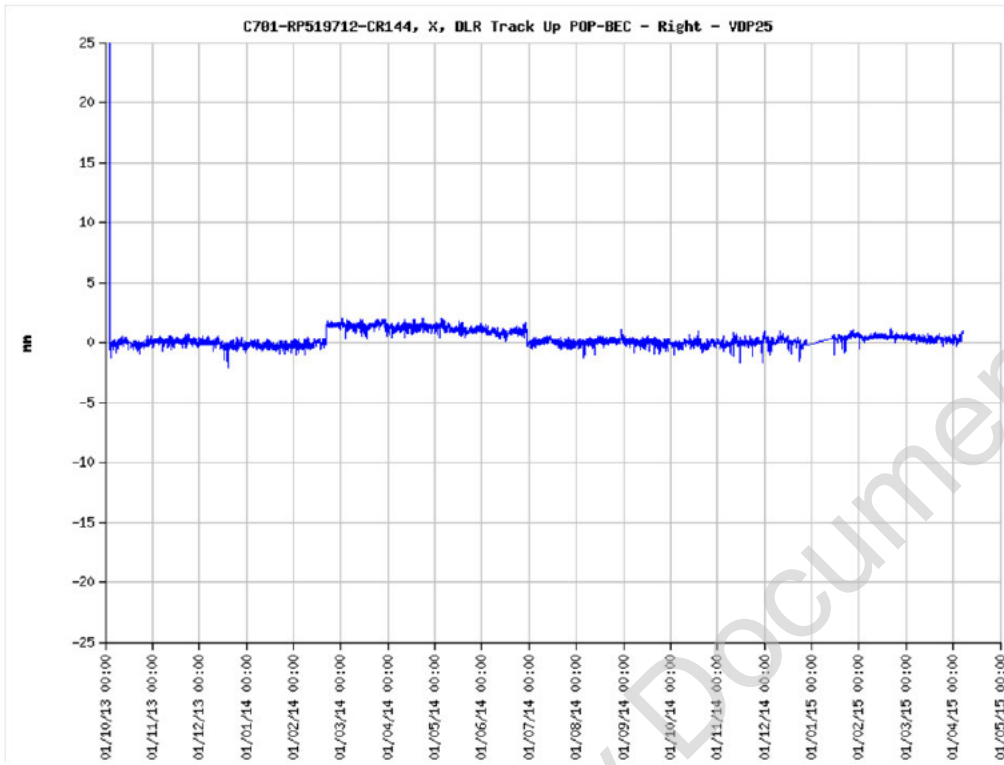


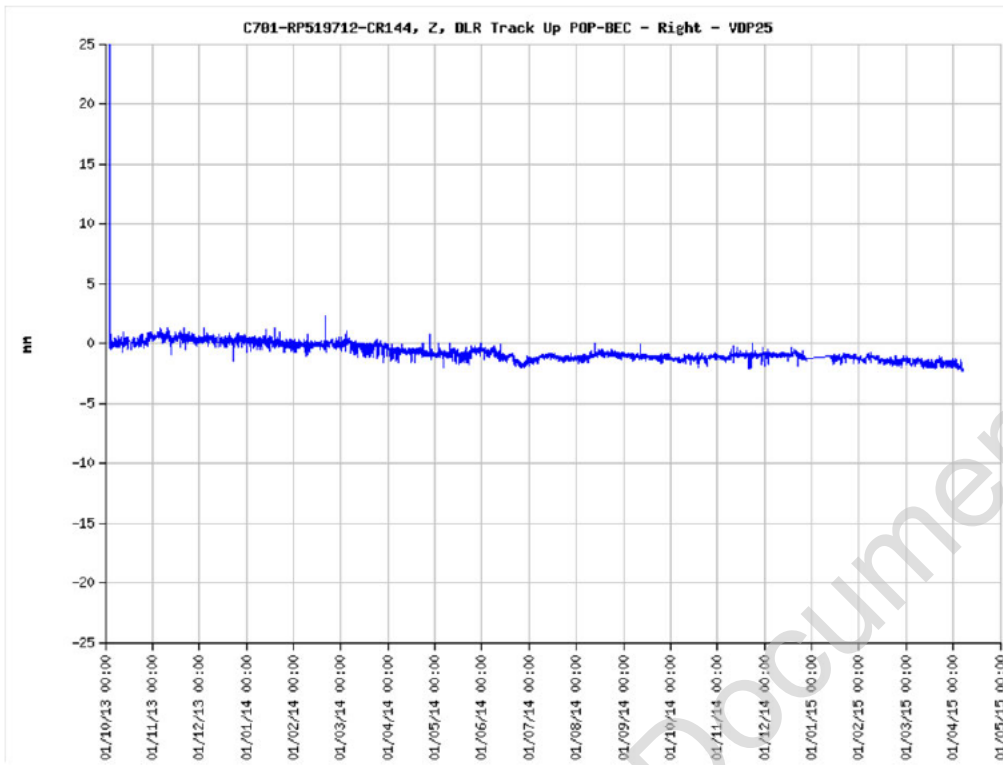
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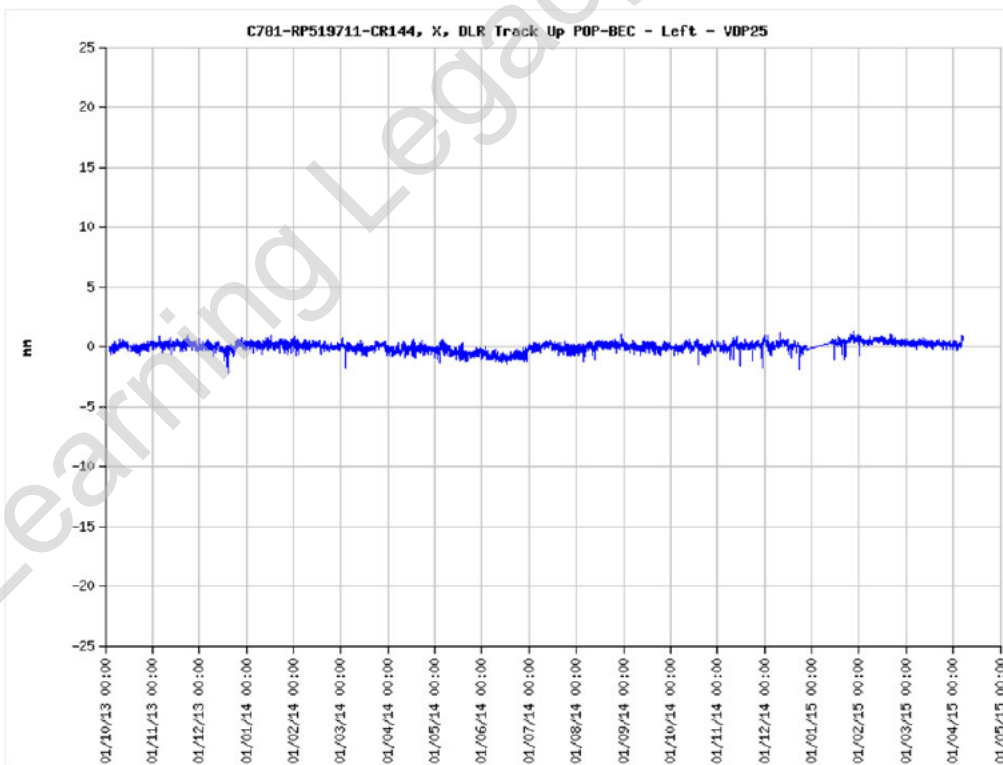


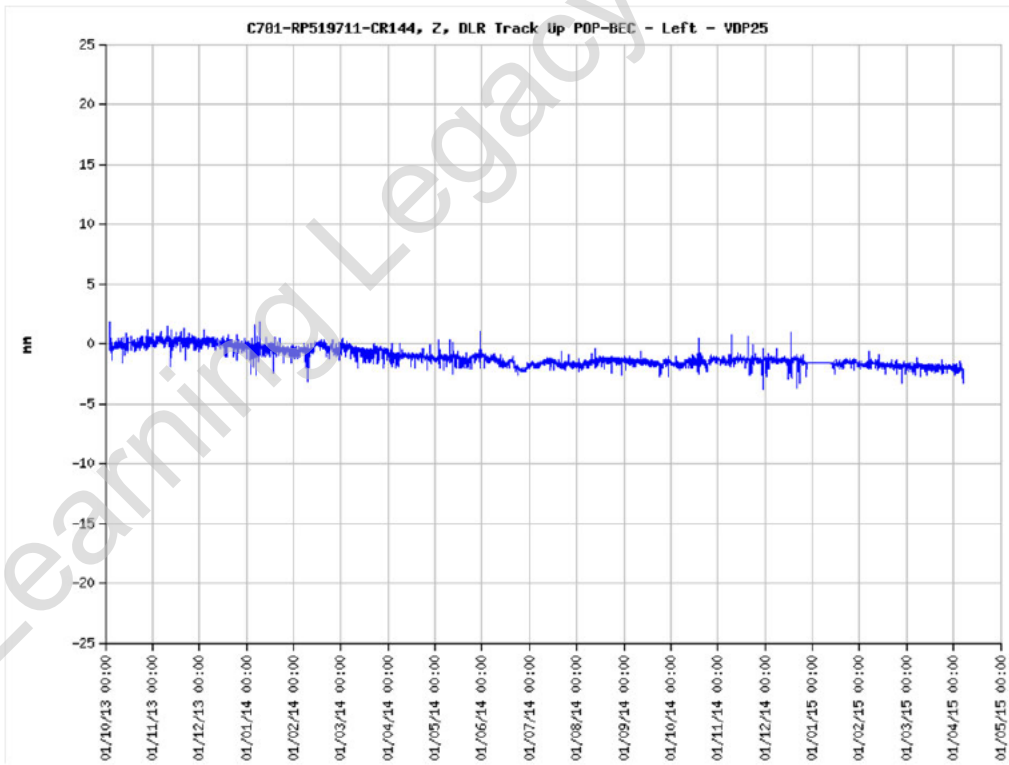
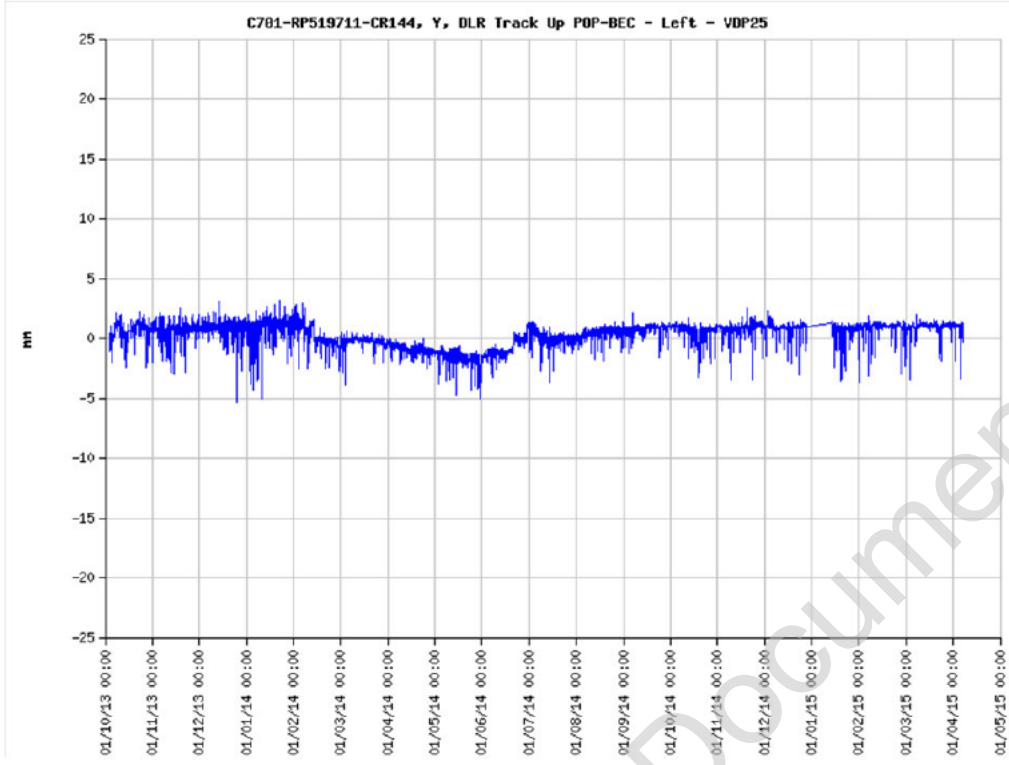
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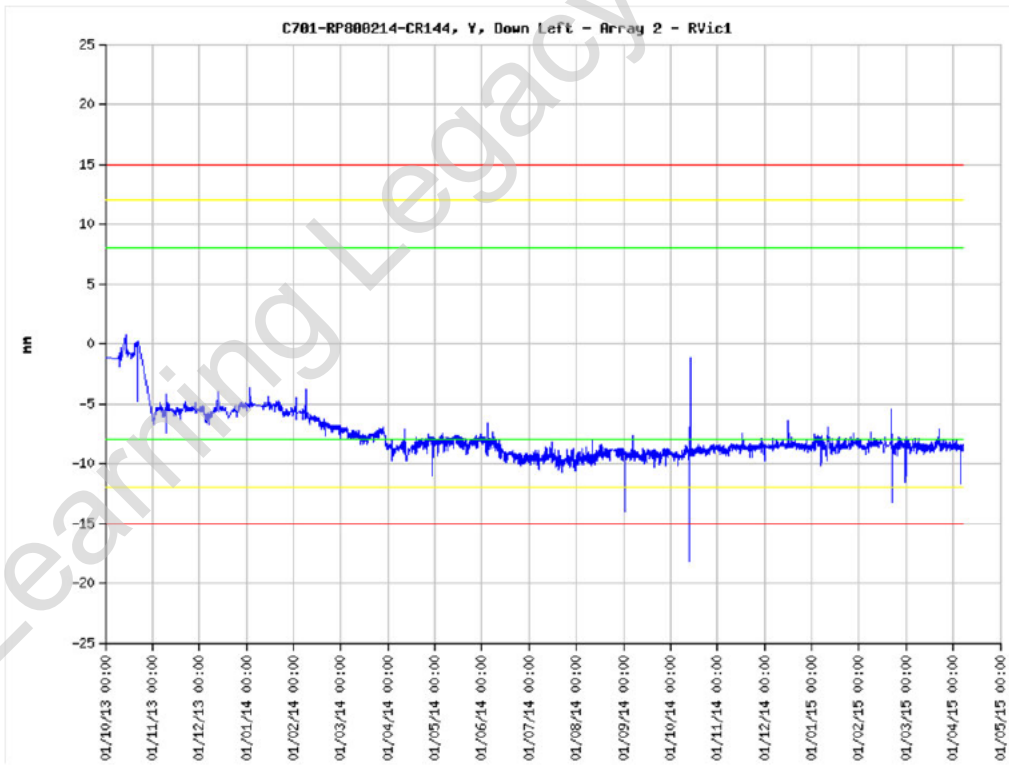
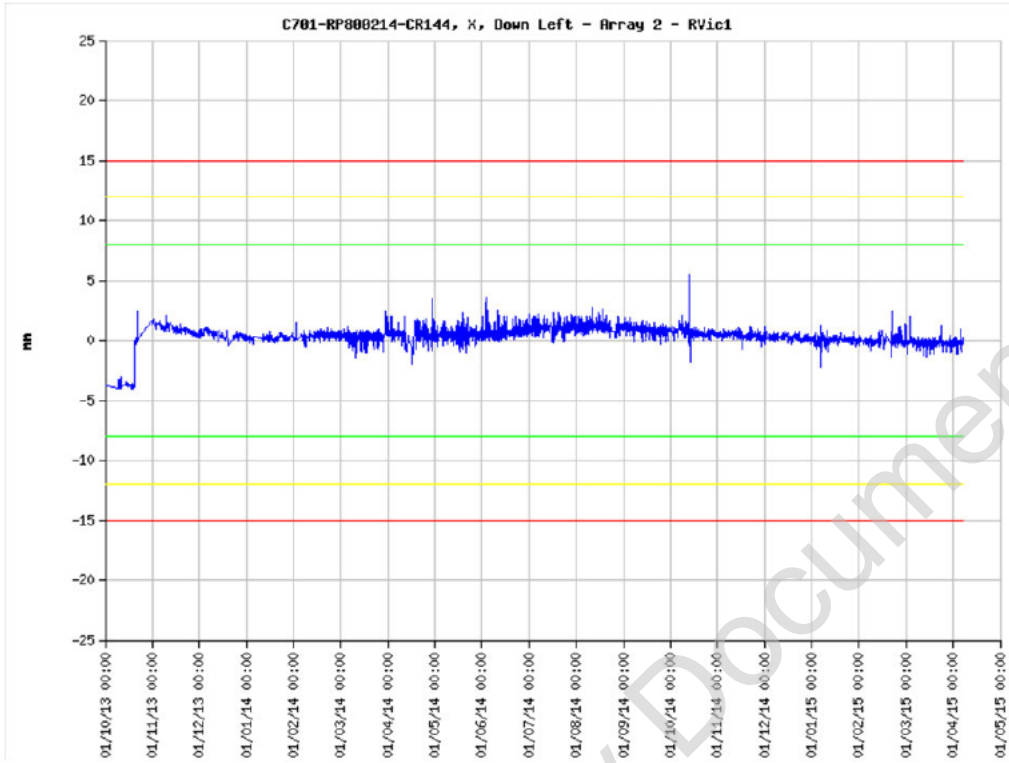


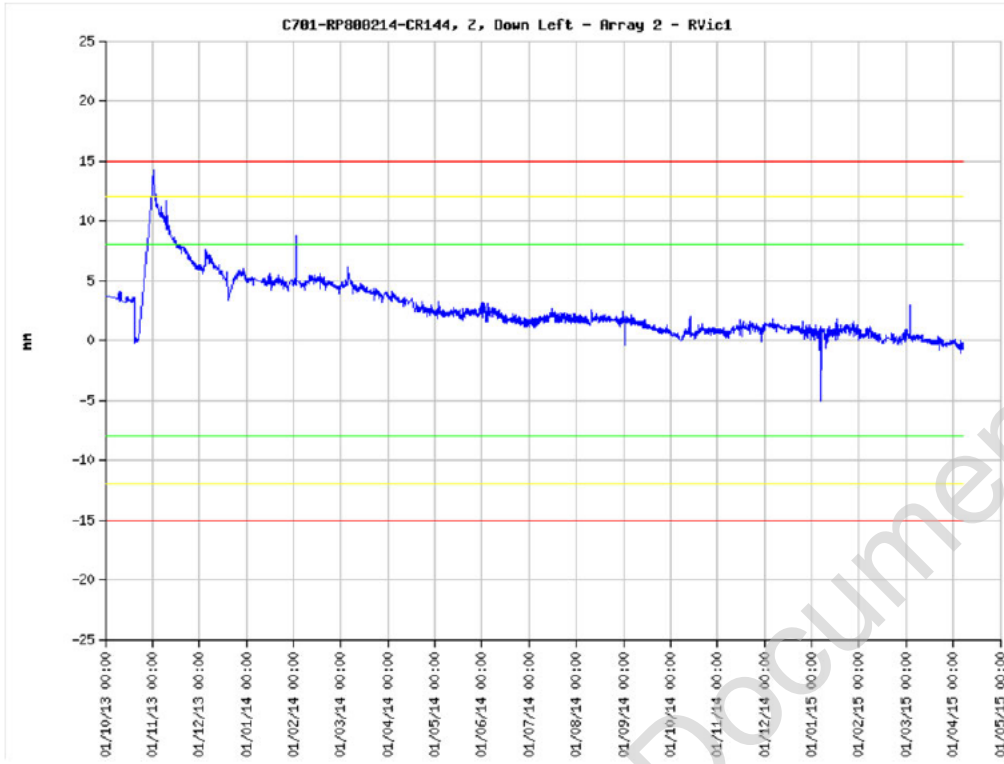
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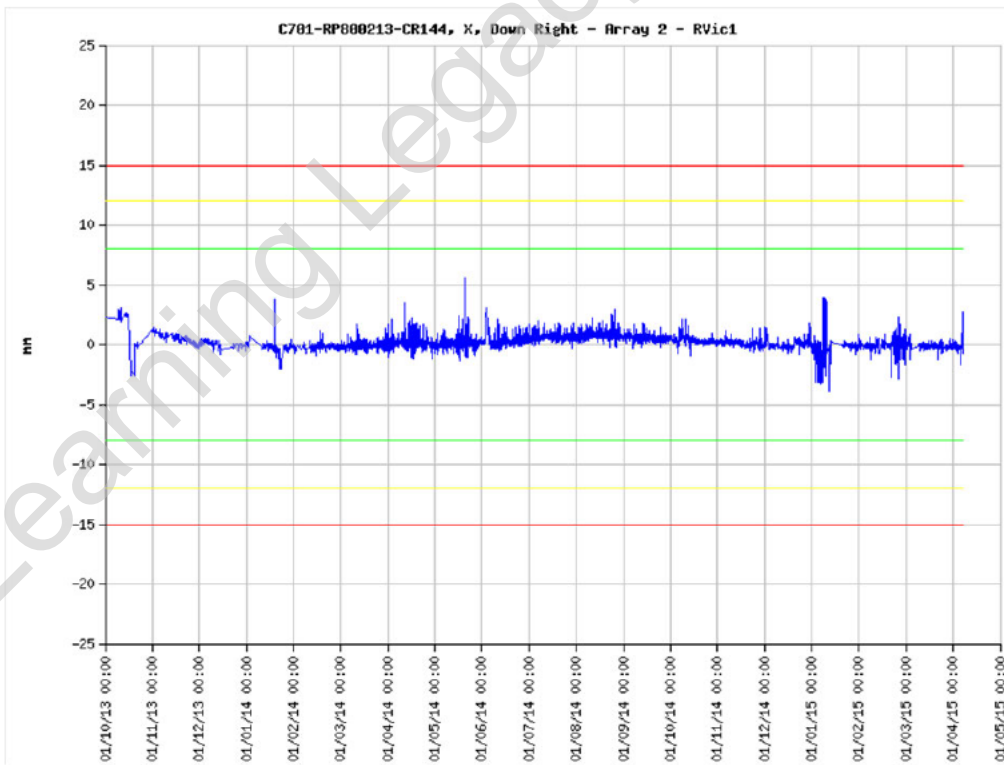


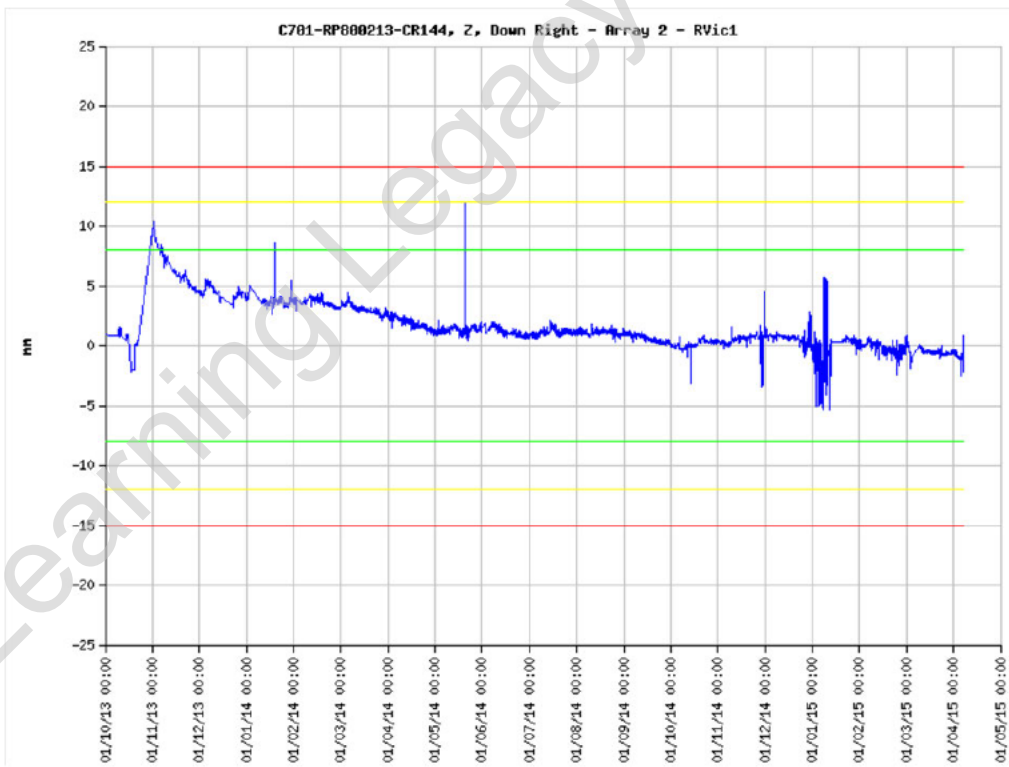
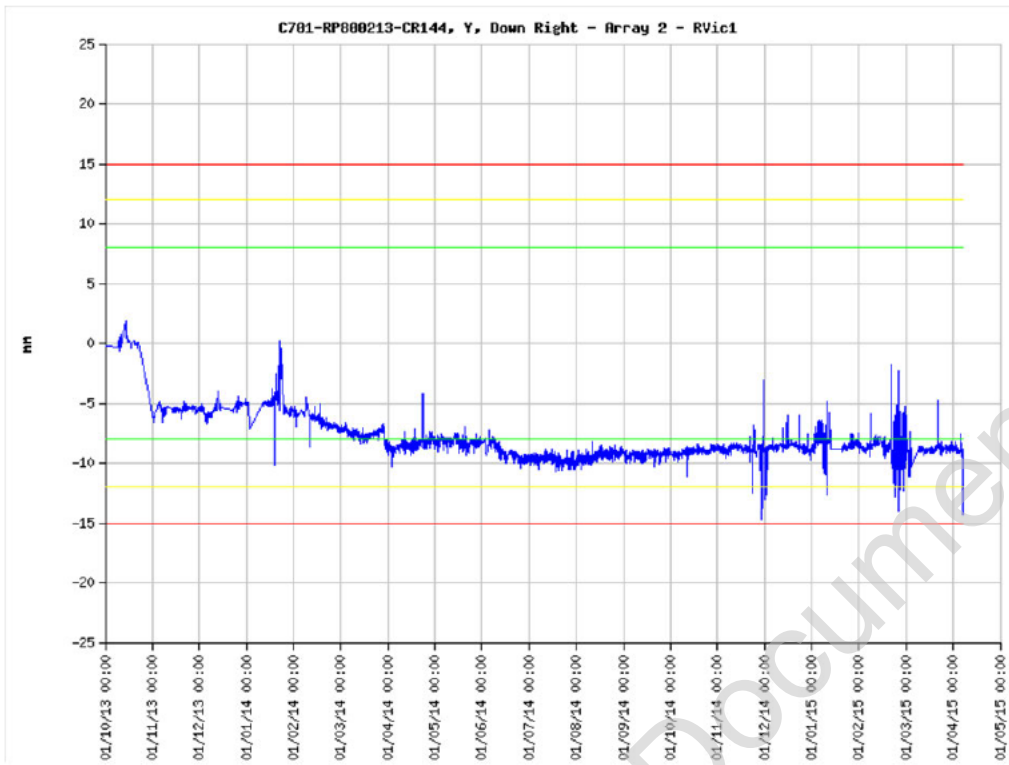
VDP C701-RP800214



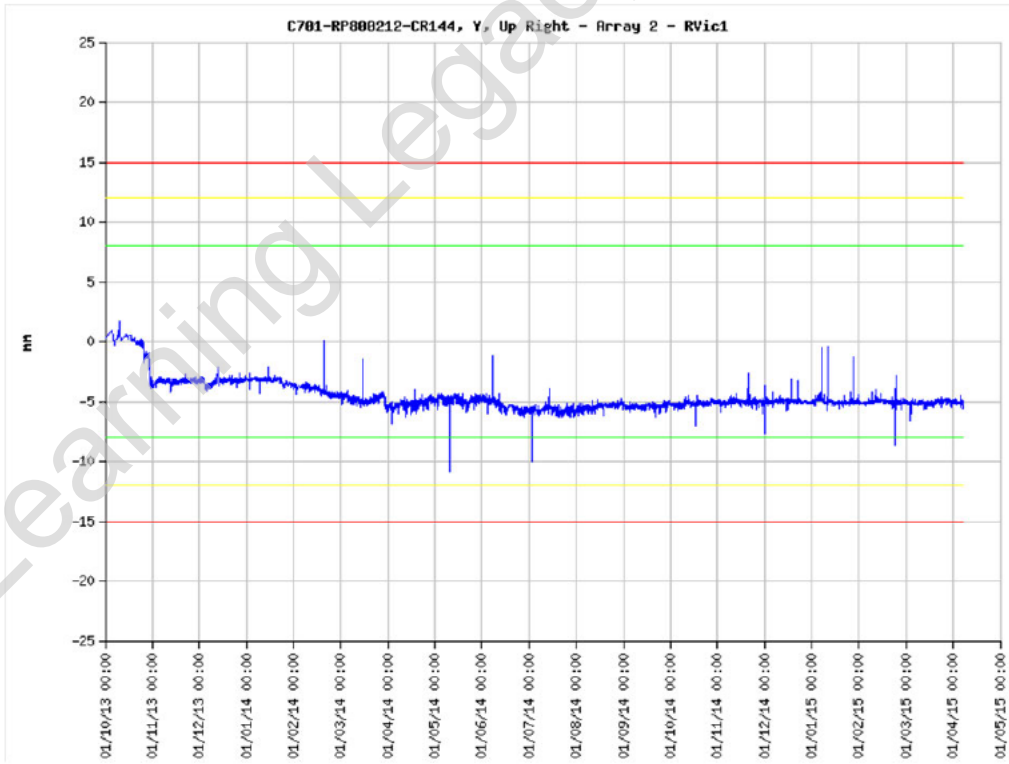
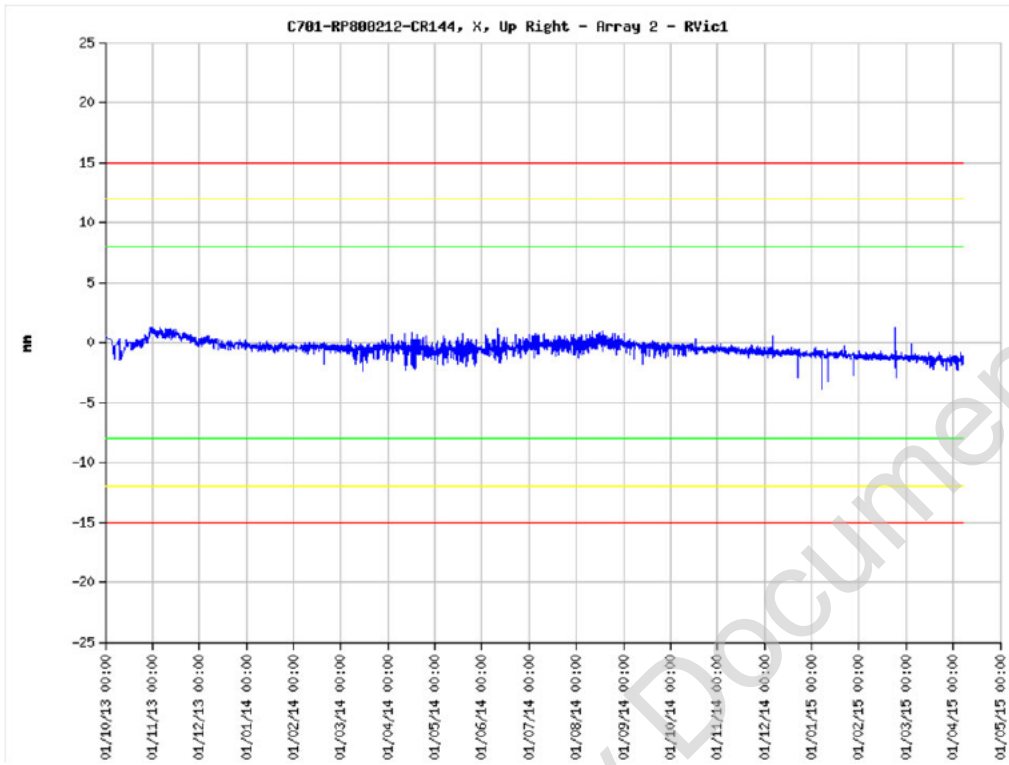


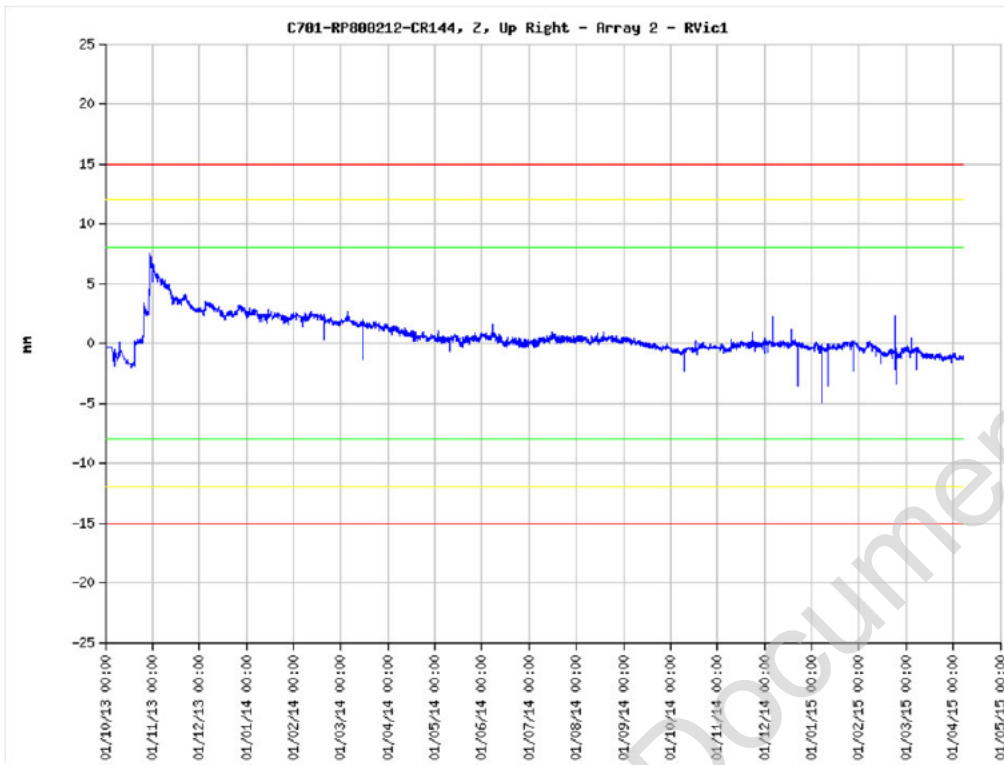
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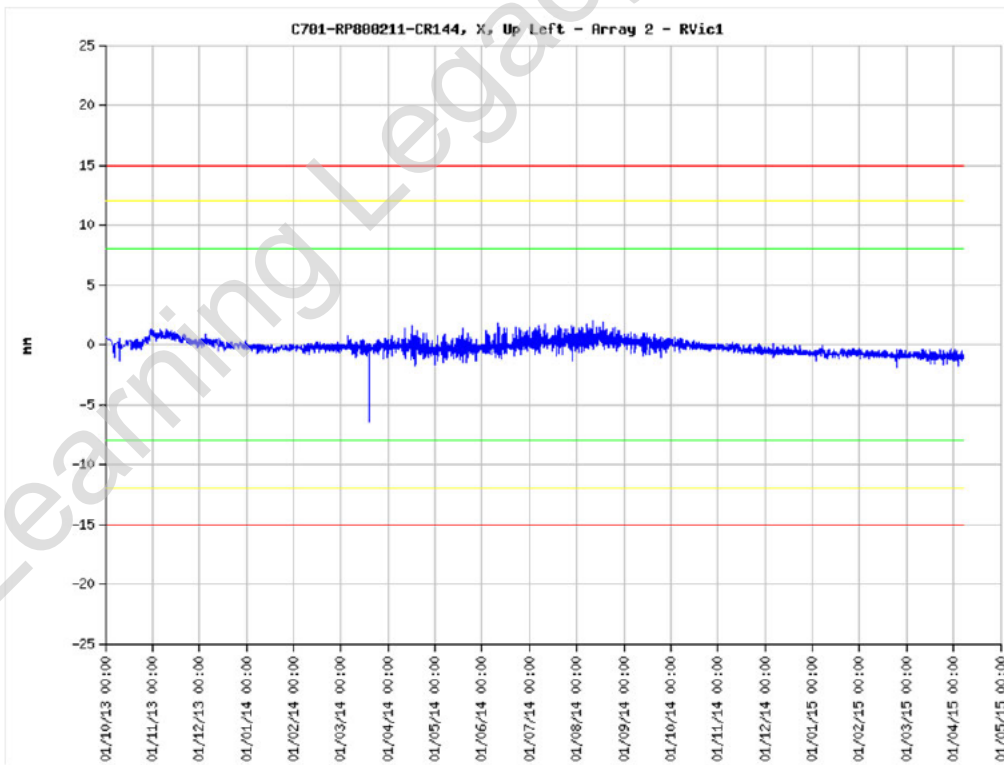


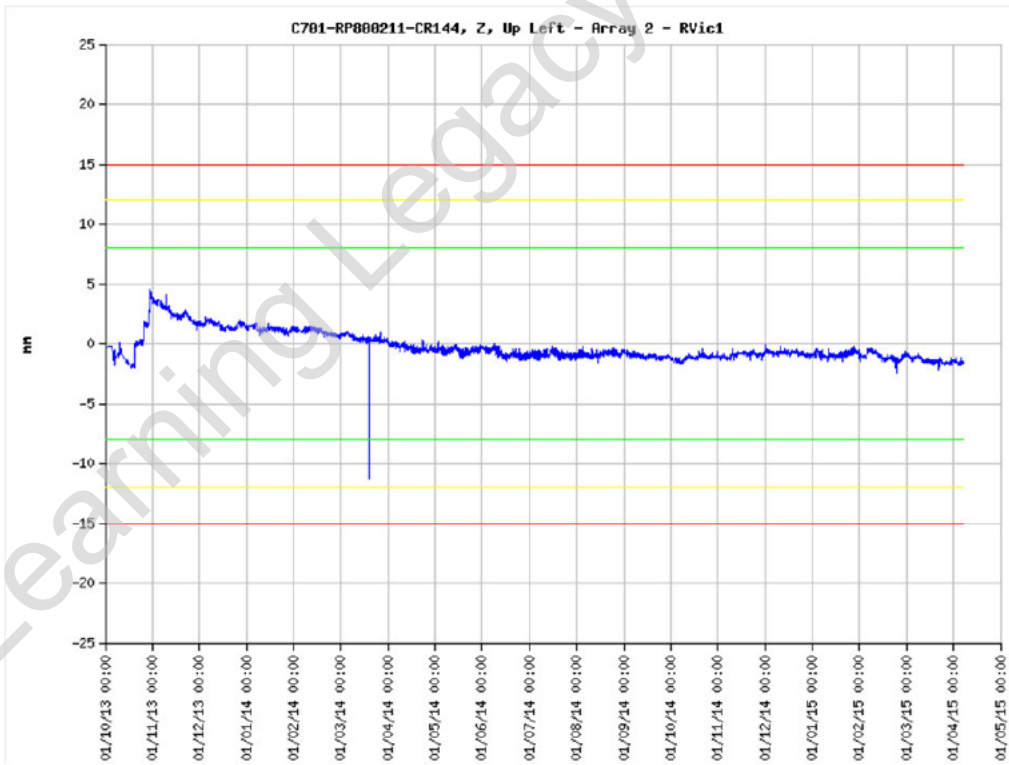
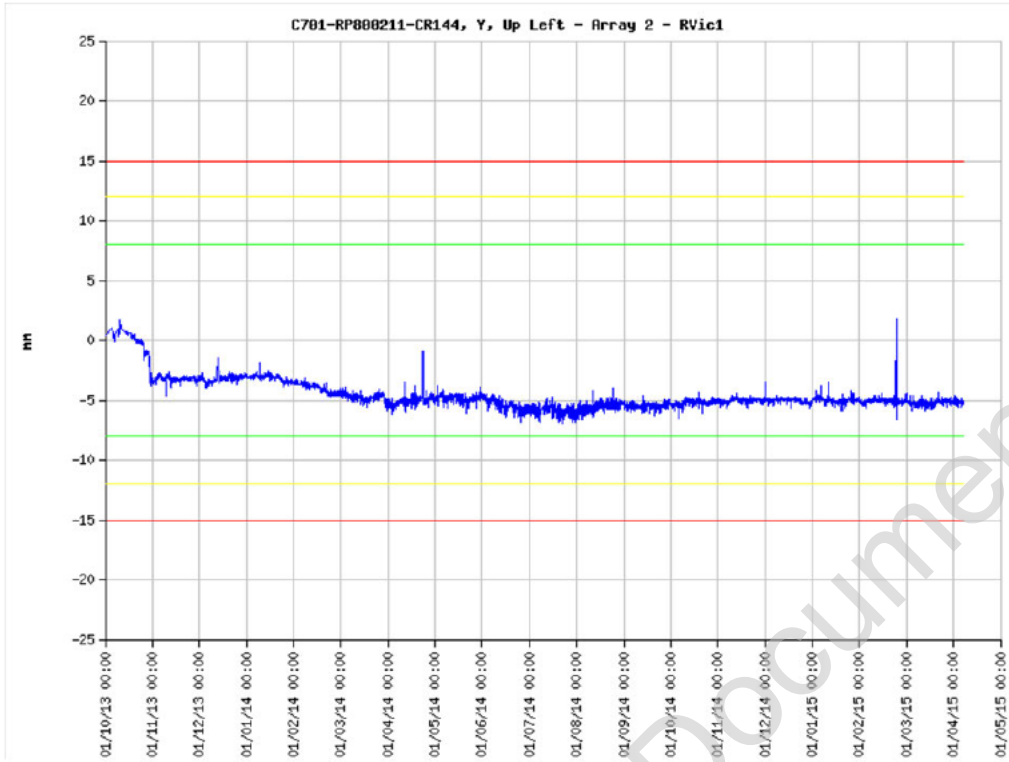
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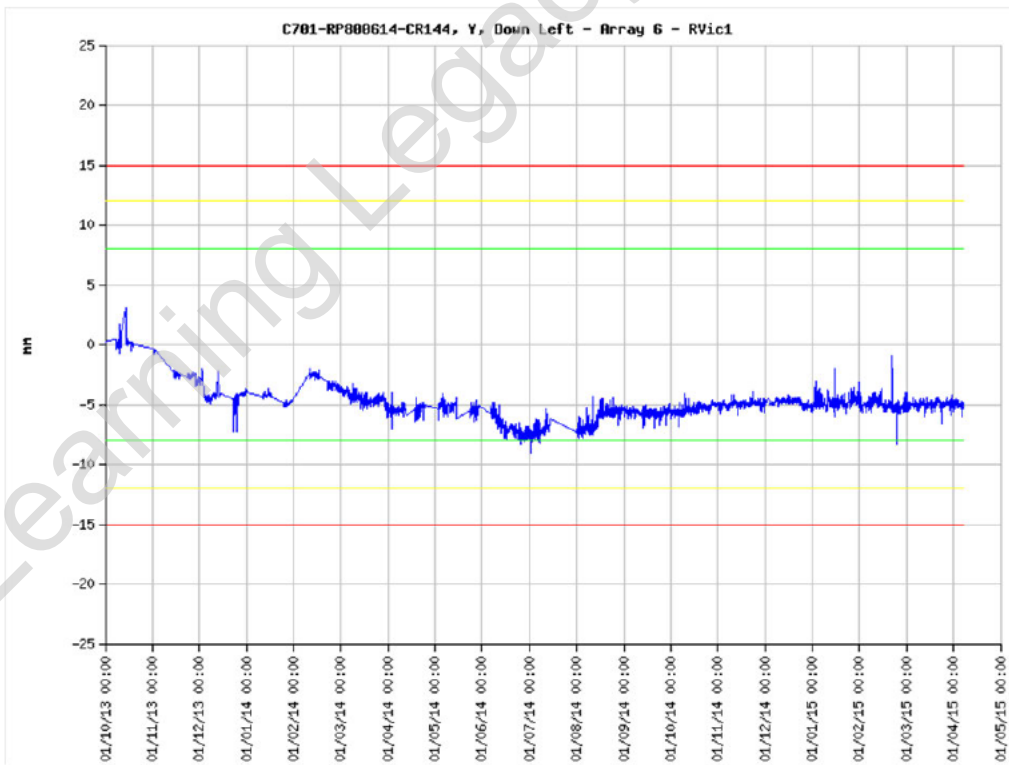
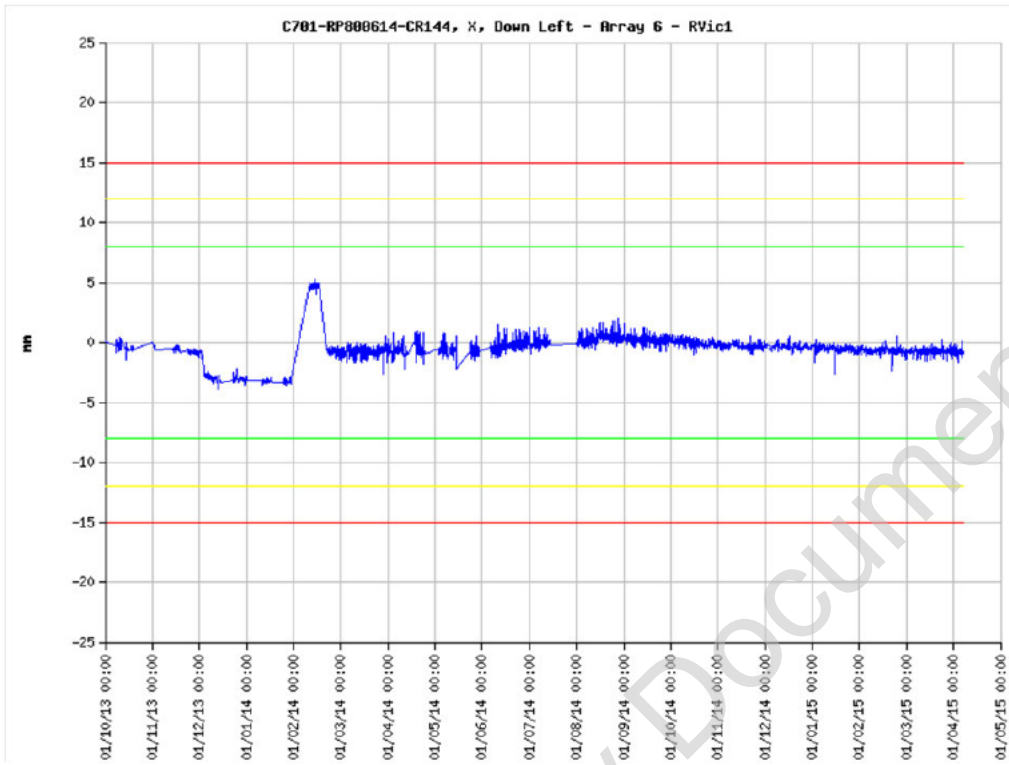


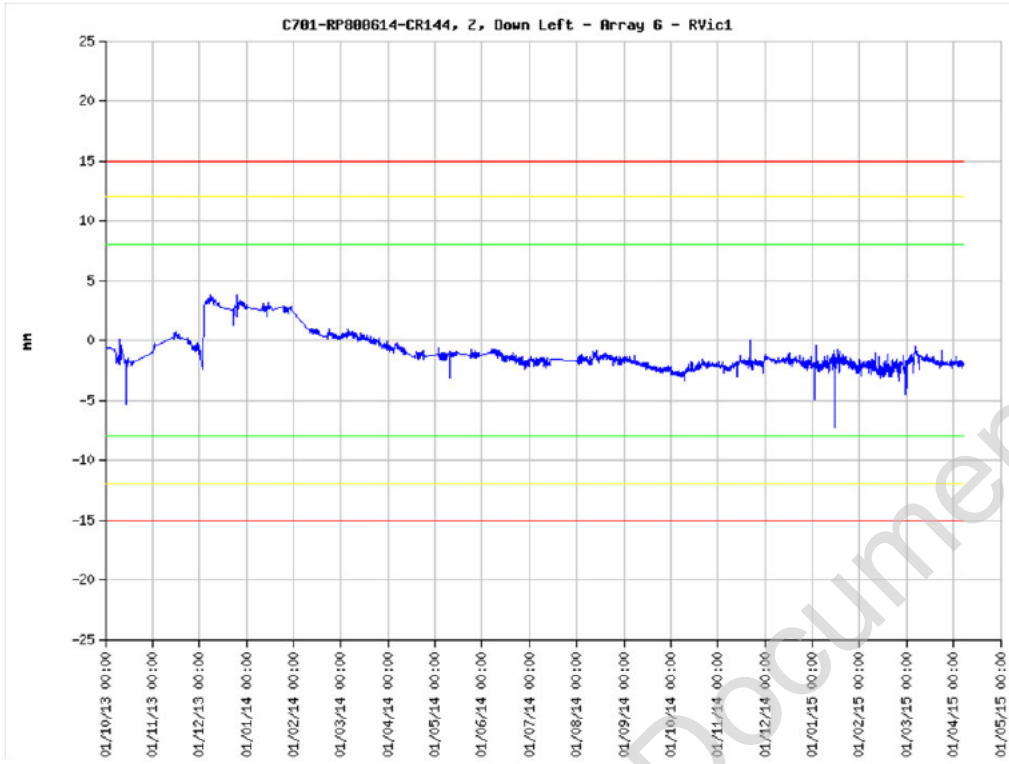
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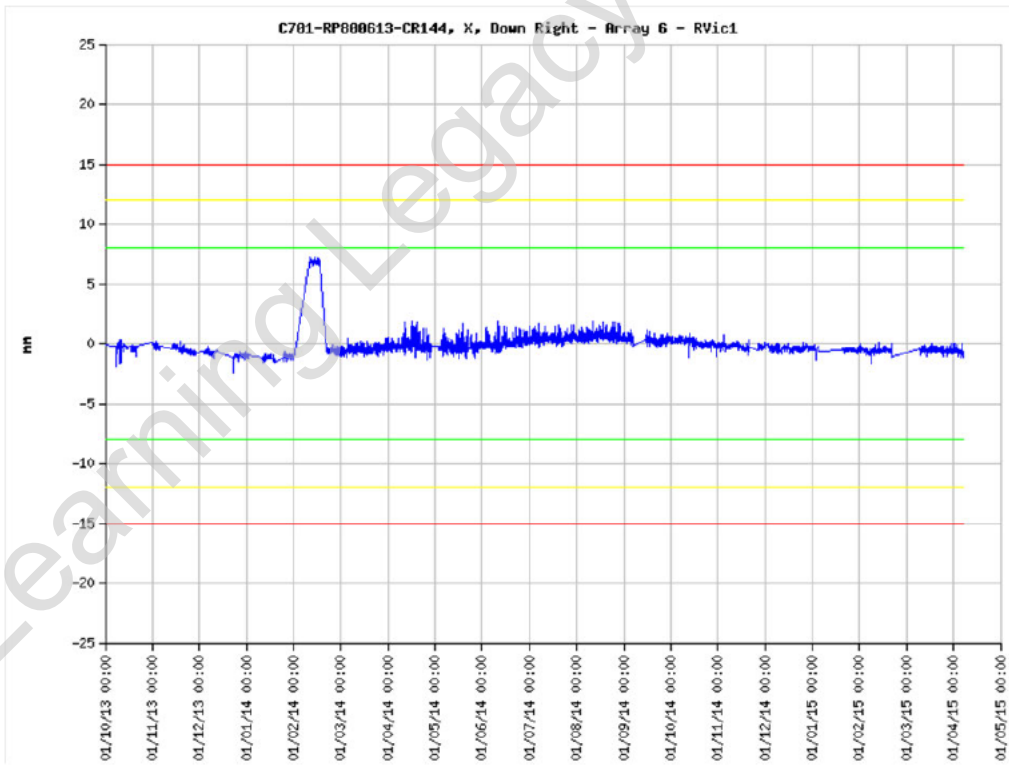


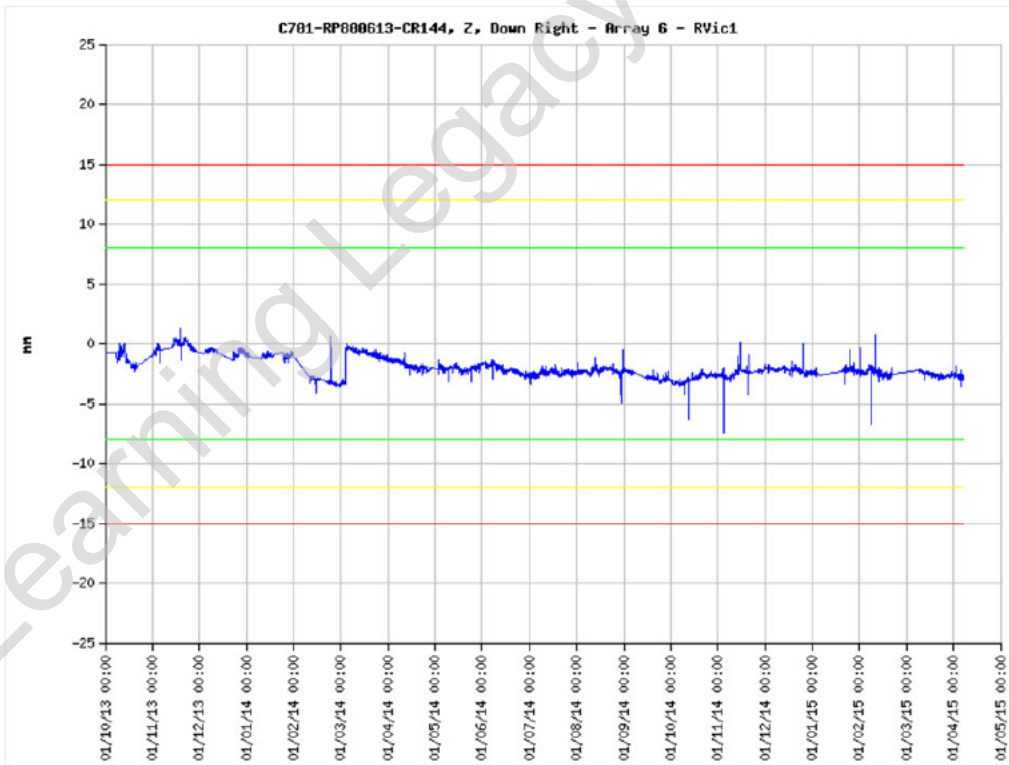
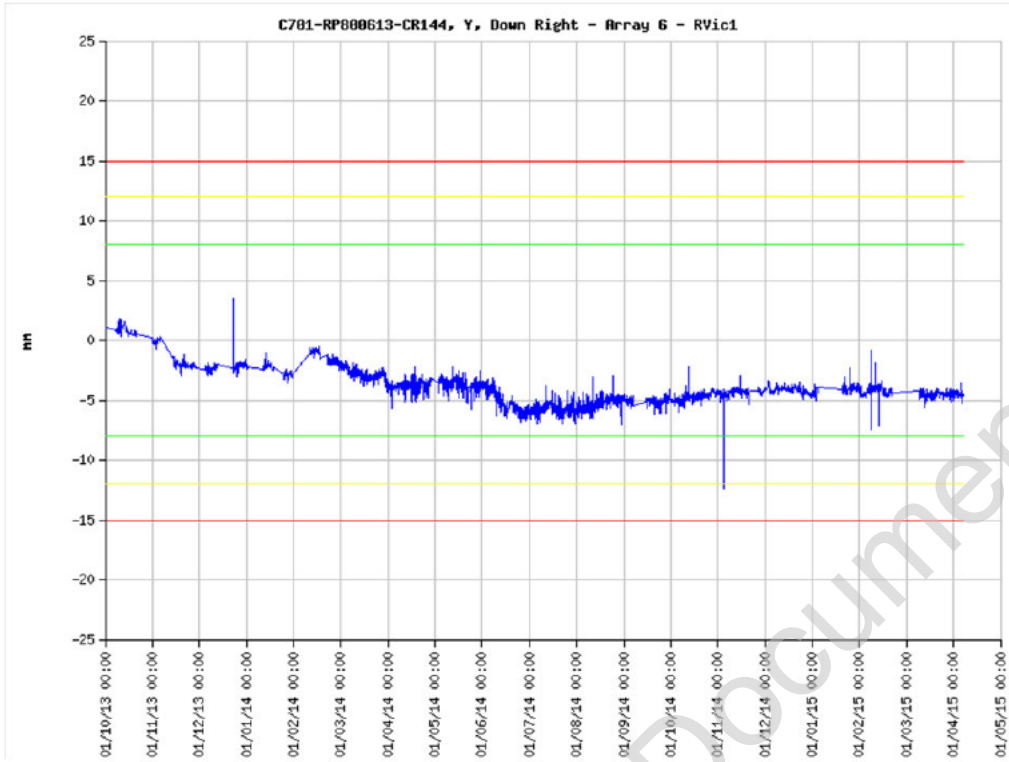
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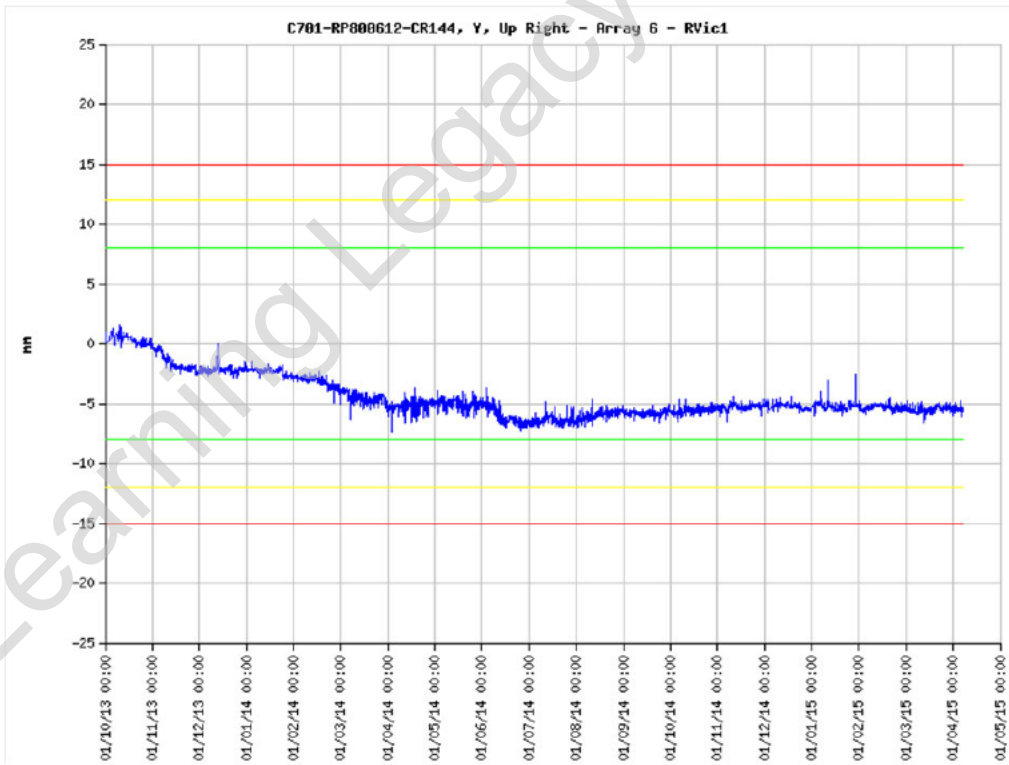
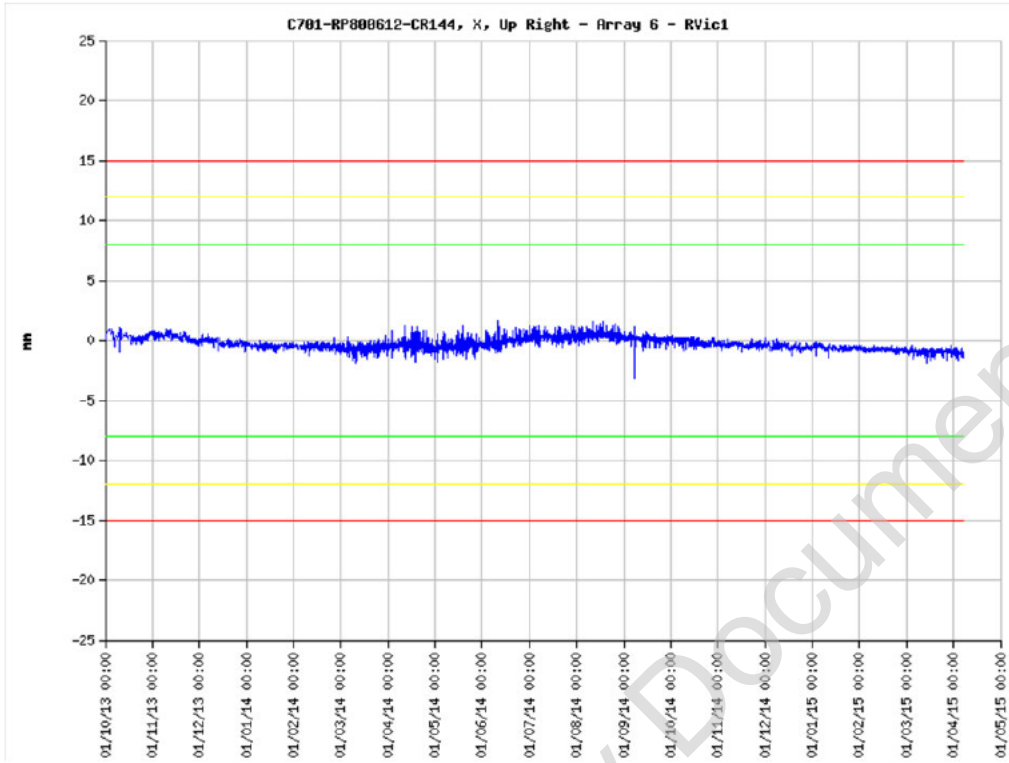


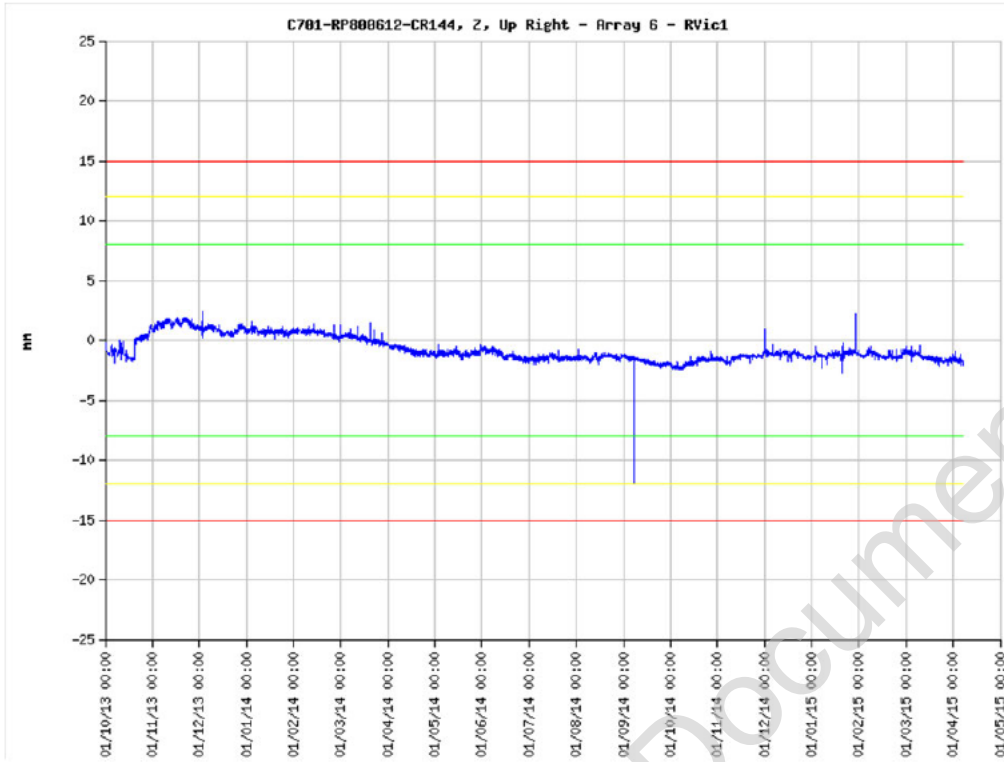
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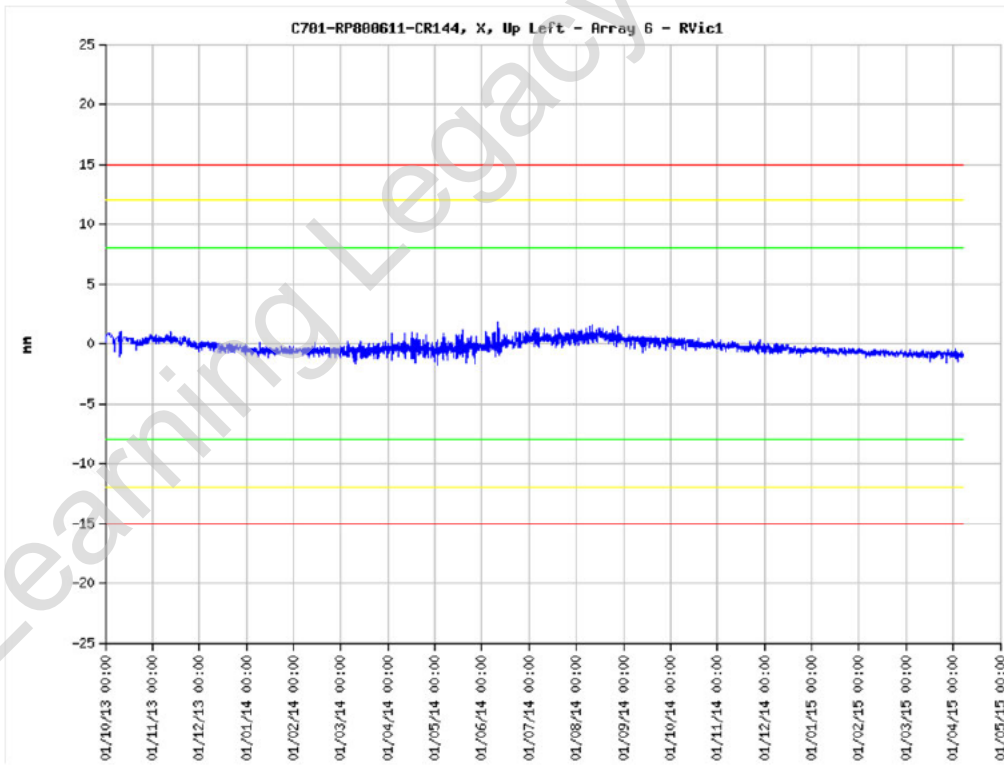


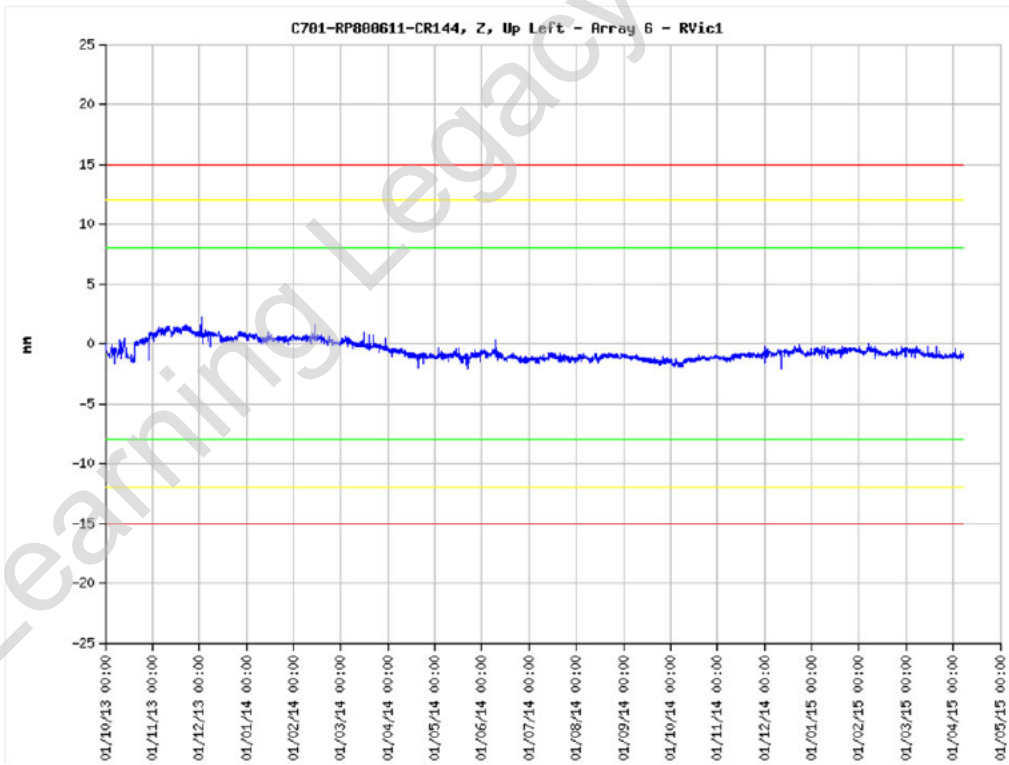
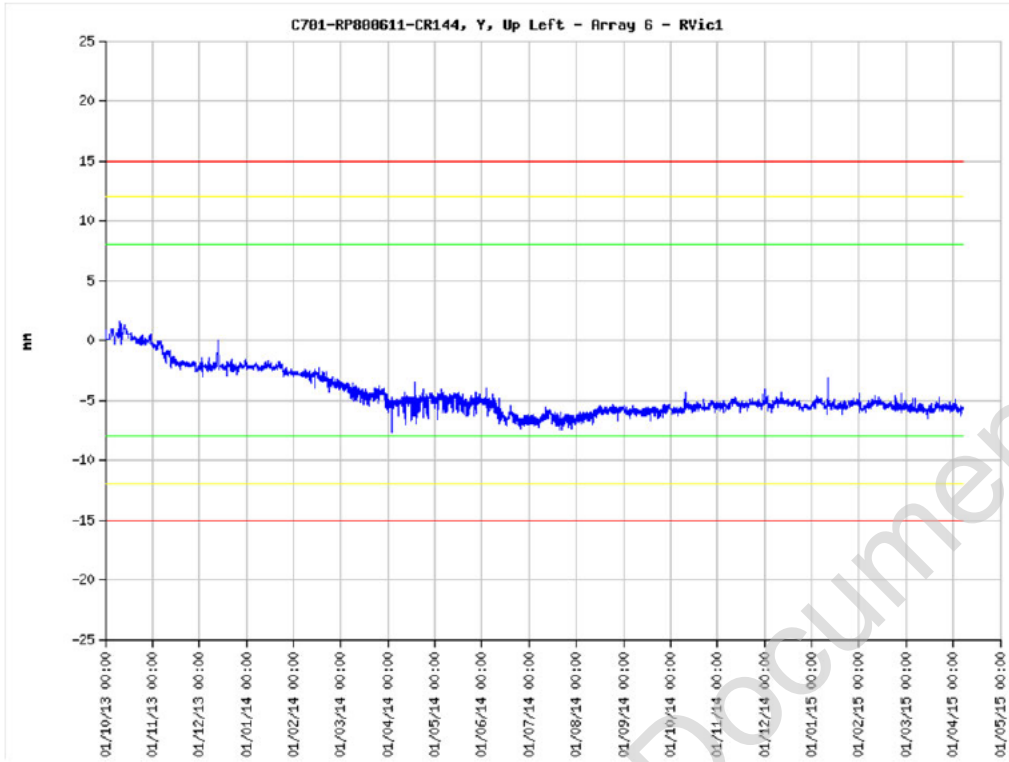
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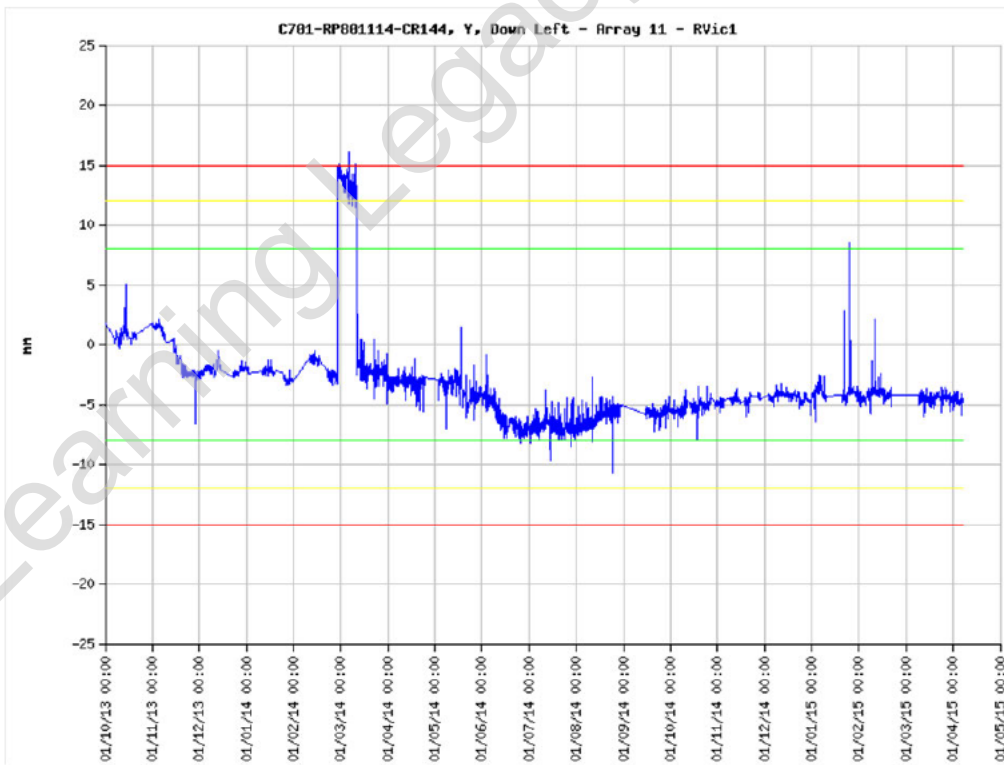
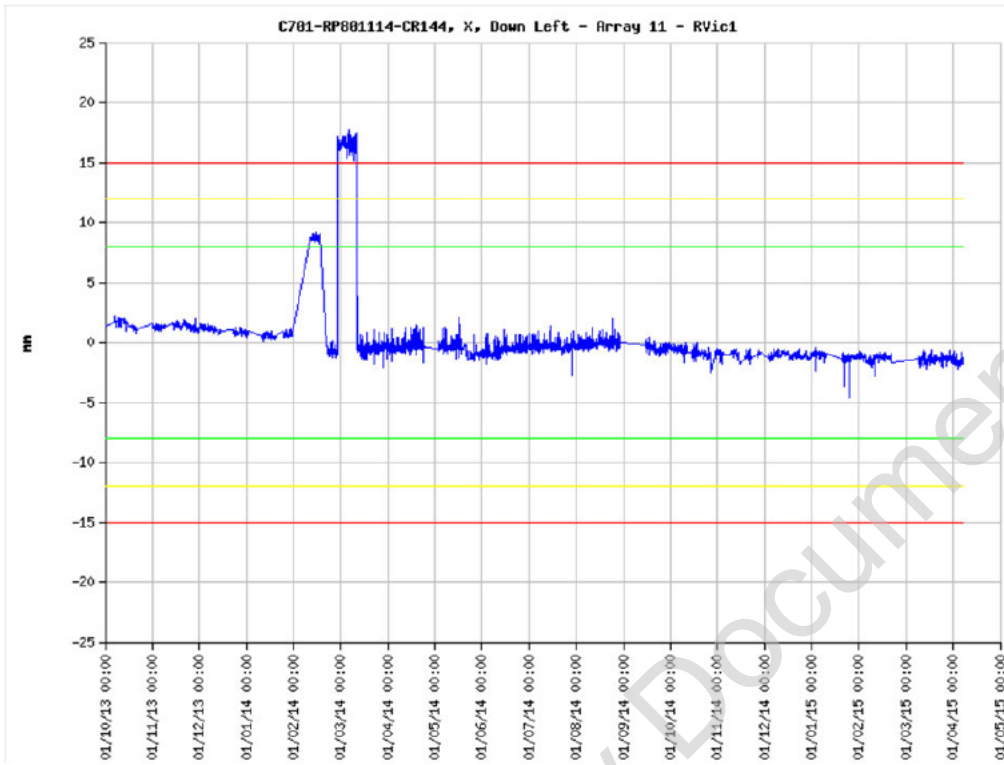


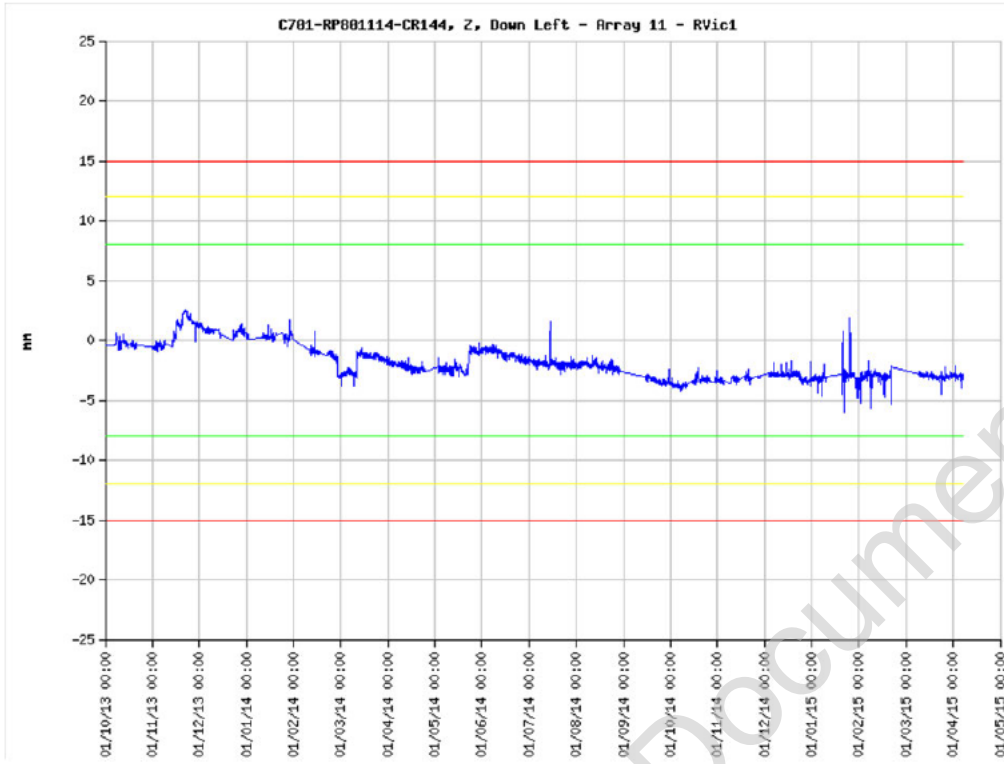
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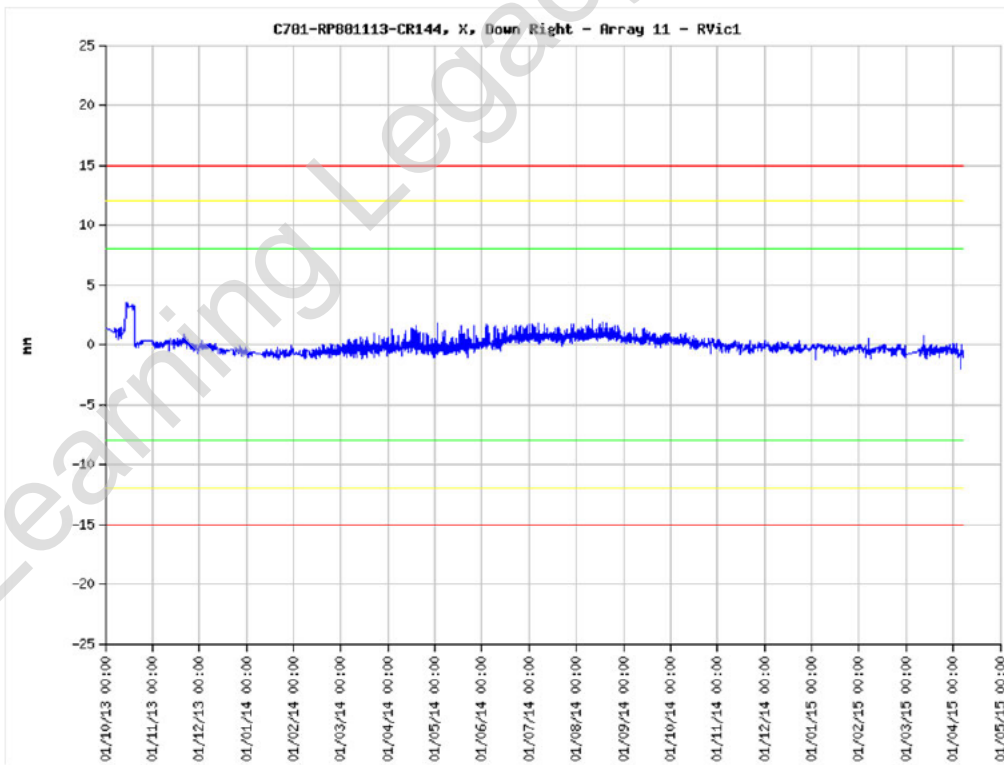


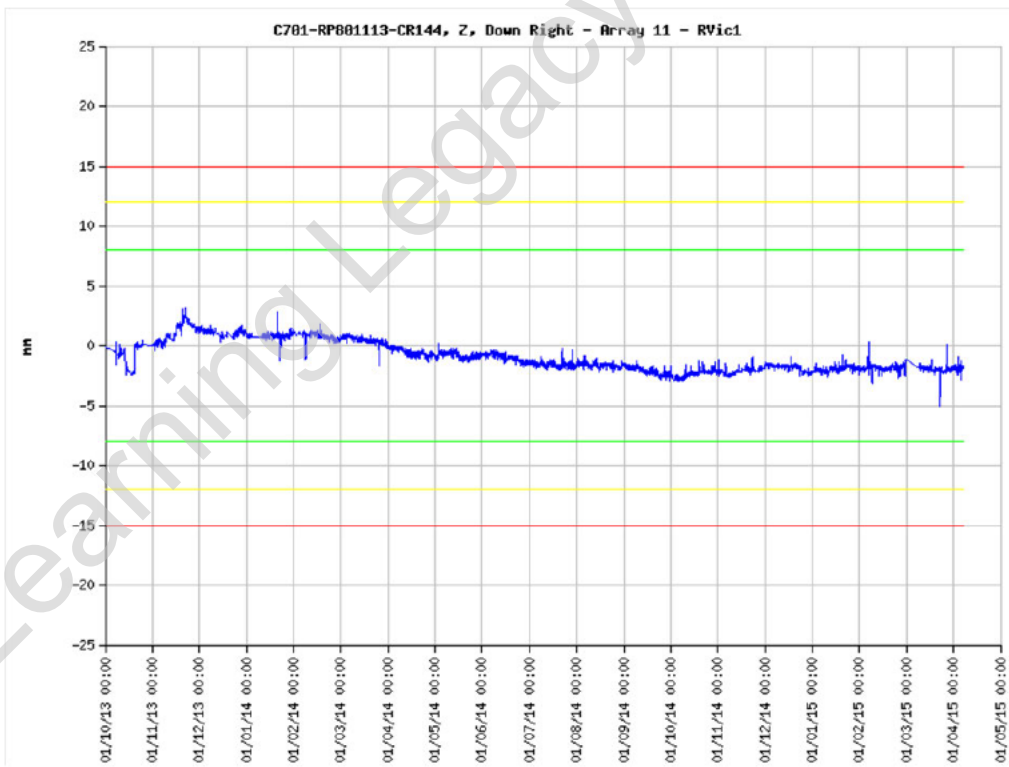
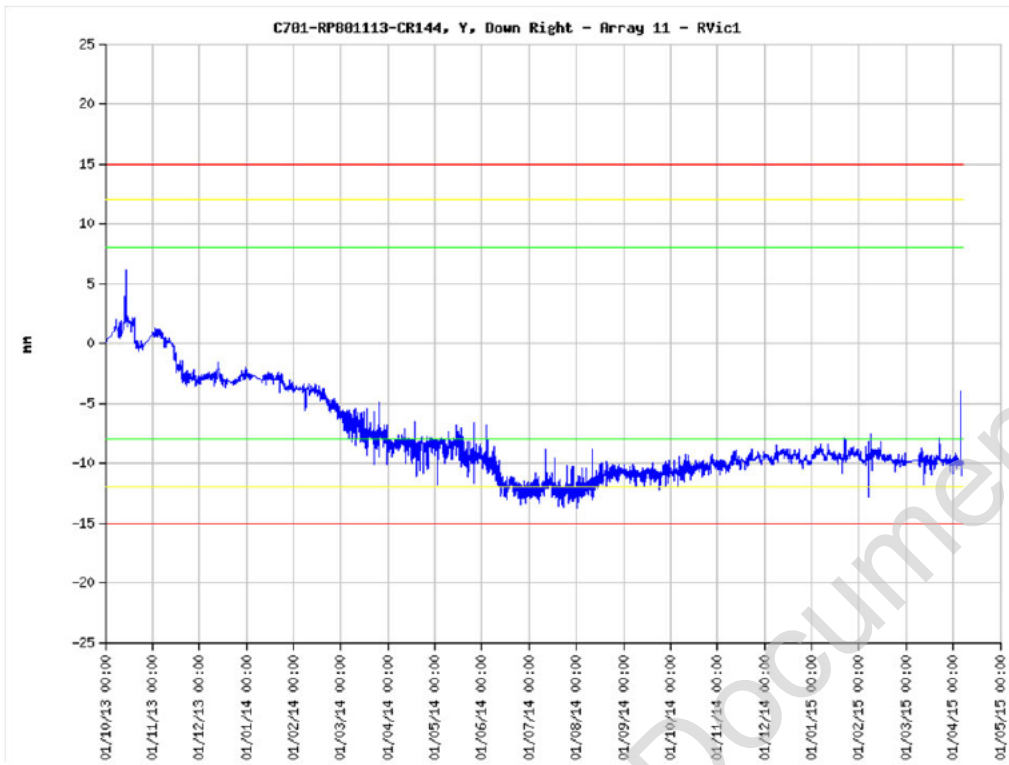
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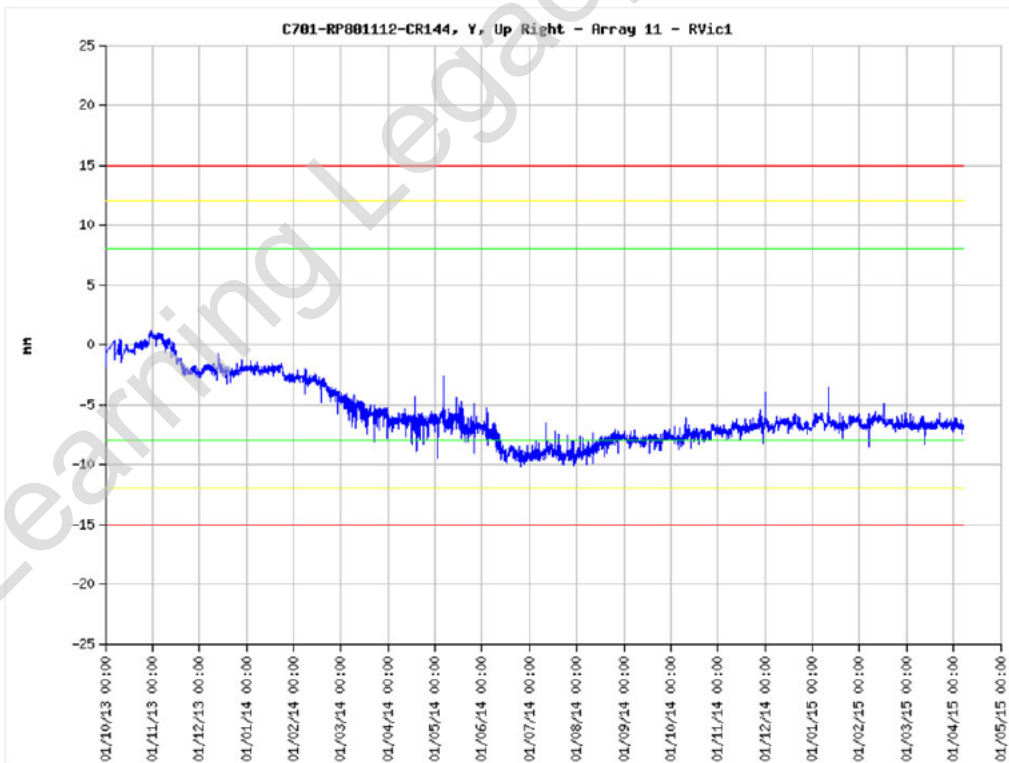
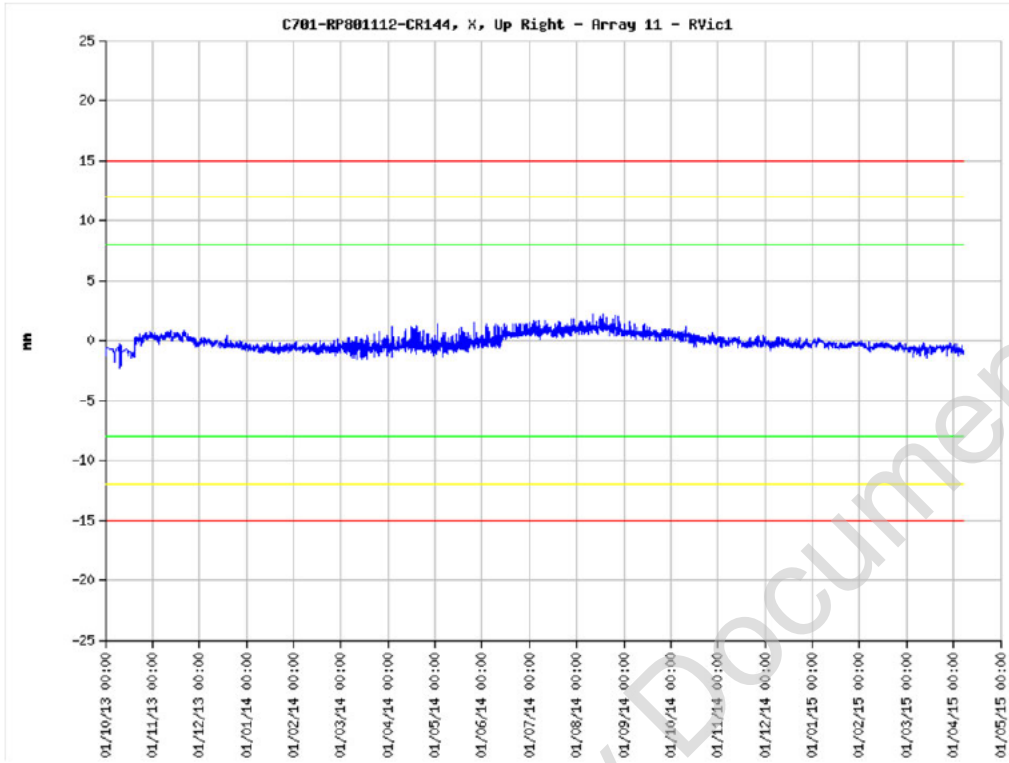


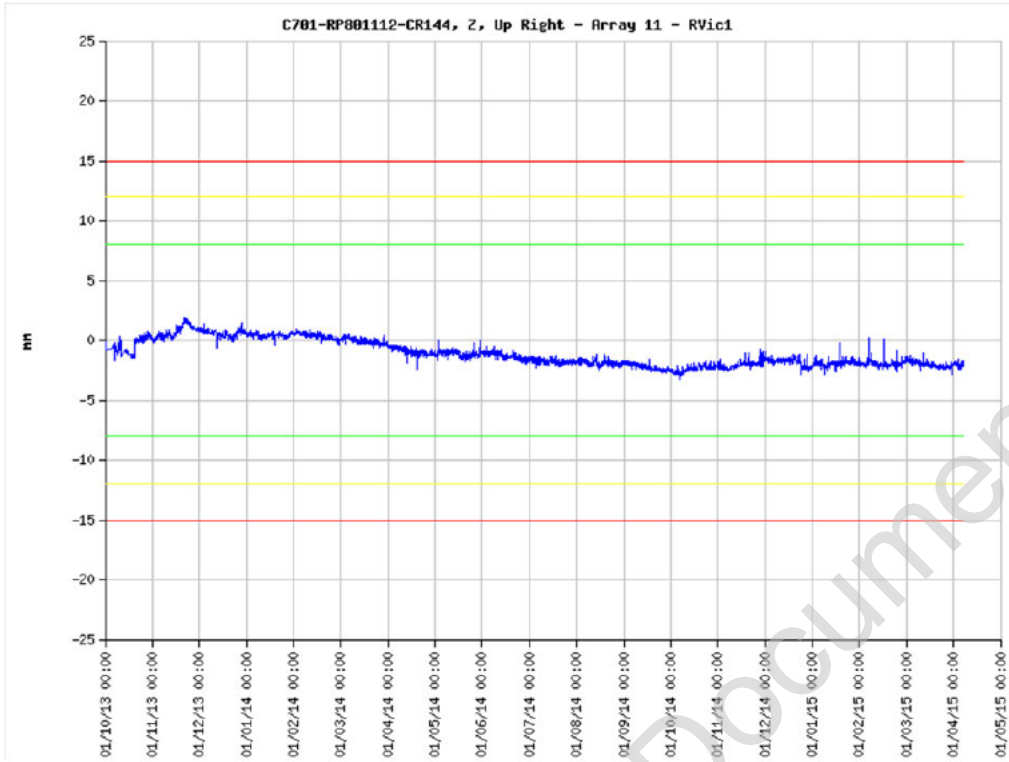
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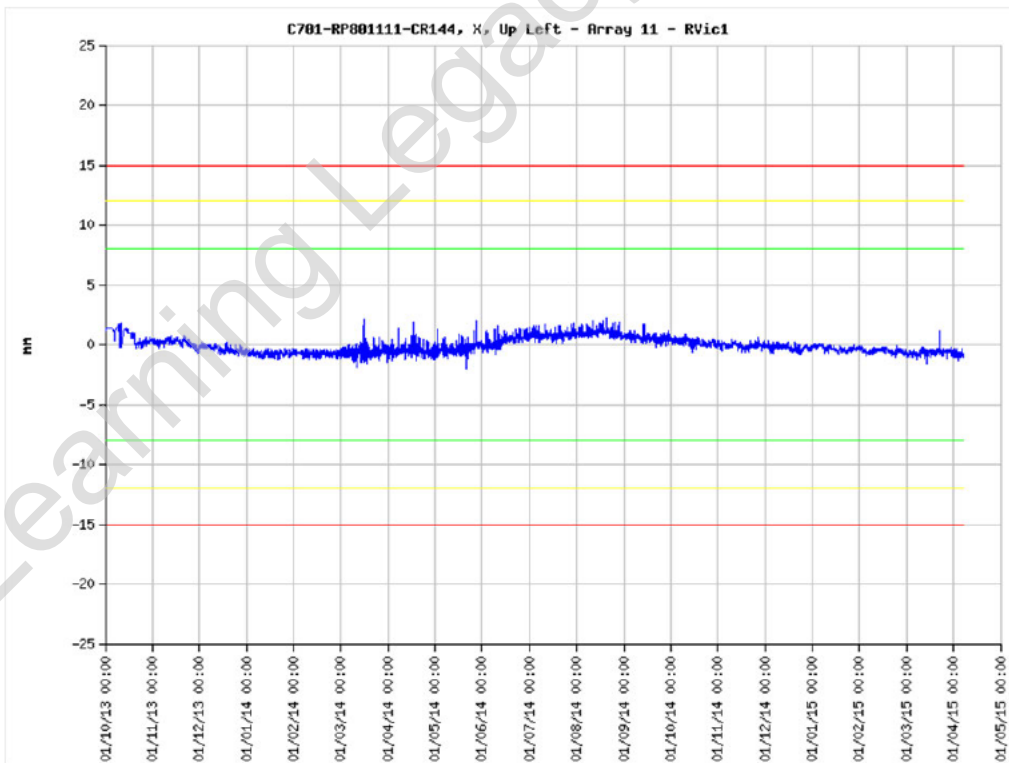


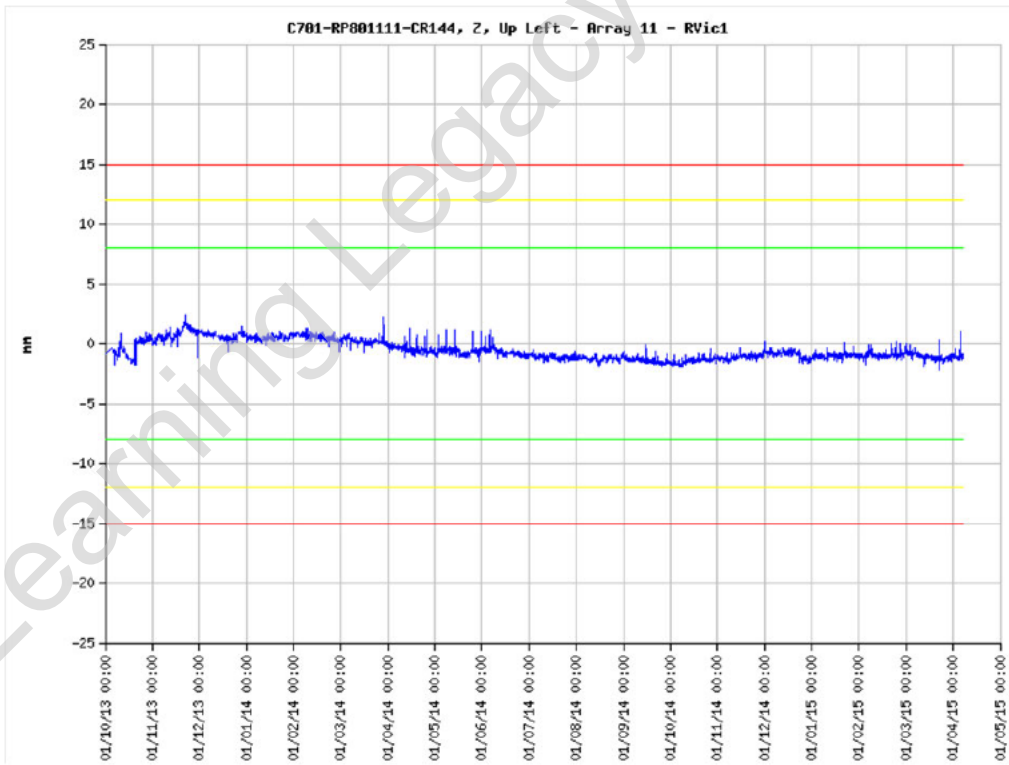
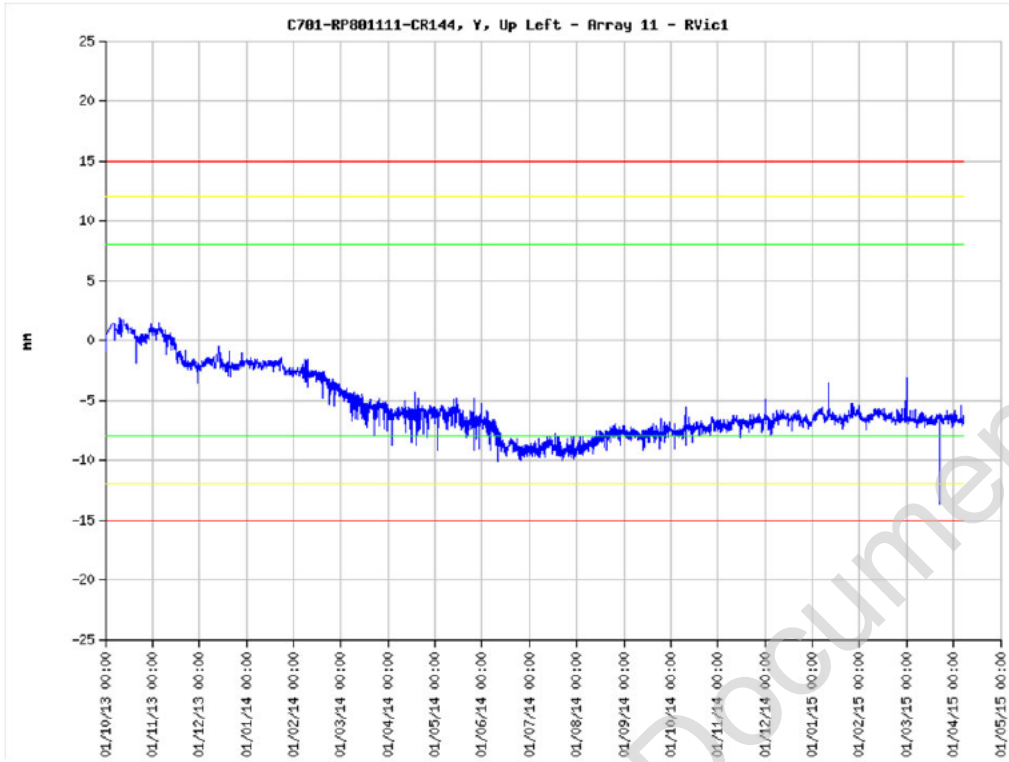
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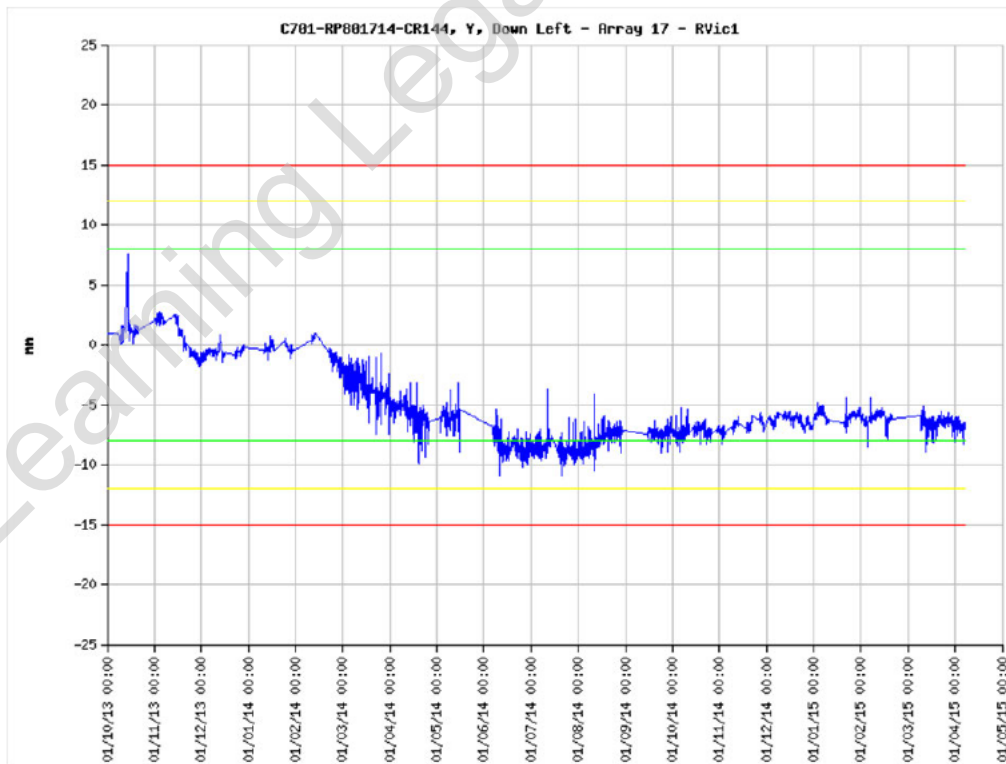
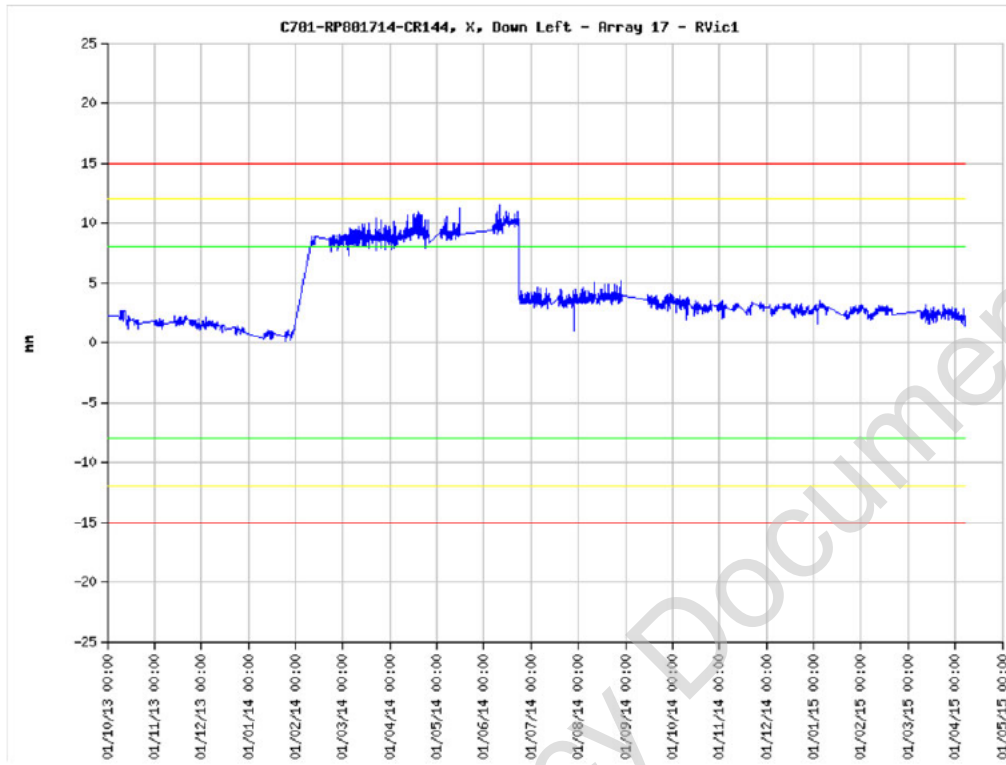


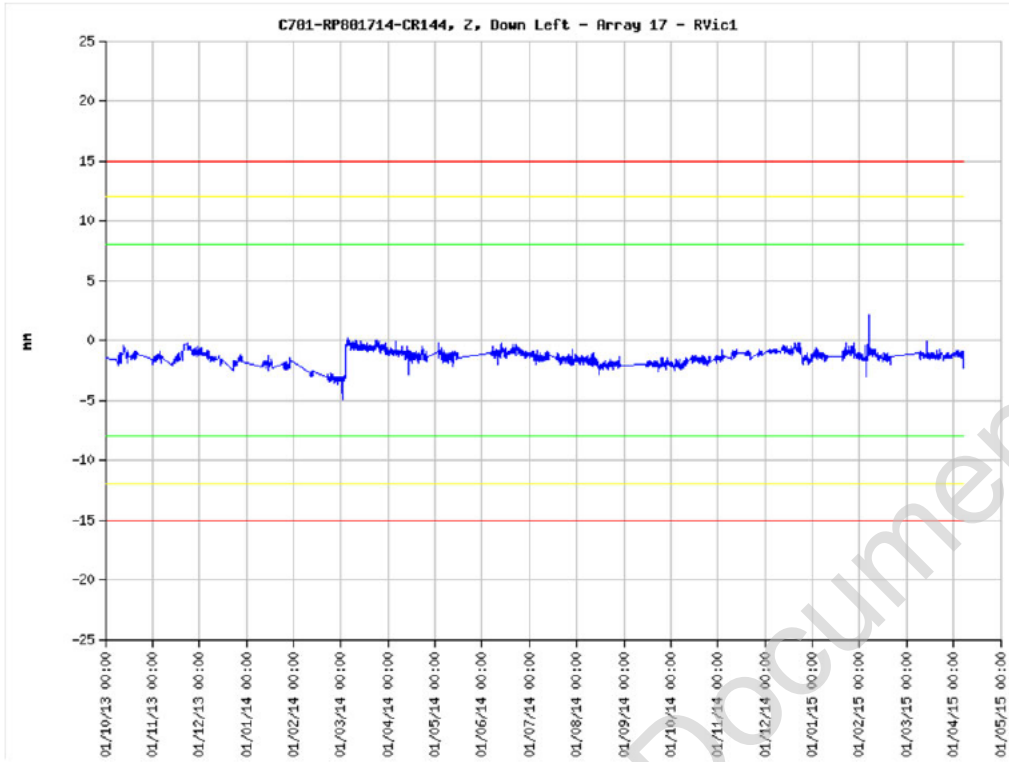
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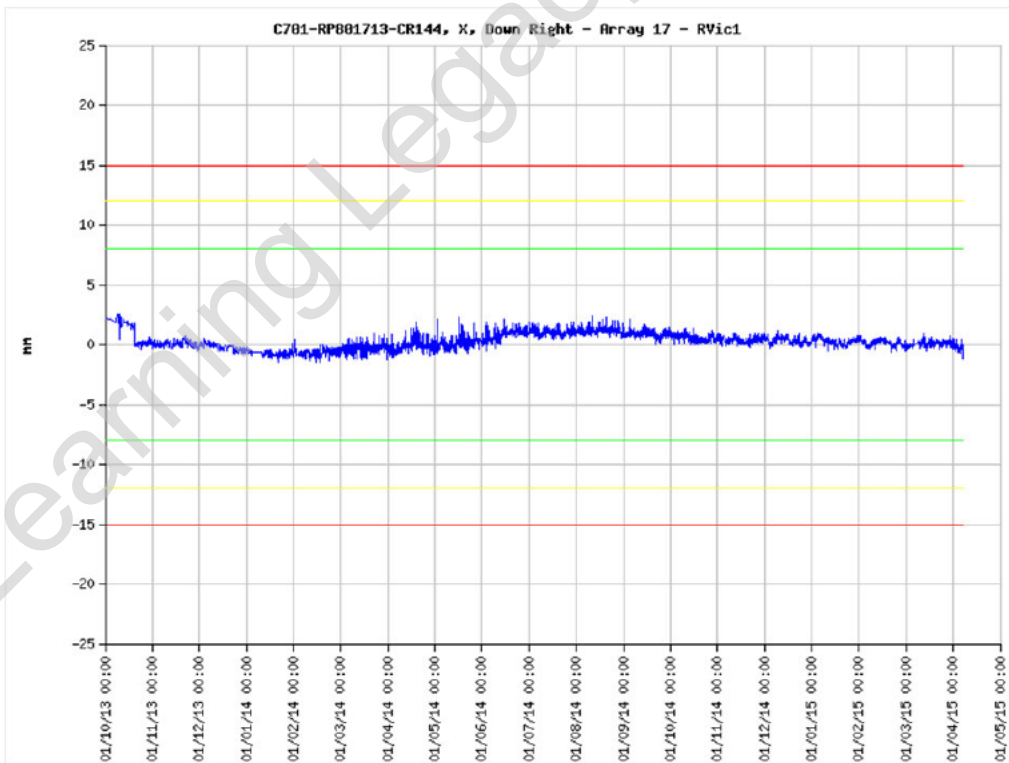


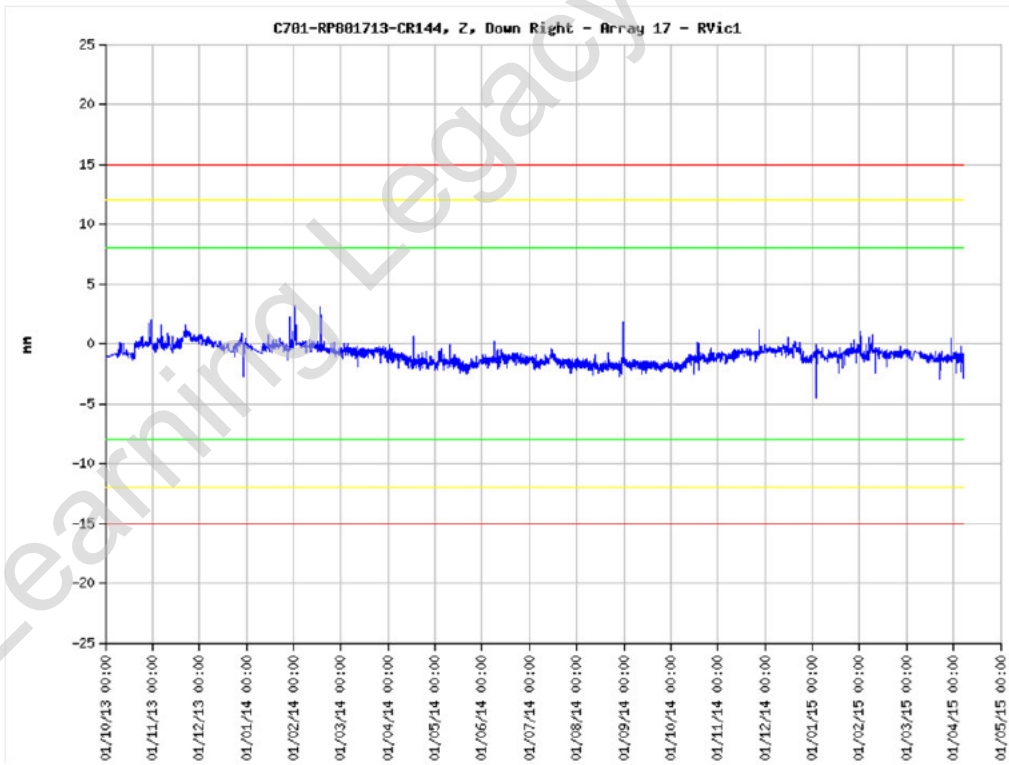
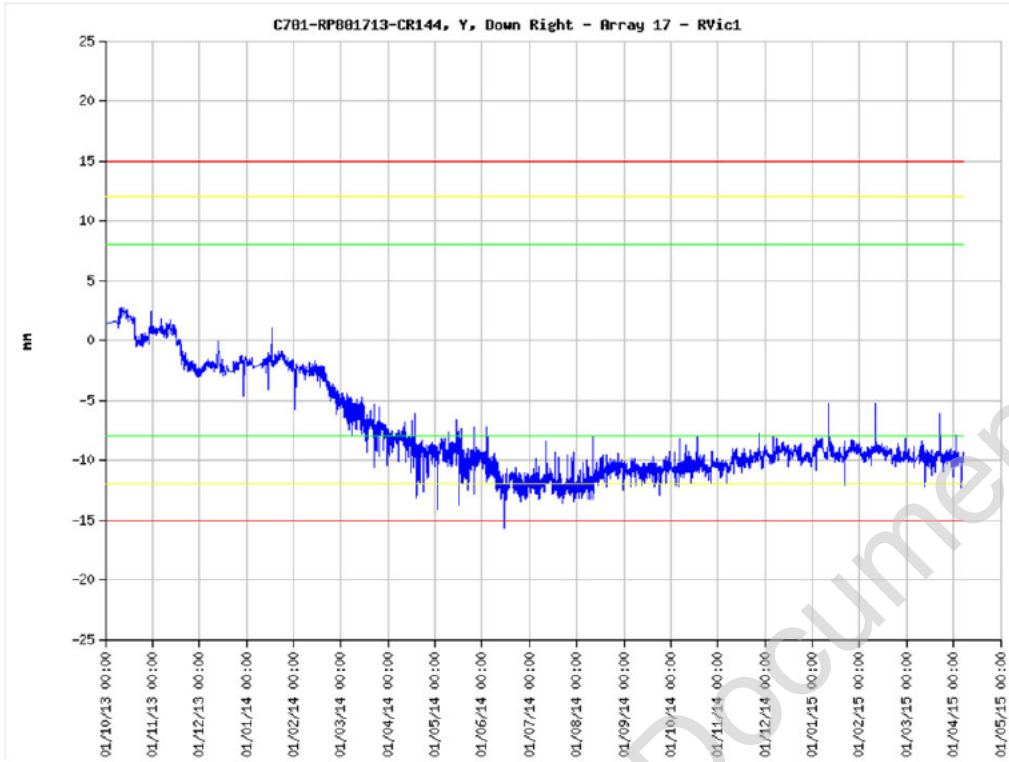
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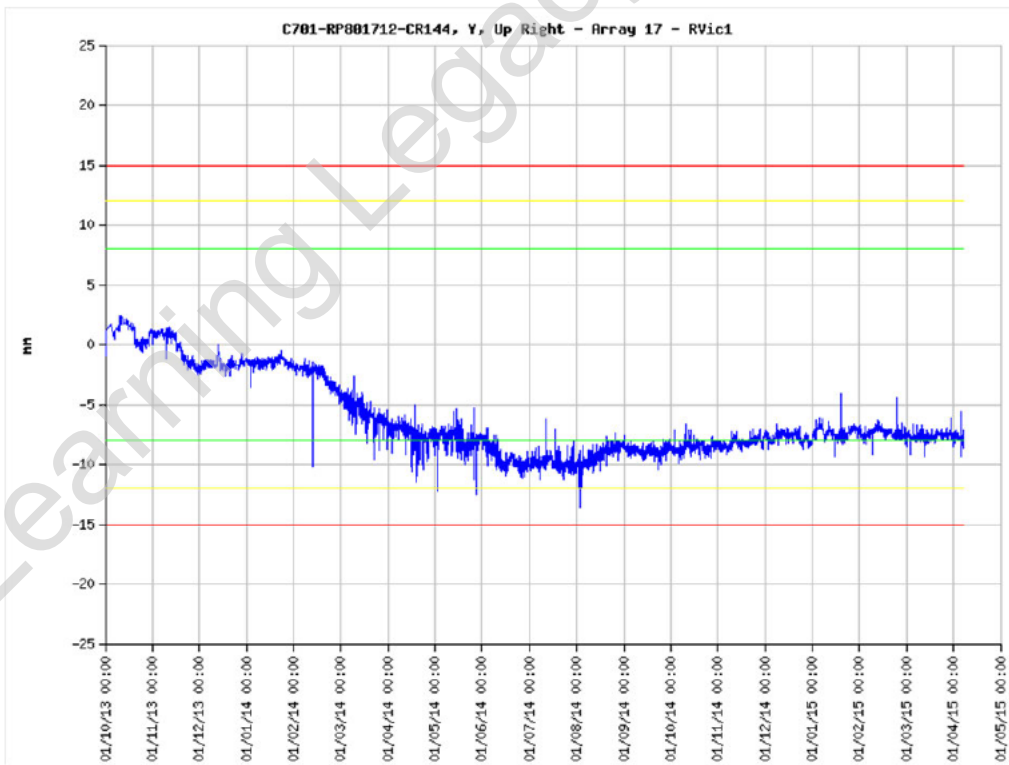
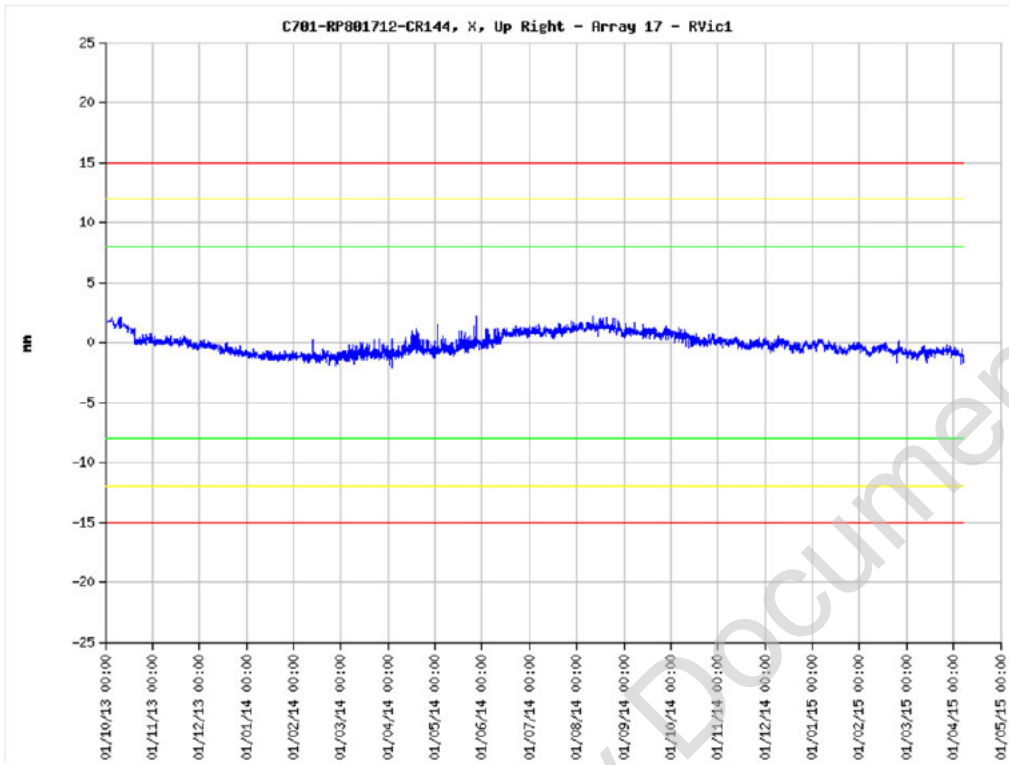


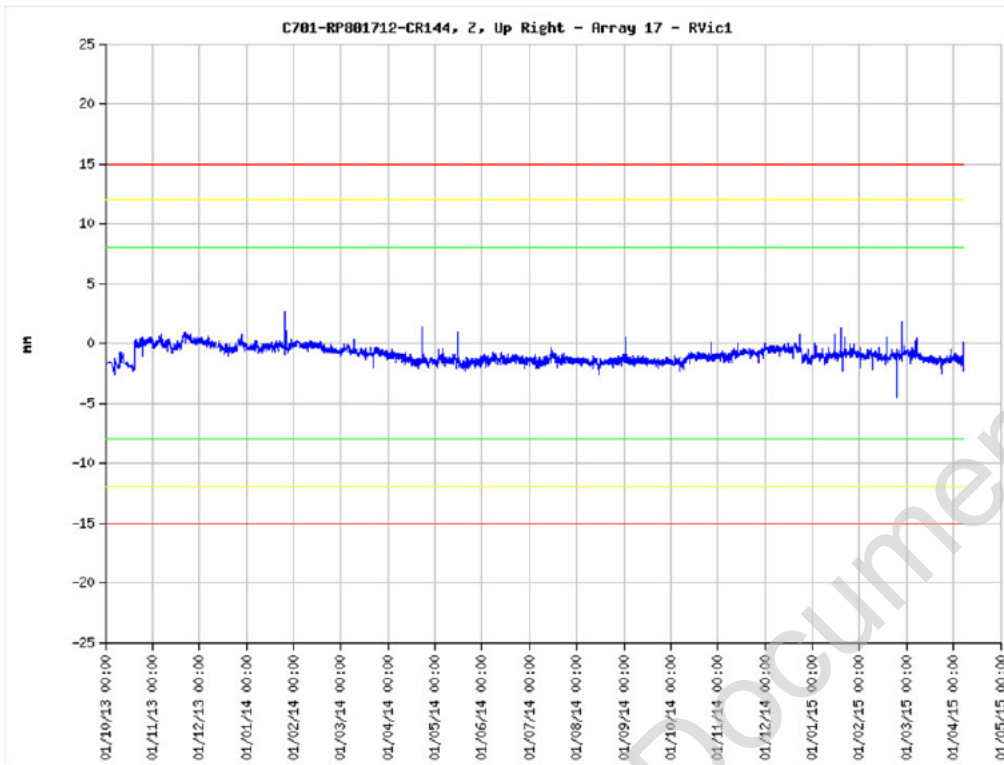
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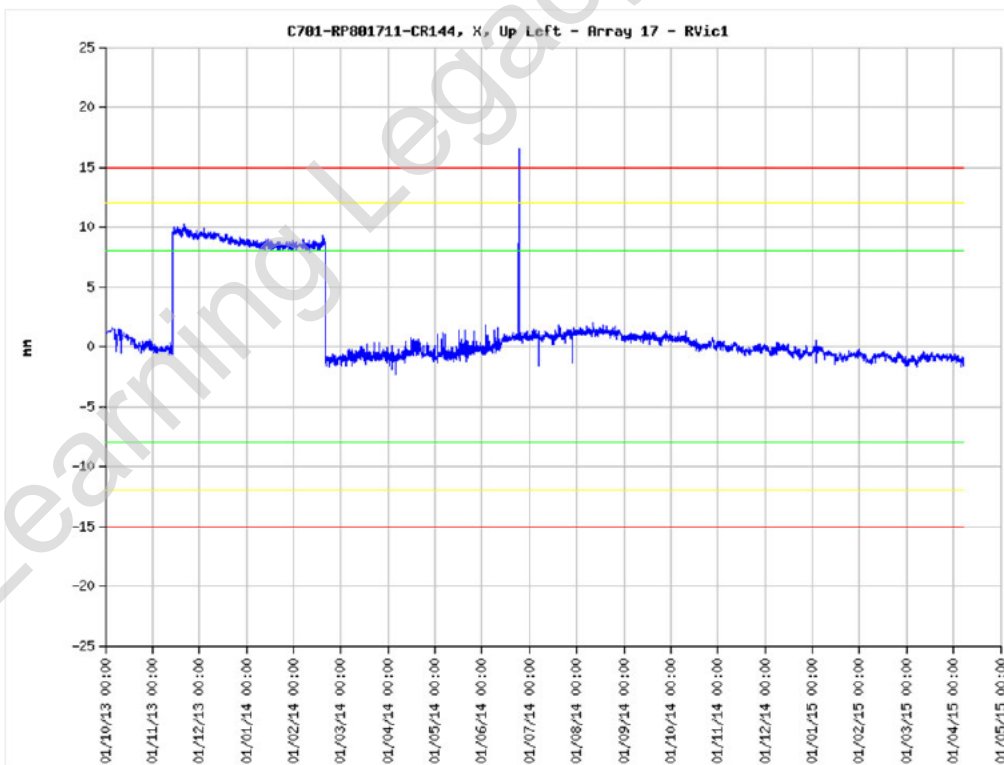


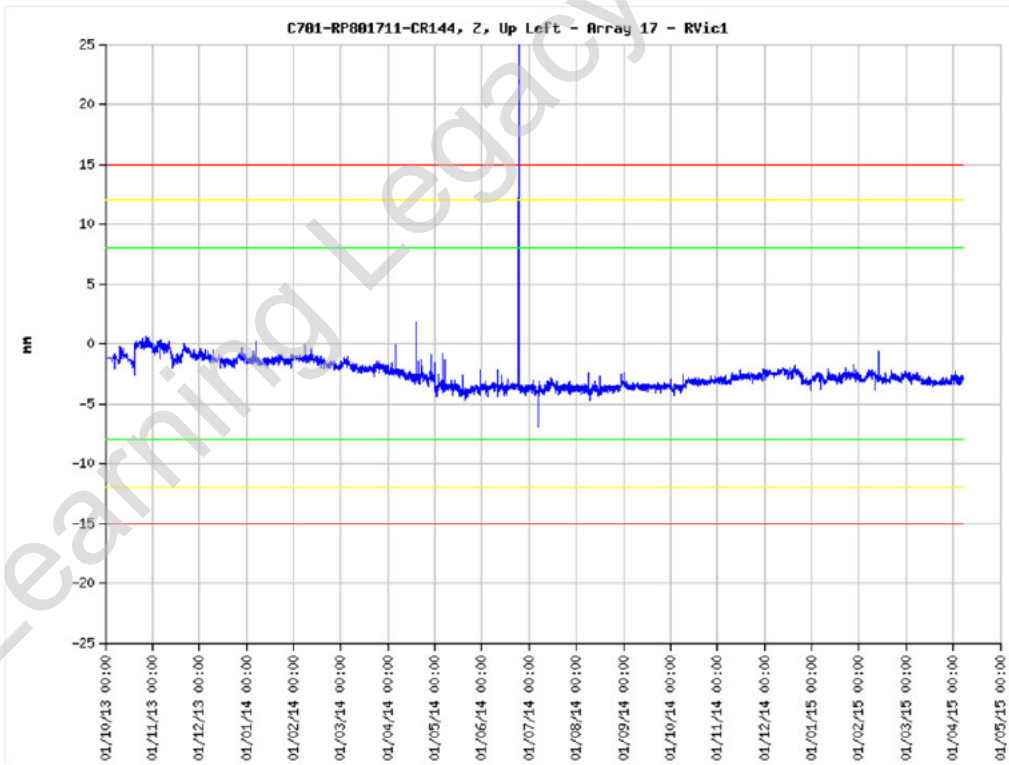
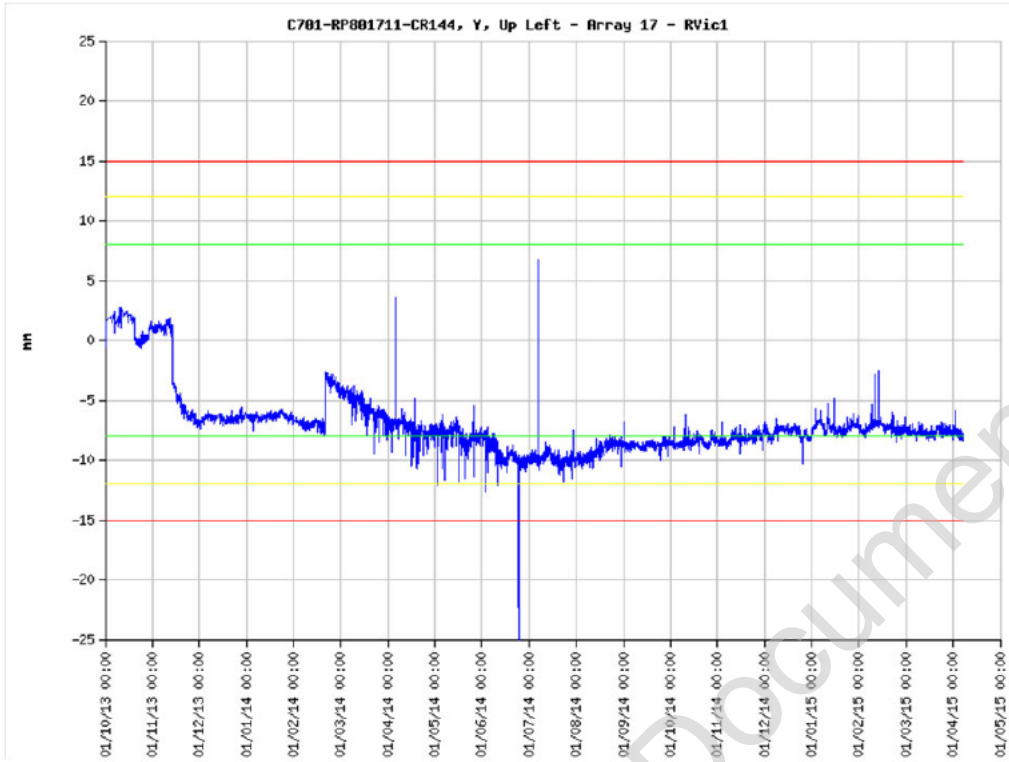
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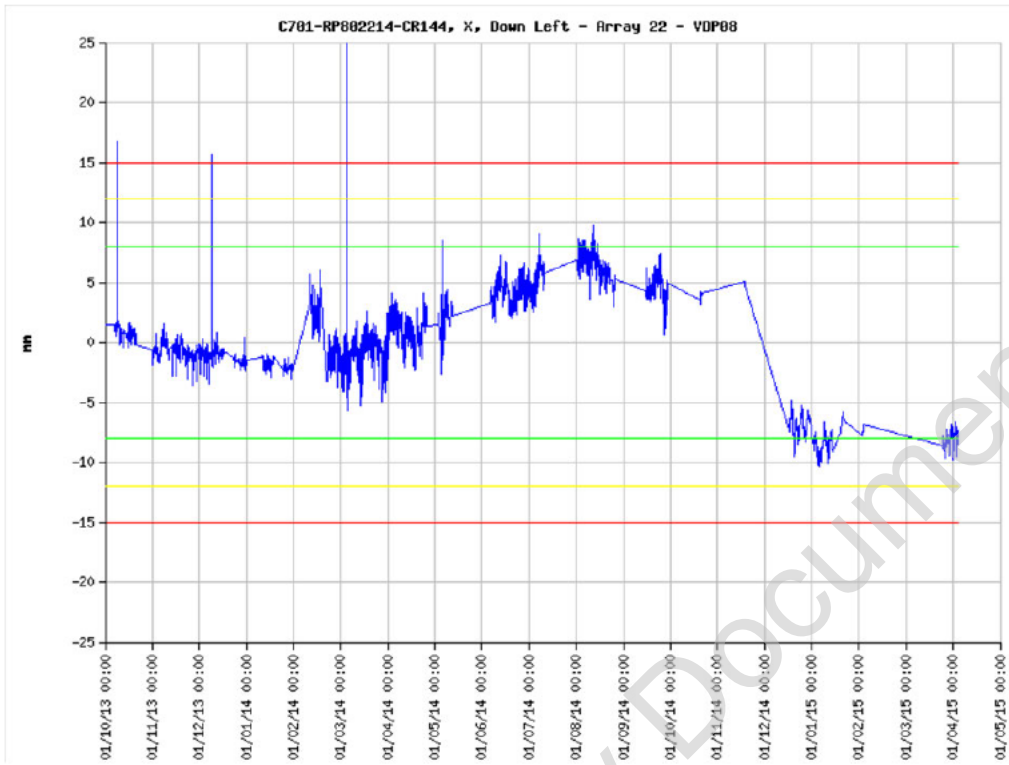


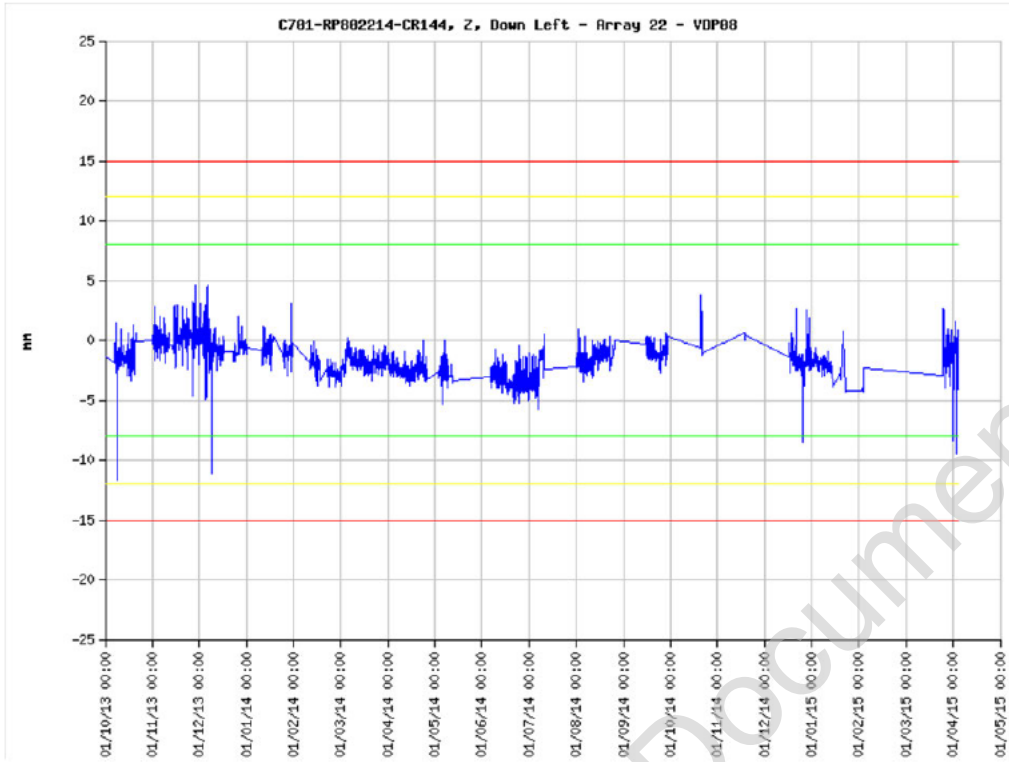
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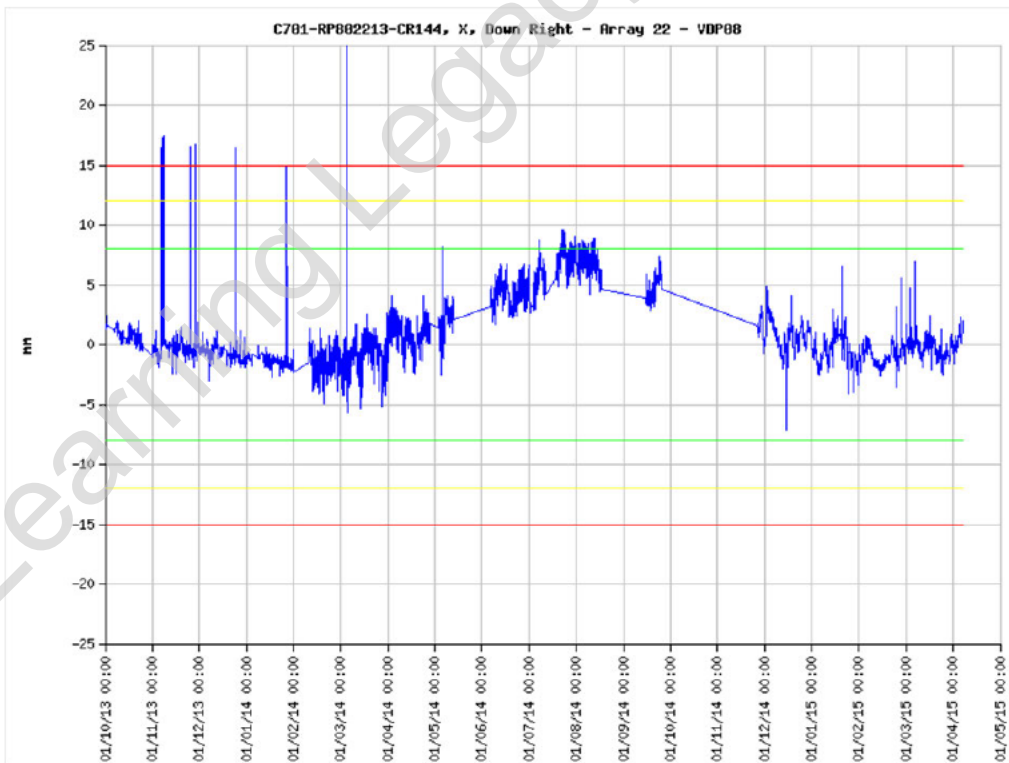


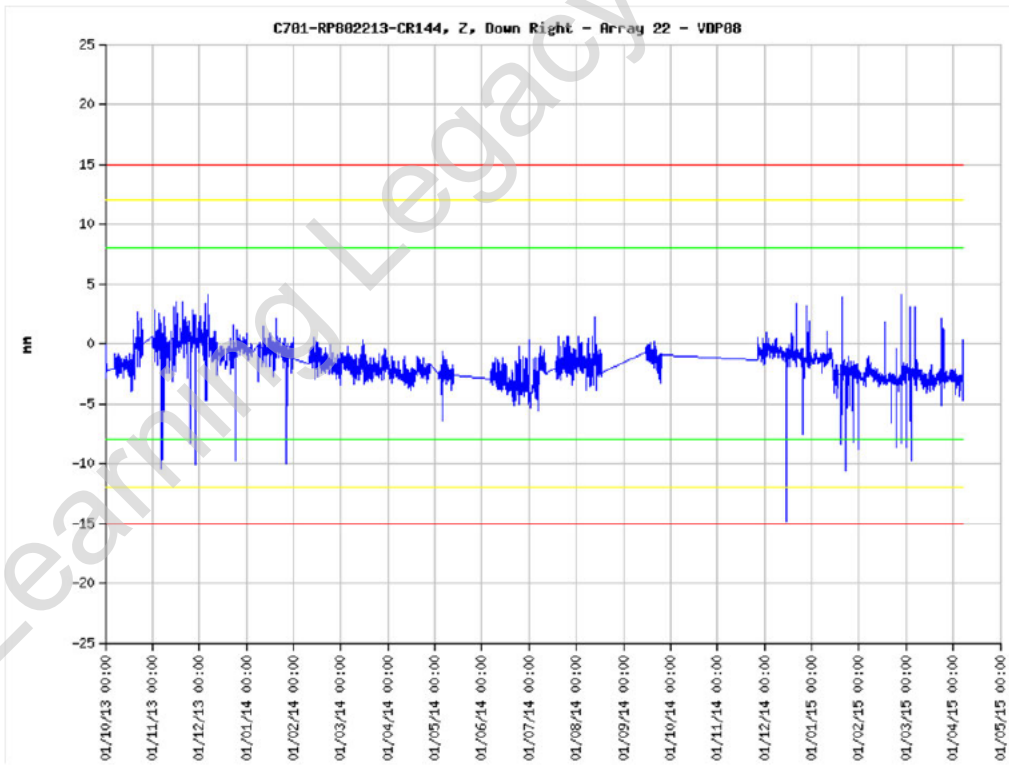
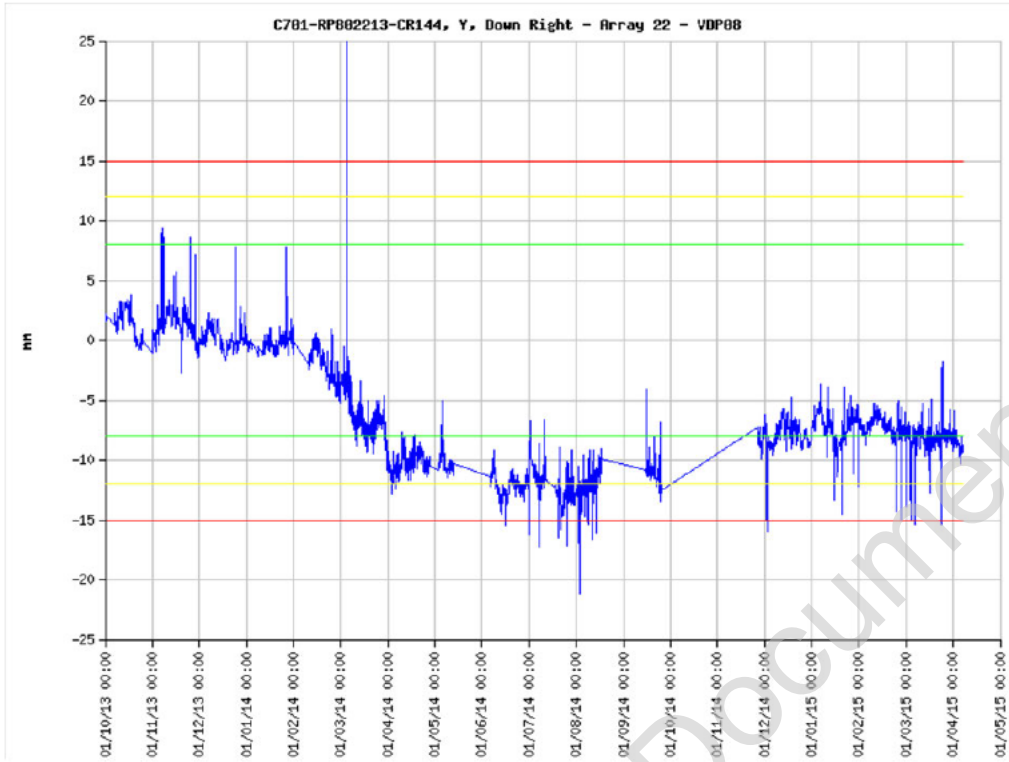
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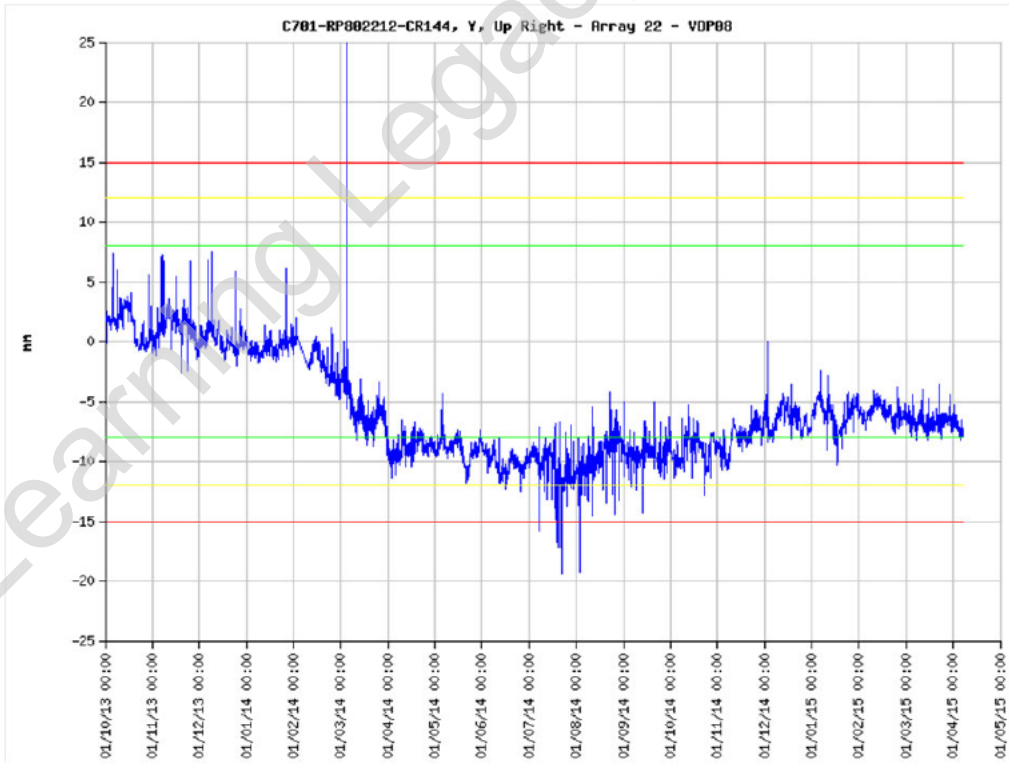
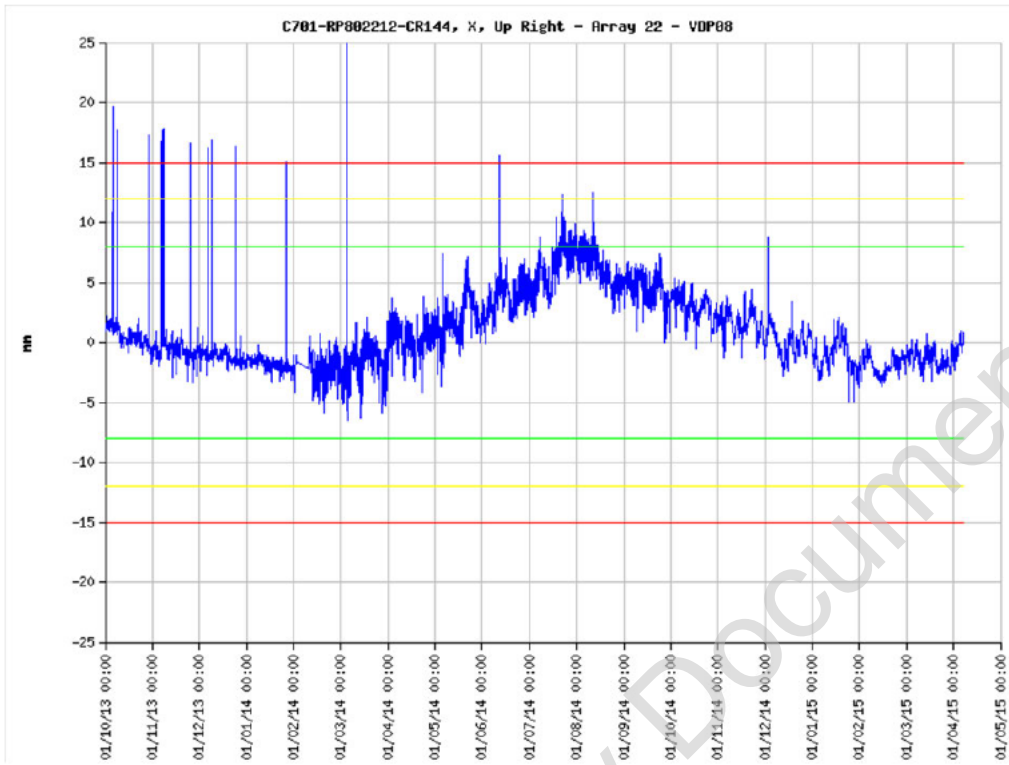


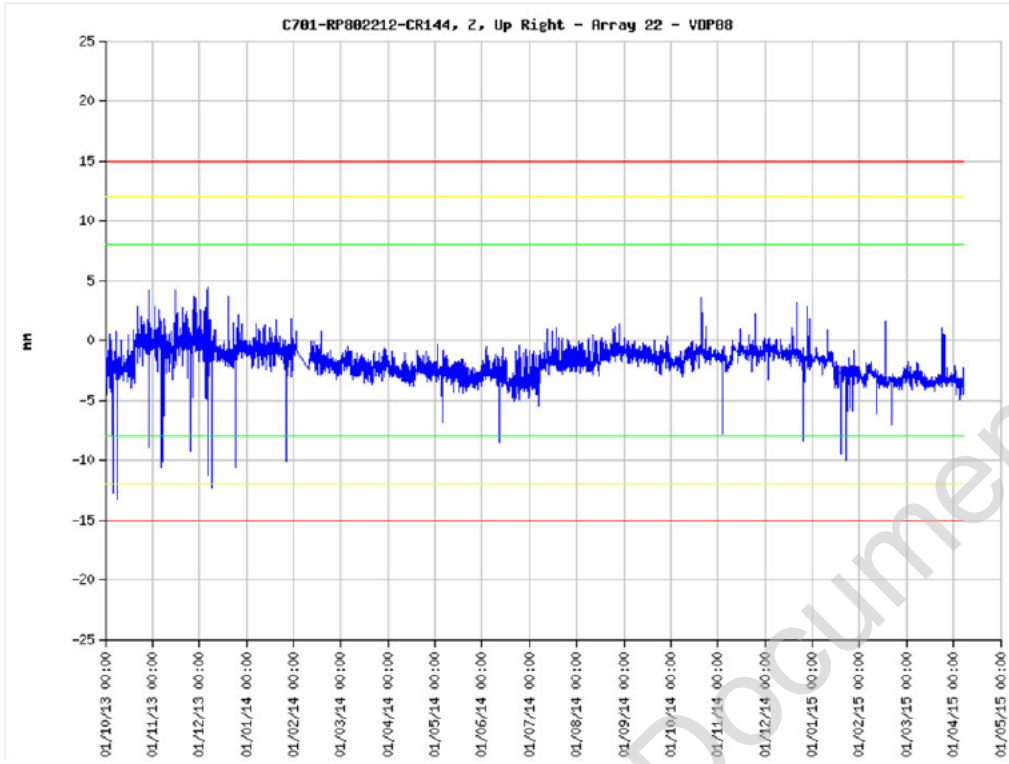
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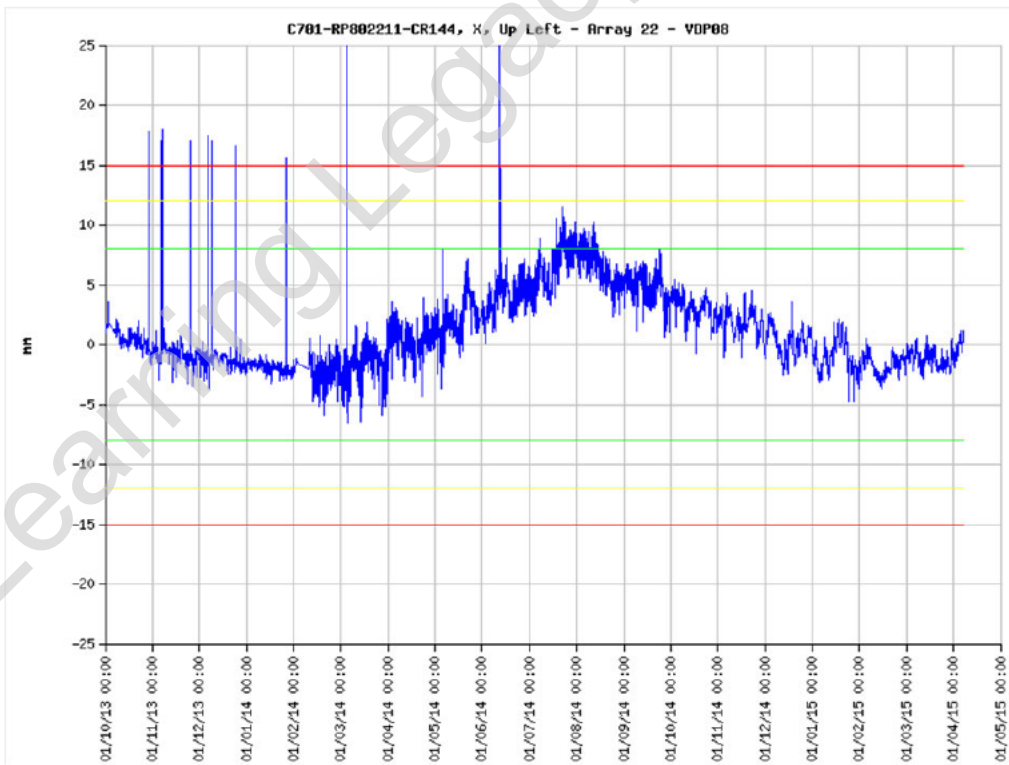


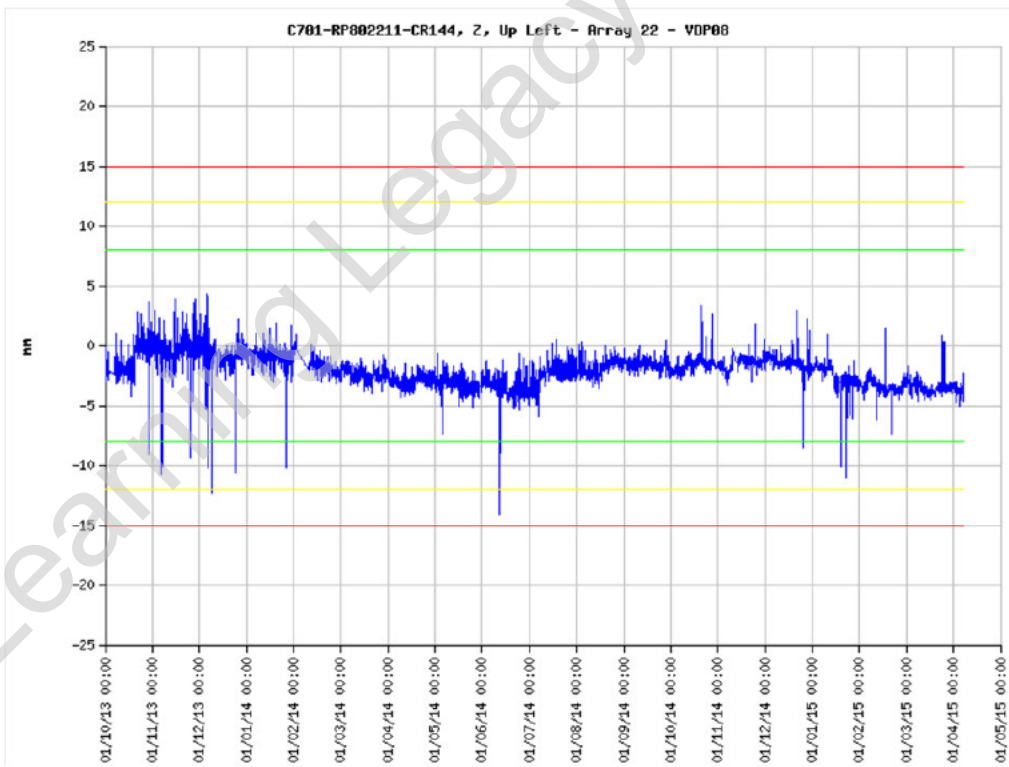
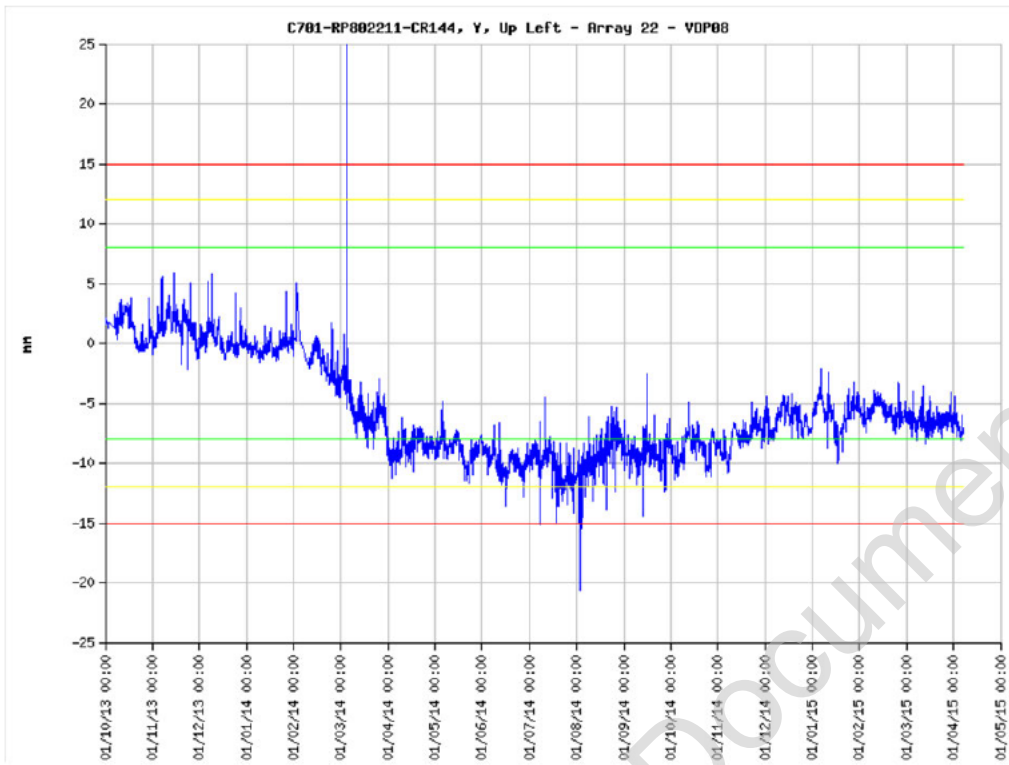
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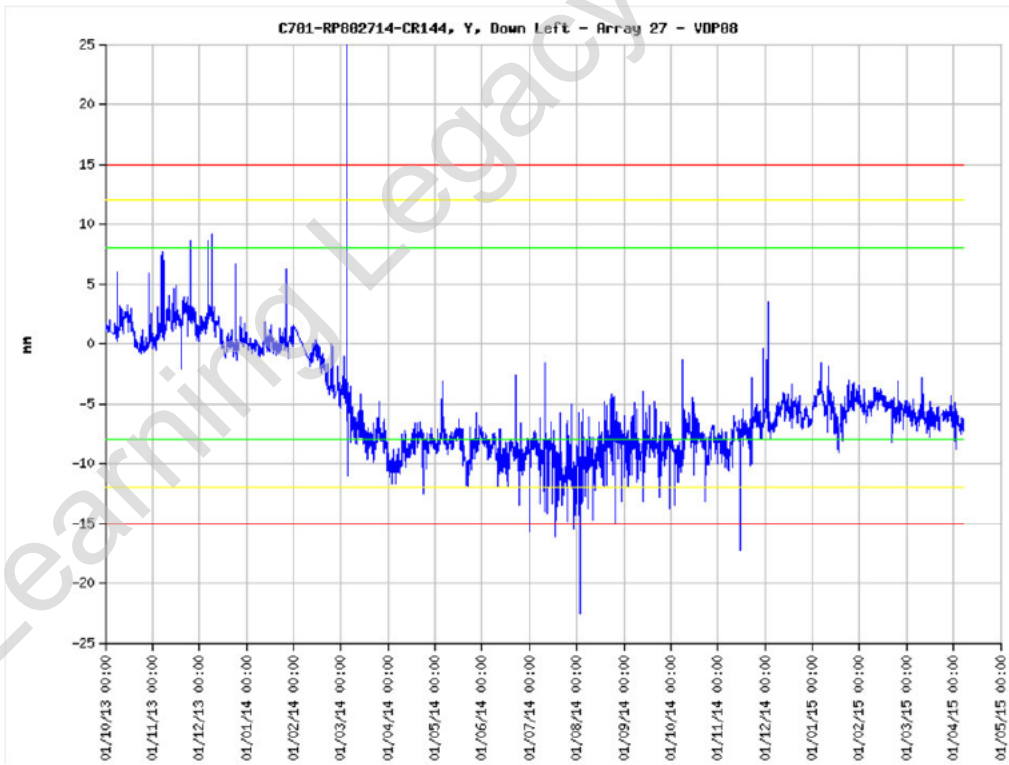
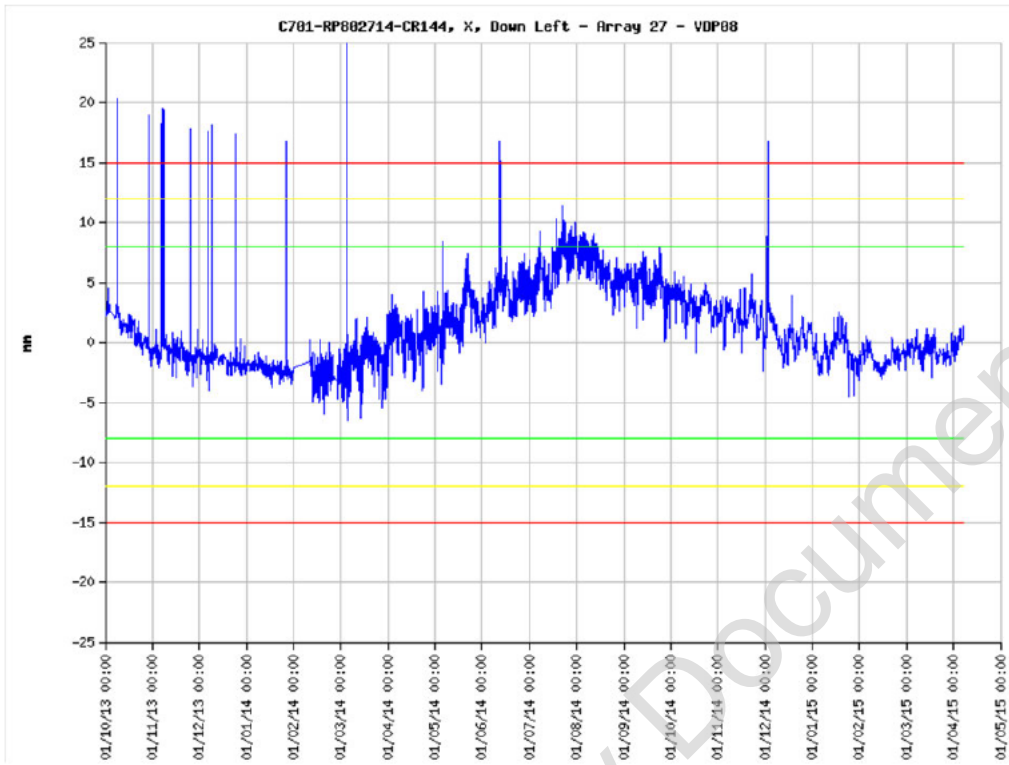


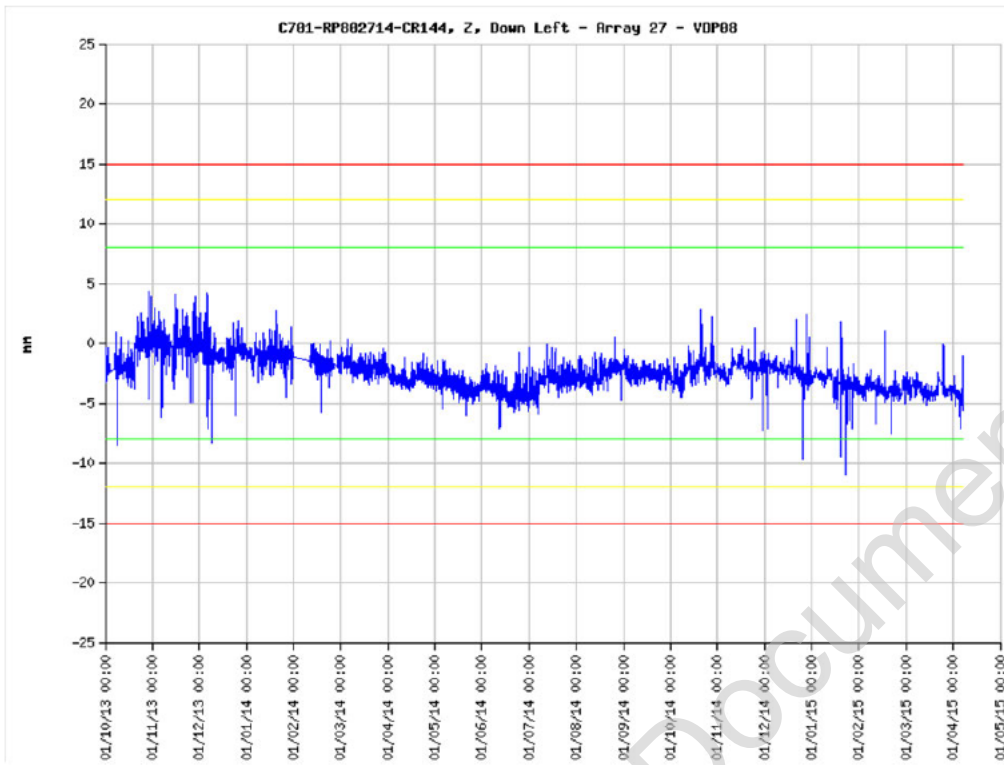
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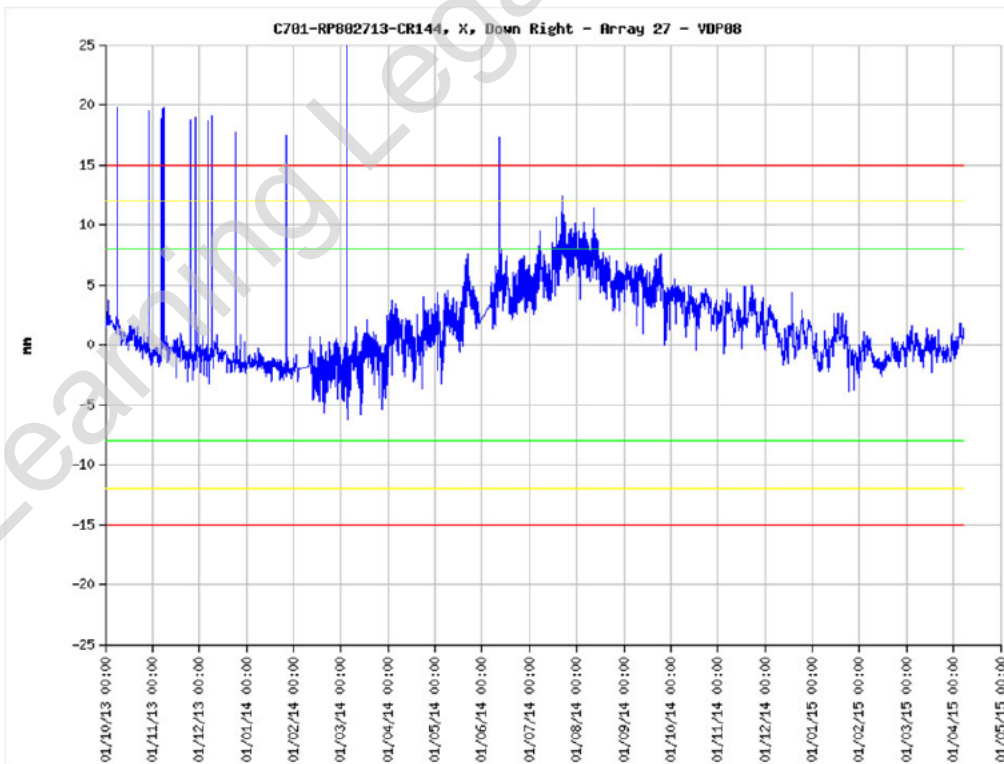


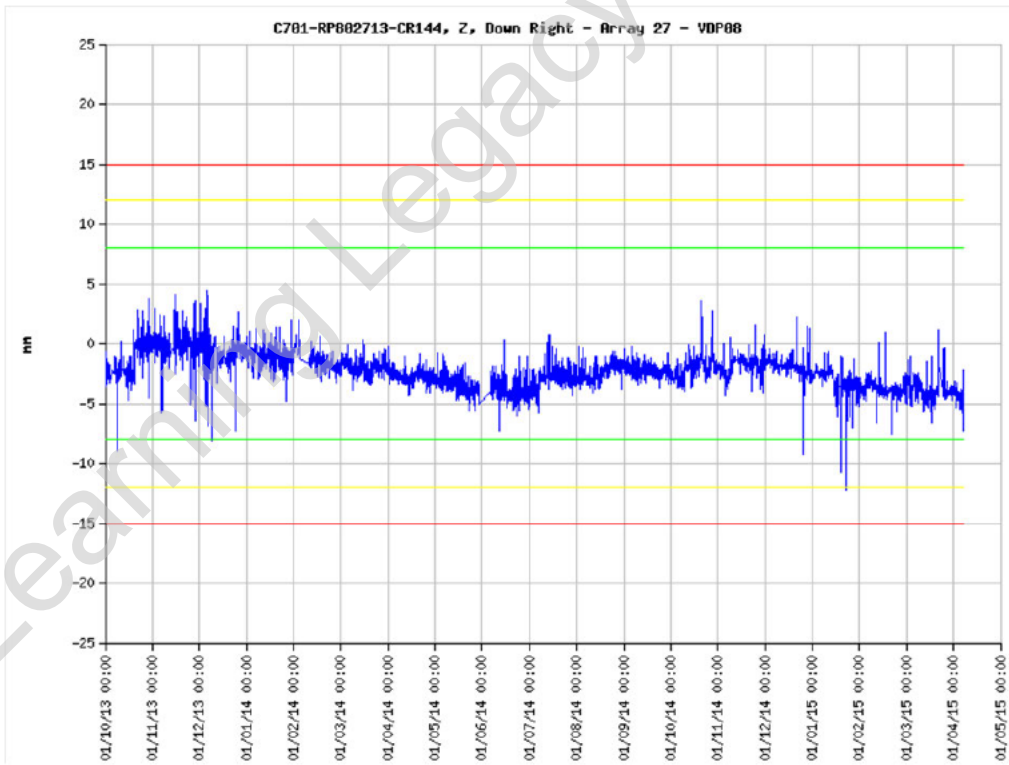
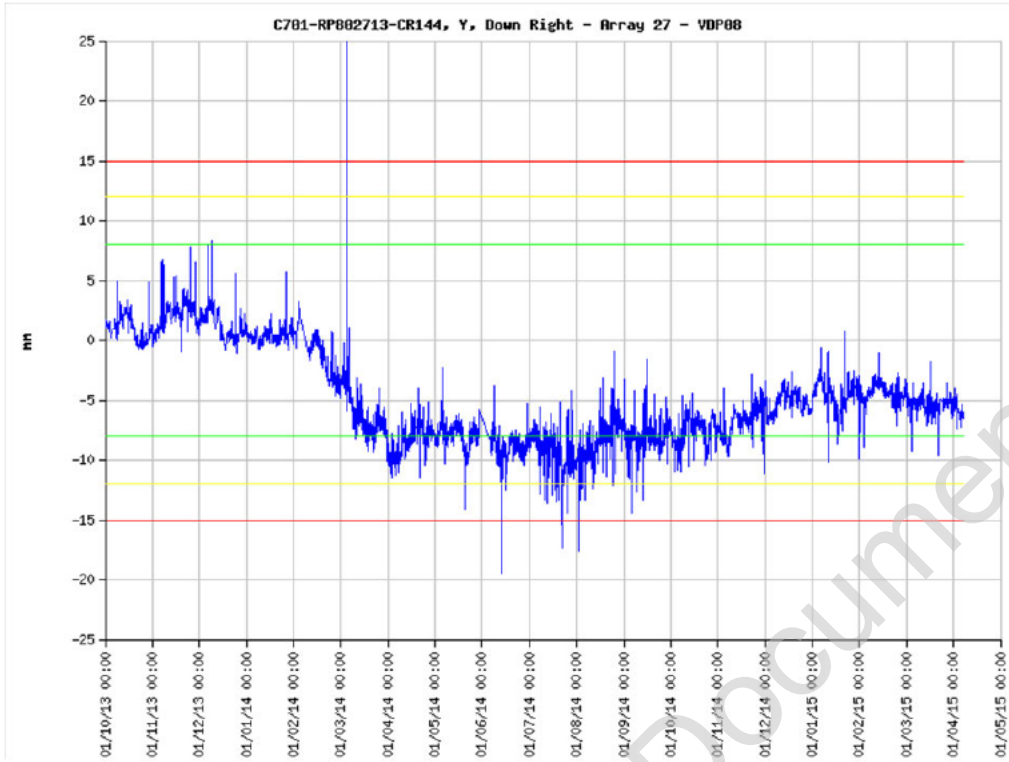
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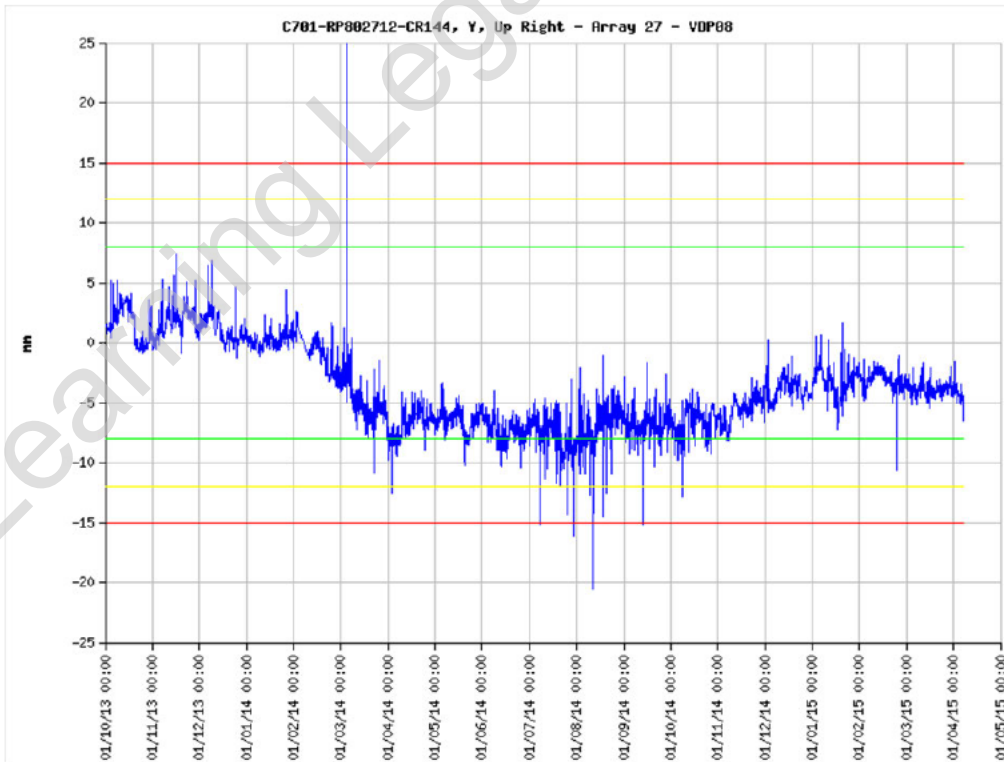
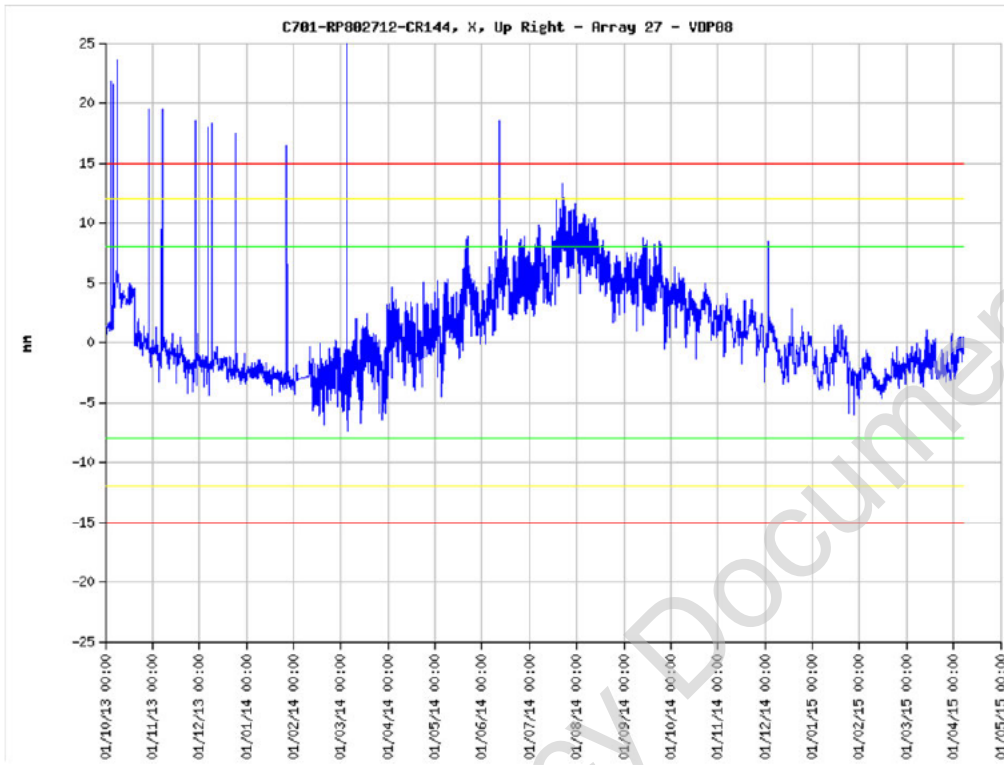


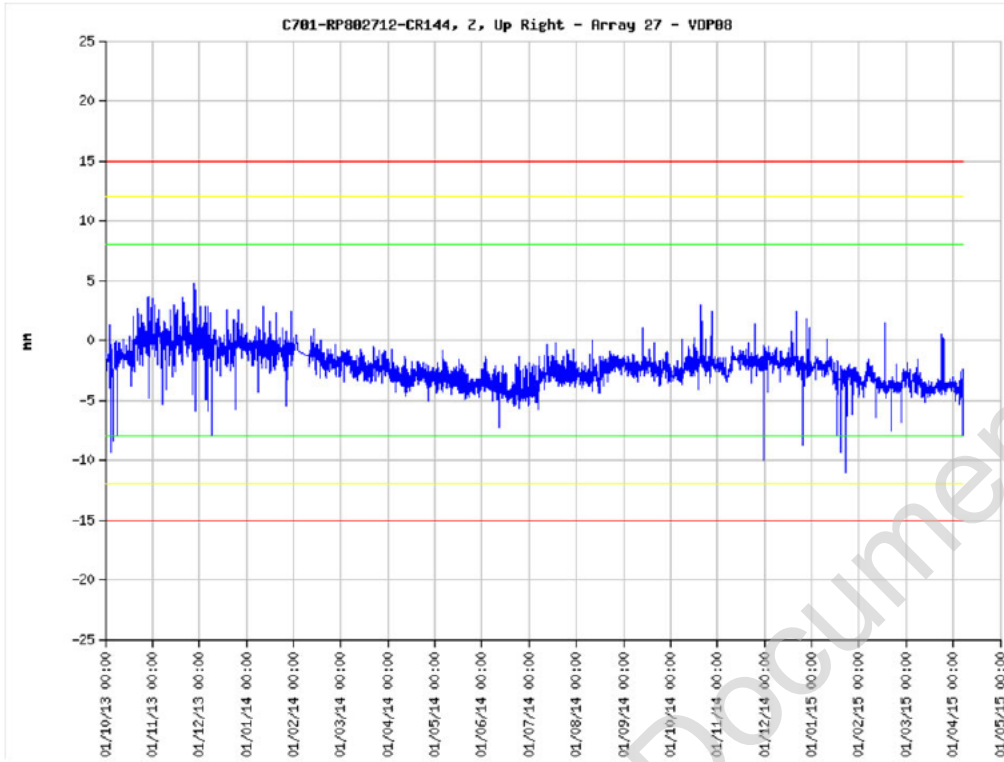
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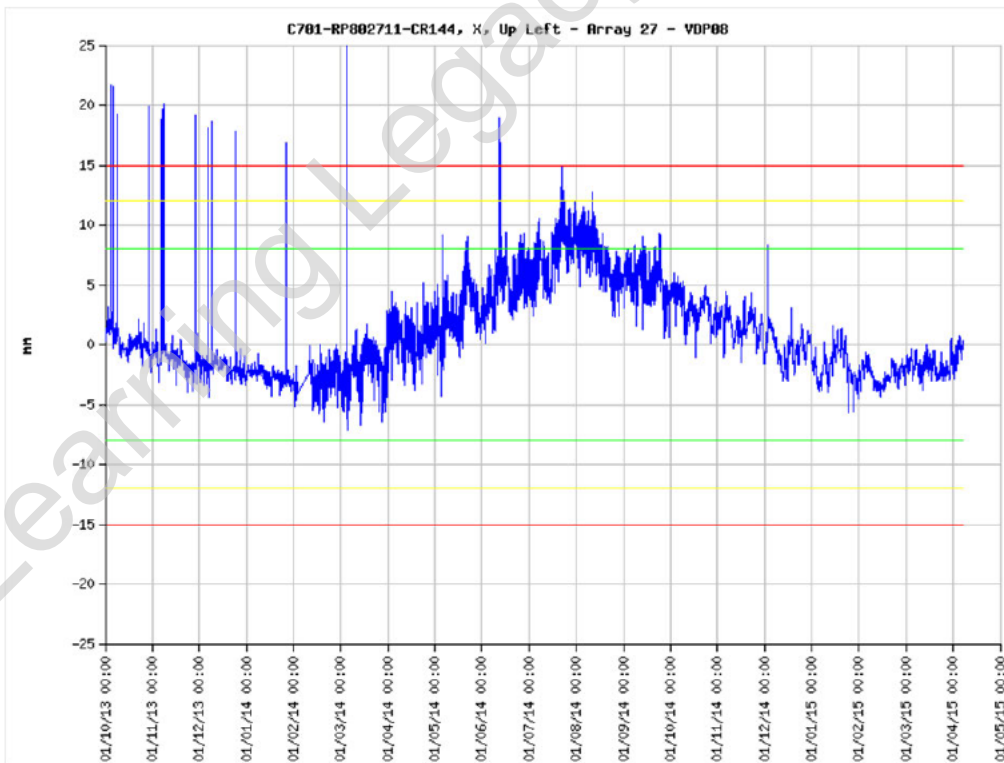


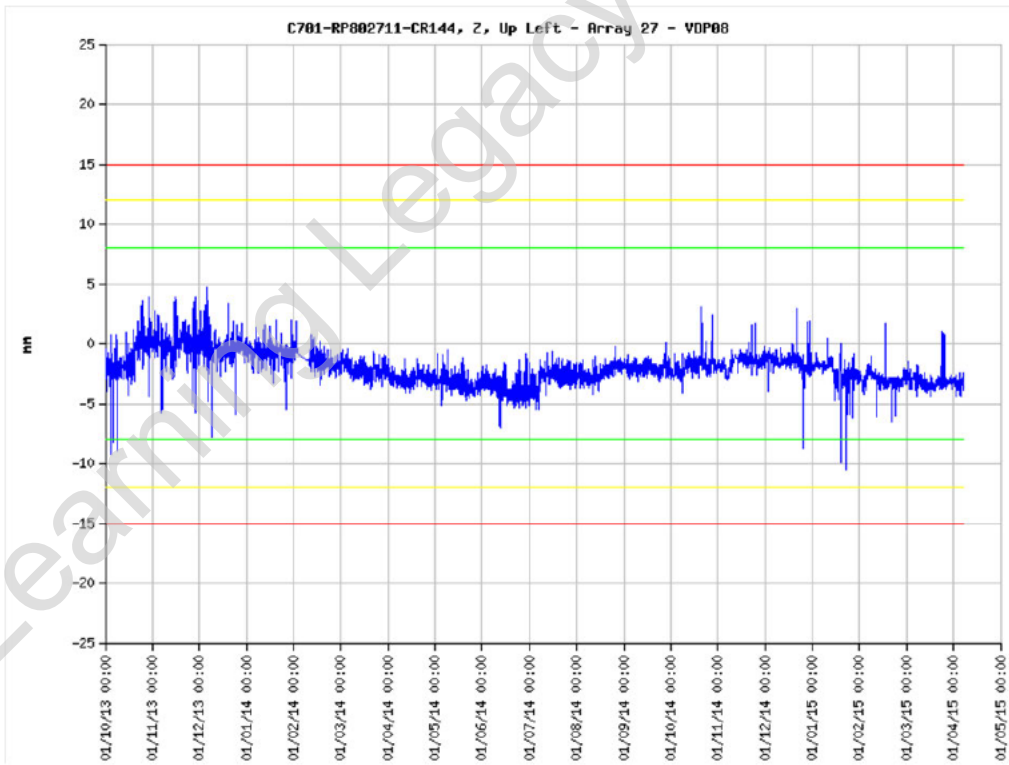
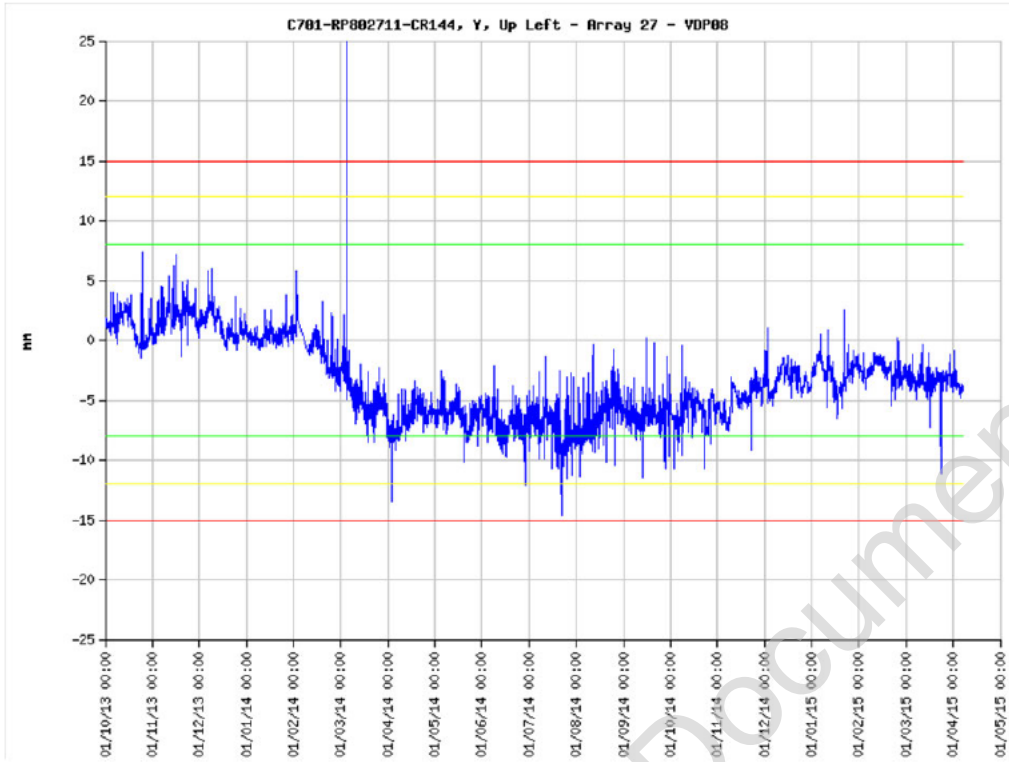
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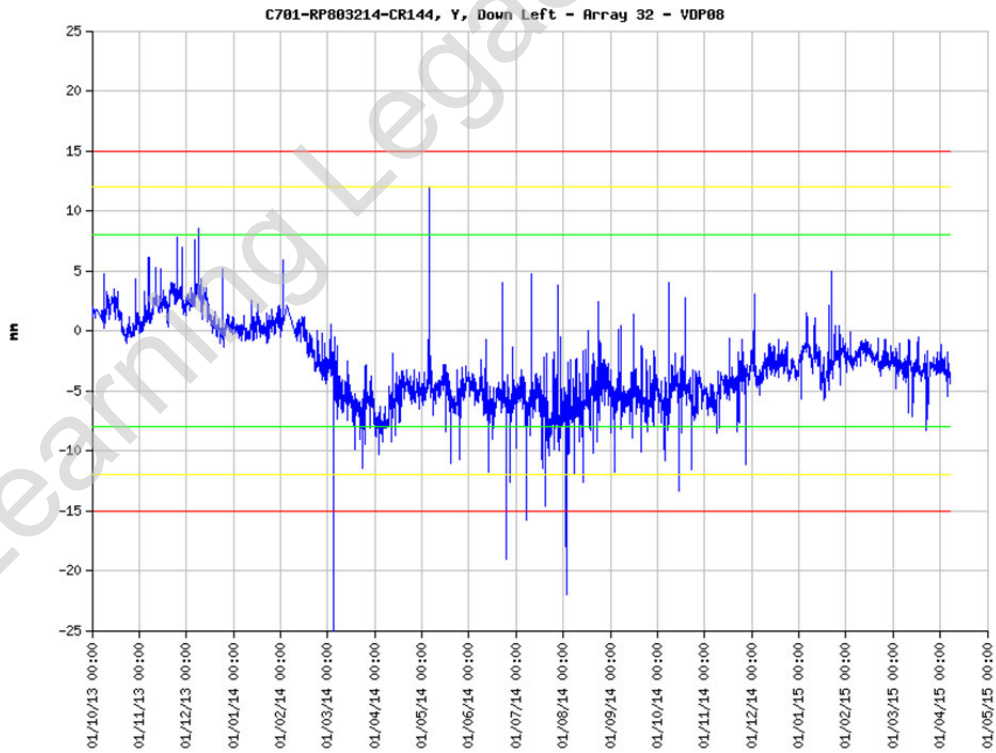
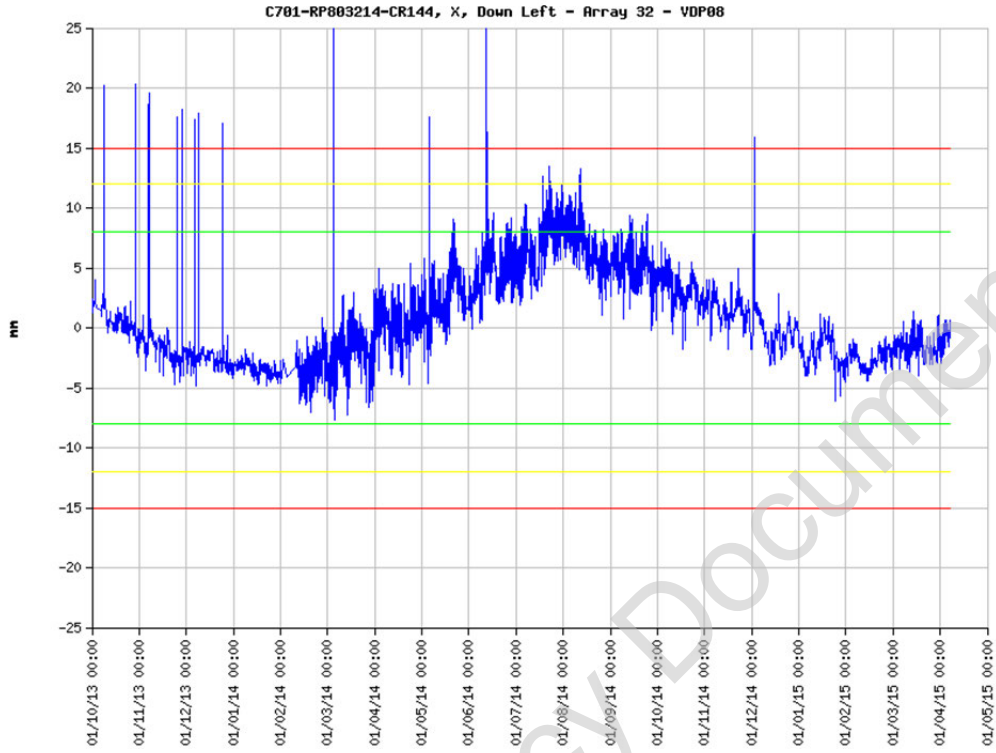


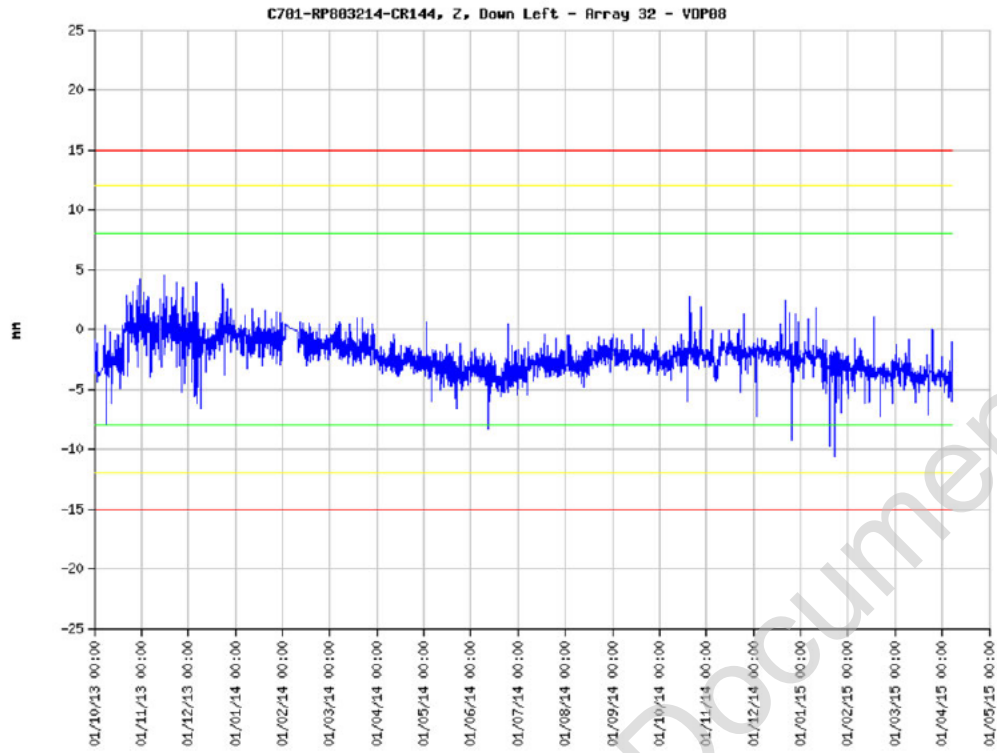
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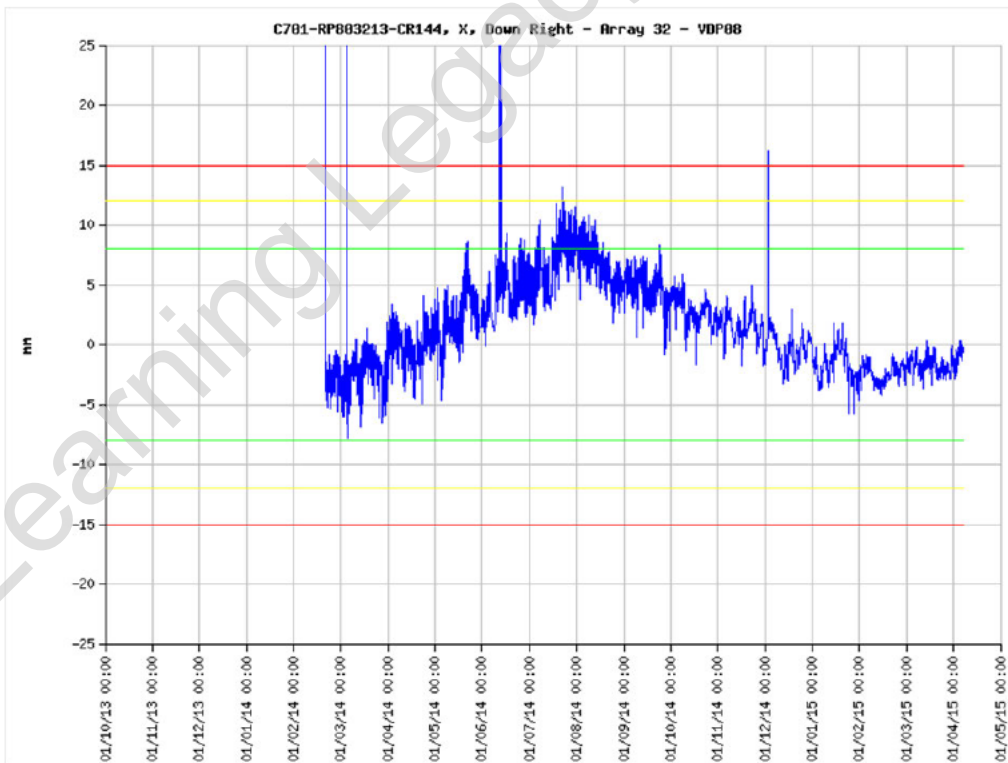


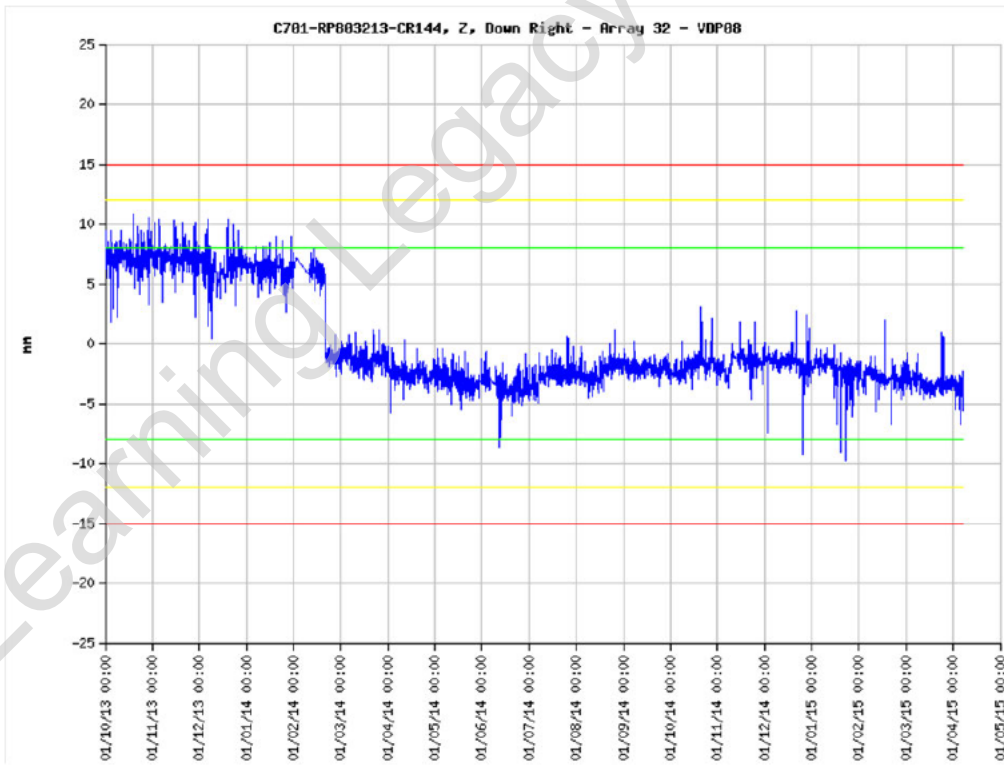
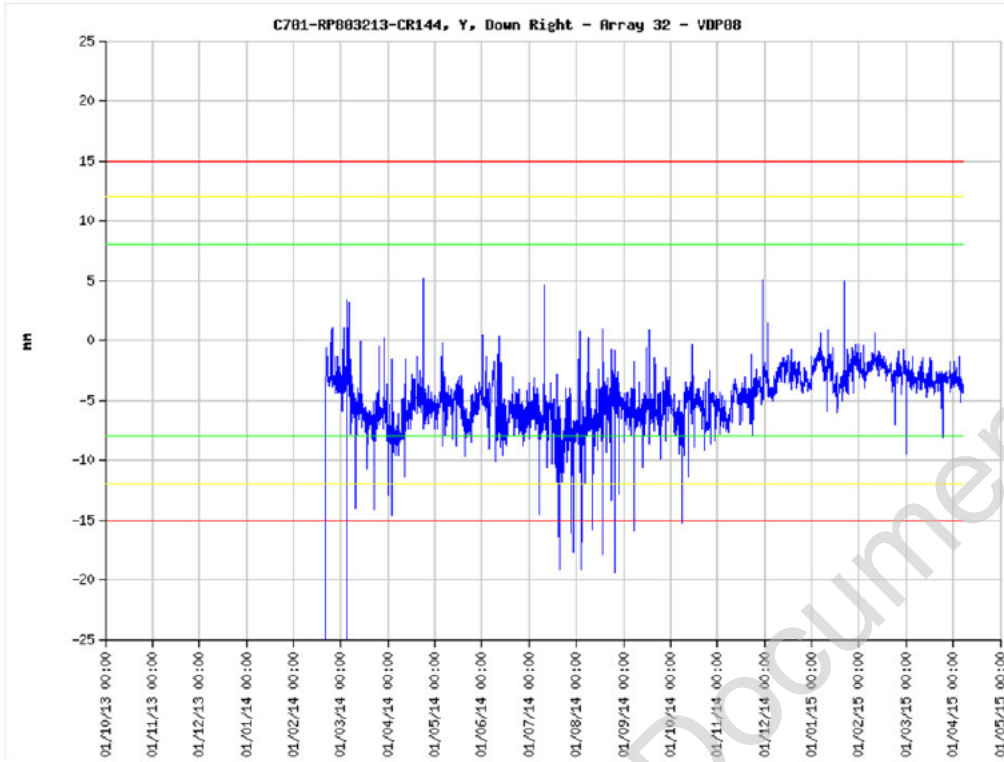
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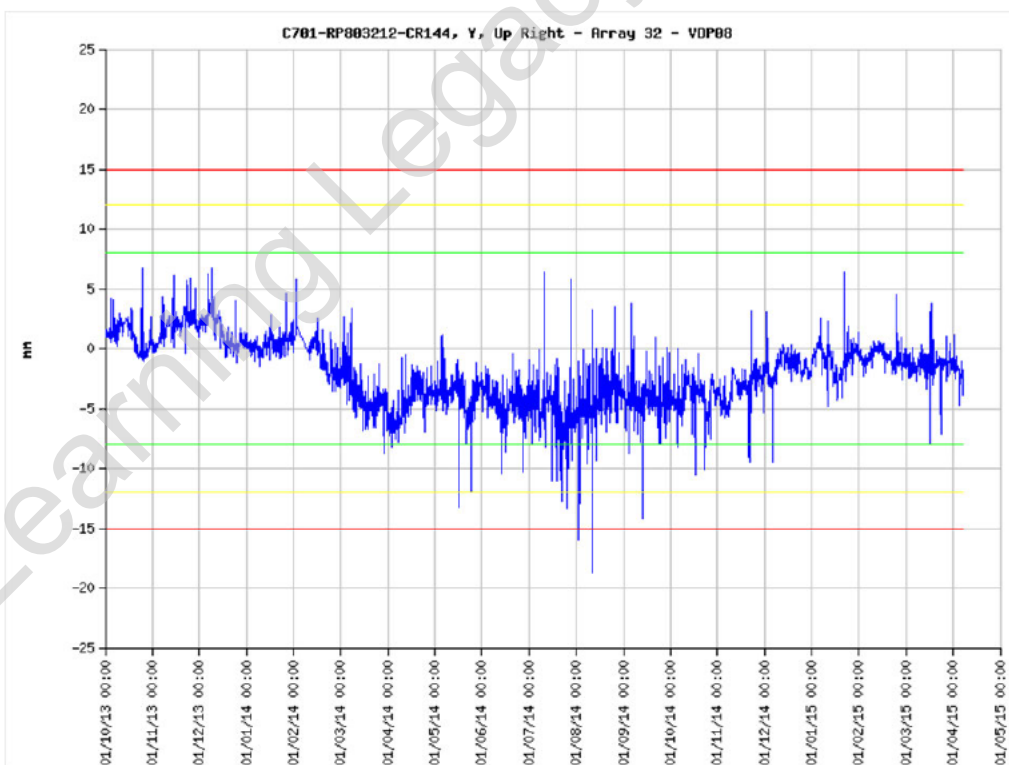
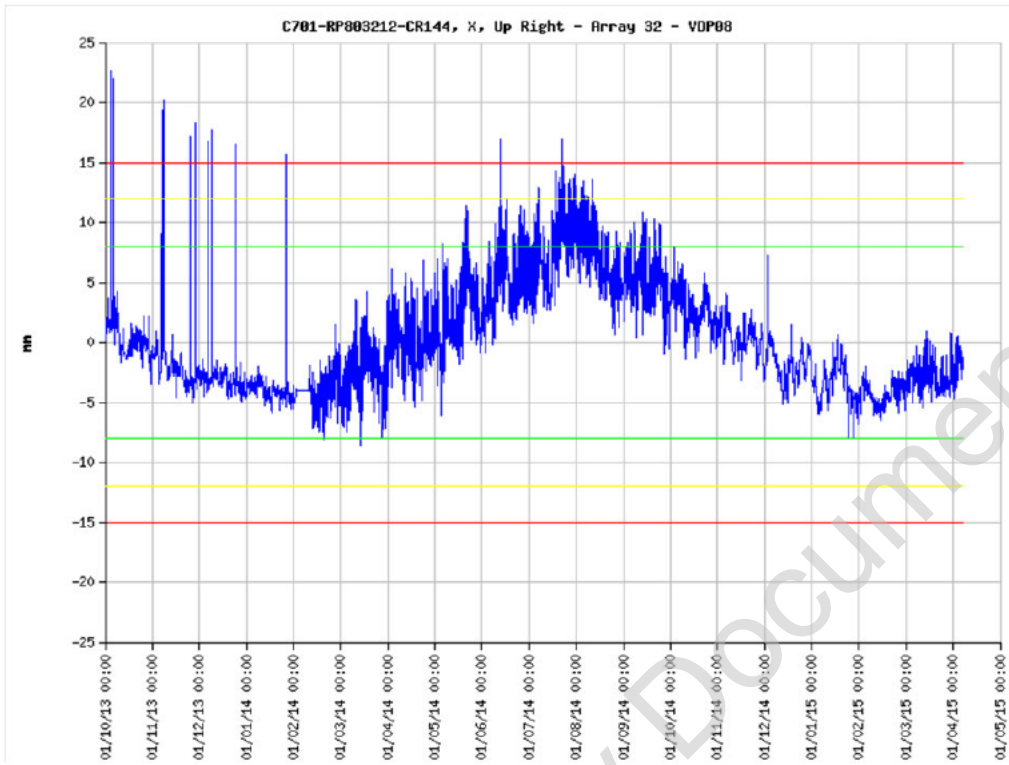


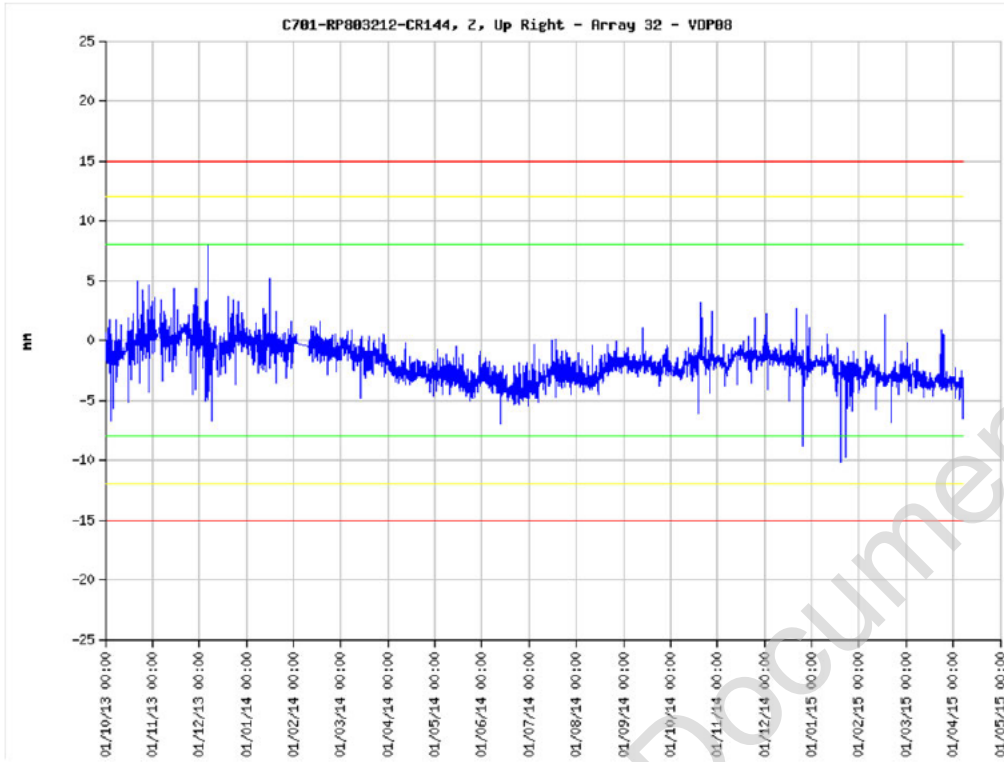
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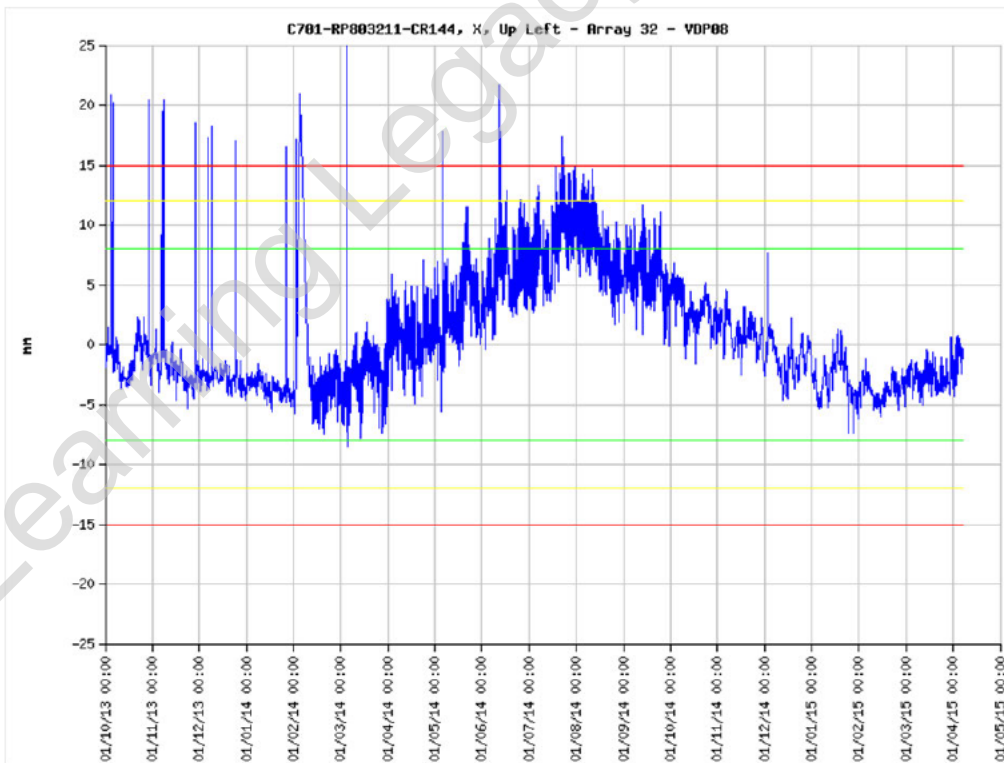


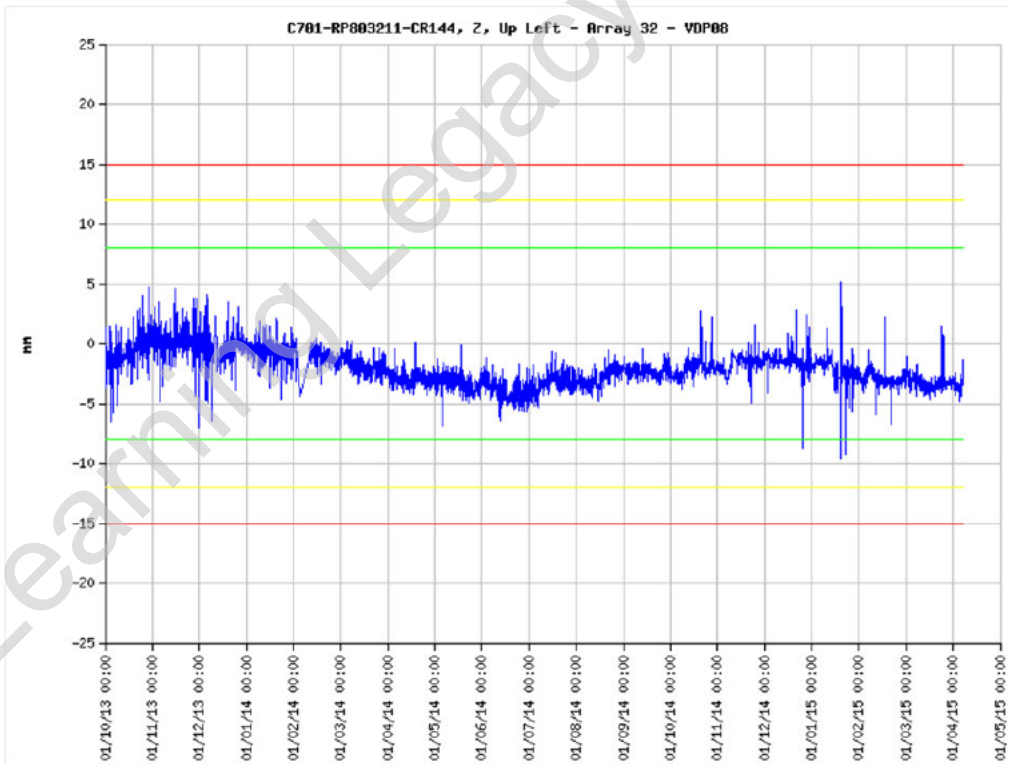
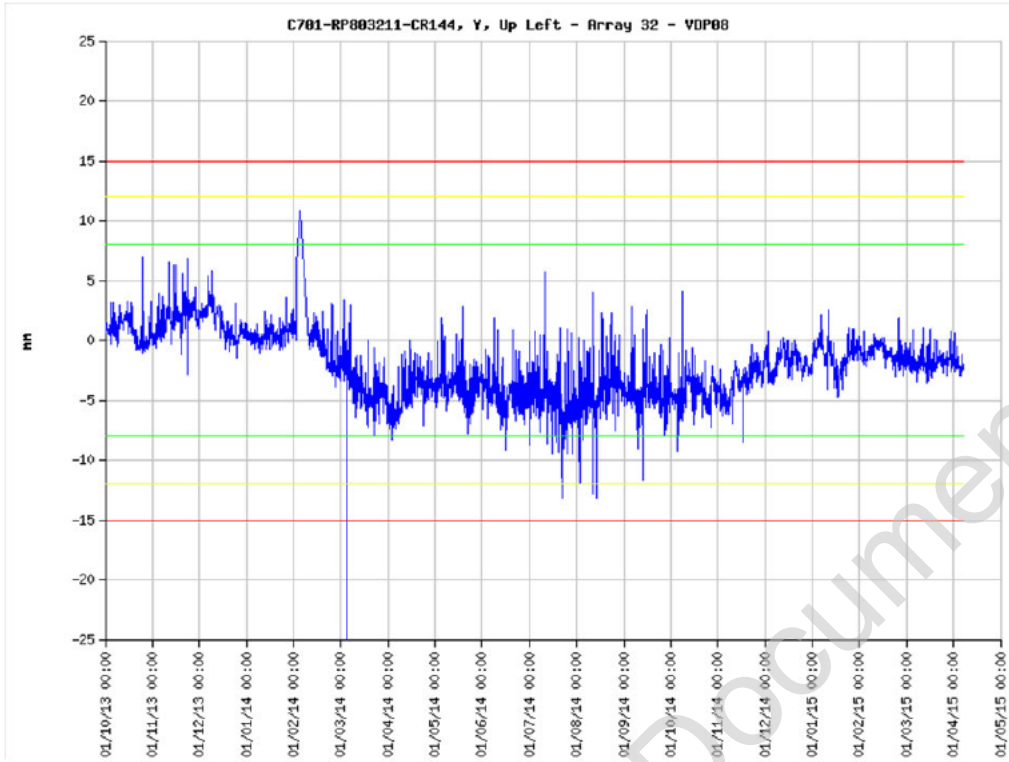
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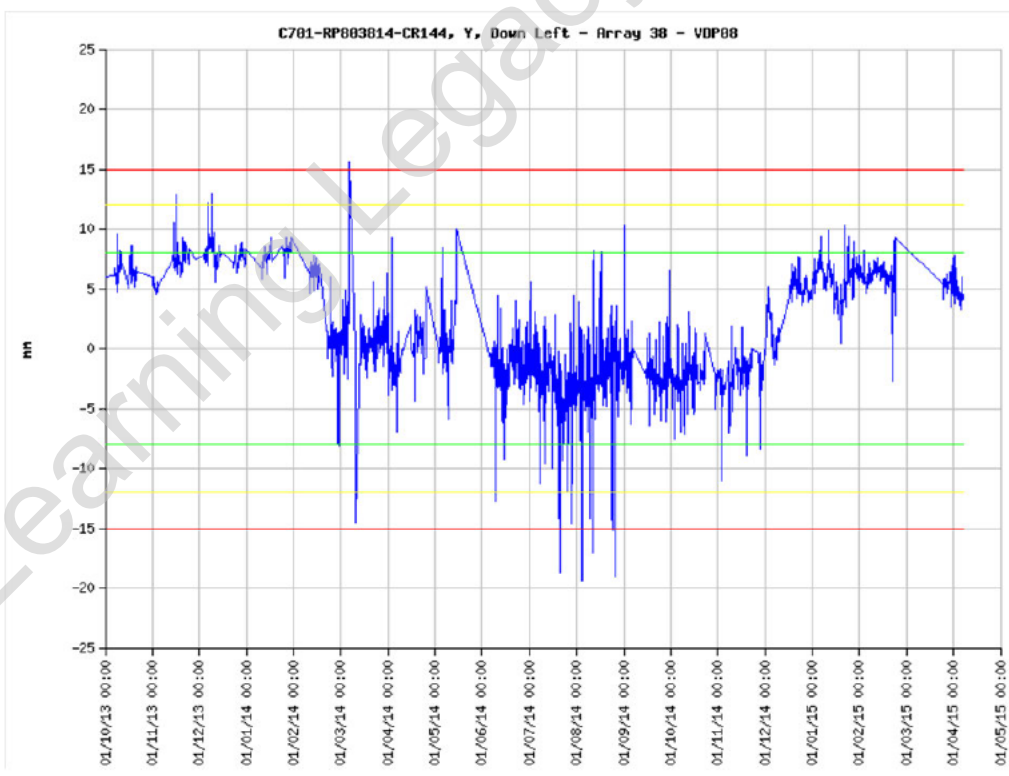
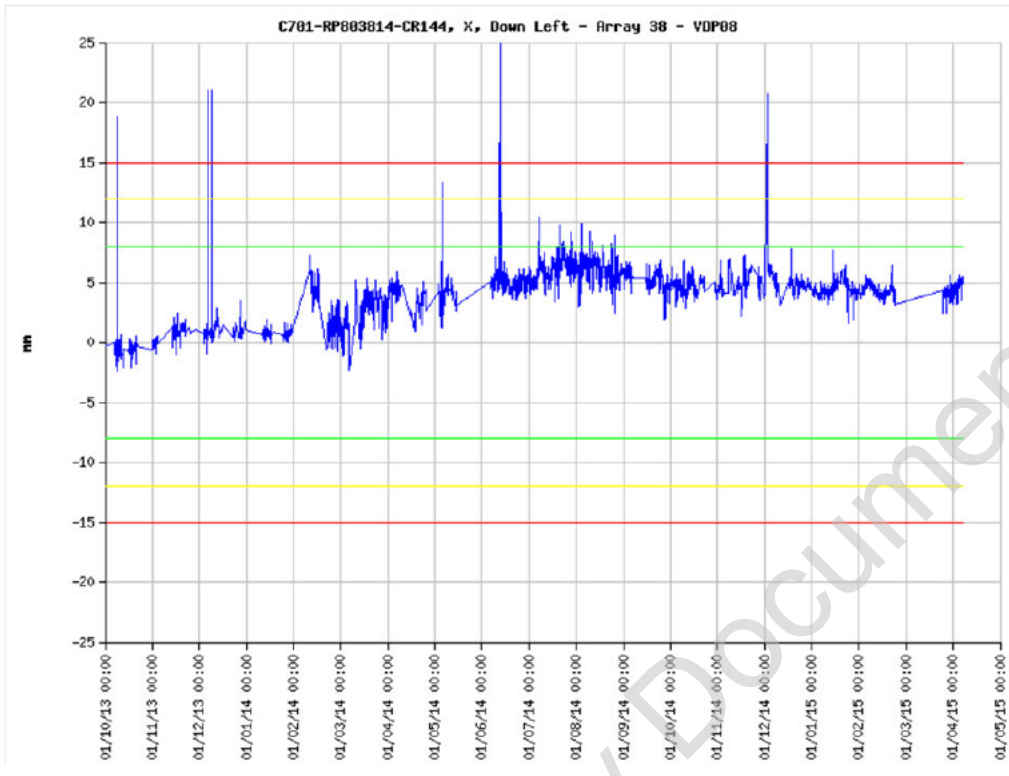


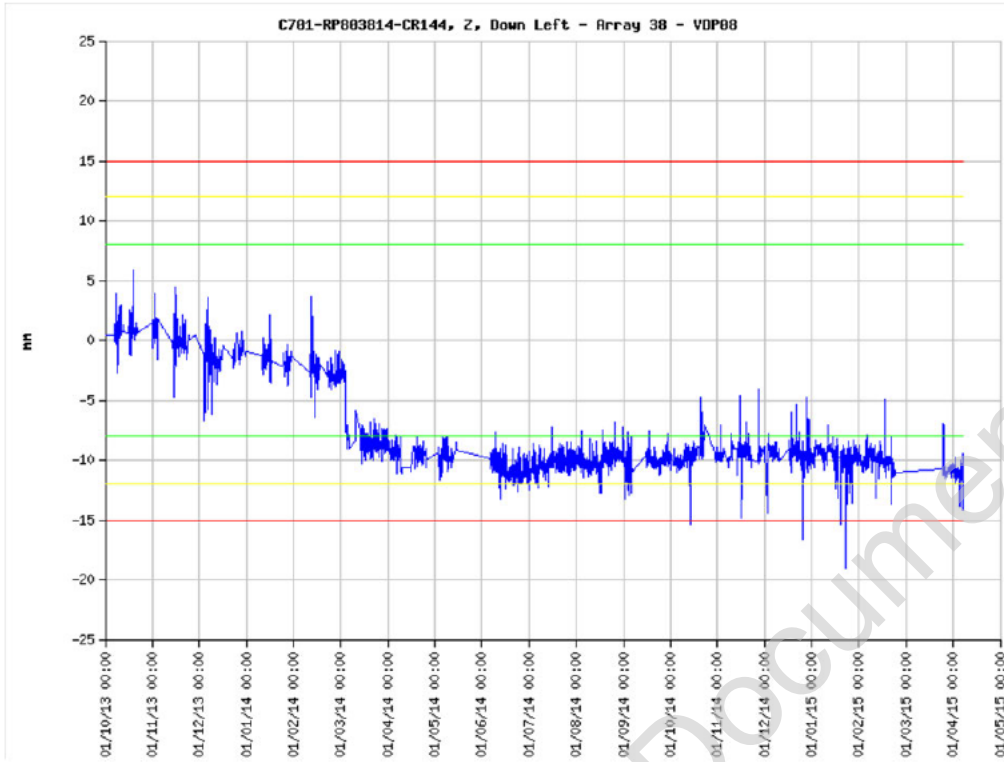
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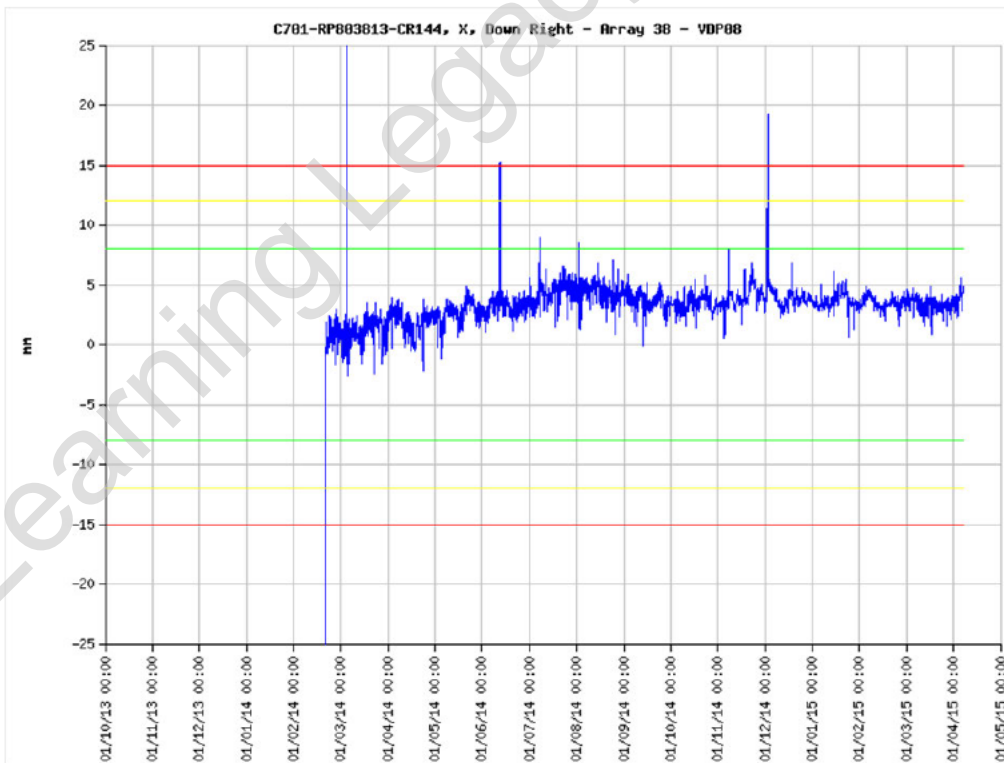


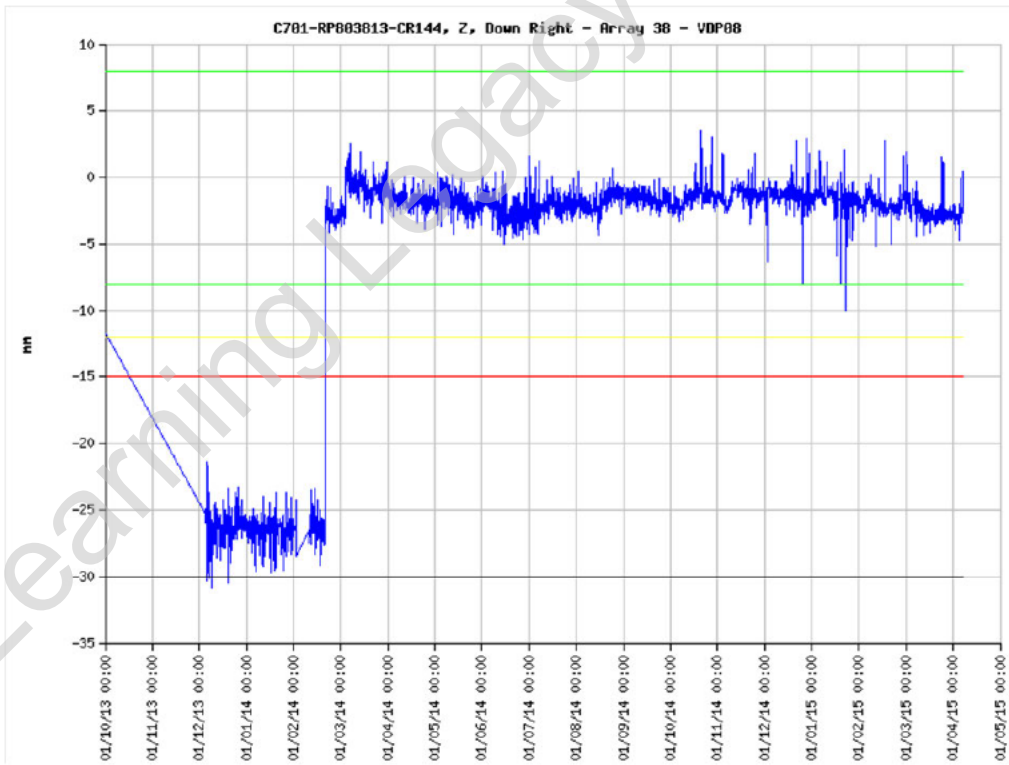
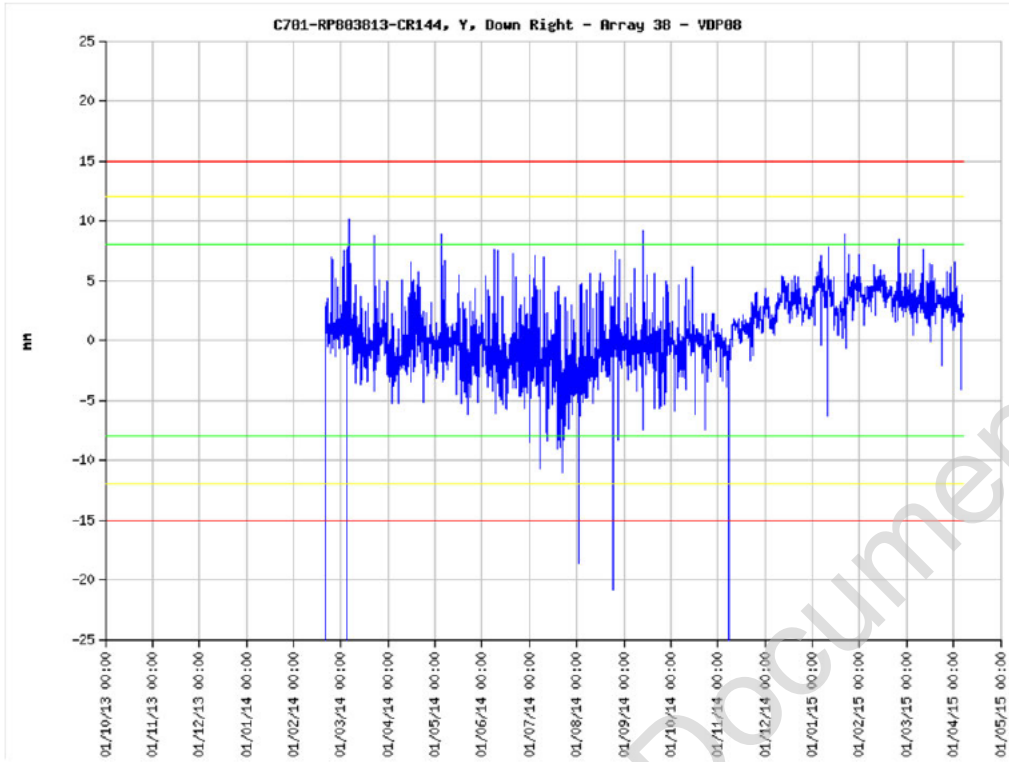
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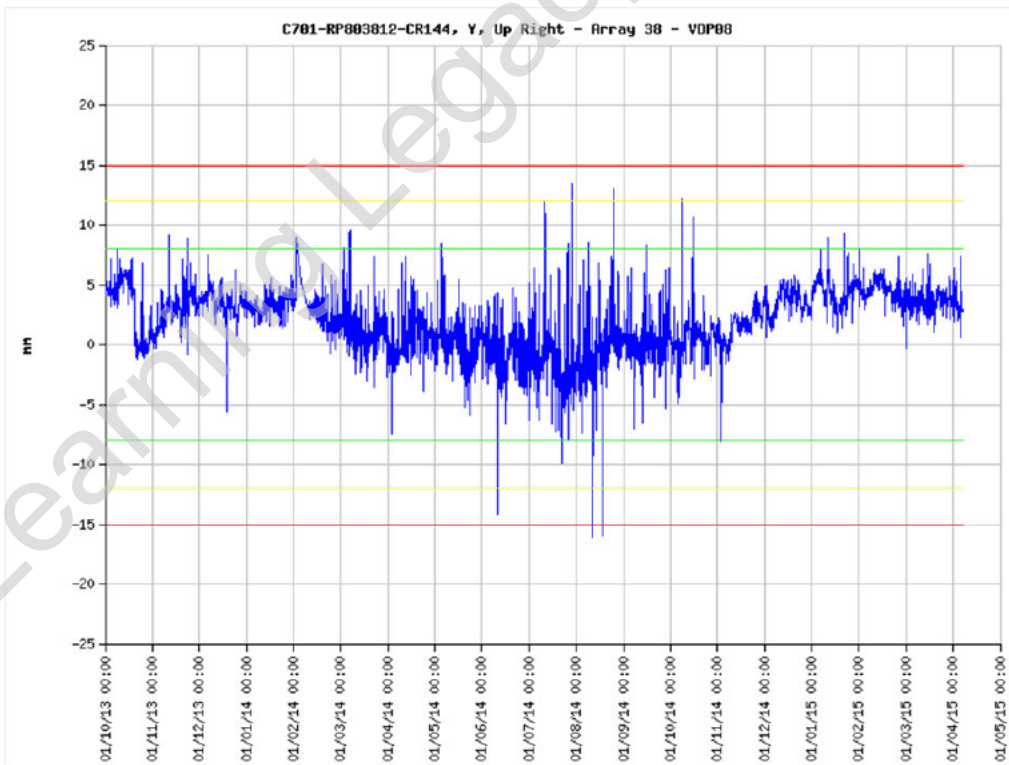
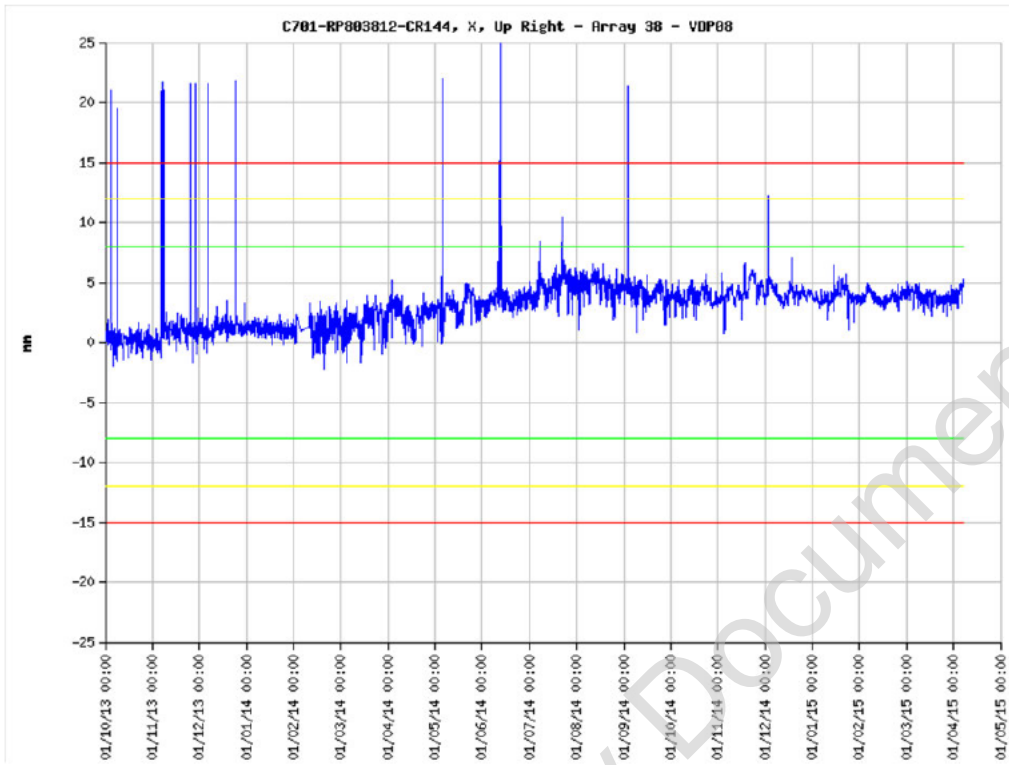


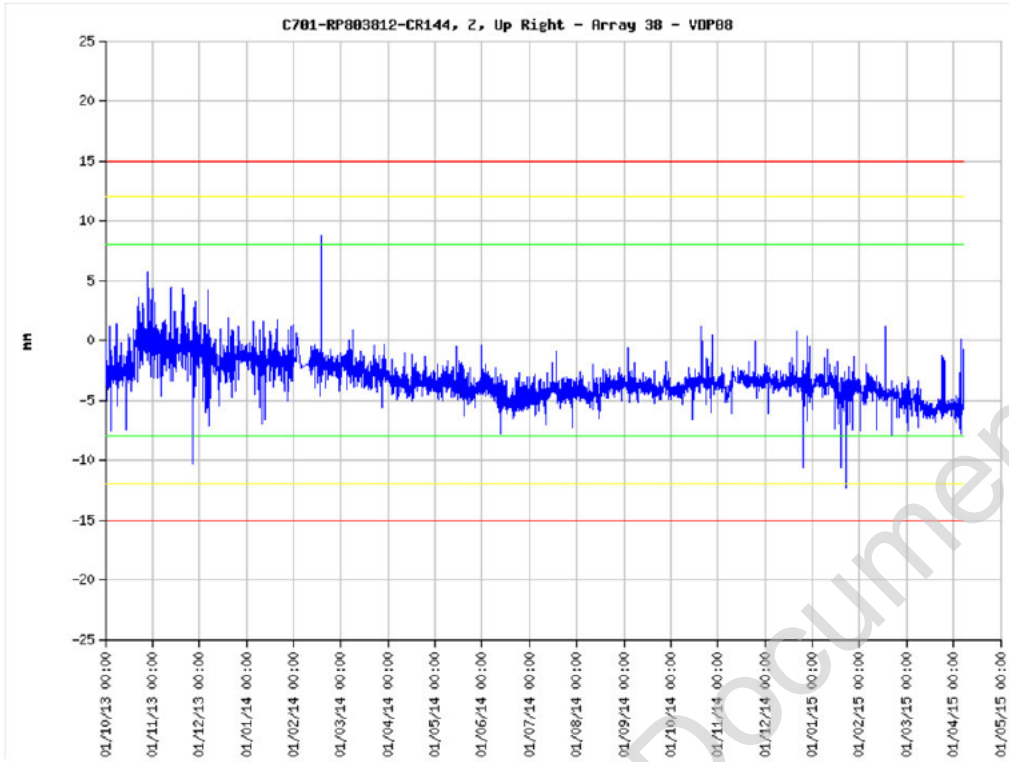
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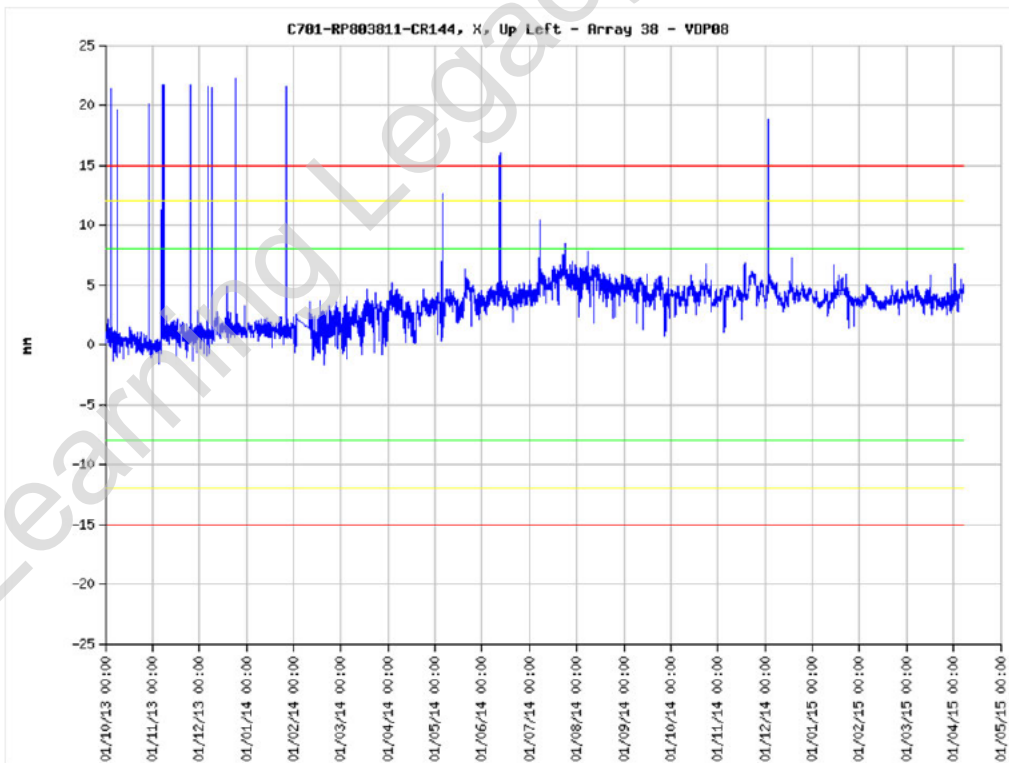


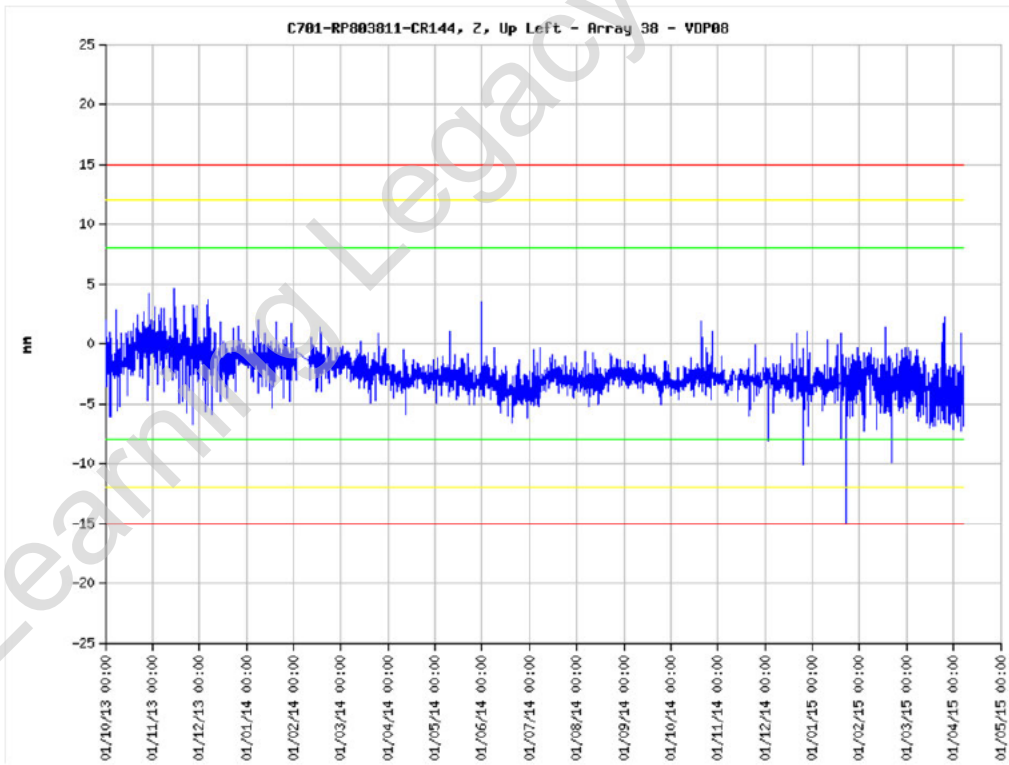
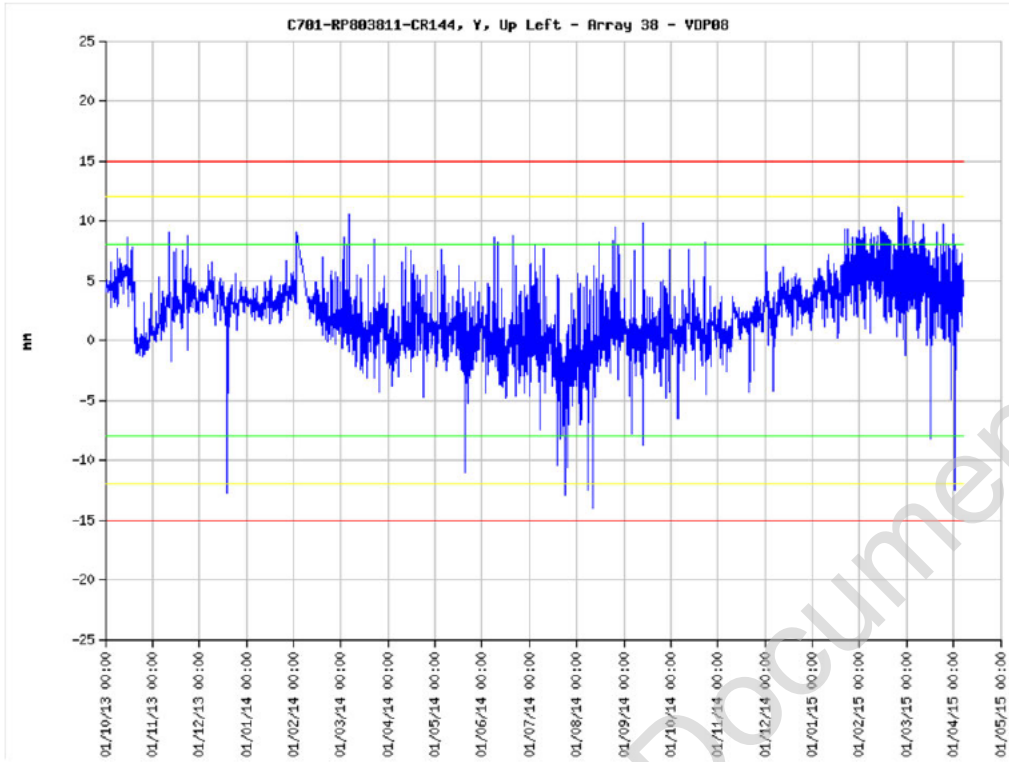
VDP C701-RP803812





VDP C701-RP803811

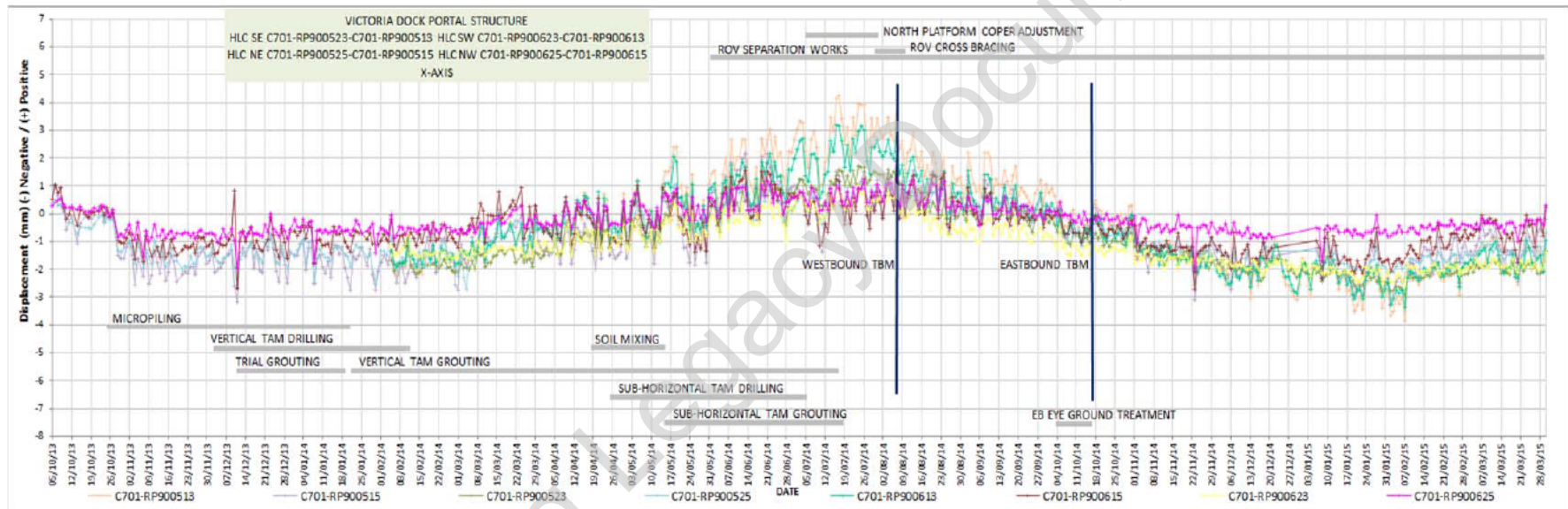


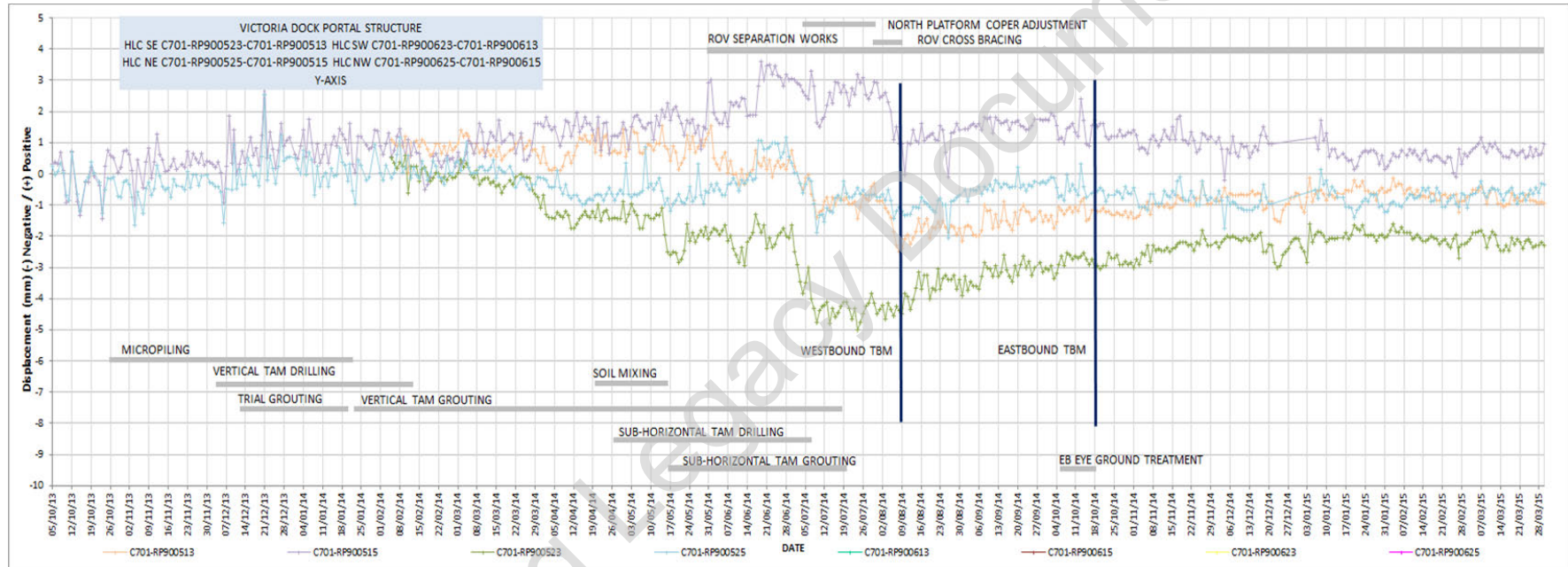


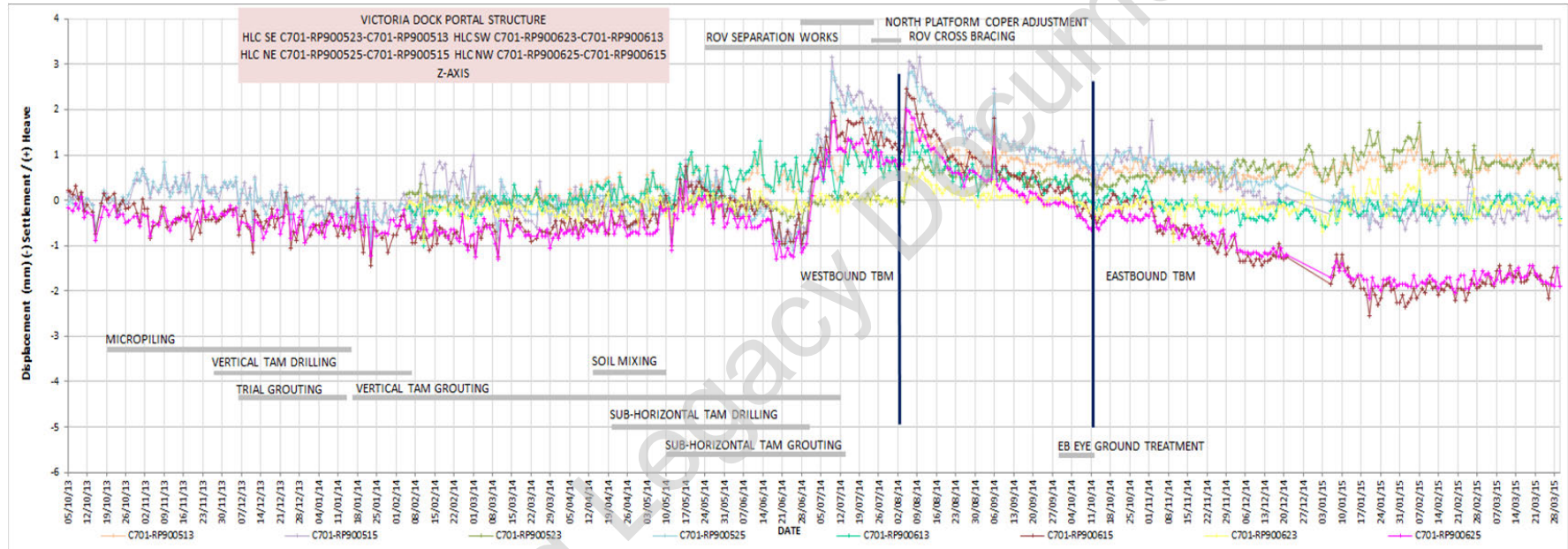
Learning Legacy Document

Appendix 5: ROYAL VICTORIA STATION STRUCTURE. C701

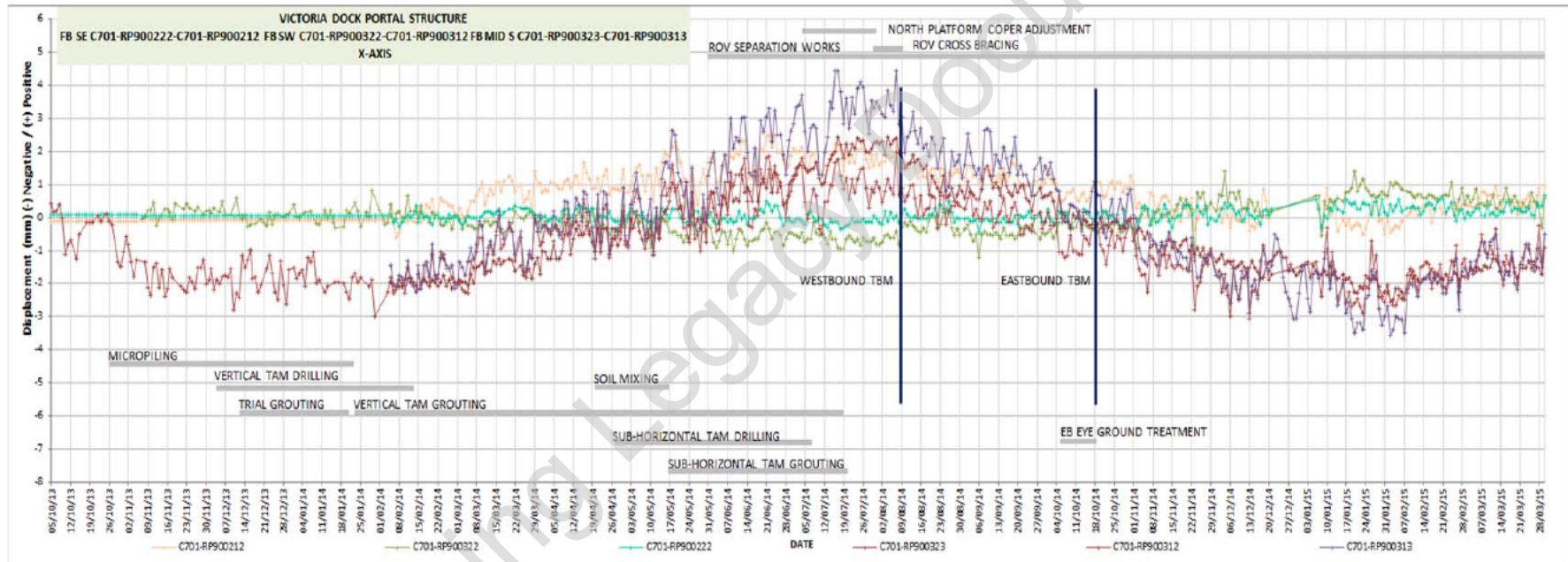
HLC: SE C701-RP900523-C701-RP900513 / HLC SW C701-RP900623-C701-RP900613 / HLC NE C701-RP900525-C701-RP900515 / HLC NW C701-RP900625-C701-RP900615

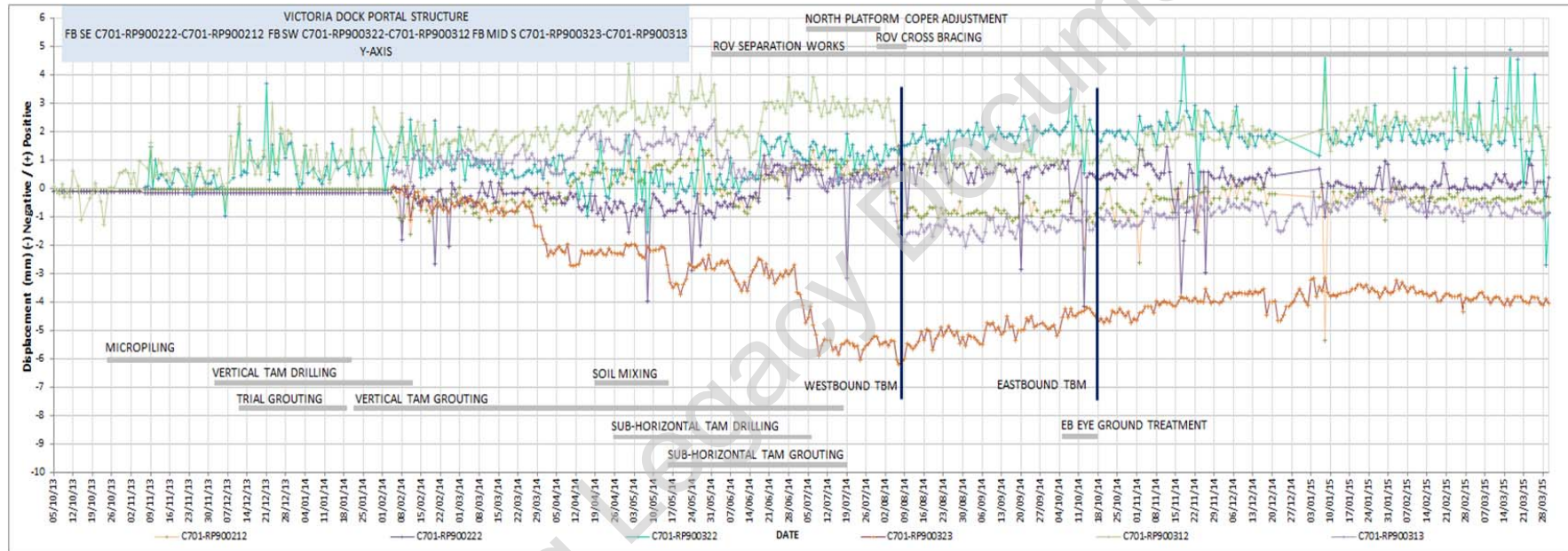


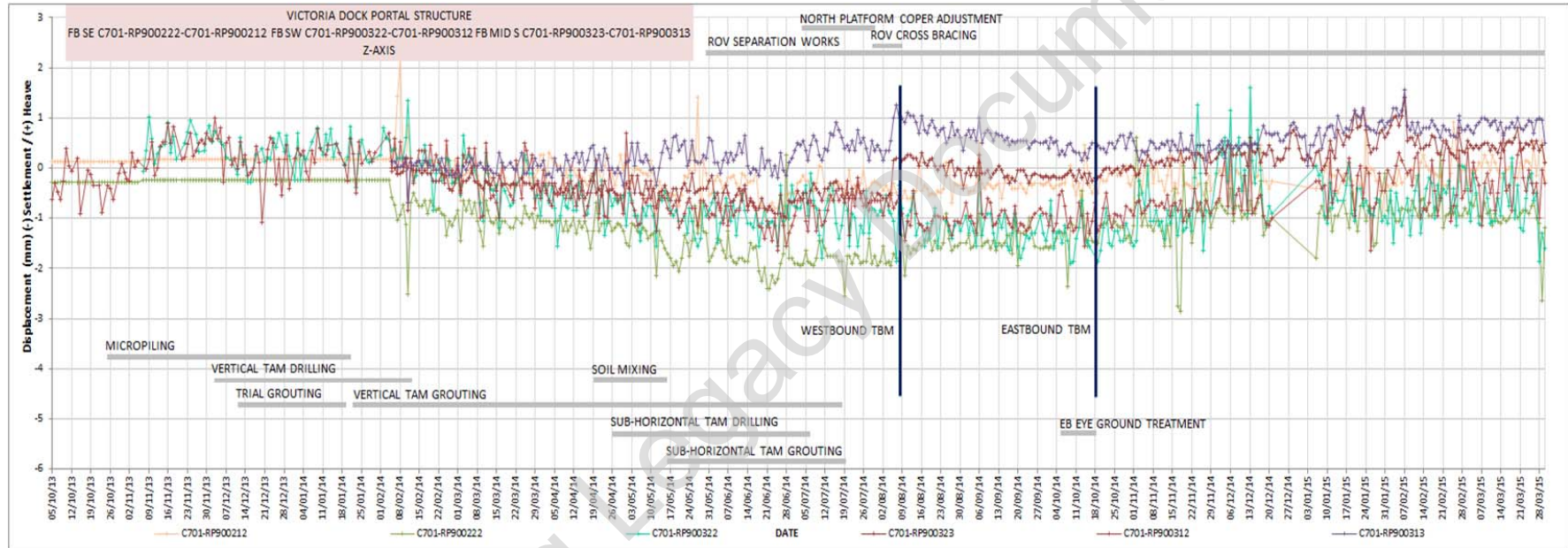


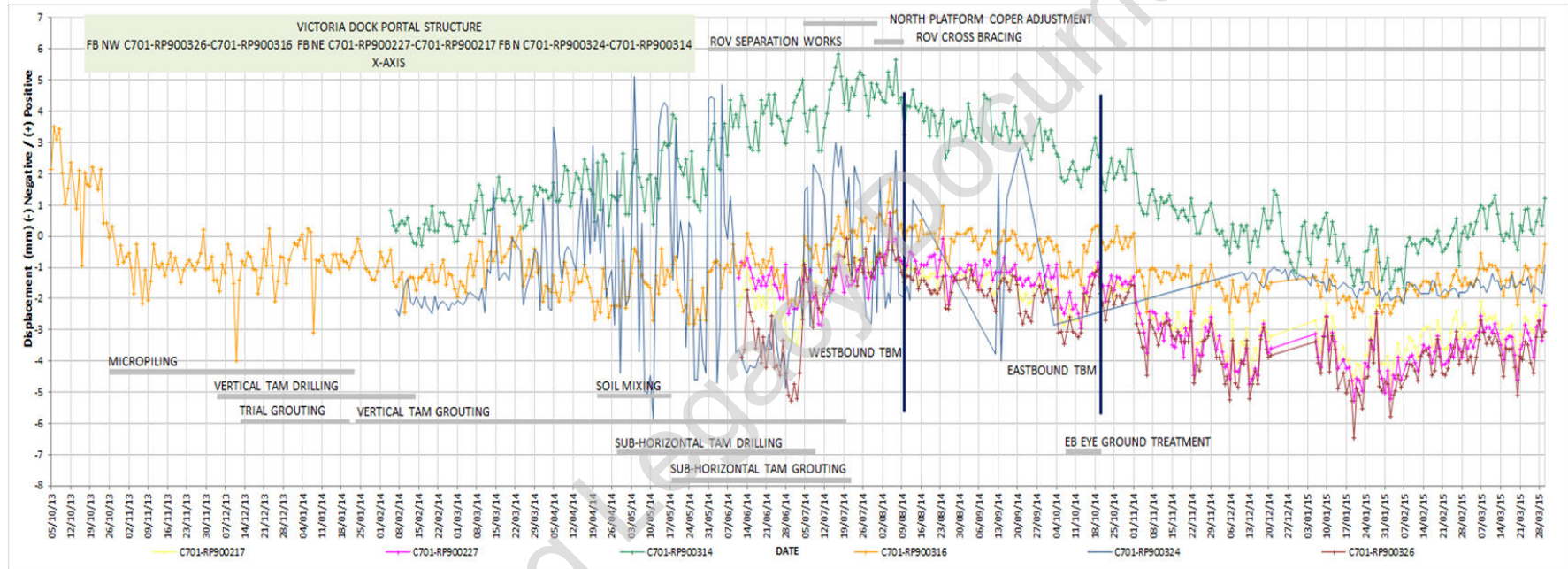


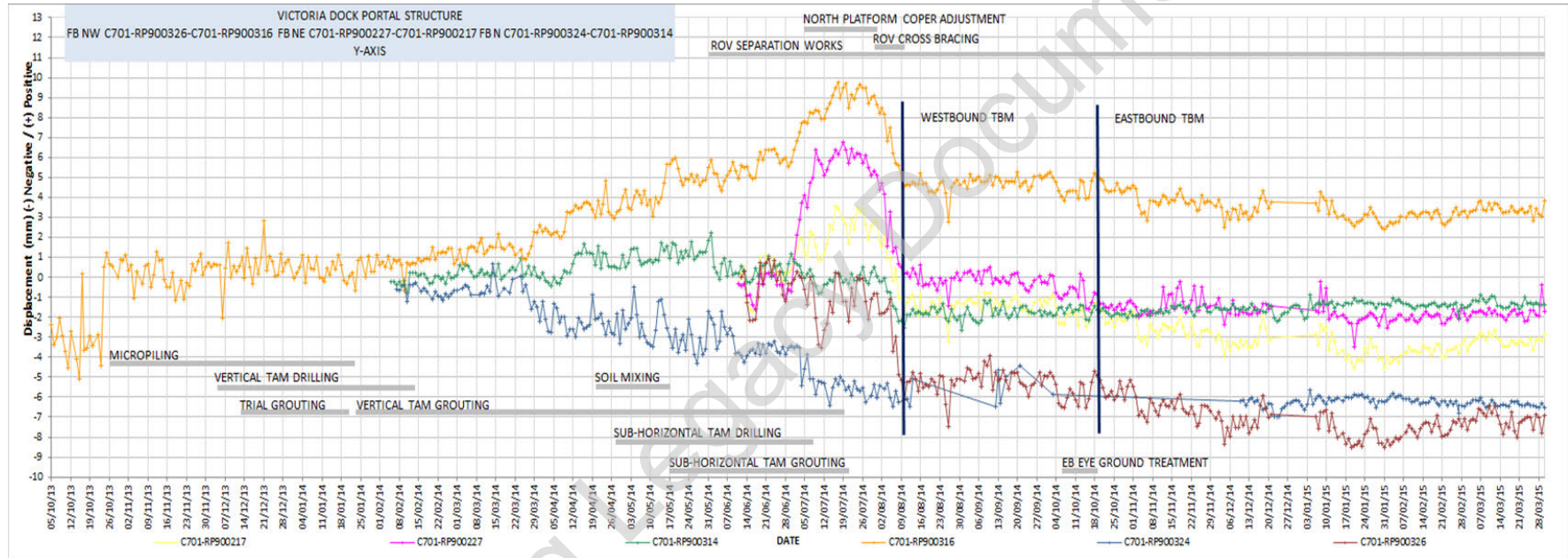
FB: SW C701-RP900322-C701-RP900312 / SE C701-RP900222-C701-RP900212 / NE C701-RP900227-C701-RP900217 / NW C701-RP900326-C701-RP900316 / S C701-RP900323-C701-RP900313 / NW C701-RP900324-C701-RP900314

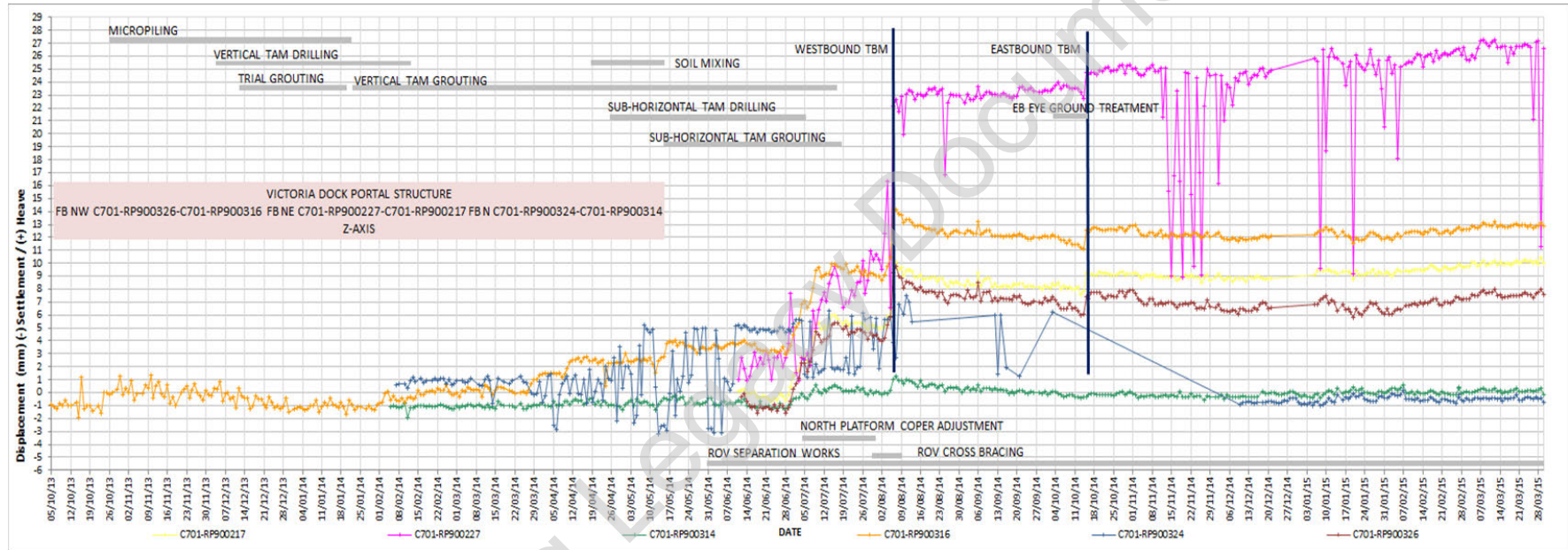




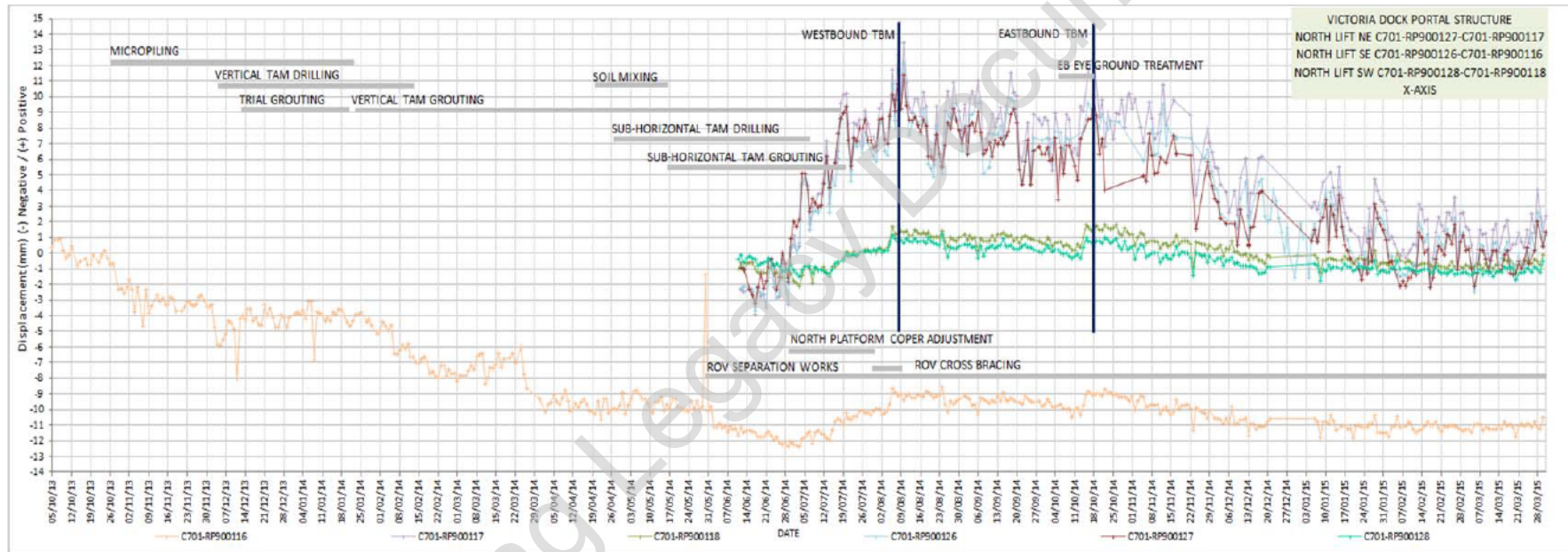


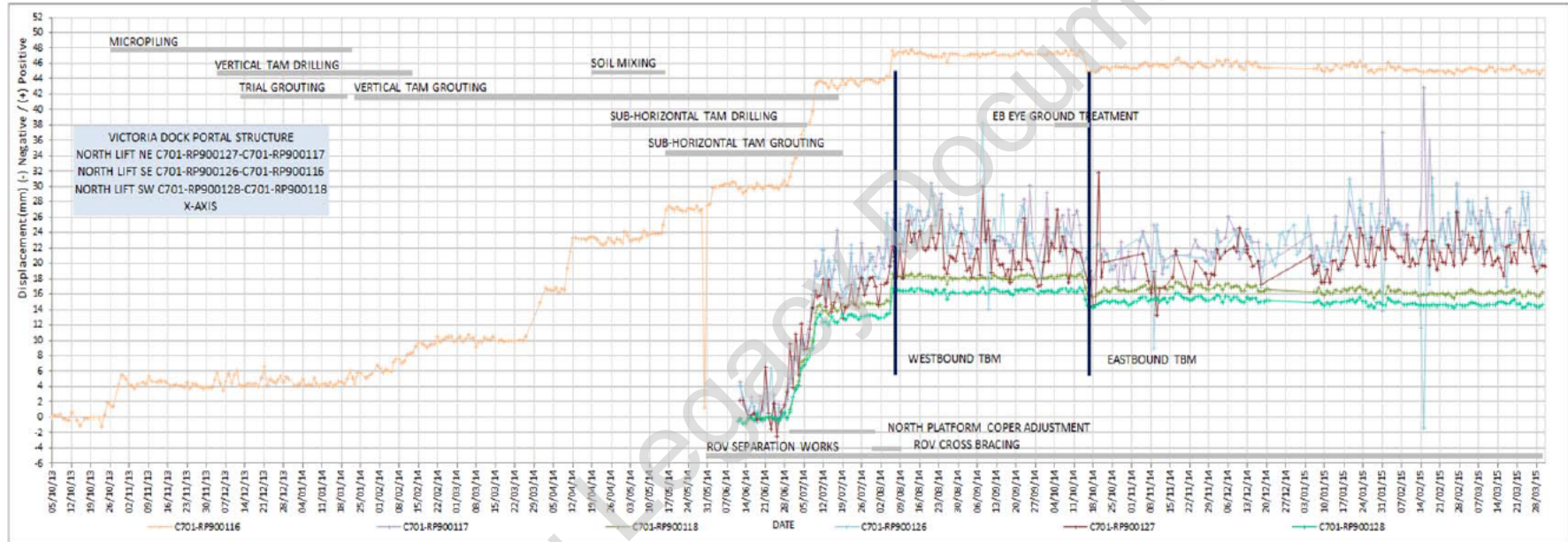




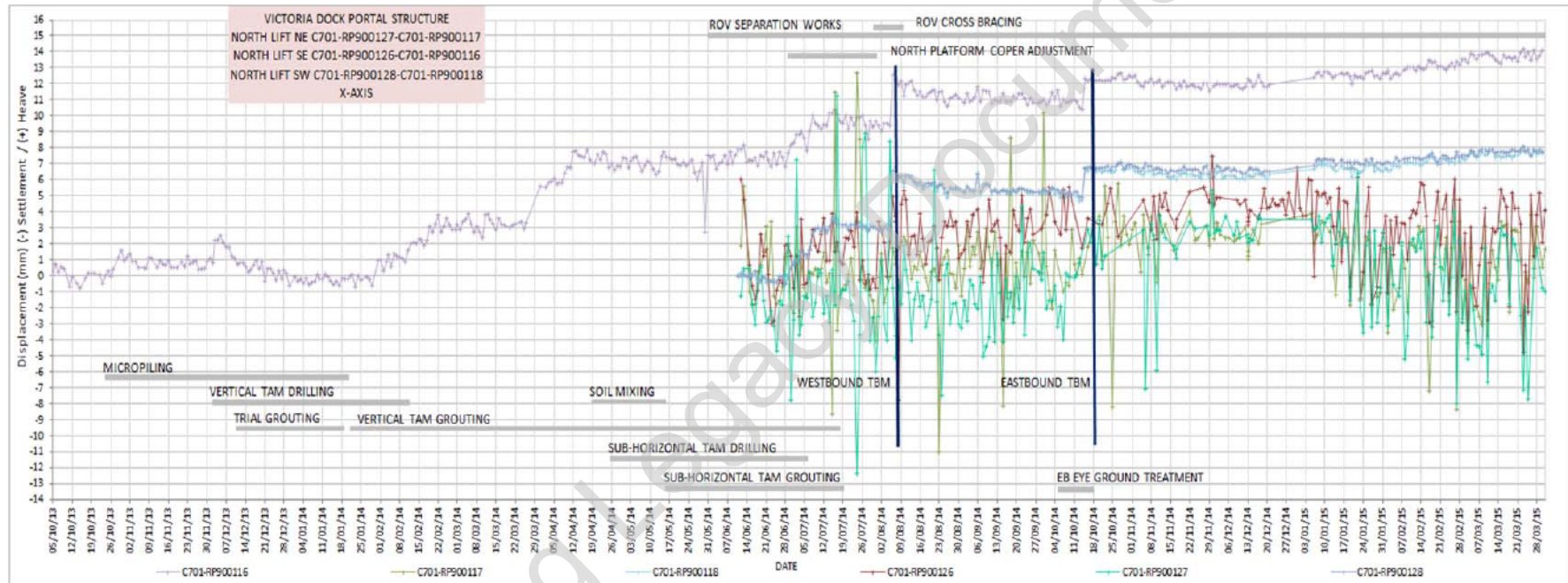


NORTH LIFT: NE LOW C701-RP900127 / HIGH C701-RP900117, SW LOW C701-RP900128 / HIGH C701-RP900118 AND SE LOW C701-RP900126 / HIGH C701-RP900116

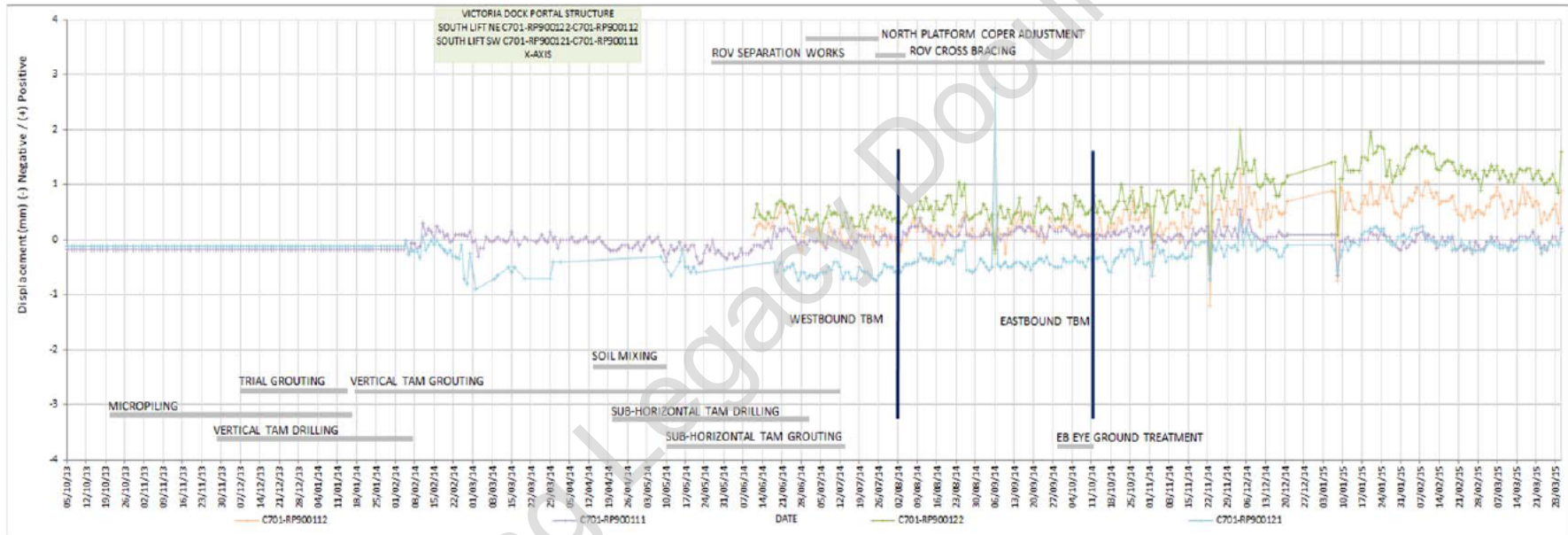


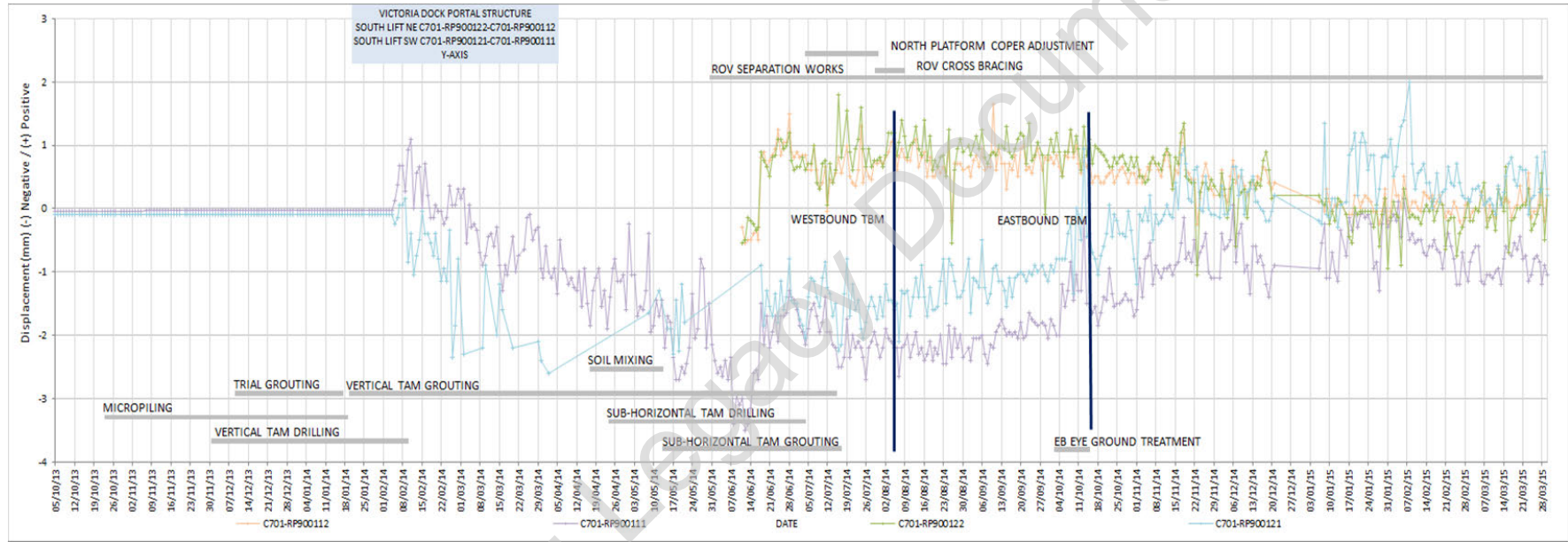


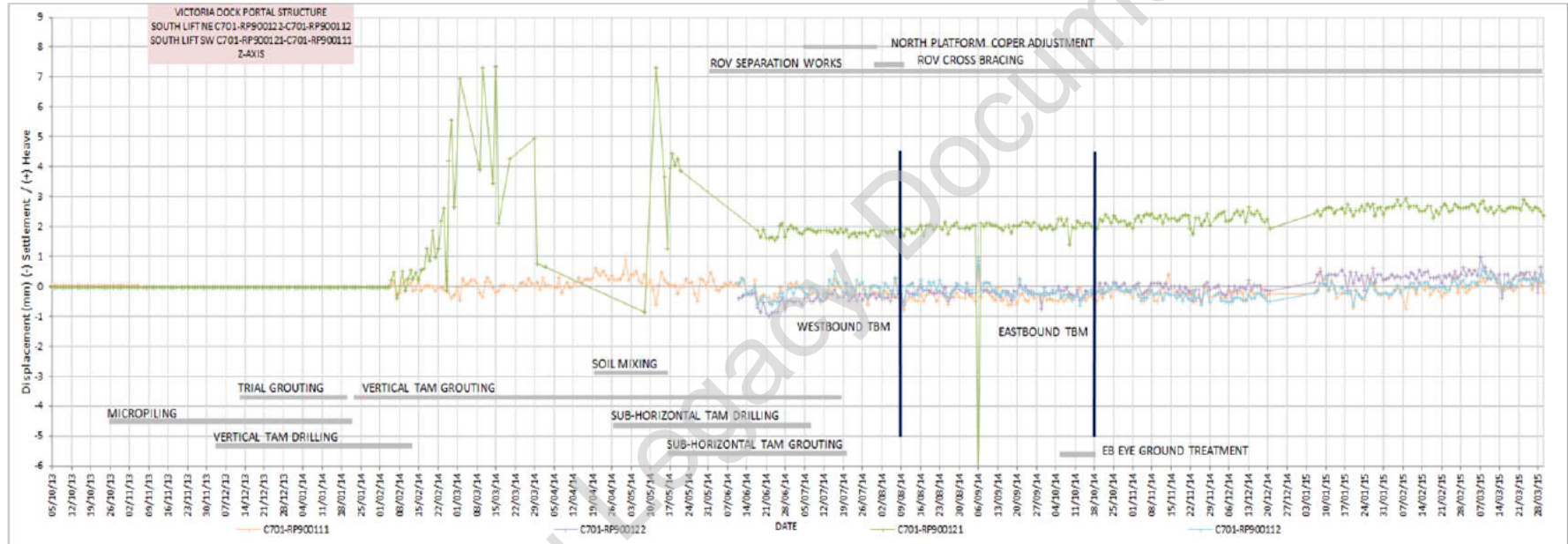
Learning from Experience Document



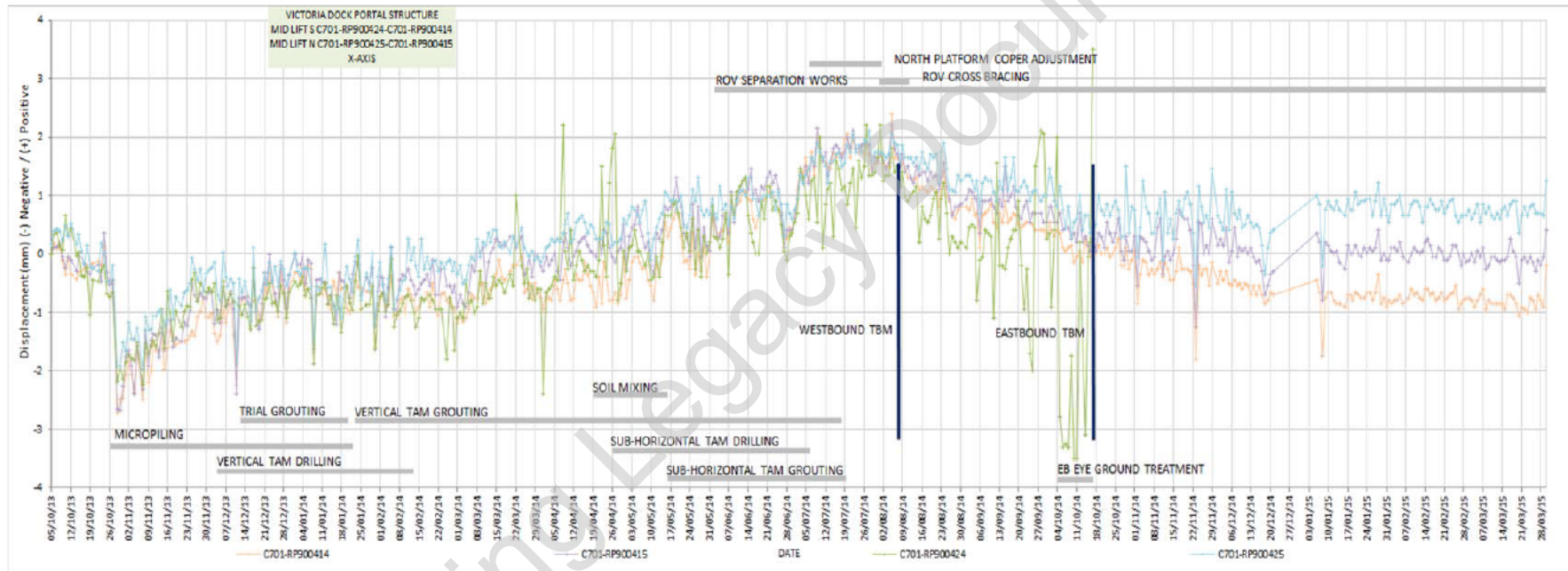
SOUTH LIFT: NE LOW C701-RP900122 / HIGH C701-RP900112 AND SW LOW C701-RP900121 / HIGH C701-RP900111

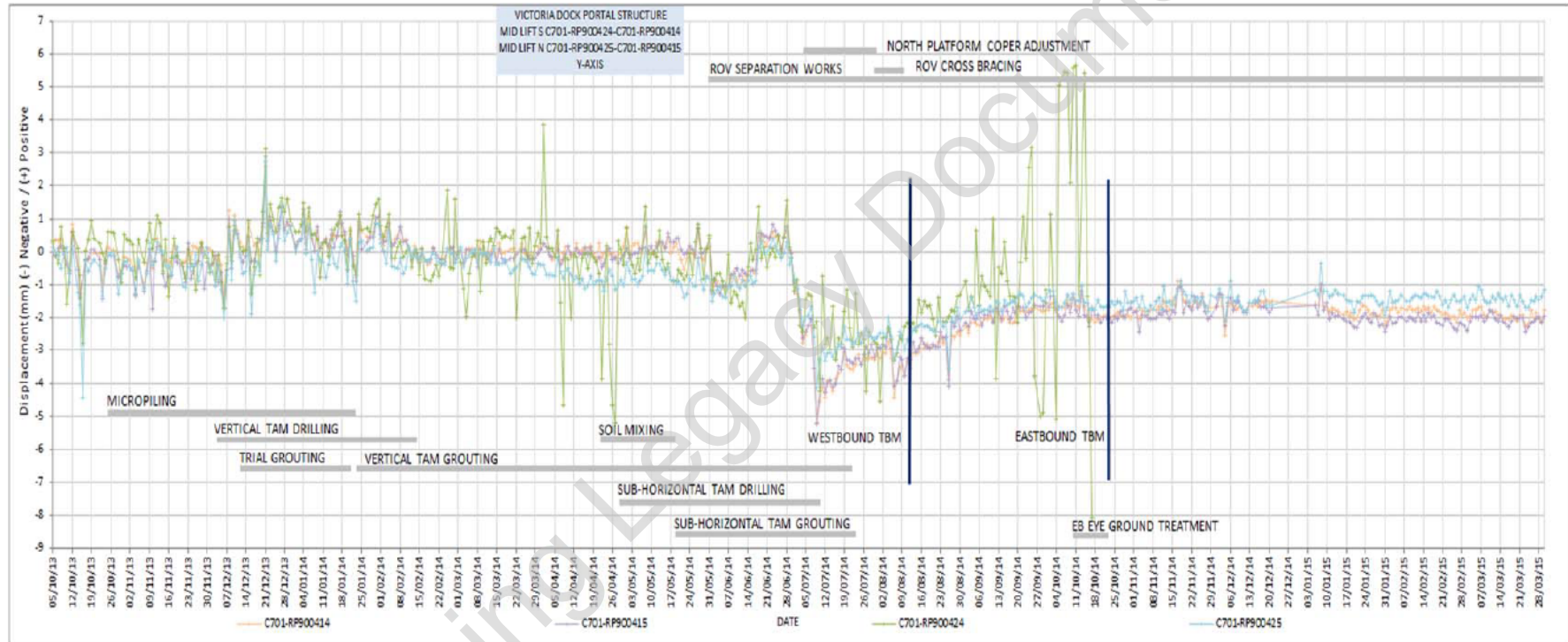


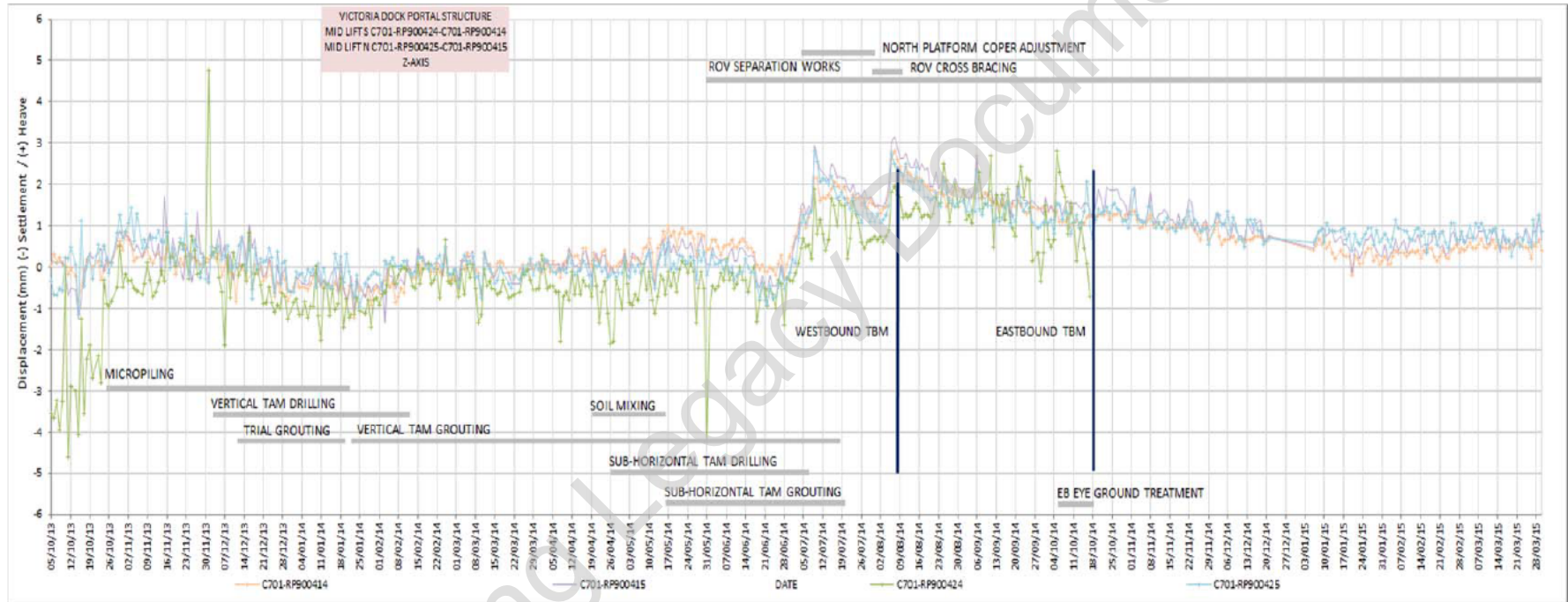




MID LIFT S LOW C701-RP900424 / HIGH C701-RP900414 AND MID LIFT N LOW C701-RP900425 / HIGH C701-RP900415







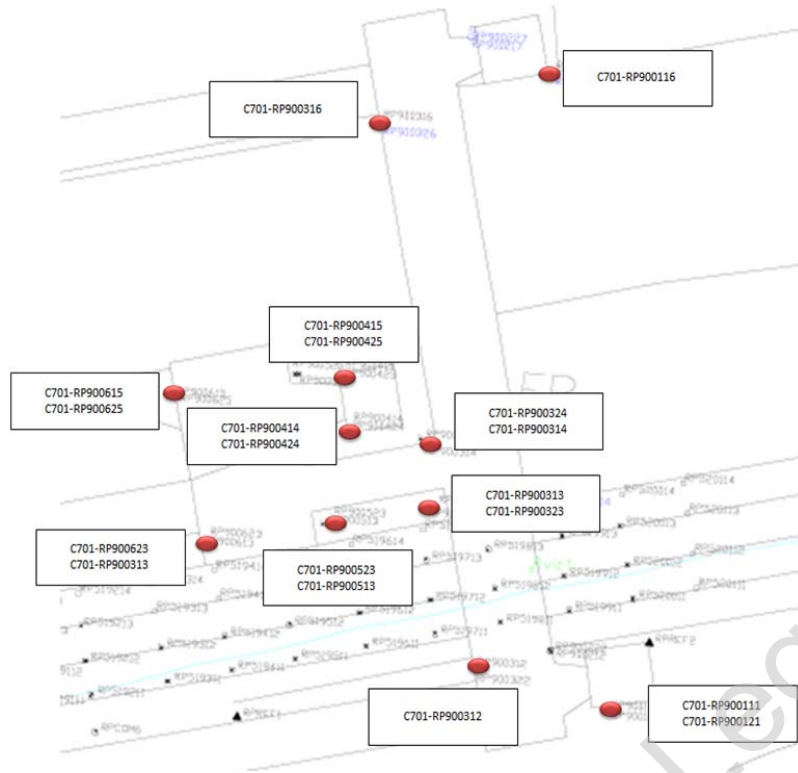
MANUAL READINGS

Learning Legacy Document

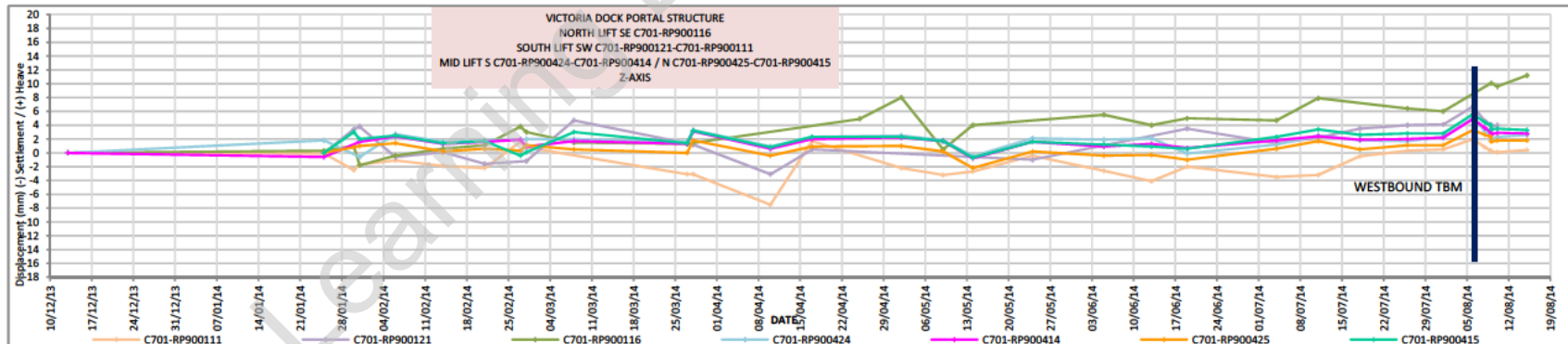
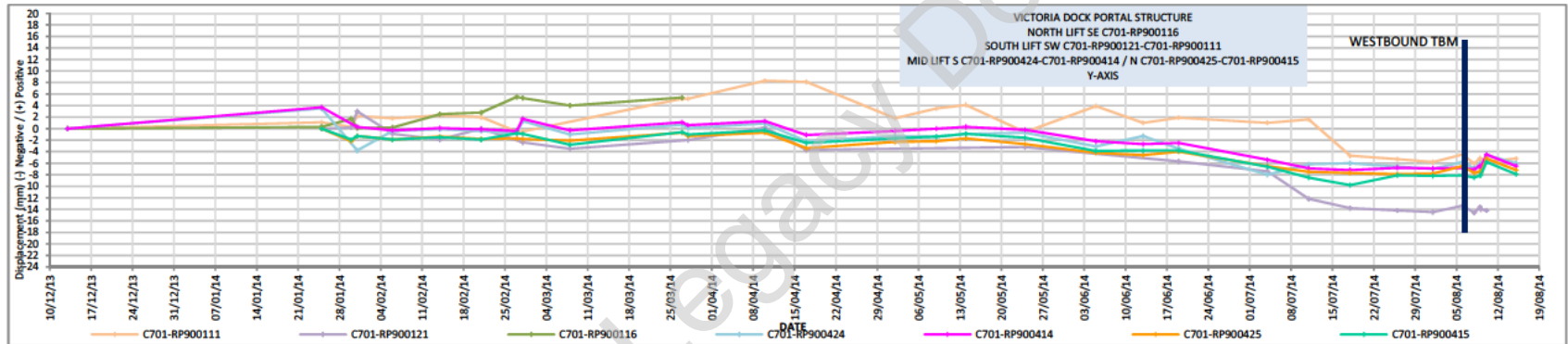
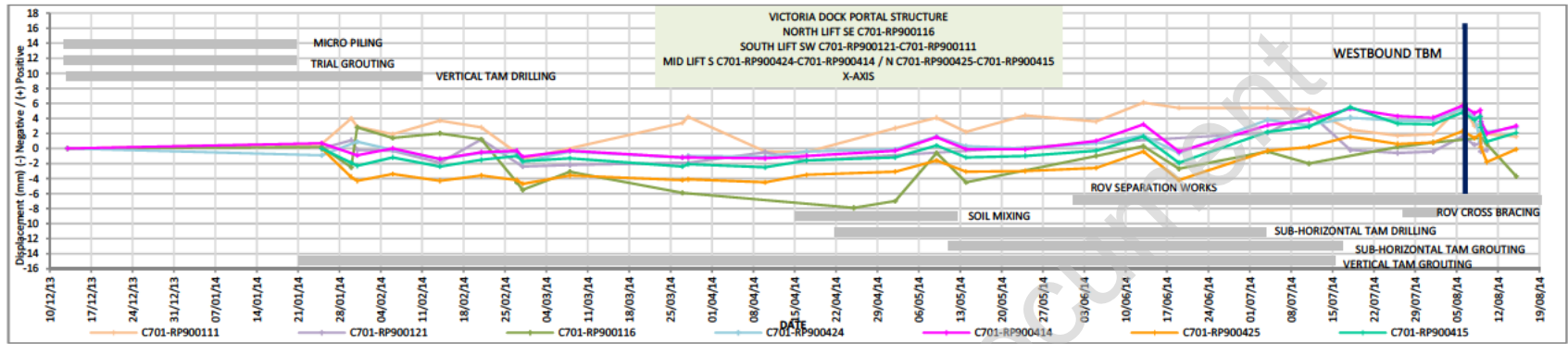
MANUAL READINGS

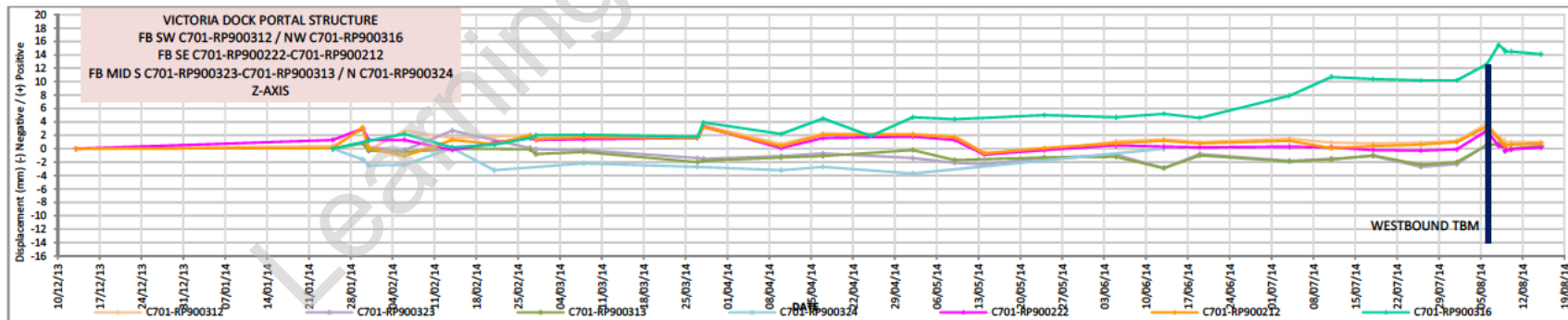
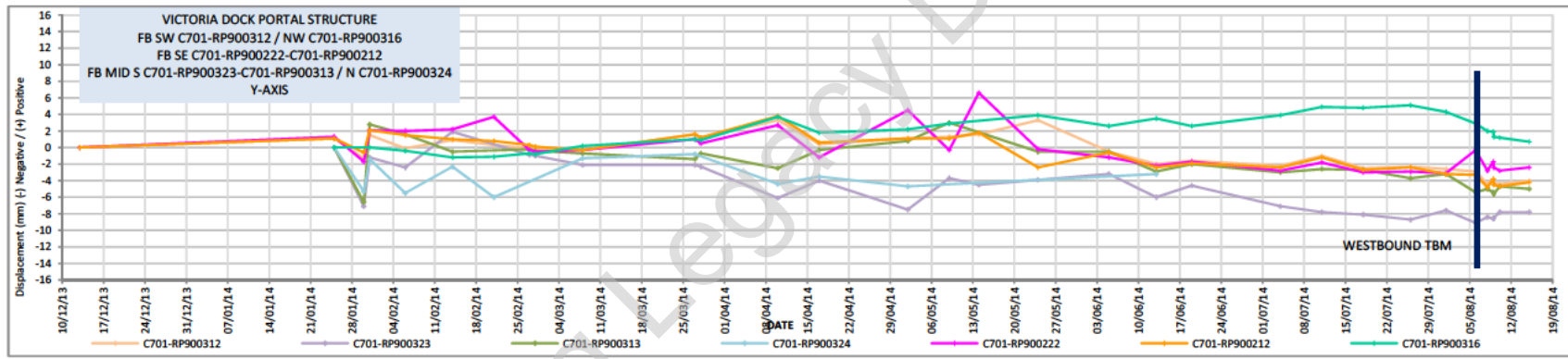
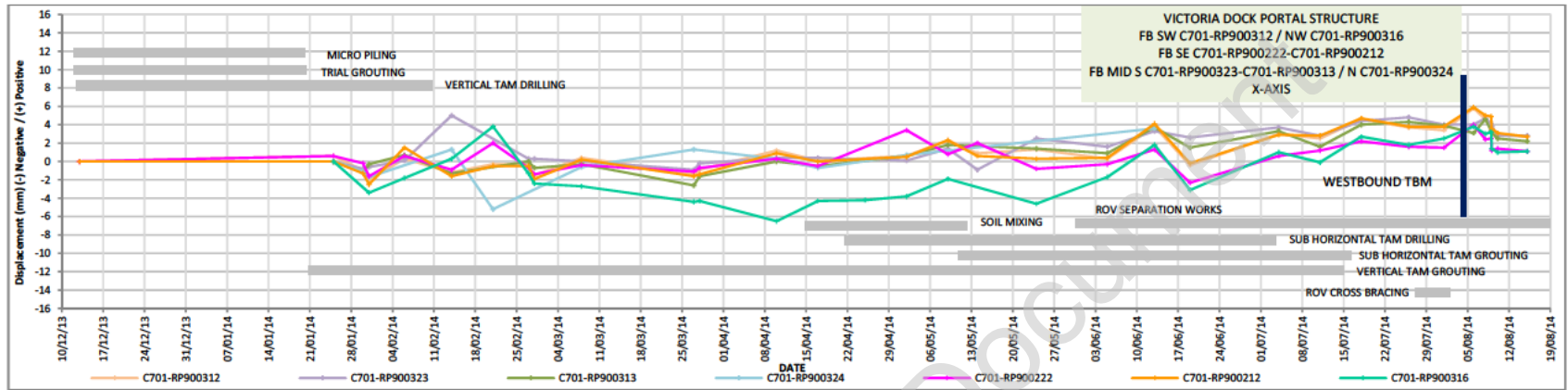
AREA	ORIENTATIO	COLUMN LOW/HIGH	SENSOR
SOUTH LIFT	NE	COLUMN LOW	C701-RP900122
SOUTH LIFT	NE	COLUMN HIGH	C701-RP900112
SOUTH LIFT	SW	COLUMN LOW	C701-RP900121
SOUTH LIFT	SW	COLUMN HIGH	C701-RP900111
NORTH LIFT	NE	COLUMN LOW	C701-RP900127
NORTH LIFT	NE	COLUMN HIGH	C701-RP900117
NORTH LIFT	SE	COLUMN LOW	C701-RP900126
NORTH LIFT	SE	COLUMN HIGH	C701-RP900116
NORTH LIFT	SW	COLUMN LOW	C701-RP900128
NORTH LIFT	SW	COLUMN HIGH	C701-RP900118
MID LIFT	S	COLUMN LOW	C701-RP900424
MID LIFT	S	COLUMN HIGH	C701-RP900414
MID LIFT	N	COLUMN LOW	C701-RP900425
MID LIFT	N	COLUMN HIGH	C701-RP900415
HIGH LEVEL CONCOURSE (HLC)	SE	COLUMN LOW	C701-RP900523
HIGH LEVEL CONCOURSE (HLC)	SE	COLUMN HIGH	C701-RP900513
HIGH LEVEL CONCOURSE (HLC)	NE	COLUMN LOW	C701-RP900525
HIGH LEVEL CONCOURSE (HLC)	NE	COLUMN HIGH	C701-RP900515
HIGH LEVEL CONCOURSE (HLC)	SW	COLUMN LOW	C701-RP900623
HIGH LEVEL CONCOURSE (HLC))	SW	COLUMN HIGH	C701-RP900613
HIGH LEVEL CONCOURSE (HLC)	NW	COLUMN LOW	C701-RP900625
HIGH LEVEL CONCOURSE (HLC)	NW	COLUMN HIGH	C701-RP900615
FOOT BRIDGE (FB)	NW	COLUMN LOW	C701-RP900326
FOOT BRIDGE (FB)	NW	COLUMN HIGH	C701-RP900316

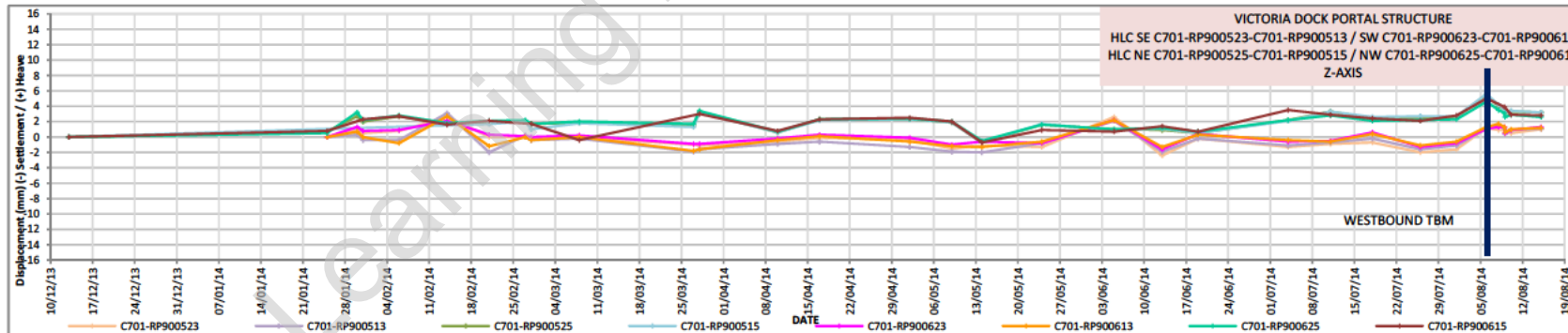
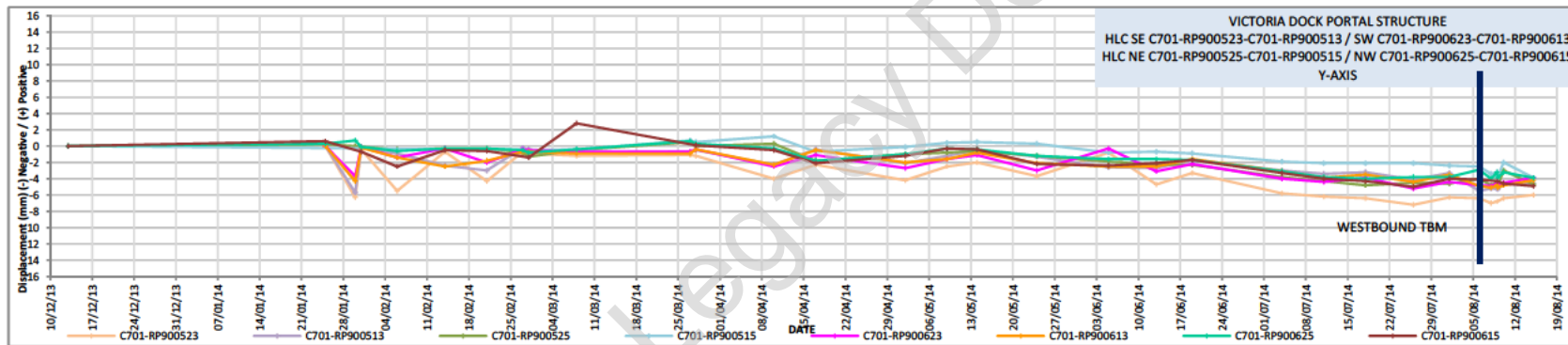
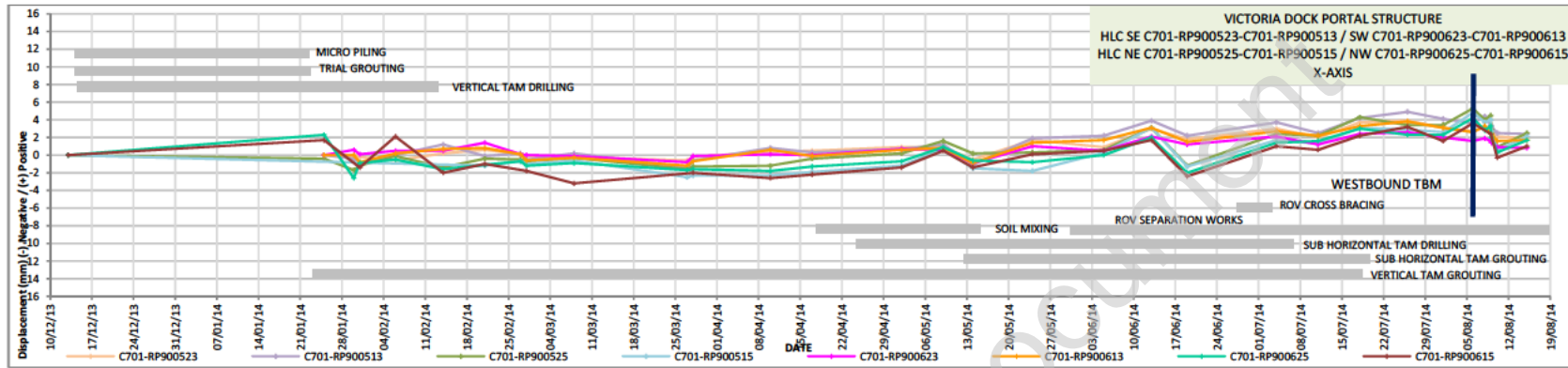
AREA	ORIENTATIO	COLUMN LOW/HIGH	SENSOR
FOOT BRIDGE (FB)	NE	COLUMN LOW	C701-RP900227
FOOT BRIDGE (FB)	NE	COLUMN HIGH	C701-RP900217
FOOT BRIDGE MID (FB MID)	S	COLUMN LOW	C701-RP900323
FOOT BRIDGE MID (FB MID)	S	COLUMN HIGH	C701-RP900313
FOOT BRIDGE MID (FB MID)	N	COLUMN LOW	C701-RP900324
FOOT BRIDGE MID (FB MID)	N	COLUMN HIGH	C701-RP900314
FOOT BRIDGE (FB)	SW	COLUMN LOW	C701-RP900322
FOOT BRIDGE (FB)	SW	COLUMN HIGH	C701-RP900312
FOOT BRIDGE (FB)	SE	COLUMN LOW	C701-RP900222
FOOT BRIDGE (FB)	SE	COLUMN HIGH	C701-RP900212



Learning Legacy Document





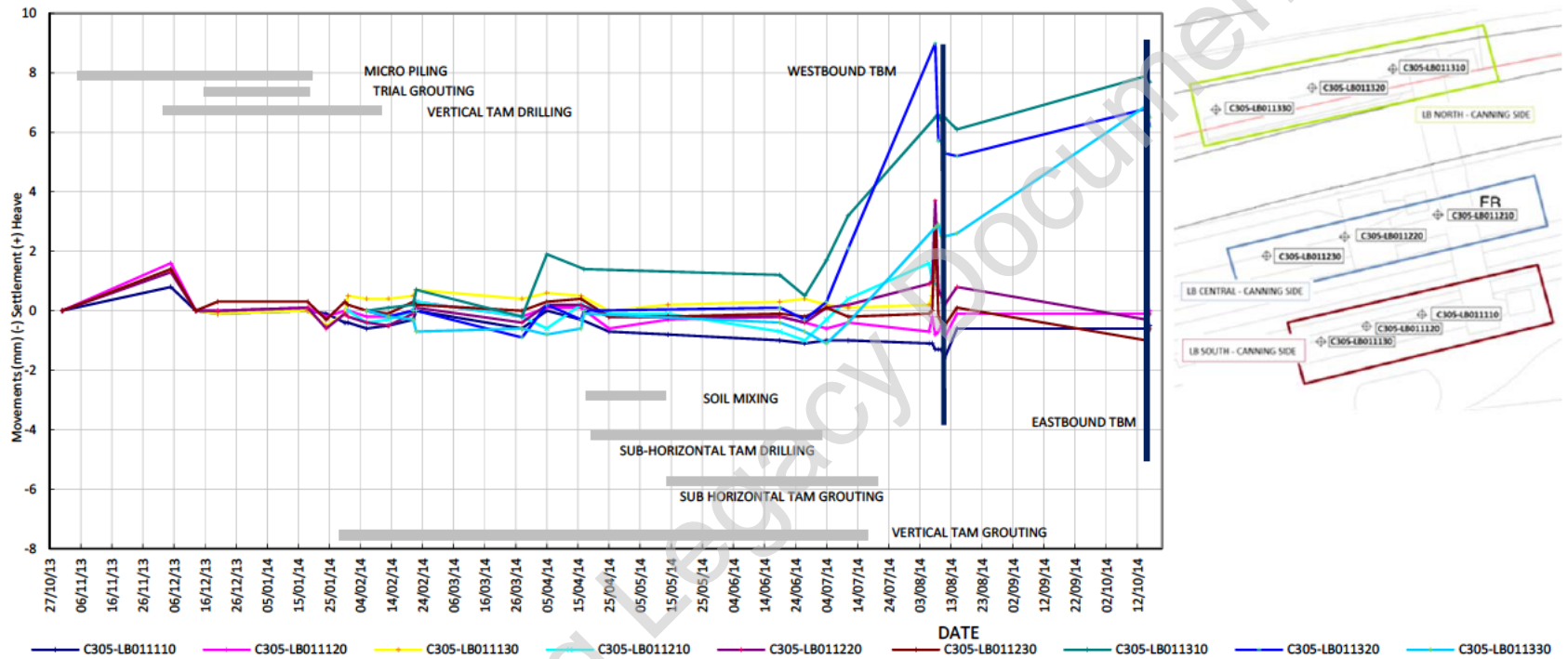


Learning Legacy Document

Appendix 6: ROYAL VICTORIA STATION. C305 MONITORING

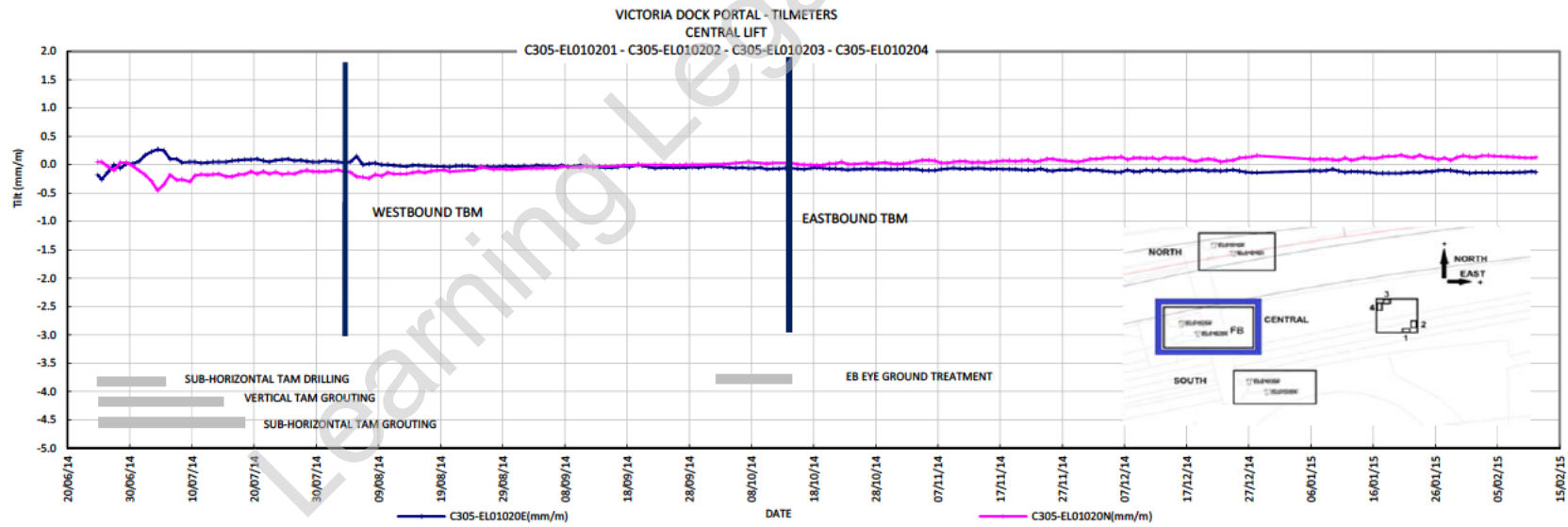
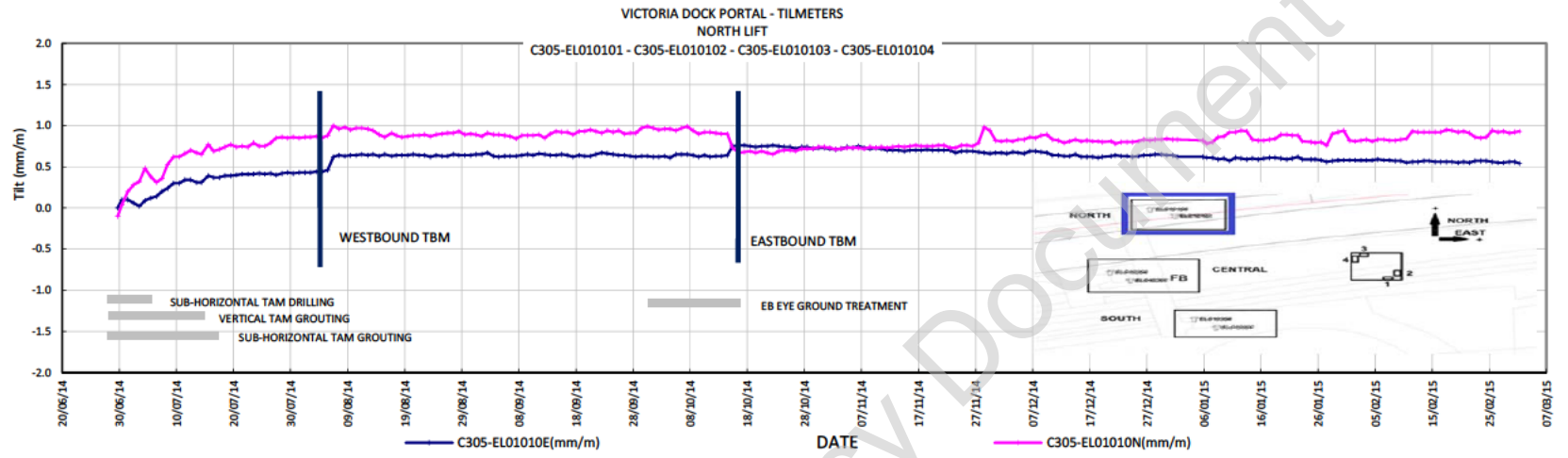
SOCKETS VICTORIA DOCK PORTAL

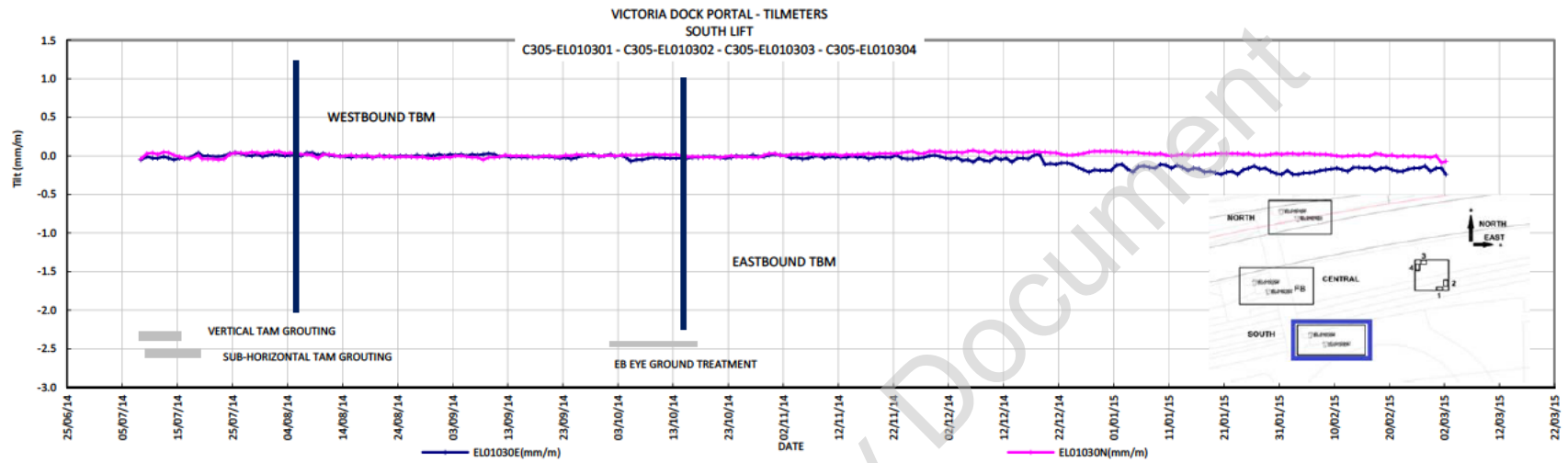
ROYAL VICTORIA SOCKETS



Learning Library Document

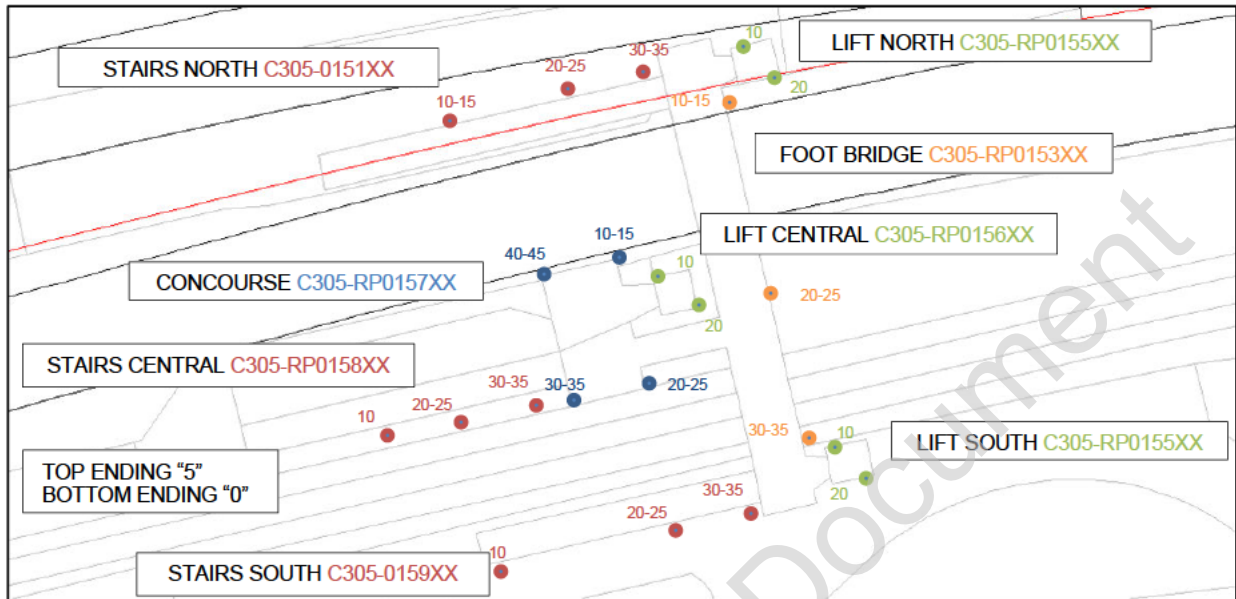
TILTMETERS VICTORIA DOCK PORTAL



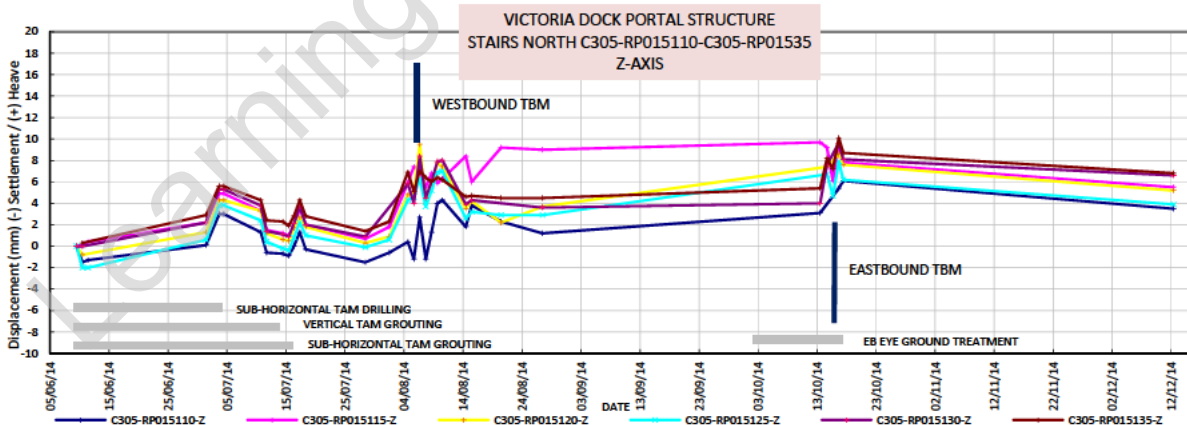
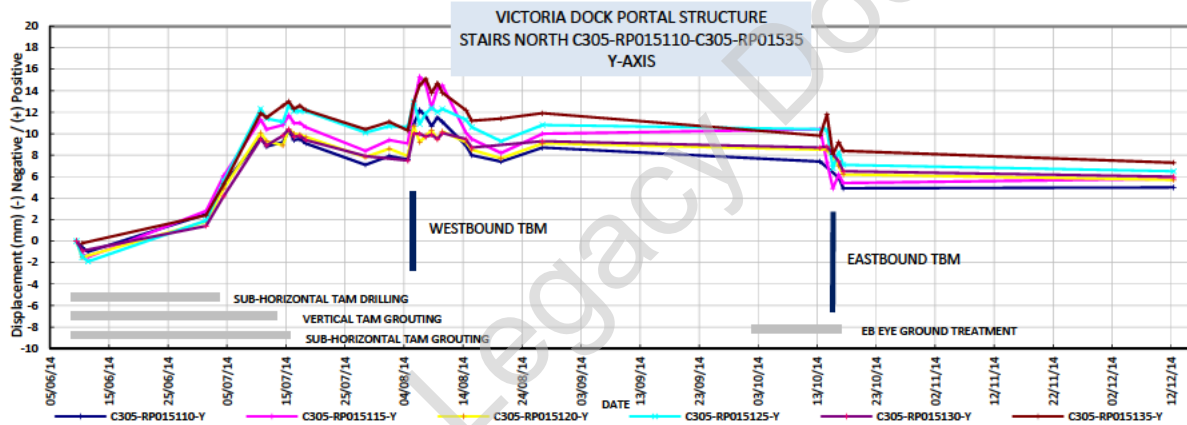
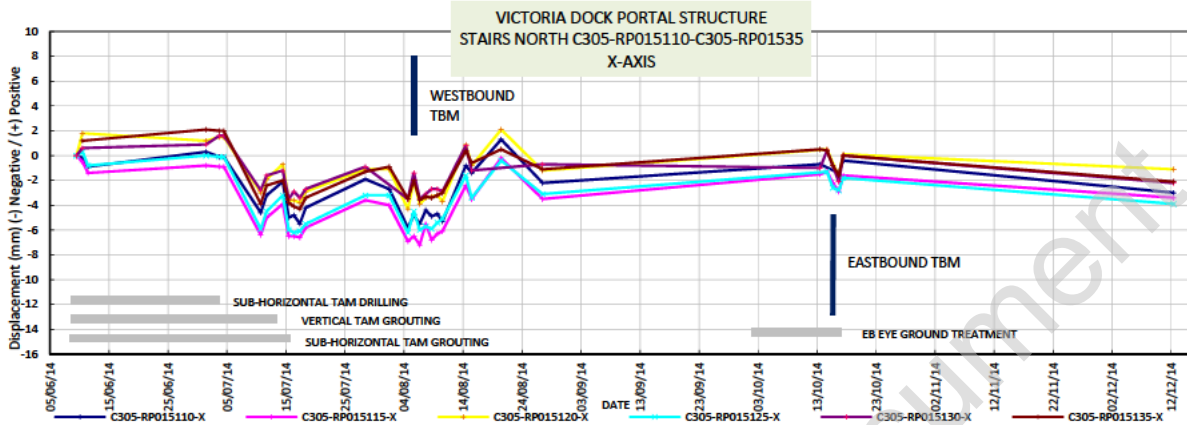


Learning Legacy Document

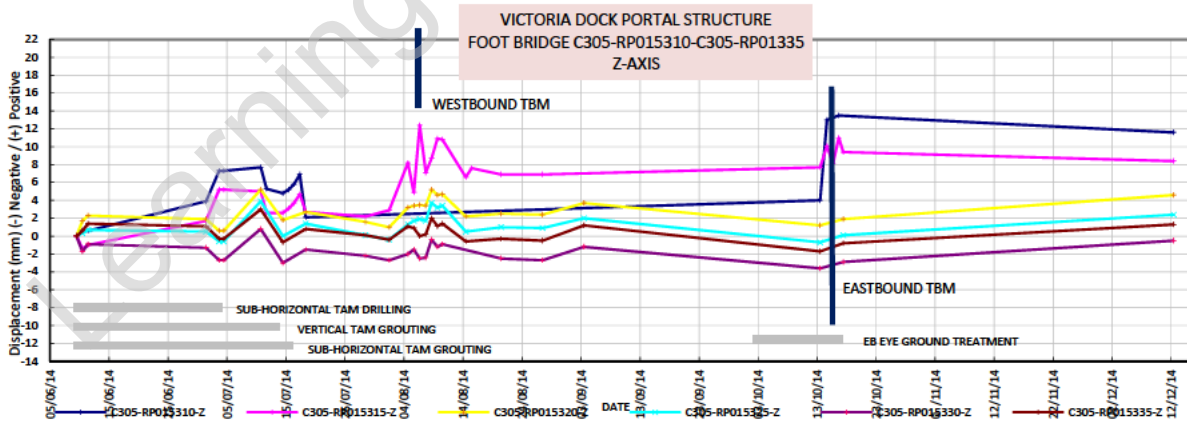
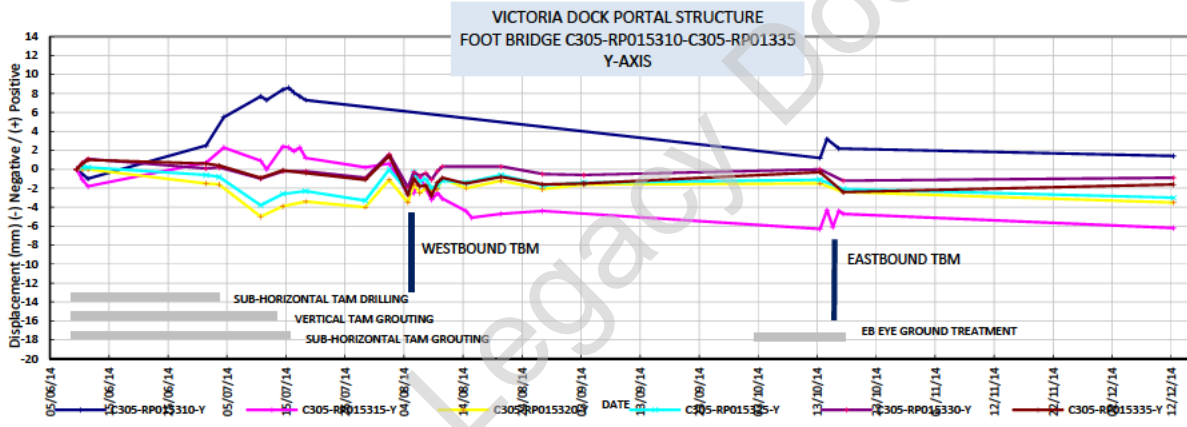
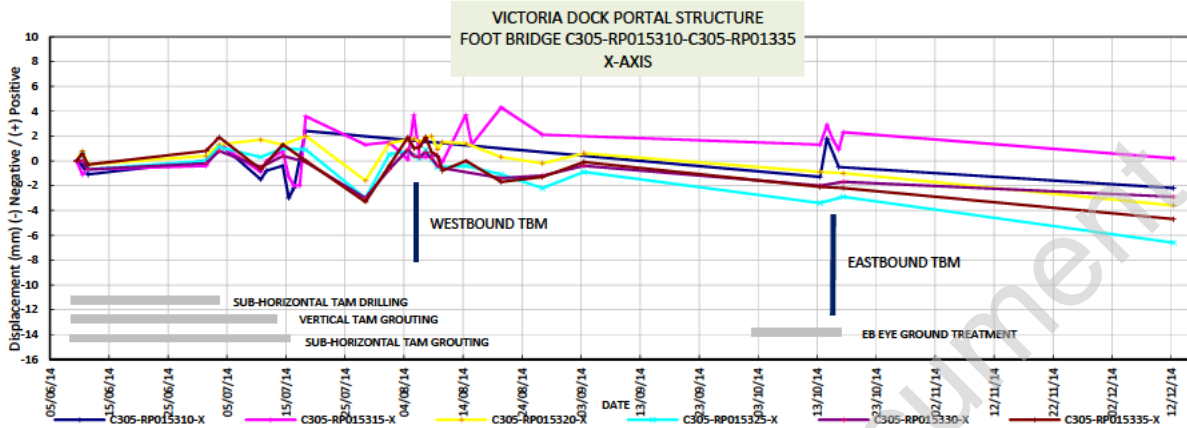
PRISMS STRUCTURE DOCK PORTAL



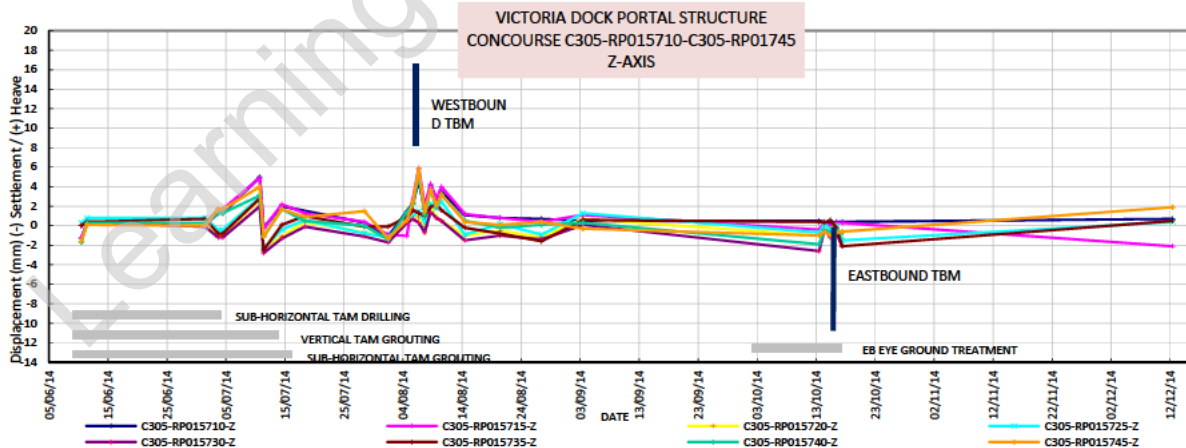
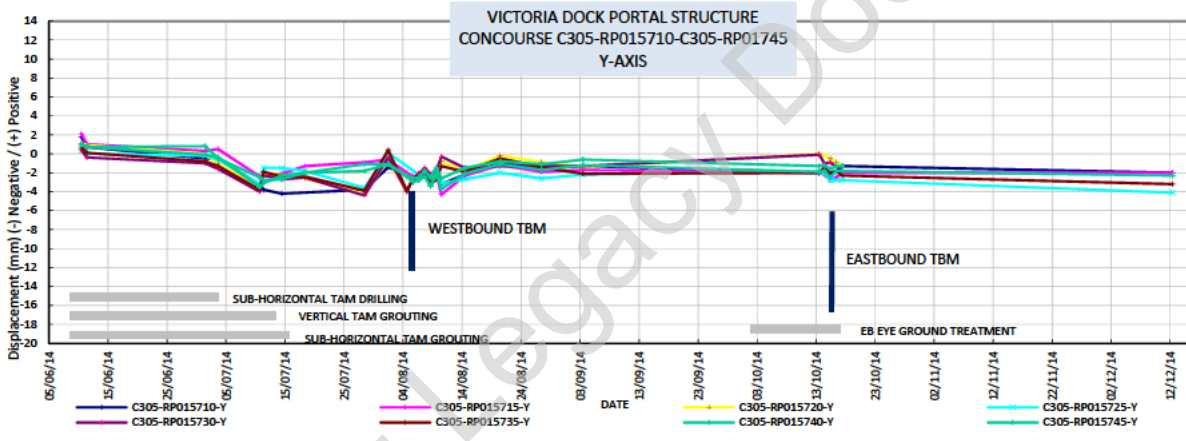
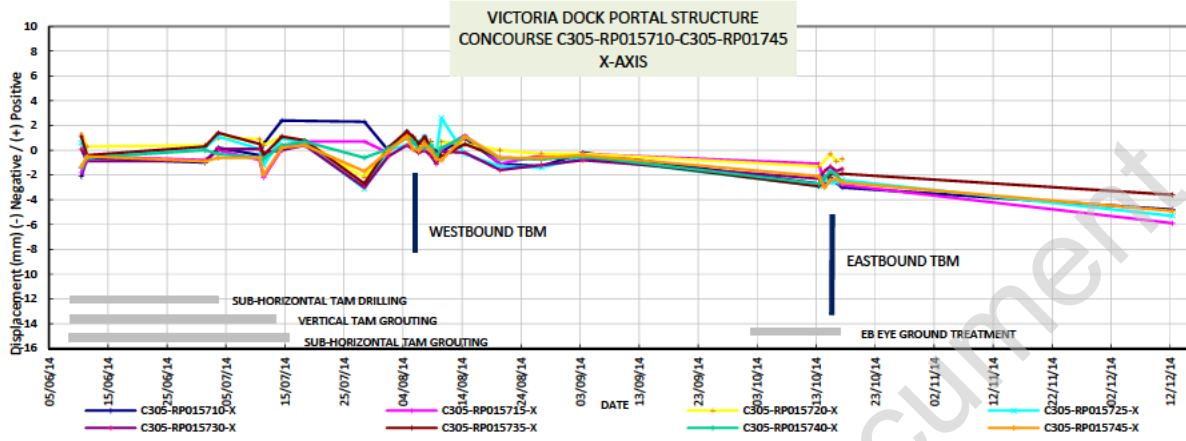
STAIRS NORTH



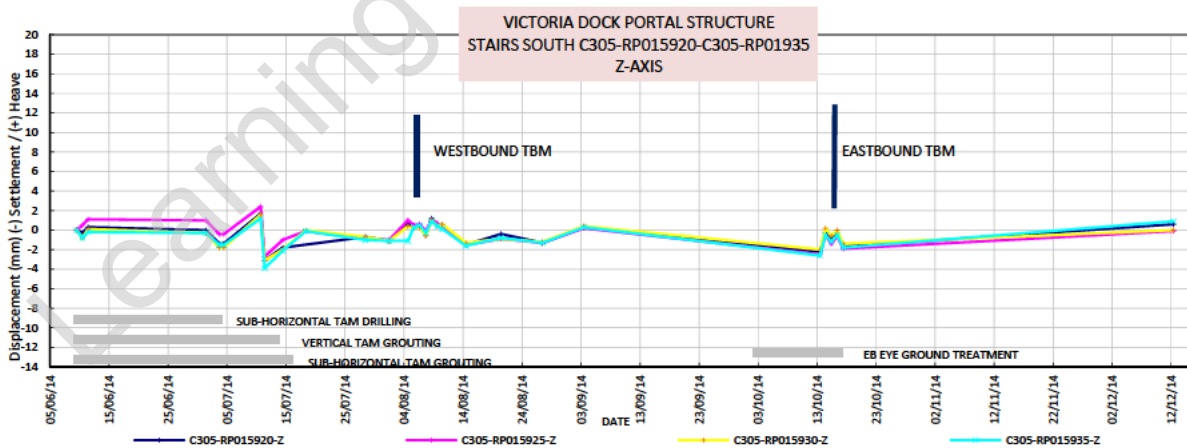
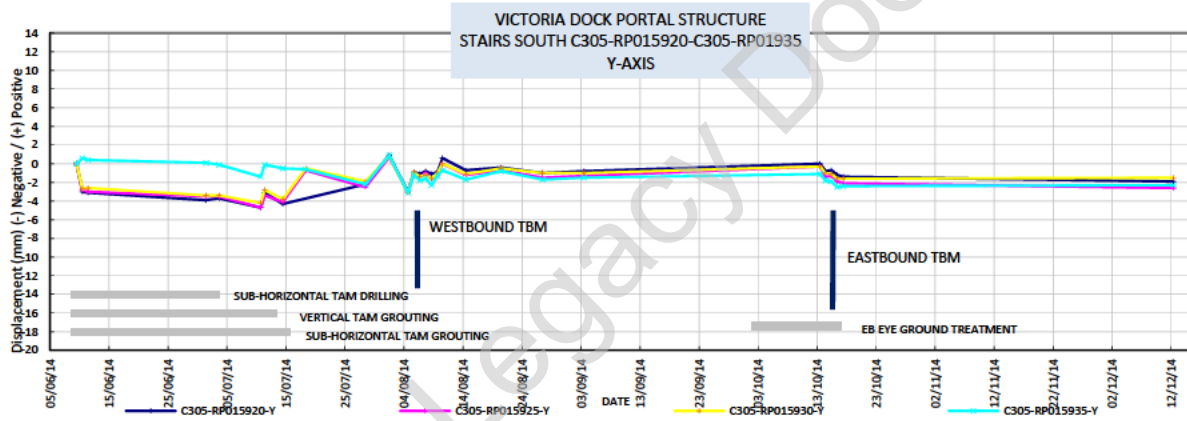
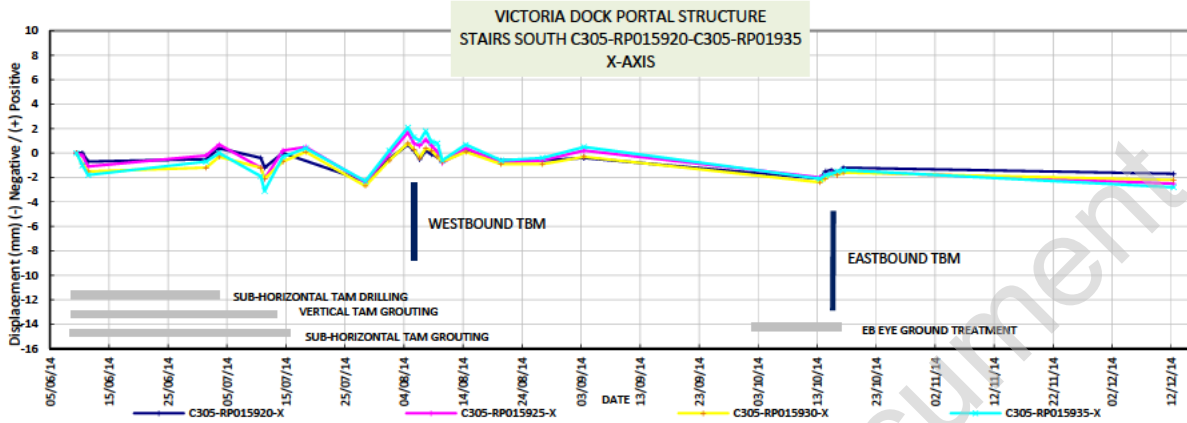
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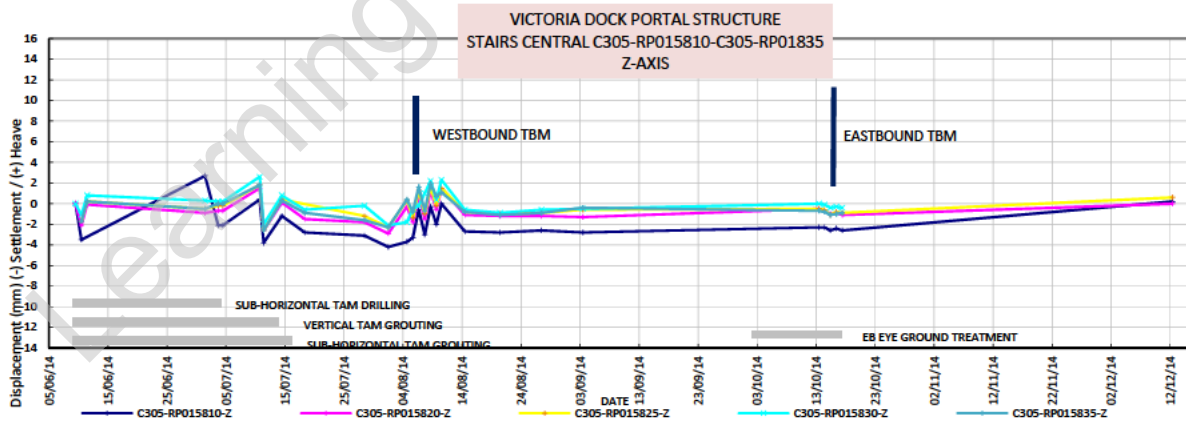
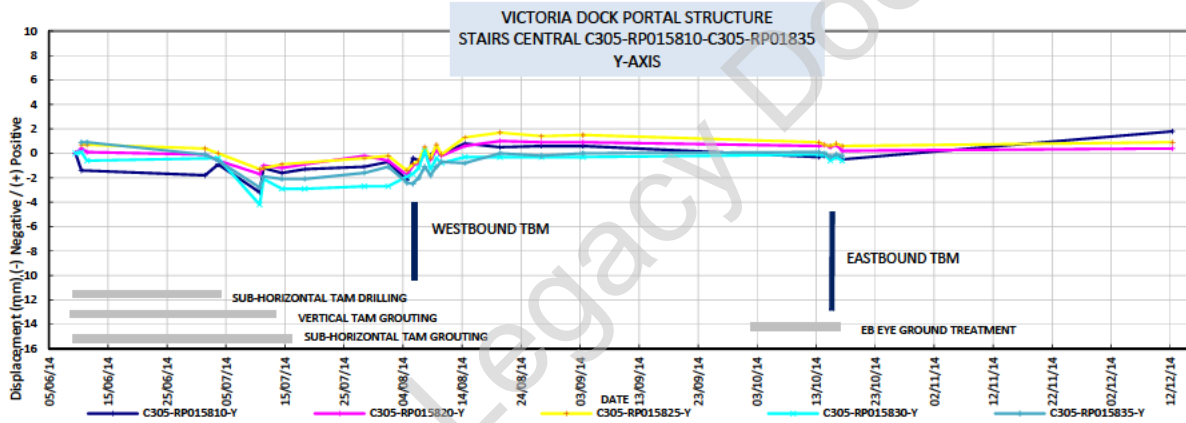
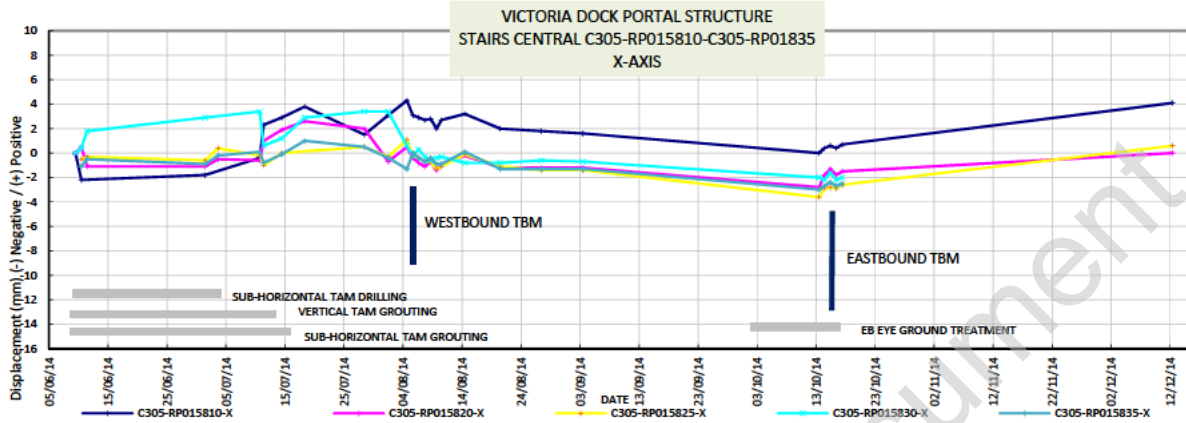
CONCOURSE



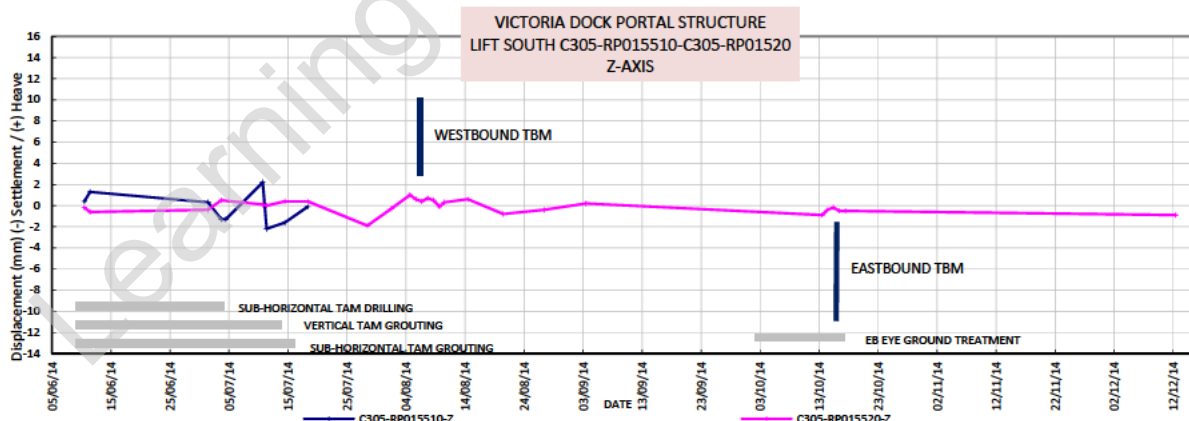
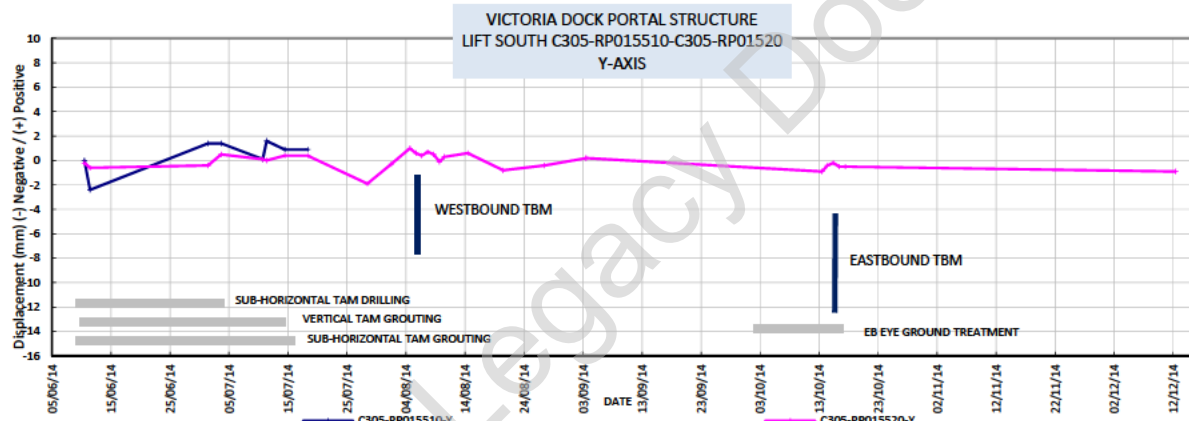
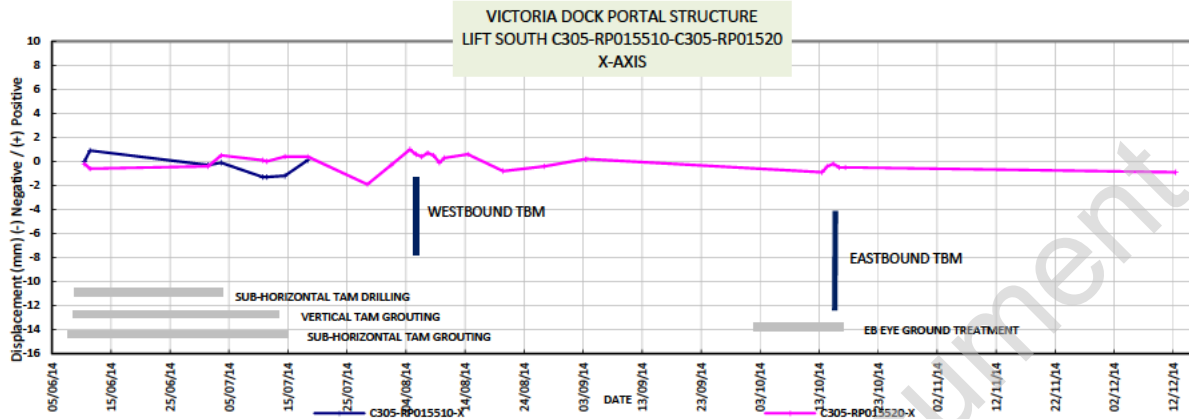
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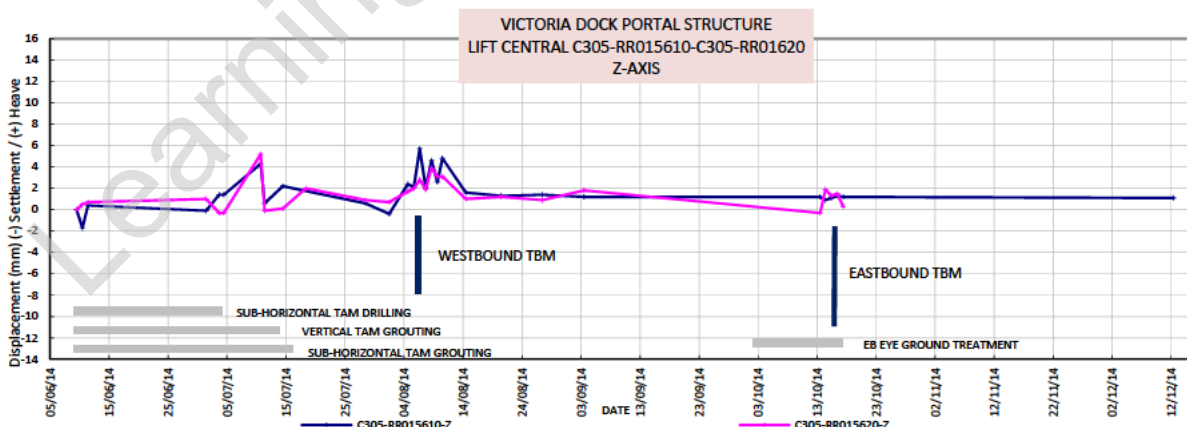
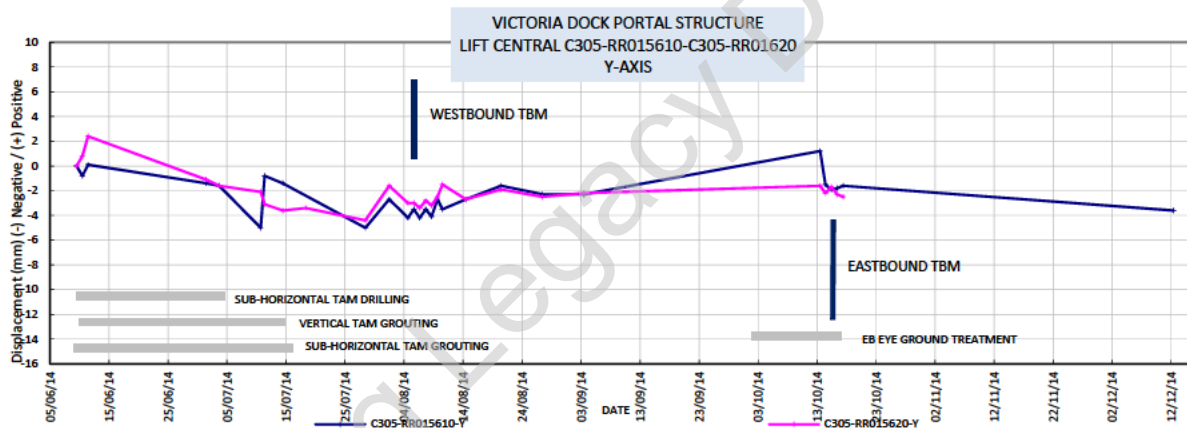
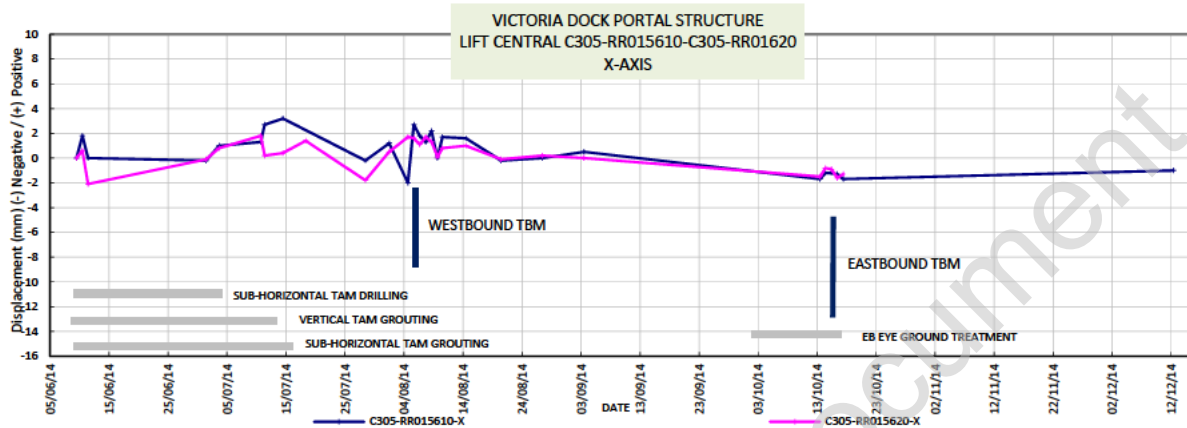
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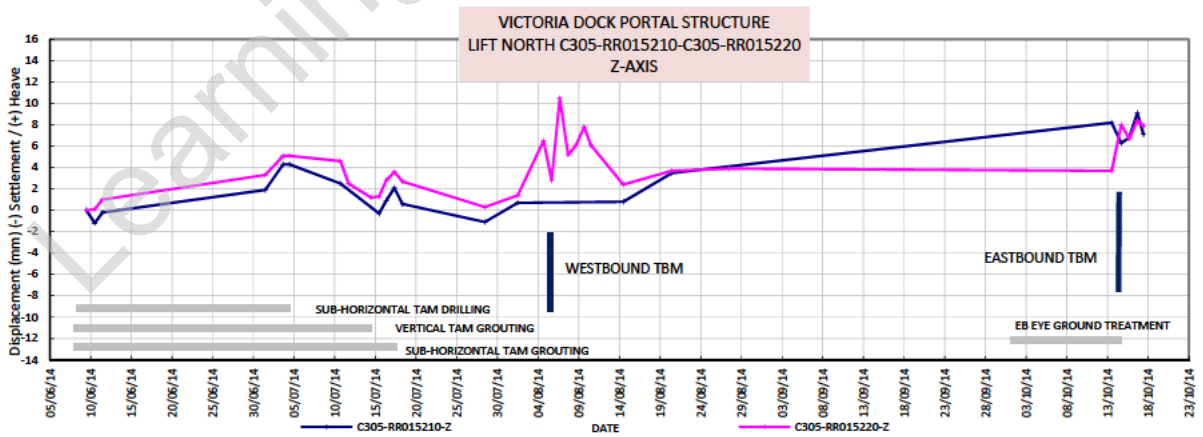
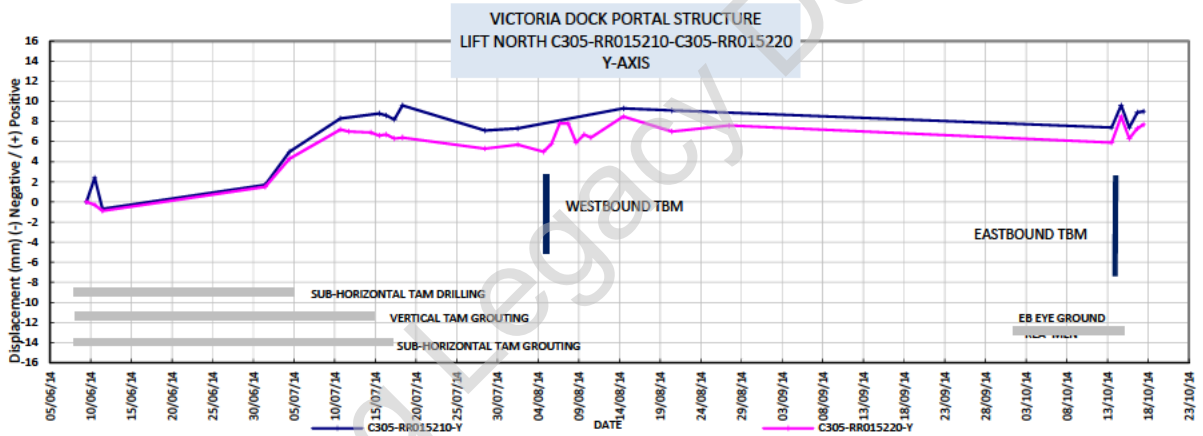
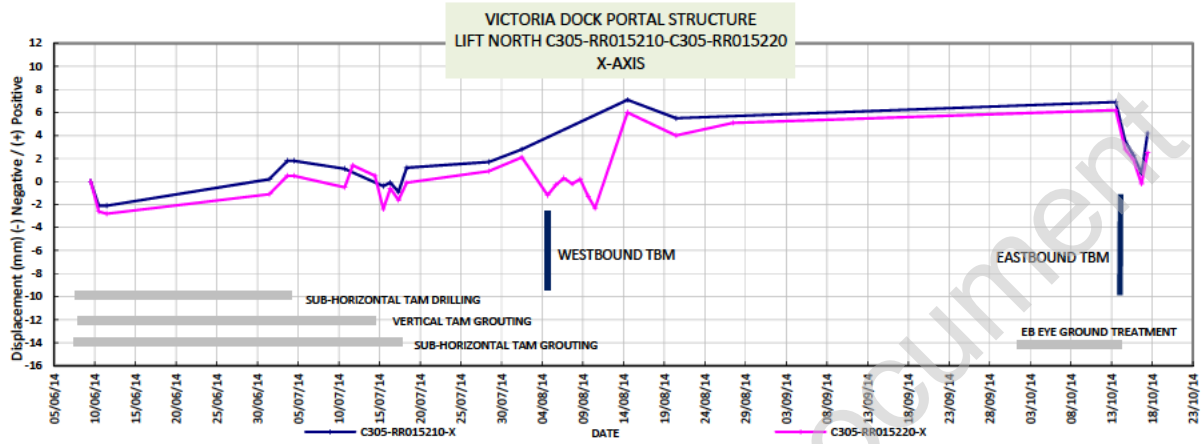
LIFT SOUTH



LIFT CENTRAL

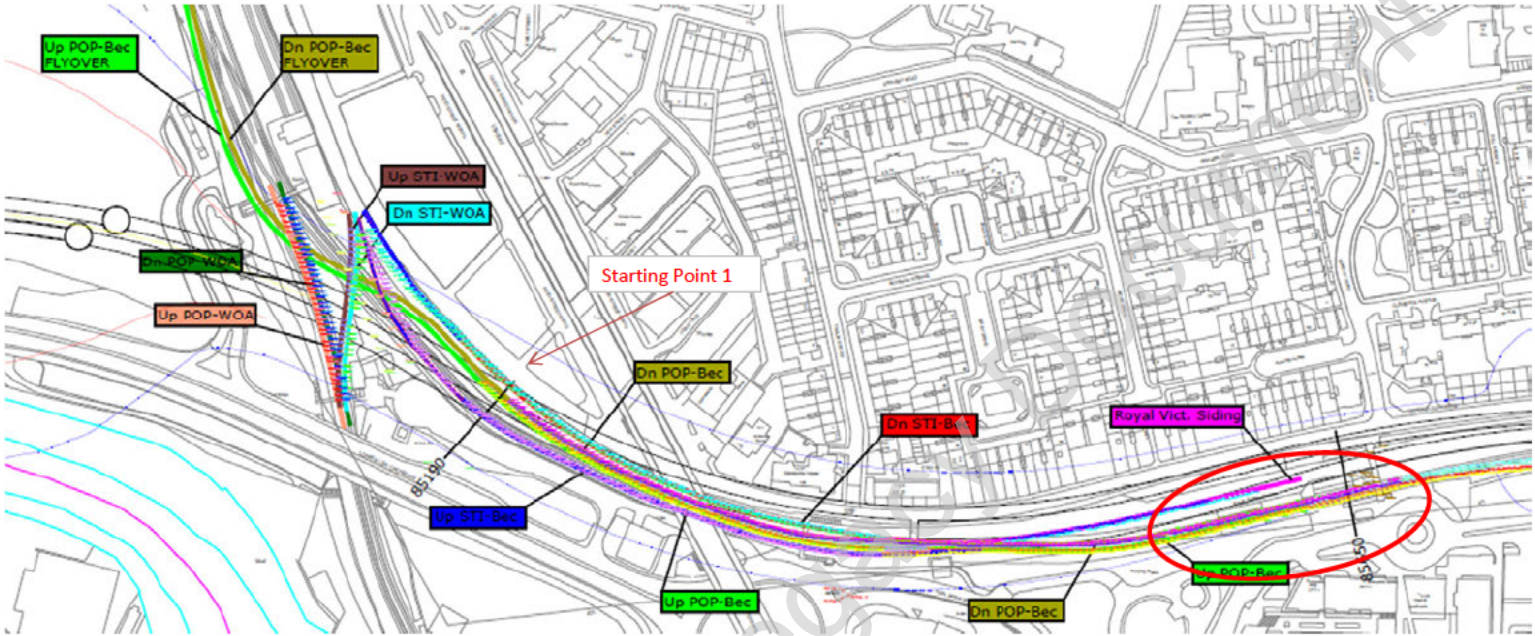


LIFT NORTH



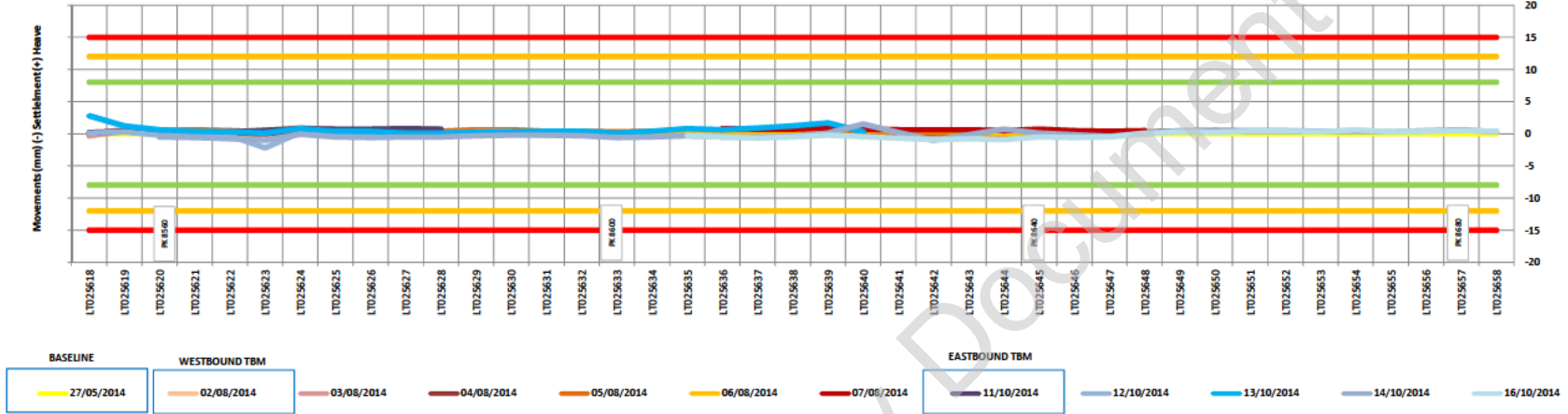
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Appendix 7: DLR TRACK LEVELLING

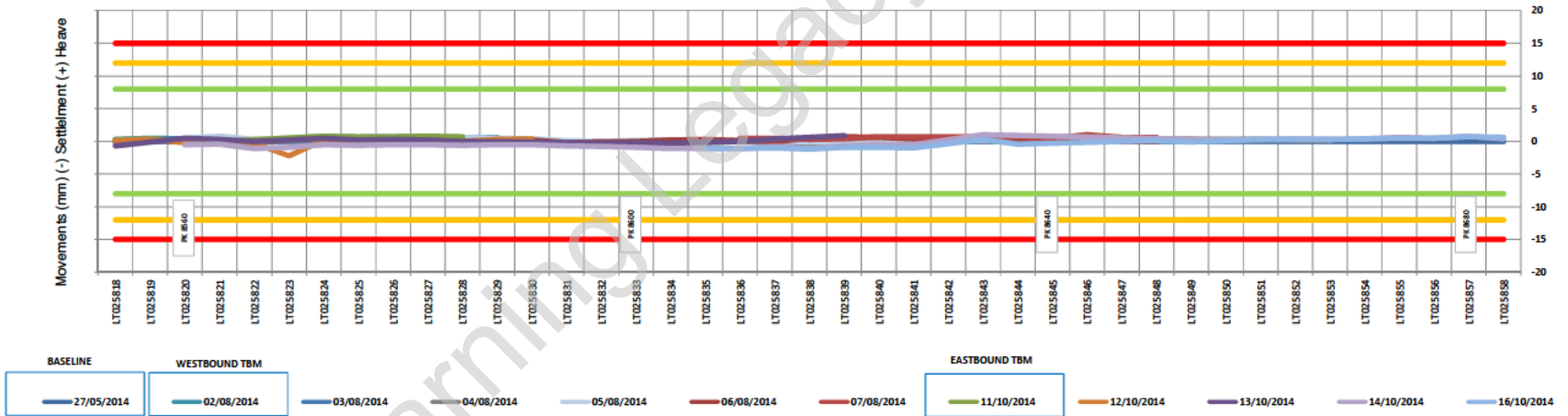


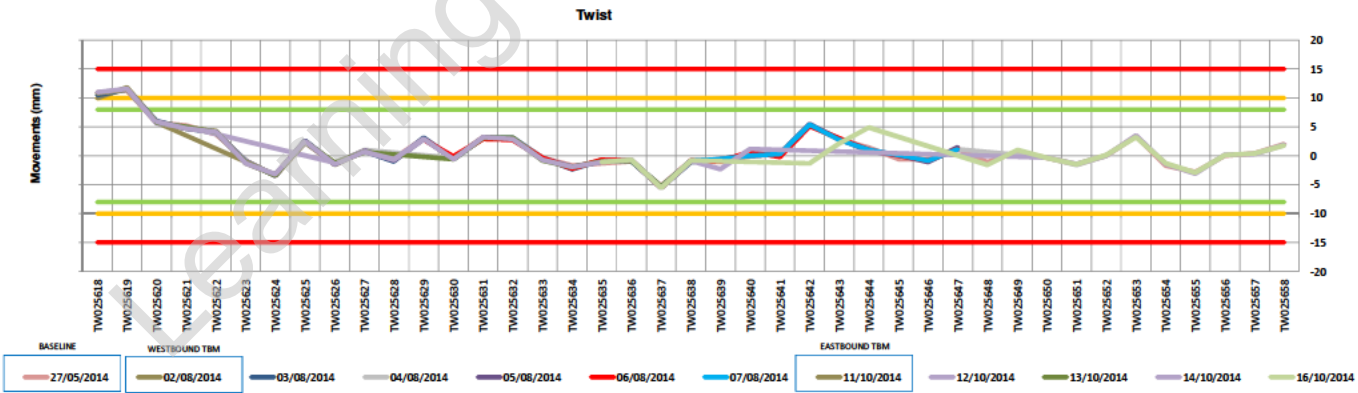
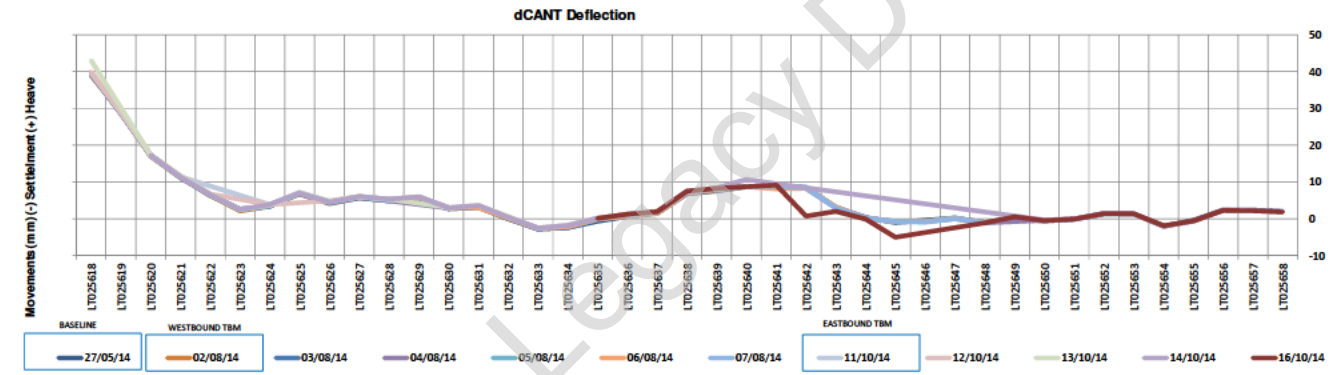
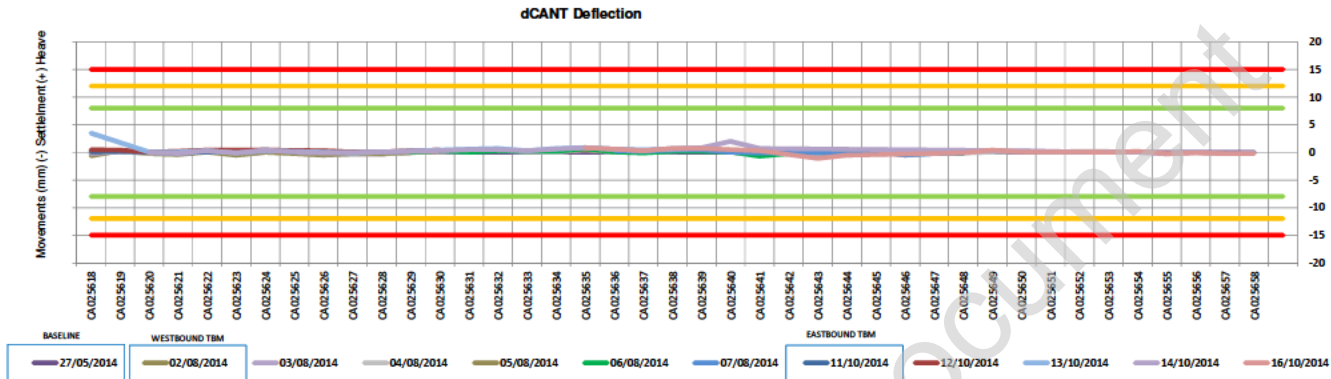
Learning Leap

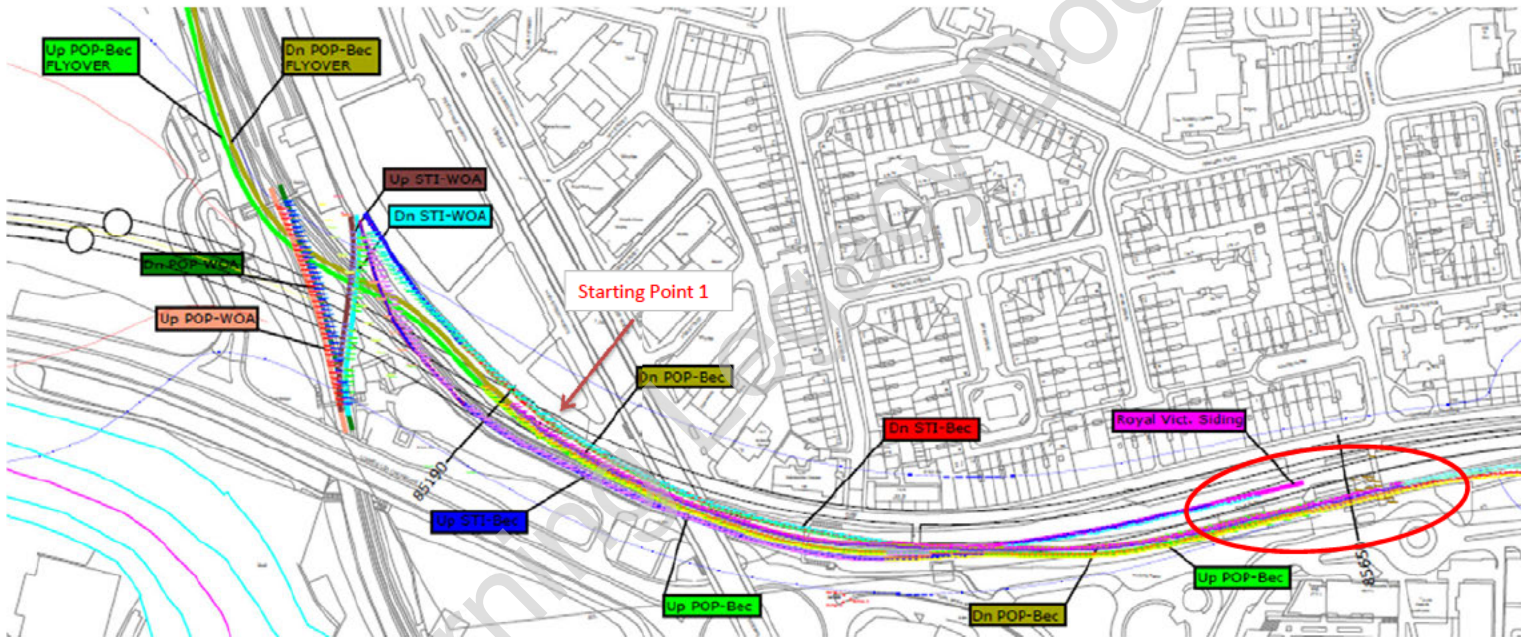
DLR-Cess-Leveling



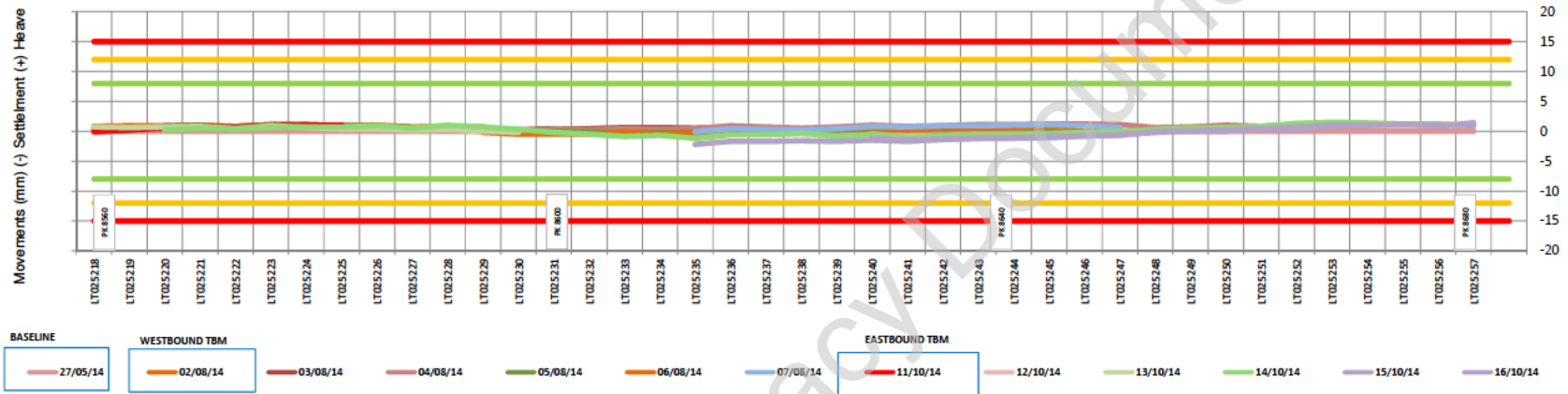
DLR-6ft-Leveling



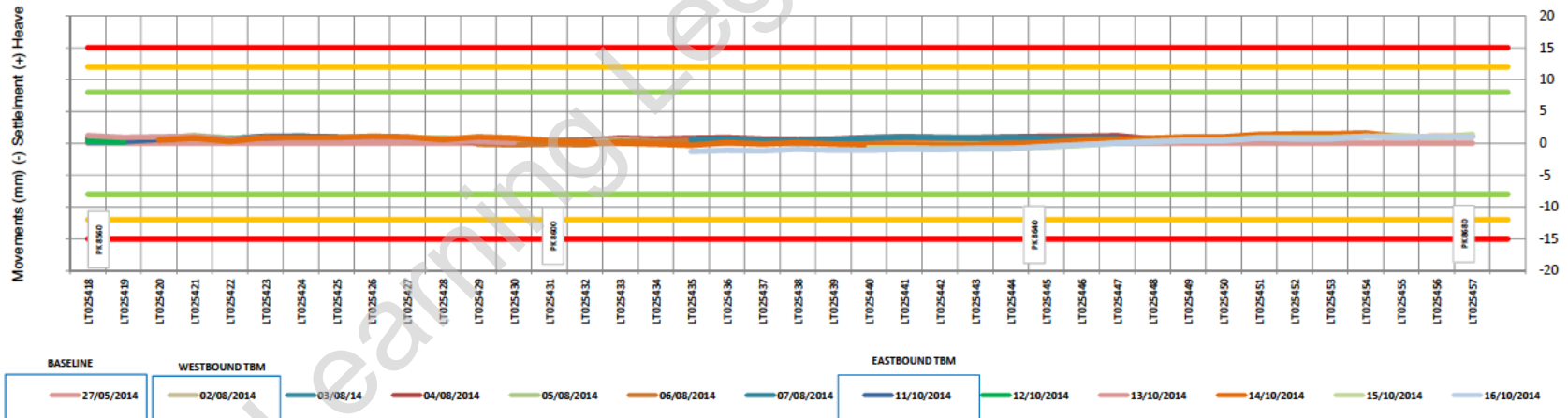




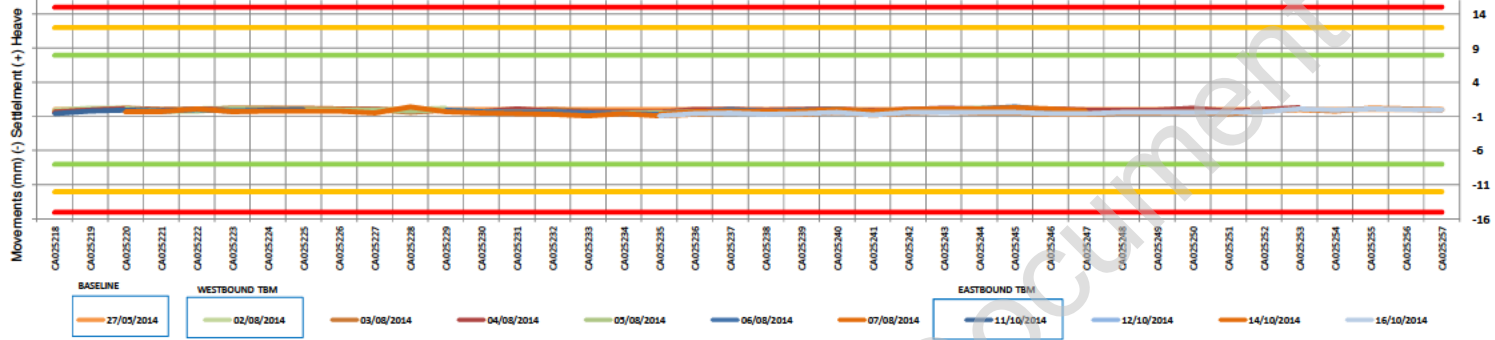
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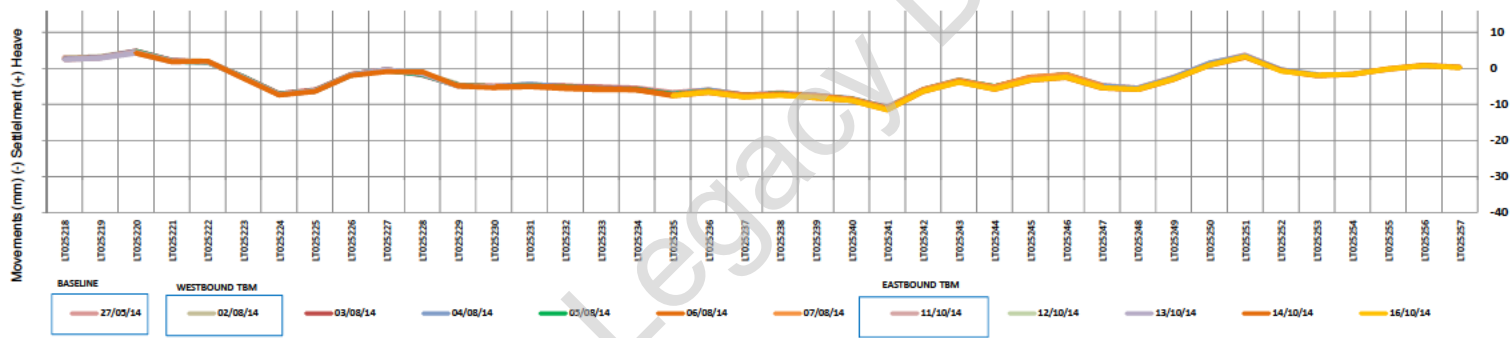
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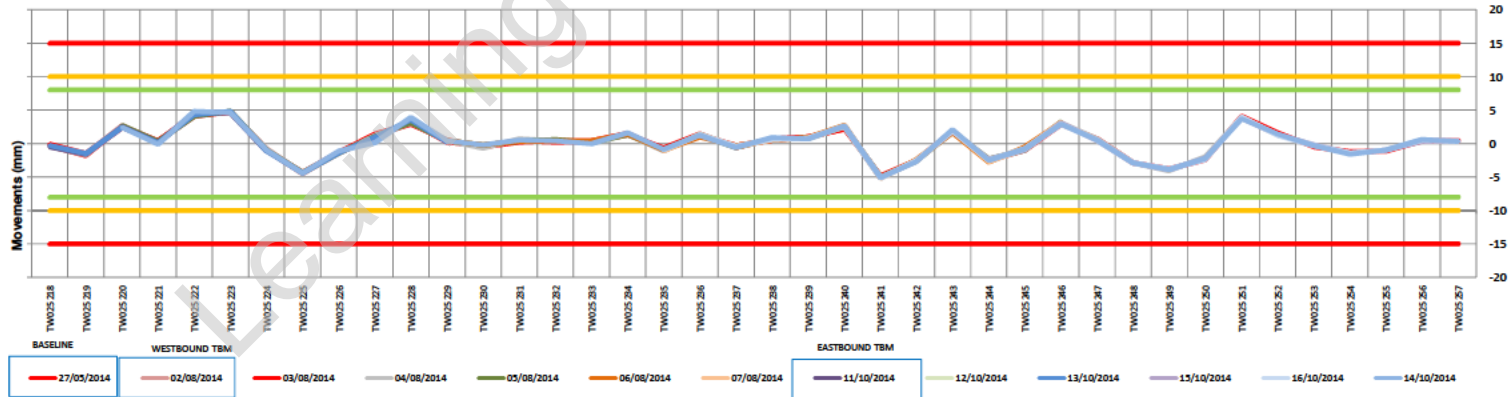
dCANT Deflection

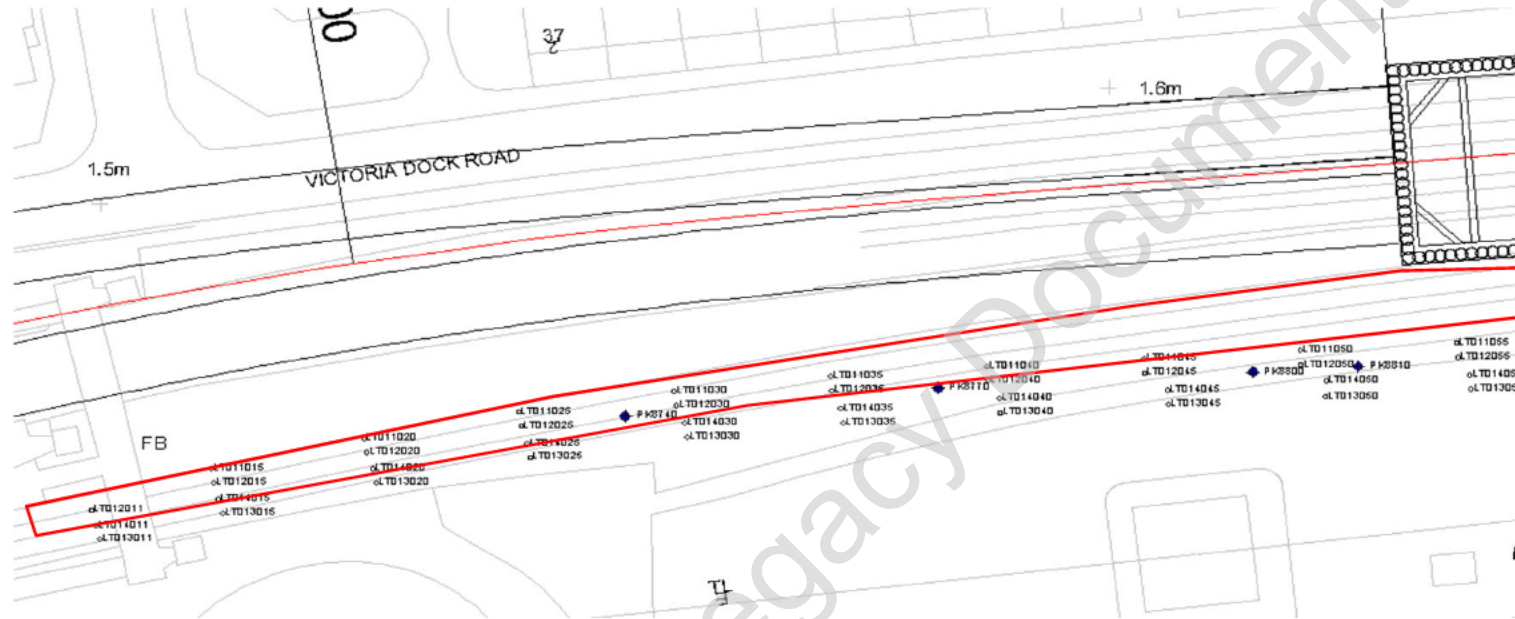


Absolute CANT Deflection



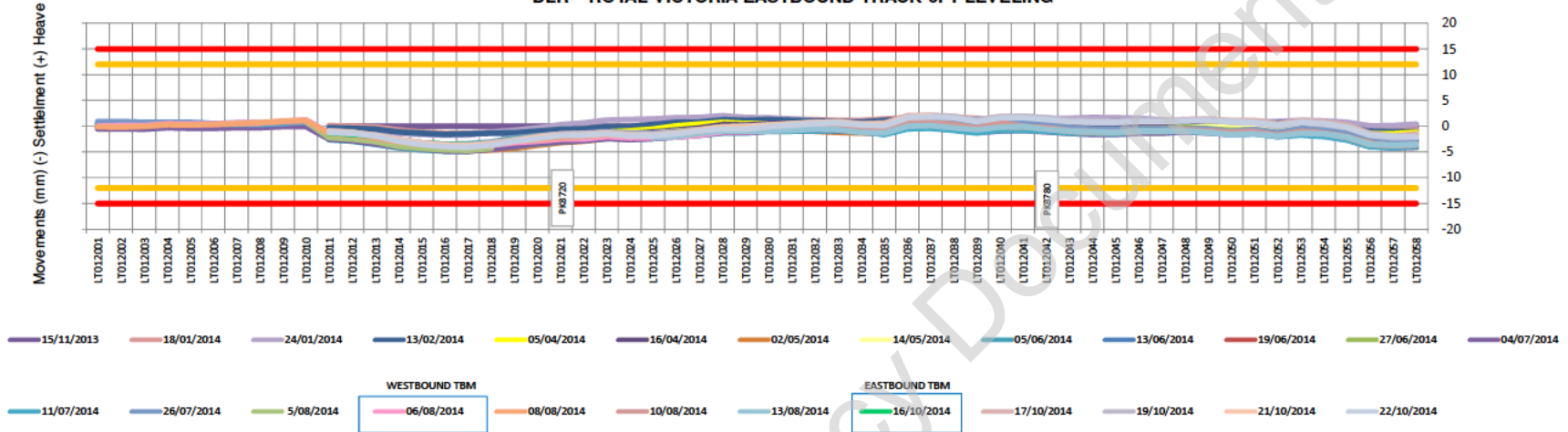
Twist



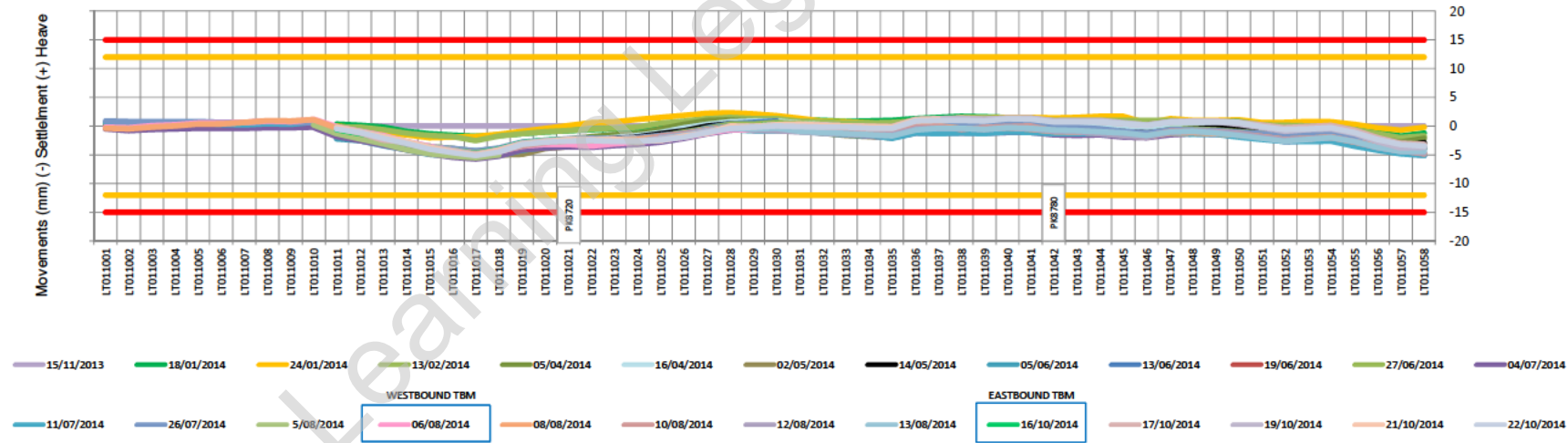


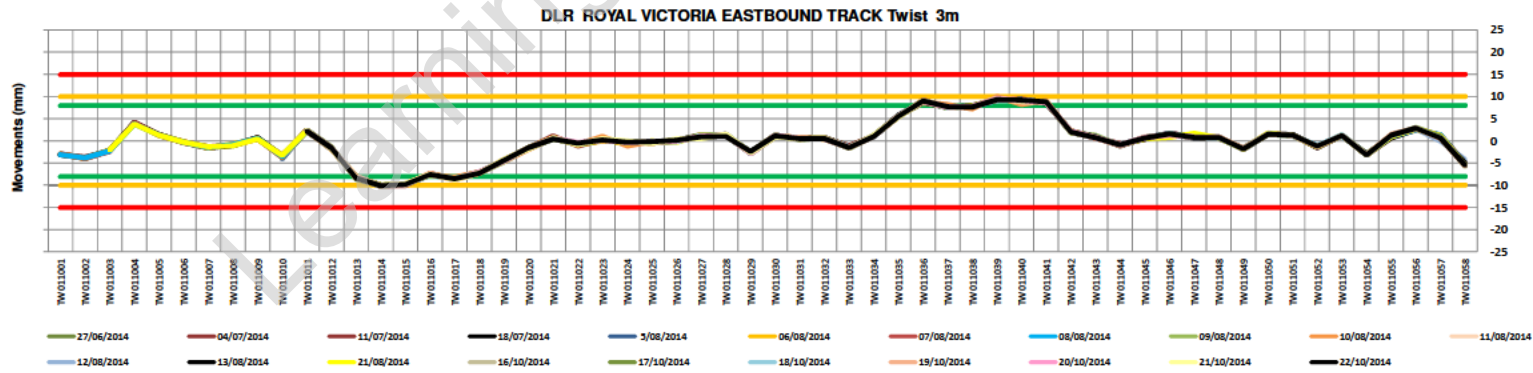
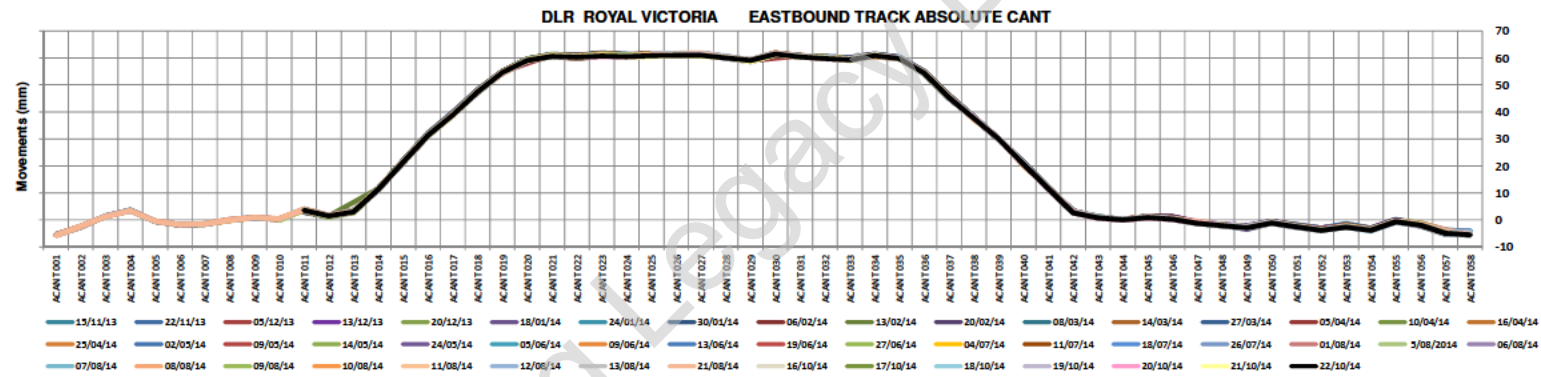
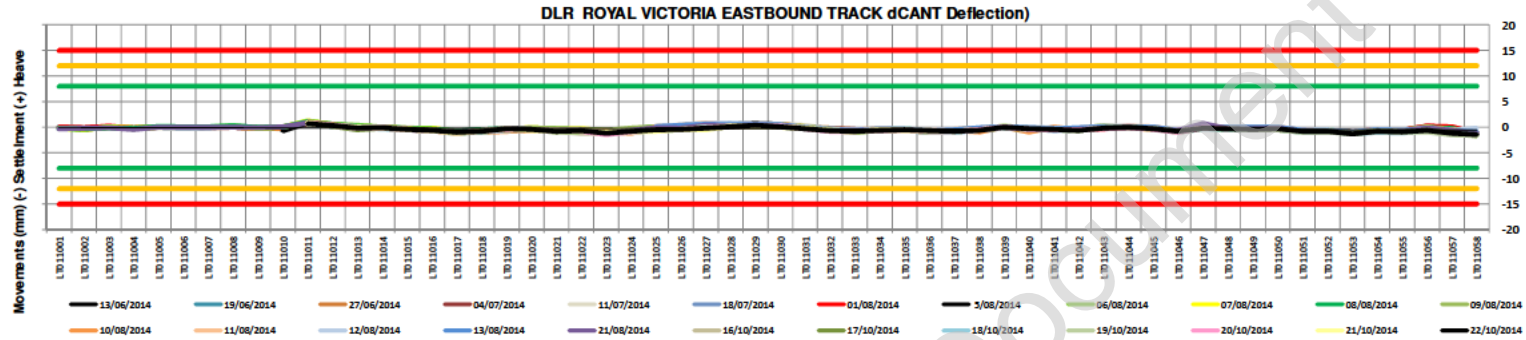
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DLR ROYAL VICTORIA EASTBOUND TRACK 6FT-LEVELING

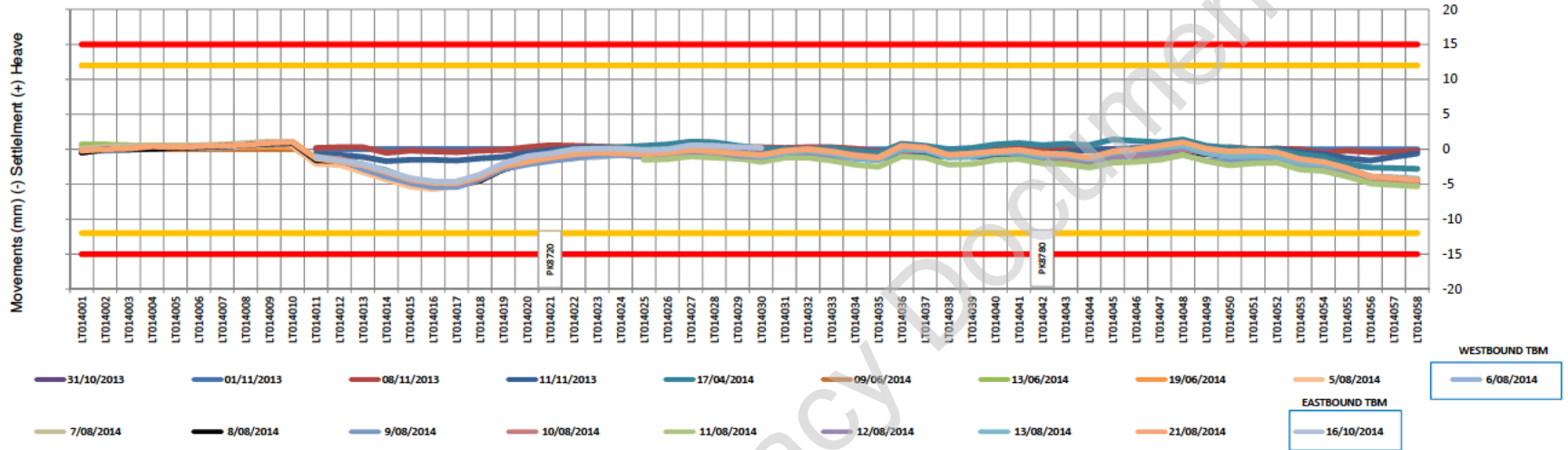


DLR ROYAL VICTORIA EASTBOUND TRACK Cess-LEVELING





DLR ROYAL VICTORIA WESTBOUND TRACK 6FT-LEVELING



DLR ROYAL VICTORIA WESTBOUND TRACK Cess-LEVELING

