DelftCluster
Railway transition zones & Switches

Factual report long-term measurements

A.D. Hartman
dr.ir. P. Hölscher

Deltares

Title
DelftCluster
Railway transition zones & Switches

Project	Reference	Pages
1001069-000	1001069-000-GEO-0005-sr	53

Keywords
Railways, Field test

Summary
For the DelftCluster 'Railway transition zones and switches' project, extensive measurements are made. The measurements are divided into three types: Field survey, short-term and long-term measurements. The long-term measurements are described in this report.

The goal of the reports is to make sure that all measurements are available to everyone involved and to properly name all the measurements. This will prevents problems with wrong or old data, additionally it will facilitate the communication between all involved in the project

This report describes all the long term measurements both at the culvert and the switch. The main focus of the report is on leveling of the rails with the use of different instruments.

Version	Date	Author	Initials	Review	Initials	Approval	Initials
01	Jul. 2009	A.D. Hartman		dr.ir. P. Hölscher		ing. M. Hutteman	
02	Nov. 2009	A.D. Hartman		ir. A. Verweij		ing. M. Hutteman	

State
final

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1 Introduction

For the Delft Cluster project “Railway Transition zones” extensive field-testing has been performed. Testing took place on the railway track Gouda-Goverwelle (GoGo) on a culvert and on a Switch. Many different parties were involved in the testing and numerous different types of tests were performed. Al the different tests ad up to a large amount of data supplied by different parties and thus supplied in different formats. This report is a part of a series of factual reports, which give a complete overview of al test performed and their results. All reports are written in the same format and tests are named in similar fashion. The reports also describe the structure of a database that contains all data. This database is supplied digitally along with the reports.

The complete series of reports consists of:

A. Field survey.
   1001069-000-GEO-0004 Factual report soil investigation
B. Short-term measurements May 2008.
   1001069-000-GEO-0003 Factual report short term measurements 2008
C. Short-term measurements April/May 2009.
   1001069-010-GEO-0004 Factual report short term measurements 2009
D. Long-term measurements.
   1001069-000-GEO-0005 Factual report long-term measurements.

This report (A) gives a complete overview of all the long-term measurements and the results. The long-term measurements focus on levelling.

In Chapter 2 and 3 all measurements are presented and discussed. To enable further studying of the data, the original data is available. Chapter 4 shows where the data can be found.

2 Measurements at the culvert

2.1 Levelling of the rail

The height of the rail is measured from 10 June 2008 until 09 June 2009. In this period the track the track was raised twice during maintenance. In the night from 8-9 July 2008, regular maintenance has been carried out at the culvert. Between 26 September and 7 October 2008 (presumably at 6-7 October), the (regular) maintenance was carried out at the east-side (Woerden side) of the culvert only. At the west side, no changes were made. Finally, the project stopped at 30 June due to maintenance at the culvert. This maintenance was required since otherwise a speed limit was needed.

The top of the rail head is measured above 60 sleepers. Sleeper number 30 is the sleeper that is located close to the centre of the culvert. Both the right (north) and left (south) rail are levelled. The positive axis points in upward direction.

In the beginning, all measurements are related to the average level of three masts: 28/25 (between sleeper 17 and 18), 28/27 and 28/29. Later on, some improvements have been made:

- 7 October 2008: the level of the masts relative to the measurement device is given.
- 27 November 2008, a scratch at the culvert is also levelled, the level of the track is recalculated with respect to that level.
- 21 January 2009, a measurement bolt has been installed in the culvert. From that moment, the measurements are relative to the bolt.

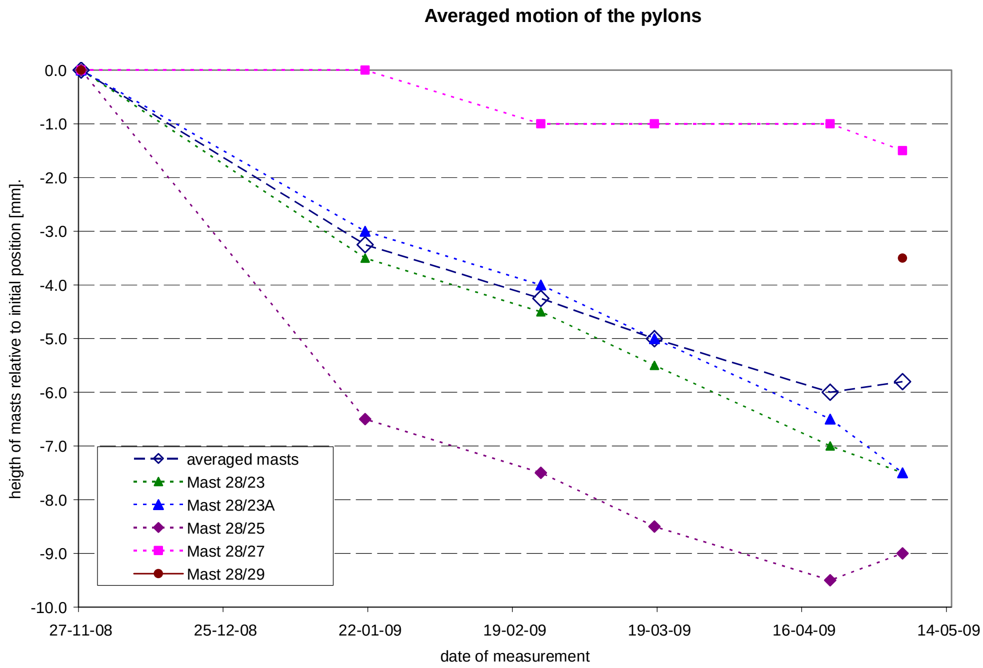

Figure 2.1 *Averaged settlement of the masts relative to the culvert*

Figure 2.1 A shows the motion of the masts relative to the culvert. In a six month period the masts have settled about 6 mm. This means that the measurements before November 2008, must be handled with care for the motion of the reference during that period.

Appendix A shows the results of the levelling graphically. First all the levelling for the left rail are shown. Then, the results of the levelling are divided per period between maintenance. Similar plots are given for the right rail.

2.2 Levelling of the approach slabs

In the slab at West-side (Gouda), a hole was drilled. In this hole, a bar with thread is placed. At the slab the East-side (Woerden), a plate with a hole is glued to the slab. In the hole, a bar with thread is placed.
These two bars have been continuously in their position, they are not removed between measurements.

During each reading, the height of the bars was measured relative to the height of a bolt on the culvert near the working road. This was done by ordinary levelling apparatus, using two levelling staffs: one on the bar in the hole and one on the bolt at the culvert. These staffs were removed after each measurement.

Since the distance between the two staffs is small, it is believed that the accuracy of this measurement is about 1 mm. The given values are thus relative to the first measurement. The culvert is considered as a stiff point, so the changes of the level are relative to the culvert. The level of the rods is measured from July 2008 until June 2009. The results of the levelling are shown in table and Figure 2.1. The squires represent the measure in Figure 2.1 the dashed lines are for illustration purpose only.

Date	Level of approach slab A (east) [m]	Level of approach slab B (west) [m]	Settlement east [m]	Settlement west [m]
29-07-2008	-1.033	-1.233	0	0
02-09-2008	-1.032	-1.234	-0.001	0.001
30-09-2008	-1.034	-1.236	0.001	0.003
29-10-2008	-1.035	-1.237	0.002	0.004
21-01-2009	-1.035	-1.237	0.002	0.004
09-06-2009	-1.038	-1.241	0.005	0.008

Table 2.1 Results levelling approach slab

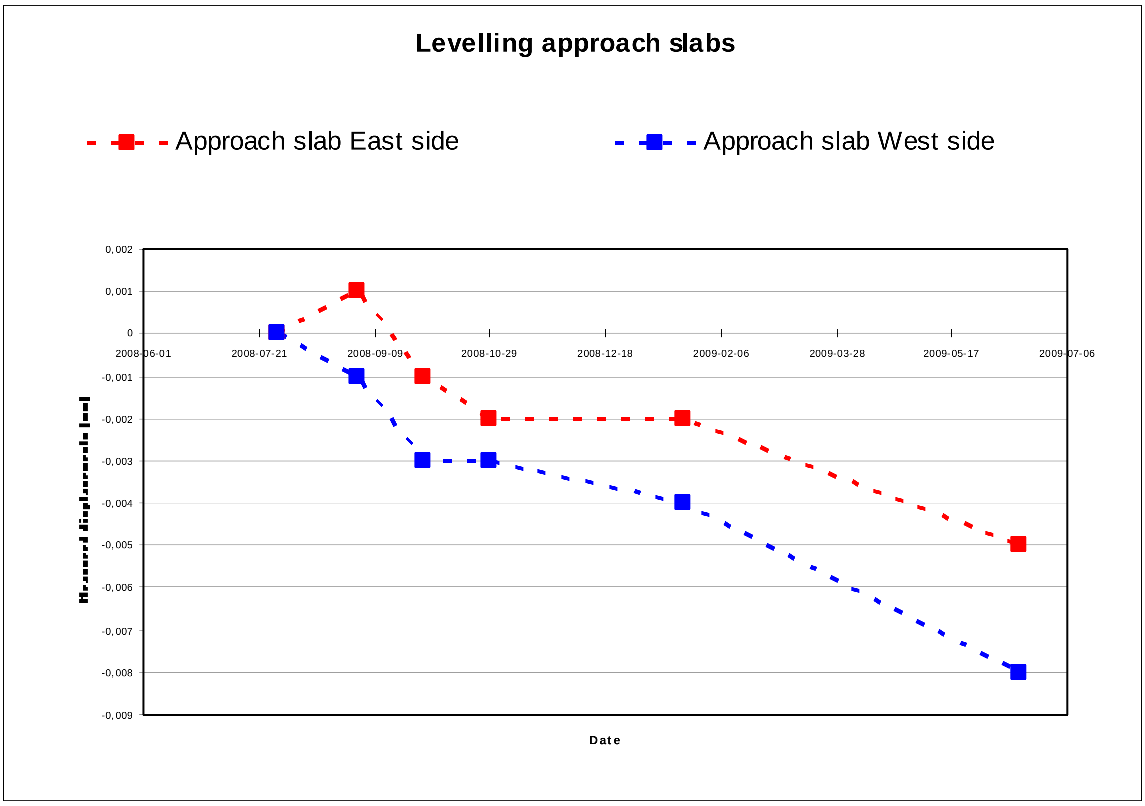

Figure 2.2 *Results levelling approach slabs*

2.3 Hanging sleeper measurements

The hanging distance of the sleepers is measured using Vortok void indicators, see Figure 2.3 for some information. A void indicator exists of a house, which is fixed at the sleeper. Within the house, two bars are placed in line. The lower free-hanging bar has a foot, which stands on the ballast. The upper bar has a frictional element, which can carry the weight of the bar. If the sleeper moves downward into the void under the sleeper, the lower bar pushed the upper bar upwards, but when the sleeper moves upward, the frictional element prevents the upper bar to move down again.

The elements are placed at the end of the sleeper. This means that the devices have some distance of about 20-30 cm to the rails. Since the sleeper may bend, and the ballast is tamped under the rail only, the measured void may deviate from the real void.

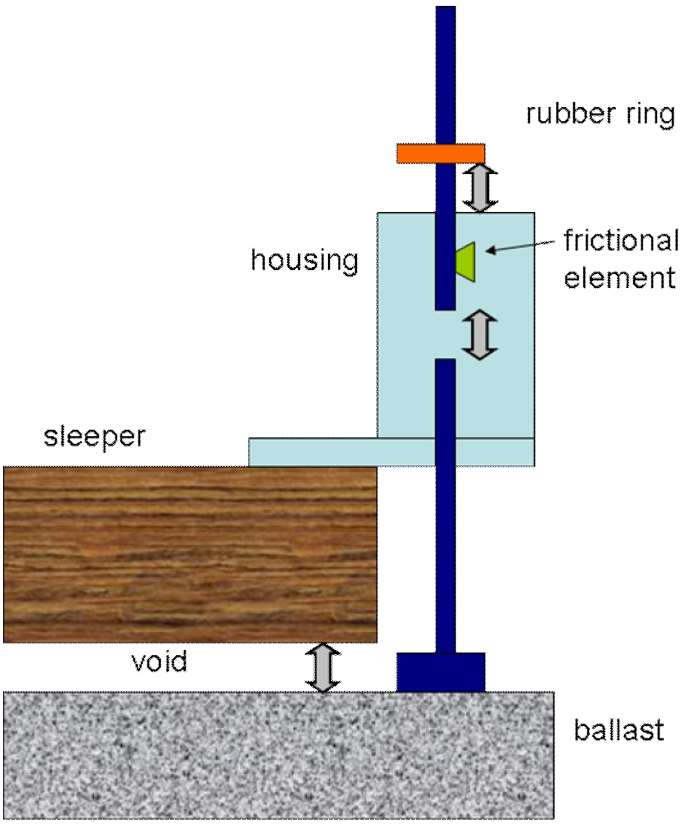

Figure 2.3 Principle Vortok void device

The accuracy of these devices is limited, to about 3 mm. The measurement method suggested by the producer, is using the rubber ring which sticks to the upper bar. Initially this is push down to zero. However, it turned out that sometimes the rubber ring shows zero void, while the upper bar could be pushed downwards. Therefore, another mehod was also used during the last measurements. Then the position of the top of the upper bar (relative to the housing) was measured before and after pushing the upper bar down. The difference between these to readings should be equal to the voit. This leads to an expected accuracy of 3 mm

Figure 2.4 gives the results of the measurements. During the period between 21 April and 6 May, the devices are read on Monday and Tuesday night. The averaged value is presented in the Figure, together with the 5% lower and 95% upper limit. These limits are based on the Student-t distribution with 5 degrees of freedom (during three weeks two readings per week are done).

After the measurement a slight increase of hanging distance might be observed, but this is not significant. Four and seven weeks after the weekly readings additional readings are done. These are also drawn in Figure 2.4. S light increase is observed around the sleppers 40 and 25, but these changes are statistically not significant.

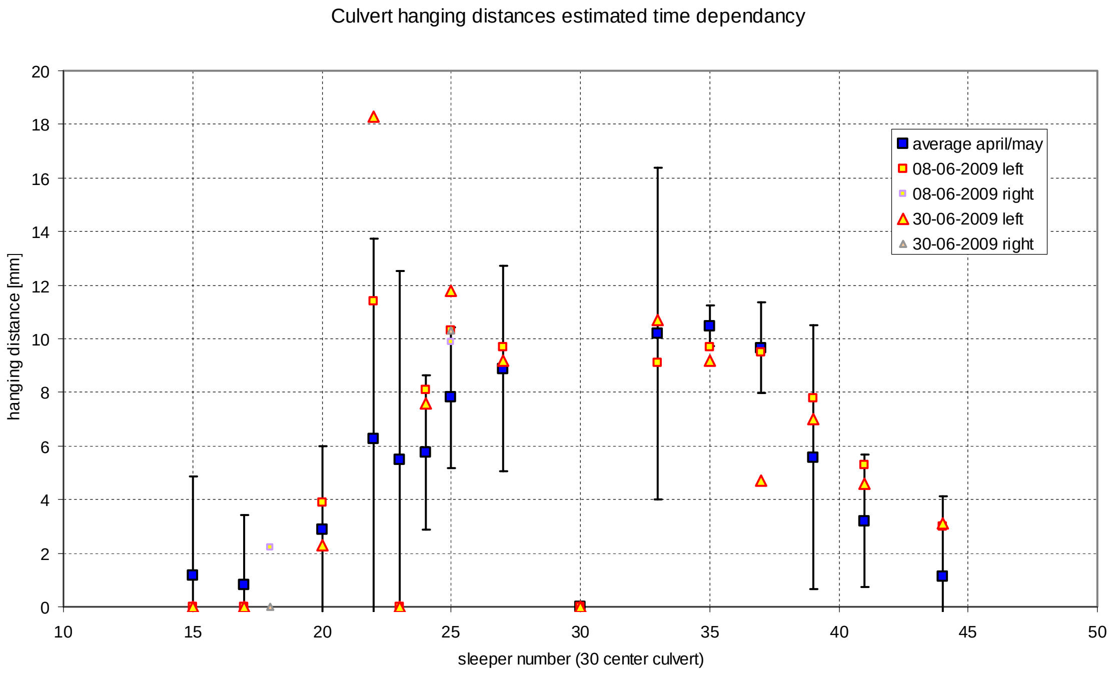

Figure 2.4 Results of hanging sleeper measurements

2.4 Track height measuring system

The track level measurement system (BHMS) of Baas had been installed at the sleepers at the North side of the rails. Displacement transducers are installed on the sleepers 14 to 46, on each fourth sleeper. In total 9 transducers are installed. Table 2.2 shows the position of the transducers.

Sleeper number	Distance to center culvert	Instrument number	Column number in mat-file
14	-9.6	1	2
18	-7.2	2	3
22	-4.8	3	4
26	-2.4	4	5
30	0	5	6
34	2.4	6	7
38	4.8	7	8
42	7.2	8	9
46	9.6	9	10

Table 2.2 Position displacement transducers BHMS; negative distance means at Woerden side of Culvert

In total 521 measurements are done, these are more or less equally spaced in time. In the MAT file the first and last column are dummy positions, so they do not contain a signal from the instruments. Channnel 2 tot 9 contain the signals from the instruments.

2.5 Pore water pressure measurements

Close to the culvert, the pore water pressure is measured from November 2008 until June 2009. Table 2.3 gives the locations of the instruments. The results of the measurements are given in Figure 2.5. The spike, which goes off the scale, is caused by disconnecting the instrument during the short-term measurements. The locations of the instruments are measured using GPS during the short-term measurement 2009.

Instrument	X coordinate	Y coordinate
C P01	111567,91	447518,77
C P02	111556,98	447520,32

Table 2.3 Location of pore water pressure instruments

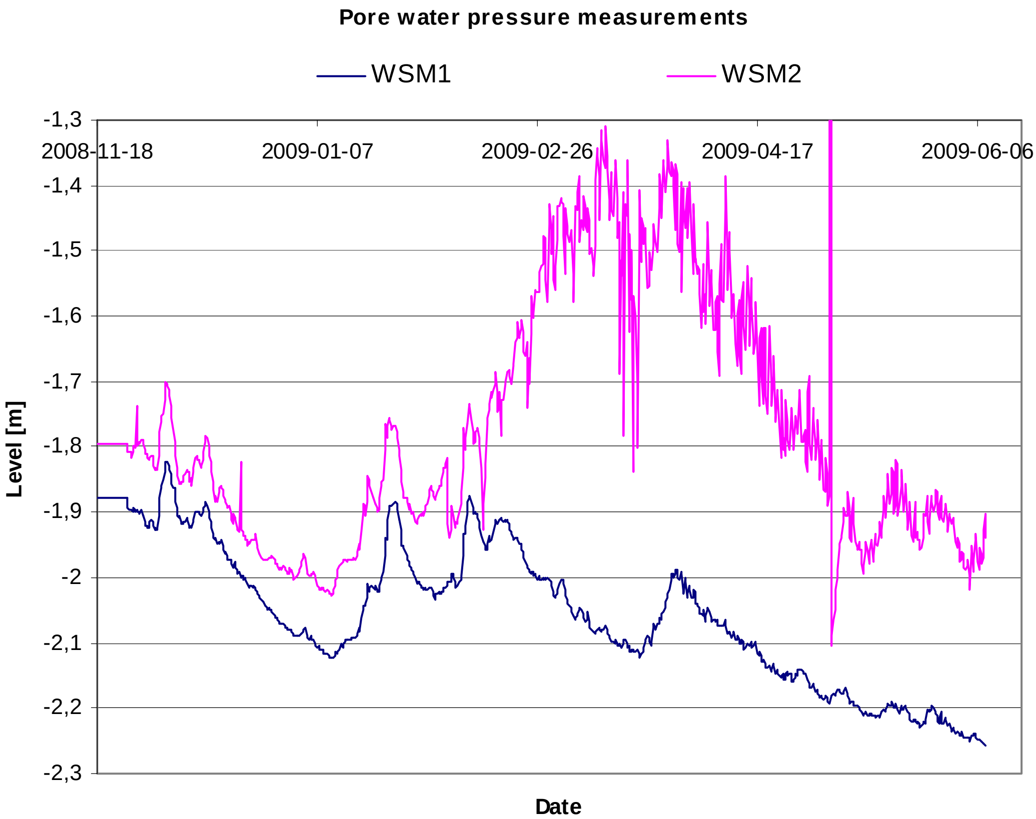

Figure 2.5 Pore water pressure measurements

2.6 Inclination measurements

Near the culvert 7 pipes for inclinometer test were installed. Table 2.4 shows the location of the measuring pipes. The pipes are installed vertically.

Measuring point	X	Y	Z (top) [m]
HMB02	111571	447520.1	0.33
HMB03	111568	447520.6	0.33
HMB04	111567.8	447518.8	0.08
HMB05	111553.4	447522.7	0.25
HMB06	111555.6	447522.4	0.32
HMB07	111557.2	447522.1	0.3
HMB08	111556.4	447520.8	0.12

Table 2.4 Location of inclinometer pipes

The inclination of the pipe is measured by lowering a instrument in the pipe and retrieving it. Inside the pipe the instrument is guided by two grooves inside the pipe to ensure it does not rotate. There is a measurement every 50 cm, starting at the bottom of the pipe. The measurements are always performed twice, rotating the instrument 180 degrees between measurements. The difference between the two measurements is an indication of the accuracy of the system, determined at 0.33 mm/m.

If the bottom end of the pipe is fixed in a firm layer (e.g. the pleistocene sand), this section can be used as a reference for the rest of the pipe. It can also be used for estimation of the accuracy of the measurements.

Figure 2.6 gives an example of a measurement. The dotted straight lines show the expected accuracy based on information on the internet site of the producer. It is clear that the results are always within the accuracy interval. They do not show a clear trend over time either. In the ballast larger displacements are sometimes observed.

The conclusion drawn from these measurements is limited: If the some deformation in horizontal direction occurs, it is smaller than approximately 1 mm per year. For the ballast the view is quite fuzzy.

The results of the inclinometer measurements are shown in Appendix D. First the displacement of HMB02-HMB08 is given in the A-direction. Then the direction in the B-direction is given for all pipes.

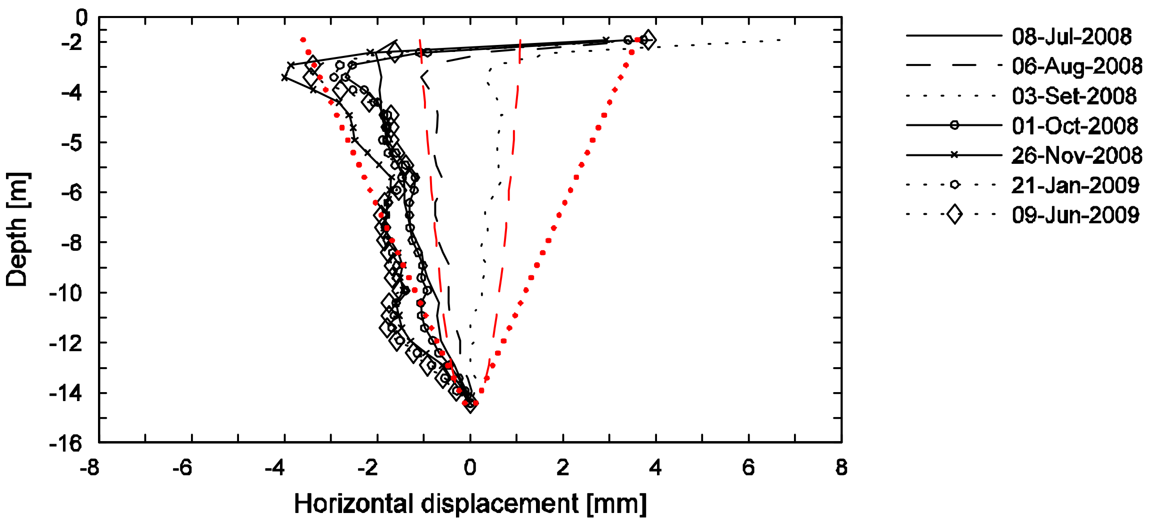

Figure 2.6 Example of inclinometer measurement

2.7 EU Rail scout measurement

On the 27th of October 2008 the Gouda-Goverwelle railway track was measured by a Eu Rail scout measuring train. The results of this measurement are compared to results of the leveling.

The measurement of the track is added tot this report as Appendix E. In Figure 2.7 a detail from the results of the measurement is shown. The culvert is allegedly located between the two gray lines, based on the distance indication. However, it seems more likely that it is located more to the right, where a larger horizontal deflection is visible.

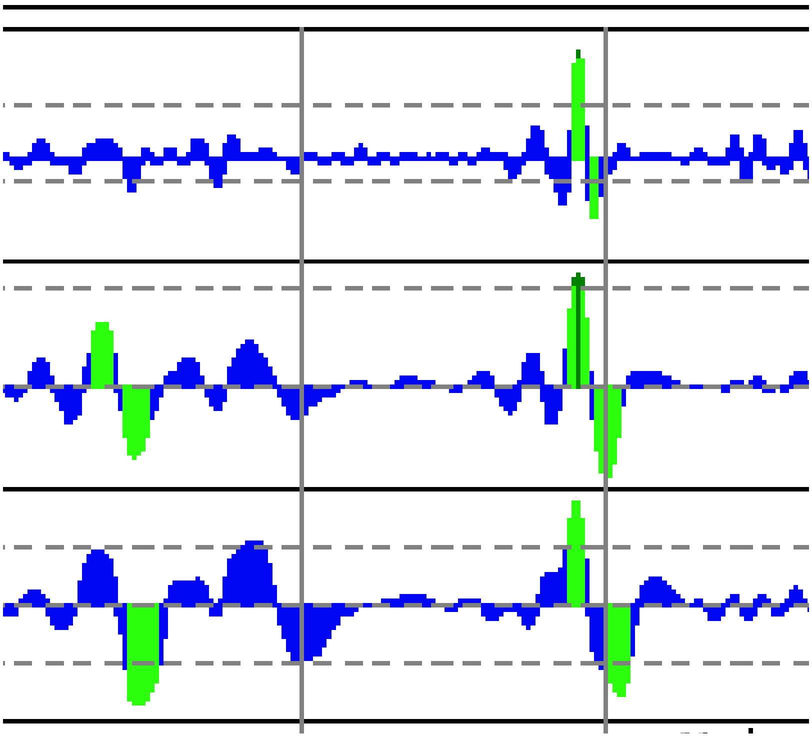

Figure 2.7 Track deflection at the culvert, over 1m, 10m, and 15m chord

2.7.1 Processing of the track levelling

Based on the leveling as described in chapter 2.1, the deflection of the track over 1,2 m, 9,6 m, and 14,4 m are determent. This is done for the levelling of 7 October and 27 November 2008, 3 weeks before and 4 weeks after the EU rail scout measurement respectively. The calculated value is the difference between the measured value at the considered point compared to the average value over a 3, 17, and 25 sleeper interval respectively. This processing method is according to [Hogeweg, 2002].

The results over a 1.2 m chord do not allow for a good comparison with the Eu Rail scout measurement, the results give a very turbulent view. The most likely scource of this problem is the difference in measuring frequency. The EU Railscout measurement has 5 measuring point over a single 1.2 m chord, whereas the leveling has only 3 measured values over a 1.2 m chord. Over a longer chord this problem is reduced because the chord contains more measuring points. Additionally, it is possible that the EU Rail scout makes an additional processing step, which is unknown to Deltares.

Appendix figures E.2 to E.5 show the results for the 9.6 and 14.4 m chords. The shape of these figures matches the results of the EU Railscout to a reasonable level; a high peak followed by a somewhat lower negative peak. The numerical values correspond reasonable as well.

2.7.2 Processing of the track leveling performed at 5th of may 2009

The day that the short-term measurements were performed a leveling measurement was carried out as well. This leveling has been processed in the same manner as the other levellings. Figures E.6 and E.7 show the results. Compared to the figures based on the measurements made a year earlier, not a lot has changed. The shape is almost identical, only the values are somewhat higher.

A remarkable detail is the fact that the deflection of the track behind the culvert is larger than the deflection in front of the culvert.

3 Measurements at the Switch

3.1 Levelling of the rail

The levelling of the rail at the switch is identical to the levelling of the rail at the culvert. The switch levelling took place from 26 September 2008 until 12 June 2009. The results of the levelling are in Appendix B. The results are divided into left and right rails for both the straight and the outgoing sections of the switch. This makes a total of four graphs
.

4 Structure of the data

All data named in this report is also given in digital format. All data is in Microsoft Excel spreadsheets. The data is laid out identical to the chapters of this report with chapter being folders and paragraphs being files. All names are identical to the chapters and paragraphs.

5 References

[Hogeweg, 2002]
Hogeweg, H.W., Overgangsconstructies van aardebaan naar kunstwerk voor spoorconstructies (in Dutch)
Afstudeerverslag TU-Delft, afdeling CiTG, January 2002.

[ProRail, 2008]
Results of the Eurailscout measurements 27 October 2008
Delivered as PDF via e-mail.

A Culvert levelling results

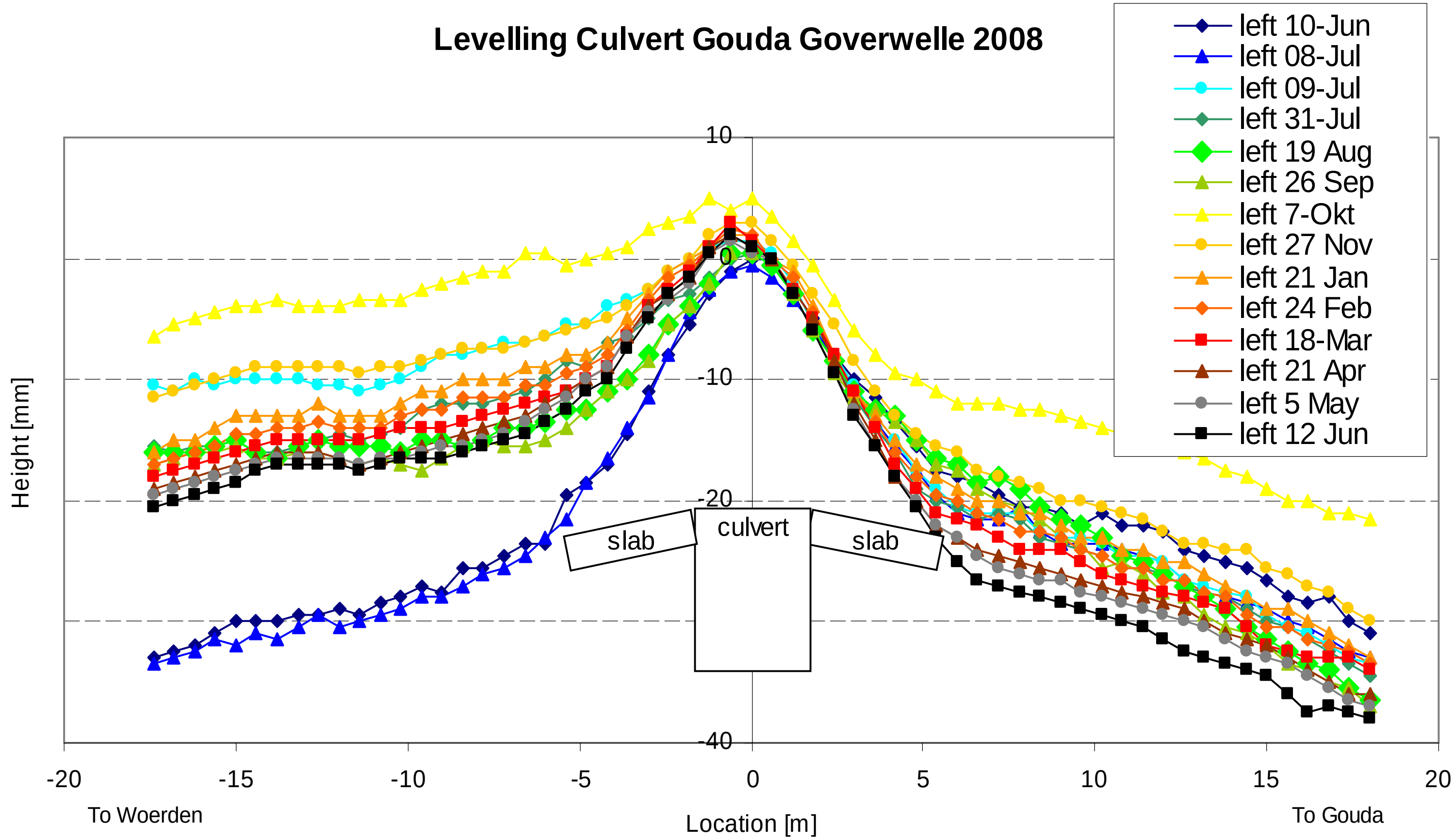

Figure A.1 *Levelling culvert left rail complete*

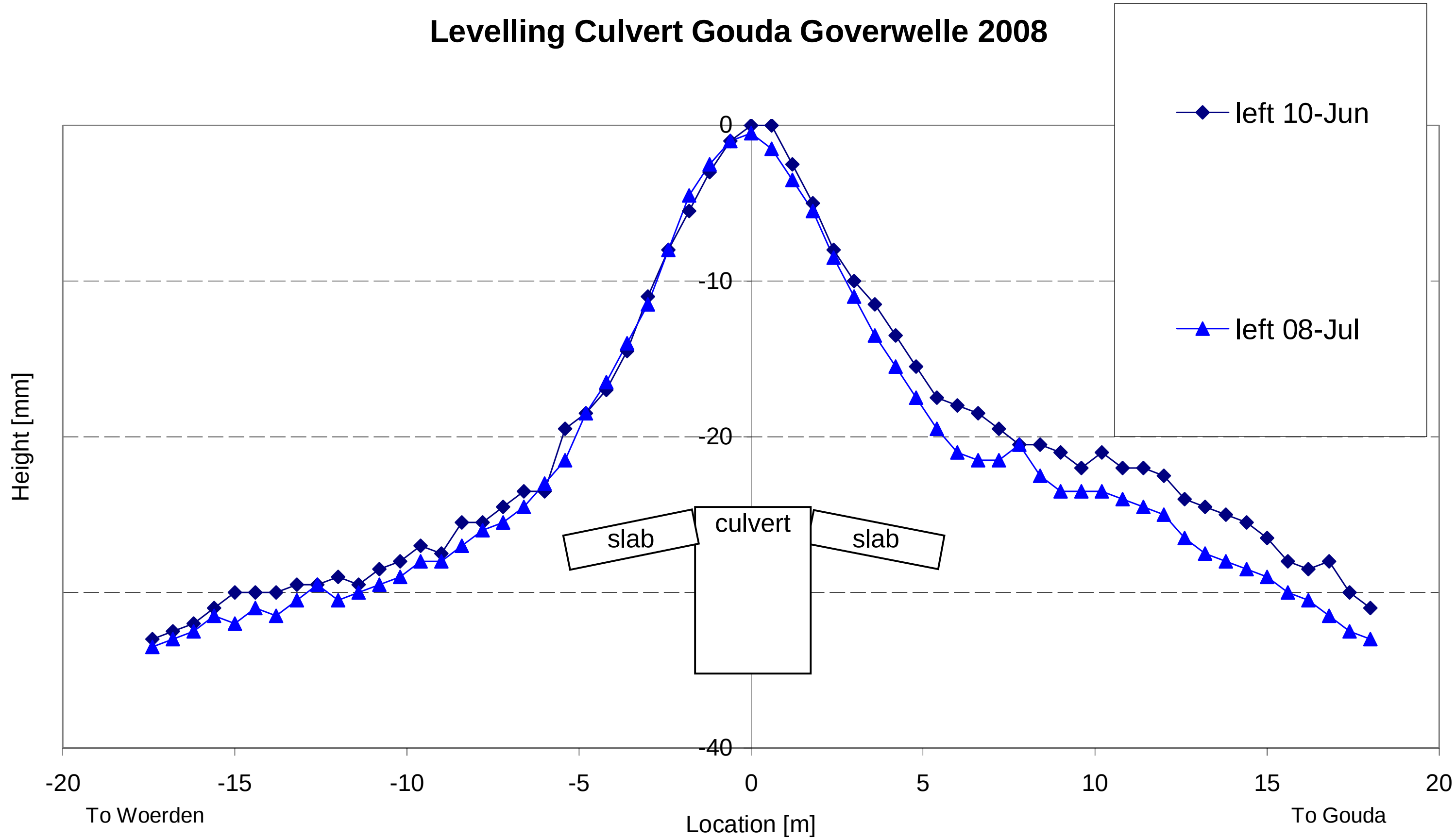

Figure A.2 Levelling culvert left rail 1st period

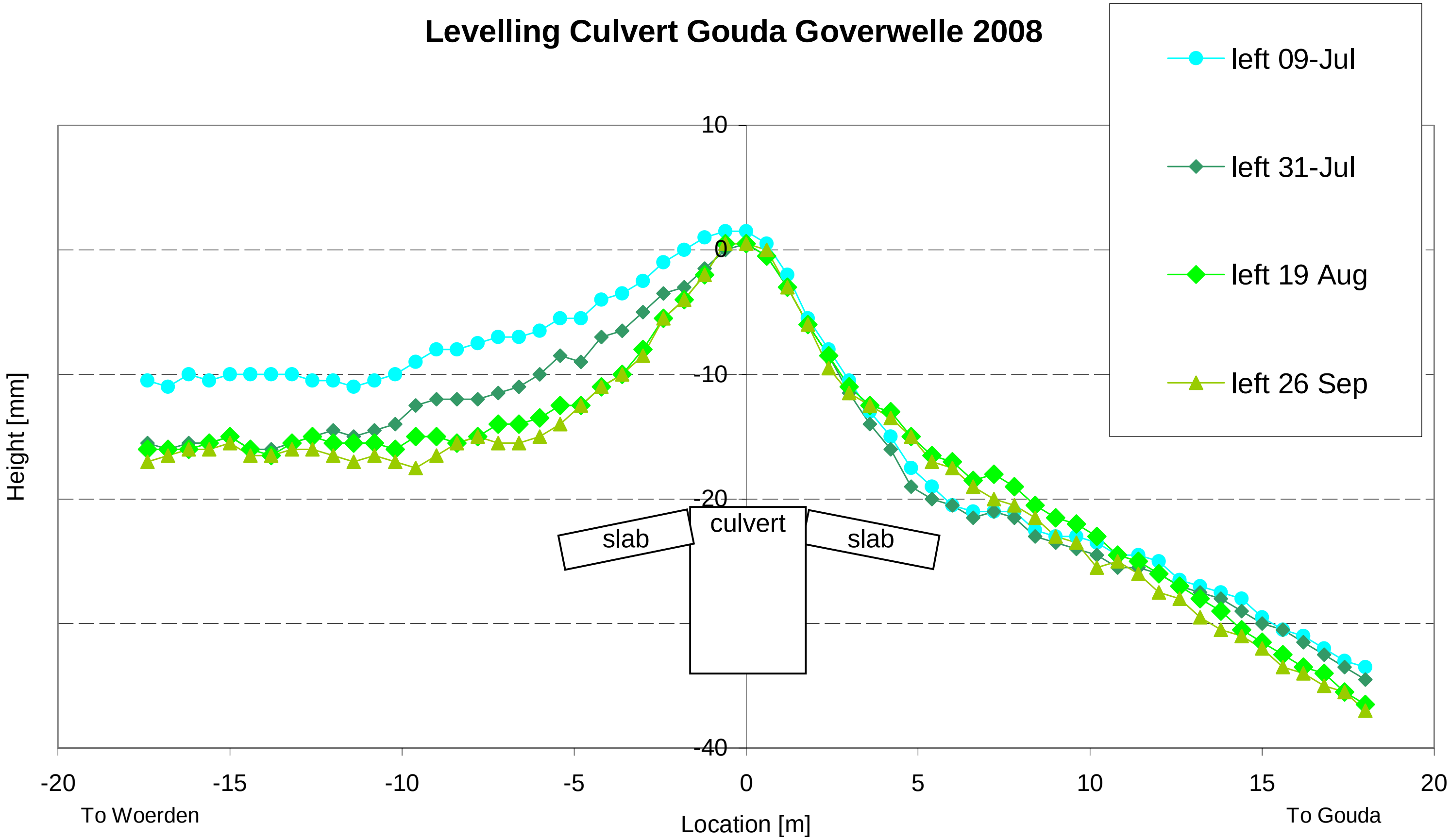

Figure A.3 *Levelling culvert left rail 2nd period*

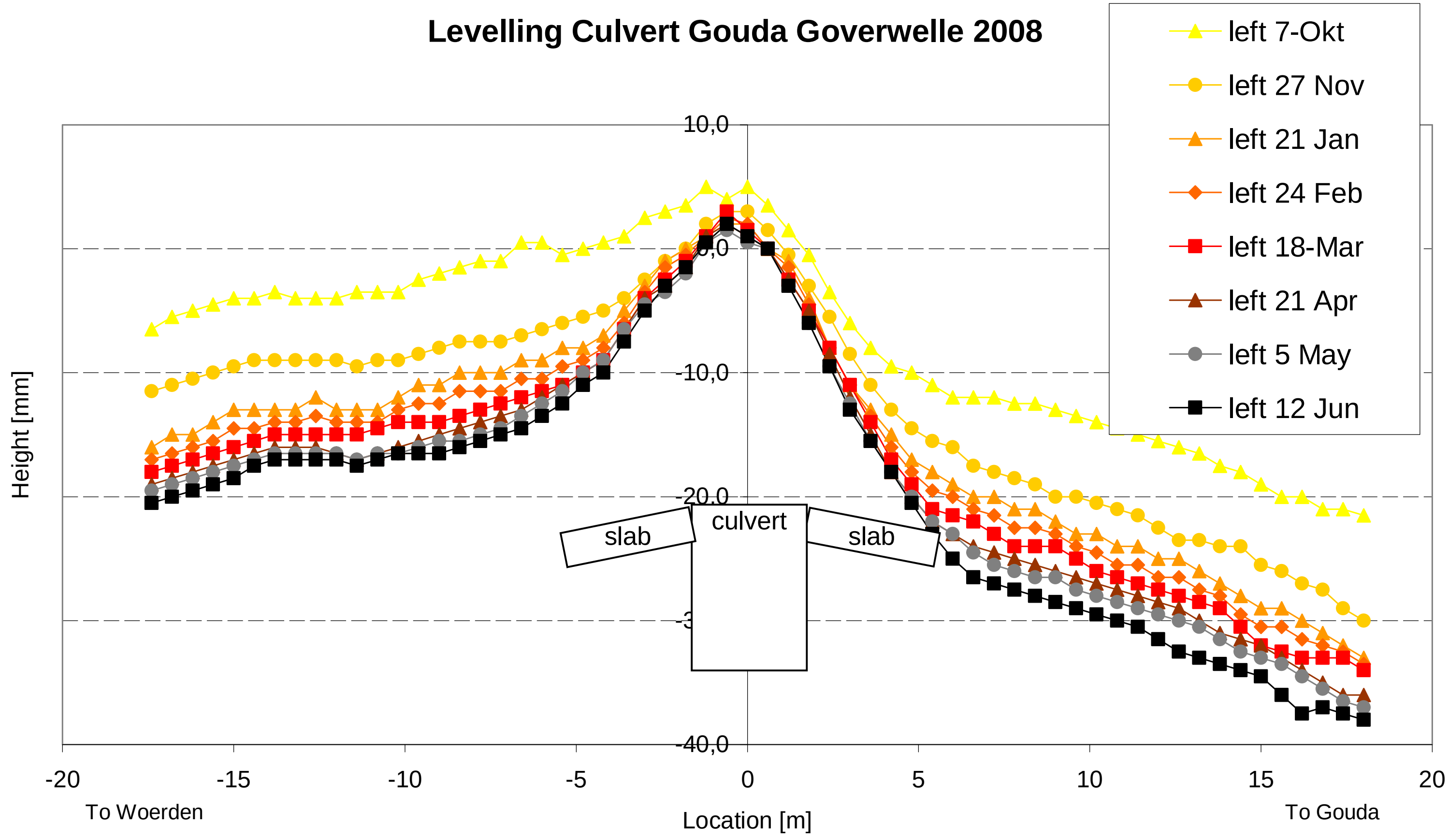

Figure A.4 *Levelling culvert left rail 3rd period*

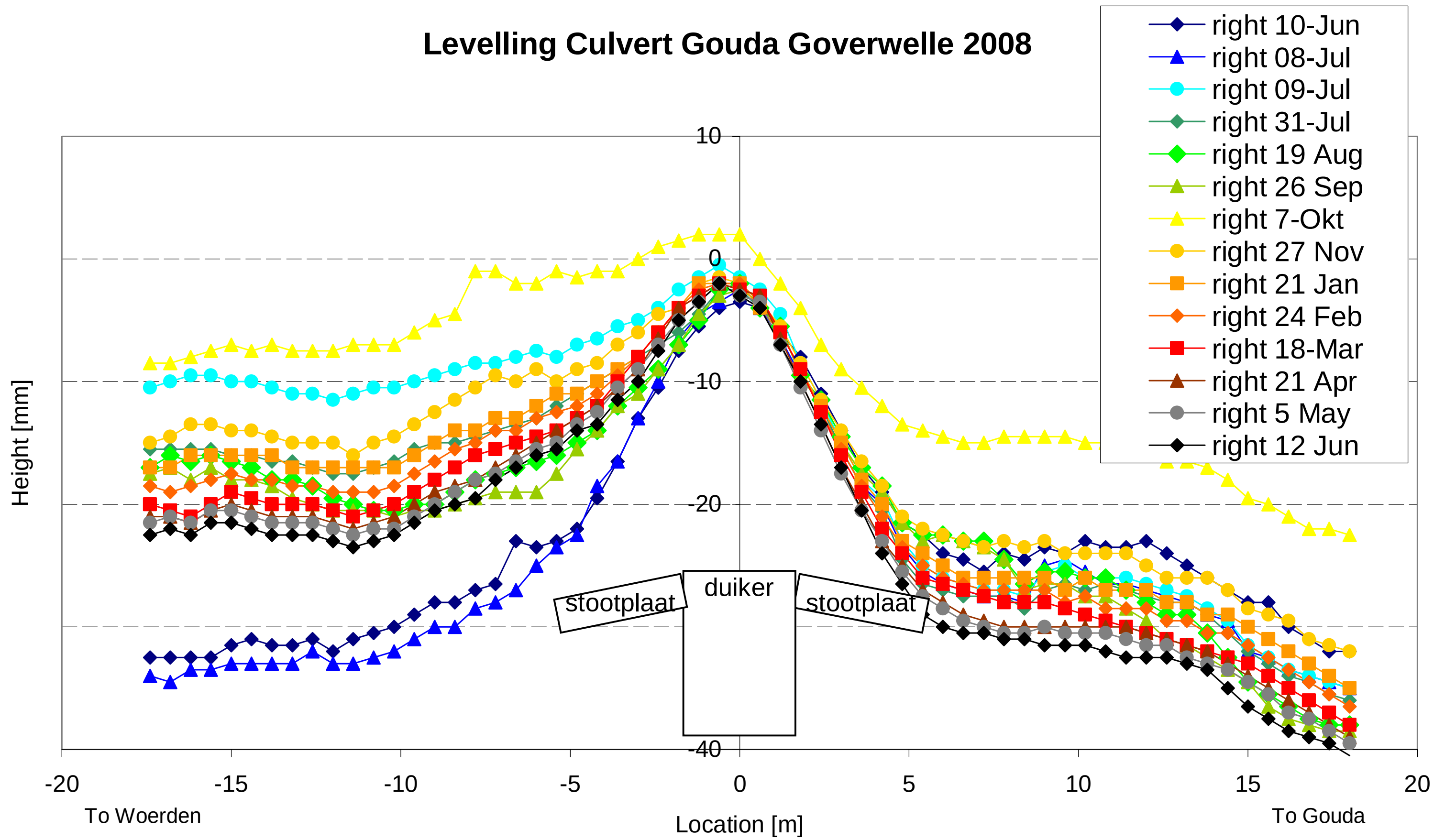

Figure A.5 *Levelling culvert right rail complete*

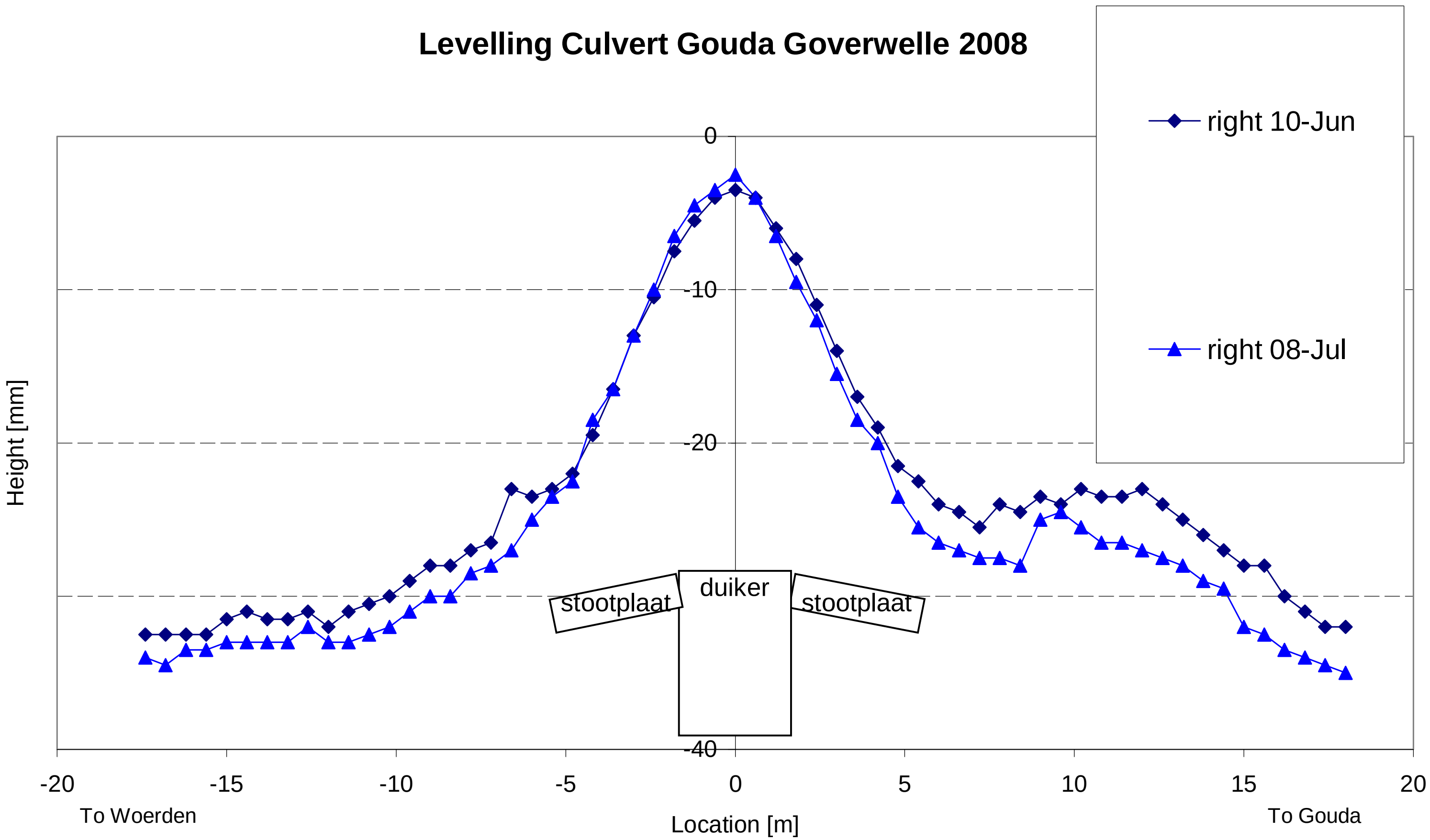

Figure A.6 *Levelling culvert right rail 1st period*

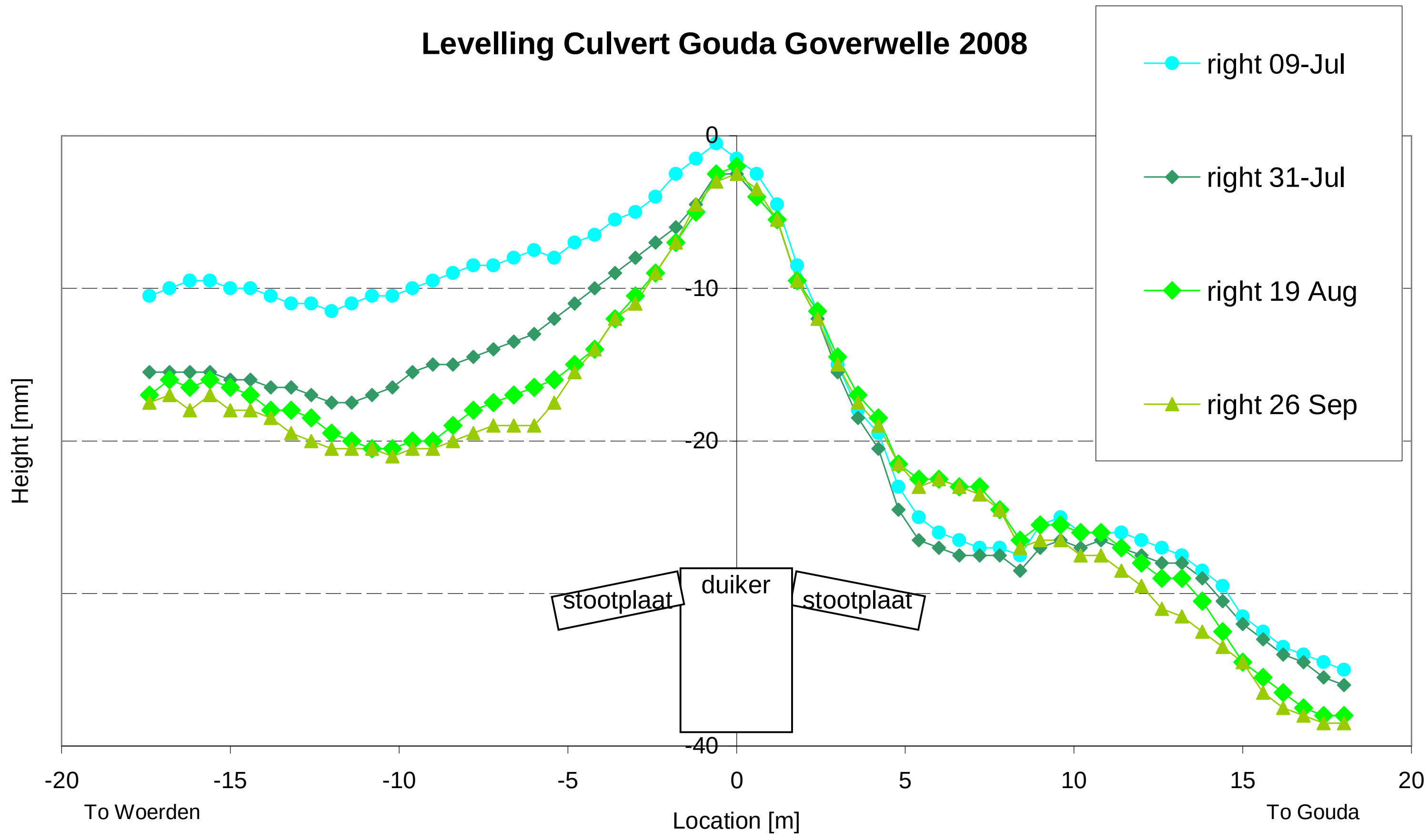

Figure A.7 *Levelling culvert right rail 2nd period*

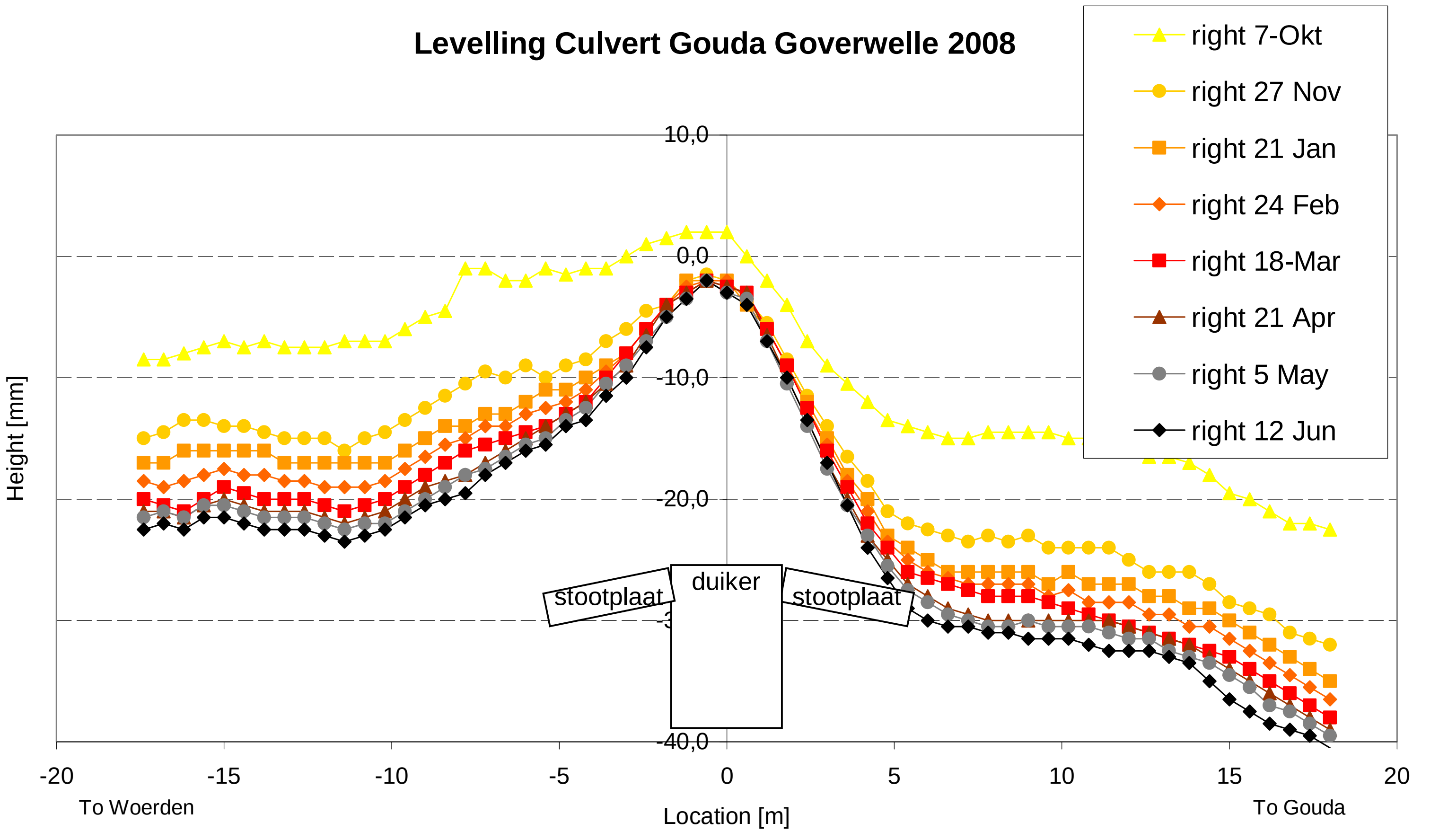

Figure A.8 *Levelling culvert right rail 3rd period*

B Switch levelling results

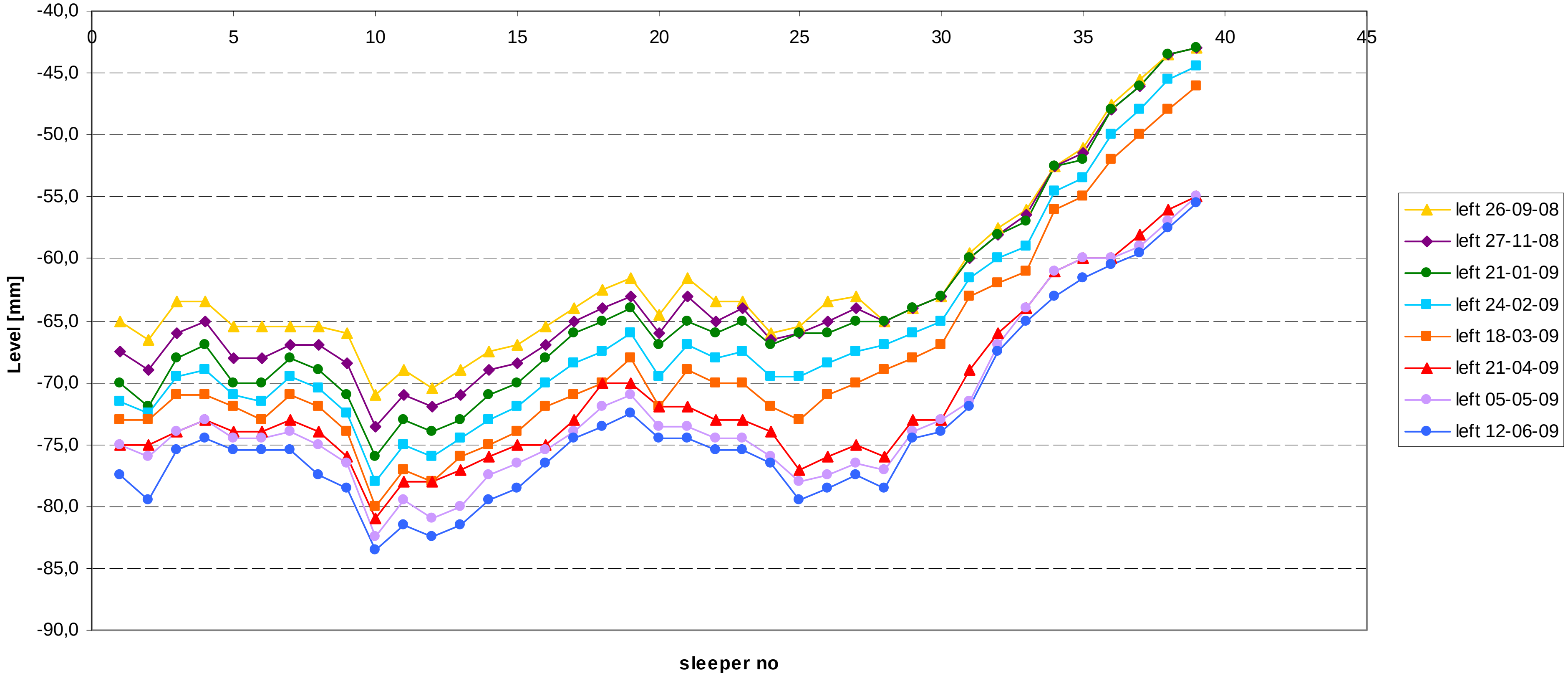

Figure B.1 *Switch levelling left rail “straight” section.*

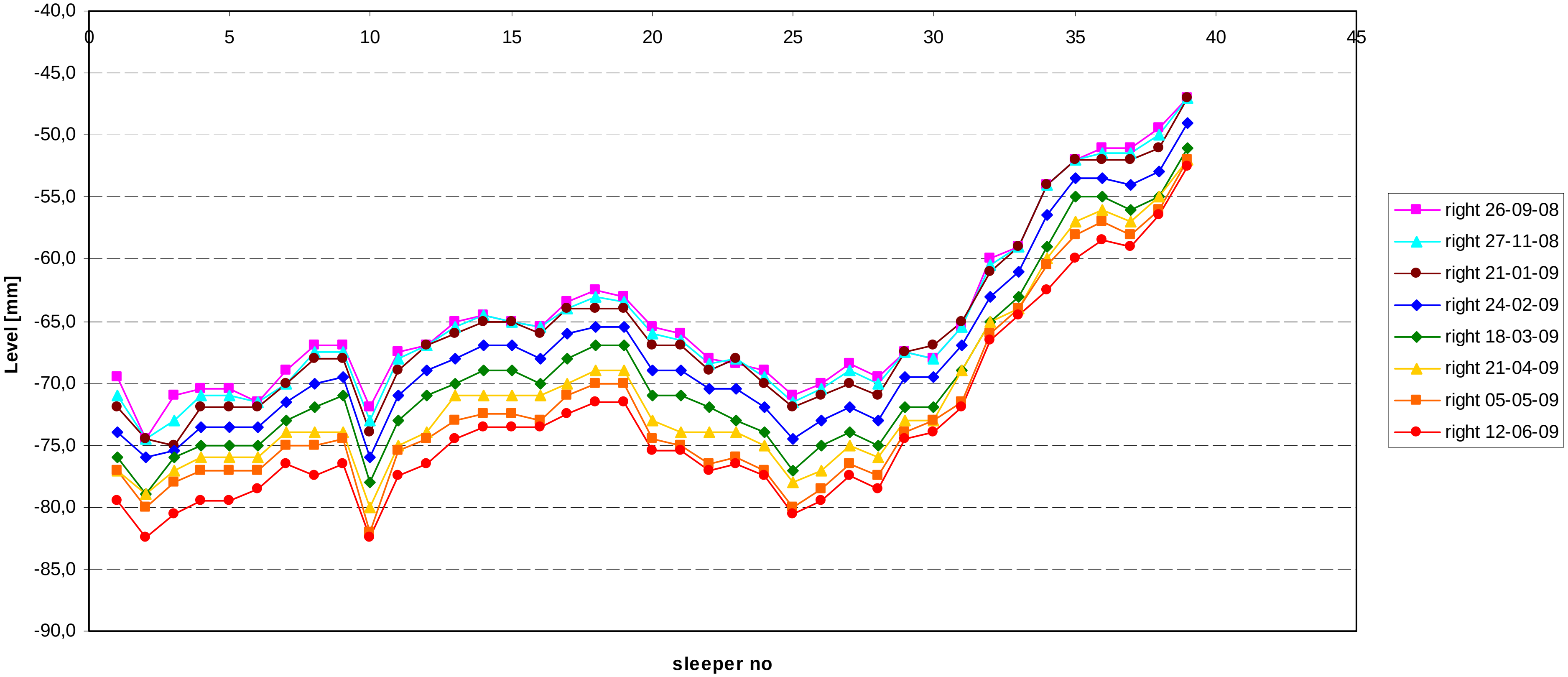

Figure B.2 *Switch levelling right rail “straight” section*

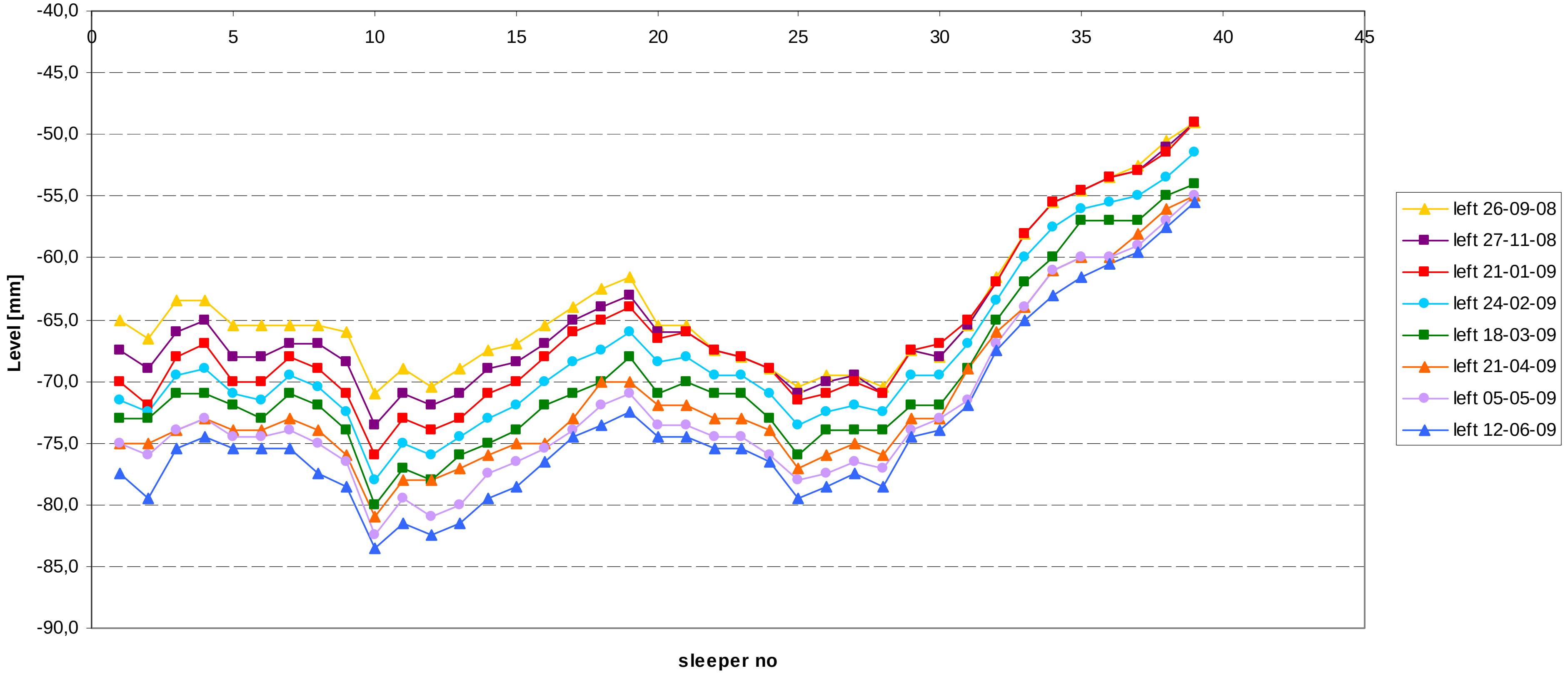

Figure B.3 *Switch levelling left rail "outgoing" section*

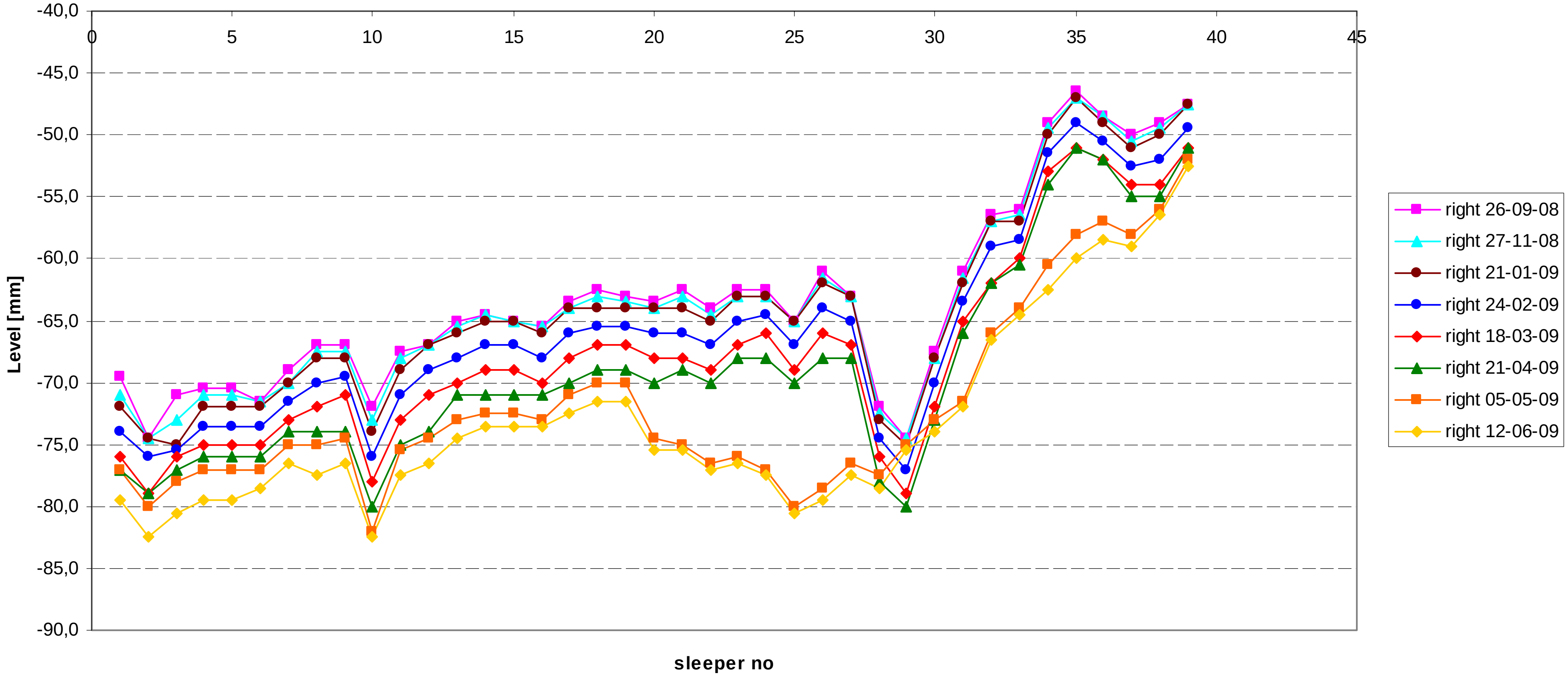

Figure B.4 Switch levelling right rail “outgoing”

C Location of Vortok Void indicators

Schaal 1:150

Legenda: inmeten punten H-codes nabij station Goverwelle te Gouda

C H12 Code new

G–codes baanvak_gouda_woerden_wissel	.dwg	300	21–08–2009

Deltares PO Box 177, 2600 MH Delft, The Netherlands T +31 (0)88 335 7200 www.deltares.nl
Stieltjesweg 2, 2628 CK Delft, The Netherlands F +31 (0)15 261 0821 info@deltares.nl

	date	drw.
	21-08-2009	Ros.
RAILWAY WOERDEN - GOUDA TOP VIEW CULVERT & SWITCH	project 1001069.006	ctr. Pl.
OVERVIEW HANGING SLEEPER INDICATORS	annex	form. 300/1300

D Results of inclinometer measurements

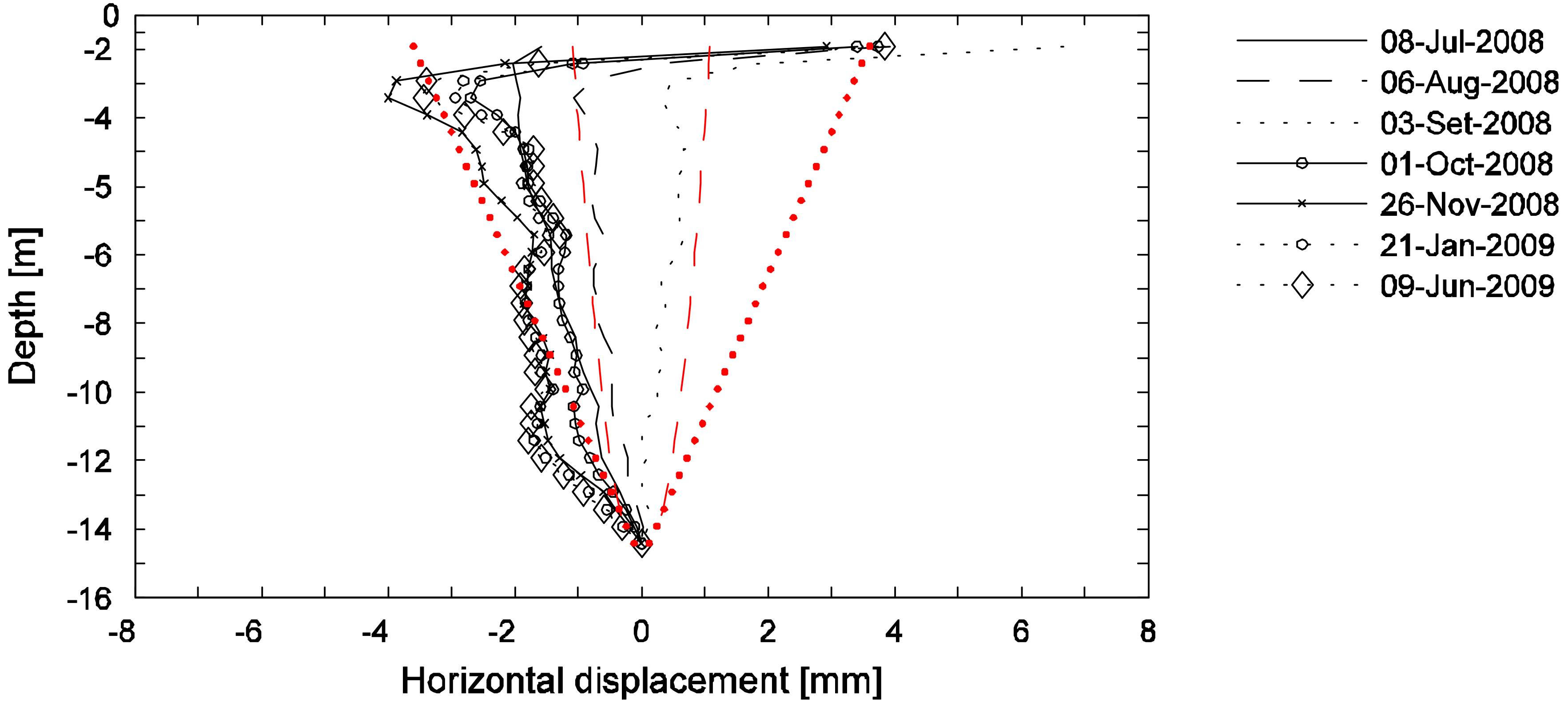

Figure D.1 *Results HMB02 A-direction*

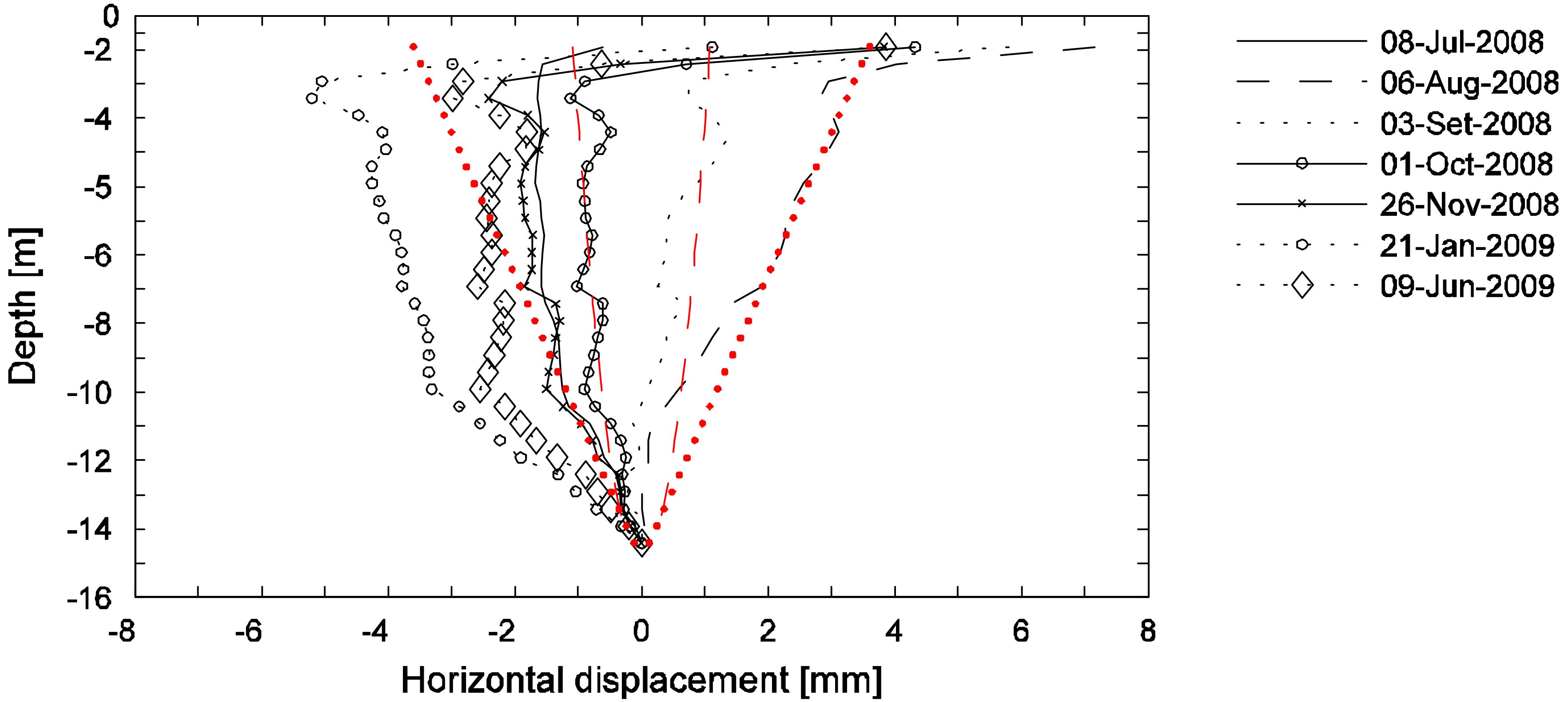

Figure D.1 *Results of HMB03 A-direction*

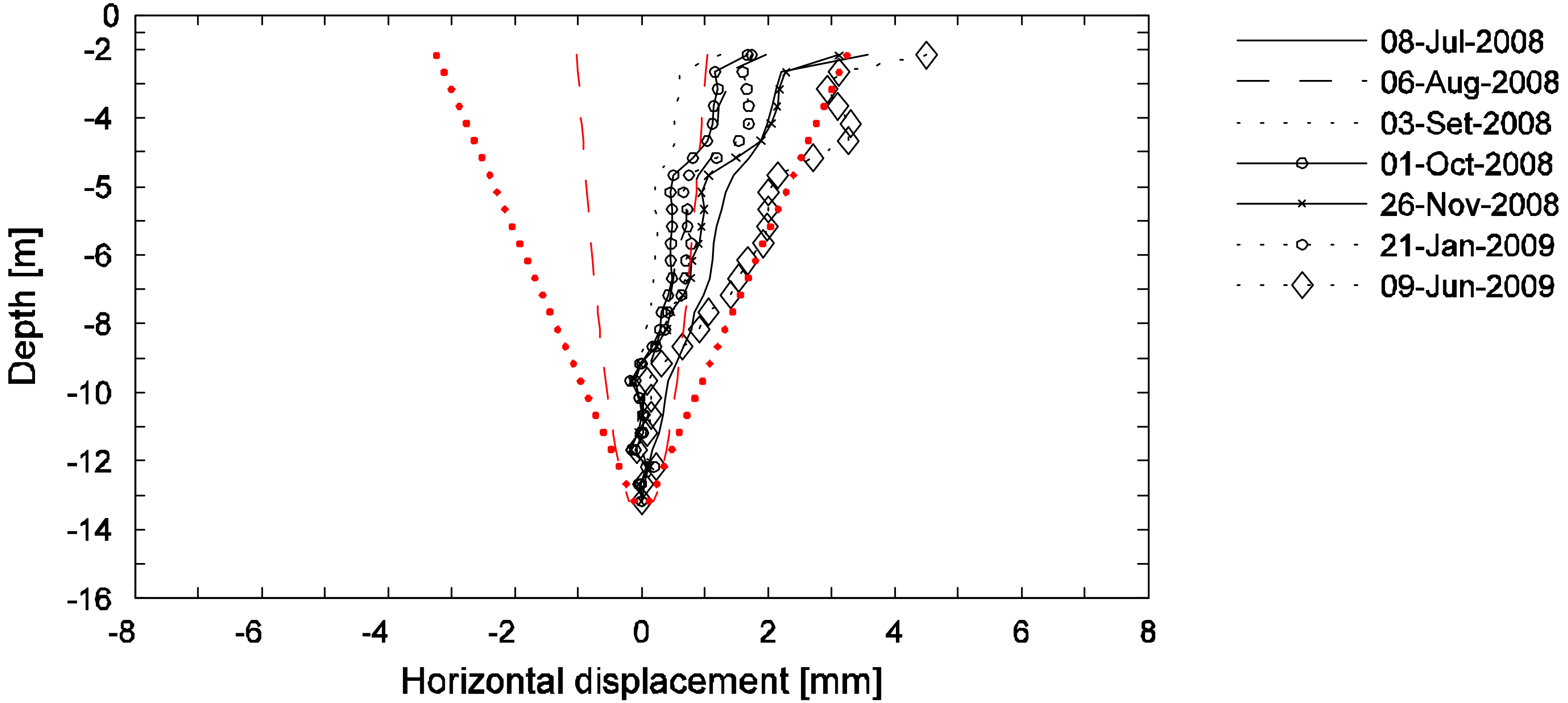

Figure D.2 *Results HMB04 A-direction*

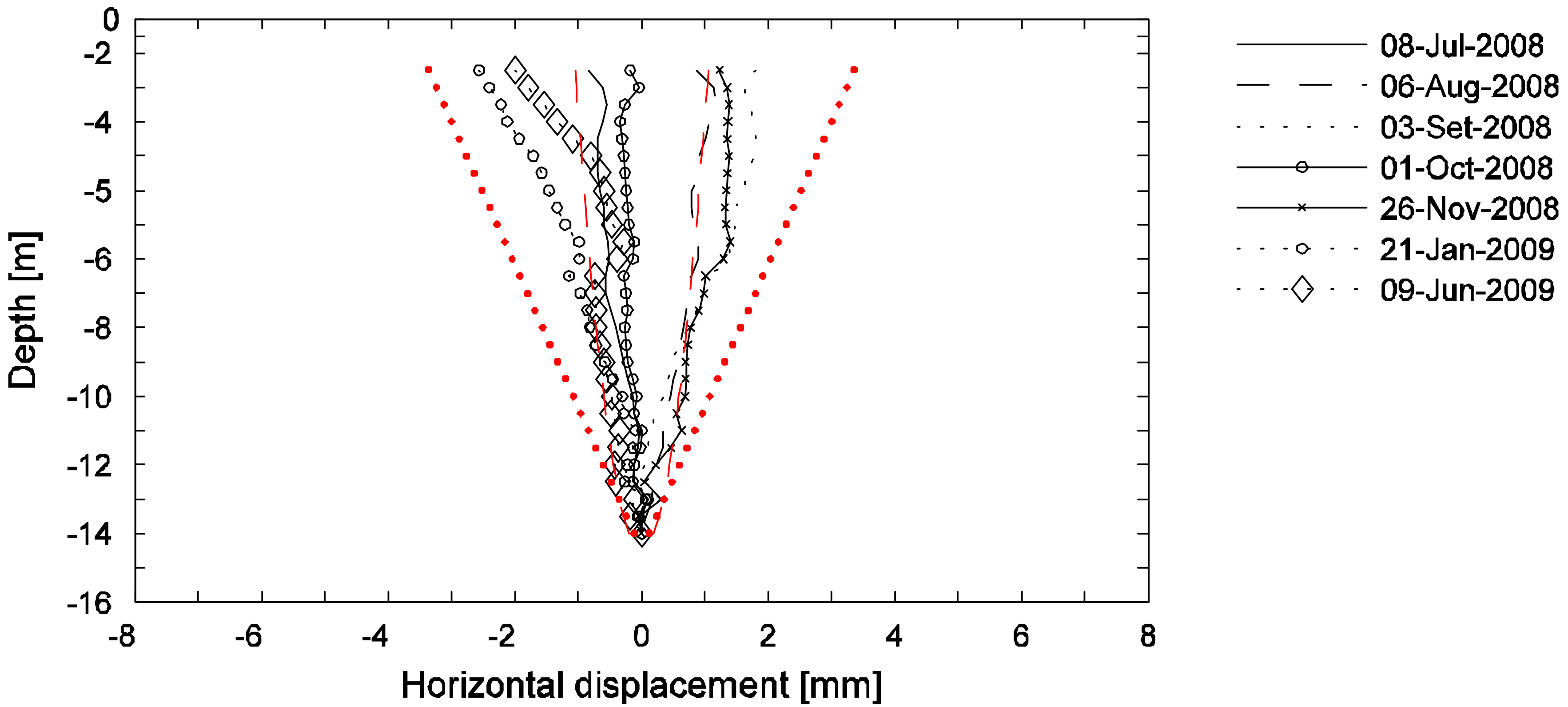

Figure D.3 *Results HMB05 A-direction*

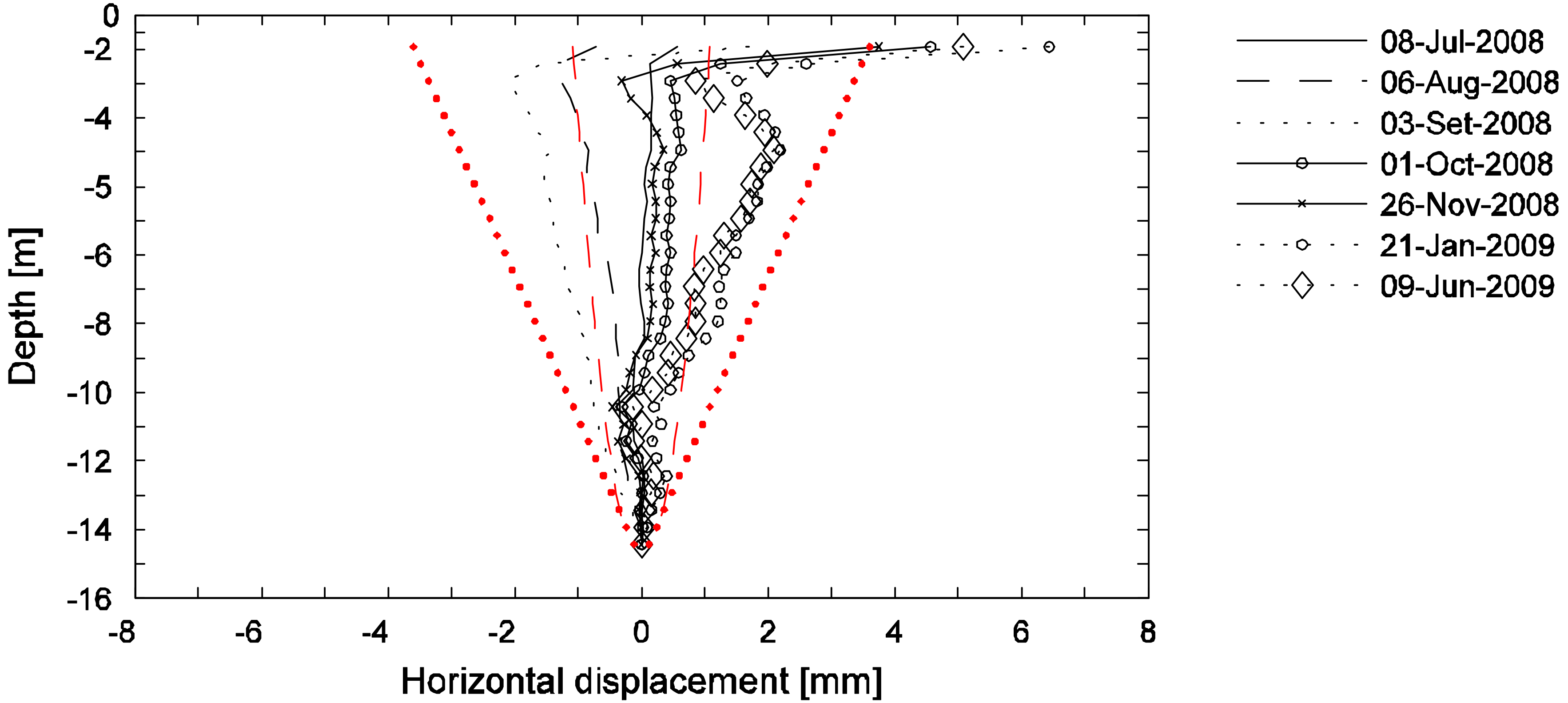

Figure D.4 *Results HMB06 A-direction*

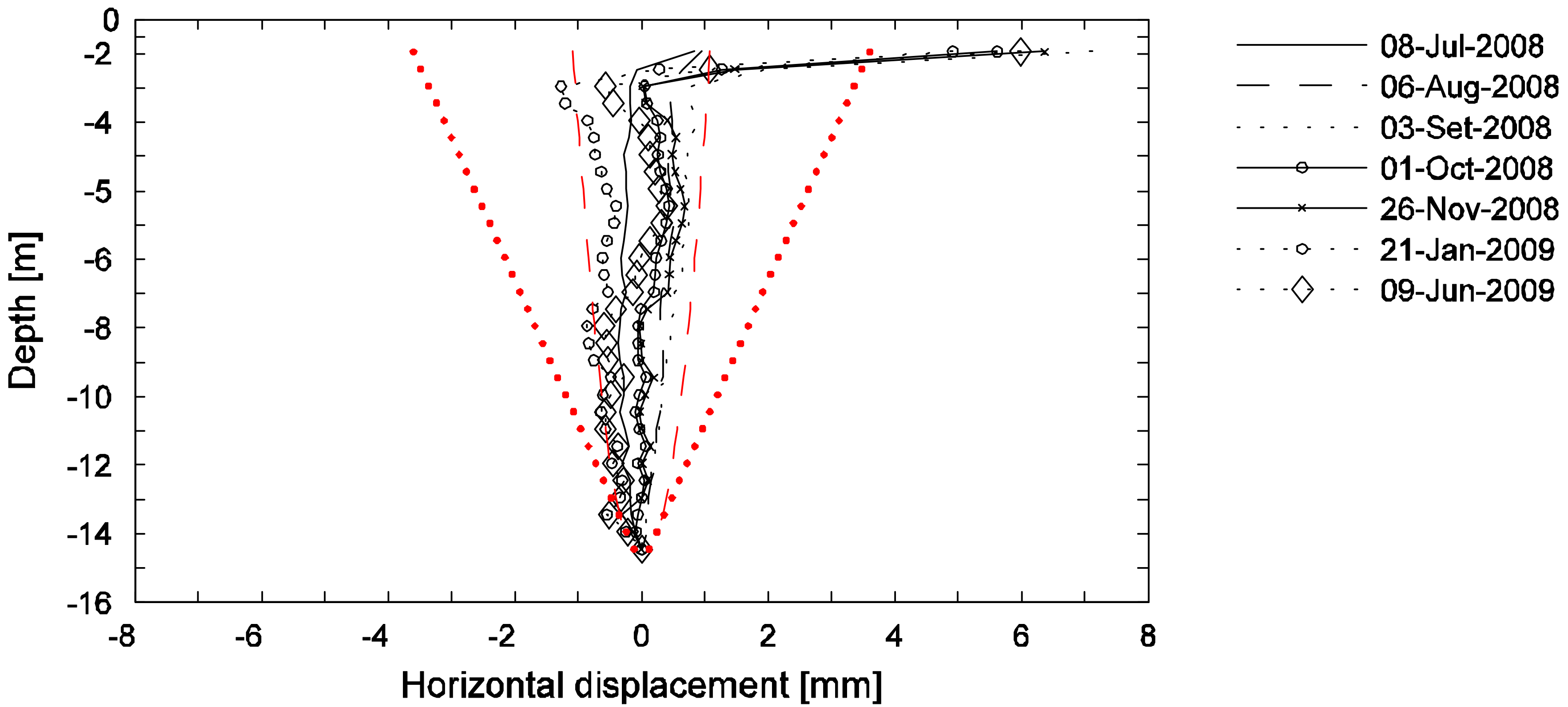

Figure D.5 *Results HMB07 A-direction*

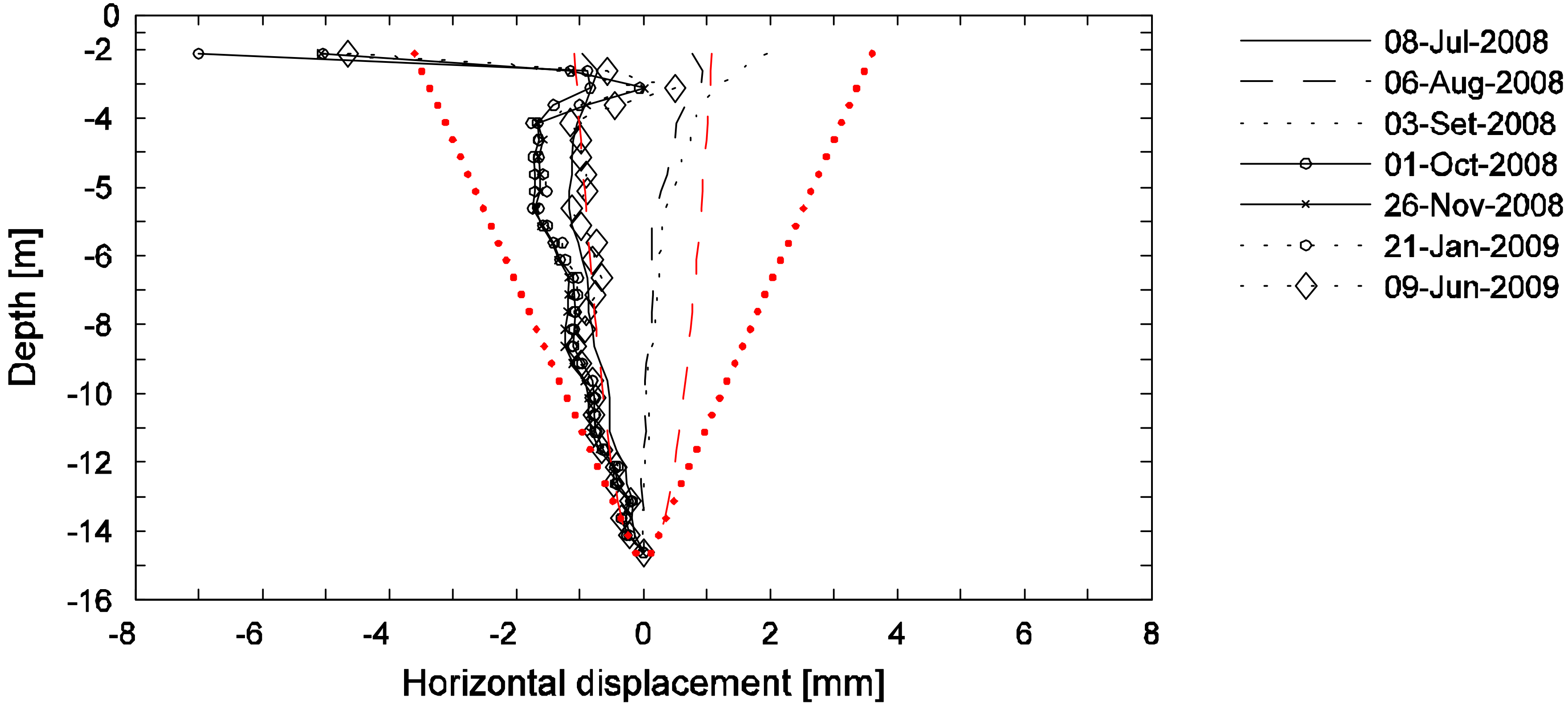

Figure D.6 *Results of HMB08 A-direction*

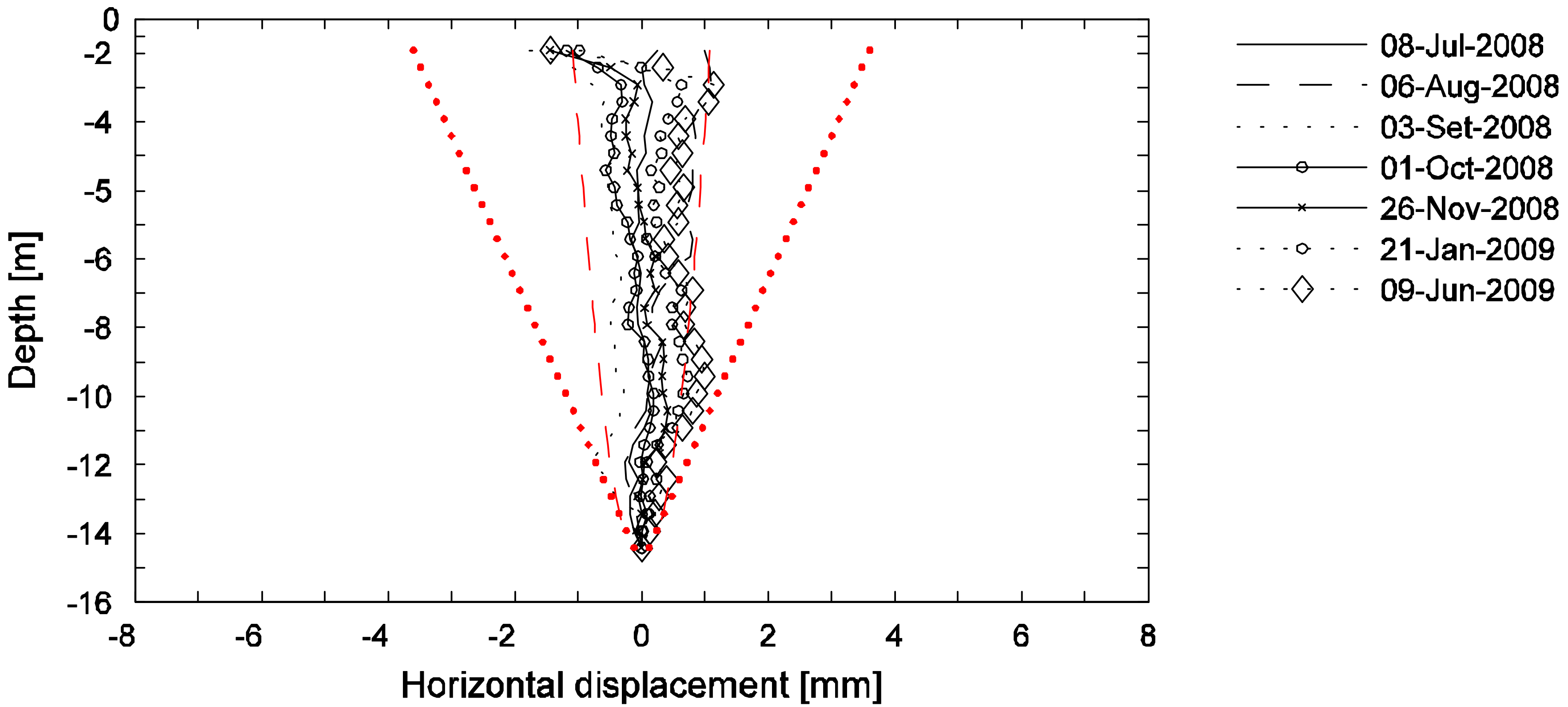

Figure D.7 *HMB02 B-direction*

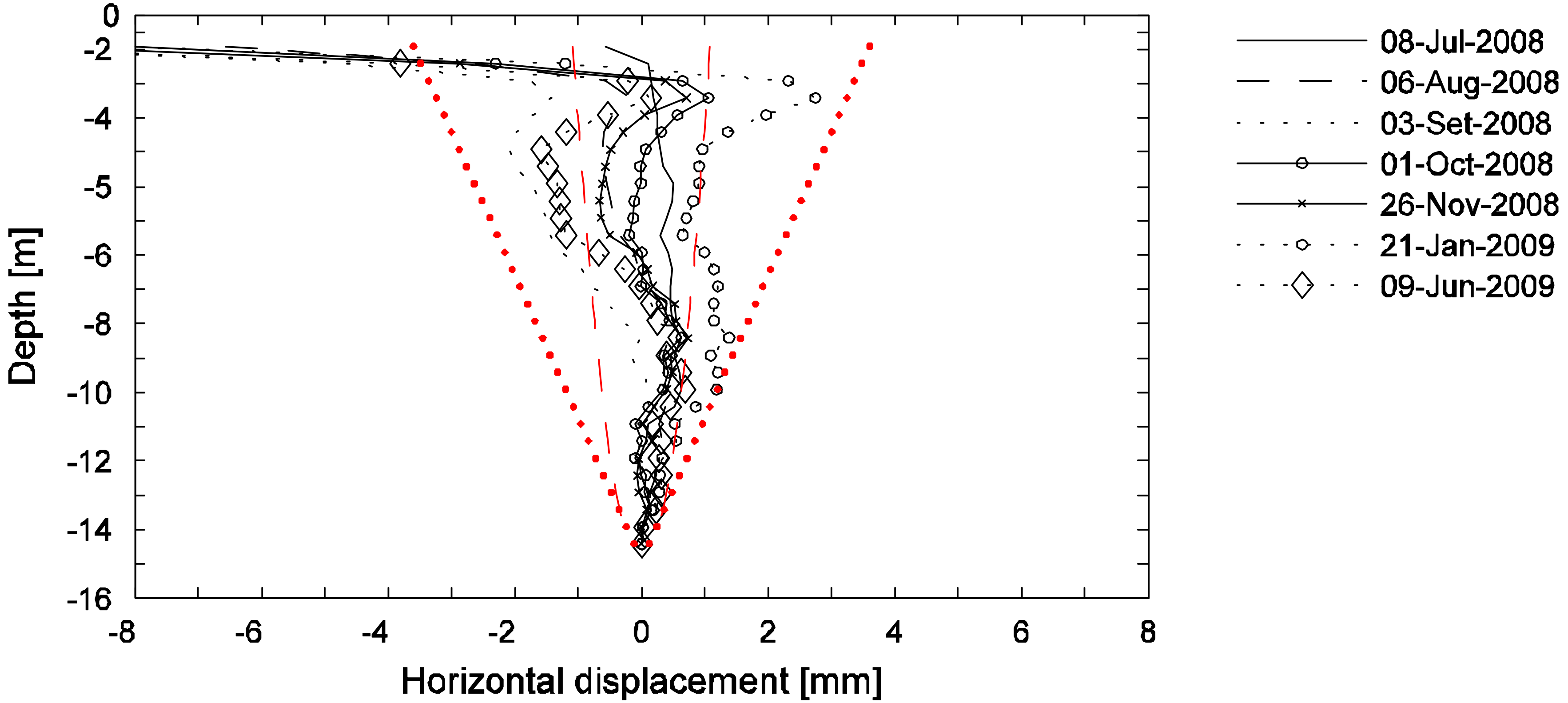

Figure D.8 HMB03 B-direction

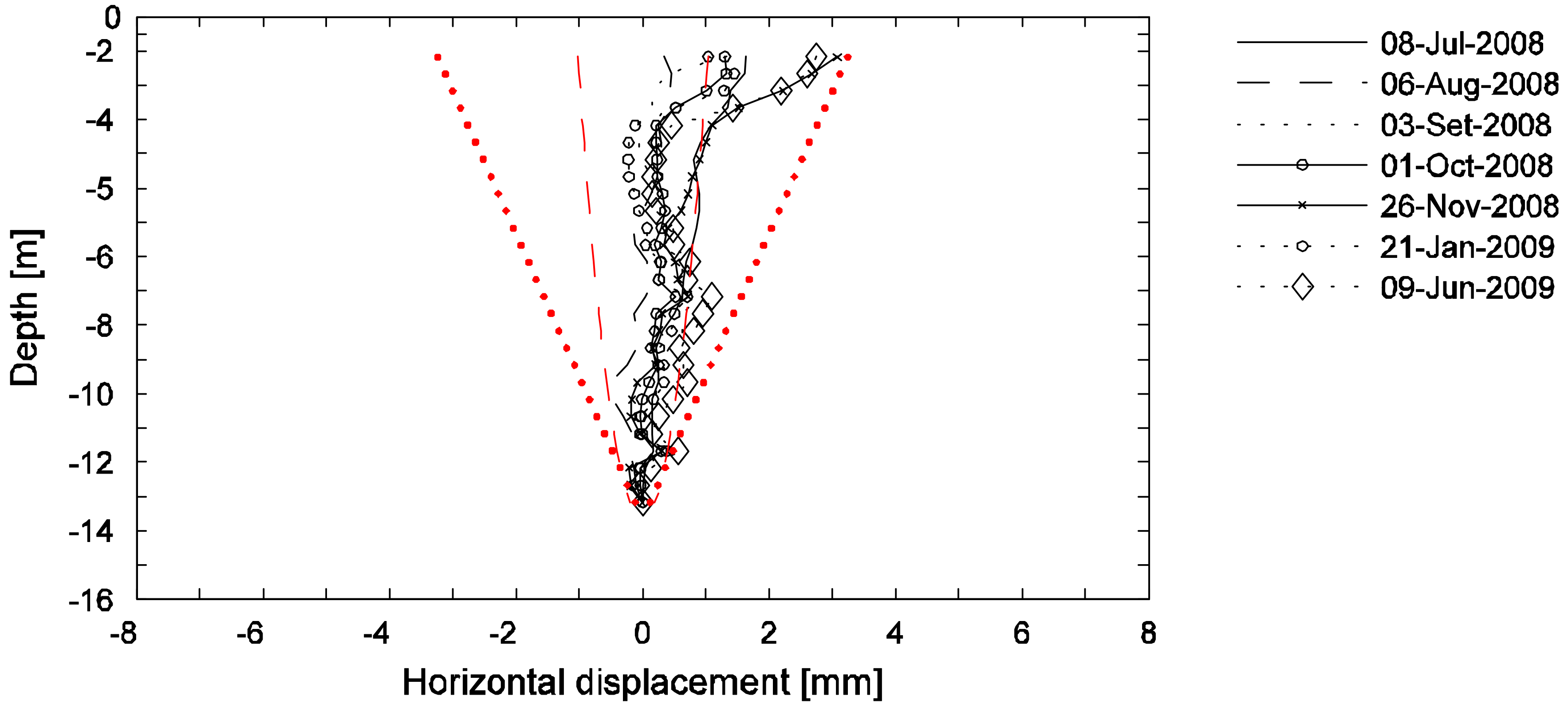

Figure D.9 *HMB04 B-direction*

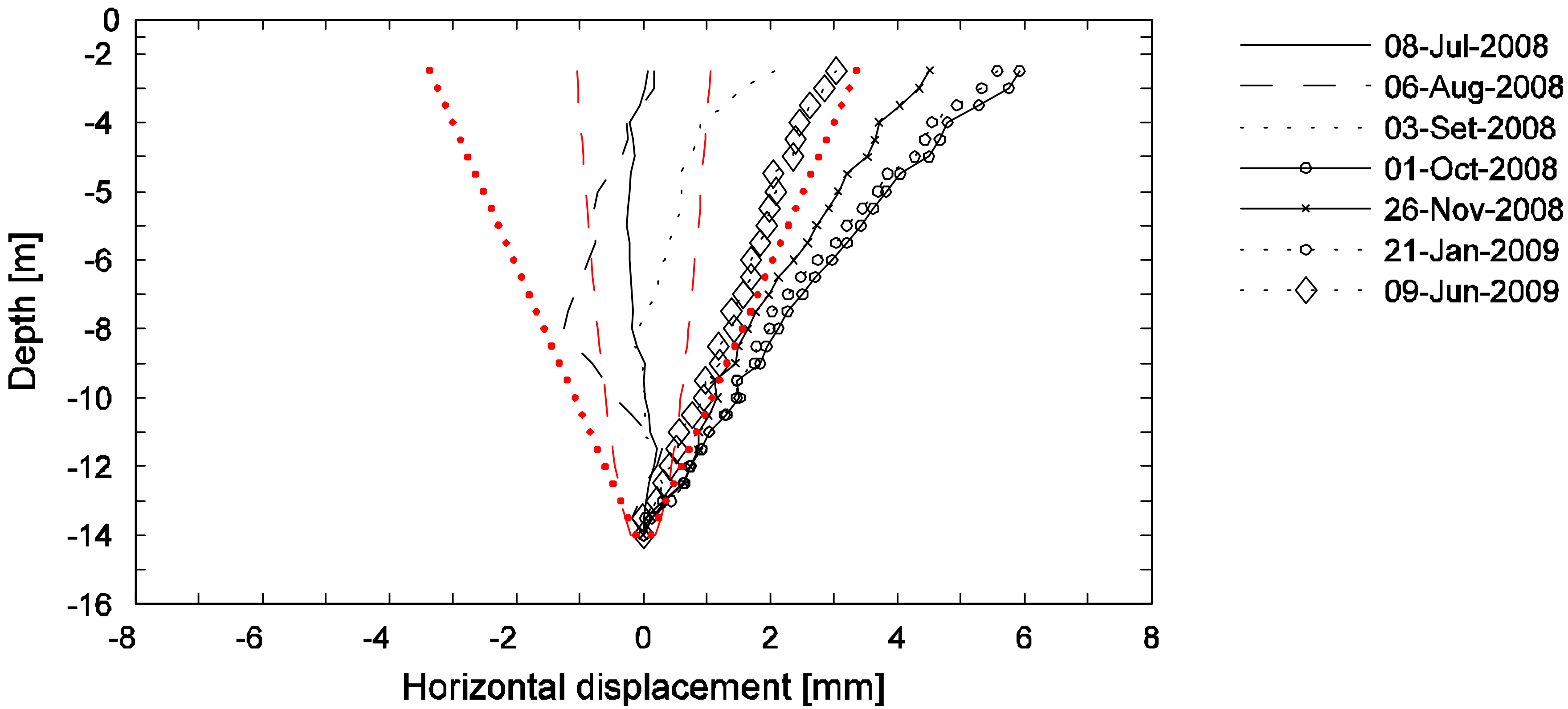

Figure D.10 *HMB05 B-direction*

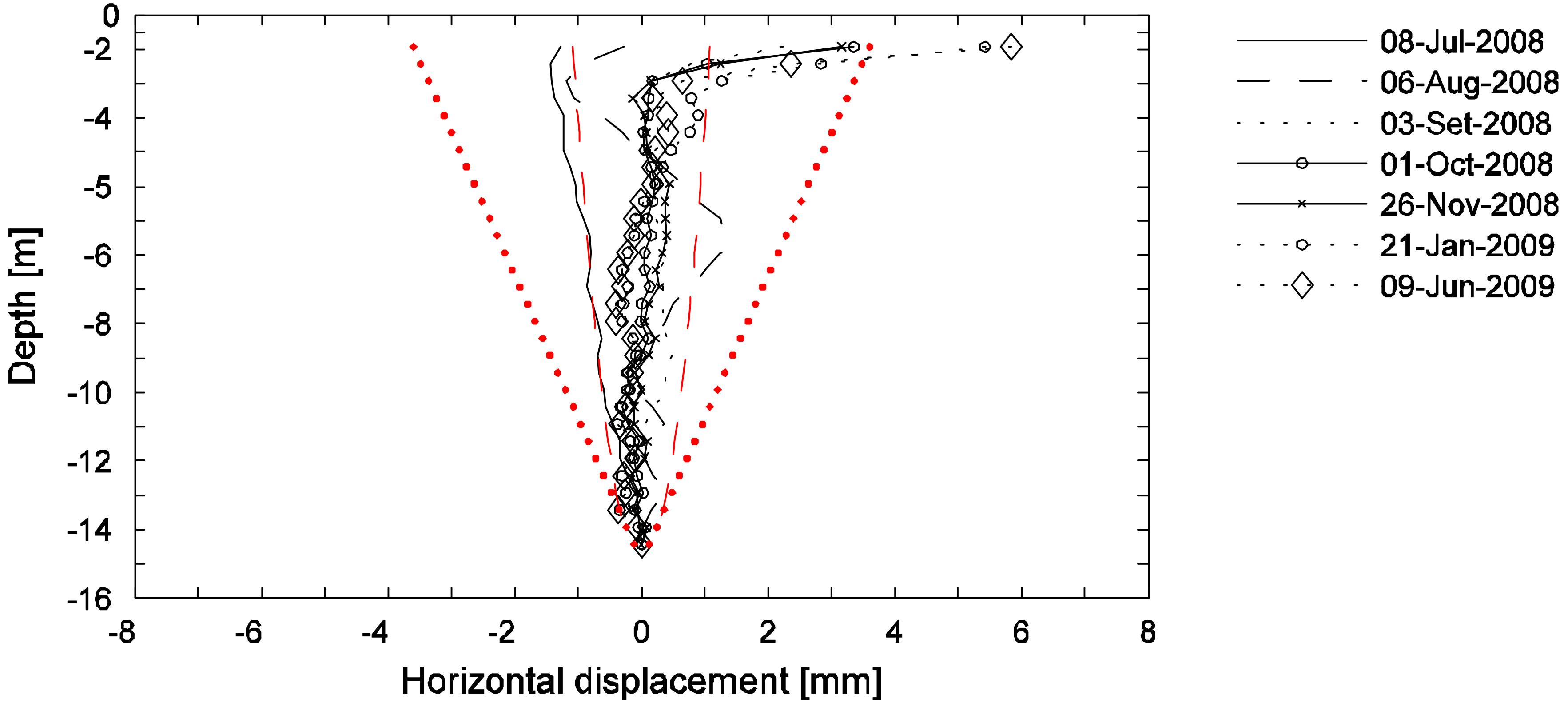

Figure D.11 *HMB06 B-direction*

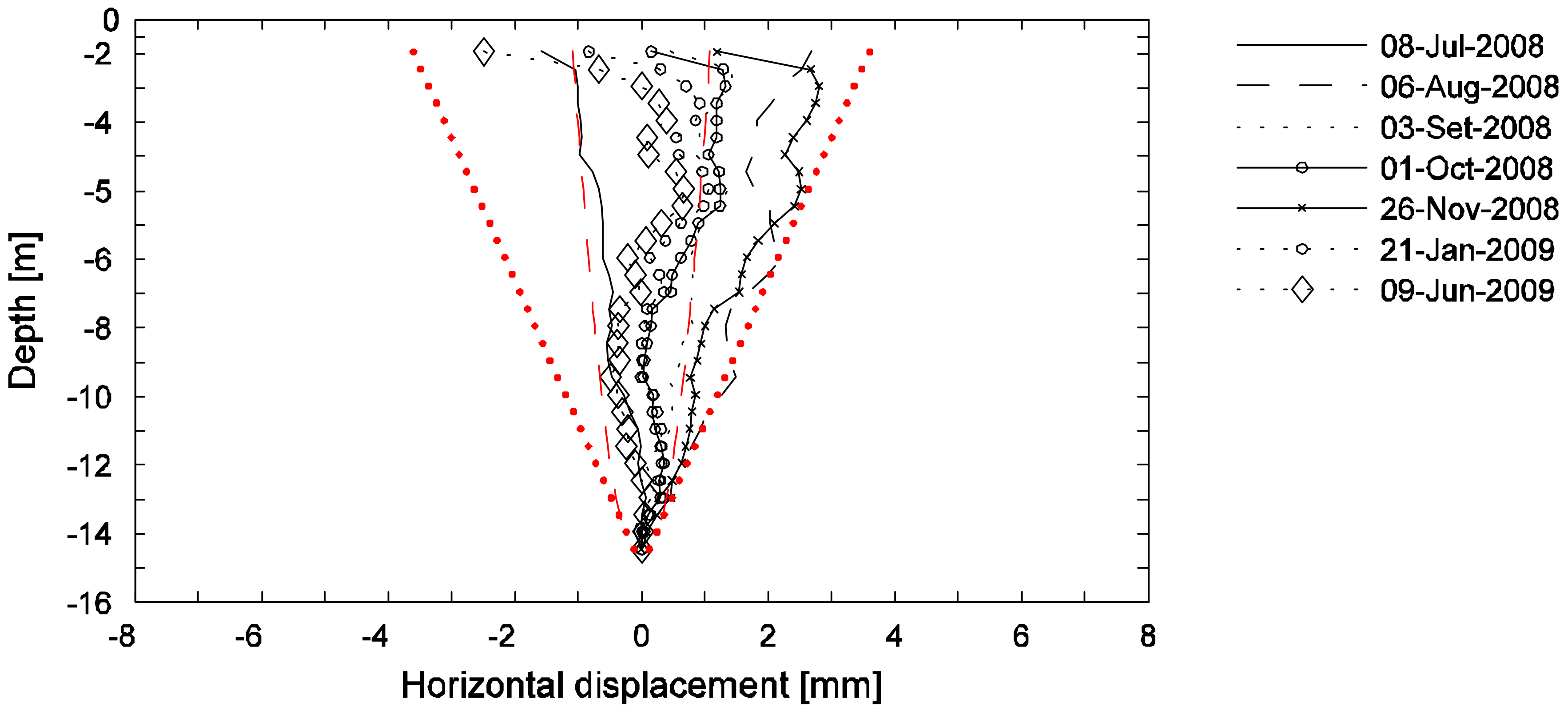

Figure D.12 *HMB07 B-direction*

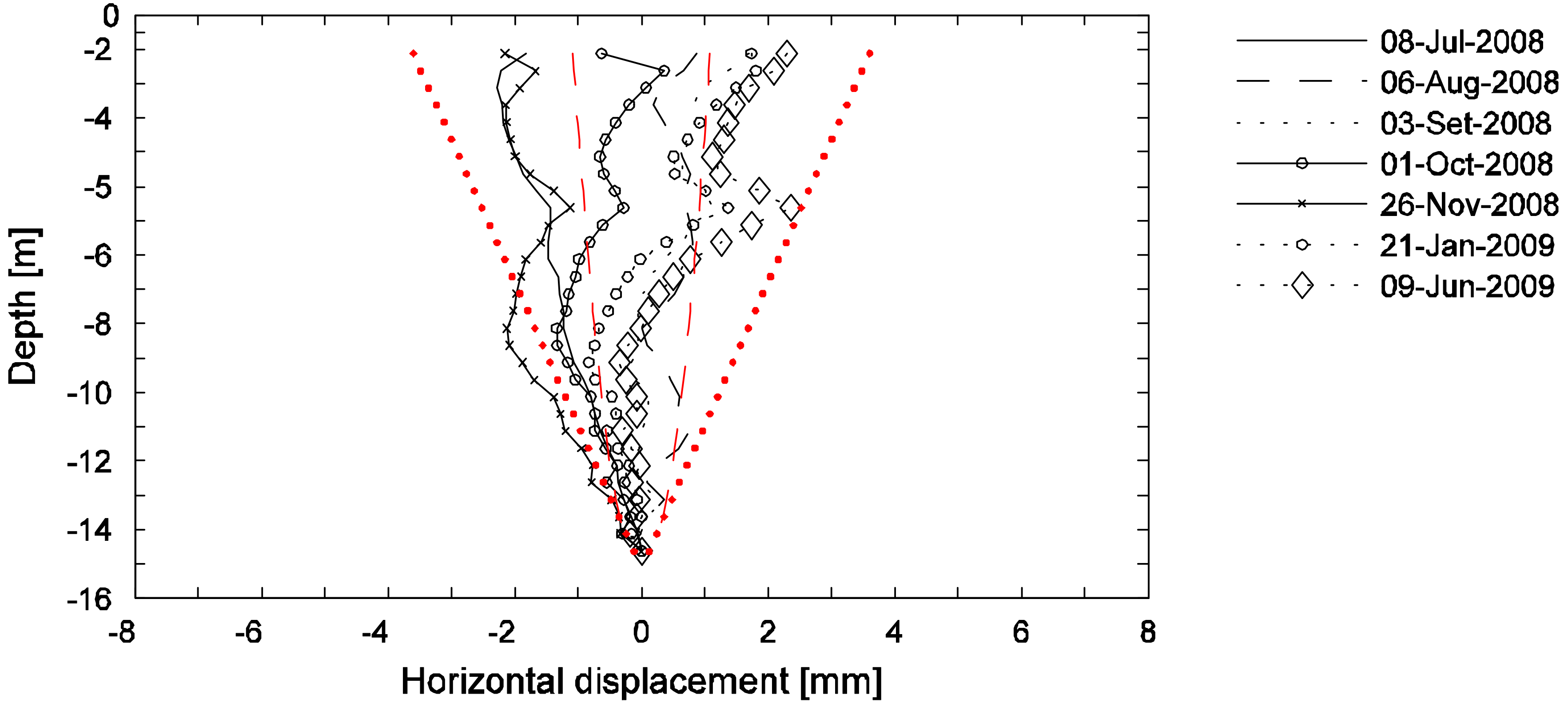

Figure D.13 HMB08 B-direction