Our Ref: DV/BC/J12093

Southern Testing
Environmental & Geotechnical

Keeble House, Stuart Way
East Grinstead, West Sussex RH19 4QA

t 01342 333100 f 01342 410321
e info@southerntesting.co.uk w southerntesting.co.uk

11th November 2016

Tully De'Ath Consultants
Sheridan House
Hartfield Road
Forest Row
East Sussex - RH18 5EA

For the attention of Mr T Purchase

Dear Tom,

Re: Kidderpore Avenue, Impact of the Proposed Basement Construction on the Thames Water Utility Pipe in terms of Ground Movements.

We write further to your request to carry out an assessment of the impact of the proposed construction on the Thames Utility Water Main located in Croft Way close to the south eastern boundary of the site. This letter report summarises the results of the analysis.

1 Assumptions and models used for the analysis of ground movements

The construction of the proposed Lord Cameron Building and Rosalind Franklin Building will result in a series of ground movements which could potentially affect the Thames Water Utility Pipe. For the purpose of the assessment criteria of the utility cast iron pipe the following was adopted:

- Maximum Allowable Tensile strain = 100με
- Maximum Allowable Compressive Strain = 1200με
- Maximum Allowable joint rotation = 0.1 degree
- Maximum Allowable joint pull out = 3mm
- Axial strain reduction factor = 0.2
- Pipe internal diameter = 21" (533.4mm)
- Pipe Thickness = 1.06" (26.9)
- Pipe Segmental length = 12 feet (3657.6mm)

The various scenarios (cases) considered in the analysis are as follows:

Case 1: Demolition of the Existing Lord Cameron Building and Rosalind Franklin Buildings which will give rise to soil unloading movements. For the purpose of the analysis an unload pressure of 48kPa has been assumed to model the loading from both buildings.

Case 2: Combined effects of soil unloading from demolition of the building and installation of piled foundations and piled walls located closest to the Thames Water Pipe. For the purpose of the analysis the closest discrete piles/piled walls have been modelled as a series of piled walls (see Figure C1: Appendix B). It is considered that where discrete piles have been modelled as piled walls is a conservative approach.

Case 3: Combined effects of soil unloading from demolition of the building, installation of piled foundations and piled walls located closest to the Thames Water Pipe and excavation in front of the piled walls.

Case 4: As per **Case 3** above together with reloading of the soils and soil unloading due excavations associated with the construction of the proposed Lord Cameron Building and Rosalind Franklin Buildings. While these structures are to be founded on piles they have been conservatively modelled as equivalent UDL's over their respective footprints. In the case of the Lord Cameron Building a UDL of 45kPa has been adopted and 60kPa for Rosalind Franklin.

Case 5: As per **Case 4** but for the long-term drained condition.

Cases 1-4 assume that there is no delay in the construction program and the soil responses are all short term (undrained) movements within the underlying Claygate Member and London Clay Formations.

Information relating to proposed pile lengths, existing and proposed formation levels were provided by the Structural Engineers Tully De'Ath (refer Appendix A).

1.1 Soil Model Adopted

The effect of demolition of the existing buildings, excavation of the soils to form the basements and sunken courtyard area and the reloading affects associated with the proposed construction will cause changes in vertical stress at the new formation levels. This resulting vertical ground movements are normally modelled as producing a short-term (undrained) response followed by a longer term (drained) response. The predicted ground responses have been modelled using the OASYS program PDISP. This program assumes a linear elastic behaviour of the soil and a flexible structure. In reality, the finite stiffness of the structure(s) and will tend to redistribute or smooth out the movements, when compared to those predicted by PDISP. The settlement calculations therefore represent free field movements unaffected by the stiffness of the structure(s) and are likely to be conservative (i.e. the distortions of the structure would be less than those obtained from the predicted movements).

The rigid base for the analysis was taken as 0.0m OD. Existing site levels vary between approximately 90-91m OD.

The elastic soil stiffness parameters of the underlying Claygate Member (which typically extends down to approximately 8m below site levels) and London Clay have been estimated using the following relationships:

E_u=425xCu (where E_u is the undrained soil stiffness and C_u is the undrained stiffness)
E'=0.75E_u (where E' is the drained stiffness)

An undrained Poisson's ratio of 0.5 and drained Poisson's ratio of 0.2 have been adopted.

On the basis of the findings of the ground investigation, the undrained shear strength of the Claygate Member is on average 50kPa. The C_u at the top of the London Clay is estimated to be 86kPa thereby increasing at 4kPa/metre depth.

It should be noted that the vertical movements due to changes in vertical stress take no account of the effect of the proposed piled foundations and piled walls to restrain vertical movements of the soil. It should also be noted that in practice, the heave movements that develop outside of the basement areas from unloading/reloading of the soils do not occur in isolation from other ground movements associated with basement construction and excavations (as discussed below).

1.2 Movements due to pile installation and Excavation in Front of the Walls

In addition to the changes in vertical stress caused by demolition and excavation of the soil to form the basement/sunken courtyard areas, the installation of piled walls, and then the removal of soil from in front of the new walls will also generate both horizontal and vertical movement in the ground. Assessment of the ground movements resulting from the pile installation and the excavation to form the basement has been undertaken with reference to CIRIA guide C580 "Embedded retaining walls – guidance for economic design". This provides guidance on the horizontal and vertical movements of the soil adjacent to an embedded retaining wall as a result of pile installation and of excavation in front of the wall based on numerous case histories, for the case of a high stiffness (propped) retaining wall and a low stiffness (cantilevered) retaining wall.

Estimates of movements due to pile installation and basement excavation using CIRIA guide C580, are based on empirical data. Since such data is likely collected during and soon after construction, it is assumed to include any short term heave element. However, long-term ground movements from changes in vertical stress would likely not have occurred when the measurements of ground movement were made.

1.2.1 Movements due to Pile Installation

Ground movement guidance in C580 is divided into movements resulting from pile installation and from the mass excavation in front of the wall. However, the empirically derived relationship for ground movements resulting from pile installation given in the CIRIA guide is now considered to be overly conservative, since more recent projects have demonstrated that significantly smaller movements can be achieved with good quality workmanship, with negligible horizontal movements caused by pile installation, and vertical movements limited to 0.025% of pile length, and extending no more than 1.5 times the pile length from the pile wall.

1.2.2 Movements due to Excavation in Front of the Piled Wall

The methodology within C580 indicates that the excavation to create the basement will, for a high stiffness (propped) wall, produce horizontal movements of 0.15% of the excavation depth at the wall, with movements extending to four times the depth of the excavation, while peak vertical movements will be about 0.1% of the excavation depth, with such movements becoming zero at 3.5 times the depth of the excavation. Horizontal movements will decrease in a generally linear fashion with distance from the wall, whereas vertical movements peak at about half the excavation depth from the wall, with movements at the wall being about 0.05% of the excavation depth.

The movements derived from the CIRIA guidance are based on the empirical data within C580. As such, it is assumed that they include any short term element of ground movement due to vertical stress change. However, it is unlikely that the C580 data includes the long-term movements resulting from vertical stress

changes. Therefore for the **Case 5** scenario total ground movements resulting from the proposed development are therefore taken as the sum of the predicted ground movements using C580, plus the difference in estimated PDISP movements between short and long-term conditions.

1.3 Method of Analysis

Analysis of movements associated with installation of the piled wall models and excavation to the front of the walls was carried out using the Oasys program XDISP. For each case considered vertical movements associated with unloading and reloading of the soils were modelled using the Oasys program PDISP. The damage assessments to the TWA pipe were carried out using XDISP together with movements imported from the PDISP analysis.

Case 1

"Demolition of the Existing Lord Cameron Building and Rosalind Franklin Buildings and soil unloading movements."

The short-term (undrained) analysis undertaken using PDISP indicates that within the central area heave movements likely to arise as a result of the demolition of the buildings are in the region of about 12-15mm (see Figure U1 Appendix B). As noted previously for the purpose of the analysis the closest piles/piled walls to the TWA pipe have been modelled as a series of piled walls (see Figure C1 Appendix B). Displacement Lines 1 and 2 were input into the model to assess the movements along the TWA pipe line and to carry out the damage assessment to the pipe using XDISP. Based upon the information provided by Thames Water, the top of the pipe varies between 90.0mOD and 90.3mOD and in this instance (for modelling purposes) an average value of 90.15mOD for the top of the pipe has been adopted.

The movements along to pipe route are given in Figures Case 1/Lines 1 and 2 (Appendix B) along with the output from XDISP of the damage assessment to the pipe. A summary of the maximum values of tensile strain, compressive strain, joint rotation, and joint pull out are summarised below:

Assessment Criteria		Predicted
Tensile Strain	100με	6.169 με
Compressive Strain	1200 με	6.166 με
Joint Rotation	0.1°	0.0043°
Joint Pull Out	3mm	0.0442mm

No exceedances of the above assessment criteria were noted.

Case 2

"Combined effects of soil unloading from demolition of the building and installation of piled foundations and piled walls located closest to the Thames Water Pipe."

For this case the movements along to pipe route are given in Figures Case 2/Lines 1 and 2 (Appendix C) along with the output from XDISP of the damage assessment to the pipe. A summary of the maximum values of tensile strain, compressive strain, joint rotation, and joint pull out are summarised below:

Assessment Criteria		Predicted
Tensile Strain	100με	90.338 με
Compressive Strain	1200 με	90.315 με
Joint Rotation	0.1°	0.0535°
Joint Pull Out	3mm	0.554mm

No exceedances of the above assessment criteria were noted.

Case 3

"Combined effects of soil unloading from demolition of the building, installation of piled foundations and piled walls located closest to the Thames Water Pipe and excavation in front of the piled walls."

During the initial analysis it was assumed that the wall in the area of the sunken courtyard would be a low stiffness (cantilevered) wall. However in the subsequent analysis tensile strains of >100με were predicted in the pipe in several pipe locations. Accordingly it was necessary to revise the model to a high stiffness (propped) retaining wall conditions for all walls.

For this case the movements along to pipe route are given in Figures Case 3/Lines 1 and 2 (Appendix D) along with the output from XDISP of the damage assessment to the pipe. A summary of the maximum values of tensile strain, compressive strain, joint rotation, and joint pull out are summarised below:

Assessment Criteria		Predicted
Tensile Strain	100με	79.704 με
Compressive Strain	1200 με	270.845 με
Joint Rotation	0.1°	0.0569°
Joint Pull Out	3mm	0.793mm

No exceedances of the above assessment criteria were noted.

Case 4

As per Case 3 above together with reloading of the soils and soil unloading due excavations associated with the construction of the proposed Lord Cameron Building and Rosalind Franklin Buildings.

For this case the movements along the pipe route are given in Figures Case 4/Lines 1 and 2 (Appendix E) along with the output from XDISP of the damage assessment to the pipe. A summary of the maximum values of tensile strain, compressive strain, joint rotation, and joint pull out are summarised below:

Assessment Criteria		Predicted
Tensile Strain	100με	82.885 με
Compressive Strain	1200 με	271.777 με
Joint Rotation	0.1°	0.0604°
Joint Pull Out	3mm	0.822mm

No exceedances of the above assessment criteria were noted.

Case 5:

As per Case 4 above but for the long-term drained condition.

As noted previously the movements derived from the CIRIA guidance are based on the empirical data within C580. As such, it is assumed that they include any short term element of ground movement due to vertical stress change. However, it is unlikely that the C580 data includes the long-term movements resulting from vertical stress changes. Therefore for the Case 5 scenario total ground movements resulting from the proposed development are therefore taken as the sum of the predicted ground movements using C580, plus the difference in estimated PDISP movements between short and long-term conditions.

For this case the movements along to pipe route are given in Figures Case 5/Lines 1 and 2 (Appendix F) along with the output from XDISP of the damage assessment to the pipe. A summary of the maximum values of tensile strain, compressive strain, joint rotation, and joint pull out are summarised below:

Assessment Criteria		Predicted
Tensile Strain	100με	81.669 με
Compressive Strain	1200 με	271.397 με
Joint Rotation	0.1°	0.05814°
Joint Pull Out	3mm	0.810mm

No exceedances of the above assessment criteria were noted.

1.4 Comments

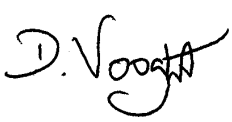
In summary the analyses for the proposed works has established that for the short and long term conditions the predicted movements for the various scenarios (cases) considered do not give rise to any exceedances in relation to the assessment criteria considered.

The above assumes that good quality working practice during pile construction is employed and that appropriate propping (temporary and permanent) of the excavation/walls is maintained at all times to achieve "high stiffness" wall conditions.

A formal monitoring system should be employed during construction in order to observe and monitor ground movements. Monitoring data should be checked against predefined trigger limits to give early indications if any deviating ground movements are occurring.

If you have any further queries or we can be of further assistance, please do not hesitate to contact us.

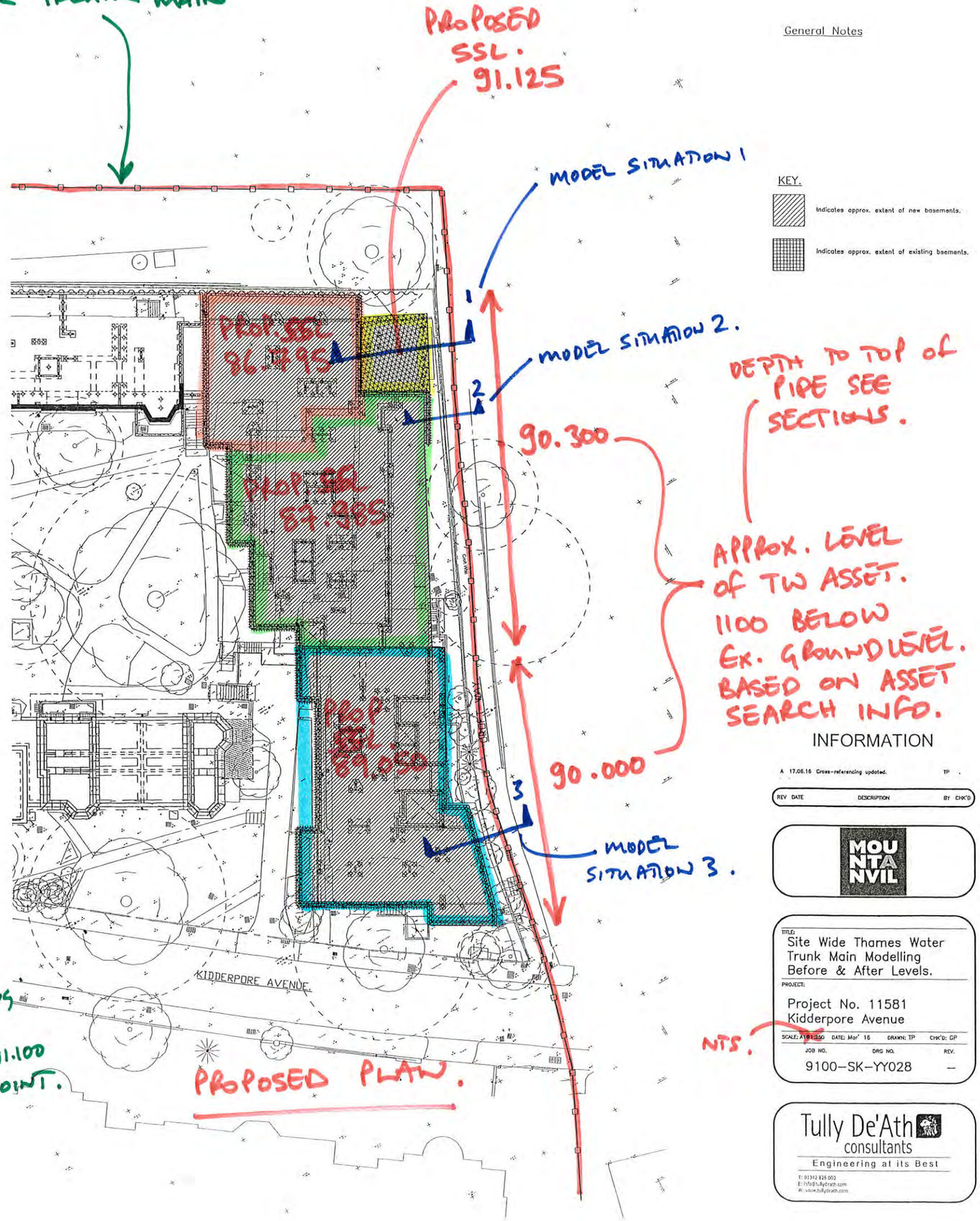
Yours sincerely,



D Vooght
For and on behalf of
Southern Testing Laboratories Limited
DDI: 01 342 333130

APPENDIX A

Engineers Sketches of Existing and Proposed Structures



General Notes

KEY.

Indicates approx. extent of new basements.

Indicates approx. extent of existing basements.

INFORMATION

REV	DATE	DESCRIPTION	BY	CHK'D
A	17.06.16	Cross-referencing updated.	TP	.

MOUNTAINVIL

TITLE:
Site Wide Thames Water Trunk Main Modelling Before & After Levels.

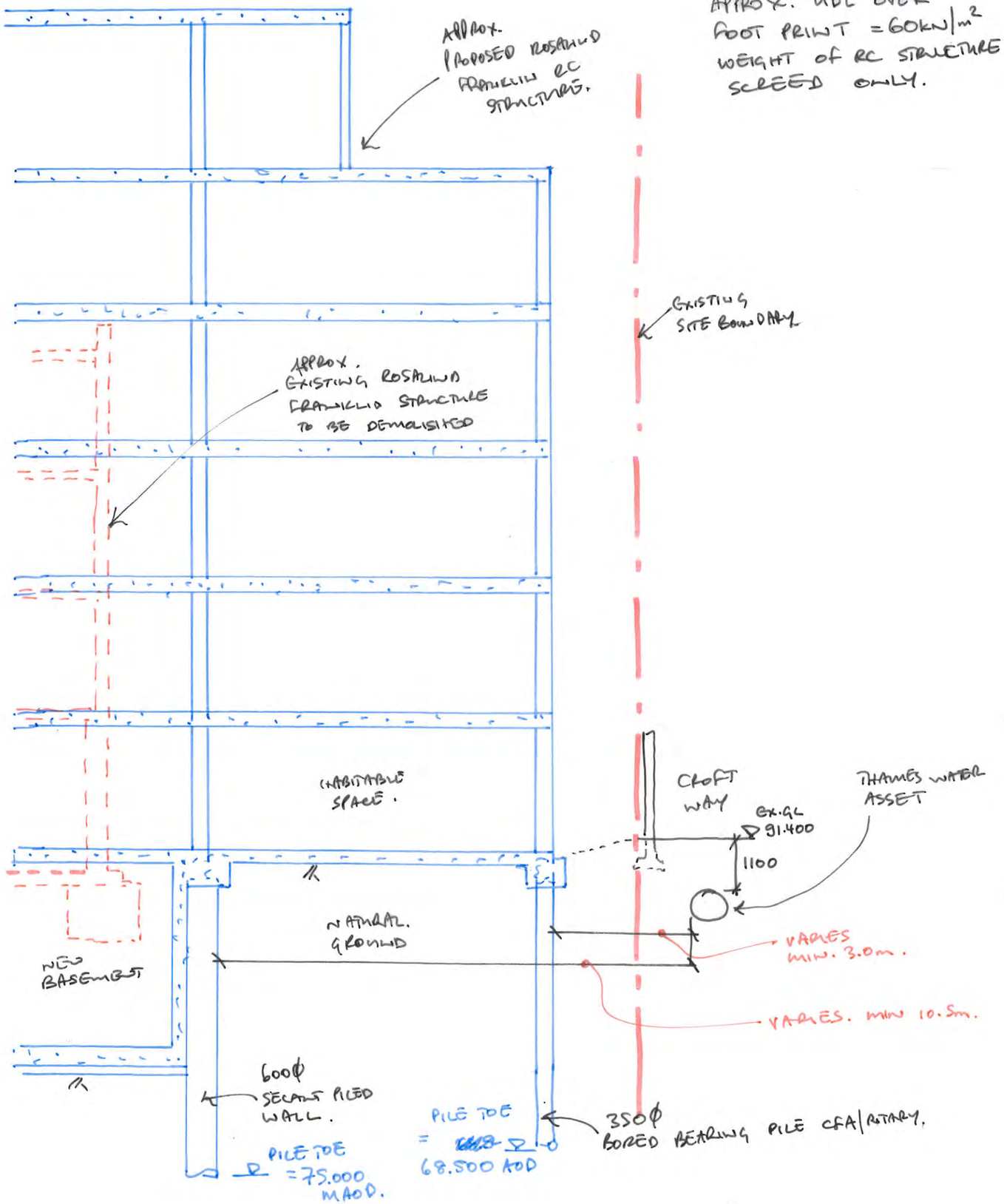
PROJECT:
Project No. 11581
Kidderpore Avenue

SCALE: A1@1:250	DATE: Mar' 16	DRAWN: TP	CHK'D: GP
JOB NO.	DRG NO.	REV.
	9100–SK–YY028	–

NTS.

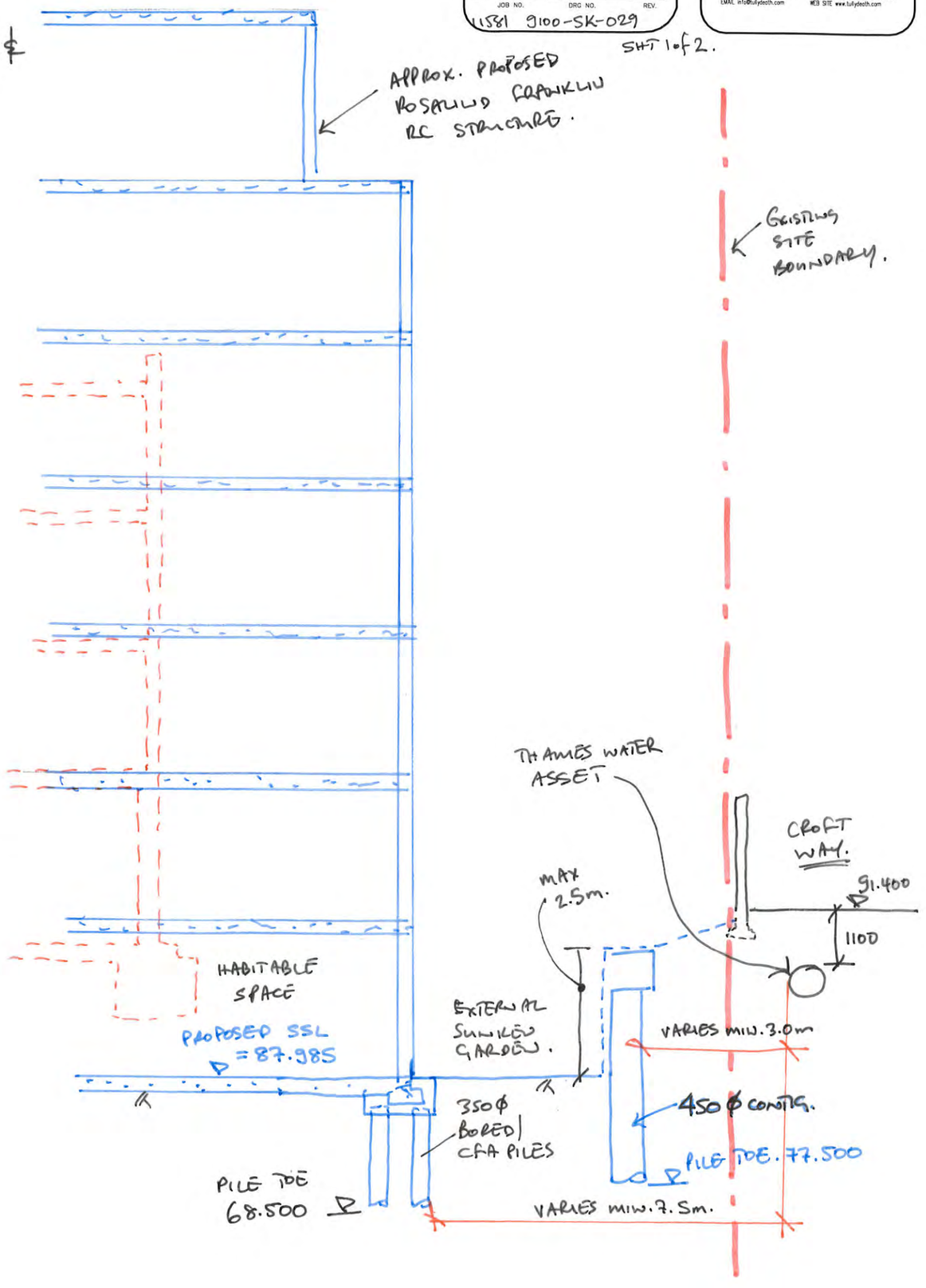
Tully De'Ath consultants
Engineering at its Best
T: 01342 825 003
E: info@tullydeath.com
W: www.tullydeath.com

MODEL SITUATION 1.



ROSALIND FRANKLIN
APPROX. UDL OVER FOOT PRINT = 60KN/m²
WEIGHT OF RC STRUCTURE & SCREED ONLY.

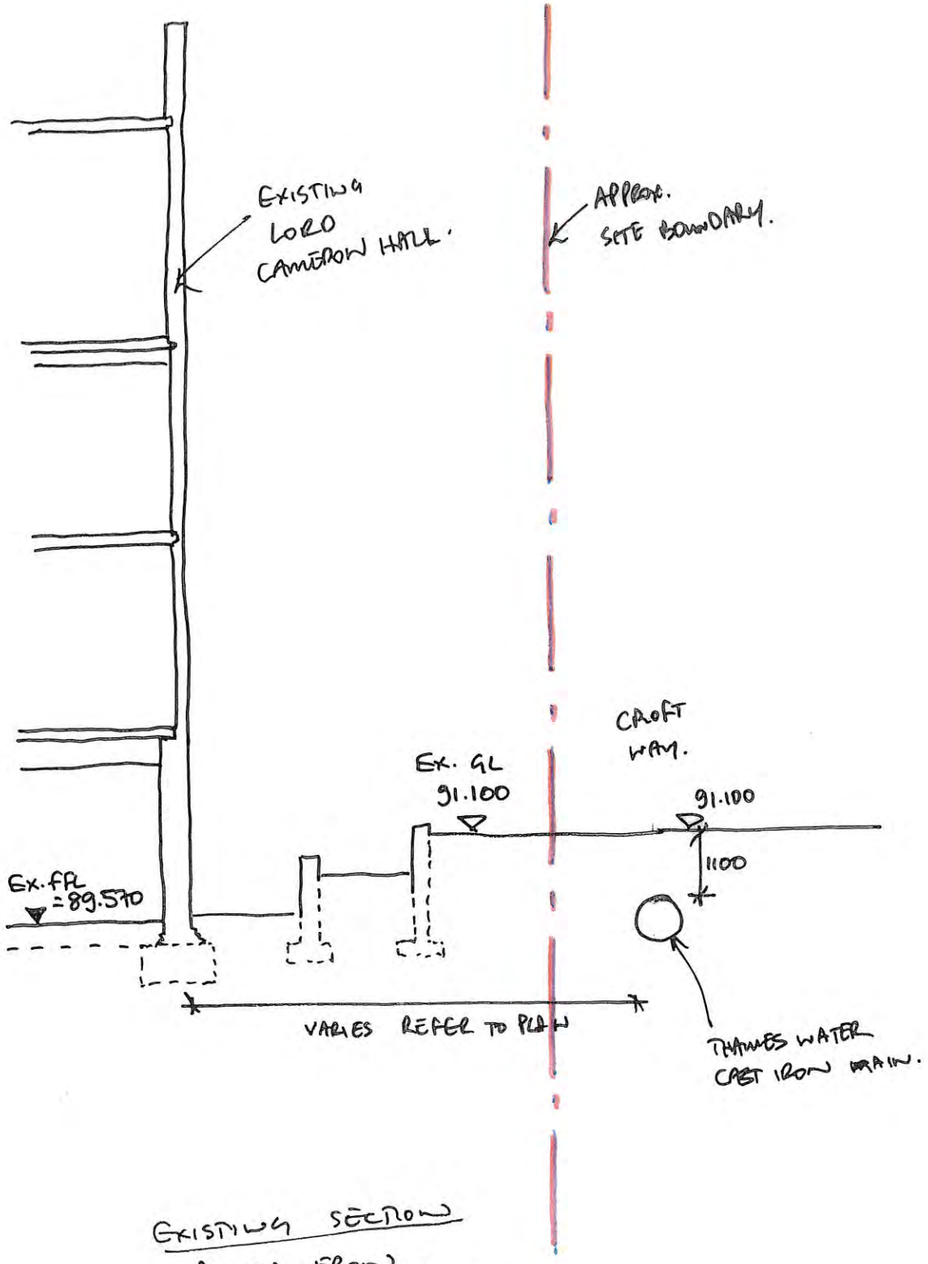
MODEL SITUATION 2



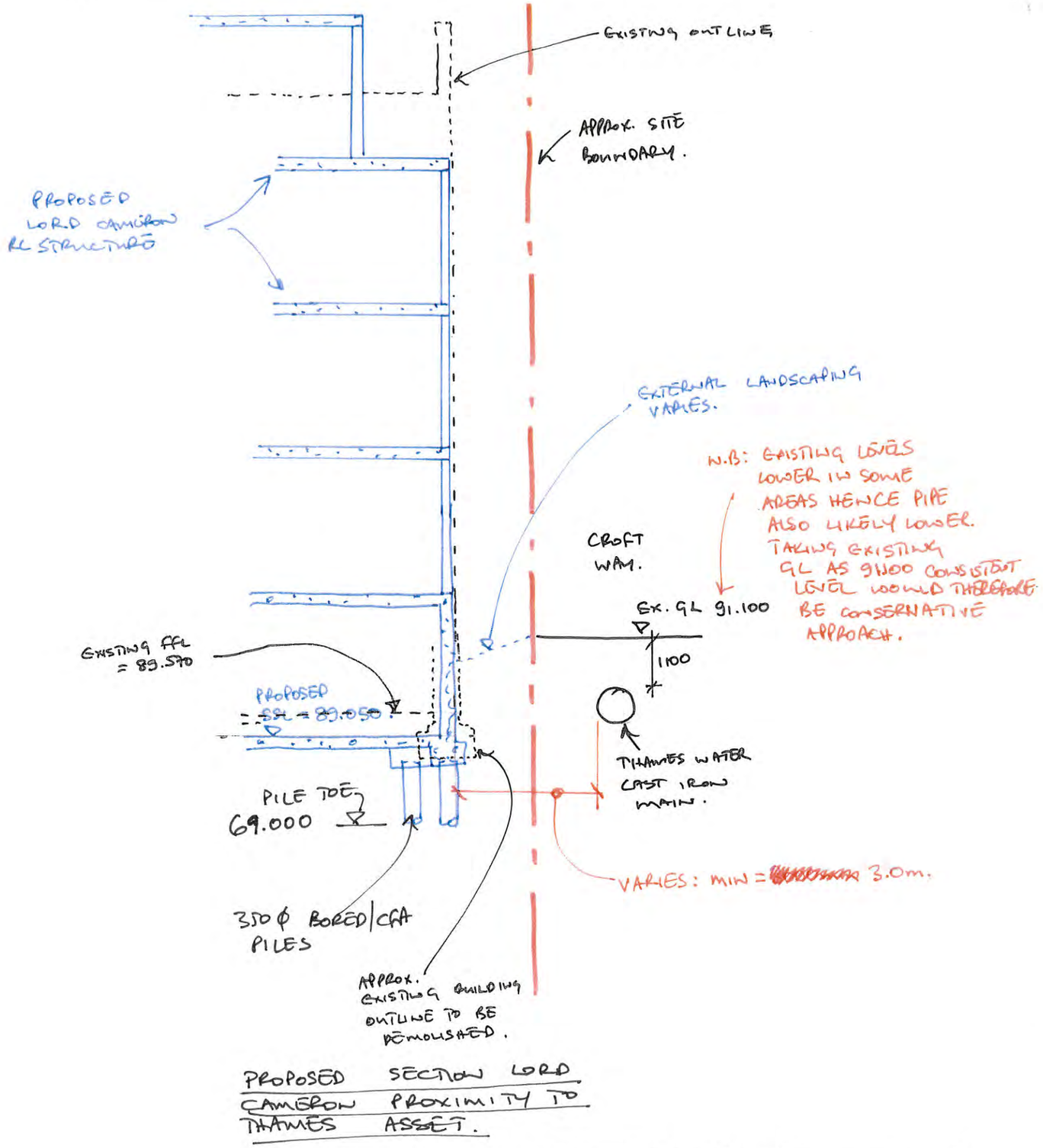
TITLE: ~~SITE WIDE THAMES~~ WATER MODEL SITUATION 2 & 3. - SHT 1 of 2
PROJECT: KILBURN PARK AV.
SCALE: NTS DATE: 10/16 DRAWN: CHK'D:
JOB NO. 11581 DRG NO. 9100-SK-029 REV.

Tully De'Ath consultants
Engineering at its Best
SHERIDAN HOUSE, HARTFIELD ROAD, FOREST ROW, SUSSEX RH18 5EA
TELEPHONE 01342 828 000 FACSIMILE 01342 828 001
EMAIL info@tullydeath.com WEB SITE www.tullydeath.com

SHT 1 of 2.



EXISTING SECTION LORD CAMERON PROXIMITY TO THAMES ASSET.



PROPOSED SECTION LORD CAMERON PROXIMITY TO THAMES ASSET.

MODEL SIMULATION 3.

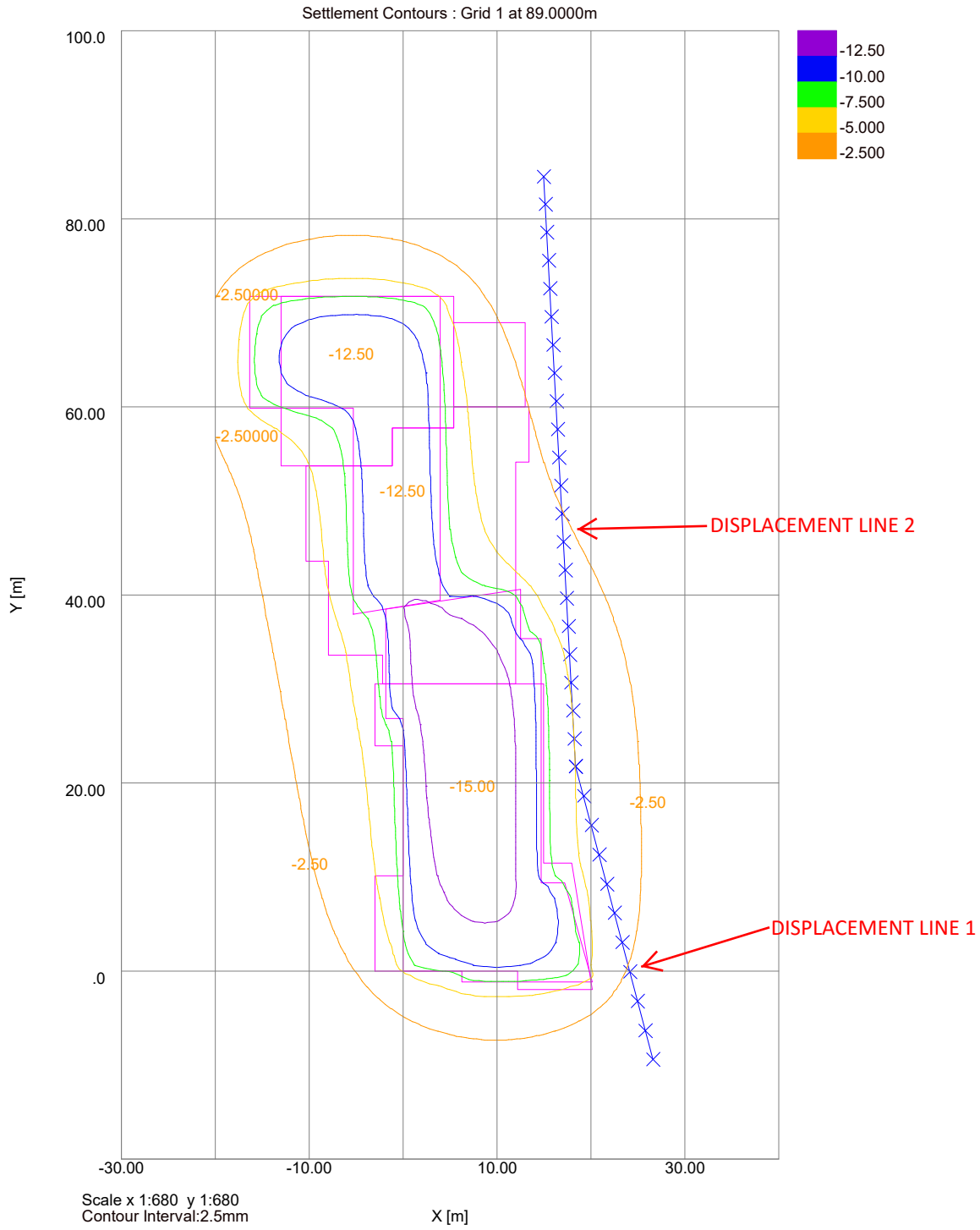
↑ REFER TO 9100-SK-44028.

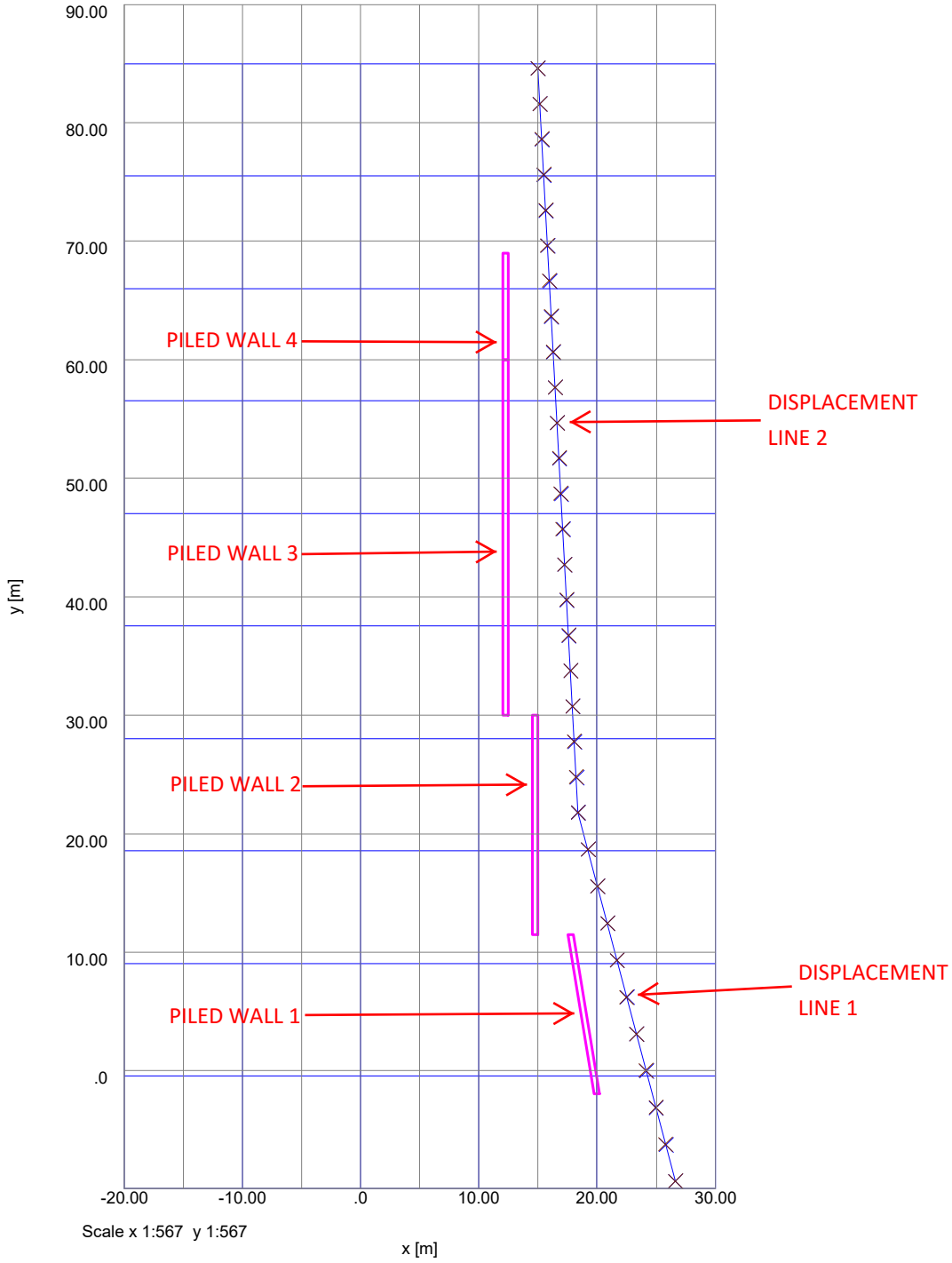
TITLE: SITE WIDE THAMES WATER MODEL SIMULATION 1, 2 & 3 SHT 2 of 2
PROJECT: KIDDERPORE AV.
SCALE: NTS DATE: 10/16 DRAWN: CHK'D:
JOB NO. 11581 DRG NO. 9100-SK-44028 REV.

Tully De'Ath consultants
Engineering at its Best
SHERIDAN HOUSE, HARTFIELD ROAD, FOREST ROW, SUSSEX RH18 5EA
TELEPHONE 01342 828 000 FACSIMILE 01342 828 001
EMAIL info@tullydeath.com WEB SITE www.tullydeath.com

APPENDIX B

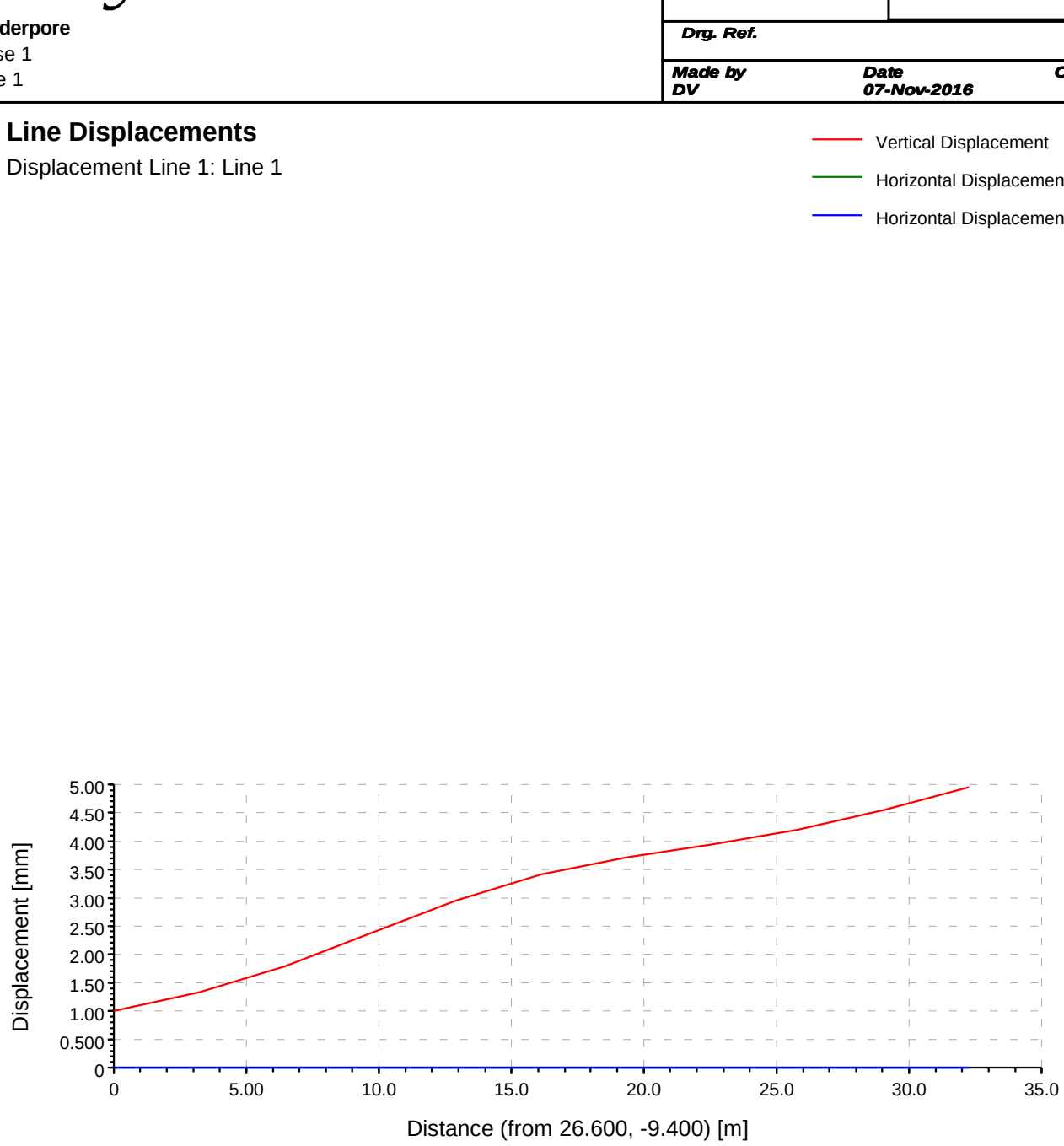
Case 1-Figures and XDISP output


Settlement Contours : Grid 1 at 89.0000m
-12.50
-10.00
-7.500
-5.000
-2.500
100.0
80.00
60.00
40.00
20.00
.0
Y [m]
-30.00
-10.00
10.00
30.00
X [m]
-2.50000
-12.50
-2.50000
-12.50
-15.00
-2.50
-2.50
DISPLACEMENT LINE 2
DISPLACEMENT LINE 1
Scale x 1:680 y 1:680
Contour Interval:2.5mm


90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
.0
y [m]
-20.00
-10.00
.0
10.00
20.00
30.00
x [m]
Scale x 1:567 y 1:567
PILED WALL 4
PILED WALL 3
PILED WALL 2
PILED WALL 1
DISPLACEMENT LINE 2
DISPLACEMENT LINE 1

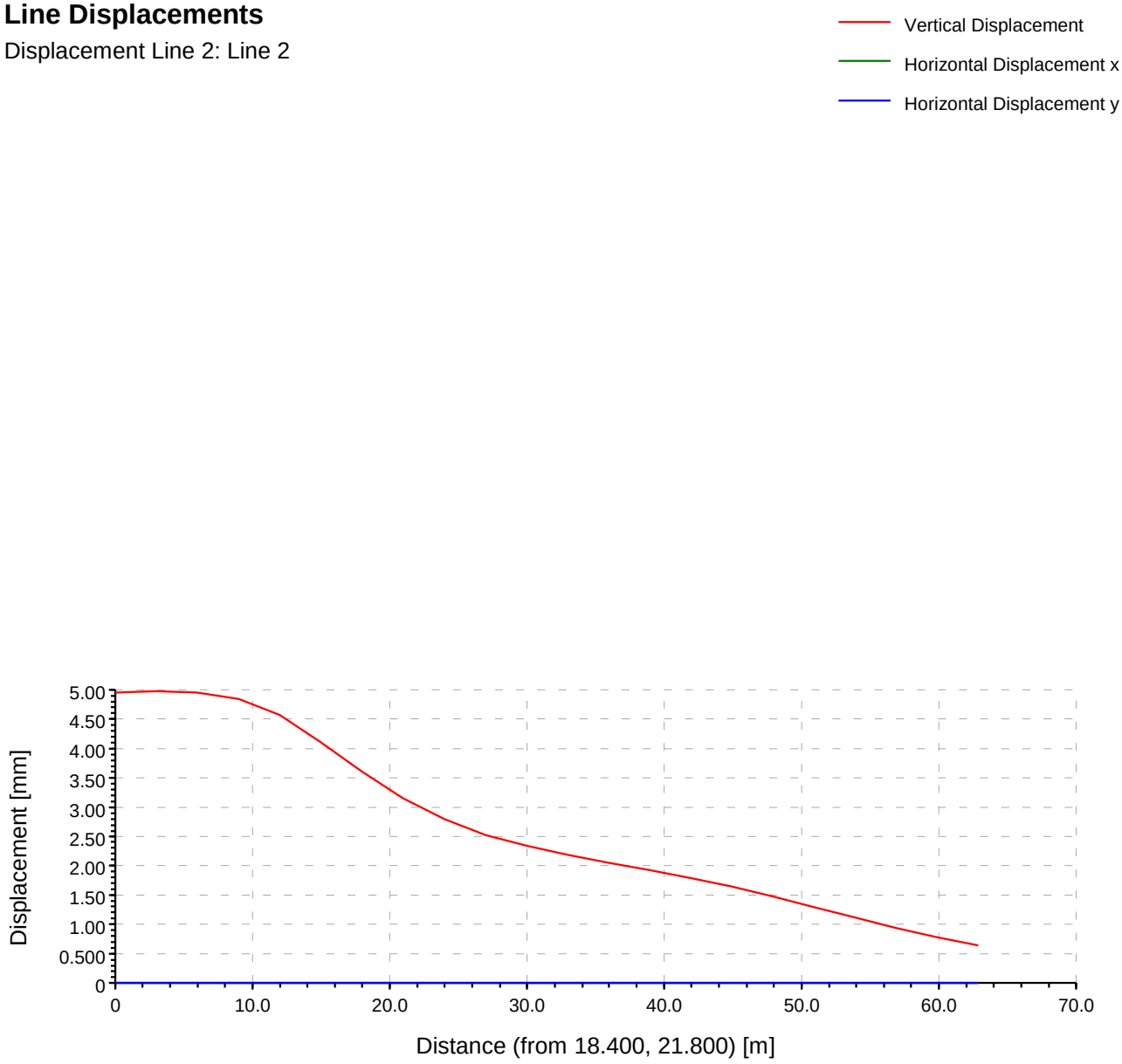
Line Displacements

Displacement Line 1: Line 1



Line Displacements

Displacement Line 2: Line 2



Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Displacement and Strain Results

Type/No. Name	Dist.	Coordinates x	y	z	Displacements x	y	z	Horizontal displacement along Line	Horizontal displacement perpendicular to Line	Angle of Line to x Axis
	[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[°]
Line 1	Line 1	26.60000	-9.40000	90.15000	0.0	0.0	-0.99866	0.0	0.0	104.73 *
	3.2260	25.78000	-6.28000	90.15000	0.0	0.0	-1.3297	0.0	0.0	104.73 *
	6.4519	24.96000	-3.16000	90.15000	0.0	0.0	-1.7830	0.0	0.0	104.73 *
	9.6779	24.14000	-0.04000	90.15000	0.0	0.0	-2.3660	0.0	0.0	104.73 *
	12.904	23.32000	3.08000	90.15000	0.0	0.0	-2.9581	0.0	0.0	104.73 *
	16.130	22.50000	6.20000	90.15000	0.0	0.0	-3.4163	0.0	0.0	104.73 *
	19.356	21.68000	9.32000	90.15000	0.0	0.0	-3.7177	0.0	0.0	104.73 *
	22.582	20.86000	12.44000	90.15000	0.0	0.0	-3.9369	0.0	0.0	104.73 *
	25.808	20.04000	15.56000	90.15000	0.0	0.0	-4.2009	0.0	0.0	104.73 *
	29.034	19.22000	18.68000	90.15000	0.0	0.0	-4.5432	0.0	0.0	104.73 *
	32.260	18.40000	21.80000	90.15000	0.0	0.0	-4.9485	0.0	0.0	104.73 *
Line 2	Line 2	18.40000	21.80000	90.15000	0.0	0.0	-4.9485	0.0	0.0	93.099 *
	2.9949	18.23810	24.79048	90.15000	0.0	0.0	-4.9754	0.0	0.0	93.099 *
	5.9897	18.07619	27.78095	90.15000	0.0	0.0	-4.9511	0.0	0.0	93.099 *
	8.9846	17.91429	30.77143	90.15000	0.0	0.0	-4.8363	0.0	0.0	93.099 *
	11.979	17.75238	33.76190	90.15000	0.0	0.0	-4.5669	0.0	0.0	93.099 *
	14.974	17.59048	36.75238	90.15000	0.0	0.0	-4.1111	0.0	0.0	93.099 *
	17.969	17.42857	39.74286	90.15000	0.0	0.0	-3.6085	0.0	0.0	93.099 *
	20.964	17.26667	42.73333	90.15000	0.0	0.0	-3.1544	0.0	0.0	93.099 *
	23.959	17.10476	45.72381	90.15000	0.0	0.0	-2.7938	0.0	0.0	93.099 *
	26.954	16.94286	48.71429	90.15000	0.0	0.0	-2.5289	0.0	0.0	93.099 *
	29.949	16.78095	51.70476	90.15000	0.0	0.0	-2.3333	0.0	0.0	93.099 *
	32.943	16.61905	54.69524	90.15000	0.0	0.0	-2.1800	0.0	0.0	93.099 *
	35.938	16.45714	57.68571	90.15000	0.0	0.0	-2.0479	0.0	0.0	93.099 *
	38.933	16.29524	60.67619	90.15000	0.0	0.0	-1.9208	0.0	0.0	93.099 *
	41.928	16.13333	63.66667	90.15000	0.0	0.0	-1.7868	0.0	0.0	93.099 *
	44.923	15.97143	66.65714	90.15000	0.0	0.0	-1.6379	0.0	0.0	93.099 *
	47.918	15.80952	69.64762	90.15000	0.0	0.0	-1.4718	0.0	0.0	93.099 *
	50.913	15.64762	72.63810	90.15000	0.0	0.0	-1.2927	0.0	0.0	93.099 *
	53.907	15.48571	75.62857	90.15000	0.0	0.0	-1.1102	0.0	0.0	93.099 *
	56.902	15.32381	78.61905	90.15000	0.0	0.0	-0.93545	0.0	0.0	93.099 *
	59.897	15.16190	81.60952	90.15000	0.0	0.0	-0.77653	0.0	0.0	93.099 *
	62.892	15.00000	84.60000	90.15000	0.0	0.0	-0.63715	0.0	0.0	93.099 *

* Result includes imported displacement(s).

Specific Utility Damage Results - Coordinates and Displacements

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start point	Coordinates x	y	z	Displacements x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	Displacements at (n-Lp) x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	Displacements at (n+Lp) x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility
	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
6.45191	24.96000	-3.16000	90.15000	0.00000	0.00000	-1.78298	0.00000	0.00000	0.00000	0.00000	0.00000	-1.28538	0.00000	0.00000	0.00000	0.00000	0.00000	-2.44527	0.00000	0.00000
12.90383	23.32000	3.08000	90.15000	0.00000	0.00000	-2.95808	0.00000	0.00000	0.00000	0.00000	0.00000	-2.28789	0.00000	0.00000	0.00000	0.00000	0.00000	-3.45669	0.00000	0.00000
19.35574	21.68000	9.32000	90.15000	0.00000	0.00000	-3.71771	0.00000	0.00000	0.00000	0.00000	0.00000	-3.35495	0.00000	0.00000	0.00000	0.00000	0.00000	-3.97226	0.00000	0.00000
25.80766	20.04000	15.56000	90.15000	0.00000	0.00000	-4.20086	0.00000	0.00000	0.00000	0.00000	0.00000	-3.90755	0.00000	0.00000	0.00000	0.00000	0.00000	-4.59751	0.00000	0.00000
Iteration: 2																		
9.67787	24.14000	-0.04000	90.15000	0.00000	0.00000	-2.36597	0.00000	0.00000	0.00000	0.00000	0.00000	-1.72227	0.00000	0.00000	0.00000	0.00000	0.00000	-3.01945	0.00000	0.00000
16.12979	22.50000	6.20000	90.15000	0.00000	0.00000	-3.41632	0.00000	0.00000	0.00000	0.00000	0.00000	-2.87878	0.00000	0.00000	0.00000	0.00000	0.00000	-3.74707	0.00000	0.00000
22.58170	20.86000	12.44000	90.15000	0.00000	0.00000	-3.93691	0.00000	0.00000	0.00000	0.00000	0.00000	-3.67735	0.00000	0.00000	0.00000	0.00000	0.00000	-4.24671	0.00000	0.00000

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start point	Coordinates x	y	z	Displacements x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	Displacements at (n-Lp) x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	Displacements at (n+Lp) x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility
	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
5.98971	18.07619	27.78095	90.15000	0.00000	0.00000	-4.95106	0.00000	0.00000	0.00000	0.00000	0.00000	-4.96947	0.00000	0.00000	0.00000	0.00000	0.00000	-4.77664	0.00000	0.00000
11.97942	17.75238	33.76190	90.15000	0.00000	0.00000	-4.56694	0.00000	0.00000	0.00000	0.00000	0.00000	-4.86170	0.00000	0.00000	0.00000	0.00000	0.00000	-3.99982	0.00000	0.00000
17.96913	17.42857	39.74286	90.15000	0.00000	0.00000	-3.60854	0.00000	0.00000	0.00000	0.00000	0.00000	-4.21204	0.00000	0.00000	0.00000	0.00000	0.00000	-3.07453	0.00000	0.00000
23.95885	17.10476	45.72381	90.15000	0.00000	0.00000	-2.79381	0.00000	0.00000	0.00000	0.00000	0.00000	-3.25493	0.00000	0.00000	0.00000	0.00000	0.00000	-2.48560	0.00000	0.00000
29.94856	16.78095	51.70476	90.15000	0.00000	0.00000	-2.33329	0.00000	0.00000	0.00000	0.00000	0.00000	-2.58757	0.00000	0.00000	0.00000	0.00000	0.00000	-2.15075	0.00000	0.00000
35.93827	16.45714	57.68571	90.15000	0.00000	0.00000	-2.04788	0.00000	0.00000	0.00000	0.00000	0.00000	-2.21394	0.00000	0.00000	0.00000	0.00000	0.00000	-1.89114	0.00000	0.00000
41.92798	16.13333	63.66667	90.15000	0.00000	0.00000	-1.78677	0.00000	0.00000	0.00000	0.00000	0.00000	-1.94895	0.00000	0.00000	0.00000	0.00000	0.00000	-1.60113	0.00000	0.00000
47.91769	15.80952	69.64762	90.15000	0.00000	0.00000	-1.47181	0.00000	0.00000	0.00000	0.00000	0.00000	-1.67087	0.00000	0.00000	0.00000	0.00000	0.00000	-1.25226	0.00000	0.00000
53.90740	15.48571	75.62857	90.15000	0.00000	0.00000	-1.11019	0.00000	0.00000	0.00000	0.00000	0.00000	-1.33233	0.00000	0.00000	0.00000	0.00000	0.00000	-0.90026	0.00000	0.00000
Iteration: 2																		
8.98457	17.91429	30.77143	90.15000	0.00000	0.00000	-4.83628	0.00000	0.00000	0.00000	0.00000	0.00000	-4.95646	0.00000	0.00000	0.00000	0.00000	0.00000	-4.46600	0.00000	0.00000
14.97428	17.59048	36.75238	90.15000	0.00000	0.00000	-4.11110	0.00000	0.00000	0.00000	0.00000	0.00000	-4.62658	0.00000	0.00000	0.00000	0.00000	0.00000	-3.50797	0.00000	0.00000
20.96399	17.26667	42.73333	90.15000	0.00000	0.00000	-3.15436	0.00000	0.00000	0.00000	0.00000	0.00000	-3.71982	0.00000	0.00000	0.00000	0.00000	0.00000	-2.73516	0.00000	0.00000
26.95370	16.94286	48.71429	90.15000	0.00000	0.00000	-2.52892	0.00000	0.00000	0.00000	0.00000	0.00000	-2.87365	0.00000	0.00000	0.00000	0.00000	0.00000	-2.29935	0.00000	0.00000
32.94341	16.61905	54.69524	90.15000	0.00000	0.00000	-2.18000	0.00000	0.00000	0.00000	0.00000	0.00000	-2.37660	0.00000	0.00000	0.00000	0.00000	0.00000	-2.01975	0.00000	0.00000
38.93312	16.29524	60.67619	90.15000	0.00000	0.00000	-1.92082	0.00000	0.00000	0.00000	0.00000	0.00000	-2.07714	0.00000	0.00000	0.00000	0.00000	0.00000	-1.75381	0.00000	0.00000
44.92284	15.97143	66.65714	90.15000	0.00000	0.00000	-1.63791	0.00000	0.00000	0.00000	0.00000	0.00000	-1.81645	0.00000	0.00000	0.00000	0.00000	0.00000	-1.43214	0.00000	0.00000
50.91255	15.64762	72.63810	90.15000	0.00000	0.00000	-1.29266	0.00000	0.00000	0.00000	0.00000	0.00000	-1.50859	0.00000	0.00000	0.00000	0.00000	0.00000	-1.07150	0.00000	0.00000
56.90226	15.32381	78.61905	90.15000	0.00000	0.00000	-0.93545	0.00000	0.00000	0.00000	0.00000	0.00000	-1.15060	0.00000	0.00000	0.00000	0.00000	0.00000	-0.74566	0.00000	0.00000

Specific Utility Damage Results - Pullouts and Rotations

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the Sagging utility's vs Hogging point	Coordinates Vertical	Pullout Check Rotation Check

x	y	z	Rotation	Threshold Limit	Left Seg. Axial Unfactored	Left Seg. Axial Factored	Left Seg. Flexural Unfactored	Left Seg. Flexural Factored	Right Seg. Axial Unfactored	Right Seg. Axial Factored	Right Seg. Flexural Unfactored	Right Seg. Flexural Factored	Total Axial Unfactored	Total Axial Factored	Total Flexural Unfactored	Total Flexural Factored	Pullout Unfactored	Pullout Factored	Threshold Limit	
[m]	[m]	[m]	[Deg]	[Deg]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]		
Iteration: 1																				
6.45191	24.96000	-3.16000	90.15000	0.00000	0.00000	0.01335	0.01335	0.00000	0.00000	0.01335	0.01335	0.00000	0.00000	0.02671	0.02671	0.02671	0.02671	-	OK	
0.00258	0.00258	-	OK	Sagging																
12.90383	23.32000	3.08000	90.15000	0.00000	0.00000	0.01391	0.01391	0.00000	0.00000	0.01391	0.01391	0.00000	0.00000	0.02783	0.02783	0.02783	0.02783	-	OK	
0.00269	0.00269	-	OK	Hogging																
19.35574	21.68000	9.32000	90.15000	0.00000	0.00000	0.00877	0.00877	0.00000	0.00000	0.00877	0.00877	0.00000	0.00000	0.01755	0.01755	0.01755	0.01755	-	OK	
0.00169	0.00169	-	OK	Hogging																
25.80766	20.04000	15.56000	90.15000	0.00000	0.00000	0.00838	0.00838	0.00000	0.00000	0.00838	0.00838	0.00000	0.00000	0.01676	0.01676	0.01676	0.01676	-	OK	
0.00162	0.00162	-	OK	Sagging																
Iteration: 2																				
9.67787	24.14000	-0.04000	90.15000	0.00000	0.00000	0.00079	0.00079	0.00000	0.00000	0.00079	0.00079	0.00000	0.00000	0.00159	0.00159	0.00159	0.00159	-	OK	
0.00015	0.00015	-	OK	Sagging																
16.12979	22.50000	6.20000	90.15000	0.00000	0.00000	0.01677	0.01677	0.00000	0.00000	0.01677	0.01677	0.00000	0.00000	0.03354	0.03354	0.03354	0.03354	-	OK	
0.00324	0.00324	-	OK	Hogging																
22.58170	20.86000	12.44000	90.15000	0.00000	0.00000	0.00407	0.00407	0.00000	0.00000	0.00407	0.00407	0.00000	0.00000	0.00815	0.00815	0.00815	0.00815	-	OK	
0.00079	0.00079	-	OK	Sagging																

Note: Total pullout ignores the axial component where this is negative (i.e. compression).

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's vs start Hogging point	Coordinates x	y	z	Rotation	Threshold Limit	Left Seg. Axial Unfactored	Left Seg. Axial Factored	Left Seg. Flexural Unfactored	Left Seg. Flexural Factored	Right Seg. Axial Unfactored	Right Seg. Axial Factored	Right Seg. Flexural Unfactored	Right Seg. Flexural Factored	Total Axial Unfactored	Total Axial Factored	Total Flexural Unfactored	Total Flexural Factored	Pullout Unfactored	Pullout Factored	Threshold Limit	Pullout Check
[m]	[m]	[m]	[m]	[Deg]	[Deg]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]		
Iteration: 1																					
5.98971	18.07619	27.78095	90.15000	0.00000	0.00000	0.01265	0.01265	0.00000	0.00000	0.01265	0.01265	0.00000	0.00000	0.02530	0.02530	0.02530	0.02530	-	OK		
0.00244	0.00244	-	OK	Hogging																	
11.97942	17.75238	33.76190	90.15000	0.00000	0.00000	0.02209	0.02209	0.00000	0.00000	0.02209	0.02209	0.00000	0.00000	0.04417	0.04417	0.04417	0.04417	-	OK		
0.00427	0.00427	-	OK	Hogging																	
17.96913	17.42857	39.74286	90.15000	0.00000	0.00000	0.00564	0.00564	0.00000	0.00000	0.00564	0.00564	0.00000	0.00000	0.01127	0.01127	0.01127	0.01127	-	OK		
0.00109	0.00109	-	OK	Sagging																	
23.95885	17.10476	45.72381	90.15000	0.00000	0.00000	0.01240	0.01240	0.00000	0.00000	0.01240	0.01240	0.00000	0.00000	0.02480	0.02480	0.02480	0.02480	-	OK		
0.00239	0.00239	-	OK	Sagging																	
29.94856	16.78095	51.70476	90.15000	0.00000	0.00000	0.00582	0.00582	0.00000	0.00000	0.00582	0.00582	0.00000	0.00000	0.01164	0.01164	0.01164	0.01164	-	OK		
0.00112	0.00112	-	OK	Sagging																	
35.93827	16.45714	57.68571	90.15000	0.00000	0.00000	0.00076	0.00076	0.00000	0.00000	0.00076	0.00076	0.00000	0.00000	0.00151	0.00151	0.00151	0.00151	-	OK		
0.00015	0.00015	-	OK	Sagging																	
41.92798	16.13333	63.66667	90.15000	0.00000	0.00000	0.00190	0.00190	0.00000	0.00000	0.00190	0.00190	0.00000	0.00000	0.00380	0.00380	0.00380	0.00380	-	OK		
0.00037	0.00037	-	OK	Hogging																	
47.91769	15.80952	69.64762	90.15000	0.00000	0.00000	0.00166	0.00166	0.00000	0.00000	0.00166	0.00166	0.00000	0.00000	0.00332	0.00332	0.00332	0.00332	-	OK		
0.00032	0.00032	-	OK	Hogging																	
53.90740	15.48571	75.62857	90.15000	0.00000	0.00000	0.00099	0.00099	0.00000	0.00000	0.00099	0.00099	0.00000	0.00000	0.00198	0.00198	0.00198	0.00198	-	OK		
0.00019	0.00019	-	OK	Sagging																	
Iteration: 2																					
8.98457	17.91429	30.77143	90.15000	0.00000	0.00000	0.02028	0.02028	0.00000	0.00000	0.02028	0.02028	0.00000	0.00000	0.04056	0.04056	0.04056	0.04056	-	OK		
0.00392	0.00392	-	OK	Hogging																	
14.97428	17.59048	36.75238	90.15000	0.00000	0.00000	0.00711	0.00711	0.00000	0.00000	0.00711	0.00711	0.00000	0.00000	0.01422	0.01422	0.01422	0.01422	-	OK		
0.00137	0.00137	-	OK	Hogging																	
20.96399	17.26667	42.73333	90.15000	0.00000	0.00000	0.01186	0.01186	0.00000	0.00000	0.01186	0.01186	0.00000	0.00000	0.02372	0.02372	0.02372	0.02372	-	OK		
0.00229	0.00229	-	OK	Sagging																	
26.95370	16.94286	48.71429	90.15000	0.00000	0.00000	0.00934	0.00934	0.00000	0.00000	0.00934	0.00934	0.00000	0.00000	0.01868	0.01868	0.01868	0.01868	-	OK		
0.00180	0.00180	-	OK	Sagging																	
32.94341	16.61905	54.69524	90.15000	0.00000	0.00000	0.00295	0.00295	0.00000	0.00000	0.00295	0.00295	0.00000	0.00000	0.00589	0.00589	0.00589	0.00589	-	OK		
0.00057	0.00057	-	OK	Sagging																	
38.93312	16.29524	60.67619	90.15000	0.00000	0.00000	0.00087	0.00087	0.00000	0.00000	0.00087	0.00087	0.00000	0.00000	0.00173	0.00173	0.00173	0.00173	-	OK		
0.00017	0.00017	-	OK	Hogging																	
44.92284	15.97143	66.65714	90.15000	0.00000	0.00000	0.00221	0.00221	0.00000	0.00000	0.00221	0.00221	0.00000	0.00000	0.00441	0.00441	0.00441	0.00441	-	OK		
0.00043	0.00043	-	OK	Hogging																	
50.91255	15.64762	72.63810	90.15000	0.00000	0.00000	0.00042	0.00042	0.00000	0.00000	0.00042	0.00042	0.00000	0.00000	0.00085	0.00085	0.00085	0.00085	-	OK		
0.00008	0.00008	-	OK	Hogging																	
56.90226	15.32381	78.61905	90.15000	0.00000	0.00000	0.00206	0.00206	0.00000	0.00000	0.00206	0.00206	0.00000	0.00000	0.00411	0.00411	0.00411	0.00411	-	OK		
0.00040	0.00040	-	OK	Sagging																	

Note: Total pullout ignores the axial component where this is negative (i.e. compression).

Specific Utility Damage Results - Strains

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start point	Coordinates x	y	z	Pipe Strain Check Axial	Flexural Tension Unfactored	Flexural Tension Factored	Flexural Compression Unfactored	Flexural Compression Factored	Tension Total Unfactored	Tension Total Factored	Check	Compression Total Unfactored	Compression Total Factored	Check	Radius of Curvature Check Radius of Curvature	Threshold Limit		Peak flexural tensile strain orientation angle (w.r.t global z-axis)
[m]	[m]	[m]	[m]	[με]	[με]	[με]	[με]	[με]	[με]	[με]		[με]	[με]		[m]			[Deg]
6.45191	24.96000	-3.16000	90.15000	0.012898	0.0025796	3.6976	3.6976	-3.6976	-3.6976	3.71046	3.70014	OK	-3.68466	-3.69498	OK	8.0222E+4	-	-	180.00000
9.67787	24.14000	-0.04000	90.15000	0.016586	0.0033172	0.26003	0.26003	-0.26003	-0.26003	0.27662	0.26335	OK	-0.24345	-0.25672	OK	1.1407E+6	-	-	180.00000
12.90383	23.32000	3.08000	90.15000	0.013252	0.0026503	3.8156	3.8156	-3.8156	-3.8156	3.82881	3.81821	OK	-3.80231	-3.81291	OK	7.7741E+4	-	-	0.00000
16.12979	22.50000	6.20000	90.15000	0.0069311	0.0013862	4.4709	4.4709	-4.4709	-4.4709	4.47785	4.47231	OK	-4.46399	-4.46953	OK	6.6345E+4	-	-	0.00000
19.35574	21.68000	9.32000	90.15000	0.0032552	651.04E-6	2.3426	2.3426	-2.3426	-2.3426	2.34584	2.34324	OK	-2.33933	-2.34193	OK	1.2662E+5	-	-	0.00000
22.58170	20.86000	12.44000	90.15000	0.0028038	560.76E-6	1.2753	1.2753	-1.2753	-1.2753	1.27814	1.27590	OK	-1.27254	-1.27478	OK	2.3258E+5	-	-	180.00000
25.80766	20.04000	15.56000	90.15000	0.0044158	883.16E-6	2.2358	2.2358	-2.2358	-2.2358	2.24022	2.23669	OK	-2.23139	-2.23492	OK	1.3267E+5	-	-	180.00000

Note: Tensile strains are +ve, compressive strains are -ve.
Note: The peak flexural tensile strain orientation angle is measured with respect to the global z-axis by looking at the end point of the utility from the start point. Anti-clockwise is positive.

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start point	Coordinates x	y	z	Pipe Strain Check Axial	Flexural Tension Unfactored	Flexural Tension Factored	Flexural Compression Unfactored	Flexural Compression Factored	Tension Total Unfactored	Tension Total Factored	Check	Compression Total Unfactored	Compression Total Factored	Check	Radius of Curvature Check Radius of Curvature	Threshold Limit		Peak flexural tensile strain orientation angle (w.r.t global z-axis)
[m]	[m]	[m]	[m]	[με]	[με]	[με]	[με]	[με]	[με]	[με]		[με]	[με]		[m]			[Deg]
2.99486	18.23810	24.79048	90.15000	0.0	0.0	1.6981	1.6981	-1.6981	-1.6981	1.69813	1.69813	OK	-1.69813	-1.69813	OK	1.7468E+5	-	-	0.00000
5.98971	18.07619	27.78095	90.15000	269.90E-6	53.980E-6	2.9897	2.9897	-2.9897	-2.9897	2.98995	2.98973	OK	-2.98941	-2.98963	OK	9.9216E+4	-	-	0.00000

Distance from the utility's start	Coordinates					Pipe Strain Check							Radius of Curvature Check				Peak flexural tensile strain orientation angle (w.r.t
8.98457	17.91429	30.77143	90.15000	0.0020564	411.28E-6	5.1117	5.1117	-5.1117	-5.1117	5.11372	5.11207	OK	-5.10960	-5.11125	OK	5.8029E+4	-	-	0.00000
11.97942	17.75238	33.76190	90.15000	0.0073291	0.0014658	6.1676	6.1676	-6.1676	-6.1676	6.17488	6.16902	OK	-6.16022	-6.16608	OK	4.8094E+4	-	-	0.00000
14.97428	17.59048	36.75238	90.15000	0.012801	0.0025603	1.5454	1.5454	-1.5454	-1.5454	1.55825	1.54801	OK	-1.53265	-1.54289	OK	1.9193E+5	-	-	0.00000
17.96913	17.42857	39.74286	90.15000	0.012757	0.0025514	1.6005	1.6005	-1.6005	-1.6005	1.61322	1.60301	OK	-1.58770	-1.59791	OK	1.8534E+5	-	-	180.00000
20.96399	17.26667	42.73333	90.15000	0.0092508	0.0018502	3.0962	3.0962	-3.0962	-3.0962	3.10549	3.09808	OK	-3.08698	-3.09438	OK	9.5802E+4	-	-	180.00000
23.95885	17.10476	45.72381	90.15000	0.0054518	0.0010904	3.1634	3.1634	-3.1634	-3.1634	3.16885	3.16449	OK	-3.15795	-3.16231	OK	9.3767E+4	-	-	180.00000
26.95370	16.94286	48.71429	90.15000	0.0029557	591.15E-6	2.2908	2.2908	-2.2908	-2.2908	2.29374	2.29138	OK	-2.28783	-2.29019	OK	1.2949E+5	-	-	180.00000
29.94856	16.78095	51.70476	90.15000	0.0016967	339.33E-6	1.4004	1.4004	-1.4004	-1.4004	1.40212	1.40076	OK	-1.39873	-1.40008	OK	2.1181E+5	-	-	180.00000
32.94341	16.61905	54.69524	90.15000	0.0011352	227.04E-6	0.69995	0.69995	-0.69995	-0.69995	0.70108	0.70017	OK	-0.69881	-0.69972	OK	4.2378E+5	-	-	180.00000
35.93827	16.45714	57.68571	90.15000	936.22E-6	187.24E-6	0.16713	0.16713	-0.16713	-0.16713	0.16807	0.16732	OK	-0.16619	-0.16694	OK	1.7748E+6	-	-	180.00000
38.93312	16.29524	60.67619	90.15000	950.19E-6	190.04E-6	0.23084	0.23084	-0.23084	-0.23084	0.23179	0.23103	OK	-0.22989	-0.23065	OK	1.2850E+6	-	-	0.00000
41.92798	16.13333	63.66667	90.15000	0.0011154	223.09E-6	0.48998	0.48998	-0.48998	-0.48998	0.49109	0.49020	OK	-0.48886	-0.48976	OK	6.0538E+5	-	-	0.00000
44.92284	15.97143	66.65714	90.15000	0.0013825	276.50E-6	0.57002	0.57002	-0.57002	-0.57002	0.57140	0.57029	OK	-0.56863	-0.56974	OK	5.2038E+5	-	-	0.00000
47.91769	15.80952	69.64762	90.15000	0.0016612	332.23E-6	0.43155	0.43155	-0.43155	-0.43155	0.43321	0.43188	OK	-0.42988	-0.43121	OK	6.8735E+5	-	-	0.00000
50.91255	15.64762	72.63810	90.15000	0.0018225	364.50E-6	0.11002	0.11002	-0.11002	-0.11002	0.11184	0.11039	OK	-0.10820	-0.10966	OK	2.6960E+6	-	-	0.00000
53.90740	15.48571	75.62857	90.15000	0.0017783	355.67E-6	0.25578	0.25578	-0.25578	-0.25578	0.25756	0.25614	OK	-0.25400	-0.25543	OK	1.1597E+6	-	-	180.00000
56.90226	15.32381	78.61905	90.15000	0.0015516	310.32E-6	0.52298	0.52298	-0.52298	-0.52298	0.52453	0.52329	OK	-0.52143	-0.52267	OK	5.6718E+5	-	-	180.00000

Note: Tensile strains are +ve, compressive strains are -ve.
Note: The peak flexural tensile strain orientation angle is measured with respect to the global z-axis by looking at the end point of the utility from the start point. Anti-clockwise is positive.

Specific Utility Damage Results - Maximum Values

Name	Jointed	Displacement Data Type	Displacement Data	Maximum Pullout (Factored)		Maximum Rotation (Factored)		Maximum Strain (Factored) Tension		Maximum Strain (Factored) Compression		Minimum Radius of Curvature		Maximum Displacement Vertical		Maximum Displacement Horizontal x		Maximum Displacement Horizontal y
				Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location Value
				[m]	[mm]	[m]	[Deg]	[m]	[με]	[m]	[με]	[m]	[m]	[m]	[mm]	[m]	[mm]	[m] [mm]
Cast Iron Main	Yes	Displacement	Line 1	16.130	0.033539	16.130	0.00324	16.12979	4.47231	16.12979	-4.46953	16.130	6.6345E+4	32.259	-4.9484	32.259	0.0	32.259 0.0
Line 1		Line																
Cast Iron Main	Yes	Displacement	Line 2	11.979	0.044170	11.979	0.00427	11.97942	6.16902	11.97942	-6.16608	11.979	4.8094E+4	2.9949	-4.9754	62.891	0.0	62.891 0.0
Line 2		Line																

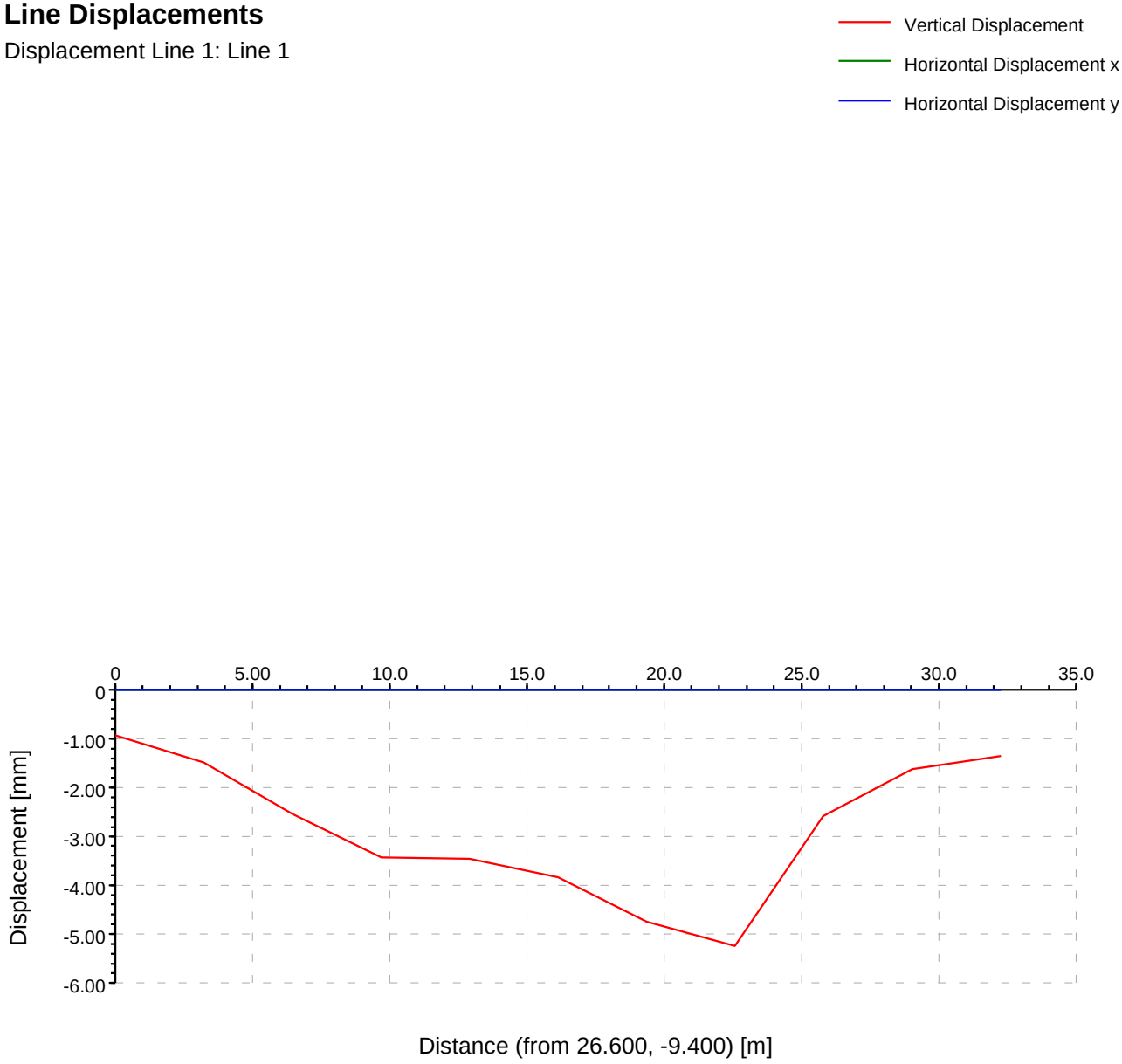
Note: * symbol indicates that the value has exceeded one of (or both) the limiting criteria

APPENDIX C

Case 2-Figures and XDISP output

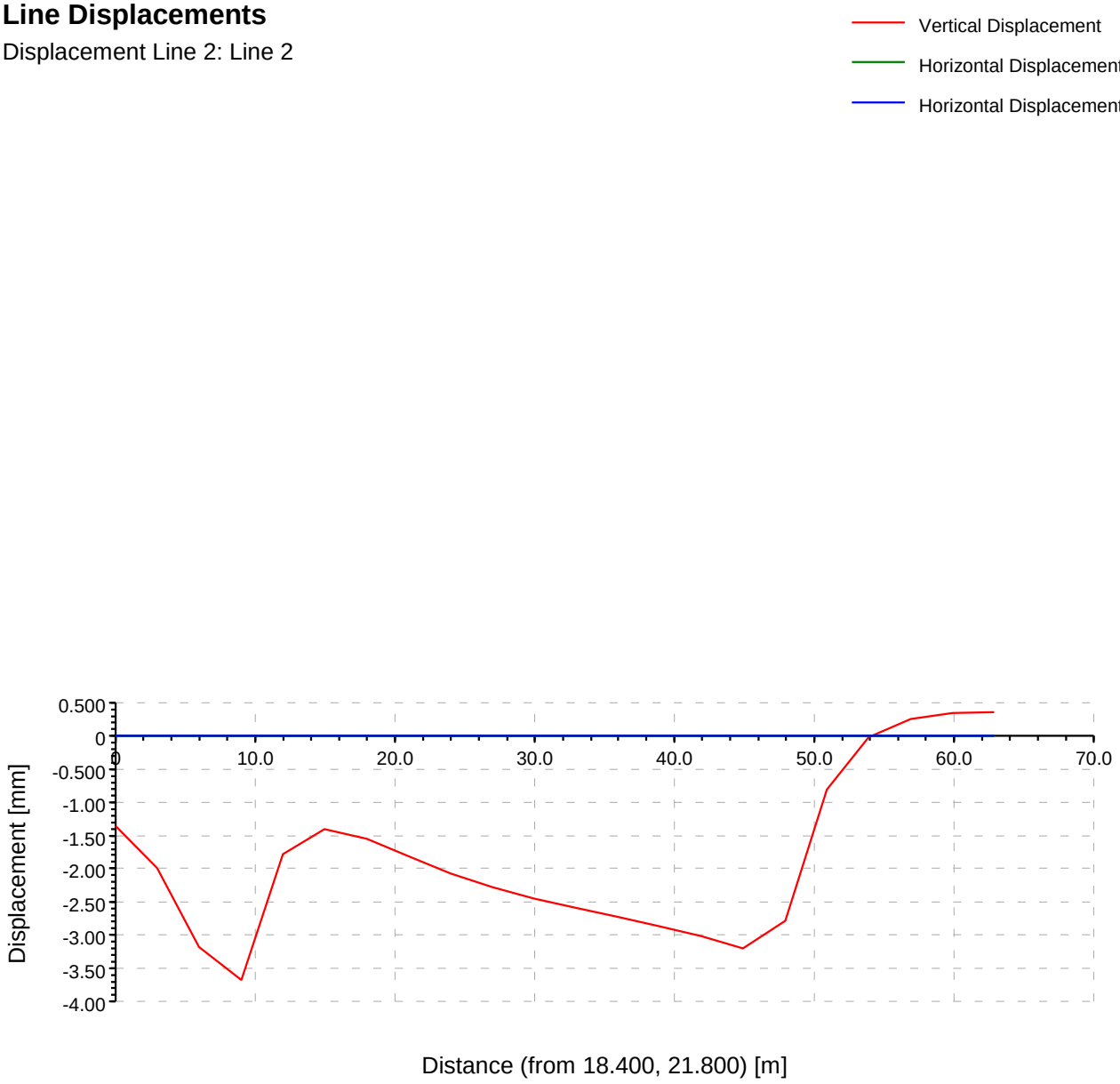
Line Displacements

Displacement Line 1: Line 1



Line Displacements

Displacement Line 2: Line 2



Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Displacement and Strain Results

Type/No.		Coordinates			Displacements					Angle of Line to x Axis
Name	Dist.	x	y	z	x	y	z	Horizontal displacement along Line	Horizontal displacement perpendicular to Line	
	[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[°]
Line 1	Line 1	26.60000	-9.40000	90.15000	0.0	0.0	0.92708	0.0	0.0	104.73 *
	3.2260	25.78000	-6.28000	90.15000	0.0	0.0	1.4798	0.0	0.0	104.73 *
	6.4519	24.96000	-3.16000	90.15000	0.0	0.0	2.5407	0.0	0.0	104.73 *
	9.6779	24.14000	-0.04000	90.15000	0.0	0.0	3.4396	0.0	0.0	104.73 *
	12.904	23.32000	3.08000	90.15000	0.0	0.0	3.4651	0.0	0.0	104.73 *
	16.130	22.50000	6.20000	90.15000	0.0	0.0	3.8396	0.0	0.0	104.73 *
	19.356	21.68000	9.32000	90.15000	0.0	0.0	4.7492	0.0	0.0	104.73 *
	22.582	20.86000	12.44000	90.15000	0.0	0.0	5.2440	0.0	0.0	104.73 *
	25.808	20.04000	15.56000	90.15000	0.0	0.0	2.5698	0.0	0.0	104.73 *
	29.034	19.22000	18.68000	90.15000	0.0	0.0	1.6251	0.0	0.0	104.73 *
	32.260	18.40000	21.80000	90.15000	0.0	0.0	1.3512	0.0	0.0	104.73 *
Line 2	Line 2	18.40000	21.80000	90.15000	0.0	0.0	1.3512	0.0	0.0	93.099 *
	2.9949	18.23810	24.79048	90.15000	0.0	0.0	1.9984	0.0	0.0	93.099 *
	5.9897	18.07619	27.78095	90.15000	0.0	0.0	3.1807	0.0	0.0	93.099 *
	8.9846	17.91429	30.77143	90.15000	0.0	0.0	3.6706	0.0	0.0	93.099 *
	11.979	17.75238	33.76190	90.15000	0.0	0.0	1.7840	0.0	0.0	93.099 *
	14.974	17.59048	36.75238	90.15000	0.0	0.0	1.4050	0.0	0.0	93.099 *
	17.969	17.42857	39.74286	90.15000	0.0	0.0	1.5446	0.0	0.0	93.099 *
	20.964	17.26667	42.73333	90.15000	0.0	0.0	1.8149	0.0	0.0	93.099 *
	23.959	17.10476	45.72381	90.15000	0.0	0.0	2.0752	0.0	0.0	93.099 *
	26.954	16.94286	48.71429	90.15000	0.0	0.0	2.2848	0.0	0.0	93.099 *
	29.949	16.78095	51.70476	90.15000	0.0	0.0	2.4521	0.0	0.0	93.099 *
	32.943	16.61905	54.69524	90.15000	0.0	0.0	2.5945	0.0	0.0	93.099 *
	35.938	16.45714	57.68571	90.15000	0.0	0.0	2.7274	0.0	0.0	93.099 *
	38.933	16.29524	60.67619	90.15000	0.0	0.0	2.8637	0.0	0.0	93.099 *
	41.928	16.13333	63.66667	90.15000	0.0	0.0	3.0202	0.0	0.0	93.099 *
	44.923	15.97143	66.65714	90.15000	0.0	0.0	3.1960	0.0	0.0	93.099 *
	47.918	15.80952	69.64762	90.15000	0.0	0.0	2.7819	0.0	0.0	93.099 *
	50.913	15.64762	72.63810	90.15000	0.0	0.0	0.80090	0.0	0.0	93.099 *
	53.907	15.48571	75.62857	90.15000	0.0	0.0	0.021621	0.0	0.0	93.099 *
	56.902	15.32381	78.61905	90.15000	0.0	0.0	-0.25528	0.0	0.0	93.099 *
	59.897	15.16190	81.60952	90.15000	0.0	0.0	-0.34414	0.0	0.0	93.099 *
	62.892	15.00000	84.60000	90.15000	0.0	0.0	-0.35599	0.0	0.0	93.099 *

* Result includes imported displacement(s).

Specific Utility Damage Results - Coordinates and Displacements

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start point	Coordinates			Displacements			Displacements at (n-Lp)						Displacements at (n+Lp)					
	x	y	z	x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility
	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
6.45191	24.96000	-3.16000	90.15000	0.00000	0.00000	2.54069	0.00000	0.00000	0.00000	0.00000	0.00000	1.40574	0.00000	0.00000	0.00000	0.00000	3.44298	0.00000	0.00000
12.90383	23.32000	3.08000	90.15000	0.00000	0.00000	3.46511	0.00000	0.00000	0.00000	0.00000	0.00000	3.31918	0.00000	0.00000	0.00000	0.00000	3.96144	0.00000	0.00000
19.35574	21.68000	9.32000	90.15000	0.00000	0.00000	4.74918	0.00000	0.00000	0.00000	0.00000	0.00000	3.78946	0.00000	0.00000	0.00000	0.00000	4.88587	0.00000	0.00000
25.80766	20.04000	15.56000	90.15000	0.00000	0.00000	2.56981	0.00000	0.00000	0.00000	0.00000	0.00000	5.17775	0.00000	0.00000	0.00000	0.00000	1.58844	0.00000	0.00000
Iteration: 2																		
9.67787	24.14000	-0.04000	90.15000	0.00000	0.00000	3.43956	0.00000	0.00000	0.00000	0.00000	0.00000	2.39860	0.00000	0.00000	0.00000	0.00000	3.51526	0.00000	0.00000
16.12979	22.50000	6.20000	90.15000	0.00000	0.00000	3.83962	0.00000	0.00000	0.00000	0.00000	0.00000	3.46169	0.00000	0.00000	0.00000	0.00000	4.81545	0.00000	0.00000
22.58170	20.86000	12.44000	90.15000	0.00000	0.00000	5.24402	0.00000	0.00000	0.00000	0.00000	0.00000	4.62737	0.00000	0.00000	0.00000	0.00000	2.44329	0.00000	0.00000

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start point	Coordinates			Displacements			Displacements at (n-Lp)						Displacements at (n+Lp)					
	x	y	z	x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility
	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
5.98971	18.07619	27.78095	90.15000	0.00000	0.00000	3.18069	0.00000	0.00000	0.00000	0.00000	0.00000	1.85509	0.00000	0.00000	0.00000	0.00000	3.25286	0.00000	0.00000
11.97942	17.75238	33.76190	90.15000	0.00000	0.00000	1.78398	0.00000	0.00000	0.00000	0.00000	0.00000	3.56213	0.00000	0.00000	0.00000	0.00000	1.43588	0.00000	0.00000
17.96913	17.42857	39.74286	90.15000	0.00000	0.00000	1.54458	0.00000	0.00000	0.00000	0.00000	0.00000	1.48889	0.00000	0.00000	0.00000	0.00000	1.87256	0.00000	0.00000
23.95885	17.10476	45.72381	90.15000	0.00000	0.00000	2.07517	0.00000	0.00000	0.00000	0.00000	0.00000	1.75507	0.00000	0.00000	0.00000	0.00000	2.32186	0.00000	0.00000
29.94856	16.78095	51.70476	90.15000	0.00000	0.00000	2.45213	0.00000	0.00000	0.00000	0.00000	0.00000	2.23839	0.00000	0.00000	0.00000	0.00000	2.62389	0.00000	0.00000
35.93827	16.45714	57.68571	90.15000	0.00000	0.00000	2.72742	0.00000	0.00000	0.00000	0.00000	0.00000	2.56294	0.00000	0.00000	0.00000	0.00000	2.89836	0.00000	0.00000
41.92798	16.13333	63.66667	90.15000	0.00000	0.00000	3.02017	0.00000	0.00000	0.00000	0.00000	0.00000	2.83354	0.00000	0.00000	0.00000	0.00000	3.10433	0.00000	0.00000
47.91769	15.80952	69.64762	90.15000	0.00000	0.00000	2.78193	0.00000	0.00000	0.00000	0.00000	0.00000	3.15708	0.00000	0.00000	0.00000	0.00000	0.62834	0.00000	0.00000
53.90740	15.48571	75.62857	90.15000	0.00000	0.00000	0.02162	0.00000	0.00000	0.00000	0.00000	0.00000	1.23955	0.00000	0.00000	0.00000	0.00000	-0.27496	0.00000	0.00000
Iteration: 2																		
8.98457	17.91429	30.77143	90.15000	0.00000	0.00000	3.67061	0.00000	0.00000	0.00000	0.00000	0.00000	2.91889	0.00000	0.00000	0.00000	0.00000	1.70006	0.00000	0.00000
14.97428	17.59048	36.75238	90.15000	0.00000	0.00000	1.40497	0.00000	0.00000	0.00000	0.00000	0.00000	2.20173	0.00000	0.00000	0.00000	0.00000	1.60445	0.00000	0.00000
20.96399	17.26667	42.73333	90.15000	0.00000	0.00000	1.81494	0.00000	0.00000	0.00000	0.00000	0.00000	1.51367	0.00000	0.00000	0.00000	0.00000	2.12159	0.00000	0.00000
26.95370	16.94286	48.71429	90.15000	0.00000	0.00000	2.28481	0.00000	0.00000	0.00000	0.00000	0.00000	2.01754	0.00000	0.00000	0.00000	0.00000	2.48364	0.00000	0.00000
32.94341	16.61905	54.69524	90.15000	0.00000	0.00000	2.59445	0.00000	0.00000	0.00000	0.00000	0.00000	2.41508	0.00000	0.00000	0.00000	0.00000	2.75760	0.00000	0.00000
38.93312	16.29524	60.67619	90.15000	0.00000	0.00000	2.86372	0.00000	0.00000	0.00000	0.00000	0.00000	2.69797	0.00000	0.00000	0.00000	0.00000	3.05911	0.00000	0.00000
44.92284	15.97143	66.65714	90.15000	0.00000	0.00000	3.19602	0.00000	0.00000	0.00000	0.00000	0.00000	2.98553	0.00000	0.00000	0.00000	0.00000	2.34327	0.00000	0.00000
50.91255	15.64762	72.63810	90.15000	0.00000	0.00000	0.80090	0.00000	0.00000	0.00000	0.00000	0.00000	2.87362	0.00000	0.00000	0.00000	0.00000	-0.03969	0.00000	0.00000
56.90226	15.32381	78.61905	90.15000	0.00000	0.00000	-0.25528	0.00000	0.00000	0.00000	0.00000	0.00000	0.19417	0.00000	0.00000	0.00000	0.00000	-0.34676	0.00000	0.00000

Specific Utility Damage Results - Pullouts and Rotations

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the Sagging utility's vs start Hogging point	Coordinates			Pullout Check	Rotation Check
			Vertical		

x	y	z	Rotation	Threshold Limit	Rotation	Threshold Limit	Pullout										Threshold Limit	
							Left Seg.				Right Seg.				Total			
							Axial		Flexural		Axial		Flexural		Axial		Flexural	
							Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored
[m]	[m]	[m]	[m]	[Deg]	[m]	[Deg]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
6.45191	24.96000	-3.16000	90.15000	0.00364	-	OK	0.00000	0.00000	0.01887	0.01887	0.00000	0.00000	0.01887	0.01887	0.00000	0.00000	0.03773	0.03773
12.90383	23.32000	3.08000	90.15000	0.00549	-	OK	0.00000	0.00000	0.02841	0.02841	0.00000	0.00000	0.02841	0.02841	0.00000	0.00000	0.05683	0.05683
19.35574	21.68000	9.32000	90.15000	0.01289	-	OK	0.00000	0.00000	0.06674	0.06674	0.00000	0.00000	0.06674	0.06674	0.00000	0.00000	0.13348	0.13348
25.80766	20.04000	15.56000	90.15000	0.02548	-	OK	0.00000	0.00000	0.13190	0.13190	0.00000	0.00000	0.13190	0.13190	0.00000	0.00000	0.26379	0.26379
Iteration: 2																		
9.67787	24.14000	-0.04000	90.15000	0.01512	-	OK	0.00000	0.00000	0.07827	0.07827	0.00000	0.00000	0.07827	0.07827	0.00000	0.00000	0.15654	0.15654
16.12979	22.50000	6.20000	90.15000	0.00936	-	OK	0.00000	0.00000	0.04848	0.04848	0.00000	0.00000	0.04848	0.04848	0.00000	0.00000	0.09697	0.09697
22.58170	20.86000	12.44000	90.15000	0.05353	-	OK	0.00000	0.00000	0.27711	0.27711	0.00000	0.00000	0.27711	0.27711	0.00000	0.00000	0.55422	0.55422

Total				
Flexural		Total		
Unfactored	Factored	Unfactored	Factored	
[mm]	[mm]	[mm]	[mm]	
0.03773	0.03773	0.03773	0.03773	- OK
0.05683	0.05683	0.05683	0.05683	- OK
0.13348	0.13348	0.13348	0.13348	- OK
0.26379	0.26379	0.26379	0.26379	- OK
0.15654	0.15654	0.15654	0.15654	- OK
0.09697	0.09697	0.09697	0.09697	- OK
0.55422	0.55422	0.55422	0.55422	- OK

Note: Total pullout ignores the axial component where this is negative (i.e. compression).

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start point	Coordinates			Rotation Check		Vertical Sagging vs Hogging	Pullout Check											
	x	y	z	Rotation	Threshold Limit	Rotation	Threshold Limit	Pullout									Threshold Limit	
								Left Seg.				Right Seg.				Total		
								Axial		Flexural		Axial		Flexural		Axial		Flexural
								Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored
	[m]	[m]	[m]	[m]	[Deg]	[m]	[Deg]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
5.98971	18.07619	27.78095	90.15000	0.01963	-	OK	Sagging	0.00000	0.00000	0.10164	0.10164	0.00000	0.00000	0.10164	0.10164	0.00000	0.00000	0.20328
11.97942	17.75238	33.76190	90.15000	0.02240	-	OK	Hogging	0.00000	0.00000	0.11596	0.11596	0.00000	0.00000	0.11596	0.11596	0.00000	0.00000	0.23192
17.96913	17.42857	39.74286	90.15000	0.00426	-	OK	Hogging	0.00000	0.00000	0.02208	0.02208	0.00000	0.00000	0.02208	0.02208	0.00000	0.00000	0.04416
23.95885	17.10476	45.72381	90.15000	0.00115	-	OK	Sagging	0.00000	0.00000	0.00595	0.00595	0.00000	0.00000	0.00595	0.00595	0.00000	0.00000	0.01190
29.94856	16.78095	51.70476	90.15000	0.00066	-	OK	Sagging	0.00000	0.00000	0.00340	0.00340	0.00000	0.00000	0.00340	0.00340	0.00000	0.00000	0.00681
35.93827	16.45714	57.68571	90.15000	0.00010	-	OK	Hogging	0.00000	0.00000	0.00052	0.00052	0.00000	0.00000	0.00052	0.00052	0.00000	0.00000	0.00105
41.92798	16.13333	63.66667	90.15000	0.00161	-	OK	Sagging	0.00000	0.00000	0.00831	0.00831	0.00000	0.00000	0.00831	0.00831	0.00000	0.00000	0.01662
47.91769	15.80952	69.64762	90.15000	0.02786	-	OK	Sagging	0.00000	0.00000	0.14421	0.14421	0.00000	0.00000	0.14421	0.14421	0.00000	0.00000	0.28842
53.90740	15.48571	75.62857	90.15000	0.01443	-	OK	Hogging	0.00000	0.00000	0.07471	0.07471	0.00000	0.00000	0.07471	0.07471	0.00000	0.00000	0.14942
Iteration: 2																		
8.98457	17.91429	30.77143	90.15000	0.04264	-	OK	Sagging	0.00000	0.00000	0.22075	0.22075	0.00000	0.00000	0.22075	0.22075	0.00000	0.00000	0.44149
14.97428	17.59048	36.75238	90.15000	0.01560	-	OK	Hogging	0.00000	0.00000	0.08078	0.08078	0.00000	0.00000	0.08078	0.08078	0.00000	0.00000	0.16157
20.96399	17.26667	42.73333	90.15000	0.00008	-	OK	Hogging	0.00000	0.00000	0.00044	0.00044	0.00000	0.00000	0.00044	0.00044	0.00000	0.00000	0.00087
26.95370	16.94286	48.71429	90.15000	0.00107	-	OK	Sagging	0.00000	0.00000	0.00555	0.00555	0.00000	0.00000	0.00555	0.00555	0.00000	0.00000	0.01110
32.94341	16.61905	54.69524	90.15000	0.00025	-	OK	Sagging	0.00000	0.00000	0.00132	0.00132	0.00000	0.00000	0.00132	0.00132	0.00000	0.00000	0.00263
38.93312	16.29524	60.67619	90.15000	0.00046	-	OK	Hogging	0.00000	0.00000	0.00240	0.00240	0.00000	0.00000	0.00240	0.00240	0.00000	0.00000	0.00481
44.92284	15.97143	66.65714	90.15000	0.01665	-	OK	Sagging	0.00000	0.00000	0.08622	0.08622	0.00000	0.00000	0.08622	0.08622	0.00000	0.00000	0.17243
50.91255	15.64762	72.63810	90.15000	0.01930	-	OK	Hogging	0.00000	0.00000	0.09991	0.09991	0.00000	0.00000	0.09991	0.09991	0.00000	0.00000	0.19983
56.90226	15.32381	78.61905	90.15000	0.00561	-	OK	Hogging	0.00000	0.00000	0.02903	0.02903	0.00000	0.00000	0.02903	0.02903	0.00000	0.00000	0.05806

Total				
Flexural		Total		
Factored	Unfactored	Factored		
[mm]	[mm]	[mm]	[mm]	
0.20328	0.20328	0.20328	0.20328	- OK
0.23192	0.23192	0.23192	0.23192	- OK
0.04416	0.04416	0.04416	0.04416	- OK
0.01190	0.01190	0.01190	0.01190	- OK
0.00681	0.00681	0.00681	0.00681	- OK
0.00105	0.00105	0.00105	0.00105	- OK
0.01662	0.01662	0.01662	0.01662	- OK
0.28842	0.28842	0.28842	0.28842	- OK
0.14942	0.14942	0.14942	0.14942	- OK
0.44149	0.44149	0.44149	0.44149	- OK
0.16157	0.16157	0.16157	0.16157	- OK
0.00087	0.00087	0.00087	0.00087	- OK
0.01110	0.01110	0.01110	0.01110	- OK
0.00263	0.00263	0.00263	0.00263	- OK
0.00481	0.00481	0.00481	0.00481	- OK
0.17243	0.17243	0.17243	0.17243	- OK
0.19983	0.19983	0.19983	0.19983	- OK
0.05806	0.05806	0.05806	0.05806	- OK

Note: Total pullout ignores the axial component where this is negative (i.e. compression).

Specific Utility Damage Results - Strains

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start point	Coordinates			Pipe Strain Check												Radius of Curvature Check		Peak flexural tensile strain orientation angle (w.r.t global z-axis)
	x	y	z	Axial		Flexural				Tension		Compression				Radius of Curvature	Threshold Limit	
						Tension		Compression		Total		Total						
				Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Check	Check			
[m]	[m]	[m]	[m]	[με]	[με]	[με]	[με]	[με]	[με]	[με]	[με]	[με]	[με]			[m]		[Deg]
6.45191	24.96000	-3.16000	90.15000	0.046134	0.0092267	4.6192	4.6192	-4.6192	-4.6192	4.66530	4.62839	-4.57303	-4.60994	OK	OK	6.4216E+4	-	180.00000
9.67787	24.14000	-0.04000	90.15000	0.010264	0.0020528	24.892	24.892	-24.892	-24.892	24.90271	24.89450	-24.88219	-24.89040	OK	OK	1.1916E+4	-	180.00000
12.90383	23.32000	3.08000	90.15000	0.0019224	384.47E-6	9.9467	9.9467	-9.9467	-9.9467	9.94865	9.94711	-9.94480	-9.94634	OK	OK	2.9821E+4	-	0.00000
16.12979	22.50000	6.20000	90.15000	0.019805	0.0039610	15.250	15.250	-15.250	-15.250	15.27019	15.25435	-15.23058	-15.24642	OK	OK	1.9450E+4	-	0.00000
19.35574	21.68000	9.32000	90.15000	0.023690	0.0047381	11.821	11.821	-11.821	-11.821	11.84462	11.82567	-11.79724	-11.81620	OK	OK	2.5093E+4	-	180.00000
22.58170	20.86000	12.44000	90.15000	0.057050	0.011410	90.327	90.327	-90.327	-90.327	90.38388	90.33824	-90.26978	-90.31542	OK	OK	3.2839E+3	-	180.00000
25.80766	20.04000	15.56000	90.15000	0.15731	0.031461	49.296	49.296	-49.296	-49.296	49.45347	49.32763	-49.13886	-49.26471	OK	OK	6.0172E+3	-	0.00000

Note: Tensile strains are +ve, compressive strains are -ve.
Note: The peak flexural tensile strain orientation angle is measured with respect to the global z-axis by looking at the end point of the utility from the start point. Anti-clockwise is positive.

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start point	Coordinates			Pipe Strain Check												Radius of Curvature Check		Peak flexural tensile strain orientation angle (w.r.t global z-axis)
	x	y	z	Axial		Flexural				Tension		Compression				Radius of Curvature	Threshold Limit	
						Tension		Compression		Total		Total						
				Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Check	Check			
[m]	[m]	[m]	[m]	[με]	[με]	[με]	[με]	[με]	[με]	[με]	[με]	[με]	[με]			[m]		[Deg]
2.99486	18.23810	24.79048	90.15000	0.046644	0.0093288	17.698	17.698	-17.698	-17.698	17.74507	17.70775	-17.65178	-17.68909	OK	OK	1.6760E+4	-	0.00000
5.98971	18.07619	27.78095	90.15000	0.038971	0.0077943	22.898	22.898	-22.898	-22.898	22.93688	22.90570	-22.85894	-22.89011	OK	OK	1.2954E+4	-	180.00000

Distance from the utility's start	Coordinates					Pipe Strain Check							Radius of Curvature Check			Peak flexural tensile strain orientation angle (w.r.t	
8.98457	17.91429	30.77143	90.15000	0.027187	0.0054375	78.596	78.596	-78.596	-78.596	78.62339	78.60164	OK	-78.56902	-78.59077	OK	3.7740E+3	-	-	180.00000
11.97942	17.75238	33.76190	90.15000	0.071538	0.014308	49.859	49.859	-49.859	-49.859	49.93083	49.87360	OK	-49.78776	-49.84499	OK	5.9492E+3	-	-	0.00000
14.97428	17.59048	36.75238	90.15000	798.73E-6	159.75E-6	17.152	17.152	-17.152	-17.152	17.15233	17.15169	OK	-17.15073	-17.15137	OK	1.7294E+4	-	-	0.00000
17.96913	17.42857	39.74286	90.15000	0.0023424	468.47E-6	4.3240	4.3240	-4.3240	-4.3240	4.32631	4.32444	OK	-4.32163	-4.32350	OK	6.8600E+4	-	-	0.00000
20.96399	17.26667	42.73333	90.15000	0.0039234	784.69E-6	0.33494	0.33494	-0.33494	-0.33494	0.33887	0.33573	OK	-0.33102	-0.33416	OK	8.8559E+5	-	-	180.00000
23.95885	17.10476	45.72381	90.15000	0.0030769	615.39E-6	1.6729	1.6729	-1.6729	-1.6729	1.67597	1.67351	OK	-1.66982	-1.67228	OK	1.7731E+5	-	-	180.00000
26.95370	16.94286	48.71429	90.15000	0.0019804	396.09E-6	1.3997	1.3997	-1.3997	-1.3997	1.40166	1.40007	OK	-1.39770	-1.39928	OK	2.1192E+5	-	-	180.00000
29.94856	16.78095	51.70476	90.15000	0.0013362	267.25E-6	0.82677	0.82677	-0.82677	-0.82677	0.82810	0.82703	OK	-0.82543	-0.82650	OK	3.5878E+5	-	-	180.00000
32.94341	16.61905	54.69524	90.15000	0.0010561	211.23E-6	0.30950	0.30950	-0.30950	-0.30950	0.31056	0.30971	OK	-0.30844	-0.30929	OK	9.5840E+5	-	-	180.00000
35.93827	16.45714	57.68571	90.15000	0.0010105	202.09E-6	0.11039	0.11039	-0.11039	-0.11039	0.11140	0.11059	OK	-0.10938	-0.11019	OK	2.6871E+6	-	-	0.00000
38.93312	16.29524	60.67619	90.15000	0.0011945	238.89E-6	0.66657	0.66657	-0.66657	-0.66657	0.66777	0.66681	OK	-0.66538	-0.66634	OK	4.4500E+5	-	-	0.00000
41.92798	16.13333	63.66667	90.15000	0.0015390	307.79E-6	0.64123	0.64123	-0.64123	-0.64123	0.64277	0.64154	OK	-0.63969	-0.64092	OK	4.6259E+5	-	-	0.00000
44.92284	15.97143	66.65714	90.15000	791.04E-6	158.21E-6	19.510	19.510	-19.510	-19.510	19.51085	19.51022	OK	-19.50927	-19.50990	OK	1.5204E+4	-	-	180.00000
47.91769	15.80952	69.64762	90.15000	0.079949	0.015990	51.821	51.821	-51.821	-51.821	51.90128	51.83732	OK	-51.74138	-51.80534	OK	5.7240E+3	-	-	180.00000
50.91255	15.64762	72.63810	90.15000	0.10619	0.021238	39.744	39.744	-39.744	-39.744	39.85028	39.76533	OK	-39.63791	-39.72286	OK	7.4633E+3	-	-	0.00000
53.90740	15.48571	75.62857	90.15000	0.015547	0.0031093	16.614	16.614	-16.614	-16.614	16.62966	16.61722	OK	-16.59856	-16.61100	OK	1.7854E+4	-	-	0.00000
56.90226	15.32381	78.61905	90.15000	0.0018644	372.89E-6	6.2191	6.2191	-6.2191	-6.2191	6.22099	6.21950	OK	-6.21726	-6.21875	OK	4.7695E+4	-	-	0.00000

Note: Tensile strains are +ve, compressive strains are -ve.
Note: The peak flexural tensile strain orientation angle is measured with respect to the global z-axis by looking at the end point of the utility from the start point. Anti-clockwise is positive.

Specific Utility Damage Results - Maximum Values

Name	Jointed	Displacement Data Type	Displacement Data	Maximum Pullout (Factored)		Maximum Rotation (Factored)		Maximum Strain (Factored) Tension		Maximum Strain (Factored) Compression		Minimum Radius of Curvature		Maximum Displacement Vertical		Maximum Displacement Horizontal x		Maximum Displacement Horizontal y	
				Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value
				[m]	[mm]	[m]	[Deg]	[m]	[με]	[m]	[με]	[m]	[m]	[m]	[mm]	[m]	[mm]	[m]	[mm]
Cast Iron Main	Yes	Displacement	Line 1	22.582	0.55422	22.582	0.05353	22.58170	90.33824	22.58170	-90.31542	22.582	3.2839E+3	22.582	5.2440	32.259	0.0	32.259	0.0
Line 1		Line																	
Cast Iron Main	Yes	Displacement	Line 2	8.9846	0.44149	8.9846	0.04264	8.98457	78.60164	8.98457	-78.59077	8.9846	3.7740E+3	8.9846	3.6706	62.891	0.0	62.891	0.0
Line 2		Line																	

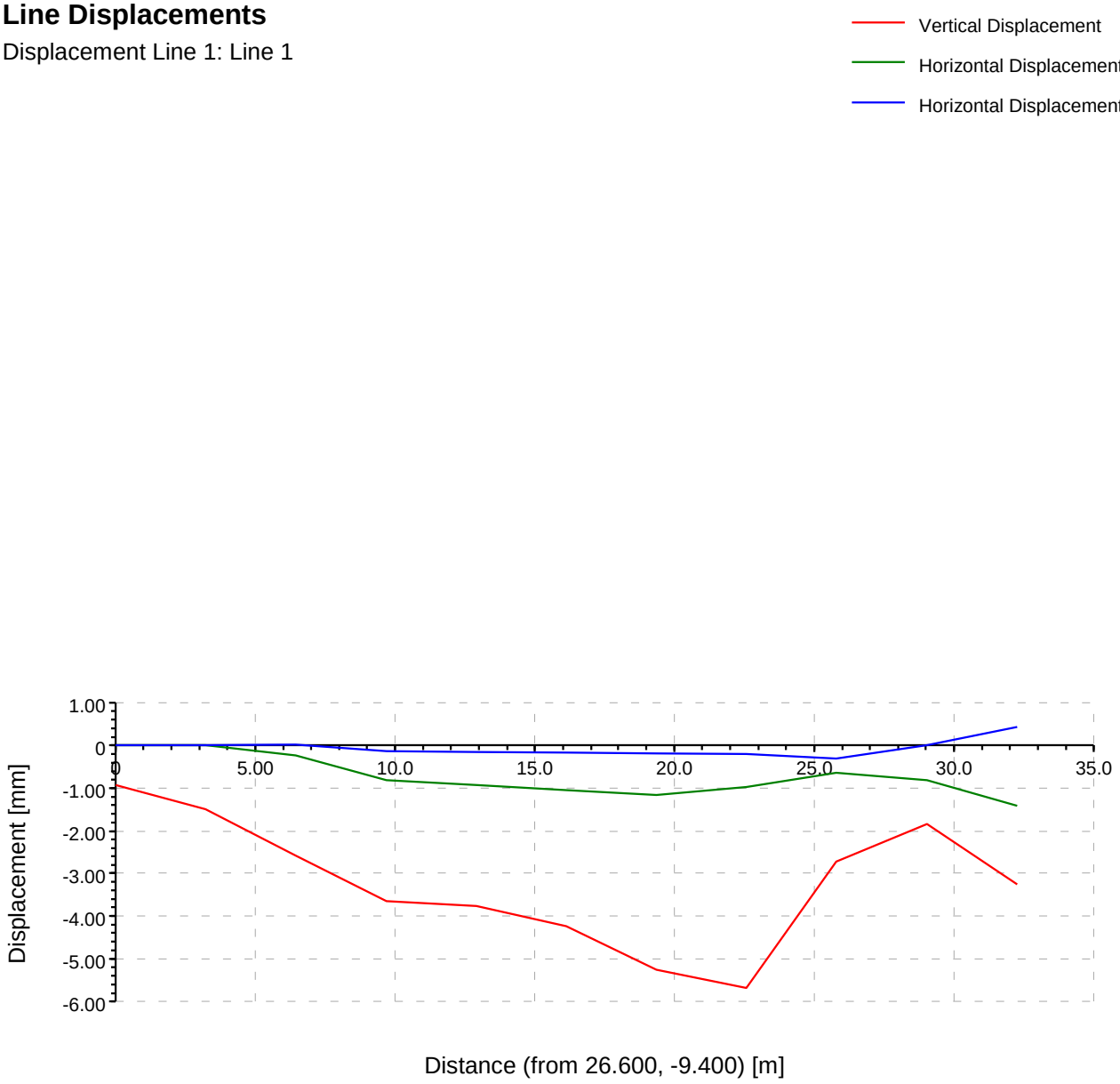
Note: * symbol indicates that the value has exceeded one of (or both) the limiting criteria

APPENDIX D

Case 3-Figures and XDISP output

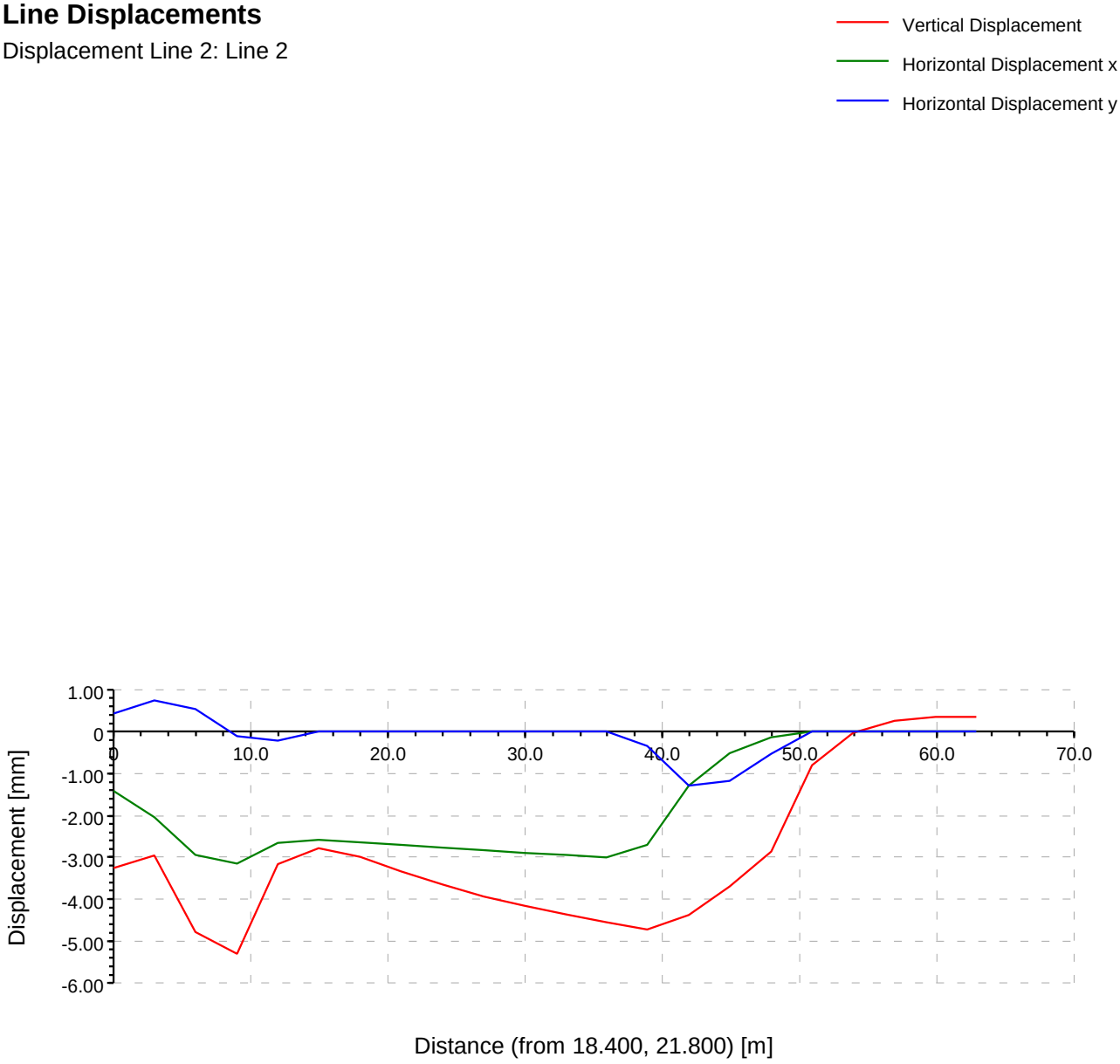
Line Displacements

Displacement Line 1: Line 1



Line Displacements

Displacement Line 2: Line 2



Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Displacement and Strain Results

Type/No.		Coordinates			Displacements					Angle of Line to x Axis
Name	Dist.	x	y	z	x	y	z	Horizontal displacement along Line	Horizontal displacement perpendicular to Line	
	[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[°]
Line 1	Line 1	26.60000	-9.40000	90.15000	0.0	0.0	0.92708	0.0	0.0	104.73 *
	3.2260	25.78000	-6.28000	90.15000	0.0	0.0	1.4798	0.0	0.0	104.73 *
	6.4519	24.96000	-3.16000	90.15000	-0.23708	0.019739	2.5898	0.079353	0.22427	104.73 *
	9.6779	24.14000	-0.04000	90.15000	-0.81280	-0.13246	3.6575	0.078498	0.81977	104.73 *
	12.904	23.32000	3.08000	90.15000	-0.92661	-0.15100	3.7661	0.089490	0.93456	104.73 *
	16.130	22.50000	6.20000	90.15000	-1.0404	-0.16955	4.2396	0.10048	1.0493	104.73 *
	19.356	21.68000	9.32000	90.15000	-1.1542	-0.18810	5.2614	0.11147	1.1641	104.73 *
	22.582	20.86000	12.44000	90.15000	-0.96665	-0.20212	5.6878	0.050233	0.98628	104.73 *
	25.808	20.04000	15.56000	90.15000	-0.63517	-0.31344	2.7350	-0.14169	0.69398	104.73 *
	29.034	19.22000	18.68000	90.15000	-0.81750	0.0	1.8392	0.20780	0.79065	104.73 *
	32.260	18.40000	21.80000	90.15000	-1.4076	0.42915	3.2635	0.77285	1.2523	104.73 *
Line 2	Line 2	18.40000	21.80000	90.15000	-1.4076	0.42915	3.2635	0.50462	1.3824	93.099 *
	2.9949	18.23810	24.79048	90.15000	-2.0315	0.74790	2.9689	0.85663	1.9881	93.099 *
	5.9897	18.07619	27.78095	90.15000	-2.9535	0.54237	4.7922	0.70124	2.9199	93.099 *
	8.9846	17.91429	30.77143	90.15000	-3.1445	-0.10457	5.3040	0.065581	3.1456	93.099 *
	11.979	17.75238	33.76190	90.15000	-2.6615	-0.21661	3.1718	-0.072416	2.6693	93.099 *
	14.974	17.59048	36.75238	90.15000	-2.5911	0.0	2.7920	0.14008	2.5873	93.099 *
	17.969	17.42857	39.74286	90.15000	-2.6518	0.0	2.9978	0.14336	2.6479	93.099 *
	20.964	17.26667	42.73333	90.15000	-2.7125	0.0	3.3338	0.14664	2.7085	93.099 *
	23.959	17.10476	45.72381	90.15000	-2.7732	0.0	3.6588	0.14992	2.7692	93.099 *
	26.954	16.94286	48.71429	90.15000	-2.8339	0.0	3.9321	0.15320	2.8298	93.099 *
	29.949	16.78095	51.70476	90.15000	-2.8946	0.0	4.1616	0.15649	2.8904	93.099 *
	32.943	16.61905	54.69524	90.15000	-2.9554	0.0	4.3641	0.15977	2.9510	93.099 *
	35.938	16.45714	57.68571	90.15000	-3.0161	0.0	4.5550	0.16305	3.0117	93.099 *
	38.933	16.29524	60.67619	90.15000	-2.7115	-0.34285	4.7265	-0.19576	2.7261	93.099 *
	41.928	16.13333	63.66667	90.15000	-1.2747	-1.2896	4.3779	-1.2188	1.3425	93.099 *
	44.923	15.97143	66.65714	90.15000	-0.51547	-1.1691	3.7023	-1.1395	0.57792	93.099 *
	47.918	15.80952	69.64762	90.15000	-0.14205	-0.53315	2.8698	-0.52469	0.17066	93.099 *
	50.913	15.64762	72.63810	90.15000	0.0	0.0	0.80090	0.0	0.0	93.099 *
	53.907	15.48571	75.62857	90.15000	0.0	0.0	0.021621	0.0	0.0	93.099 *
	56.902	15.32381	78.61905	90.15000	0.0	0.0	-0.25528	0.0	0.0	93.099 *
	59.897	15.16190	81.60952	90.15000	0.0	0.0	-0.34414	0.0	0.0	93.099 *
	62.892	15.00000	84.60000	90.15000	0.0	0.0	-0.35599	0.0	0.0	93.099 *

* Result includes imported displacement(s).

Specific Utility Damage Results - Coordinates and Displacements

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start point	Coordinates			Displacements					Displacements at (n-Lp)					Displacements at (n+Lp)				
	x	y	z	x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility
	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
6.45191	24.96000	-3.16000	90.15000	-0.23708	0.01974	2.58982	0.07935	0.22427	0.00000	0.00000	1.40574	0.00000	0.00000	-0.82804	-0.13494	3.67209	0.07997	0.22427
12.90383	23.32000	3.08000	90.15000	-0.92661	-0.15100	3.76612	0.08949	0.93456	-0.73569	-0.11207	3.51455	0.07861	0.74002	-1.05566	-0.17203	4.37641	0.10195	0.93456
19.35574	21.68000	9.32000	90.15000	-1.15423	-0.18810	5.26137	0.11147	1.16413	-1.02518	-0.16707	4.17615	0.09901	1.03397	-0.92226	-0.21703	5.29230	0.02453	1.16413
25.80766	20.04000	15.56000	90.15000	-0.63517	-0.31344	2.73495	-0.14169	0.69398	-0.99178	-0.20024	5.63065	0.05843	1.01010	-0.89653	0.05747	2.02997	0.28347	0.69398
Iteration: 2																		
9.67787	24.14000	-0.04000	90.15000	-0.81280	-0.13246	3.65754	0.07850	0.81977	-0.20533	0.01710	2.44115	0.06873	0.19424	-0.94185	-0.15349	3.82953	0.09096	0.81977
16.12979	22.50000	6.20000	90.15000	-1.04042	-0.16955	4.23956	0.10048	1.04934	-0.91136	-0.14852	3.75158	0.08802	0.91918	-1.12911	-0.18997	5.31848	0.10327	1.04934
22.58170	20.86000	12.44000	90.15000	-0.96665	-0.20212	5.68776	0.05023	0.98628	-1.13899	-0.18561	5.12452	0.11000	1.14876	-0.65959	-0.27146	2.61499	-0.09488	0.98628

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start point	Coordinates			Displacements					Displacements at (n-Lp)					Displacements at (n+Lp)				
	x	y	z	x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility
	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
5.98971	18.07619	27.78095	90.15000	-2.95350	0.54237	4.79217	0.70124	2.91986	-1.89336	0.67732	3.03413	0.77868	1.85397	-3.03757	-0.12938	4.83190	0.03503	2.91986
11.97942	17.75238	33.76190	90.15000	-2.66145	-0.21661	3.17182	-0.07242	2.66927	-3.10223	0.03868	5.19069	0.20633	3.09561	-2.60452	0.00000	2.83755	0.14080	2.66927
17.96913	17.42857	39.74286	90.15000	-2.65179	0.00000	2.99776	0.14336	2.64791	-2.60666	-0.04796	2.87609	0.09302	2.60544	-2.72594	0.00000	3.40575	0.14737	2.64791
23.95885	17.10476	45.72381	90.15000	-2.77321	0.00000	3.65883	0.14992	2.76916	-2.69906	0.00000	3.25937	0.14591	2.69511	-2.84737	0.00000	3.98293	0.15393	2.76916
29.94856	16.78095	51.70476	90.15000	-2.89464	0.00000	4.16158	0.15649	2.89041	-2.82048	0.00000	3.87161	0.15248	2.81636	-2.96880	0.00000	4.40640	0.16050	2.89041
35.93827	16.45714	57.68571	90.15000	-3.01607	0.00000	4.55504	0.16305	3.01166	-2.94191	0.00000	4.31928	0.15904	2.93761	-2.39337	-0.55248	4.64935	-0.42229	3.01166
41.92798	16.13333	63.66667	90.15000	-1.27468	-1.28959	4.37791	-1.21880	1.34254	-2.77896	-0.26693	4.68857	-0.11631	2.78933	-0.43279	-1.02826	3.51797	-1.00336	1.34254
47.91769	15.80952	69.64762	90.15000	-0.14205	-0.53315	2.86979	-0.52469	0.17066	-0.68358	-1.19576	3.85191	-1.15705	0.74723	0.00000	0.00000	0.62834	0.00000	0.17066
53.90740	15.48571	75.62857	90.15000	0.00000	0.00000	0.02162	0.00000	0.00000	-0.03145	-0.11805	1.25901	-0.11618	0.03779	0.00000	0.00000	-0.27496	0.00000	0.00000
Iteration: 2																		
8.98457	17.91429	30.77143	90.15000	-3.14454	-0.10457	5.30403	0.06558	3.14559	-2.74934	0.58788	4.38845	0.73565	2.71354	-2.64587	-0.16865	3.08772	-0.02536	3.14559
14.97428	17.59048	36.75238	90.15000	-2.59107	0.00000	2.79199	0.14008	2.58728	-2.76842	-0.19180	3.64395	-0.04186	2.77474	-2.66523	0.00000	3.07217	0.14408	2.58728
20.96399	17.26667	42.73333	90.15000	-2.71250	0.00000	3.33378	0.14664	2.70853	-2.63834	0.00000	2.95220	0.14263	2.63448	-2.78666	0.00000	3.71934	0.15065	2.70853

Distance from the utility's start	Coordinates x	y	z	Displacements				Displacements at (n-Lp)				Displacements at (n+Lp)			
26.95370	16.94286	48.71429	90.15000	-2.83393	0.00000	3.93213	0.15320	2.82978	-2.75977	0.00000	3.58685	0.14920	2.75573	-2.90809	0.00000	4.20643	0.15721
2.82978																	
32.94341	16.61905	54.69524	90.15000	-2.95536	0.00000	4.36413	0.15977	2.95104	-2.88120	0.00000	4.11077	0.15576	2.87699	-2.94864	-0.07592	4.59302	0.08360
2.95104																	
38.93312	16.29524	60.67619	90.15000	-2.71153	-0.34285	4.72654	-0.19576	2.72610	-3.00263	0.00000	4.51277	0.16232	2.99824	-1.10657	-1.26290	4.22831	-1.20124
2.72610																	
44.92284	15.97143	66.65714	90.15000	-0.51547	-1.16907	3.70231	-1.13949	0.57792	-1.59284	-1.07996	4.45510	-0.99227	1.64889	-0.11059	-0.41509	2.41168	-0.40851
0.57792																	
50.91255	15.64762	72.63810	90.15000	0.00000	0.00000	0.80090	0.00000	0.00000	-0.22473	-0.67396	3.05413	-0.66082	0.26084	0.00000	0.00000	-0.03969	0.00000
0.00000																	
56.90226	15.32381	78.61905	90.15000	0.00000	0.00000	-0.25528	0.00000	0.00000	0.00000	0.00000	0.19417	0.00000	0.00000	0.00000	0.00000	-0.34676	0.00000
0.00000																	

Specific Utility Damage Results - Pullouts and Rotations

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start	Coordinates x	y	z	Pullout Check Rotation Check Vertical Sagging vs Hogging point	Pullout														Threshold Limit	
					Left Seg.				Right Seg.				Total							
					Axial		Flexural		Axial		Flexural		Axial		Flexural		Total			
					Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Rotation	Threshold Limit
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[Deg]	[Deg]	
Iteration: 1																				
6.45191	24.96000	-3.16000	90.15000	0.03968	0.03968	0.03242	0.03242	0.07966	0.07966	0.03242	0.03242	0.03999	0.03999	0.06484	0.06484	0.10482	0.10482	-	OK	
0.00626	0.00626	-	OK	Sagging																
12.90383	23.32000	3.08000	90.15000	0.08405	0.08405	0.02955	0.02955	0.09572	0.09572	0.02955	0.02955	0.01167	0.01167	0.05910	0.05910	0.07077	0.07077	-	OK	
0.00571	0.00571	-	OK	Hogging																
19.35574	21.68000	9.32000	90.15000	0.10524	0.10524	0.09001	0.09001	0.06800	0.06800	0.09001	0.09001	-0.03724	-0.03724	0.18002	0.18002	0.18002	0.18002	-	OK	
0.01739	0.01739	-	OK	Sagging																
25.80766	20.04000	15.56000	90.15000	-0.04163	-0.04163	0.18176	0.18176	0.07089	0.07089	0.18176	0.18176	0.11252	0.11252	0.36353	0.36353	0.47605	0.47605	-	OK	
0.03511	0.03511	-	OK	Hogging																
Iteration: 2																				
9.67787	24.14000	-0.04000	90.15000	0.07361	0.07361	0.09373	0.09373	0.08473	0.08473	0.09373	0.09373	0.01112	0.01112	0.18747	0.18747	0.19859	0.19859	-	OK	
0.01811	0.01811	-	OK	Sagging																
16.12979	22.50000	6.20000	90.15000	0.09425	0.09425	0.04802	0.04802	0.10188	0.10188	0.04802	0.04802	0.00763	0.00763	0.09605	0.09605	0.10368	0.10368	-	OK	
0.00928	0.00928	-	OK	Hogging																
22.58170	20.86000	12.44000	90.15000	0.08012	0.08012	0.29499	0.29499	-0.02233	-0.02233	0.29499	0.29499	-0.10244	-0.10244	0.58998	0.58998	0.58998	0.58998	-	OK	
0.05698	0.05698	-	OK	Sagging																

Note: Total pullout ignores the axial component where this is negative (i.e. compression).

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start	Coordinates x	y	z	Pullout Check Rotation Check Vertical Sagging vs Hogging point	Pullout														Threshold Limit	
					Left Seg.				Right Seg.				Total							
					Axial		Flexural		Axial		Flexural		Axial		Flexural		Total			
					Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Rotation	Threshold Limit
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[Deg]	[Deg]	
Iteration: 1																				
5.98971	18.07619	27.78095	90.15000	0.73996	0.73996	0.15904	0.15904	0.36813	0.36813	0.15904	0.15904	-0.37183	-0.37183	0.31808	0.31808	0.31808	0.31808	-	OK	
0.03072	0.03072	-	OK	Sagging																
11.97942	17.75238	33.76190	90.15000	0.06696	0.06696	0.13965	0.13965	0.03419	0.03419	0.13965	0.13965	-0.03277	-0.03277	0.27930	0.27930	0.27930	0.27930	-	OK	
0.02697	0.02697	-	OK	Hogging																
17.96913	17.42857	39.74286	90.15000	0.11819	0.11819	0.02336	0.02336	0.14536	0.14536	0.02336	0.02336	0.02717	0.02717	0.04672	0.04672	0.07389	0.07389	-	OK	
0.00451	0.00451	-	OK	Hogging																
23.95885	17.10476	45.72381	90.15000	0.14792	0.14792	0.00611	0.00611	0.15193	0.15193	0.00611	0.00611	0.00401	0.00401	0.01222	0.01222	0.01623	0.01623	-	OK	
0.00118	0.00118	-	OK	Sagging																
29.94856	16.78095	51.70476	90.15000	0.15448	0.15448	0.00366	0.00366	0.15849	0.15849	0.00366	0.00366	0.00401	0.00401	0.00732	0.00732	0.01133	0.01133	-	OK	
0.00071	0.00071	-	OK	Sagging																
35.93827	16.45714	57.68571	90.15000	0.16105	0.16105	0.05521	0.05521	-0.12962	-0.12962	0.05521	0.05521	-0.29066	-0.29066	0.11042	0.11042	0.11042	0.11042	-	OK	
0.01066	0.01066	-	OK	Sagging																
41.92798	16.13333	63.66667	90.15000	-0.66755	-0.66755	0.06548	0.06548	-1.11108	-1.11108	0.06548	0.06548	-0.44353	-0.44353	0.13097	0.13097	0.13097	0.13097	-	OK	
0.01265	0.01265	-	OK	Sagging																
47.91769	15.80952	69.64762	90.15000	-0.84087	-0.84087	0.10729	0.10729	-0.26234	-0.26234	0.10729	0.10729	0.57853	0.57853	0.21458	0.21458	0.79311	0.79311	-	OK	
0.02072	0.02072	-	OK	Sagging																
53.90740	15.48571	75.62857	90.15000	-0.05809	-0.05809	0.07635	0.07635	0.00000	0.00000	0.07635	0.07635	0.05809	0.05809	0.15270	0.15270	0.21079	0.21079	-	OK	
0.01475	0.01475	-	OK	Hogging																
Iteration: 2																				
8.98457	17.91429	30.77143	90.15000	0.40062	0.40062	0.26484	0.26484	0.02011	0.02011	0.26484	0.26484	-0.38051	-0.38051	0.52969	0.52969	0.52969	0.52969	-	OK	
0.05116	0.05116	-	OK	Sagging																
14.97428	17.59048	36.75238	90.15000	0.04911	0.04911	0.09422	0.09422	0.14208	0.14208	0.09422	0.09422	0.09297	0.09297	0.18844	0.18844	0.28142	0.28142	-	OK	
0.01820	0.01820	-	OK	Hogging																
20.96399	17.26667	42.73333	90.15000	0.14464	0.14464	0.00032	0.00032	0.14864	0.14864	0.00032	0.00032	0.00401	0.00401	0.00065	0.00065	0.00466	0.00466	-	OK	
0.00006	0.00006	-	OK	Hogging																
26.95370	16.94286	48.71429	90.15000	0.15120	0.15120	0.00576	0.00576	0.15521	0.15521	0.00576	0.00576	0.00401	0.00401	0.01151	0.01151	0.01552	0.01552	-	OK	
0.00111	0.00111	-	OK	Sagging																
32.94341	16.61905	54.69524	90.15000	0.15776	0.15776	0.00653	0.00653	0.12169	0.12169	0.00653	0.00653	-0.03608	-0.03608	0.01305	0.01305	0.01305	0.01305	-	OK	
0.00126	0.00126	-	OK	Sagging																
38.93312	16.29524	60.67619	90.15000	-0.01672	-0.01672	0.11882	0.11882	-0.69850	-0.69850	0.11882	0.11882	-0.68178	-0.68178	0.23765	0.23765	0.23765	0.23765	-	OK	
0.02295	0.02295	-	OK	Sagging																
44.92284	15.97143	66.65714	90.15000	-1.06588	-1.06588	0.06692	0.06692	-0.77400	-0.77400	0.06692	0.06692	0.29188	0.29188	0.13384	0.13384	0.42572	0.42572	-	OK	
0.01293	0.01293	-	OK	Sagging																
50.91255	15.64762	72.63810	90.15000	-0.33041	-0.33041	0.11649	0.11649	0.00000	0.00000	0.11649	0.11649	0.33041	0.33041	0.23297	0.23297	0.56339	0.56339	-	OK	
0.02250	0.02250	-	OK	Hogging																
56.90226	15.32381	78.61905	90.15000	0.00000	0.00000	0.02903	0.02903	0.00000	0.00000	0.02903	0.02903	0.00000	0.00000	0.05806	0.05806	0.05806	0.05806	-	OK	
0.00561	0.00561	-	OK	Hogging																

Note: Total pullout ignores the axial component where this is negative (i.e. compression).

Specific Utility Damage Results - Strains

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start	Coordinates x	y	z	Pipe Strain Check Axial	Flexural	Tension	Compression	Radius of Curvature Check Radius of Threshold Limit	Peak flexural tensile strain orientation angle (w.r.t global z-axis)

				Tension		Compression		Total		Check	Total		Check	Curvature							
				Unfactored	Factored	Unfactored	Factored	Unfactored	Factored		Unfactored	Factored									
[m]	[m]	[m]	[m]	[με]	[με]	[με]	[με]	[με]	[με]		[με]	[με]		[m]				[Deg]			
6.45191	24.96000	-3.16000	90.15000	12.232	2.4463	10.649	10.649	-10.649	-10.649	22.88115	13.09583	OK	-8.20316	OK	2.7853E+4	-	-	263.49481			
9.67787	24.14000	-0.04000	90.15000	1.5938	0.31875	30.580	30.580	-30.580	-30.580	32.17368	30.89867	OK	-28.98616	-30.26117	OK	9.7000E+3	-	-	153.38083			
12.90383	23.32000	3.08000	90.15000	3.4119	0.68239	10.399	10.399	-10.399	-10.399	13.81143	11.08188	OK	-6.98756	-9.71711	OK	2.8523E+4	-	-	0.00000			
16.12979	22.50000	6.20000	90.15000	3.4347	0.68694	15.630	15.630	-15.630	-15.630	19.06519	16.31741	OK	-12.19574	-14.94352	OK	1.8977E+4	-	-	0.00000			
19.35574	21.68000	9.32000	90.15000	-7.7629	-7.7629	18.910	18.910	-18.910	-18.910	11.14758	11.14758	OK	-26.67336	-26.67336	OK	1.5686E+4	-	-	153.82737			
22.58170	20.86000	12.44000	90.15000	-39.159	-39.159	96.372	96.372	-96.372	-96.372	57.21273	57.21273	OK	-135.53085	-135.53085	OK	3.0779E+3	-	-	178.06020			
25.80766	20.04000	15.56000	90.15000	24.600	4.9200	59.672	59.672	-59.672	-59.672	84.27158	64.59163	OK	-35.07171	-54.75166	OK	4.9709E+3	-	-	-10.70741			

Note: Tensile strains are +ve, compressive strains are -ve.
Note: The peak flexural tensile strain orientation angle is measured with respect to the global z-axis by looking at the end point of the utility from the start point. Anti-clockwise is positive.

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start point	Coordinates			Pipe Strain Check											Radius of Curvature Check			Peak flexural tensile strain orientation angle (w.r.t global z-axis)
	x	y	z	Axial	Flexural				Tension		Compression				Radius of Curvature	Threshold Limit		
					Tension		Compression		Total		Check	Total		Check				
				Unfactored	Factored	Unfactored	Factored	Unfactored	Factored			Unfactored	Factored					
[m]	[m]	[m]	[m]	[με]	[με]	[με]	[με]	[με]	[με]	[με]		[με]	[με]		[m]			[Deg]
2.99486	18.23810	24.79048	90.15000	32.893	6.5786	70.864	70.864	-70.864	-70.864	103.75698	77.44266	OK	-37.97119	-64.28551	OK	4.1858E+3	-	-	-8.75100
5.98971	18.07619	27.78095	90.15000	-131.97	-131.97	49.256	49.256	-49.256	-49.256	-	-	-	-181.22929	-181.22929	OK	6.0221E+3	-	-	151.70337
8.98457	17.91429	30.77143	90.15000	-129.13	-129.13	90.473	90.473	-90.473	-90.473	-	-	-	-219.60041	-219.60041	OK	3.2786E+3	-	-	165.12998
11.97942	17.75238	33.76190	90.15000	12.529	2.5059	59.403	59.403	-59.403	-59.403	71.93228	61.90880	OK	-46.87358	-56.89706	OK	4.9934E+3	-	-	-12.68182
14.97428	17.59048	36.75238	90.15000	36.024	7.2049	19.933	19.933	-19.933	-19.933	55.95758	27.13801	OK	-	-12.72822	OK	1.4881E+4	-	-	-13.68683
17.96913	17.42857	39.74286	90.15000	1.1003	0.22005	4.3071	4.3071	-4.3071	-4.3071	5.40739	4.52717	OK	-3.20685	-4.08707	OK	6.8868E+4	-	-	0.00000
20.96399	17.26667	42.73333	90.15000	1.1023	0.22045	0.36246	0.36246	-0.36246	-0.36246	1.46473	0.58292	OK	-	-0.14201	OK	8.1836E+5	-	-	180.00000
23.95885	17.10476	45.72381	90.15000	1.1012	0.22023	1.7116	1.7116	-1.7116	-1.7116	2.81277	1.93184	OK	-0.61044	-1.49137	OK	1.7330E+5	-	-	180.00000
26.95370	16.94286	48.71429	90.15000	1.0997	0.21994	1.4501	1.4501	-1.4501	-1.4501	2.54983	1.67007	OK	-0.35043	-1.23019	OK	2.0455E+5	-	-	180.00000
29.94856	16.78095	51.70476	90.15000	1.0988	0.21976	0.88947	0.88947	-0.88947	-0.88947	1.98824	1.10922	OK	-	-0.66971	OK	3.3349E+5	-	-	180.00000
32.94341	16.61905	54.69524	90.15000	1.0983	0.21967	0.38499	0.38499	-0.38499	-0.38499	1.48333	0.60466	OK	-	-0.16533	OK	7.7046E+5	-	-	180.00000
35.93827	16.45714	57.68571	90.15000	-59.354	-59.354	11.467	11.467	-11.467	-11.467	-	-	-	-70.82061	-70.82061	OK	2.5868E+4	-	-	93.20918
38.93312	16.29524	60.67619	90.15000	-230.66	-230.66	40.181	40.181	-40.181	-40.181	-	-	-	-270.84495	-270.84495	OK	7.3822E+3	-	-	115.34779
41.92798	16.13333	63.66667	90.15000	-157.48	-157.48	23.150	23.150	-23.150	-23.150	-	-	-	-180.63039	-180.63039	OK	1.2813E+4	-	-	242.15489
44.92284	15.97143	66.65714	90.15000	115.93	23.187	12.908	12.908	-12.908	-12.908	128.84160	36.09438	OK	-	-	-	2.2981E+4	-	-	246.29209
47.91769	15.80952	69.64762	90.15000	190.36	38.073	41.631	41.631	-41.631	-41.631	231.99419	79.70339	OK	-	-3.55799	OK	7.1251E+3	-	-	190.83349
50.91255	15.64762	72.63810	90.15000	87.712	17.542	43.022	43.022	-43.022	-43.022	130.73324	60.56388	OK	-	-25.47919	OK	6.8948E+3	-	-	-7.53838
53.90740	15.48571	75.62857	90.15000	0.015547	0.0031093	16.614	16.614	-16.614	-16.614	16.62966	16.61722	OK	-16.59857	-16.61100	OK	1.7854E+4	-	-	0.00000
56.90226	15.32381	78.61905	90.15000	0.0018644	372.89E-6	6.2191	6.2191	-6.2191	-6.2191	6.22099	6.21950	OK	-6.21726	-6.21875	OK	4.7695E+4	-	-	0.00000

Note: Tensile strains are +ve, compressive strains are -ve.
Note: The peak flexural tensile strain orientation angle is measured with respect to the global z-axis by looking at the end point of the utility from the start point. Anti-clockwise is positive.

Specific Utility Damage Results - Maximum Values

Name	Jointed	Displacement Data Type	Displacement Data	Maximum Pullout (Factored)		Maximum Rotation (Factored)		Maximum Strain (Factored) Tension		Maximum Strain (Factored) Compression		Minimum Radius of Curvature		Maximum Displacement Vertical		Maximum Displacement Horizontal x		Maximum Displacement y	
				Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value
				[m]	[mm]	[m]	[Deg]	[m]	[με]	[m]	[με]	[m]	[m]	[m]	[mm]	[m]	[mm]	[m]	[mm]
Cast Iron Main	Yes	Displacement	Line 1	22.582	0.58998	22.582	0.05698	25.80766	64.59163	22.58170	-135.53085	22.582	3.0779E+3	22.582	5.6878	32.259	0.77275	32.259	1.2522
Line 1		Line																	
Cast Iron Main	Yes	Displacement	Line 2	47.918	0.79311	8.9846	0.05116	47.91769	79.70339	38.93312	-270.84495	8.9846	3.2786E+3	8.9846	5.3040	41.928	-1.2188	8.9846	3.1456
Line 2		Line																	

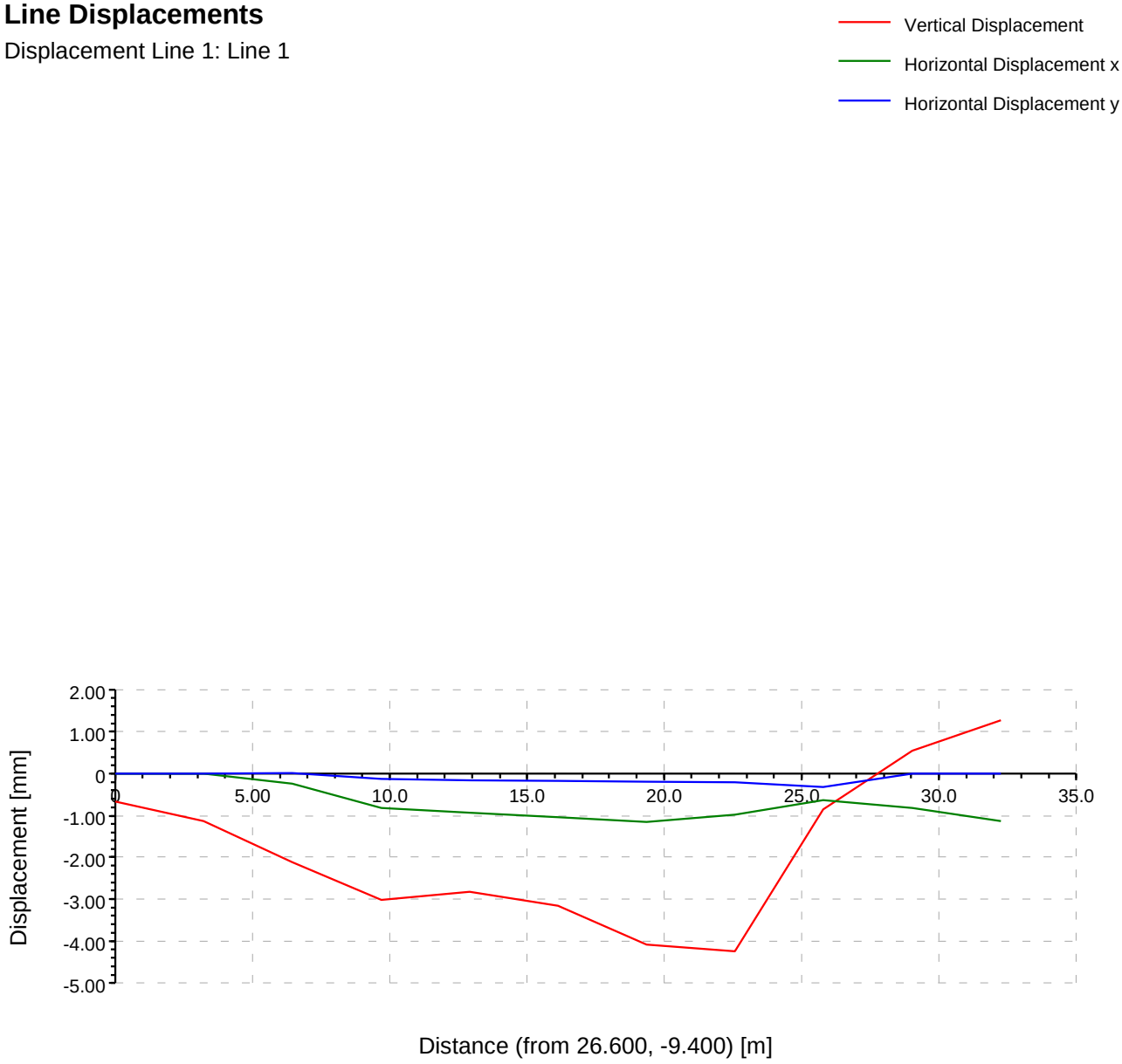
Note: * symbol indicates that the value has exceeded one of (or both) the limiting criteria

APPENDIX E

Case 4-Figures and XDISP output

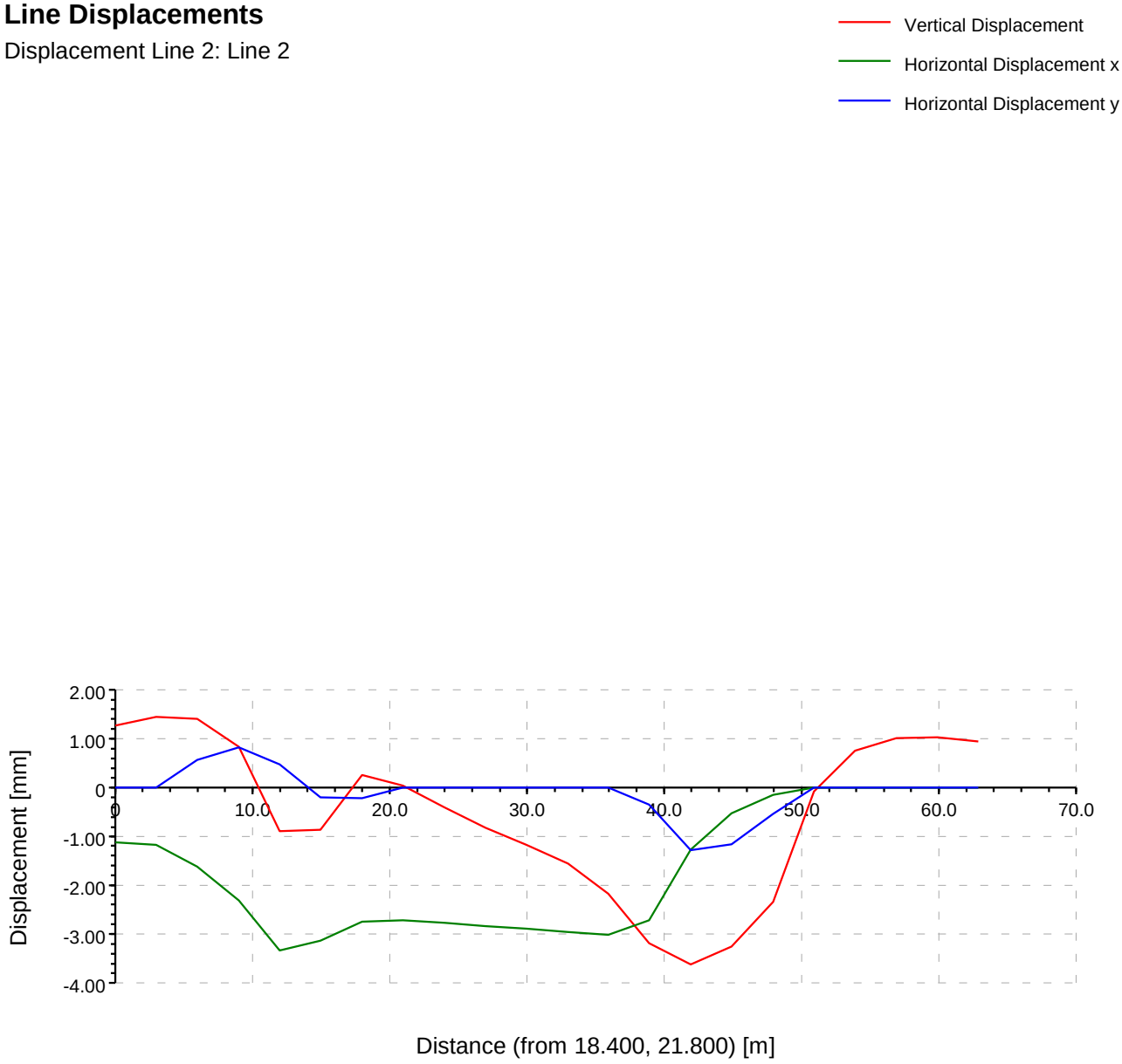
Line Displacements

Displacement Line 1: Line 1



Line Displacements

Displacement Line 2: Line 2



Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Displacement and Strain Results

Type/No. Name	Dist.	Coordinates x	y	z	Displacements x	y	z	Horizontal displacement along Line	Horizontal displacement perpendicular to Line	Angle of Line to x Axis	
	[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[°]	
Line 1	Line 1	26.60000	-9.40000	90.15000	0.0	0.0	0.66158	0.0	0.0	104.73	*
	3.2260	25.78000	-6.28000	90.15000	0.0	0.0	1.1237	0.0	0.0	104.73	*
	6.4519	24.96000	-3.16000	90.15000	-0.23708	0.019700	2.1132	0.079315	0.22428	104.73	*
	9.6779	24.14000	-0.04000	90.15000	-0.81280	-0.13246	3.0106	0.078498	0.81977	104.73	*
	12.904	23.32000	3.08000	90.15000	-0.92661	-0.15100	2.8347	0.089490	0.93456	104.73	*
	16.130	22.50000	6.20000	90.15000	-1.0404	-0.16955	3.1531	0.10048	1.0493	104.73	*
	19.356	21.68000	9.32000	90.15000	-1.1542	-0.18810	4.0871	0.11147	1.1641	104.73	*
	22.582	20.86000	12.44000	90.15000	-0.96666	-0.20212	4.2406	0.050233	0.98628	104.73	*
	25.808	20.04000	15.56000	90.15000	-0.63517	-0.31344	0.85531	-0.14169	0.69398	104.73	*
	29.034	19.22000	18.68000	90.15000	-0.81750	0.0	-0.55596	0.20780	0.79065	104.73	*
	32.260	18.40000	21.80000	90.15000	-1.1250	0.0	-1.2691	0.28596	1.0880	104.73	*
Line 2	Line 2	18.40000	21.80000	90.15000	-1.1250	0.0	-1.2691	0.060819	1.1234	93.099	*
	2.9949	18.23810	24.79048	90.15000	-1.1857	0.0	-1.4390	0.064101	1.1840	93.099	*
	5.9897	18.07619	27.78095	90.15000	-1.6323	0.57351	-1.4108	0.66092	1.5989	93.099	*
	8.9846	17.91429	30.77143	90.15000	-2.3125	0.82352	-0.83640	0.94733	2.2646	93.099	*
	11.979	17.75238	33.76190	90.15000	-3.3357	0.46899	0.88698	0.64863	3.3054	93.099	*
	14.974	17.59048	36.75238	90.15000	-3.1293	-0.19973	0.85871	-0.030268	3.1355	93.099	*
	17.969	17.42857	39.74286	90.15000	-2.7385	-0.21221	-0.26236	-0.063854	2.7459	93.099	*
	20.964	17.26667	42.73333	90.15000	-2.7125	0.0	-0.047281	0.14664	2.7085	93.099	*
	23.959	17.10476	45.72381	90.15000	-2.7732	0.0	0.39760	0.14992	2.7692	93.099	*
	26.954	16.94286	48.71429	90.15000	-2.8339	0.0	0.81648	0.15320	2.8298	93.099	*
	29.949	16.78095	51.70476	90.15000	-2.8946	0.0	1.1854	0.15649	2.8904	93.099	*
	32.943	16.61905	54.69524	90.15000	-2.9554	0.0	1.5588	0.15977	2.9510	93.099	*
	35.938	16.45714	57.68571	90.15000	-3.0161	0.0	2.1826	0.16305	3.0117	93.099	*
	38.933	16.29524	60.67619	90.15000	-2.7115	-0.34285	3.1917	-0.19576	2.7261	93.099	*
	41.928	16.13333	63.66667	90.15000	-1.2747	-1.2896	3.6160	-1.2188	1.3425	93.099	*
	44.923	15.97143	66.65714	90.15000	-0.51547	-1.1691	3.2625	-1.1395	0.57792	93.099	*
	47.918	15.80952	69.64762	90.15000	-0.14205	-0.53315	2.3384	-0.52469	0.17066	93.099	*
	50.913	15.64762	72.63810	90.15000	0.0	0.0	0.080350	0.0	0.0	93.099	*
	53.907	15.48571	75.62857	90.15000	0.0	0.0	-0.76300	0.0	0.0	93.099	*
	56.902	15.32381	78.61905	90.15000	0.0	0.0	-1.0086	0.0	0.0	93.099	*
	59.897	15.16190	81.60952	90.15000	0.0	0.0	-1.0209	0.0	0.0	93.099	*
	62.892	15.00000	84.60000	90.15000	0.0	0.0	-0.94123	0.0	0.0	93.099	*

* Result includes imported displacement(s).

Specific Utility Damage Results - Coordinates and Displacements

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start point	Coordinates x	y	z	Displacements x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	Displacements at (n-Lp) x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	Displacements at (n+Lp) x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility
[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
6.45191	24.96000	-3.16000	90.15000	-0.23708	0.01970	2.11319	0.07932	0.22428	0.00000	0.00000	1.06185	0.00000	0.00000	-0.82804	-0.13494	2.98700	0.07997	0.22428
12.90383	23.32000	3.08000	90.15000	-0.92661	-0.15100	2.83470	0.08949	0.93456	-0.73569	-0.11208	2.89037	0.07861	0.74002	-1.05566	-0.17203	3.27818	0.10195	0.93456
19.35574	21.68000	9.32000	90.15000	-1.15423	-0.18810	4.08707	0.11147	1.16413	-1.02518	-0.16707	3.11045	0.09901	1.03397	-0.92226	-0.21703	3.78726	0.02453	1.16413
25.80766	20.04000	15.56000	90.15000	-0.63517	-0.31344	0.85531	-0.14169	0.69398	-0.99178	-0.20024	4.22008	0.05843	1.01010	-0.85868	0.00000	-0.65147	0.21827	0.69398
Iteration: 2																		
9.67787	24.14000	-0.04000	90.15000	-0.81280	-0.13246	3.01055	0.07850	0.81977	-0.20533	0.01706	1.98067	0.06869	0.19425	-0.94185	-0.15349	2.87734	0.09096	0.81977
16.12979	22.50000	6.20000	90.15000	-1.04042	-0.16955	3.15309	0.10048	1.04934	-0.91136	-0.14852	2.85825	0.08802	0.91918	-1.12911	-0.18997	4.10764	0.10327	1.04934
22.58170	20.86000	12.44000	90.15000	-0.96666	-0.20212	4.24064	0.05023	0.98628	-1.13899	-0.18561	3.96198	0.11000	1.14876	-0.65959	-0.27146	0.66631	-0.09488	0.98628

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start point	Coordinates x	y	z	Displacements x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	Displacements at (n-Lp) x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	Displacements at (n+Lp) x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility
[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
5.98971	18.07619	27.78095	90.15000	-1.63231	0.57351	-1.41084	0.66092	1.59892	-1.17227	0.00000	-1.40139	0.06337	1.17056	-2.53903	0.74502	-0.45480	0.88119	1.59892
11.97942	17.75238	33.76190	90.15000	-3.33566	0.46899	0.88698	0.64863	3.30543	-2.16186	0.76816	-0.96360	0.88391	2.11718	-3.04276	-0.20250	0.61047	-0.03770	3.30543
17.96913	17.42857	39.74286	90.15000	-2.73847	-0.21221	-0.26236	-0.06385	2.74594	-3.17500	-0.05166	0.86497	0.12006	3.17315	-2.72594	0.00000	0.05123	0.14737	2.74594
23.95885	17.10476	45.72381	90.15000	-2.77321	0.00000	0.39760	0.14992	2.76916	-2.71825	-0.04699	-0.09491	0.10003	2.71682	-2.84737	0.00000	0.89817	0.15393	2.76916
29.94856	16.78095	51.70476	90.15000	-2.89464	0.00000	1.18542	0.15649	2.89041	-2.82049	0.00000	0.72373	0.15248	2.81636	-2.96880	0.00000	1.69693	0.16050	2.89041
35.93827	16.45714	57.68571	90.15000	-3.01607	0.00000	2.18259	0.16305	3.01166	-2.94191	0.00000	1.47613	0.15904	2.93761	-2.39337	-0.55248	3.28563	-0.42229	3.01166
41.92798	16.13333	63.66667	90.15000	-1.27468	-1.28959	3.61601	-1.21880	1.34254	-2.77896	-0.26693	2.96824	-0.11631	2.78933	-0.43279	-1.02826	3.05789	-1.00336	1.34254
47.91769	15.80952	69.64762	90.15000	-0.14205	-0.53315	2.33845	-0.52469	0.17066	-0.68358	-1.19576	3.34078	-1.15705	0.74723	0.00000	0.00000	-0.10639	0.00000	0.17066
53.90740	15.48571	75.62857	90.15000	0.00000	0.00000	-0.76300	0.00000	0.00000	-0.03145	-0.11805	0.58036	-0.11618	0.03779	0.00000	0.00000	-1.01132	0.00000	0.00000
Iteration: 2																		
8.98457	17.91429	30.77143	90.15000	-2.31247	0.82352	-0.83640	0.94733	2.26457	-1.53343	0.44652	-1.41708	0.52877	1.50704	-3.28997	0.32091	0.88072	0.49830	2.26457
14.97428	17.59048	36.75238	90.15000	-3.12931	-0.19973	0.85871	-0.03027	3.13553	-3.10910	0.54749	0.50538	0.71477	3.07495	-2.73272	-0.16522	-0.21473	-0.01724	3.13553
20.96399	17.26667	42.73333	90.15000	-2.71250	0.00000	-0.04728	0.14664	2.70853	-2.82501	-0.20945	-0.01412	-0.05642	2.83220	-2.78666	0.00000	0.49035	0.15065	

Distance from the utility's start	Coordinates x	y	z	Displacements				Displacements at (n-Lp)				Displacements at (n+Lp)			
2.70853															
26.95370	16.94286	48.71429	90.15000	-2.83393	0.00000	0.81648	0.15320	2.82978	-2.75977	0.00000	0.29909	0.14920	2.75573	-2.90809	0.00000	1.26810	0.15721
2.82978																	
32.94341	16.61905	54.69524	90.15000	-2.95536	0.00000	1.55881	0.15977	2.95104	-2.88120	0.00000	1.10373	0.15576	2.87699	-2.94864	-0.07592	2.40603	0.08360
2.95104																	
38.93312	16.29524	60.67619	90.15000	-2.71153	-0.34285	3.19167	-0.19576	2.72610	-3.00263	0.00000	2.04447	0.16232	2.99824	-1.10657	-1.26290	3.53774	-1.20124
2.72610																	
44.92284	15.97143	66.65714	90.15000	-0.51547	-1.16907	3.26250	-1.13949	0.57792	-1.59284	-1.07996	3.52205	-0.99227	1.64889	-0.11059	-0.41509	1.83844	-0.40851
0.57792																	
50.91255	15.64762	72.63810	90.15000	0.00000	0.00000	0.08035	0.00000	0.00000	-0.22473	-0.67396	2.54306	-0.66082	0.26084	0.00000	0.00000	-0.81738	0.00000
0.00000																	
56.90226	15.32381	78.61905	90.15000	0.00000	0.00000	-1.00861	0.00000	0.00000	0.00000	0.00000	-0.57626	0.00000	0.00000	0.00000	0.00000	-1.00323	0.00000
0.00000																	

Specific Utility Damage Results - Pullouts and Rotations

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start	Coordinates x	y	z	Pullout Check Rotation Check Vertical Sagging vs Hogging point	Pullout												Threshold Limit Rotation	
					Left Seg. Axial		Left Seg. Flexural		Right Seg. Axial		Right Seg. Flexural		Total Axial		Total Flexural		Total	
					Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored
	[m]	[m]	[m]		[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
6.45191	24.96000	-3.16000	90.15000	0.03966	0.03966	0.03449	0.03449	0.07964	0.07964	0.03449	0.03449	0.03999	0.03999	0.06899	0.06899	0.10897	0.10897	- OK
0.00666	0.00666	-	OK Sagging															
12.90383	23.32000	3.08000	90.15000	0.08405	0.08405	0.04081	0.04081	0.09572	0.09572	0.04081	0.04081	0.01167	0.01167	0.08162	0.08162	0.09329	0.09329	- OK
0.00788	0.00788	-	OK Hogging															
19.35574	21.68000	9.32000	90.15000	0.10524	0.10524	0.10726	0.10726	0.06800	0.06800	0.10726	0.10726	-0.03724	-0.03724	0.21453	0.21453	0.21453	0.21453	- OK
0.02072	0.02072	-	OK Sagging															
25.80766	20.04000	15.56000	90.15000	-0.04163	-0.04163	0.15507	0.15507	0.03829	0.03829	0.15507	0.15507	0.07992	0.07992	0.31013	0.31013	0.39005	0.39005	- OK
0.02995	0.02995	-	OK Hogging															
Iteration: 2																		
9.67787	24.14000	-0.04000	90.15000	0.07360	0.07360	0.10251	0.10251	0.08473	0.08473	0.10251	0.10251	0.01113	0.01113	0.20502	0.20502	0.21616	0.21616	- OK
0.01980	0.01980	-	OK Sagging															
16.12979	22.50000	6.20000	90.15000	0.09425	0.09425	0.05359	0.05359	0.10188	0.10188	0.05359	0.05359	0.00763	0.00763	0.10718	0.10718	0.11481	0.11481	- OK
0.01035	0.01035	-	OK Hogging															
22.58170	20.86000	12.44000	90.15000	0.08012	0.08012	0.31258	0.31258	-0.02233	-0.02233	0.31258	0.31258	-0.10244	-0.10244	0.62516	0.62516	0.62516	0.62516	- OK
0.06038	0.06038	-	OK Sagging															

Note: Total pullout ignores the axial component where this is negative (i.e. compression).

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start	Coordinates x	y	z	Pullout Check Rotation Check Vertical Sagging vs Hogging point	Pullout												Threshold Limit Rotation	
					Left Seg. Axial		Left Seg. Flexural		Right Seg. Axial		Right Seg. Flexural		Total Axial		Total Flexural		Total	
					Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored
	[m]	[m]	[m]		[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
5.98971	18.07619	27.78095	90.15000	0.36215	0.36215	0.08700	0.08700	0.77105	0.77105	0.08700	0.08700	0.40891	0.40891	0.17399	0.17399	0.58290	0.58290	- OK
0.01680	0.01680	-	OK Hogging															
11.97942	17.75238	33.76190	90.15000	0.76627	0.76627	0.20849	0.20849	0.30546	0.30546	0.20849	0.20849	-0.46081	-0.46081	0.41699	0.41699	0.41699	0.41699	- OK
0.04027	0.04027	-	OK Sagging															
17.96913	17.42857	39.74286	90.15000	0.02810	0.02810	0.12133	0.12133	0.04176	0.04176	0.12133	0.12133	0.01365	0.01365	0.24266	0.24266	0.25632	0.25632	- OK
0.02344	0.02344	-	OK Hogging															
23.95885	17.10476	45.72381	90.15000	0.12498	0.12498	0.00188	0.00188	0.15193	0.15193	0.00188	0.00188	0.02695	0.02695	0.00376	0.00376	0.03071	0.03071	- OK
0.00036	0.00036	-	OK Hogging															
29.94856	16.78095	51.70476	90.15000	0.15448	0.15448	0.00404	0.00404	0.15849	0.15849	0.00404	0.00404	0.00401	0.00401	0.00808	0.00808	0.01209	0.01209	- OK
0.00078	0.00078	-	OK Hogging															
35.93827	16.45714	57.68571	90.15000	0.16105	0.16105	0.06285	0.06285	-0.12962	-0.12962	0.06285	0.06285	-0.29066	-0.29066	0.12571	0.12571	0.12571	0.12571	- OK
0.01214	0.01214	-	OK Hogging															
41.92798	16.13333	63.66667	90.15000	-0.66755	-0.66755	0.10893	0.10893	-1.11108	-1.11108	0.10893	0.10893	-0.44353	-0.44353	0.21787	0.21787	0.21787	0.21787	- OK
0.02104	0.02104	-	OK Sagging															
47.91769	15.80952	69.64762	90.15000	-0.84087	-0.84087	0.12151	0.12151	-0.26234	-0.26234	0.12151	0.12151	0.57853	0.57853	0.24303	0.24303	0.82155	0.82155	- OK
0.02347	0.02347	-	OK Sagging															
53.90740	15.48571	75.62857	90.15000	-0.05809	-0.05809	0.08885	0.08885	0.00000	0.00000	0.08885	0.08885	0.05809	0.05809	0.17770	0.17770	0.23579	0.23579	- OK
0.01716	0.01716	-	OK Hogging															
Iteration: 2																		
8.98457	17.91429	30.77143	90.15000	0.73805	0.73805	0.09428	0.09428	0.72282	0.72282	0.09428	0.09428	-0.01523	-0.01523	0.18856	0.18856	0.18856	0.18856	- OK
0.01821	0.01821	-	OK Hogging															
14.97428	17.59048	36.75238	90.15000	0.34225	0.34225	0.12152	0.12152	-0.02376	-0.02376	0.12152	0.12152	-0.36601	-0.36601	0.24304	0.24304	0.24304	0.24304	- OK
0.02347	0.02347	-	OK Sagging															
20.96399	17.26667	42.73333	90.15000	0.04511	0.04511	0.04898	0.04898	0.14864	0.14864	0.04898	0.04898	0.10353	0.10353	0.09797	0.09797	0.20150	0.20150	- OK
0.00946	0.00946	-	OK Hogging															
26.95370	16.94286	48.71429	90.15000	0.15120	0.15120	0.00533	0.00533	0.15521	0.15521	0.00533	0.00533	0.00401	0.00401	0.01067	0.01067	0.01468	0.01468	- OK
0.00103	0.00103	-	OK Sagging															
32.94341	16.61905	54.69524	90.15000	0.15776	0.15776	0.03240	0.03240	0.12169	0.12169	0.03240	0.03240	-0.03608	-0.03608	0.06480	0.06480	0.06480	0.06480	- OK
0.00626	0.00626	-	OK Hogging															
38.93312	16.29524	60.67619	90.15000	-0.01672	-0.01672	0.12250	0.12250	-0.69850	-0.69850	0.12250	0.12250	-0.68178	-0.68178	0.24500	0.24500	0.24500	0.24500	- OK
0.02366	0.02366	-	OK Sagging															
44.92284	15.97143	66.65714	90.15000	-1.06588	-1.06588	0.10721	0.10721	-0.77400	-0.77400	0.10721	0.10721	0.29188	0.29188	0.21441	0.21441	0.50629	0.50629	- OK
0.02071	0.02071	-	OK Sagging															
50.91255	15.64762	72.63810	90.15000	-0.33041	-0.33041	0.12865	0.12865	0.00000	0.00000	0.12865	0.12865	0.33041	0.33041	0.25731	0.25731	0.58772	0.58772	- OK
0.02485	0.02485	-	OK Hogging															
56.90226	15.32381	78.61905	90.15000	0.00000	0.00000	0.03549	0.03549	0.00000	0.00000	0.03549	0.03549	0.00000	0.00000	0.07099	0.07099	0.07099	0.07099	- OK
0.00686	0.00686	-	OK Hogging															

Note: Total pullout ignores the axial component where this is negative (i.e. compression).

Specific Utility Damage Results - Strains

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start	Coordinates x	y	z	Pipe Strain Check	Radius of Curvature Check	Peak flexural tensile strain orientation angle (w.r.t global z-axis)
point						

x	y	z	Axial	Flexural				Tension		Compression		Radius of Curvature	Threshold	Limit	Curvature
				Tension		Compression		Total	Check	Total	Check				
			Unfactored	Factored	Unfactored	Factored	Unfactored	Factored		Unfactored	Factored				
[m]	[m]	[m]	[m]	[με]	[με]	[με]	[με]	[με]	[με]		[με]	[με]		[m]			[Deg]
6.45191	24.96000	-3.16000	90.15000	12.217	2.4435	10.901	10.901	-10.901	-10.901	23.11845	13.34449	OK	-	-8.45750	OK	2.7211E+4	-	-	256.06909
9.67787	24.14000	-0.04000	90.15000	1.5893	0.31785	33.518	33.518	-33.518	-33.518	35.10740	33.83599	OK	-31.92886	-33.20028	OK	8.8497E+3	-	-	155.87222
12.90383	23.32000	3.08000	90.15000	3.4081	0.68162	14.087	14.087	-14.087	-14.087	17.49529	14.76880	OK	-10.67907	-13.40556	OK	2.1056E+4	-	-	0.00000
16.12979	22.50000	6.20000	90.15000	3.4267	0.68534	17.546	17.546	-17.546	-17.546	20.97282	18.23145	OK	-14.11939	-16.86076	OK	1.6905E+4	-	-	-0.00002
19.35574	21.68000	9.32000	90.15000	-7.7739	-7.7739	23.756	23.756	-23.756	-23.756	15.98225	15.98225	OK	-31.53000	-31.53000	OK	1.2486E+4	-	-	159.44485
22.58170	20.86000	12.44000	90.15000	-39.110	-39.110	100.92	100.92	-100.92	-100.92	61.81147	61.81147	OK	-140.03203	-140.03203	OK	2.9391E+3	-	-	178.14768
25.80766	20.04000	15.56000	90.15000	24.698	4.9397	57.348	57.348	-57.348	-57.348	82.04644	62.28773	OK	-32.64967	-52.40838	OK	5.1723E+3	-	-	-11.14669

Note: Tensile strains are +ve, compressive strains are -ve.
Note: The peak flexural tensile strain orientation angle is measured with respect to the global z-axis by looking at the end point of the utility from the start point. Anti-clockwise is positive.

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start point	Coordinates			Pipe Strain Check										Radius of Curvature Check				Peak flexural tensile strain orientation angle (w.r.t global z-axis)
	x	y	z	Axial	Flexural				Tension		Compression			Radius of Curvature	Threshold	Limit		
					Tension		Compression		Total		Check	Total	Check					
				Unfactored	Factored	Unfactored	Factored	Unfactored	Factored			Unfactored	Factored					
[m]	[m]	[m]	[m]	[με]	[με]	[με]	[με]	[με]	[με]	[με]		[με]	[με]		[m]			[Deg]
2.99486	18.23810	24.79048	90.15000	160.19	20.838	13.425	13.425	-13.425	-13.425	113.61666	33.46298	OK	-	-	-	2.2096E+4	-	-	-60.79343
5.98971	18.07619	27.78095	90.15000	147.48	29.496	19.878	19.878	-19.878	-19.878	167.35671	49.37344	OK	-	-	-	1.4923E+4	-	-	-24.65205
8.98457	17.91429	30.77143	90.15000	-1.9377	-1.9377	39.972	39.972	-39.972	-39.972	38.03437	38.03437	OK	-41.90972	-41.90972	OK	7.4208E+3	-	-	-18.08579
11.97942	17.75238	33.76190	90.15000	-163.16	-163.16	70.422	70.422	-70.422	-70.422	-	-	-	-233.58389	-233.58389	OK	4.2121E+3	-	-	145.34733
14.97428	17.59048	36.75238	90.15000	-118.93	-118.93	36.863	36.863	-36.863	-36.863	-	-	-	-155.79189	-155.79189	OK	8.0466E+3	-	-	168.63300
17.96913	17.42857	39.74286	90.15000	29.549	5.9099	45.698	45.698	-45.698	-45.698	75.24689	51.60739	OK	-16.14814	-39.78764	OK	6.4910E+3	-	-	-14.76649
20.96399	17.26667	42.73333	90.15000	35.697	7.1393	8.2624	8.2624	-8.2624	-8.2624	43.95914	15.40177	OK	-	-1.12308	OK	3.5900E+4	-	-	-23.10222
23.95885	17.10476	45.72381	90.15000	1.1066	0.22132	0.85954	0.85954	-0.85954	-0.85954	1.96611	1.08085	OK	-	-0.63822	OK	3.4510E+5	-	-	180.00220
26.95370	16.94286	48.71429	90.15000	1.1048	0.22097	1.6518	1.6518	-1.6518	-1.6518	2.75667	1.87280	OK	-0.54701	-1.43087	OK	1.7957E+5	-	-	179.99886
29.94856	16.78095	51.70476	90.15000	1.1038	0.22077	0.14727	0.14727	-0.14727	-0.14727	1.25112	0.36804	OK	-	-	-	2.0141E+6	-	-	0.00000
32.94341	16.61905	54.69524	90.15000	1.1100	0.22201	8.2807	8.2807	-8.2807	-8.2807	9.39072	8.50270	OK	-7.17066	-8.05869	OK	3.5821E+4	-	-	0.00000
35.93827	16.45714	57.68571	90.15000	-59.318	-59.318	17.130	17.130	-17.130	-17.130	-	-	-	-76.44874	-76.44874	OK	1.7316E+4	-	-	41.93924
38.93312	16.29524	60.67619	90.15000	-230.64	-230.64	41.141	41.141	-41.141	-41.141	-	-	-	-271.77677	-271.77677	OK	7.2100E+3	-	-	118.03767
41.92798	16.13333	63.66667	90.15000	-157.50	-157.50	32.875	32.875	-32.875	-32.875	-	-	-	-190.37005	-190.37005	OK	9.0228E+3	-	-	218.50968
44.92284	15.97143	66.65714	90.15000	115.93	23.185	22.264	22.264	-22.264	-22.264	138.18948	45.44938	OK	-	-	-	1.3323E+4	-	-	212.06055
47.91769	15.80952	69.64762	90.15000	190.39	38.077	44.807	44.807	-44.807	-44.807	235.19474	82.88485	OK	-	-6.72990	OK	6.6200E+3	-	-	190.05714
50.91255	15.64762	72.63810	90.15000	87.733	17.547	47.127	47.127	-47.127	-47.127	134.85983	64.67366	OK	-	-29.58058	OK	6.2941E+3	-	-	-6.87833
53.90740	15.48571	75.62857	90.15000	0.016526	0.0033053	19.768	19.768	-19.768	-19.768	19.78477	19.77155	OK	-19.75172	-19.76494	OK	1.5005E+4	-	-	0.00000
56.90226	15.32381	78.61905	90.15000	926.75E-6	185.35E-6	7.7171	7.7171	-7.7171	-7.7171	7.71799	7.71725	OK	-7.71614	-7.71688	OK	3.8437E+4	-	-	0.00000

Note: Tensile strains are +ve, compressive strains are -ve.
Note: The peak flexural tensile strain orientation angle is measured with respect to the global z-axis by looking at the end point of the utility from the start point. Anti-clockwise is positive.

Specific Utility Damage Results - Maximum Values

Name	Jointed	Displacement Data Type	Displacement Data	Maximum Pullout (Factored)		Maximum Rotation (Factored)		Maximum Strain (Factored) Tension		Maximum Strain (Factored) Compression		Minimum Radius of Curvature		Maximum Displacement Vertical		Maximum Displacement Horizontal x		y
				Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	
				[m]	[mm]	[m]	[Deg]	[m]	[με]	[m]	[με]	[m]	[m]	[m]	[mm]	[m]	[mm]	[m]
Cast Iron Main Line 1	Yes	Displacement	Line 1	22.582	0.62516	22.582	0.06038	25.80766	62.28773	22.58170	-140.03203	22.582	2.9391E+3	22.582	4.2406	32.259	0.28595	19.356
Cast Iron Main Line 2	Yes	Displacement	Line 2	47.918	0.82155	11.979	0.04027	47.91769	82.88485	38.93312	-271.77677	11.979	4.2121E+3	41.928	3.6160	41.928	-1.2188	11.979

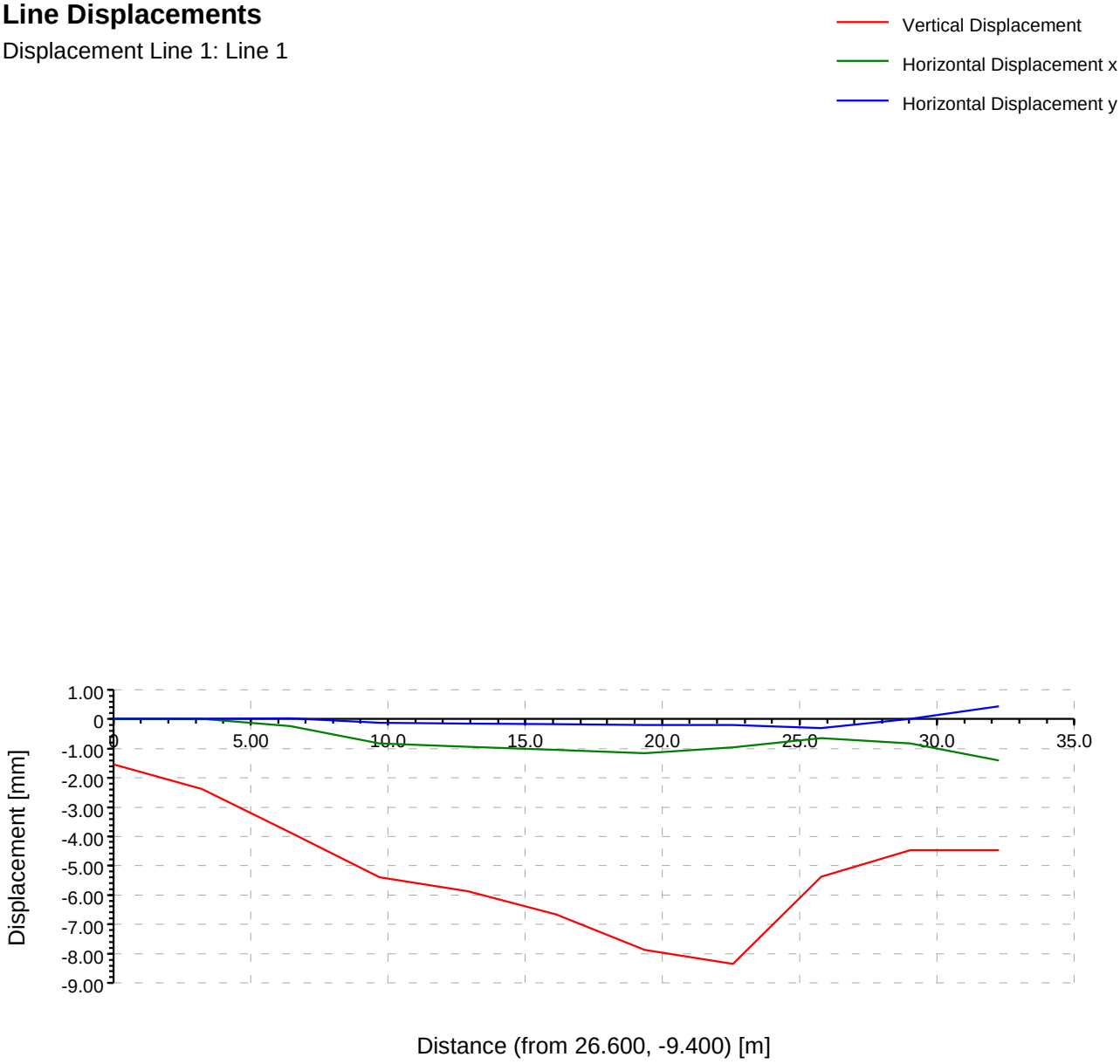
Note: * symbol indicates that the value has exceeded one of (or both) the limiting criteria

APPENDIX F

Case 5-Figures and XDISP output

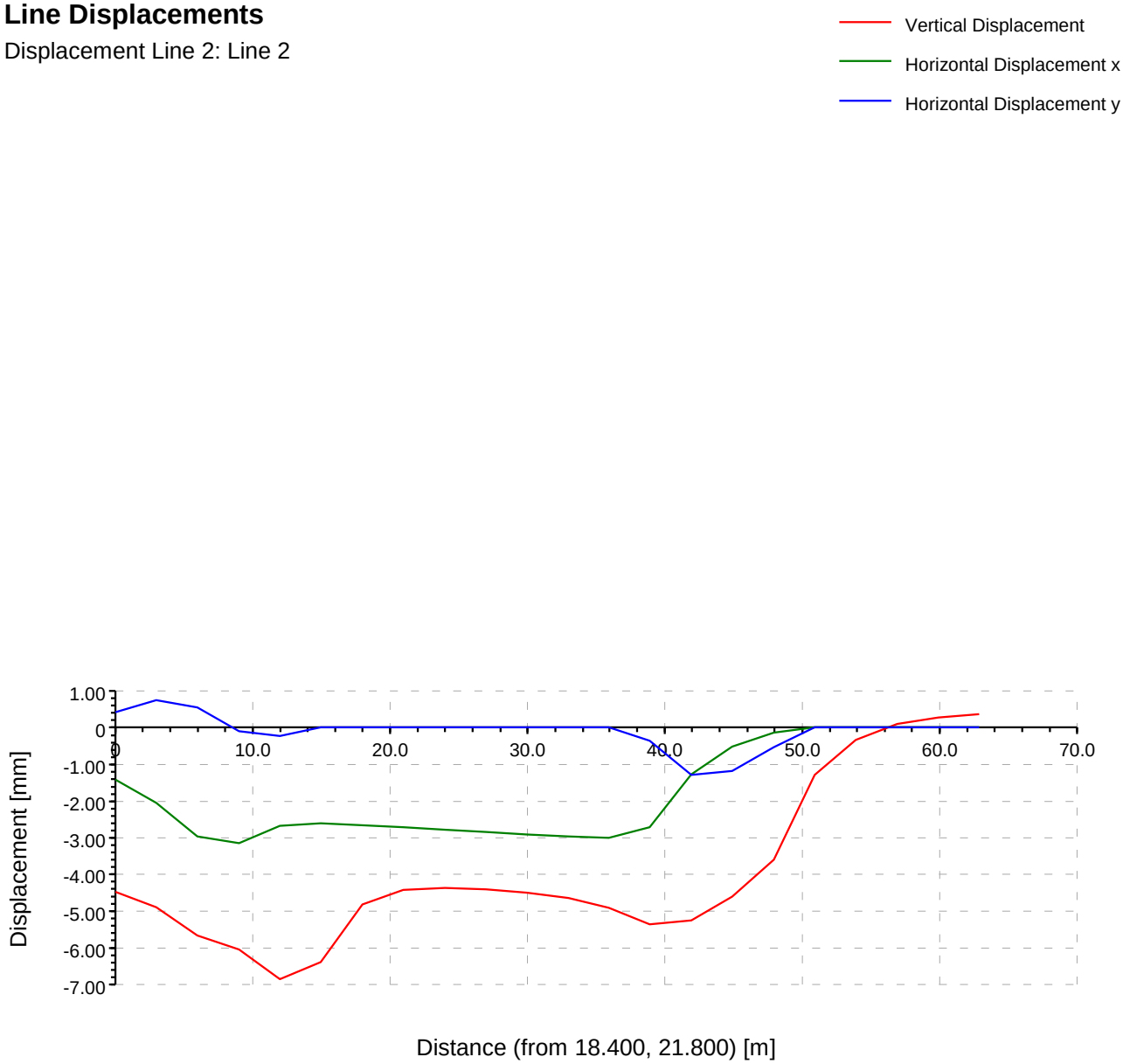
Line Displacements

Displacement Line 1: Line 1



Line Displacements

Displacement Line 2: Line 2



Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Displacement and Strain Results

Type/No. Name	Dist.	Coordinates x	y	z	Displacements x	y	z	Horizontal displacement along Line	Horizontal displacement perpendicular to Line	Angle of Line to x Axis
	[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[°]
Line 1	Line 1	26.60000	-9.40000	90.15000	0.0	0.0	1.5471	0.0	0.0	104.73 *
	3.2260	25.78000	-6.28000	90.15000	0.0	0.0	2.3675	0.0	0.0	104.73 *
	6.4519	24.96000	-3.16000	90.15000	-0.23708	0.019700	3.8513	0.079315	0.22428	104.73 *
	9.6779	24.14000	-0.04000	90.15000	-0.81280	-0.13246	5.3919	0.078498	0.81977	104.73 *
	12.904	23.32000	3.08000	90.15000	-0.92661	-0.15100	5.8638	0.089490	0.93456	104.73 *
	16.130	22.50000	6.20000	90.15000	-1.0404	-0.16955	6.6499	0.10048	1.0493	104.73 *
	19.356	21.68000	9.32000	90.15000	-1.1542	-0.18810	7.8814	0.11147	1.1641	104.73 *
	22.582	20.86000	12.44000	90.15000	-0.96666	-0.20212	8.3390	0.050233	0.98628	104.73 *
	25.808	20.04000	15.56000	90.15000	-0.63517	-0.31344	5.3715	-0.14169	0.69398	104.73 *
	29.034	19.22000	18.68000	90.15000	-0.81750	0.0	4.4741	0.20780	0.79065	104.73 *
	32.260	18.40000	21.80000	90.15000	-1.4076	0.42915	4.4766	0.77285	1.2523	104.73 *
Line 2	Line 2	18.40000	21.80000	90.15000	-1.4076	0.42915	4.4766	0.50462	1.3824	93.099 *
	2.9949	18.23810	24.79048	90.15000	-2.0315	0.74790	4.9005	0.85663	1.9881	93.099 *
	5.9897	18.07619	27.78095	90.15000	-2.9535	0.54237	5.6580	0.70124	2.9199	93.099 *
	8.9846	17.91429	30.77143	90.15000	-3.1445	-0.10457	6.0362	0.065581	3.1456	93.099 *
	11.979	17.75238	33.76190	90.15000	-2.6615	-0.21661	6.8483	-0.072416	2.6693	93.099 *
	14.974	17.59048	36.75238	90.15000	-2.5911	0.0	6.3933	0.14008	2.5873	93.099 *
	17.969	17.42857	39.74286	90.15000	-2.6518	0.0	4.8311	0.14336	2.6479	93.099 *
	20.964	17.26667	42.73333	90.15000	-2.7125	0.0	4.4352	0.14664	2.7085	93.099 *
	23.959	17.10476	45.72381	90.15000	-2.7732	0.0	4.3701	0.14992	2.7692	93.099 *
	26.954	16.94286	48.71429	90.15000	-2.8339	0.0	4.4154	0.15320	2.8298	93.099 *
	29.949	16.78095	51.70476	90.15000	-2.8946	0.0	4.5078	0.15649	2.8904	93.099 *
	32.943	16.61905	54.69524	90.15000	-2.9554	0.0	4.6444	0.15977	2.9510	93.099 *
	35.938	16.45714	57.68571	90.15000	-3.0161	0.0	4.9199	0.16305	3.0117	93.099 *
	38.933	16.29524	60.67619	90.15000	-2.7115	-0.34285	5.3693	-0.19576	2.7261	93.099 *
	41.928	16.13333	63.66667	90.15000	-1.2747	-1.2896	5.2604	-1.2188	1.3425	93.099 *
	44.923	15.97143	66.65714	90.15000	-0.51547	-1.1691	4.6059	-1.1395	0.57792	93.099 *
	47.918	15.80952	69.64762	90.15000	-0.14205	-0.53315	3.5972	-0.52469	0.17066	93.099 *
	50.913	15.64762	72.63810	90.15000	0.0	0.0	1.2920	0.0	0.0	93.099 *
	53.907	15.48571	75.62857	90.15000	0.0	0.0	0.32477	0.0	0.0	93.099 *
	56.902	15.32381	78.61905	90.15000	0.0	0.0	-0.089106	0.0	0.0	93.099 *
	59.897	15.16190	81.60952	90.15000	0.0	0.0	-0.27797	0.0	0.0	93.099 *
	62.892	15.00000	84.60000	90.15000	0.0	0.0	-0.36344	0.0	0.0	93.099 *

* Result includes imported displacement(s).

Specific Utility Damage Results - Coordinates and Displacements

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start point	Coordinates x	y	z	Displacements x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	Displacements at (n-Lp) x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	Displacements at (n+Lp) x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility
	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
6.45191	24.96000	-3.16000	90.15000	-0.23708	0.01970	3.85127	0.07932	0.22428	0.00000	0.00000	2.25759	0.00000	0.00000	-0.82804	-0.13494	5.45513	0.07997	0.22428
12.90383	23.32000	3.08000	90.15000	-0.92661	-0.15100	5.86377	0.08949	0.93456	-0.73569	-0.11208	5.18560	0.07861	0.74002	-1.05566	-0.17203	6.81483	0.10195	0.93456
19.35574	21.68000	9.32000	90.15000	-1.15423	-0.18810	7.88139	0.11147	1.16413	-1.02518	-0.16707	6.54462	0.09901	1.03397	-0.92226	-0.21703	7.94158	0.02453	1.16413
25.80766	20.04000	15.56000	90.15000	-0.63517	-0.31344	5.37154	-0.14169	0.69398	-0.99178	-0.20024	8.27771	0.05843	1.01010	-0.89653	0.05747	4.47446	0.28347	0.69398
Iteration: 2																		
9.67787	24.14000	-0.04000	90.15000	-0.81280	-0.13246	5.39194	0.07850	0.81977	-0.20533	0.01706	3.65255	0.06869	0.19425	-0.94185	-0.15349	5.96905	0.09096	0.81977
16.12979	22.50000	6.20000	90.15000	-1.04042	-0.16955	6.64990	0.10048	1.04934	-0.91136	-0.14852	5.80058	0.08802	0.91918	-1.12911	-0.18997	7.94267	0.10327	1.04934
22.58170	20.86000	12.44000	90.15000	-0.96666	-0.20212	8.33900	0.05023	0.98628	-1.13899	-0.18561	7.71646	0.11000	1.14876	-0.65959	-0.27146	5.25135	-0.09488	0.98628

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start point	Coordinates x	y	z	Displacements x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	Displacements at (n-Lp) x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility	Displacements at (n+Lp) x	y	z	Horizontal displacement along utility	Horizontal displacement perpendicular to utility
	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
Iteration: 1																		
5.98971	18.07619	27.78095	90.15000	-2.95350	0.54237	5.65795	0.70124	2.91986	-1.89336	0.67732	4.80662	0.77868	1.85397	-3.03757	-0.12938	6.21605	0.03503	2.91986
11.97942	17.75238	33.76190	90.15000	-2.66145	-0.21661	6.84828	-0.07242	2.66927	-3.10223	0.03868	5.95248	0.20633	3.09561	-2.60451	0.00000	6.04740	0.14080	2.66927
17.96913	17.42857	39.74286	90.15000	-2.65179	0.00000	4.83107	0.14336	2.64791	-2.60666	-0.04796	6.49407	0.09302	2.60544	-2.72594	0.00000	4.42080	0.14737	2.64791
23.95885	17.10476	45.72381	90.15000	-2.77321	0.00000	4.37007	0.14992	2.76916	-2.69906	0.00000	4.52288	0.14591	2.69511	-2.84737	0.00000	4.43586	0.15393	2.76916
29.94856	16.78095	51.70476	90.15000	-2.89464	0.00000	4.50782	0.15649	2.89041	-2.82049	0.00000	4.40536	0.15248	2.81636	-2.96880	0.00000	4.70544	0.16050	2.89041
35.93827	16.45714	57.68571	90.15000	-3.01607	0.00000	4.91994	0.16305	3.01166	-2.94191	0.00000	4.61419	0.15904	2.93761	-2.39337	-0.55248	5.34516	-0.42229	3.01166
41.92798	16.13333	63.66667	90.15000	-1.27468	-1.28959	5.26044	-1.21880	1.34254	-2.77896	-0.26693	5.26976	-0.11631	2.78933	-0.43279	-1.02826	4.38257	-1.00336	1.34254
47.91769	15.80952	69.64762	90.15000	-0.14205	-0.53315	3.59725	-0.52469	0.17066	-0.68358	-1.19576	4.75084	-1.15705	0.74723	0.00000	0.00000	1.07780	0.00000	0.17066
53.90740	15.48571	75.62857	90.15000	0.00000	0.00000	0.32477	0.00000	0.00000	-0.03145	-0.11805	1.80241	-0.11618	0.03779	0.00000	0.00000	-0.13093	0.00000	0.00000
Iteration: 2																		
8.98457	17.91429	30.77143	90.15000	-3.14454	-0.10457	6.03624	0.06558	3.14559	-2.74934	0.58788	5.49023	0.73565	2.71354	-2.64587	-0.16865	6.74754	-0.02536	3.14559
14.97428	17.59048	36.75238	90.15000	-2.59107	0.00000	6.39333	0.14008	2.58728	-2.76842	-0.19180	6.66847	-0.04186	2.77474	-2.66523	0.00000	4.74342	0.14408	2.58728
20.96399	17.26667	42.73333	90.15000	-2.71250	0.00000	4.43523	0.14664	2.70853	-2.63834	0.00000	5.17700	0.14263	2.63448	-2.78666	0.00000	4.38011	0.15065	2.70853

Distance from the utility's start	Coordinates x	y	z	Displacements				Displacements at (n-Lp)				Displacements at (n+Lp)			
26.95370	16.94286	48.71429	90.15000	-2.83393	0.00000	4.41540	0.15320	2.82978	-2.75977	0.00000	4.38450	0.14920	2.75573	-2.90809	0.00000	4.53807	0.15721
2.82978																	
32.94341	16.61905	54.69524	90.15000	-2.95536	0.00000	4.64444	0.15977	2.95104	-2.88120	0.00000	4.48735	0.15576	2.87699	-2.94864	-0.07592	5.01943	0.08360
2.95104																	
38.93312	16.29524	60.67619	90.15000	-2.71153	-0.34285	5.36925	-0.19576	2.72610	-3.00263	0.00000	4.85894	0.16232	2.99824	-1.10657	-1.26290	5.11551	-1.20124
2.72610																	
44.92284	15.97143	66.65714	90.15000	-0.51547	-1.16907	4.60591	-1.13949	0.57792	-1.59284	-1.07996	5.28454	-0.99227	1.64889	-0.11059	-0.41509	3.08679	-0.40851
0.57792																	
50.91255	15.64762	72.63810	90.15000	0.00000	0.00000	1.29196	0.00000	0.00000	-0.22473	-0.67396	3.82059	-0.66082	0.26084	0.00000	0.00000	0.23313	0.00000
0.00000																	
56.90226	15.32381	78.61905	90.15000	0.00000	0.00000	-0.08911	0.00000	0.00000	0.00000	0.00000	0.53893	0.00000	0.00000	0.00000	0.00000	-0.29689	0.00000
0.00000																	

Specific Utility Damage Results - Pullouts and Rotations

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start	Coordinates x	y	z	Pullout Check														Rotation Check Threshold Limit		Vertical Sagging vs Hogging point	Rotation Threshold Limit	
				Left Seg.						Right Seg.						Total						
				Axial		Flexural		Axial		Flexural		Axial		Flexural		Total						
				Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored					
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]				[Deg]	[Deg]
Iteration: 1																						
6.45191	24.96000	-3.16000	90.15000	0.03966	0.03966	0.03136	0.03136	0.07964	0.07964	0.03136	0.03136	0.03999	0.03999	0.06272	0.06272	0.10270	0.10270	-	OK		0.00606	0.00606
12.90383	23.32000	3.08000	90.15000	0.08405	0.08405	0.02274	0.02274	0.09572	0.09572	0.02274	0.02274	0.01167	0.01167	0.04547	0.04547	0.05715	0.05715	-	OK		0.00439	0.00439
19.35574	21.68000	9.32000	90.15000	0.10524	0.10524	0.10728	0.10728	0.06800	0.06800	0.10728	0.10728	-0.03724	-0.03724	0.21455	0.21455	0.21455	0.21455	-	OK		0.02072	0.02072
25.80766	20.04000	15.56000	90.15000	-0.04163	-0.04163	0.16740	0.16740	0.07089	0.07089	0.16740	0.16740	0.11252	0.11252	0.33480	0.33480	0.44732	0.44732	-	OK		0.03234	0.03234
Iteration: 2																						
9.67787	24.14000	-0.04000	90.15000	0.07360	0.07360	0.10245	0.10245	0.08473	0.08473	0.10245	0.10245	0.01113	0.01113	0.20490	0.20490	0.21604	0.21604	-	OK		0.01979	0.01979
16.12979	22.50000	6.20000	90.15000	0.09425	0.09425	0.03610	0.03610	0.10188	0.10188	0.03610	0.03610	0.00763	0.00763	0.07220	0.07220	0.07982	0.07982	-	OK		0.00697	0.00697
22.58170	20.86000	12.44000	90.15000	0.08012	0.08012	0.30101	0.30101	-0.02233	-0.02233	0.30101	0.30101	-0.10244	-0.10244	0.60201	0.60201	0.60201	0.60201	-	OK		0.05814	0.05814

Note: Total pullout ignores the axial component where this is negative (i.e. compression).

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start	Coordinates x	y	z	Pullout Check														Rotation Check Threshold Limit		Vertical Sagging vs Hogging point	Rotation Threshold Limit	
				Left Seg.						Right Seg.						Total						
				Axial		Flexural		Axial		Flexural		Axial		Flexural		Total						
				Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored	Unfactored	Factored					
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]				[Deg]	[Deg]
Iteration: 1																						
5.98971	18.07619	27.78095	90.15000	0.73996	0.73996	0.08028	0.08028	0.36813	0.36813	0.08028	0.08028	-0.37183	-0.37183	0.16056	0.16056	0.16056	0.16056	-	OK		0.01551	0.01551
11.97942	17.75238	33.76190	90.15000	0.06696	0.06696	0.14061	0.14061	0.03419	0.03419	0.14061	0.14061	-0.03277	-0.03277	0.28122	0.28122	0.28122	0.28122	-	OK		0.02716	0.02716
17.96913	17.42857	39.74286	90.15000	0.11819	0.11819	0.10161	0.10161	0.14536	0.14536	0.10161	0.10161	0.02717	0.02717	0.20323	0.20323	0.23040	0.23040	-	OK		0.01963	0.01963
23.95885	17.10476	45.72381	90.15000	0.14792	0.14792	0.01773	0.01773	0.15193	0.15193	0.01773	0.01773	0.00401	0.00401	0.03545	0.03545	0.03946	0.03946	-	OK		0.00342	0.00342
29.94856	16.78095	51.70476	90.15000	0.15448	0.15448	0.00772	0.00772	0.15849	0.15849	0.00772	0.00772	0.00401	0.00401	0.01543	0.01543	0.01944	0.01944	-	OK		0.00149	0.00149
35.93827	16.45714	57.68571	90.15000	0.16105	0.16105	0.05486	0.05486	-0.12962	-0.12962	0.05486	0.05486	-0.29066	-0.29066	0.10973	0.10973	0.10973	0.10973	-	OK		0.01060	0.01060
41.92798	16.13333	63.66667	90.15000	-0.66755	-0.66755	0.08523	0.08523	-1.11108	-1.11108	0.08523	0.08523	-0.44353	-0.44353	0.17047	0.17047	0.17047	0.17047	-	OK		0.01646	0.01646
47.91769	15.80952	69.64762	90.15000	-0.84087	-0.84087	0.11554	0.11554	-0.26234	-0.26234	0.11554	0.11554	0.57853	0.57853	0.23109	0.23109	0.80961	0.80961	-	OK		0.02232	0.02232
53.90740	15.48571	75.62857	90.15000	-0.05809	-0.05809	0.08293	0.08293	0.00000	0.00000	0.08293	0.08293	0.05809	0.05809	0.16585	0.16585	0.22394	0.22394	-	OK		0.01602	0.01602
Iteration: 2																						
8.98457	17.91429	30.77143	90.15000	0.40062	0.40062	0.07632	0.07632	0.02011	0.02011	0.07632	0.07632	-0.38051	-0.38051	0.15263	0.15263	0.15263	0.15263	-	OK		0.01474	0.01474
14.97428	17.59048	36.75238	90.15000	0.04911	0.04911	0.11348	0.11348	0.14208	0.14208	0.11348	0.11348	0.09297	0.09297	0.22695	0.22695	0.31993	0.31993	-	OK		0.02192	0.02192
20.96399	17.26667	42.73333	90.15000	0.14464	0.14464	0.05568	0.05568	0.14864	0.14864	0.05568	0.05568	0.00401	0.00401	0.11136	0.11136	0.11537	0.11537	-	OK		0.01076	0.01076
26.95370	16.94286	48.71429	90.15000	0.15120	0.15120	0.00744	0.00744	0.15521	0.15521	0.00744	0.00744	0.00401	0.00401	0.01488	0.01488	0.01889	0.01889	-	OK		0.00144	0.00144
32.94341	16.61905	54.69524	90.15000	0.15776	0.15776	0.01873	0.01873	0.12169	0.12169	0.01873	0.01873	-0.03608	-0.03608	0.03746	0.03746	0.03746	0.03746	-	OK		0.00362	0.00362
38.93312	16.29524	60.67619	90.15000	-0.01672	-0.01672	0.12093	0.12093	-0.69850	-0.69850	0.12093	0.12093	-0.68178	-0.68178	0.24186	0.24186	0.24186	0.24186	-	OK		0.02336	0.02336
44.92284	15.97143	66.65714	90.15000	-1.06588	-1.06588	0.08498	0.08498	-0.77400	-0.77400	0.08498	0.08498	0.29188	0.29188	0.16996	0.16996	0.46184	0.46184	-	OK		0.01641	0.01641
50.91255	15.64762	72.63810	90.15000	-0.33041	-0.33041	0.12105	0.12105	0.00000	0.00000	0.12105	0.12105	0.33041	0.33041	0.24209	0.24209	0.57251	0.57251	-	OK		0.02338	0.02338
56.90226	15.32381	78.61905	90.15000	0.00000	0.00000	0.03408	0.03408	0.00000	0.00000	0.03408	0.03408	0.00000	0.00000	0.06816	0.06816	0.06816	0.06816	-	OK		0.00658	0.00658

Note: Total pullout ignores the axial component where this is negative (i.e. compression).

Specific Utility Damage Results - Strains

Utility: Cast Iron Main Line 1 | Sub-utility: Sub 1

Distance from the utility's start	Coordinates x	y	z	Pipe Strain Check				Radius of Curvature Check		Peak flexural tensile strain orientation angle (w.r.t global z-axis)
				Axial	Flexural	Tension	Compression	Radius of Threshold Limit		

				Tension		Compression		Total		Check	Total		Check	Curvature			
				Unfactored	Factored	Unfactored	Factored	Unfactored	Factored		Unfactored	Factored					
[m]	[m]	[m]	[m]	[με]	[με]	[με]	[με]	[με]	[με]		[με]	[με]		[m]			[Deg]
6.45191	24.96000	-3.16000	90.15000	12.285	2.4569	10.704	10.704	-10.704	-10.704	22.98832	13.16067	OK	-	-8.24684	OK	2.7712E+4	-	-	-81.29172
9.67787	24.14000	-0.04000	90.15000	1.6317	0.32633	33.404	33.404	-33.404	-33.404	35.03592	33.73059	OK	-31.77259	-33.07793	OK	8.8798E+3	-	-	155.78471
12.90383	23.32000	3.08000	90.15000	3.4269	0.68537	8.9587	8.9587	-8.9587	-8.9587	12.38560	9.64410	OK	-5.53185	-8.27335	OK	3.3110E+4	-	-	0.00000
16.12979	22.50000	6.20000	90.15000	3.4568	0.69135	12.694	12.694	-12.694	-12.694	16.15053	13.38511	OK	-9.23699	-12.00241	OK	2.3368E+4	-	-	-0.00003
19.35574	21.68000	9.32000	90.15000	-7.7538	-7.7538	23.582	23.582	-23.582	-23.582	15.82823	15.82823	OK	-31.33586	-31.33586	OK	1.2578E+4	-	-	159.28617
22.58170	20.86000	12.44000	90.15000	-39.160	-39.160	97.679	97.679	-97.679	-97.679	58.51895	58.51895	OK	-136.83909	-136.83909	OK	3.0367E+3	-	-	178.08617
25.80766	20.04000	15.56000	90.15000	24.601	4.9203	60.035	60.035	-60.035	-60.035	84.63669	64.95552	OK	-35.43378	-55.11494	OK	4.9408E+3	-	-	-10.64181

Note: Tensile strains are +ve, compressive strains are -ve.
Note: The peak flexural tensile strain orientation angle is measured with respect to the global z-axis by looking at the end point of the utility from the start point. Anti-clockwise is positive.

Utility: Cast Iron Main Line 2 | Sub-utility: Sub 2

Distance from the utility's start point	Coordinates			Pipe Strain Check											Radius of Curvature Check			Peak flexural tensile strain orientation angle (w.r.t global z-axis)
	x	y	z	Axial	Flexural				Tension		Compression				Radius of Curvature	Threshold Limit		
					Tension		Compression		Total		Check	Total		Check				
				Unfactored	Factored	Unfactored	Factored	Unfactored	Factored			Unfactored	Factored					
[m]	[m]	[m]	[m]	[με]	[με]	[με]	[με]	[με]	[με]	[με]		[με]	[με]		[m]			[Deg]
2.99486	18.23810	24.79048	90.15000	32.880	6.5760	15.426	15.426	-15.426	-15.426	48.30620	22.00238	OK	-	-8.85048	OK	1.9228E+4	-	-	-44.33763
5.98971	18.07619	27.78095	90.15000	-132.03	-132.03	26.504	26.504	-26.504	-26.504	-	-	-	-158.53497	-158.53497	OK	1.1192E+4	-	-	118.23974
8.98457	17.91429	30.77143	90.15000	-129.14	-129.14	27.292	27.292	-27.292	-27.292	-	-	-	-156.43579	-156.43579	OK	1.0869E+4	-	-	58.29065
11.97942	17.75238	33.76190	90.15000	12.443	2.4886	43.884	43.884	-43.884	-43.884	56.32709	46.37255	OK	-31.44075	-41.39528	OK	6.7593E+3	-	-	197.28787
14.97428	17.59048	36.75238	90.15000	36.081	7.2162	36.923	36.923	-36.923	-36.923	73.00349	44.13889	OK	-0.84198	-29.70658	OK	8.0336E+3	-	-	187.33903
17.96913	17.42857	39.74286	90.15000	1.1496	0.22992	38.575	38.575	-38.575	-38.575	39.72472	38.80503	OK	-37.42549	-38.34518	OK	7.6895E+3	-	-	0.00005
20.96399	17.26667	42.73333	90.15000	1.0991	0.21983	10.936	10.936	-10.936	-10.936	12.03525	11.15595	OK	-9.83699	-10.71630	OK	2.7123E+4	-	-	0.00000
23.95885	17.10476	45.72381	90.15000	1.0962	0.21924	3.6542	3.6542	-3.6542	-3.6542	4.75037	3.87342	OK	-2.55800	-3.43495	OK	8.1174E+4	-	-	-0.00052
26.95370	16.94286	48.71429	90.15000	1.0964	0.21929	1.5572	1.5572	-1.5572	-1.5572	2.65365	1.77650	OK	-0.46077	-1.33792	OK	1.9048E+5	-	-	0.00122
29.94856	16.78095	51.70476	90.15000	1.0969	0.21938	1.4618	1.4618	-1.4618	-1.4618	2.55875	1.68123	OK	-0.36495	-1.24247	OK	2.0291E+5	-	-	0.00000
32.94341	16.61905	54.69524	90.15000	1.0985	0.21971	4.5932	4.5932	-4.5932	-4.5932	5.69173	4.81290	OK	-3.49465	-4.37348	OK	6.4579E+4	-	-	0.00000
35.93827	16.45714	57.68571	90.15000	-59.348	-59.348	12.811	12.811	-12.811	-12.811	-	-	-	-72.15896	-72.15896	OK	2.3154E+4	-	-	63.34149
38.93312	16.29524	60.67619	90.15000	-230.66	-230.66	40.734	40.734	-40.734	-40.734	-	-	-	-271.39734	-271.39734	OK	7.2819E+3	-	-	116.94449
41.92798	16.13333	63.66667	90.15000	-157.49	-157.49	27.290	27.290	-27.290	-27.290	-	-	-	-184.77663	-184.77663	OK	1.0869E+4	-	-	228.59768
44.92284	15.97143	66.65714	90.15000	115.94	23.188	16.638	16.638	-16.638	-16.638	132.57941	39.82665	OK	-	-	-	1.7828E+4	-	-	225.25910
47.91769	15.80952	69.64762	90.15000	190.40	38.080	43.589	43.589	-43.589	-43.589	233.98869	81.66926	OK	-	-5.50954	OK	6.8050E+3	-	-	190.34120
50.91255	15.64762	72.63810	90.15000	87.748	17.550	44.611	44.611	-44.611	-44.611	132.35939	62.16107	OK	-	-27.06191	OK	6.6490E+3	-	-	-7.26824
53.90740	15.48571	75.62857	90.15000	0.026582	0.0053164	18.299	18.299	-18.299	-18.299	18.32557	18.30430	OK	-18.27240	-18.29367	OK	1.6210E+4	-	-	0.00000
56.90226	15.32381	78.61905	90.15000	0.0050630	0.0010126	7.4416	7.4416	-7.4416	-7.4416	7.44663	7.44257	OK	-7.43650	-7.44055	OK	3.9860E+4	-	-	0.00000

Note: Tensile strains are +ve, compressive strains are -ve.
Note: The peak flexural tensile strain orientation angle is measured with respect to the global z-axis by looking at the end point of the utility from the start point. Anti-clockwise is positive.

Specific Utility Damage Results - Maximum Values

Name	Jointed	Displacement Data Type	Displacement Data	Maximum Pullout (Factored)		Maximum Rotation (Factored)		Maximum Strain (Factored) Tension		Maximum Strain (Factored) Compression		Minimum Radius of Curvature		Maximum Displacement Vertical		Maximum Displacement Horizontal x		Maximum Displacement Horizontal y	
				Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value	Location	Value
				[m]	[mm]	[m]	[Deg]	[m]	[με]	[m]	[με]	[m]	[m]	[m]	[mm]	[m]	[mm]	[m]	[mm]
Cast Iron Main Line 1	Yes	Displacement Line	Line 1	22.582	0.60201	22.582	0.05814	25.80766	64.95552	22.58170	-136.83909	22.582	3.0367E+3	22.582	8.3390	32.259	0.77275	32.259	1.2522
Cast Iron Main Line 2	Yes	Displacement Line	Line 2	47.918	0.80961	11.979	0.02716	47.91769	81.66926	38.93312	-271.39734	50.913	6.6490E+3	11.979	6.8483	41.928	-1.2188	8.9846	3.1456

Note: * symbol indicates that the value has exceeded one of (or both) the limiting criteria