Vattenfall Wind Power Ltd

Thanet Extension Offshore Wind Farm

Annex 2-3: Geophysical Investigation Report 2 of 3 - Geophysical Site Survey

June, 2017, Revision A

Document Reference: 6.4.2.3.2

Pursuant to: APFP Reg. 5(2)(a)

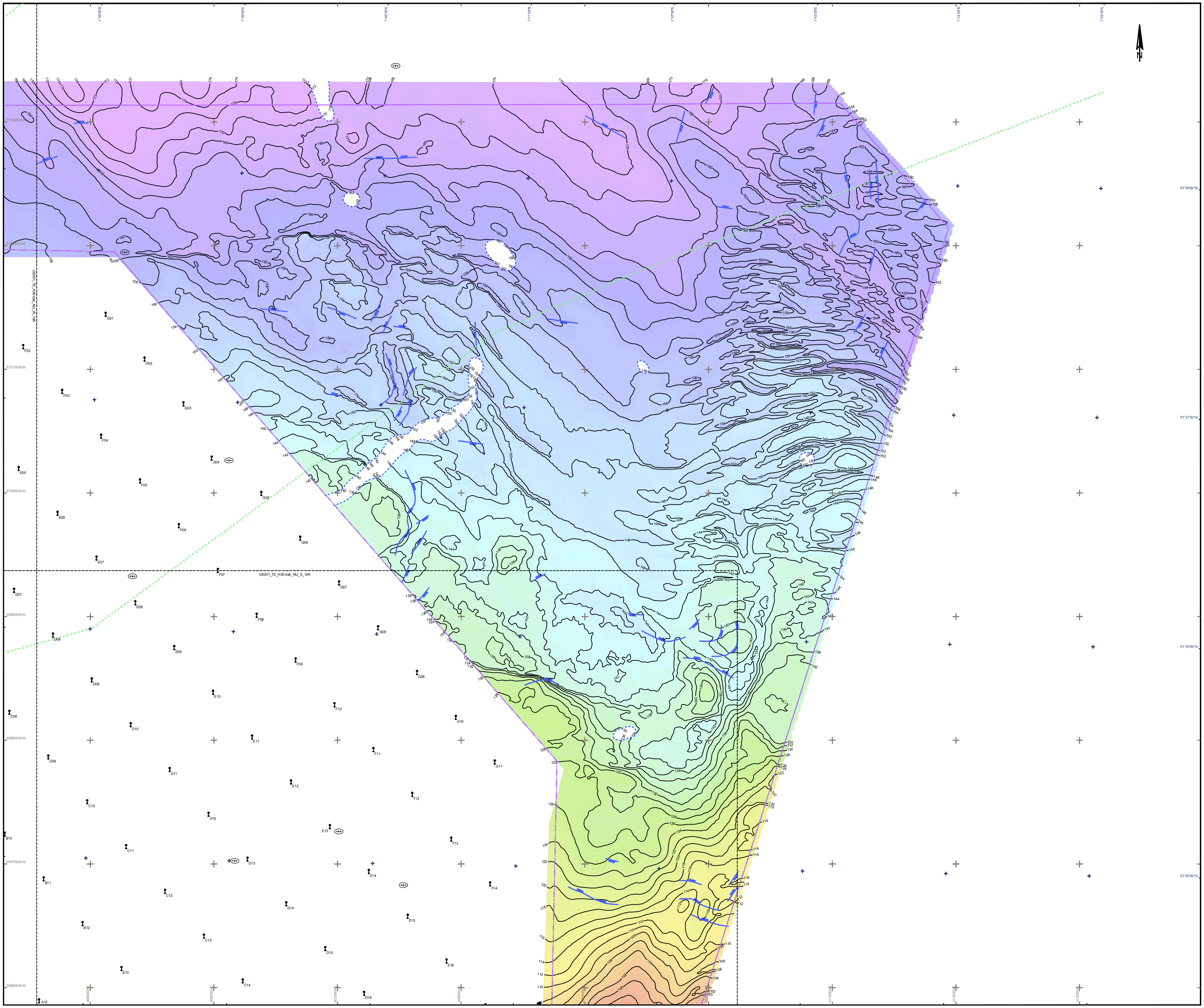
Vattenfall Wind Power Ltd

Thanet Extension Offshore Wind Farm

Annex 2-3: Geophysical Investigation Report 2 of 3 - Geophysical Site Survey

June, 2018

Drafted By:	Fugro Group
Approved By:	Helen Jameson
Date of Approval	June 2018
Revision	A



LEGEND:

GENERAL

- U.T.M. GRID
- GEOGRAPHICAL GRID
- EXISTING CABLE ROUTES
- WIND FARM BOUNDARY (TOW)
- WIND FARM BOUNDARY (TEOW), BASED ON SURVEY LINE PLAN
- CHART MATCHLINE
- E01 TURBINE LOCATION WITH ID NUMBER (TOW)
- WRECK (FROM ENC AND ADMIRALTY CHARTS)

DEPTH TO BASE OF UPPER CHALK Fm. (HORIZON H30)

- 130 DEPTH IN METRES BELOW SEABED (CONTOURS AT 2 METRE INTERVAL)
- FAULT AT H30
- H30 MASKING ZONE

DEPTH IN METRES BELOW SEABED
THE DEPTH OF H30 RANGES BETWEEN 83 m AND 178 mbsb

90.0
120.0
150.0
>180.0

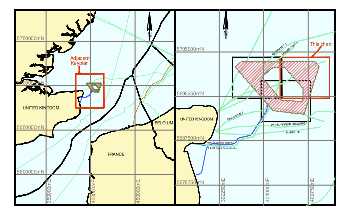
NOTES:

1. INTERPRETATION BASED ON UHR SEISMIC DATA.
2. ALL DEPTHS ARE BELOW SEABED.
3. DUE TO THE SURVEY LINE SPACING AND THE GREAT LATERAL VARIATION, THE DEPTH VALUES BETWEEN LINES WERE INTERPOLATED (LOW CONFIDENCE).
4. GRIDDING ALGORITHM: MINIMUM CURVATURE. GRIDDING PARAMETER: CELL SIZE 25X25 m, SMOOTHNESS 11. CONTOUR PARAMETERS: THRESHOLD 30, CONTOUR INTERVAL 2 m.
5. TWO-WAY TIME UHR DATA WAS CONVERTED TO DEPTH USING A SMOOTHED VELOCITY FIELD DERIVED FROM PICKED RMS VELOCITIES. CALCULATED DEPTHS ARE CONSIDERED TO BE ACCURATE TO +/- 5%.
6. SEISMIC INTERPRETATION OF THE LOCAL STRATIGRAPHY WAS CORRELATED WITH BGS REPORT IN THAMES ESTUARY.
7. BACKGROUND INFORMATION IS EXTRACTED FROM ENC AND ADMIRALTY CHARTS.

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM

GEODETIC DATUM	European Terrestrial Reference System 1989
ELLIPSOID	GRS 1980
Semi-Major Axis	6,378,137.000
Inverse Flattening	298.257 222 101
PROJECTION	ETRS89 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	ITRF2008 to ETRS89 for Epoch 2016. 647540984 (25 August 2016)
Source	EPSG dX=+0.05376 dY=+0.05096 dZ=-0.08847 rX=-0.002239" rY=-0.013547" rZ=+0.021897" Scale=+0.0026718ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



VATTENFALL WIND POWER LTD
St Andrews House, Haugh Lane, Hexham NE45 3QQ, Northumberland, United Kingdom
Tel +44 1434 611300

FUGRO SURVEY B.V.
Prismastraat 4, P.O. Box 130, 2630 AC Nootdorp, The Netherlands
Tel: +31 70 311 1800, Fax: +31 70 311 1838, Email: fsbvinfo@fugro.com

GEOPHYSICAL SITE SURVEY
UK CONTINENTAL SHELF, NORTH SEA
THANET EXTENSION OFFSHORE WIND FARM
DEPTH TO BASE OF UPPER CHALK Fm. (HORIZON H30)
METRES BELOW SEABED
EAST

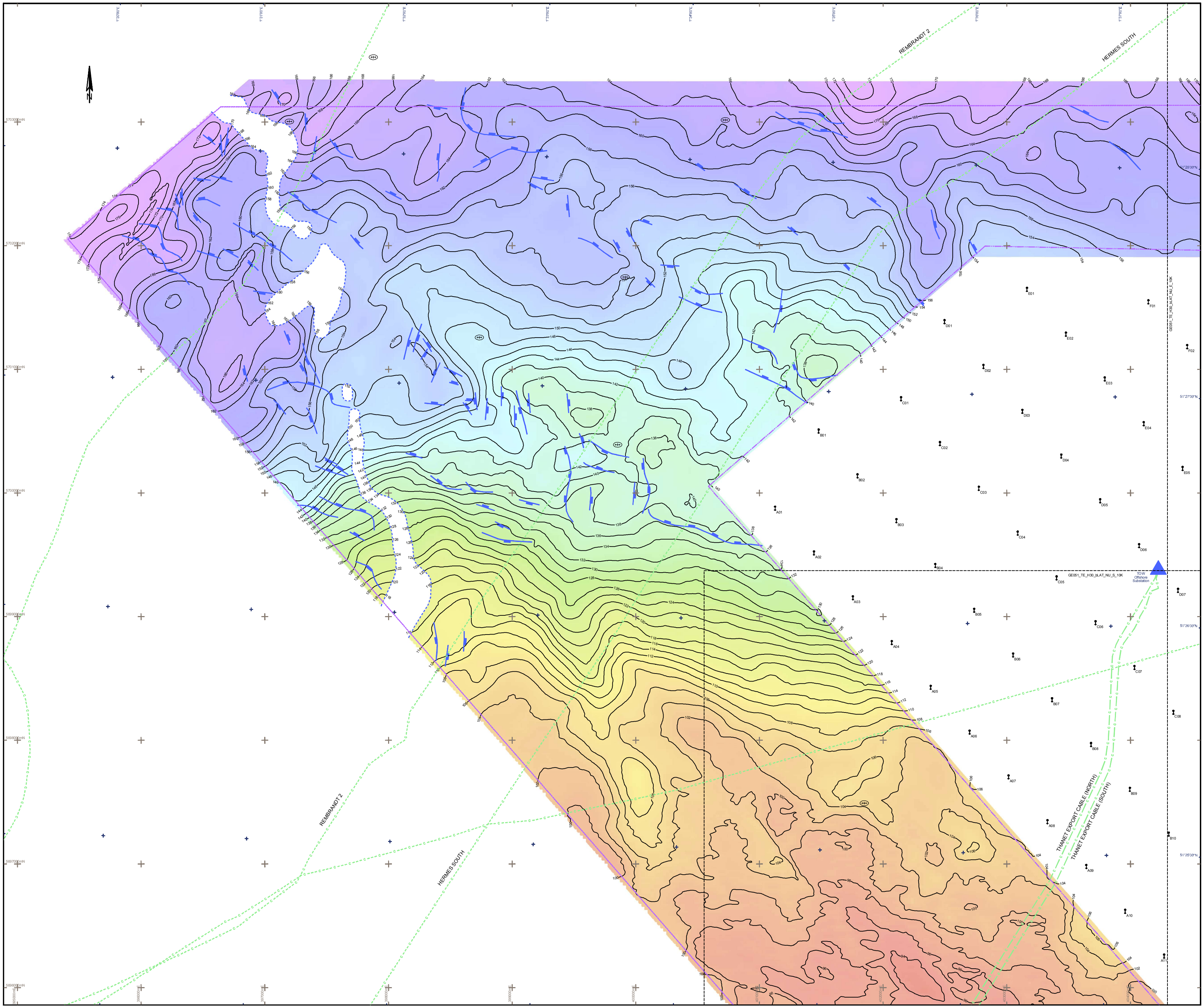
SCALE 1 : 10000 at A0

0 100 200 400 600 800 1000 metres
0 1000 2000 3000 feet

Vessel: FUGRO PIONEER | Survey Date: JUL - SEPT 2016 | Project Ref: GE051

Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	25/11/2016	Issue for Approval	MvL / TW	RB / MS	VMN	PPL
0	03/04/2017	Final Issue	MvL / TW	RB / MS	VMN	PPL

Client Ref:	Drawing No:	Chart:	Encl:
-	GE051_TE_H30-bsb_NU_E_10K	1 of 3	64



LEGEND:

GENERAL

- U.T.M. GRID
- GEOGRAPHICAL GRID
- EXISTING CABLE ROUTES
- WIND FARM BOUNDARY (TOW)
- WIND FARM BOUNDARY (TEOW), BASED ON SURVEY LINE PLAN
- CHART MATCHLINE
- TURBINE LOCATION WITH ID NUMBER (TOW)
- WRECK (FROM ENC AND ADMIRALTY CHARTS)

DEPTH TO BASE OF UPPER CHALK Fm. (HORIZON H30)

- DEPTH IN METRES BELOW SEABED (CONTOURS AT 2 METRE INTERVAL)
- FAULT AT H30
- H30 MASKING ZONE

DEPTH IN METRES BELOW SEABED
THE DEPTH OF H30 RANGES BETWEEN 83 m AND 178 m bsb

90.0
120.0
150.0
>180.0

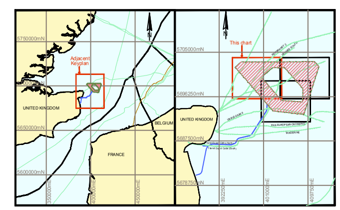
NOTES:

1. INTERPRETATION BASED ON UHR SEISMIC DATA.
2. ALL DEPTHS ARE BELOW SEABED.
3. DUE TO THE SURVEY LINE SPACING AND THE GREAT LATERAL VARIATION, THE DEPTH VALUES BETWEEN LINES WERE INTERPOLATED (LOW CONFIDENCE).
4. GRIDDING ALGORITHM: MINIMUM CURVATURE. GRIDDING PARAMETER: CELL SIZE 25X25 m, SMOOTHNESS 11. CONTOUR PARAMETERS: THRESHOLD 30, CONTOUR INTERVAL 2 m.
5. TWO-WAY TIME UHR DATA WAS CONVERTED TO DEPTH USING A SMOOTHED VELOCITY FIELD DERIVED FROM PICKED RMS VELOCITIES. CALCULATED DEPTHS ARE CONSIDERED TO BE ACCURATE TO +/- 5%.
6. SEISMIC INTERPRETATION OF THE LOCAL STRATIGRAPHY WAS CORRELATED WITH BGS REPORT IN THAMES ESTUARY.
7. BACKGROUND INFORMATION IS EXTRACTED FROM ENC AND ADMIRALTY CHARTS.

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM

GEODETIC DATUM	European Terrestrial Reference System 1989
ELLIPSOID	GRS 1980
Semi-Major Axis	6,378,137.000
Inverse Flattening	298.257 222 101
PROJECTION	ETRS89 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	ITRF2008 to ETRS89 for Epoch 2016. 647540984 (25 August 2016)
Source	EPSG dX=+0.05376 dY=+0.05096 dZ=-0.08847 rX=-0.002239" rY=-0.013547" rZ=+0.021897" Scale=+0.0026718ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



VATTENFALL WIND POWER LTD
St Andrews House, Haugh Lane, Hexham NE45 3QQ, Northumberland, United Kingdom
Tel +44 1434 611300

FUGRO SURVEY B.V.
Prismastraat 4, P.O. Box 130, 2630 AC Nootdorp, The Netherlands
Tel: +31 70 311 1800, Fax: +31 70 311 1838, Email: fsbvinfo@fugro.com

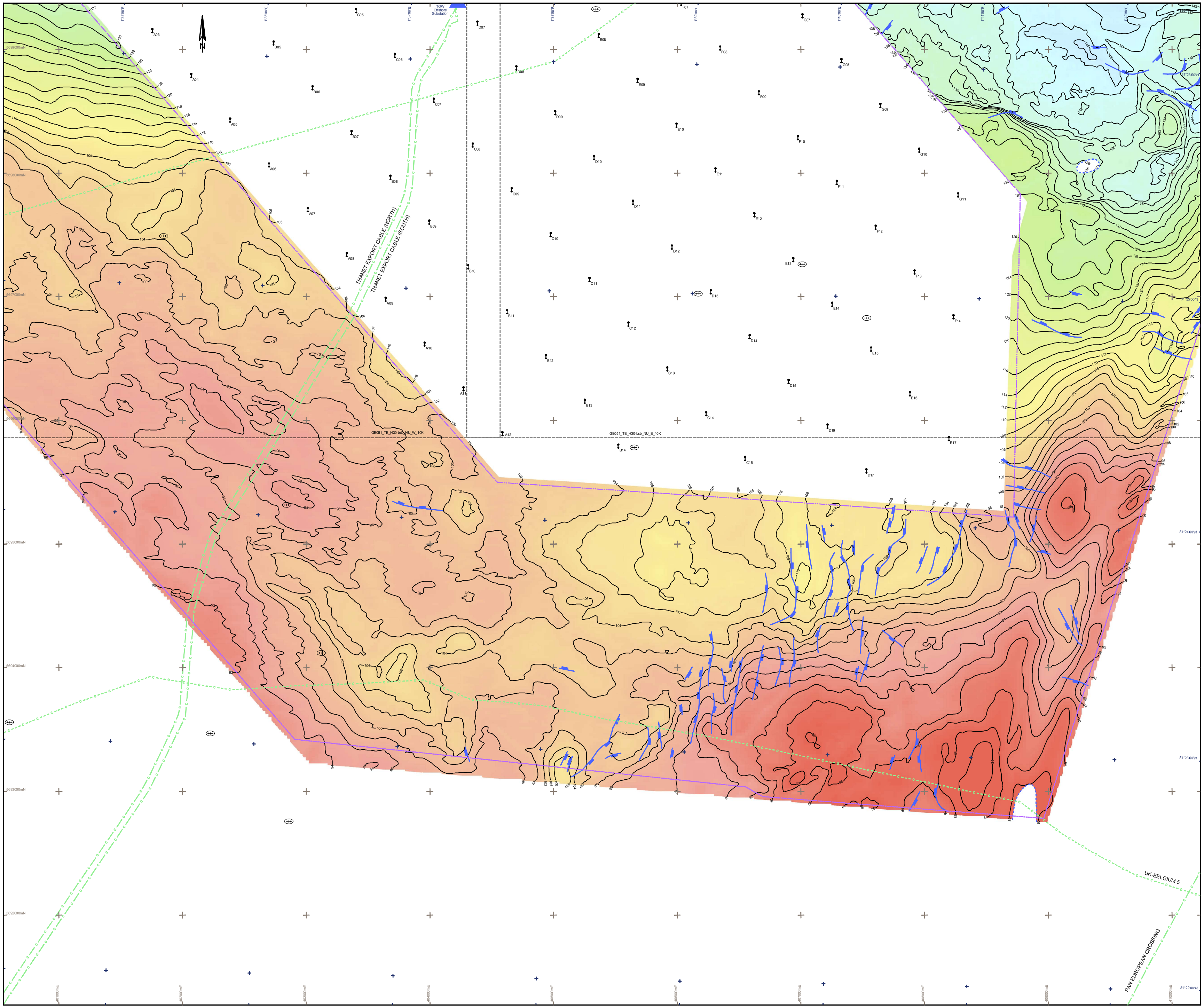
GEOPHYSICAL SITE SURVEY
UK CONTINENTAL SHELF, NORTH SEA
THANET EXTENSION OFFSHORE WIND FARM
DEPTH TO BASE OF UPPER CHALK Fm. (HORIZON H30)
METRES BELOW SEABED
WEST

SCALE 1 : 10000 at A0

0 100 200 400 600 800 1000 metres
0 1000 2000 3000 feet

Vessel: FUGRO PIONEER	Survey Date: JUL - SEPT 2016	Project Ref: GE051				
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	25/11/2016	Issue for Approval	MvL / TW	RB / MS	VMN	PPL
0	03/04/2017	Final Issue	MvL / TW	RB / MS	VMN	PPL

Client Ref:	Drawing No:	Chart:	Encl:
-	GE051_TE_H30-bsb_NU_W_10K	2 of 3	65



LEGEND:

GENERAL

- U.T.M. GRID
- GEOGRAPHICAL GRID
- EXISTING CABLE ROUTES
- WIND FARM BOUNDARY (TOW)
- WIND FARM BOUNDARY (TEOW), BASED ON SURVEY LINE PLAN
- CHART MATCHLINE
- E01 TURBINE LOCATION WITH ID NUMBER (TOW)
- WRECK (FROM ENC AND ADMIRALTY CHARTS)

DEPTH TO BASE OF UPPER CHALK Fm. (HORIZON H30)

- 130 DEPTH IN METRES BELOW SEABED (CONTOURS AT 2 METRE INTERVAL)
- FAULT AT H30
- H30 MASKING ZONE

DEPTH IN METRES BELOW SEABED
THE DEPTH OF H30 RANGES BETWEEN 83 m AND 178 m bsb

90.0
120.0
150.0
>180.0

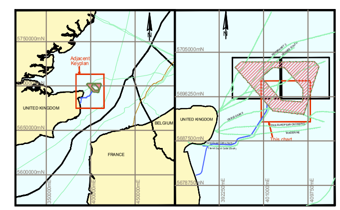
NOTES:

1. INTERPRETATION BASED ON UHR SEISMIC DATA.
2. ALL DEPTHS ARE BELOW SEABED.
3. DUE TO THE SURVEY LINE SPACING AND THE GREAT LATERAL VARIATION, THE DEPTH VALUES BETWEEN LINES WERE INTERPOLATED (LOW CONFIDENCE).
4. GRIDDING ALGORITHM: MINIMUM CURVATURE. GRIDDING PARAMETER: CELL SIZE 25X25 m, SMOOTHNESS 11. CONTOUR PARAMETERS: THRESHOLD 30, CONTOUR INTERVAL 2 m.
5. TWO-WAY TIME UHR DATA WAS CONVERTED TO DEPTH USING A SMOOTHED VELOCITY FIELD DERIVED FROM PICKED RMS VELOCITIES. CALCULATED DEPTHS ARE CONSIDERED TO BE ACCURATE TO +/- 5%.
6. SEISMIC INTERPRETATION OF THE LOCAL STRATIGRAPHY WAS CORRELATED WITH BGS REPORT IN THAMES ESTUARY.
7. BACKGROUND INFORMATION IS EXTRACTED FROM ENC AND ADMIRALTY CHARTS.

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM

GEODETIC DATUM	European Terrestrial Reference System 1989
ELLIPSOID	GRS 1980
Semi-Major Axis	6,378,137.000
Inverse Flattening	298.257 222 101
PROJECTION	ETRS89 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	ITRF2008 to ETRS89 for Epoch 2016. 647540984 (25 August 2016)
Source	EPSG dX=+0.05376 dY=+0.05096 dZ=-0.08847 rX=-0.002239" rY=-0.013547" rZ=+0.021897" Scale=+0.0026718ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



VATTENFALL WIND POWER LTD
St Andrews House, Haugh Lane, Hexham NE45 3QQ, Northumberland, United Kingdom
Tel +44 1434 611300

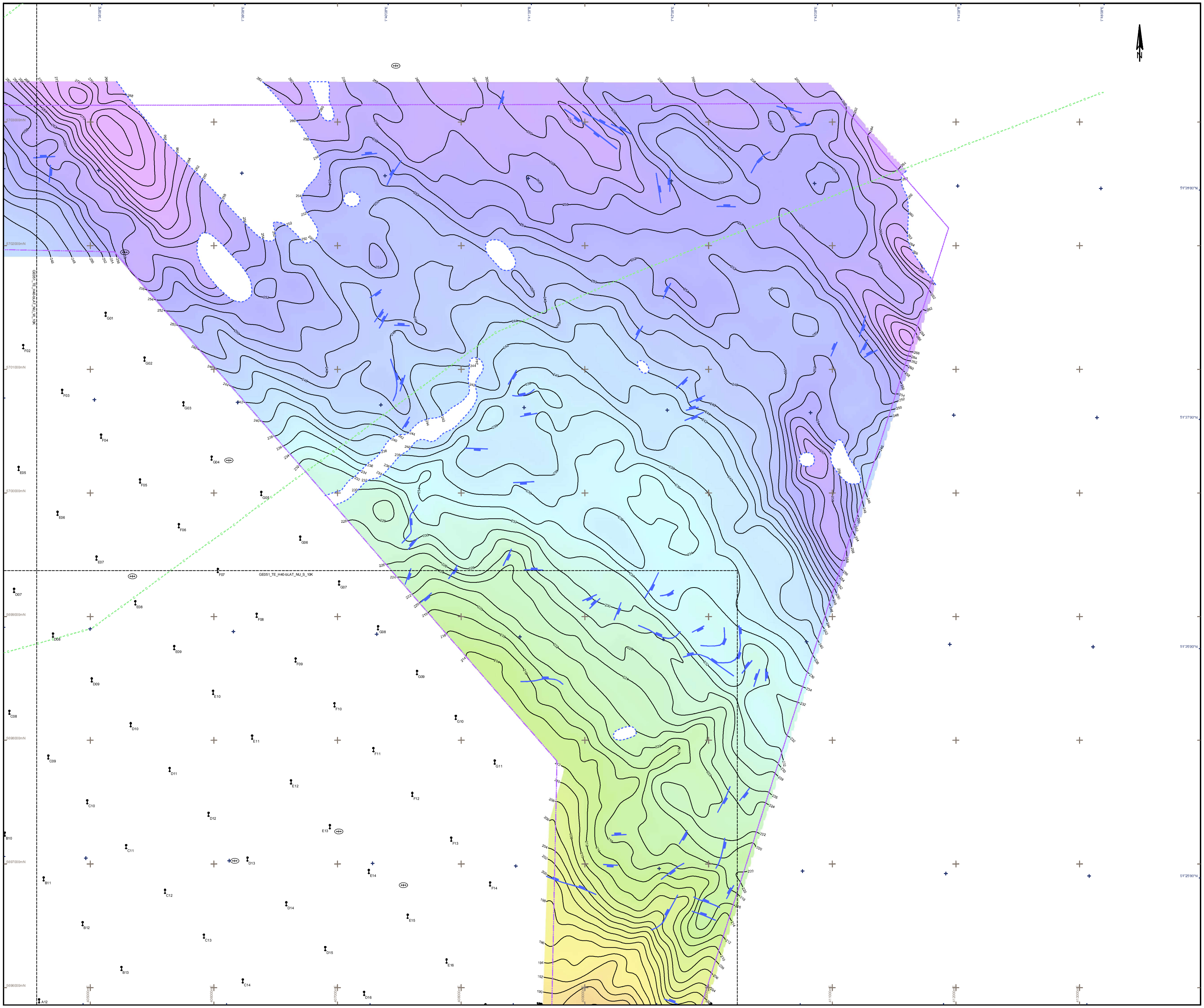
FUGRO SURVEY B.V.
Prismastraat 4, P.O. Box 130, 2630 AC Nootdorp, The Netherlands
Tel: +31 70 311 1800, Fax: +31 70 311 1838, Email: fsbvinfo@fugro.com

GEOPHYSICAL SITE SURVEY
UK CONTINENTAL SHELF, NORTH SEA
THANET EXTENSION OFFSHORE WIND FARM
DEPTH TO BASE OF UPPER CHALK Fm. (HORIZON H30) METRES BELOW SEABED SOUTH

SCALE 1 : 10000 at A0

0 100 200 400 600 800 1000 metres
0 1000 2000 3000 feet

Vessel: FUGRO PIONEER			Survey Date: JUL - SEPT 2016	Project Ref: GE051			
Issue No:	Date:	Description:		Interpr:	Drawn:	Chkd:	Appr:
1	25/11/2016	Issue for Approval		MvL / TW	RB / MS	VMN	PPL
0	03/04/2017	Final Issue		MvL / TW	RB / MS	VMN	PPL
Client Ref: -		Drawing No: GE051_TE_H30-bsb_NU_S_10K		Chart: 3 of 3		Encl: 66	



LEGEND:

GENERAL

- U.T.M. GRID
- GEOGRAPHICAL GRID
- EXISTING CABLE ROUTES
- WIND FARM BOUNDARY (TOW)
- WIND FARM BOUNDARY (TEOW), BASED ON SURVEY LINE PLAN
- CHART MATCHLINE
- TURBINE LOCATION WITH ID NUMBER (TOW)
- WRECK (FROM ENC AND ADMIRALTY CHARTS)

DEPTH TO BASE OF MIDDLE CHALK Fm. (HORIZON H40)

- DEPTH IN METRES BELOW LAT (CONTOURS AT 2 METRE INTERVAL)
- FAULT AT H40
- H40 NOT WELL DEFINED

DEPTH IN METRES BELOW LAT
THE DEPTH OF H40 RANGES BETWEEN 161 m AND 275 m bLAT

165.0
190.0
215.0
240.0
265.0

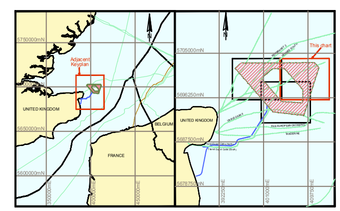
NOTES:

1. INTERPRETATION BASED ON UHR SEISMIC DATA.
2. ALL DEPTHS REDUCED TO LOWEST ASTRONOMICAL TIDE.
3. DUE TO THE SURVEY LINE SPACING AND THE GREAT LATERAL VARIATION, THE DEPTH VALUES BETWEEN LINES WERE INTERPOLATED (LOW CONFIDENCE).
4. GRIDDING ALGORITHM: MINIMUM CURVATURE. GRIDDING PARAMETER: CELL SIZE 25X25 m, SMOOTHNESS 11. CONTOUR PARAMETERS: THRESHOLD 30, CONTOUR INTERVAL 2 m.
5. TWO-WAY TIME UHR DATA WAS CONVERTED TO DEPTH USING A SMOOTHED VELOCITY FIELD DERIVED FROM PICKED RMS VELOCITIES. CALCULATED DEPTHS ARE CONSIDERED TO BE ACCURATE TO +/- 5%.
6. SEISMIC INTERPRETATION OF THE LOCAL STRATIGRAPHY WAS CORRELATED WITH BGS REPORT IN THAMES ESTUARY.
7. BACKGROUND INFORMATION IS EXTRACTED FROM ENC AND ADMIRALTY CHARTS.

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM

GEODETIC DATUM	European Terrestrial Reference System 1989
ELLIPSOID	GRS 1980
Semi-Major Axis	6,378,137.000
Inverse Flattening	298.257 222 101
PROJECTION	ETRS89 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	ITRF2008 to ETRS89 for Epoch 2016. 647540984 (25 August 2016)
Source	EPSG
	dX=+0.05376 dY=+0.05096 dZ=-0.08847
	rX=-0.002239" rY=-0.013547" rZ=+0.021897" Scale=+0.0026718ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



VATTENFALL WIND POWER LTD
St Andrews House, Haugh Lane, Hexham NE45 3QQ, Northumberland, United Kingdom
Tel +44 1434 611300

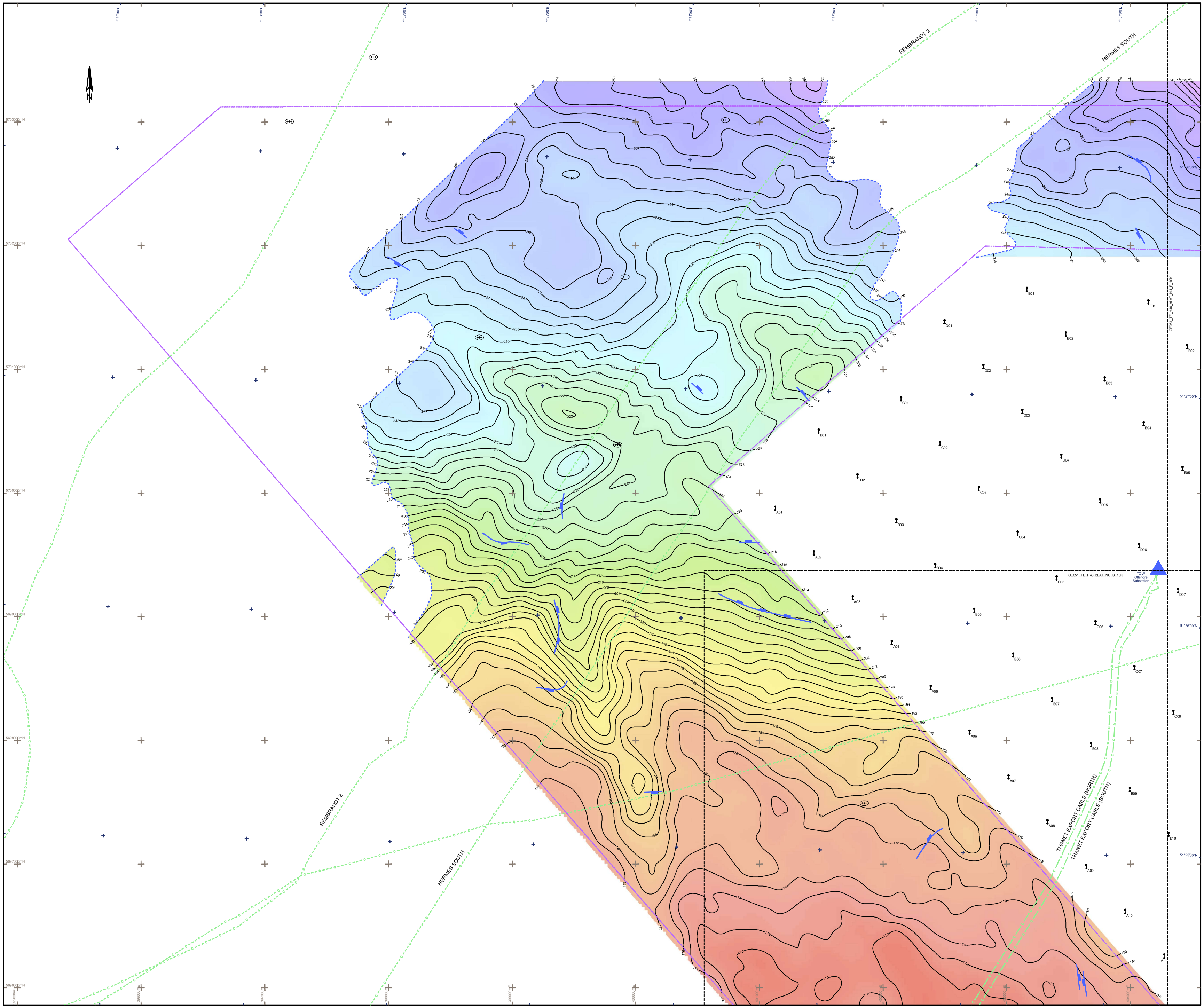
FUGRO SURVEY B.V.
Prismastraat 4, P.O. Box 130, 2630 AC Nootdorp, The Netherlands
Tel: +31 70 311 1800, Fax: +31 70 311 1838, Email: fsbvinfo@fugro.com

GEOPHYSICAL SITE SURVEY
UK CONTINENTAL SHELF, NORTH SEA
THANET EXTENSION OFFSHORE WIND FARM
DEPTH TO BASE OF MIDDLE CHALK Fm. (HORIZON H40)
METRES BELOW LAT
EAST

SCALE 1 : 10000 at A0

Vessel: FUGRO PIONEER		Survey Date: JUL - SEPT 2016	Project Ref: GE051			
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	25/11/2016	Issue for Approval	MvL / TW	RB / MS	VMN	PPL
0	03/04/2017	Final Issue	MvL / TW	RB / MS	VMN	PPL

Client Ref:	Drawing No:	Chart:	Encl:
-	GE051_TE_H40_bLAT_NU_E_10K	1 of 3	67



LEGEND:

GENERAL

- U.T.M. GRID
- GEOGRAPHICAL GRID
- EXISTING CABLE ROUTES
- WIND FARM BOUNDARY (TOW)
- WIND FARM BOUNDARY (TEOW), BASED ON SURVEY LINE PLAN
- CHART MATCHLINE
- TURBINE LOCATION WITH ID NUMBER (TOW)
- WRECK (FROM ENC AND ADMIRALTY CHARTS)

DEPTH TO BASE OF MIDDLE CHALK Fm. (HORIZON H40)

- DEPTH IN METRES BELOW LAT (CONTOURS AT 2 METRE INTERVAL)
- FAULT AT H40
- H40 NOT WELL DEFINED

DEPTH IN METRES BELOW LAT
THE DEPTH OF H40 RANGES BETWEEN 161 m AND 275 m bLAT

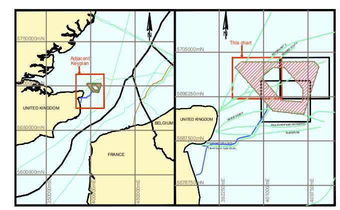
165.0
190.0
215.0
240.0
265.0

NOTES:

1. INTERPRETATION BASED ON UHR SEISMIC DATA.
2. ALL DEPTHS REDUCED TO LOWEST ASTRONOMICAL TIDE.
3. DUE TO THE SURVEY LINE SPACING AND THE GREAT LATERAL VARIATION, THE DEPTH VALUES BETWEEN LINES WERE INTERPOLATED (LOW CONFIDENCE).
4. GRIDDING ALGORITHM: MINIMUM CURVATURE. GRIDDING PARAMETER: CELL SIZE 25X25 m, SMOOTHNESS 11. CONTOUR PARAMETERS: THRESHOLD 30, CONTOUR INTERVAL 2 m.
5. TWO-WAY TIME UHR DATA WAS CONVERTED TO DEPTH USING A SMOOTHED VELOCITY FIELD DERIVED FROM PICKED RMS VELOCITIES. CALCULATED DEPTHS ARE CONSIDERED TO BE ACCURATE TO +/- 5%.
6. SEISMIC INTERPRETATION OF THE LOCAL STRATIGRAPHY WAS CORRELATED WITH BGS REPORT IN THAMES ESTUARY.
7. BACKGROUND INFORMATION IS EXTRACTED FROM ENC AND ADMIRALTY CHARTS.

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM	
GEODETIC DATUM	European Terrestrial Reference System 1989
ELLIPSOID	GRS 1980
Semi-Major Axis	6,378,137.000
Inverse Flattening	298.257 222 101
PROJECTION	ETRS89 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	ITRF2008 to ETRS89 for Epoch 2016. 647540984 (25 August 2016)
Source	EPSG dX=+0.05376 dY=+0.05096 dZ=-0.08847 rX=-0.002239" rY=-0.013547" rZ=+0.021897" Scale=+0.0026718ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



VATTENFALL WIND POWER LTD

St Andrews House, Haugh Lane, Hexham NE45 3QQ, Northumberland, United Kingdom
Tel +44 1434 611300

FUGRO SURVEY B.V.

Prismastraat 4, P.O. Box 130, 2630 AC Nootdorp, The Netherlands
Tel: +31 70 311 1800, Fax: +31 70 311 1838, Email: fsbvinfo@fugro.com

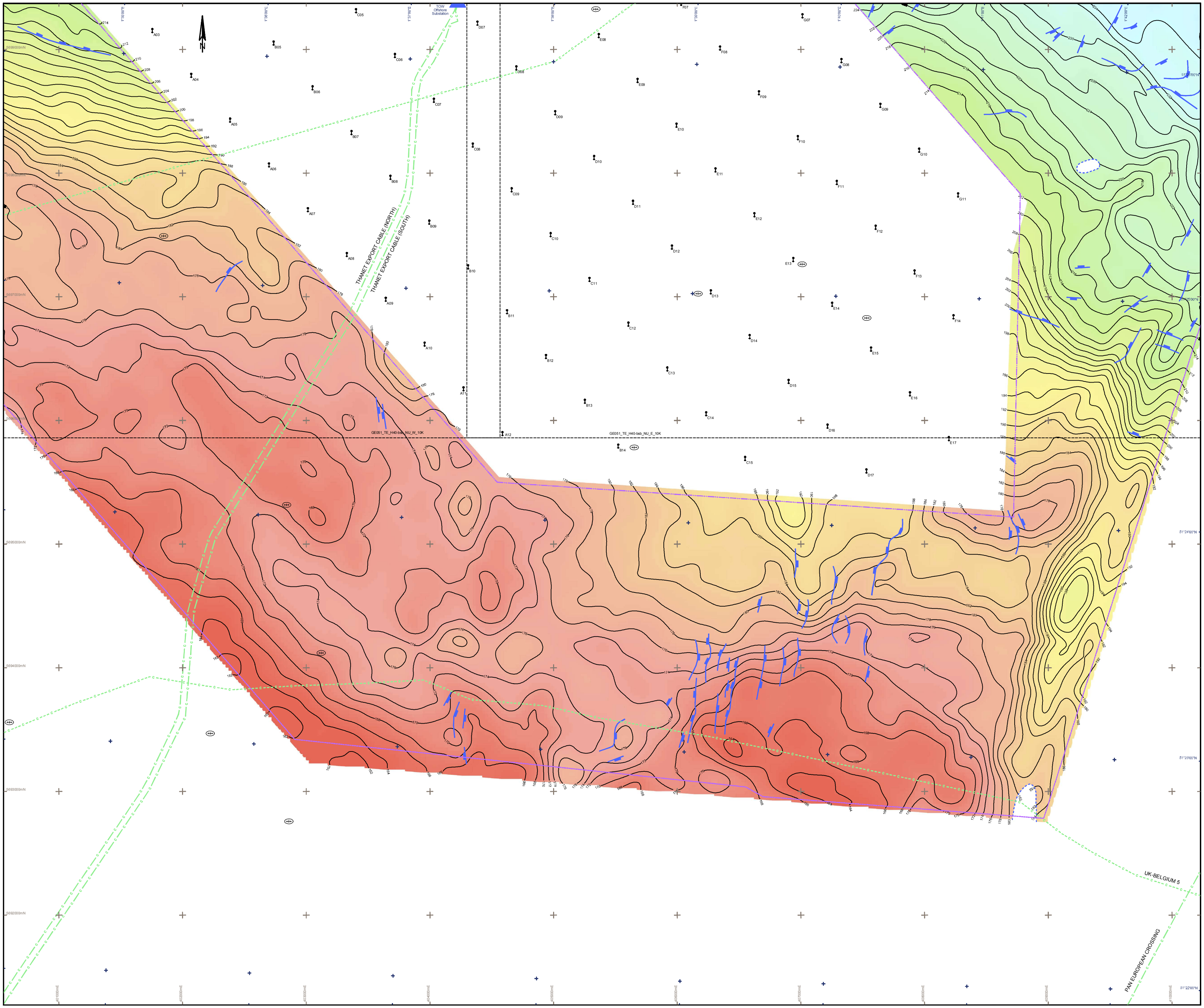
GEOPHYSICAL SITE SURVEY
UK CONTINENTAL SHELF, NORTH SEA
THANET EXTENSION OFFSHORE WIND FARM
DEPTH TO BASE OF MIDDLE CHALK Fm. (HORIZON H40) METRES BELOW LAT WEST

SCALE 1 : 10000 at A0

0 100 200 400 600 800 1000 metres
0 1000 2000 3000 feet

Vessel: FUGRO PIONEER	Survey Date: JUL - SEPT 2016	Project Ref: GE051				
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	25/11/2016	Issue for Approval	MvL / TW	RB / MS	VMN	PPL
0	03/04/2017	Final Issue	MvL / TW	RB / MS	VMN	PPL

Client Ref:	Drawing No:	Chart:	Encl:
-	GE051_TE_H40-bLAT_NU_W_10K	2 of 3	68



LEGEND:

GENERAL

- U.T.M. GRID
- GEOGRAPHICAL GRID
- EXISTING CABLE ROUTES
- WIND FARM BOUNDARY (TOW)
- WIND FARM BOUNDARY (TEOW), BASED ON SURVEY LINE PLAN
- CHART MATCHLINE
- TURBINE LOCATION WITH ID NUMBER (TOW)
- WRECK (FROM ENC AND ADMIRALTY CHARTS)

DEPTH TO BASE OF MIDDLE CHALK Fm. (HORIZON H40)

- DEPTH IN METRES BELOW LAT (CONTOURS AT 2 METRE INTERVAL)
- FAULT AT H40
- H40 NOT WELL DEFINED

DEPTH IN METRES BELOW LAT
THE DEPTH OF H40 RANGES BETWEEN 161 m AND 275 m bLAT

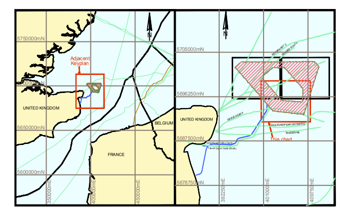
165.0
190.0
215.0
240.0
265.0

NOTES:

1. INTERPRETATION BASED ON UHR SEISMIC DATA.
2. ALL DEPTHS REDUCED TO LOWEST ASTRONOMICAL TIDE.
3. DUE TO THE SURVEY LINE SPACING AND THE GREAT LATERAL VARIATION, THE DEPTH VALUES BETWEEN LINES WERE INTERPOLATED (LOW CONFIDENCE).
4. GRIDDING ALGORITHM: MINIMUM CURVATURE. GRIDDING PARAMETER: CELL SIZE 25X25 m, SMOOTHNESS 11. CONTOUR PARAMETERS: THRESHOLD 30, CONTOUR INTERVAL 2 m.
5. TWO-WAY TIME UHR DATA WAS CONVERTED TO DEPTH USING A SMOOTHED VELOCITY FIELD DERIVED FROM PICKED RMS VELOCITIES. CALCULATED DEPTHS ARE CONSIDERED TO BE ACCURATE TO +/- 5%.
6. SEISMIC INTERPRETATION OF THE LOCAL STRATIGRAPHY WAS CORRELATED WITH BGS REPORT IN THAMES ESTUARY.
7. BACKGROUND INFORMATION IS EXTRACTED FROM ENC AND ADMIRALTY CHARTS.

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM	
GEODETIC DATUM	European Terrestrial Reference System 1989
ELLIPSOID	GRS 1980
Semi-Major Axis	6,378,137.000
Inverse Flattening	298.257 222 101
PROJECTION	ETRS89 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	ITRF2008 to ETRS89 for Epoch 2016. 647540984 (25 August 2016)
Source	EPSG dX=+0.05376 dY=+0.05096 dZ=-0.08847 rX=-0.002239" rY=-0.013547" rZ=+0.021897" Scale=+0.0026718ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



VATTENFALL WIND POWER LTD
St Andrews House, Haugh Lane, Hexham NE45 3QQ, Northumberland, United Kingdom
Tel +44 1434 611300

FUGRO SURVEY B.V.
Prismastraat 4, P.O. Box 130, 2630 AC Nootdorp, The Netherlands
Tel: +31 70 311 1800, Fax: +31 70 311 1838, Email: fsbvinfo@fugro.com

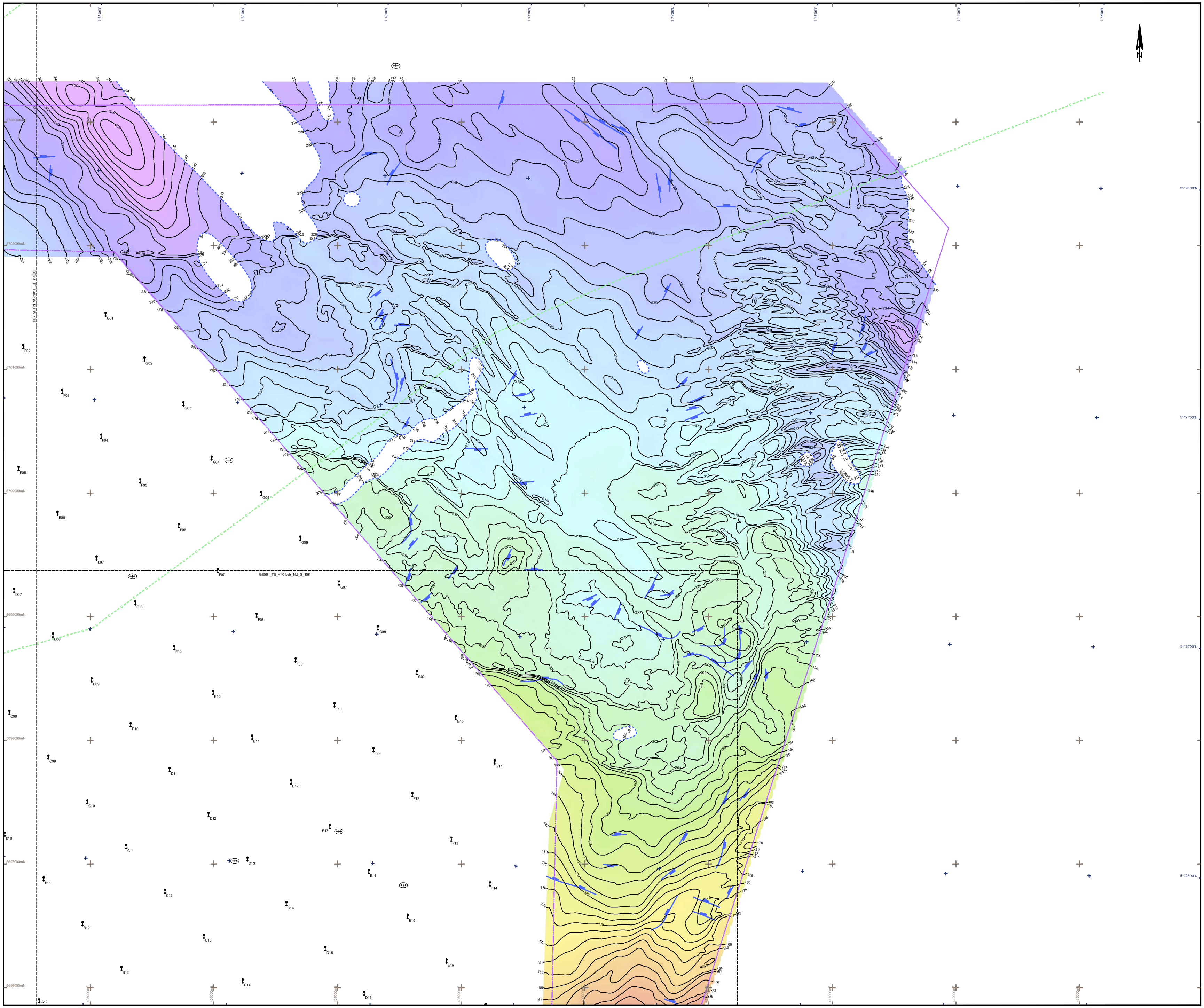
GEOPHYSICAL SITE SURVEY
UK CONTINENTAL SHELF, NORTH SEA
THANET EXTENSION OFFSHORE WIND FARM
DEPTH TO BASE OF MIDDLE CHALK Fm. (HORIZON H40) METRES BELOW LAT SOUTH

SCALE 1 : 10000 at A0

0 100 200 400 600 800 1000 metres
0 1000 2000 3000 feet

Vessel: FUGRO PIONEER		Survey Date: JUL - SEPT 2016	Project Ref: GE051			
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	25/11/2016	Issue for Approval	MvL / TW	RB / MS	VMN	PPL
0	03/04/2017	Final Issue	MvL / TW	RB / MS	VMN	PPL

Client Ref:	Drawing No:	Chart:	Encl:
-	GE051_TE_H40-bLAT_NU_S_10K	3 of 3	69



LEGEND:

GENERAL

- U.T.M. GRID
- GEOGRAPHICAL GRID
- EXISTING CABLE ROUTES
- WIND FARM BOUNDARY (TOW)
- WIND FARM BOUNDARY (TEOW), BASED ON SURVEY LINE PLAN
- CHART MATCHLINE
- E01 TURBINE LOCATION WITH ID NUMBER (TOW)
- WRECK (FROM ENC AND ADMIRALTY CHARTS)

DEPTH TO BASE OF MIDDLE CHALK Fm. (HORIZON H40)

- 230 DEPTH IN METRES BELOW SEABED (CONTOURS AT 2 METRE INTERVAL)
- FAULT AT H40
- H40 NOT WELL DEFINED

DEPTH IN METRES BELOW SEABED
THE DEPTH OF H40 RANGES BETWEEN 138 m AND 253 m bsb

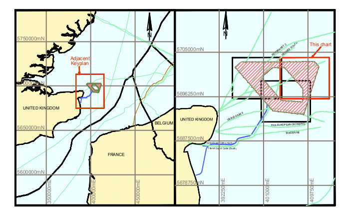
150.0
175.0
200.0
225.0
250.0

NOTES:

1. INTERPRETATION BASED ON UHR SEISMIC DATA.
2. ALL DEPTHS ARE BELOW SEABED.
3. DUE TO THE SURVEY LINE SPACING AND THE GREAT LATERAL VARIATION, THE DEPTH VALUES BETWEEN LINES WERE INTERPOLATED (LOW CONFIDENCE).
4. GRIDDING ALGORITHM: MINIMUM CURVATURE. GRIDDING PARAMETER: CELL SIZE 25X25 m, SMOOTHNESS 11. CONTOUR PARAMETERS: THRESHOLD 30, CONTOUR INTERVAL 2 m.
5. TWO-WAY TIME UHR DATA WAS CONVERTED TO DEPTH USING A SMOOTHED VELOCITY FIELD DERIVED FROM PICKED RMS VELOCITIES. CALCULATED DEPTHS ARE CONSIDERED TO BE ACCURATE TO +/- 5%.
6. SEISMIC INTERPRETATION OF THE LOCAL STRATIGRAPHY WAS CORRELATED WITH BGS REPORT IN THAMES ESTUARY.
7. BACKGROUND INFORMATION IS EXTRACTED FROM ENC AND ADMIRALTY CHARTS.

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM	
GEODETIC DATUM	European Terrestrial Reference System 1989
ELLIPSOID	GRS 1980
Semi-Major Axis	6,378,137.000
Inverse Flattening	298.257 222 101
PROJECTION	ETRS89 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	ITRF2008 to ETRS89 for Epoch 2016. 647540984 (25 August 2016)
Source	EPSG dX=+0.05376 dY=+0.05096 dZ=-0.08847 rX=-0.002239" rY=-0.013547" rZ=+0.021897" Scale=+0.0026718ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



VATTENFALL WIND POWER LTD
St Andrews House, Haugh Lane, Hexham NE45 3QQ, Northumberland, United Kingdom
Tel +44 1434 611300

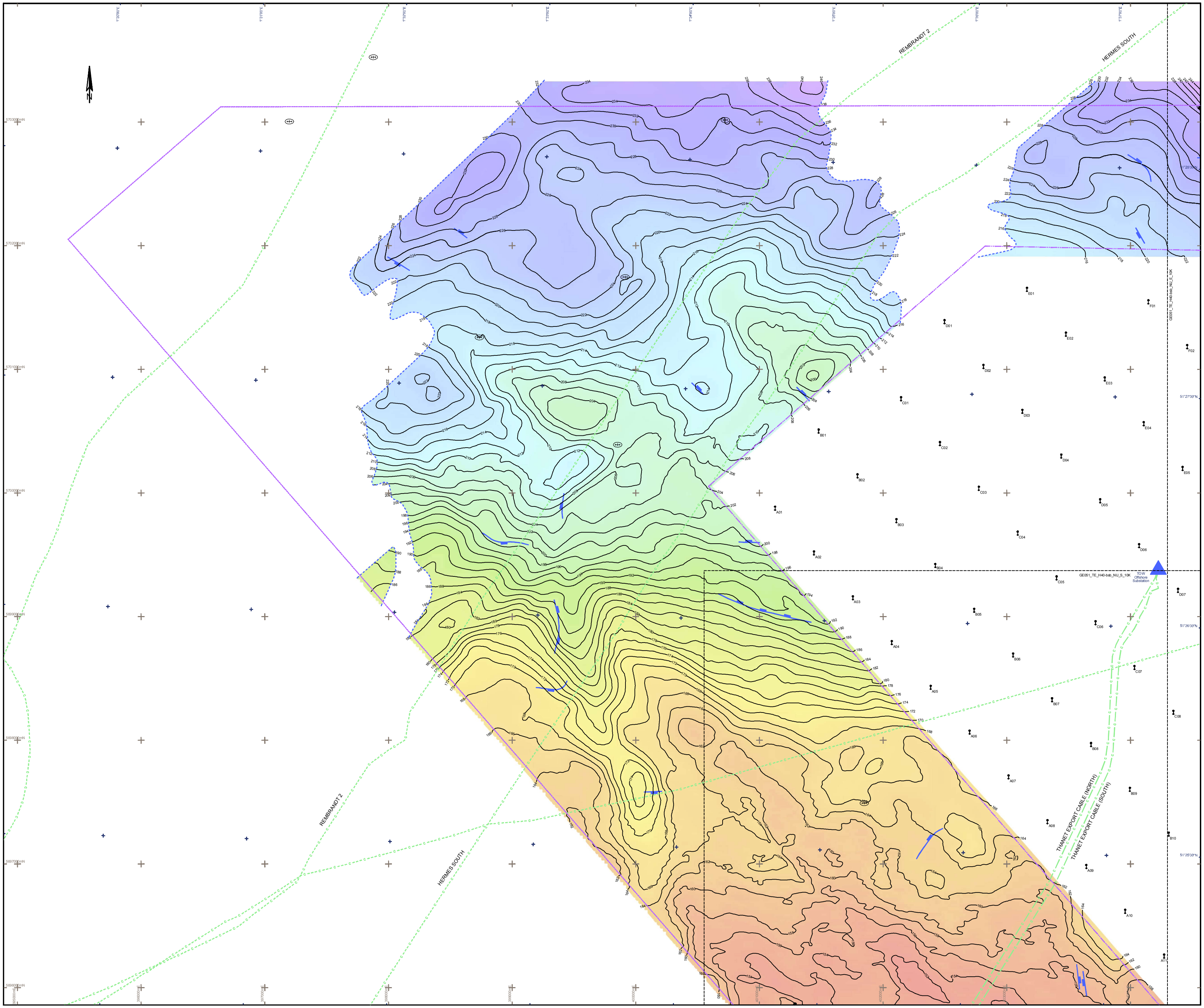
FUGRO SURVEY B.V.
Prismastraat 4, P.O. Box 130, 2630 AC Nootdorp, The Netherlands
Tel: +31 70 311 1800, Fax: +31 70 311 1838, Email: fsbvinfo@fugro.com

GEOPHYSICAL SITE SURVEY
UK CONTINENTAL SHELF, NORTH SEA
THANET EXTENSION OFFSHORE WIND FARM
DEPTH TO BASE OF MIDDLE CHALK Fm. (HORIZON H40) METRES BELOW SEABED EAST

SCALE 1 : 10000 at A0

0 100 200 400 600 800 1000 metres
0 1000 2000 3000 feet

Vessel: FUGRO PIONEER			Survey Date: JUL - SEPT 2016	Project Ref: GE051			
Issue No:	Date:	Description:		Interpr:	Drawn:	Chkd:	Appr:
1	25/11/2016	Issue for Approval		MvL / TW	RB / MS	VMN	PPL
0	03/04/2017	Final Issue		MvL / TW	RB / MS	VMN	PPL
Client Ref: -		Drawing No: GE051_TE_H40-bsb_NU_E_10K		Chart: 1 of 3		Encl: 70	



LEGEND:

GENERAL

- U.T.M. GRID
- GEOGRAPHICAL GRID
- EXISTING CABLE ROUTES
- WIND FARM BOUNDARY (TOW)
- WIND FARM BOUNDARY (TEOW), BASED ON SURVEY LINE PLAN
- CHART MATCHLINE
- TURBINE LOCATION WITH ID NUMBER (TOW)
- WRECK (FROM ENC AND ADMIRALTY CHARTS)

DEPTH TO BASE OF MIDDLE CHALK Fm. (HORIZON H40)

- 230 — DEPTH IN METRES BELOW SEABED (CONTOURS AT 2 METRE INTERVAL)
- FAULT AT H40
- H40 NOT WELL DEFINED

DEPTH IN METRES BELOW SEABED
THE DEPTH OF H40 RANGES BETWEEN 138 m AND 253 m bsb

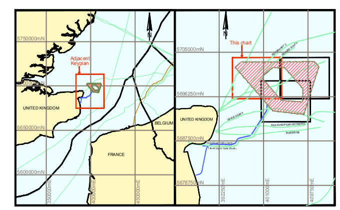
150.0
175.0
200.0
225.0
250.0

NOTES:

1. INTERPRETATION BASED ON UHR SEISMIC DATA.
2. ALL DEPTHS ARE BELOW SEABED.
3. DUE TO THE SURVEY LINE SPACING AND THE GREAT LATERAL VARIATION, THE DEPTH VALUES BETWEEN LINES WERE INTERPOLATED (LOW CONFIDENCE).
4. GRIDDING ALGORITHM: MINIMUM CURVATURE. GRIDDING PARAMETER: CELL SIZE 25X25 m, SMOOTHNESS 11. CONTOUR PARAMETERS: THRESHOLD 30, CONTOUR INTERVAL 2 m.
5. TWO-WAY TIME UHR DATA WAS CONVERTED TO DEPTH USING A SMOOTHED VELOCITY FIELD DERIVED FROM PICKED RMS VELOCITIES. CALCULATED DEPTHS ARE CONSIDERED TO BE ACCURATE TO +/- 5%.
6. SEISMIC INTERPRETATION OF THE LOCAL STRATIGRAPHY WAS CORRELATED WITH BGS REPORT IN THAMES ESTUARY.
7. BACKGROUND INFORMATION IS EXTRACTED FROM ENC AND ADMIRALTY CHARTS.

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM	
GEODETIC DATUM	European Terrestrial Reference System 1989
ELLIPSOID	GRS 1980
Semi-Major Axis	6,378,137.000
Inverse Flattening	298.257 222 101
PROJECTION	ETRS89 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	ITRF2008 to ETRS89 for Epoch 2016. 647540984 (25 August 2016)
Source	EPSG dX=+0.05376 dY=+0.05096 dZ=-0.08847 rX=-0.002239" rY=-0.013547" rZ=+0.021897" Scale=+0.0026718ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



VATTENFALL WIND POWER LTD
St Andrews House, Haugh Lane, Hexham NE45 3QQ, Northumberland, United Kingdom
Tel +44 1434 611300

FUGRO SURVEY B.V.
Prismastraat 4, P.O. Box 130, 2630 AC Nootdorp, The Netherlands
Tel: +31 70 311 1800, Fax: +31 70 311 1838, Email: fsbvinfo@fugro.com

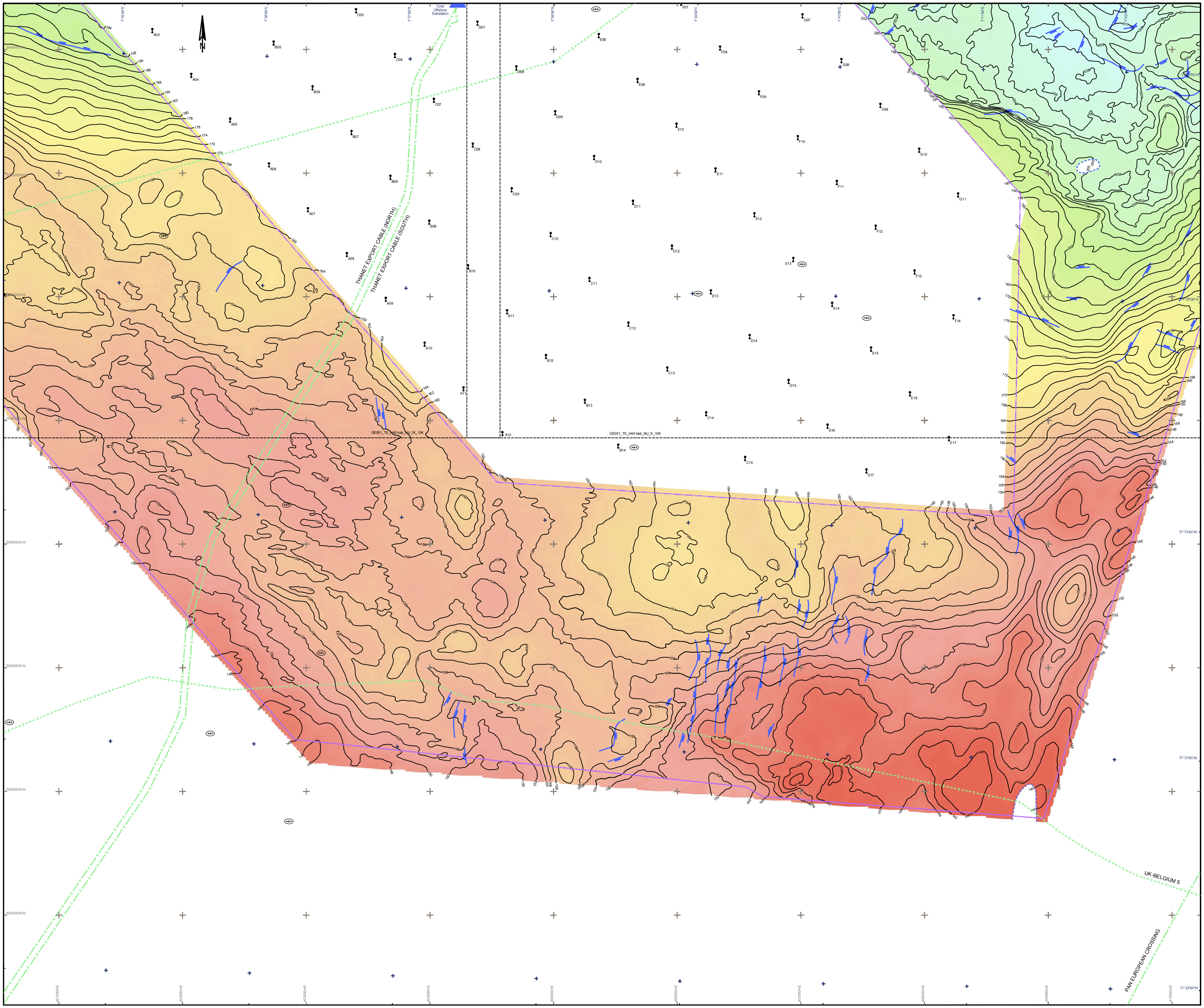
GEOPHYSICAL SITE SURVEY
UK CONTINENTAL SHELF, NORTH SEA
THANET EXTENSION OFFSHORE WIND FARM
DEPTH TO BASE OF MIDDLE CHALK Fm. (HORIZON H40) METRES BELOW SEABED WEST

SCALE 1 : 10000 at A0

0 100 200 400 600 800 1000 metres
0 1000 2000 3000 feet

Vessel: FUGRO PIONEER		Survey Date: JUL - SEPT 2016	Project Ref: GE051			
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	25/11/2016	Issue for Approval	MvL / TW	RB / MS	VMN	PPL
0	03/04/2017	Final Issue	MvL / TW	RB / MS	VMN	PPL

Client Ref:	Drawing No:	Chart:	Encl:
-	GE051_TE_H40-bsb_NU_W_10K	2 of 3	71



LEGEND:

GENERAL

- U.T.M. GRID
- GEOGRAPHICAL GRID
- EXISTING CABLE ROUTES
- WIND FARM BOUNDARY (TOW)
- WIND FARM BOUNDARY (TEOW), BASED ON SURVEY LINE PLAN
- CHART MATCHLINE
- TURBINE LOCATION WITH ID NUMBER (TOW)
- WRECK (FROM ENC AND ADMIRALTY CHARTS)

DEPTH TO BASE OF MIDDLE CHALK Fm. (HORIZON H40)

- DEPTH IN METRES BELOW SEABED (CONTOURS AT 2 METRE INTERVAL)
- FAULT AT H40
- H40 NOT WELL DEFINED

DEPTH IN METRES BELOW SEABED
THE DEPTH OF H40 RANGES BETWEEN 138 m AND 253 m bsb

150.0
175.0
200.0
225.0
250.0

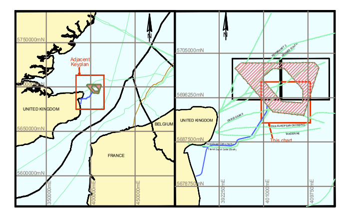
NOTES:

1. INTERPRETATION BASED ON UHR SEISMIC DATA.
2. ALL DEPTHS ARE BELOW SEABED.
3. DUE TO THE SURVEY LINE SPACING AND THE GREAT LATERAL VARIATION, THE DEPTH VALUES BETWEEN LINES WERE INTERPOLATED (LOW CONFIDENCE).
4. GRIDDING ALGORITHM: MINIMUM CURVATURE. GRIDDING PARAMETER: CELL SIZE 25X25 m, SMOOTHNESS 11. CONTOUR PARAMETERS: THRESHOLD 30, CONTOUR INTERVAL 2 m.
5. TWO-WAY TIME UHR DATA WAS CONVERTED TO DEPTH USING A SMOOTHED VELOCITY FIELD DERIVED FROM PICKED RMS VELOCITIES. CALCULATED DEPTHS ARE CONSIDERED TO BE ACCURATE TO +/- 5%.
6. SEISMIC INTERPRETATION OF THE LOCAL STRATIGRAPHY WAS CORRELATED WITH BGS REPORT IN THAMES ESTUARY.
7. BACKGROUND INFORMATION IS EXTRACTED FROM ENC AND ADMIRALTY CHARTS.

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM

GEODETIC DATUM	European Terrestrial Reference System 1989
ELLIPSOID	GRS 1980
Semi-Major Axis	6,378,137.000
Inverse Flattening	298.257 222 101
PROJECTION	ETRS89 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	ITRF2008 to ETRS89 for Epoch 2016. 647540984 (25 August 2016)
Source	EPSG dX=+0.05376 dY=+0.05096 dZ=-0.08847 rX=-0.002239" rY=-0.013547" rZ=+0.021897" Scale=+0.0026718ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



VATTENFALL WIND POWER LTD
St Andrews House, Haugh Lane, Hexham NE45 3QQ, Northumberland, United Kingdom
Tel +44 1434 611300

FUGRO SURVEY B.V.
Prismastraat 4, P.O. Box 130, 2630 AC Nootdorp, The Netherlands
Tel: +31 70 311 1800, Fax: +31 70 311 1838, Email: fsbvinfo@fugro.com

GEOPHYSICAL SITE SURVEY
UK CONTINENTAL SHELF, NORTH SEA

THANET EXTENSION OFFSHORE WIND FARM

DEPTH TO BASE OF MIDDLE CHALK Fm. (HORIZON H40) METRES BELOW SEABED SOUTH

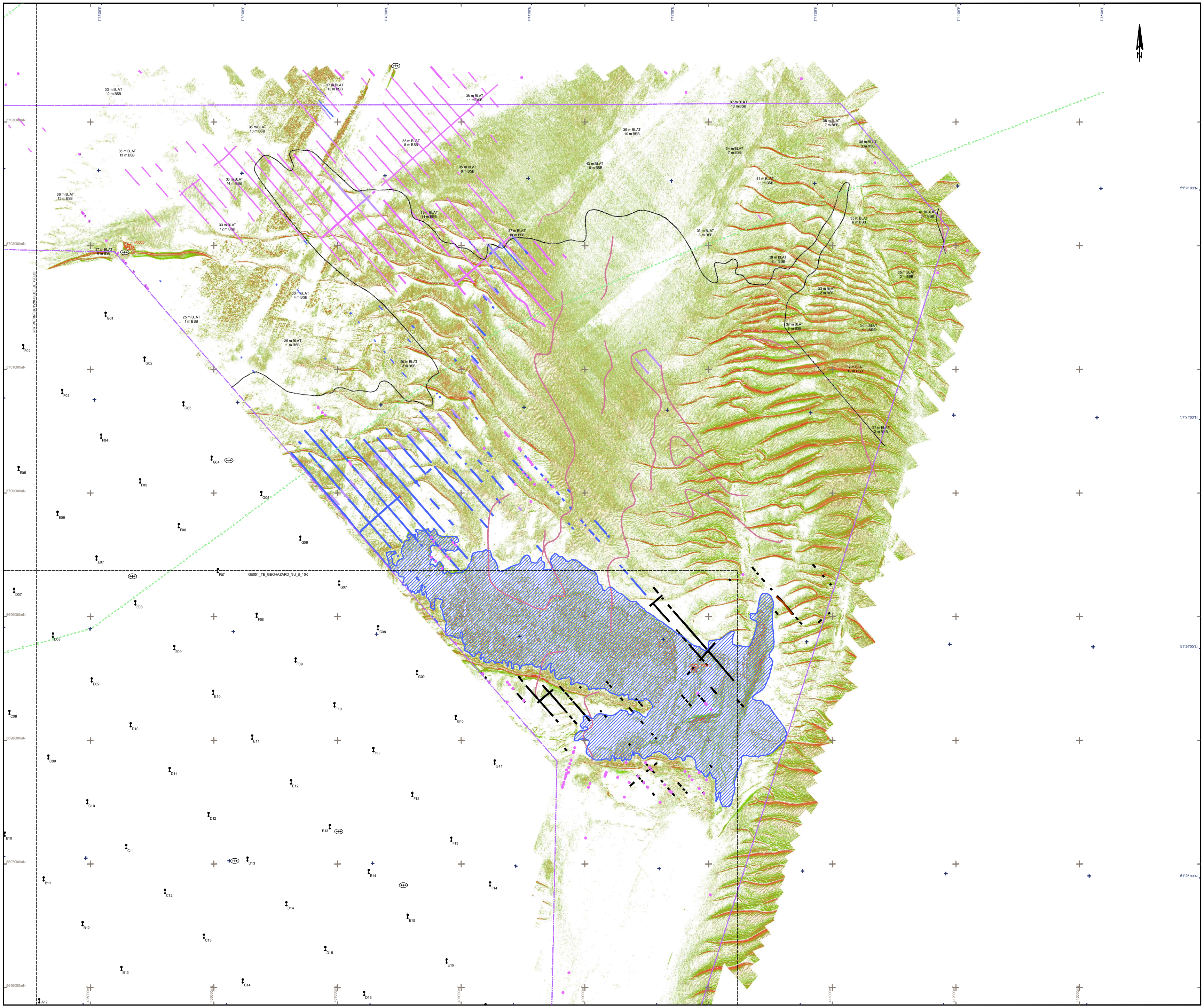
SCALE 1 : 10000 at A0

Vessel: FUGRO PIONEER	Survey Date: JUL - SEPT 2016	Project Ref: GE051				
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	25/11/2016	Issue for Approval	MvL / TW	RB / MS	VMN	PPL
0	03/04/2017	Final Issue	MvL / TW	RB / MS	VMN	PPL

Client Ref:	Drawing No:	Chart:	Encl:
-	GE051_TE_H40-bsb_NU_S_10K	3 of 3	72

F. GEOHAZARD CHART

Drawing	Chart Name	Scale
Geohazard Chart	GE051_TE_GEOHAZARD_NU_10K	1 : 10,000



LEGEND:

GENERAL

- U.T.M. GRID
- GEOGRAPHICAL GRID
- EXISTING CABLE ROUTES
- WIND FARM BOUNDARY (TOW)
- WIND FARM BOUNDARY (TEOW), BASED ON SURVEY LINE PLAN
- CHART MATCHLINE
- E01 TURBINE LOCATION WITH ID NUMBER (TOW)
- WRECK (FROM ENC AND ADMIRALTY CHARTS)
- P123 AS-FOUND WRECK WITH SSS ID NUMBER (PREFIX OMITTED)

SEABED HAZARDS AND GEOHAZARDS

- AS-FOUND CABLE / UNKNOWN LINEAR DEBRIS
- 10 m LINEAR DEBRIS WITH LENGTH
- REEF
- OUTCROP

SEABED GRADIENT (IN DEGREES)

- 5.0
- 10.0
- >15.0

SUB-SEABED GEOHAZARDS

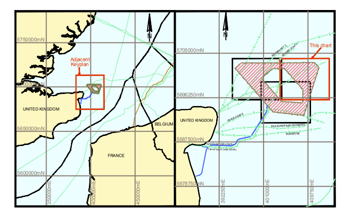
- TOP OF DIFFRACTIONS WITH DEPTH IN METRES BLAT / BSB
- POSSIBLE BURIED BOULDERS
- POSSIBLE SHALLOW GAS UHRS
- POSSIBLE SHALLOW GAS SUB-BOTTOM PROFILER
- POSSIBLE HARD OR GRAVEL LAYERS UHRS
- POSSIBLE HARD OR GRAVEL LAYERS SUB-BOTTOM PROFILER
- CHAOTIC REFLECTION (POSSIBLE COARSE SEDIMENTS) SUB-BOTTOM PROFILER
- POSSIBLE PEAT / ORGANIC SAND OR ORGANIC CLAY
- APPROXIMATE PALAEOCHANNEL EDGES MAPPED AT DIFFERENT LEVELS WITHIN UNIT C & E

NOTES:

1. THE SEABED FEATURES INTERPRETATION WAS BASED ON EDGETECH 4200 SIDESCAN SONAR TOWFISH'S OPERATED AT 100/600 kHz FOR FUGRO PIONEER AT A RANGE OF 125 m. THE SUB-SEABED FEATURES INTERPRETATION WAS BASED ON SUB-BOTTOM PROFILER AND UHR SEISMIC DATA.
2. THE INTERPRETATION SOFTWARE USED IS SONARWIZ AND SMT KINGDOM.
3. BACKGROUND INFORMATION IS EXTRACTED FROM ENC AND ADMIRALTY CHARTS.

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM	
GEODETIC DATUM	European Terrestrial Reference System 1989
ELLIPSOID	GRS 1980
Semi-Major Axis	6,378,137.000
Inverse Flattening	298.257 222 101
PROJECTION	ETRS89 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	ITRF2008 to ETRS89 for Epoch 2016. 647540984 (25 August 2016)
Source	EPSG
	dX=+0.05376 dY=+0.05096 dZ=-0.08847
	rX=-0.002239" rY=-0.013547" rZ=+0.021897" Scale=+0.0026718ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



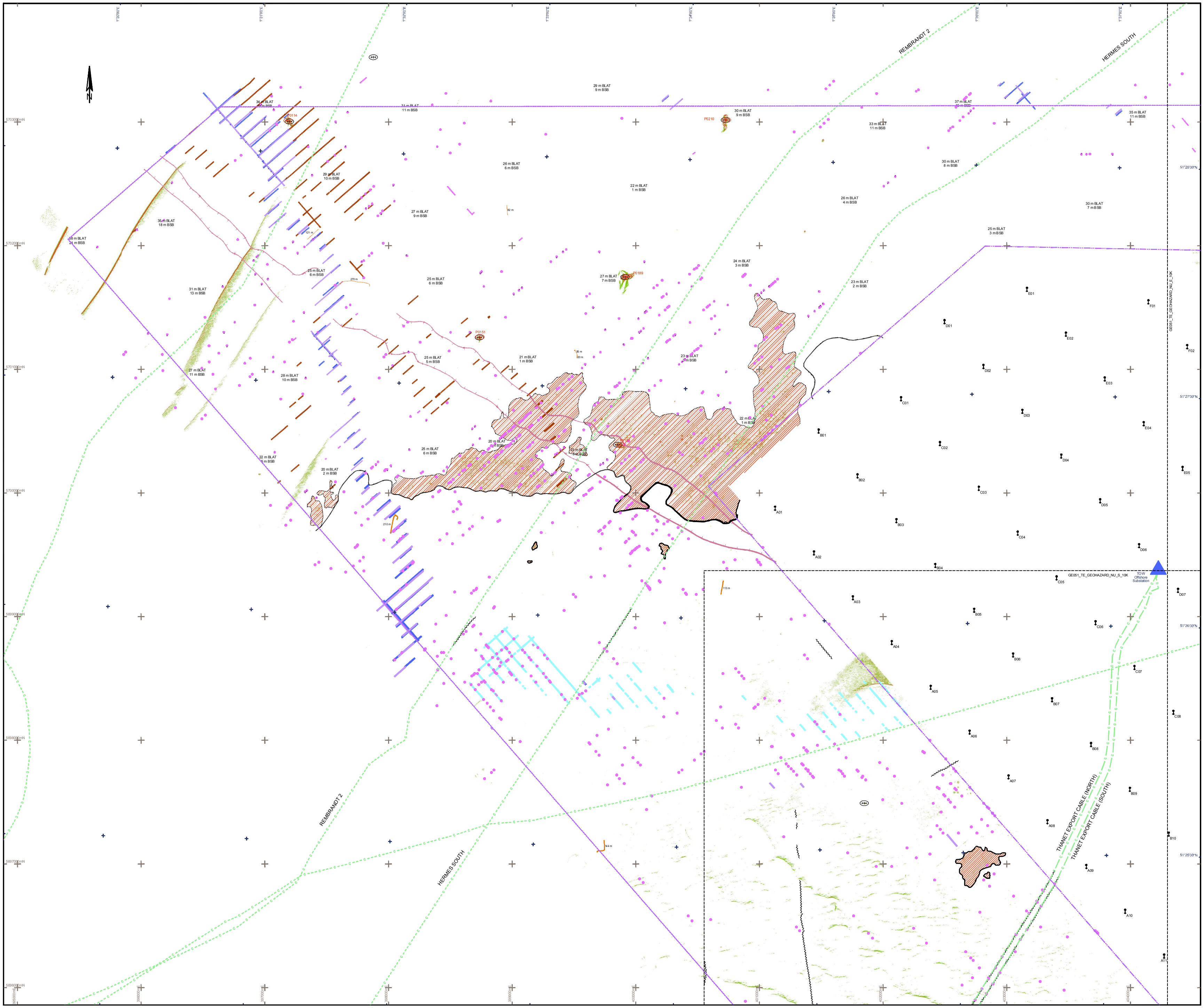
VATTENFALL WIND POWER LTD
St Andrews House, Haugh Lane, Hexham NE45 3QQ, Northumberland, United Kingdom
Tel +44 1434 611300

FUGRO SURVEY B.V.
Prismastraat 4, P.O. Box 130, 2630 AC Nootdorp, The Netherlands
Tel: +31 70 311 1800, Fax: +31 70 311 1838, Email: fsbvinfo@fugro.com

GEOPHYSICAL SITE SURVEY
UK CONTINENTAL SHELF, NORTH SEA
THANET EXTENSION OFFSHORE WIND FARM
GEOHAZARD CHART
EAST

SCALE 1 : 10000 at A0

Vessel: FUGRO PIONEER		Survey Date: JUL - SEPT 2016	Project Ref: GE051			
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	25/11/2016	Issue for Approval	MvL / TW	RB / MS	VMN	PPL
0	03/04/2017	Final Issue	MvL / TW	RB / MS	VMN	PPL
Client Ref: -		Drawing No: GE051_TE_GEOHAZARD_NU_E_10K	Chart: 1 of 3		Encl: 73	



LEGEND:

GENERAL
- U.T.M. GRID
- GEOGRAPHICAL GRID
- EXISTING CABLE ROUTES
- WIND FARM BOUNDARY (TOW)
- WIND FARM BOUNDARY (TEOW), BASED ON SURVEY LINE PLAN
- CHART MATCHLINE
- TURBINE LOCATION WITH ID NUMBER (TOW)
- WRECK (FROM ENC AND ADMIRALTY CHARTS)
- AS-FOUND WRECK WITH SSS ID NUMBER (PREFIX OMITTED)

SEABED HAZARDS AND GEOHAZARDS
- AS-FOUND CABLE / UNKNOWN LINEAR DEBRIS
- LINEAR DEBRIS WITH LENGTH
- REEF
- OUTCROP

SEABED GRADIENT (IN DEGREES)
- 5.0
- 10.0
- >15.0

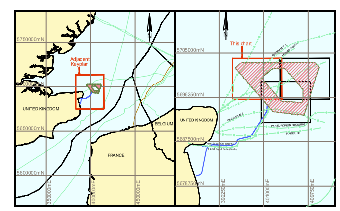
SUB-SEABED GEOHAZARDS
- TOP OF DIFFRACTIONS WITH DEPTH IN METRES BLAT / BSB
- POSSIBLE BURIED BOULDERS
- POSSIBLE SHALLOW GAS UHRS
- POSSIBLE SHALLOW GAS SUB-BOTTOM PROFILER
- POSSIBLE HARD OR GRAVEL LAYERS UHRS
- POSSIBLE HARD OR GRAVEL LAYERS SUB-BOTTOM PROFILER
- CHAOTIC REFLECTION (POSSIBLE COARSE SEDIMENTS) SUB-BOTTOM PROFILER
- POSSIBLE PEAT / ORGANIC SAND OR ORGANIC CLAY
- APPROXIMATE PALAEOCHANNEL EDGES MAPPED AT DIFFERENT LEVELS WITHIN UNIT C & E

NOTES:

1. THE SEABED FEATURES INTERPRETATION WAS BASED ON EDGETECH 4200 SIDESCAN SONAR TOWFISH'S OPERATED AT 100/600 kHz FOR FUGRO PIONEER AT A RANGE OF 125 m. THE SUB-SEABED FEATURES INTERPRETATION WAS BASED ON SUB-BOTTOM PROFILER AND UHR SEISMIC DATA.
2. THE INTERPRETATION SOFTWARE USED IS SONARWIZ AND SMT KINGDOM.
3. BACKGROUND INFORMATION IS EXTRACTED FROM ENC AND ADMIRALTY CHARTS.

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM	
GEODETIC DATUM	European Terrestrial Reference System 1989
ELLIPSOID	GRS 1980
Semi-Major Axis	6,378,137.000
Inverse Flattening	298.257 222 101
PROJECTION	ETRS89 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	ITRF2008 to ETRS89 for Epoch 2016. 647540984 (25 August 2016)
Source	EPSG dX=+0.05376 dY=+0.05096 dZ=-0.08847 rX=-0.002239" rY=-0.013547" rZ=+0.021897" Scale=+0.0026718ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



VATTENFALL WIND POWER LTD
St Andrews House, Haugh Lane, Hexham NE45 3QQ, Northumberland, United Kingdom
Tel +44 1434 611300

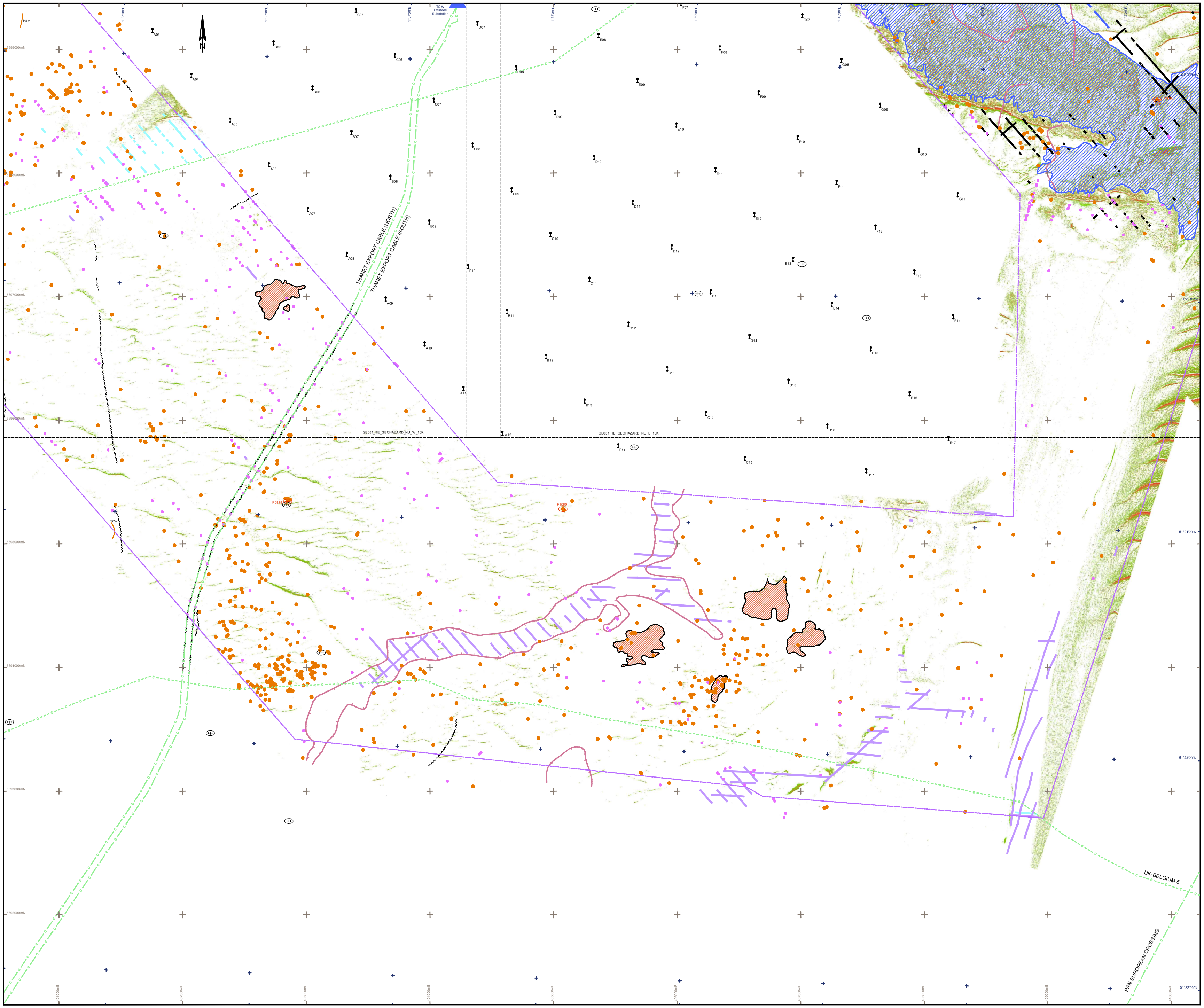
FUGRO SURVEY B.V.
Prismastraat 4, P.O. Box 130, 2630 AC Nootdorp, The Netherlands
Tel: +31 70 311 1800, Fax: +31 70 311 1838, Email: fsbvinfo@fugro.com

GEOPHYSICAL SITE SURVEY
UK CONTINENTAL SHELF, NORTH SEA
THANET EXTENSION OFFSHORE WIND FARM
GEOHAZARD CHART
WEST

SCALE 1 : 10000 at A0

Vessel: FUGRO PIONEER		Survey Date: JUL - SEPT 2016	Project Ref: GE051			
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	25/11/2016	Issue for Approval	MvL / TW	RB / MS	VMN	PPL
0	03/04/2017	Final Issue	MvL / TW	RB / MS	VMN	PPL

Client Ref:	Drawing No:	Chart:	Encl:
-	GE051_TE_GEOHAZARD_NU_W_10K	2 of 3	74



LEGEND:

GENERAL

- U.T.M. GRID
- GEOGRAPHICAL GRID
- EXISTING CABLE ROUTES
- WIND FARM BOUNDARY (TOW)
- WIND FARM BOUNDARY (TEOW), BASED ON SURVEY LINE PLAN
- CHART MATCHLINE
- E01 TURBINE LOCATION WITH ID NUMBER (TOW)
- WRECK (FROM ENC AND ADMIRALTY CHARTS)
- P123 AS-FOUND WRECK WITH SSS ID NUMBER (PREFIX OMITTED)

SEABED HAZARDS AND GEOHAZARDS

- AS-FOUND CABLE / UNKNOWN LINEAR DEBRIS
- 10 m LINEAR DEBRIS WITH LENGTH
- REEF
- OUTCROP

SEABED GRADIENT (IN DEGREES)

5.0
10.0
>15.0

SUB-SEABED GEOHAZARDS

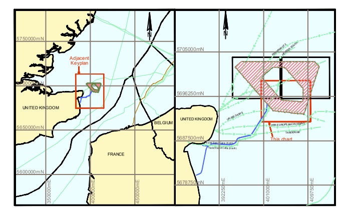
- 36 m BLAT / 10 m BSB TOP OF DIFFRACTIONS WITH DEPTH IN METRES BLAT / BSB
- POSSIBLE BURIED BOULDERS
- POSSIBLE SHALLOW GAS UHRS
- POSSIBLE SHALLOW GAS SUB-BOTTOM PROFILER
- POSSIBLE HARD OR GRAVEL LAYERS UHRS
- POSSIBLE HARD OR GRAVEL LAYERS SUB-BOTTOM PROFILER
- CHAOTIC REFLECTION (POSSIBLE COARSE SEDIMENTS) SUB-BOTTOM PROFILER
- POSSIBLE PEAT / ORGANIC SAND OR ORGANIC CLAY
- APPROXIMATE PALAEOCHANNEL EDGES MAPPED AT DIFFERENT LEVELS WITHIN UNIT C & E

NOTES:

1. THE SEABED FEATURES INTERPRETATION WAS BASED ON EDGETECH 4200 SIDESCAN SONAR TOWFISH'S OPERATED AT 100/600 kHz FOR FUGRO PIONEER AT A RANGE OF 125 m. THE SUB-SEABED FEATURES INTERPRETATION WAS BASED ON SUB-BOTTOM PROFILER AND UHR SEISMIC DATA.
2. THE INTERPRETATION SOFTWARE USED IS SONARWIZ AND SMT KINGDOM.
3. BACKGROUND INFORMATION IS EXTRACTED FROM ENC AND ADMIRALTY CHARTS.

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM	
GEODETIC DATUM	European Terrestrial Reference System 1989
ELLIPSOID	GRS 1980
Semi-Major Axis	6,378,137.000
Inverse Flattening	298.257 222 101
PROJECTION	ETRS89 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	ITRF2008 to ETRS89 for Epoch 2016. 647540984 (25 August 2016)
Source	EPSG
	dX=+0.05376 dY=+0.05096 dZ=-0.08847
	rX=-0.002239" rY=-0.013547" rZ=+0.021897" Scale=+0.0026718ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



VATTENFALL WIND POWER LTD
St Andrews House, Haugh Lane, Hexham NE45 3QQ, Northumberland, United Kingdom
Tel +44 1434 611300

FUGRO SURVEY B.V.
Prismastraat 4, P.O. Box 130, 2630 AC Nootdorp, The Netherlands
Tel: +31 70 311 1800, Fax: +31 70 311 1838, Email: fsbvinfo@fugro.com

GEOPHYSICAL SITE SURVEY
UK CONTINENTAL SHELF, NORTH SEA
THANET EXTENSION OFFSHORE WIND FARM
GEOHAZARD CHART
SOUTH

SCALE 1 : 10000 at A0

0 100 200 400 600 800 1000 metres
0 1000 2000 3000 feet

Vessel: FUGRO PIONEER	Survey Date: JUL - SEPT 2016	Project Ref: GE051				
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	25/11/2016	Issue for Approval	MvL / TW	RB / MS	VMN	PPL
0	03/04/2017	Final Issue	MvL / TW	RB / MS	VMN	PPL

Client Ref:	Drawing No:	Chart:	Encl:
-	GE051_TE_GEOHAZARD_NU_S_10K	3 of 3	75

G. UHR SEISMIC PROCESSING REPORT

Fugro

Geophysical Site Survey

UK Continental Shelf, North Sea

Thanet Extension Offshore Wind Farm

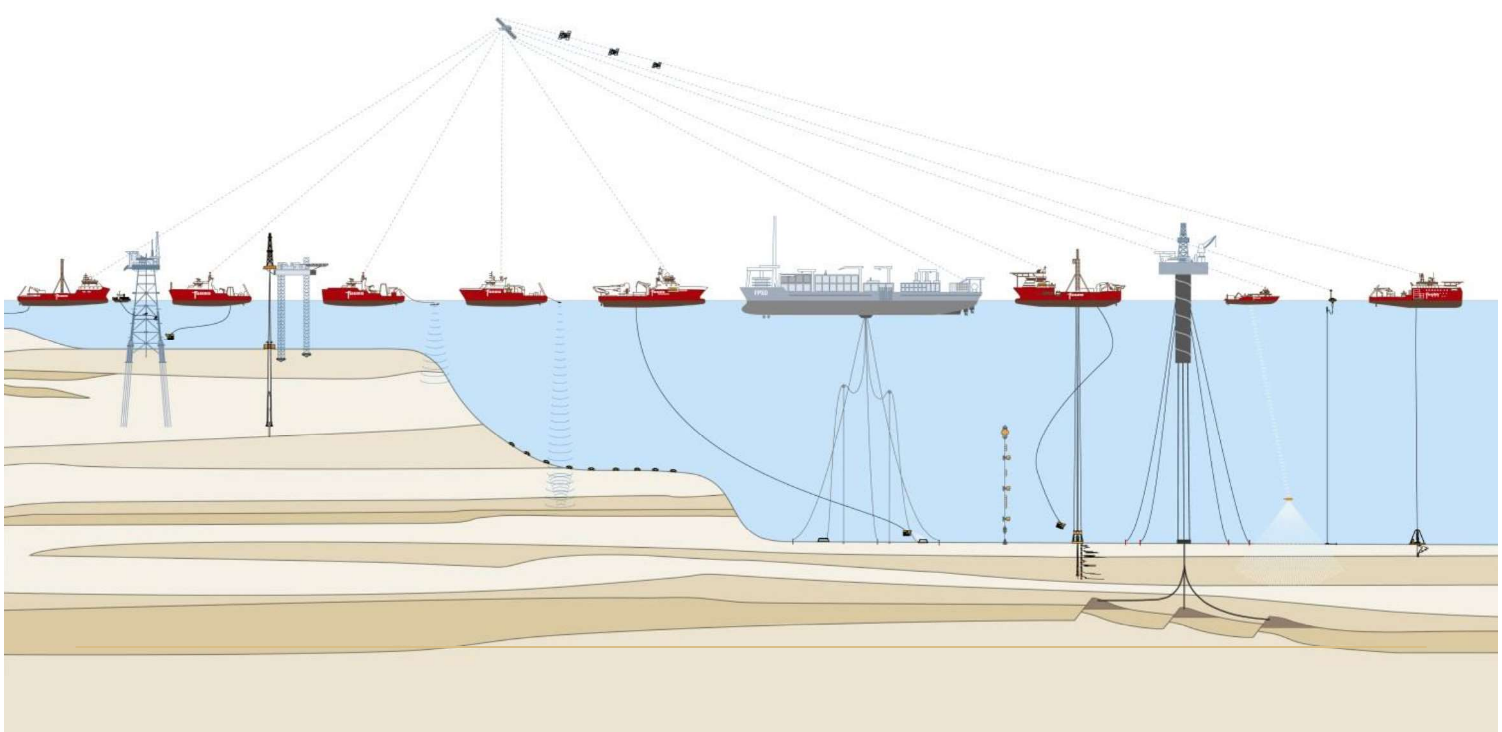
UHR SEISMIC DATA PROCESSING REPORT

July to September 2016

Fugro Report No.: GE051-R1 / Appendix G

Revision 0

Vattenfall Wind Power Limited

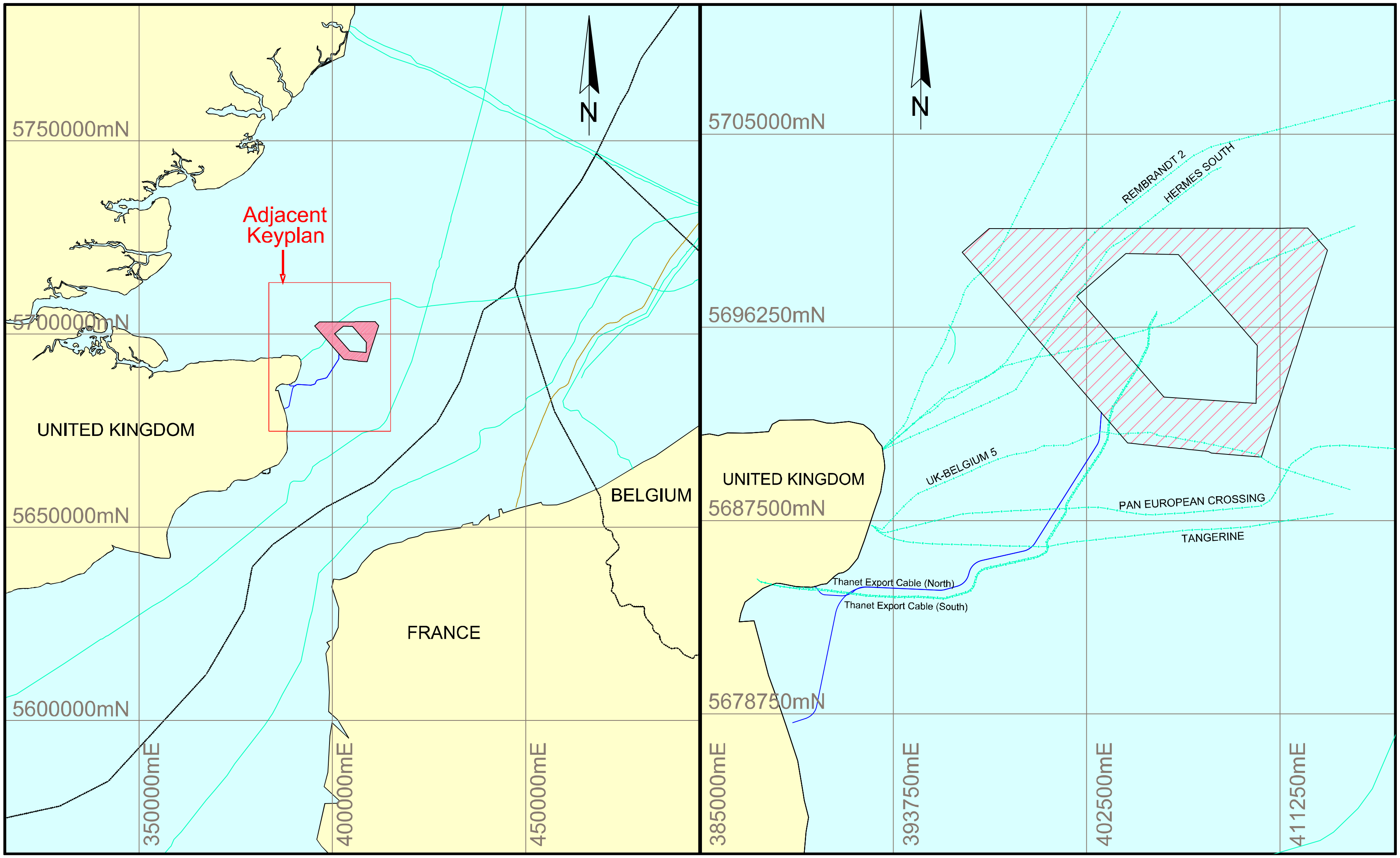


This page is intentionally left blank.

Prepared by: Fugro Survey B.V.
Prismastraat 4
2631 RT Nootdorp
P.O. Box 130
2630 AC Nootdorp
The Netherlands
Phone +31 70 3111444
Fax +31 70 3111838
E-mail: FSBVinfo@fugro.com
Trade Register Nr: 34070322 / VAT Nr:005621409B11

Prepared for: Thanet Offshore Wind Limited
clo Vattenfall Offshore Wind Power
1't Floor
1 Tudor Street
London
EC4Y OAH

0	Final Issue	C. Chalut-Natal	G.Bais	P-P. Lebbink	03 April 2016
1	Issue for Approval	C. Chalut-Natal	G.Bais	G.Bais	25 November 2016
Rev	**Description**	**Prepared**	**Checked**	**Approved**	**Date**


N
5750000mN
5700000mN
5650000mN
5600000mN
350000mE
400000mE
450000mE
UNITED KINGDOM
FRANCE
BELGIUM
Adjacent
Keyplan
N
5705000mN
5696250mN
5687500mN
5678750mN
385000mE
393750mE
402500mE
411250mE
UNITED KINGDOM
REMBRANDT 2
HERMES SOUTH
UK-BELGIUM 5
PAN EUROPEAN CROSSING
TANGERINE
Thanet Export Cable (North)
Thanet Export Cable (South)

KEYPLAN

CONTENTS

APPENDICES

TABLES

ABBREVIATIONS

AGC	Automatic Gain Controller
CDP	Common Depth Point
CMP	Common Middle Point
CVA	Claritas Velocity Analysis
DAS	Deconvolution After Stack
FFT	Fast Fourier Transform
LAT	Lowest Astronomical Tide
MBES	MultiBeam Echo Sounder
NMO	Normal Move Out
RMS	Root Mean Square
SRME	Surface Related Multiple Elimination
SVD	Single Value Decomposition
SWNA	Surface Wave Noise Attenuation
TFDN	Time-Frequency De-Noise
UHR	Ultra High Resolution

1. UHR SEISMIC DATA ACQUISITION AND QC

1.1 Introduction

The purpose of the Ultra High Resolution seismic survey is to provide interpretable seismic sections to show the thickness of the main geological formations and to locate any structural complexities or geohazards.

During the acquisition, strong tidal currents affected the data quality in all acquisition directions:

- Lines run into the current directions had low feather angle but the high speed through the water increased turbulence and noise on the streamer, inducing source and streamer instability;
- Lines run in the opposite current direction were less noisy but the feather angle was high;
- Lines run with lateral current presented very high feather angle and source and streamer instability.

For comparison, two lines, one with a low feather angle and the other with a high feather angle for both the sparker and the minigun data are shown in Appendix M.

For minigun data (Block 3, 4 and 5), the challenge was to fix the amplitude variation due to the difficulty of balancing the streamer, the attenuation of the long-period multiples mainly associated with the seafloor and the removal of the high vessel noise.

For sparker data (Block1, 2A and 2B), the major processing challenges were the attenuation of the strong secondary bubbles produced by the source, the attenuation of the long-period and the removal of the high vessel noise.

Sparker systems have a reputation of generating long and complex seismic signatures due to secondary bubbles which are considered as short path multiple. Secondary bubbles generate destructive interference that can strongly attenuate amplitudes at some frequencies of particular interest and severely degrade the vertical resolution of the data. Therefore, one of the main aims of the processing was to reduce this multiple energy to boost the vertical resolution of the data and to increase the signal to noise ratio. To see this improvement in resolution produced by the processing, refer to Appendix E - Figure 0.10 to Figure 0.14.

For both sparker and minigun data, elimination of multiple reflections was addressed with the SRME algorithm in the pre-stack phase and with a targeted demultiple (a combination of different routines) in the post-stack phase (refer to Appendix B- Figure 0.5 and Appendix C- Figure 0.8 to see the effects of the demultiple routines for Sparker data, refer to Appendix H - Figure 0.23 and Appendix I - Figure 0.27 for minigun data).

Vessel noise was greatly attenuated in the pre-stack phase with a combination of denoise routine as Time Frequency Denoise, Wavelet Denoise, surface wave attenuation and FK filter (refer to Appendix B - Figure 0.4 and C - Figure 0.7 for sparker data and refer to Appendix H- Figure 0.21 and Appendix I -Figure 0.25 for minigun data).

Time to depth conversion was done considering the entire dataset to minimise mismatches between sparker and minigun lines. Examples of intersections between lines of each block are presented in Appendix O and the shifts measured on different reflectors are reported in Appendix Table 1. Most part of the mismatches are lower than 1.5 m and the maximum values are lower than 2 m in depth, which confirms the data consistency between all lines. Higher mismatches are found at intersections between sparker and minigun lines. Indeed, sparker and minigun data are not directly comparable due to their different frequency content. There is a maximum mismatch of 2.5 m at an intersection between Sparker and minigun lines on a sea bed high.

213 lines were processed, for a total of 1058 km full fold (refer to Table 1.1). Orientation and spacing of the lines are given in the Table 1.2.

Table 1.1: Number of kilometres processed

Block	Number of km total	Number of km full fold)
1	336.07	331.75
2A	29.32	28.21
2B	288.44	284.26
3	256.91	254.32
4	88.89	87.04
5	73.59	72.23
Total	1073.22	1057.81

Table 1.2: Seismic lines details

Block / Source	Lines	Orientation	Number of lines	Spacing [m]
Block 1 / Sparker	Main lines	138°	27	100
		318°	27	
	Cross lines	48°	2	1000
		228°	4	
Block 2A / Sparker	Main lines	89°	8	100
		269°	5	
	Cross lines	48°	1	NA
		138°	1	
Block 2B / Sparker	Main lines	48°	23	100
		228°	27	
	Cross lines	138°	5	1000
		318	2	
Block 3 / Minigun	Main lines	138°	15	100
		318°	12	
	Cross lines	48°	5	1000
		228°	4	
Block 4 / Minigun	Main lines	93°	14	100
		273°	11	
	Cross lines	228°	1	NA

Block / Source	Lines	Orientation	Number of lines	Spacing [m]
Block 5 / Minigun	Main lines	17°	10	100
		197°	7	
	Cross lines	228°	2	1000

1.2 Data Quality Control

At the beginning of the survey, pulse tests were performed for both sources. These tests are registered with a calibrated hydrophone and enable to check the conformity of the sources signatures with the manufacturer's signatures libraries.

The number of tips and the source power of the Sparker were tested during the first test lines to achieve the best trade-off between penetration and resolution. 360 tip and a source power of 600 J were chosen as the best values.

Streamer depth was also tested to obtain the best compromise between resolution and good signal to noise ratio. The chosen streamer depth was 0.5 m. For a detailed description of these values refer to the QC logs in Appendix P.

Streamer depth was monitored by three depth controllers, two of which were also compass birds. Streamer feather angles were regulated using the compass birds. This for two reasons: the shallow depth of the target and the short length of the streamer. Noise levels were checked at the start and at the end of all the lines. All the observations regarding feather angle, bird depths and noise levels were annotated on the observer and QC logs (refer to Appendix Q and P).

On board quality control of the UHR data was performed by experienced seismic processors utilising the CGG Uniseis seismic processing. Parameter tests (e.g. notch frequency analysis), noise analysis and preliminary processing were completed in order to produce a preliminary brute stack for each survey line (Figure 1.1).

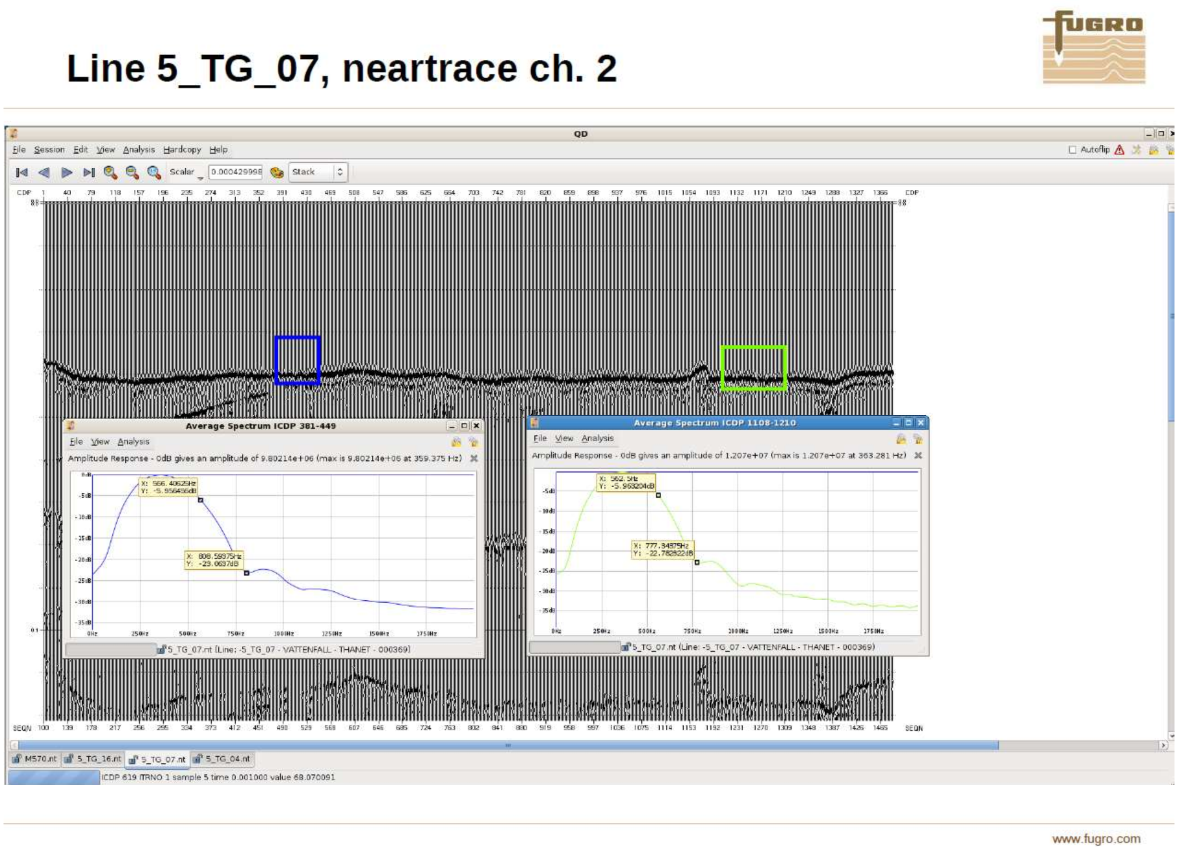


Figure 1.1: Example of parameter test (notch frequency analysis)

1.3 Acquisition Parameters

The acquisition parameters for the Sparker UHR survey were as follows:

Sparker	GSO 540 (360) tip sparker
Source tow depth	0.5 m
Source output energy	600/800 J
Shot point interval	1.56 m
Streamer	Geometrics GeoEel solid streamer
Streamer tow depth	0.5 m
Length active section	150 m
No. of Groups	48
Hydrophones per group	4
Group interval	3.125
Streamer sensitivity	20 µV/µB
Record length	330 ms
Sampling interval	0.250 ms (1/4th)
Lateral offset	5.1 m
Inline Offset	5.0 m

The acquisition parameters for the Minigun UHR survey were as follows:

Minigun	Sleeve gun 5 cu.in.
Source tow depth	0.75 m
Source output energy	5 Cu.in
Shot point interval	3.125 m
Streamer	Geometrics GeoEel solid streamer
Streamer tow depth	0.75 m
Length active section	150 m
No. of Groups	48
Hydrophones per group	4
Group interval	3.125
Streamer sensitivity	20 µV/µB
Record length	330 ms
Sampling interval	0.250 ms (1/4th)
Lateral offset	5.1 m
Inline Offset	5.0 m

1.4 Source Receiver Offset

In order to ensure reliable source-receiver geometry, offsets were carefully checked on the seismic data. This was done by measuring the first arrival times in the shot domain and converting the times to metres using the sound velocity profile data.

1.5 Source Stability

The stability, quality and amplitude of the source was evaluated during the onboard quality control process. These attributes are best exemplified in the shape of the first arrival wavelet (a visible pulse recorded of the event travelling directly through the water from the source array to the first trace). Each trace in a shot gather will record a first arrival. However, the direct wave gets distorted by the receiver ghost and by the merging of the first arrival and the water bottom event on the farther offsets. Therefore, the first trace of each shot is selected and displayed next to each other to produce a near trace section. On the near trace section the direct wave can be visually inspected to confirm the stability of the wavelet shape. Furthermore, the first arrival will always be recorded at the same time from shot to shot unless there is a change in the tow depth of the source or receiver cable.

The recorded wavelet of the sparker was stable in shape and quite stable in time throughout the whole survey showing the high quality repeatability of the source used. Indeed, the variations in time were due to the strong currents and the sea conditions.

The recorded minigun wavelet presented some variations in time for the same environmental conditions. At the beginning of the survey, the gun controller was not firing at a constant time rate inducing sharp lateral changes in the data. Residual static corrections were tested in the office during acquisition and the decision was made that the problem could be addressed by processing and that these lines were acceptable.

The source stability was also evaluated with the power spectrum of the first arrival and the water bottom reflection. A change in depth of the source or receiver will result in differences in the frequencies recorded. Some correspondences between streamer depth and notch frequency are given in Table 1.3.

Table 1.3: Streamer depth and notch frequency

Streamer depth (m)	Notch frequency (Hz)
0.2	3795
0.4	1898
0.7	1084
0.8	949

1.6 QC Processing Flow – Sparker data

1.6.1 Transcription

The field data were converted from SEG-D format to CGG Uniseis internal format.

1.6.2 Near Trace Plot

The near trace was plotted and checked carefully to determine if there is a timing problem.

An example of a near trace plot is given in Appendix A.

1.6.3 Gain Recovery

A T^2 amplitude gain recovery to correct seismic data for geometrical spreading was used.

1.6.4 Frequency Filter

A Butterworth shaped frequency filter was applied in order to limit the frequencies to the useful signal range. The optimal low cut and high cut values chosen were 150 Hz and 1800 Hz respectively.

1.6.5 Trace Editing

The data was inspected in the shot domain to assess the signal to noise ratio, noise types, and other types of issues. Missing shots and shots with dead traces were logged in order to help further processing. Channel 23 was spiky during the whole Thanet survey. A polarity check was performed on the first line of the survey; no reverted polarity was detected.

Examples of raw shot gather and shot gather after gain recovery and band pass filter are given in Appendix B- Figure 0.1 and Figure 0.2.

1.6.6 CMP Gather

Seismic data was sorted into 48 fold CMP gathers.

1.6.7 Brute Velocity Analysis

A brute velocity was picked in the middle of the first acquired line using a recorded water velocity of 1517 m/s.

1.6.8 NMO Correction

The CMP gathers were Normal Move Out (NMO) corrected using the Dix 2^{nd} order equation. Velocity picked in the previous step was used.

1.6.9 Front End Mute

A brute outer trace mute removed the regions of the CMP gather which suffered unacceptable NMO stretch.

1.6.10 Brute Stack

Stacking was performed using $1/\sqrt{N}$ mute compensation.

1.6.11 Noise Analysis

For each trace, the Root Mean Square (RMS) amplitude was computed in the shot domain in a selected time window. A trapezoidal time window was chosen above the first arrival to assess the level of noise.

1.6.12 Processing Test

To better evaluate the data quality and the efficiency of processing, some routines were run for QC. Prestack routines as despiking, FK filter and deconvolution and post stack routine including migration help in rejecting or accepting the seismic lines.

1.6.13 Navigation Merge

When available, navigation data were merged with seismic data in order to determine potential navigation processing issues or missed shots.

1.7 QC Processing Flow – Minigun Data

1.7.1 Transcription

The field data were converted from SEG-D format to CGG Uniseis internal format.

1.7.2 Near Trace Plot

The near trace was plotted and checked carefully to determine if there is a timing problem.

An example of a near trace plot is given in Appendix G.

1.7.3 Gain Recovery

A T^2 amplitude gain recovery to correct seismic data for geometrical spreading was used.

1.7.4 Frequency Filter

A Butterworth shaped frequency filter was applied in order to limit the frequencies to the useful signal range. The optimal low cut and high cut values chosen were 40 Hz and 1800 Hz respectively.

1.7.5 Trace Editing

The data was inspected in the shot domain to assess the signal to noise ratio, noise types, and other types of issues. Missing shots and shots with dead traces were logged in order to help further processing. Channel 23 was spiky during the whole Thanet survey. A polarity check was performed on the first line of the survey; no reverted polarity was detected.

Examples of raw shot gather and shot gather after gain recovery and band pass filter are given in Appendix H - Figure 0.19 and Figure 0.20.

1.7.6 CMP Gather

Seismic data was sorted into 24 fold CMP gathers.

1.7.7 Brute Velocity Analysis

A brute velocity was picked in the middle of the first acquired line using a recorded water velocity of 1517 m/s.

1.7.8 NMO Correction

The CMP gathers were Normal Move Out (NMO) corrected using the Dix 2nd order equation. Velocity picked in the previous step was used.

1.7.9 Front End Mute

A brute outer trace mute removed the regions of the CMP gather which suffered unacceptable NMO stretch.

1.7.10 Brute Stack

Stacking was performed using $1/\sqrt{N}$ mute compensation.

1.7.11 Noise Analysis

For each trace, the Root Mean Square (RMS) amplitude was computed in the shot domain in a selected time window. A trapezoidal time window was chosen above the first arrival to assess the level of noise.

1.7.12 Navigation Merge

When available, navigation data were merged with seismic data in order to determine potential navigation processing issues or missed shots.

2. UHR SEISMIC PROCESSING SUMMARY

2.1 Offshore Data Processing

The UHR lines were processed in the Fugro Oceansismica Office in Rome, using the CGG Uniseis seismic processing package.

The processing flow was thoroughly tested to get the best improvement in the seismic data quality. Shot editing was initially carried out; several tests were done to choose the seismic processing parameters. At each new test stage, the data quality is analysed on both shots and stacks display.

2.2 Description of Sparker Data Processing

2.2.1 Transcription

Field data were converted to CGG Uniseis internal format.

2.2.2 Geometry Assignment and Trace Editing

Geometry assignment to traces was applied; bad shots and traces were omitted and dummy shots inserted where necessary.

2.2.3 Pre-processing

An amplitude gain recovery was applied to correct seismic data for geometrical spreading. A wide Butterworth band pass filter was applied to remove the low frequency swell noise.

2.2.4 Denoising

Time-Frequency De-Noise (TFDN) was applied to reduce swell noise and other kinds of noise in the shot gathers. TFDN works by transforming a number of traces in a short sliding time window to the frequency domain. In this window and working on single frequencies at a time it computes an attribute value (median, low quartile etc.) of the spectral amplitude. If any frequency component in a given trace is larger than a threshold (defined as a fraction of the computed attribute), TFDN attenuates the anomalous amplitude at that frequency, in the current trace under investigation, to the level of the threshold attribute.

FK filtering is often used to remove linear coherent noise because data with different dips in the TX domain maps in different regions of the FK domain. The data is transformed from the TX to the FK domain with a 2D Fast Fourier Transform (FFT). Before the transformation the data is expanded (the number of traces and the number of samples are both rounded up to a greater power of two), a necessity for the FFT. A filter is constructed in the FK Domain selecting zones which are to be passed or rejected. In this case, polygons were picked to delimit the area containing the dipping noise to be rejected. After muting, the data is inverse transformed in the TX domain.

To attenuate coherent noise a Surface Wave Noise Attenuation (SWNA) routine was also applied. The method is basically an averaging of samples from adjacent traces at each temporal frequency.

To attenuate random and coherent noise a surgical mute was applied in the wavelet domain. A variation on the Discrete Wavelet transform called a Stationary Wavelet transform was used to convert the data in the wavelet domain.

To remove spikes an automatic trace editing routine (despike) was applied. This routine despikes zeroes in trace windows which have an abnormal peak-to-median or a mean which lies outside a specified standard deviation.

Time-Frequency De-Noise (TFDN) was also applied to reduce swell noise and other kind of noise in the common offset domain. An example of denoise effects can be seen in Appendix C - Figure 0.7.

2.2.5 Demultiple

To reduce multiple energy, SRME (Surface Related Multiple Elimination) was carried out. SRME uses the geometry of shot recording to estimate all possible multiples that can be generated by the surface. Before evaluating the multiple model, the recorded data was extrapolated to zero offset and a mute was applied to the input shot records to remove direct arrival and guided wave energy. The predicted multiples energy was removed from the input gathers with a double adaptive matching algorithm, the first done in the offset plain domain and the second in the shot domain. Before adaptive subtraction, the modelled multiples were NMO corrected and any energy above the first seafloor multiple was removed by muting. An example of demultiple effects can be seen in Appendix C - Figure 0.8.

2.2.6 Velocity Analysis

Seismic velocities were picked every 500 m using Uniseis Interactive Velocity Analysis (MGIVA) package. Velocity analysis included semblance displays, interactive gather and stack, constant velocity stack panels and full line stacks showing the location of the pickings (refer to Appendix D - Figure 0.9).

2.2.7 CMP Gather and Navigation Merging

Seismic data were sorted into 48 fold CMP gathers and merged with navigation.

2.2.8 NMO Correction

The CMP gathers were NMO corrected using the Dix 2^{nd} order equation. The velocity picked in the previous step was used.

2.2.9 Front End Mute

An outer trace mute was applied to remove the regions of the CMP gather which suffered unacceptable NMO stretch. A single mute profile was used for all the lines.

2.2.10 Stack

Stacking was performed using $1/\sqrt{N}$ compensation, where N is the actual fold of stack at some particular time in the section ($1 < N < MAXFOLD$).

2.2.11 Deconvolution After Stack (DAS)

For spiking or predictive deconvolution the Wiener-Levinson algorithm is applied to the autocorrelation of the derivation window to produce a time domain operator which will be either spiking or predictive, depending on the specified operator and gap length. Then, the operator is convolved with the original trace in the time-domain. Operator and gap lengths were chosen to produce a spiking time domain operator to remove Sparker secondary bubbles and therefore to enhance the vertical resolution. Four operators were used to account for the signal variation with time and two successive DAS were applied (refer to Appendix E – Figure 0.11).

2.2.12 Filter

A Butterworth band pass filter was applied to remove extra noise.

2.2.13 FX filter

FX Deconvolution is a process designed to effectively attenuate random noise by prediction of the non-random signal content in a seismic trace. Events with similar dips appear as a sinusoidal complex signal along a given frequency slice, and are therefore predictable. For each frequency in the transforms, an optimum deconvolution operator is used to predict the next trace in the sequence. Any difference between the predicted waveform and the actual one can be classified as noise, and removed.

2.2.14 Post-stack FK filter

FK filtering is often used to remove linear coherent noise because data with different dips in the TX domain maps in different regions of the FK domain. The data is transformed from the TX to the FK domain with a 2D Fast Fourier Transform (FFT). Before the transformation the data is expanded (the number of traces and the number of samples are both rounded up to a greater power of two), a necessity for the FFT. A filter is constructed in the FK Domain selecting zones which are to be passed or rejected. In this case, polygons were picked to delimit the area containing the dipping noise to be rejected. After muting the data is inverse transformed in the TX domain.

Refer to Appendix E - Figure 0.12 for stack after FX and FK filters.

2.2.15 Targeted Demultiple (Areas 2A and 2B)

Single Value Decomposition (SVD) was used to remove the first and second order water-bottom multiple residual energy. SVD is a powerful tool for detecting laterally coherent signals in multi trace recordings. It constructs an orthogonal (data dependent) set of directions ordered according to the degree of variance they witness. These directions form the basis elements for a transform called a Karhunen-Loeve transform.

2.2.16 Velocity Smoothed Field

A smoothed velocity field derived from picked velocities was used for migration. Spatial smoothing of velocity fields was performed by blending the field at each control position with contributions from its neighbours. The neighbouring contributions are down weighted by an inverse radial distance scheme.

2.2.17 Post-stack Kirchhoff Time Migration

To collapse diffractions and move reflectors to their true subsurface position a post-stack Kirchhoff time migration was applied. A spherical spreading factor of 1/(root TV squared) was applied before summation. A wavelet shaping factor was applied to correct distortions of the amplitude and the phase spectra introduced by the summation. An Obliquity factor was applied to take in account the angle dependency of amplitudes (refer to Appendix E – Figure 0.13).

2.2.18 Gabor Deconvolution

The Gabor transform is a short window Fourier transform that allows a time-frequency representation of the time domain seismic trace. The signal is first multiplied by a Gaussian function and the output function is then transformed with a Fourier transform. The deconvolution process itself is implemented as a time-frequency domain spectral division based on the Gabor transform. An average deconvolution operator is derived from the Gabor spectrum and applied for the whole ensemble.

2.2.19 NLMEAN Random Noise Attenuation

The method is based on the redundancy present in the data. Each seismic sample is replaced by the weighted average of all the other samples in a window. The weight of each sample in the average is dependent on the similarity between the neighbourhoods of the considered samples, regardless of proximity. This makes the average non local.

Refer to Appendix E – Figure 0.14 for stack after Gabor deconvolution and random noise attenuation.

2.2.20 Tides Correction and Final Statics

Time shifts were applied to correct for the tidal effect. Tide corrections derived from static shifts were applied to match the multibeam water bottom which was vertically referenced to the Lowest Astronomical Tide (LAT). From the P1/90, this water bottom was imported in the seismic stack as a horizon, and then a shift was applied to obtain the best match between seismic water bottom and MultiBeam Echo Sounder (MBES) water bottom for the overall line.

2.2.21 SEG-Y (True Amplitude)

True Amplitude migrated SEG-Y outputs were performed with a standard 3200 byte EBCDIC textual header which contains the recording data and processing flow.

2.2.22 SEG-Y (Equalized)

Automatic Gain Controller (AGC) Equalization was applied to balance the final section. To equalize the section a time window was slid sample-by-sample to derive the "amplitude model" for the traces. To avoid the problem of large amplitude events casting shadows over adjacent weaker events, two different length AGC windows were used. At any sample, the model trace was derived from whichever model gave the greater value. Furthermore, the original character of the section is often lost because noise is equalised to the same level as coherent signal. The equalisation has no respect for any signal "stand-out". To solve this problem, a percentage of equalisation was defined and applied. SEG-Y outputs were performed with a standard 3200 byte EBCDIC textual header which contains the recording data and processing flow. True amplitude sections are preferred for interpretation. (Refer to Appendix E – Figure 0.16 for equalized section).

2.2.23 SEG-Y (Depth)

Data was converted from the time to the depth domain using the smoothed velocity field derived from pickings. . For each line the true Amplitude migrated section was output using a standard 3200 byte EBCDIC textual header which contains the recording data and processing flow.

2.3 Description of Minigun Data Processing

2.3.1 Transcription

Field data were converted to CGG Uniseis internal format.

2.3.2 Geometry Assignment and Trace Editing

Geometry assignment to traces was applied; bad shots and traces were omitted and dummy shots inserted where necessary.

2.3.3 Pre-processing

An amplitude gain recovery was applied to correct seismic data for geometrical spreading. A wide Butterworth band pass filter was applied to remove the low frequency swell noise.

2.3.4 Denoising

Time-Frequency De-Noise (TFDN) was applied to reduce swell noise and other kind of noise in the shot gathers. TFDN works by transforming a number of traces in a short sliding time window to the frequency domain. In this window and working on single frequencies at a time it computes an attribute value (median, low quartile etc.) of the spectral amplitude. If any frequency component in a given trace is larger than a threshold (defined as a fraction of the computed attribute), TFDN attenuates the anomalous amplitude at that frequency, in the current trace under investigation, to the level of the threshold attribute.

To remove spikes an automatic trace editing routine (despike) was applied. This routine despikes zeroes in trace windows which have an abnormal peak-to-median or a mean which lies outside a specified standard deviation.

To attenuate coherent noise a Surface Wave Noise Attenuation (SWNA) routine was also applied. The method is basically an averaging of samples from adjacent traces at each temporal frequency.

An example of denoise effects can be seen in Appendix I - Figure 0.25.

2.3.5 Residual Statics Corrections

A combination of two routines has been used to compensate the source firing variation.

NEBULA computes statics based on summed cross-correlations at source and receiver location. It uses a pilot trace constructed at each CDP using a weighted mix of stacked traces or input from an external stack data set. Input CDP must be NMO corrected and muted. Cross-correlations of the pilot trace with traces in the respective CDP gather are summed into buffers for each source and receiver station number before being resampled and picked to derive a static values that are output to disk files and then applied to seismic data.

PASTA is an automatic residual statics programme which applies static shifts to traces on a CDP-consistent basis, using cross-correlations of NMO-corrected CDP gather traces with a CDP pilot trace for each depth point.

An example of data after residual statics correction effects can be seen in Appendix I.

2.3.6 Demultiple

To reduce multiple energy, SRME (Surface Related Multiple Elimination) was carried out. SRME uses the geometry of shot recording to estimate all possible multiples that can be generated by the surface. Before evaluating the multiple model, the recorded data was extrapolated to zero offset and a mute was applied to the input shot records to remove direct arrival and guided wave energy. The predicted multiples energy was removed from the input gathers with a double adaptive matching algorithm, the first done in the offset plain domain and the second in the shot domain. Before adaptive subtraction, the modelled multiples were NMO corrected and any energy above the first seafloor multiple was removed by muting. An example of demultiple effects can be seen in Appendix I - Figure 0.27.

2.3.7 Velocity Analysis

Seismic velocities were picked every 500 m using Uniseis Interactive Velocity Analysis (MGIVA) package. Velocity analysis included semblance displays, interactive gather and stack, constant velocity stack panels and full line stacks showing the location of the pickings (refer to Appendix J - Figure 0.28).

2.3.8 CMP Gather and Navigation Merging

Seismic data were sorted into 24 fold CMP gathers and merged with navigation.

2.3.9 NMO Correction

The CMP gathers were NMO corrected using the Dix 2nd order equation. The velocity picked in the previous step was used.

2.3.10 Front End Mute

An outer trace mute was applied to remove the regions of the CMP gather which suffered unacceptable NMO stretch. A single mute profile was used for all the lines.

2.3.11 Stack

Stacking was performed using $1/\sqrt{N}$ compensation, where N is the actual fold of stack at some particular time in the section ($1 < N <$ MAXFOLD).

2.3.12 Targeted Demultiple

Single Value Decomposition (SVD) was used to remove the first and second order water-bottom multiple residual energy. SVD is a powerful tool for detecting laterally coherent signals in multi trace recordings. It constructs an orthogonal (data dependent) set of directions ordered according to the degree of variance they witness. These directions form the basis elements for a transform called a Karhunen-Loeve transform (refer to Appendix K – Figure 0.30).

2.3.13 FK Filter

FK filtering is often used to remove linear coherent noise because data with different dips in the TX domain maps in different regions of the FK domain. A tapered fan shaped filter was applied to the data in the F-K domain with rejected data outside of the fan (refer to Appendix K – Figure 0.31).

2.3.14 Velocity Smoothed Field

A smoothed velocity field derived from picked velocities was used for migration. Spatial smoothing of velocity fields was performed by blending the field at each control position with contributions from its neighbours. The neighbouring contributions are down weighted by an inverse radial distance scheme.

2.3.15 Post-stack Kirchhoff Time Migration

To collapse diffractions and move reflectors to their true subsurface position a post-stack Kirchhoff time migration was applied. A spherical spreading factor of 1/(root TV squared) was applied before summation. A wavelet shaping factor was applied to correct distortions of the amplitude and the phase spectra introduced by the summation. An Obliquity factor was applied to take in account the angle dependency of amplitudes (refer to Appendix K – Figure 0.32).

2.3.16 Time Variant Filter

A Time Variant Butterworth shaped frequency filter was applied to enhance the signal to noise ratio of the final stack. Different windows and high cut / low cut values were tested in order to ensure the best results with minimum loss of information. Amplitude decay was analysed and a final gain function was applied (refer to Appendix K – Figure 0.33).

2.3.17 Tides Correction and Final Statics

Time shifts were applied to correct for the tidal effect. Static shifts were applied to match the multibeam water bottom which was vertically referenced to the Lowest Astronomical Tide (LAT). From the P1/90, this water bottom was imported in the seismic stack as a horizon, and then a shift was applied to obtain the best match between seismic water bottom and MultiBeam Echo Sounder (MBES) water bottom for the overall line.

2.3.18 SEG-Y (True Amplitude)

True Amplitude migrated SEG-Y outputs were performed with a standard 3200 byte EBCDIC textual header which contains the recording data and processing flow.

2.3.19 SEG-Y (Equalized)

Automatic Gain Controller (AGC) Equalization was applied to balance the final section. To equalize the section a time window was slid sample-by-sample to derive the "amplitude model" for the traces. SEG-Y outputs were performed with a standard 3200 byte EBCDIC textual header which contains the recording data and processing flow. True amplitude sections are anyway preferred for interpretation (refer to Appendix K –Figure 0.35 for equalized section).

2.3.20 Velocity Adjustment

The stacking smoothed velocities were used to perform the time to depth conversion. These time to depth conversion velocities could not be calibrated on stratigraphy as no information was available on the depth in the survey area. As sparker data are more reliable at the depth of interest (shallower part) the decision was made to adjust the velocities of the minigun data in order to reduce the discrepancies at the intersection between sparker and minigun depth sections. So a variation on the previously smoothed velocities was applied, as a percentage of the original velocity.

2.3.21 SEG-Y (Depth)

Data was converted from the time to the depth domain using the smoothed velocity field derived from pickings. For each line the true amplitude migrated section was output using a standard 3200 byte EBCDIC textual header which contains the recording data and processing flow. An example of final sections can be seen in Appendix L - Figure 0.36.

2.4 Final Processing Sequence and Parameters

Table 2.1 to

Table **2.5** indicate the main parameters and the final processing sequence used to process the UHR data.

Table 2.1: Final processing sequence and parameters – Sparker data

Transcription	From SEG-D to CGG Uniseis internal format.
Static correction for instrumental delay	22 ms
Geometry assignment and Traces Edit	
Geometrical divergence correction	T^2 amplitude gain recovery
Band Pass Filter	18 dB/Oct, 40 Hz – 1800 Hz, 53 dB/Oct
Time Frequency Denoise (TFDN) – pass 1	0 to 1800 Hz; Application from 100 ms to 320 ms; Attribute = Median; Threshold = 4 * Median
Time Frequency Denoise (TFDN) – pass 2	0 to 100 Hz; Application from 0 ms to 320 ms; Attribute = Lower Quartile (LQT); Threshold = 4 * LQT
FK Filter	Polygon muting in the FK domain
Surface Wave Noise Attenuation (SWNA)	Surface velocity 2000 m/s
WAVlet DeNoise (WAVDN)	
Despike	
Time Freqeuncy Denoise in Common offset domain	0 to 1800 Hz; Application from 80 ms to 320 ms; Attribute = Median; Threshold = 4 * Median
SRME	Extrapolation to zero offset; Time shift: 0 ms
Match in common offset domain	Filter length 20 ms; Window length 100 ms
Match in shot domain	Filter length 20 ms; Window length 100 ms
Velocity Analysis	every 500 m
Velocity smoothed field	Weight = 1/r^0.1 (r=radial distance) Search radial distance = 2000 m
CMP sorting & Navigation Assignment	48 fold
NMO Correction	Dix 2^{nd} Order
Front End Mute	A single mute for all lines – see Table 2.2
Stack	1/Root N compensation
Deconvolution After Stack (DAS)	4 operators / trace Operator 5 ms, Gap 2.4 ms Definition window 30-100 ms Application time 30 ms Operator 5 ms, Gap 2.4 ms Definition window 70-100 ms Application time 80 ms Operator 5 ms, Gap 2.5 ms Definition window 150-250 ms Application time 160 ms Operator 5 ms, Gap 4 ms Definition window 200-300 ms Application time 220 ms
Deconvolution After Stack (DAS)	1 operator / trace Operator 7.55 ms, Gap 2.25 ms Definition window 20-63 ms Application time 30 ms
Band Pass filter	18 dB/Oct, 200 Hz – 1500 Hz, 53 dB/Oct
FX Filter	
FK Filter	Polygon muting in the FK domain
Targeted Demultiple (Areas 2A and 2B)	Single Value Decomposition
Post stack Kirchhoff migration	180 traces half-aperture; No velocity variation
Gabor deconvolution (GABOR)	
Non Local Mean (NLMEAN)	
Tide Corrections and Static Shifts	Vertical reference to LAT
SEG-Y (True Amplitude)	Migrated True Amplitude
SEG-Y (Equalized)	AGC parameters: Major derivation window length: 200 ms Minor derivation window length: 15 ms Percentage of equalisation: 30
SEG-Y (Depth)	Migrated True Amplitude

Details about position of shot point and CDP numbers and their coordinates in the SEG-Y headers are given in Table 2.6.

Table 2.2: Front end mute

Offset (m)	Time (ms)	Offset (m)	Time (ms)
7	18	90	90
37	32	111	118
46	38	139	153
58	53	152	171
71	71		

Table 2.3: Final processing sequence and parameters – Minigun data

Transcription	From SEG-D to CGG Uniseis internal format.
Static correction for instrumental delay	4 ms
Geometry assignment and Traces Edit	
Geometrical divergence correction	T^2 amplitude gain recovery
Band Pass Filter	18 dB/Oct, 40 Hz – 1800 Hz, 53 dB/Oct
Time Frequency Denoise (TFDN) – pass 1	0 to 100 Hz; Application from 0 ms to 300/330 ms; Attribute = Lower Quartile (LQT); Threshold = 4 * LQT
Time Frequency Denoise (TFDN) – pass 2	0 to 120 Hz; Application from 180 ms to 300/330 ms; Attribute = Lower Quartile (LQT); Threshold = 4 * LQT
Surface Wave Noise Attenuation (SWNA)	Surface velocity 2000 m/s
WAVlet DeNoise (WAVDN)	
Despike	
NEBULA	
PASTA	
SRME	Extrapolation to zero offset; Time shift: 0 ms
Match in common offset domain	Filter length 5 ms; Window length 30 ms
Match in shot domain	Filter length 5 ms; Window length 30 ms
Velocity Analysis	every 500 m
Velocity smoothed field	Weight = 1/r^0.1 (r=radial distance) Search radial distance = 2000 m
CMP sorting & Navigation Assignment	24 fold
NMO Correction	Dix 2nd Order
Front End Mute	Keyed on water bottom – see Table 2.4
Stack	1/Root N compensation
Targeted Demultiple (Areas 2A and 2B)	Single Value Decompostion
FX Filter (Blocks 3 and 4)	
FK Filter	+/- 0.8 ms / trace
Targeted Demultiple	Single Value Decompostion
Post stack Kirchhoff migration	180 traces half-aperture; No velocity variation
Time Variamt band Pass Filter	see Table 2.5
Tide Corrections and Static Shifts	Vertical reference to LAT
SEG-Y (True Amplitude)	Migrated True Amplitude
SEG-Y (Equalized)	AGC Derivation window 100 ms
Velocity variation	100 ms - 91%, 200 ms - 94%, 330 ms -101%
SEG-Y (Depth)	Migrated True Amplitude

Details about position of shot point and CDP numbers and their coordinates in the SEG-Y headers are given in Table 2.6.

Table 2.4: Front end mute for Minigun data

Trace	Time (ms)	Trace	Time (ms)	Trace	Time (ms)
Water bottom 26 ms		Water bottom 53 ms		Water bottom 69 ms	
1	22	1	49	1	65
11	22	11	50	15	65
19	45	23	86	21	86
35	72	35	101	27	101
47	121	47	129	47	120

Table 2.5: Time variant band pass filter values for Minigun data

Low-cut slope (dB/octave)	Low-cut freq. (Hz)	High-cut freq. (Hz)	High-cut slope (dB/octave)	Start Application Time (ms)
13	50	750	48	0
13	40	550	48	110

Table 2.6: SEG-Y binary headers

Headers	Bytes
Shot point number	17 – 20
CDP number	21 – 24
CDP X coordinates	73 – 76 and 81-84
CDP Y coordinates	77 – 80 and 85-88

APPENDICES

A. SPARKER NEAR TRACE: EXAMPLE OF A NEAR TRACE SECTION

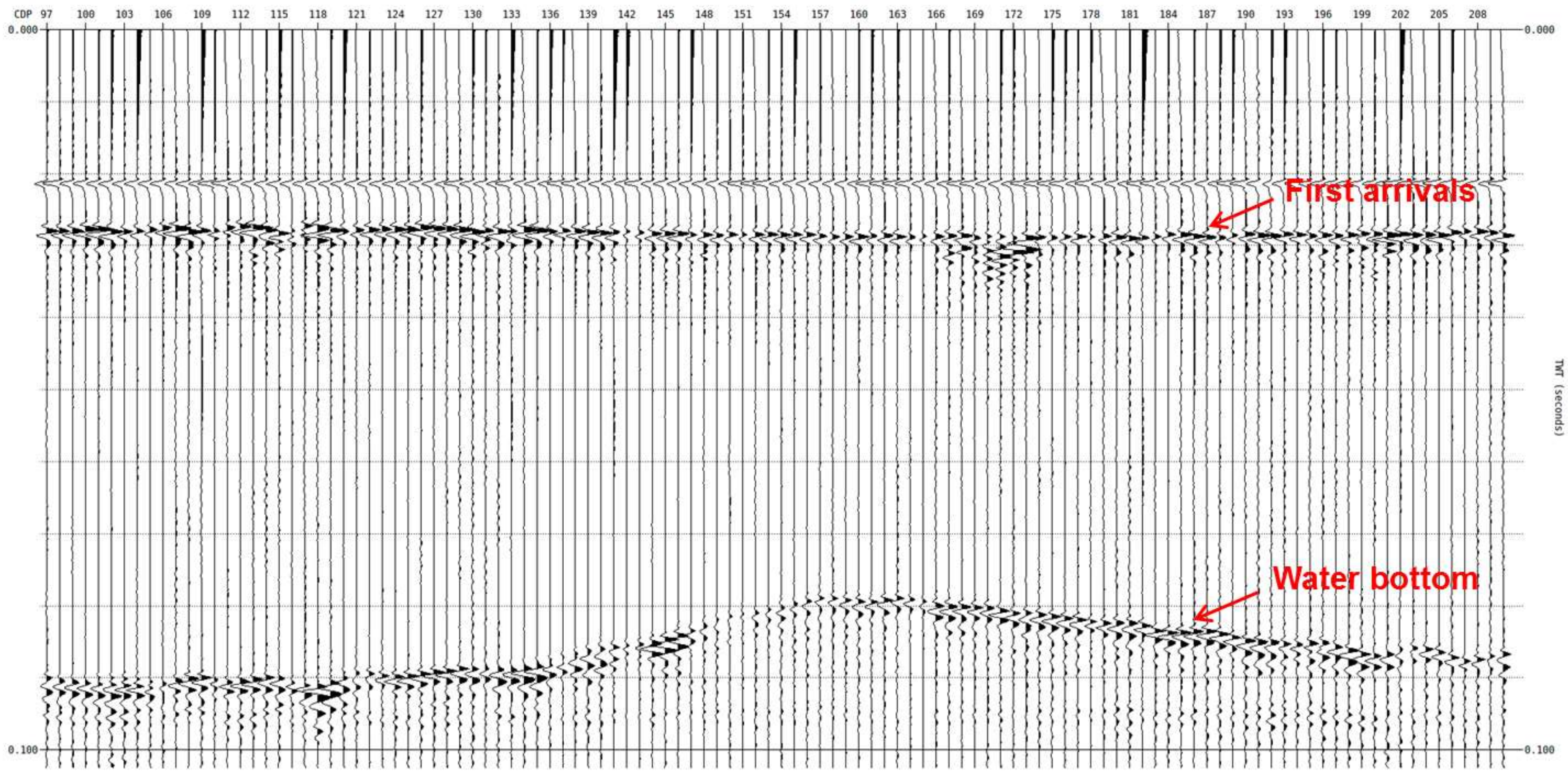


Figure 0.1: Line 1_TS_01 near trace gather zoom

B. SPARKER SHOT GATHERS FROM LINE 1_TS_01

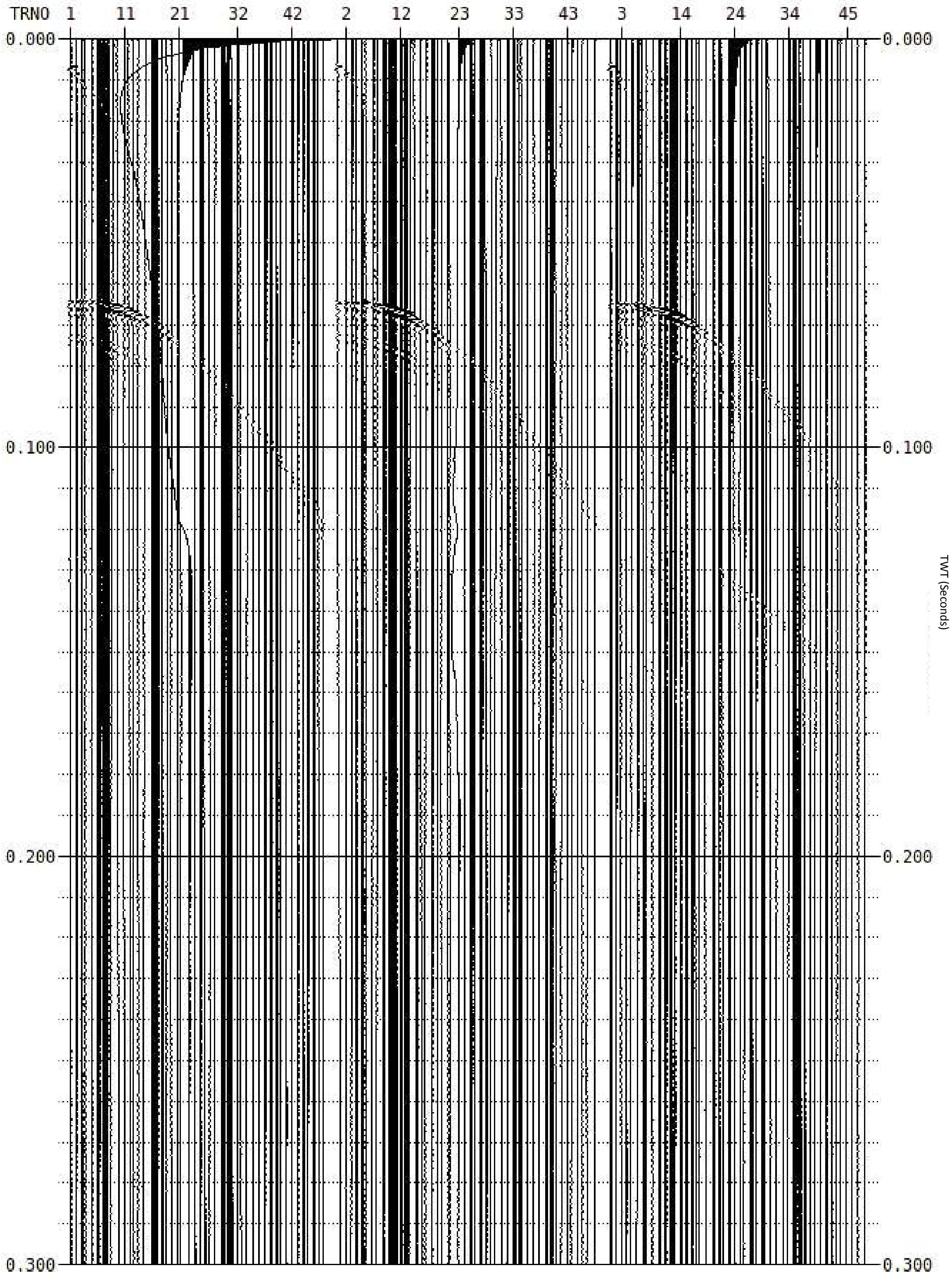


Figure 0.2: Sparker raw shots. Note the low frequency swell noise.

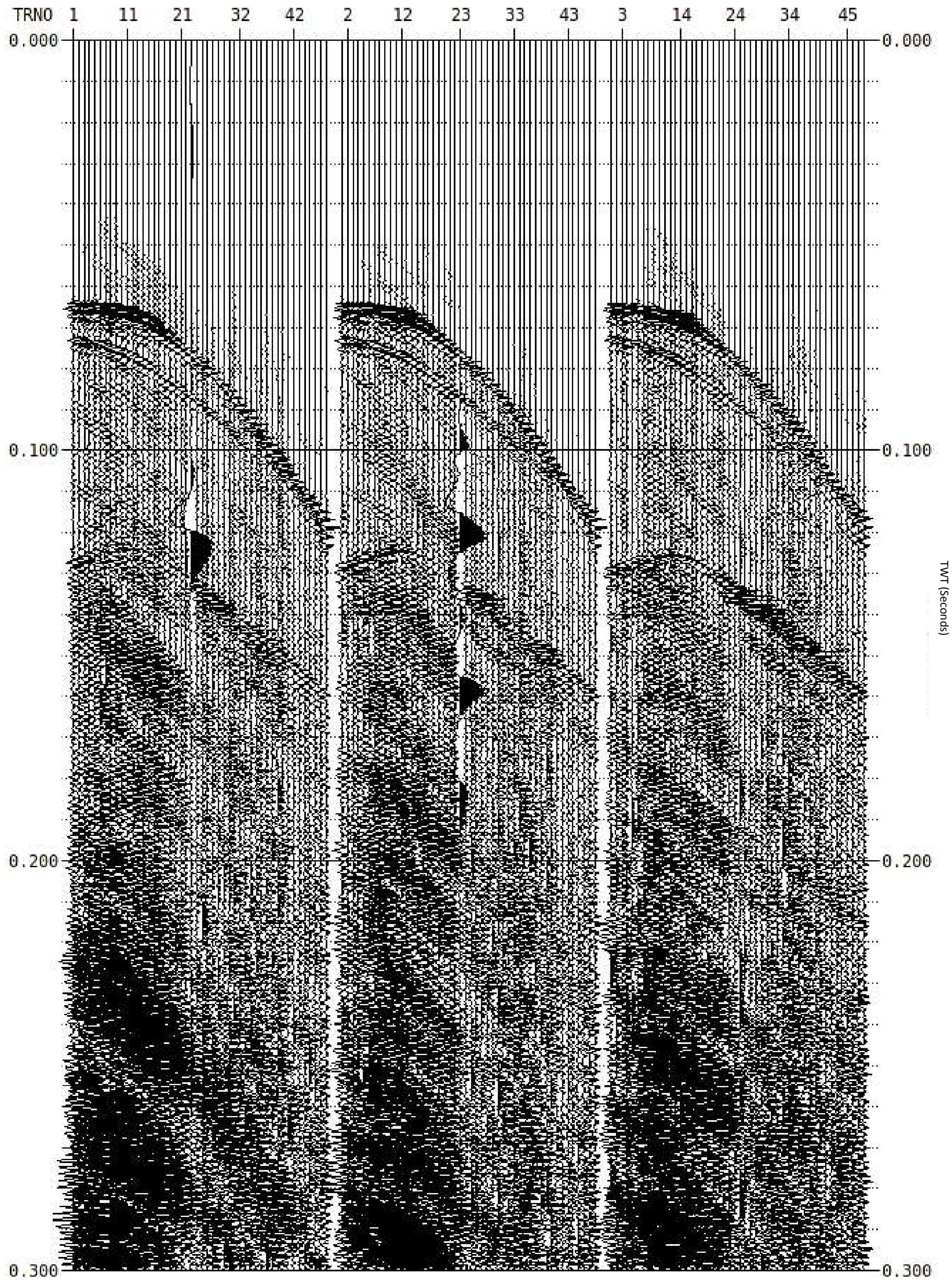


Figure 0.3: Sparker shots after editing phase. The band pass filter has removed the low frequency swell noise. The signal to noise ratio is very low, in particular note the high linear vessel noise at late times.

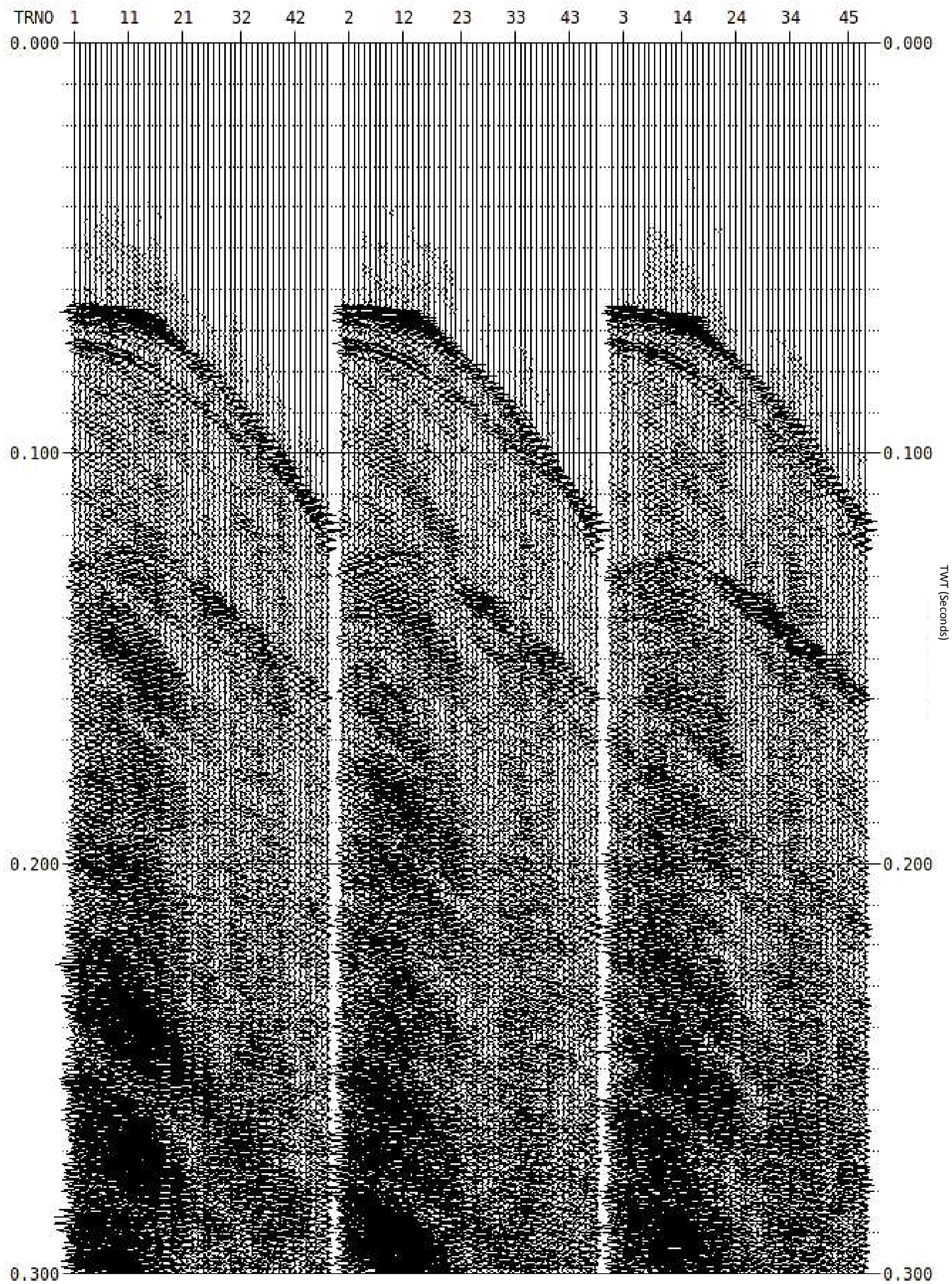


Figure 0.4: Sparker shots after denoise routines. Linear noise has been greatly reduced by the FK filtering.

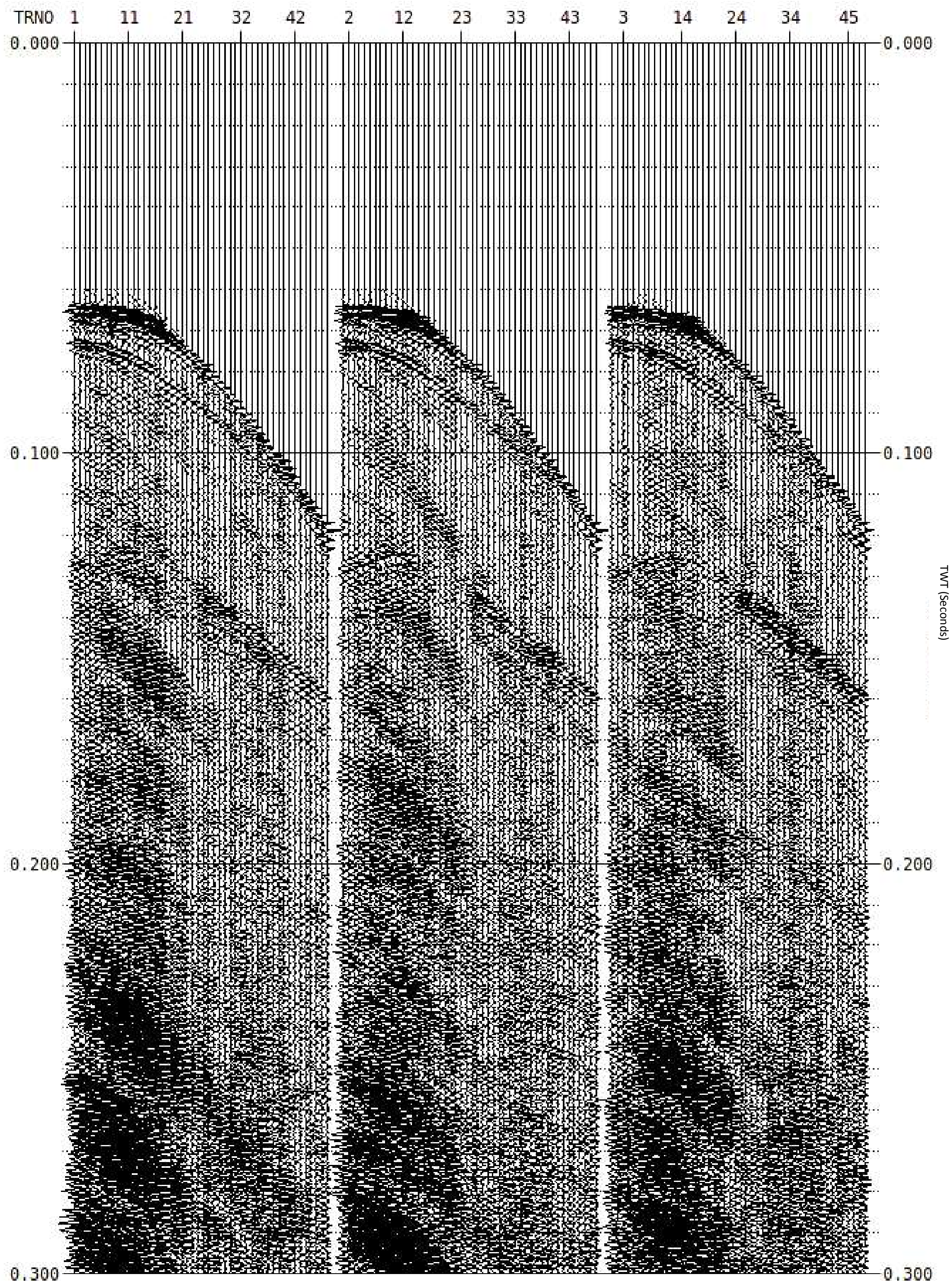


Figure 0.5: Sparker shots after SRME

C. STACKS OF SPARKER LINE 1_TS_01: PRE-STACK ROUTINES

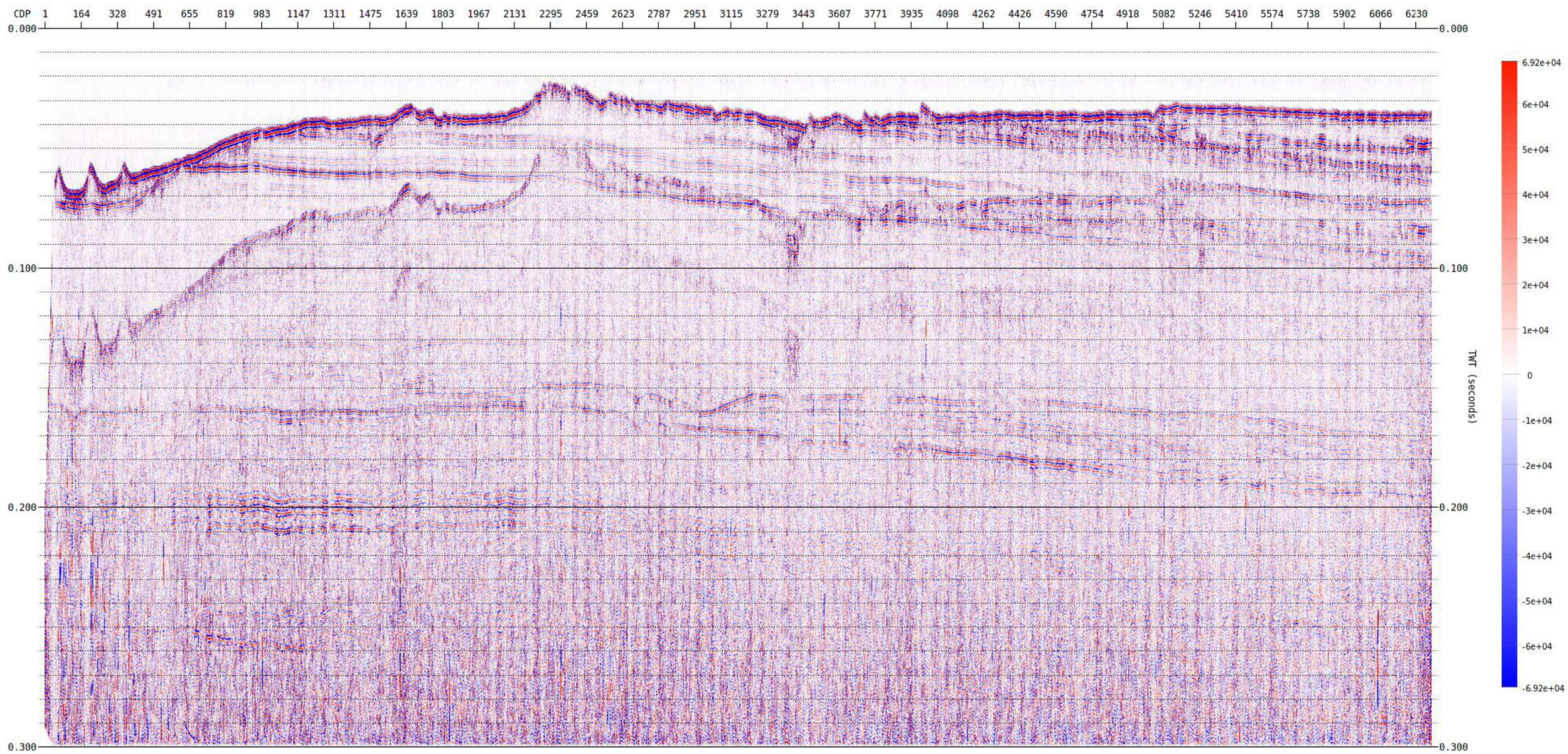


Figure 0.6: Brute Stack. Note the water bottom multiple and the vessel noise at late times.

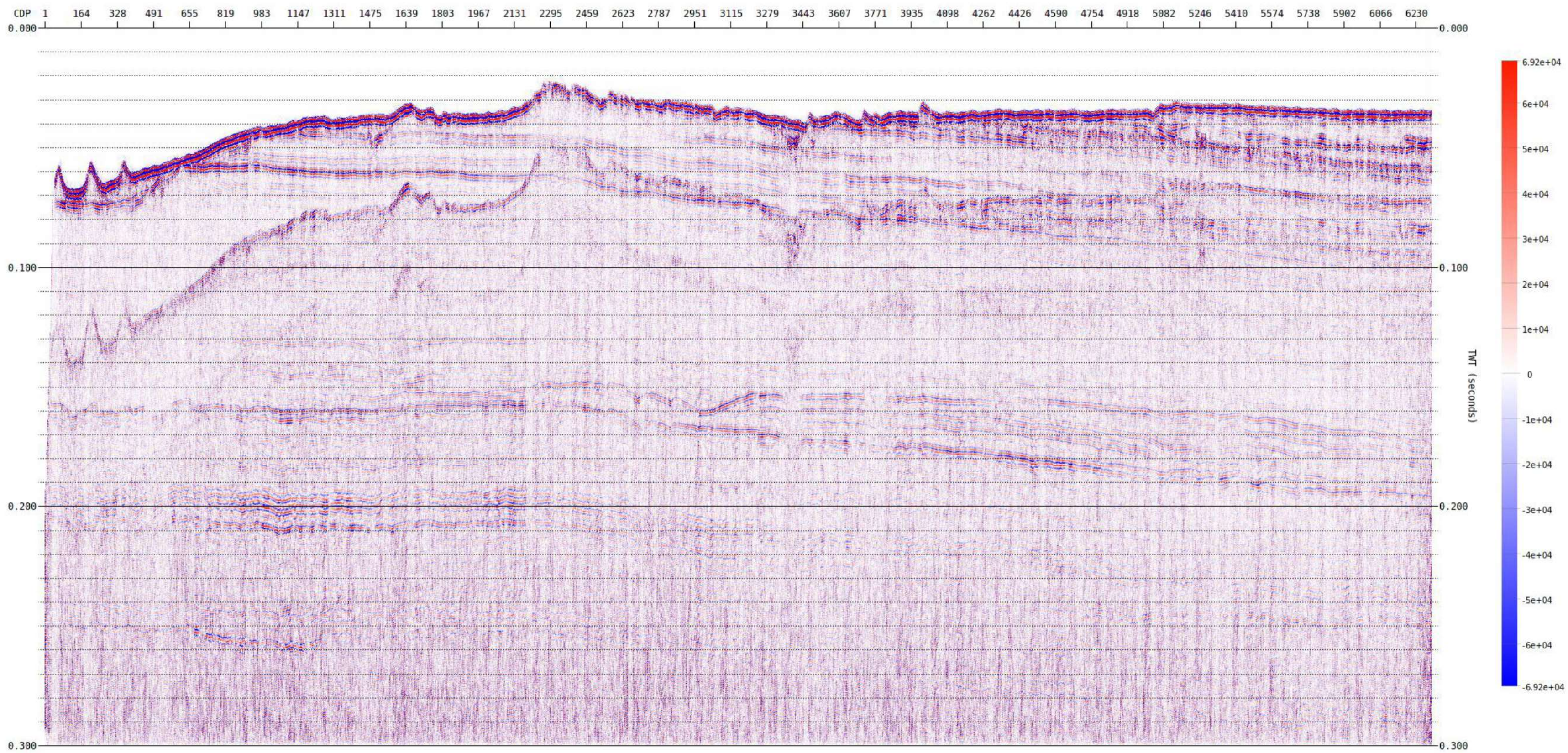


Figure 0.7: After denoise routines. Note the great reduction of noise at late times.

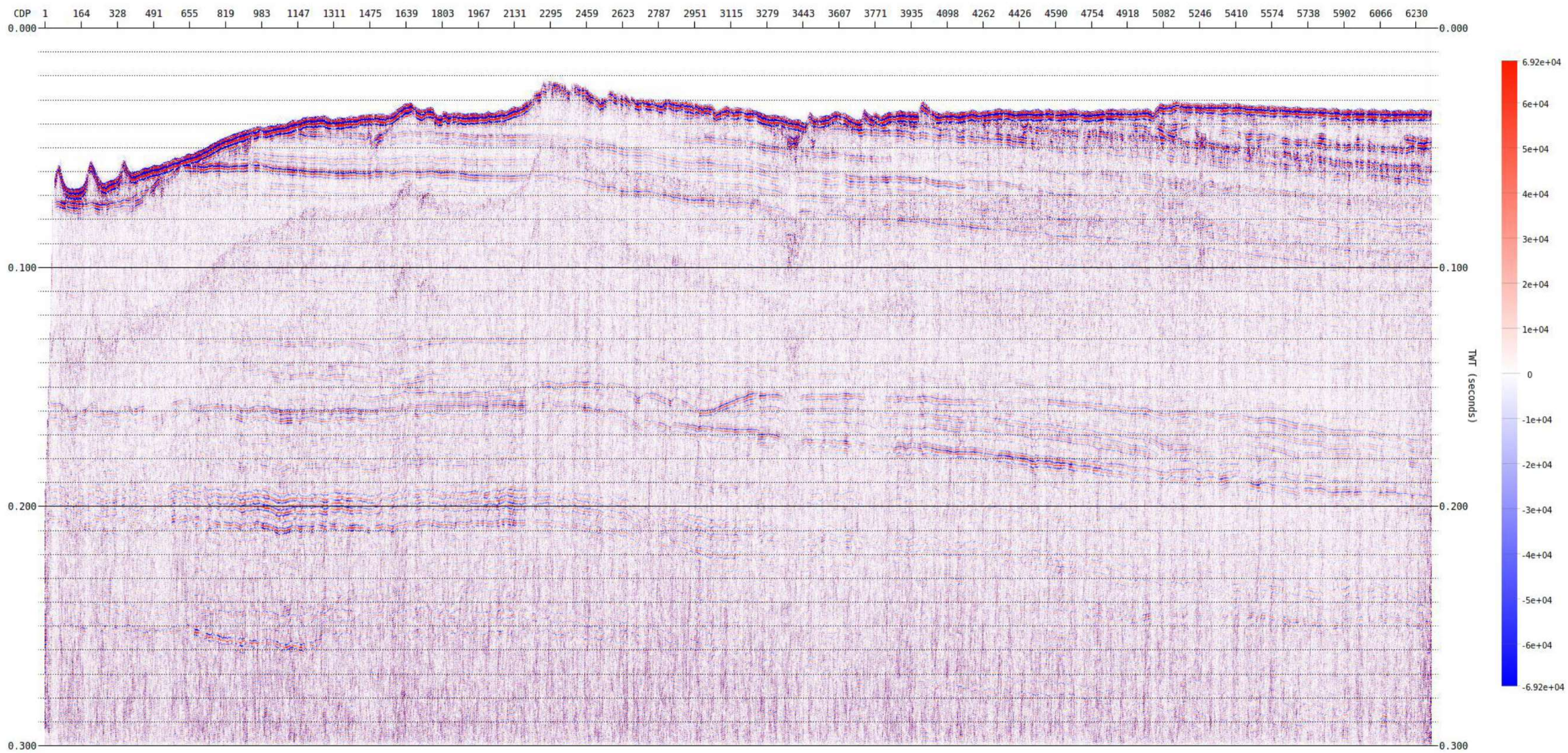


Figure 0.8: After SRME. Multiple reflections have been greatly attenuated.

D. VELOCITY ANALYSIS: EXAMPLE OF VELOCITY PICKING FOR SPARKER DATA

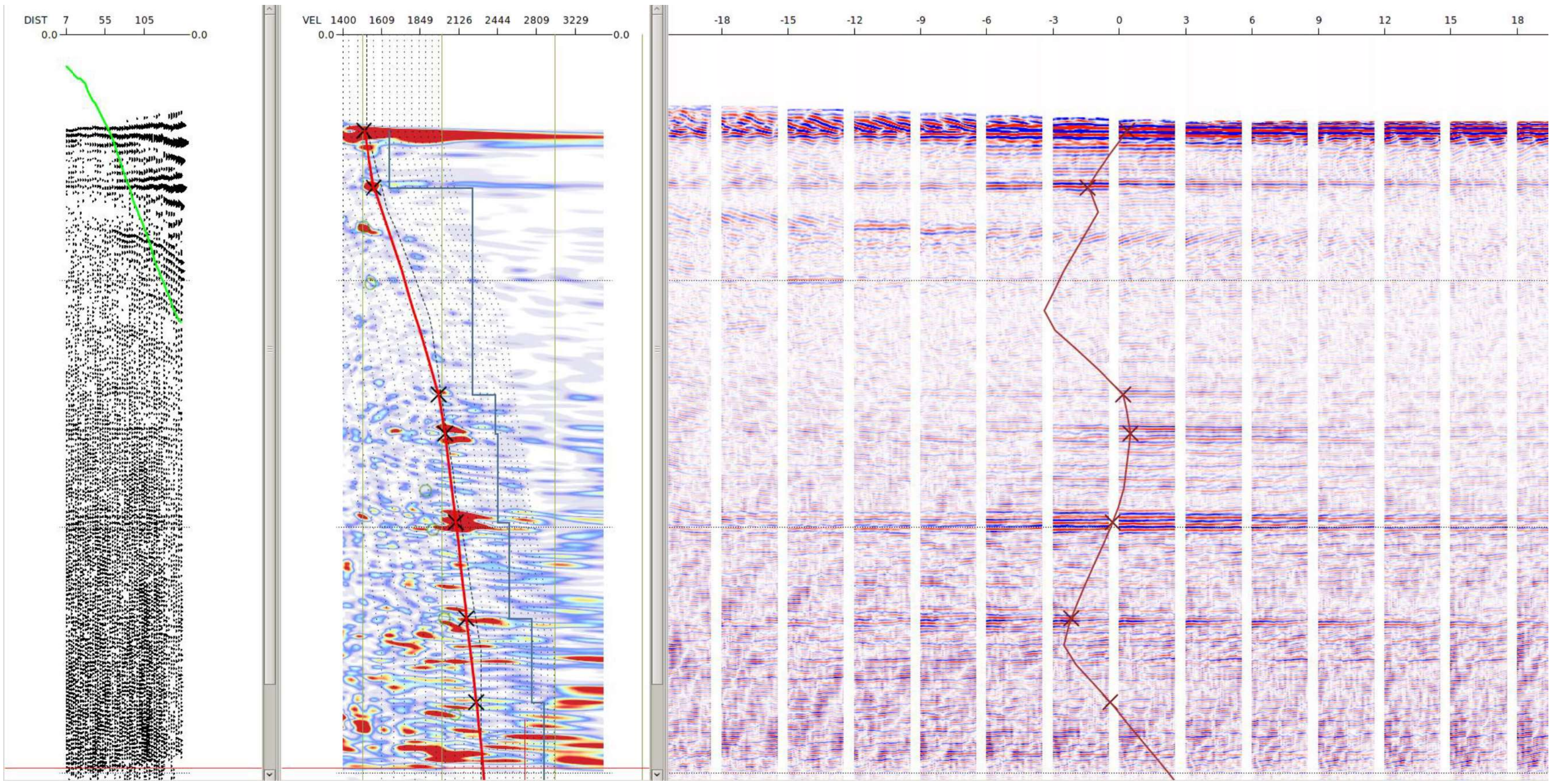


Figure 0.9: Line 1_TS_01 CDP Gather (left) – semblance (centre) – constant percentage velocity stack (right).

E. STACKS OF SPARKER LINE 1_TS_01: POST-STACK ROUTINES

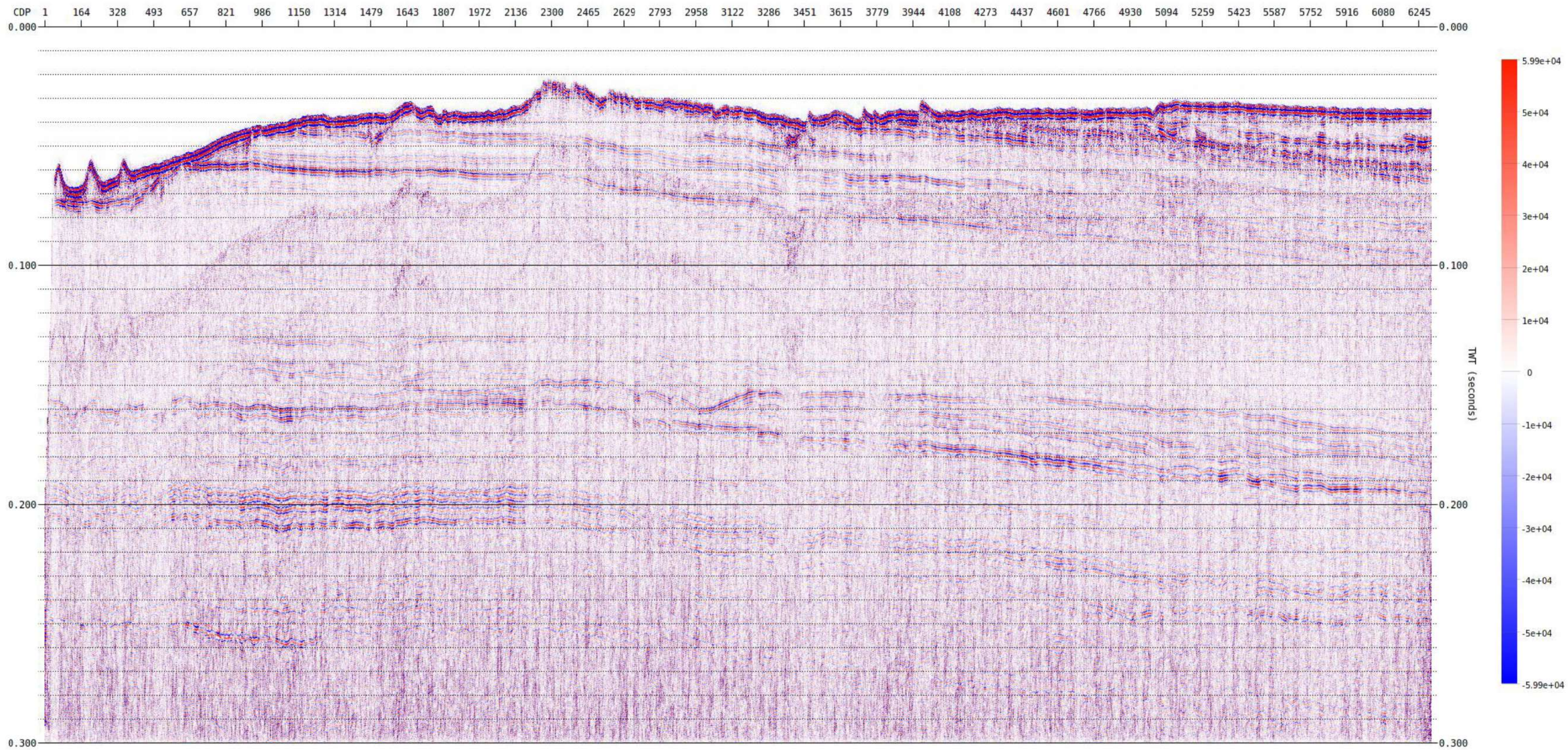


Figure 0.10: After velocity picking. Note the enhancement in lateral coherency of the primary reflections and the attenuation of multiple reflections.

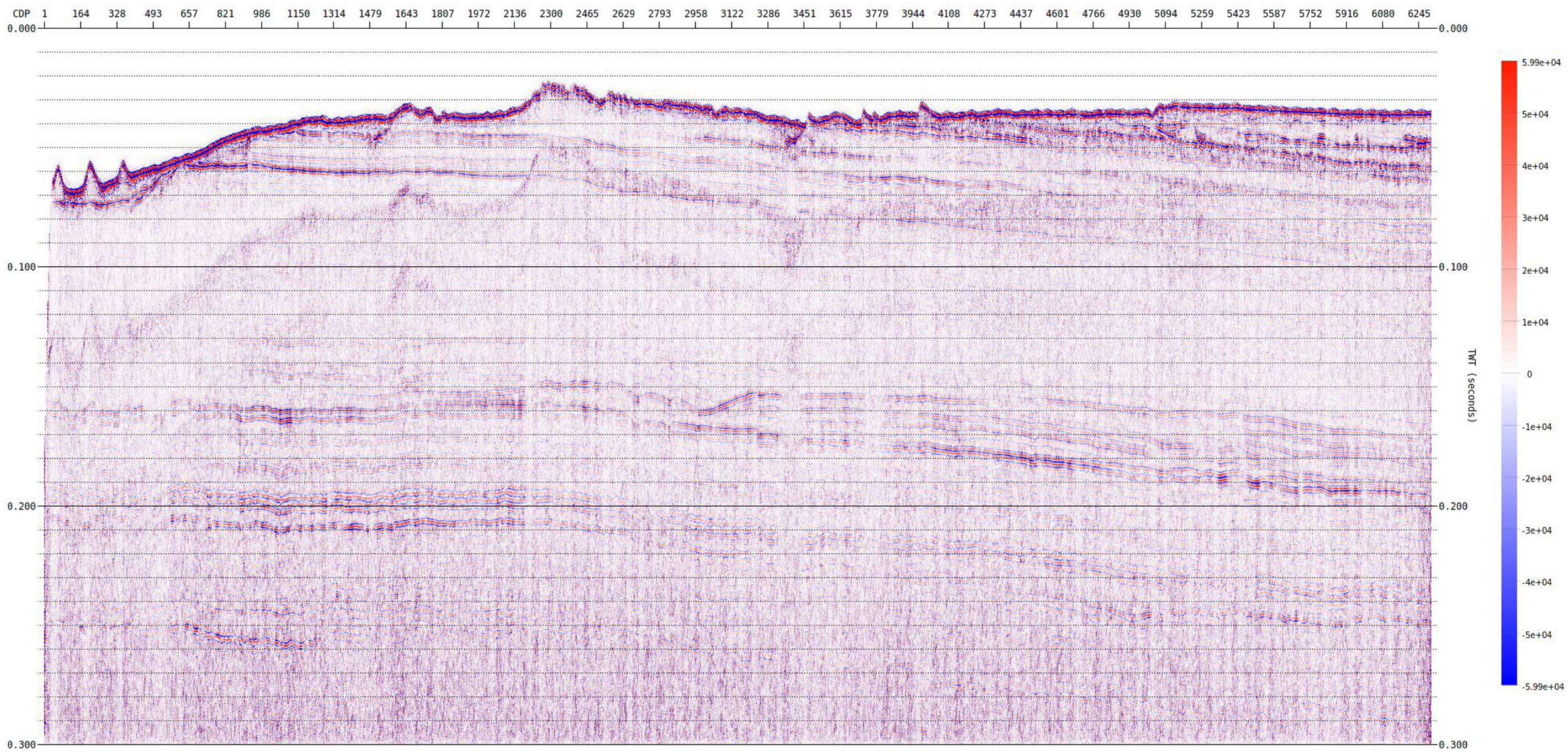


Figure 0.11: After deconvolution. Ringing due to secondary bubbles has been greatly reduced increasing the vertical resolution of the data

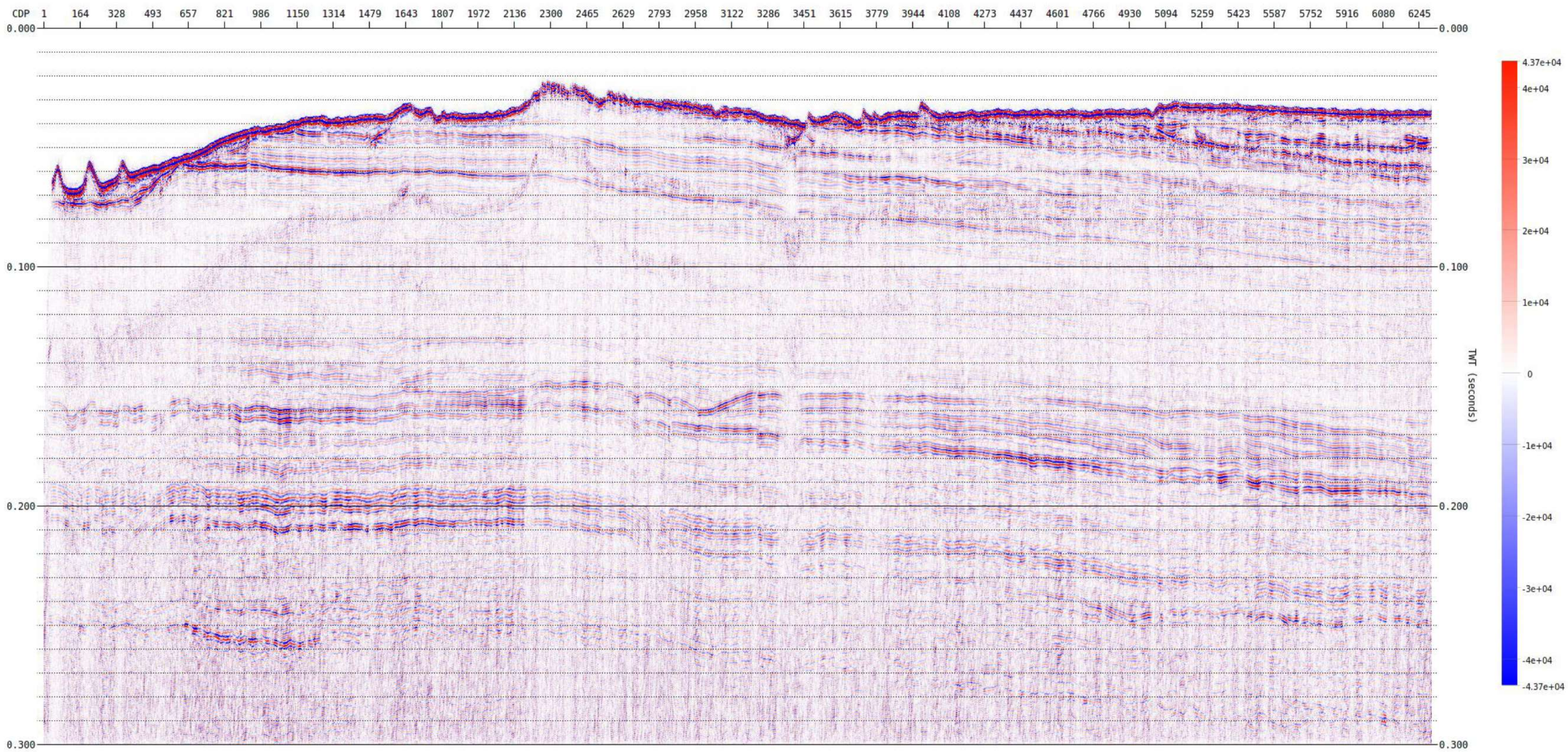


Figure 0.12: FX and FK filtering. Random noise has been attenuated increasing the signal to noise ratio.

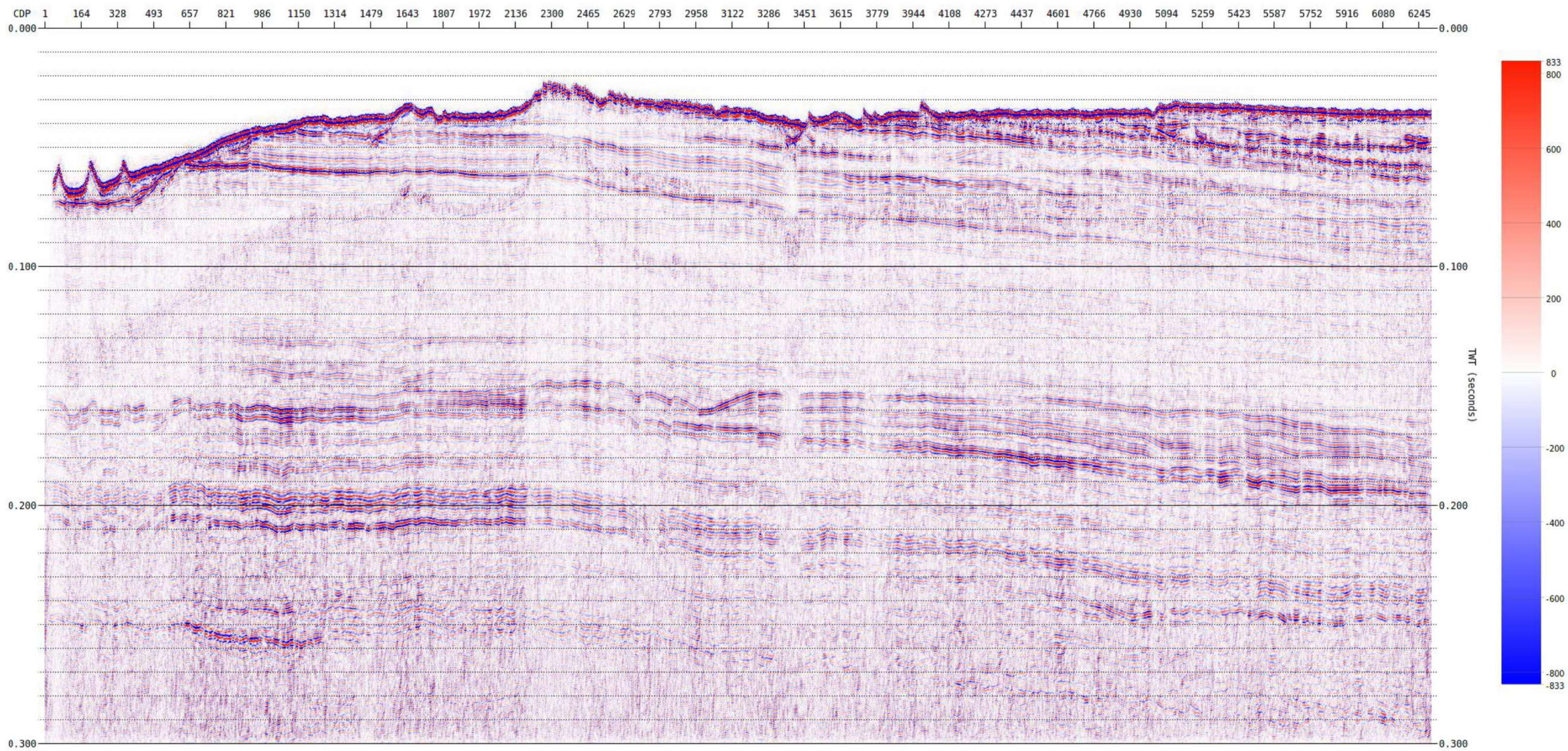


Figure 0.13: After migration

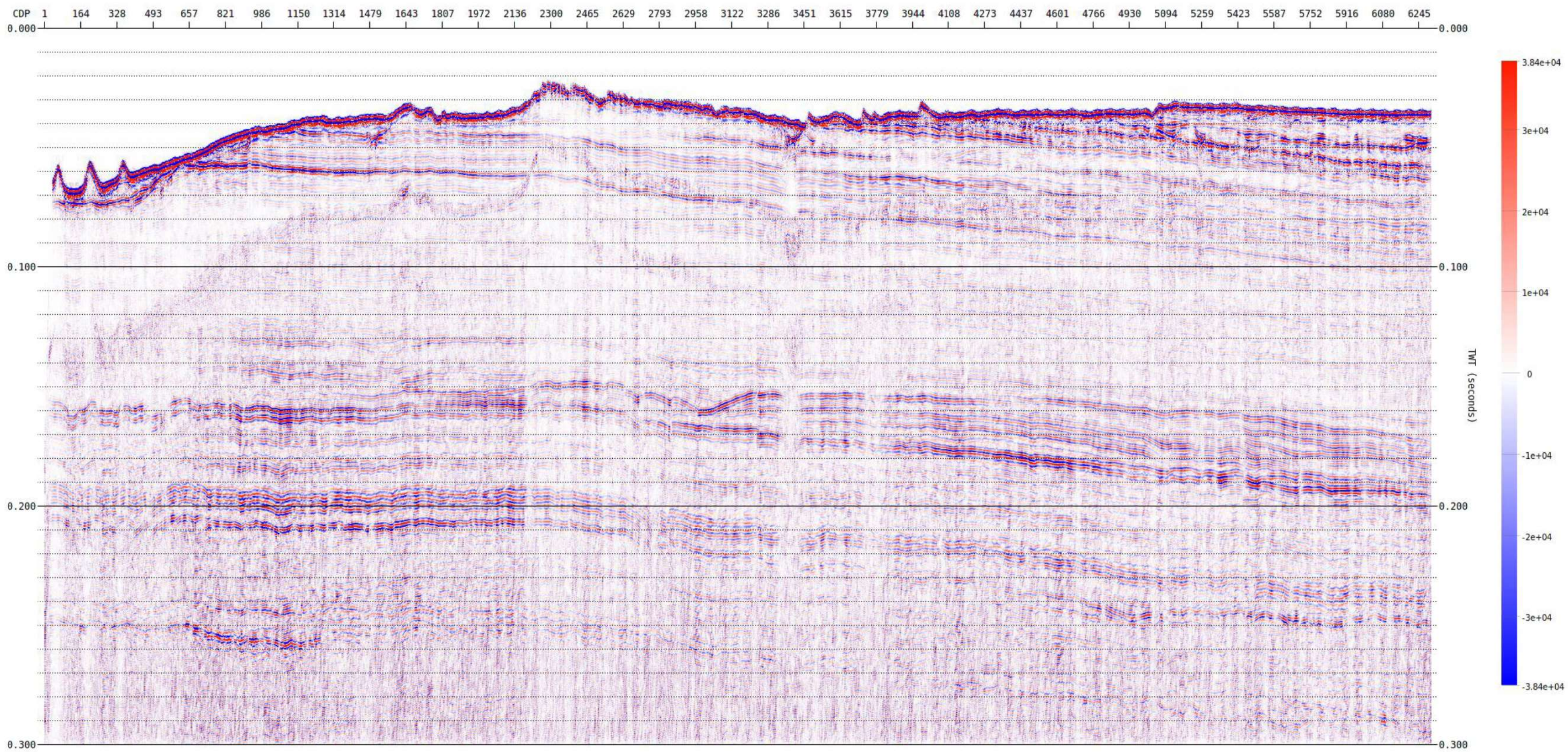


Figure 0.14: Final Stack after post migration processing (Gabor deconvolution and NLMEAN).

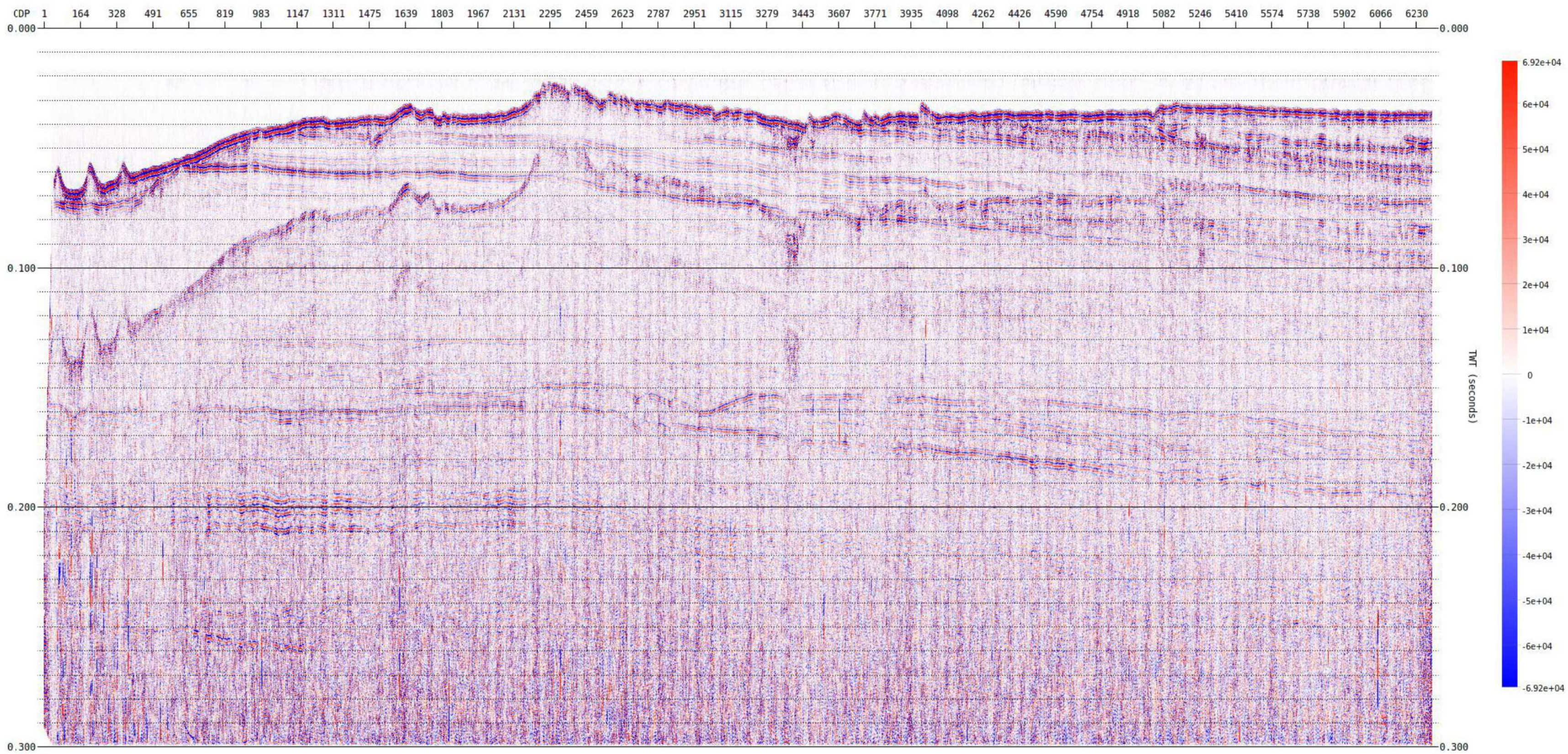


Figure 0.15: Brute stack to compare with final result

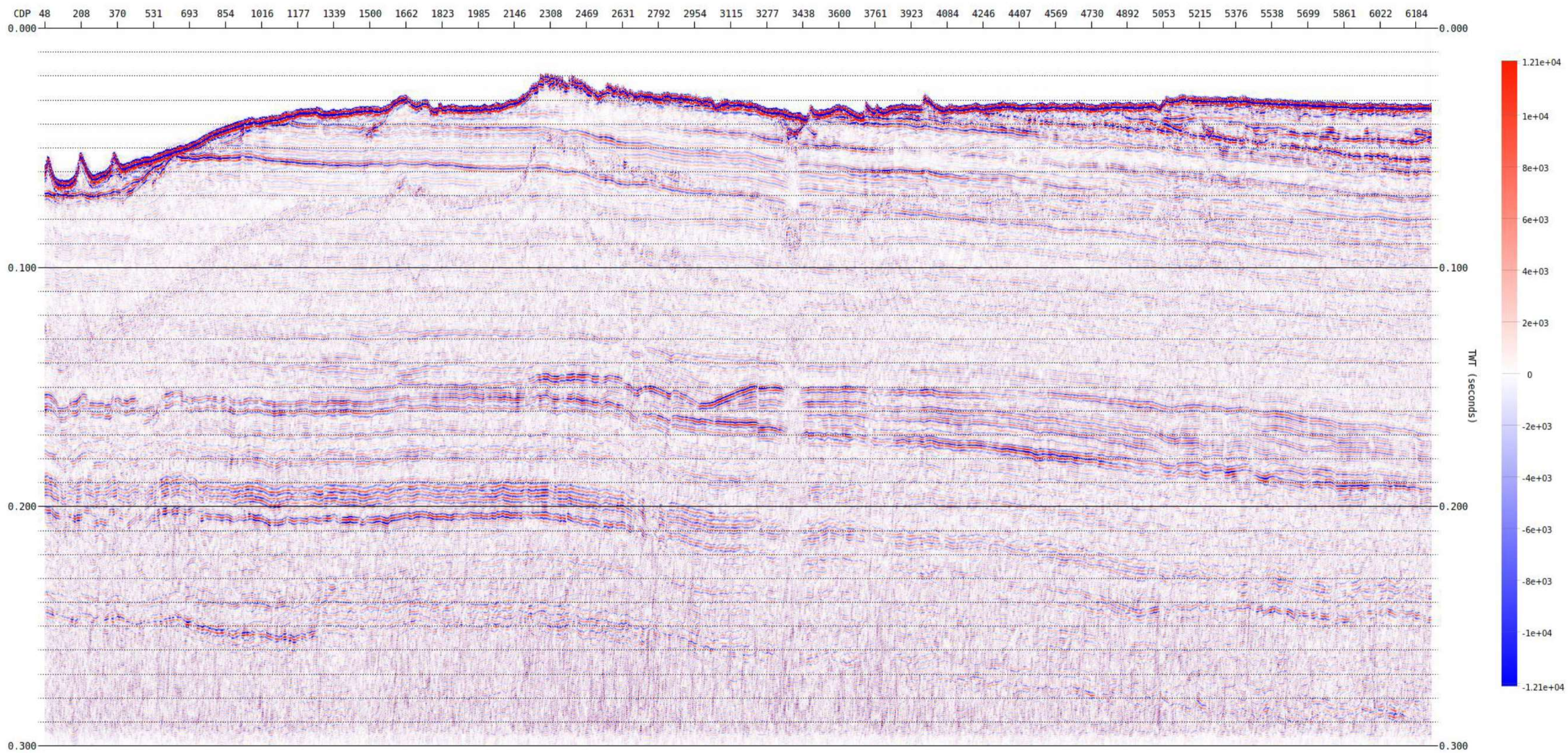


Figure 0.16: Final stack equalized amplitude

F. DEPTH STACKS OF SPARKER LINE 1_TS_01

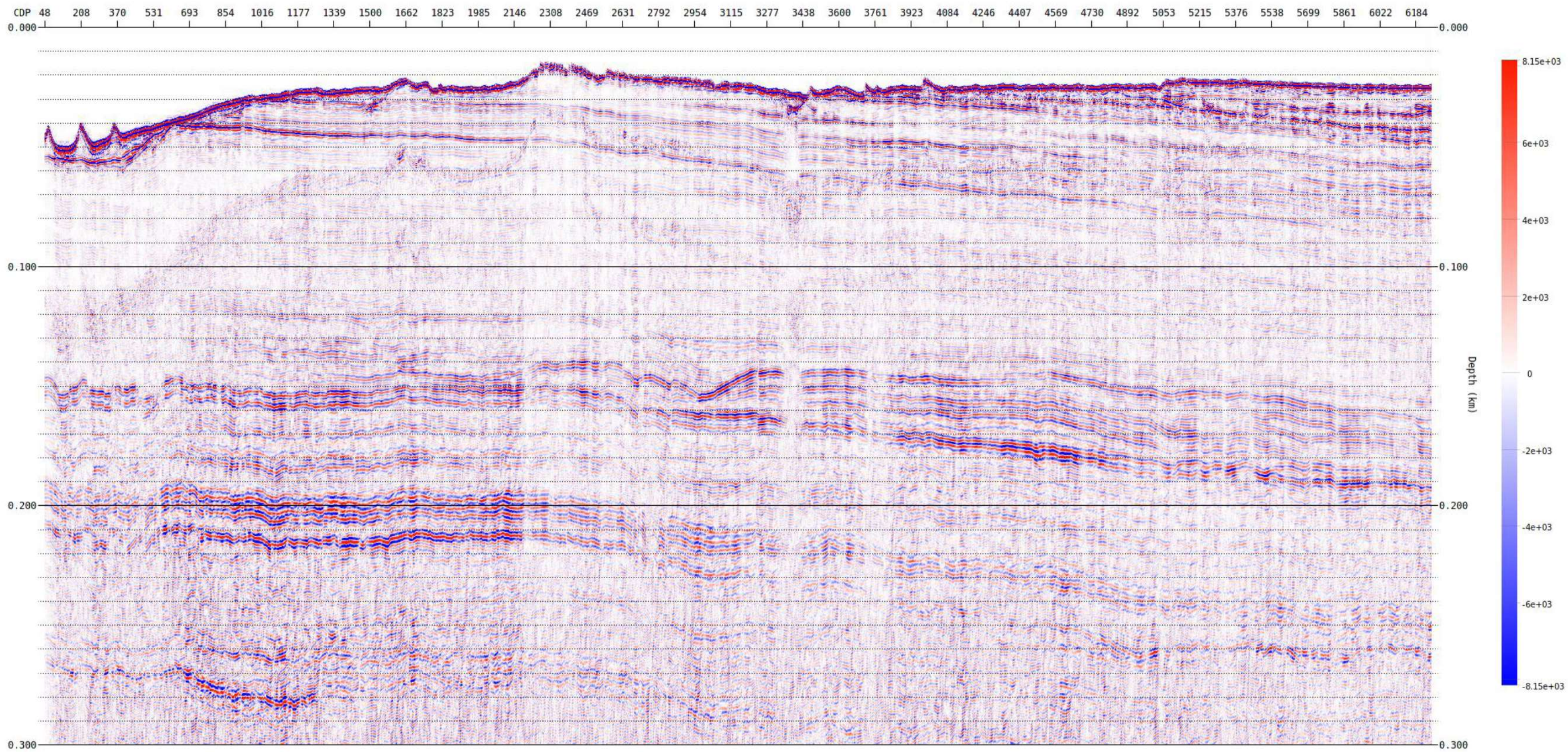


Figure 0.17: Final section in depth true amplitude

G. MINIGUN NEAR TRACE: EXAMPLE OF A NEAR TRACE SECTION

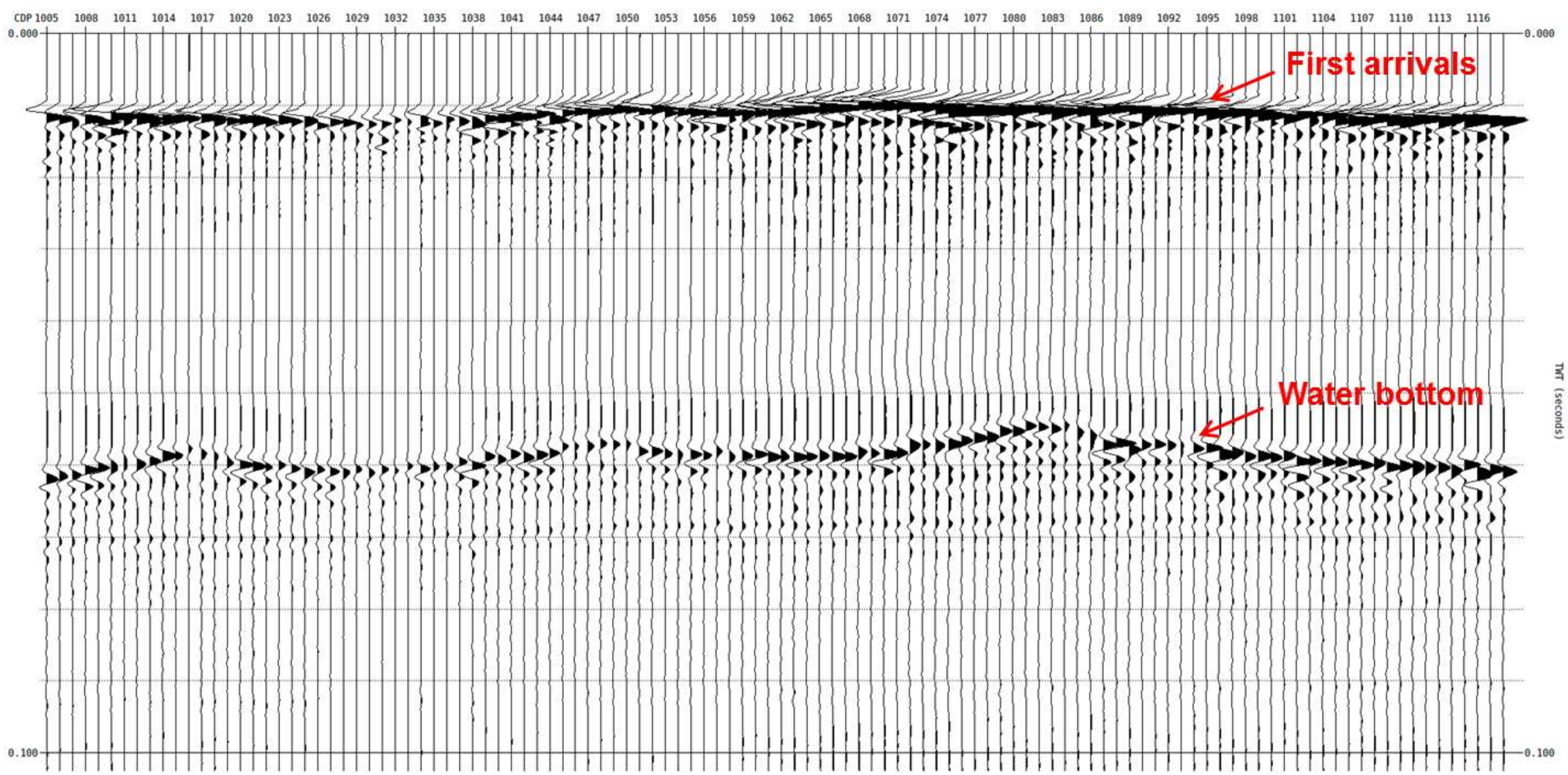


Figure 0.18: Line M570 near trace gather zoom

H. MINIGUN SHOT GATHERS FROM LINE M570

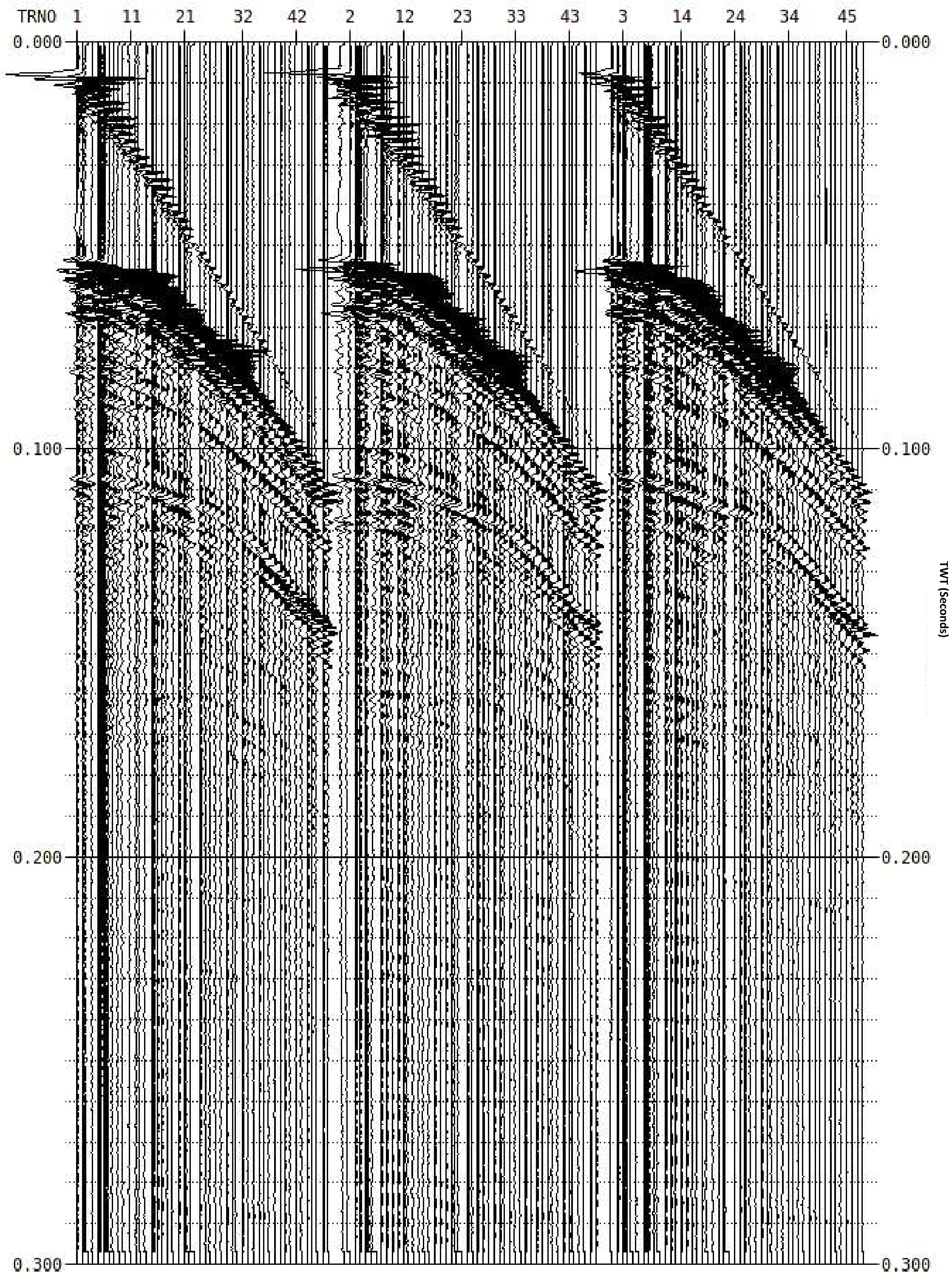


Figure 0.19: Minigun raw shots

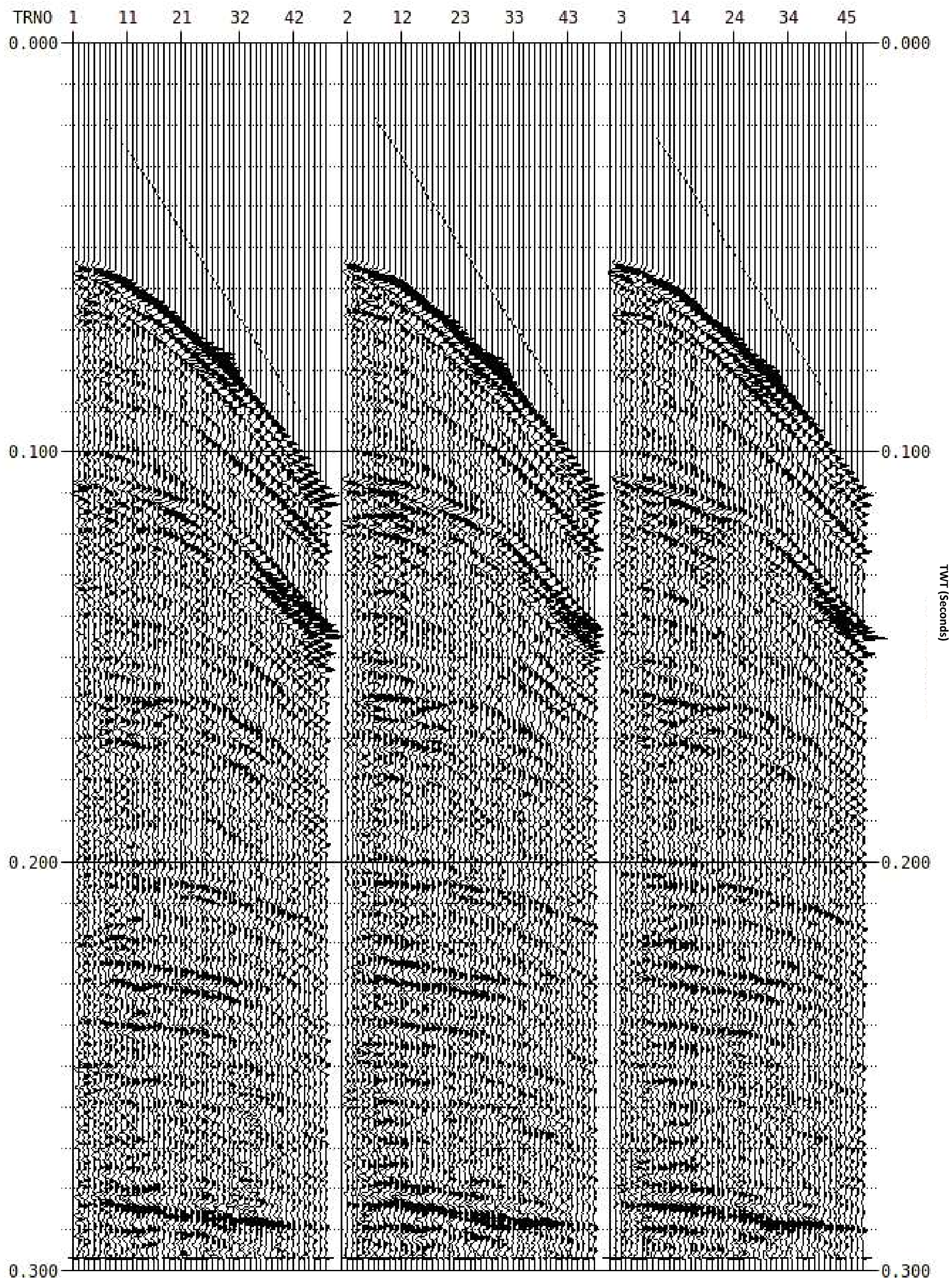


Figure 0.20: Minigun shots after edit

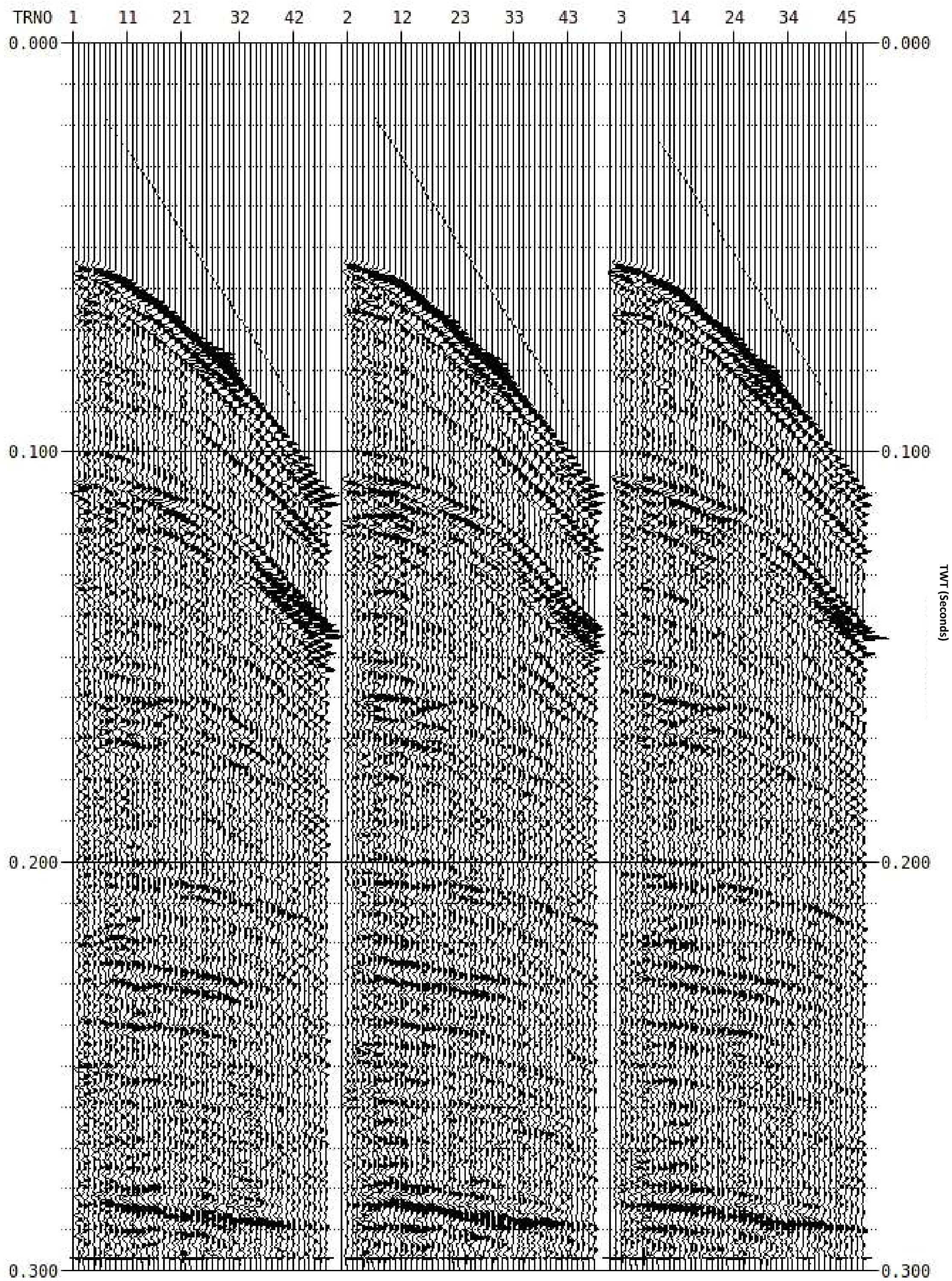


Figure 0.21: Minigun shots after denoise

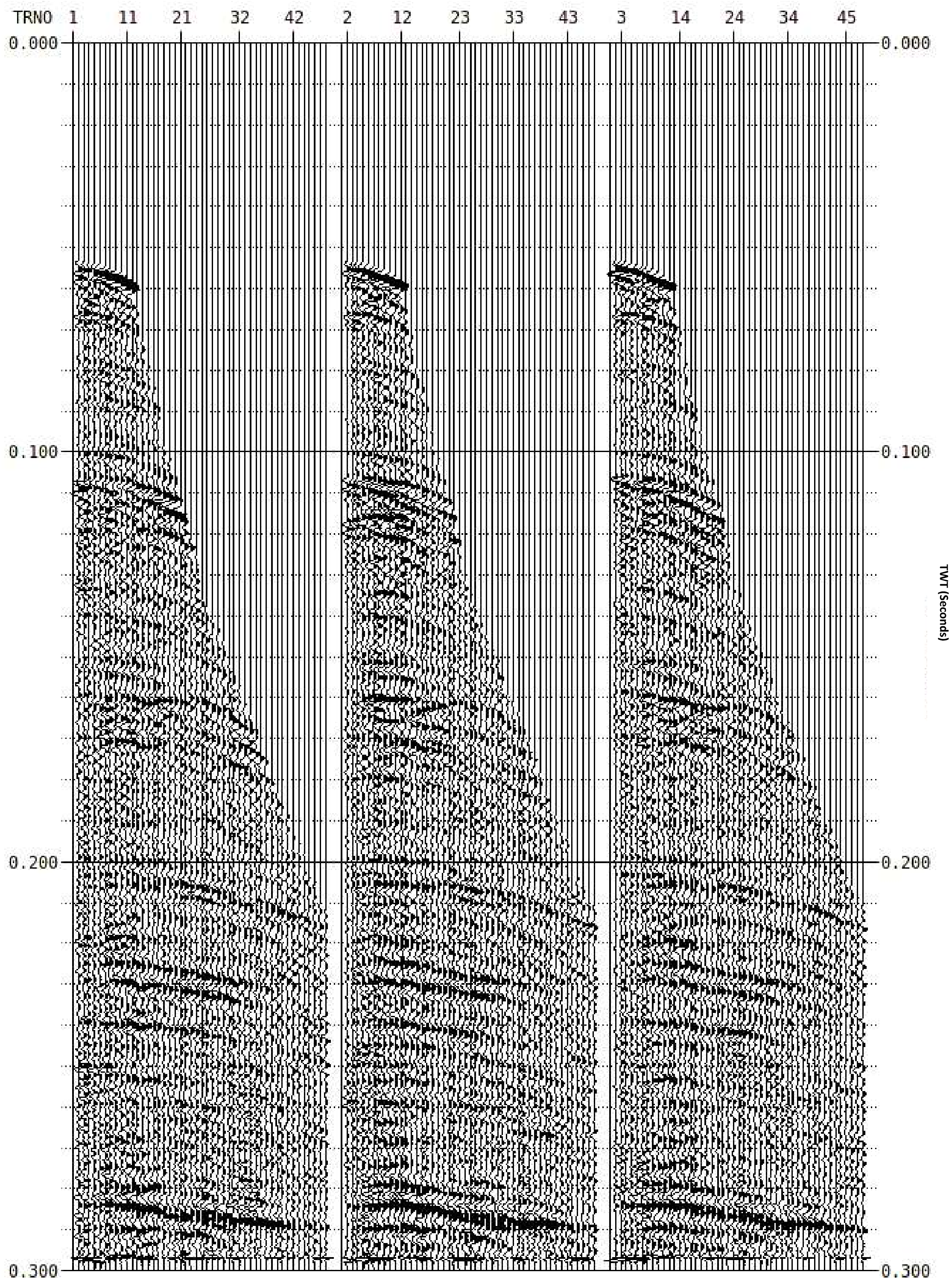


Figure 0.22: Minigun shots after residual statics corrections – The routines are applied on the NMO-corrected and muted CDP gather, note the effect of the mute back in shot gathers.

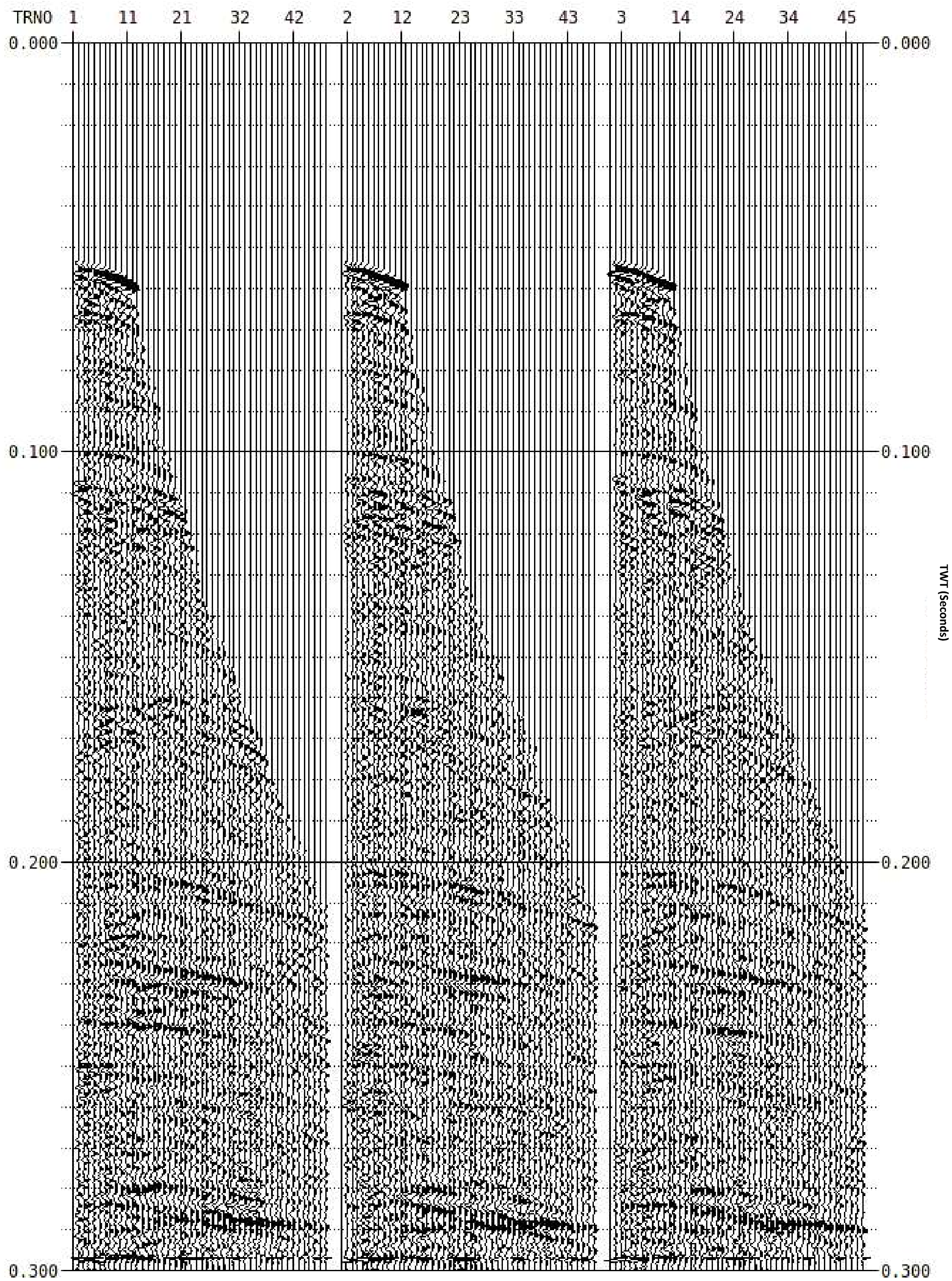


Figure 0.23: Minigun after SRME

I. STACKS OF MINIGUN LINE M570: PRE-STACK ROUTINES

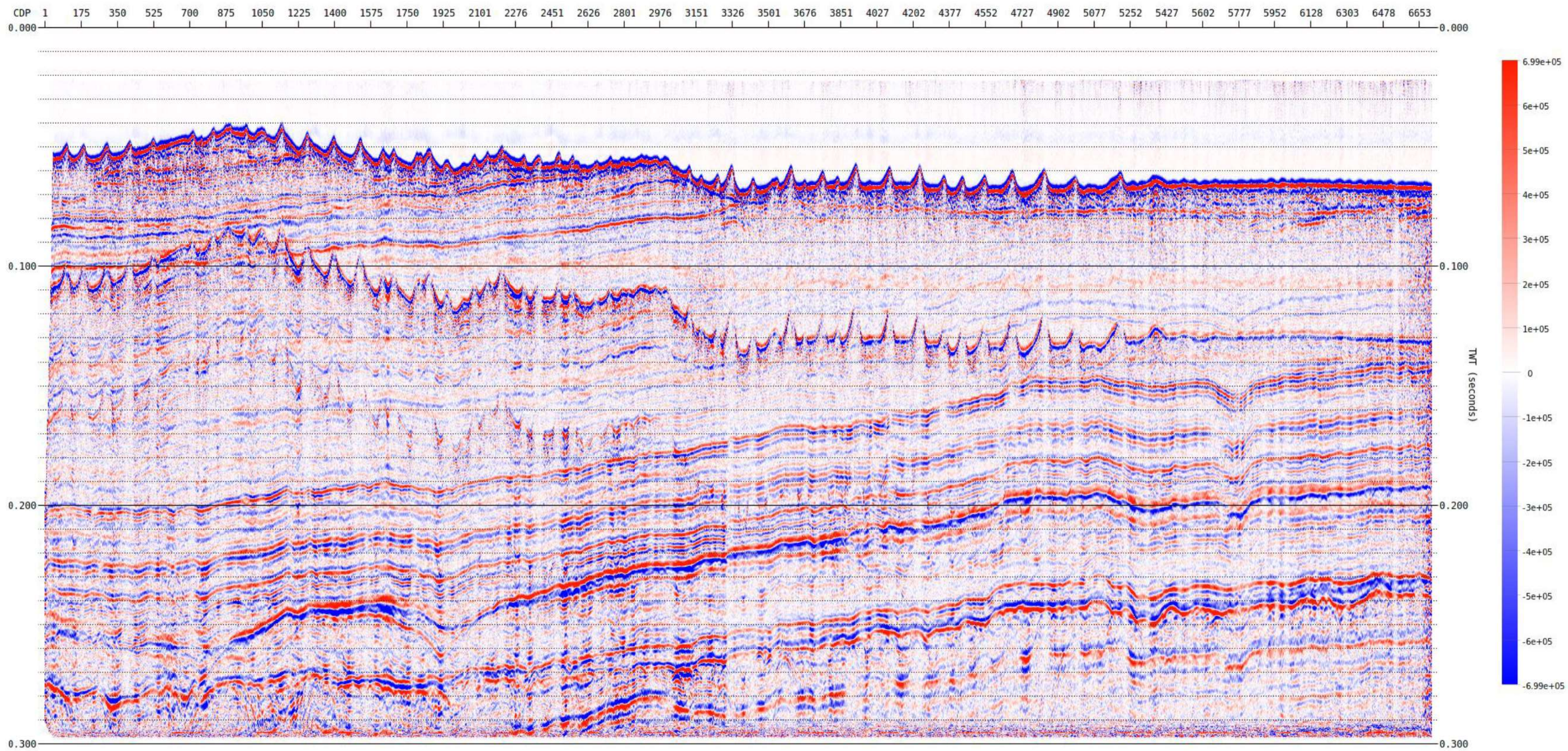


Figure 0.24: Brute stack

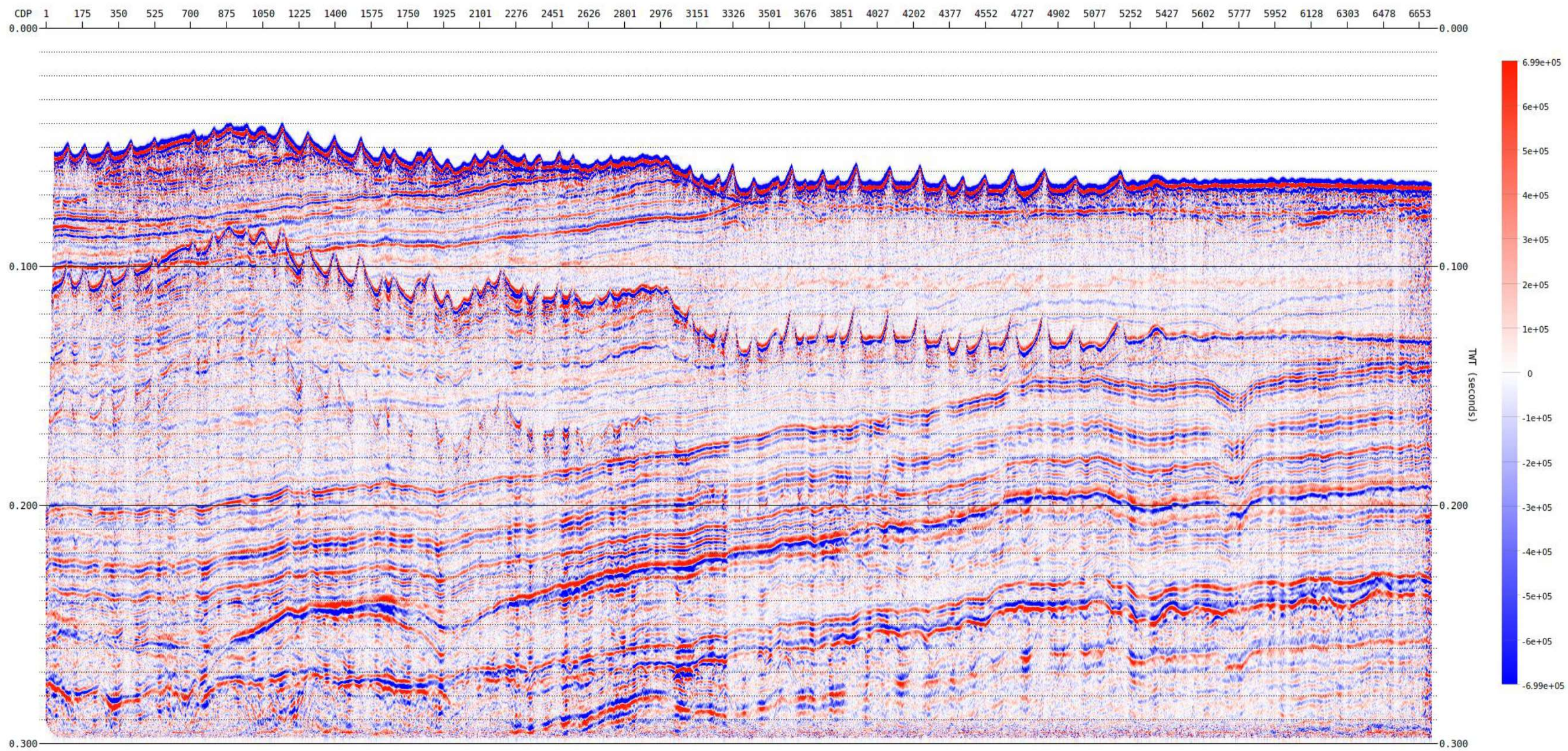


Figure 0.25: Stack after denoise

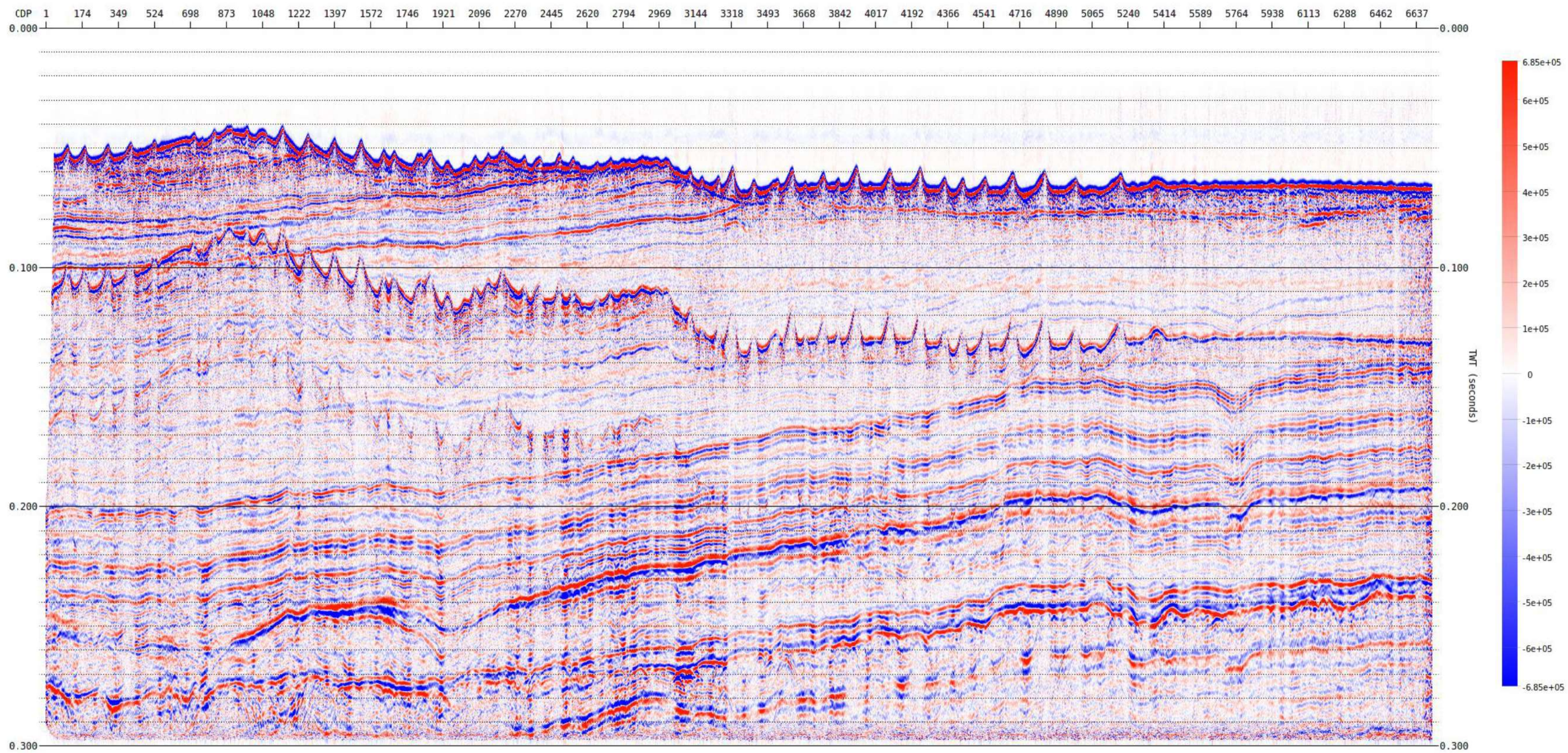


Figure 0.26: Stack after residual statics correction

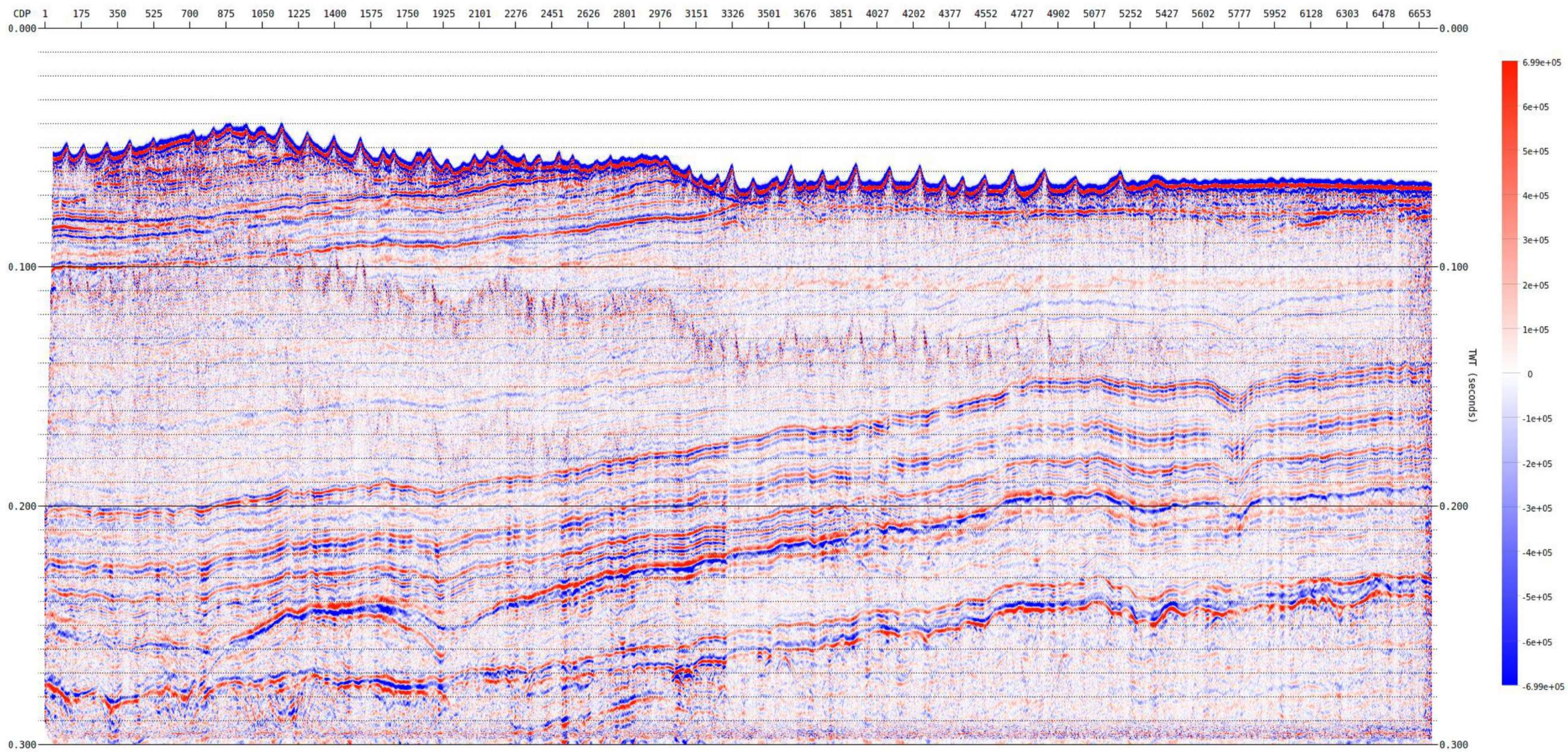


Figure 0.27: Stack after SRME

J. VELOCITY ANALYSIS: EXAMPLE OF VELOCITY PICKING

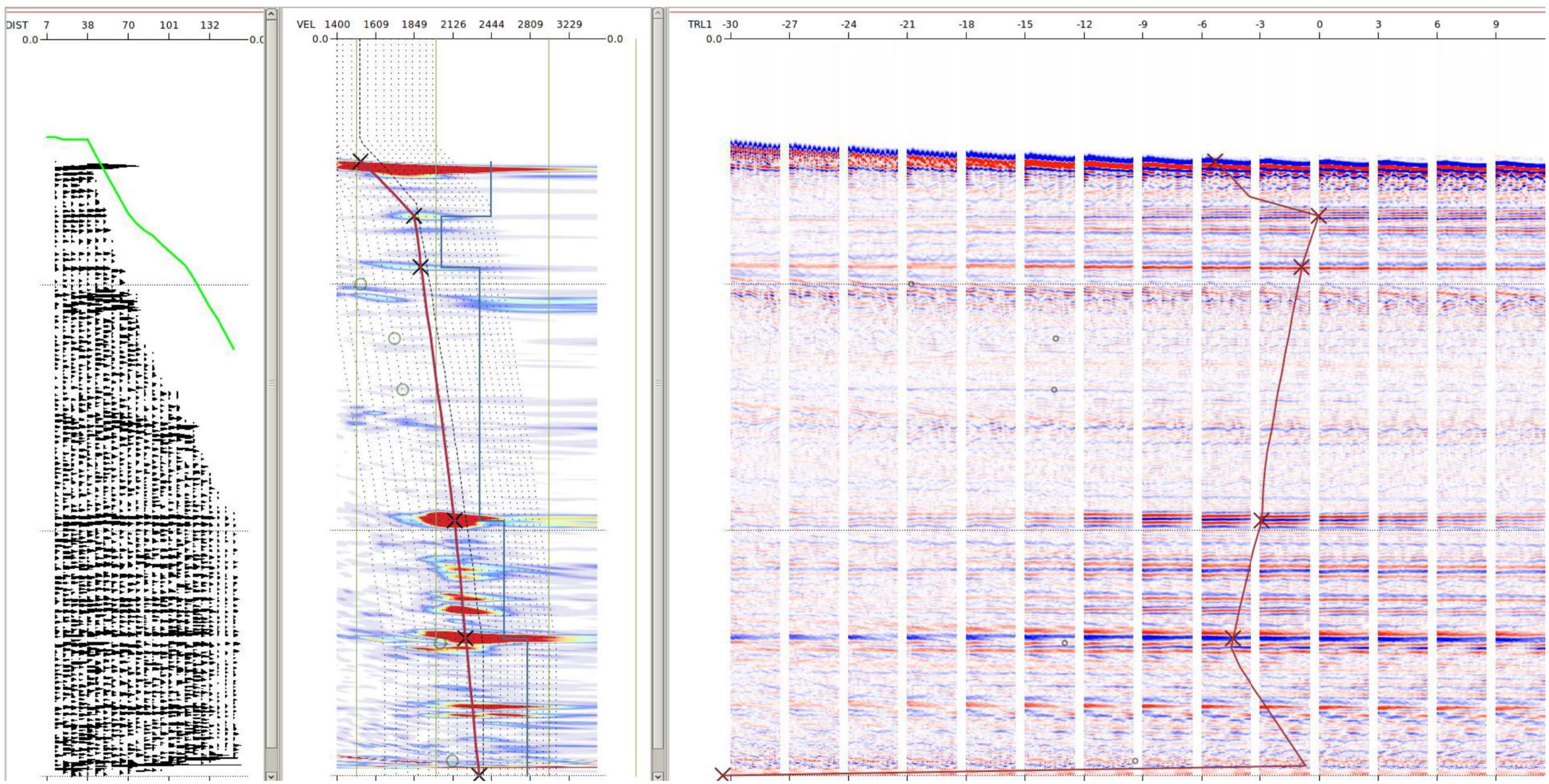


Figure 0.28: Minigun line M570 CDP Gather (left) – semblance (centre) – constant percentage velocity stack (right).

K. STACKS OF MINIGUN LINE M570: POST-STACK ROUTINES

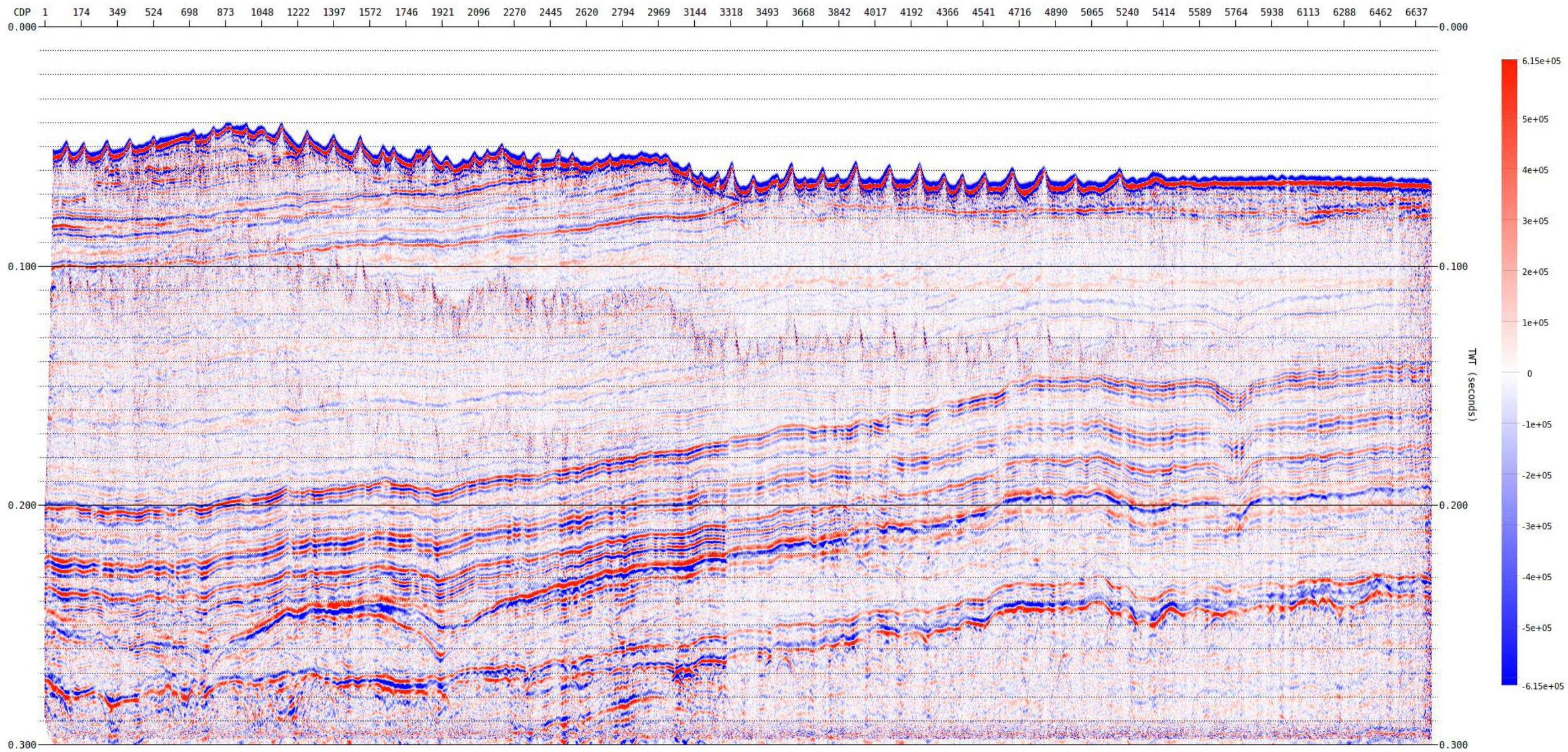


Figure 0.29: Stack after velocity picking

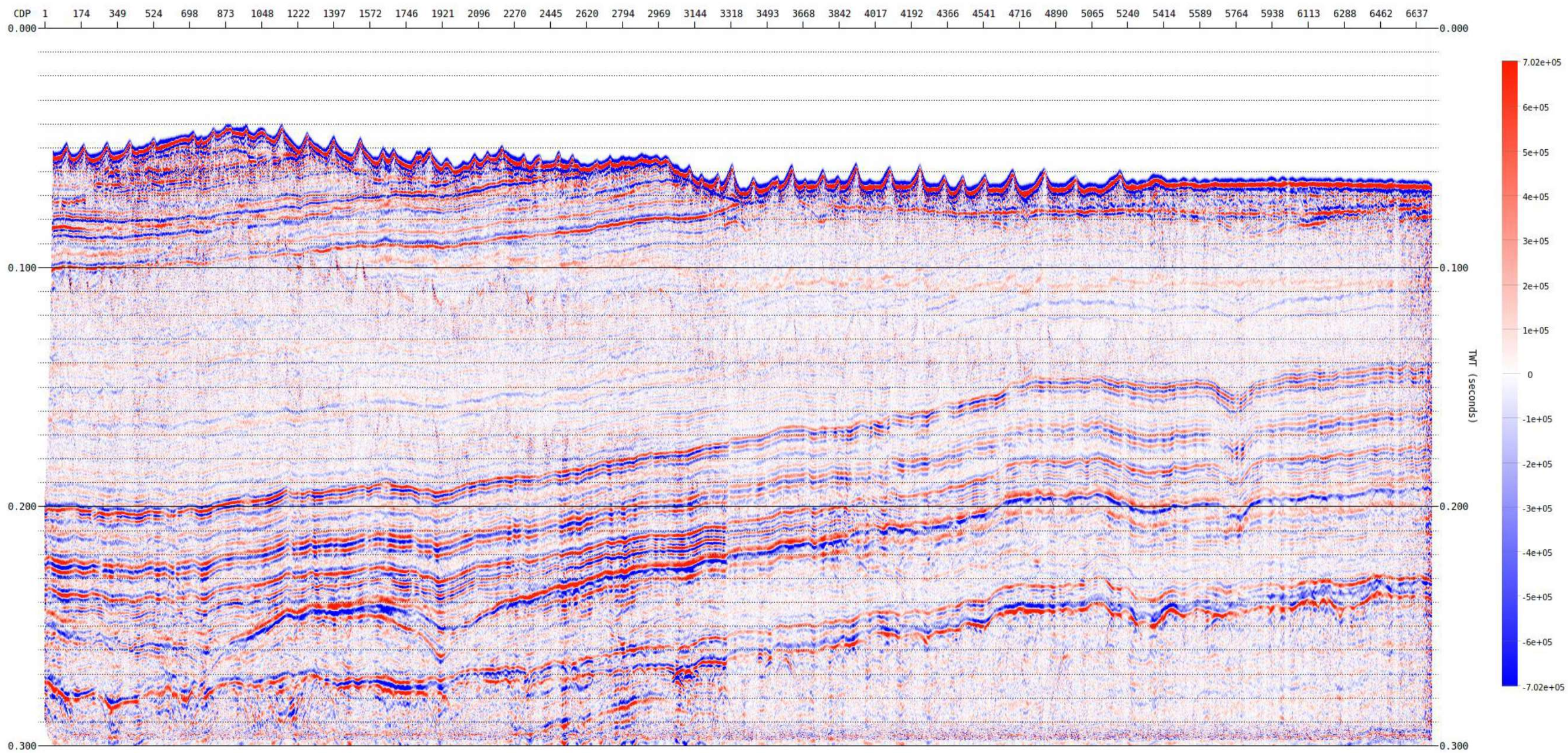


Figure 0.30: Stack after targeted demultiple

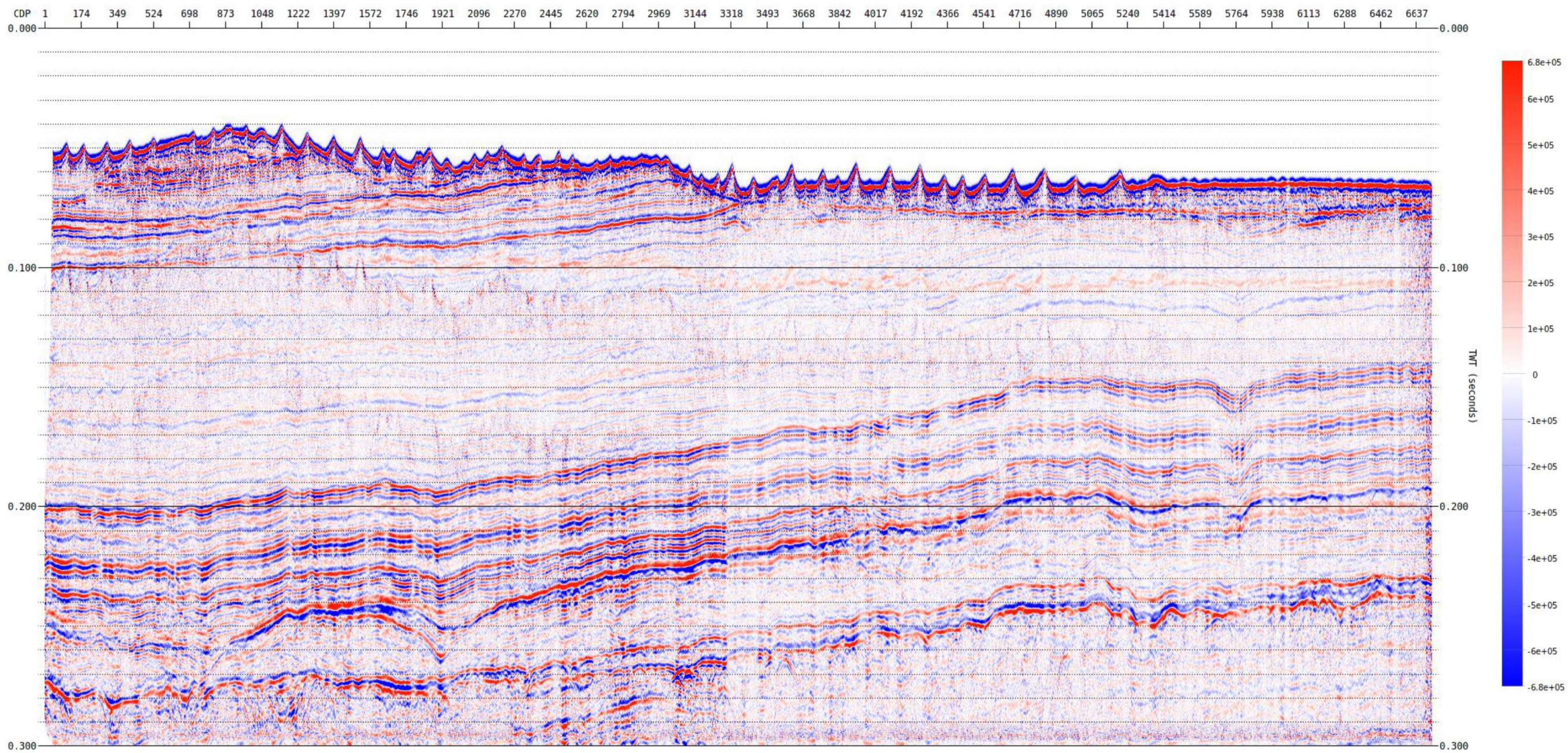


Figure 0.31: Stack after FK filter

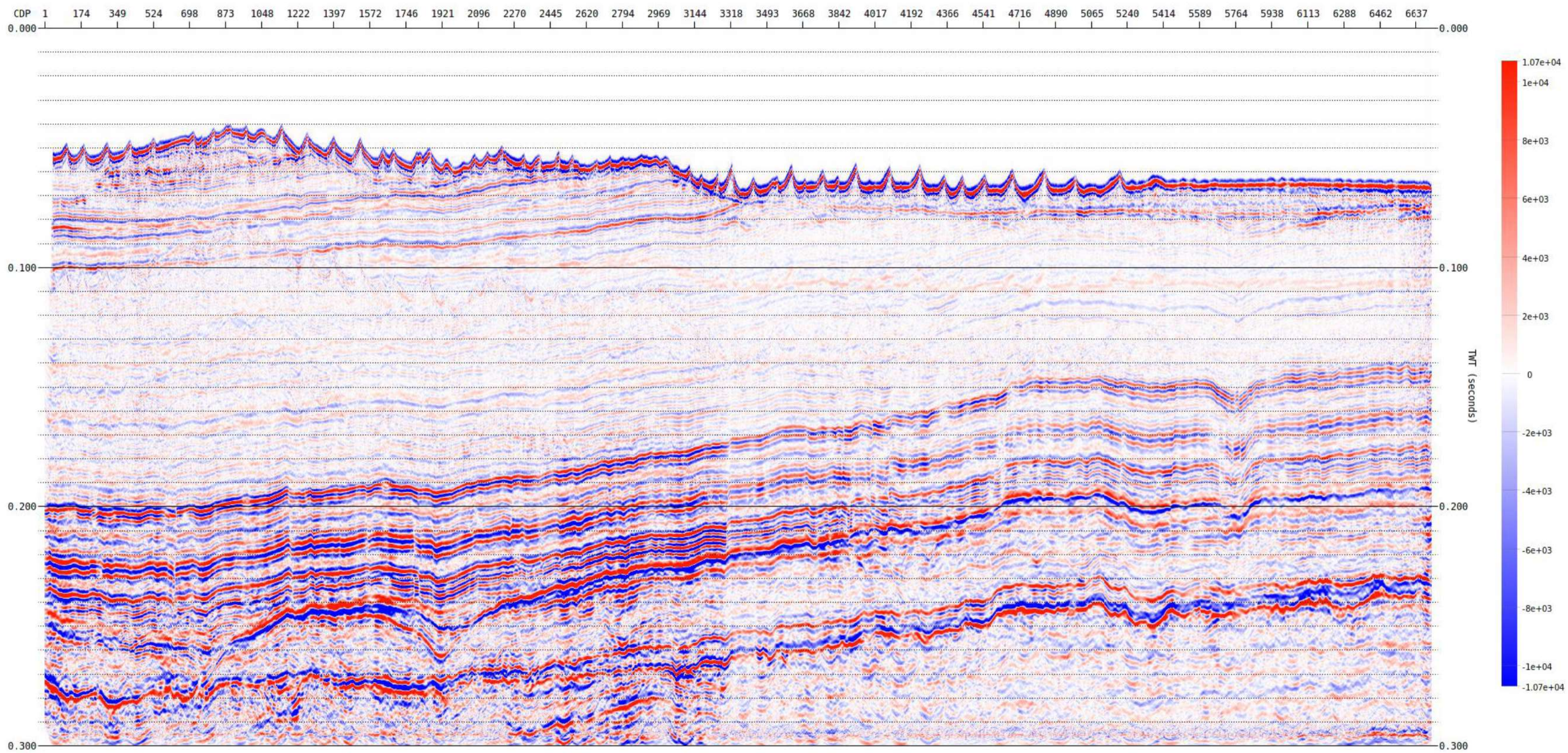


Figure 0.32: Stack after migration

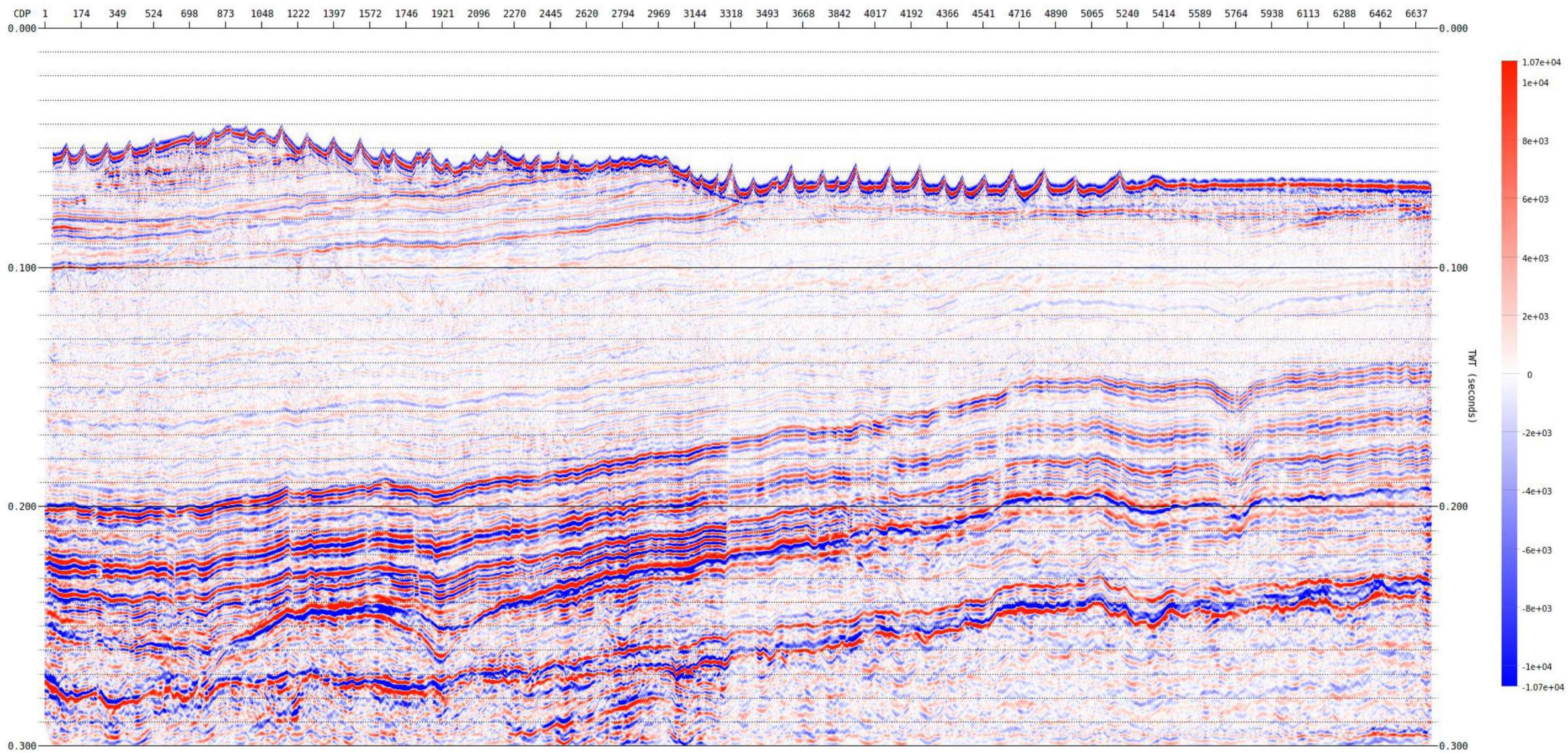


Figure 0.33: Final true amplitude after time variant filter

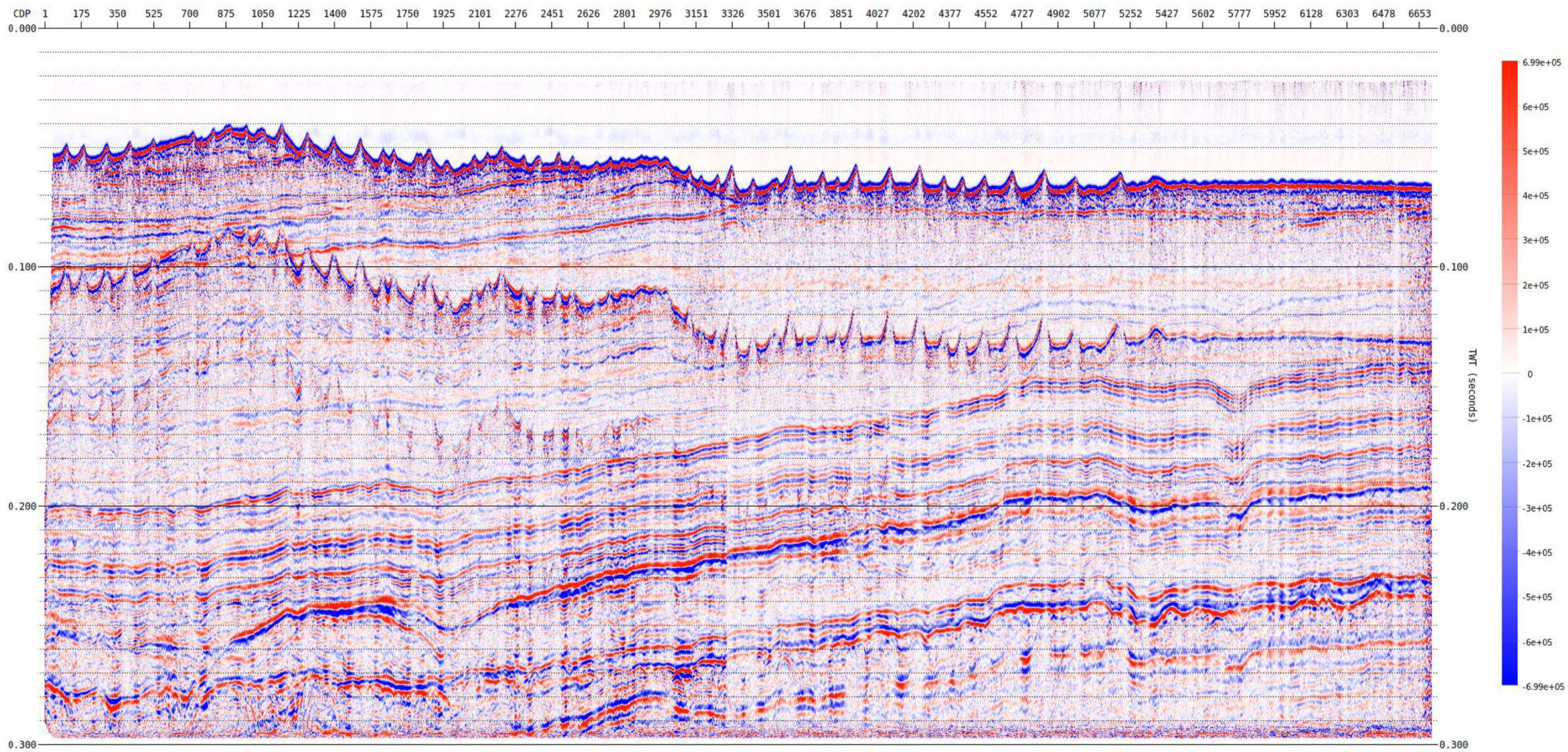


Figure 0.34: Brute stack for comparison with final stack

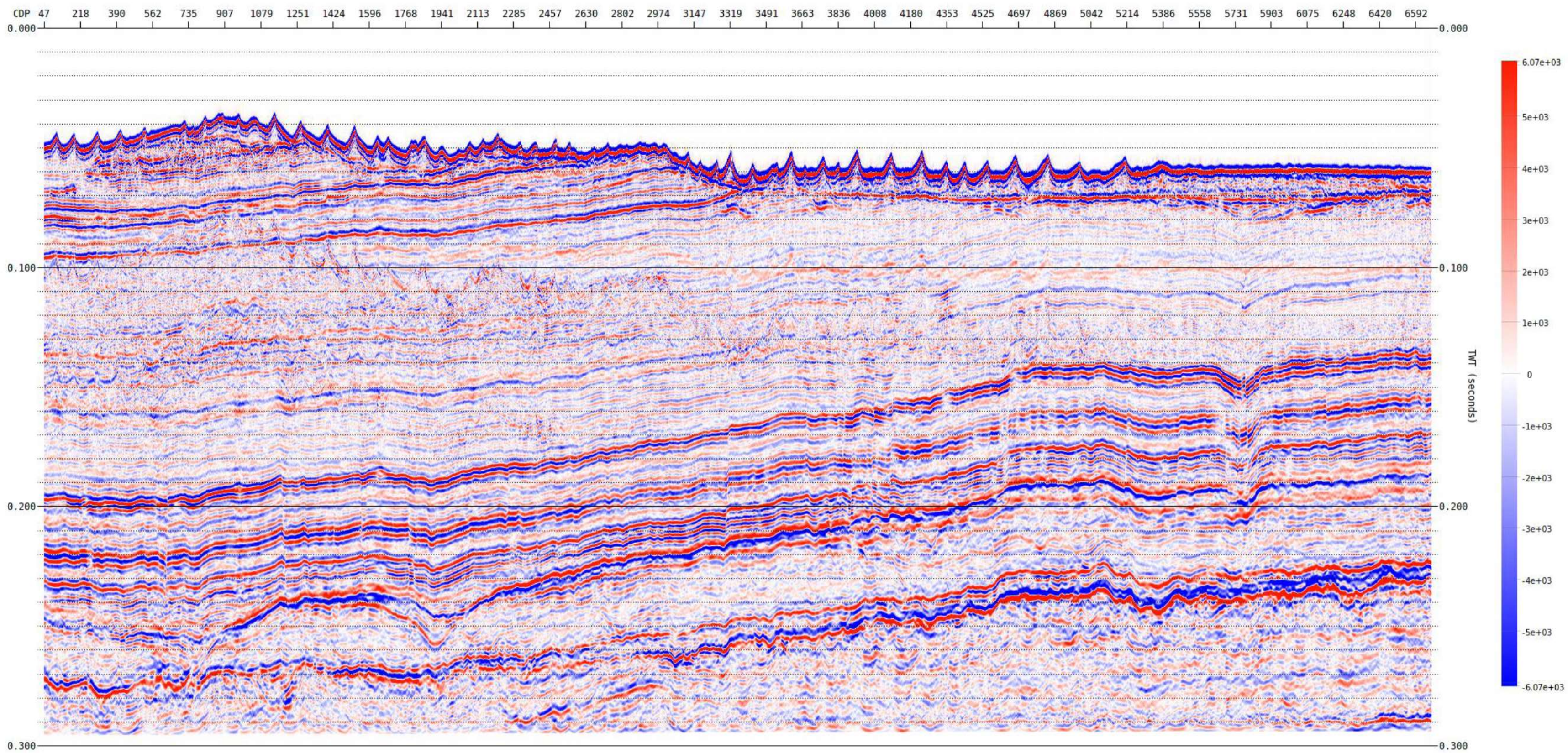


Figure 0.35: Final equalized amplitude section

L. DEPTH STACK OF MINIGUN LINE M570

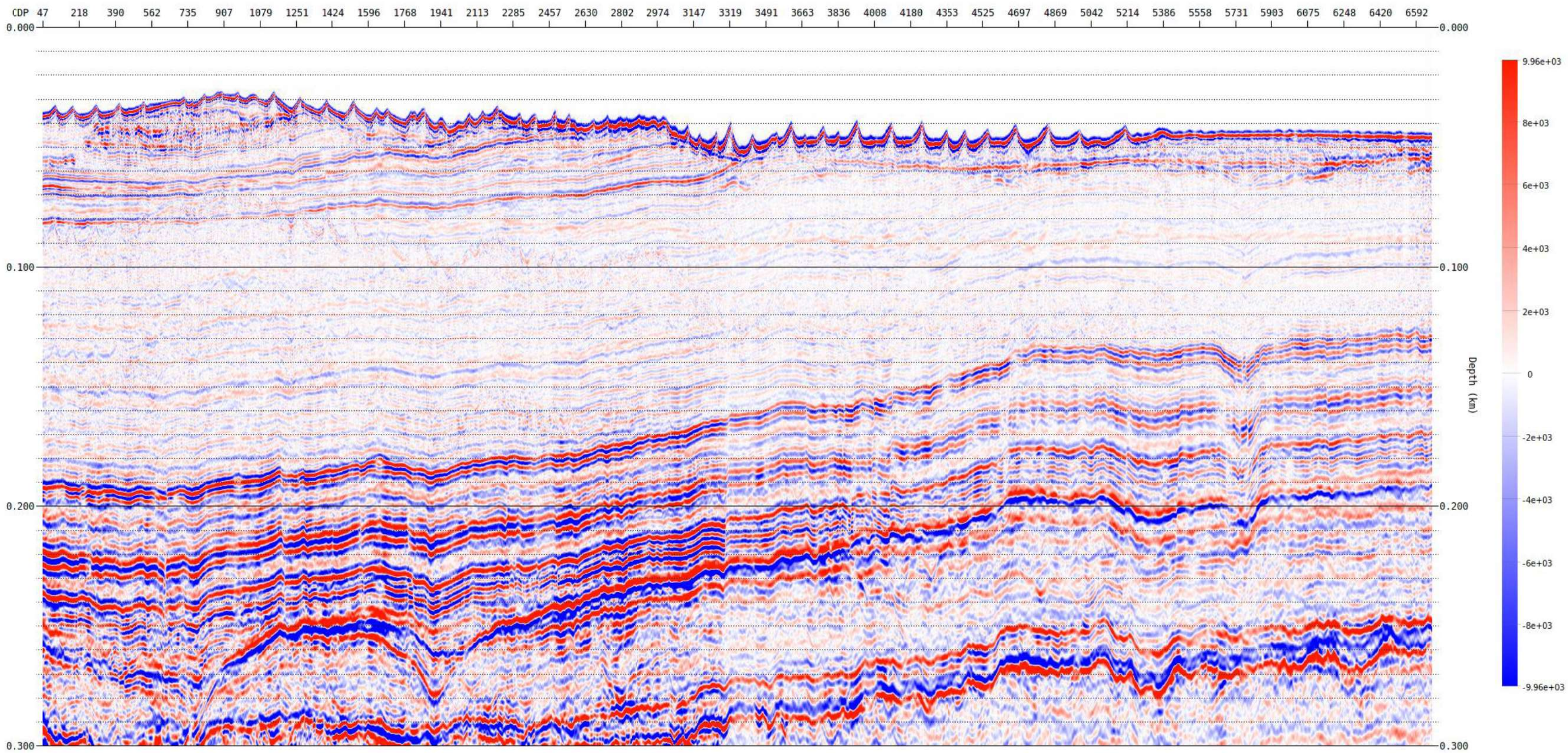


Figure 0.36: Final true amplitude depth section

M. FEATHER ANGLE COMPARISON

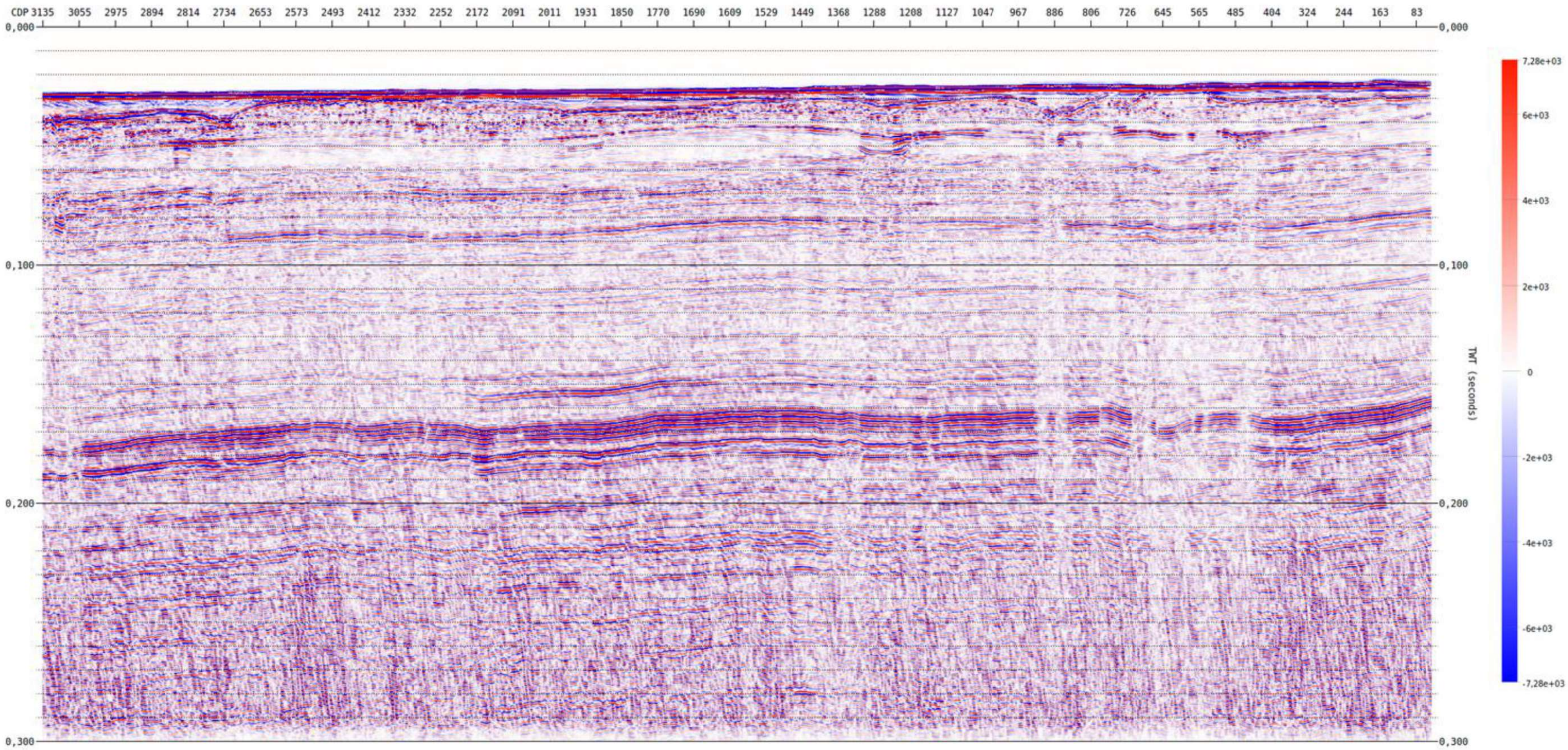


Figure 0.37: Sparker line 2B_TS_27_B - Final Stack - True Amplitude Migrated – Feather angle 11P.

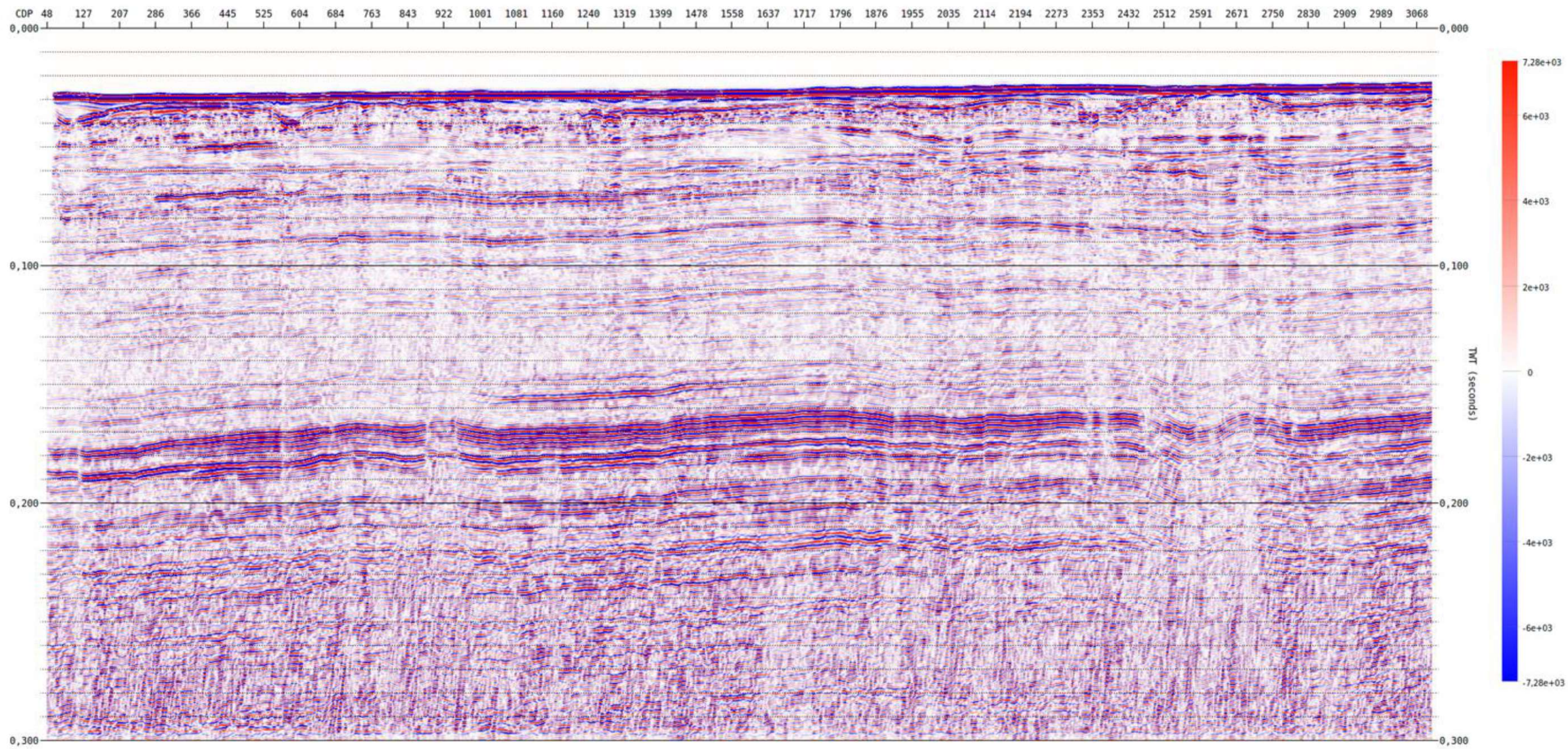


Figure 0.38: Sparker line 2B_TS_28 - Final Stack - True Amplitude Migrated – Feather angle 16P.

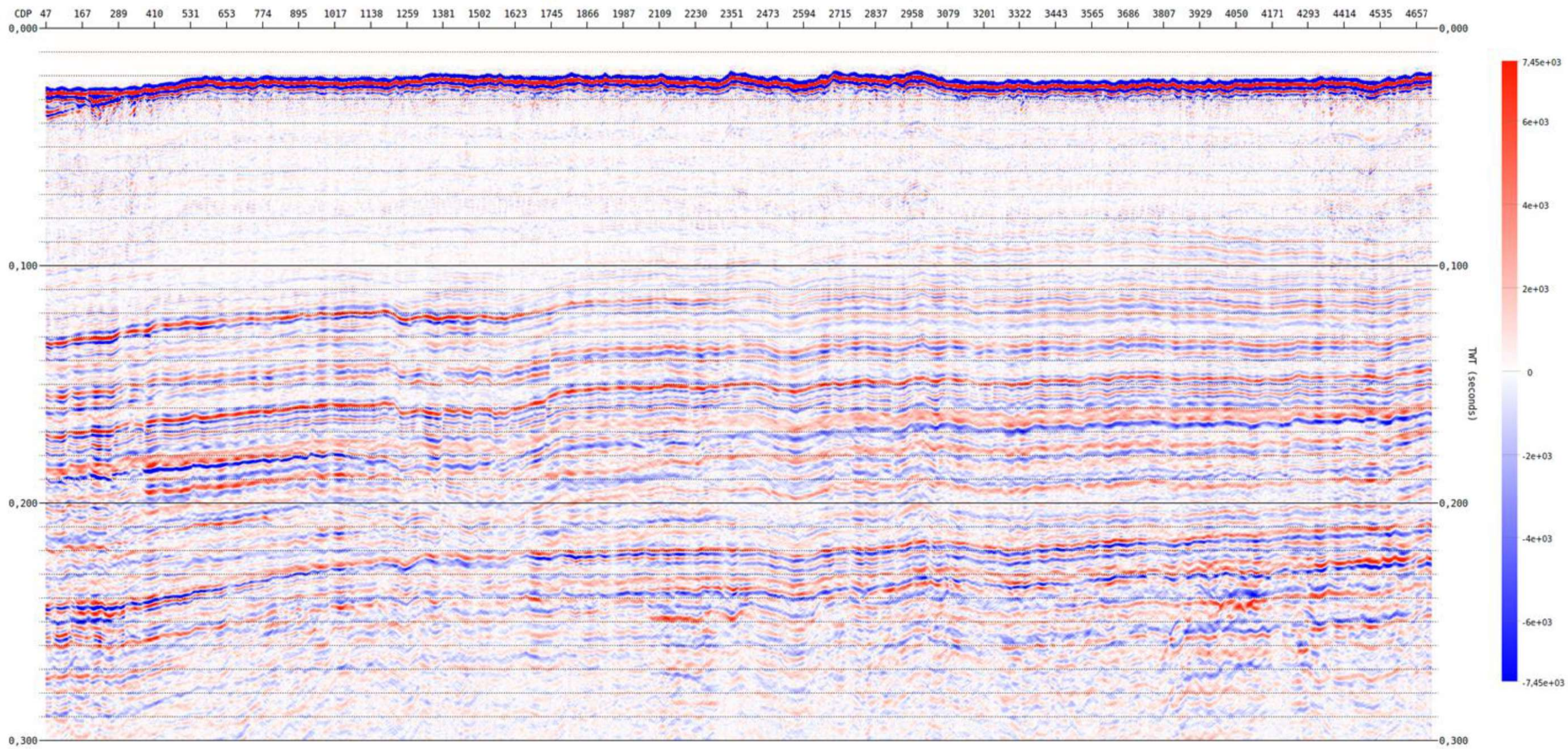


Figure 0.39: Minigun line 3_TG_25_A - Final Stack - True Amplitude Migrated – Feather angle 9.6P.

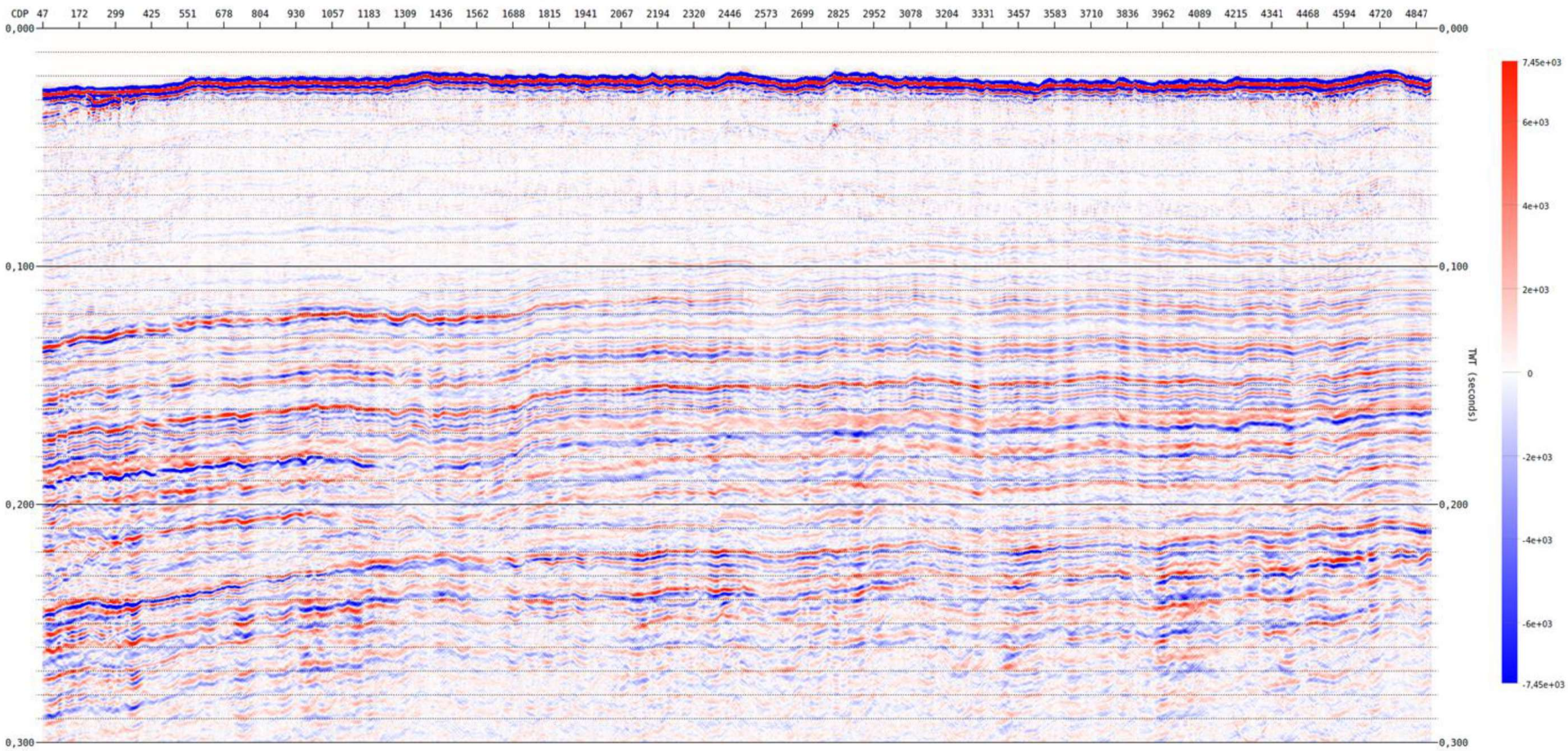
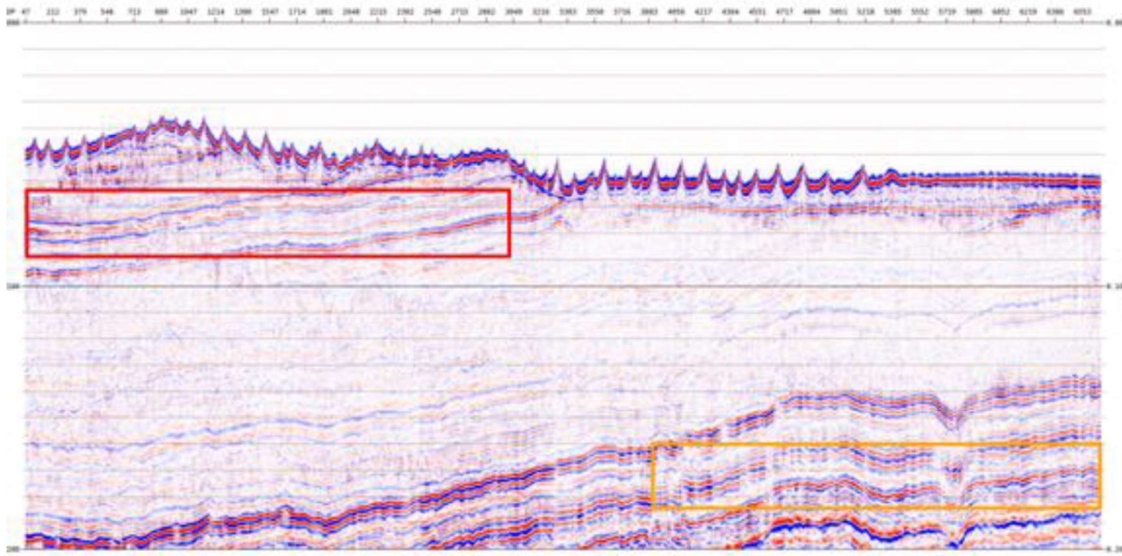
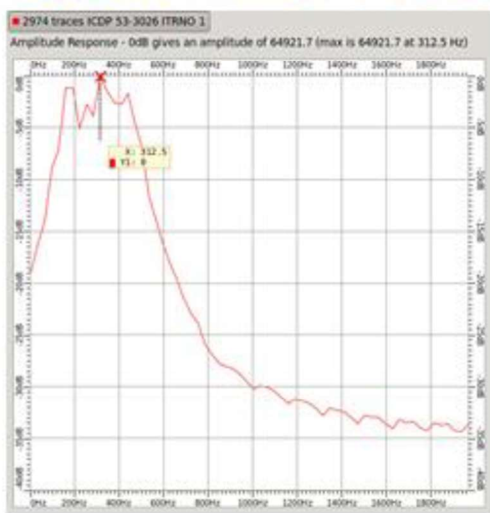
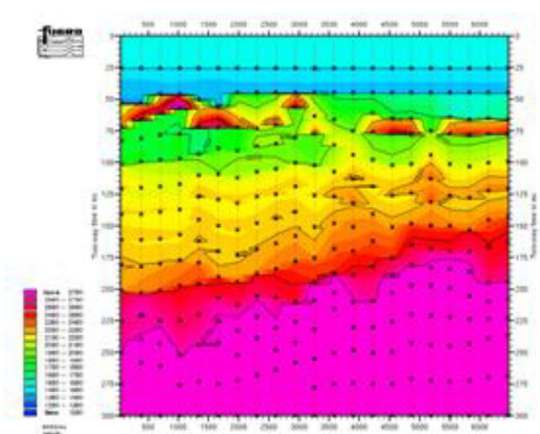


Figure 0.40: Minigun line 3_TG_24 - Final Stack - True Amplitude Migrated – Feather angle 19S.

N. RESOLUTION: SPECTRAL ANALYSIS AND RESOLUTION ESTIMATION

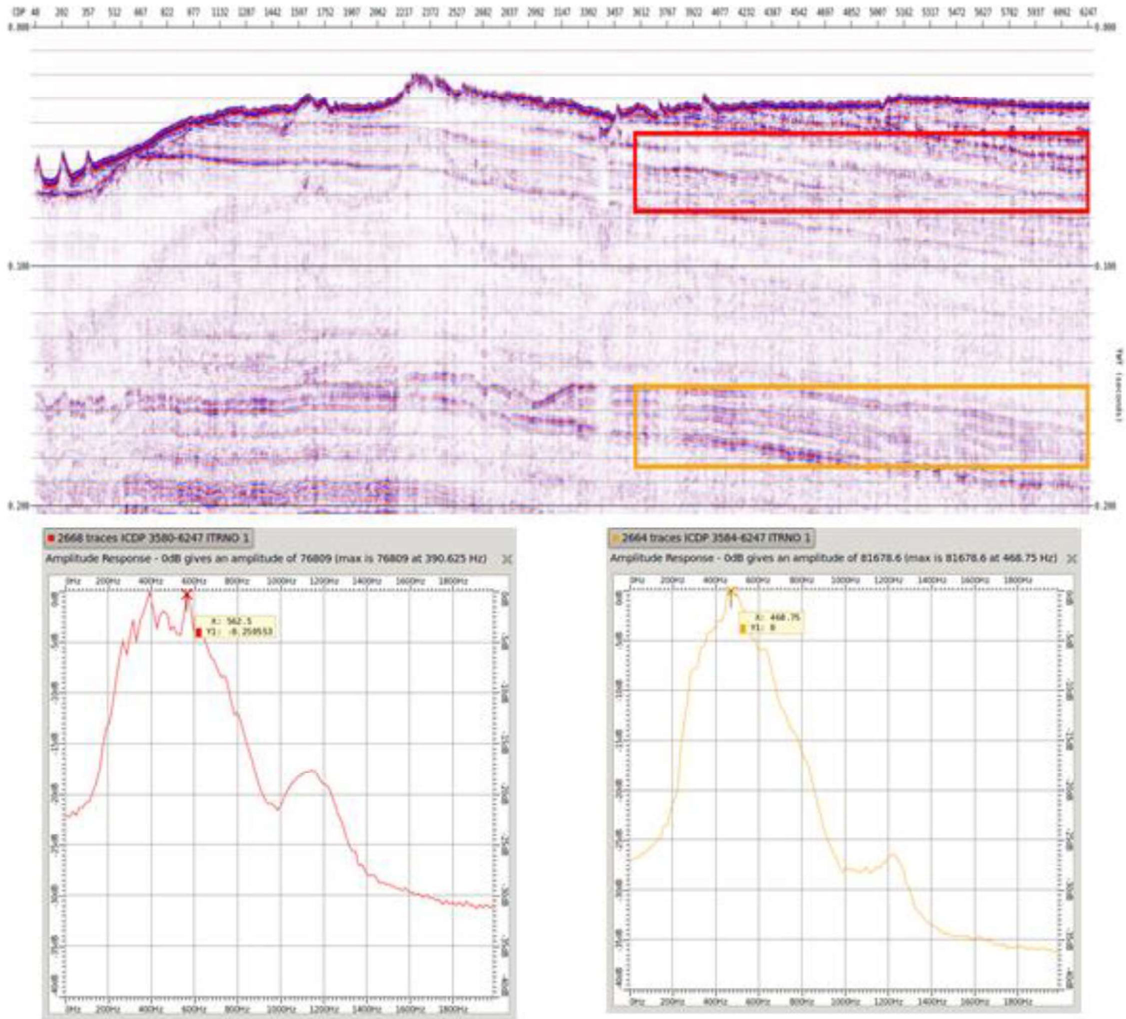


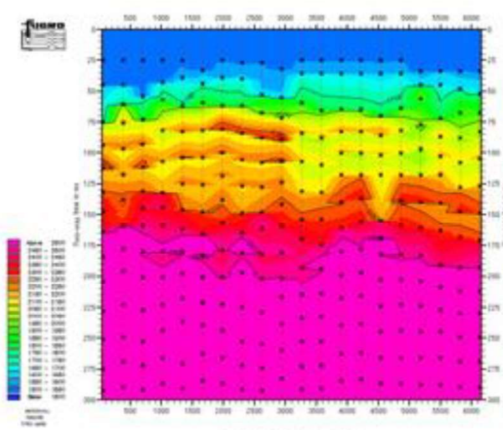




	Lowest value – loose sediments	Highest value – hard sediments	Lowest value – loose sediments	Highest value – hard sediments
P wave Velocity (m/s)	1600	2700	1600	2700
Frequence (Hz)	313	313	188	188
Lamda (m)	5,1	8,6	8,5	14,4
Lambda/4 (m)	1,3	2,2	2,1	3,6

Figure 0.41: Resolution spectral analysis for minigun data.





	Lowest value – loose sediments	Highest value – hard sediments	Lowest value – loose sediments	Highest value – hard sediments
P wave Velocity (m/s)	1600	2700	1600	2700
Frequence (Hz)	563	563	469	469
Lamda (m)	2,8	4,8	3,4	5,7
Lambda/4 (m)	0,7	1,2	0,9	1,4

Figure 0.42: Resolution spectral analysis for sparker data.

O. UNCERTAINTIES EVALUATION ON INTERSECTIONS BETWEEN FINAL STACK IN DEPTH

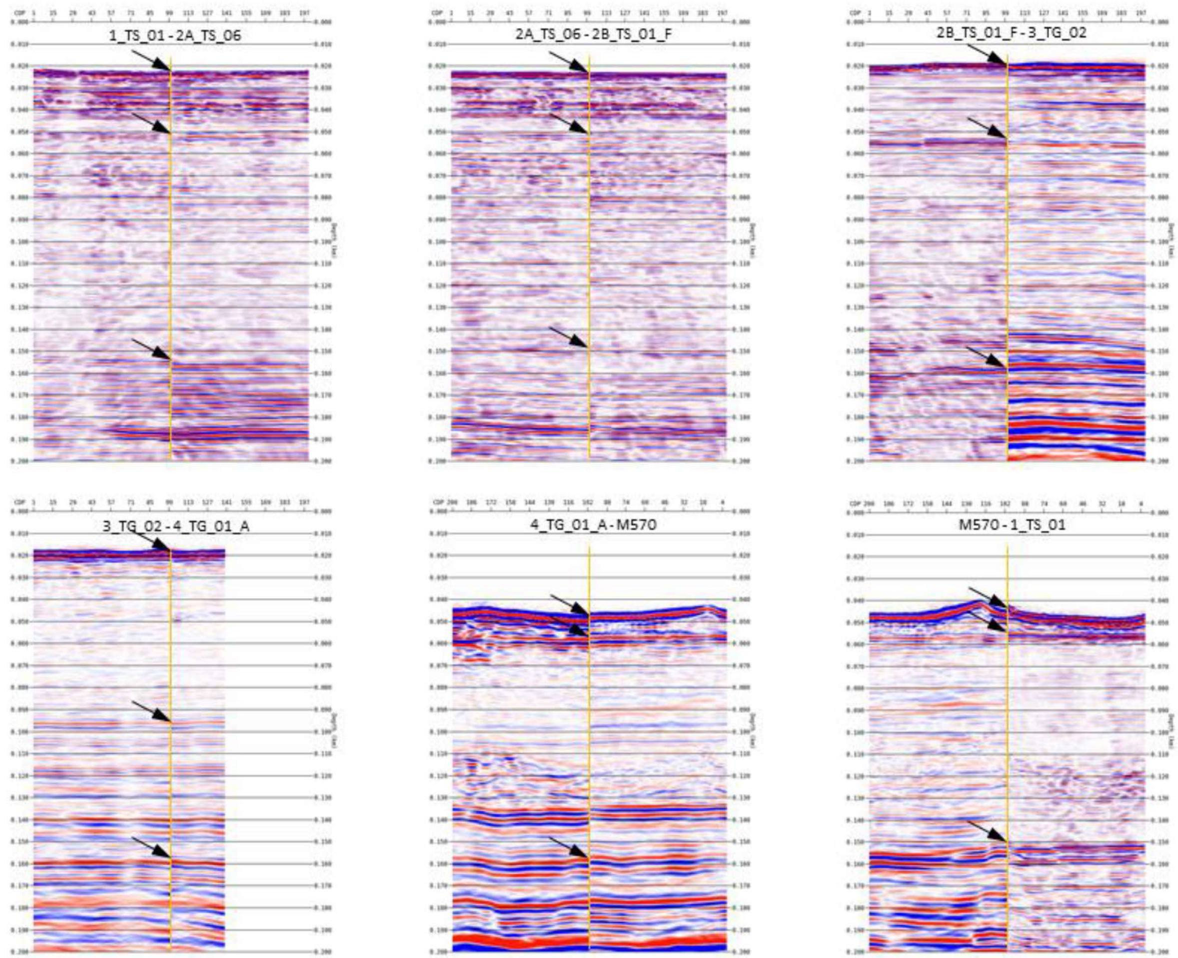


Figure 0.43: Intersections between final stack in depth.

Appendix Table 1: Intersections mismatch

Intersections	Depth of obs. I (m)	Mismatch I (m)	Depth of obs. II (m)	Mismatch II (m)	Depth of obs. III (m)	Mismatch III (m)	Note
1_TS_01-2A_TS_06	22	0	50	<0.5	155	<1	Sparker
2A_TS_06-2B_TS_01_F	23	0	50	<1.5	150	<1.5	Sparker
2B_TS_01_F-3_TG_02	18	<0.5	53	<1	155	<1	Sparker-Minigun: difference in amplitude
3_TG_02-4_TG_01_A	17	<0.5	95	<0.5	157	<1.5	Minigun
4_TG_01_A-M570	46	<1	58	<1	158	<2	Minigun
M570-1_TS_01	44	<2.5	58	<0.5	150	<1.5	Minigun - sparker, intersection on water bottom high

P. QC LOGS

Client: Vattenfall | **Vessel: Fugro Pioneer** | **Project No:** 16J369
Project: Windfarm | **THANET_BLOCK1**

QC Specs	Max Feather: +/- 7 between adj. lines	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.5	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

QC GEO : Ahmet Senocak / Danilo Seccia

A = ACCEPT; R = REJECT; M = MARGINAL

Geometrics GeoEI, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
GSO Sparker 360 tips, power 600/800 J
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, dhot int. 1.56 m Streamer Depth 0.5 m

Date	Seq No.	Line No.	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
5-Aug		1_TS_53	100	1426		99-1427	13.30	15.30	0.1	1.1			13S	A		Lost fix 969. 600J power. Noisy
5-Aug		1_TS_46	100	2021		99-2022	12.90	10.50	0.2	1.0			5,3P	A		600J power. Slight noise. Far channels not balanced. Noisy
5-Aug		1_TS_53_A	1000	2280		999-2281	15.10	14.80	0.1	1.5			1,7P	A		800J power
5-Aug		1_TS_48	100	1862		999-1862	13.10	13.40	0.3	1.0			20S	R		spiky. High FA at EOL
5-Aug		1_TS_51	100	1643		99-1643	18.00	18.90	0.1	1.6			13P	R		Very noisy, spikes through the line. Opposite current
5-Aug		1_TS_44	100	2246		99-2248	12.80	13.90	0.2	1.2			27S	R		Lost fix 2050, 2071 Noisy, spikes through the line. Strong current
6-Aug		1_TS_49_A	100	2623		99-2624	12	14	0.4	1.5			6S	A		Spiky.
6-Aug		1_TS_42	100	2402		99-2403	20	24	0.3	1.5			13P	R		Noisy, spikes through the line. Opposite current
6-Aug		1_TS_47	100	1909		99-1910	11.5	14.3	0.3	1.6			20S	R/A		Noisy, spikes through the line, strong cross current
6-Aug		1_TS_40	100	2566		99-2567	17.7	22	0.2	1.6			17P	R		Very noisy, spikes. Strong cross current. Shot 100 correspond to fix
6-Aug		1_TS_45	100	2032		99-2033	17.6	19.5	0.3	1.3			26S	R		very high feather angle due to strong cross current. Lost fix 698
6-Aug		1_TS_38	100	2768		99-2769	21	19	0.1	1.9			19P	R		Noisy, spikes through the line due to sea coditions/current
6-Aug		1_TS_43	100	2266		99-2267	22	23	0.2	1.7			18S	R		Strong cross current. High feather angle. High FA only at SOL
6-Aug		1_TS_36	100	29*48		99-2949	15	19	0.4	1.5			10P	A		Spiky.
6-Aug		1_TS_41	100	2484		99-2485	15	16	0.2	1.4			9P	R		noisy spiky trhrouh the line
6-Aug		1_TS_34	100	3121		99-3126	13.7	13.7	0.2	1.5			28S	R		Noisy, spikes through the line. Very high feather angle due to strong
6-Aug		1_TS_32	100	3340		99-3340	11.4	13.6	0.3	1.3			18S	R		Noisy. High feather due to strong current. Spikes through the line. Ch
6-Aug		1_TS_39_A	1000	3607		999-3608	13.3	10.6	0.3	1.1			2,3S	A		spikes through the line
6-Aug		1_TS_30	100	3568		99-3569	13.4	18.6	0.1	1.1			13P	R		Many spikes through the line. Strong current in opposite direction
6-Aug		1_TS_37	100	2897		99-2898	14.4	11.3	0.4	1.2			27S	R		Spiky. Far channel not balanced
6-Aug		1_TS_28	100	3847		99-3847	18.2	14.7	0.1	1.4			25P	R		Strong current in opposite direction. Very noisy and spiky
6-Aug		1_TS_35	100	3057		99-3038	11.4	12.4	0.1	1.3			24S	R		Shot 121 corresponds to fix 100.781 bad shot. Noisy, spiky
6-Aug		1_TS_26	100	3979		99-3980	25.9	15.9	0.2	1.3			13P	R		Noisy. Many spikes through the line. Current in opposit direction
6-Aug		1_TS_33	100	3366		99-3367	17.8	12.2	0.2	1.3			5S	A		Noisy, spiky.
6-Aug		1_TS_24	100	4129		99-4130	12.60	10.20	0.3	0.8			13S	A		random spikes
6-Aug		1_TS_31	100	3565		99-3566	27.10	16.80	0.1	1.2			15P	R		Strong current
7-Aug		1_TS_22	100	4304		99-4305	11.00	15.00	0.2	1.2			17S	R		Marginal, high FA. Lost fix 2218, 2627, 3790
7-Aug		1_TS_29	100	1861		99-1862	35.00	11.00	0.4	1.0			7P	R		3.125. Noisy
7-Aug		1_TS_20	100	2245		99-2246	30.00	17.00	0.2	1.4			11P	R		3.125. Noisy

Client: Vattenfall **Vessel: Fugro Pioneer** **Project No:** 16J369
Project: Windfarm **THANET_BLOCK1**

QC Specs	Max Feather: +/- 7 between adj. lines	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.5	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

QC GEO : Ahmet Senocak / Danilo Seccia

A = ACCEPT; R = REJECT; M = MARGINAL

Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
GSO Sparker 360 tips, power 600/800 J
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, dhot int. 1.56 m Streamer Depth 0.5 m

Date	Seq No.	Line No.	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
7-Aug		1_TS_27	100	1945		99-1946	15.00	16.00	0.2	1.2			21S	R		3.125. Noisy. High FA
7-Aug		1_TS_18	100	2374		99-2375	19.00	23.00	0.2	1.3			19P	R		3.125. Noisy
7-Aug		1_TS_25	100	2043		99-2044	16.00	24.00	0.4	1.1			25S	R		3.125 Noisy. High FA
7-Aug		1_TS_16	100	4813		99-4814	18.00	14.00	0.2	1.0			7P	M		Shot 113 corresponds to fix 100. Lost fix 4251 Noisy spiky. Against the
7-Aug		1_TS_29_A	1000	4491		99-4492	25.00	21.00	0.2	1.1			5P	A		noisy and spiky
7-Aug		1_TS_14	100	5047		99-5048	13.00	17.70	0.1	1.5			26S	R		worsening of the weather conditions at EOL. Spiky. High FA. Lost fix
10-Aug		1_TS_23	100	4262		99-4263	15.00	19.00	0.4	0.9			13P	A		Spikes through the line, mostly on ch. 23
10-Aug		1_TS_12	100	5283		99-5284	21.00	30.00	0.4	0.8			9P	A		Lost fix 1419, 2473, 4576. Many spikes through the line
10-Aug		1_TS_21	100	4427		99-4428	19.00	14.00	0.3	0.8			12P	A		Noisy spiky trhrouh the line
10-Aug		1_TS_10	100	5466		99-5467	23.00	13.00	0.4	1.1			11P	A		Lost fixes 3455, 3671, 4001 Noisy spiky trhrouh the line
10-Aug		1_TS_19	100	4624		99-4625	19.00	19.00	0.4	1.1			4S	A		Lost fix 431 534 641 794 797 808 811 1170 1429
10-Aug		1_TS_08	100	5661		99-5662	11.00	12.30	0.3	0.8			22S	R		Lost fix1286 3302 4100. Noisy spyky. High FA
10-Aug		1_TS_17	100	4820		99-4821	20.30	14.70	0.1	1.1			21P	R		Lost fix 839 849 898 1196 3301 3709 3712 3713 3799. Noisy, spiky.
10-Aug		1_TS_06	100	5856		99-5857	10.90	10.20	0.2	0.9			25S	R		Lost fix 4094, 4996, 5036, 5037, High FA
10-Aug		1_TS_15	100	5020		99-5021	14.10	10.30	0.1	1.1			16P	M		Lost fixes 2149, 3112 noiisy spikes
10-Aug		1_TS_02	100	6240		99-6241	12.90	8.20	0.1	1.2			3S	R		Lost fix 1433 1938 2054 2549 3770 3771 3772 3773. Noisy spike.
10-Aug		1_TS_16_A	100	900										R		LINE ABORTED DUE TO SPARKER PROBLEM
10-Aug		1_TS_01	100	6343		99-6344	7.20	12.90	0.1	1.2			10S	A		some spikes. Lost fix 3692 3750 3753 3754 3823 3853 5156 5352 6007 6337 6340
10-Aug		1_TS_04	100	6042		99-6043	11.40	10.90	0.1	1.1			8P	A		lost fix 5156. many spikes through the line
10-Aug		1_TS_13	100	5189		99-5190	10.80	12.50	0.2	0.8			5.6S	A		Lost fixes 3324 3401. Spikes
11-Aug		1_TS_07	100	5761		99-5762	15.00	13.00	0.3	1.0			13S	A		noisy spiky trhrouh the line
11-Aug		1_TS_11	100	5375		99-5376	11.00	12.00	0.4	1.5			13P	A		Spiky.
11-Aug		1_TS_05	100	5939		99-5940	14.00	14.00	0.2	0.9			7S	A		random spikes
11-Aug		1_TS_09	100	5557		99-5558	12.00	12.00	0.3	0.9			15S	A		Lost fixes 4750, 5059 random spikes
11-Aug		1_TS_03	100	6117		99-6118	15.00	13.00	0.1	1.2			15S	A		Lost fixes 2836, Spiky.
11-Aug		1_TS_52	100	1516		99-1516	17.00	17.00	0.4	0.9			13S	A		spikes through the line

Client: Vattenfall **Vessel: Fugro Pioneer** **Project No:** 16J369
Project: Windfarm **THANET_BLOCK1**

QC Specs	Max Feather: +/- 7 between adj. lines	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.5	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

Date	Seq No.	Line No.	Shot Point No.		Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars)		Streamer		MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	QC GEO : Ahmet Senocak / Danilo Seccia
			SOL	EOL			SOL	EOL	Min Depth	Max Depth						Comments A = ACCEPT; R = REJECT; M = MARGINAL
Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms. GSO Sparker 360 tips, power 600/800 J Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s Geometrics solid 48 channels, Group Int 3.125, dhot int. 1.56 m Streamer Depth 0.5 m																
11-Aug		1_TS_50	100	1680		99-1681	19.00	16.00	0.2	0.7			8P	A		File 100 corresponds to fix 115. noisy spiky trhrouh the line
11-Aug		1_TG_XL_05	100	3433		99-3434	16.00	16.30	0.3	0.9			11P	A		Spikes through the line, mostly on ch. 23 LINE NAME IS WRONG IT SHOULD BE TS
11-Aug		1_TG_XL_06	100	2834		99-2835	22.00	18.40	0.2	1.2			11S	A		spikes through the line LINE NAME IS WRONG IT SHOULD BE TS
11-Aug		1_TS_XL_03	100	2852		99-2853	16.10	16.50	0.4	0.9			15P	A		noisy spiky trhrouh the line
11-Aug		1_TS_XL_04	100	3365		99-3366	20.00	23.90	0.1	1.3			7P	R		very noisy and sppyki
11-Aug		1_TS_XL_01	100	1344		99-1345	17.90	13.40	0.4	1.5			11P	A		Spiky.
11-Aug		1_TS_XL_02	100	2080		99-2081	18.10	15.70	0.1	0.7			6P	R		noisy
bang box replacement																
19-Aug		1_TS_34_A	1000	1244		999-1244	12.00						27S	R		LINE ABORTED DUE TO HIGH FA
19-Aug		1_TS_XL_04_A	1000	4462		999-4463	13.00	15.00	0.2	0.9			11P	A		Lost fix 1766, 2694, 3841, 4360 Spikes through the line, mostly on ch.
19-Aug		1_TS_14_A	1000	5956		999-5962	10.00	16.60	0.2	1.0			11S	A		Lost fix 3823, 3876, 4418, 4474, 4695, 5580 Noise from vessel in the
26-Aug		1_TS_04_A			ran for side scan											
26-Aug		1_TS_02_A	1000	7089	138°	999-7089		11.00	0.2	1.0			8P	A		some spikes along line mostly on chan 23, channels 40-48 less energy noise Abeam to ahead
26-Aug		1_TS_15_A	1000	5846	318°	999-5846	10.00	11.00	0.3	1.2			6P	A		Lost fix 4204 , chan 23 noisy, noise Abeam to ahead
26-Aug		1_TS_17_A	1000	5549	318°	999-5550	15.00	12.00	2.0	0.9			17P	R		high feather angle
26-Aug		1_TS_06_A	1000	6575	138°	999-6576	12.00	12.00	0.3	0.9			15S	A		
26-Aug		1_TS_08_A	1000	6610	318°	999-6611	9.00	10.00	0.3	0.8			8P	A		missed fix 6610
26-Aug		1_TS_18_A	1000	5674	138°	999-5675	10	11	0.2	1			10P	A		
26-Aug		1_TS_25_A	1000	4924	318°	999-4925	13.00	10.00	0.2	0.9			15S	A		missed fixes 3262,3842
27-Aug		1_TS_20_A	1000	5203	138°	999-5204	13.00	13.00	0.2	0.8			11P	A		
27-Aug		1_TS_28_A	1000	4695	318°	999-4696	10.00	9.00	0.1	0.7			6S	A		Lost fixes 2518,2724
27-Aug		1_TS_17_B	2000	6673	138°	999-6674	11	11	0.3	1			12S	A		chan 23 noisy

Client: Vattenfall | **Vessel: Fugro Pioneer** | **Project No:** 16J369

Project: Windfarm | **THANET_BLOCK1**

QC Specs: Max Feather: +/- 7 between adj. lines; Streamer Depth: 0.5; Max Amb.Noise:; Source Timing: +/- 0.5; Max Misfires:; Max Consec. Misfires:; **Max Bad Traces at SOL:** 1; **Max Bad Trcs During Line:** 3

QC GEO : Ahmet Senocak / Danilo Seccia

A = ACCEPT; R = REJECT; M = MARGINAL

Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
GSO Sparker 360 tips, power 600/800 J
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, dhot int. 1.56 m Streamer Depth 0.5 m

Date	Seq No.	Line No.	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
27-Aug		1_TS_30_A	1000	4000	318°									R		LINE ABORTED DUE TO GEOMETRICS RECORDER CRASH
27-Aug		1_TS_51_A	1000	2464	318°	999-2465	13	16	0.5	0.9			3S	A		chan 23 noisy
27-Aug		1_TS_44_A	1000	3114	138°	999-3115	16	15	0.2	1			7P	A		chan 23 noisy
27-Aug		1_TS_47_A	1000	2834	318°	999-2835	11	16	0.3	1.1			12P	A		chan 23 noisy
27-Aug		1_TS_40_A	1000	3526	138°	999-3527	17	18	0.1	1.2			11P	R		chan 23 noisy, very noisy
27-Aug		1_TS_45_A	1000	3054	318°	999-3055	12	16	0.3	0.9			11S	R		chan 23 noisy, very noisy
27-Aug		1_TS_37_A	1000	3913	138°	999-3914	10	13	0.4	1			5P	R		chan 23 noisy, very noisy
27-Aug		1_TS_41_A	1000	3375	318°	999-3376	16	17	0.2	1.8			6P	R		chan 23 noisy, very noisy, fix 3053 missed
27-Aug		1_TS_26_A	1000	4871	138°	999-4872	14	13	0.2	1.3			15P	R		chan 23 noisy, very noisy
28-Aug		1_TS_38_A	1000	3746	318°	999-3747	14	15	0.3	0.9			17S	R		chan 23 noisy, high FA, missed fixes 1671,1701,2338,3744
28-Aug		1_TS_27_A	1000	4726	138°	999-4726	11	11	0.2	0.8			8P	A		chan 23 noisy, missed fix 4022
28-Aug		1_TS_41_B	2000	4405	318°	999-4407	11	12	0.3	1.1			6S	A		chan 23 noisy,
28-Aug		1_TS_31_A	1000	4352	138°	999-4353	15	19	0.2	1			11S	A		chan 23 noisy,
28-Aug		1_TS_35_A	1000	3957	318°	999-3959	15	12	0.3	0.9			12P	R		chan 23 noisy, bol noisy
28-Aug		1_TS_32_A	1000	3607	138°		10		0.2	0.7			21S	R		LINE ABORTED DUE TO HIGH FA
28-Aug		1_TS_34_B	2000	5077	138°	1999-5078	14	16	0.2	1.2			11S	A		missed fix 4761
28-Aug		1_TS_32_B	2000	5251	318°	1999-5252	12	19	0.2	1.5			10S	R		Very noisy, spikes through the line.
28-Aug		1_TS_45_B	2000	2880	318°	1999-3881	14	17	0.3	1.3			14S	R		very noisy
28-Aug		1_TS_32_C												R		LINE ABORTED DUE TO HIGH FA and weather

Client: Vattenfall | **Vessel: Fugro Pioneer** | **Project No:** 16J369
Project: Windfarm | **THANET_BLOCK1**

QC Specs	Max Feather: +/- 7 between adj. lines	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.5	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

QC GEO : Ahmet Senocak / Danilo Seccia

A = ACCEPT; R = REJECT; M = MARGINAL

Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
GSO Sparker 360 tips, power 600/800 J
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, dhot int. 1.56 m Streamer Depth 0.5 m

Date	Seq No.	Line No.	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
29-Aug		1_TS_26_B	2000	5826	138°	1999-5827	15	16	0.3	1.2			11P	A		chan 23 noisy,
29-Aug		1_TS_38_B	2000	4716	318°	1999-4717	13	15	0.3	1			4S	A		
29-Aug		1_TS_30_B	2000	5461	138°	1999-5462	21	24	0.3	1.1			14S	R		missed fix 2470
29-Aug		1_TS_37_B	2000	4837	318°	1999-4838	22	17	0.2	1			15S	R		
29-Aug		1_TS_32_D	4000	7252	138°	3999-7253	12	16	0.3	1			15S	A		
29-Aug		1_TS_42_B	2000	4319	318°	1999-4320	16	15	0.3	1.1			8S	A		
29-Aug		1_TS_30_C	3000	6462	138°	2999-6463	13	14	0.1	1.1			12P	A		
29-Aug		1_TS_22_B	2000	4319	318°	1999-4320	16	15	0.3	0.9			16S	R		possibly rerun high FA
29-Aug		1_TS_35_C	3000	6033	138°	2999-6034	11	14	0.2	1.2			6S	A		x
29-Aug		1_TS_43_A	1000	3302	318°	999-3303	16	12	0.2	1			9P	A		
29-Aug		1_TS_37_C	3000	5894	138°	2999-5892	11	11	0.3	0.9			23S	A		missed fixes 5559,5699,5824
29-Aug		1_TS_45_C	3000	5208	318°	2999-5209	15	16	0.2	1.3			18P	R		missed fixes 4546,4618,4716,high fa
29-Aug		1_TS_40_C	3000	5611	138°	2999-5612	14	13	0.3	1			22S	R		high fa
29-Aug		1_TS_48_A	1000	2914	318°	999-2915	15	15	0.3	0.8			10P	R		missed fixes 1877,1889,2323,2644, very noisy
29-Aug		1_TS_22_C	3000	7346	138°	2999-7347	18	13	0.3	1.3			7P	A		missed fixes 6638, 6659, noisy
30-Aug		1_TS_40_D												R		LINE ABORTED DUE TO HIGH FA
30-Aug		1_TS_40_E	5000	7546	318°	4999-7547	11	11	0.3	0.8			14S	A		
30-Aug		1_TS_45_D	4000	6008	138°	3999-6010	13	12	0.4	0.8			7S	A		
30-Aug		1_TS_48_B	2000	3758	318°	1999-3759	11	13	0.3	0.7			10P	A		

FUGRO OCEANSISMICA S.p.A.
DIGITAL SEISMIC DATA QC LOG

Client: Vattenfall | **Vessel: Fugro Pioneer** | **Project No:** 16J369
Project: Windfarm | **THANET_BLOCK_2a**

QC Specs | Max Feather: +/- 7 between adj. lines | Max Amb.Noise: | Max Misfires: | **Max Bad Traces at SOL:** 1
Streamer Depth: 0.5 | Source Timing: +/- 0.5 | Max Consec. Misfires: | **Max Bad Trcs During Line:** 3

QC GEO : Ahmet Senocak

A = ACCEPT; R = REJECT; M = MARGINAL

Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
GSO Sparker 360 tips, power 600/800 J
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, shot int. 1.56 m Streamer Depth 0.5 m

Date	Seq No.	Line No.	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
29-Aug		2A_TS_13	100	513	269°	99-514	20	15	0,2	1,5			6S	R	R	
29-Aug		2A_TS_01	100	2110	89°	99-2111	17	12	0,3	1			4P	A	A	missed fixes 309, 729
29-Aug		2A_TS_12	100	685	269°	99-686	13	13	0,2	1			1P	A	A	tanker ship passing on starboard side
29-Aug		2A_TS_09	100	1073	89°	99-1074	15	11	0,3	0,7			4S	A	A	
30-Aug		2A_TS_11	100	995	89°	99-996	13	10	0,4	0,8			4P	A	A	missed fixes 774,843
30-Aug		2A_TS_10	100	965	269°	99-966	12	11	0,2	1			3P	R	R	noisy
30-Aug		2A_TS_05	100	1583	89°	99-1584	13	12	0,2	1,4			8S	A	A	
30-Aug		2A_TS_08	100	1170	269°	99-1171	11	11	0,3	0,7			9P	A	A	no data for first 20 shots. Bang box stopped
31-Aug		2A_TS_07	100	1339	89°	99-1341	16	14	0,3	0,8			4P	A	A	
31-Aug		2A_TS_06	100	1493	269°	99-1494	13	13	0,2	1			3P	A	A	
31-Aug		2A_TS_02	100	1959	89°	99-1960	10	12	0,2	1,2			14S	A	A	
31-Aug		2A_TS_03	100	1869	269°	99-1870	13	13	0,2	0,8			14P	A	A	missed fix 1660
1-Sep		2A_TS_XL_01	100	1463	48°	99-1464	13	18	0,2	1,6			18P	A	A	HIGH FA ONLY AT BOL ??, streamer not straight
1-Sep		2A_TS_XL_02	100	1341	138°	99-1342	11	12	0,1	0,9			15P	A	A	noisy, missed fixes 223, 1329, 1341
2-Sep		2A_TS_04	100	1701	268°	99-1702	13	13	0,3	1			7S	A	A	missed fix 1699
2-Sep		2A_TS_13_A	1000	1523	89°	999-1524	17	19	0,2	0,5			13P	R	R	very noisy
3-Sep		2A_TS_10_A	2001	2859	89°	2000-2860		13	0,3	1			14S	A	A	File # 2001 corresponds to fix # 1000
3-Sep		2A_TS_13_B	2000	2439	89°	1999-2440	14	14	0,2	1,3			7P	A	A	

Client: VATTENFALL **Vessel: Fugro Pioneer** **Project No:** 16J369

Project: Windfarm **THANET_BLOCK_2b**

QC Specs	Max Feather: +/- 7 between adj. lines	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.5	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

QC GEO : Ahmet Senocak / Vincenzo Vitale

Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
GSO Sparker 360 tips, power 600/800 J
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, shot int. 1.56 m Streamer Depth 0.5 m CHA NNEL #23 DEAD OR SPIKY

A = ACCEPT; R = REJECT; M = MARGINAL

Date	Seq No.	Line No.	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
30-Aug		2B_TS_14	100	4233	228°	99-4234	14	13	0,4	0,7	4		14S	A		missed fixes 2568, 3389,3758, 4036
30-Aug		2B_TS_07	100	4756	48°	99-4757	16	14	0,2	1			10S	R		noisy
30-Aug		2B_TS_12	100	4378	228°	99-4234	11	12	0,3	0,7	3		11S	A		missed fixes 3391, 3705, 4379
30-Aug		2B_TS_15	100	2079	48°									R		LINE ABORTED DUE TO NAVIGATION
30-Aug		2B_TS_05_A	1000	5825	48°	999-5826	11	13	0,4	0,7			14P	A		
30-Aug		2B_TS_10	100	4491	228°	99-4492	12	13	0,2	0,9			7S	A		
30-Aug		2B_TS_03	100	5074	48°	99-5075	15	14	0,2	0,8	1		10S	A		missed fix 3630
30-Aug		2B_TS_18	100	3917	228°	99-3918	12	15	0,3	0,7			15P	A		
30-Aug		2B_TS_11	100	4368	48°	99-4369	14	18	0,1	1,4			7S	R		very noisy
30-Aug		2B_TS_16	100	4033	228°	99-4034	17	13	0,4	0,8	1		8S	A		missed fix 3474,noisy
30-Aug		2B_TS_13	100	4237	48°	99-4238	14	13	0,1	1,2	1		15P	A		missed fix 4156, high FA
30-Aug		2B_TS_20	100	3799	228°	99-3800	14	14	0,2	0,9	1		15S	A		missed fix 3798
31-Aug		2B_TS_15	100	4170	48°	99-4171	12	14	0,2	0,8	1		15P	A		missed fix 1725
31-Aug		2B_TS_22	100	3632	228°	99-3633	16	14	0,1	1,6			4S	A		
31-Aug		2B_TS_17	114	4008	48°	99-3393	14	13	0,3	0,7	1		5S	A		missed fix 1069
31-Aug		2B_TS_24	100	3514	228°	99-3516	12	13	0,2	1			11P	A		
31-Aug		2B_TS_19	100	3850	48°	99-3851	15	14	0,2	0,9			14S	A		
31-Aug		2B_TS_26	100	3333	228°	99-3334	12	11	0,3	1,2			16P	A		high FA
31-Aug		2B_TS_21	100	3704	48°	99-3706	18	14	0,1	1,2	1		12S	R		missed fix 3303, very noisy

Client: VATTENFALL | **Vessel: Fugro Pioneer** | **Project No:** 16J369

Project: Windfarm | **THANET_BLOCK_2b**

QC Specs	Max Feather: +/- 7 between adj. lines	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.5	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

QC GEO : Ahmet Senocak / Vincenzo Vitale

A = ACCEPT; R = REJECT; M = MARGINAL

Geometrics GeoEl, Record Length 300 ms Sample Rate 0,25ms., System Delay 4 ms.
GSO Sparker 360 tips, power 600/800 J
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, shot int. 1.56 m Streamer Depth 0.5 m CHANNEL #23 DEAD OR SPIKY

Date	Seq No.	Line No.	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
31-Aug		2B_TS_28	100	3201	228°	99-3202	14	14	0,4	0,9			16P	A		high FA, missed fix 2588
31-Aug		2B_TS_01	100	5212	48°	99-5213	16	14	0,2	1,2	1		6S	R		Missed fix 1556, Recorder fault Files 1572-1574 no fix (0), last good fix number 5211, noisy,??
31-Aug		2B_TS_02	100	5114	228°	99-5115	11	14	0,2	1,1	2		12S	A		noisy, missed fixes 1793,4540
31-Aug		2B_TS_09	100	4589	48°	99-4590	15	12	0,2	1,2	6		15P	A		missed fixes 198,204,207,216,3539,4594
31-Aug		2B_TS_08	100	4653	228°	99-4653	15	13	0,1	1,4	1		6S	A		noisy, missed fix 4158
31-Aug		2B_TS_04	100	4896	48°	99-4897	12	13	0,2	1			6S	A		
31-Aug		2B_TS_25	100	3322	228°	99-3323	13	18	0,3	1,1			14P	A		
31-Aug		2B_TS_23	100	3470	48°	99-3471	19	16	0,1	1,3			6S	A		
31-Aug		2B_TS_30	100	3084	228°	99-3085	19	14	0,2	1			13S	A		
31-Aug		2B_TS_27	100	3274	48°	99-3275	16	17	0,1	0,8	6		16P	R		high fa, missed fixes 1127, 1199, 2876, 2918, 2949, 3269
1-Sep		2B_TS_32	100	2887	228°	99-2888	18	14	0,2	1,1			14S	R		very noisy
1-Sep		2B_TS_29	100	3123	48°	99-3124	18	14	0,3	1,3			6P	R		very noisy
1-Sep		2B_TS_34	100	2748	228°	99-2749	17	15	0,2	0,8			11P	R		very noisy
1-Sep		2B_TS_31	100	2876	228°	99-2877	17		0,3	0,8			17S	R		high FA, spikes on various channels
1-Sep		2B_TS_36	100	2596	228°	99-2597	15	14	0,3	0,9			17P	R		high FA, noisy
1-Sep		2B_TS_33	100	2832	48°	99-2833	11	16	0,3	0,9			15S	A		
1-Sep		2B_TS_38	100		228°									R		LINE ABORTED DUE TO HIGH FA
1-Sep		2B_TS_XL_07	100	3638	138°	99-3639	16	14	0,3	0,7	6		20S	R	m	high FA, missed fixes 503, 1239, 1504, 2081, 2366, 3473
1-Sep		2B_TS_XL_04	100	3082	138°	99-3083	20	13	0,2	1,1			16P	R		high FA,

Client: VATTENFALL | **Vessel: Fugro Pioneer** | **Project No:** 16J369
Project: Windfarm | **THANET_BLOCK_2b**

QC Specs	Max Feather: +/- 7 between adj. lines	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.5	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
GSO Sparker 360 tips, power 600/800 J
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, shot int. 1.56 m Streamer Depth 0.5 m CHANNEL #23 DEAD OR SPIKY

QC GEO : Ahmet Senocak / Vincenzo Vitale

A = ACCEPT; R = REJECT; M = MARGINAL

Date	Seq No.	Line No.	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
1-Sep		2B_TS_50	100	1556	228°	99-1557		16	0,2	0,8	2		13P	A		missed fixes 902, 1259
1-Sep		2B_TS_45	100	1928	48°	99-1928	16	14	0,2	1	1		3S	A		missed fix 1925
1-Sep		2B_TS_48	100	1733	48°	99-1734	14	13	0,4	0,6	1		11S	A		missed fix 469
1-Sep		2B_TS_43	100	2007	48°	99-2008	13	13	0,1	1			14P	A		
1-Sep		2B_TS_46	100	1841	228°	99-1842	13	13	0,1	1			13S	A		File 1728 no fix number
1-Sep		2B_TS_47	100	1685	48°	99-1686	12	14	0,3	0,7	3		12P	A		missed fixes 483, 1591, 1627
1-Sep		2B_TS_XL_03	100	2177	138°	99-2178	14	15	0,2	1,2			14P	R		noisy, line stopped for fishing boat on line
1-Sep		2B_TS_XL_01	100	1294	138°	99-1295	19	15	0,4	0,9			3P	A		
1-Sep		2B_TS_06	100	4771	228°	99-4772	13	13	0,4	1	7		14P	R		noisy, fix file starts as 101, missed fixes 2371, 2925, 2963, 3568, 3738, 3905, 4128
1-Sep		2B_TS_35	100	2547	48°	99-2548	19	21	0,2	1,1			10S	R		missed fix 2316
1-Sep		2B_TS_40	100	2289	228°	99-2290	16	13	0,2	2,1	2		9P	R		missed fixes 1487,1489. file 1491 fix no: 0 ?? , file:2289 fix:100 ??
1-Sep		2B_TS_37	100	2484	48°	99-2485	16	16	0,2	1,2	1		9P	A		missed fix 2480, file:2484 fix:100 ??
1-Sep		2B_TS_42	100	2089	228°	99-2089	20	16	0,3	1	1		16S	A		High FA at EOL for few fixes, missed fix 2088
1-Sep		2B_TS_39	100	2363	48°	99-2364	18	16	0,3	0,8	1		22P	R		High FA, missed fix 2363
2-Sep		2B_TS_38_A	100	3350	228°	99-3352	16	16	0,3	1			12S	R		noisy
2-Sep		2B_TS_41	100	2226	48°	99-2227	20	19	0,4	1,1			12P	A		
2-Sep		2B_TS_44	100	2015	228°	99-2016	16	14	0,3	0,8			6P	A		
2-Sep		2B_TS_49	100	1653	48°	99-1654	16	19	0,4	0,8			23P	R		High FA
2-Sep		2B_TS_XL_06	100	5625	138°	99-5626		22	0,4	1	4		5P	A		missed fixes 1191, 1535,4074,4259

Client: VATTENFALL | **Vessel: Fugro Pioneer** | **Project No:** 16J369
Project: Windfarm | **THANET_BLOCK_2b**

QC Specs: Max Feather: +/- 7 between adj. lines; Streamer Depth: 0.5; Max Amb.Noise: ; Source Timing: +/- 0.5; Max Misfires: ; Max Consec. Misfires: ; **Max Bad Traces at SOL:** 1; **Max Bad Trcs During Line:** 3

QC GEO : Ahmet Senocak / Vincenzo Vitale

A = ACCEPT; R = REJECT; M = MARGINAL

Geometrics GeoEl, Record Length 300 ms Sample Rate 0,25ms., System Delay 4 ms.
GSO Sparker 360 tips, power 600/800 J
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, shot int. 1.56 m Streamer Depth 0.5 m CHANNEL #23 DEAD OR SPIKY

Date	Seq No.	Line No.	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
2-Sep		2B_TS_XL_05	100	5619	318°	99-5621	17		0,2	1,1	2		7P	R		noisy, missed fixes 3787,5207
2-Sep		2B_TS_XL_02	100	1708	138°	99-1708	14		0,4	0,8	7		18S	R		High FA, no noise file, missed fixes 426,447,482,1103,1338,1429,1713
2-Sep		2B_TS_11_A	1000	5358	228°	999'5359	18	15	0,3	1,1			13P	R		
2-Sep		2B_TS_01_A	1000	6051	48°	999-6052	17	25	0,2	1,2	2		10P	R		missed fixes 2413,2643, not better than 01 original
2-Sep		2B_TS_XL_03_A	1000	3145	138°	999-3146	22	32	0,2	0,8			16P	R		high fa at eol
2-Sep		2B_TS_21_A	1000	4576	228°	999-4577	29	15	0,2	1,5			5S	R		noisy
2-Sep		2B_TS_15_A	100	4103	48°	99-4104	21	29	0,3	1,2			14S	NA		DO NOT PROCESS (RERUN FOR MULTI BEAM ONLY)
2-Sep		2B_TS_19_A	1000	4787	228°	999-4788	19	18	0,2	0,9			18P	NA		DO NOT PROCESS (RERUN FOR MULTI BEAM ONLY)
2-Sep		2B_TS_21_B	2000	5490	48°	1999-5491	19	21	0,3	0,9			13S	R		NOISER THAN 21 AND 21A
2-Sep		2B_TS_29_A	1000	3888	228°	999-3889	24	14	0,2	0,8			15P	R		noisy
2-Sep		2B_TS_27_A	1000	4037	48°	999-4038	21	18	0,1	0,9			12S	R		noisy
2-Sep		2B_TS_34_A	1000	3527	228°	999-3528	22	14	0,2	1,1			11P	R		noisy, poor uhr data
2-Sep		2B_TS_31_A	1000	3891	48°	999-3892	20	18	0,4	0,8			11P	A		
3-Sep		2B_TS_36_A	1000	3476	228°	999-3478		15	0,3	0,9			17S	R		HIGH FA
3-Sep		2B_TS_32_A	1000	3789	48°	999-3789		15	0,3	0,8			22S	R		HIGH FA , data looks reasonable
3-Sep		2B_TS_XL_O6_A	1000	6558	138°	999-6559	16	18	0,3	0,9			17P	R		HIGH FA , 2B_TS_XL_06 original line accepted
3-Sep		2B_TS_XL_05_A	1000	6532	318°	999-6533	17	21	0,2	0,9			18S	R		HIGH FA
3-Sep		2B_TS_35_A	1000	3400	48°	999-3547	14	15	0,2	1			17S	R		HIGH FA at bol
3-Sep		2B_TS_07_A	1000	5777	228°	999-5777	18		0,2	0,7			23P	R		HIGH FA all line

Client: VATTENFALL **Vessel: Fugro Pioneer** **Project No:** 16J369
Project: Windfarm **THANET_BLOCK_2b**

QC Specs	Max Feather: +/- 7 between adj. lines	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.5	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

QC GEO : Ahmet Senocak / Vincenzo Vitale

A = ACCEPT; R = REJECT; M = MARGINAL

Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
GSO Sparker 360 tips, power 600/800 J
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, shot int. 1.56 m Streamer Depth 0.5 m CHANNEL #23 DEAD OR SPIKY

Date	Seq No.	Line No.	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
3-Sep		2B_TS_11_B	2000	6298	48°	1999-6299	17	15	0,2	1,2			10S	R		bol noisy, rest of line is ok
3-Sep		2B_TS_01_B	1000	6046	228°	999-6047	15	20	0,1	1,1			18S	R		HIGH FA, very noisy
5-Sep		2B_TS_27_B	2000	5180	228°	1999-5182	16	18	0,1	1,5			4S	R	R	noisy, chan #8 is dead or spiky, channel #23 repaired
5-Sep		2B_TS_11_C	3000	7358	48°	2999-7359	14	16	0,1	3			4S	A	A	Bit noisy, chan #8 is dead or spiky
5-Sep		2B_TS_29_B	2000	5004	228°	1999-5005	16	11	0,2	0,9			14P	A	A	Bit noisy, chan #8 is dead or spiky
5-Sep		2B_TS_21_C	3000	6603	48°	2999-6604	15	13	0,3	1,2			15P	A	A	Bit noisy, chan #8 is dead or spiky
5-Sep		2B_TS_XL_02_A	1000	2622	137°	999-2623	15	15	0,3	2			9S	A	A	Bit noisy, chan #8 is dead or spiky
5-Sep		2B_TS_07_B	2000	6644	228°	1999-6645	14	12	0,3	1,4			19P	R	R	Bit noisy, chan #8 is dead or spiky,HIGH FA
5-Sep		2B_TS_01_C	3000	8062	48°	2999-8063	19	13	0,1	1,3			8S	R	R	noisy, chan #8 is dead or spiky,poor uhr data quality especially at the SOL
5-Sep		2B_TS_XL_04_A	1000	3946	138°	999-3947	16	14	0	1,2	1		5P	A	A	noisy, chan #8 is dead or spiky ,missed fixes 1605
5-Sep		2B_TS_XL_03_B	2000	3722	318°	1999-3723	12	17	0,3	1,5	1		15S	A	A	noisy, chan #8 is dead or spiky ,missed fixes 3488
5-Sep		2B_TS_40_A	1000	3102	138°	999-3103	18	14	0,2	1,2	1		6S	A	A	Chan #8 dead or spiky
5-Sep		2B_TS_36_B	2000	4315	48°	1999-4316	18	17	0,3	1,3	4		7S	A	A	Chan #8 dead or spiky, missed fixes 4035,4156,4221,4270
5-Sep		2B_TS_39_A	1000	3287	228°	999-3288	14	13	0,3	1,2			10P	A	A	Chan #8 dead or spiky
5-Sep		2B_TS_XL_07_A	1000	4511	138°	999-4512	12	17	0,3	0,7			3S	A	A	Chan #8 dead or spiky
5-Sep		2B_TS_XL_05_B	2000	7455	318°	1999-7465	12	12	0,1	1,1			9P	A	A	Chan #8 dead or spiky
5-Sep		2B_TS_49_A	1000	2626	228°	999-2627	13	12,26	0,4	0,7	4		9P	A	A	?? Chan #8 dead or spiky, missed fixes 1510,1807,2417,2470,
6-Sep		2B_TS_35_B	1000	3576	48°	1999-4576	16,87	16,89	0,1	1,1			4P	R	R	Attention First fix#1000, noisy
6-Sep		2B_TS_38_C	3000	5338	228°	2999-5339	16,82	13,8	0,2	0,8			16S	A	m	There is NO Line 2B_TS_38_B, High FA at BOL only

Client: VATTENFALL | **Vessel: Fugro Pioneer** | **Project No:** 16J369
Project: Windfarm | **THANET_BLOCK_2b**

QC Specs	Max Feather: +/- 7 between adj. lines	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.5	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

QC GEO : Ahmet Senocak / Vincenzo Vitale

A = ACCEPT; R = REJECT; M = MARGINAL

Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
GSO Sparker 360 tips, power 600/800 J
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, shot int. 1.56 m Streamer Depth 0.5 m CHANNEL #23 DEAD OR SPIKY

Date	Seq No.	Line No.	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
6-Sep		2B_TS_06_A	1000	5714	48°	999-5713	12.47	14.17	0.2	0.9	1		19P	R	R	HIGH FA BOL TO EOL, missed fix 4753
6-Sep		2B_TS_07_C	3000	7699	228°	2999-7689	16.16	18.53	0.1	1.1	9		11S	R	R	noisy,missed fixes 4001, 4480,4501,4506,4536,4588,4893,5960,7025,
6-Sep		2B_TS_06_B	2000	6704	48°	1999-6705	13	20	0	0.9	2		9P	A	A	noisy,missed fixes 4172,5535.
6-Sep		2B_TS_07_D	4000	8635	228°	3999-8636	15	11	0.1	1.5			9P	A	R	Attention First fix#2000, noisy streamer not balanced. The best possible result after 3 rerun
6-Sep		2B_TS_01_D	4000	9069	48°	3999-9069	14	21	0.3	1			10S	A	R	noisy,missed fixes 7818,The best possible result after 3 rerun
6-Sep		2B_TS_35_C	3000	5567	228°	2999-5568	18	12	0.4	0.9	1		14P	A	A	noisy,missed fixes 5504,
6-Sep		2B_TS_27_C	3000	6146	48°	2999-6147	17	16	0	1.7			10S	A	R	
6-Sep		2B_TS_34_B	2000	4614	228°	1999-4615	15	22	0.4	0.8	3		8P	A	A	noisy,missed fixes 2373,2625,2644
6-Sep		2B_TS_07_E	5000	9594	48°	4999-9595	16	14	0.2	1	4		15P	A	A	noisy,missed fixes 7881,8279,9327,9529
6-Sep		2B_TS_01_E	5000	10038	228°	4999-10038	14	13	0.2	0.9			15S	R	R	noisy,missed fixes
6-Sep		2B_TS_27_D	4000	7134	48°	3999-7129	13	12	0.3	0.8	6		11P	A	A	missed fixes 5576,5807,5826,5838,6554,6862
6-Sep		2B_TS_01_F	100	5149	228°	99-5148	15	17	0.4	0.7	2		9P	A	A	missed fixes 4560,5138
6-Sep		2B_TS_32_B	2000	4765	48°	1999-4764	15	17	0.4	0.8	2		11S	A	A	missed fixes 2280,4593

FUGRO OCEANSISMICA S.p.A.
DIGITAL SEISMIC DATA QC LOG

Client: Vattenfall Project: Windfarm	Vessel: Fugro Pioneer Thanet BLOCK3_4	Project No:	16J369

QC Specs	Max Feather:	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.75	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

QC GEO : Danilo Seccia

A = ACCEPT; R = REJECT; M = MARGINAL

Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
Sleave Guns 5 Cu in, Gun Depth 0.75 m, Shot Int 3.125.
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, Streamer Depth 0.75 m

IMPORTANT NOTES:
1. It is all but impossible to properly balance the streamer and keep the FA within the specs due to the local environmental conditions (mostly currents and, at times, sea state).
2. Some lines had been re-run up to three or even four times; still without being able to improve significantly on the data quality. Realistically there is no point in continuing these re-runs

Line	Seq No.	date	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
3_TG_XL_01			100	1371										R		gun problem
4_TG_25			100	1016		99-1017	15.00	-	0.2	1.3			12P	R		Noisy due to strong current in opposite direction
4_TG_01_A			1000	2878		999-2879	10.50	13.60	0.1	1.3			7P	A		1415, 1745 missfire
4_TG_15			100	1424		99-1425	12.90	11.00	0.1	1.3			13P	A		File 101 corresponds to fix 100. 768 missfire
4_TG_11			100	1583		99-1584	14.20	18.60	0.1	1.5			14S	R		274 missfire. Line agains the current
4_TG_XL_01			100	870		99-871	16.90	20.30	0.6	1.1			9.1P	A		
3_TG_XL_01_A			1000	2268		999-2269	22.70	18.90	0.2	1.3			1.5P	A		1070 1751 missfire. Best possible result
4_TG_11_A			1000	2488		999-2489	14.10	13.40	0.2	1.5			12P	A		1901 bad shot, 2480 missfire
4_TG_25_A			1000	1953		999-1954	14.70	11.00	0.2	1.3			13.5S	A		1121 missfire extrashot, 1662 bad shot
4_TG_15_A			1000	2327		999-2328	15.70	17.50	0.1	1.3			20P	R		1120-1500 noise from astern. 1520 bad shot. Worse than 15. High FA
3_TG_15			100	2765		99-2766	19.00	21.00	0.2	0.8			11S	A		736 missfire, 1640, 2297 bad shot
3_TG_06			100	3097		99-3098	8.00	19.00	0.2	1.0			5P	A		228, 499, 1799, 2054, 2321, 2860 missfire. extrahots
3_TG_13			100	2855		99-2856	16.00	19.00	0.2	1.0			10P	A		466, 1073 1667 1937 extrashot
3_TG_04			100	3150		99-3151	14.00	25.00	0.1	1.5			14S	A		Fix 100 corresponds to fix 100. 1252 1921 extrashot .2568 bad shot. Lost fix 1291 plus one more. Best possible result
3_TG_09			100	2988		99-2980	16.00	14.00	0.2	1.2			10P	A		981 extrashot 2281 bad shot. Marginal due to strong current
3_TG_08			100	3053		99-3054	15.00	15.60	0.1	1.4			2.7S	A		marginal. Best possible result
3_TG_19			100	2663		99-2664	11.90	12.40	0.3	1.3			6S	A		Bad shot 329. extrashot: 667 1305 2294. Marginal from 2583
3_TG_10			100	2972		99-2973	23.00	19.30	0.1	1.3			6P	R		116extrashot. 2060 bad shot. Noisy due to increasing bad weather
3_TG_21														R		very noisy.
3_TG_12			100	4355		99-4356	13.6	15.7	0.1	1.1			5.6S	R		lost fix 2237, 3040. Shot on time
3_TG_23			100	3754		99-3755	13.9	15.3	0.1	1.3			5.2P	R		Lost fixes 1610, 1800, 1869, 1887. 3227 bad shot. Shot on time
3_TG_14			100	4245		99-4246	14.5	14.4	0.1	1.3			16S	R		Lost fixes1005 1162 2004 2022 2779 2806 3087 3613. 1735 bad shot. 4157 missfire. Shot on time

Client: Vattenfall | **Vessel: Fugro Pioneer** | **Project No:** 16J369
Project: Windfarm | **Thanet BLOCK3_4**

QC Specs	Max Feather:	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.75	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

Line	Seq No.	date	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	QC GEO : Danilo Seccia Comments A = ACCEPT; R = REJECT; M = MARGINAL
Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms. Sleave Guns 5 Cu in, Gun Depth 0.75 m, Shot Int 3.125. Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s Geometrics solid 48 channels, Group Int 3.125, Streamer Depth 0.75 m																
3_TG_25			100	3681		99-3681	13		0.2	1.2			8P	R		Shot on time
3_TG_16			100	2763		99-2764	15	15	0.2	1.4			4P	A		1241 extrashot noise from astern from 600 to 750. 1241 2115 missfire. Marginal strong current. Best possible result
3_TG_27			100	2387		99-2388	11	18	0.2	1.2			14P	A		320 629 missfire. Marginal strong current
3_TG_18			100	2695		99-2696	15	15	0.1	1.2			11P	R		1413 extrashot. 1102 missfire. 1734 bad shot
3_TG_11			100	2392		99-2393	14	15	0.1	1.3			14S	A		1232 extrashot, 1580 missfire
3_TG_02			100	3241		99-3242	30	17	0.2	1.1			8P	A		2024 bad shot. 3025 missfire
3_TG_01			100	3311		99-3312	14	15	0.2	1.3			10P	R		3245 missfire. Marginal strong current
3_TG_26			100	2419		99-2420	16	11.2	0.2	1.3			9S	A		675 1332 missfire
3_TG_XL_08			100	925		99-926	15.9	10.4	0.4	1.3			8.9S	A		489 missfire
3_TG_XL_09			100	935		99-936	13.2	15.4	0.1	1.3			19P	R		850 extrashot. High FA
3_TG_XL_06			100	951		99-952	15.2	17.1	0.2	1.3			9.5S	A		Accepted marginal
3_TG_XL_07			100	947		99-948	17	20.4	0.1	1.4			18P	R		High FA. Decreasing to 15 to EOL.
3_TG_XL_04			100	939		99-940	13.9	16.4	0.1	1.6			7S	R		369 lost fix
3_TG_XL_05			100	932		99-933	18.4	23.4	0.3	1.1			19P	R		High FA
4_TG_24			100	720		99-721	15.30	17.40	0.1	1.4			16S	R		noisy line
4_TG_16			100	1035		99-1036	10.90	16.50	0.3	1.4			24P	R		318 bad shot. Rejected due to high FA
3_TG_03			100	3210		99-3211	12.50	16.90	0.2	1.4			10P	A		1067 missfire
3_TG_07			100	3073		99-3074	16.80	12.70	0.1	1.4			9.7P	A		Accepted even if marginal in the first part. 607 extrashot. Best possible
3_TG_05			100	3140		99-3141	13.40	14.00	0.2	1.3			12S	A		3118 extrashot
3_TG_17			100	2322		99-2723	11.00	16.00	0.3	1.3			9P	A		lost fix 2151, 2469 bad shot
4_TG_21			100	829		99-831	13.00	13.00	0.3	1.1			10P	A		spiky
4_TG_18			100	950		99-951	15.00	16.00	0.2	1.1			9P	A		spikes
4_TG_23			100	758		99-759	17.00	14.00	0.3	1.0			12S	A		349 bad shot, 636 extrashot
3_TG_20			100	2630		99-2631	22.00	12.00	0.1	1.4			13P	R		862 missfire
3_TG_24			100	2551		99-2552	14.00	22.00	0.1	1.3			19S	A		High FA
3_TG_12_A			100	3812		99-3813	19.00	14.00	0.1	1.4			14P	R		1378 bad shot. 1680 extrashot
3_TG_23_A			100	3425		99-3826	14.00	16.00	0.2	1.5			7S	R		2370 2961 bad shot. 3245 extrashot
3_TG_14_A			100	3749		99-3750	16.00	17.00	0.3	1.2			10S	A		1259 3350 missfire. 2996 3689 bad shot
3_TG_25_A			100	3355		99-3356	13.00	14.20	0.2	1.3			9.6P	A		2323 2620 bad shot

Client: Vattenfall **Vessel: Fugro Pioneer** **Project No:** 16J369
Project: Windfarm **Thanet BLOCK3_4**

QC Specs	Max Feather:	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.75	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

QC GEO : Danilo Seccia

A = ACCEPT; R = REJECT; M = MARGINAL

Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
Sleave Guns 5 Cu in, Gun Depth 0.75 m, Shot Int 3.125.
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, Streamer Depth 0.75 m

Line	Seq No.	date	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
3_TG_XL_03			100	1148		99-1149	18,50	21,20	0.2	1.6			15P	A		337 bad shot
4_TG_19			100	912		99-913	13,70	13,20	0.3	1.2			10S	A		
4_TG_14			100	1112		99-1113	13,40	15,20	0.2	1.2			15P	A		318 missfire. 658 extrashot
4_TG_17			100	972		99-973	17,30	20,20	0.1	1.3			15S	R		increase in ambient noise
3_TG_XL_02			100	1037		99-1038	21,50	21,40	0.4	1.1			20P	R		466 lost fix. High FA
3_TG_22			100	2559		99-2560	23,50	13,00	0.1	1.4			14P	R		Fix 100 corresponds to shot 101. 642 extrahot. Rejected due to bad weather
3_TG_23_B			2000	4423		1999-4424	13,80	17,00	0.1	1.3			15S	A/M		result
4_TG_22			100	765		99-766	16,20	19,10	0.3	1.2			4P	A		247 bad shot. Very noisy. Accepted even if marginal. Best possible result
4_TG_13			100	1150		99-1151	13,10	21,80	0.4	1.1			12S	A		430 extrashot. Swell noise
3_TG_10_A			1000	3817		999-3872	14,60	15,00	0.2	1.4			16S	A		100 2130 3063 missfire 1540 bad shot
3_TG_21_A			1000	3488		999-3489	16,00	15,00	0.1	1.5			10P	A		Accepted even if marginal. 2638 bad shot
4_TG_20			100	880		99-881	13,00	12,00	0.2	1.2			5P	A		480 extrashot. Spikes
4_TG_09			100	1311		99-1312	14,00	17,00	0.4	1.2			9P	A		1026 extrashot. Spikes
4_TG_12			100	1199		99-1200	18,00	18,00	0.2	1.2			14P	A		spikes
4_TG_05			100	1460		99-1461	14,00	18,00	0.1	1.3			19P	R		lost fix 943. Spikes
3_TG_16_A			1000	3685		999-3686	19,00	14,00	0.1	2.0			19P	R		extrashot
3_TG_20_A			1000	3541		999-3542	12,00	15,00	0.2	1.3			17S	A		1194. High FA only at the center. Decresing towards EOL. Best possible
4_TG_08			100	1349		99-1350	14,00	16,00	0.2	1.1			9P	A		spikes
4_TG_03			100	1559		99-1560	12,00	16,00	0.2	1.2			14S	A		243 extrashot. Spkies
3_TG_XL_04_A			1000	1864		999-1865	19,00	13,60	0.4	1.2			15P	A		
3_TG_12_B			2000	4804		1999-4805	18,90	18,60	0.2	1.3			14S	A		3457 extrashot. Accepted, second rerun
3_TG_22_A			1000	3462		999-3463	12,40	13,50	0.2	1.6			4,9S	A		1306 1873 2458 extrashots. 2745 missfire spikes
4_TG_10			100	1266		99-1267	17,00	28,30	0.1	1.6			14S	R		noisy line
3_TG_07_A			1000	3973		999-3974	21,80	18,00	0.1	1.7			13P	R		ambient noise. Worse than 07
4_TG_16_A			1000	1933		999-1934	15,50	19,40	0.3	1.3			8S	A		spikes.
4_TG_22_A			1000	1694		999-1695	16,90	24,50	0.2	1.6			15P	R		worse than 22.

Client: Vattenfall | **Vessel: Fugro Pioneer** | **Project No:** 16J369
Project: Windfarm | **Thanet BLOCK3_4**

QC Specs	Max Feather:	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.75	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

QC GEO : Danilo Seccia

A = ACCEPT; R = REJECT; M = MARGINAL

Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
Sleave Guns 5 Cu in, Gun Depth 0.75 m, Shot Int 3.125.
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, Streamer Depth 0.75 m

Line	Seq No.	date	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLIENT	Comments
3_TG_18_A														R		aborted due to high FA
4_TG_07			100	1391		99-1392	17.00	18.00	0.1	1.6			10P	A		Fix 100 corresponds to file 101. Spikes
4_TG_04			100	1494		99-1495	17.00	20.00	0.2	1.3			8P	A		Fix 100 corresponds to file 101. 1495 missfire. Spikes
4_TG_06			100	1429		99-1430	20.00	19.00	0.3	1.2			14P	A		Spikes, 1429 missfire
4_TG_02			100	1585		99-1586	11.00	20.00	0.2	1.2			14P	A		487 extrashot
4_TG_10_A			1000	2171		99-2172	16.00	14.00	0.2	1.5			12P	A		spikes
3_TG_XL_02_A			1000	2158		99-2159	17.00	22.30	0.1	1.1			8.9S	R		1119 1912 missfire. Noisy
3_TG_XL_05_A			1000	1897		999-1898	23.50	16.40	0.5	1.9			19P	A		High FA only at SOL, spikes
3_TG_XL_07_A			1000	1834		999-1835	17.20	22.30	0.2	1.5			12P	A		spikes. Very marginal.
3_TG_XL_09_A			1000	1892		999-1893	15.70	16.00	0.3	1.2			3.4S	A		spikes
3_TG_18_B			2000	4615		1999-4616	14.00	36.00	0.3	1.3			4.8P	A		3226 bad shot
3_TG_XL_02_B			2000	3052		1999-3053	17.70	23.90	0.3	1.2			20P	R		High FA
3_TG_20_B			2000	4529		1999-4530	22.30	16.40	0.1	1.6			15P	R		4485 missfire. Worse than 20_A
3_TG_24_A			1000	3402		999-3403	18.70	16.90	0.2	1.3			24S	R		High FA. Spikes
3_TG_XL_02_D			4000	5031		3999-5032	18.30	15.10	0.1	1.2			5S	A		
4_TG_24_B			2000	2631		1999-2632	17.20	16.80	0.2	1.1			8P	A		
4_TG_14_A			1000	2025		1000-2026	13.10	20.00	0.1	1.3			22S	R		1313 missfire. High FA. Use 14
3_TG_08_A														R		aborted due to high FA
3_TG_08_B			2000	4947		1999-4948	16.00	16.00	0.1	1.9			13P	R		3375 4845. extrashot. Worse than 08 second rerun
4_TG_05_A			1000	2382		999-2383	16.00	15.00	0.1	1.5			5S	A		Lost fix 1269 spikes
4_TG_17_A			1000	1884		999-1485	17.00	12.00	0.3	1.2			7S	A		spikes,
3_TG_04_A			1000	4092		999-4093	-	19.00					13P	R		lost fix 1296. Shot 1000 correspond to fix 1001. Worse than 04
3_TG_XL_07_B			2000	2940		1999-2940	-	-	0.1	1.3			25S	R		High FA. Use XL_07 or XL_07_A
3_TG_01_A			1000	4230		999-4231	16.00	23.00	0.1	1.4			10P	A		2489 bad shot. 2793 4106 extrashot
3_TG_09_A			1000	3920		999-3920	21.00	20.30	0.1	1.6			14P	R		Worse than 09
3_TG_07_C			3000	5967		2999-5968							>20	R		FA very high

Client: Vattenfall	Vessel: Fugro Pioneer	Project No:	16J369
Project: Windfarm	Thanet BLOCK5		

QC Specs	Max Feather:	Max Amb.Noise:	Max Misfires:	Max Bad Traces at SOL:	1
	Streamer Depth: 0.75	Source Timing: +/- 0.5	Max Consec. Misfires:	Max Bad Trcs During Line:	3

QC GEO : Danilo Seccia

Geometrics GeoEl, Record Length 300 ms Sample Rate 0.25ms., System Delay 4 ms.
Sleave Guns 5 Cu in, Gun Depth 0.75 m, Shot Int 3.125.
Inline Offset (to center first group) 5 m, Lateral offset 5.1 m, Water velocity 1517 m/s
Geometrics solid 48 channels, Group Int 3.125, Streamer Depth 0.75 m

IMPORTANT NOTES:
1. It is all but impossible to properly balance the streamer and keep the FA within the specs due to the local environmental conditions (mostly currents and, at times, sea state).
2. Some lines had been re-run up to three or even four times; still without being able to improve significantly on the data quality. Realistically there is no point in continuing these re-runs

Line	Seq No.	date	Shot Point No. SOL	Shot Point No. EOL	Dir.	SOL-EOL with noise files	Noise (RMS) (Micro-bars) SOL	Noise (RMS) (Micro-bars) EOL	Streamer Min Depth	Streamer Max Depth	MISS-SHOTS	Max Feather calculated from TB plotted	Max Feather	Accept / Reject by QC	Accept / Reject by CLI	Comments — A = ACCEPT; R = REJECT; M = MARGINAL
M570			100	3434	196°	99-3435	14.00	23.00	0.3	1.5		4P		A		Bad shot 2228,2229. Noisy around 2580. 2229 extrashot. Swell noise worsening of the weather at EOL
5_TG_16			100	1484	17°	99-1485	15.10	8.80	0.5	2.6		8P		A		far channels out of specs through the line. Strong currents from behind
5_TG_14			100	1536	17°	99-1537	20.40	13.20	0.2	1.9		3P		M		Strong current, streamer not balanced in the second half of the line. Accepet after discussion with the office
5_TG_09			100	1654	197°	99-1565	22.5	14.9	0.3	1.4		12P		A		109 extrashot, 110 bad shot. Noisy due to currents
5_TG_12			100	1578	17°	99-1579	17.9	23.2	0.2	1.3		6S		A		Noise from astern around 600. 823 extrashot, 824 bad shot. Noisy due to weather
5_TG_07			100	1710	197°	99-1711	17.4	15.1	0.4	1.0		11P		A		146 extrashot, 147 bad shot. Far channels not balanced through the line, currents from behind
5_TG_10			100	1620	17°	99-1621	22.8	18	0.1	1.2		2S/2P		M		Poor streamer balancing due to currents and seastate. Noisy, spiky. Accepted after discussion with the office
5_TG_08			100	1652	17°	99-1659	-	30.4	0.4	1.2		12P		M		193 extrashot, 194 bad shot. 378 extrashot, 379 bad shot. Very noisy through the line due to weather. Accepted after discussion with the office.
5_TG_05			100	763	17°	99-764	19.6	14.1	0.4	1.3		6.2S		A		Noisy due to weather. Streamer not balanced especially on the far channels.
5_TG_04			100	672	197°	99-673	19.2	17.9	0.4	1.0		2.2S		A		Noisy due to weather
5_TG_01			100	405	197°	99-406	17.9	14.2	0.2	1.2		1P		A		Some slight blanking. Noise due to weather
gun controller replacement																
5_TG_15_D			4000	5447		3999-5448	13.00	13.50	0.4	1.6		6S		A		4607 4881 missfire
5_TG_11_D			4000	5549		3999-5550	31.00	20.00	0.4	1.3		4P		A		4841 5516 missfire, 5072 bad shott
5_TG_13_E			5000	6494		4999-6495	16.00	-	0.5	1.2		9S		A		6231 missfire
5_TG_03_B			2000	2484		1999-2485	16.00	18.00	0.3	1.5		10P		A		noisy due to strong currant and poor seastate. Best possible result
5_TG_06_C			3000	3753		2999-3755	33.00	21.00	0.3	1.3		6S		A		3084 bad shot. 3364 missfire
5_TG_XL_01			100	1216		99-1217	23.00	14.00	0.3	1.1		18S		A		Hifg FA, starting from 12
5_TG_02_C			3000	3395		2999-3395	17.00	16.00	0.5	1.0		10P		A		lost fix 3072
5_TG_XL_02_B			2000	2396		1999-2397	11.50	15.00	0.4	1.2		12P		A		2061 missfire