UNIVERSITY OF TEXAS INSTITUTE FOR GEOPHYSICS

NZ 3D PSDM REPROCESSING

SEISMIC DATA PROCESSING REPORT

CGG SERVICES (SINGAPORE) PTE LTD

cgg.com

Passion for Geoscience

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1. INTRODUCTION

Project required the reprocessing of NZ3D volume, which is along the Hikurangi subduction zone on the east coast of the North Island of New Zealand, employing a Pre-Stack Depth Migration (PSDM). CGG carried out this re-processing project in the Singapore Centre from August 2020 through to August 2021.

The processing area totalled ~840 km^2, including all the acquired data with water depth varying from 55m to 3541m.

1.1 SURVEY LOCATION

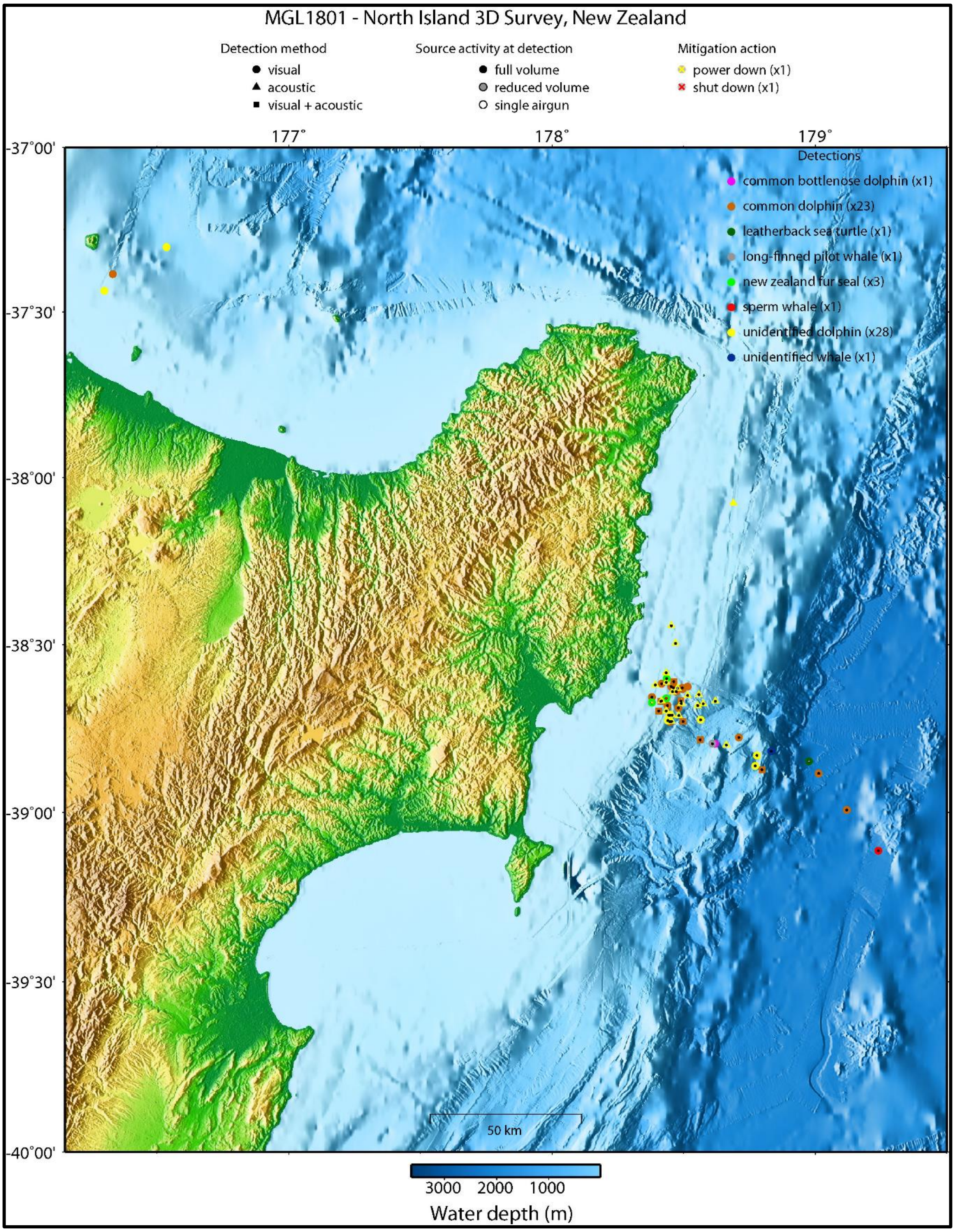


Figure 1: Survey Location

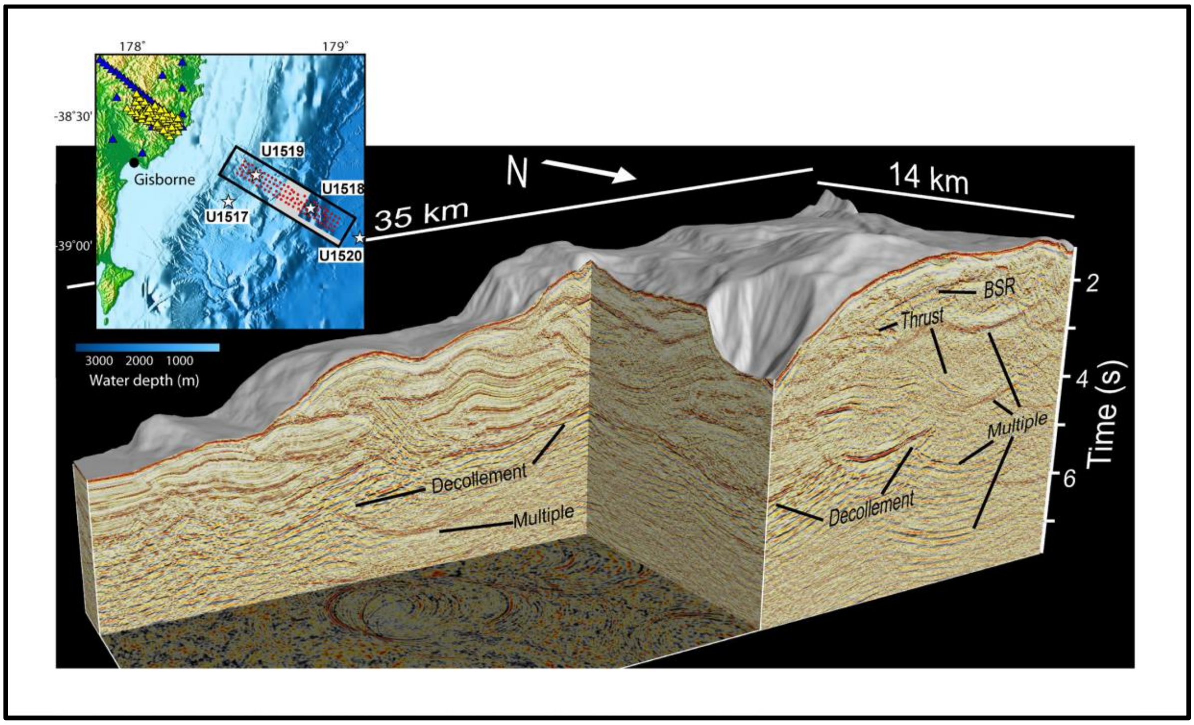


Figure 2: Survey Area (840km²)

1.2 PROCESSING GOALS

This project aims to produce a TTI velocity and PSDM volumes for the 840 km² area and to build a depth image with preservation of amplitudes for interpretation of the targets of interest. For this objective, the following are the processing flow applied on the data.

Time Processing

1) Noise filtering
2) Removal of any acquisition footprint
3) Trace regularization
4) Source deconvolution
5) Multiple suppression including 3D SRME
6) Preliminary velocity model building
7) Apply mutes, nmo….
8) Kirchhoff post stack time migration

Depth Imaging

9) Build TTI velocity model iteratively with PSDM
10) Kirchhoff PSDM
11) Possible RTM

1.3 KEY PERSONNEL – CONTRACTOR AND UTIG

CGG Singapore Personnel

Mr. Qing Xu	–	VP Geoscience APAC, SI Asia
Mr. Barry Hung	–	Imaging Manager Singapore Scope
Mr. Xiaodong Wu	–	Imaging Supervisor, SI Singapore
Mr. Zongying Gong	–	Imaging Teamer Leader, SI Singapore
Ms. Xinyue Gao	–	Imaging Geophysicist, SI Singapore
Mr. Gang Wang	–	Project Leader, SI Singapore

University of Texas for Geophysics

Mr. Nanthan L. Bangs	–	Senior Research Scientist

2. GEODETIC PARAMETERS AND GRID DEFINITION

2.1 GEODETIC REFERENCE

Survey Datum:

Survey Datum	:	World Geodetic System (WGS84)
Ellipsoid	:	WGS84
Semi Major Axis	:	6378137 M
1/Flattening	:	298.2572236
GPS Datum	:	WGS84
Ellipsoid	:	WGS84
Semi Major Axis	:	6378137 M
1/Flattening	:	298.257223563
Geoid Height, EGM96 Model	:	16.1 M

Map projection:

Projection	:	Universal Transverse Mercator
Projection System	:	UTM 60S
Latitude of Origin	:	0ºN
Longitude of Origin	:	177ºE
False Northing	:	1000000 M
False Easting	:	500000 M

2.2 GRID DEFINITION (PROCESSING)

4 corner points of Pre-Binning Grid: 6.25m x 18.75m
Crossline Bin Size: 6.25m
Inline Bin Size: 18.75m

Below is the processing grid (4 corner points) pre-binning (6.25m x 18.75m).

POINTS	X CO-ORDINATE	Y CO-ORDINATE	XLINE	INLINE
P1	679919.00	5676560.00	1	1
P2	616256.74	5716186.27	11999	1
P3	625164.22	5730496.75	11999	900
P4	688826.49	5690870.48	1	900

4 corner points of Binning and post-migration Grid: 12.5m x 18.75m
Crossline Bin Size: 12.5m
Inline Bin Size: 18.75m

Below are the Binning grid (12.5m x 18.75m) coordinates (after binning, pre-migration and post-migration).

POINTS	X CO-ORDINATE	Y CO-ORDINATE	XLINE	INLINE
P1	679919.00	5676560.00	1	1
P2	616256.74	5716186.27	6000	1
P3	625164.22	5730496.75	6000	900
P4	688826.49	5690870.48	1	900

2.3 REGULARIZED OFFSET DEFINITION

Minimum offset 250m
Maximum offset 5950m
Offset increment 100m
Total fold 58

3. ACQUISITION SUMMARY

3.1 ACQUISITION INFORMATION

The first sequence was started on January 6th 2018 by Marcus G. Langseth Cruise. The total sail kilometers of source data is 5489.25 km. The line completing the survey was finished on February 8th 2018.

3.2 ACQUISITION PARAMETERS

General

Survey	NZ 3D
Country	New Zealand

Survey definition

Acquisition Mode	3D
Shot interval	25m (Flip/Flop)
Inline offset	164.7~199.7 m

Energy Source

Source type	BOLT Air-Sound Source
Number of sources	2
Air pressure	1900 +/- 100 psi
Volume	3300 in^3
Number of sub-arrays	2 per source
Source separation	75 m
Sub-array separation	8 m
Source length	16.52 m
Gun synchronization	+/- 2 ms
Shot interval	25m (Flip/Flop)
Depth	7 m
Source controller	SeaMAP DigiShot

Streamer

Type of streamer	Sentinel Solid Acquisition Section (SSAS) 3Hz
Number of streamers	4
Streamer sensitivity	19.7 V/bar
Streamer length	5850 m
Number of groups	468 per streamer
Group interval	12.5 m
Group length	12.5 m
Hydrophone type	Sercel Flexible Hydrophone
Streamer separation	150 m
Streamer depth	8m

Data Recording

Recording System	Sercel Seal 408
Data Channels	4 x 468
File Format	SEG D 8058
Recording Media	USB Disks
Record Length	9500 ms
Sample Rate	2 ms
High Cut Filter	200Hz, 370dB/octave
Low Cut Filter	3Hz digital, 4.7Hz total, 12dB/octave
Polarity Convention	SEG, positive pressure gives negative number

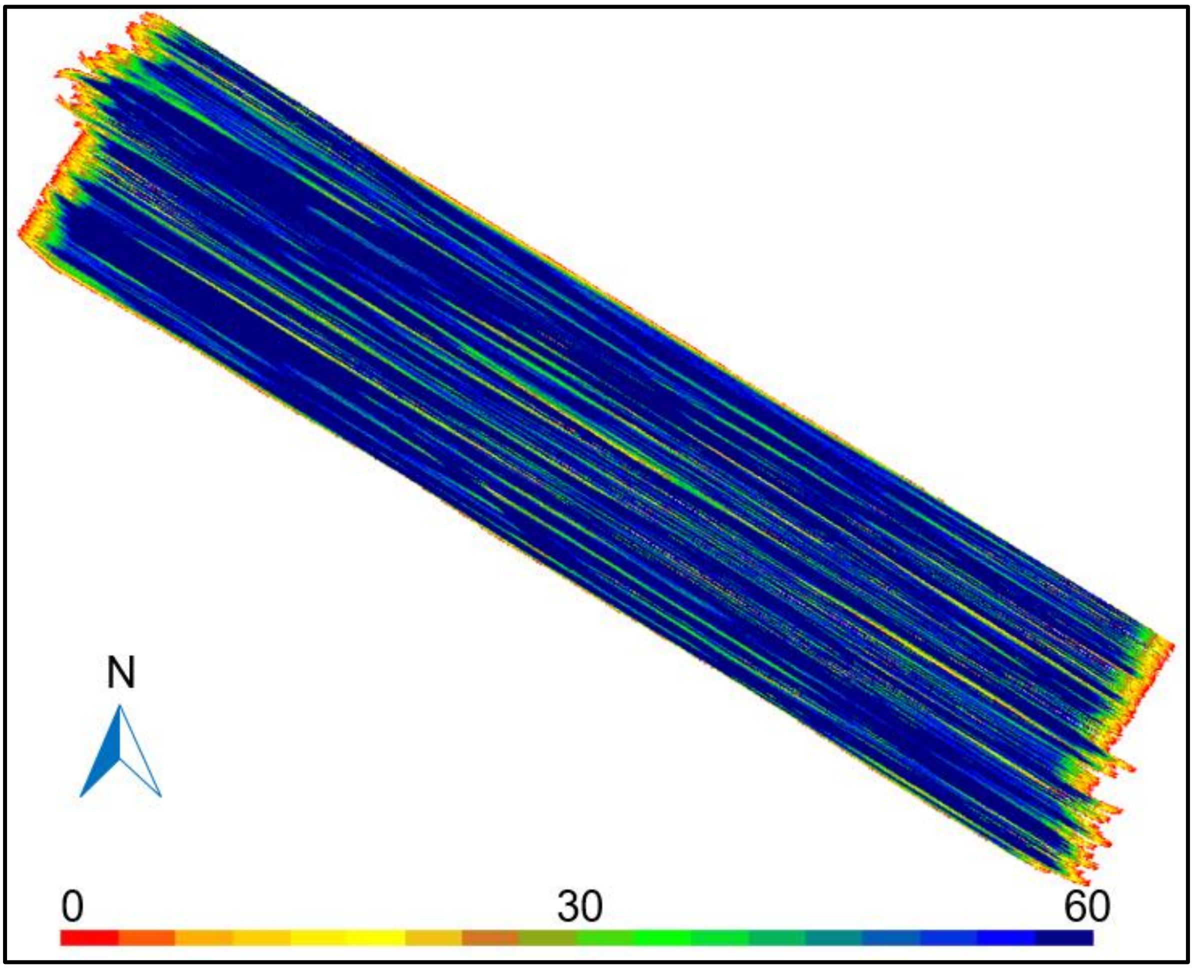


Figure 3: Real world fold coverage after navigation merge.

PROJECT MANAGEMENT

4.1 REPORTING PROCEDURES

CGG's Secure Client Portal, an interactive project-tracking database, was utilised for official status reporting. The interactive project-tracking database covered:

- Emails
- QCs
- Project Status Reports including Microsoft Excel spread sheets
- Testing
- Velocity model building

The portal was made accessible to UTIG via CGG's global web site. A weekly report was sent to UTIG every Wednesday. The report summarised the previous week's work decisions and the plan for the upcoming week. It also displayed the progress chart, logged the information from previous reports, and summarised the tests undertaken.

Fortnightly conference calls were held to discuss and review tests and project progress. These sessions were particularly effective in resolving any issues that required clarification and immediate action. Fortnightly teleconference started from August 2020.

The figures in the next page show examples of the status reports.

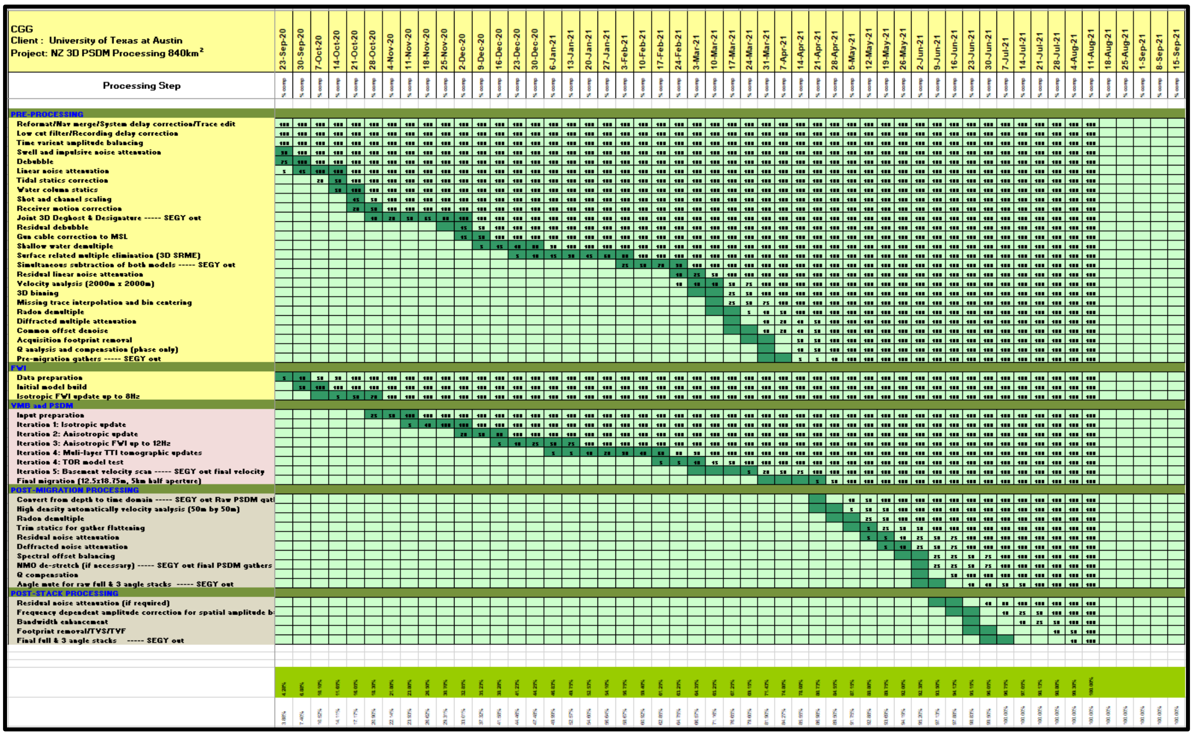


Figure 4: Weekly Status Report

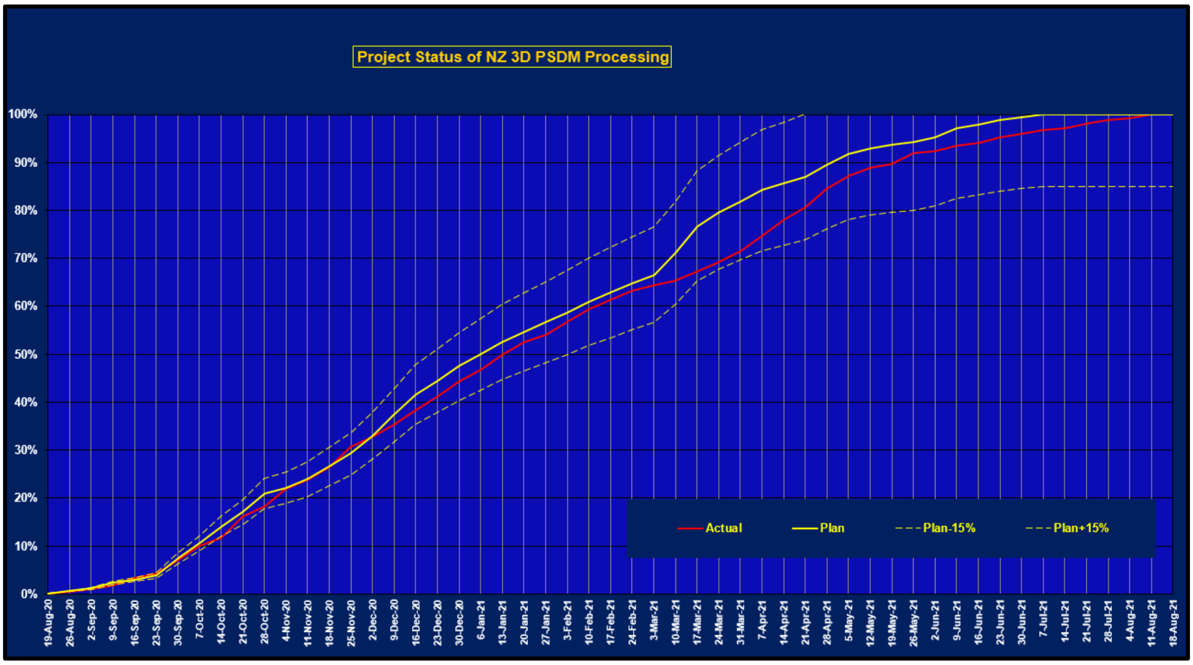


Figure 5: Project Timeline

5. PROCESSING SUMMARY

5.1 PROCESSING FLOW - BRIEF SUMMARY

The following processes were applied by CGG.

Pre-processing

1. Reformat and data QC
2. Navigation-merge
3. Trace edits
4. Low-frequency noise suppression
5. Recording delay correction
6. Swell noise attenuation and despiking
7. Tidal Statics
8. Water column statics correction
9. Shot and channel scaling
10. Receiver motion correction using Sparse-Tau-P method
11. Linear noise attenuation
12. Joint 3D source-receiver Deghosting and Designature
13. Gun/Cable static corrections
14. Comprehensive demultiple package:
15. Model-based water-layer demultiple (MWD) – water bottom-related multiple modelling
16. Iterative 3D-SRME – helpful to attenuate higher order multiple
17. Simultaneous subtraction of MWD and SRME models in curvelet domain
18. Velocity Analysis 2km x 2km and Radon demultiple on 2D CMP
19. Q analysis and compensation (phase only)
20. 3D binning and data regularization on nominal grid
21. Diffracted multiple attenuation
22. Acquisition footprint removal
23. Offset domain denoise
    - ***SEG-Y out Pre-migration gathers***

Pre-stack depth migration

Depth velocity model building

24. Build initial velocity model (existing information to be incorporated)

25. Fast Track Kirchhoff PreSDM (50 x 50m output)
    - ***SEG-Y out Fast Track Stack***
26. FWI 8Hz
27. Tomographic Velocity update
28. FWI 12Hz
29. Multi-Layers TTI Tomographic updates from shallow to deep
30. Basement Velocity Scan
31. Model validation through gridded migration QC throughout (50 x 50m)
    - ***SEG-Y out Final TTI Velocity***

Migration

32. Final TTI Kirchhoff PreSDM (12.5 x 25m output; max half aperture 5km)
33. Convert to time domain
    - ***SEG-Y out Raw PSDM gathers***
34. High Density Velocity Analysis - every 50mx50mx20ms
35. Gather flattening
36. Radon demultiple
37. Residual denoise using co-denoise in Curvelet domain
38. Diffracted noise attenuation
39. Spectral Offset Balancing
40. NMO de-stretch (if necessary)
    - ***SEG-Y out Final PSDM gathers***
41. Angle mute and angle stacks
    - ***SEG-Y out Raw Stack and 3 x Angle Stacks***
42. Residual noise attenuation (if necessary)
43. Frequency dependent amplitude correction for spatial amplitude balancing
44. Bandwidth Enhancement
45. Footprint removal
46. Time Variant Scaling/Time Variant Filter
    - ***SEG-Y out Final Full Stack and 3 x Angle Stacks***

6. TESTING

The pre-processing tests were applied to selected lines. Where applicable, the parameters presented are tabulated and the production parameters are the same as recommended.

6.1 SEISMIC NAVIGATION MERGE

Objective:

To correct for the offset mismatch with data, causing water bottom misalignment in stacks.

Procedure:

- Pick the direct arrival time (D-wave time) to calculate the new offset values that will match with the data.
- Re-calculate receiver positions using the new offset values, assuming shot positions and azimuth angles are correct.
- Only the following sail lines are adjusted: Sequences 001~012, 016, 018, 029, 049, 051, 056, and 058.

Display:

Receiver position map, common offset, 2d stack, and 3d stack.

Observation and Recommendation:

The result shows proposed adjustment of receiver positions are effective. It is recommended to proceed with this adjustment before more accurate positions available from acquisition team.

See for more details.
PPT\t01_nav01.pdf

6.2 LOW CUT FILTER

Objective:

To attenuate extreme low frequency noise.

Procedure:

- Low Cut Filter (LCF) was applied to shot gathers.
- A LCF of 3 Hz was already applied in the acquisition system, so we tested 2.5 Hz and 3 Hz LCF.

Display:

- Test line: Seq 018 (Gun 1 Cable 2); Sequence 039 (Gun 2 Cable 1).
- Display: Selected shot gathers and stacks.

Observation and Recommendation:

- LCF of 2.5 Hz attenuates low frequency noise without hurting the primaries and is recommended for production.
- Harsher low cut filter can be applied later (after de-ghost) if necessary.

See for more details.
PPT\t02_LCF01.pdf

6.3 TVS & RESAMPLING

Objective:

To balance the amplitude and resample to 4ms for later processing.

Procedure:

- A time variant scaler reference is applied to the Water Bottom two-way Time (WBT):

Time (sec)	WBT	WBT+0.4	WBT+1	WBT+2	WBT+3	WBT+5
Scaler (dB)	0	-5	5	15	25	35

- After TVS, we resample the data to 4ms with the anti-aliasing filter (115Hz, 160 dB/octave). And resample back to 2ms for comparison.

Display:

- Test line: Seq 018 (Gun 1 Cable 2); Sequence 039 (Gun 2 Cable 1).
- Display: Selected shot gathers and stacks.

Observation and Recommendation:

TVS reasonably balances the amplitude of primary events which helps the succeeding processing steps and QC. Resample to 4ms will save processing time with minor loss of high frequency, away from main deep targets. Both processes are recommended for production

See for more details.
PPT\t03_TVS01.pdf

6.4 SWELL NOISE ATTENUATION

Objective:

To attenuate swell noise and high amplitude spikes.

Procedure:

- Below 20 Hz, swell noise is attenuated using joint low-rank and sparse inversion.
- Above 20 Hz, spikes are attenuated using FX deconvolution from designed start time.

Display:

- Test line: Sailline Sequence 018 (Gun 1 Cable 2); Sailline Sequence 039 (Gun 2 Cable 1).
- Display: Selected shot gathers, stacks, and amplitude maps.

Observation and Recommendation:

Swell noises have been attenuated after joint low-rank and sparse inversion together with FX deconvolution process without hurting primaries. Hence it is recommended to use this in production.

See for more details.
PPT\t04_SNA01.pdf

6.5 DEBUBBLE

Objective:

To attenuate the bubble energies.

Procedure:

A predictive/gap deconvolution filter is designed on source signature with source and receiver ghost. This filter is then applied on the seismic data to attenuate the bubble energy.

The following two source signatures are used for testing:

- **Modelled Signature (MS)** obtained from Nucleus based on acquisition gun array layout and volume.

- **Statistical Signature (SS)** obtained from aligning and stacking water bottom below 1 sec.

Display:

- Test line: Seq 018 (Gun 1 Cable 2); Sequence 039 (Gun 2 Cable 1).
- Display: Selected shot gathers, stacks, and amplitude spectrum.

Observation and Recommendation:

Debubble filter from statistical signature reasonably removes bubble energy without creating artifact compared to the one from modelled signature. We recommend to use statistical signature to generate debubble filter and apply it in production.

See for more details.
PPT\t05_debubble01.pdf

6.6 LINEAR NOISE ATTENUATION

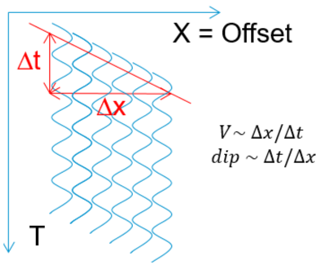
Objective:

To attenuate linear noise.

Procedure:

Linear noise attenuation is done on shot gathers in Tau-P domain and the parameters are designed around apparent sound velocity in water.

Start Time	Primary Protection dip (ms/tr)	Corresponding cut-off apparent velocity (m/s)
WBT+700	-8.1 ~ 8.1	1540 m/s
WBT+1300	-7.7 ~ 7.7	1620 m/s
WBT+2000	-6.9 ~ 6.9	1810 m/s
WBT+4500	-5.6 ~ 5.6	2230 m/s



Display:

- Test line: Seq 018 (Gun 1 Cable 2); Sequence 039 (Gun 2 Cable 1).
- Display: Selected shot gathers, stacks, and amplitude maps.

Observation and Recommendation:

This test shows linear noise is attenuated in the data while keeping the primary data intact. Hence it is recommended to use in production.

See for more details.
PPT\t06_lna01.pdf

6.7 TIDAL & WATER COLUMN STATICS CORRECTION

Objective:

To correct statics shift caused by tide and water column statics, which is caused by changes in water velocity due to temperature and salinity variation

Procedure:

- The statics shifts in time are computed based on the formula: Tidal shift = (tide height * 2) / water velocity. The statics was corrected with calculated tidal shift to individual shots.
- Water column statics are derived by the relative static shift between adjacent sail lines and be corrected along sail lines.
- A near trace bin (offset 200m~offset 500m) was generated after linear noise removal with NMO applied for improvement display and water column statics picking.

Observation:

Tidal & water column statics correction can improve event continuity and is recommended to be applied in production.

See for more details.
PPT\t07_static_correction01.pdf

6.8 SHOT & CHANNEL SCALING

Objective:

To solve the amplitude variation caused by different sensitivity among shots and receivers.

Procedure:

- Amplitude is corrected by applying the scaler which is estimated from RMS amplitude variation across shot and channel.
- RMS amplitude is calculated from defined time window

Shot Scalar Estimation Window			Channel Scalar Estimation Window		
Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
5 traces	11 traces	21 traces	21 traces	36 traces	51 traces
Test 2 is recommended			Test 2 is recommended		

Observation:

Shot and channel scaling solves the amplitude variation caused by different shot & channel sensitivity and enhances the consistency of the amplitude, while keeping the major amplitude trend.

Hence, it is recommended for production.

See for more details.
PPT\t08_shot_channel_scaling01.pdf

6.9 RECEIVER MOTION CORRECTION

Objective:

To remove the time difference caused by receiver movement during data acquisition.

Procedure:

- This is accomplished by applying a time-variant spatial shift related to the boat speed in Tau-P domain.
- The correction is a lateral shift in offset towards smaller offset.

Observation:

The traces were repositioned to compensate the effect of receiver motion. Hence, it is recommended for production.

See for more details.
PPT\t09_receiver_motion_correction_01.pdf

6.10 JOINT DEGHOST & DESIGNATURE

Objective:

To remove the source & receiver ghost and process designature concurrently.

Procedure:

CGG's pre-migration 3D de-ghosting technology - ghost wavefield elimination (GWE) done in sparse Tau - p domain. GWE is able to remove both source and receiver ghost to produce ghost free dataset.

Observation:

Ghosts are removed from input data and primaries are more visible. The notch frequency is compensated and low frequency is recovered. Phase is well aligned after processing. It's recommended for production.

See for more details.
PPT\t10_joint_deghost_designature01.pdf

6.11 RESIDUAL BUBBLE REMOVAL

Objective:

To remove residual bubble energy.

Procedure:

We proceeded with QC for the survey and found some low frequency residual bubble on the seismic data.

For most saillines, the residual bubble energy is weak, only few lines (seq041) are strongly affected.

For this step, we first flatten and align the water bottom using the first channel of near cables, then stack the traces into a wavelet which is used for the debubble filter (gap deconvolution) design. This filter is then applied on the seismic data to attenuate the residual bubble energy.

Observation:

Debubble filter removes residual bubble energy without touching primaries and high frequency components. Therefore, it's recommended to apply for production before demultiple.

See for more details.
PPT\t11_residual_debubble01.pdf

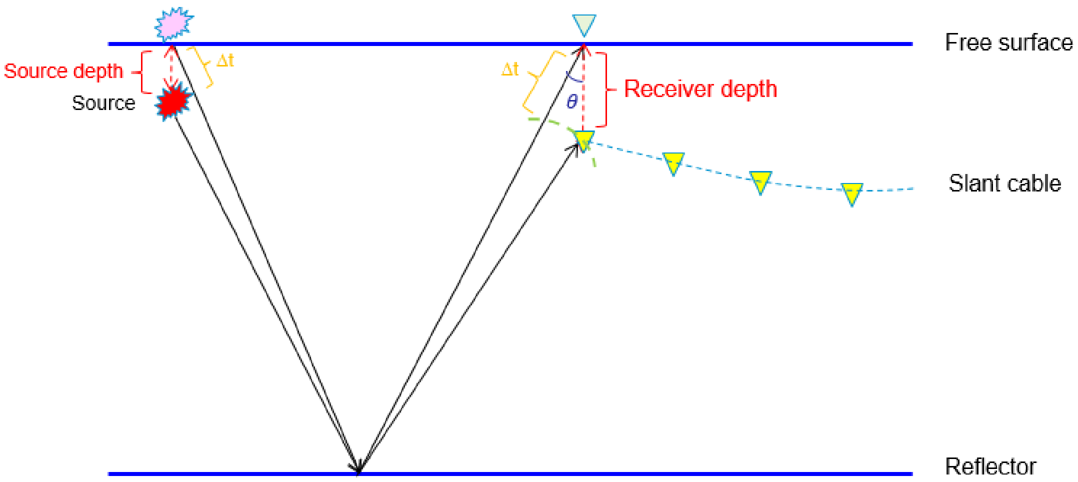
6.12 SOURCE SENSOR DATUM CORRECTION

Objective:

To correct gun & cable to mean sea level.

Procedure:

To apply Normal Moveout (NMO) time shift based on gun & cable depth and ray path angle.



Observation:

The data are shifted downwards as if acquired with source and receiver lying at the mean sea level. The correction is necessary for modelling free surface-related multiples, so it is recommended to be applied on the production.

See for more details.
PPT\t12_source_sensor_datum_correction01.pdf

6.13 SHALLOW WATER DEMULTIPLE

Objective:

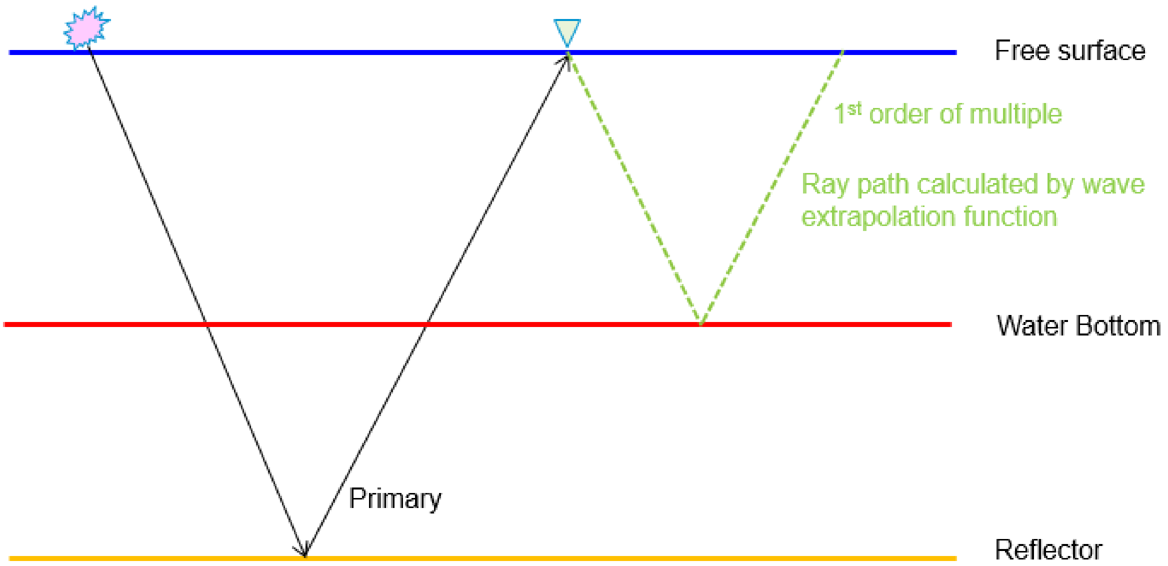
To generate water bottom-related multiple models for the shallow water area by Model-based Water-layer Demultiple Technique (MWD).

Procedure:

Water bottom related multiple is considered as an additional bounce reflected at water bottom.

The multiples are modelled by a given water bottom horizon and wave extrapolation function.

Demultiple is processed by subtracting multiple model from input seismic.



Observation:

The water bottom-related multiples at shallow water area are well modeled, residuals from other reflection horizon will be further modeled by SRME. The current demultiple result is under preliminary subtraction, for final production, a simultaneous subtraction with both MWD and SRME model will be applied.

See for more details.
PPT\t13_shallow_water_demultiple01.pdf

6.14 SURFACE RELATED MULTIPLE ELIMINATION

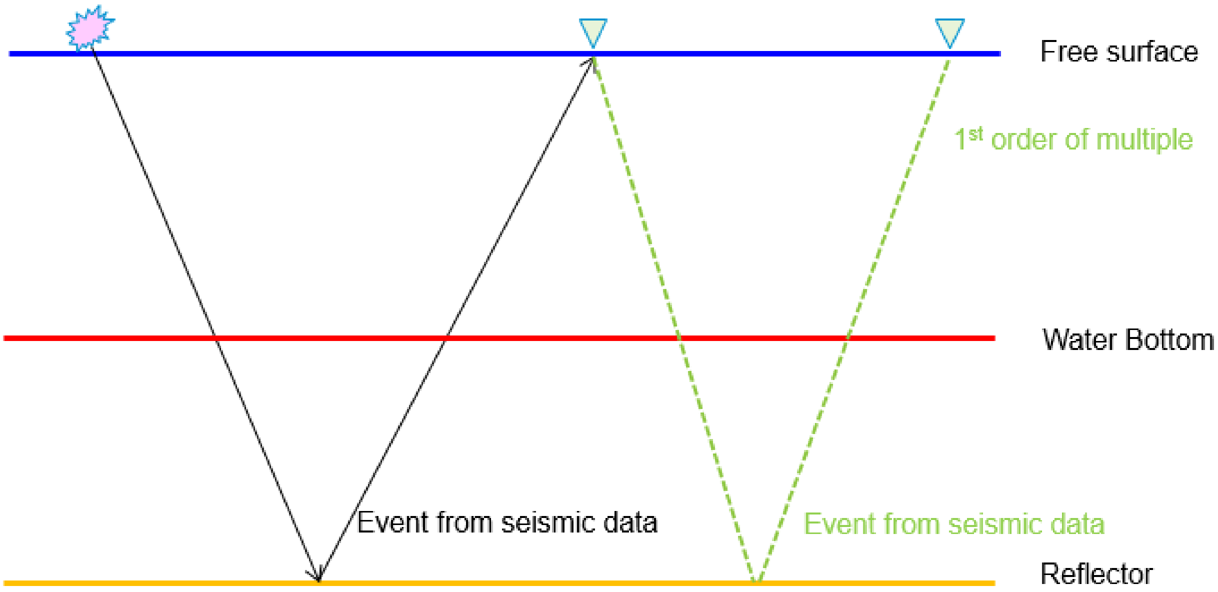
Objective:

To generate free surface-related multiple model by 3D SRME technique.

Procedure:

Free surface-related multiple is modeled by convolving seismic with itself.

Demultiple is processed by subtracting multiple model from input seismic.



Observation:

Free surface-related multiples are well modeled. The demultiple results shown in the following slides are for preliminary subtraction with SRME only; and for final production, a simultaneous subtraction with both MWD and SRME model is tested.

See for more details.
[PPT\t14_SRME_01.pdf]

6.15 SIMULTANEOUS SUBTRACTION OF MWD AND SRME MODEL

Objective:

To remove free surface related multiple.

Procedure:

Subtract MWD & SRME models from input seismic to achieve multiple free seismic data.

Observation:

Simultaneous subtraction with both MWD & SRME models shows benefit in multiple removal and primary protection. It's recommended to apply for production.

See for more details.
PPT\t15_multiple_subtraction_01.pdf

6.16 RESIDUAL LINEAR NOISE ATTENUATION

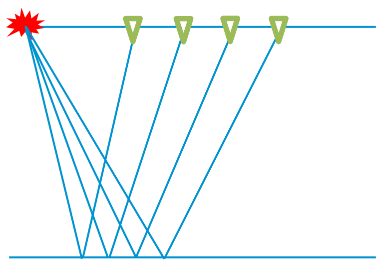
Objective:

To attenuate residual linear noise

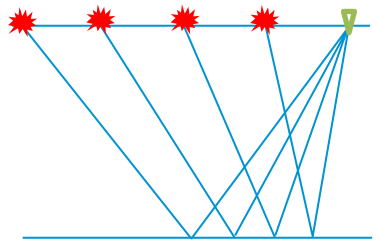
Procedure:

Linear noise attenuation is done on shot and receiver gathers in Tau-P domain

Start Time	Primary Protection dip (ms/tr)	Corresponding cut-off apparent velocity (m/s)
WBT+700	-8.0 ~ 8.0	1560 m/s
WBT+1300	-6.5 ~ 6.5	1900 m/s
WBT+1750	-4.6 ~ 4.6	2700 m/s
WBT+4300	-3.4 ~ 3.4	3600 m/s
WBT+6700	-3.1 ~ 3.1	4000 m/s



Shot gather



Receiver gather

Observation:

Residual linear noise is attenuated in the data while keeping the primary data intact. It's recommended to apply for production.

See for more details.
PPT\t16_residual_LNA_01.pdf
PPT\t16_residual_LNA_02.pdf

6.17 TRACE REGULARIZATION & INTERPOLATION

Objective:

To regularize and interpolate traces.

Procedure:

Trace regularization & interpolation (grid 12.5m x 18.75m) is done using anti-leakage Fourier transform algorithm.

The test is carried out in common offset domain at near (250m), middle (1750m) & far (4050m) offset respectively.

Observation:

All the traces are regularized and well interpolated. It's recommended to apply regularization & interpolation for production.

See for more details.
PPT\t17_regularization_interpolation_01.pdf

6.18 VELOCITY ANALYSIS

Objective:

To update NMO RMS velocity for following radon demultiple.

Procedure:

Velocity is picked based on latest depth interval velocity from VMB (it4).

- Convert depth interval velocity from VMB to time RMS velocity.
- Pick velocity on CDP gathers (after NMO).

Observation:

Primaries are flatter on CDP gathers, which it's beneficial for later radon demultiple. It's recommended to apply for production.

See for more details.
PPT\t18_velocity_analysis_01.pdf

6.19 RADON DEMULTIPLE

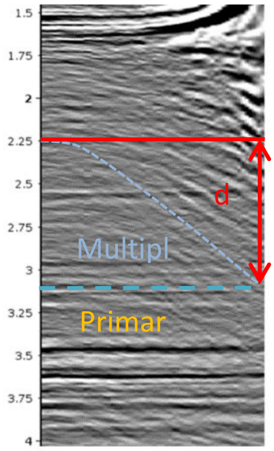
Objective:

To attenuate residual multiples

Procedure:

The radon de-multiple is applied on CDP gathers (NMO applied).

- Start time: WBT+1700 (protect primary diffraction tails).
- When dt > 700ms, event will be considered as multiples.



Observation:

Curling down multiples are removed and primaries are undamaged. It is recommended to apply for this for production.

See for more details.
PPT\t19_radon_01.pdf

6.20 FOOTPRINT REMOVAL

Objective:

To remove acquisition footprint in common offset domain.

Procedure:

- Calculate RMS amplitude at every 2000ms consecutively starting from WBT-30.
- Compute the scalar by smoothing footprint with 500m-Subline direction, 100m–Crossline direction.
- Apply the scalar on input data to remove footprint.

Observation:

The acquisition footprint observed on amplitude map is attenuated. It's recommend to apply footprint removal for production.

See for more details
PPT\t20_footprint_01.pdf

6.21 DIFFRACTED MULTIPLE REMOVAL

Objective:

To attenuate diffracted multiple energy.

Procedure:

- The process is based on the difference in frequency content between primaries and multiples.
- Attenuation is tested with designed time window (WBT*2 -100 ~ 9500ms).

Multiple attenuation is tested common offset (near 250m, middle 1750m, far 4050m).

Observation:

Diffracted multiple energy is attenuated and primaries are untouched. It's recommended to apply for production.

See for more details
PPT\t21_diffracted_multiple_removal_01.pdf

6.22 COMMON OFFSET DENOISE

Objective:

To attenuate noise on common offset domain.

Procedure:

Attenuation is tested in Subline & Crossline direction.

Low frequency (0-6hz) random noise is attenuated on whole survey*.

High frequency (8-30hz) random noise is attenuated at deep part (below 7000ms)*.

Strong dipping noise through crossline direction is attenuated.

* Sternfels, R., Viguier, G., Gondoin, R. and Le Meur, D, 2015, Multidimensional simultaneous random plus erratic noise attenuation and interpolation for seismic data by joint low-rank and sparse inversion: Geophysics, 80, No 6, WD129-WD141.

Observation:

Noise energy on common offset is attenuated and primaries are untouched. It's recommended to apply before migration.

See for more details
PPT\t22_common_offset_denoise_01.pdf

6.23 Q ANALYSIS AND COMPENSATION

Objective:

To apply the Q value to correct for the effects of earth absorption by phase compensation.

Procedure:

The parameters for the Q compensation (Phase only) are as follows:

Window: 500 – 1500ms; 2500 – 4500ms
Q value : 105
Frequency window for analysis: 4 ~ 55Hz
Reference frequency: 35Hz

Observation:

Phase deviation caused by earth absorption is compensated, meanwhile the structure of event keep the same.

See for more details
PPT\t23_Q_phase_01.pdf

6.24 FINAL TTI KIRCHHOFF MIGRATION

Objective:

Final migration using Tilted Transverse Isotropic (TTI) Kirchhoff Migration method.

Procedure:

Apply Kirchhoff migration with 5km aperture.

Q-phase compensation is applied before migration.

Observation:

Post migration stack presents more clear imaging versus VMB volume, and meanwhile shows benefit in primary preservation.

See for more details
PPT\t24_final_migration_01.pdf

6.25 CONVERT FROM DEPTH TO TIME DOMAIN

Objective:

To convert migrated volume from depth to time domain.

Procedure:

Smooth converting velocity by 1000m – subline direction, 500m – crossline direction, 40m – vertical, to avoid structure undulation. Water velocity is kept consistent.

Observation:

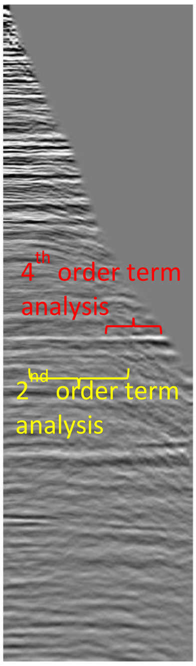
Time stack converted with smoothed velocity presents more reasonable structure, it's recommended to apply for depth-time conversion.

See for more details
PPT\t25_depth_time_conversion_01.pdf

6.26 HIGH DENSITY AUTOMATICALLY VELOCITY ANALYSIS

Objective:

To correct for theresidual moveout (RMO) after migration.



Procedure:

- Input gathers are from TTI Kirchhoff migration converted to time domain.
- Precondition of gathers is done to minimize the possibility of multiple interference via mild Radon-demultiple.
- Moveout velocity (2nd* order term) is estimated by H.W. Swan's* AVO analysis approach.
- 4th* order term is estimated with 2nd* order term.
- Both items are used for NMO.

* Herbert W. Swan. *Seismic velocities from amplitude variations with offset SEG* ***2000*** Expanded Abstracts.

$$t^2 = t_0^2 + \frac{x^2}{v_{NMO}^2} - \frac{2\eta x^4}{v_{NMO}^2\left[t_0^2 v_{NMO}^2 + (1+2\eta)x^2\right]}$$

Observation:

Time stack converted with smoothed velocity presents more reasonable structure, it's recommended to apply for depth-time conversion.

See for more details
PPT\t26_high_density_automatically_velocity_analysis_01.pdf

6.27 RADON DEMULTIPLE

Objective:

To remove residual multiples on TTI Kirchhoff Migration gathers.

Procedure:

The method separates primaries and multiples according to parabolas.

- Start time: WBT + 600ms
- Transform range: -2000ms < dt < 3000ms at offset 5950.

Primary protection range (ms)			
Time	dtmin	dmax	Reference Offset
WBT + 1000	-1900 ms	500 ms	5950
WBT + 3000	-1900 ms	200 ms	5950
WBT + 5000	-1900 ms	150 ms	5950

Observation:

Residual multiple energy is attenuated on CDP gathers and primaries are more obvious. It's recommended to apply for production.

See for more details
PPT\t27_postmigration_radon_01.pdf

6.28 TRIM STATIC CORRECTION

Objective:

To further flatten cdp gathers.

Procedure:

- Input gathers are CDP gathers after Radon de-multiple.
- Use near angle (8-12 degree angle) events as a reference to compute the static shift value.
- 3D Smoothing on trim statics shift.
- Apply trim statics shift on the gathers.

Observation:

CDP gathers are flatter, primaries are more focused on stack. It's recommended to apply for production.

See for more details
PPT\t28_trim_static_correction_01.pdf

6.29 POST MIGRATION DENOISE

Objective:

To further attenuate noise energy on post migration dataset.

Procedure:

Noise attenuation is applied on common offset domain.
Target noise – migration swing & residual diffracted multiple.
Noise are separated by primary dipping information.

Observation:

After post migration denoise, migration swing energy is reduced, residual diffracted multiple energy is attenuated while primaries are preserved. It's recommended to apply for production.

See for more details
PPT\t29_postmigration_denoise01.pdf

6.30 Q COMPENSATION (AMPLITUDE)

Objective:

To apply Q value which account for the earth absorption effect for amplitude compensation.

Procedure:

We previously estimated Q value around 105 with reference frequency of 35 Hz.
We set three test for Q value compensation limitation: (1) 5dB (2) 10dB (3) 15dB

Observation:

Q compensation limited at 10 dB is recommended, where high frequency energy get compensated and noise energy boost remains low. Therefore, we recommend to apply 10 dB Q compensation limitation for production.

See for more details
PPT\t30_Q_amplitude01.pdf

6.31 SPECTRA OFFSET BALANCING

Objective:

To balance offset spectra on CDP gathers.

Procedure:

- The reference wavelet spectrum is estimated using near angles (2 degree to 8 degree) on CDP gathers.
- The reference spectrum is used to calculate the frequency compensation for all the offsets.
- Compensation is applied to boost up the high frequencies of the mid & far-offset data.

Display:

CDP Gathers, time stack (near, mid & far angle stack), amplitude spectra.

Observation & Recommendation:

After offset spectra balancing, high frequencies at mid and far offset are compensated. And the amplitude spectra of mid and far angle stack shows a broader bandwidth. We recommend to apply for production.

See for more details
PPT\t31_offset_balance01.pdf

6.32 ANGLE MUTE & FULL/ANGLE STACK

Objective:

To test inner and outer angle mute for full/angle stack.

Procedure:

- Input is CDP gathers after offset spectra balancing.
- Inner muting angle are tested with 0, 3, 5 degree.
- Outer muting angle are tested with 30, 35, 40 degree.
- The stacks with different angle mute are generated.

Display:

IL711, 300, 530 and 776: CDP Gathers, full stacks with different angle mutes.

Observation & Recommendation:

Inner angle mute of 3 degree and outer angle mute of 35 degree give good quality of stack at target zone and have best balance between event focusing and useful angle. So we recommend to use angle mute of 3~35 degree for full stack on the production.

See for more details
PPT\t32_angle_mute01.pdf
PPT\t32_angle_mute02.pdf
PPT\t32_angle_mute_for_angle_stack.pdf

6.33 RESIDUAL NOISE ATTENUATION

Objective:

To attenuate residual noise in stack

Procedure:

- Migration swing attenuation: Apply dip-filter in the F-K domain to attenuate the migration swing observed in crossline direction. Apply area is controlled by hand mute.
- High frequency noise attenuation: High frequency high dipping noise is attenuated in control area.

Display:

Full stack selected subline and crossline

Observation & Recommendation:

- Residual noise attenuation can improve signal noise ratio.
- Recommend apply residual noise attenuation to production.

See for more details
PPT\t33_residual_noise_attenuation.pdf

6.34 FREQUENCY DEPENDENT AMPLITUDE CORRECTION

Objective:

To further balance spatially-variant amplitude (apply to full stack only).

Procedure:

- Convert data to time domain.
- Compute the modelled attenuation scalars using the spectral ratio method for Q-estimation.
- Apply spatial variant residual Q compensation.

Display:

Selected the subline and crossline in depth domain.

Observation & Recommendation:

- Spatially variant amplitude anomalies is compensated by residual Q compensation and data interpretability is improved.
- Recommend apply amplitude correction to full stack production.

See for more details
PPT\t34_frequency_dependent_amplitude_correction_for_spatial_amplitude.pdf

6.35 BANDWIDTH ENHANCEMENT

Objective:

To extend the bandwidth of full stack data.

Procedure:

- Input data is full stack in time domain.
- Bandwidth enhancement in curvelet domain is a spectrum whitening technology, which can better enhance signal while depressing noise.

Display:

- Selected subline and crossline in time domain.
- Spectrum.

Observation & Recommendation:

- Bandwidth enhancement broadens the frequency spectrum.
- Bandwidth enhancement is recommended for production.

See for more details
PPT\t35_bandwidth_enhancement.pdf

6.36 FOOTPRINT REMOVAL

Objective:

To further remove amplitude variations due to acquisition footprint.

Procedure:

- Calculate RMS amplitude at every 500ms consecutively starting from WBT-30.
- Smooth amplitudes in subline direction to remove effect of geology from the amplitude maps.
- Apply smoothing with 500m (diameter) on amplitude map to compute the scalars for each window.
- Apply the scalar on input data to remove footprint.

Display:

- Amplitude map, full and angle stack.
- Selected crossline.

Observation & Recommendation:

- The acquisition footprint observed on amplitude map is attenuated.
- It's recommend to apply footprint removal for production.

See for more details
PPT\t36_footprint_removal.pdf

6.37 TIME-VARIANT AMPLITUDE SCALING (TVS) AND TIME-VARIANT FILTER (TVF)

Objective:

- Apply a time-variant amplitude scaling (TVS).
- Apply a time-variant filter (TVF) to attenuate high frequency noise.

Procedure:

- TVS parameters is WBT variies, because the geology is different in shallow and deep water area.

WBT=0ms	WBT=1000ms	WBT=4500ms
0ms → 0dB	0ms → 0dB	0ms → 0dB
500ms → 0dB	1500ms → 0dB	5500ms → 0dB
2000ms → 20dB	4000ms → 15dB	6500ms → 5dB
4000ms → 25dB	6000ms → 20dB	7500ms → 15dB
7000ms →25dB	7000ms →25dB	9000ms →25dB
9500ms →25dB	9500ms →25dB	9500ms →25dB

- Time-Variant Filter (TVF) parameters:

Time	High cut filter (Hz)	Slope (dB/Oct)
0-6000ms	-	-
6500-7000ms	50	36
7500-9500ms	18	36

Display:

- Full and angle stack in depth domain.
- Selected subline and crossline.

Observation & Recommendation:

- TVS can well balance the amplitude from shallow to deep.
- TVF attenuates the high frequency noise without touching the primary.
- TVS and TVF is recommend to production.

See for more details
PPT\t37_tvs_and_tvf.pdf

7. VELOCITY MODEL BUILDING

7.1 FULL WAVEFORM INVERSION (FWI) PREPARATION

Objective:

To evaluate the Full Waveform Inversion (FWI) initial model and wavelet.

Procedure:

- Initial depth velocity model was converted and smoothed from legacy time RMS model. This is used for FWI synthetic shot modelling.
- FWI synthetic shot data is compared with real shot data for both streamer and OBN survey to evaluate the initial model.

Display:

Initial velocity, source wavelet, and FWI synthetic.

Observation and Recommendation:

- The water velocity of the initial model is quite reasonable. At some places the velocity just beneath sea floor may be too fast.
- Current OBN data seems to have recording issues. The shape of the wavelet from real data does not match with synthetic data.

See for more details
PPT_VMB\f00_isofwi01.pdf

7.2 ISOTROPIC FWI

Objective:

To QC isotropic (ISO) FWI result.

Procedure:

- Isotropic FWI was run with both streamer and OBS data from 2.5 Hz to 7Hz. Only refraction energy is used in the velocity inversion. For OBS data, a mute is applied to exclude the data that is affected by the recording issue.
- To evaluate the result, a depth migration volume was generated using data after the low cut filter.

Display:

Velocity and FWI synthetic.

Observation and Recommendation:

Current ISO FWI gives reasonable update down to ~2km beneath Water Bottom (WB). Velocity updated deeper than this depth is hard to be evaluated at the moment, due to interference of multiples. We're working on a VMB depth migration volume with major preprocessing steps applied (de-ghost and de-multiple), so we can evaluate the ISO fwi model and proceed to ISO tomography before building TTI model and TTIFWI.

See for more details
PPT_VMB\f01_isofwi01.pdf

7.3 ISOTROPIC FWI – MIGRATION QC

Objective:

To QC the isotropic (ISO) FWI result via depth migration.

Procedure:

- The VMB migration input is prepared from the production data after linear noise attenuation.
- Several key steps were applied to reasonably clean the data. These processes include WCS, RMC, 2D deghost, 3D demultiple, and some simple denoise.
- Kirchhoff depth migrations were done with 5 km aperture and down to 15 km. A time variant scale was applied to balance the amplitude for QC purpose.

Display:

Velocity and migrated depth full stack & gathers.

Observation and Recommendation:

ISO FWI velocity gives overall flatter gathers and improvements on migrated stack, compared to initial velocity. We recommend to move on to ISO tomography.

See for more details
PPT_VMB\f02_isofwi02.pdf

7.4 IT1 – ISOTROPIC TOMOGRAPHY

Objective:

To update overall velocity trend and to get accurate shallow velocity for anisotropy analysis.

Procedure:

- The input is migration result after isotropic (ISO) FWI update.
- Residual move-out information was picked on CDP gathers on a grid size 50m X 56.25m.
- Isotropic non-linear tomography was applied globally from water bottom to 15 km.

Display:

Velocity and migrated depth full stack & gathers.

Observation and Recommendation:

Iteration 1 (IT1) tomography globally flattens CDP gathers. Events in the deep area are simpler and more geological, compared to previous result. Events close to water bottom are flat from near to far angle, indicating a reasonable velocity for anisotropy analysis.

See for more details
PPT_VMB\v01_it1_iso_tomo.pdf

7.5 IT2 – TTI MODEL

Objective:

To convert IT1 ISO model to TTI models.

Procedure:

- Based on the well analysis, we constructed delta model with 4% below unconformity surface and 0% above the surface, where unconformity surface was picked on IT1 volume.
- Epsilon is 1.25 x Delta, which is 5% based on epsilon scanning result.
- Theta and phi was also picked on IT1 volume with depth variant smoothing.

Display:

Velocity models, profiles at well locations, and migrated depth full stack & gathers.

Observation and Recommendation:

Introducing TTI parameters results in a upward shift of migration result where delta is not 0%. The TTI velocity is now matches well sonic recordings.

See for more details
PPT_VMB\v02_it2_v01.pdf

7.6 IT2 – TTI TOMOGRAPHY

Objective:

To adjust TTI velocity model for TTIFWI.

Procedure:

We updated the delta and epsilon base on the new unconformity surfaces. We further updated the velocity using TTI tomography (TOMO) to get better starting model for TTIFWI.

Display:

Velocity models and migrated depth full stack & gathers.

Observation and Recommendation:

The TTI tomography reasonably improves the gather flatness and event focus on stack. We recommend to move on to TTIFWI.

See for more details
PPT_VMB\v02_it2_v02.pdf

7.7 IT3 – TTI FWI 7HZ

Objective:

To QC intermediate 7Hz TTI FWI result.

Procedure:

- TTI FWI was run with both streamer and OBS data from 2.5 Hz to 7Hz. Refraction energy is used in both data sets and reflection energy of streamer data is also included in the inversion.
- 7Hz TTI FWI velocity was used to generate the synthetic shots.

Display:

Velocity and FWI synthetic.

Observation and Recommendation:

Current TTI FWI gives more detailed velocity that aligns more with geology, compared with IT2 TTI tomographic velocity. Synthetic shots have better match with the real data indicating a reasonable update. We'll continue the TTI FWI update to 12 Hz according to our contract.

See for more details
PPT_VMB\v03_it3_v01.pdf

7.8 IT3 – 12HZ TTI FWI

Objective:

To QC 12 Hz TTI FWI result.

Procedure:

- TTI FWI was run with both streamer and OBS data from 2.5 Hz to 12Hz. Refraction energy is used in both data sets and reflection energy of streamer data is also included in the inversion.
- An updated migration input was used with less residual multiples and artifacts, mainly due to the change from 2D deghost to 3D deghost and common offset denoise.

Display:

Velocity, migrated depth full stack & gathers.

Observation and Recommendation:

12Hz TTI FWI gives more detailed velocity that aligns more with geology, compared with IT2 TTI tomographic velocity. Migration with FWI velocity shows overall improvement, especially dipping events in the target area.

See for more details
PPT_VMB\v03_it3_v02.pdf

7.9 IT4 – RTM TEST

Objective:

To evaluate the benefit from RTM compared to Kirchhoff migration.

Procedure:

TTI RTM was run to 20Hz using IT4 velocity.

Display:

Migrated depth full stack & gathers.

Observation and Recommendation:

20Hz TTI RTM result has less migration swings and high frequency noises. Events in the deep sections are more continuous and better illuminated at places where velocity is complex.

See for more details
PPT_VMB\v04_it4_rtm.pdf

7.10 IT4 – TOR TEST

Objective:

To evaluate the benefit derived from tilted orthorhombic (TOR) VMB.

Procedure:

- OBS data were divided into 6 azimuth sectors, which were used to run 6 TTIFWI. Tilted orthorhombic TOR models were then built base on 6 TTI models to handle azimuthal anisotropy.
- OBS only TOR FWI was run using converted TOR models as starting model to fully utilize the benefit from TOR setting.

Display:

Velocity models, migrated depth full stack & gathers.

Observation and Recommendation:

20Hz TTI QRTM result has less migration swings and high frequency noises. Events in the deep sections are more continuous and better illuminated at places where velocity is complex.

See for more details
PPT_VMB\v04_it4_TOR.pdf

7.11 IT4 – PART1

Objective:

To further improve deep velocity, especially in the middle and west part.

Procedure:

Based on IT3 result, theta and phi were updated. Epsilon is increased from 5% to 8% in the middle to west part based on previous epsilon scanning result. TTIFWIwas then run with updated anisotropy from 2.5Hz to 5Hz.

Display:

Velocity, migrated depth full stack & gathers.

Observation and Recommendation:

In the low S/N area from middle to west of the survey, the velocity in the deeper area is more geological, resulting in a better imaging of the central dipping events. We'll continue to focus this area for better velocity.

See for more details
PPT_VMB\v04_it4_v01.pdf

7.12 IT4 – PART2

Objective:

To further improve deep velocity, especially in the middle and west part.

Procedure:

Following the previous intermediate result, TTI FWI was run to 6Hz. An anomalous inverse Q absorption model was derived from FWI velocity (mainly below the BSR where gas accumulates) and was added to the FWI velocity only inversion. This approach gives a FWI velocity that results in flatter gathers in the gas zone.

Display:

Velocity, migrated depth full stack & gathers.

Observation and Recommendation:

In the low S/N area from middle to west of the survey, the velocity in the deeper area is more geological and results in a better imaging of the central dipping events. We'll continue to focus this area for better velocity.

See for more details
PPT_VMB\v04_it4_v02.pdf

7.13 IT4 – PART3

Objective:

To further improve deep velocity, especially in the middle and west part.

Procedure:

Following the previous TTI FWI result, a global TTI tomography is applied to further flatten gathers, especially outside OBS data coverage.

Display:

Velocity, migrated depth full stack & gathers.

Observation and Recommendation:

The flatness of the gathers are improved. Events on the stack have better focus and continuity. We recommend to proceed with this IT4 velocity.

See for more details
PPT_VMB\v04_it4_v03.pdf

7.14 IT5 – PART1

Objective:

To further improve deep velocity, especially in the middle and west part.

Procedure:

Following the previous global TTI tomography, a high resolution tomography is applied on the east side and scanning tomography is applied on the east deep part, that outside the OBN FWI coverage.

Display:

Velocity, migrated depth full stack & gathers.

Observation and Recommendation:

The flatness of the gathers are improved. Events on stack have better focus and continuity. We'll further update the deep velocity.

See for more details
PPT_VMB\v04_it5_v01.pdf

7.15 IT5 – PART2

Objective:

To further improve deep velocity, especially in the middle and west part.

Procedure:

Following the previous velocity update, scanning tomography is applied on the east side and deep section. Further high resolution tomography is applied to localized area to fine tune the velocity.

Display:

Velocity, migrated depth full stack & gathers.

Observation and Recommendation:

The flatness of the gathers are improved. And events on stack have better focus and continuity. We recommend to use this velocity for final migration.

See for more details
PPT_VMB\v04_it5_v02.pdf

8 FUTURE WORKS

8.1 WIDE AZIMUTH ACQUISITION

Current acquired data is of narrow azimuth. A wide azimuth acquisition and tilted orthorhombic velocity model building should benefit deep complex thrust fault imaging.

8.2 Q MIGRATION

Since we observed gas pockets beneath BSR, a Q migration will further improve the overall amplitude and phase of events beneath these gas pockets.

8.3 RTM

To fully utilize the benefit of high resolution velocity, reduce migration swings, image complex structures with multipath rays, RTM will further improve the final image.

8.4 LS-RTM

LS-RTM may also further improves image by handling the imbalanced illumination and further suppress the migration swings.

9 CONCLUSION

CGG successfully completed all processing work and achieved the following objectives:

- Signal to noise ratio was significantly improved with several passes of effective noise attenuation.
- Joint de-ghosting was applied to remove both source and receiver ghost.
- Comprehensive de-multiple package was applied to eliminate both short period and long period multiples.
- Missing traces caused by acquisition were properly interpolated before migration to ensure good quality imaging across whole survey.
- Include OBN data in the early stage of TLFWI which help FWI to penetrate deeper, and finally resolve the large velocity error across thrust faults in the target zone.
- Multilayer and scanning tomography were applied to derive accurate velocities for better imaging of the overthrust complex.

To ensure the best results could be achieved CGG employed their latest technologies:

- To increase data bandwidth, a broadband processing flow was applied by removing both source and receiver ghost through CGG joint de-ghosting technology. The low frequency component was much enhanced and ghost notches were compensated.
- A comprehensive de-multiple package was applied to remove multiples effectively. SWD effectively attenuated short period water surface related multiples. 3D SRME was used to model the long-period multiples. Radon de-multiple used VA1 velocities to further remove multiples based on move-out. Curvelet domain subtraction was able to separate primaries and multiples with better primary preservation.
- Joint streamer & OBN TL-FWI has been applied leading to higher resolution seismic data with better identification of geologic features such as channeling and faults.
- In the shallow, joint inversion has benefited from the streamer to gain high resolution velocity of complex structure.
- In the deep, the significant benefit derived from joint inversion are mainly due to long OBN offsets that enable deep penetration and resolve large velocity variation.
- For deep area imaging, multilayer non-linear tomography and scanning tomography methods helped to correct large velocity errors in the deeper section and produced clearer imaging of those areas with complex structure.

The project was completed in a timely manner with all major milestone products delivered on schedule.

Communication between Mr. Nathan Bangs and CGG was frequent and effective, also a key factor to ensuring project success and a high quality reprocessed 3D volume. The communication level was high throughout the processing via email, online meetings and CGG's *Engage* information sharing. This high level of communication had significant impact on the processing schedules, decisions, resolving concerns and delivery of the products.

Comprehensive tests were performed at every stage to ensure the implementation of optimum parameters for signal processing, noise attenuation, multiple removal, imaging, velocity analysis and stacking. Leading-edge technology such as TL-FWI were tested extensively and applied at the production stage. TOR VMB and RTM were also tested while not applied in the production.

Figure 11 to Figure 14 are the comparisons between CGG final PSDM stack volume and Vintage PSTM volume in depth domain.

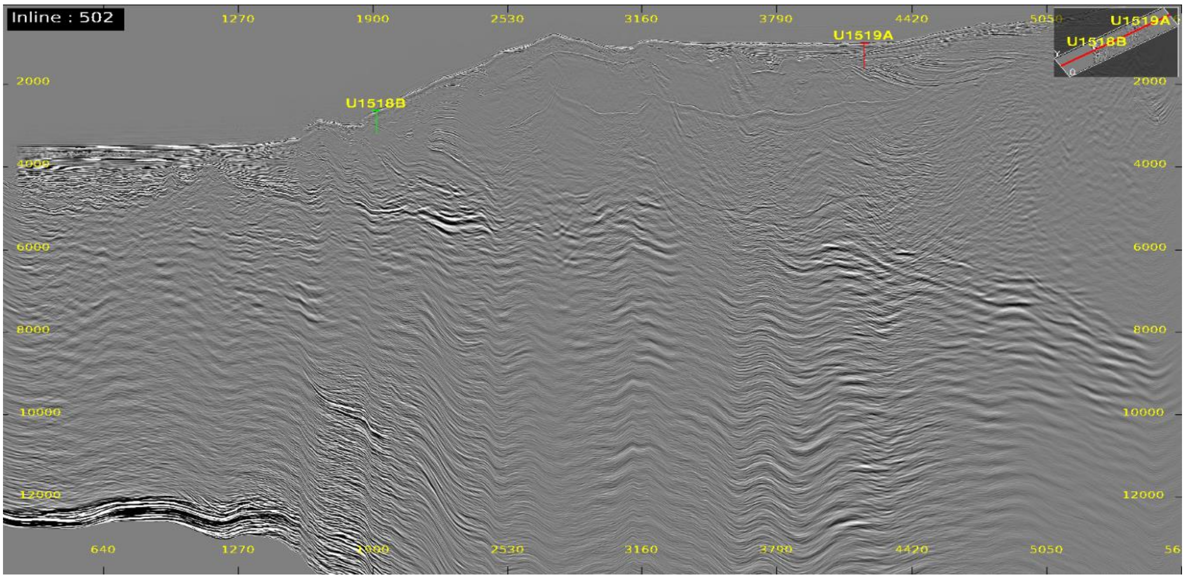


Figure 6: Vintage PSTM data in depth converted with final velocity (Subline 502)

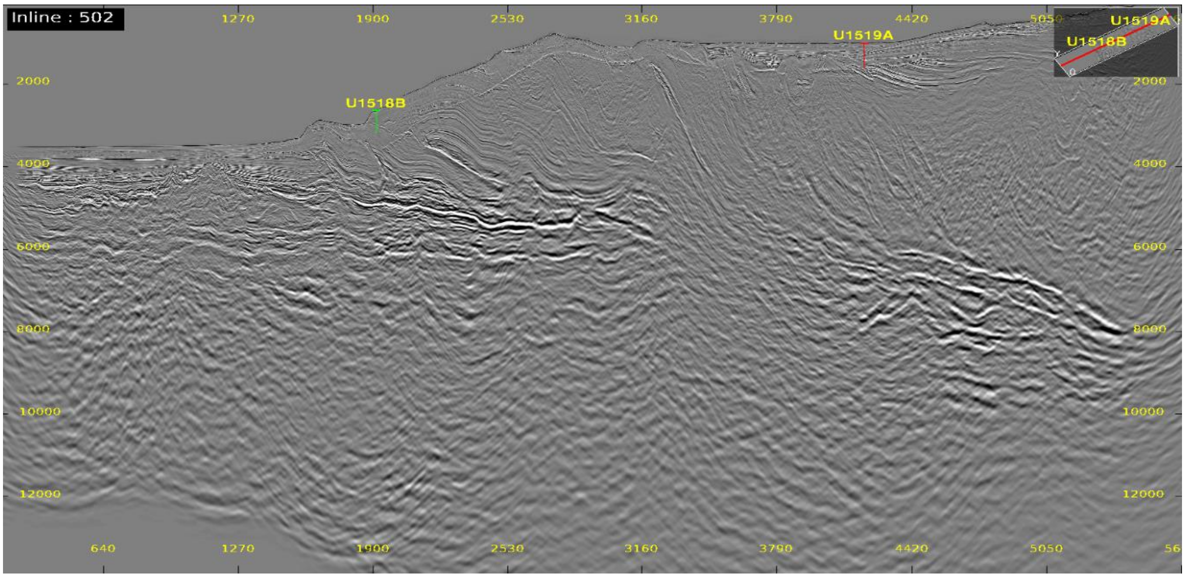


Figure 7: CGG 2020 new PSDM processing data in depth with final velocity (Subline 502)

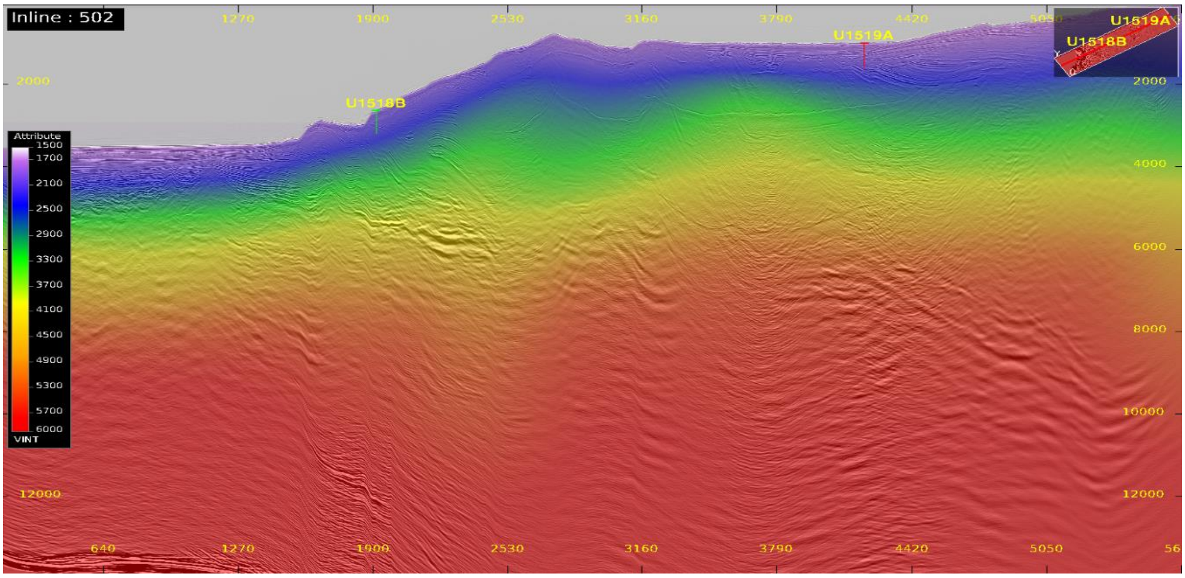


Figure 3: vintage PSTM data in depth with vintage velocity (Subline 502)

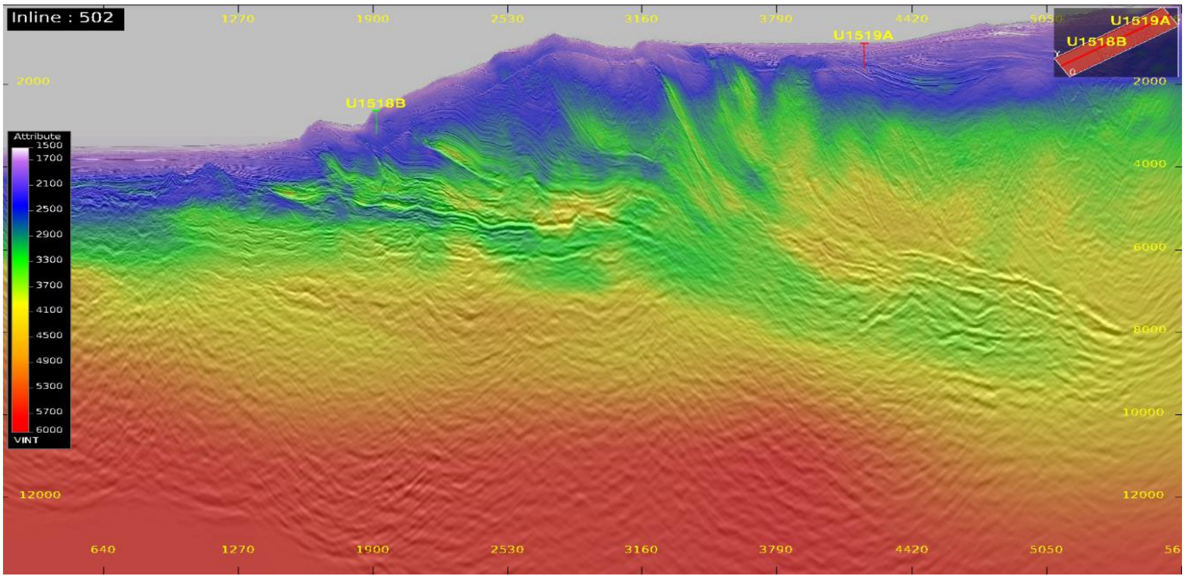


Figure 4: CGG 2020 new processing data in depth with final velocity (Subline 502)

APPENDIX A – LOCATION OF PROCESSING

The processing of the project was performed at the **CGG Singapore Centre**:

CGG Services Singapore Pte Ltd
9 Serangoon North Ave 5
Singapore 554531
Tel +65 6723 5500
Fax +65 6723 5550
www.cgg.com

APPENDIX B – ADDRESS OF CLIENT

University of Texas Institute for Geophysics

University of Texas at Austin
10100 Burnet Road
Bldg 196, ROC 3.216
AUSTIN TX 78758
United States

APPENDIX C – DELIVERABLES

C.1 DELIVERABLES LIST SUMMARY

Below is the deliverables list summary. EBCDIC header and tape logs will be listed in later stage. Only one example EBCDIC header for same type of data will be provided.

Gather Deliverables							**Total Size (GB)**	
S/No.	**Description**	**Processing**	**Domain**	**Format**	**Media**	**# Copy**	**Size (1 copy)**	**Tape (Size x No.)**
	Pre-migration							
01	Shot Gathers Before Demultiple	After residual debubble	Time	SEGY	USB	2	2.5T	3TB X 2
02	CDP Binned Gathers (Input to migration)	After residual noise attenuation (without NMO correction, without divergence correction)	Time	SEGY	USB	2	2.2T	8TB X 2
	Pre-stack CIG Gathers							
03	Raw TTI Pre-Stack Depth Kirchhoff Gathers	Just After TTI Kirchhoff PSDM	Depth	SEGY	USB	2	3.7T	
04	Final TTI Pre-Stack Depth Kirchhoff Gathers	Just After Q amplitude compensation, before stacking	Depth	SEGY	USB	2	3.7T	
Stack Deliverables								
S/No.	**Description**	**Processing**	**Domain**	**Format**	**Media**	**# Copy**	**Size GB**	
	TTI Kirchhoff Full Stacks							
05	Raw Q-TORT Kirchhoff Full Stack	With gather processing, just after stacking	Depth & Time	SEGY	USB	2	107G	
06	Final Q-TORT Kirchhoff Full Stacks	After post stack processing	Depth & Time	SEGY	USB	2	107G	
	TTI Kirchhoff Stacks - Angle Stacks							
07	Raw TTI Kirchhoff Angle Stacks (3 volumes in total: Near/Mid/Far)	With gather processing, just after stacking	Depth	SEGY	USB	2	196G	6TBX2
08	Final TTI Kirchhoff Angle Stacks (3 volumes in total: Near/Mid/Far)	With post stack process (excluding bandwide extension and spacial amplitude balancing)	Depth	SEGY	USB	2	196G	
Velocity Deliverables								
S/No.	**Description**	**Processing**	**Domain**	**Format**	**Media**	**# Copy**	**Size GB**	
9	Final velocities: Vp/Epsilon/Delta/Theta/Phi/ InverseQ/Depth to time conversion velocity (50m x 56.25m x 20m)	FWI and 5 iterations of VMB	Depth	SEGY	USB	2	8.8G	
10	Stacking Velocity	After post-migration high density velocity analysis	Time	SEGY	USB	2	8.7G	

Figure 8: Deliverable list

C.2 PRE-BINNING SHOT GATHERS (TIME DOMAIN)

EBCDIC HEADER EXAMPLE

POLARITY: NEGTIVE IS INCREASE OF ACOUSTIC IMPEDENCE; PHASE: ZERO

```
**************************** EBCDIC headers ***************************
 C01 CLIENT:    THE UNIVERSITY OF TEXAS AT AUSTIN   VENDOR: CGG    DATE: 20210506
 C02 PROJECT:   NZ 3D PROCESSING
 C03 FORMAT:    SEGY IBM 32 BIT FLOATING POINT      XY UNITS: METERS
 C04 DATA DESC: PRE-SRME SHOT GATHERS               Z  UNITS: MS
 C05 DATA TYPE: SHOT GATHERS 879 - 3485
 C06 SAILLINE : 001   INLINE: 432 - 468   XLINE: 503 - 11387(BEFORE BIN*)
 C07 RECORD LENGTH: 9500MS;     SAMPLE RATE: 4MS;      NUMBER OF SAMPLES:3751
 C08
 C09 -----------------------PROCESSING SEQUENCE----------------------------------
 C10 REFORMAT; NAV MERGE; TRACE EDITS; LOW CUT FILTER; TVS;RESAMPLE TO 4MS
 C11 SWELL NOISE ATTENUATION; DE-BUBBLE; LINEAR NOISE ATTENUATION;
 C12 TIDAL STATICS CORRECTION; WATER COLUMN STATICS; SHOT CHANNEL SCALING
 C13 RECEIVER MOTION CORRECTION; 3D JOINT DE-GHOST & DE-SIGNATURE;
 C14 RESIDUAL DE-BUBBLE; SSD CORRECTION; REVERSE TVS
 C15
 C16 POLARITY: NEGATIVE IS INCREASE OF ACOUSTIC IMPEDENCE
 C17 *XL NUMBER IS DOUBLED BEFORE BINNING
 C18 -------------------- KEY TRACE HEADERS (BYTES)----------------------------
 C19 LINESEQ....................(005-008) NAVSHOT......................(017-020)
 C20 CHANNEL....................(013-016) OFFSET.......................(037-040)
 C21 SCALAR APPLIED TO BYTE LOCATIONS 041-068 ..........................(069-070)
 C22 SCALAR APPLIED TO BYTE LOCATIONS 073-088 AND 181-188 ..............(071-072)
 C23 REC ELEVATION...............(041-044) SHOT ELEVATION ..............(045-048)
 C24 REAL WORLD SHOT_X ..........(073-076) REAL WORLD SHOT_Y ...........(077-080)
 C25 REAL WORLD REC_X ...........(081-084) REAL WORLD REC_Y ............(085-088)
 C26 CDP NO......................(021-024) YEAR ........................(157-158)
 C27 DAY ........................(159-160) HOUR ........................(161-162)
 C28 MINUTE .....................(163-164) SECOND.......................(165-166)
 C29 REAL WORLD COORD_X *100 ....(181-184) REAL WORLD COORD_Y *100 .....(185-188)
 C30 INLINE......................(189-192) CROSSLINE....................(193-196)
 C31 GUNCODE ................... (227-230) STREAMER NUMBER..............(231-234)
 C32 CDP = SUBLINE*100000+CROSSLINE
 C33
 C34 -----------------------GRID DEFINITION-------------------------------------
 C35 PROCESSING GRID(4 CORNER POINTS): XL 6.25M; IL 18.75M; RW X; RW Y)
 C36 PROJ:UTM 60S DATUM:WGS84 UNITS:M CM:177 E
 C37 POINT1                         1;     1; 679919.00; 5676560.00
 C38 POINT2                     11999;     1; 616256.74; 5716186.27
 C39 POINT3                     11999;   900; 625164.22; 5730496.75
 C40 POINT4                         1;   900; 688826.49; 5690870.48

*************************** Binary headers ***************************
```

Figure 9: Example EBCDIC Header for Pre-binning Shot Gathers

TAPE LOG

TAPE LOG	
CLIENT:	THE UNIVERSITY OF TEXAS AT AUSTIN
PROJECT:	NZ 3D PROCESSING
USB ID:	NZ3D_FINAL_DELIVERABLE_SHOT_GATHERS
Domain:	TIME
MAX LENGTH	9500MS/SR:4MS
Format:	SEGY
Date:	JULY 2021

TRACE HEADER	BYTE LOCATIONS
CHANNEL	013-016
NAVSHOT	017-020
CDP	021-024
OFFSET	037-040
REC ELEVATION	041-044
SHOT ELEVATION	045-048
REAL WORLD SHOT_X	073-076
REAL WORLD SHOT_Y	077-080
REAL WORLD REC_X	081-084
REAL WORLD REC_Y	085-088
YEAR	157-158
DAY	159-160
HOUR	161-162
MINUTE	163-164
SECOND	165-166
REAL WORLD COORD_X *100	181-184
REAL WORLD COORD_Y *100	185-188
INLINE	189-192
CROSSLINE	193-196
GUNCODE	227-230
STREAMER NUMBER	231-234

FOUR CORNER POINTS:

CROSSLINE	SUBLINE	XREAL	YREAL
1	1	679919.00	5676560.00
11999	1	616256.74	5716186.27
11999	900	625164.22	5730496.75
1	900	688826.49	5690870.48

folder	files	size
01_b4srme_shot	01_PRE_SRME_SHOT_GATHER_001.sgy	44
	01_PRE_SRME_SHOT_GATHER_002.sgy	44
	01_PRE_SRME_SHOT_GATHER_003.sgy	44
	01_PRE_SRME_SHOT_GATHER_004.sgy	45
	01_PRE_SRME_SHOT_GATHER_005.sgy	44
	01_PRE_SRME_SHOT_GATHER_006.sgy	45
	01_PRE_SRME_SHOT_GATHER_007.sgy	44
	01_PRE_SRME_SHOT_GATHER_008.sgy	44
	01_PRE_SRME_SHOT_GATHER_009.sgy	45
	01_PRE_SRME_SHOT_GATHER_010.sgy	45

	01_PRE_SRME_SHOT_GATHER_011.sgy	44
	01_PRE_SRME_SHOT_GATHER_012.sgy	44
	01_PRE_SRME_SHOT_GATHER_013.sgy	45
	01_PRE_SRME_SHOT_GATHER_014.sgy	44
	01_PRE_SRME_SHOT_GATHER_015.sgy	45
	01_PRE_SRME_SHOT_GATHER_016.sgy	45
	01_PRE_SRME_SHOT_GATHER_017.sgy	44
	01_PRE_SRME_SHOT_GATHER_018.sgy	45
	01_PRE_SRME_SHOT_GATHER_020.sgy	45
	01_PRE_SRME_SHOT_GATHER_021.sgy	44
	01_PRE_SRME_SHOT_GATHER_022.sgy	44
	01_PRE_SRME_SHOT_GATHER_023.sgy	44
	01_PRE_SRME_SHOT_GATHER_024.sgy	44
	01_PRE_SRME_SHOT_GATHER_025.sgy	45
	01_PRE_SRME_SHOT_GATHER_026.sgy	44
	01_PRE_SRME_SHOT_GATHER_027.sgy	45
	01_PRE_SRME_SHOT_GATHER_028.sgy	44
	01_PRE_SRME_SHOT_GATHER_029.sgy	45
	01_PRE_SRME_SHOT_GATHER_030.sgy	44
	01_PRE_SRME_SHOT_GATHER_031.sgy	45
	01_PRE_SRME_SHOT_GATHER_032.sgy	44
	01_PRE_SRME_SHOT_GATHER_033.sgy	45
	01_PRE_SRME_SHOT_GATHER_034.sgy	43
	01_PRE_SRME_SHOT_GATHER_035.sgy	44
	01_PRE_SRME_SHOT_GATHER_036.sgy	43
	01_PRE_SRME_SHOT_GATHER_037.sgy	44
	01_PRE_SRME_SHOT_GATHER_039.sgy	44
	01_PRE_SRME_SHOT_GATHER_040.sgy	44
	01_PRE_SRME_SHOT_GATHER_041.sgy	44
	01_PRE_SRME_SHOT_GATHER_042.sgy	44
	01_PRE_SRME_SHOT_GATHER_043.sgy	44
	01_PRE_SRME_SHOT_GATHER_044.sgy	44
	01_PRE_SRME_SHOT_GATHER_045.sgy	44
	01_PRE_SRME_SHOT_GATHER_046.sgy	44
	01_PRE_SRME_SHOT_GATHER_047.sgy	44
	01_PRE_SRME_SHOT_GATHER_048.sgy	44
	01_PRE_SRME_SHOT_GATHER_049.sgy	44
	01_PRE_SRME_SHOT_GATHER_050.sgy	45
	01_PRE_SRME_SHOT_GATHER_051.sgy	8.4
	01_PRE_SRME_SHOT_GATHER_053.sgy	18
	01_PRE_SRME_SHOT_GATHER_054.sgy	24
	01_PRE_SRME_SHOT_GATHER_055.sgy	43
	01_PRE_SRME_SHOT_GATHER_056.sgy	43
	01_PRE_SRME_SHOT_GATHER_057.sgy	44

	01_PRE_SRME_SHOT_GATHER_058.sgy	39
	01_PRE_SRME_SHOT_GATHER_059.sgy	44
	01_PRE_SRME_SHOT_GATHER_060.sgy	43
	01_PRE_SRME_SHOT_GATHER_061.sgy	44

C.3 MIGRATION INPUT GATHERS (TIME DOMAIN)

EBCDIC HEADER EXAMPLE

POLARITY: NEGTIVE IS INCREASE OF ACOUSTIC IMPEDENCE; PHASE: ZERO

```
**************************** EBCDIC headers ***************************
 C01 CLIENT:    THE UNIVERSITY OF TEXAS AT AUSTIN   VENDOR: CGG    DATE: 20210723
 C02 PROJECT:   NZ 3D PROCESSING
 C03 FORMAT:    SEGY IBM 32 BIT FLOATING POINT      XY UNITS: METERS
 C04 DATA DESC: PRE-MIGRATION CDP GATHERS           Z  UNITS: MS
 C05 DATA TYPE: CDP GATHERS
 C06 INLINE: 29 - 50   XLINE: 187 - 5539
 C07 RECORD LENGTH: 9500MS;     SAMPLE RATE: 4MS;      NUMBER OF SAMPLES:2376
 C08
 C09 -----------------------PROCESSING SEQUENCE----------------------------------
 C10 REFORMAT; NAV MERGE; TRACE EDITS; LOW CUT FILTER; TVS;RESAMPLE TO 4MS
 C11 SWELL NOISE ATTENUATION; DE-BUBBLE; LINEAR NOISE ATTENUATION;
 C12 TIDAL STATICS CORRECTION; WATER COLUMN STATICS; SHOT CHANNEL SCALING
 C13 RECEIVER MOTION CORRECTION; 3D JOINT DE-GHOST & DE-SIGNATURE;
 C14 RESIDUAL DE-BUBBLE; SSD CORRECTION; SHALLOW WATER DEMULTIPLE; 3D SRME
 C15 SIMULTANEOUS SUBTRACTION IN CURVELET DOMAIN; RESIDIAL LNA;
 C16 3D BINNING (12.5X18.75); TRACE REGUL & INTERP; VELOCITY ANALYSIS; RADON
 C17 DIFFRACTED MUL ATTENUATION; COMMON OFFSET DENOISE; FOOTPRINT REMOVAL;
 C18 Q PHASE COMPENSATION; REVERSE TVS
 C19
 C20 POLARITY: NEGATIVE IS INCREASE OF ACOUSTIC IMPEDENCE
 C21 --------------------- KEY TRACE HEADERS (BYTES)-----------------------------
 C22 LINESEQ.....................(005-008) NAVSHOT......................(017-020)
 C23 CHANNEL.....................(013-016) OFFSET.......................(037-040)
 C24 SCALAR APPLIED TO BYTE LOCATIONS 041-068 .........................(069-070)
 C25 SCALAR APPLIED TO BYTE LOCATIONS 073-088 AND 181-188 ..............(071-072)
 C26 REC ELEVATION...............(041-044) SHOT ELEVATION ..............(045-048)
 C27 REAL WORLD SHOT_X ..........(073-076) REAL WORLD SHOT_Y ...........(077-080)
 C28 REAL WORLD REC_X ...........(081-084) REAL WORLD REC_Y ............(085-088)
 C29 REAL WORLD COORD_X *100 ....(181-184) REAL WORLD COORD_Y *100 .....(185-188)
 C30 INLINE......................(189-192) CROSSLINE....................(193-196)
 C31 GUNCODE ................... (227-230) STREAMER NUMBER..............(231-234)
 C32 CDP NO......................(021-024) CDP = SUBLINE*100000+CROSSLINE
 C33
 C34 -----------------------GRID DEFINITION--------------------------------------
 C35 PROCESSING GRID(4 CORNER POINTS): XL 12.5M; IL 18.75M; RW X; RW Y)
 C36 PROJ:UTM 60S DATUM:WGS84 UNITS:M CM:177 E
 C37 POINT1                            1;     1; 679919.00; 5676560.00
 C38 POINT2                         6000;     1; 616256.74; 5716186.27
 C39 POINT3                         6000;   900; 625164.22; 5730496.75
 C40 POINT4                            1;   900; 688826.49; 5690870.48

*************************** Binary headers **************************
```

Figure 10: Example EBCDIC Header for Migration Input Gathers

TAPE LOG

TAPE LOG			
CLIENT:	**THE UNIVERSITY OF TEXAS AT AUSTIN**		
PROJECT:	**NZ 3D PROCESSING**		
USB ID:	**MIGRATION_INPUT_AND_PSDM_RAW_GATHER**		
Domain:	**DEPTH/TIME**		
MAX LENGTH	**15000M/SR:4M 9500MS/SR:4MS**		
Format:	**SEGY**		
Date:	**JULY 2021**		

TRACE HEADER	BYTE LOCATIONS
3DCDP	21 - 24
OFFSET	37 - 40
CDPX (x100)	181 - 184
CDPY (x100)	185 - 188
SUBLINE	189 - 192
CROSSLINE	193 - 196

FOUR CORNER POINTS:

CROSSLINE	SUBLINE	XREAL	YREAL
1	1	679919.00	5676560.00
6000	1	616256.74	5716186.27
6000	900	625164.22	5730496.75
1	900	688826.49	5690870.48

folder	files	size
02_migration_input_cdp	02_MIGIN_CDP_GATHER_IL029_TO_050.sgy	34G
	02_MIGIN_CDP_GATHER_IL051_TO_070.sgy	55G
	02_MIGIN_CDP_GATHER_IL071_TO_090.sgy	56G
	02_MIGIN_CDP_GATHER_IL091_TO_110.sgy	56G
	02_MIGIN_CDP_GATHER_IL111_TO_130.sgy	56G
	02_MIGIN_CDP_GATHER_IL131_TO_150.sgy	56G
	02_MIGIN_CDP_GATHER_IL151_TO_170.sgy	56G
	02_MIGIN_CDP_GATHER_IL171_TO_190.sgy	56G
	02_MIGIN_CDP_GATHER_IL191_TO_210.sgy	56G
	02_MIGIN_CDP_GATHER_IL211_TO_230.sgy	56G
	02_MIGIN_CDP_GATHER_IL231_TO_250.sgy	56G
	02_MIGIN_CDP_GATHER_IL251_TO_270.sgy	55G
	02_MIGIN_CDP_GATHER_IL271_TO_290.sgy	56G
	02_MIGIN_CDP_GATHER_IL291_TO_310.sgy	56G
	02_MIGIN_CDP_GATHER_IL311_TO_330.sgy	55G
	02_MIGIN_CDP_GATHER_IL331_TO_350.sgy	54G
	02_MIGIN_CDP_GATHER_IL351_TO_370.sgy	54G

	02_MIGIN_CDP_GATHER_IL371_TO_390.sgy	55G
	02_MIGIN_CDP_GATHER_IL391_TO_410.sgy	55G
	02_MIGIN_CDP_GATHER_IL411_TO_430.sgy	56G
	02_MIGIN_CDP_GATHER_IL431_TO_450.sgy	57G
	02_MIGIN_CDP_GATHER_IL451_TO_470.sgy	56G
	02_MIGIN_CDP_GATHER_IL471_TO_490.sgy	55G
	02_MIGIN_CDP_GATHER_IL491_TO_510.sgy	55G
	02_MIGIN_CDP_GATHER_IL511_TO_530.sgy	56G
	02_MIGIN_CDP_GATHER_IL531_TO_550.sgy	56G
	02_MIGIN_CDP_GATHER_IL551_TO_570.sgy	56G
	02_MIGIN_CDP_GATHER_IL571_TO_590.sgy	56G
	02_MIGIN_CDP_GATHER_IL591_TO_610.sgy	56G
	02_MIGIN_CDP_GATHER_IL611_TO_630.sgy	55G
	02_MIGIN_CDP_GATHER_IL631_TO_650.sgy	55G
	02_MIGIN_CDP_GATHER_IL651_TO_670.sgy	55G
	02_MIGIN_CDP_GATHER_IL671_TO_690.sgy	55G
	02_MIGIN_CDP_GATHER_IL691_TO_710.sgy	54G
	02_MIGIN_CDP_GATHER_IL711_TO_730.sgy	54G
	02_MIGIN_CDP_GATHER_IL731_TO_750.sgy	55G
	02_MIGIN_CDP_GATHER_IL751_TO_770.sgy	55G
	02_MIGIN_CDP_GATHER_IL771_TO_790.sgy	54G
	02_MIGIN_CDP_GATHER_IL791_TO_810.sgy	53G
	02_MIGIN_CDP_GATHER_IL811_TO_829.sgy	31G

C.4 RAW PRE-STACK DEPTH KIRCHHOFF GATHERS (DEPTH DOMAIN)

EBCDIC HEADER EXAMPLE

POLARITY: NEGTIVE IS INCREASE OF ACOUSTIC IMPEDENCE; PHASE: ZERO

```
**************************** EBCDIC headers ***************************
 C01 CLIENT:    THE UNIVERSITY OF TEXAS AT AUSTIN   VENDOR: CGG    DATE: 20210723
 C02 PROJECT:   NZ 3D PROCESSING
 C03 FORMAT:    SEGY IBM 32 BIT FLOATING POINT      XY UNITS: METERS
 C04 DATA DESC: PSDM RAW CDP GATHERS                Z  UNITS: METERS
 C05 DATA TYPE: CDP GATHERS
 C06 INLINE: 30 - 50   XLINE: 12 - 5759
 C07 RECORD LENGTH: 15000M;     SAMPLE RATE: 4M;      NUMBER OF SAMPLES:3751
 C08
 C09 -----------------------PROCESSING SEQUENCE----------------------------------
 C10 REFORMAT; NAV MERGE; TRACE EDITS; LOW CUT FILTER; TVS;RESAMPLE TO 4MS
 C11 SWELL NOISE ATTENUATION; DE-BUBBLE; LINEAR NOISE ATTENUATION;
 C12 TIDAL STATICS CORRECTION; WATER COLUMN STATICS; SHOT CHANNEL SCALING
 C13 RECEIVER MOTION CORRECTION; 3D JOINT DE-GHOST & DE-SIGNATURE;
 C14 RESIDUAL DE-BUBBLE; SSD CORRECTION; SHALLOW WATER DEMULTIPLE; 3D SRME
 C15 SIMULTANEOUS SUBTRACTION IN CURVELET DOMAIN; RESIDIAL LNA;
 C16 3D BINNING (12.5X18.75); TRACE REGUL & INTERP; VELOCITY ANALYSIS; RADON
 C17 DIFFRACTED MUL ATTENUATION; COMMON OFFSET DENOISE; FOOTPRINT REMOVAL;
 C18 Q PHASE COMPENSATION; REVERSE TVS; TTI DEPTH KIRCHHOFF MIGRATION;
 C19
 C20 POLARITY: NEGATIVE IS INCREASE OF ACOUSTIC IMPEDENCE
 C21 --------------------- KEY TRACE HEADERS (BYTES)----------------------------
 C22 CDP NO......................(021-024) CDP = SUBLINE*100000+CROSSLINE
 C23 OFFSET......................(037-040)
 C24 REAL WORLD COORD_X *100......(181-184)
 C25 REAL WORLD COORD_Y *100 .....(185-188)
 C26 INLINE......................(189-192)
 C27 CROSSLINE...................(193-196)
 C28
 C29 -----------------------GRID DEFINITION-------------------------------------
 C30 PROCESSING GRID(4 CORNER POINTS): XL 12.5M; IL 18.75M; RW X; RW Y)
 C31 PROJ:UTM 60S DATUM:WGS84 UNITS:M CM:177 E
 C32 POINT1                            1;     1; 679919.00; 5676560.00
 C33 POINT2                         6000;     1; 616256.74; 5716186.27
 C34 POINT3                         6000;   900; 625164.22; 5730496.75
 C35 POINT4                            1;   900; 688826.49; 5690870.48
 C36
 C37
 C38
 C39
 C40

*************************** Binary headers ***************************
```

Figure 11: Example EBCDIC Header for RAW Kirchhoff PSDM Gathers

TAPE LOG

TAPE LOG			
CLIENT:	THE UNIVERSITY OF TEXAS AT AUSTIN		
PROJECT:	NZ 3D PROCESSING		
USB ID:	MIGRATION_INPUT_AND_PSDM_RAW_GATHER		
Domain:	DEPTH/TIME		
MAX LENGTH	15000M/SR:4M 9500MS/SR:4MS		
Format:	SEGY		
Date:	JULY 2021		

TRACE HEADER	BYTE LOCATIONS
3DCDP	21 - 24
OFFSET	37 - 40
CDPX (x100)	181 - 184
CDPY (x100)	185 - 188
SUBLINE	189 - 192
CROSSLINE	193 - 196

FOUR CORNER POINTS:

CROSSLINE	SUBLINE	XREAL	YREAL
1	1	679919.00	5676560.00
6000	1	616256.74	5716186.27
6000	900	625164.22	5730496.75
1	900	688826.49	5690870.48

folder	files	size
03_psdm_raw_gather	03_PSDM_RAW_CDP_GATHER_IL030_TO_050.sgy	100G
	03_PSDM_RAW_CDP_GATHER_IL051_TO_070.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL071_TO_090.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL091_TO_110.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL111_TO_130.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL131_TO_150.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL151_TO_170.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL171_TO_190.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL191_TO_210.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL211_TO_230.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL231_TO_250.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL251_TO_270.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL271_TO_290.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL291_TO_310.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL311_TO_330.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL331_TO_350.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL351_TO_370.sgy	95G

	03_PSDM_RAW_CDP_GATHER_IL371_TO_390.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL391_TO_410.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL411_TO_430.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL431_TO_450.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL451_TO_470.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL471_TO_490.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL491_TO_510.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL511_TO_530.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL531_TO_550.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL551_TO_570.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL571_TO_590.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL591_TO_610.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL611_TO_630.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL631_TO_650.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL651_TO_670.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL671_TO_690.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL691_TO_710.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL711_TO_730.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL731_TO_750.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL751_TO_770.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL771_TO_790.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL791_TO_810.sgy	95G
	03_PSDM_RAW_CDP_GATHER_IL811_TO_829.sgy	90G

C.5 FINAL PRE-STACK DEPTH KIRCHHOFF GATHERS (DEPTH DOMAIN)

EBCDIC HEADER EXAMPLE

POLARITY: NEGTIVE IS INCREASE OF ACOUSTIC IMPEDENCE; PHASE: ZERO

```
**************************** EBCDIC headers ***************************
 C01 CLIENT:    THE UNIVERSITY OF TEXAS AT AUSTIN   VENDOR: CGG    DATE: 20210723
 C02 PROJECT:   NZ 3D PROCESSING
 C03 FORMAT:    SEGY IBM 32 BIT FLOATING POINT      XY UNITS: METERS
 C04 DATA DESC: PSDM FINAL CDP GATHERS              Z  UNITS: METERS
 C05 DATA TYPE: CDP GATHERS
 C06 INLINE: 30 - 50   XLINE: 13 - 5759
 C07 RECORD LENGTH: 15000M;     SAMPLE RATE: 4M;      NUMBER OF SAMPLES:3751
 C08
 C09 -----------------------PROCESSING SEQUENCE---------------------------------
 C10 REFORMAT; NAV MERGE; TRACE EDITS; LOW CUT FILTER; TVS;RESAMPLE TO 4MS
 C11 SWELL NOISE ATTENUATION; DE-BUBBLE; LINEAR NOISE ATTENUATION;
 C12 TIDAL STATICS CORRECTION; WATER COLUMN STATICS; SHOT CHANNEL SCALING
 C13 RECEIVER MOTION CORRECTION; 3D JOINT DE-GHOST & DE-SIGNATURE;
 C14 RESIDUAL DE-BUBBLE; SSD CORRECTION; SHALLOW WATER DEMULTIPLE; 3D SRME
 C15 SIMULTANEOUS SUBTRACTION IN CURVELET DOMAIN; RESIDIAL LNA;
 C16 3D BINNING (12.5X18.75); TRACE REGUL & INTERP; VELOCITY ANALYSIS; RADON
 C17 DIFFRACTED MUL ATTENUATION; COMMON OFFSET DENOISE; FOOTPRINT REMOVAL;
 C18 Q PHASE COMPENSATION; REVERSE TVS; TTI DEPTH KIRCHHOFF MIGRATION;
 C19 CONVERT TO TIME; HIGH DENSITY AUTOMATICALLY VELOCITY ANALYSIS;
 C20 RADON DEMULTIPLE; TRIM STATICS FOR GATHER FLATTENING; DENOISE;
 C21 Q AMPLITUDE COMPENSATION; SPECTRAL OFFSET BALANCING; CONVERT TO DEPTH
 C22
 C23 POLARITY: NEGATIVE IS INCREASE OF ACOUSTIC IMPEDENCE
 C24 --------------------- KEY TRACE HEADERS (BYTES)----------------------------
 C25 CDP NO......................(021-024) CDP = SUBLINE*100000+CROSSLINE
 C26 OFFSET......................(037-040)
 C27 REAL WORLD COORD_X *100......(181-184)
 C28 REAL WORLD COORD_Y *100 .....(185-188)
 C29 INLINE......................(189-192)
 C30 CROSSLINE...................(193-196)
 C31
 C32 -----------------------GRID DEFINITION-------------------------------------
 C33 PROCESSING GRID(4 CORNER POINTS): XL 12.5M; IL 18.75M; RW X; RW Y)
 C34 PROJ:UTM 60S DATUM:WGS84 UNITS:M CM:177 E
 C35 POINT1                            1;     1; 679919.00; 5676560.00
 C36 POINT2                         6000;     1; 616256.74; 5716186.27
 C37 POINT3                         6000;   900; 625164.22; 5730496.75
 C38 POINT4                            1;   900; 688826.49; 5690870.48
 C39
 C40

*************************** Binary headers **************************
```

Figure 12: Example EBCDIC Header for Final Kirchhoff PSDM Gathers

TAPE LOG

TAPE LOG			
CLIENT:	THE UNIVERSITY OF TEXAS AT AUSTIN		
PROJECT:	NZ 3D PROCESSING		
USB ID:	PSDM_FINAL_GATHER_STACK_AND_VELOCITY		
Domain:	DEPTH/TIME		
MAX LENGTH	15000M/SR:4M 9500MS/SR:4MS		
Format:	SEGY		
Date:	AUGUST 2021		

TRACE HEADER	BYTE LOCATIONS
3DCDP	21 - 24
OFFSET	37 - 40
CDPX (x100)	181 - 184
CDPY (x100)	185 - 188
SUBLINE	189 - 192
CROSSLINE	193 - 196

FOUR CORNER POINTS:

CROSSLINE	SUBLINE	XREAL	YREAL
1	1	679919.00	5676560.00
6000	1	616256.74	5716186.27
6000	900	625164.22	5730496.75
1	900	688826.49	5690870.48

folder	files	size
04_psdm_final_gather	04_PSDM_FINAL_CDP_GATHER_IL030_TO_050.sgy	100G
	04_PSDM_FINAL_CDP_GATHER_IL051_TO_070.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL071_TO_090.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL091_TO_110.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL111_TO_130.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL131_TO_150.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL151_TO_170.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL171_TO_190.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL191_TO_210.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL211_TO_230.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL231_TO_250.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL251_TO_270.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL271_TO_290.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL291_TO_310.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL311_TO_330.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL331_TO_350.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL351_TO_370.sgy	95G

	04_PSDM_FINAL_CDP_GATHER_IL371_TO_390.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL391_TO_410.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL411_TO_430.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL431_TO_450.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL451_TO_470.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL471_TO_490.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL491_TO_510.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL511_TO_530.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL531_TO_550.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL551_TO_570.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL571_TO_590.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL591_TO_610.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL611_TO_630.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL631_TO_650.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL651_TO_670.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL671_TO_690.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL691_TO_710.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL711_TO_730.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL731_TO_750.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL751_TO_770.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL771_TO_790.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL791_TO_810.sgy	95G
	04_PSDM_FINAL_CDP_GATHER_IL811_TO_829.sgy	90G

C.6 RAW KIRCHHOFF FULL STACK (TIME AND DEPTH DOMAIN)

EBCDIC HEADER EXAMPLE

POLARITY: NEGTIVE IS INCREASE OF ACOUSTIC IMPEDENCE; PHASE: ZERO

```
*************************** EBCDIC headers **************************
 C01 CLIENT:    THE UNIVERSITY OF TEXAS AT AUSTIN   VENDOR: CGG    DATE: 20210730
 C02 PROJECT:   NZ 3D PROCESSING
 C03 FORMAT:    SEGY IBM 32 BIT FLOATING POINT      XY UNITS: METERS
 C04 DATA DESC: RAW PSDM FULL STACK IN TIME         Z  UNITS: MS
 C05 DATA TYPE: STACK
 C06 INLINE: 30 - 829          XLINE: 13 - 5759
 C07 RECORD LENGTH: 9500MS;     SAMPLE RATE: 4MS;      NUMBER OF SAMPLES:2376
 C08
 C09 -----------------------PROCESSING SEQUENCE---------------------------------
 C10 REFORMAT; NAV MERGE; TRACE EDITS; LOW CUT FILTER; TVS;RESAMPLE TO 4MS
 C11 SWELL NOISE ATTENUATION; DE-BUBBLE; LINEAR NOISE ATTENUATION;
 C12 TIDAL STATICS CORRECTION; WATER COLUMN STATICS; SHOT CHANNEL SCALING
 C13 RECEIVER MOTION CORRECTION; 3D JOINT DE-GHOST & DE-SIGNATURE;
 C14 RESIDUAL DE-BUBBLE; SSD CORRECTION; SHALLOW WATER DEMULTIPLE; 3D SRME
 C15 SIMULTANEOUS SUBTRACTION IN CURVELET DOMAIN; RESIDIAL LNA;
 C16 3D BINNING (12.5X18.75); TRACE REGUL & INTERP; VELOCITY ANALYSIS; RADON
 C17 DIFFRACTED MUL ATTENUATION; COMMON OFFSET DENOISE; FOOTPRINT REMOVAL;
 C18 Q PHASE COMPENSATION; REVERSE TVS; TTI DEPTH KIRCHHOFF MIGRATION;
 C19 CONVERT TO TIME; HIGH DENSITY AUTOMATICALLY VELOCITY ANALYSIS;
 C20 RADON DEMULTIPLE; TRIM STATICS FOR GATHER FLATTENING; DENOISE;
 C21 Q AMPLITUDE COMPENSATION; SPECTRAL OFFSET BALANCING;
 C22 STACK WITH ANGLE MUTE 3-35 DEGREE; DENOISE;
 C23
 C24 POLARITY: NEGATIVE IS INCREASE OF ACOUSTIC IMPEDENCE
 C25 --------------------- KEY TRACE HEADERS (BYTES)----------------------------
 C26 CDP NO......................(021-024) CDP = SUBLINE*100000+CROSSLINE
 C27 FOLD........................(031-032) OFFSET...............(037-040)
 C28 REAL WORLD COORD_X *100......(181-184)
 C29 REAL WORLD COORD_Y *100 .....(185-188)
 C30 INLINE......................(189-192)
 C31 CROSSLINE...................(193-196)
 C32
 C33 -----------------------GRID DEFINITION-------------------------------------
 C34 PROCESSING GRID(4 CORNER POINTS): XL 12.5M; IL 18.75M; RW X; RW Y)
 C35 PROJ:UTM 60S DATUM:WGS84 UNITS:M CM:177 E
 C36 POINT1                           1;     1; 679919.00; 5676560.00
 C37 POINT2                        6000;     1; 616256.74; 5716186.27
 C38 POINT3                        6000;   900; 625164.22; 5730496.75
 C39 POINT4                           1;   900; 688826.49; 5690870.48
 C40

************************** Binary headers **************************
```

Figure 13: Example EBCDIC Header Raw Kirchhoff Stack – Full Stack in Time Domain

TAPE LOG

TAPE LOG	
CLIENT:	THE UNIVERSITY OF TEXAS AT AUSTIN
PROJECT:	NZ 3D PROCESSING
USB ID:	PSDM_FINAL_GATHER_STACK_AND_VELOCITY
Domain:	DEPTH/TIME
MAX LENGTH	15000M/SR:4M 9500MS/SR:4MS
Format:	SEGY
Date:	AUGUST 2021

TRACE HEADER	BYTE LOCATIONS
3DCDP	21 - 24
OFFSET	37 - 40
CDPX (x100)	181 - 184
CDPY (x100)	185 - 188
SUBLINE	189 - 192
CROSSLINE	193 - 196

FOUR CORNER POINTS:

CROSSLINE	SUBLINE	XREAL	YREAL
1	1	679919.00	5676560.00
6000	1	616256.74	5716186.27
6000	900	625164.22	5730496.75
1	900	688826.49	5690870.48

folder	files	size
05_raw_psdm_full_stack	05_RAW_PSDM_FULL_STACK_DEPTH.sgy	66G
	05_RAW_PSDM_FULL_STACK_TIME.sgy	42G

C.7 FINAL KIRCHHOFF FULL STACK (TIME AND DEPTH DOMAIN)

EBCDIC HEADER EXAMPLE

POLARITY: NEGTIVE IS INCREASE OF ACOUSTIC IMPEDENCE; PHASE: ZERO

```
**************************** EBCDIC headers ***************************
 C01 CLIENT:    THE UNIVERSITY OF TEXAS AT AUSTIN   VENDOR: CGG    DATE: 20210806
 C02 PROJECT:   NZ 3D PROCESSING
 C03 FORMAT:    SEGY IBM 32 BIT FLOATING POINT      XY UNITS: METERS
 C04 DATA DESC: FINAL PSDM FULL STACK IN TIME       Z  UNITS: MS
 C05 DATA TYPE: STACK
 C06 INLINE: 30 - 829           XLINE: 13 - 5759
 C07 RECORD LENGTH: 9500MS;     SAMPLE RATE: 4MS;      NUMBER OF SAMPLES:2376
 C08
 C09 -----------------------PROCESSING SEQUENCE----------------------------------
 C10 REFORMAT; NAV MERGE; TRACE EDITS; LOW CUT FILTER; TVS;RESAMPLE TO 4MS
 C11 SWELL NOISE ATTENUATION; DE-BUBBLE; LINEAR NOISE ATTENUATION;
 C12 TIDAL STATICS CORRECTION; WATER COLUMN STATICS; SHOT CHANNEL SCALING
 C13 RECEIVER MOTION CORRECTION; 3D JOINT DE-GHOST & DE-SIGNATURE;
 C14 RESIDUAL DE-BUBBLE; SSD CORRECTION; SHALLOW WATER DEMULTIPLE; 3D SRME
 C15 SIMULTANEOUS SUBTRACTION IN CURVELET DOMAIN; RESIDIAL LNA;
 C16 3D BINNING (12.5X18.75); TRACE REGUL & INTERP; VELOCITY ANALYSIS; RADON
 C17 DIFFRACTED MUL ATTENUATION; COMMON OFFSET DENOISE; FOOTPRINT REMOVAL;
 C18 Q PHASE COMPENSATION; REVERSE TVS; TTI DEPTH KIRCHHOFF MIGRATION;
 C19 CONVERT TO TIME; HIGH DENSITY AUTOMATICALLY VELOCITY ANALYSIS;
 C20 RADON DEMULTIPLE; TRIM STATICS FOR GATHER FLATTENING; DENOISE;
 C21 Q AMPLITUDE COMPENSATION; SPECTRAL OFFSET BALANCING;
 C22 STACK WITH ANGLE MUTE 3-35 DEGREE; DENOISE;
 C23 FREQUENCY DEPENDENT AMPLITUDE CORRECTION; BANDWIDTH ENHANCEMENT;
 C24 FOOTPRINT REMOVAL; TVS; TVF;
 C25 POLARITY: NEGATIVE IS INCREASE OF ACOUSTIC IMPEDENCE
 C26 --------------------- KEY TRACE HEADERS (BYTES)----------------------------
 C27 CDP NO......................(021-024) CDP = SUBLINE*100000+CROSSLINE
 C28 FOLD........................(031-032) OFFSET...............(037-040)
 C29 REAL WORLD COORD_X *100......(181-184)
 C30 REAL WORLD COORD_Y *100 .....(185-188)
 C31 INLINE......................(189-192)
 C32 CROSSLINE...................(193-196)
 C33
 C34 -----------------------GRID DEFINITION-------------------------------------
 C35 PROCESSING GRID(4 CORNER POINTS): XL 12.5M; IL 18.75M; RW X; RW Y)
 C36 PROJ:UTM 60S DATUM:WGS84 UNITS:M CM:177 E
 C37 POINT1                          1;      1; 679919.00; 5676560.00
 C38 POINT2                       6000;      1; 616256.74; 5716186.27
 C39 POINT3                       6000;    900; 625164.22; 5730496.75
 C40 POINT4                          1;    900; 688826.49; 5690870.48

*************************** Binary headers ***************************
```

Figure 14: Example EBCDIC Header Final Kirchhoff Stack – Full Stack in Time Domain

TAPE LOG

TAPE LOG	
CLIENT:	THE UNIVERSITY OF TEXAS AT AUSTIN
PROJECT:	NZ 3D PROCESSING
USB ID:	PSDM_FINAL_GATHER_STACK_AND_VELOCITY
Domain:	DEPTH/TIME
MAX LENGTH	15000M/SR:4M 9500MS/SR:4MS
Format:	SEGY
Date:	AUGUST 2021

TRACE HEADER	BYTE LOCATIONS
3DCDP	21 - 24
OFFSET	37 - 40
CDPX (x100)	181 - 184
CDPY (x100)	185 - 188
SUBLINE	189 - 192
CROSSLINE	193 - 196

FOUR CORNER POINTS:

CROSSLINE	SUBLINE	XREAL	YREAL
1	1	679919.00	5676560.00
6000	1	616256.74	5716186.27
6000	900	625164.22	5730496.75
1	900	688826.49	5690870.48

folder	files	size
06_final_psdm_full_stack	06_FINAL_PSDM_FULL_STACK_DEPTH.sgy	66G
	06_FINAL_PSDM_FULL_STACK_TIME.sgy	42G

C.8 RAW KIRCHHOFF ANGLE STACK (DEPTH DOMAIN)

EBCDIC HEADER EXAMPLE

POLARITY: NEGTIVE IS INCREASE OF ACOUSTIC IMPEDENCE; PHASE: ZERO

```
*************************** EBCDIC headers ***************************
 C01 CLIENT:    THE UNIVERSITY OF TEXAS AT AUSTIN   VENDOR: CGG    DATE: 20210801
 C02 PROJECT:   NZ 3D PROCESSING
 C03 FORMAT:    SEGY IBM 32 BIT FLOATING POINT      XY UNITS: METERS
 C04 DATA DESC: RAW PSDM NEAR STACK IN DEPTH        Z  UNITS: METERS
 C05 DATA TYPE: STACK
 C06 INLINE: 30 - 829           XLINE: 13 - 5759
 C07 RECORD LENGTH: 15000M;     SAMPLE RATE: 4M;      NUMBER OF SAMPLES:3751
 C08
 C09 -----------------------PROCESSING SEQUENCE-----------------------------------
 C10 REFORMAT; NAV MERGE; TRACE EDITS; LOW CUT FILTER; TVS;RESAMPLE TO 4MS
 C11 SWELL NOISE ATTENUATION; DE-BUBBLE; LINEAR NOISE ATTENUATION;
 C12 TIDAL STATICS CORRECTION; WATER COLUMN STATICS; SHOT CHANNEL SCALING
 C13 RECEIVER MOTION CORRECTION; 3D JOINT DE-GHOST & DE-SIGNATURE;
 C14 RESIDUAL DE-BUBBLE; SSD CORRECTION; SHALLOW WATER DEMULTIPLE; 3D SRME
 C15 SIMULTANEOUS SUBTRACTION IN CURVELET DOMAIN; RESIDIAL LNA;
 C16 3D BINNING (12.5X18.75); TRACE REGUL & INTERP; VELOCITY ANALYSIS; RADON
 C17 DIFFRACTED MUL ATTENUATION; COMMON OFFSET DENOISE; FOOTPRINT REMOVAL;
 C18 Q PHASE COMPENSATION; REVERSE TVS; TTI DEPTH KIRCHHOFF MIGRATION;
 C19 CONVERT TO TIME; HIGH DENSITY AUTOMATICALLY VELOCITY ANALYSIS;
 C20 RADON DEMULTIPLE; TRIM STATICS FOR GATHER FLATTENING; DENOISE;
 C21 Q AMPLITUDE COMPENSATION; SPECTRAL OFFSET BALANCING;
 C22 STACK WITH ANGLE MUTE 03-14 DEGREE; DENOISE; CONVERT TO DEPTH
 C23
 C24 POLARITY: NEGATIVE IS INCREASE OF ACOUSTIC IMPEDENCE
 C25 --------------------- KEY TRACE HEADERS (BYTES)-----------------------------
 C26 CDP NO.......................(021-024) CDP = SUBLINE*100000+CROSSLINE
 C27 FOLD.........................(031-032) OFFSET...............(037-040)
 C28 REAL WORLD COORD_X *100......(181-184)
 C29 REAL WORLD COORD_Y *100 .....(185-188)
 C30 INLINE.......................(189-192)
 C31 CROSSLINE....................(193-196)
 C32
 C33 -----------------------GRID DEFINITION--------------------------------------
 C34 PROCESSING GRID(4 CORNER POINTS): XL 12.5M; IL 18.75M; RW X; RW Y)
 C35 PROJ:UTM 60S DATUM:WGS84 UNITS:M CM:177 E
 C36 POINT1                            1;     1; 679919.00; 5676560.00
 C37 POINT2                         6000;     1; 616256.74; 5716186.27
 C38 POINT3                         6000;   900; 625164.22; 5730496.75
 C39 POINT4                            1;   900; 688826.49; 5690870.48
 C40

************************** Binary headers **************************
```

Figure 15: Example EBCDIC Header Raw Kirchhoff Stack – Angle Stack in Depth Domain

TAPE LOG

TAPE LOG			
CLIENT:	THE UNIVERSITY OF TEXAS AT AUSTIN		
PROJECT:	NZ 3D PROCESSING		
USB ID:	PSDM_FINAL_GATHER_STACK_AND_VELOCITY		
Domain:	DEPTH/TIME		
MAX LENGTH	15000M/SR:4M 9500MS/SR:4MS		
Format:	SEGY		
Date:	AUGUST 2021		

TRACE HEADER	BYTE LOCATIONS
3DCDP	21 - 24
OFFSET	37 - 40
CDPX (x100)	181 - 184
CDPY (x100)	185 - 188
SUBLINE	189 - 192
CROSSLINE	193 - 196

FOUR CORNER POINTS:

CROSSLINE	SUBLINE	XREAL	YREAL
1	1	679919.00	5676560.00
6000	1	616256.74	5716186.27
6000	900	625164.22	5730496.75
1	900	688826.49	5690870.48

folder	files	size
07_raw_psdm_angle_stack	07_RAW_PSDM_NEAR_STACK_DEPTH.sgy	66G
	07_RAW_PSDM_MIDDLE_STACK_DEPTH.sgy	66G
	07_RAW_PSDM_FAR_STACK_DEPTH.sgy	66G

C.9 FINAL KIRCHHOFF ANGLE STACK (DEPTH DOMAIN)

EBCDIC HEADER EXAMPLE

POLARITY: NEGTIVE IS INCREASE OF ACOUSTIC IMPEDENCE; PHASE: ZERO

```
*************************** EBCDIC headers ***************************
 C01 CLIENT:    THE UNIVERSITY OF TEXAS AT AUSTIN   VENDOR: CGG    DATE: 20210801
 C02 PROJECT:   NZ 3D PROCESSING
 C03 FORMAT:    SEGY IBM 32 BIT FLOATING POINT      XY UNITS: METERS
 C04 DATA DESC: FINAL PSDM NEAR STACK IN DEPTH    Z  UNITS: METERS
 C05 DATA TYPE: STACK
 C06 INLINE: 30 - 829          XLINE: 13 - 5759
 C07 RECORD LENGTH: 15000M;     SAMPLE RATE: 4M;      NUMBER OF SAMPLES:3751
 C08
 C09 -----------------------PROCESSING SEQUENCE----------------------------------
 C10 REFORMAT; NAV MERGE; TRACE EDITS; LOW CUT FILTER; TVS;RESAMPLE TO 4MS
 C11 SWELL NOISE ATTENUATION; DE-BUBBLE; LINEAR NOISE ATTENUATION;
 C12 TIDAL STATICS CORRECTION; WATER COLUMN STATICS; SHOT CHANNEL SCALING
 C13 RECEIVER MOTION CORRECTION; 3D JOINT DE-GHOST & DE-SIGNATURE;
 C14 RESIDUAL DE-BUBBLE; SSD CORRECTION; SHALLOW WATER DEMULTIPLE; 3D SRME
 C15 SIMULTANEOUS SUBTRACTION IN CURVELET DOMAIN; RESIDIAL LNA;
 C16 3D BINNING (12.5X18.75); TRACE REGUL & INTERP; VELOCITY ANALYSIS; RADON
 C17 DIFFRACTED MUL ATTENUATION; COMMON OFFSET DENOISE; FOOTPRINT REMOVAL;
 C18 Q PHASE COMPENSATION; REVERSE TVS; TTI DEPTH KIRCHHOFF MIGRATION;
 C19 CONVERT TO TIME; HIGH DENSITY AUTOMATICALLY VELOCITY ANALYSIS;
 C20 RADON DEMULTIPLE; TRIM STATICS FOR GATHER FLATTENING; DENOISE;
 C21 Q AMPLITUDE COMPENSATION; SPECTRAL OFFSET BALANCING;
 C22 STACK WITH ANGLE MUTE 03-14 DEGREE; DENOISE;
 C23 FOOTPRINT REMOVAL; TVS; TVF; CONVERT TO DEPTH
 C24
 C25 POLARITY: NEGATIVE IS INCREASE OF ACOUSTIC IMPEDENCE
 C26 --------------------- KEY TRACE HEADERS (BYTES)----------------------------
 C27 CDP NO.......................(021-024) CDP = SUBLINE*100000+CROSSLINE
 C28 FOLD.........................(031-032) OFFSET...............(037-040)
 C29 REAL WORLD COORD_X *100......(181-184)
 C30 REAL WORLD COORD_Y *100 .....(185-188)
 C31 INLINE.......................(189-192)
 C32 CROSSLINE....................(193-196)
 C33
 C34 -----------------------GRID DEFINITION-------------------------------------
 C35 PROCESSING GRID(4 CORNER POINTS): XL 12.5M; IL 18.75M; RW X; RW Y)
 C36 PROJ:UTM 60S DATUM:WGS84 UNITS:M CM:177 E
 C37 POINT1                           1;     1; 679919.00; 5676560.00
 C38 POINT2                        6000;     1; 616256.74; 5716186.27
 C39 POINT3                        6000;   900; 625164.22; 5730496.75
 C40 POINT4                           1;   900; 688826.49; 5690870.48

*************************** Binary headers ***************************
```

Figure 16: Example EBCDIC Header Final Kirchhoff Stack – Angle Stack in Depth Domain

TAPE LOG

TAPE LOG			
CLIENT:	**THE UNIVERSITY OF TEXAS AT AUSTIN**		
PROJECT:	**NZ 3D PROCESSING**		
USB ID:	**PSDM_FINAL_GATHER_STACK_AND_VELOCITY**		
Domain:	**DEPTH/TIME**		
MAX LENGTH	**15000M/SR:4M 9500MS/SR:4MS**		
Format:	**SEGY**		
Date:	**AUGUST 2021**		

TRACE HEADER	BYTE LOCATIONS
3DCDP	21 - 24
OFFSET	37 - 40
CDPX (x100)	181 - 184
CDPY (x100)	185 - 188
SUBLINE	189 - 192
CROSSLINE	193 - 196

FOUR CORNER POINTS:

CROSSLINE	SUBLINE	XREAL	YREAL
1	1	679919.00	5676560.00
6000	1	616256.74	5716186.27
6000	900	625164.22	5730496.75
1	900	688826.49	5690870.48

folder	files	size
08_final_psdm_angle_stack	08_FINAL_PSDM_NEAR_STACK_DEPTH.sgy	66G
	08_FINAL_PSDM_MIDDLE_STACK_DEPTH.sgy	66G
	08_FINAL_PSDM_FAR_STACK_DEPTH.sgy	66G

C.10 FINAL MIGRATION VELOCITY VOLUMES (DEPTH DOMAIN)

EBCDIC HEADER EXAMPLE

```
**************************** EBCDIC headers ***************************
 C01 CLIENT:    THE UNIVERSITY OF TEXAS AT AUSTIN   VENDOR: CGG    DATE: 20210804
 C02 PROJECT:   NZ 3D PROCESSING
 C03 FORMAT:    SEGY IBM 32 BIT FLOATING POINT      XY UNITS: METERS
 C04 DATA DESC: FINAL MIGRATION VELOCITY   Z  UNITS: METERS
 C05 DATA TYPE: VELOCITY
 C06 INLINE: 1 - 868 (INC. OF 3)  XLINE: 11 - 5699 (INC. OF 4)
 C07 RECORD LENGTH: 15000M;     SAMPLE RATE: 20M;      NUMBER OF SAMPLES:751
 C08
 C09 -----------------------PROCESSING SEQUENCE----------------------------------
 C10 REFORMAT; NAV MERGE; TRACE EDITS; LOW CUT FILTER; TVS;RESAMPLE TO 4MS
 C11 SWELL NOISE ATTENUATION; DE-BUBBLE; LINEAR NOISE ATTENUATION;
 C12 TIDAL STATICS CORRECTION; WATER COLUMN STATICS; SHOT CHANNEL SCALING
 C13 RECEIVER MOTION CORRECTION; 3D JOINT DE-GHOST & DE-SIGNATURE;
 C14 RESIDUAL DE-BUBBLE; SSD CORRECTION;
 C15 SHALLOW WATER DEMULTIPLE*; 3D SRME*; RESIDUAL NOISE ATTENUATION*
 C16 3D BINNING AT 12.5M X 18.75M GRID*; TRACE INTERP. AND REG.*
 C17 COMMON OFFSET RESIDUAL DENOISE*
 C18 VELOCITY MODEL BUILDING - ISO FWI, IT1, IT2, IT3 (TTI FWI), IT4, IT5
 C19
 C20 *PROCESSES WITH PARAMETERS FOR VMB ONLY, NOT OPTIMAL FOR PRODUCTION
 C21
 C22
 C23
 C24
 C25
 C26
 C27 --------------------- KEY TRACE HEADERS (BYTES)----------------------------
 C28 SCALAR APPLIED TO BYTE LOCATIONS 073-088 AND 181-188 ..............(071-072)
 C29 REAL WORLD COORD_X *100 ....(181-184) REAL WORLD COORD_Y *100 .....(185-188)
 C30 INLINE.....................(189-192) CROSSLINE...................(193-196)
 C31 REAL WORLD COORD_X .........(205-208) REAL WORLD COORD_Y ..........(209-212)
 C32 CDP NO......................(021-024) CDP = SUBLINE*100000+CROSSLINE
 C33
 C34 -----------------------GRID DEFINITION-------------------------------------
 C35 PROCESSING GRID(4 CORNER POINTS): XL 12.5M; IL 18.75M; RW X; RW Y)
 C36 PROJ:UTM 60S DATUM:WGS84 UNITS:M CM:177 E
 C37 POINT1                          1;     1; 679919.00; 5676560.00
 C38 POINT2                       6000;     1; 616256.74; 5716186.27
 C39 POINT3                       6000;   900; 625164.22; 5730496.75
 C40 POINT4                          1;   900; 688826.49; 5690870.48

*************************** Binary headers ***************************
```

Figure 17: Example EBCDIC Header for Final Migration Vp Velocity

TAPE LOG

TAPE LOG			
CLIENT:	THE UNIVERSITY OF TEXAS AT AUSTIN		
PROJECT:	NZ 3D PROCESSING		
USB ID:	PSDM_FINAL_GATHER_STACK_AND_VELOCITY		
Domain:	DEPTH/TIME		
MAX LENGTH	15000M/SR:4M 9500MS/SR:4MS		
Format:	SEGY		
Date:	AUGUST 2021		

TRACE HEADER	BYTE LOCATIONS
3DCDP	21 - 24
OFFSET	37 - 40
CDPX (x100)	181 - 184
CDPY (x100)	185 - 188
SUBLINE	189 - 192
CROSSLINE	193 - 196

FOUR CORNER POINTS:

CROSSLINE	SUBLINE	XREAL	YREAL
1	1	679919.00	5676560.00
6000	1	616256.74	5716186.27
6000	900	625164.22	5730496.75
1	900	688826.49	5690870.48

folder	files	size
09_final_velocity_model	09_FINAL_DEPTH_INTERVAL_VELOCITY.sgy	1.3G
	09_FINAL_DEPTH_DELTA.sgy	1.3G
	09_FINAL_DEPTH_EPSILON.sgy	1.3G
	09_FINAL_DEPTH_THETA.sgy	1.3G
	09_FINAL_DEPTH_PHI.sgy	1.3G
	09_FINAL_DEPTH_Q.sgy	1.3G
	09_FINAL_TIME-DEPTH_CONVERT_VELOCITY_IN_DEPTH.sgy	1.3G

C.11 HIGH DENSITY STACKING VELOCITY (TIME DOMAIN)

EBCDIC HEADER EXAMPLE

```
**************************** EBCDIC headers ***************************
 C01 CLIENT:    THE UNIVERSITY OF TEXAS AT AUSTIN   VENDOR: CGG    DATE: 20210804
 C02 PROJECT:   NZ 3D PROCESSING
 C03 FORMAT:    SEGY IBM 32 BIT FLOATING POINT      XY UNITS: METERS
 C04 DATA DESC: HIGH DENSITY 2ND ORDER STACKING VELOCITY   Z  UNITS: MS
 C05 DATA TYPE: VELOCITY
 C06 INLINE: 31 - 829 (INC. OF 2)  XLINE: 13 - 5759 (INC. OF 2)
 C07 RECORD LENGTH: 9500MS;     SAMPLE RATE: 10MS;      NUMBER OF SAMPLES:951
 C08
 C09 -----------------------PROCESSING SEQUENCE----------------------------------
 C10 REFORMAT; NAV MERGE; TRACE EDITS; LOW CUT FILTER; TVS;RESAMPLE TO 4MS
 C11 SWELL NOISE ATTENUATION; DE-BUBBLE; LINEAR NOISE ATTENUATION;
 C12 TIDAL STATICS CORRECTION; WATER COLUMN STATICS; SHOT CHANNEL SCALING
 C13 RECEIVER MOTION CORRECTION; 3D JOINT DE-GHOST & DE-SIGNATURE;
 C14 RESIDUAL DE-BUBBLE; SSD CORRECTION; SHALLOW WATER DEMULTIPLE; 3D SRME
 C15 SIMULTANEOUS SUBTRACTION IN CURVELET DOMAIN; RESIDIAL LNA;
 C16 3D BINNING (12.5X18.75); TRACE REGUL & INTERP; VELOCITY ANALYSIS; RADON
 C17 DIFFRACTED MUL ATTENUATION; COMMON OFFSET DENOISE; FOOTPRINT REMOVAL;
 C18 Q PHASE COMPENSATION; REVERSE TVS; TTI DEPTH KIRCHHOFF MIGRATION;
 C19 CONVERT TO TIME; HIGH DENSITY AUTOMATICALLY VELOCITY ANALYSIS;
 C20
 C21
 C22
 C23
 C24
 C25
 C26
 C27 --------------------- KEY TRACE HEADERS (BYTES)-----------------------------
 C28 SCALAR APPLIED TO BYTE LOCATIONS 073-088 AND 181-188 ..............(071-072)
 C29 REAL WORLD COORD_X *100 ....(181-184) REAL WORLD COORD_Y *100 .....(185-188)
 C30 INLINE......................(189-192) CROSSLINE....................(193-196)
 C31 REAL WORLD COORD_X .........(205-208) REAL WORLD COORD_Y ..........(209-212)
 C32 CDP NO......................(021-024) CDP = SUBLINE*100000+CROSSLINE
 C33
 C34 -----------------------GRID DEFINITION--------------------------------------
 C35 PROCESSING GRID(4 CORNER POINTS): XL 12.5M; IL 18.75M; RW X; RW Y)
 C36 PROJ:UTM 60S DATUM:WGS84 UNITS:M CM:177 E
 C37 POINT1                            1;     1; 679919.00; 5676560.00
 C38 POINT2                         6000;     1; 616256.74; 5716186.27
 C39 POINT3                         6000;   900; 625164.22; 5730496.75
 C40 POINT4                            1;   900; 688826.49; 5690870.48

*************************** Binary headers ***************************
```

Figure 18: Example EBCDIC Header for High Density Stacking Velocity

TAPE LOG

TAPE LOG			
CLIENT:	THE UNIVERSITY OF TEXAS AT AUSTIN		
PROJECT:	NZ 3D PROCESSING		
USB ID:	PSDM_FINAL_GATHER_STACK_AND_VELOCITY		
Domain:	DEPTH/TIME		
MAX LENGTH	15000M/SR:4M 9500MS/SR:4MS		
Format:	SEGY		
Date:	AUGUST 2021		

TRACE HEADER	BYTE LOCATIONS
3DCDP	21 - 24
OFFSET	37 - 40
CDPX (x100)	181 - 184
CDPY (x100)	185 - 188
SUBLINE	189 - 192
CROSSLINE	193 - 196

FOUR CORNER POINTS:

CROSSLINE	SUBLINE	XREAL	YREAL
1	1	679919.00	5676560.00
6000	1	616256.74	5716186.27
6000	900	625164.22	5730496.75
1	900	688826.49	5690870.48

folder	files	size
10_high_density_stacking_velocity	10_HIGH_DENSITY_2ND_ORDER_STACKING_VELOCITY.sgy	4.4G
	10_HIGH_DENSITY_4TH_ORDER_COEFFICIENT.sgy	4.4G

APPENDIX D – FAR-FIELD SIGNATURE

D.1 FAR-FIELD SIGNATURE WITH SOURCE GHOST

FARFIELD SIGNATURE LISTING

Farfield signature was generated by Nucleus+ version 2.9.0
Farfield signature was generated by Marine source modelling version 2.1.0
Farfield signature was generated by Source Kernel version 1.0.0

Name of farfield dataset : FarField_filter

Source array name : IluFarrA
Total array volume (cu.in.) : 3300.0
Source average depth (m) : 7.0
Streamer depth (m) : NA
Streamer group length (m) : NA
Average pressure (psi) : 2000.0
Notional refl. coeff : -1.00
Farfield refl. coeff : -1.00
Primary amplitude (bar m) : 44.80
Peak-peak amplitude (bar m) : 90.73
Pulse/Bubble ratio : 26.82
Bubble period (+) (ms) : 121.750
Bubble period (-) (ms) : 148.500
Geometrical spreading : 2.00
Sea water temperature (C) : 5.0
Sea water velocity (m/s) : 1500.0

Filter parameters
Filter type : Sercel SEAL mp_3/6-200/370
Low cut frequency (Hz) : 3.0
High cut frequency (Hz) : 200.0
Low cut slope (dB/oct) : 6.0
High cut slope (dB/oct) : 370.0
Start time (ms) : -64.0
Index of time zero : 129

Sample interval (ms) : 0.5

Farfield position
Farfield distance (m) : 9000.0
Dip angle (degrees) : 0.0
Azimuth angle (degrees) : 0.0

Amplitudes are in bar m
Time is increasing horizontally

0.000	0.000	0.000	0.000	0.000	0.000	-0.000
-0.000	-0.000	0.000	0.000	0.000	0.000	0.000
0.000	-0.000	-0.000	-0.000	-0.000	-0.000	0.000

0.000	0.000	0.000	-0.000	-0.000	-0.001	-0.001
-0.000	0.000	0.001	0.001	0.001	0.001	-0.000
-0.001	-0.002	-0.002	-0.002	0.000	0.003	0.004
0.004	0.003	-0.001	-0.005	-0.007	-0.007	-0.004
0.002	0.009	0.013	0.012	0.006	-0.004	-0.014
-0.020	-0.018	-0.008	0.008	0.023	0.032	0.027
0.010	-0.014	-0.037	-0.048	-0.039	-0.012	0.024
0.056	0.070	0.055	0.014	-0.039	-0.084	-0.099
-0.074	-0.014	0.062	0.122	0.138	0.098	0.010
-0.094	-0.173	-0.189	-0.126	-0.001	0.141	0.242
0.253	0.158	-0.017	-0.207	-0.334	-0.335	-0.193
0.049	0.301	0.457	0.438	0.229	-0.106	-0.439
-0.628	-0.572	-0.260	0.208	0.652	0.876	0.748
0.270	-0.405	-1.011	-1.267	-0.992	-0.206	0.838
1.718	1.979	1.333	-0.180	-2.101	-3.604	-3.683
-1.443	3.591	11.248	20.635	30.283	38.457	43.585
44.667	41.558	35.019	26.529	17.889	10.739	6.114
4.185	4.237	4.913	4.640	2.107	-3.333	-11.458
-21.230	-31.069	-39.276	-44.473	-45.930	-43.710	-38.585
-31.778	-24.614	-18.197	-13.180	-9.707	-7.509	-6.090
-4.962	-3.810	-2.576	-1.424	-0.630	-0.434	-0.931
-2.014	-3.401	-4.733	-5.682	-6.048	-5.810	-5.107
-4.173	-3.250	-2.511	-2.014	-1.710	-1.487	-1.224
-0.850	-0.369	0.145	0.582	0.839	0.862	0.665
0.320	-0.067	-0.395	-0.596	-0.652	-0.593	-0.472
-0.347	-0.254	-0.198	-0.160	-0.105	-0.004	0.153
0.353	0.563	0.744	0.865	0.908	0.880	0.802
0.705	0.617	0.556	0.526	0.521	0.528	0.537
0.541	0.543	0.549	0.568	0.605	0.661	0.730
0.802	0.867	0.918	0.950	0.965	0.966	0.961
0.953	0.947	0.943	0.942	0.942	0.941	0.941
0.943	0.950	0.961	0.980	1.004	1.033	1.064
1.095	1.123	1.149	1.170	1.188	1.203	1.215
1.225	1.234	1.242	1.249	1.256	1.263	1.271
1.280	1.291	1.304	1.320	1.337	1.356	1.375
1.395	1.416	1.436	1.455	1.474	1.492	1.509
1.526	1.541	1.557	1.572	1.586	1.601	1.616
1.632	1.648	1.665	1.683	1.702	1.722	1.743
1.765	1.789	1.814	1.840	1.868	1.896	1.925
1.955	1.984	2.014	2.042	2.069	2.094	2.116
2.133	2.145	2.150	2.147	2.134	2.111	2.074
2.024	1.959	1.878	1.783	1.674	1.554	1.424
1.289	1.151	1.015	0.885	0.762	0.651	0.552
0.467	0.398	0.343	0.302	0.274	0.256	0.247
0.243	0.240	0.234	0.223	0.204	0.174	0.132
0.079	0.015	-0.057	-0.137	-0.219	-0.303	-0.383
-0.458	-0.525	-0.579	-0.618	-0.641	-0.644	-0.627
-0.590	-0.532	-0.456	-0.364	-0.260	-0.146	-0.026
0.096	0.216	0.332	0.442	0.545	0.639	0.726
0.804	0.874	0.938	0.996	1.049	1.097	1.141
1.181	1.215	1.245	1.268	1.284	1.291	1.288
1.273	1.245	1.202	1.144	1.070	0.980	0.876
0.760	0.634	0.502	0.367	0.232	0.101	-0.026
-0.145	-0.256	-0.358	-0.448	-0.527	-0.592	-0.643
-0.678	-0.696	-0.699	-0.686	-0.660	-0.623	-0.576
-0.523	-0.466	-0.406	-0.345	-0.285	-0.225	-0.167

-0.112	-0.060	-0.012	0.030	0.065	0.093	0.111
0.120	0.119	0.107	0.083	0.047	-0.000	-0.060
-0.133	-0.218	-0.315	-0.422	-0.539	-0.663	-0.794
-0.928	-1.063	-1.198	-1.329	-1.454	-1.572	-1.680
-1.777	-1.862	-1.934	-1.992	-2.036	-2.068	-2.086
-2.091	-2.086	-2.070	-2.046	-2.015	-1.979	-1.941
-1.901	-1.862	-1.826	-1.792	-1.762	-1.736	-1.714
-1.694	-1.676	-1.659	-1.643	-1.625	-1.607	-1.585
-1.561	-1.533	-1.501	-1.465	-1.423	-1.377	-1.326
-1.270	-1.211	-1.147	-1.081	-1.013	-0.943	-0.872
-0.801	-0.731	-0.662	-0.595	-0.531	-0.469	-0.411
-0.356	-0.306	-0.260	-0.220	-0.185	-0.156	-0.134
-0.119	-0.110	-0.109	-0.114	-0.125	-0.142	-0.163
-0.187	-0.214	-0.242	-0.270	-0.297	-0.322	-0.343
-0.361	-0.375	-0.384	-0.386	-0.384	-0.375	-0.362
-0.343	-0.319	-0.292	-0.262	-0.230	-0.197	-0.164
-0.132	-0.100	-0.071	-0.044	-0.019	0.004	0.025
0.044	0.062	0.079	0.096	0.112	0.128	0.144
0.161	0.177	0.193	0.210	0.227	0.244	0.261
0.278	0.295	0.312	0.328	0.343	0.357	0.369
0.381	0.392	0.403	0.413	0.423	0.434	0.445
0.456	0.467	0.478	0.489	0.500	0.511	0.521
0.532	0.542	0.552	0.563	0.573	0.583	0.593
0.603	0.613	0.623	0.633	0.643	0.653	0.663
0.673	0.683	0.693	0.703	0.713	0.723	0.732
0.742	0.751	0.761	0.769	0.777	0.785	0.793
0.799	0.805	0.811	0.816	0.820	0.823	0.825
0.826	0.826	0.825	0.823	0.820	0.815	0.810
0.803	0.794	0.784	0.771	0.757	0.740	0.721
0.700	0.677	0.653	0.628	0.601	0.574	0.546
0.517	0.487	0.456	0.424	0.391	0.359	0.327
0.295	0.264	0.234	0.205	0.177	0.150	0.124
0.098	0.074	0.051	0.028	0.008	-0.012	-0.029
-0.045	-0.058	-0.070	-0.079	-0.086	-0.091	-0.093
-0.093	-0.090	-0.084	-0.076	-0.065	-0.052	-0.036
-0.018	0.001	0.023	0.046	0.070	0.096	0.123
0.151	0.179	0.207	0.235	0.264	0.291	0.318
0.343	0.367	0.389	0.410	0.428	0.443	0.455
0.463	0.468	0.468	0.464	0.456	0.442	0.423
0.399	0.369	0.335	0.297	0.254	0.208	0.159
0.108	0.055	0.002	-0.052	-0.105	-0.156	-0.206
-0.253	-0.296	-0.337	-0.373	-0.406	-0.435	-0.460
-0.482	-0.501	-0.516	-0.529	-0.540	-0.549	-0.557
-0.564	-0.571	-0.577	-0.583	-0.590	-0.597	-0.604
-0.611	-0.619	-0.626	-0.633	-0.640	-0.645	-0.651
-0.655	-0.658	-0.660	-0.661	-0.661	-0.660	-0.657
-0.653	-0.647	-0.640	-0.632	-0.623	-0.612	-0.601
-0.588	-0.575	-0.561	-0.546	-0.531	-0.515	-0.499
-0.482	-0.465	-0.448	-0.430	-0.413	-0.396	-0.379
-0.362	-0.345	-0.329	-0.313	-0.298	-0.284	-0.270
-0.257	-0.244	-0.233	-0.222	-0.211	-0.202	-0.193
-0.184	-0.177	-0.170	-0.163	-0.157	-0.152	-0.147
-0.143	-0.138	-0.134	-0.130	-0.126	-0.122	-0.118
-0.114	-0.109	-0.105	-0.100	-0.096	-0.091	-0.085
-0.080	-0.073	-0.067	-0.061	-0.054	-0.046	-0.039
-0.031	-0.023	-0.015	-0.007	0.002	0.010	0.019

0.029	0.038	0.047	0.056	0.066	0.075	0.084
0.093	0.102	0.111	0.120	0.130	0.139	0.148
0.156	0.165	0.173	0.181	0.188	0.196	0.203
0.209	0.216	0.222	0.229	0.235	0.240	0.245
0.250	0.255	0.259	0.262	0.265	0.268	0.271
0.273	0.275	0.276	0.277	0.277	0.278	0.277
0.277	0.276	0.274	0.272	0.270	0.266	0.262
0.258	0.253	0.247	0.241	0.235	0.229	0.222
0.215	0.207	0.198	0.189	0.179	0.169	0.159
0.149	0.138	0.128	0.117	0.107	0.096	0.086
0.075	0.065	0.055	0.045	0.035	0.025	0.016
0.007	-0.002	-0.010	-0.018	-0.025	-0.033	-0.039
-0.046	-0.052	-0.058	-0.063	-0.068	-0.073	-0.078
-0.082	-0.086	-0.089	-0.092	-0.095	-0.098	-0.100
-0.102	-0.103	-0.105	-0.105	-0.106	-0.105	-0.105
-0.104	-0.103	-0.101	-0.099	-0.096	-0.093	-0.090
-0.087	-0.083	-0.079	-0.075	-0.071	-0.066	-0.061
-0.056	-0.051	-0.046	-0.040	-0.035	-0.029	-0.023
-0.017	-0.011	-0.006	0.000	0.007	0.013	0.019
0.025	0.032	0.038	0.045	0.052	0.059	0.066
0.072	0.079	0.086	0.093	0.101	0.108	0.115
0.122	0.129	0.135	0.142	0.149	0.156	0.162
0.169	0.176	0.182	0.188	0.194	0.200	0.206
0.211	0.216	0.221	0.226	0.230	0.235	0.239
0.242	0.245	0.248	0.251	0.253	0.255	0.256
0.257	0.258	0.258	0.258	0.257	0.256	0.255
0.253	0.250	0.247	0.244	0.240	0.236	0.231
0.226	0.220	0.214	0.208	0.201	0.193	0.185
0.177	0.168	0.159	0.149	0.139	0.129	0.119
0.108	0.097	0.087	0.076	0.065	0.054	0.044
0.033	0.023	0.013	0.004	-0.005	-0.014	-0.022
-0.030	-0.038	-0.045	-0.052	-0.058	-0.064	-0.070
-0.075	-0.080	-0.085	-0.090	-0.094	-0.098	-0.102
-0.106	-0.109	-0.113	-0.116	-0.119	-0.123	-0.126
-0.129	-0.132	-0.135	-0.138	-0.141	-0.144	-0.147
-0.150	-0.153	-0.156	-0.159	-0.162	-0.165	-0.168
-0.170	-0.173	-0.176	-0.178	-0.181	-0.183	-0.186
-0.189	-0.191	-0.194	-0.196	-0.199	-0.201	-0.204
-0.206	-0.209	-0.211	-0.214	-0.217	-0.220	-0.223
-0.226	-0.229	-0.232	-0.235	-0.239	-0.242	-0.245
-0.248	-0.251	-0.255	-0.258	-0.261	-0.264	-0.266
-0.269	-0.272	-0.274	-0.277	-0.279	-0.281	-0.283
-0.284	-0.286	-0.287	-0.288	-0.288	-0.289	-0.289
-0.288	-0.288	-0.287	-0.286	-0.285	-0.283	-0.282
-0.280	-0.277	-0.275	-0.272	-0.269	-0.265	-0.262
-0.258	-0.254	-0.250	-0.245	-0.240	-0.236	-0.231
-0.226	-0.220	-0.215	-0.209	-0.203	-0.197	-0.191
-0.184	-0.178	-0.171	-0.164	-0.157	-0.150	-0.143
-0.135	-0.127	-0.120	-0.112	-0.104	-0.095	-0.087
-0.079	-0.070	-0.062	-0.053	-0.044	-0.035	-0.026
-0.017	-0.008	0.001	0.010	0.019	0.028	0.038
0.047	0.056	0.066	0.075	0.084	0.094	0.103
0.112	0.121	0.131	0.140	0.149	0.158	0.167
0.176	0.185	0.194	0.203	0.212	0.220	0.229
0.237	0.246	0.254	0.262	0.270	0.278	0.286
0.293	0.301	0.308	0.315	0.322	0.329	0.336

0.342	0.348	0.354	0.360	0.365	0.371	0.376
0.380	0.385	0.389	0.393	0.397	0.400	0.403
0.405	0.408	0.410	0.411	0.412	0.413	0.414
0.414	0.413	0.412	0.411	0.409	0.407	0.404
0.401	0.398	0.394	0.389	0.384	0.379	0.373
0.367	0.360	0.353	0.346	0.338	0.330	0.321
0.312	0.303	0.293	0.284	0.274	0.263	0.252
0.242	0.230	0.219	0.207	0.196	0.184	0.172
0.160	0.148	0.136	0.124	0.112	0.100	0.087
0.075	0.063	0.051	0.039	0.027	0.016	0.004
-0.007	-0.018	-0.029	-0.040	-0.050	-0.061	-0.071
-0.080	-0.090	-0.099	-0.108	-0.117	-0.125	-0.133
-0.141	-0.148	-0.156	-0.162	-0.169	-0.175	-0.181
-0.187	-0.193	-0.198	-0.203	-0.208	-0.212	-0.217
-0.221	-0.224	-0.228	-0.231	-0.235	-0.237	-0.240
-0.242	-0.245	-0.247	-0.248	-0.250	-0.251	-0.252
-0.253	-0.253	-0.254	-0.254	-0.255	-0.255	-0.254
-0.254	-0.254	-0.253	-0.252	-0.252	-0.251	-0.250
-0.249	-0.247	-0.246	-0.245	-0.243	-0.241	-0.240
-0.238	-0.236	-0.234	-0.232	-0.229	-0.227	-0.224
-0.222	-0.219	-0.216	-0.213	-0.210	-0.207	-0.203
-0.200	-0.196	-0.193	-0.189	-0.185	-0.181	-0.177
-0.173	-0.168	-0.164	-0.160	-0.156	-0.151	-0.147
-0.142	-0.138	-0.133	-0.128	-0.123	-0.119	-0.114
-0.109	-0.104	-0.100	-0.095	-0.091	-0.086	-0.082
-0.078	-0.073	-0.069	-0.065	-0.061	-0.057	-0.053
-0.050	-0.046	-0.043	-0.040	-0.037	-0.034	-0.031
-0.028	-0.025	-0.023	-0.020	-0.018	-0.016	-0.014
-0.012	-0.010	-0.009	-0.007	-0.006	-0.005	-0.004
-0.003	-0.002	-0.001	-0.000	0.000	0.001	0.001
0.002	0.002	0.002	0.003	0.003	0.003	0.003
0.004	0.004	0.004	0.004	0.004	0.005	0.005
0.005	0.005	0.005	0.006	0.006	0.006	0.007
0.007	0.008	0.009	0.009	0.010	0.011	0.012
0.013	0.014	0.015	0.016	0.018	0.019	0.021
0.023	0.024	0.026	0.028	0.030	0.032	0.034
0.037	0.039	0.041	0.044	0.047	0.049	0.052
0.055	0.058	0.061	0.064	0.067	0.070	0.074
0.077	0.080	0.084	0.087	0.090	0.094	0.097
0.101	0.104	0.108	0.112	0.115	0.119	0.123
0.126	0.130	0.134	0.137	0.141	0.145	0.148
0.152	0.155	0.159	0.162	0.165	0.169	0.172
0.175	0.178	0.181	0.184	0.186	0.189	0.191
0.194	0.196	0.198	0.200	0.202	0.204	0.206
0.207	0.208	0.209	0.210	0.211	0.212	0.213
0.213	0.213	0.214	0.214	0.213	0.213	0.212
0.211	0.210	0.209	0.207	0.206	0.204	0.203
0.201	0.199	0.196	0.194	0.191	0.188	0.185
0.182	0.178	0.174	0.170	0.166	0.162	0.157
0.152	0.148	0.143	0.138	0.132	0.127	0.121
0.115	0.109	0.103	0.097	0.090	0.083	0.077
0.070	0.063	0.056	0.049	0.042	0.035	0.027
0.020	0.012	0.005	-0.003	-0.011	-0.018	-0.026
-0.034	-0.041	-0.049	-0.056	-0.064	-0.072	-0.079
-0.087	-0.094	-0.102	-0.109	-0.117	-0.124	-0.131
-0.137	-0.144	-0.150	-0.157	-0.163	-0.169	-0.174

-0.180	-0.185	-0.190	-0.195	-0.199	-0.204	-0.208
-0.212	-0.215	-0.219	-0.222	-0.225	-0.228	-0.231
-0.233	-0.236	-0.238	-0.240	-0.241	-0.243	-0.244
-0.245	-0.246	-0.246	-0.246	-0.247	-0.246	-0.246
-0.245	-0.244	-0.243	-0.242	-0.241	-0.239	-0.238
-0.236	-0.234	-0.232	-0.229	-0.227	-0.224	-0.222
-0.219	-0.216	-0.212	-0.209	-0.206	-0.203	-0.199
-0.195	-0.192	-0.188	-0.184	-0.180	-0.176	-0.172
-0.167	-0.163	-0.159	-0.154	-0.150	-0.146	-0.141
-0.136	-0.132	-0.127	-0.122	-0.118	-0.113	-0.108
-0.103	-0.098	-0.094	-0.089	-0.084	-0.079	-0.074
-0.070	-0.065	-0.060	-0.055	-0.050	-0.045	-0.040
-0.035	-0.031	-0.026	-0.021	-0.017	-0.012	-0.007
-0.002	0.002	0.007	0.011	0.016	0.020	0.025
0.029	0.034	0.038	0.043	0.047	0.051	0.055
0.060	0.064	0.068	0.072	0.076	0.080	0.083
0.087	0.091	0.094	0.098	0.101	0.105	0.108
0.111	0.114	0.117	0.120	0.123	0.126	0.129
0.131	0.134	0.136	0.139	0.141	0.143	0.146
0.148	0.150	0.152	0.153	0.155	0.156	0.158
0.159	0.160	0.161	0.162	0.163	0.164	0.165
0.165	0.165	0.166	0.166	0.166	0.166	0.165
0.165	0.165	0.164	0.164	0.163	0.162	0.161
0.160	0.159	0.157	0.156	0.154	0.153	0.151
0.149	0.147	0.145	0.143	0.141	0.139	0.136
0.134	0.131	0.129	0.126	0.123	0.120	0.118
0.115	0.112	0.109	0.106	0.102	0.099	0.096
0.093	0.089	0.086	0.083	0.079	0.076	0.073
0.069	0.066	0.063	0.059	0.056	0.052	0.049
0.045	0.042	0.039	0.035	0.032	0.029	0.026
0.022	0.019	0.016	0.013	0.010	0.007	0.004
0.001	-0.001	-0.004	-0.007	-0.010	-0.013	-0.015
-0.018	-0.020	-0.022	-0.025	-0.027	-0.029	-0.031
-0.033	-0.036	-0.038	-0.040	-0.041	-0.043	-0.045
-0.047	-0.048	-0.050	-0.052	-0.053	-0.054	-0.056
-0.057	-0.058	-0.060	-0.061	-0.062	-0.063	-0.064
-0.065	-0.066	-0.067	-0.068	-0.069	-0.069	-0.070
-0.071	-0.072	-0.072	-0.073	-0.074	-0.074	-0.075
-0.076	-0.076	-0.077	-0.077	-0.078	-0.078	-0.079
-0.079	-0.080	-0.080	-0.080	-0.081	-0.081	-0.082
-0.082	-0.082	-0.082	-0.083	-0.083	-0.083	-0.083
-0.083	-0.083	-0.083	-0.083	-0.083	-0.083	-0.083
-0.083	-0.083	-0.083	-0.083	-0.082	-0.082	-0.082
-0.081	-0.081	-0.080	-0.080	-0.079	-0.079	-0.078
-0.078	-0.077	-0.077	-0.076	-0.075	-0.074	-0.073
-0.072	-0.071	-0.070	-0.069	-0.068	-0.067	-0.066
-0.065	-0.064	-0.062	-0.061	-0.060	-0.058	-0.057
-0.055	-0.054	-0.052	-0.051	-0.050	-0.048	-0.046
-0.045	-0.043	-0.041	-0.040	-0.038	-0.036	-0.034
-0.033	-0.031	-0.029	-0.027	-0.026	-0.024	-0.022
-0.020	-0.019	-0.017	-0.015	-0.013	-0.011	-0.010
-0.008	-0.006	-0.005	-0.003	-0.001	0.000	0.002
0.004	0.005	0.007	0.008	0.010	0.011	0.013
0.014	0.015	0.017	0.018	0.019	0.021	0.022
0.023	0.024	0.025	0.027	0.028	0.029	0.030
0.031	0.031	0.032	0.033	0.034	0.035	0.035

0.036	0.037	0.037	0.038	0.038	0.039	0.039
0.040	0.040	0.041	0.041	0.041	0.042	0.042
0.042	0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.044	0.044	0.044	0.044
0.044	0.043	0.043	0.043	0.043	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.041	0.041	0.041	0.041	0.040	0.040
0.040	0.040	0.040	0.039	0.039	0.039	0.039
0.039	0.038	0.038	0.038	0.038	0.038	0.038
0.037	0.037	0.037	0.037	0.037	0.036	0.036
0.036	0.036	0.036	0.036	0.036	0.036	0.036
0.035	0.035	0.035	0.035	0.035	0.035	0.034
0.034	0.034	0.034	0.033	0.033	0.033	0.033
0.033	0.033	0.033	0.032	0.032	0.032	0.031
0.031	0.031	0.030	0.030	0.029	0.029	0.029
0.028	0.028	0.028	0.027	0.027	0.026	0.026
0.025	0.025	0.024	0.023	0.023	0.022	0.021
0.020	0.020	0.019	0.018	0.017	0.016	0.015
0.014	0.013	0.013	0.012	0.011	0.010	0.009
0.008	0.006	0.005	0.003	0.002	0.000	-0.001
-0.002	-0.003	-0.004	-0.004	-0.005	-0.006	-0.007
-0.008	-0.009	-0.011	-0.012	-0.013	-0.014	-0.015
-0.016	-0.017	-0.018	-0.019	-0.020	-0.021	-0.023
-0.024	-0.026	-0.027	-0.028	-0.029	-0.030	-0.031
-0.032	-0.032	-0.033	-0.034	-0.035	-0.036	-0.037
-0.037	-0.038	-0.038	-0.039	-0.040	-0.040	-0.041
-0.042	-0.042	-0.043	-0.043	-0.044	-0.044	-0.045
-0.045	-0.045	-0.045	-0.045	-0.045	-0.045	-0.045
-0.045	-0.045	-0.045	-0.045	-0.045	-0.045	-0.045
-0.045	-0.045	-0.045	-0.045	-0.045	-0.044	-0.044
-0.044	-0.044	-0.043	-0.043	-0.043	-0.042	-0.042
-0.042	-0.041	-0.041	-0.040	-0.040	-0.039	-0.039
-0.038	-0.038	-0.037	-0.037	-0.036	-0.036	-0.035
-0.034	-0.034	-0.033	-0.033	-0.032	-0.032	-0.031
-0.030	-0.030	-0.029	-0.028	-0.028	-0.027	-0.026
-0.026	-0.025	-0.024	-0.024	-0.023	-0.022	-0.022
-0.021	-0.020	-0.019	-0.019	-0.018	-0.017	-0.017
-0.016	-0.015	-0.014	-0.014	-0.013	-0.012	-0.011
-0.011	-0.010	-0.010	-0.009	-0.008	-0.007	-0.006
-0.006	-0.005	-0.004	-0.003	-0.002	-0.002	-0.001
-0.000	0.000	0.001	0.002	0.003	0.004	0.004
0.005	0.006	0.007	0.008	0.008	0.009	0.010
0.010	0.011	0.012	0.013	0.013	0.014	0.015
0.015	0.016	0.017	0.018	0.018	0.019	0.020
0.021	0.021	0.022	0.022	0.023	0.023	0.024
0.025	0.025	0.026	0.027	0.027	0.028	0.028
0.029	0.029	0.030	0.030	0.030	0.031	0.031
0.032	0.032	0.032	0.033	0.033	0.033	0.033
0.034	0.034	0.034	0.035	0.035	0.035	0.035
0.035	0.035	0.035	0.035	0.035	0.035	0.035
0.035	0.035	0.035	0.036	0.036	0.036	0.035
0.035	0.035	0.035	0.034	0.034	0.034	0.034
0.033	0.033	0.033	0.033	0.032	0.032	0.032
0.031	0.031	0.030	0.030	0.030	0.029	0.029
0.028	0.028	0.027	0.027	0.027	0.026	0.026
0.025	0.025	0.024	0.024	0.023	0.023	0.022

0.021	0.021	0.020	0.020	0.019	0.019	0.018
0.017	0.017	0.016	0.016	0.015	0.014	0.014
0.013	0.013	0.012	0.012	0.011	0.010	0.010
0.009	0.009	0.008	0.007	0.007	0.006	0.006
0.005	0.005	0.004	0.003	0.003	0.002	0.002
0.001	0.001	-0.000	-0.001	-0.001	-0.002	-0.002
-0.003	-0.003	-0.004	-0.004	-0.005	-0.005	-0.006
-0.006	-0.007	-0.007	-0.008	-0.008	-0.009	-0.009
-0.010	-0.010	-0.011	-0.011	-0.012	-0.012	-0.013
-0.013	-0.014	-0.014	-0.014	-0.015	-0.015	-0.016
-0.016	-0.017	-0.017	-0.017	-0.018	-0.018	-0.019
-0.019	-0.019	-0.020	-0.020	-0.020	-0.021	-0.021
-0.021	-0.022	-0.022	-0.022	-0.023	-0.023	-0.023
-0.023	-0.024	-0.024	-0.024	-0.024	-0.024	-0.025
-0.025	-0.025	-0.025	-0.025	-0.026	-0.026	-0.026
-0.026	-0.026	-0.027	-0.027	-0.027	-0.027	-0.027
-0.027	-0.027	-0.027	-0.028	-0.028	-0.028	-0.028
-0.028	-0.028	-0.028	-0.028	-0.029	-0.029	-0.029
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-0.029	-0.029	-0.029	-0.029	-0.029	-0.029	-0.029
-0.029	-0.029	-0.028	-0.028	-0.028	-0.028	-0.028
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-0.022	-0.021	-0.021	-0.020	-0.020	-0.019	-0.018
-0.018	-0.017	-0.017	-0.016	-0.015	-0.015	-0.014
-0.014	-0.013	-0.012	-0.011	-0.011	-0.010	-0.009
-0.008	-0.007	-0.007	-0.006	-0.005	-0.004	-0.003
-0.002	-0.001	-0.000	0.001	0.002	0.003	0.003
0.004	0.005	0.006	0.007	0.008	0.009	0.010
0.011	0.012	0.013	0.014	0.015	0.016	0.017
0.018	0.019	0.020	0.021	0.022	0.023	0.024
0.025	0.026	0.027	0.028	0.028	0.029	0.030
0.031	0.032	0.032	0.033	0.034	0.035	0.035
0.036	0.037	0.037	0.038	0.038	0.039	0.040
0.040	0.041	0.042	0.042	0.043	0.043	0.043
0.044	0.044	0.045	0.045	0.045	0.045	0.045
0.046	0.046	0.046	0.046	0.046	0.046	0.046
0.046	0.046	0.045	0.045	0.045	0.045	0.045
0.044	0.044	0.044	0.043	0.043	0.042	0.042
0.041	0.041	0.040	0.040	0.039	0.038	0.038
0.037	0.036	0.036	0.035	0.034	0.033	0.032
0.031	0.031	0.030	0.029	0.028	0.027	0.026
0.025	0.024	0.022	0.021	0.020	0.019	0.018
0.017	0.016	0.015	0.014	0.012	0.011	0.010
0.009	0.008	0.007	0.006	0.004	0.003	0.002
0.001	-0.000	-0.001	-0.002	-0.004	-0.005	-0.006
-0.007	-0.008	-0.009	-0.011	-0.012	-0.013	-0.014
-0.015	-0.016	-0.017	-0.018	-0.019	-0.020	-0.021
-0.022	-0.023	-0.024	-0.025	-0.026	-0.027	-0.028
-0.028	-0.029	-0.030	-0.031	-0.031	-0.032	-0.033
-0.033	-0.034	-0.034	-0.035	-0.035	-0.036	-0.036
-0.037	-0.037	-0.038	-0.038	-0.039	-0.039	-0.040
-0.040	-0.040	-0.040	-0.041	-0.041	-0.041	-0.042
-0.042	-0.042	-0.042	-0.042	-0.042	-0.042	-0.042
-0.041	-0.041	-0.041	-0.040	-0.040	-0.040	-0.040

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-0.038	-0.037	-0.037	-0.037	-0.036	-0.036	-0.035
-0.035	-0.034	-0.034	-0.033	-0.032	-0.032	-0.031
-0.030	-0.029	-0.029	-0.028	-0.028	-0.027	-0.026
-0.026	-0.025	-0.024	-0.023	-0.022	-0.022	-0.021
-0.020	-0.019	-0.018	-0.018	-0.017	-0.016	-0.015
-0.015	-0.014	-0.013	-0.012	-0.011	-0.010	-0.009
-0.009	-0.008	-0.007	-0.006	-0.005	-0.004	-0.004
-0.003	-0.002	-0.001	-0.000	0.001	0.002	0.002
0.003	0.004	0.005	0.006	0.006	0.007	0.008
0.009	0.009	0.010	0.011	0.011	0.012	0.013
0.013	0.014	0.015	0.015	0.016	0.017	0.017
0.018	0.018	0.019	0.019	0.020	0.020	0.021
0.021	0.021	0.022	0.022	0.023	0.023	0.023
0.024	0.024	0.025	0.025	0.025	0.026	0.026
0.026	0.027	0.027	0.027	0.027	0.027	0.028
0.028	0.028	0.028	0.028	0.028	0.029	0.029
0.029	0.029	0.029	0.029	0.029	0.028	0.028
0.028	0.028	0.028	0.028	0.028	0.028	0.028
0.028	0.028	0.028	0.028	0.027	0.027	0.027
0.027	0.027	0.026	0.026	0.026	0.026	0.026
0.025	0.025	0.025	0.025	0.024	0.024	0.024
0.023	0.023	0.022	0.022	0.022	0.021	0.021
0.021	0.020	0.020	0.020	0.019	0.019	0.018
0.018	0.017	0.017	0.016	0.016	0.015	0.015
0.015	0.014	0.014	0.013	0.013	0.012	0.012
0.011	0.011	0.010	0.009	0.009	0.008	0.008
0.007	0.007	0.006	0.006	0.005	0.005	0.004
0.004	0.003	0.003	0.002	0.002	0.001	0.000
-0.000	-0.001	-0.001	-0.002	-0.002	-0.003	-0.004
-0.004	-0.005	-0.005	-0.006	-0.006	-0.007	-0.008
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-0.012	-0.012	-0.013	-0.013	-0.014	-0.014	-0.015
-0.015	-0.015	-0.016	-0.016	-0.017	-0.017	-0.018
-0.018	-0.019	-0.019	-0.020	-0.020	-0.020	-0.021
-0.021	-0.021	-0.021	-0.022	-0.022	-0.022	-0.023
-0.023	-0.023	-0.023	-0.023	-0.024	-0.024	-0.024
-0.024	-0.025	-0.025	-0.025	-0.025	-0.025	-0.025
-0.025	-0.026	-0.025	-0.025	-0.025	-0.025	-0.025
-0.025	-0.025	-0.025	-0.025	-0.025	-0.024	-0.024
-0.024	-0.024	-0.023	-0.023	-0.023	-0.023	-0.023
-0.022	-0.022	-0.022	-0.022	-0.022	-0.021	-0.021
-0.021	-0.021	-0.020	-0.020	-0.019	-0.019	-0.019
-0.018	-0.018	-0.017	-0.017	-0.017	-0.016	-0.016
-0.015	-0.015	-0.014	-0.014	-0.013	-0.013	-0.012
-0.012	-0.012	-0.011	-0.011	-0.010	-0.010	-0.009
-0.009	-0.008	-0.008	-0.007	-0.007	-0.006	-0.006
-0.005	-0.005	-0.004	-0.003	-0.003	-0.002	-0.002
-0.001	-0.001	-0.000	0.000	0.001	0.001	0.002
0.002	0.003	0.003	0.004	0.004	0.005	0.005
0.006	0.006	0.007	0.007	0.008	0.008	0.009
0.009	0.010	0.010	0.011	0.011	0.011	0.012
0.012	0.012	0.013	0.013	0.013	0.014	0.014
0.014	0.015	0.015	0.015	0.016	0.016	0.016
0.017	0.017	0.017	0.017	0.018	0.018	0.018
0.018	0.018	0.019	0.019	0.019	0.019	0.019

0.019	0.019	0.019	0.019	0.020	0.020	0.020
0.020	0.020	0.020	0.020	0.020	0.020	0.020
0.020	0.020	0.020	0.020	0.020	0.020	0.020
0.020	0.020	0.019	0.019	0.019	0.019	0.019
0.018	0.018	0.018	0.018	0.018	0.018	0.017
0.017	0.017	0.017	0.016	0.016	0.016	0.016
0.015	0.015	0.015	0.014	0.014	0.014	0.013
0.013	0.013	0.012	0.012	0.012	0.011	0.011
0.011	0.010	0.010	0.009	0.009	0.009	0.008
0.008	0.007	0.007	0.007	0.006	0.006	0.006
0.005	0.005	0.004	0.004	0.003	0.003	0.003
0.002	0.002	0.002	0.001	0.001	0.000	-0.000
-0.001	-0.001	-0.002	-0.002	-0.003	-0.003	-0.003
-0.004	-0.004	-0.004	-0.005	-0.005	-0.005	-0.006
-0.006	-0.007	-0.007	-0.007	-0.007	-0.008	-0.008
-0.008	-0.009	-0.009	-0.009	-0.009	-0.010	-0.010
-0.010	-0.010	-0.010	-0.011	-0.011	-0.011	-0.011
-0.012	-0.012	-0.012	-0.013	-0.013	-0.013	-0.013
-0.013	-0.013	-0.014	-0.014	-0.014	-0.014	-0.014
-0.014	-0.014	-0.014	-0.015	-0.015	-0.015	-0.015
-0.015	-0.015	-0.015	-0.015	-0.015	-0.015	-0.015
-0.015	-0.015	-0.015	-0.015	-0.015	-0.014	-0.014
-0.014	-0.014	-0.014	-0.014	-0.014	-0.014	-0.014
-0.014	-0.014	-0.013	-0.013	-0.013	-0.013	-0.013
-0.012	-0.012	-0.012	-0.012	-0.012	-0.012	-0.012
-0.011	-0.011	-0.011	-0.011	-0.010	-0.010	-0.010
-0.010	-0.009	-0.009	-0.009	-0.009	-0.009	-0.008
-0.008	-0.008	-0.008	-0.008	-0.007	-0.007	-0.007
-0.007	-0.006	-0.006	-0.006	-0.005	-0.005	-0.005
-0.004	-0.004	-0.004	-0.004	-0.003	-0.003	-0.003
-0.003	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001
-0.001	-0.001	-0.000	0.000	0.000	0.001	0.001
0.001	0.001	0.001	0.001	0.001	0.002	0.002
0.002	0.003	0.003	0.003	0.004	0.004	0.004
0.004	0.004	0.004	0.004	0.005	0.005	0.005
0.005	0.005	0.006	0.006	0.006	0.006	0.006
0.007	0.007	0.007	0.007	0.007	0.007	0.007
0.007	0.007	0.007	0.008	0.008	0.008	0.008
0.008	0.008	0.008	0.008	0.008	0.008	0.008
0.008	0.008	0.008	0.009	0.009	0.009	0.009
0.009	0.009	0.009	0.009	0.009	0.009	0.009
0.009	0.009	0.009	0.009	0.009	0.009	0.009
0.008	0.008	0.008	0.009	0.009	0.009	0.009
0.009	0.009	0.008	0.008	0.008	0.008	0.008
0.008	0.008	0.008	0.008	0.009	0.009	0.008
0.008	0.008	0.007	0.007	0.006	0.006	0.006
0.006	0.007	0.007	0.007	0.007	0.007	0.007
0.006	0.006	0.006	0.006	0.006	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.004	0.004	0.004	0.004	0.003
0.003	0.003	0.003	0.003	0.003	0.003	0.003
0.003	0.003	0.002	0.002	0.002	0.001	0.001
0.001	0.001	0.001	0.001	0.001	0.001	0.001
0.000	0.000	-0.000	-0.000	-0.000	-0.000	-0.000
-0.000	-0.000	-0.000	-0.001	-0.001	-0.001	-0.001
-0.001	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002

-0.002	-0.002	-0.003	-0.003	-0.003	-0.003	-0.003
-0.003	-0.003	-0.003	-0.004	-0.004	-0.004	-0.004
-0.004	-0.004	-0.004	-0.004	-0.004	-0.005	-0.005
-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
-0.005	-0.005	-0.005	-0.005	-0.006	-0.006	-0.006
-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006
-0.006	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007
-0.007	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007
-0.007	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007
-0.007	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007
-0.007	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007
-0.007	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007
-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006
-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.005
-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
-0.005	-0.005	-0.005	-0.005	-0.004	-0.004	-0.004
-0.004	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002
-0.002	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001
-0.001	-0.001	-0.001	-0.000	-0.000	-0.000	0.000
0.000	0.000	0.001	0.001	0.001	0.001	0.001
0.001	0.002	0.002	0.002	0.002	0.002	0.002
0.002	0.003	0.003	0.003	0.003	0.003	0.004
0.004	0.004	0.004	0.004	0.004	0.004	0.004
0.004	0.004	0.004	0.005	0.005	0.005	0.005
0.005	0.005	0.006	0.006	0.006	0.006	0.006
0.006	0.006	0.006	0.006	0.006	0.007	0.007
0.007	0.007	0.007	0.007	0.007	0.007	0.007
0.007	0.007	0.007	0.007	0.007	0.007	0.007
0.007	0.007	0.007	0.007	0.008	0.008	0.008
0.008	0.008	0.007	0.007	0.007	0.007	0.007
0.007	0.007	0.007	0.007	0.007	0.007	0.007
0.007	0.007	0.007	0.007	0.007	0.007	0.007
0.007	0.007	0.006	0.006	0.006	0.006	0.006
0.006	0.006	0.006	0.006	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.004	0.004
0.004	0.004	0.004	0.004	0.003	0.003	0.003
0.003	0.003	0.003	0.003	0.002	0.002	0.002
0.002	0.002	0.002	0.002	0.001	0.001	0.001
0.001	0.001	0.000	0.000	0.000	-0.000	-0.000
-0.000	-0.000	-0.000	-0.001	-0.001	-0.001	-0.001
-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
-0.002	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
-0.003	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004
-0.004	-0.004	-0.005	-0.005	-0.005	-0.005	-0.005
-0.005	-0.005	-0.005	-0.005	-0.006	-0.006	-0.006
-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006
-0.007	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007
-0.007	-0.007	-0.006	-0.006	-0.006	-0.006	-0.006
-0.006	-0.006	-0.006	-0.006	-0.007	-0.007	-0.007
-0.007	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007
-0.007	-0.007	-0.007	-0.006	-0.006	-0.006	-0.006
-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006
-0.006	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.004
-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004

-0.004	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002
-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001
-0.001	-0.001	-0.001	-0.000	-0.000	-0.000	-0.000
0.000	0.000	0.000	0.000	0.000	0.001	0.001
0.001	0.001	0.001	0.001	0.001	0.001	0.002
0.002	0.002	0.002	0.002	0.002	0.002	0.002
0.003	0.003	0.003	0.003	0.003	0.003	0.003
0.004	0.004	0.004	0.004			

APPENDIX E – DEBUBBLE FILTER

E.1 DEBUBBLE FILTER

Time is increasing horizontally.

Sample rate is 4ms. Start time is 0ms and end time is 1000ms. Sample count is 251

1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.004432	0.000580	-0.002904	0.010372	-0.012418	0.005893	-0.022386
-0.008561	-0.033484	-0.023507	-0.042043	-0.036086	-0.044760	-0.046978
-0.053574	-0.043679	-0.053685	-0.051572	-0.050348	-0.045570	-0.048442
-0.049134	-0.055076	-0.060913	-0.061254	-0.048559	-0.039344	-0.031161
-0.029199	-0.026056	-0.026814	-0.020709	-0.015294	-0.009257	-0.003788
0.001515	0.004776	0.008921	0.011367	0.014058	0.014024	0.015126
0.014253	0.011288	0.010686	0.011713	0.011471	0.014209	0.017018
0.018446	0.019074	0.019094	0.016585	0.015769	0.012739	0.011016
0.007371	0.004512	0.002322	0.001838	0.001398	0.003187	0.003830
0.005123	0.006226	0.006509	0.006539	0.005913	0.003630	0.002184
-0.001256	-0.004449	-0.008557	-0.011125	-0.012935	-0.014226	-0.015822
-0.015839	-0.014767	-0.010857	-0.008072	-0.004430	-0.001092	0.002334
0.004647	0.006115	0.006277	0.006904	0.007023	0.006019	0.004481
0.003446	0.001359	-0.000819	-0.002571	-0.003493	-0.005099	-0.005883
-0.007248	-0.007208	-0.007871	-0.006862	-0.005841	-0.003602	-0.002214
-0.000356	0.000929	0.003383	0.003734	0.004764	0.005578	0.006582
0.006784	0.006959	0.006801	0.006568	0.005693	0.005479	0.004501
0.003679	0.002204	0.000888	-0.000751	-0.001666	-0.002857	-0.003717
-0.004935	-0.004525	-0.004873	-0.004066	-0.003894	-0.003403	-0.003083
-0.001970	-0.001695	-0.001245	-0.001457	-0.000674	-0.000150	0.001156
0.000852	0.001809	0.002107	0.002282	0.001883	0.002975	0.003014
0.002750	0.002662	0.003208	0.002259	0.001753	0.000481	0.000696
-0.000764	-0.001492	-0.002349	-0.002452	-0.003683	-0.003678	-0.003820
-0.003739	-0.003889	-0.003220	-0.003032	-0.002305	-0.001991	-0.000572
-0.000236	0.001023	0.001619	0.002952	0.002792	0.003119	0.003279
0.003882	0.002551	0.002733	0.001992	0.001418	0.000511	0.000287
-0.000829	-0.000195	-0.001020	-0.000397	-0.000535	-0.000003	-0.000010
0.000771	0.000186	0.000914	0.000490	0.000547	-0.000105	0.000771
-0.000156	0.000007	-0.000695	0.000310	-0.000462	0.000801	0.000206
0.000010	-0.001763	-0.000875	-0.001357	-0.000923	-0.001304	-0.000590
-0.000978	-0.000133	-0.000712	-0.000153	-0.001452	-0.001027	-0.001687
-0.000892	-0.002059	-0.000782	-0.001454	-0.000415	-0.001472	-0.000332
-0.001544	-0.000601	-0.001972	-0.000811	-0.002351	-0.000462	-0.001505
-0.000307	-0.001023	-0.000287	-0.000647	0.000047	-0.000013	