Integrated Services in
Petroleum Exploration and Production

Processing Report

for

Seismic Australia

Otway-Sorell 2D Acquisition 2001

February 2002

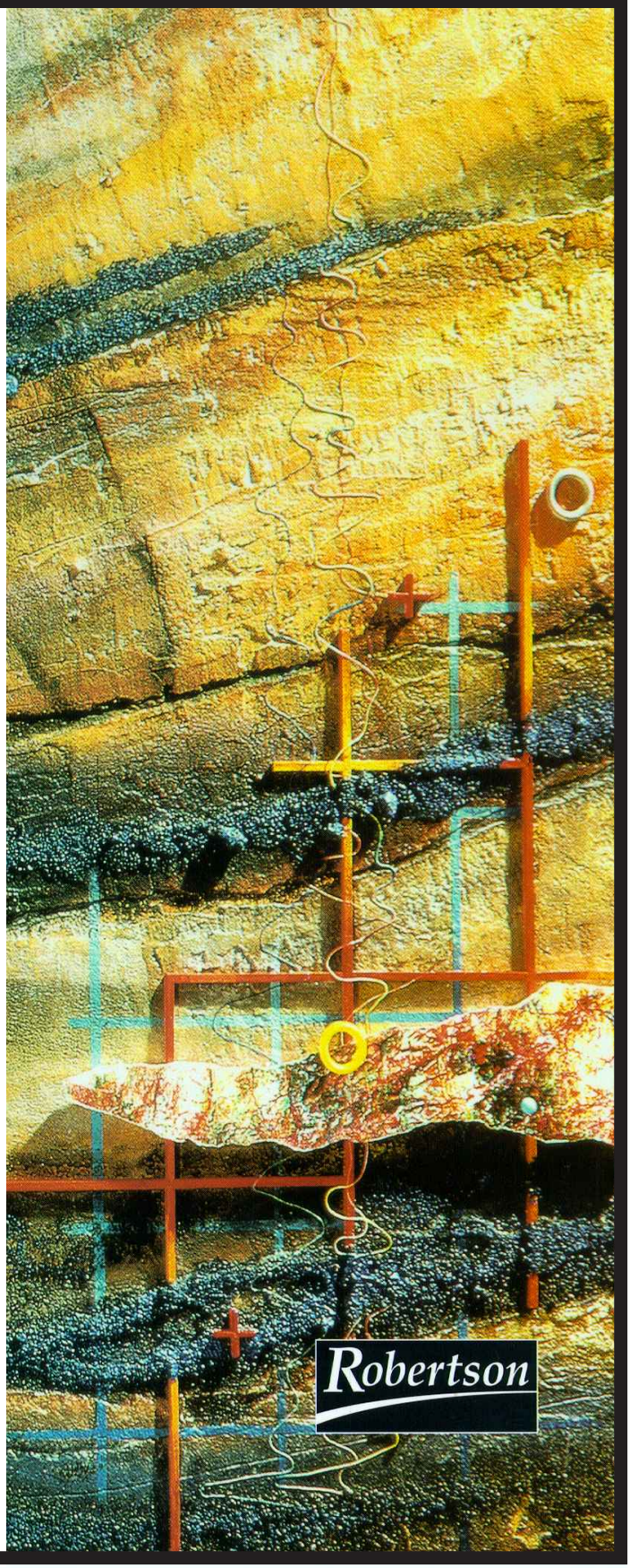

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TABLE OF CONTENTS

SECTIONS	CONTENTS	Page Numbers
1.0	Introduction	1
1.1	Personnel	1
1.2	Survey Map	2
2.0	Testing	3
2.1	Parameter Testing	3
3.0	Comments & Conclusion	4
4.0	General Processing Sequence	5
5.0	Processing Techniques	6-13
6.0	Acquisition Parameters	14

APPENDICES

SECTIONS	CONTENTS	Page Numbers
A	Line Listing	15

1.0 INTRODUCTION

The Otway-Sorell 2D Acquisition 2001 project consists of 33 lines totalling 3612.6km. The objective was to provide a sparse exploration 2D over frontier areas in the Otway and Sorell basins for current and future releases of offshore petroleum exploration acreage. Several wells exist in shallow water that were tied to allow stratigraphic information to be correlated into larger deep-water structures.

Acquisition was conducted by the Fugro-Geoteam vessel MV Geo Arctic and data processing was performed at Robertson Research Australia' s office in Perth.

Good to very good data quality was achieved and areas of interest were highlighted for future surveys and reprocessing.

1.1 PERSONNEL

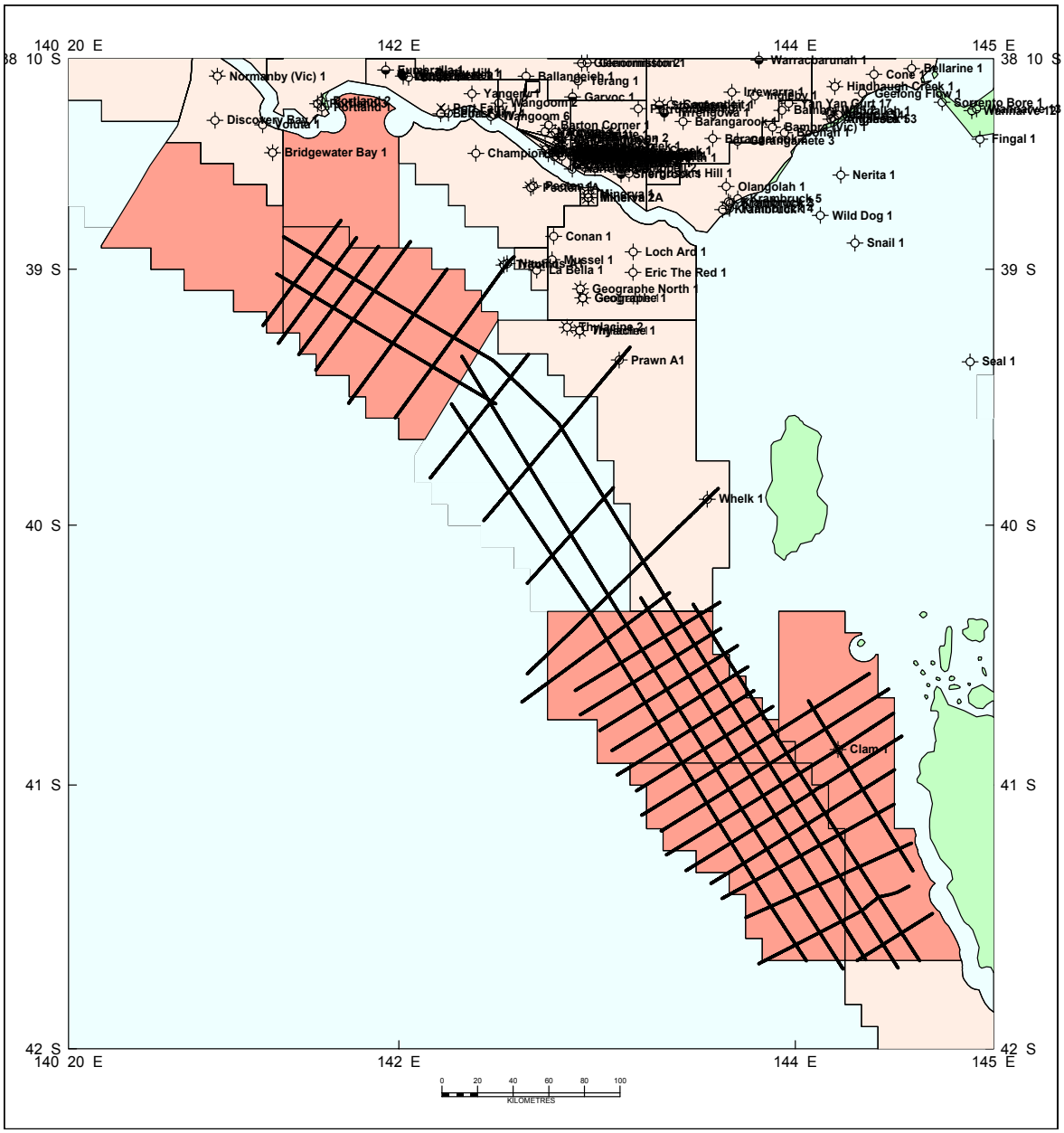
Robertson Research Australia.

Kelly Beauglehole	Processing Manager
Narcisa Lazarescu	Geophysicist
Francis Foo	Geophysicist

Seismic Australia

Jan Ostby	Geophysical Projects Manager
Michael Davidson	Geophysicist

1.2 SURVEY MAP



2.0 TESTING

2.1 PARAMETER TESTING

Extensive testing was performed to determine the optimum processing sequence. Testing procedures were conducted on a selected survey line, DS01-139 and performed by Kelly Beauglehole of Robertson Research Australia, with significant input from Jan Ostby and Michael Davidson of Seismic Australia. A processing sequence was established for the area with parameters varied to account for changing water depth.

Parameter selection was made with consideration for the processing objective of improving the imaging of complex structural patterns, in particular, tilted fault blocks beneath the edge of the Continental Margin. Particular attention was focused on the parameterisation of processes such as signature deconvolution, multiple attenuation, predictive deconvolution, pre-stack time migration and post-stack time migration.

3.0 COMMENTS & CONCLUSION

Processing the Otway-Sorell data set yielded good data quality despite variations in water depths and geology along the lines.

Due to the variations in water depths and geology covered in this survey, special care was taken with spatially varying parameters according to water depths. Designature design windows, mutes, pre-stack and post stack predictive deconvolution design and application windows, dip limits and bandpass filter were adjusted according to water depths. Special care was taken in picking velocities. Percentages of reduction in migration velocities were also adjusted according to geology and water depths.

The use of pre-stack time migration gave a better definition of steep dips surrounding the structure of complex geology.

4.0 GENERAL PROCESSING SEQUENCE

TRANSCRIPTION
|
GAIN RECOVERY/ RESAMPLE
|
MULTI CHANNEL FILTER (SHOT AND RECEIVER DOMAIN)
|
TVRMIX
|
SIGNATURE DECONVOLUTION
|
CDP GATHER
|
VELOCITY ANALYSIS (1st pass at 2 km intervals)
|
FK MULTIPLE ATTENUATION
|
DMO
|
PRE-STACK TIME MIGRATION
|
VELOCITY ANALYSIS (2nd pass at 1km intervals)
|
NMO CORRECTION & MUTES
|
PRE-STACK SCALING
|
GUN & CABLE STATIC CORRECTIONS
|
FORWARD FK MIGRATION
|
RAW STACK
|
MINIMUM TO ZERO PHASE CONVERSION
|
MIGRATION WITH PRE-MIGRATION SCALING
|
TAU-P FILTER
|
RESIDUAL GAIN CORRECTION
|
BANDPASS FILTER
|
POST STACK SCALING

5.0 PROCESSING TECHNIQUES

A brief description of each of the processes used in the processing sequence follows:

The processing length was 12 seconds for the DS01 survey. All data were processed at 4ms.

Please note that parameters are spatially varied according to water depths for processes such as signature deconvolution, predictive deconvolution, mutes, bandpass filters and percentages of reduction in migration velocity functions.

Parameters shown in this section for these processes are applicable for a seafloor time at 100 milliseconds.

5.1 TRANSCRIPTION

Field data were converted to Robertson's internal format for processing. RRA's internal processing format is trace sequential, with samples in 32 bit IEEE floating point. At intermediate processing stages the data is stored on magnetic tape in sixteen-bit integer with a gain ranging scalar for each trace.

Survey	Field tape format
DS01	SEG-D field tape copy

5.2 GAIN RECOVERY

A gain function was applied to the data set to compensate for amplitude decay. The function applied used t squared compensation for inelastic attenuation and spherical divergence losses. (t is two way travel time in milliseconds).

5.3 RESAMPLE

Data were resampled from 2 ms to 4 ms sample rate. Resampling is performed in the frequency domain and effectively applies a "brick-wall" zero phase anti-alias filter.

5.4 MULTI CHANNEL FILTER (SHOT & RECEIVER DOMAIN)

A symmetrical "velocity" filter was designed in the F-K domain to preserve the primary reflection signal and to discriminate against coherent dipping noise trains. The filter employs a cosine-squared taper from k = 0 to the velocity intercept at each frequency. The input data was conditioned with a 300 ms AGC, and the scalars preserved for removal subsequent to the application of the F-K filter. A cut off velocity of 1500 m/sec was used in the shot domain and 1250m/sec was used in the receiver domain.

5.5 RECEIVER ARRAY SIMULATION

Receiver array simulation was applied as shown below.

A time variant trace mix was performed down NMO curves. The data were mixed to establish the desired output illustrated in the following table:

Time (ms)	Trace weights
3000	0-1-2-1-0
7000	1-2-3-2-1

Alternative traces were output to produce a new number of traces and a new group interval.

DS01 Survey	# of Output Traces	New Group Interval (m)
12 Seconds	279	25

5.6 SIGNATURE DECONVOLUTION

Robertson Research's signature deconvolution routine is based on Taner's method for estimating a minimum phase signature from a mixed phase record. The method involves the application of an inverse exponential gain to the data to force the essentially mixed phase data to minimum phase before the Wiener double inverse method (which presumes minimum phase input) is used to derive the minimum phase source signature. However, as this gain will affect the shape of the derived wavelet, it is then removed before deconvolving with the original un-gained data.

A data derived 300 ms wavelet, designed using all offsets was chosen for the sequence. An exponential gain function of -6 dB/sec was applied and removed in the wavelet estimation in accordance with Taner's method of minimum phase conditioning. The output minimum phase wavelets were shaped to a bandwidth of 6-70 Hz with filter slopes of 18 dB/oct for the low-cut and 48 dB/oct for the high-cut.

Offsets	Design windows

500	500-3500 ms
4122	3000-5600 ms

5.7 CDP GATHER

The shot records were sorted into common depth point gathers, with the maximum fold and spacing of the gathers for the DS01 survey tabled below:

Survey	Coverage	CDP Interval
DS01	9300	12.5

5.8 FIRST PASS VELOCITY ANALYSIS

First pass velocities were determined using Robertson's "MGIVA" interactive velocity analysis program. Each velocity analysis comprised a semblance display, a 60 CDP stacked panel repeated 15 times with a suite of velocity functions, and a central CDP gather. The suite of functions were generated using 0%, +/-5 %, +/-10%, +/-15%, +/-20 %, +/-26%, +/-32%, and +/-40% increments from a central velocity function. The central function was derived from a brute velocity that varied according to water depth.

A mild F-K multiple attenuation was applied to enhance the primary energy of the data before the analyses using the following percentages of the brute velocity function: -10% at 0ms, -16% at 1200ms and -20% from 3500ms to 10000ms. This was applied for the purpose of the analyses only.

The velocity analysis incorporated a map of all velocity locations, and the semblance display included functions from proximate lines. This enabled the velocities to be picked with knowledge of areal velocity trends. Velocity QC could be performed more effectively when discordant velocities could be recognised on the map (Velocity slices could be shown at 25 horizons).

5.9 F-X MULTIPLE ATTENUATION

F-X multiple attenuation was performed and was found to be effective. The process of multiple attenuation in the F-K domain typically involves applying appropriate normal moveout to the data, transforming them into the F-K plane, applying an appropriate filter designed to preserve the primaries in the negative quadrant and re-transforming the filtered data back to CDP gathers.

Using this approach, the impulse response on the F-K filter is generated by populating a model F-K space with 1's and designing some filter to attenuate the required areas. The reverse FFT's are applied to generate the time domain impulse response of the FK filter. The CDP gathers can then be filtered by taking the impulse response and the CDP gather, and performing multiplication in the frequency domain and convolution in the spatial domain.

Adjacent CDP's were merged to form supergathers (thus reducing the potential for aliasing). After demultiple the supergathers were split back to their original component CDP's.

Normal moveout was performed and the percentage slowing function of first pass velocities was -6% at 0ms, -8% from 800 to 2500ms, -10% at 4500ms, -12% at 6500 and -15% at 10000ms.

A 300ms AGC was applied prior to, and removed after, multiple attenuation.

5.10 DIP MOVEOUT

Robertson Research's DMO program applies 2D convolution operators to map the data accurately from non-zero to zero offset in the manner described by Deregowski and Rocca (1981). The convolution is conveniently implemented by the summation method, and applied to traces in common offset order. This procedure achieves the desirable partial migration, whereby traces with common mid-points, but different source-receiver offsets, relate to the same sub-surface locations after DMO, for all dips. After DMO all reflection events appear, for the purposes of normal moveout correction, to have originated from horizontal reflectors. Therefore, optimum stack response for all reflector dips can be obtained from conventional moveout corrections based on velocity functions undistorted by reflector dips.

The number of common offset planes used in DMO was equivalent to the maximum fold of the data (Refer to the table under section 5.7, CDP Gather).

5.11 PRE-STACK TIME MIGRATION

Offsets were regularised and partially stacked to form common offset planes. Migration was performed in the frequency-wavenumber domain on the common offset planes using Stolt's F-K method with a constant velocity of 1500 m/s..

Survey	Number of offset planes
DS01	93

5.12 SECOND PASS VELOCITY ANALYSIS

Second pass velocities were determined using Robertson's "MGIVA" interactive velocity analysis program. Each velocity analysis comprised a semblance display, a 60 CDP stacked panel repeated 15 times with a suite of velocity functions, and a central CDP gather. The suite of functions were generated using 0%, +/- 3%, +/-6%, +/-9%, +/-12%, +/-16%, +/-20%, and +/-24% increments from a central velocity function. This central function was derived from the first pass velocity analyses (see Section 5.8).

The velocity analysis incorporated a map of all velocity locations, and the semblance display included functions from proximate lines. This enabled the velocities to be picked with knowledge of areal velocity trends. Velocity QC could be performed more effectively when discordant velocities could be recognised on the map (Velocity slices could be shown at 25 horizons).

5.13 NMO CORRECTION

Fourth order NMO correction was performed using the final picked velocity functions.

5.14 OUTER-TRACE MUTE

A post-NMO outer trace mute was applied for two main reasons :

- to remove any coherent noise on the outer traces and
- to reduce contamination from the effect of NMO stretch on the far offsets.

Offset distance (m)	*Application times (ms)*
336	0
396	200
768	600
2880	1775
5040	2975
7380	4300
8580	4900

5.15 PRE-STACK SCALING

A dual window AGC was performed with window lengths of 1200 ms and 400 ms at 60% application. The short window stopped at 10000 ms.

5.16 INNER-TRACE MUTE

A post NMO inner trace mute was applied to help remove remnant multiple energy still apparent on the inner traces following multiple attenuation:

Offset distance (m)	*Application times (ms)*
94	1200-tmax
485	1600-tmax
800	2500-tmax

5.17 COMMON DEPTH POINT STACK

The traces within each common depth point gather were summed using 1/root(N) stack compensation. For the maximum fold produced and output CDP interval see section 5.7.

5.18 STATICS

A static compensation for gun and cable depths was applied. The static value applied was calculated using average gun and cable depths supplied in the observer's reports. The value used for the DS01 survey, with an error of +/-1 ms, is shown in the table below:

Survey	**Static Correction applied (ms)**
DS01	11

5.19 INVERSE MIGRATION

Forward modelling was performed using a constant velocity of 1500 m/s to de-migrate the data set.

5.20 ZERO PHASE CONVERSION

Data were converted from minimum phase to zero phase. The spectral estimate was made using the Wiener-Levinson double inverse method. A phase rotation of 180 degrees was applied to make it SEG negative.

5.21 WAVE EQUATION MIGRATION

A second order 65 degree finite difference migration scheme was used. The migration model velocities were based on laterally and vertically smoothed stacking velocities with the following percentages of reduction.

Time (ms)	*% of velocity*
0	100
450	95
950	90

3000	85
6000	80
10000	75

5.22 TAU-P FILTER

Tau-p filtering provides an effective time variant dip filter, and enhances coherent events while discriminating against random noise. Semblance enhancement of the data in the Tau-p domain, together with editing of sections

of the Tau-p plane, permits retention of data within specified dip limits at any time and enhancement of these dips after transformation back into x - t space.

Dip limits used were +/- 6ms/trace from 0ms to TMAX ms.

5.23 RESIDUAL GAIN CORRECTION

To produce balanced stacks a residual gain correction was applied. A time variant incremental gain curve was applied from the water bottom as follows:
0dB at time zero, 4dB at time 1000ms, 8dB at time 2000ms and 12dB at time 3000ms. Spatial variance was achieved by supplying TVEL functions. The first time value at each location was used as the time value from which to apply the incremental gain curve.

5.24 BAND PASS FILTER

Unwanted noise that lay outside the frequency range of the desired reflection and diffraction data was removed by the application of a series of zero phase time variant cosine squared tapered filters.

Parameter summary:

Application times (ms)	Frequency limits (Hz)
1200	4-8-60-70
2000	4-8-40-50
3000	4-6-30-40
5000	3-5-20-30
7000	3-5-15-25

5.25 POST STACK SCALING

A dual window, time variant AGC method was used for post stack scaling. The negative effects normally associated with AGC are avoided by employing two different length windows to determine the amplitude model (using the minimum

of the two mean amplitudes determined at each sample), then conditioning the model by a weighted mix with the amplitude model derived from a single window per trace.

Parameter summary

Window lengths of 1200 ms and 400 ms
Equalization applied : 60
Short window stopped 8000 ms

5.26 DISPLAY

A 1:50000 scale was used for final display. The DS01 survey had a stack CDP interval of 12.5 metres (Refer to 5.17 Common Depth Point Stack), therefore it was displayed with every second trace plotted. A 1:2:1 trace mix prior to decimation was also applied.

6.0 ACQUISITION PARAMETERS

6.1 Survey: DS01

Description	**DS01**
Data recorded by:	FUGRO-GEOTEAM
Date recorded:	2001
Vessel:	M/V Geo Arctic
Seismic source:-	
Type:	Airgun array
Pressure/Volume:	2000 psi/3660 cu.in.
Depth:	6 metres (average)
Shot interval:	37.5 metres
Recording system:-	
Format:	SEG-D
Record length:	12 seconds
Sample interval:	2 ms
Filters:Low	4Hz@18dB/oct.
:High	206Hz@265dB/oct.
Streamer:-	
Streamer length:	7000 metres
Streamer depth:	10.33 metres (average)
Number of groups:	560
Near group number:	1
Group interval:	12.5 metres
Near group offset:	150.21 metres (average)
SP annotation:	Referenced to Shot Point Position

APPENDIX A

Line Listing

Line Name	Shotpoint Range	CDP Range	# of Km's
DS01-107	101-1630	1-4866	57.375
DS01-108	101-1634	1-4878	57.525
DS01-109	101-1665	1-4971	58.688
DS01-110	101-1961	1-5859	69.787
DS01-112	101-2034	1-6078	72.525
DS01-114	101-2431	1-7269	87.412
DS01-117	101-1929	1-5763	68.588
DS01-120	101-2724	1-8148	98.400
DS01-123	101-1581	1-4719	55.537
DS01-126	101-3152	1-9432	114.450
DS01-128	101-2199	1-6573	78.713
DS01-130	101-2035	1-6081	72.563
DS01-131	101-1981	1-5919	70.537
DS01-132	101-1946	1-5814	69.225
DS01-133	101-1919	1-5733	68.213
DS01-134	101-1927	1-5757	68.512
DS01-135	101-1922	1-5742	68.325
DS01-136A	101-3143	1-9405	114.113
DS01-137	101-3143	1-9405	114.113
DS01-138_A_B	101-3132	1-9372	113.700
DS01-139	101-2978	1-8910	107.925
DS01-140	101-2542	1-7602	91.575
DS01-141X_A	101-2317	1-6927	83.137
DS01-142X	101-2146	1-6414	76.725
DS01-144X_A_B	101-2003	1-5985	71.363
DS01-146	101-1100	1-3276	37.500
DS01-201	101-2363	1-7065	84.863
DS01-203_A	101-4883	1-14625	179.363
DS01-204X	101-11284	1-33828	419.400
DS01-205X_A	101-4926	1-14754	180.975
DS01-206X_A	101-8324	1-24948	308.400
DS01-207	101-3060	1-9156	111.000
DS01-208X_A	101-7622	1-22842	282.075
		Total Km's	**3612.600**