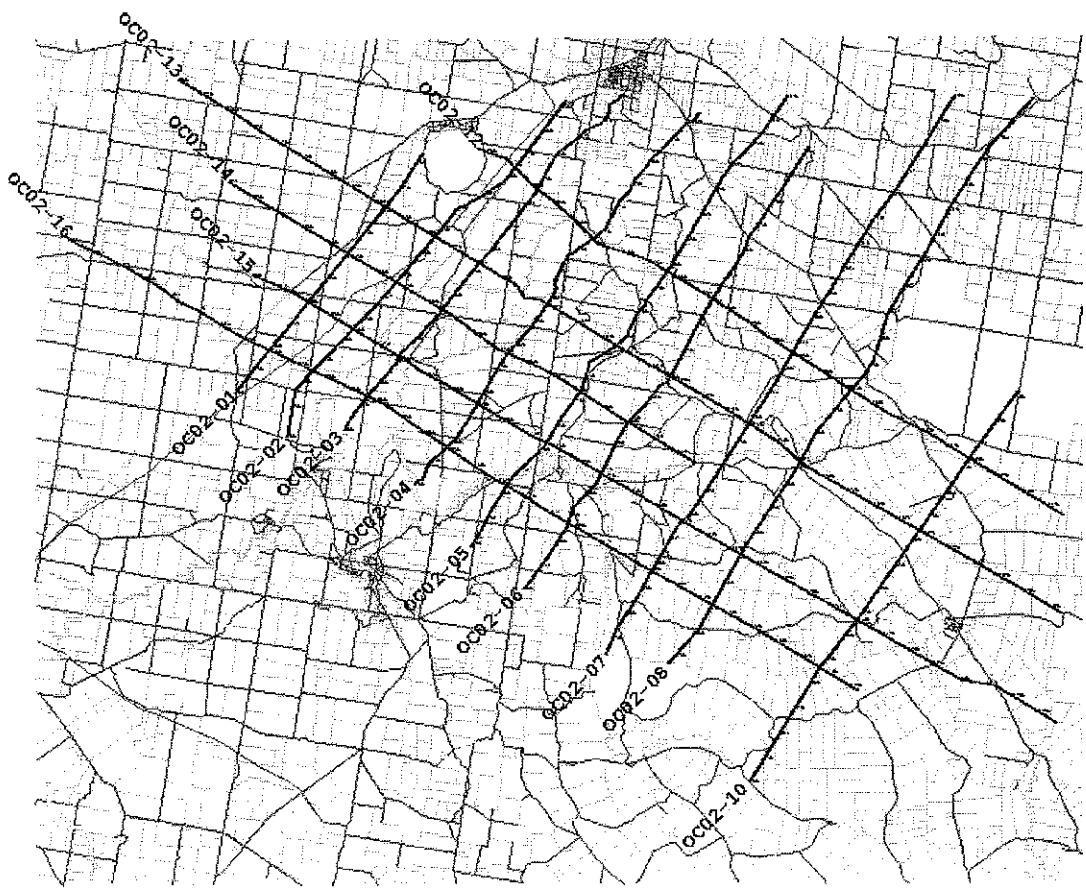
# SURVEY OPERATIONS

# END OF CONTRACT REPORT

# COBDEN 2D

# SANTOS LIMITED

# VICTORIA



# FINAL SURVEY REPORT

## For

# SANTOS LIMITED

## PEP 153

## COBDEN 2D SEISMIC SURVEY

LINES

OC02-01

OC02-02

OC02-03

OC02-04

OC02-05

OC02-06

OC02-07

OC02-08

OC02-10

OC02-12

OC02-13

OC02-14

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OC02-16

JAN / FEB / MARCH 2002

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# 1.0 INTRODUCTION

WesternGeco was contracted by Santos Limited to undertake the Cobden 2D survey. The prospect is situated between townships of Timboon and Cobden in Victoria's Otway Basin. This area is part of Exploration Permit PEP 153 belonging to Santos Limited (hereafter referred to as Santos).

The ranging of line commenced on the 23rd January. Surveying line fieldwork commenced on 25th January 2002 and was completed on 10th March 2002. A total of 297.36 kilometres was surveyed and ranged. The survey control was established between 21st and 25th of January.

An advance two person scouting crew arrived in Peterborough on Friday 18th January. After making contact with the permit officer a quick scout of the prospect was conducted. Over the next few days a more extensive reconnaissance of the prospect was conducted and the survey control established. Seven base stations were established in the initial control run. The remainder of the surveyors arrived on the 22nd of January. The surveyors and GPS operators prepared maps, painted and numbered pegs and installed the GPS units and radios in the hire vehicles while the permitting was completed.

At commencement, the survey crew was based out of Peterborough and during the prospect survey office moved to the Cascade Motel in Camperdown until the completion. Production rate was slower than anticipated due to several factors including the terrain, inexperience in 2D operations and later in the prospect the lack of gates.

The survey work was accomplished using Real Time Kinematic GPS (RTK) methods and conventional levelling methods. A GPS backpacking crew was used to survey through areas of remnant native vegetation.

## 2.0 LINE SUMMARY

The original survey of Cobden 2D consisted of 16 lines totalling 349.36 kilometres, however this was reduced to 14 lines totalling 297.36 kilometres during the survey. The station interval for the survey was 20.0m.

The individual line details are listed below.

| Line | Start | End | Stn Int. | Total |
|---|---|---|---|---|
| OC02-01 | 200 | 720 | 20 | 10.40 |
| OC02-02 | 200 | 962 | 20 | 15.24 |
| OC02-03 | 200 | 958 | 20 | 15.16 |
| OC02-04 | 200 | 1020 | 20 | 16.40 |
| OC02-05 | 200 | 1152 | 20 | 19.04 |
| OC02-06 | 200 | 1112 | 20 | 18.24 |
| OC02-07 | 220 | 1350 | 20 | 22.60 |
| OC02-08 | 230 | 1392 | 20 | 23.24 |
| OC02-10 | 200 | 1012 | 20 | 16.24 |
| OC02-12 | 200 | 1380 | 20 | 23.60 |
| OC02-13 | 200 | 1974 | 20 | 35.48 |
| OC02-14 | 200 | 1136 | 20 | 18.72 |
| OC02-15 | 200 | 1786 | 20 | 31.72 |
| OC02-16 | 200 | 1764 | 20 | 31.28 |
| | | | Total | 297.36 |

Lines OC02-09 and OC02-11 were cut from the program. Lines OC02-03, OC02-04, OC02-06, OC02-07, OC02-08, OC02-10 and other lines were cut short at the client's request. Line OC02-012 was extended at the client's request.

# 3.0 PERSONNEL AND EQUIPMENT

## 3.1 PERSONNEL

The WesternGeco survey crew consisted of twelve people. The following is a list of personnel utilized during the survey:

| Name | Duties |
|---|---|
| Charlie Johnson | Senior Surveyor |
| Ben Zillman | Senior Surveyor |
| Scot Townsend | Ranging |
| Dave Black | Ranging |
| Jens Tolsdorf | Survey |
| Janne Turunen | Survey |
| Jay Argent | Survey |
| Denis O'Sullivan | Survey |
| Haydn Kreicbergs | Survey |
| Ian Seeto | Survey |
| Geard Mackenzie | GPS Operator |
| Matt Skinner | GPS Operator |
| Dan Kool | GPS Operator |
| Tim Browne | GPS Operator |
| Trent Davies | Utility |
| Andrew Gleeson | Utility |

## 3.2 EQUIPMENT

The following equipment was used during the survey:

| | |
|---|---|
| **Ranging** | 2 Toyota Landcruiser Ute |
| | 2 Trimble NT300 GPS receivers |
| | 2 VHF Crew radio |
| | 2 UHF radio (Survey communications) |
| | 1 Toshiba Notebook computer |
| **Survey/Chaining** | 3 Toyota Landcruiser utes |
| | 1 Toyota Landcruiser Wagon |
| | 4 Trimble 4000 SSi GPS receiver |
| | 2 Trimble 4700 GPS receivers |
| | 2 TSC1 Survey controllers |
| | 3 TDC1 Survey controllers |
| | 5 Beech Base station radio/modem |
| | 6 Beech Portable radio/modems |
| | 1 Leica Total Station |
| | 2 VHF Crew radios |
| | 5 UHF radios |
| | 1 Desktop computer |
| | 2 Dell Laptop Computer |
| | 1 Canon S4500 printer |
| | Trimble Processing software |
| | GPSeismic Processing software |
| | Survey consumables |

# 4.0 LINE PREPARATION

Two ranging crews were deployed throughout the prospect. Each ranging crew had a Toyota landcruiser fitted with Trimble NT300 GPS/display unit and a handheld garmin GPS unit. The rangers used a combination of design coordinates and topographic maps to scout and bend lines to avoid obstacles and fit the lines to the surrounding terrain.

The lines were ranged and bent in a manner sensitive to landholder requirements and environmental considerations.

Line preparation and permitting was contracted to Exploration Field Services and supervised by Ray Willox. Five fencing crews and two slashers were used during the survey. Each of the fencing crews consisted of two persons. A fire tender attended each slasher.

Ray Willox also liaised with the survey and recording crews. He, and his personnel handled the permitting, keeping the landholders informed of the progress of the survey and when the line preparation and survey crews would be entering onto their land. Some problems were encountered with line relocations onto properties that had not been permitted or had failed to be covered by the original permitting.

# 5.0 SURVEYING METHODS

## 5.1 SURVEY DATUMS

GPS field survey data was collected in World Geodetic System 1984 (WGS84) datum. It was then down loaded into GPSeismic software (by Dynamic Survey Solutions) for conversion to the Australian datum. WGS84 coordinates were converted to the Geocentric Datum of Australia 1994 (GDA94) and output in Map Grid of Australia Zone 54 coordinates. Ellipsoidal heights were converted to the Australian Height Datum (AHD) using the OSU91A geoid separation model.

The following parameters define the World Geodetic System 1984 datum:

| | |
|---|---|
| **Datum** | World Geodetic System 1984 (WGS84) |
| **Ellipsoid** | WGS84 |
| **Semi-Major Axis** | 6 378 137.0 |
| **Inverse Flattening** | 298.257223563 |
| **Unit of Measure** | International Metre |

The following parameters define the Geocentric Datum of Australia 1994:

| | |
|---|---|
| **Datum** | Geocentric Datum of Australia 1994 (GDA94) |
| **Ellipsoid** | Geodetic Reference System 1980 (GRS80) |
| **Semi-Major Axis** | 6 378 137.0 |
| **Inverse Flattening** | 298.257222101 |
| **Unit of Measure** | International Metre |

For all intents and purposes GDA94 is the same as WGS84, so no transformations were applied.

The following parameters define the Map Grid of Australia 1994 - Zone 54:

| | |
|---|---|
| **Projection:** | Universal Transverse Mercator |
| **Latitude of origin:** | 0° |
| **Central Meridian (CM):** | 141° E |
| **Scale Factor at CM:** | 0.9996 |
| **False Easting:** | 500 000 |
| **False Northing:** | 10 000 000 |
| **Unit of Measure:** | International Metre |

## 5.2 SURVEY METHODS

The 'real time' kinematic (RTK), and the kinematic GPS surveying method was used during the surveying of the prospect.

The **'real time' kinematic (RTK)** method uses a radio and modem connected to a GPS receiver on a known base point. The base radio broadcasts raw GPS data measured at the base and the base position directly to a radio and modem connected to a roving GPS receiver. Thus the roving receiver can calculate it's own position to within a few centimetres, eliminating time-consuming post-processing. Position data in WGS 84 format was collected in Trimble TSC1 and TDC1 data collectors and downloaded into GPSeismic software where datum transformations and geoid separations were applied. The data was then edited and QC checked.

The **static** method involves setting up a receiver to log data on a known point then logging data on unknown points with a roving receiver for periods upwards of 15 minutes depending on the length of the baseline and satellite geometry. This enables the change in geometry of the satellite positions to be measured and by post-processing the data an accurate position can be determined. RTK base stations were surveyed using the static method for positioning.

**Conventional trigonometric levelling** was used to survey between GPS points through heavily timbered areas. A Leica TC1610 Total Station electronic theodolite was used for this.

The static method was used for establishing control and surveying new base positions. The survey crew used the RTK method for line chaining / surveying.

## 5.3 CHAINING METHODS

The chaining of the prospect was done using a combination of 2 methods.

The first method was RTK chaining. This involved placing and surveying the station in at the same time. The RTK chaining crews contained two people to minimize back strain on the surveyors/GPS operators while removing the need to lean out of the vehicle in order to place a peg in the ground. Having a two person RTK chaining crew helps with opening gates and the drawing of line trace diagrams.

The second method used was a two person conventional chaining crew, this involves using a 100m (5 stations) plastic coated wire rope. These points were surveyed using conventional trigonometric heighting.

## 5.4 SURVEY CONTROL

The datum for the Cobden 2D survey was trig station Cooriejong. The Geocentric Datum of Australia 1994 coordinates and AHD height for these sites are:

| Station | East | North | Elevation | Remarks |
|---|---|---|---|---|
| Cooriejong | 678466.098 | 5735676.611 | 151.647 | PSM |

Ties to old Permanent Markers are listed below:

| Station | Line | Delta E. | Delta N. | Delta Ht. |
|---|---|---|---|---|
| PM418+8 | B92-08 | 2.6 | -0.6 | 0.4 |
| PM492 +17 | B92-08 | 2.6 | -0.6 | 0.4 |
| PM565+8 | B92-08 | 2.7 | -0.4 | 0.2 |
| PM356+20 | TME85-4 | -1.4 | 5.0 | 0.5 |
| PM393+22 | TME85-4 | -0.2 | 1.9 | 0.4 |

## 5.5 DATA PROCESSING AND QUALITY CONTROL

Survey data collected in the field was processed in different ways depending on which survey method was used.

Static points were processed using Trimble Geomatics Office software. This produced data in WGS84 format. This data then had the geoid separation applied using the OSU91A model. The data was then set to GPSeismic for editing and QC checks.

For 'real time' kinematic (RTK) data, as the field data was collected in WGS84 format, it was downloaded into GPSeismic software where datum transformations and geoid separations were applied to obtain Map Grid of Australia 1994 (MGA94) Zone 54 coordinates and AHD heights. The data was then exported to a text file for use by the IMS (Information Management System) department.

The enhanced QC capabilities of GPSeismic allow for many checks, some of which are listed below:

- The GPS base coordinate and elevation is checked against the correct data.
- Checks on PDOP, HDOP and VDOP for each point recorded.
- Checks on initialisations and unit variance.
- Compute delta x, y and z for 'check' shots onto other stations.

- Check for duplicate stations and gaps.
- Checks for stations out of specifications.
- Checks on GPS status at time of recording.
- Check the measured distance between stations
- Check elevations at intersection between lines

## 5.6 PERMANENT MARKERS

The surveyors placed 3 Permanent Markers at appropriate points distributed over the prospect. Where possible the PM was placed close to fences to avoid disturbance by livestock or agricultural activities. These markers consist of a steel fencing post with steel dumpy at the base and an aluminium tag, with the line name, station number and any comments inscribed upon it.

A listing of Permanent Marker information is included as Appendix A of this report.

## 5.7 TRACE DIAGRAMS

The chaining crew prepared line trace sketches showing details of Permanent Markers, line intersections, crew access, hazards and any other features of importance to the recording crew. The final draft of these was passed on to the recording crew for copying and distribution. A prospect map was drafted with roads, tracks, pipelines, fences, gates and other relevant information by the Senior Surveyor and passed onto the recording crew.

# 6.0 HEALTH, SAFETY AND ENVIRONMENT

The prospect was located on the southern coastline in Victoria, between the townships of Timboon and Cobden. The majority of the survey was located in intense dairy farmland with small areas in native vegetation.

The Curdies River and its tributes ran through centre of the prospect. The topography around the river systems consisted of steep valleys with densely timbered sections. The remainder of the prospect was rolling hill vegetated predominately with grasslands with occasional clumps of Cyprus pines that acted as windbreaks and shade.

Line preparation was carried out in accordance with the environmental code of practice, as set out by Santos.

As a result of a high emphasis being placed on, safety by WesternGeco, there were no lost time incidents during the prospect. WesternGeco safety policies were adhered to and regular safety meetings were held to discuss relevant safety and environmental matters. Daily "toolbox" meetings were held to discuss current issues concerning the prospect and operations.

All WesternGeco vehicles were fitted with fire extinguishers, Driveright monitors and first aid kits. In addition, some WesternGeco personnel hold Senior First Aid certificates. The Driveright vehicle monitoring devices assist in controlling vehicle speeds and driver behaviour.

All WesternGeco personnel carried out their duties in an environmentally aware manner. All rubbish generated in the field was returned to camp for proper disposal.

# 7.0 CONCLUSION

The line preparation of the Cobden 2D was conducted in an efficient and environmentally sensitive manner. All client and company environmental constraints and guidelines were comprehensively adhered to for the full duration of the survey. Problems were encountered with locating lines within the original specifications as this lead to an excessive amount of skipped VPs. The tolerances for the line positioning were reviewed and more bending was allowed.

The surveying of the Cobden 2D seismic survey was a slow and tedious task. The numerous fences, trees and steep verdant hills prevented the chaining crews from establishing a rhythm and reaching the expected production. Towards the completion of the prospect the survey crews caught and overtook the fencing crews. The lack of gates was a great hindrance as a great deal of time was lost finding access.

The method used for ranging the lines was very efficient. The number of skipped vibe points, because of houses and other buildings, the lines were bent more vigorously after the excessive numbers of skips was reviewed.

On more than one occasion it was discovered that properties were not permitted and the ranging crews entered properties that had been overlooked by the permitting staff. This caused last minute changes to the location of the lines or hurried permitting of the property.

Un-seasonally wet weather caused changes in the ranging order with some areas becoming too wet to work on. The wet weather had the one advantage of reducing fire ban days to nil. Two days were lost to wet weather. Lines dropped from the program, that had been pegged and ranged but were not used by recording, had little effect on the survey crew's already depleted lead.

The steep terrain had an undesirable affect on the range of the GPS base stations. Although eight base stations were originally established, an extra two stations had to be established to achieve total coverage. Extra time was lost moving the bases at short notice as the crews entered deep valleys and unexpectedly lost radio link with the GPS base. At the completion of the prospect the surveyors lead had been reduced to approximately three days.

In one incident attributed to the survey department, a boundary gate was not shut properly, and the stock escaped on to the road. There was one survey crew working in the area where this occurred and consequently they were held responsible.

All safety guidelines were complied with, and as a result no accidents or lost time injuries occurred.

# APPENDIX A

## LIST OF PERMANENT MARKERS

Permanent Markers established during the Cobden 2D survey.

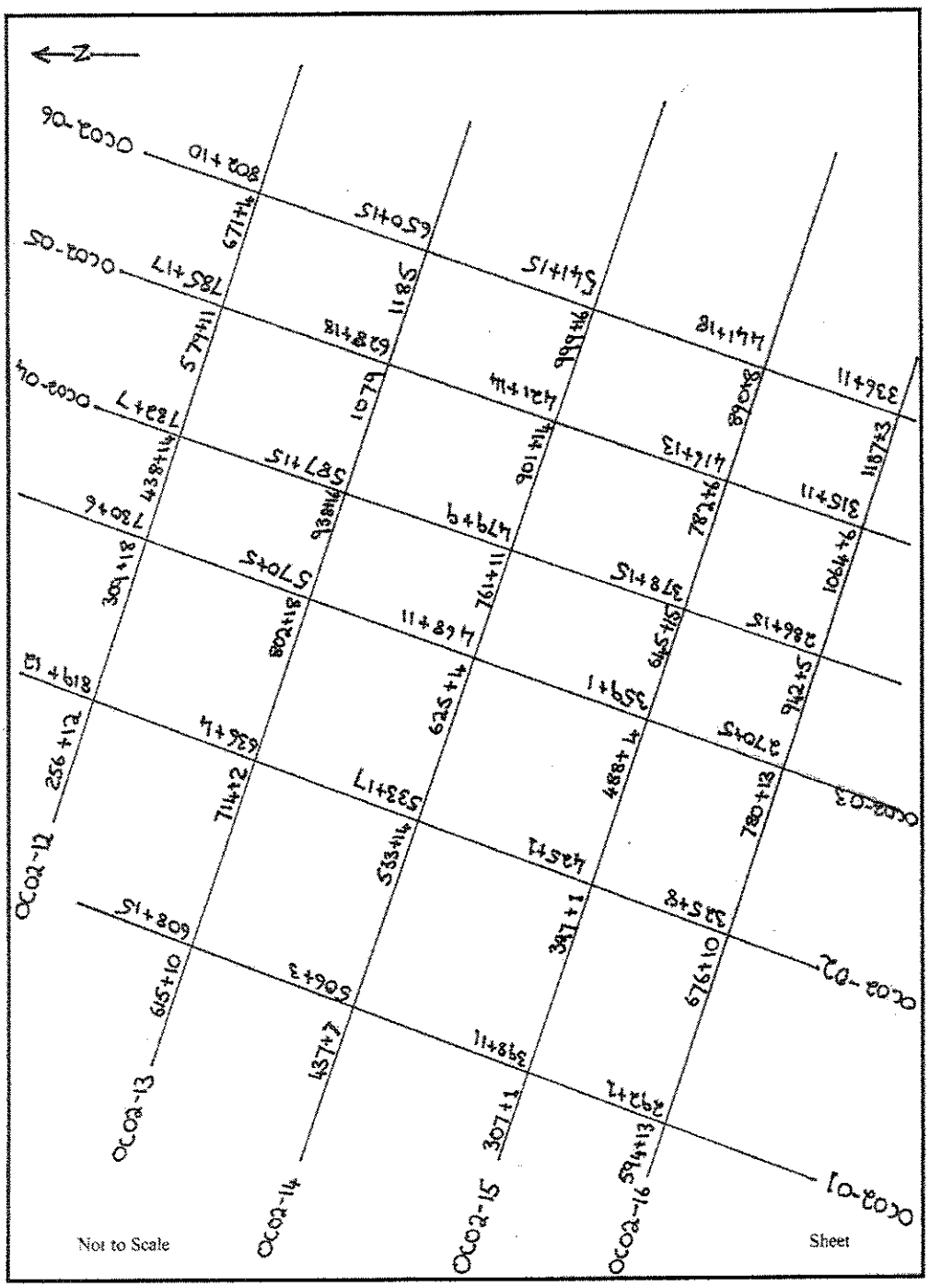
| Station | Easting | Northing | Elev. | Line |
|---|---|---|---|---|
| PM 328+9 | 686 836.98 | 5 733 626.77 | 163.79 | OC02-10 |
| PM 903+1 | 693 421.01 | 5 743 035.42 | 162.78 | OC02-10 |
| PM 270+8 | 669 736.25 | 5 748 364.68 | 128.24 | OC02-15 |

# APPENDIX B

## APPENDIX B
### Intersection Diagram

Area : Cobden 2D

Date : Jan/Feb/March 2002



## APPENDIX B

**Intersection Diagram**

Area : Cobden 2D

Date : Jan/Feb/March 2002