

MICROFILMED

NOTES ON
THE CORRECTION AND UNIFICATION OF
GRAVITY SURVEYS
BY
AMOCO IN THE ZEEHAN AREA

by D.E. Leaman
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Up to 1981 Amoco installed a set of grids in the Zeehan area. A range of surveys were undertaken, as detailed in the relevant reports for EL 4/78. A complete gravity coverage was observed. Lines were pegged and levelled and high precision results could have been expected. Sadly this was not the case and this report explains why.

I was engaged by the Mines Department to review the data supplied as part of the licence conditions, attempt full correction of it and translate it to a normalised format such that it could be included in the TASGRAV data base (refer Richardson and Leaman, 1987). In this way the data becomes of benefit to future explorers in the region - not simply to those reworking these particular grids.

No terrain corrections were attempted or reported by Amoco and yet there is a range of 0.10 to 2.50 mGal in this adjustment. Much of this effect was probably disguised in the compound high order and non geological trend surfaces used to generate residuals. The effect of the absence of terrain correction would have been variable; systematic in some grids, irregular in others. This problem, quite separate from the mechanical observational and processing issues noted below was evident to me in mid 1983 when I was asked to comment on a farm-in proposal on the Maxim grid. I was disturbed by that brief sighting of the data and some of the presumptions made. Amoco were advised but took no action to remedy the flaws.

This report is not the place to attempt re-interpretation or discuss regional separations.

However, several of the problems and concerns evident in this data set occur all too frequently. Most should not and all belie poor supervision or specification and some ignorance of what constitutes good gravity technique and data.

These notes were prepared as an outline of the strengths and weaknesses of the data set as included in TASGRAV. In addition the notes provide subsequent workers an appreciation of what was done by Amoco, what has been done by me, and what should have been done in the first instance. Imperfections and problems persist but it is believed that most have been recognised and listed. This listing should allow realistic application of this data. There is no doubt that the results are more than compatible with the more regional elements of the TASGRAV data base but the precision of Bouguer results within the Amoco surveys, although variable, is generally better than 0.08 mGal.

Any reader of the Amoco reports (or joint venturers on EL 4/78) should be aware of the issues described. The application of correct height and gravity base datum and terrain corrections modifies many interpretive concepts directly - especially regional trend separations.

1. Fieldwork appears to have been competently undertaken by Solo Geophysics and Wongela Geophysics. Elements of the various surveys were tied to absolute datum, ties repeated and good local base stations established. Within each grid adequate loops were observed to remove drift. Unfortunately, as will emerge in other comments, the use of two contractors coupled with poor or non-existent supervision has led to an array of poor practices and deficiencies overall. Thus individual units of survey are reliable but were not organised for accurate interconnection, correlation or correction to normalised datum. I believe this has greatly limited its original use by Amoco since structural components in any anomalies could not be appraised.
2. Field sheets were taken from the observers and processed in a fragmentary, amateurish and quite unsatisfactory manner. Much of this work appears to have been done by Amoco's own staff and, as seems to occur frequently, lack of experience of the needs and issues related to gravity data has degraded potentially excellent observations. The results submitted to the Mines Department - as plotted by individual grids - may be reasonably sound (by no means certain, see below) but cannot be correlated between grids or to surveys on state datum. Various inappropriate assumptions were also made concerning suitable densities or trend removal but I do not propose to discuss these here other than to comment that much of the curious trend orientations noted are partly the result of omission of the terrain correction in some grids. Some of these presumptions can be recognised in the explanatory notes provided by Amoco (see reproductions). Time and incomplete records inevitably blur recollection.
3. Base station and tie station values derived from the data set are given in the table. The state tie is ZEEHAN 9903 (Richardson, 1981). Note that only the core grid or isolated grids were tied to absolute datum.

Zeehan 9903	Zeehan-Queenstown-Burnie rd jn.	980298.24
Swansea grid	1400,1200	980306.16
Rose Valley, Baura		980344.32
Pyramid		980322.96
Nubeena	1500,2000	980304.87
Sassafras	2000,1500 (see notes)	980299.57
Amoco house verandah	Zeehan	980307.88
Grieves de facto base (DEL)	1500,4900	980332.48

The terrain corrections quoted must be regarded as minima in all cases due to the absence of records concerning the local surface features about the station (within 25 m). In some cases the deviation could exceed 0.25 mGal. All calculations have been based on 1:25000 topographic maps using the Hammer method to zone M (22 km) using the grid

recovery used. The grid recovery, or its original description, also leave something to be desired in some instances. The positional errors probably do not exceed 50 m in any part of the coverage but this may on occasion lead to sizeable deviation in terrain correction estimates on steep slopes.

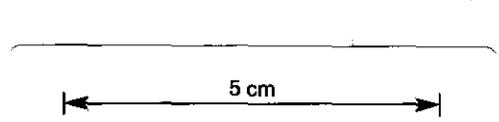
Data within each grid set has been drift corrected, elevation adjusted to AHD and linked by the most precise route permitted by the data to state gravity datum. No independent tide correction was made since loop periods were short and the tidal effect is largely removed within the drift correction.

4. The Nubeena grid. The Amoco base (2000E, 1500N) was relocated and surveyed by Mines Department survey for use as an ultimate tie. AMG value 362121, 5358597.5, AHD 216.3 m. Amoco quote 228.2 m for this elevation. All elevations have been adjusted to the resurveyed figure. Although some conflict appears to exist between relocated pegs and the quoted Amoco magnetic orientations the most consistent solution is Amoco's and this has been retained. Gravity base tied direct. Original data included some in-accurate drift corrections.
5. The Austral grid. This grid illustrates the problems of loose grid ties and fragmental reductions. Amoco quote 1000,1500 as being equivalent to 2000,1500 of the Nubeena grid. Within this survey loop control was poor and drift corrections were not simple. A key link to the Nubeena grid, which could be tied to state datum, fell within a loop and not as a properly observed end point. This is inexcusable given its status with respect to this and other grids and reflects bad supervision and specification. Some stations were not on any drift controlled loop. Looping and station grouping was also rather disorganised. Internally the grid is reasonably satisfactory but its linking to absolute values is poor.
6. The Maxim grid. This is an extension of the Austral grid, rotated to the west. Its fundamental tie point is also an intra loop station (again bad practice). Two meters were used and there is no means of checking quoted scale constants or meter numbers. However, the constant for half the grid is quoted as 1.0428. This is highly suspect since it would imply that meter #35 was used at the very top of its range. Other site usage suggests that 3000 has been subtracted from all values for convenience. The probable constant is thus 1.0464 (mid range as to be expected). Ties between meter usage are also few and far between. Differences may exceed 0.03 mGal as suggested by stations 464 and 531 (my numbering). Coordinate system linkages are 1350, 2000 Austral = 1362, 2032 Maxim (my station 396) inferred as 362278.9, 5359187.1 AMG.

7. The Oceana grid. This is also related to the Nubeena grid and similar comments apply. Coordinates 710, 250 Austral = 1400, 3500 Oceana (inferred as 362276, 5357323.7 AMG). Gravity linked by station 219 in my numbering (as in TASGRAV). This link could have been first rate if Austral had been properly tied to Nubeena.
8. The Pyramid grid. This is an extension of the Oceana grid. The elevation differential between Mines Department ties and Amoco stated values is -11.6 m. The reason for the 0.3 m offset within the grid network is not explained but does suggest a surveying error in the Amoco links presented. A separate base station was observed but it was not used as part of the grid! Instead, the survey was linked to point 1400, 2700 of the Oceana grid. This needlessly degrades the overall precision of the entire integration. The Pyramid grid is in two parts which have been standardised to the Oceana grid (by Amoco). This presentation was used for transfer to AMG after checking with Mines Department rechecks and verification of map contour levels and patterns. Two meters were used on this grid but once again the links depend on intra loop stations!
9. The Sassafras grid. This is an isolated grid north east of Zeehan. Mines Department recovery of the grid was uncertain due to the confusion between "pegs" 2000,1500 and 1500,2000. However, the former is a nominal position, as shown in the Figure, which provides a proper gravity base link. This survey grid is of good quality. The grid core point is at 1500,2000. The grid was reconstructed from the few pegs picked up and levelled by the Mines Department by noting elevation differences and separations given the approximate orientation of the base line. The possible maximum error in recovery is about 10 m. Elevations have been transferred from an arbitrary reference to AHD in the process. The elevation of the Amoco gravity base (table) is 184.8 m while the grid base (1500,2000) is at 186.1 m. The appropriate scale constant should be 1.00925, not 1.00928. Some problems were noted at line ends with respect to elevations and terrain corrections. The original Amoco maps show a negative gradient along the west side of the grid. This is due to absence of terrain correction. However, the magnetic positioning of the grid is imprecise and line ends may be imperfectly corrected. The results, as included in TASGRAV, are far better than no correction at all however.
10. The Rose Valley grid. Many of the comments here also apply to the Baura, Southern, Grieves and Myrtle grids. A Figure showing the relationship is included. This grouping of grids with various orientations was unified in terms of the Grieves grid renumbered. The "true" values quoted by Amoco have been transferred to AMG based on a partial Mines Department resurvey near Rose

005

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SASSAFRAS GRID
Scale 1:5000

Surveyor: G. Renn

-30°T

Peg 0182.3 = (1550, 2200)

Peg 0187.1 (= 1500, 2150)

192.0 @ Peg (= 1600, 2000)

BASE PEG + 186.1
E. 364,727.0
N. 5,364,272.4
A.H.D. 184.8

reference
 1500, 2000
 (364742,
 5364277)

"base point"
 "2000, 1500"
 Amoco nominal height used = 200m

1500 E
baseline

5,364,000 m.N.

360,000 m.E.

364,000 m.E.

365,000 m.E.

959006

Valley. This process revealed some inconsistencies in some Amoco plots (e.g. Fig 3 for EL 4/73 of Badger River grids, and plan A78-608/m83-1968) which imply a potential easting offset of 100 m near the link between the Southern and Grieves grids. Since the Grieves grid has been taken as the regional reference this was potentially serious. Checks with known points, road intersections and topographic patterns has enabled recovery within 50 m at the limits of the network. This has implications only for the terrain corrections at the end of lines within the Grieves and Myrtle grids where slopes rise steeply from flat plains. All elevations were AHD but ties between grids indicates a general reproducibility of 3 to 5 cm with occasional deviations of 20 cm.

The grid combine reflects a topsy style growth and this was coupled with failure to rigorously refer each unit to the same, or properly linked, gravity base system.

All gravity values have been referred to Amoco gravity base (table). The Rose Valley grid is equivalent in quality to any of the isolated grids or Nubeena.

11. The Baura grid. This grid was directly linked to the Rose Valley grid and used the same tie point. This was proper and represents one of the few instances of sound practice. Some terrain corrections may be suspect at line ends due to positional uncertainty. Two meters were used and properly base referred (see guidelines at end of this report).
12. The Southern grid. The gravity base point used was 1500,4900 on the re-organised Grieves grid system. It was not separately related to the primary tie network. Links to the Baura grid occur within loops and several overlaps were averaged in order to assign a value for the Grieves base. Variations in level of 5 to 50 cm were noted in the process and only stations with differences less than 5 cm in quoted height were used for assessment of the gravity differences.
Staff handling reduction also misread the meter observations and applied a constant of 1.0428, not 1.0464. A secondary base (60850,46500) was used but this was not directly referred to the principal tie (very bad practice) and was linked in only one loop.
13. The Grieves grid. The gravity base was obtained as defined above. Again positions were marginal at the limits of each line leading to loss of reliability in terrain corrections on the slopes.
14. The Myrtle grid. The Grieves base is tied directly to only half the survey. The remainder is tied by loop overlaps using a secondary base at 60500,50200. Only one definite link was observed with a precision of 0.02 mGal.
In the Southern-Grieves-Myrtle grids the absence of recognisable base points and absolute positional recovery

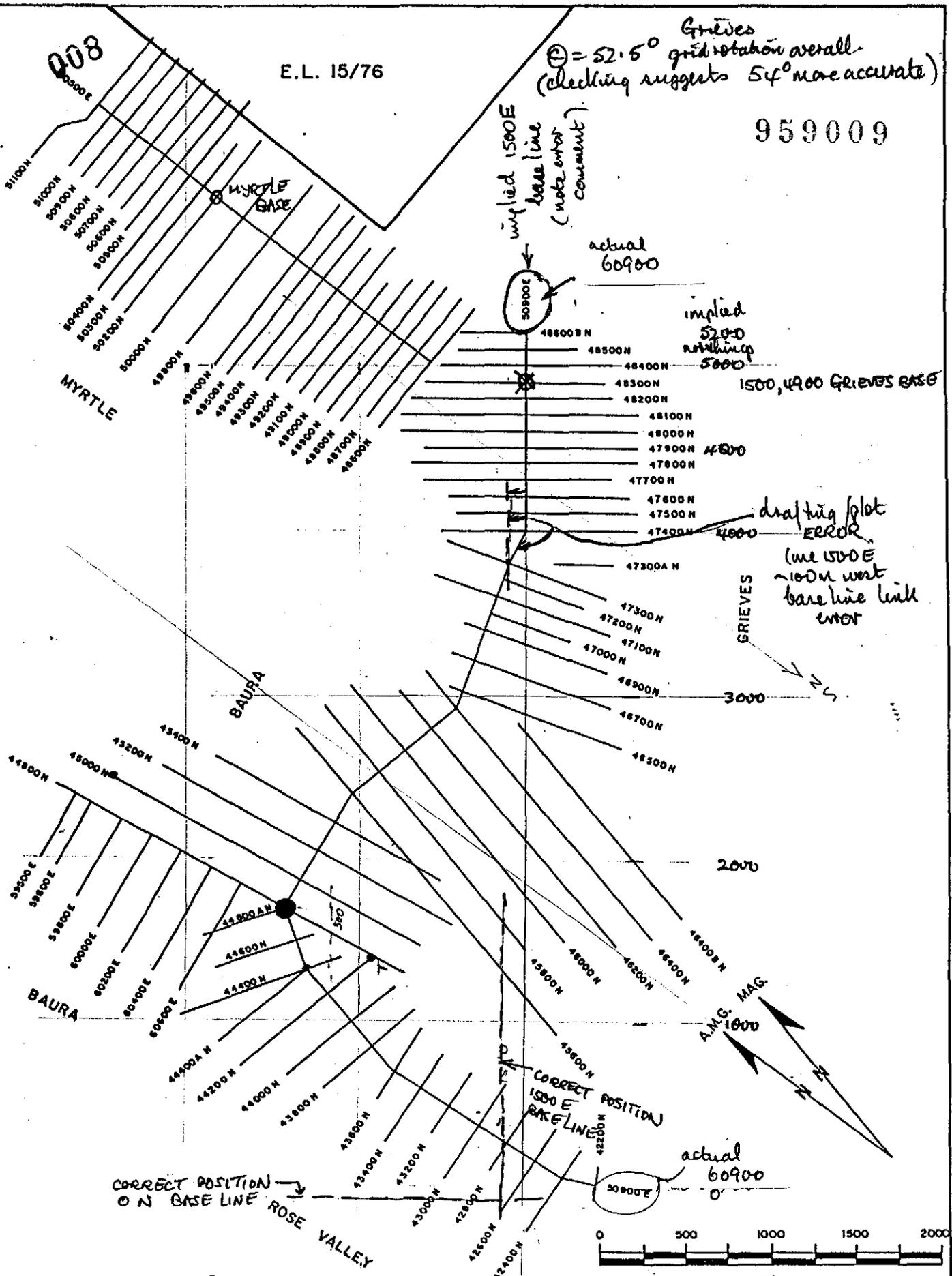
limits the precision of terrain corrections on the steep slopes at the line ends. This is a situation in which a general compass layout should be picked up and confirmed at its extremities at the time of survey. Loss of pegs and labels with time inevitably reduces the chances of reliable later recovery.

15. The Swansea grid. This, being isolated, was absolutely tied. The nominal Amoco assigned elevation of 300 m at the base point (1400, 1200) has been revised to 238 m following check survey.

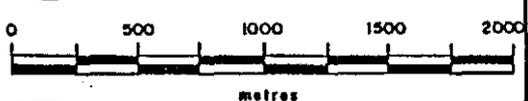
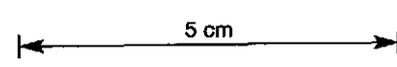
E.L. 15/76

Grievés
① = 52.5° grid rotation overall -
(checking suggests 54° more accurate)

959009



ROSE VALLEY BASE
 60900, 44800 = 361261, 5309086 AMG
 ON GRIEVÉS GRID NOTATION = 215, 1724



[EZ]	
PROJECT: E.L. 4/73 ZEEHAN	
BADGER RIVER GRIDS	
AS AT 30-5-'85	
Compiled: I. MAT. Date: 2-7-'85	PLAN NO
Drawn: R.J.R. Scale:	Fig. 3

CONCLUSIONS

Amoco's line results can be accepted as reasonably valid, with the exception of most line ends, for the Sassafras, and Rose Valley-Myrtle grids. In the other grids terrain corrections are much more variable and less systematic. The internal problems within the surveys does mean that great care must be exercised when referring lines of one grid to lines of another. These problems have now been largely overcome.

Within the unified survey set precision varies from grid to grid due to the poor techniques applied. This comment refers to values on state datum, and not to separate grid surveys. It should be noted that Amoco's less than ideal technique would perhaps have been adequate on a single grid basis if observations had been terrain corrected. However, Amoco could not, as TASGRAV data now can not, precisely recover grid to grid relationships. This means that even the originator of the survey did not get its optimum benefit. The users of TASGRAV will receive the best possible integration - and one which is terrain corrected.

The problems evident in data handling and processing of this data are almost universal in those cases where field observations are transferred from contractors to in-house staff who usually lack experience in gravity data treatment. An accurate, unified reduction could have been provided from the original sheets provided some extra links or bases were observed at the time. The reduction process actually used was clumsy but appeared sophisticated. It was unnecessarily complex and tended to obscure the critical elements of the data set.

The rigour of the treatments and the nature of the comments made indicates what is required of gravity data if they are to be used absolutely or for reliable future reference. See also guidelines below. Although Amoco doubtless received results appropriate for its level of treatment and objectives (?) (with the exception of some misleading "regional" effects and probably weakened interpretation) the techniques employed certainly limited use of the data, introduced unnecessary weakness and made the data useless for future reference. This analysis has recovered the data set for future use by other explorers but at a cost. There is some loss in precision, where the grids were interlinked rather than base linked, and some risk of random error at line ends due to location error for the terrain corrections. The former is probably of the order of 0.05 mGal while the latter may locally exceed 0.20 mGal. These degraded final results, while not significantly diminishing the usefulness of the data set or precluding its insertion in TASGRAV, need not have occurred. That the problems related to survey links, multiple meters and observers did occur is evidence of bad supervision and inadequate understanding of the reduction process. This implies poor specification as well.

Users of this data must be aware of precision loss on line ends wherever steep slopes or abrupt slope changes are involved. This is probably not significant for most practical purposes given the present coverage and the restriction of the problem to extremities.

GUIDELINES FOR GOOD GRAVITY SURVEYS

These suggestions are based on long experience and the degradations suffered by this data, and include

1. Ensure short period (approx 2 hr) looping on conveniently located points on stable ground.
2. Link the key loop points to a primary station within or near the grid. This linking should be direct with no loop stations en-route and must be repeated. Alternatively key loop points can be linked to each other with only some linked to a primary point.
3. The primary point should be linked to a point on the State or National Gravity grid. At least three return loops should be observed (>6 observations) to establish the interval (more if the distance to a state tie exceeds a travel time of half an hour).
4. Such primary points can be raised to datum status and used to tie other surveys in the area if they are conveniently located, unambiguously defined and on stable, level ground - and the interval to the state network firmly established.
5. Note that no intra loop station can or should be used for links at any level between surveys. Loop bases or, preferably, primary points must be used.
6. If the local base point is well located it can be used as base for a set of local grids and linked (as in 1 and 2 above) each day or at the start of each new grid to set up an in-grid reference point. At no stage should the gravity observations grow (or be linked) in a topsy-like manner.
7. Where it is necessary to change meters, meter scales, operators, or link segments with differing meters or constants the principles in 1, 2, 3 must be applied. Each new operator should find the primary points and use them and any meter change must be referred to such points - NEVER to intra loop stations where status is already suspect.
8. No interpretive factors should be inserted during the reduction phase. All data should be reduced at a single density and all anomaly-density implications reviewed separately as part of an interpretation. 2.67 t/cu m is a useful, practical and realistic reference density for presentation of normalised data which in no way precludes variation review at a later stage.

9. Field observations should include
 - line/peg/station number
 - time and meter reading
 - date, weather, meter number and scale value
 - nature of ground or meter problems
 - height of meter base plate above ground level
 - description of local topography about station where features which may affect the immediate terrain correction could not reasonably be deduced from the best base map available. Notes of conditions up to 25 m away may be necessary.
10. Every effort should be made to select sites which are level for up to 5 m (at least) about the station. Not always possible - so note details. Level the actual site observed by the meter after the survey. Naturally there may be variations on this theme if the grid has already been used for other purposes.
11. Reduction should follow drift correction (which on short loops with a good meter will be dominated by the tide correction). Reports should note the ellipsoid used for reduction and the simple, direct data input system used by the Bureau of Mineral Resources and the Mines Department is recommended. Supplied data should take that standard form. See Richardson (1981b).
12. The limits of the grid, at least, should be check surveyed and referred to an unambiguous grid such as AMG. This removes much of the positional uncertainty on steep slopes - especially where the grid system is complex and irregular or dependent on general compass locations.

REFERENCES

- Richardson, R.G., 1981. West Coast Gravity Tie Stations. Unpub. Rept. Dep. Mines Tasm, 1981/7
- Richardson, R.G., 1981b. FORTRAN programs for performing gravity reduction. Unpub. Rept. Dep. Mines Tasm, 1981/34
- Richardson, R.G., and Leaman, D.E., 1987. TASGRAV - The Tasmanian Gravity Data base. Unpub. Rept. Dep. Mines Tasm, 1987/02

013

959014

Report submitted on behalf of
Leaman Geophysics
by

D. Leaman

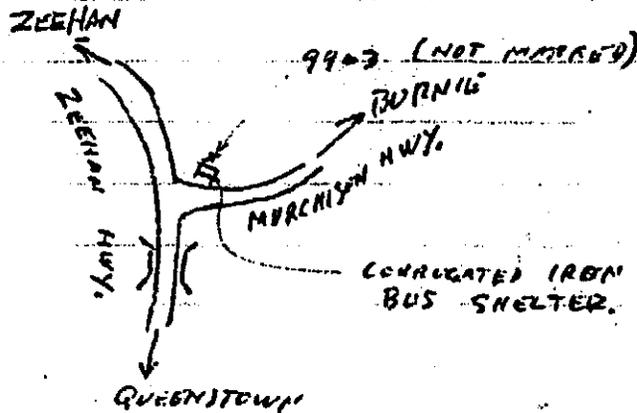
Dr. D.E. Leaman, B.Sc., Ph.D
M.Aus.I.M.M., M.M.I.C.A

Jan 27, 1987

SOME NOTES SUPPLIED BY AMOCO

GRAVITY BASE DETAILS

NATIONAL GRID Survey tied via Station 9903
 O.G. 980298.24 mg.



GRIEVE'S GRID. Station 4900N/1500E

Next to peg. Base plate on ground

MYATLE GRID Station 70200N/60500E

Next to peg. Base plate in survey legs.

SOUTHERN GRID Station 46500N/60850E

Next to peg at side of road. Base plate on ground.

BENCH MARK Land and Survey SPM 6373

West of Strathgovan Line Road, south of line 45000N on Southern Grid. Near marks. Base plate on ground.

Observed Gravity and Elevations of above stations can be obtained from data sheets after data reduction.

from Amoco.

Note: assumption that obs g and elevation deducible from reductions. Not so. Only false, grid referenced values deducible. Accurate state datum values for either measurements depend on ties and recovery; possible only for elevations. Failure to organise good intra survey gravity ties leads to loss in overall precision though each unit retains internal precision.

RL

Tas Gravity Data

959016

Bob,

For each grid ~~at~~ find the following data

1. Raw Data

Easting, Northing, Day, Time, Reading, Height above ground, Elevation

2. Data following non density dependent corrections

Easting, Northing, True Easting, True Northing, Corrections etc.

Note that the "True" coordinates are resolved back to the original grid (either Oceana, Austral or Grievos) ^{or Maxim (with Austral)}

3. Bouguer gravity for 2.6 gm/cc

The grids are tied together as follows

Maxim (ML Austral)

by itself although it
does butt onto the Austral grid

Austral

tied to

Austral (of course)

Nubeena

same grid as

Austral

Oceana

Oceana

Pyramed

tied to

Oceana

(ie "True" coordinates are Oceana coordinates)

All the six above have been tied together in values, see the comments at the head of each data set for what corresponds to what. Note that each grid has its own gravity datum as 50 milligal and to get them to match it will be necessary to add or subtract a constant value over each grid. Does this make sense? If not give me a call.

the Myrtle

Grievess

Southern

Baura

Rose Valley

} All tied to Grievess
in ~~coordinate~~ "True Coordinates"
Gravity origins different, but they
contain common points.

Elevations of grids which are tied together are to a common origin but I'm not sure whether they are tied to the AHD system.

Give me a call when you have the data so I can explain it better.

These notes from Amoco, designed to assist recovery of the data, illustrate many of the problems. They also show that the best of good will cannot overcome memory loss or poor/limited notes from the time of survey.

Doubts on levels have been removed by picking up enough pegs to establish each grid (grid combine) and grid positions have been determined in the same way.

The elevations quoted in TASSRAV are generally accurate AHD.

Positions are somewhat orientation dependent due to location of few pegs and acceptance (largely) of Amoco magnetic orientations. As noted in the text this may lead to problems with some end of line terrain corrections.

Coordinates need to be assigned when the survey is new and fresh in all minds - i.e., when the location of the world is not in doubt.

Gravity ties are the poor relation. Perhaps fine for an individual grid; not so for the entire coverage.

No terrain corrections

Invalid density in many cases.

D.