

LEAMAN GEOPHYSICS

Registered office:
3 MALUKA STREET, BELLERVE, TAS. 7018
All correspondence to:
GPO BOX 320, HOBART, TAS. 7001
Telephone: (002) 441233
Fax: (002) 44 6674

ASSESSMENT OF GRAVITY SURVEY, CITY OF LAUNCESTON for LAUNCESTON CITY CORPORATION SEISMIC ZONATION STUDY

By
Dr D. E. Leaman
September 1994

SUMMARY

A detailed gravity survey of the central portion of the city of Launceston has demonstrated the existence of some narrow and deep ancient valley systems filled with relatively unconsolidated materials.

The survey, and its interpretation, indicates the general form, thickness and distribution of the vibration and stability sensitive materials within the region and greatly adds to the perspective currently supplied by surface geological mapping and limited direct sampling and drilling. No previously applied method has provided as much information about the general subsurface conditions; all previous information has merely constrained limits in some areas.

The survey reveals the presence of at least two deep channels filled with variably consolidated materials and shows that an irregular veneer occurs patchily across hills in many areas. One of these deep channels underlies half of the central business district. The soft sedimentary rocks have been deposited on an old eroded landscape which has been formed by block faulting. Parts of this ancient landscape have now been exhumed and a range of relationships between the old and modern landscapes and surfaces, and the materials which have blanketed the region, are now exposed.

The most anomalous zone, in terms of structural control of these deposits, occurs in the South Launceston–Sandhill area. In this region there is clear evidence for cross structuring and basin dilation and this region is likely to be sensitive to any seismic activity — quite apart from any problems generated within the materials themselves.

This situation may be contrasted with the Invermay–Mowbray region where recent alluvial deposits and fills coat solid basement at very shallow depth.

The information provided by the survey will allow focussed location of seismic sensors in order to properly monitor variations in seismic responses. The information provided by this survey may also be used to guide foundation and design rule studies in the Launceston area. The geological patterns observed could not have been reliably predicted using any pre-existing information.

The work undertaken may be considered the minimum required for assessment of this complex area and there are many areas, now shown to be critically located, which are inadequately assessed. These include the Mayfield–Alanvale area, the Elphin–Newstead–St Leonards axis adjacent to the North Esk River and, most critically, the regions south of Punchbowl and west of Kings Meadows. It is strongly recommended that this survey be extended into these areas.

INTRODUCTION

This report describes a detailed gravity survey of the central portion of the City of Launceston and discusses the possible implications of the observations for geological and engineering appraisal of the area. Some outlying suburbs have been partially covered by the survey.

The survey was undertaken in support of the seismic zonation study planned for later in 1994. This will be completed by the Australian Geological Survey Organisation. Given limitations on budgets, time and equipment available it is important that the seismic sensors for that study be located in representative as well as critical or sensitive locations. Sites sampled should present an array of conditions; including various proportions of covering materials on bedrock, bedrock, near major fault zones, over axes of thick sedimentation and in areas of natural or other fills. The fundamental problem is how to define this range of sites and ensure that a proper assessment is made. No random selection is likely to achieve these goals (as hindsight proves here — see below).

Normal geological maps cannot provide the necessary information since these merely indicate surface conditions and, without some drilling or comparable control, may only suggest areal limits on the materials. Unfortunately drilling control is both expensive and limited in coverage.

Geophysical methods offer a relatively rapid and economic means of assessing substantial areas provided the information sought is associated with a physical contrast and some subsurface control is available somewhere in the area.

The principal bedrock of the region is Jurassic dolerite. This rock is hard, fractured, dense and elastic. It may also be variably weathered but its presence normally assures better than satisfactory foundation conditions and limited seismic risk.

The dolerite of the Launceston area is commonly covered by semi-consolidated materials which include clays, sands, conglomerates, silts and fill. Most of it is natural and reflects the geological history of the area. These materials are soft, often compressible, water saturated, non magnetic, plastic and of low density. And it is these deposits which must be defined.

Clear physical contrasts exist; either in terms of strength, water content, electrical conductivity, magnetic, density or acoustic properties and a range of geophysical methods could be applied. Some, however, depend on line traverse techniques and require undisturbed background settings. Thus electrical methods, which are less direct and more expensive than gravity or magnetic methods, are difficult to use in an urban environment with many stray electrical fields. Similarly, the cheap and rapid magnetic method faces problems due to the occurrence of non-geological ferrous objects. Seismic methods using the acoustic contrasts could be employed but these are slow, costly and far from easy to undertake in an active urban environment. Adequate coverage of an area the size of the city of Launceston might take months using electrical or seismic methods in any event. Only one method can be employed in a built up area which is both sensitive to the material contrast involved and insensitive to urban activity, and which can be undertaken without any environmental problems. This is the gravity method based on the density contrasts observed.

A gravity survey was recommended on the basis of these reasons. Such a survey can cover a large area in a short time but does require detailed levelling information if the results are to be detailed and reliable. All corrections necessary to convert meter observations of the Earth's gravity field can be defined in terms of position and location in the landscape.

The survey was planned and undertaken by Dr R. G. Richardson of Mineral Resources Tasmania using Sodin meter S183 with a scale constant of 0.1014. Observations have been tied to state datum at Punchbowl (station 9451.9901; observed gravity 980 288.04 mGal). Basic data reductions and plots were provided by Mineral Resources Tasmania with terrain corrections, compilations and interpretation by Leaman Geophysics.

STATEMENT OF PROBLEM

Low density sands and clays of Tertiary, and perhaps Cretaceous, age fill some ancient valley systems and coat the hills around the Launceston region. Few estimates of the thickness of these deposits are available but many slopes draped with these materials are notoriously unstable.

Younger sediments, alluvials — including silts, gravels and fills, are common in the valley floors and marshy areas near sea level. These materials may have negligible strength and be thixotropic. Vibration may amplify any instability or weakness.

Within the Launceston area these deposits overlie Jurassic dolerite; a massive crystalline rock which may show patchy and occasionally deep weathering to clays. It is often difficult to separate a normal weathering profile on dolerite from Tertiary deposits which may have a very different profile in depth. Part of the problem is due to the fact that the Tertiary deposits have been partially derived from ancient weathering and transport of weathered dolerite.

While geological mapping may define unambiguous areas there is rarely sufficient clear exposure to adequately resolve all boundaries and interfaces between materials and never enough to predict their thickness or geometric form although some uncontrolled inferences may be made.

The existence of few drill sites or deep excavations within the region also means that interfaces are largely undefined and any information which does exist may not be representative — or, indeed, accurately described due to the property overlaps which may occur.

The present distribution of materials within the region reflects the structural and depositional history over the past one hundred million years.

Cretaceous and Tertiary faulting has offset and hinged large blocks within the North Tasmania region so that most formations now dip shallowly to the west. Erosion occurred throughout this process as various blocks, or parts of blocks, were uplifted with the result that deep channels and drainage patterns not unlike the modern landscape between Lilydale and Scottsdale were engraved into the fault blocks. The faults, themselves, have often been etched out due to the fracturing and deeper weathering which is normally associated with such structures. Most of the deep channels follow fault lines.

During the Tertiary period changed base levels resulted in flooding of the entire area and the Launceston region was part of a large inland lake. This filled in time and the final sediment-shore level may be found at about 250 m above present sea level. The great plains of the Cressy–Longford area are a larger, less disturbed, remnant of this same system.

More recent erosion has now begun to remove much of this lake deposit and new drainage patterns are cutting into both the lake deposits and the old landforms buried beneath them. Many complex relationships may result and there is no single, simple description for either the relationships between old and modern landforms or the composition of the materials in between. Thus some modern hills are entirely composed of lake material and, if the slope is excessive, these may be unstable. Other hills have a veneer of lake deposits on bedrock, and the veneer may be very irregular in form and thickness since it will partly reflect the original bedrock landscape. If the material is thin and locally derived it may resist slope failure. If thick it may, if the slope is oversteepened or disturbed, fail. Other hills may be composed of bedrock (dolerite) with small patches of weathering and thick soils. Some of this weathering might be modern; some may be ancient and part of the old pre-lake land surface.

These irregular relationships must be defined if sensible planning is to become feasible, or if landslip or seismic risk is to be properly appraised. It is also clear that the information may directly influence building regulations, practices and foundation needs and that these may vary considerably across the metropolitan area.

This study considers only the more general requirements in order to suggest zones which may be used or appraised representatively for the zonation study. Much more analysis, and data, is required to provide subdivision detail, or information for other purposes.

In terms of the seismic zonation study this has meant identification of deep channels and an estimation of their depth; an indication of the variation of composition within typical hills; evaluation of likely hill top cover thickness ranges; general location of bedrock; the amount of alluvial fill in the valley systems and an appraisal of the location of the main faults and any anomalous features they might possess. Local seismic activity is likely to be focussed along such structures and any dilational offsets may emphasise vibration.

SURVEY RESULTS

The results of the gravity survey have been compiled and presented as Map 1 and in Figures 1, 2, 8 and 9 as a contoured map of the gravity field.

The presentation offered is in the form of a residual Bouguer anomaly. This means that the data has been reduced and corrected with the assumption that all rocks in the area have a density of 2.67 g/cm^3 . This normalisation process also allows for variations in position within the area and height above sea level since the gravity field varies in a known way according to position on the Earth's surface. The aim of all corrections is the removal of whole Earth factors so that only the local geological effects remain. Deep crustal effects have also been removed using a model known as MANTLE91 and the resulting map reflects only density variations in the upper part of the Earth's crust. In the case of a small survey such as this most of the variations can be accounted for by near surface changes in materials.

Notice that the normalisation or reduction process assumes that all rocks are the same. This is not so. Indeed, the point of the survey was definition of major variations. However, since it has been assumed that all are the same wherever the rocks are denser than the assumption the results will be more positive, and where less dense the results will be more negative. The magnitude of the results is a crude indication of the distribution of materials. Unfortunately there are many possible combinations of low and high density materials in this area, both in terms of density contrast and thickness totals and there may be an infinite range of possible results. For this reason direct inspection of the map has limited value and only the largest elements can be accepted as being significant without analysis.

Proper appraisal of the gravity field requires evaluation and calculation of the interactive effects of land forms, geological forms and rock relationships. This quantitative process is outlined below.

Figure 1 (Map 1) shows the results and indicates the location of Launceston suburbs.

Three gross positive ribs and two relatively negative belts can be observed. The positive axes are located east of the North Esk River from St Leonards through Ravenswood, from South Norwood to Mowbray, and west of the River Tamar between Prospect and West Riverside. The negative zones extend either along the North Esk valley to Mowbray Heights and Alanvale or along the River Tamar south to Kings Meadows. The Tamar axis is most pronounced (and also well defined by the survey) but is abruptly terminated near Sandhill and Kings Meadows. This zone is clearly anomalous since the marked, narrow anomaly bells out. This can only mean structural dilation and termination.

All zones display some variation in values which must reflect the balance between materials and their thickness. The interpretation considers the gross elements and the origin of the variations.

INTERPRETATION

A simple, nominal interpretation was suggested in the last section; a deep and narrow valley filled with low density materials is present along the Tamar axis and another, less pronounced or developed, along the North Esk valley. The first of these has either long been known or suspected. Its extreme narrowness, and its extension south to Kings Meadows, are surprises revealed by this new survey.

This narrow feature clearly has steep sides and must be deeply filled. It is clearly an etched fault zone. But it is also abruptly terminated although the precise nature of the gravity field is uncertain due to lack of data. The terminal zone is wider than the main channel and Figure 2 suggests a possible fracture pattern which might explain this feature. Such a pattern would imply sub E–W extension and an opening of the channel at termination. If true, this would imply more material infill and perhaps a change in composition and rate of infill as well. Structures of this type have never been suspected in the area but they are seismically of high risk since any new stress, either along the main fault or normal to it, will reactivate this closure structure and the effects will be amplified.

Some other sub E–W elements can be recognised in the anomaly patterns. One of the most pronounced extends through the Windmill Hill area where it is aligned with the opening of the gorge to the First Basin. It would appear that the gorge has been cut along an old fracture system and that this fracture extends some distance to the east of the main N–S Tamar faulting.

Few other grain elements can be described reliably due to uneven data coverage but some are suggested in Figure 2.

The low anomalies along the North Esk valley are not well defined and it is not clear how continuous or wide the effect really is. As a gross trend, however, it can be traced north to Mowbray Heights. These built-up areas, like the South Launceston zone, may be founded on thick valley fills etched into major fault zones.

The gravity survey leaves no doubt as to the orientation of the major structures; NNW–SSE. Some other important elements trend ENE but these lack the obvious continuity of the N–S structures. Most other grain changes are subtler and may reflect older controls on the underlying eroded landscape which has been covered by lake sediments. They may thus be clues to past activity but not necessarily large scale features.

Few other comments may be offered based on inspection of the data compilations.

Further appraisal depends on calculation of actual gravity responses and comparison with those observed. This process can account for the subtle ranges and interactions inevitably involved.

All model calculations assume a density of 2.00 g/cm^3 for recent unconsolidated materials (including alluvium and fill) and Tertiary lake deposits, and 2.90 g/cm^3 for Jurassic dolerite. These may be accepted as bulk estimates. Variations almost certainly exist and the lake deposits may range between 1.9 and 2.2 g/cm^3 while the alluvials may have densities less than 1.5 g/cm^3 locally. The dolerite may range between 2.80 and 3.00 g/cm^3 but an integrated average of about 2.90 is typical. Deviations in the dolerite estimate will not seriously alter the interpretation but modest changes in the density of the covering rocks may alter depth estimates considerably. There is no way of controlling these estimates at the present time and they should be accepted as indicative only. The geometric form of the covering materials, however, will be valid even if the depth range is suspect. Thus variations in material or changes in thickness can be accurately located; the estimate of thickness only will depend on the density assumed. Back calculation against known bedrock depths near City Park and the hospital do suggest that use of a density of 2.00 g/cm^3 is a reasonable practice at this stage of analysis.

Five profiles have been modelled in detail in order to appraise the possible contributions to the observed gravity field and suggest some scale for the features described above. The location of the profiles is shown in Figure 1.

Figures 1, 2 and Map 1 also present some surface geological information. The confirmed distribution of exposed, unambiguous dolerite is shown. Other areas have probable Tertiary or other deposits at surface but there is no indication of thickness. Much of this detailed mapping review, and decisions about exposed rock types, is in progress and the base map presents only a preliminary and provisional version of the information available. Mr S. M. Forsyth and Mineral Resources Tasmania are acknowledged as sources of this bedrock data.

It will be noted that there is a general correlation between high gravity values and large exposures of dolerite basement. This correlation would suggest that dolerite occurs at shallow depth between South Norwood and Mowbray (the central positive axis) even though very little rock is exposed.

The profiles are described from north to south since the most anomalous and most poorly covered region lies in the southern area near Kings Meadows.

Profile 5 (Figure 3)

The section extends from Trevallyn across the City Park region and along Henry Street to Ravenswood. It samples all the primary features of the gravity field.

The profile is generally very positive with the one large negative excursion and two lesser variations.

The model includes the known surface distribution of materials and shows that deep changes are associated with each river system. The general westerly dip of the fault blocks is easily recovered although the zone west of the River Tamar (Trevallyn Fault) may not dip west. This may be an illusion due to insufficient data or the dolerite intrusion may actually rise to the west.

It is possible that part of this effect could be due to sources deeper than those modelled but this is unlikely since the deeper contrasts are about one sixth of those relevant to the model and are of course applied from depths at least 200 m below surface. This option cannot be sustained for other models west of the Trevallyn Fault and it may be that the data sampling is inadequate on the heights of Trevallyn or that the dolerite density should be modified. It is more likely that there is a veneer of covering clays at the western end of the section although these have not been mapped thus far. Less than 20 m thickness of these materials would provide a good curve match at the end of the profile. This discussion suggests how it is possible to identify deep anomalous sources or suggest possible surface explanations in the absence of controlling information. The implication of cover west of Trevallyn is something which might be checked should the survey, or city development, extend to line end.

All models employ consistent assumptions and properties and curve fitting criteria. Since each samples the structure differently any deviation implied in these factors can be taken as an indication of error. The curves have all been fitted with a calculated shift of 8 mGal which suggests that the rocks deep below Launceston are denser than average crust but the effect applies to the entire survey area and is not relevant to the present assessment.

The model also shows that there is little alluvial cover on dolerite in the area north of City Park and east of Inveresk. There is unlikely to be more than 5 to 10 metres of this river-deposited cover. The erosion and fill along the North Esk Valley is also relatively minor when compared to the Tamar structure even though the fault displacement overall is not significantly less. The maximum thickness of fill in the North Esk zone is estimated at about 50 metres.

Profile 4 (Figure 4)

This section extends from near the First Basin to Ravenswood South through Windmill Hill and Elphin.

The model illustrates how variable basement and cover patterns can introduce subtle variations in the gravity field. Windmill Hill contains a rock core but is essentially a large residual volume of lake deposits. The change in thickness accounts for the depression near the hill axis. The cover is locally very thin in the eastern part of the central business district. The material is much thicker along the North Esk valley although this might not have been anticipated from simple inspection of anomaly amplitude which is similar to that near the hill. Note, however, that the total thickness after allowance for terrain is similar.

Subtler variations may be observed near the First Basin and east of Ravenswood. The anomaly near the First Basin is not easily explained unless the thickness of dolerite is a little less than shown since the cover distribution cannot account for the general anomaly form. Part of the deviation may be due to three dimensional effects off the line of the profile. The extreme nature of the deep Trevallyn Fault depression is again evident.

Profile 3 (Figure 5)

This section extends from Summerhill along Brougham Street to David Street on the hill and along Hoblers Bridge Road to north Waverley.

This model illustrates the variability of the thickness of cover on the hill south of Windmill Hill and there is a substantial rock core. Only a small portion of this rock core is exposed. The cover is much thinner at the northing of Howick Street.

The increased scale of deposition along the North Esk River system and its underlying fault control. The more abrupt Trevallyn Fault trench remains dominant.

Thin cover patches occur in the Summerhill and Waverley areas but, as the model fits show, it is not easy to properly estimate them. Lack of data is the principal problem.

Profile 2 (Figure 6)

This profile extends from the southern Summerhill area through Sandhill and Punch Bowl to Waverley.

The model clarifies the possible origin of the anomalous block pattern at the termination of the Tamar axis. The main trench is much shallower overall but there is a large block of covering material to the east. The eastern side of the hill axis contains a rock rib and this is exposed in Punch Bowl.

The North Esk axis is much more significant at this northing and it may be that there has been a transfer of structural displacements from the Trevallyn to North Esk axes. There are not enough data at present to confirm this theory.

Profile 1 (Figure 7)

This section extends from the southern Kings Meadows area along Quarantine Road to St Leonards.

A large volume of covering material is evident both west and east of Norwood. This section is only indicative since the survey is very limited in this area.

The positive effect near Kings Meadows is along strike from the Trevallyn–Tamar structure of previous sections and confirms the massive change in style of all structures south of Kings Meadows. At this northing the North Esk structures are clearly dominant.

It is possible that the fault inferred east of Kings Meadows represents the continuation of the Trevallyn Fault system — but much reduced in scale and offset by about one kilometre to the east in the critical Sandhill–South Launceston area.

CONCLUSIONS

The most enlightened desire by the Corporation of Launceston to assess and define the materials and geological hazards of the Launceston region in order to provide improved, sensible planning and advice has been rewarded with impressive results from this initial attempt to provide a gravity survey of the region.

The survey, and its interpretation, has been able to resolve a series of major structures and imply the nature of variations within the complex materials which coat, or form, many of the hills. It is these covering materials which present most of the geological hazards although the deposits along the major structural axes may also pose severe problems of many kinds — including consolidation and compaction variations.

The survey, although undertaken to assist planning of the location of the seismic zonation study, clearly has significant applications in land stability and other foundation studies. The interpretation provided within the report provides a basic guide to the quantification of the gravity anomalies in terms of the sensitive materials.

Key elements of the interpretation have been summarised in Figure 8. It appears that three or four fault axes pass through the Launceston area and each of these has led to some deep engravures, subsequently filled with soft sedimentary rocks. The two major axes lie along the Trevallyn–Tamar lineament and the North Esk valley (perhaps to Mowbray Heights). The thickness of material and scale of structures may be controlled by a major near E–W hinge extending from Sandhill to Norwood such that the Esk system becomes larger in the St Leonards region. Much potentially unstable cover may be present in the region west of South Norwood although but the precise volume cannot be implied due to limited survey.

Relatively thin and patchy cover is present on the hills east of Ravenswood and St Leonards and west of Trevallyn, Glen Dhu and Prospect. Much more substantial, and much more variable, cover is present within the Windmill Hill to South Launceston axis. The anomalous zone lies between South Launceston and Kings Meadows near Sandhill. It is interesting that the Lawrence Vale susceptible zone corresponds to this area. Substantial covering deposits may also occur south of South Norwood and east of Kings Meadows.

It also appears that the coverage of alluvials and fills in the City Park and eastern Inveresk–Invermay area is negligible. Major variations occur beneath the central business district and due allowance should be made for this fact in all future planning.

It is strongly recommended that the survey be enlarged to infill the significant gaps which presently exist and that the interpretation be upgraded subsequently. This may require some additional levelling. Areas which would benefit from further survey are marked in Figure 9.

*Report submitted on behalf of Leaman Geophysics by:
Dr D. E. Leaman, B.Sc., Ph.D., F. Aus. I.M.M., M.M.I.C.A.
Date: 31 August 1994*

HOW TO 'READ' THE MODEL INTERPRETATION DIAGRAMS

The model interpretation diagrams have a standard form and may be appraised consistently.

A title, describing the model or the particular version, is given at the bottom of the page.

A header, at the top of the page, describes the nature of the methods used (e.g. two dimensional — 2D) and whether gravity or magnetic data is involved.

Two scales are provided on the left hand side of the diagram. The upper scale defines the magnitude of the anomalous response. The full scale range is stated and there are five divisions of this range. The lower scale defines the depth range in the model. This is also divided into five parts and the maximum depth range is stated beneath the model.

A distance scale is given in the centre of the diagram. The length of the profile is stated and it is divided into ten equal parts. All distances and depths are quoted in metres.

The magnetic anomaly scale is in nT, and the gravity scale in mgal. The upper part of the diagram contains two profiles; the broken line represents the observed data and the heavier, continuous line the calculated effect of the model shown in the lower part of the diagram.

The model is defined by colour or pattern according to the sources and contrasts used. Separate magnetic and gravity models may be provided for the same section or profile since not all units may contribute to each calculation. Separate presentation allows for clear appraisal of what contributes to each anomaly type without confusion of many profiles in the upper half of the diagram.

Some other information is also provided in the diagram. The two shift statements in the lower right hand corner define precisely what was required to produce the curve match shown. The magnitude of the shift values is not usually important; their relationship is — and this should be consistent within a given area or data set. Irregularities in fit differential may indicate inconsistent or faulty solutions. This indication is provided regardless of the quality of fit, which may be absolutely perfect, but also quite irrelevant.

The issues involved in sound modelling practice and judgement about validity of solutions may be complex but have been distilled into five critical criteria. These have been discussed in three publications and review is recommended. Some of these criteria are often quoted but it is rare to find all five applied consistently. Most modern modelling programs either do not display, or do not retain, the crucial shift information which forms a critical part of one test.

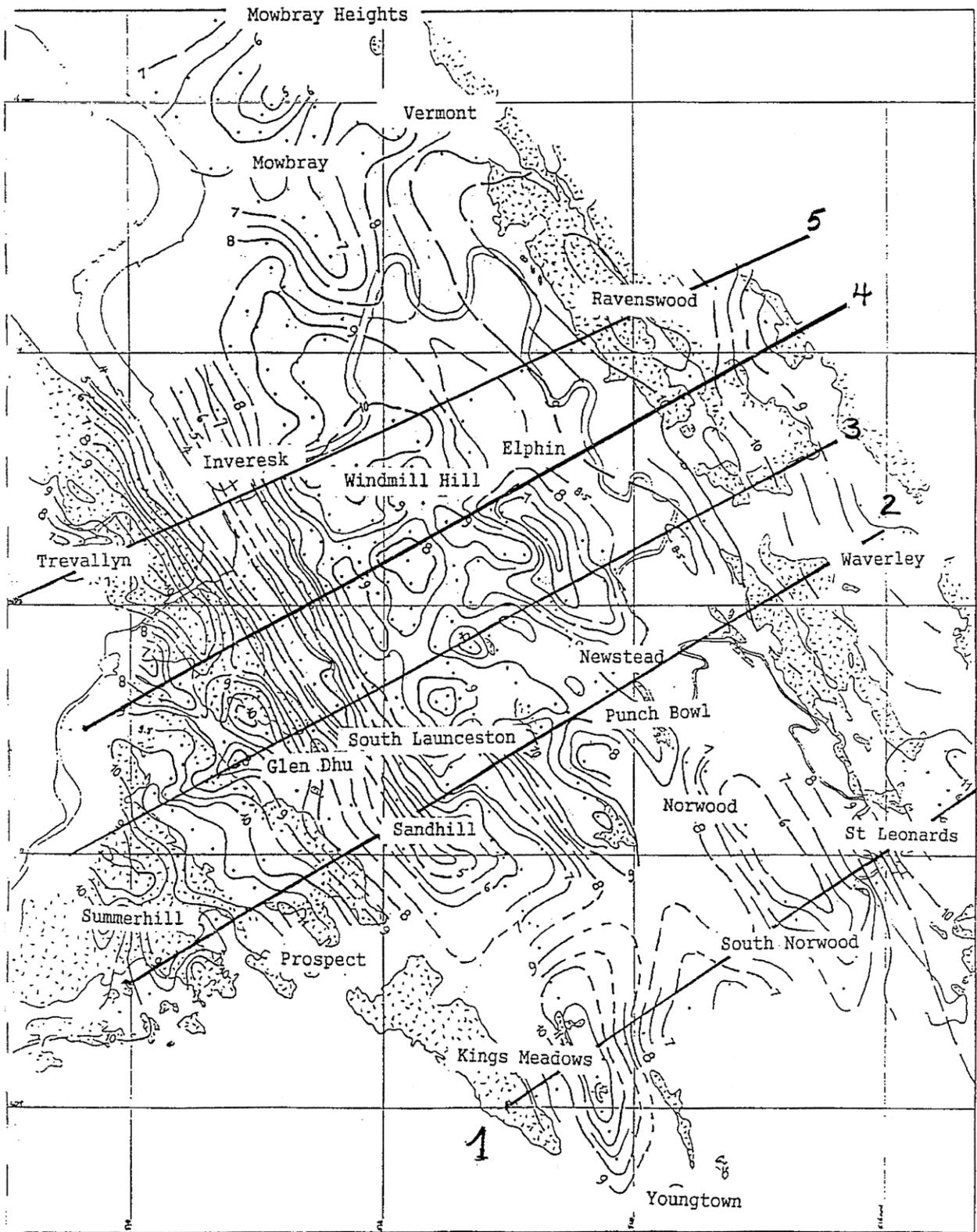
The reader is referred to:

EAEG Extended Abstracts, 54th Annual Meeting, Paris, 1992, p 372–3.

First Break. April 1994.

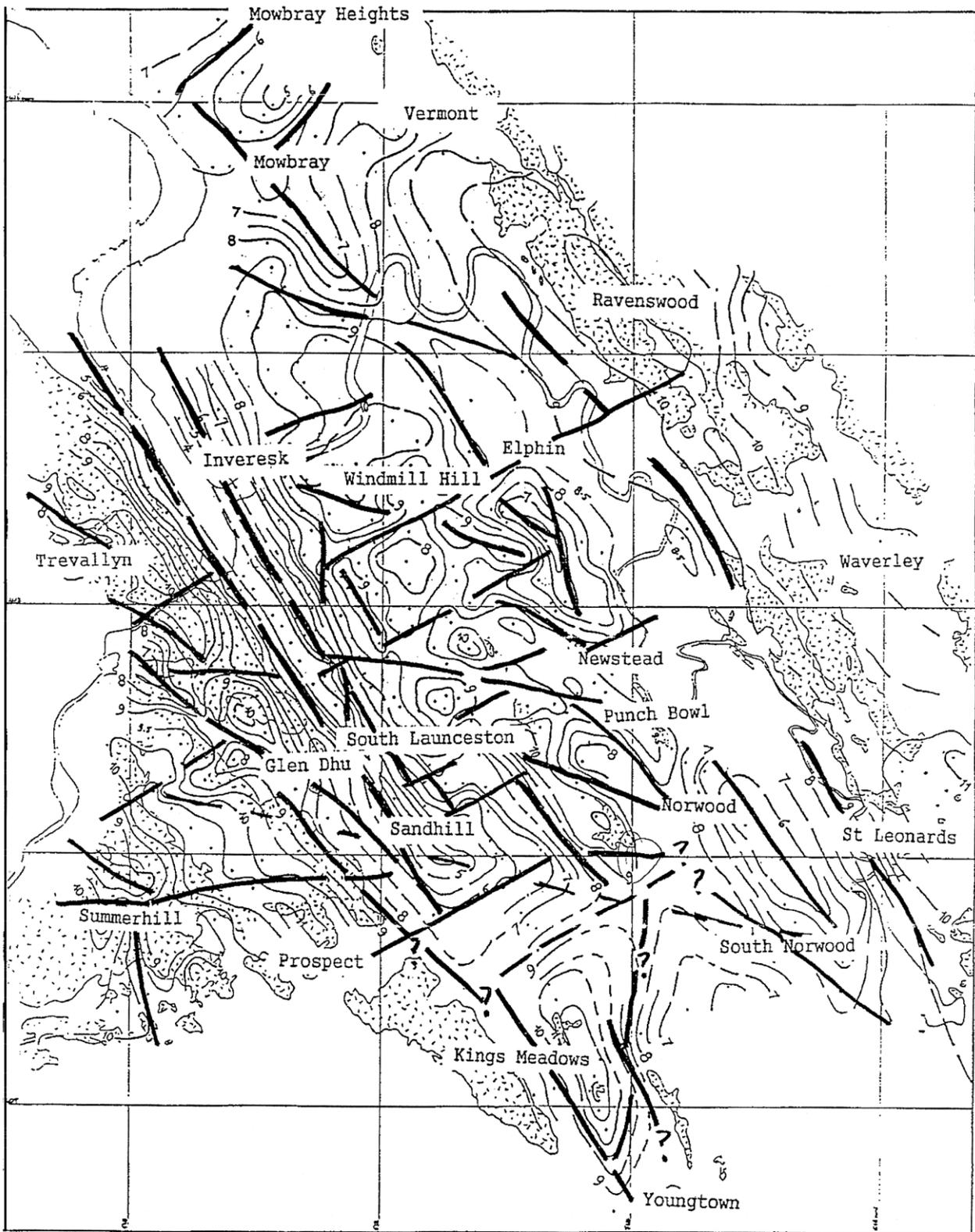
Exploration Geophysics course manual. Vol 13. University of Tasmania Key Centre for Ore Deposit and Exploration Studies.

All papers are titled 'Criteria for evaluation of potential field interpretations'.



RESIDUAL GRAVITY FIELD - LAUNCESTON
 LOCATION OF MODELLED PROFILES

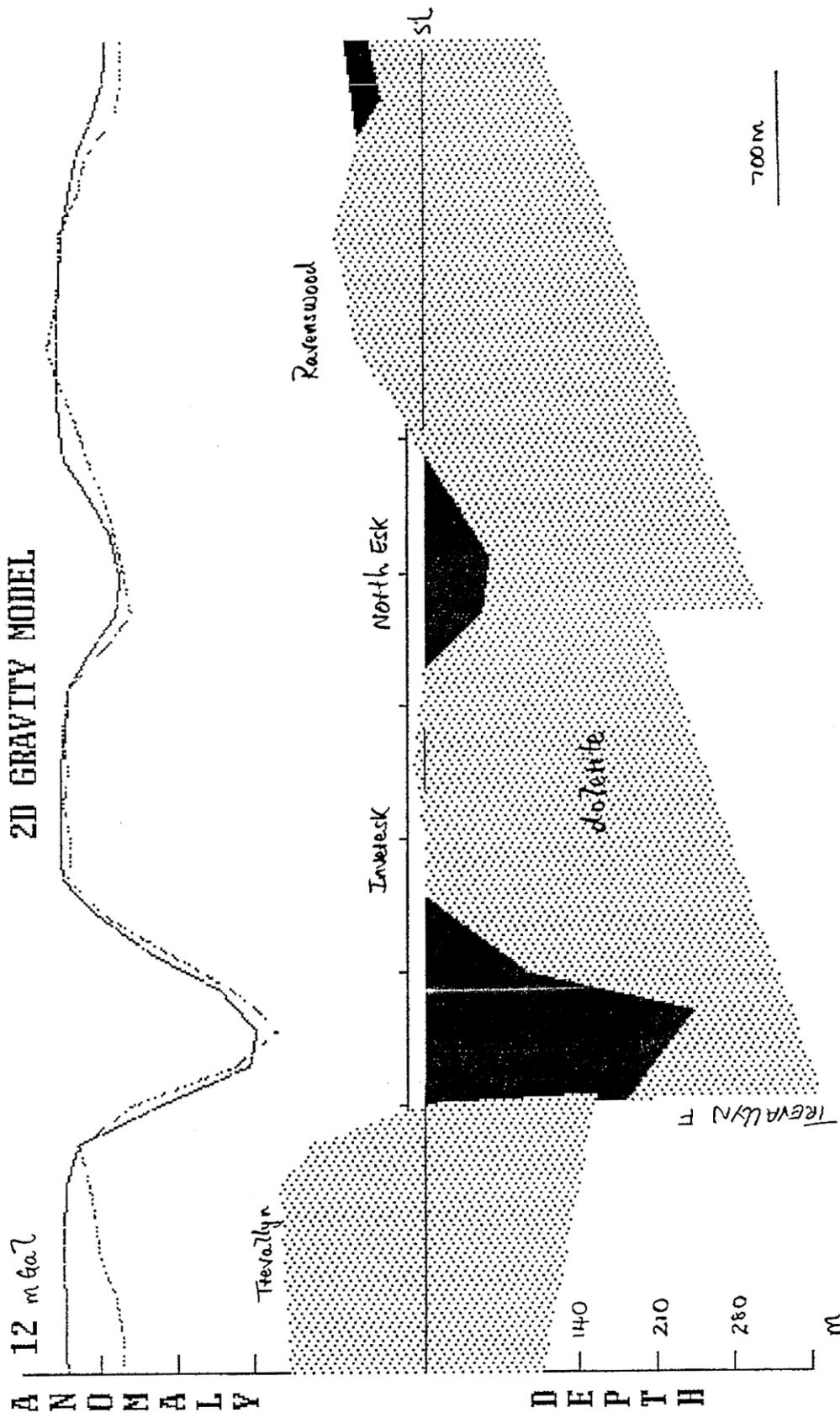
FIGURE 1



RESIDUAL GRAVITY FIELD - LAUNCESTON
 LOCATION OF ANOMALOUS AND OTHER TRENDS

FIGURE 2

1:40,000
 2km grid



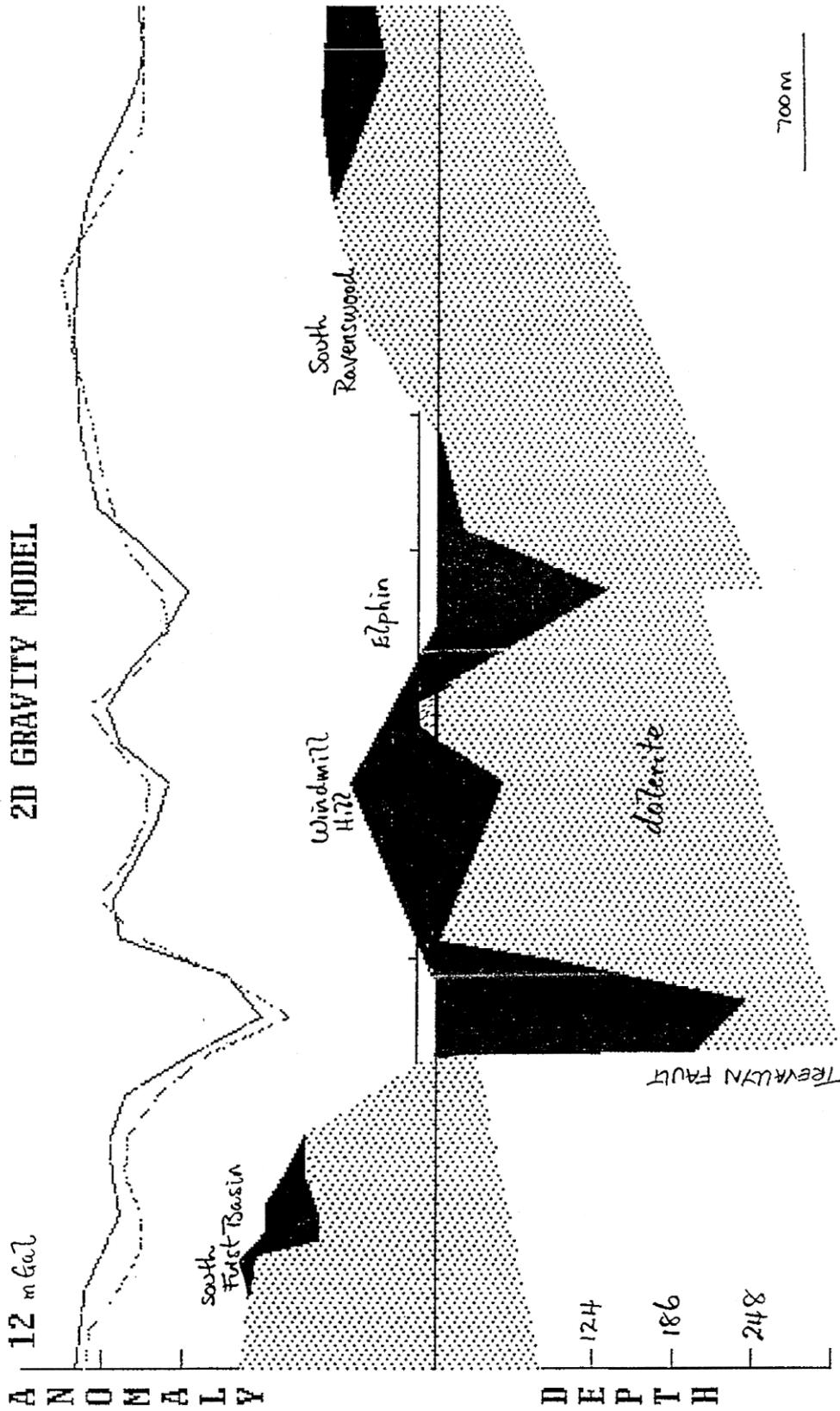
7000

FIGURE 3

LAUNCESTON LINE 5 DISTANCE
 TREVALLYN - INVERESK - HENRY STREET

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2D GRAVITY MODEL

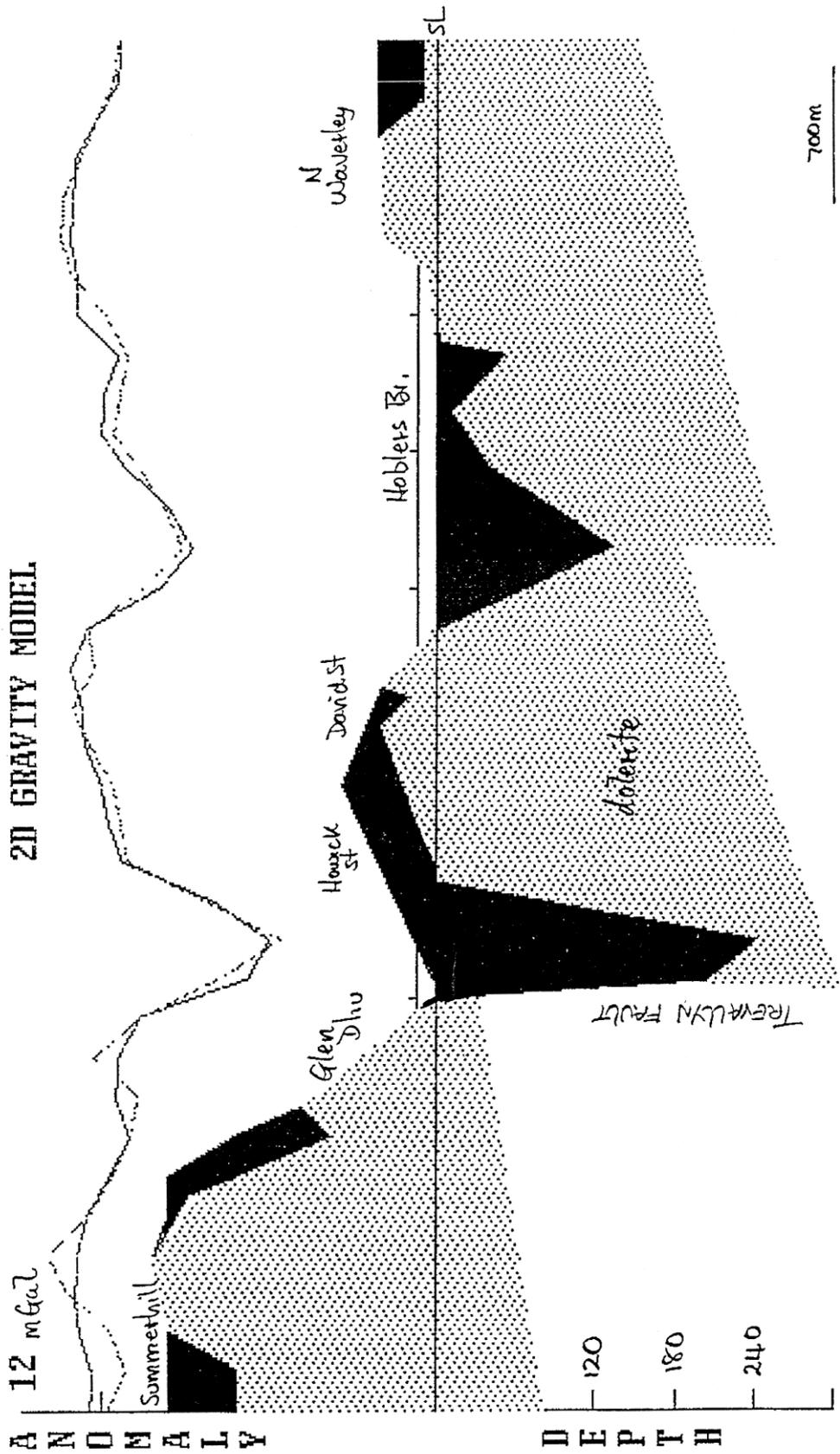


310

LAUNCESTON LINE 4 DISTANCE 7000
 SOUTH FIRST BASIN - SOUTH RAVENSWOOD FIGURE 4

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2D GRAVITY MODEL



--- OBS SHIFT 0
 --CALC SHIFT 8
 7000

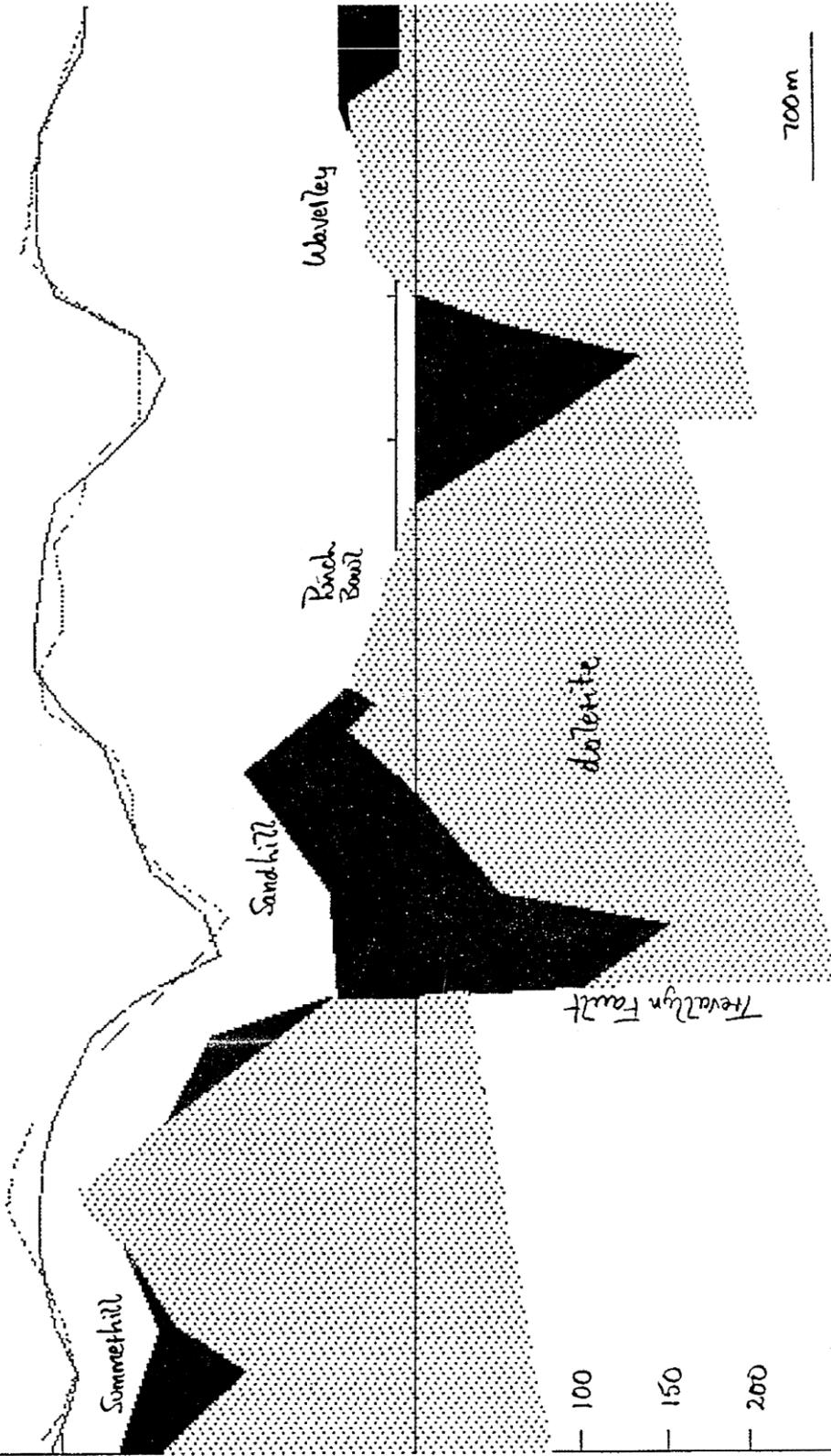
LAUNCESTON LINE 3 DISTANCE
 SUMMERHILL - BROUGHAM ST - HOBLERS BR RD FIGURE 5

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A N O M A L Y

12 mgal

2D GRAVITY MODEL



m
250

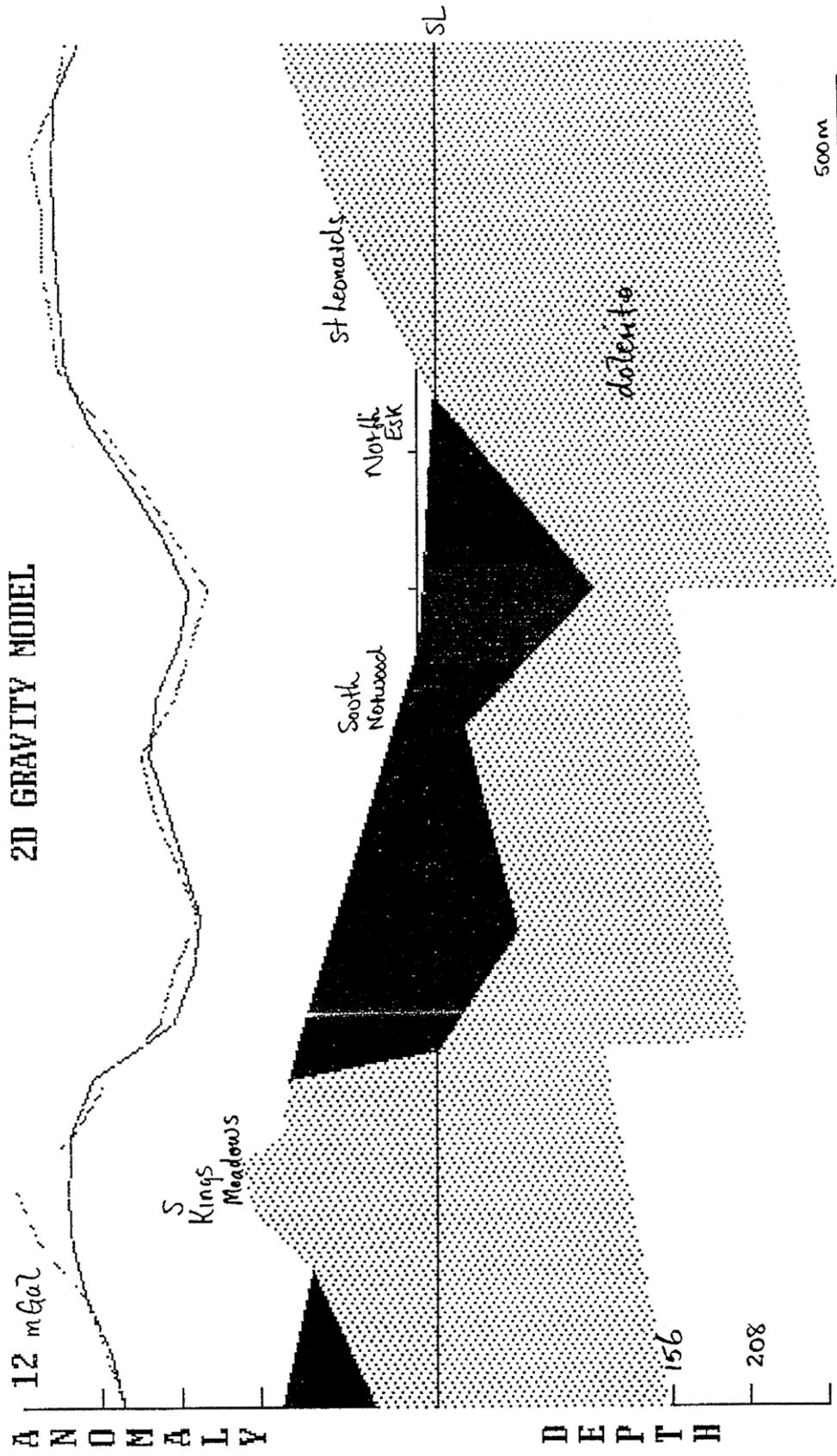
700m

... OBS SHIFT 0
 -- CALC SHIFT 8 7000

LAUNCESTON LINE 2 DISTANCE
 SUMNERHILL - SANDHILL - WAVERLEY

FIGURE 6

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 Australia



... OBS SHIFT 0
 -- CALC SHIFT 8

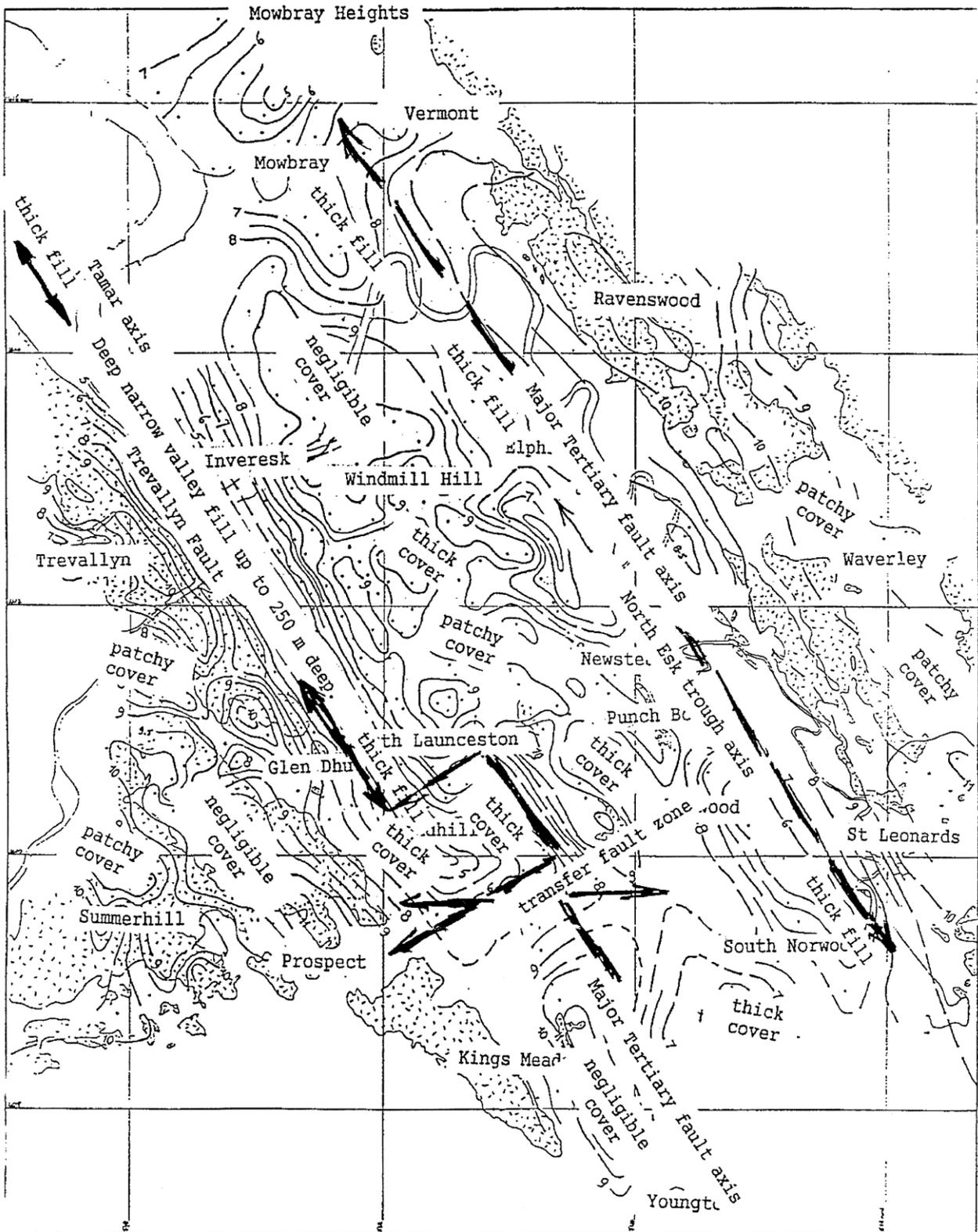
5000

FIGURE 7

LAUNCESTON LINE 1
QUARANTINE ROAD - ST LEONARDS
 DISTANCE

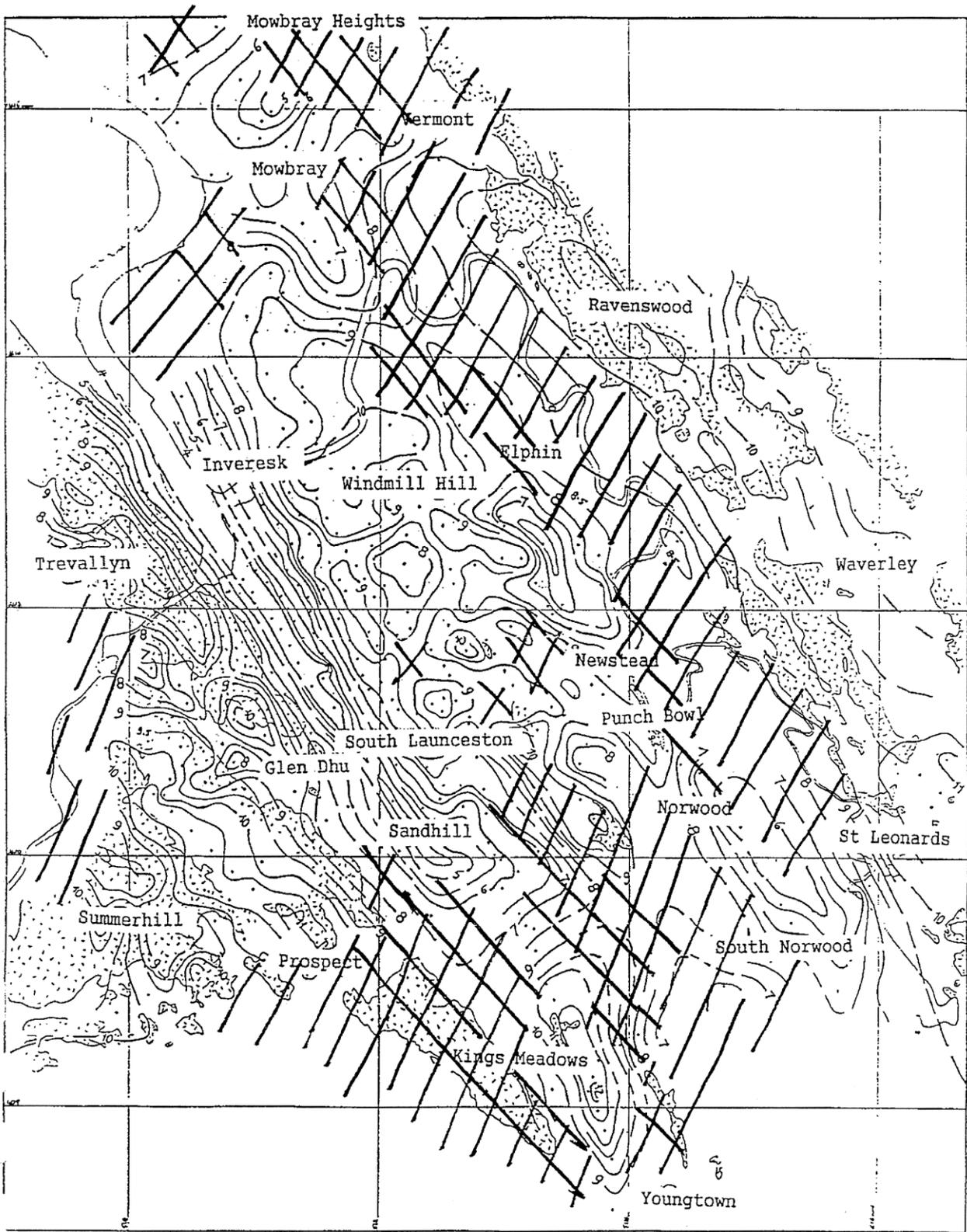
LEAMAN GEOPHYSICS
 GPO Box 320 D
 Hobart Tas 7001
 Australia

M 260



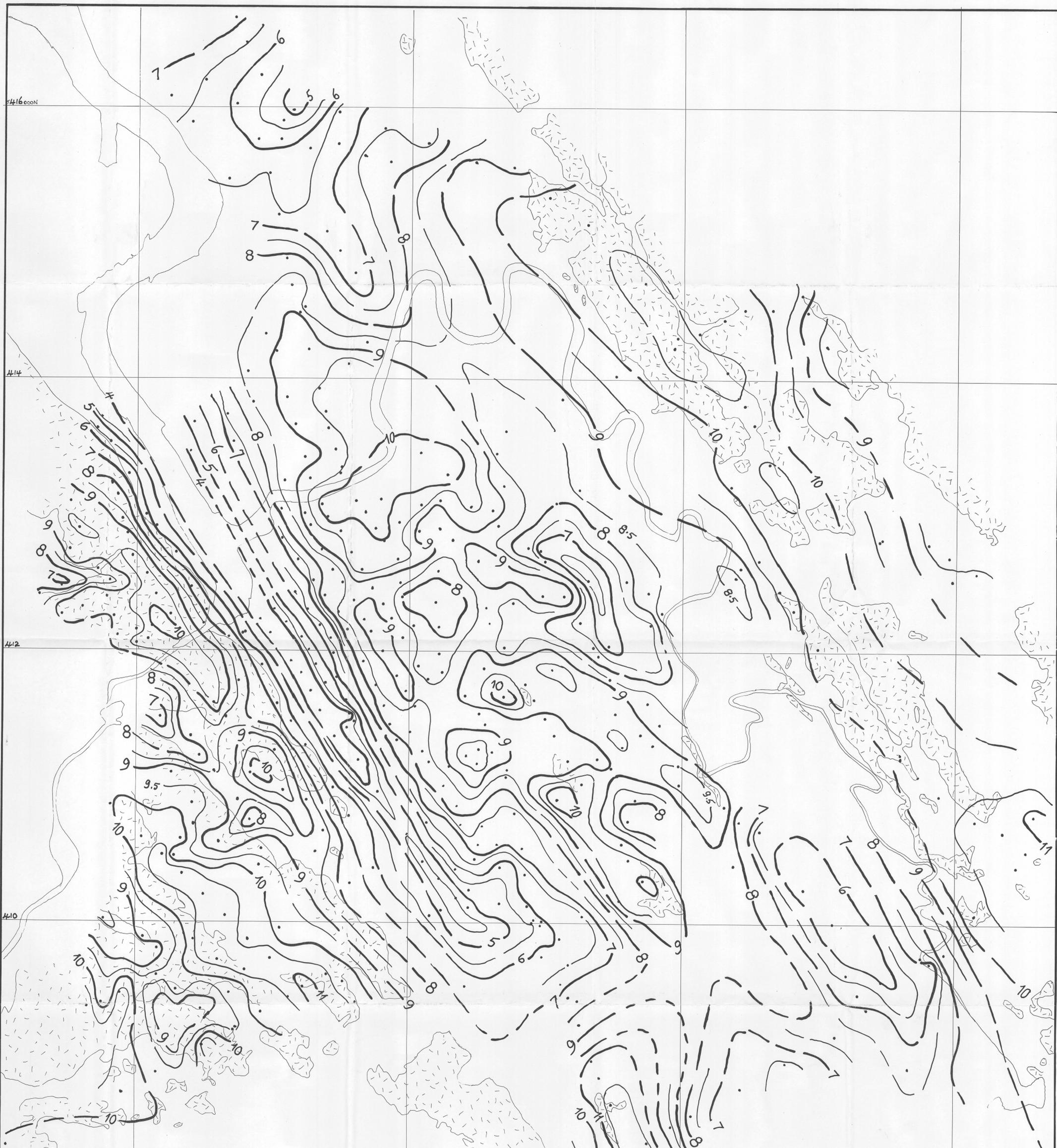
RESIDUAL GRAVITY FIELD - LAUNCESTON
SUMMARY OF CURRENT INTERPRETATION

FIGURE 8



RESIDUAL GRAVITY FIELD - LAUNCESTON
 AREAS WHERE FURTHER GRAVITY COVERAGE IS RECOMMENDED
 Priority areas cross hatched

FIGURE 9



LAUNCESTON
RESIDUAL BOUGUER ANOMALY
DETAILED GRAVITY SURVEY

Contour interval 0.5, 1 mGal.
 Reduction density: 2.67 gm/cc.
 Bouguer to residual processing using MANTLE91 model.

Data acquisition and data base: Mineral Resources Tasmania
 Dr. R.G. Richardson

Geological control and provisional base map:
 Mineral Resources Tasmania
 S.M. Forsyth

Map compilation and interpretation: Leaman Geophysics
 Dr. D.E. Leaman

September 1994. Map subject to revision.

5 cm

1000 m

510

512

514

516 cont.