7th Annual Conference Association of Public Authority Surveyors (NSW) Inc.

incorporating
NSW Staff Surveyors Association Inc
77th Annual Conference

Tending the Vine

Pokolbin
April 2001

LANDCOM **welcomes all delegates to the**

7th Annual Conference
Association of Public Authority Surveyors

and the

77th Annual Conference
NSW Staff Surveyors Association Inc

Creating Better Places to Live and Work

The publication of these papers has been proudly sponsored by

LANDCOM

Table of Contents

Moving Higher Up the Food Chain: The Dynamic Relationship Between the Government Surveyor and the Cadastre. **7**
Mark Gordon 7
Water Boundaries - Department Land and Water Conservation Requirements And Processes **9**
Kevin Thompson, Geoff Songberg and Ken Green 9
Rock Art and Cave Painting : A Surveyor's Perspective **25**
J. G. Fryer 25
An Assessment of the Geoid in Mountainous Terrain in NSW **33**
Andrew Rigelsford 33
Digital Record Tracings for Coal Mines **41**
Matthew Smith 41
Auditing the Height Network of New South Wales **49**
Owen Moss and George Baitch 49
Cadastral Upgrade in House and Our Way **61**
John Perry 61
Sandgate Cemetery - Challenges of the 21st Century **65**
Terry St George 65

Moving Higher Up the Food Chain: The Dynamic Relationship Between the Government Surveyor and the Cadastre.

Mark Gordon
General Manager Geomatics
Roads & Traffic Authority, Parramatta

Abstract

There are a selected number of age-old questions which defy response. Questions like: "If people from Poland are called 'Poles', why aren't people from Holland called 'Holes'?" or "Why isn't 11 pronounced 'onety-one'?", or even "Why is the man who invests all your money called a 'broker'?" With a recent (December 2000) 'survey' – if you'll excuse the expression – of the Surveying profession indicating that only 17% of surveyors work in the public sector, the question needs to be asked "Why employ government surveyors at all?". However, this question, once raised, demands a response.

There are five categories of service that a survey firm can offer:

- Traditional
- Developing
- Expert advice
- Specialist
- Leading Edge

All these services exist as parts of a highly competitive market. The most secure position in any competitive environment is one which contains a large degree of sustainable competitive advantage. This advantage can lie in either one or a combination of areas, although 'price' appears to be one which (wrongly or rightly) is most lauded. Any survey firm must be able to accurately define firstly its market, and secondly its strengths in that market, in order to have any chance of survival. However, the market for the public sector surveyor is constantly changing, and the onus is always on public sector surveyors to prove their worth to the government employer and to the community at large.

Over the past three years, the Roads & Traffic Authority has won five of the Institution of Surveyors Excellence in Surveying Awards, and has been the only organisation – public or private – to have won a prize in each year of the Awards' existence. One reason for this is because the surveying discipline within the Authority has been prepared to remove itself from its lower level, "comfort zone", technologies into areas that may be of higher risk to itself but of greater benefit to its employer. Significantly, and perhaps not surprisingly, there is less competition at these higher levels of the food chain but a greater opportunity to constructively contribute to the larger organisation. With contribution comes recognition and, ultimately, sustainable reputation.

In recent years, the work of the RTA's Surveying Services Section in cadastral information management and property surveying exemplifies its dynamic reaction to a changing market. Such work clearly demonstrates the ability of surveyors to exploit

the opportunities that their education, training and experience provide. Knowledge, and its application to go where no one has gone before, is our sustainable competitive advantage. In other words, and to return to our age-old questions: some men see things as they are and say "why?" - surveyors must dream of things that never were and say "why not?".

Water Boundaries - Department Land and Water Conservation Requirements And Processes

Kevin Thompson, Geoff Songberg and Ken Green
Land NSW Surveyors, Department Land and Water Conservation

Abstract

Surveyors from the Land NSW coastal offices will present a paper and hold a forum for discussion with respect to the following issues:-

1. National Competition Policy and the reorganisation of government agencies including Department of Land and Water Conservation. Land NSW a business arm of DL&WC is now the administrator of Crown land including approvals for certain Crown boundaries, including Mean High Water and non-tidal stream boundaries.

2. Booker Bay – Community issues vs freehold title and common law. With projected increase of NSW coastal population conflict over the use of foreshore lands is certain.

3. Freeze on MHWM investigations 23 March 1999 led to changes to procedures and a review of MHWM "administration" including standard of applications, existing MHW definitions, and veracity of registered plans.

4. Influence of Survey Practice Regulations, Registrar General's Directions and Surveyor General Directions on Department of Land and Water Conservation's procedures.

5. Examination of common boundary case types and regulatory requirements

6. Surveyors' Regulations – Discussion with respect to definitions and Departmental\t consents. Surveyor General consent to be removed from regulations. DL&WC through Land NSW will continue to protect the Crown interest by verifying the technical aspects of surveys involving Crown land.

7. Previous survey standards are generally sub-professional. The Dept does not charge a fee (current fee is to the SG under SPR clause 57(6)) but this could change. The quality of the application could have a direct influence on any fee applicable.

8. Introduction of a 'Checklist' to accompany applications for Dept consent.

9. Revisit Peter Blume's 1995 Conference paper "MHWM Revisited". Analysis of tides.

Who we are?

We, are, part ex-Lands Department. The Lands Department went through a series of name changes in the 1980's, including Crown Lands Office, and was eventually amalgamated with the Soil Conservation Service to form the Department of

Conservation and Land Management (CaLM). Calm we were anything but and the government did not leave the reorganisation of departments alone. It wasn't to long before we found ourselves amalgamated with Water Resources, and the Coast and Estuaries sections of Public Works. The new entity became the Department of Land and Water Conservation (DLWC, not DLaWC or LaWC).

We were just settling in to the new department when it was realigned in line with the National Competition Policy. Operator and regulator functions were separated with Land NSW being formed within DLWC to take on the operational role of Crown land administration. Basically we are what is left of the operational component of the former Lands Department. We lament the loss of surveyors from what was the paramount surveying department in the state which now contains only 6 practising registered surveyors. It is now the task of the 5 surveyors who reside along the coast to examine all mean high water boundaries and other associated water boundaries where they impact on Crown land. This is in areas not controlled by Sydney Ports, Waterways Authority, etc.

Mean High Water - The call for change

Recently a series of re-determinations of MHWM boundaries at Booker Bay on the Central Coast which were based on claims for accretion, were subsequently approved under the Surveyors (Practice) Regulations 1996 (SPR 1996). The local community objected to the perceived loss of public access to the foreshore as this area had historically been extensively used for public recreation.

The tug of war between opposing ownerships along ambulatory boundaries however has been going on ever since rivers and streams became property boundaries. Booker Bay was a catalyst that brought this juggling act to the attention of parliament and the wider public causing a freeze to be placed on all cases. However, the real issue highlighted by public concern expressed during this case, is a planning/social one but certainly not one of land ownership, since common law is clear on freehold rights pertaining to ambulatory boundaries.

As a direct response to the Minister's freeze "on any further property boundary changes that could impinge on public access" that commenced 23rd March 1999, the procedures for examining and approving mean high water boundary definitions have come under close scrutiny. The Minister's delegation was partially removed from the Surveyor General and now currently rests with the General Manager Land NSW. The freeze was partially lifted on 21 June 1999 as interim changes to the procedures were effected.

The implementation of new procedures did not however allow all cases to be dealt with. Part of the new procedures called for the assessment of public access, whether it be legal access or perceived access. If there is a possible conflict between an alteration in the mean high water boundary and public access, then the case will be deferred until the government has fully considered the Coastal Council report and implements any changes, if appropriate.

At present the whole process of approving ambulatory boundaries is in a state flux and is under review by Land NSW investigating surveyors.

Push for greater stringency

Sydney Morning Herald, page 6, Monday, 29th January 2001. **"Alarm as population flocks to the coast"**. According to the article (appendix A) the population along the eastern seaboard is projected to increase up to four fold in the next 20 years. The article reinforces the need to preserve the waterways in a manner that is sustainable for all concerned. The pressures on waterways due to recreational activities will only increase together with the need for access to the water and along the foreshores. It was the possible loss of public access along the foreshore that brought about the review of the approval process.

The flip side of this is also applicable. Just as the waterway has become more valuable so has the land. There is probably a perception that the land has a greater monetary value seeing that it is a physical entity owned by an individual. The owner will more keenly feel the loss of any land from erosion. Any gain in the amount of land as a consequence of accretion would be highly prized, but not at the unscrupulous loss of public land - the waterway.

As the values and demands of both the public and private land increase, assurances will need to be made that any changes in the common boundaries are beyond refute. The increasing competition for the foreshore lands and the powers of lobby groups with interest in public access to coastal lands will raise the scrutiny of mean high water mark re-definitions to new levels of scrutiny. The current review of procedures is aimed at ensuring clear and unambiguous protocols are in place to protect not only the public interest but the private interest as well. It is part of the role of Land NSW surveyors to investigate each case on its merits and ensure adherence to regulation and correct definition. The assessment of mean high water will however depend on the quality of the available information and reports supplied by the applicant

Old Mean High Water

Because the land has become more valuable more owners have tried to realise the greatest return possible from their land. Invariably if the land has frontage to the water then the value is even greater as there is potential to undertake water oriented development.

A common misconception held by land owners and even some surveyors is that the dimensions given on the plan to the mean high water are absolute and fix the title boundary. Often, plans - particularly identification plans - show the mean high water of the deposited plan as the title boundary despite also indicating another location of the physical mean high water. What some people have forgotten is that the mean high water is an ambulatory boundary and thus can move over time. The deposited plan is merely a statement of the location of the mean high water boundary at the time of the survey. An assessment of the manner in which the tide line has changed must be undertaken before a conclusion can be arrived at as to is the location of the title boundary.

The doctrine of change is a complete topic on its own. However if the change has been natural, gradual and imperceptible then the title boundary also moves and the present mean high water line will be the title boundary despite being different to the

previous plan. If the change however has been sudden, whether by the hands of nature or man, then the title boundary does not change. The land owner may be left with a strip of Crown land between them and the water or may even have physical waters edge through their land.

The Sydney Morning Herald complemented the January 29 article with another on the same page showing the owner of the property standing knee deep in water below mean high water but still within his property. See appendix B for a reprint. The conflict between the forces of nature, cadastral boundaries, owner rights and public waterway access will make for an interesting settlement.

A disclosure of differences in the line of mean high water may not necessarily reflect a physical change. One of the reasons that some properties have had cause to be resurveyed is that differences have been found between the location of mean high water shown on the deposited plan and where it exists today. With the increases in property values and the desire to maximise potential, correct identification of the mean high water boundary is essential. Many cases investigated have disclosed incorrect original definitions of mean high water. Surveyors in the past have not taken due diligence in locating the "true" mean high water. Whether this is a reflection of the considered worth of the land being surveyed or a field practice of doing what is most convenient and cost effective is unknown. Some examples of incorrect mean high water definitions include:

Traverse lines about 30 metres from mean high water on top of a high bluff 20 metres above water level. The mean high water line being only approximately shown.
Top of a rock shelf
Edge of vegetation frequently adopted, usually at the back of a sandy beach
Along the outside edge of the mangroves

New Mean High Water

Do not think that only old mean high water definitions are prone to error. If the current standard of definition is anything to go on then the ability of surveyors to deal with ambulatory boundaries remains poor. The standard of cases presented for investigation is one of the main concerns of the current review. The treatment that has been given to these, sometimes complex definitions, ranges from poor to undeniably wrong and contrary to the existing regulations and/or guidelines. Both mean high water and non-tidal stream bank definition have been treated poorly, eg:

Locating a 20 metre wide reserve boundary parallel to the existing bank despite changes of 30 metres in the location of the bank. This is contrary to the survey practice regulation (SPR 21(1)) which requires the boundary to be placed parallel to the position of original bank at the time of the grant.
Moving the water boundary over 70 metres while at the same time making a statement on the plan that the definition was substantially the same as the previous definition. This one capped it off by showing in the report, with photographs, that large changes had occurred due to recent flooding.
On a tidal foreshore that had been subject to reclamation the mean high water was shown at the present location in one section, along an arbitrary line through some of the reclamation, then following the line of the previous plan for the remainder.

There are, of course, cases where the right thing is done but a review of cases over the last 12 months shows that these are in the minority.

Water Boundary Changes

Of particular concern to the Land NSW investigating surveyors is the poor quality of reports being sent by applicant surveyors, especially when changes to the water boundary must be dealt with. SPR 57-6 requires a comprehensive report to be made to the Surveyor General when seeking a change to the mean high water boundary. The Surveyor Generals directions are silent on non-tidal streams however the Registrar Generals directions (7.3.3.2) require a report to be furnished.

The report needs to address the process of change not the fact that there has been a change. It is quite evident that changes have occurred when plans are compared. Recent reports accompanying applications, supposedly dealing with the changes to the boundary, have been as brief as, 'here is my plan please endorse it' or a one liner, 'the change has occurred gradually and imperceptibly'. There has been one report submitted that simply said that they were having a run on these sort of cases lately and hoped everything was in order. Needless to say nothing was in order. Very rarely is there any information or supporting documentation to back up any statement that is made.

The onus of proving the location of the new boundary rests solely with the applicant. If the definition is proving difficult or beyond the experience of the applicant, then appropriate professional advice should be sought.

Reports dealing with changed water boundaries need to address the processes involved in the change. They need to be properly structured with anything relevant that will show how the change came about. Such information ideally should include photographs, terrestrial and aerial, local witness reports, statutory declarations, geotechnical reports, scientific studies, etc. Surveyors should not forget that they might not be the only ones looking at a particular stretch of river. There may be riparian process studies available that can be incorporated in an application. Reports should also include details of how the current boundary was defined, was it by tidal observations, transfer of level from some known point related to mean high water or was the definition a quick observation of the bank with a 'that looks good' line adopted. Don't laugh, such a method may be appropriate in quite a lot of circumstances. For example, a stable vertical shoreline containing oyster growth can be adopted with reasonable confidence as the MHWM, whereas the existence of a flat shoreline should investigated carefully eg mangroves.

The process of determining how a change came about can be a much wider issue than determining the location of present physical bank or mean high water. Investigations can go beyond regular cadastral boundary surveying practice. Such a topic is also beyond this presentation however the issue may spark the interest of someone who would like to provide enlightenment in future conferences.

Not Only Mean High Water

Since the freeze on mean high water, the Registrar General also has been more stringent in dealing with all ambulatory property boundaries. At first only mean high water boundary definitions were given closer scrutiny however non-tidal boundaries, where they affect Crown land have also come under investigation. There have been an increasing number of requisitions from the Registrar General for surveyors to obtain approval from Land NSW for not only mean high water boundaries but also boundaries associated with non-tidal streams. Refer to Registrar Generals directions for deposited plans Section 7.3 Natural Boundaries.

Requests for approval of non-tidal stream boundaries has prompted expansion of protocols for approving mean high water boundaries into the non-tidal area. It is expected that eventually any private land that is resurveyed along a water boundary, or an offset (inland boundary of reserve or road), where Crown land could be affected will need to gain the approval of Land NSW. Such an approval may even extend to non-tidal lakes and lagoons, despite the doctrine of accretion and erosion not applying.

There is also a need to remind surveyors that it is a requirement of the current SPR (Clause 9,1,c) to show structures and improvements along boundaries. This includes water boundaries. Experience has shown that this requirement is often ignored. It is also a requirement of the Registrar General directions to show both the existing bank and the current boundary if the two are not coincidental (7.3.3.2)

Regulations and Directions

If some surveyors are a little bewildered about the complex series of regulations and directions that affect ambulatory boundary definition and approval then they are probably not alone. Not only are the regulations and directions out of date but they are sometimes conflicting. Who has to approve what is even more obscure. Each type of ambulatory boundary case requires a slightly different approach and has its own approval regime. Following is a run down of the current situation with respect to Crown land.

Mean High Water Unchanged.

Regulation: Surveyors (Practice) Regulation 1996, clause 55, 57(1-5), 59

Directions: Surveyor General, clause 4, 4.1, 4.1.1, 4.1.3, 4.2, 4.2.1, 4.2.3, 4.2.4: Registrar General, clause 7.3.1, 7.3.2.1, 7.3.2.3, 7.3.2.4, 7.8.2.

Approvals: SPR 57(5). Minister for Crown Lands Act 1989 currently delegated to General Manager Land NSW. Both SG and RG directions indicate Crown land's approval is not required if the definition is substantially the same as the previous. There is nothing in the current SPR to support this and in fact if SPR clause 57(5) were followed strictly as written then such a practice should not occur as, under that clause, approval to all definitions "must be obtained". LTO however will only accept the plan if the prior definition is less that 10 years old and also has Crown lands approval. Note that a signed approval in the Crown lands approval box is not an approval of mean high water. This approval is with

respect to section 173 of the Crown Lands Act 1989 and does not cover mean high water.

Fees: Nil

Lodgement: Land Titles Office (LTO)

Mean High Water Changed.

Regulation: Surveyors (Practice) Regulation 1996, clause 55, 57(1-6), 59

Directions: Surveyor General, clause 4, 4.1, 4.1.2, 4.1.3, 4.2, 4.2.2, 4.2.3, 4.2.4 Registrar General, clause 7.3.1, 7.3.2.1, 7.3.2.3, 7.8.2

Approvals: Surveyor General for SPR 57(6). Minister CLA delegate, General Manager Land NSW for SPR 57(5).

Fee: $120 (payed to Surveyor General). No fee to Land NSW. Cheque made out to Department Land and Water Conservation as a transfer will be made to the Surveyor General.

Lodgement: Land NSW Newcastle prior to LTO.

Landward Reserve Boundary to MHW

Regulation: Surveyors (Practice) Regulation 1996, clause 58

Directions: Surveyor General, clause 3.2. Registrar General, clause 7.3.5, 7.8.2.

Approvals: Minister CLA delegate, General Manager Land NSW. RG direction for approval from the Surveyor General (Clause 7.3.5) is incorrect as the delegation has changed. Note: this is not a redefinition of mean high water although it is usually shown, changed or not.

Fee: Nil

Lodgement: Land NSW Newcastle prior to LTO.

Landward Road Boundary to MHW

Regulation: Surveyors (Practice) Regulation 1996, clause 21, Roads Act 1993, sections 18-21

Directions: Surveyor General, clause 3.2, Registrar General, clause 7.8.3.1, 7.8.3.2, 9.5.2, 8.5.3

Approvals: For SPR approval is required from the Minister CLA as there are no delegations. For Crown roads under the Roads Act approval is from Resource Access and Compliance, the regulator component of the ex Lands Department operating within the regional structure of DLWC. Other roads such as Council roads will require similar approvals from the respective road authority.

Fee: Nil

Lodgement: Land NSW Newcastle for action with respect to SPR 21. It will be forwarded for action required by the Roads Act.

Non-Tidal Stream Bank, both Changed and Unchanged

Regulation: Surveyors (Practice) Regulation 1996, clause 56, 59

Directions: Surveyor General, clause 3.2, Registrar General, clause 7.3.3.2, 7.3.4, 7.8.2

Approval: RG directions require Crown land approval. This will only be in cases where either the bed of the stream or the land on the opposite bank, is Crown land. A check of the Crown grant for the land being surveyed will be needed to ascertain if the bed of the stream is Crown land. The beds of all streams were reserved to the Crown on 3rd May 1918 in the eastern and central divisions and 31 May 1935 in the western division of the state.

Fee: Nil

Lodgement: Local district office of DLWC where there is a Land NSW presence. These are the old Lands Department offices, not the ex Soil Conservation or Water Resources offices. After approval from DLWC then to LTO.

Landward Reserve Boundary to Non-Tidal Stream

Regulation: Surveyors (Practice) Regulation 1996, clause 21

Directions: Surveyor General, clause 3.2, Registrar General, clause nil

Approval: Minister CLA as there are no current delegations.

Fee: Nil

Lodgement: Local district office of DLWC where there is a Land NSW presence.

Landward Road Boundary to Non-Tidal Stream

Regulation: Surveyors (Practice) Regulation 1996, clause 21, Roads Act 1993, sections 18-21

Directions: Surveyor General, clause 3.2, Registrar General, clause 7.8.3.1, 7.8.3.2, 9.5.2, 8.5.3

Approval: Minister CLA, in the case of a Crown road, as there are no current delegations. RAC section of DLWC for the Roads Act.

Fee: Nil in the case of Crown roads.

Lodgement: Local district office of DLWC where there is a Land NSW presence but only for cases involving a Crown road. Lodgement directly the respective road authority, eg Council, for other classes of road.

Non Tidal Lakes and Lagoons

Regulation: Surveyors (Practice) Regulation 1996, no requirement

Directions: Surveyor General, clause 3.1, Registrar General, clause 7.3.3.1

Approval: Surveyor General according to his directions and Land NSW (Crown lands) according to RG directions

Fee: Unknown

Lodgement: Confusing but it is suggested that the Local district office of DLWC where there is a Land NSW presence would be appropriate. Note. The possibility of road or reserve fronting the lake also exists (see previous non-tidal stream sections). Also note. Accretion/erosion does not apply and the boundary is that shown for the original grant.

The above summation is only with respect to Crown land. In the case of waterways in the administration of other authorities, such as Port Jackson, Botany Bay, Port Hunter and Port Kembla, consent from those authorities should be sought similar to above.

Responsibility

Even though some cases are reviewed and/or approved by Land NSW, LTO or Surveyor General, the ultimate responsibility for the definition rests with the surveyor. If in the future there is a fault found with the survey then the surveyor will be called on to remedy the situation. Quality of treatment of water boundaries and survey definition is therefore important. This applies not only to the surveyor undertaking the definition but also the authority reviewing the case.

In an effort to clarify the procedures required of a surveyor, we are currently investigating the possibility of a checklist, which will need to be completed and forwarded with any application. It may seem like yet another form to fill in, but at least it will be an aid to surveyors in ensuring they have carried out what is required of them.

Where is the ambulatory boundary?

An ambulatory boundary can be difficult to define. Not all problems encountered can be addressed by the limited expertise of the surveyor. Many definitions for the delineation of ambulatory boundaries have resulted from legal cases, which do not necessarily translate easily to practical application.

Section 172 of the Crown Lands Act 1989 provides definitions of bank, bed, lake and river however the debate still continues as to exactly what constitutes the bed. What exactly is the "average or mean stage without reference to extraordinary freshets in time of flood or to extreme droughts"? Which flows are extraordinary, or what are the ordinary ones for that matter? Similarly which level of drought is classed as extreme? The bed fits somewhere in the part that "is alternately covered and left bare with an increase or diminution in the supply of water". Is it the waters edge or do you need to take into consideration an amount for when the stream runs a banker, but not yet in flood? An excellent precis covering this topic was presented by Dick Kernebone to the 62nd Staff Surveyors Conference as Salamanda Bay in 1988. Perhaps it is time for a fresh look at this topic however is beyond the scope of this paper but someone may like to take it up in the future.

The Survey (Practice) Regulation 1996 clause 57(1) supplies the mean high water definition as "the line of mean high tide between the ordinary high-water spring and ordinary high water-neap tides". Just what is ordinary is not clear, but it does not mean ordinarily occurring (Attorney General v's Chambers 1854). There are a number of suggested determination methods. These include:

levelling from a long standing tide gauge where MHW is known,
range ratio method,
adopting an AHD level for MHW found from coastal studies,
local tide observations over a lunar cycle (27 days 7 hrs 43 min 11.5 sec, one revolution about the earth) or as some text indicate a lunar phase (29 days 12 hr 44 min 11.5 sec, between one full moon and the next) (Encarta97).

For a quick look at mean high water, figure 1 is the observations of high tide at Camp Cove in Sydney Harbour for the period 1 July 1999 to 30 June 2000.

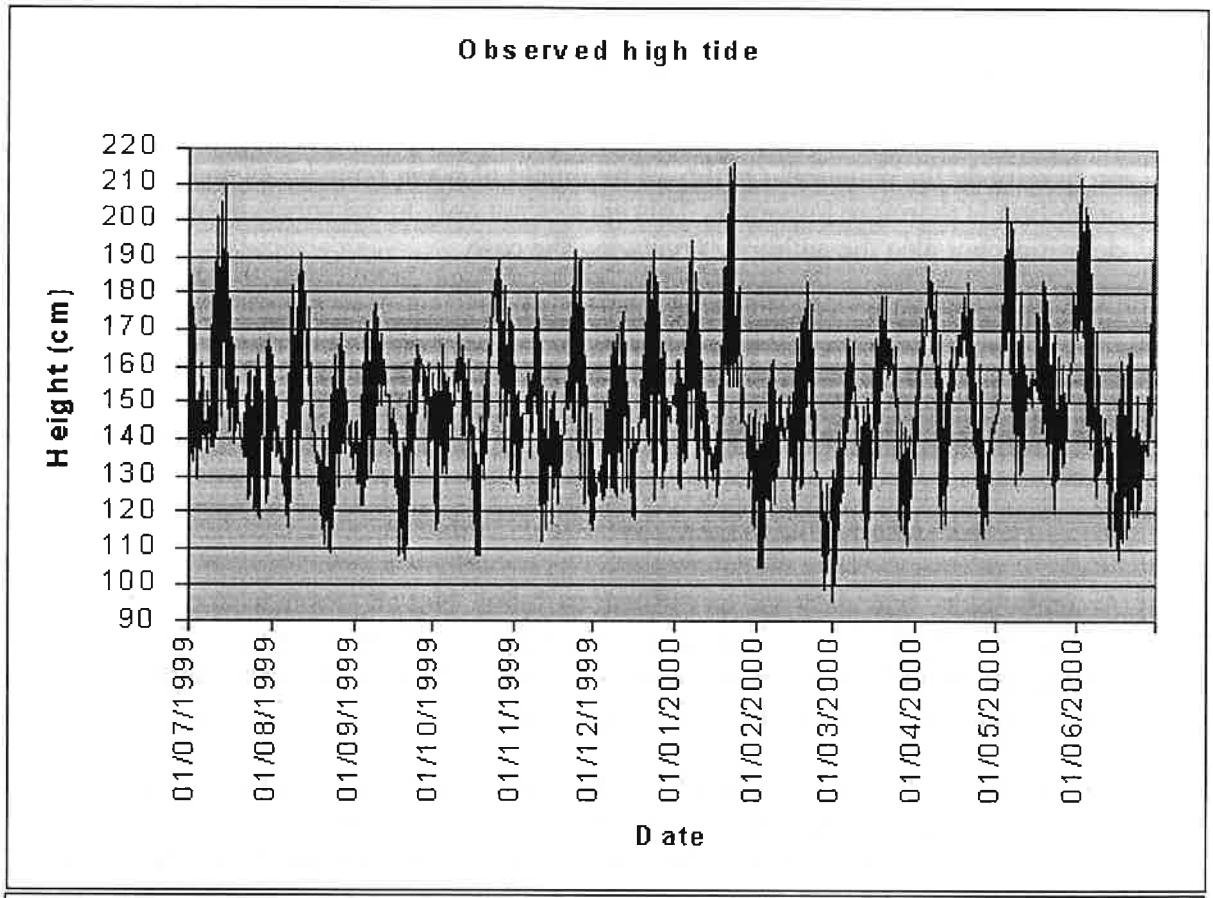


Figure 1. High tides Sydney 1 July 1999 to 30 June 2000

The mean for this set of observations is 148 cm however the official mean high water for Sydney Harbour for the same period is 145 cm. The mean value that has been calculated includes all the tides. The big question is which are the ordinary spring and neap tides? The bigger question is which are the tides outside the official SPR range that must be deleted before a mean can be taken?

Observations over a lunar period could include some of the "unwanted" tides, which if included could cause a bias in the observations. Figure 2 is an example of observations of high tide for a lunar cycle the mean for the period being 150 cm. This period includes some of the highest tides observed in the year and some of the lowest. Which ones must be selected for removal before a mean can be taken? When the year was divided up into lunar cycles the mean values ranged from 138 cm to 157 cm. This is a considerable variation and if you are considering an accurate determination of mean high water over a very flat foreshore then the determined boundary could vary by tens of metres depending upon which cycle was used. Variations due to atmospheric pressure, river flows and wind/wave action can also cause an undesirable bias.

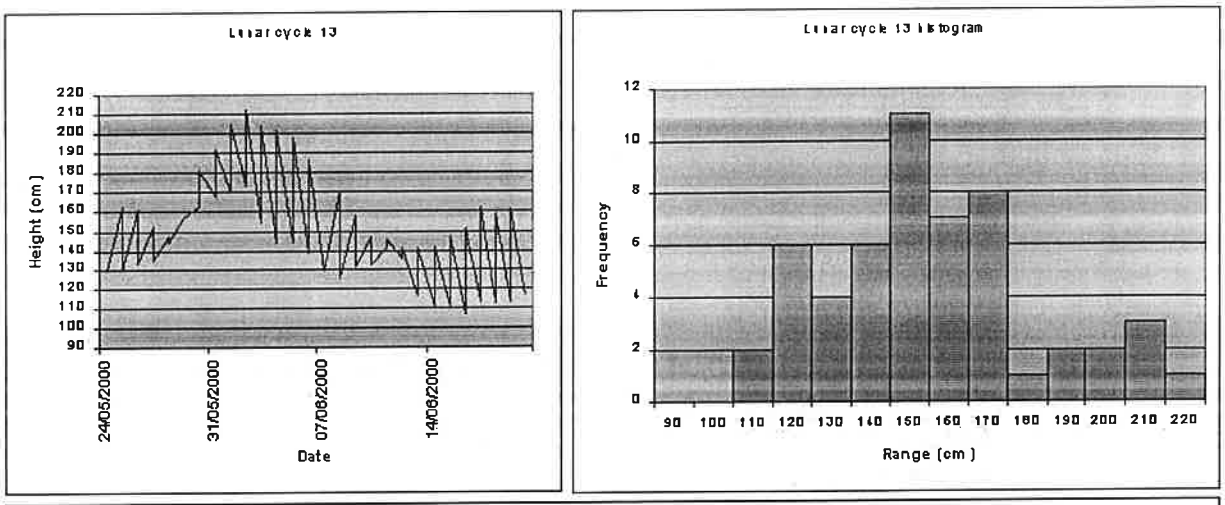


Figure 2. Lunar cycle observations, high tides 24 May 2000 to 20 June 2000

Figure 3 gives an example of a cycle that perhaps does not include any of the tides that need to be excluded. The mean of 157 cm however is still very high and considerably different from the desired mean of 145 cm. The ISG manual indicates a possible accuracy of ±15 mm for this methodology. Observations would seem to indicate otherwise.

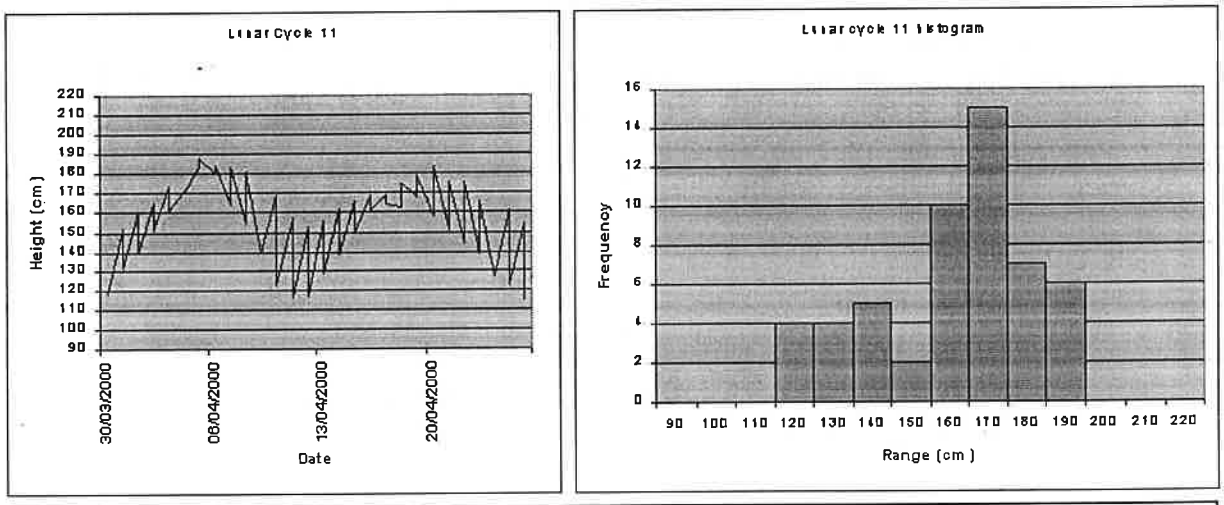


Figure 3. Lunar cycle observations, high tides 30 March 2000 to 26 April 2000

One of the things that should be noted is that the officially published mean high water level includes all observed tidal data. The SPR mean high water that surveyors should use in determining a boundary does not include all tides. Therefore the mean high water commonly used by surveyors as obtained from authorities such as Manly Hydraulics Laboratory cannot in theory be used. A value of mean high water determined over long range observations and published as an AHD value is by far the easiest, most accurate and verifiable method of determining mean high water. It also provides an easy method of determining if any changes have occurred. Perhaps there should be consideration given to moving away from the definition of mean high water

that has been handed down to us from legal cases to a more scientific, reproducible and manageable method.

There have been a number of papers presented to the NSW Staff Surveyors conferences previously. Most noted of these is the paper dealing with the definition of mean high water which was presented by Peter Blume at the 1995 Port Macquarie conference.

Conclusion

The public amenity and land owner entitlements of foreshore land come into considerable conflict at the mean high water boundary. When changes are effected on that boundary then the conflicts can become even greater. The legal processes of changing the boundary may not necessarily coincide with nature's changing of the physical mean high water. It is the cadastral surveyor who must examine the processes at work and arrive at an informed decision as to where the common legal boundary should lie.

The investigating surveyors of Land NSW within the Department of Land and Water Conservation undertake the role of examining definitions of the mean high water boundary of foreshore lands on behalf of the Minister administering the Crown Lands Act 1989. It is their role to ensure all factors are taken into consideration for agreement on the location of the mean high water boundary. As conditions, legislation and public demands change, the procedures adopted for dealing with this sometimes confusing boundary must also change. Those procedures are presently under review to meet the challenges of the future. Not only has mean high water come under closer scrutiny but also other ambulatory boundaries into which protocols will be expanded. The outcome proposed will be a set of guidelines that will be of benefit to all. The support and input of the surveying industry is required to ensure that Surveyors are seen as valuable professionals who are competent in resolving these issues.

References

Attorney General v Chambers (1854) 43 English Reports 486

Blume, P. (1995). *Mean high water revisited.* 71st NSW Staff Surveyors, 1st Association of Public Authority Surveyors NSW conference, Port Macquarie, April 1995.

Kernebone, R.A. (1988*). Section 235A Crown Lands Consolidation Act 1913. Locating the bank of watercourses.* 62nd NSW Staff Surveyors Conference, Salamanda Bay April 1988

Manual of the New South Wales Integrated Survey Grid, NSW Department of Lands (1976)

Registrar General's directions for plans: Volume 1 – Deposited plans. Land Titles Office Sydney (1998).

Surveyor General's directions for survey practice. Cadastral Management Unit, Land Information Centre, Bathurst. (1993, 1994, 1997, 2000).

Tidal data. Manly Hydraulics Laboratory, Sydney (2001)

Woodford, J. (2001). *Alarm as population flocks to the coast.* The Sydney Morning Herald, Monday, January 29, 2001. Page 6

Woodford, J. (2001). *Underwater block of land awash with legal troubles.* The Sydney Morning Herald, Monday, January 29, 2001. Page 6

APPENDIX A

Alarm bells over wave of development along coast

Date: 29/01/2001

By James Woodford, Environment Writer

The NSW coastline faces a wave of urban developments in the next 20 years. Councils predict up to a four-fold surge in their populations.

The State Government has asked local government officials to prepare settlement plans which detail where this massive influx of people will live.

According to documents produced by local governments on the coast and population projections by the Department of Urban Affairs and Planning, the North Coast will experience unprecedented population growth in the next two decades.

There are already more than 625,000 people living along the coast outside the area between Newcastle and Shoalhaven. By 2020, this will almost double to almost 1.1 million. The population of Tweed Shire is projected to rise from 46,200 to nearly 190,000.

Housing estates are also rapidly sprawling through the Illawarra in areas such as Shellharbour. Councils have earmarked slabs of land they say may need to be developed to cope with the influx.

But conservationists and the Government's own NSW Coastal Council are worried about this population explosion. They are calling on the Government to ensure coastal environments are not threatened by large-scale subdivisions driven by developers.

The natural areas campaigner at the Total Environment Centre, Ms Fran Kelly, said a blueprint for coastal development was needed.

"They're not only proposing to double the population, they're doubling the concreting of the coast," she said.

"It's like developers are eating all the land up. It's as if the paradise lifestyle is eating up the paradise.

"Newly rezoned or potential urban development sites are frequently in areas that give best returns to developers yet are the most environmentally sensitive - land along immediate coast, around coastal lakes, headlands, wetlands and other environmentally sensitive greenfield sites."

The centre wants a moratorium on approvals for major subdivisions and is pressing the Premier, Mr Carr, to order an overhaul of the way developers do business.

The chief executive officer of the Nature Conservation Council, Ms Kathy Ridge, said without a moratorium there would be a panicked rush to develop the coast. "We can't have people exploiting the vacuum created," she said.

The chairman of the Coastal Council, Professor Bruce Thom, said the population projections were under-estimates. "I see a situation where population growth as projected involves substantial increases beyond the present and councils are attempting to accommodate that in their planning," he said. "The question is, how do we undertake that planning?"

The coastal crush was driven in part by the good life, said Professor Peter Murphy from the University of NSW's Faculty of the Built Environment. The shift to the coast, termed counter urbanisation, had been traditionally dominated by retirees. However, increasingly, new coastal migrants were affluent professionals looking for investment opportunities and lifestyle outlets, those escaping the high cost of city living, and people looking for alternative lifestyles in a natural environment.

In a recent letter to the Minister for Urban Affairs and Planning, Dr Refshauge, the Total Environment Centre raised the issue of broad-scale subdivision developments in almost every council area between Sydney and the Queensland border.

In areas such as north Hawks Nest in the Great Lakes Council area, a 600-lot subdivision is planned opposite a koala habitat and national park.

Shoalhaven City Council has proposed that large areas near Jervis Bay be examined for potential development as housing estates. A 1,000-lot development has been proposed in Vincentia, and a large development on the Jervis Bay Road is being pursued.

APPENDIX B

Land submerged since surveyed in the 19th century ... Geoff Payne on one of his blocks at Batemans Bay. Photo: Andrew Taylor

Underwater block of land awash with legal difficulties

Date: 29/01/2001

A man wants to build on his land, but part of it is now underwater, James Woodford writes.

Instead of a lawn, Geoff Payne's backyard comprises half a hectare under the Clyde River Estuary at Batemans Bay - a legal minefield causing heartache as far north as Macquarie Street in Sydney.

Mr Payne, a South Coast developer and land valuer, is the first to concede that his block of land raises some interesting questions about the way property was originally carved up by European settlers.

His piece of Batemans Bay foreshore was subdivided in 1838 by the earliest surveyors in the district and comprises 10 parcels of land totalling one hectare in size. His problem is that only four of the titles are today above the mean high tide mark. The other six spend most of the time completely submerged.

All 10 of the blocks have a fixed rear boundary, which means that even though his land has been drastically eroded his back "fence" has stayed put - marker posts are still visible out in the middle of the estuary. Near the half-submerged posts, under several metres of water is a 30-metre-wide strip of land set aside by the 19th century surveyors to ensure public access to the foreshore. Today only the strongest of swimmers could take advantage of that guaranteed right of way.

In the next few weeks the issue of how eroded waterfront land is managed will be considered by State Cabinet. It is understood that Mr Payne's case is regarded as one of the most extreme examples of a submerged land title in NSW.

Mr Payne bought the properties five years ago and set a goal of making it usable within a decade. He has been planting 400 trees a year to try to stabilise the part of his land that is above the water and has been successful in reclaiming a large section by vegetating low-lying sand dunes.

He blames the construction of the Batemans Bay Bridge in the 1950s for the erosion of his land.

A solution to make his land worth owning has been to propose a 150-seat restaurant on piers. He has not yet lodged a development application with the Eurobodalla Shire Council but says one may be imminent.

The beauty of his proposal, Mr Payne said, was that the fact his land was submerged was crucial to the pier concept. His plans would not diminish public access to the beach at all.

"The restaurant idea came out of necessity," Mr Payne said. "It's nice to own a beach and it's an unusual piece of land but we are trying to get some purpose out of it. "

To do anything with his property Mr Payne estimates he would have to deal with at least 10 different government agencies, including NSW Fisheries, the Department of Land and Water Conservation and even the Water Police. "Their concern is that this is a navigable waterway," he said.

The chairman of the NSW Coastal Council, Professor Bruce Thom, said Batemans Bay was not the only place where land titles were clashing with the erosive force of the sea. At Collaroy and Narrabeen authorities were also confronted with the problem of privately owned sections of beach. Similar issues existed on the North Coast at Byron Bay.

"The Coastal Council is concerned about the implications of this kind of development extending into the waters of Batemans Bay and we will be investigating this development ," Professor Thom said.

Rock Art and Cave Painting : A Surveyor's Perspective

J. G. Fryer
Department of Civil, Surveying and Environmental Engineering
University of Newcastle, NSW, Australia 2308
e-mail: cejgf@cc.newcastle.edu.au

Abstract

On every continent there are reminders of prior civilizations. Many of these are not just artefacts such as jewelry or bronze arrow-heads, but involve deliberate and thoughtful changes to the landscape for reasons often best known to that culture's traditional ceremonies and beliefs.
This paper and its presentation will show some classic examples from Europe and then compare them to some little known Australian and Hunter Valley cave paintings, rock engravings and tree markings. These local examples probably pre-date their European counterparts by many thousands of years.
An ongoing research project to combine modern technology and the concept of knowledge-based reasoning from the discipline of information science is briefly discussed. The roles which surveyors may take in recording pre-history is emphasized.

Introduction.

This paper has been written as a result of a personal interest in archaeology, specifically those traces of prior civilizations which have left the landscape altered or marked in some way. Why? Probably because that is exactly what surveyors do and have always done : *mark the landscape*. As this paper and its accompanying talk represent a small voyage of personal discovery, it must be stressed that it is not a definitive exposition of ancient monuments or rock art. If it raises interest and/or appreciation, in the reader, viewer or listener, then it has achieved its modest goal.

Time Frames.

The prehistory artefacts of Europe date from about 14,000 BP. (The abbreviation 'BP' will be used to refer to dates 'before present'). The superb cave paintings in Spain and France, which show early hunters in pursuit of now-extinct bison and other game, have been dated back to this time. Of course, civilizations existed before then, but they did not leave monuments which could survive the last Ice Age (from 10 to 17,000 years BP).

The rock monuments of Great Britain and Ireland, such as standing stone arrangements like Stonehenge, are dated in the range 4,000 to 7,000 BP. The impressive circular rock burial chamber at Newgrange (50km north of Dublin, Ireland) has a diameter of 87 metres, stands 13 metres high and is dated at 5,200 BP. This is just after the last Ice Age, a time when much of Europe was uninhabitable. These UK stone monuments (as an example see Figure 1) are generally accepted as having been constructed prior to the pyramids of Egypt which were about 4,000 BP. The classic structures of the Greeks are "only" about 3,000 years old.

Much later modifications of the landscape came with figures such as the Cerne Giant (see Figure 2). This 57 metre long figure in southern England was formed about 1500

BP by scraping away the top-soil and exposing the underlying chalk hillside. Fertility symbols are frequently associated with many ancient monuments, statues, paintings or artefacts.

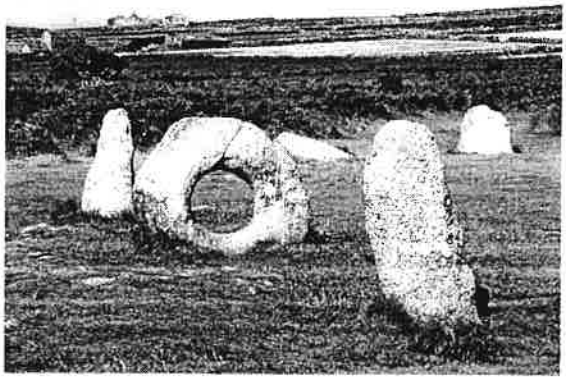


Figure 1. Men-an-tol Stone Arrangement, Cornwall.

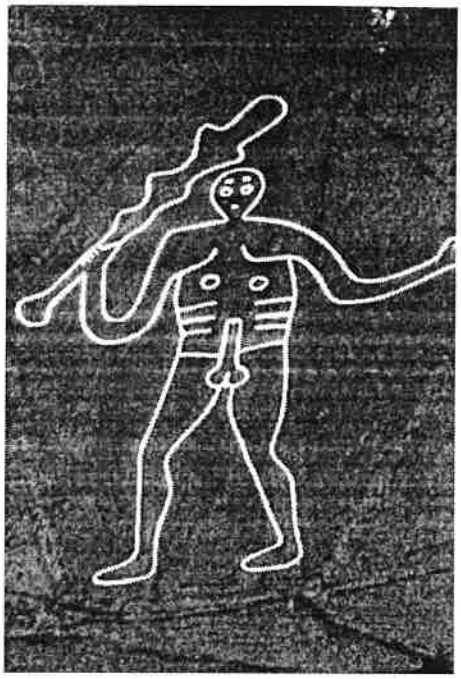


Figure 2. The Cerne Giant, a 57 metre long chalk figure, Southern England.

In some northern European countries, such as Finland, the rock was basically too hard to break up to construct monuments or make rock engravings. Paintings were placed directly onto exposed rock surfaces and some have survived to the present time and been dated to the post Ice Age period at about 5,000 years BP.

Finland is extremely interesting from a surveying/geological viewpoint as it is still experiences post Ice Age uplift. The land has risen some 50 metres as a re-bound effect of the great weight of ice melting, and is still rising at 10mm/year. This means that small paintings on rock-faces next to waterways placed by travellers, fishermen or hunters are now some 50 metres up the face of often sheer cliffs, and have been directly exposed to severe weather conditions. As the sizes of rock paintings in this region were mostly only 100mm, this makes them very difficult to find, see or record. See Figure 3 for a typical example of Finnish rock art.

Figure 3. Finnish rock art.

Time Frames in Australia.

Perhaps because Australia was largely unaffected by the Ice Age which blanketed Europe 10,000 to 15,000 years ago, much evidence of prior occupation of the country still exists. Some examples of datings include :
Rock engravings – 42,000 years BP (South Australia)
Cave paintings – 5,000 in NSW and 25,000 in Northern Territory
Edge-ground axes – 3,000 in NSW to 23,000 in Northern Territory
Carved trees – unlikely to be greater than 3,000 years
Burial sites – a staggering 60,000 BP in NSW (Mungo man)

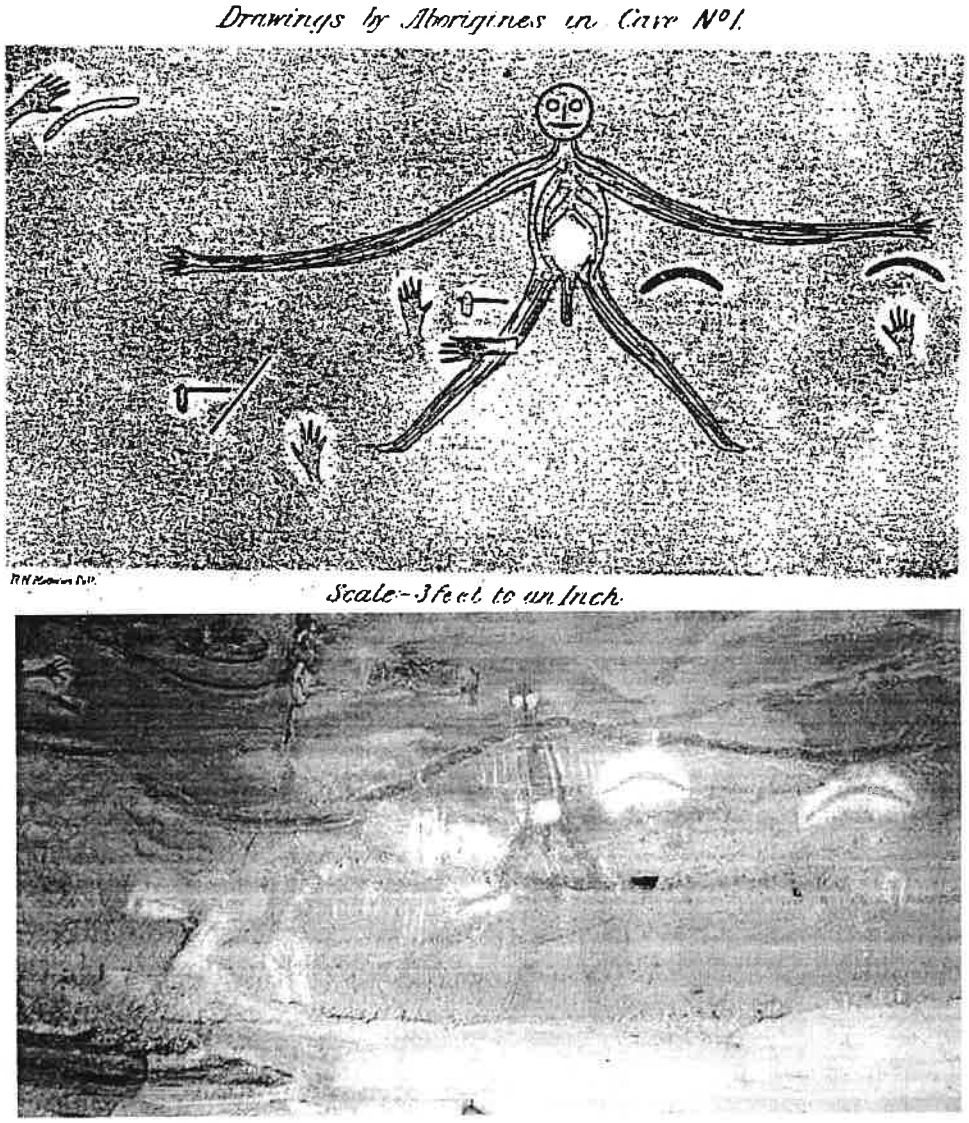


Figure 4. Baiame, The Maker of All Things. A comparison of Surveyor Mathew's field-notes (1880) and a recent photograph, Hunter Valley, NSW.

Cave Paintings

Aboriginal cave paintings have become a tourist attraction in Australia since their relatively recent (late 1960's and 70's) 're-discovery'. Although the existence of some cave paintings was well-known since the time of European colonization, not much attention had been paid to their systematic discovery, recording or recognition

until the 1960's. It has been argued that this corresponds to the development of archaeological courses in Australian universities and the recognition given to indigenous peoples by the government around that time.

Many of the earliest recordings were by surveyors, often in the role of explorers. Excellent examples of aboriginal rock art and cave paintings can be found in papers published by Surveyor Robert Hamilton Mathews (1841–1918). Figure 4 shows a comparison of one of his field-note sketches and a recent photograph taken in the Singleton area of the Hunter Valley.

Aboriginal paintings have been examined and categorized in several ways. One categorization, by Chaloupka (1993) describes four different *periods*, or time-frames. These are :

- Creation (or Dreaming),
- Sorcery,
- Love-Magic, and,
- Secular (day-to-day) activities.

Within these broad periods, dating back to 50,000 years ago, various *styles* can be identified. These styles include *X-ray*, in which the internal organs may be seen, *dynamic* (examples of running, hunting, perspiration dropping off foreheads, etc.), and *stylized* where the painted figures have more of a cartoon-like appearance than a true-life representation.

Several factors which are time-based may be noticed in cave paintings. These include the effects of the large 120 to 150 metre rise in sea level around Australia at the end of the last Ice Age (around 8,000 years BP). Caves which had been a long way from the ocean and up till then had contained images of only kangaroos, emus and the like, started to display images of salt-water fish, crocodiles and sea-birds. Similarly, the appearance, and then disappearance, of now extinct animals such as the thylacine and diprotodon from paintings in caves provide another form of evidence as to the antiquity of the art-work. See Figure 5.

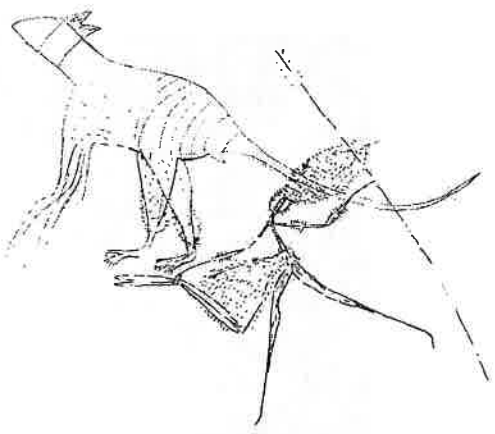


Figure 5. Thylacine (Tasmanian Tiger) and Stylised Hunter (detail from cave painting, Northern Territory)

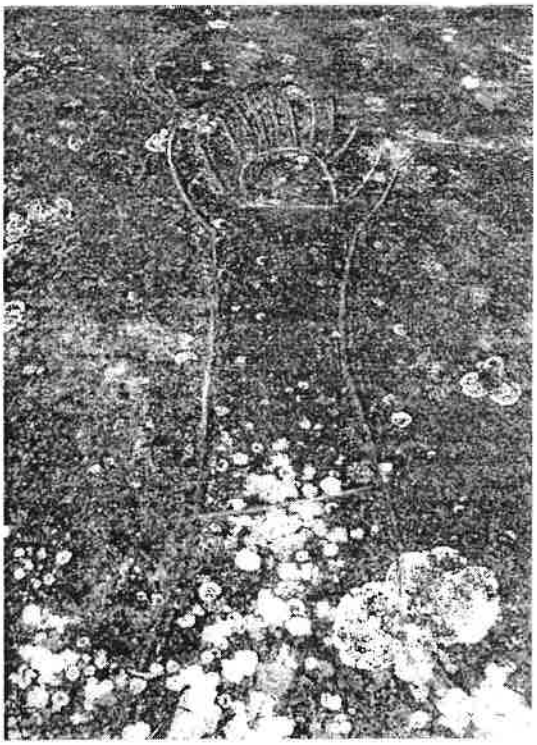
Very often, mixed periods and styles may be seen in the same cave. More confusing can be the over-painting of images when dating is required. Sometimes images have been of such cultural or ceremonial importance that they have been 're-touched' over the centuries. On other occasions, more modern paintings seem to have been placed haphazardly over earlier work. The reasoning for this may never be known, although given the advances in imaging, DNA analyses, radio-carbon and other dating methods, the unknowns of today may be solved in the future.

Rock Engravings.

Engravings on rock in Australia have been dated back to 42,000 years BP. These dates are significantly older than better known engravings from Europe : such as the circular designs on Celtic crosses and entrance rocks at Neolithic burial chambers (say 5,000 BP).

There are a large number of rock engraving sites in Australia, many within close proximity of densely populated areas, yet little public recognition is given to them. Sometimes known as petroglyphs, these engravings encompass the same wide range of artistic and cultural styles as cave paintings, see Figure 6 for examples of the creation and secular themes. In addition, it would seem that directions for travellers were engraved in the rocks along walking trails. Emu foot-prints and figures pointing along ridge-lines strengthen this belief.

With the passage of time and no indigenous persons to routinely maintain the grooves in the rock, natural erosion and lichen growth makes these markings difficult to find. Occasionally the sun-angle or light rain might happen to highlight the engravings.



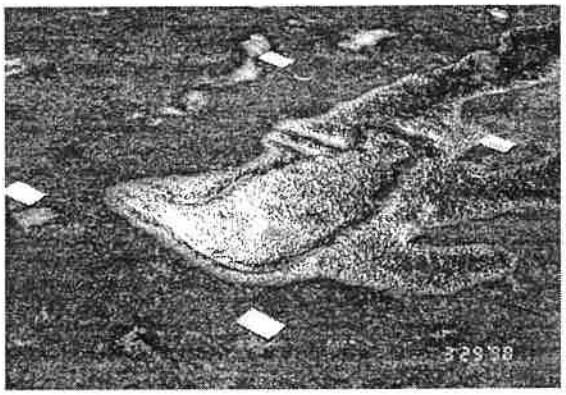


Figure 6. Examples of Rock Engravings in Hunter Valley, NSW. Note how the addition of water to an engraving enhances its visibility.

Burial Sites and Carved Trees

Throughout history, birth, life and death cycles have always been prominent themes in cultural beliefs and ceremonies. Burial patterns have ranged from the elaborate Neolithic chamber tombs in Ireland to the burial of Pharaohs in pyramids to the simple marking of a grave site with a tomb-stone. The pose of the deceased has often been important, from the curved foetal positions of ancient Britons to embalmed mummies in Egypt to the seated positions adopted by some Aboriginal tribes in Australia. A sprinkling of red ochre often accompanied the early Australian burial ceremonies and, inadvertently, provided a mechanism for dating the burial site.

Some marked trees in Australia refer to indigenous grave sites. A well-known one is that of Yuranigh's grave at Molong (near Orange, NSW). Yuranigh was one of Sir

Thomas Mitchell's guides, and apart from four engraved trees, Mitchell thought so highly of Yuranigh that he provided a marble head-stone. Remarkable, to me at least, is the striking similarity between the carved tree at Yuranigh's grave and the entrance stone to the 5,200 BP Newgrange burial chamber, 50km north of Dublin, Ireland.

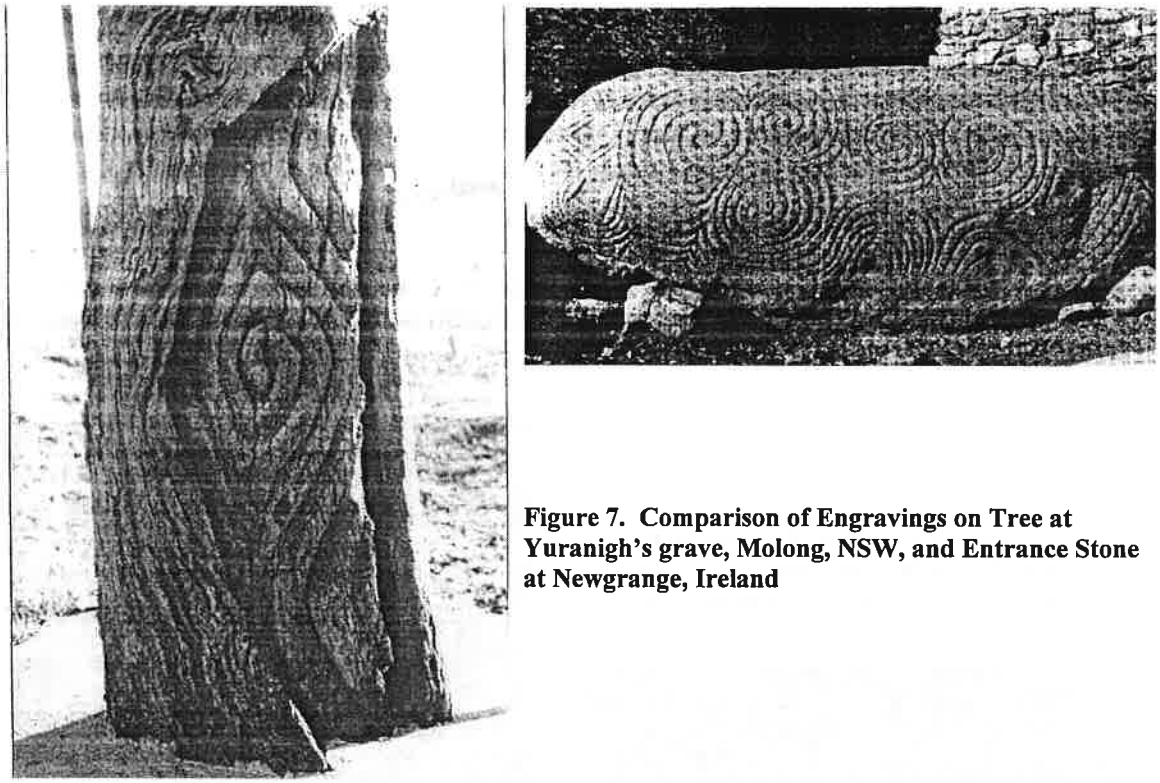


Figure 7. Comparison of Engravings on Tree at Yuranigh's grave, Molong, NSW, and Entrance Stone at Newgrange, Ireland

Other Aboriginal carved trees indicate ceremonial grounds and initiation sites, whilst those more commonly found have blazes on them as a result of canoes, shields or coolamons being excised. They all provide evidence of prior civilization and cultural beliefs, but are gradually falling prey to fires, clearing, weather conditions and time.

The New Zealand Experience

Maori have been inhabiting New Zealand for a period estimated at 800 to 1000 BP. A ten year project to find and record their rock art was established in 1994 using "Lotto" proceeds. On the South Island, most of their rock paintings were in limestone caves or directly placed onto exposed limestone rock faces. Some were painted with a mixture of animal fat and a red pigment, but most were made with charcoal.

A range of styles and themes similar to that of the art of Australian aboriginals may be seen, although much of it involves a symbolism which is not understood by present-day Maori. This description refers to the South Island where some tribal symbols and meanings have not been passed down to the present generation. See Figure 8 for some examples – "birdman", giant eagle, man-figure and symbolic painting.

Other sites show remnants only of images. Techniques used in remote sensing to enhance images are being applied to try and enhance those images which are barely visible to the spectrum of the human eye.

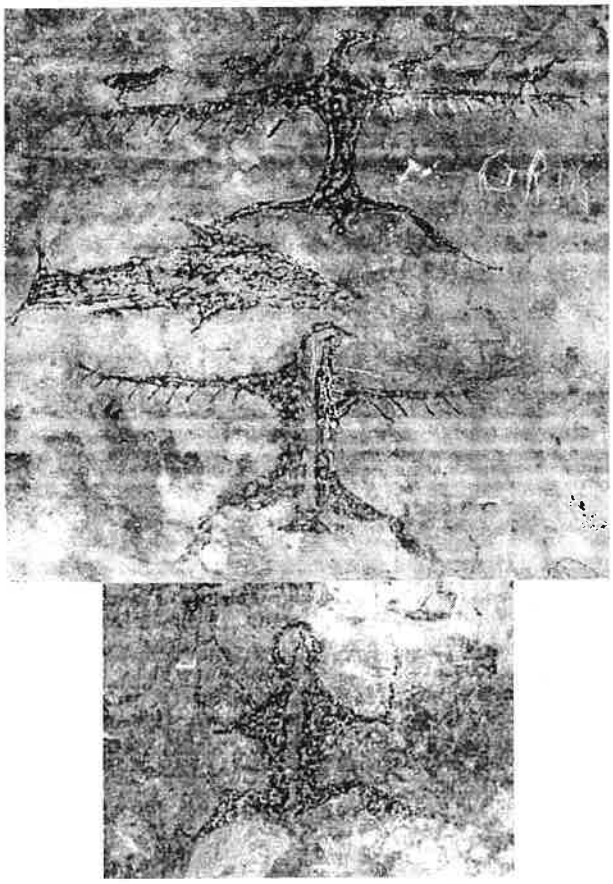


Figure 8. Maori Rock Art, near Timaru, South Island.

A Role for Surveyors?

There is no doubt that rock-art is becoming more widely recognized, globally, as a most valuable link to the past. In the past 30 years many important new sites have been discovered. In fact, the present project on the South Isalnd of New Zealand has increased the number of known sites in that region by over 300% in the past 7 years!

It has been shown that early Australian surveyors were pro-active in recording Aboriginal rock art. In recent times the paranoia regarding Native Title and Land Rights has probably done more to dampen rather than inspire enthusiasm in reporting finds of rock engravings and paintings. This must be seen as short-sighted expedience as the importance of Australia's pre-history becomes unraveled by modern scientific techniques such as radio-carbon and thermo luminescent dating and DNA sampling.

Who are better equipped than surveyors to locate and record rock art? Modern recording of sites involves the "total scene" with a survey of the surrounding area, noting the orientation and aspect of the art and detailing all other features of the landscape. The incorporation of site information into rock art GIS data bases is controversial at present, but with due consideration of who may have access to such data, is another role which surveyors may undertake.

Total scene recording can lead to the creation of virtual reality models, so links may be created from a GIS data base to the equivalent of a "virtual museum", where the rock art may be viewed in 3-D and interpretive descriptions given. Already many surveyors are creating "drive-throughs" of their new subdivisions or road designs, so the transition to virtual reality modeling is already underway. Don't let this be another area of information technology which surveyors feel it is too difficult for them to control. Who else has the training in 3-D?

Acknowledgements

Without the assistance of Garry Jones for site visits in the Hunter Valley, my passion for archaeological research would not have been ignited. The guidance of Mauriri McGlichey, Field Officer with the Ngai Tahu Maori Rock Art project is acknowledged as is that of George Benwell for making my New Zealand trip possible.

References

Although not directly quoted in the text, the following are valuable sources and starting points for those interested in further study into Australian and world rock art.

Chalmers, A., Brown, K. R., and d'Errico, F., 2000, Surveying for Ice Age Art, *Surveying World*, 5(8):40-41.

Chaloupka, G., 1993, *Journey in Time*, Reed, Australia, 256 p.

Flood, J., 1999, *Archaeology of the Dreamtime*, 4th ed., Harper-Collins, Sydney, 328 p.

Ogleby, C., 1991, Recording Aboriginal Rock Art – Beyond the Tea Towel, *First Australian Photogrammetric Conference*, Sydney, Paper 2, 8 p.

Trezise, P., 1993, *Dream Road*, Allen & Unwin, Australia, 205 p.

An Assessment of the Geoid in Mountainous Terrain in NSW

Andrew Rigelsford
Department Of Civil, Surveying and Environmental Engineering
University of Newcastle

Abstract

At present there is growing interest among the surveying profession in determining accurate orthometric heights from Global Positioning System (GPS) surveys. As a result of this interest the need to further assess the accuracy of the current Australian geoid model is becoming more apparent. Recent investigations around Australia have produced general quantitative statements on the accuracy of orthometric heights obtained using the AUSGEOID98 model. However, there still remains a greater level of uncertainty in the performance of the AUSGEOID98 geoid model, particularly in the mountainous regions of Australia.

This paper describes the results of two separate investigations into the accuracy of AUSGEOID98. Relative carrier-phase GPS observations made at AHD benchmarks are used to estimate the accuracy to which the geoid height model is known in each mountainous region. The results of the study indicate that the AUSGEOID98 geoid height model is performing well within it's specified error estimates in the Southern Highlands of NSW, but not so in the Bathurst/ Lithgow region crossing the Great Dividing Range. There is evidence to suggest however that the presence of a gross or systematic error in the first order levelling may be contributing to the mediocre results obtained in this area.

Introduction

The impact of the Global Positioning System (GPS) on traditional surveying applications has been most beneficial, particularly in the field of control surveying. In recent times, surveyors have recognised that the impressive efficiency of GPS could be further enhanced if both horizontal and vertical geodetic control standards could be achieved simultaneously. The problem associated with the vertical component lies with the existence of two entirely different height systems.

GPS is a three dimensional system providing ellipsoidal heights relative to a reference ellipsoid (ie. a mathematical approximation of mean sea level). These heights differ to orthometric heights, typically derived from geodetic levelling, referenced to the physical surface of the geoid. For GPS surveyors to achieve vertical control standards, an accurate knowledge of the position of the geoid with respect to the reference ellipsoid is therefore essential. In Australia, the AUSGEOID98 geoid height model is the current means of transforming GPS- derived ellipsoidal heights to Australian Height Datum (AHD) heights.

In 1999, the ICSM Geodesy Technical Sub-committee in conjunction with AUSLIG initiated a campaign of evaluating the accuracy of AUSGEOID98 in Australia, as part of the nationwide Height Modernisation Project. It is intended that geoid validation studies, similar to those discussed in this paper will provide the data required for the

refinement of AUSGEOID98 so as to provide accurate, economical and more reliable heighting by GPS.

This paper reports on a study of the AUSGEOID98 geoid model in two mountainous regions in NSW- from Albion Park to Berrima in the Southern Highlands and from Bathurst to Lithgow crossing the Great Dividing Range.

The Geoid in Australia – AUSGEOID98

The recent demand for an accurate geoid has been fuelled by the success of GPS surveying. In 1998 AUSLIG released a new national gravimetric geoid for Australia known as AUSGEOID98 (Featherstone and Johnston, 1998). This new model replaces previous national geoids including AUSGEOID93 and AUSGEOID91, offering improvements in areas of rugged terrain and coastal regions.

AUSGEOID98 was developed using the latest available data and computational techniques with geoid- ellipsoid separations computed on a 2' by 2' grid referenced to the GRS80 ellipsoid. It uses the EGM96 global geo-potential model (Lemoine et al 1998); the 1996 AGSO gravity database; satellite altimeter derived gravity anomalies (Sandwell and Smith, 1997) and the 9" Digital Elevation Model (DEM), (Carrol and Morse, 1996), providing the basis for terrain corrections improving the geoid model in areas of rugged terrain.
Numerous investigations have found that AUSGEOID98 is generally accurate to 0.3m in an absolute sense and in most cases provides height differences to third order levelling standards.

Analysis of AUSGEOID 98 Geoid Model

In this investigation, the performance of the AUSGEOID98 gravimetric geoid model is evaluated in two mountainous regions of NSW using GPS and spirit levelling data. To assess the accuracy of the AUSGEOID98 model for the determination of AHD height in both project areas, the two available methods of geoid validation on land were used.
The first method tests the absolute accuracy of AUSGEOID98 N values by comparing model estimates to geometrically determined geoid heights using GPS/levelling data and equation (1).

$$H = h - N \qquad \text{---- (1)}$$

Where H is the height above the geoid, AHD height (m)
h is the ellipsoidal height (m)
N is the geoid- ellipsoid separation (N value)

The second method tests the relative accuracy of the geoid ellipsoid separation (ie the gradient), by comparing GPS derived AHD height differences computed using AUSGEOID 98 and equation (2) with spirit levelled AHD height differences,

$$\Delta H = \Delta h - \Delta N \qquad \text{---- (2)}$$

Where Δ indicates a change or difference in height quantities outlined above.

The relative assessment is of more use to surveyors contemplating propagation of height differences using GPS. As such, if there is agreement within the tolerances specified for conventional geodetic levelling, then it is reasonable to assume that GPS, in conjunction with AUSGEOID98 is a viable alternative to traditional levelling techniques

The Test Data

In 2000, the Land and Property Information NSW commenced their involvement in AUSLIG's nationwide Height Modernisation project. As part of work undertaken, two GPS networks were designed to allow an assessment of AUSGEOID98 in each mountainous region. For both surveys four roving dual- frequency carrier phase Trimble GPS receivers were used in fast static mode.

The first GPS survey was carried out along the 1st and 2nd order level routes between Berrima (in the Southern Highlands) and Albion Park (South of Wollongong). GPS observation of 38 baselines formed the network, resulting in 17 stations with very accurate AHD and ellipsoidal heights, providing the data for this investigation. It is estimated that the mean standard error of the GPS ellipsoidal heights from the network adjustment is +/- 20 mm.

The second survey used in this study is a GPS and Class A (first order) geodetic levelling traverse between Bathurst and Lithgow in central western NSW. This section of the Great Western Highway characterised by mountainous undulating topography crossing the Great Dividing Range was considered an ideal study environment. GPS observation of 46 baselines formed a network resulting in 29 stations with accurate ellipsoidal and first order AHD heights. The mean standard error of the GPS ellipsoidal heights is estimated to be +/- 30 mm.

Performance of AUSGEOID98 in Wollongong/ Southern Highlands Region

An assessment of the accuracy of AUSGEOID98 in the project area was made by comparing model estimates of geoid height with geometrically determined geoid heights using equation (1) at the 17 stations used in this analysis. The model AUSGEOID98 geoid heights have been interpolated from the pre computed two-minute grid using the Bi- quadratic geoid interpolation method.
Figure 1 shows a graphical representation of the misclose determined from the comparison of model and geometrically determined geoid heights at 17 benchmarks along the profile.

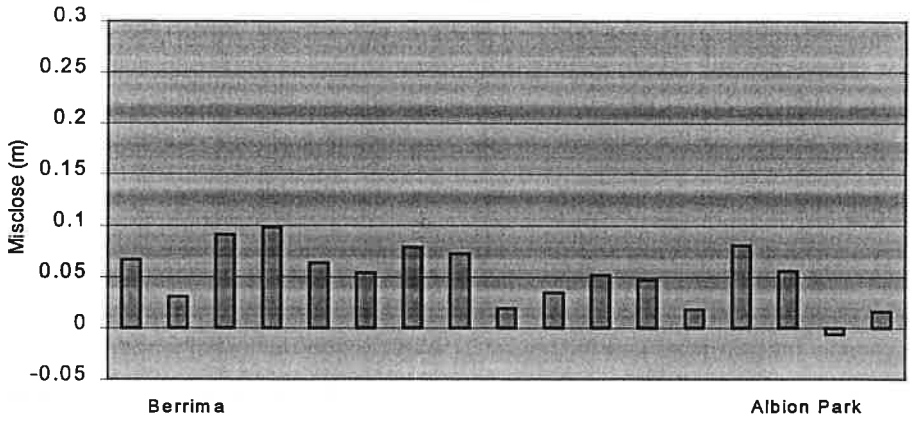


Figure 1. Differences between model and geometrically determined geoid heights from GPS/levelling

The nominal differences between geoid heights estimated by AUSGEOID98 and by GPS/Levelling at 26 benchmarks ranged from –0.006 to +0.098m. The mean difference (misclose) was 0.053m and the standard deviation of a single observed difference is 0.029m.
A consistent observation based on the results shown in Figure 1 is that AUSGEOID98 geoid heights are systematically greater than those derived geometrically using GPS and AHD data. When comparing these results from the absolute assessment to the general accuracy statement of 0.3m for AUSGEOID98 it is evident that this geoid height model offers a reasonably accurate means of transforming GPS ellipsoidal heights to AHD heights in this region.

At present however GPS is typically used in a differential sense, for the majority of satellite surveying applications as opposed to single point positioning. Differential GPS provides baseline vectors observed to give differences in ellipsoidal height between stations, which then must be transformed to a difference in AHD height using the appropriate change in geoid-ellipsoid separation. Hence an assessment of the relative accuracy of the geoid- ellipsoid separation, obtained by comparing GPS-Ausgeoid98 derived AHD height differences to published height differences is thus more informative to the GPS surveyor.
Figure 2 shows a scatter plot of the magnitude of the miscloses between GPS-Ausgeoid 98 derived AHD height differences and published height differences for all reduced baselines in the network.

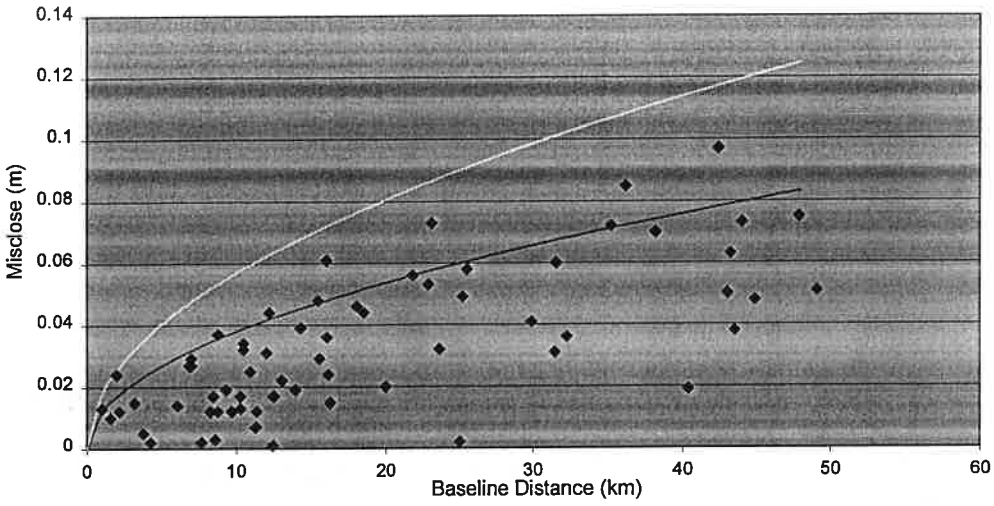


Figure 2. Magnitude of discrepancies between GPS-Ausgeoid98- Derived and published AHD Height Differences over all reduced baselines.

As the primary survey application of Ausgeoid98 is the transformation of GPS heights to the AHD, it is important to assess the results against traditional levelling specifications. The derived miscloses shown in Figure 2 were compared with the curved lines representing the allowable error tolerances under Australian third and fourth order levelling specifications. From the distribution of results 89% of all misclose values fall within third order and all values fall within fourth order levelling error limits for a variety of baseline distances.

Statistically speaking the average of the allowable misclose under 3rd order levelling specifications for the 58 reduced baseline comparisons was 0.05 m. GPS- Ausgeoid98 derived AHD height differences when compared with published height differences give an average misclose of 0.035m.

The results of this investigation indicate that in this mountainous region the geoid is well modelled by Ausgeoid98. For all but the shortest lines, GPS and Ausgeoid98 can generally obtain AHD height differences to an accuracy that indicates this technology to be a viable alternative to spirit levelling

Performance Of AUSGEOID98 in Bathurst /Lithgow Region

Figure 3 shows a graphical representation of the misclose values determined from the comparison of model geoid heights to geometrically derived geoid heights using equation (1) at 26 benchmarks along the profile

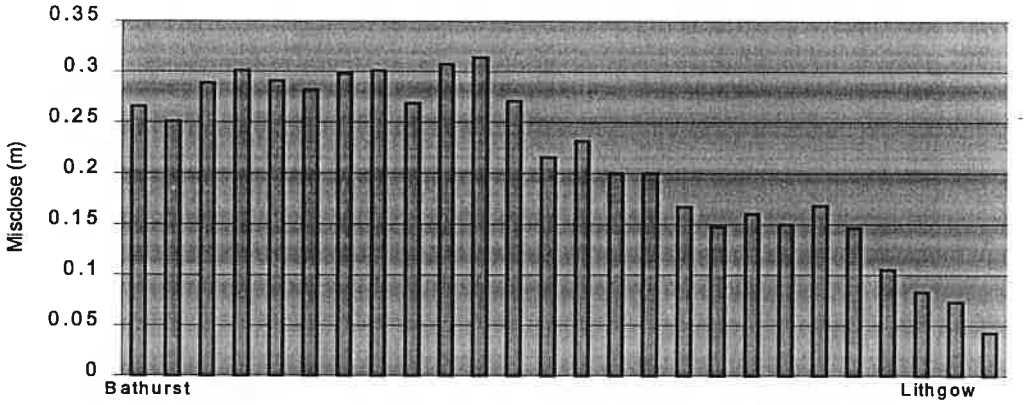


Figure 3. Differences between model and geometrically determined geoid heights from GPS/levelling

The nominal differences between geoid heights estimated by AUSGEOID98 and GPS/levelling ranged from 0.08 to 0.320m .The mean difference was 0.204m and the standard deviation of a single observed difference is 0.081m. The absolute assessment indicates that Ausgeoid98 is generally unsuitable for AHD height determination particularly in the Bathurst area where the misclose is consistently of the order of 0.3m.

As these results were generally worse than the Southern Highlands project an investigation was made into the AHD levelled heights. The misclose for the 819km loop containing the level run between Bathurst and Lithgow is +0.27m. This misclose is approximately 2 ½ times the allowable error limit according to Australian first order levelling specifications based on the loop distance (Roelse, Granger and Graham, 1975). Of particular interest is the fact that this misclose is in the corresponding direction and size as the derived miscloses between model geoid heights and GPS/levelling estimates of geoid height. This not only places doubt on the classification of levelling being classed as first order in this region, but there remains a possibility of gross or systematic error in the levelling which could be contributing to the poor results.

Figure 4 shows a scatter plot of the magnitude of the miscloses between GPS-Ausgeoid98 derived AHD height differences and published height differences for all reduced baselines in the network.

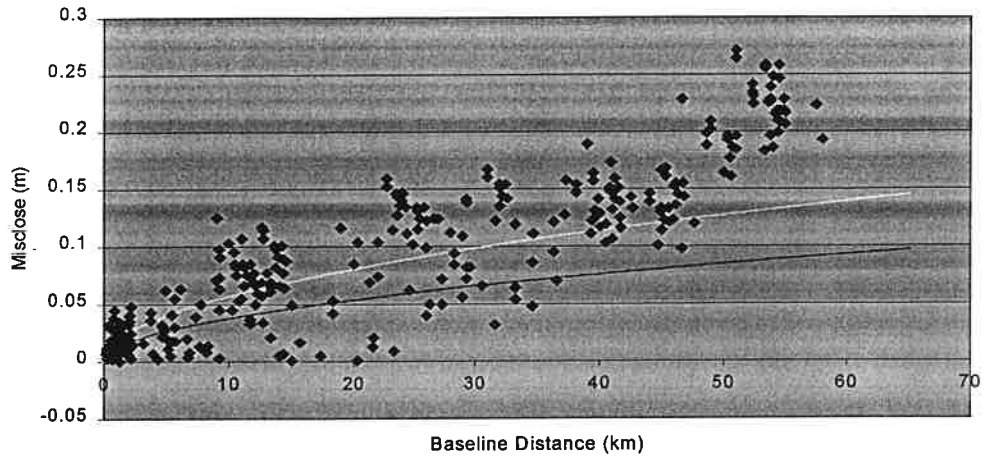


Figure 4. Magnitude of discrepancies between GPS-Ausgeoid98- Derived and published AHD Height Differences over all reduced baselines.

Once again the misclose values shown in Figure 4 above have been compared with the error tolerances for 3rd and 4th order levelling specifications. The average of the allowable misclose under 3rd order levelling specifications for the 58 reduced baseline comparisons was 0.053m. GPS-Ausgeoid98 derived AHD height differences give an average misclose of 0.096m.

The results of the relative evaluation of Ausgeoid98 in this region indicate an uncommon source of error in the gravimetric geoid crossing the Great Dividing Range. This investigation has found that Ausgeoid98 is unsuitable for AHD height determination in this area.

Conclusion

The Ausgeoid98 geoid height model is instrumental to the computation of orthometric heights on the AHD from GPS surveys. The investigations into Ausgeoid98 presented here were designed to generally indicate its performance in mountainous terrain where the greatest uncertainty currently exists.

Based on a number of comparisons with GPS and levelling in the Southern Highlands project, Ausgeoid98 has been found to provide 10cm (1 sigma) accuracy in an absolute sense and is generally capable of producing results within third order spirit levelling limits when used in a relative sense.

However the results obtained from the assessment of the geoid in the Bathurst/Lithgow region were somewhat different to those from the first investigation. Results suggest that AHD height can be estimated in Lithgow to 0.1m, and can only be achieved at the 0.3m level in Bathurst. The relative analysis found that Ausgeoid98 remains unstable for accurate AHD height determination in this area, as third or fourth order spirit levelling specifications generally were not achieved. These results indicate an uncommon error source in Ausgeoid98 geoid heights and/or deficiencies in the levelling in this region. There is evidence to suggest the possibility of gross or systematic error in the levelling although the relative analysis does not clearly show this is certain. Despite this the evidence has cast doubts as to the validity of classifying levelled heights as being first order in the project area. Further

investigations as part of the nationwide Height Modernisation Project is recommended to detect wether the problem lies with errors in the levelling or the modelling of the geoid in this area.

The series of investigations undertaken is intended to assist AUSLIG in their future refinement of national geoid height models for Australia such that they provide a more direct and accurate determination of AHD heights by GPS.

Acknowledgements

I would like to thank all involved at the Land and Property Information NSW (Bathurst & Newcastle) for giving me the opportunity to undertake the undergraduate training program in 2000. I acknowledge the support and assistance of my co-workers during this time giving me the opportunity to work on a number of projects including the one presented here.

I wish to thank all those who assisted in the completion of fieldwork used in this project. Special thanks also to Greg Dickson, Case Bosloper, Chris Hicks, Owen Moss, Glenn Jones, Neville Krahe, Tony Watson and Charles Zahra for providing the resources and continual assistance with which to conduct this research.

References

Ahmad, Z, A.Chan, and A.H.W. Kearsley.1993. National Height Datums, Levelling, GPS Heights and Geoids. Australian Journal of Geodesy, Photogrammetry & Surveying 59: 53-38

Featherstone, W.E. and G.M. Johnston.1998. Ausgeoid98: A new gravimetric geoid model for Australia. Australian Surveying and Land Information Group

Featherstone, W.E. Refinement of Gravimetric Geoid Using GPS and Levelling Data. Journal of Surveying Engineering, May 2000 vol. 126 No. 2 pp 27-54

Roelse, A, H.W.Granger and J.W.Graham, 1975. The adjustment of the Australian Levelling Survey 1970-1971. Technical Report 12 Division, National Mapping.

Digital Record Tracings for Coal Mines

Matthew Smith
University of New South Wales, Student

Introduction

This paper describes a project undertaken as a fourth year project at the University of New South Wales. The project undertaken was the creation of a Digital Record Tracing for Berrima Colliery as described within the Survey and Drafting Directions (2000). Within this journal I will recount the issues discovered when using the Survey and Drafting Directions (2000) as a guide during the creation of the DRT. This includes issues relating to the integrity of the dataset due to the method of submission to the Department of Mineral Resources.

Background

Part of the surveyor's duties within a coalmine is the preparation of a *mine working plan* and subsequent *record tracings (R.T.)*. Both of these plans are a series of transparency sheets that have two-dimensional representation of features that are required to be recorded by the Survey and Drafting Directions.

Scanned image1, sheet 24 of R.T. 59 for Berrima Colliery

The Department of Mineral Resources retains the record tracings. They are then sent to a mine each six months to be updated from the mine workings plan and then returned to the department.

As part of the new Survey and Drafting Directions (2000) within the Coal Mines (Underground) and (General) Regulations 1999, coalmines within NSW must convert from the current method of recording, storing and R.T. submission to the electronic methods stated within these directions. The terminology used for the new GIS created record tracings is the *Digital Record Tracings* (DRT).

D.R.T. Issues

Within the directions the minimum number of themes and attributes for features within those themes are stated. These themes and attributes are representing what has been

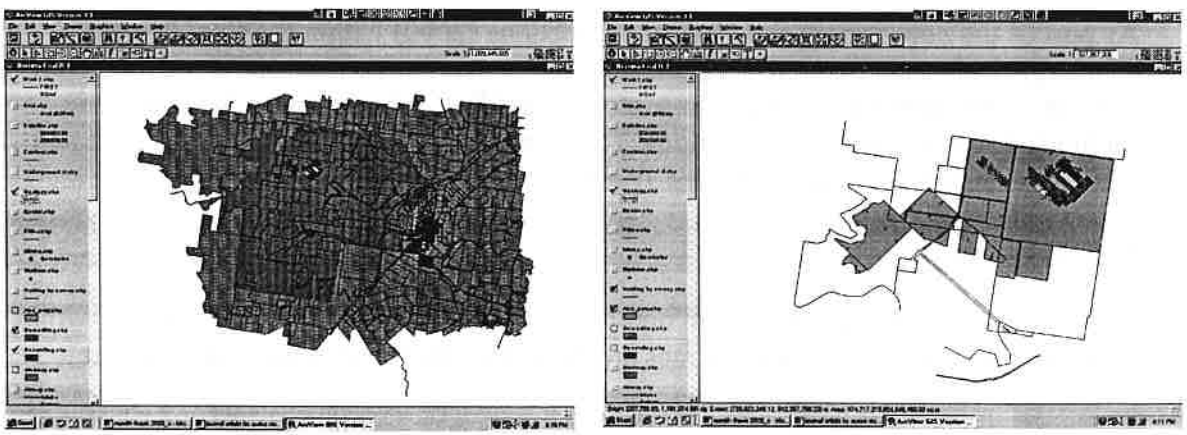
initially placed onto the original record tracings as well as enabling the recording of comments, certifications and any related data that would normally be placed within the columns and drawing area on the original record tracing (See Image).

The following are themes and their data that are required to be part of the DRT.

1 Work1 theme, mined areas within a seam
2 Contour theme, seam floor contours
3 Dateline theme, lines indicating the date during which the area was mined
4. Colliery Holdings theme, external limits of mining leases
Geology theme, geological features
Minfra theme, boreholes, shafts, drifts
Surface detail theme, surface structures
Grid theme, a grid on either ISG or MGA of 500 metre spacing
Barrier theme, limits of mining areas
Approval theme, approved mining areas
Station theme, survey control stations
When comparing the themes and attribute tables within the directions to the original record tracing there are many deficiencies in the proposed dataset.

1. The directions do not indicate each theme's preferred topology. Each theme must then be analysed to determine its appropriate topology. Most theme topologies are straightforward to determine with the exception of the colliery holdings theme. This theme represents the outer limits of the collieries leases. Generally this theme can be a polygon theme except that most mines cover large areas that incorporate many cadastral boundaries. Most mines usually survey the required lease boundaries for their immediate mining areas thus providing an ongoing theme that may have incomplete polygon areas. Another problem with the colliery holding theme is the production of the colliery holdings using the Digital Cadastre Data Base. The colliery holdings theme can be purchased from the Department of Mineral Resources but it only is an approximate position of the colliery holdings as they are massaged into place using known land parcels within the DCDB.

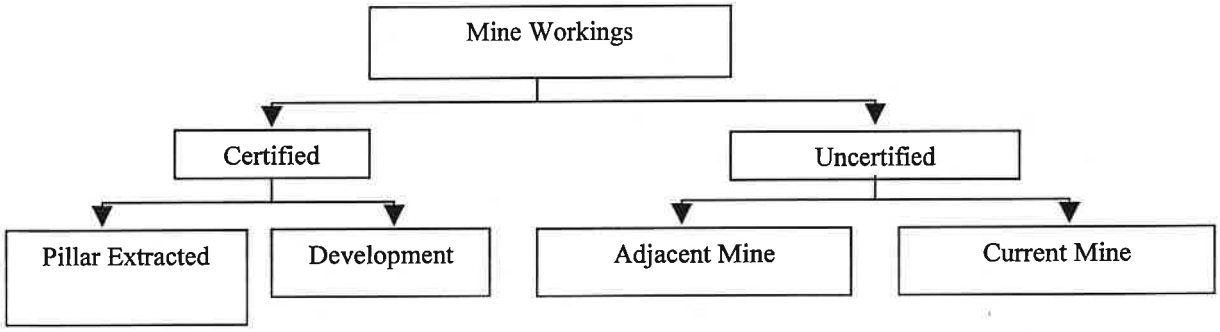
Since the DCDB produced theme is not as accurate as the survey theme, each theme should be carefully joined with clear distinctions made between each source. For the Berrima Colliery project the two themes were left separate and given two different topologies. The DCDB colliery holdings is a polygon theme and the survey by holdings a polyline theme.



Images, Holding theme by DCDB and DCDB approvals **Holding theme by survey with mine**

2. Within the directions there are no provisions for the inclusion of internal lease boundaries. For the Berrima Colliery project the internal leases have been placed within the holdings by survey theme. This creates the possibility for a polygon theme to be created from the entered data. Another problem noticed with the hard copy record tracings is that they do not indicate the new consolidated leases or extinguished leases. This new system consolidated 58 leases into one consolidated lease for Berrima Colliery. Currently the department do not have digital datasets of the consolidated leases so an investigation would have to be undertaken to research each lease's boundaries and life span.

3. There is a definite lack of surveyor's certification of the accuracy of the mine workings within the themes and the identification of other relevant mine developments that may be certified or uncertified by the mine surveyor. This flow chart best explains the different types of represented mine workings.



On the original (hard copy) record tracings, datelines were placed around mined areas during the quarterly periods with the appointed mine surveyors initials and date placed along this line. The combination of graphical line, initial and date, certified the accuracy of the area. Uncertified workings were generally accepted as an outline.

Within the DRT to represent each type of mined area and to provide the certification of surveyed mined areas, the following themes and tables were created. Within the mine-working theme (WORK1) the following fields were created.

ID	RT Number	Seam	Panel
1	59	Wongawilli	402

Colliery	Symbol ID	EXT Date	Initials
Berrima colliery	MN03	30/6/2000	BES

From this table each line can be represented within its corresponding R.T. number, seam, colliery and even panel if known. This allows for the recognition of adjacent mine workings, abandoned workings within the colliery and certified workings. By

including the surveyor's initials each line can be separated into certified or uncertified workings. What the table doesn't include is the extracted areas within the certified mine workings. These areas are very dangerous areas underground and are symbolised within the Australian Standards as a crosshatched area. With consultation with the Department of Mineral Resources it was decided to provide the same impact on the DRT as the hard copy plans have. Thus creating a series of lines within the theme that are not spatial representations of objects but graphical representations of extracted areas. The fact that not all software packages produce the same symbolisation of points and lines influenced the decision to create the feature as its Australian Symbol.

Within the dateline theme the table also included a surveyor's initial field to certify the date periods. As the extracted areas are graphical representations so is the dateline theme. To provide ease of viewing the hard copy R.T. offset these lines from the mine working lines. This method has been carried through with this DRT as the use of these lines have now become redundant within the Department of Mineral Resources but they still provide a means of investigation of the survey notes for the mine surveyor.

4. As each part of the mine is developed an initial surveying traverse is performed to give the mine direction. During this time of production, a level run is usually performed measuring the height of the seam floor as well as creating height control benchmarks along the way. At a later date a more precise horizontal control traverse is performed to establish coordinates through the panel. As indicated the two surveys of height and horizontal control are performed at different dates and therefore the use of the same marks for either survey is not normally undertaken. Under the old and current directions there is no provision for the inclusion of the height control benchmarks unless they are the same marks used for the horizontal control. Further more if a traverse is repeated and new coordinates calculated there is no record of this on the R.T. except for the new coordinates.

A height control theme was created which also includes the spot heights taken on the seam floor at each intersection. This theme's name is (underground_rl) and includes in its tables the panel name, cut through number and heading label. Thus identifying each intersection within the mine as well as providing individual spot heights and benchmarks for the creation of a TIN model. The current method of displaying the seam contour is to draw the contours on the R.T. at an unspecified contour interval. The underground_rl theme in time may supersede the contour theme.

Within the station theme for the horizontal traverse a date field and surveyors initial field allows each mark to be identified by date and surveyor, which can then be used by the surveyor in investigating previous surveys.

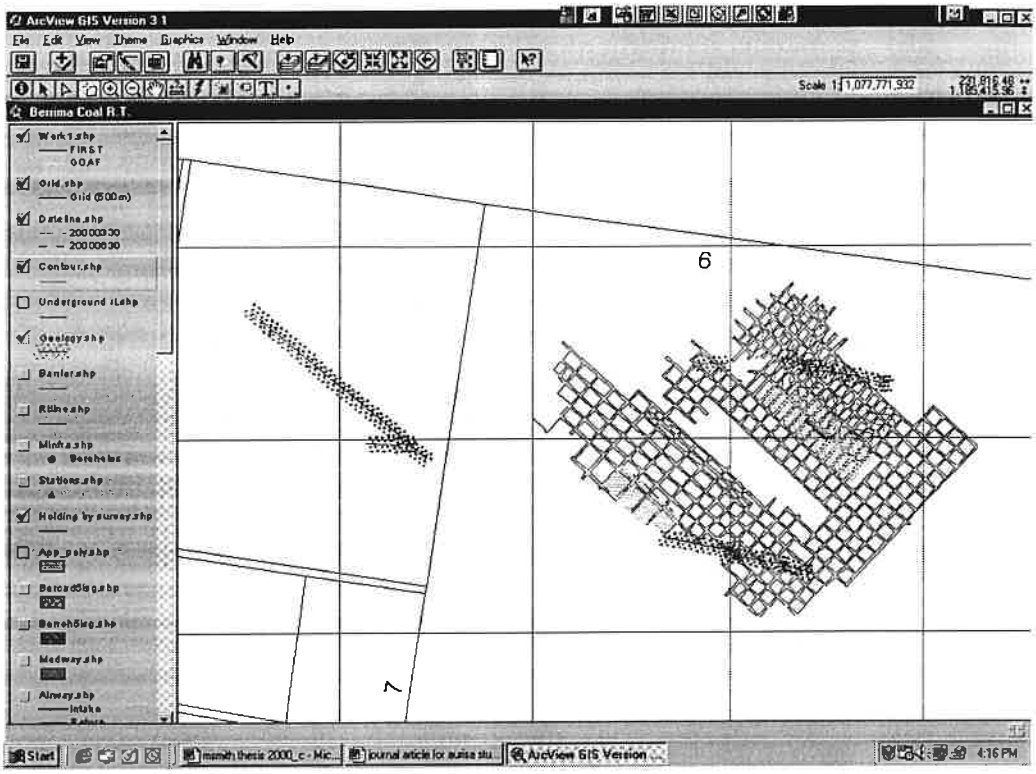


Image of the themes created in ARCVIEW for the Berrima Colliery Project
The geology, mine working (Work1) theme, Grid and colliery holdings theme have been activated.
The yellow crosshatched area is the extracted (goaf) areas of the panels.

5. To keep the DRT platform independent a field within each theme was created to provide a code that is stated within the Australian Standards 4368 to represent each feature. The Department's GIS can then read the code and each DRT will then be standardised within the departments system.

6. On the hard copy record tracings each sheet must have a cross sectional view of the strata obtained from a borehole within the limits of the sheet. There is no mention of this requirement within the DRT but use can be made of hyper links that link spatial objects to electronic files. All borehole information is recorded in the borehole log file that can be easily made into an electronic file.

7. As part of the Dam Safety Act 1978 all substantial water bodies must have a notification zone placed around it. This zone is formed by the Geological Department within the Department of Mineral Resources. The current directions make no mention of the notification zone with the DRT but I am told that the next minute's produced by the department will include this change. Having learnt about the minutes produced by the department a note should be mentioned that all mine surveyors should receive copies of the minutes relating to the DRT, after the gazettal of the directions (2000).

8. The method of locating surface structures within the surface structure theme isn't mentioned within the directions. This can create a problem to the department when mines submit different data types such as raster images of aerial photography, remote sensing and vector themes from field survey. Aerial photography and field survey data were used within the Berrima Colliery project to identify this problem. The department

developing guidelines for data acquisition and theme topology can overcome this problem.

9. With the change of all cadastre coordinates from ISG to MGA the department have decided to change all the mine record tracings to GDA94 using the MGA projection. The issue arising from this coordinate transformation is what method of transformation can be used to transform already created themes and coverages onto MGA and still retain the accuracy stated within the authorised transformation software.
The department have adopted the Ntv2 National Transformation Version 2. This transformation was design by the University of Newcastle and allows for a list of X and Y coordinates to be transformed from ISG to MGA. This transformation attempts to allow for the errors that were intrinsically within the ISG and AMG projections when converting to MGA. The proposed accuracy of the high accuracy transformation is,

- "Absolute accuracy: ~ 0.1m (95%) (except in/near Barham, NSW and Koondrook, Victoria, where the accuracy is 0.25m and 0.45m, respectively).
- Relative accuracy: similar to source." (from http://www.lpi.nsw.gov.au/gda/geod.html)

This program can be downloaded from the LIC web site http://www.lpi.nsw.gov.au/geod.html as a download called geod. Not all themes created allow for the accuracy to be 0.1m such as the survey stations theme. I propose that each stations coordinates be recalculated from the mine baseline that has both ISG and MGA coordinates.

10. Traditionally surveyors signed a table on the right of the record tracings (see Image1) to certify that the information added to the R.T. is correct. Under the directions a surveyor may sign a write once read many compact disk that comprises the DRT. Since the surveyor uses the CD for the certification the CD then becomes part of the DRT not just the data stored within it. For this method to work an archival system must be in place at the Department of Mineral Resources for each CD submitted as a DRT. If the archival of each CD were not provided then the integrity of the system would have to be in doubt each time an investigation into old workings was to be executed.

Conclusion

To ensure a successful transfer from the hard copy record tracings to the digital record tracings further instructions are needed within the Survey and Drafting Directions (2000) relating to the following matters.

- Theme topology
- Minimum amount of attributes and fields within tables
- Data acquisition
- Metadata

Implementing these simple recommendations and the use of a comprehensive archival system will ensure that no information is lost from the transfer and that the integrity of the old and newly created data is unquestionable under investigation. With these adjustments each DRT submitted would truly need a *minimal amount of editing* when placed into the departments GIS.

Bibliography

http://www.lpi.nsw.gov.au/gda/geod.html accessed 2/11/2000

NSW Government, Mining Act 1992, "Order Under Section 369"

NSW Government, Dam Safety Act 1978, Condition 13 "Methods of operation (Prescribed Dams)"

NSW Government, Coal Mines (General) Regulation 1999, p1-p46

NSW Government, Coal mines (Underground) Regulations 1999, p1- p103

NSW Government Gazette, Survey and Drafting Directions for Surveyors 1999, p14-p33

Masters E.G., UNSW School of Geomatic Engineering (1998), "Notes for spatial information systems & Land information systems", chapters1-9

Auditing the Height Network of New South Wales

Owen Moss and George Baitch
Survey, Information Sourcing
Land and Property Information, Bathurst NSW

Introduction

Why bother to check the Australian Height Datum (AHD) for New South Wales? Is it not true that AHD has been around and fully established for almost thirty years? Why is it necessary to make measurements to a height datum that has served the surveying, engineering and general community for all this time?

The answer is height needs to be revisited because of the popular take-up of Global Positioning Systems (GPS). GPS technology is now being introduced into all aspects of modern life and its resolution is increasing continuously. The second reason for auditing and determining a "better" AHD, is because the body responsible for making national decisions on geodetic matters, has decided that "it would be a good thing to do".

The determination of AHD in the first place was undertaken using the best technology of the day, which included spirit levelling and gravimetric observations. The resolution of some of the original survey information that was included in the original adjustment for the determination of AHD was variable and subject to various sources of error. They were certainly not as capable as today's surveying equipment allows.

An audit of the State's Heighting survey will produce a better result for AHD. This will suit the needs of the surveying and community that use GPS technology for a range of purposes.

Introduction of the Australian Height Datum 1971

It is useful to describe how the original vertical height determination was made in Australia. In May 1971, a simultaneous adjustment was carried out of 97,230 kilometres of first and second order two-way levelling embracing the entire continent. Mean sea level for 1966-1968 was assigned the value of zero on the Australian Height Datum at thirty tide gauges around the coast of the Australian continent. The resulting datum surface, with minor modifications, has been termed the Australian Height Datum (AHD) and was adopted by the National Mapping Council as the datum to which all vertical control for mapping is to be referred.

A network of first-order levelling was undertaken of the eastern half of New South Wales. In 1961, the Commonwealth Government made funds available for third order levelling loops over the remainder of the State, linking up with similar surveys in other states. Between 1961 and 1966, National Mapping in cooperation with the Lands Department planned and organised third order levelling surveys. The levelling was done by contract under the supervision and control of the Surveyor General. The Central Mapping Authority undertook the first order levelling along the coast and tablelands.

Until 1971, all published levels were based on the 1897 value for the Lands Department plug. In view of the discrepancy between the tidal records..., and the desirability of introducing a reliable level datum that may be expected to remain unchanged for many years, the Committee decided that the AHD should be adopted throughout the State. The imminent adoption of the metric system gave added weight to this decision.

The fact that much of the contract second-order levelling was done in imperial units has a great influence on many of the discrepancies now being sought and detected in the levelling network. Four sources of error have been identified:

- 1 foot errors that are lost within third order levelling specification (foot)
- compensating errors that manifest at intersection points(compensating)
- errors caused due to conversion of imperial measurements to metric.(conversion)
- Incorrect reports (abstracts) by contractors to prevent penalty (lies).

The nature of these imperial errors is that a gross error of 1 foot (which is relatively easy to make) in levelling, is often within the acceptable error budget for second-order specification. Table 1 below shows the expected error in millimetres as a function of section length.

Table 1: Expected Error in mm as a Function of Segment Length

Segment length (km), k	100	200	300	400	500
Classical Two-way Third Order (mm): $12\sqrt{k}$	120	170	208	240	268

Levelling loops of over 500km (which were not infrequent around the western division of the State) could easily contain a gross error of 1 foot (or 300mm) and simply be removed by linear adjustment.

From investigation, it has been revealed that some levelling loops containing compensating errors that manifested at loop intersection points. This occurs when a loop appears to meet the levelling specification, however, inadvertently transfers a compensated error to another loop.

Errors caused through conversion of imperial data to metric, where to some extent caused through inexperience with the conversion of such data, and the introduction of errors below the allowable error tolerance. This will be discussed later in this paper.

As reported above, many contract surveyors were engaged in the mammoth task of levelling the continent. It was an arduous task in the western parts of the State and central parts of the continent. It has been shown that some of these contractors, fudged their results to ensure payment or to prevent being sent out again to re-measure at their own cost. Incorrect reports (abstracts) have been detected from contractors.

It was resolved in 1971 by the Central Mapping Authority, the Department of Lands and the Division of National Mapping, that "as the basis for future levelling operations in the State".

1. All benchmarks in New South Wales are to be referred to the Australian Height Datum.
2. In the event that sections of levelling already adjusted on the AHD by the Division of National Mapping are re-run either wholly or in part, the responsibility of re-adjusting such sections lies with that Division. The responsibility for determination of values of benchmarks along new levelling sections connected to already adjusted levelling rests with the Surveyor General. Heights of previously determined junction points and other fixed points shall not be disturbed with the concurrence of the director of National Mapping.
4. Where new and additional first order levelling is run between traverses already adjusted to the AHD and agreement between this first order levelling and existing values on the AHD is to a first order standard of accuracy, simple linear adjustment can be effected.

New South Wales has committed itself to undertaking an audit of parts of the levelling network that contain suspect information.

Height Modernisation Project

The decision to undertake an audit of the State's Heighting Network was made by the Intergovernmental Committee on Surveying and Mapping (ICSM). Specifically it was the Geodesy Technical Sub Committee of ICSM that recommended to:

> "...occupy AHD Basic junction points with GPS, ... , to better assess the accuracy of AHD, to improve the ability of GPS to obtain AHD heights and to assist the further refinement of AUSGeoid."(Minutes ICSM Geodesy Group, October 1999).

ICSM is a nationally constituted body that has representatives from the principal surveying organisations from each state (usually the State's Surveyor General or equivalent person). ICSM operates loosely under the auspices and governance of the Australian and New Zealand Land Information Council (ANZLIC). The current chairperson of ANZLIC is Warwick Watkins, the Surveyor General of NSW and Director General of the Department of Information Technology and Management

Promoted by the federal government's surveying organisation AUSLIG, the Height Modernisation Project has been substantially started across the whole of Australia. The Manager for the Height Modernisation Project is Mr Jim Steed, Director of the Geodetic Information Centre, Canberra.

The motivation and objective of the Height Modernisation Project is to determine a datum model that fits the continent of Australia in relation to heighting determinations across the whole world. To achieve this, long term GPS heighting determinations have been made across the whole world and a model has been created that best fits the shape of the world.

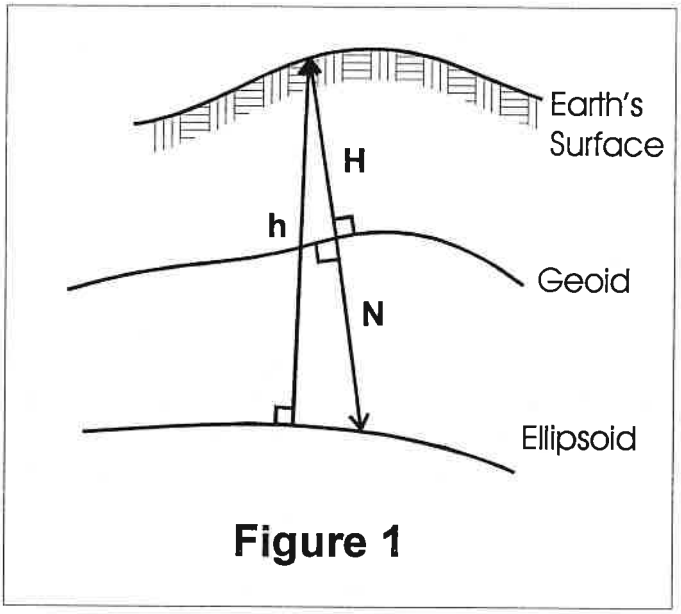
It is only through this project that the haphazard task of rectifying errors in the geoidal model for Australia has gained some order. The Project is tackling the issues of discrepancies in the levelling model in a systematic way. It has developed specifications for methodologies for the observation of heighting information using GPS.

AHD Heighting Using GPS

In order to determine a level of the earth's surface using GPS, it is necessary to know two additional values besides GPS position. They are:

- the shape and position of the Ellipsoid
- the separation between the Ellipsoid and the Geoid (*N*).

Figure 1



This is shown in Figure 1. Thus it is possible to translate GPS ellipsoidal heights to approximate Australian Height Datum using AUSGeoid98 (Johnston, 1998). The separation between the geoid and ellipsoid (*N*) transforms ellipsoidal heights (*h*), derived form GPS surveys, to heights (*H*) on the AHD according to:

$$H = h - N \qquad \textbf{Equation 1}$$

It has been known for some years that the GPS derived ellipsoidal heights (known as WGS84) are "not compatible with the Australian Height Datum" (p29, Featherstone, 1996). While AHD is nominally geoidal, and referenced to mean sea level by way of 30 tide gauges around the edge of Australia, AHD heights are "influenced by the physical force of gravity". GPS derived ellipsoidal heights are derived purely from geometry, in which gravity is not considered.

AUSGeoid98 is a two-minute grid of geoid to ellipsoid separations and the associated deflections of the vertical that have been computed for the whole of Australia. Downloadable software is available from the AUSLIG website to interpolate the value of AUSGeoid98 at any point in Australia.

However, when a GPS observation is made in accordance with the Height Modernisation Project specification, it is possible to confirm the value of *N* by

comparing the result of the geoidal height to that provided by AUSGeoid98 as shown below:

$$N_{obs} = H - h \quad \textbf{Equation 2}$$

Thus a discrepancy can be revealed between the two geoidal values N and N_{obs}. This is shown in Figure 2 below.

Figure 2

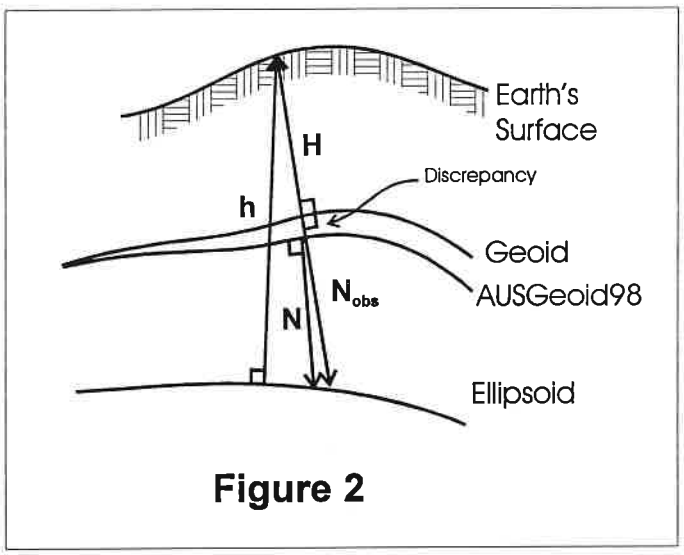


Figure 2

It is thus that the Height Modernisation Project can produce two outcomes. It can

- quantify the difference between AUSGeoid98 and the actual N value
- produce a ellipsoidal model that fits with the rest of the world.

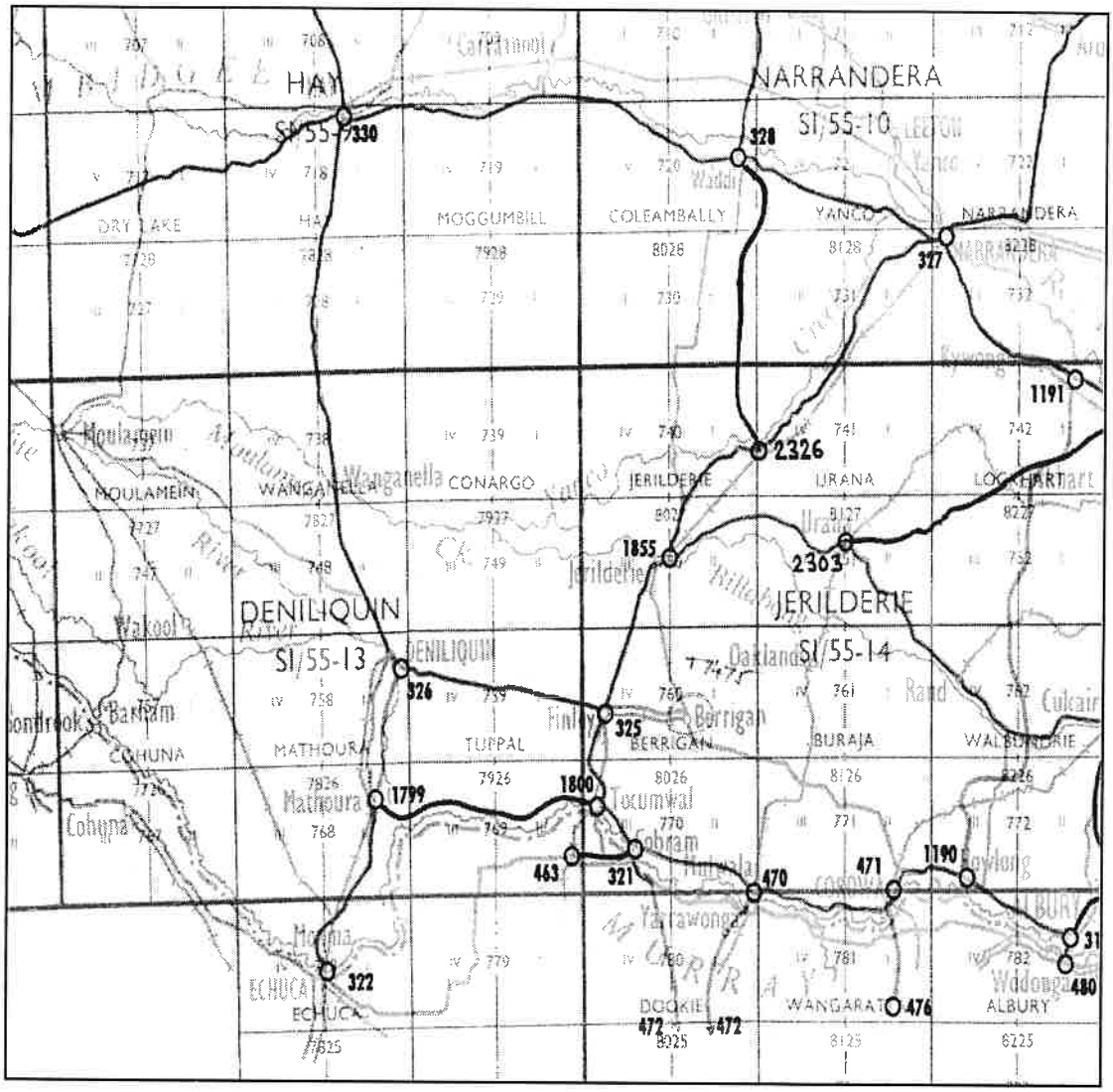
Auditing the Height Network

There are known to be gross errors in the AHD. Examination of the loop misclosures for selected parts of NSW shows inconsistencies in the network. These gross errors have been discovered, by accident or good fortune, over the past 30 years. With the concentration on the completion of the horizontal network, there has been little effort to identify and quantify these errors. During the past 5 years, with the increased emphasis on producing GPS derived height for marks (in addition to traditional horizontal values), the height network has come under closer scrutiny. The following case study will demonstrate how the LPI is attempting to systematically identify and qualify these errors in the AHD.

Case Study: Conargo - Deniliquin Adjustment Block

This analysis will concentrate on the field techniques and results of the audit of the level routes. These are shown in Diagram 1 below.

Diagram 1



Conargo - Deniliquin Adjustment Block

Extent of the Network

The network was designed to provide horizontal and vertical control to that part of the Riverina district of NSW roughly bounded by the Sturt Highway between Narrandera and Hay in the North, the Newell Highway between Narrandera and Tocumwal in the East, the Murray River between Tocumwal and Barham in the South and a line between the towns of Barham, Moulamein and Hay in the west. See Diagram 1

Design Criteria

The challenge was to design a network and observation schedule that delivered a survey of horizontal class A with a density of 15-25kms. The vertical class would be largely dependent on the results achieved, but it was generally expected that a class B or C would be achieved.

The main feature of this block is that the design samples the AHD network along 7 sections that form 2 loops

Field Procedures

The intention of the design was that the level sections are sampled every 5-15kms. Marks were occupied with dual frequency GPS and baselines computed between adjacent marks. The field technique used is rapid leap frogging. Four single person parties, each equipped with a dual frequency GPS receiver, were deployed for the observations. A typical day started with a convoy of vehicles heading out along a section of highway. The first party occupies the first mark and so on. By the time the third receiver is deployed, the observation between the first 2 marks is well underway.

The session length is dependent on the length of line, with the session length calculated using the formula 30mins + 2min per km i.e. for a 10km baseline we would observe for 50minutes. At the completion of the first baseline, receiver #1 moves to mark #5, receiver #2 waits for the completion of baseline between receiver #2 and receiver #3 and then moves to mark #6. This process continues for the rest of the day. Using this technique, distances of 150km per day can be regularly achieved, thus most AHD sections in NSW can be sampled in one to two days.

It should be emphasised at this point that prior reconnaissance and good communications are essential for this technique to achieve maximum efficiency. This sampling of the level section is part of an overall observation strategy for a 3D solution for the block. As mentioned, the desired result is for a Class A horizontal and a lesser class for vertical components.

A class A survey is defined by SP1 in terms of recommended survey techniques and practices. One important aspect is that all stations need to be occupied twice and 20% occupied three times or more. The adopted technique for sampling the levelling sections departs from this basic requirement for Class A. The result is that not all points in the adjustment will achieve a class A rating, some will be assigned class C (where there is no requirement for double occupation). This is a necessary consequence of such a large undertaking.

Results

The GPS baselines are adjusted in a 3D adjustment package. Baseline covariances are scaled by an appropriate value – (usually 0.005m and 1.5ppm of the baseline length). Orthometric heights from the AHD sections are input and assigned a standard deviation (0.025m in this case). The ellipsoid heights derived from GPS observations are converted to geoid (AHD) values by using an appropriate geoid model (AUS Geoid 98). One form of analysis that is used involves that examination of the residuals of the height observations. These residuals are a measure of the misfit of the heights to the GPS observations.

So, the question is "what is significant?" The error budget can be calculated by considering the 3 main sources of error in the model.

1. Errors in the 3rd order leveling are quantified by the formula 12√kms. For a typical distance between the marks observed is in the order of10km, the expected error is 0.038m.
2. Errors in the GPS observations approximately = 0.015m
3. Errors in the geoid model approximately 0.010m

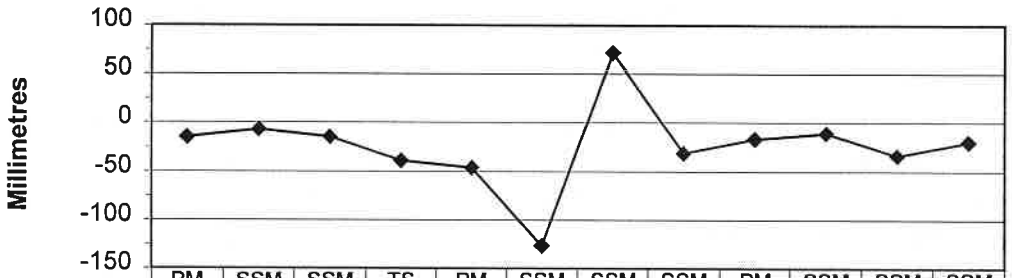
By considering the above, any residual above 0.060m should be viewed with suspicion.

For the adjustment block in question, the residual on each of the input heights has been extracted and can be seen as a graph along each of the sections – see figures 3-8 From this analysis, it is apparent that there is statistical disagreement at 2 locations:

1. In the vicinity of SSM 4198 and SSM 4201 – see Figure 3
2. At PM 5935 – see figures 4,5 & 6.

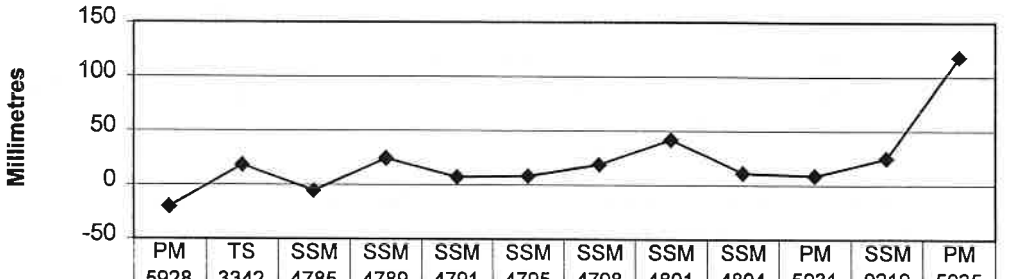
This analysis does not determine that there is an error in the leveling. The differences may be due to several factors (e.g. mark movement), however the analysis indicates that more investigation needs to be undertaken.

Figure 3
Waddi - Hay



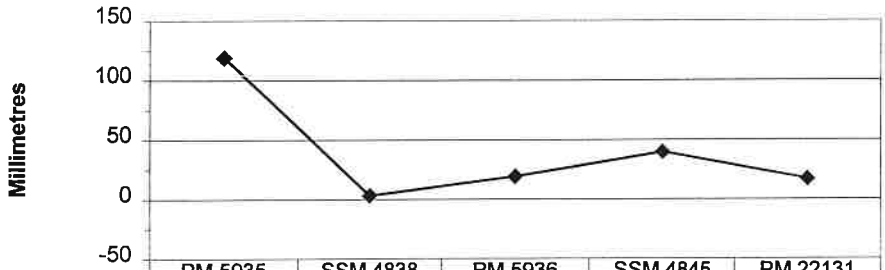
	PM 5801	SSM 4190	SSM 4192	TS 4343	PM 5802	SSM 4198	SSM 4201	SSM 4203	PM 5803	SSM 4208	SSM 4213	SSM 4215
Residuals	-15	-7	-15	-39	-46	-127	71	-31	-17	-11	-34	-20

Figure 4
Hay - Deniliquin



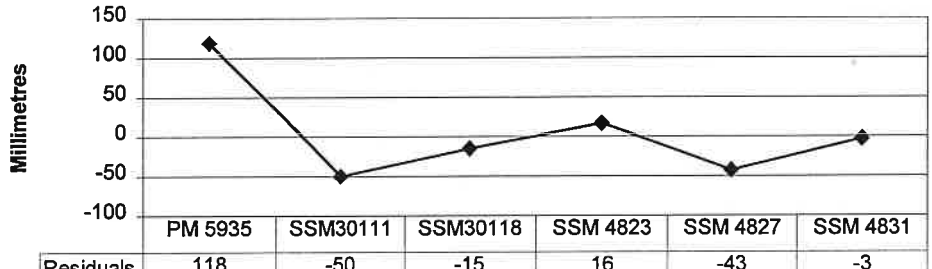
	PM 5928	TS 3342	SSM 4785	SSM 4789	SSM 4791	SSM 4795	SSM 4798	SSM 4801	SSM 4804	PM 5931	SSM 9219	PM 5935
Figure 3	-20	18	-5	24	7	8	19	42	11	9	25	118

Figure 5
Deniliquin - Finley



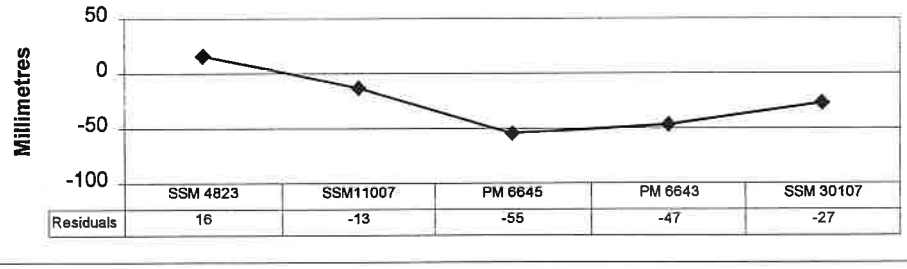
	PM 5935	SSM 4838	PM 5936	SSM 4845	PM 22131
Residuals	118	3	19	40	17

Figure 6
Deniliquin - Moama



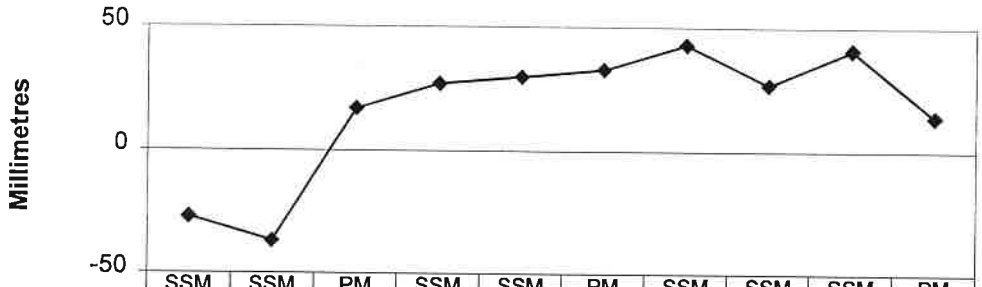
	PM 5935	SSM30111	SSM30118	SSM 4823	SSM 4827	SSM 4831
Residuals	118	-50	-15	16	-43	-3

Figure 7
Mathoura - Tocumwal



	SSM 4823	SSM11007	PM 6645	PM 6643	SSM 30107
Residuals	16	-13	-55	-47	-27

Figure 8
Tocumwal - Morundah



	SSM 30107	SSM 2730	PM 22131	SSM 2719	SSM 2715	PM 84851	SSM 2795	SSM 2700	SSM 2695	PM 4352
Residuals	-27	-37	17	27	30	33	43	27	41	14

Summary

Using this technique and analysis the LPI has been able to identify several possible sources errors in the AHD network. The need for investigation has been limited to 2 areas each extending up to 20kms. Further investigations will examine the original abstracts, loop misclosures and as a last resort the need for more field investigation. Both of the identified inconsistencies in this case study are more likely to be due to mark movement, a consequence of the expansive soils of the Hay plain.

This technique was used to discover an error of 1 foot in a section near the town of Wentworth. It was discovered that a during the course of the original leveling, a rerun was performed which verified the incorrect original run. In this circumstance, the residual analysis exhibited a "step" with the effect gradually lessening along the length of the section. This error was corrected by readjusting the section between fixed junction points. This had no effect on the AHD junction points, but corrected the "step" in the section.. Further, the error accounted for one large loop misclosure, but has increased the misclosure in an adjacent loop! We are now hot on the trail of an even larger error – exciting stuff.

Conclusion

In conclusion, an improved height network will benefit GPS users in that the geoid heights derived from the application of a gravimetric geoid model to GPS derived ellipsoid height will more closely fit with local AHD. The impetus to improve AHD is coming from the national body, AUSIG, with LPI developing techniques to identify and rectify inconsistencies in the individual sections.

References

AUSLIG, website on **"Australian Height Datum"**, www.auslig.gov.au/geodesy/datums/ahd.htm, Belconnen, ACT

Department of Lands, NSW, **"Australian Height Datum (AHD), Adoption of a new National Levelling Datum"**, March 1974, Sydney NSW.

Morgan, P., **"An Analysis of the Australian Height Datum: 1971"**, Australian Surveyor, March 1991.

Featherstone, W.E., **"An Analysis of GPS Height Determination in Western Australia"**, Australian Surveyor, March 1996.

Johnston, G.M. & Featherstone, W.E., **"AUSGeoid98: A New Gravimetric Geoid for Australia"**, Paper Presented to the 24th National Surveying Conference of the Institution of Mining Surveyors, Australia, October 1998.

Cadastral Upgrade in House and Our Way

John Perry
Senior Surveyor, Shoalhaven City Council

Introduction

An outline of the process undertaken by Shoalhaven City Council in deciding to upgrade the Cadastral Base. A simple but effective method of achieving cadastral accuracies required by the various users of the Cadastral based GIS. The pains, the gains, all the intrigues to convince oneself and others that it will work!

The Project

In 1998, in conjunction with the Public Works Department, Council through Shoalhaven Wastewater began planning sewer management scheme encompassing the areas surrounding Lake Conjola.

Survey Technical Officer, Mark Allen, coordinated the project. He can be proud of the result he obtained, at times, under great pressure.

Research revealed that there was no suitable mapping available to design the scheme and a decision was made to use photogrammetry. There would be two scales required, one for rural at 1:4,000 and one for urban at 1:2,000.

Further the photography would be rectified and digitised to allow it to be overlayed on the mapping.

The extensiveness of the project meant a considerable number of targets would be required in areas where no State ground control existed.

This would also later serve for purposes of setting out the works and of subsequent cadastral surveys for the purposes of easements, etc.

Enter the Surveyor General's Department, now gone, in the form of Darryl Halls, a Surveyor based at Eurobodalla Shire.

Darryl, as a joint project, would provide the control with GPS traversing for the photo targets and total project ground control.

Mark Allen then drew attention to the graphics base and its accuracy. Experience had shown that it is often not where it is supposed to be.

The point was raised that I had often used the existing base as a plot background when doing surveys; by the use of a DXF file of the area under survey and a similarity transformation on fixed points to get the GIS onto my co-ordinate system.

On discussion we decided while Darryl was coordinating the targets he would collect some cadastral marks.

To do this it was necessary to search the whole of the area and this was facilitated by dividing it into the village areas of Bendalong, North Bendalong, Manyana, Lake Conjola, Conjola, West Conjola, Killarney etc from which I identified an appropriate selection of corners from which co-ordinates would be obtained for marks found on the ground.

From this data I would test the transformations. I had wanted about an approximate accuracy of 100mm for urban and about 1-2m for rural.

For the purpose of the project I decided to begin with Bendalong and Nth Bendalong, which because of a road opening survey and caravan park survey, I had fairly well fixed the whole area previously and would allow a measure of quality control of the experiment.

The Experiment

To take the co-ordinates that I had determined for boundary corners on the two jobs at Bendalong and the road opening to Nth Bendalong and take out the extraneous data.

To identify the PM's and SSM's from SCIMS that I had connected to in my surveys with those that Darryl had coordinated on the job.

To do a similarity transformation using the PM's and SSM's to bring my surveys onto ISG.

Add sufficient other known points from Darryl Hall's field connections of the cadastral marks.

Then to identify the area to trial on GIS, and DXF this area to Civil CAD.

To trim the unnecessary information to fit the areas for the transformation.

To identify suitable points on the cadasta to use in the least squares transformation.

Having done this, do the transformation.

Investigate the deltas.

It didn't take very long before I found mistakes on the base where boundary lines had been connected to wrong corners and unfortunately one of those was one I wished to use in the transformation, however, I pressed on.

I then found to my obvious disgust that Civil CAD could only handle 15 points in a similarity transformation where I had considerably more of those that could have been used.

The residuals in the Helmert Transformation as you can see were far too large to achieve wheat we were setting out to get in urban areas.

I wondered at the time whether Bendalong, Nth Bendalong had already been rubber sheeted to fit in with previous digitised information. As it turned out the whole lot had been digitised.

I then decided I would use only Bendalong, the main township itself. By doing a similar process to what I had done previously I tested various transformations using different points and the result was quite obvious that the base was all over the place.

For a demonstration of what I believed I had found, I used just two points to transform a DXF file from the base to get a plot, I then as a different job plotted the whole of Bendalong directly from the original search – all the streets, blocks, etc. I then overlaid both plots at a large scale for comparison.

From this I concluded that I was going to have to plot all of the towns in the project and do the transformation in that way.

I must say that throughout the whole project this proved to be the only way that we could do it.

It also gave rise to some interesting problems such as the microfilm machine with all the printing processes was upstairs which meant bolting up and down the stairs many times, probably wasted 30% time of the whole project, there were some very poor reproductions. The efforts of the Land Titles Office to improve plan drawing standards really came home to roost when you try to plot some of these plans which you can't read at plan scale size and which had to be continually blown up which meant another trip upstairs or several trips upstairs.

It also highlighted the usual fixation problems of adjoining plans where you get differences in angles. This was overcome to a certain extent by breaking up the town areas to smaller areas and after fixing the areas with the transformation adopting adjoining points to use on the next block of information.

The running up and down the stairs is now cured because we have all of our microfilm scanned and they are now where we can call them up at the desk on a PC in Windows, and so from there you can flick from plan to plan as you do your plotting using Civil CAD.

The Process

From all of the above we have now come down with a basic set of rules which will be honed and improved over time to carry out this process which we intend to do for the whole of the City area over the next two or three years.

1. We need to use the old basic survey principal of whole to part if we are going to work in a town. The obvious place to start is to fix the street alignments, having done this we can then work block by block by holding the intersection corners.

2. Plot the search first, from this it can be determined which plans are a little confusing and where we might need more marks for overlapping information. It was also found that in the project we tended to identify too many marks in areas

where we didn't need them and not enough marks in areas where we did. So it was quite obvious that by plotting first, the judicious selection of points is facilitated.

3. Identify the corners to which we need to field inspect and connect to and at that time we should also note tree cover which will determine whether we will use GPS or conventional traversing.

4. With GPS we need to mission plan for satellite coverage, the tests we have done recently we find there are certain three or four hours of the days when it is at its best and sometimes at other times it is a little bit marginal so that will determine when to conventional traverse and when to GPS, especially if you a away from your base.

5. Do test transformations on the discreet areas and identify those common points for adjoining areas.

6. Rap it up and DXF it to Bob.

Problems Arising

1. As I mentioned earlier in the talk, most of the data management and divisional planning derived from the mainframe and graphics base overlaid by those layers relative to the divisions, now these layers have been previously plotted using the old cadastral base and are in fact now out of kilter with the new GIS base and as you can see from the Conjola Park overlay in some cases like this one like 30-40m out of place, so suddenly you have a sewer layer or a water layer or zoning layer or a flooding layer which is now in totally the wrong position.

2. A the recent APAS Conference, Roger Merrit presented a paper on a program he has written which is designed to alleviate this using a radial search program.

   This program identifies a point such as a sewer manhole or a hydrant and does a radial search to adjoining cadastral boundaries in the old base, remembers those, and uses that information on the new base to locate itself in no worse position than it was before, in relation to the boundaries but it is now better relocated with regards the ISG co-ordinates. We may not have to do this. Our IT people in conjunction with ESRI seem to have identified a more eloquent solution without the need for complex computer programming.

3. We are also looking at a possible experiment with scanning plans which should be scale accurate. This would hopefully obviate a necessity to plot all the search except in the worst instances where the plan is in such poor condition as that it cannot be done. I have some concerns that this may prove more of a problem than actually plotting but keen to test is and see how it goes.

Sandgate Cemetery - Challenges of the 21st Century

Terry St George
Land and Water Conservation, Newcastle

Precis

Sandgate Cemetery is the largest cemetery in New South Wales outside the Sydney Metropolitan area. Burial space within the cemetery is becoming limited. How can a cemetery survive with its current limited income stream? How can the cemetery continue to serve the city of Newcastle now and into the future? These are the challenges that confront Sandgate Cemetery Trust as it starts the new millennium.

Background

Sandgate Cemetery is located approximately 9km northwest of the Newcastle central business area and is located between the Pacific Highway and the main Northern Railway. The major landscape features of the Hunter River to the northwest and the Hexham Swamp wetland system to the north and west flank the 31ha site.

Since opening in 1881, there have been over 100,000 interments with approximately 80,000 individual monuments installed as memorials.

Along with the significant railway infrastructure, Sandgate Cemetery was developed with a substantial landscape network of avenues, borders and features, and many

notable buildings through the various denominational trusts established to manage the site.

Well over one hundred years since it opened, Sandgate Cemetery is firmly established as one of the most valuable cultural assets of the Hunter Region. Its scale, degree of development and embellishment, and quality of features make it the largest and most significant NSW public cemetery outside of the Sydney metropolitan area.

The Cemetery was classified by the National Trust of Australia (NSW) in 1983.

The site remains in Crown ownership and since 1987 has been administered through a Crown reserve trust. This replaced the former system of denominational trusts of which there were up to nine.

In 1992 a survey of grave plots was carried out to determine the area of land remaining available for burials.

By the end of 1992 less than 5000 grave plots were available for use and another 4000 had been previously sold or reserved but remained unused.

The average number of burials per year is currently about 350 excluding the burial of ashes. Without further development of the site or acquisition of additional land or reuse of 50 year old plots already pre-sold, there is currently about 15 -20 years available use left at the site.

It is intended that Sandgate Cemetery will continue as the regional burial site for the city of Newcastle; that it will be conserved on the basis of accepted heritage conservation principles and practice, enhanced on the basis of relevant research and appropriate design, and maintained as a high quality community resource.

As such the place will provide an appropriate landscape setting for the memorialisation of former citizens of Newcastle as well as afford reflective and passive use for current and future generations.

Heritage Status

The cemetery is currently listed under Schedule 4 of the Newcastle Local Environmental Plan, 1987 as an item of Local Heritage Significance.

On the basis of its rarity and ability to demonstrate attributes at a State and National level it would be appropriate to revise the LEP listing to State Heritage Significance.

The Department of Land and Water Conservation currently has no listing for Sandgate Cemetery as required by Section 170 of the Heritage Act, 1977; nor are there any conservation orders (permanent or interim) applying to the site under the Act.

Though currently unlisted Sandgate Cemetery satisfies various criteria for listing on the Register of the National Estate under the provisions of the Australian Heritage Commission Act, 1975.

Current Administration

The Sandgate Cemetery Trust currently administers the cemetery under the provisions of the Crown Lands Act, 1989, the Crown Lands (General Cemetery) By-Law, 1991 and the Public Health Act Regulation, 1991.

The Trust is comprised of seven members appointed for up to five years by the Minister for Land and Water Conservation.

The trustees carry out their duties on a part-time, unpaid basis.

Value

Sandgate Cemetery, as a whole, is a place of rare national environmental heritage significance. It holds aesthetic, historic, social and scientific value for past, present and future generations and the quality, quantity and diversity of its heritage resources make it an exceptional asset for promotion, interpretation and education.

Sandgate Cemetery was one of only three cemeteries in NSW to have been planned with its own internal rail branch line. It is now the only one of the three, and likely nationally, to still retain substantial elements of its railway branch line infrastructure.

Management Challenges

In 1994 Sandgate Cemetery Trust commissioned architects Suters Architects Pty Ltd to undertake a Plan of Management under the provisions of the Crown Lands Act 1989 over the cemetery. Such a plan was required to guide the Trustees on what was required in the cemetery, to identify future challenges that would confront the cemetery and to identify ways to meet those challenges.

The major issues identified in the Plan of Management are:

- *Administration and Management*

How to maintain the necessary cash flow to manage the cemetery when the number of burials is decreasing relative to cremations and burial space is limited.

What type of Trust is most suited to manage the site ie: a private trust or a council appointed trust.

Meeting the needs of different ethnic communities for above ground burial sites.

Investigating renewable tenure and re-use of gravesites within the cemetery.

- *Finance and Funding*

Identifying sources of funding and reviewing fees and charges.

Create a suitable accounting system for pre paid graves.

Investigating the need for additional land in view of the diminishing resource.

Investigate grant sources.

Investigate opportunities for provision of a lawn cemetery, columbaria, a small crematorium and a crypt development

- *Marketing*

Determination of interment demands as trends in the bereavement industry for burial v cremation.

Promoting the attributes of the cemetery that other cemeteries are lacking in Newcastle.

- *Cultural Significance*

Preparation of a Conservation Management Plan over the cemetery

- *Appearance*

Changing the harsh expansive internal appearance of the cemetery with a greening program

Improve the external appearance of the cemetery from the major arterial roads.

Managing the ever increasing weed problem.

- *General Deterioration*

Impact of the Newcastle earthquake on monuments

Detailed assessment of monuments

Develop a landscape master plan for the cemetery.

- *Functions and Amenity*

Reconstruction of roadways.

Enhancement of the railway precinct.

Addressing the Issues

DEETYA Scheme

In 1995, the first major step in addressing many of the issue contained within the Plan of Management commenced. The Trust with the assistance of then Department of Conservation and Land Management was successful in obtaining federal government funding to the value of about $2.5 million dollars under the previous Labor Governments DEETYA scheme. (Department of Employment Education and Training and Youth Affairs). The scheme was an employment and education program that resulted in the training of about 180 unemployed people. Significant funding however was available to execute major works within the cemetery and there is no doubt that this scheme was the start of the "rebirth and revitalisation" of Sandgate Cemetery.

Works undertaken in the scheme included.

- Reconstruction of external perimeter fencing and the construction of an entry facade.
- Reconstruction of the roadways.
- Supply of water and significant greening of the cemetery including some returfing.
- Construction of amenity blocks
- Repair and maintenance to many of the structures including the railway station, Chinese pavilion and other buildings.

Appointment of a Cemetery Manager

At the completion of the works, the Trust recognised the need to appoint a general manager. Until that time most of the administration of the cemetery was undertaken primarily by the Trustees. The first general manager appointed was Mr Bill Saxby who undertook with much vigour many projects that had been identified within the Plan of Management.

Office Administration

Prior to 1995 administration of the cemetery had changed little since its opening in 1881. The majority of records were entered into manual book registers for each of the cemetery sections. Limited records however between 1981 and 1985 had been micorfiched.

In effect only one copy (the original) of the majority of cemetery records existed!.

In 1996, the Trust also recognised the need and importance to automate the administration of the cemetery and commissioned myself to develop a software system to administer the cemetery. In 1997 the Trust acquired the necessary computer hardware and commenced the long and painstaking task of manually entering all records into the system. As at 1 March 2001 approximately 80% of the records have been entered.

Garden of the Innocents

During the process of record entry a number of interesting matters began to emerge. Of particular note was the number of still born babes interred in unmarked graves. In one particular area approximately 5000 were buried with no recognition or markings (up till the early eighties still born babes were taken directly from mothers at birth and placed directly in Sandgate Cemetery). It was over that area that the Trust and with the energy of Bill Saxby created a memorial Garden of the Innocents with every babes named inscribed on a wall. The opening ceremony in 1999 was a very moving ceremony with many families able to grieve for the first time.

Above Ground Crypts

In March 1999, development of the above ground crypts commenced. The crypt site includes an outdoor chapel and landscaped areas for quite reflection. The crypts were designed by EJE Architects and built by Cordukes Ltd. The provision of above ground crypts has provided a long-felt need by some sections of Newcastle's European communities. Interest in the crypts has been enormous.

Three stages of the crypt development have been completed resulting in 263 crypts. Only 73 Crypts remain available for purchase as at 1 March 2001.

Not only has the development of the Crypts satisfied the need to cater for such a demand but has also resulted in a significant income stream for the Trust.

Lawn Cemetery

The lawn cemetery which opened in early 1999 has received over 40 interments during the first ten months. An additional area has been prepared and landscaped and an avenue of trees planted along the Maitland Road frontage.

Similar to the development of the Crypts, demand for sites within the lawn cemetery has been extraordinary, and has also provided the Trust with a further significant income stream

The Jeffries/Currey(VC) Memorial Wall

A special memorial was opened in the cemetery in 2000. A review of gravestone inscriptions at Sandgate focused attention on the number of war servicemen whose names are recorded on memorials throughout the entire cemetery. Some of these are soldiers who returned home, whose deaths occurred in later years and whose burial place was in Sandgate. Others were killed in action overseas and whose names are memorialised on family tombstones.

The names have been brought together on one special memorial, the cemetery has provide an historical record of these men and women who served the Australian armed forces at war and who are interred or remembered on headstones at Sandgate Cemetery. About 1000 names are recorded on the memorial. The wall is named Jeffries/Currey(VC) Memorial Wall in honour of two local World War One Victoria Cross winners, Captain Clarence Smith Jeffries and Private William Matthew Currey, both of Wallsend.

Cemetery Expansion

Three areas adjoin the cemetery that have opportunities to allow the cemetery to investigate expansion:

- Corner of Sandgate and Maitland Road – privately owned by Newcastle City Council – an area where extension of the lawn cemetery is opportune.
- Area west of the cemetery – owned by the RTA for highway deviation – some opportunities are seen.
- Privately owned land immediately to the north of the cemetery where significant burial opportunities are available.

The Trust is aware of the eventual need to negotiate with these land holders and will in the near future commence such negotiations.

Crematorium and Columbarium – Market Research

Two crematoriums located at Beresfield and Rhyhope service the Newcastle region. Foreign corporations own both crematoriums. It is also of interest to note that these same foreign corporations control approximately 30% of the funeral industry in the Newcastle region.

In line with the outcomes of the Plan of Management, the Trust has undertaken its own market research through the administration software system. Funeral notices from the Newcastle Herald have been collated and reports generated that show:

- Foreign corporations control approximately 30% of the Newcastle Market
- Approximately 80% of deaths in the Newcastle region result in Cremation.
- Approximately 4000 deaths occur annually in the Newcastle, Maitland and Cessnock areas. (the crematorium catchment would also extend to many other areas including the Upper Hunter Valley)

On the basis that all privately owned funeral companies are likely to direct cremations to an "Australian " owned crematorium it is not unreasonable to expect that a crematorium at Sandgate Cemetery could perform about 2000 cremations annually – resulting in a gross income of about $1 million dollars.

Crematorium and Columbarium – Trust Directions

Sandgate Cemetery Trust has already commissioned the undertaking of a business plan and environmental assessment and has now commissioned Architects to prepare a development application for consideration of Newcastle City Council. The Trust is hopeful that a crematorium will be operational by the year 2002. A crematorium and columbarium will ensure a significant income stream to the Trust for ongoing management.

In summary all of the above initiatives will ensure that Sandgate Cemetery is secured financially to meet management and social challenges that lay ahead.

Whilst the cemetery has been significantly transformed since my involvement in 1994, I am convinced that in the not too distant future the cemetery will truly be a place that the community of Newcastle will take great pride.

Sandgate Cemetery Trust are commended for the initiative and commitment they have freely given for the preservation, transformation and continued management of this regionally significant resource.

References

Sandgate Cemetery **Draft Plan of Management**, Suters Architects Pty Ltd, June 1997.

Information and Cemetery Records available from Sandgate Cemetery Trust.