

University Of Southern Queensland
Faculty of Engineering and Surveying

Viability of a Coordinated Cadastre in New South Wales

A dissertation submitted by

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ABSTRACT

Cadastral boundary locations in NSW are not determined by the application of rigid mathematical processes, such determinations are made as a matter of law. Boundary reinstatements require an analysis of all existing evidence, physical and documented. Because inaccuracies exist in documented measurements and because it has been deemed desirable that every parcel of land abuts tightly against its neighbour, the doctrine of ‘monuments over measurements’ has been employed in NSW and on occasion enforced by the courts.

Technological advances have enhanced the ability of surveyors to accurately measure the dimensions of land and have increased the ease with which a single point can be accurately fixed on the Earth. Because of these advances some have suggested that a coordinated cadastral system which gives measurement precedence over other forms of evidence should be developed.

Using information gathered from two questionnaires, a literature review and a field survey this project has made an assessment of the viability of a coordinated cadastral system in NSW.

In making the assessment the project has suggested changes to the current Surveying Regulations which the author perceived would be necessary to provide for the establishment and governance of a coordinated cadastre and has proposed a method of presenting and storing coordinated cadastral information that would ensure boundary coordinates were always retrievable from registered plans relative to the current geodetic coordinate system.

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GLOSSARY

The following terms and abbreviations have been used throughout the text;

| | |
|--------|--|
| CAD | Computer Aided Drafting |
| CLASS | Measure of the achieved internal precision of a survey network (Refer SP1, p A-6) |
| DCDB | Digital Cadastral Data Base |
| DP | Deposited Plan |
| FIG | International Federation of Surveyors (Fédération Internationale des Géomètres) |
| GDA94 | Coordinate system using latitude and longitude to measure position on the GRS80 ellipsoid |
| GIS | Geographic Information System |
| GPS | Global Positioning Systems |
| ICSM | Intergovernmental Committee on Surveying and Mapping |
| LIS | Land Information Systems |
| MGA94 | Map Grid of Australia 1994, a Universal Transverse Mercator Projection based on the GRS80 Ellipsoid |
| ORDER | A measure of how well a new survey network fits with an existing survey control network. (Refer SP1, p A-9) |
| PM | Permanent Survey Mark as described by schedule 4 SR2006 |
| RM | Reference Mark as described by schedule 3 & 4 SR2006 |
| Sec | Abbreviation used by this paper to replace the words clause or section; used in reference to an Act or Regulation |
| SP1 | Standards and Practices for Control Surveys, Version 1.6 |
| SR2006 | Surveying Regulation 2006 (NSW) |

Chapter 1

Introduction

Land Surveying is not an exact science. Establishing title boundaries, or re-establishing them, is at least as much about the law, its interpretation and the gathering of evidence as it is about measurement and position fixing. (Bell & Cleary 2001, p.1)

1.1 Introduction

Cadastral boundary locations in NSW are not determined by the application of rigid mathematical processes, such determinations are made as a matter of law. Boundary reinstatements require a thorough analysis of all existing evidence both physical and documented. Because inaccuracies exist in documented measurements and because it has been deemed desirable that every parcel of land abuts tightly against its neighbour, the doctrine ‘monuments over measurements’ has been employed in NSW and on occasion enforced by the courts to preserve the proprietors spatial rights and obligations in their original locations.

Technological advances have enhanced the ability of surveying professionals to accurately measure the dimensions of land and have increased the ease with which a single point can be accurately fixed on the Earth.

Chapter 1 - Introduction

It has been suggested by some that because of these advances a cadastral system which allows coordinates to take precedence over other evidence should be developed. Development of such a system would entail radical changes to the principles currently employed by cadastral surveyors as well as significant changes to state legislation.

There is a strong argument that aspects of a coordinated cadastre would benefit NSW. However, any reform process must be sympathetic to the preservation of the proprietor's original entitlements. Establishment of a coordinated cadastre would create a situation whereby cadastral entitlements could only be redetermined as accurately as the measurements taken at the time of their coordination. The question is not so much can we create a coordinated cadastre, as should we?

1.2 Justification

The topic of a coordinated cadastre has been widely discussed by the spatial science community. An accurately coordinated cadastre would further enhance the efficiency of technologies such as GIS, CAD and GPS. Coordination of the cadastre is therefore seen by some spatial science professionals as an inevitable step in the development of the cadastral system. In addition to technological benefits, coordination of the cadastre in NSW could impose significant costs financial and otherwise upon those with legal interests in land and parties involved in the management and development of land.

Chapter 1 – Introduction

To successfully move from a system of monumentation to a system of coordination, resources and funds need to be invested into the transition. The obvious questions regarding this statement are who will invest the resources? Who will reap the benefits? Will the benefits offset the costs?

The NSW cadastral system has been built on the fundamental principle that boundary corners shall be reinstated in original positions. Land owners will expect any new cadastral system to maintain boundaries in original positions. There can be no shortcutting the transition process. *‘If a coordinated cadastre is to have the reliability and security of the existing cadastre it must be based on original boundary data.’* (Fryer 2001, p.3) To achieve consistency between coordinated boundaries and original boundaries the term “boundary data” must be interpreted to include monuments, even though monument evidence might be cast aside following the coordination process.

Discussion of the technical issues involved in the establishment of a coordinated cadastre is only one aspect of the debate on reform. By comparison these issues will be simpler to resolve than aspects such as the legal and social consequences of cadastral reform.

In fulfilling the objectives of this project it is hoped that a better understanding of the costs, benefits and the legal and social consequences of reforming the cadastre can be achieved.

Chapter 1 - Introduction

1.3 Research Objectives

The aims of this project as outlined in Appendix A were to assess the viability of converting sections of the existing cadastre into a coordinated cadastre and to develop a set of procedures to assist surveyors perform this task.

1.4 Research Methodology

The research methodology was divided into four parts. The tasks performed to meet the requirements of the project specifications were as follows.

- (a) Analysed the costs & benefits associated with the proposal to establish a coordinated cadastre.
 - (i) Identified and invited the significant users of spatial cadastral information to participate in a questionnaire designed to gather statistical data relating to the current use of cadastral information. This data was used to interpolate what costs and benefits would be associated with the proposed reform, what incentives and disincentives existed for surveyors to undertake coordination projects etc.
 - (ii) Performed a breakeven analysis on a scenario in which a surveyor performed a cadastral coordination survey and prepared

Chapter 1 – Introduction

a plan for registration over part of the long established suburb of Cambridge Gardens. The scenario dictated that the work was performed at the surveyors expense and that he was financially compensated by royalty payments. The royalties were to be received over a period of time when the coordinated cadastral survey data (i.e. registered plan) was sold by the registering authority to a third party.

- (b) Conducted a literature review aimed at researching current NSW laws as they relate to the establishment of cadastral boundaries, monumentation of cadastral boundaries and reinstatement of cadastral boundaries. Determined what changes are required to these to provide for the establishment of a co-ordinated cadastre.
- (c) Researched National and State guidelines relating to control surveys and coordination projects. Used this research to outline a general set of procedures to assist surveyors perform cadastral coordination projects.
- (d) Applied the procedures to a cadastral coordination project aimed at establishing MGA94 coordinates of critical points along road frontages in Cambridge Gardens i.e. tangent points, intersection points, splay corners etc. Presented this information in a format that was suitable for storing and disseminating the MGA information.

Chapter 1 – Introduction

1.5 Conclusions

The primary aim of this dissertation was to examine the viability of converting parts of the existing cadastre in NSW into a coordinated cadastre.

It was expected that this project would determine that a significant portion of the organisations involved in the management and development of land resources in NSW believed a coordinated cadastre would be beneficial to their organisation. It was also expected that the research would show that the establishment of a coordinated cadastral system may not be a commercially viable alternative to the system currently in place, unless a significant allocation of funds is made by the State to compensate surveyors for the survey coordination data they would be required to provide.

Chapter 2

Literature Review

2.1 Introduction

Australian law consists of Parliamentary Legislation i.e. laws made by government, Common Law i.e. case law made by the courts and Delegated Legislation i.e. laws created by parties given special authority to do so by parliament. The establishment of a coordinated cadastre in NSW would require significant changes to State Legislation and the fundamental principles of boundary reinstatement that have been established by case law.

This chapter examined literature relevant to the debate regarding the establishment of a coordinated cadastre in NSW by examining current NSW Legislation and case law relating to the establishment of cadastral boundaries, monumentation of cadastral boundaries and reinstatement of cadastral boundaries.

The aim of this review was to identify the changes that would need to be made to NSW state law in order to provide for a cadastral system which would view coordinates as the primary class of cadastral evidence. In other words, a system which adopts measurements over monuments.

Chapter 2 – Literature Review

2.2 Synopsis of Current NSW Cadastral System

The NSW cadastral system is a parcel based land information system. It is the principle source of land registration and cadastral mapping information in the State. The cadastre records the identity of parties having interests in land and the nature and the duration of those interests. Significant amounts of spatial information concerning land are also recorded as part of the cadastre.

Every parcel of land in NSW is assigned a unique numeric identifier known as a folio identifier. Folio identifiers link the title records of land to spatial records such as deposited plans, which purport to identify certain physical attributes of land, for example, location and size.

Most land interests in NSW are recorded under the Torrens Title system. The correctness of Torrens Title details recorded on the register is guaranteed by the State under the NSW ‘Real Property Act 1900’. This Act entitles any individual or organisation who ‘*suffers loss or damage ... [arising from] any act or omission of the Registrar-General*’ to compensation from the Torrens Assurance Fund. [Real Property Act 1900 Sec 129 (1) (a)]

Of importance to the discussion on cadastral reform is the fact that the Assurance Fund does not cover errors or omissions in the measurement of land. Under the current Torrens Title system the State guarantees title to land, it does not guarantee measurements of land.

Chapter 2 – Literature Review

2.3 Existing Principles of Reinstatement

The location of a boundary is primarily governed by the expressed intention of the originating party or parties or, where the intention is uncertain, by the behaviour of the parties (Ticehurst 1994, p.13-31)

Under the current principles of boundary reinstatement a surveyor, prior to giving an opinion as to the intended position of a boundary, is expected to undertake a thorough investigation of all the evidence available at the time of reinstatement. The information gathered by a surveyor as evidence of a boundaries location can be physical or analytical and is divided into in a variety of classes. Some classes take precedence over others in the eyes of the law. However, the order of priority can be altered by changes in circumstance, and every situation must be considered on its own facts. The classes of evidence are listed in their usual order of priority by the Hierarchy of Evidence, included as part of the NSW Surveyor Generals Directions.

| |
|--|
| 1. Natural features |
| 2. Original crown marking of grant boundaries |
| 3. Monuments |
| 4. Original undisturbed marking of private surveys |
| 5. Occupations |
| 6. Measurements |

Table 2.1: Hierarchy of Evidence

Source: NSW Surveyor Generals Directions No.7, 'Surveying Regulation Applications', December 2004

Chapter 2 – Literature Review

The hierarchy dictates that physical evidence found on the ground will, in most circumstances, take precedence over measurements. Brown sums up this position stating '*[Boundary] lines marked on the Earth represent the true full-scale map of the subdivision, the lines as marked upon paper are a short hand representation of what the surveyor purported to do*'. (Brown 1980, p.150) This clearly means that the lines marked on paper are subject to errors of transcription or omission and explains why the hierarchy considers monuments better evidence than measurements.

Under current NSW law, boundary reinstatement considers not '*where an entirely accurate survey would locate the lines but where did the original survey locate such lines*.' (Grimes 1976, p.378)

This fundamental concept is written into NSW State legislation. Clause 19 (1) of the NSW Surveying Regulation 2006 (SR2006) states;

If a surveyor makes a re-survey, the surveyor must adopt the boundaries as originally marked on the ground as the true boundaries unless there is sufficient evidence to show that the marks have been incorrectly placed or have been disturbed.

When complying with this requirement of the SR2006 the doctrine of 'monuments over measurements', which is in accord with the Hierarchy of Evidence (Table 2.1) is frequently applied by surveyors.

Chapter 2 – Literature Review

The NSW Surveying Regulation 2006 defines a monument as,

any natural or artificial object that is shown on an existing survey plan held by a public authority for the purpose of locating or relocating a boundary or point in a survey.

The term ‘measurement’ is not defined by the Regulations; however, the Macquarie Dictionary describes measurement as ‘*a system of measuring or of measures*’. Coordinates are a system of measurements and therefore they currently reside at the bottom of the Hierarchy of Evidence. (Table 2.1)

2.4 Arguments Supporting a Coordinated Cadastre

The proposal for establishing a survey accurate coordinated cadastre is not a new one. In fact the idea has been around for some time. Fifteen years ago Williamson discussed ‘*the introduction of coordinated cadastral surveys*’ & ‘*the introduction of coordinated cadastral survey systems where the mathematical coordinates have “legal” significance in that the coordinate overrides monumentation on the ground.*’ (Williamson 1991, p.178) Today a body of literature exists that discusses the implications of this reform, one of which is the booklet by Kaufmann & Steudler entitled ‘Cadastre 2014’, commissioned in 1994 by the International Federation of Surveyors (FIG), for the purpose of developing a modern cadastre.

Chapter 2 – Literature Review

This project concurs with the view already established by others that the stimulus for cadastral reform in Australia is not an inadequate performance on behalf of the current cadastral system. (Jones et al, 1999, p.23) On the contrary, the cadastre in NSW is successfully performing the role for which it was designed. This is evidenced by the relatively low occurrence of land ownership litigation in Australia (Department of Primary Industries Water & Environment 2005, p.2)

Despite the cadastres adequate performance, NSW needs to realise that '*a cadastre must be **demand driven**; that means it must fulfil the demands of its clients*'. (FIG 1995, p.3) To this end the NSW cadastral system must adapt to meet the needs of more recent clients such as GIS users whilst still maintaining the stability and integrity of the current system, by continuing to define boundaries through the implementation of principles such as original intention.

Governments are increasingly turning to land use regulation as a means of managing the growing consumption of land in Australia. When dealing with land management issues accurate, complete and timely information pertaining to the subject land, and often other land in the surrounding area, must be gathered. (Corporate GIS Consultants Australia Pty Ltd 2005, pg 18) At present gathering information required to present a holistic view of lands legal status can be a costly and time consuming exercise. It would be advantageous for the cadastre to be capable of linking various land attributes. The ability to link at the very least boundary geometry, title information, and the legislative and environmental restrictions effecting a parcel of land would establish a complete picture of the land's legal status. (Kaufmann & Steudler 1998, p.15)

Chapter 2 – Literature Review

In the short term establishing an accurate link between the cadastre and the MGA94 would complement the use of coordinate based technologies such as GIS and increase the marketability of cadastral information held by authorities such as the Department of Lands in NSW.

However the long term objective of Cadastral reform in NSW should be the achievement of the goals aspired to by statements one, two and six of Cadastre 2014's '*six statements*'. These statements recommend transforming the cadastre into a cost recovering multipurpose LIS, capable of storing information relating to land in thematic layers. Each thematic layer would describe an individual characteristic of land. The key to this system is its ability to use a single coordinate system to spatially reference non spatial data. (Dale 1991, p.87) Once the data in a layer is linked to a point, thematic layers can be combined to create new information about a location. For example, by combining layers **A**, **B** & **F** in figure 2.1 a developer could identify all the land parcels in an area zoned for residential development that are also affected by remnant vegetation protection zones. The developer may then avoid purchasing these parcels of land and thereby avoid added expenses and difficulties associated with them.

Chapter 2 – Literature Review

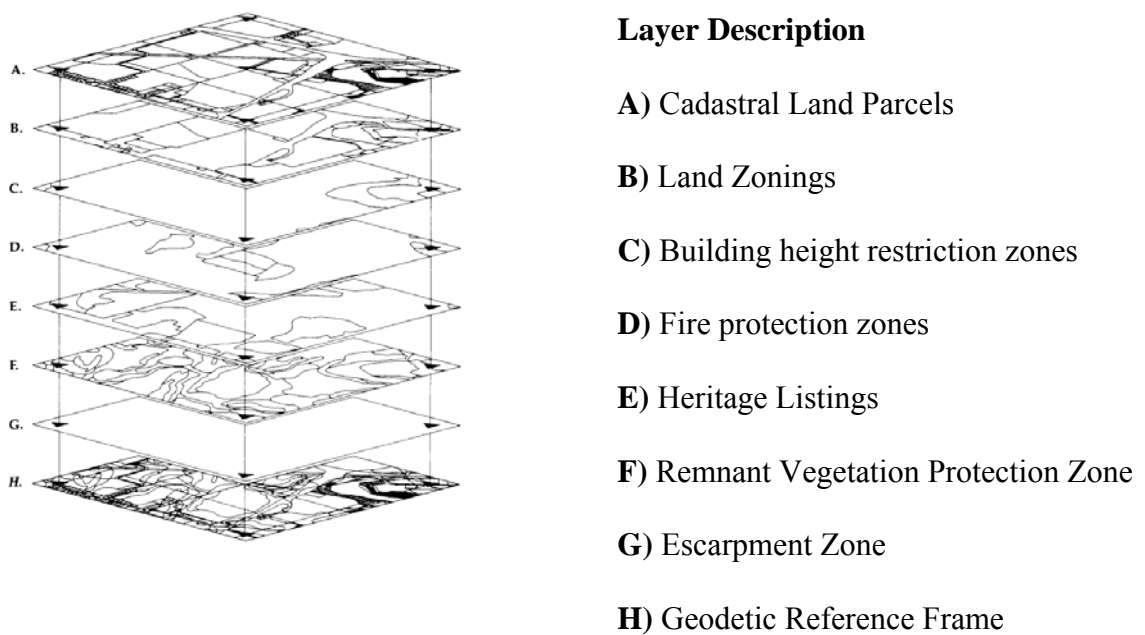


Figure 2.1 Thematic Overlay of Multipurpose Cadastre

Source: Ventura, S. '*Land Information Systems and Cadastral Applications*'

2.5 Review of Case Law Supporting Monuments as Evidence

As a rule of law monuments provide better evidence of a boundaries intended position than measurements. This position has been upheld by the courts on many occasions. Three applications of this rule are outlined below.

2.5.1 Donaldson vs. Hemmant

In the case of Donaldson vs. Hemmant (1901) 11 QJ 35, Hemmant purchased a number of lots at auction. He inspected the lots on the ground and his evidence was that he had also sighted the numbered boundary pegs of each lot. On the day of the auction

Chapter 2 – Literature Review

Hemmant was provided with a lithograph plan, he was also told on that same date the plan recorded the dimensions of the lots he intended purchasing. A number of years after the purchase date, it became apparent to Hemmant that the distances between the pegs on the ground were considerably different to the boundary lengths recorded on the plan. The court was asked to decide which evidence took priority in determining the boundary location, the pegs Hemmant had sighted or the measurements on the plan.

His Honour Griffith C.J. found that the monuments on the ground ruled. He stated;

[When dealing with land] you cannot tell by looking simply at a description on paper exactly what is the subject matter. It is necessary to have recourse to extrinsic evidence to identify the subject matter.

Extrinsic evidence is evidence which is not part of a written document. This kind of evidence may explain, vary or even contradict what has been recorded in the written form. (Greenburg & Millbrook 2000, p. 894)

In support of his decision Griffith. C.J described the priorities of the Hierarchy of Evidence and went on to say;

*The object in cases of this kind is to ... ascertain the intent of the parties.
The rule to find intent is to give most effect to those things about which men are least liable to mistake ...that is the [monuments] by which the land grant is described.*

Chapter 2 – Literature Review

Although Griffith C.J. would probably not have been familiar with the concept of a coordinated cadastre his statements are still relevant today to the proposal of establishing such a system. This is because the primary goal of a coordinated cadastre is to legally define the location of boundaries, without reference to evidence outside of the coordinates recorded in the cadastral database, that is, without extrinsic evidence.

2.5.2 South Australia vs. Victoria

The case of South Australia vs. Victoria (1914) AC 283, describes the survey between 1845 and 1850 of the common boundary between what was at that time NSW and South Australia. The line was surveyed and marked from the south coast of the mainland to the Murray River. The purported location of the marked line was 141 degrees of longitude. In 1868 after the remainder of the boundary was marked northwards of the Murray River, it was reported that, in fact, the line south of the river had been erroneously marked 3.62 kilometres west of its purported location.

The court was asked to decide if the boundary existed at the 141st degree of longitude or if, in fact, it now existed at the location at which it had been erroneously marked. The Privy Council determined that the State boundary should remain at the location it had been marked on the ground. In summing up the court made the following statement;

Chapter 2 – Literature Review

It is essential that the given boundary should be such as fixes the rights and duties of the people ...to define a boundary for such purposes it is necessary that the boundary line should be described or ascertainable on the actual surface of the Earth.

As the Privy Council stated boundaries establish where one party's legal rights and obligations end and those of another begin. Marking boundaries on the ground creates a degree of tangibility to an attribute of land that is for the most part intangible. It has been recognised by the courts that the adoption of original marks indicating the location of a boundary on the ground does more than identify where legal rights and obligations begin and end. In fact, this fixes the position of these rights and obligations at the locations they are originally marked, despite documented evidence to the contrary.

2.5.3 Moore vs. Dentice

The case of Moore vs. Dentice (1902) 20 NZLR 128 is a dispute between two parties as to the true location of the common boundary between their properties, described in Figure 2.3 as lots B and C. Both properties resulted from a subdivision of Section 135; this subdivision is also illustrated by Figure 2.3. Originally Section 135 illustrated in Figure 2.2 was described by its title as being bounded on the West by South Road, on the South by Herald Street, on the East by Section 136 and on the North by Section 15. The location of the section was not fixed by reference to any monuments.

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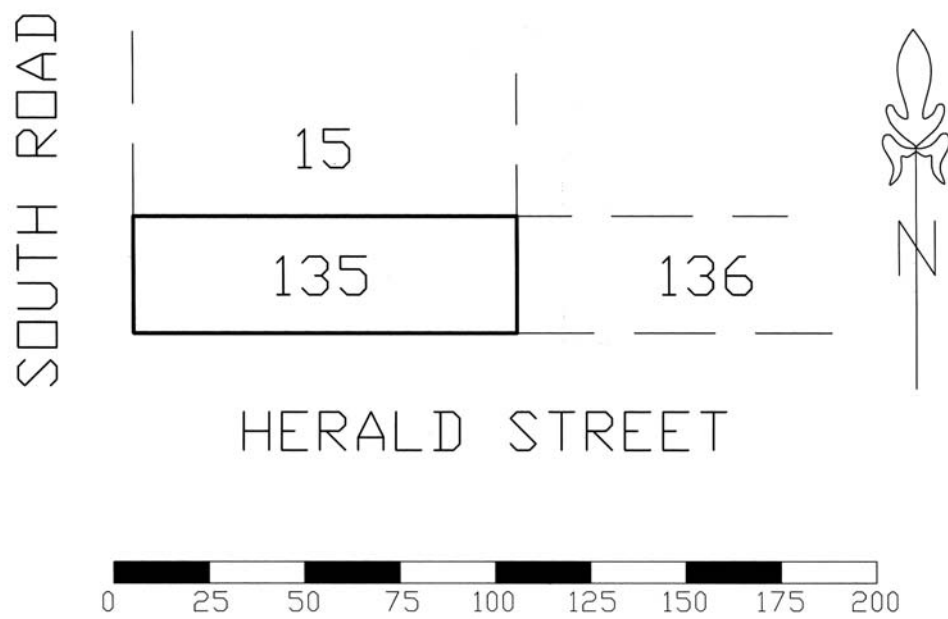


Figure 2.2: Plan Showing Bounds of Section 135

The respective titles of the subdivided lots B and C described the frontages of each and fixed their position relative to the extremities of section 135 as shown in the subdivision plan Figure 2.3.

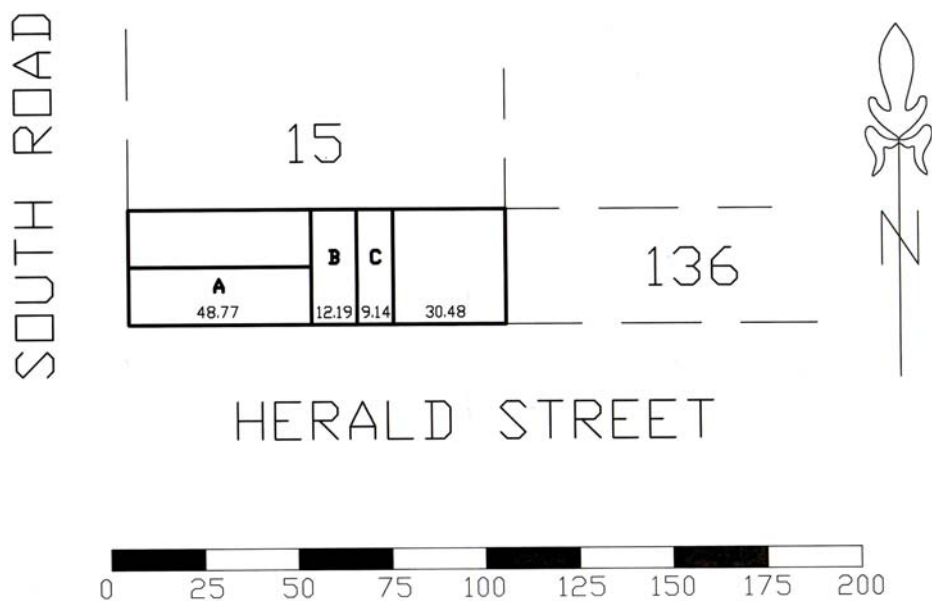


Figure 2.3: Plan Showing Subdivision of Section 135

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According to a resurvey of lot A, also created by the subdivision of Section 135, the fence along the common boundary of lots A and B encroached onto lot A. This survey was based upon the title distance of 48.77m being laid down from the alignment of South Road. The owners of lots A and B agreed to move the fence to be in accordance with the resurvey. This left a 0.40m shortage in the land occupied by lot B. Subsequently the owner of lot B claimed the common fence between lots B and C should be moved to give lot B occupation of its title dimension. During the course of surveys made for the court hearing the original boundary peg at the corner of lot B and lot C was found 0.1m east of the fence in dispute as shown in Figure 2.4.

His Honour Stout. C.J found that the monument (i.e. the original peg) was the best evidence of the location of the disputed boundary, stating '*as has been pointed out in several cases, the old pegs must fix where the land is*'.

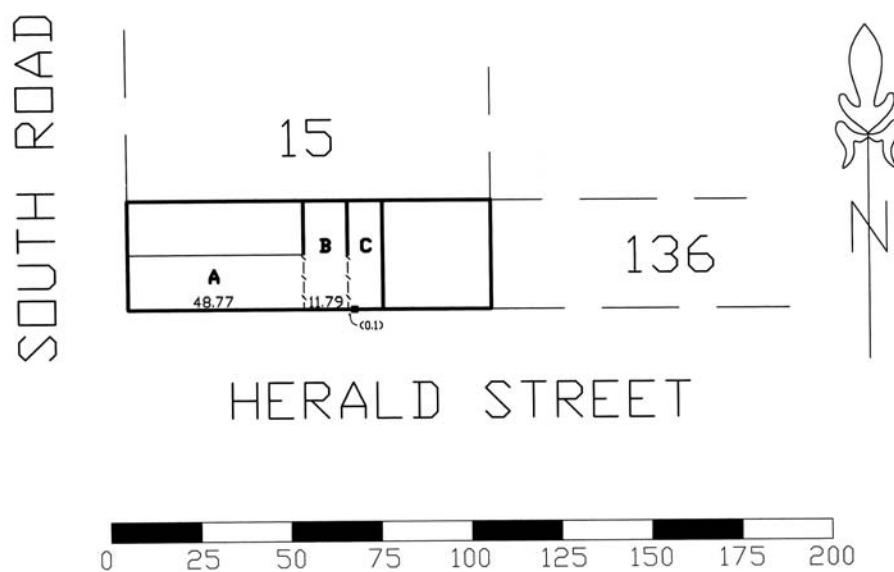


Figure 2.4: Plan Showing Land Occupied After Resurvey

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Based on evidence brought before the court it was also the finding of Stout. C.J. that the alignment of South Street was now incorrectly fixed. In relation to the alignment of South Street, Stout. C.J. said;

It may be where it ought to be, but, unless it is in the position that the original surveyor put it by pegging it on the ground, its present position is not binding.

Stouts decision and his statements regarding the alignment of South Street highlight a significant problem for a coordinated cadastre.

The problem is a coordinated cadastre would need to assume that all measurements recorded on a survey plan were 100% accurate in order to maintain the stability of the coordinated boundaries. But it cannot be guaranteed that a survey will be absolutely correct and accurate. Measurements recorded on a plan will not always be a true representation of what actually happens on the ground.

Because of this the law currently recognises that the best and most equitable way of ensuring that the rights and obligations attached to land are maintained, as they were originally intended, is to record them through the placement of or reference to monuments. This concept is demonstrated further by examination of two case studies in Section 2.7.

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2.6 Review of Legislation

The act of placing original marks, i.e. survey monuments, does more than give a visual indication of the location of spatial rights and obligations. This act often contributes greatly to the determination of a boundaries location. The courts have deemed that the adoption of original survey monuments fixes the location of rights and obligations at the position they are originally marked [South Australia vs. Victoria (1914) ac 283], despite documented evidence to the contrary. In NSW the manner in which original marks are to be placed is described by the Surveying Regulation 2006.

The Surveying Act 2002 governs the functions of the Surveyor General, the registration of surveyors, the control of surveys, the constitution and the functions of the Board of Surveyors. This project will focus on the control of surveys.

Clause 36 of the Surveying Act 2002 entitled ‘Regulations’ gives authority to the Governor to create regulations ‘*not inconsistent with the Act*’.

In particular clauses 36 (2) (a) & (b) of the Act state;

The regulations may make provision for or with respect to the following:

- (a) *the practices to be followed in the conduct of surveys*
- (b) *the form in which survey plans are to be prepared*

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In accordance with this authority, the Surveying Regulation 2006 (SR2006) has been established to outline the duties of surveyors performing surveys in NSW that create, extinguish or modify an interest in land and to stipulate the manner in which these interests are to be recorded.

A full and detailed analysis of all the clauses which constitute the SR2006 by this paper would make for an overly tedious document. Therefore, this analysis will consider the Regulations broadly, making reference to specific clauses that are of most significance to the debate on adoption of a coordinated cadastre and discussing hypothetical scenarios as is appropriate.

In keeping with the current ‘Hierarchy of Evidence’, the SR2006 places most emphasis on the placement of survey monuments as a means of recording the location of land interests. Currently, 32 of the Regulations 90 clauses make reference to survey monuments, whilst only 11 make reference to geodetic control.

2.6.1 Updating the Geodetic Reference System

Currently the Regulations require surveyors to make connections between cadastral corners and geodetic control (PMs) [SR2006 Sec 43 (1)] having a horizontal Class of C or better when submitting a Deposited Plan (DP) for registration. [SR2006 Sec 12 (2)] The coordinates of PMs to which connections are made as well as the connections themselves are to be recorded on the face of the plan. [SR2006 Sec 35 (1) (b) & (d)] However, it would be incorrect to assume that the information on the plan itself can be

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relied upon to determine the geodetic coordinates of a boundary corner depicted in this way.

Even if precedents that have been set by the courts relating to survey measurements and survey monuments are ignored, the Regulations themselves indicate that the MGA94 information depicted on the face of the plan may not be reliable. The Regulations stipulate that MGA94 information shown on the plan must not be more than 6 months old. [SR2006 Sec 12 (4)] This is a reflection of the somewhat dynamic nature of the NSW geodetic control infrastructure. Although the geodetic monuments themselves may be rigid, the coordinates used to describe their location are subject to corrections or slight adjustments. Whilst this may be a necessary evil in the development of the geodetic control network, it represents a significant problem to the establishment of a coordinated cadastre that recognises coordinates as primary evidence of boundary locations. The success of a coordinated cadastre would rely largely on the confidence interval that was able to be assigned to coordinated corners. This topic is discussed further in Section 2.6.3.

To maintain consistency within a coordinated cadastre the Surveying Regulations would need to stipulate what geodetic reference frame was to be adopted by the coordinated cadastre. The Regulations would also need to recognise the need to update this reference frame from time to time.

The coordinates of the MGA94 are derived from a Universal Transverse Mercator (UTM) projection therefore MGA94 coordinates are expressed in metres.

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This makes MGA94 an appropriate choice for the cadastral reference frame of a coordinated cadastre, as traditionally cadastral information has been expressed using linear measurement. Furthermore, most people are familiar with the linear metric system of measurement.

The coordinates of the MGA94 were determined by fixing the UTM projection onto the Geodetic Reference System 1980 (GRS80) ellipsoid at a fixed epoch in 1994. This alleviated problems associated with tectonic movements which cause coordinates in a dynamic system such as the World Geodetic System 1984 (WGS84), to constantly change as the Earth's tectonic plates move relative to the Earth's centroid.

Eventually it will become necessary to re-fix the MGA projection at another epoch. To deal with this issue the Regulations governing storage of coordinated cadastral information need to specify that coordinates are not to be recorded on the face of a registered plan. This could be achieved by changing Sec 35 (1) (b) of the SR2006 so that coordinates were instead recorded in a table annexed to the plan. This table would be similar to the imperial to metric conversion tables annexed to deposited plans in NSW today.

Each boundary point would be assigned an alpha or numeric code (i.e. point code) that would be shown on the face of the plan. This code would link the coordinate shown in the table to the boundary corner it represented on the registered plan. (See Appendix F) As it became necessary to update the MGA projection the coordinate table could also be updated without the need to amend the diagram. By also storing coordinates in an

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electronic database and prefixing point codes with plan numbers this process could be automated.

2.6.2 Residuals in a Coordinated Cadastre

The SR2006 currently requires surveys to be orientated onto a Map Grid of Australia 1994 (MGA94) azimuth adopting the grid bearing between two PMs. [SR2006 Sec 12 (2)] It is also a requirement that at least one more PM be connected to as verification of the MGA94 azimuth. [SR2006 Sec 12 (3)] Connections must be shown between the PMs that are used to orientate a survey and the subject land. [SR2006 Sec 43 (1)] For a survey of urban land the maximum length of a connection is 500 metres. For a survey of rural land the maximum length of a connection is 1000 metres. [SR2006 Sec 43 (2) (a) & (b)]

The Regulations do not stipulate a maximum acceptable residual value for the distance measured between the adopted PMs. However they do insinuate that the maximum acceptable discrepancy is to be 20mm +100 parts per million. [SR2006 Sec 12 (5)] Instructions are given by the Regulations as to what actions a surveyor must take if this degree of accuracy cannot be achieved. [SR2006 Sec 12 (5) (a) (b)]

With the aid of modern technology boundary reinstatement in a coordinated cadastre could, and probably would, occur using control that was remote from the corner to be reinstated. This is in stark contrast to the present system, which ideally uses survey monuments placed in proximity to the corner being reinstated as control.

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Under the SR2006 a reference mark cannot be placed further than 30 metres from the corner it references. [SR2006 Sec 63 (2)]

Under a coordinated cadastral system the Regulations would need to stipulate that all boundary coordinates and all survey measurements were to be considered accurate, to within a specified confidence interval, when reinstating boundaries or creating or modifying interests in land.

If all measurements and coordinates shown on a plan were considered accurate then reinstatement would become a process of setting out the accurate dimensions. If the datum point was also considered accurate then the distance between the datum and the corner being reinstated could be increased with minimal consequence. Some discretion on the behalf of the surveyor would still need to be applied. This is because the semi-major axis of the standard error ellipse of a long baseline will generally be larger than that of a short baseline measured at the same confidence interval, when based on the results of the tests for Class and Order described by the document SP1. These tests use the formula:

$$r = c (d + 0.2)$$

r = maximum allowable length of semi major axis (mm)

c = empirical factor (SP1 Table 1, p. A-7 & SP1 Table 3, p. A-10)

d = distance between coordinated corner and control point (KM)

(SP1 2004, p. A-6 – A-10).

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If all measurements and coordinates shown on a plan were considered accurate Clause 12 (5) of the SR2006 would have to be modified to reflect the testing procedures for Class and Order described by SP1. This is because the parts per million ratio discussed by this clause is a measure of the acceptable size of an inaccuracy. Therefore, a residual determined on the basis of a parts per million ratio acknowledges the existence of an inaccuracy in a measured line. A confidence limit, on the other hand, is a description of the probability of the existence of an inaccuracy. Further discussion and an example of the testing procedures for Class and Order using the formula $r = c (d + 0.2)$ have been provided in Sections 3.5.2 and 3.5.3 of this paper.

The Regulations governing the coordinated cadastre should also state the maximum acceptable size of the standard error ellipse associated with a coordinated corner under various circumstances. Table 2.2 provides an example of how the Regulations may achieve this. The criterion outlined by table 2.2 could be met when using very long baselines as datum lines by increasing the Class and Order of the reinstatement survey.

| Survey Type | r |
|--------------|-------|
| Urban Survey | 10 mm |
| Rural Survey | 50 mm |

r = maximum length of semi major axis of a coordinated cadastral corner

Table 2.2 Suggested Values for r Under a Coordinated Cadastre

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A hypothetical scenario illustrated by Figure 2.5 describes the potential effect of accepting residuals in a coordinated cadastre based on a parts per million ratio.

A four lot urban subdivision is depicted by Figure 2.5, along with survey connections made between PMs and the subdivided lots. The coordinates shown at the subdivision corners have been calculated adopting PM73325 as fixed. It can be seen that a 68mm discrepancy exists between PM73325 and PM65895. This discrepancy fits within the limits implied by the SR2006 Sec 12 (5).

If PM73325 was destroyed during the construction phases of the subdivision and a surveyor subsequently attempted to reinstate the now legally recognised coordinates adopting PM65895 as the datum point, the reinstatement marks would differ to the original corner positions by 68mm.

Any attempt to establish a coordinated cadastre would undoubtedly involve a rigorous adjustment process, most likely the least squares method. However the inclusion of residuals in the order of 20mm +100 part per million measured over long lines would degrade the accuracy of what was purported to be a mathematically accurate coordinated cadastre.

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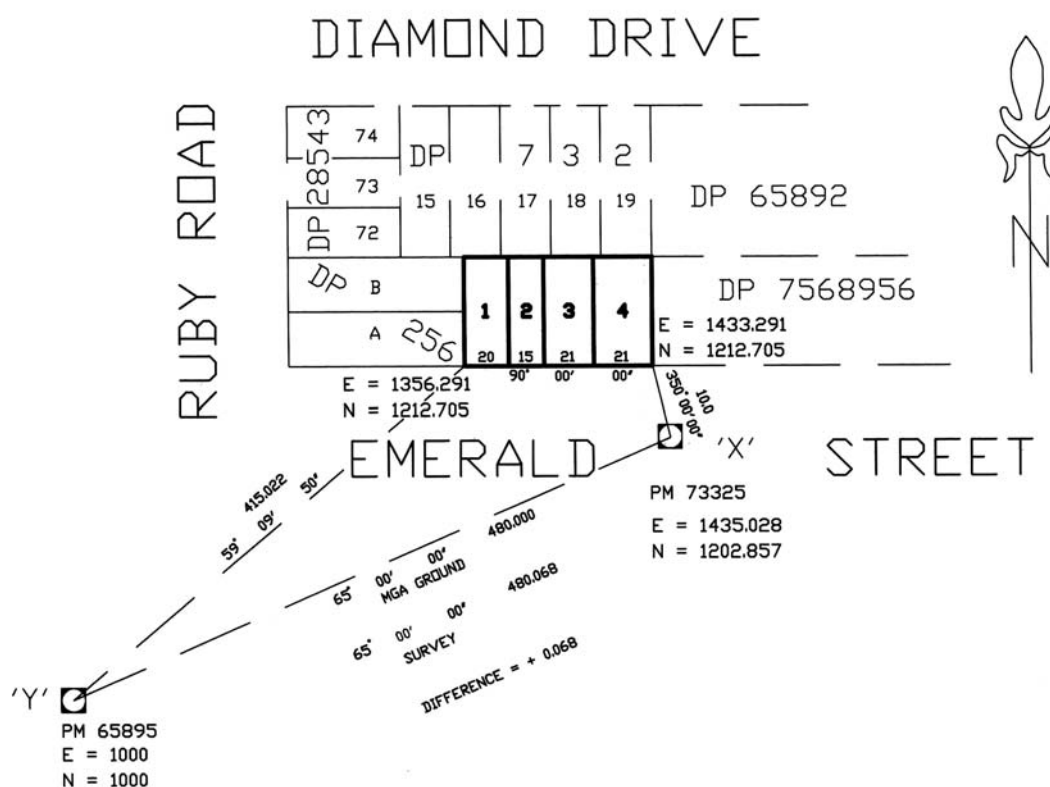


Figure 2.5: Plan Showing Survey Connections to Geodetic Monuments

Whilst this example is simplistic it highlights the problems associated with trying to reinstate a theoretically accurate mathematical cadastral model relative to what is, on the ground, an inaccurate control network.

Under current monument based principles of boundary reinstatement, surveyors use physical objects on the ground to define the location of boundaries which are represented on survey plans by measurements that are not always accurate. [Moore vs. Dentice (1902) 20 NZLR 128]

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2.6.3 Class and Order in a Coordinated Cadastre

The explanatory note (c) of the SR2006 states that the '*Regulation adopts the publication entitled Standards and Practices for Control Surveys (SP1)*'. It would also be appropriate for the Regulations governing a coordinated cadastre to adopt this document or a revision of it.

As was discussed in Section 2.6.2 the Regulations governing a coordinated cadastre will need to specify a confidence interval and a maximum length of the semi major axis of the standard error ellipse of boundary coordinates in the cadastre.

Determining the confidence interval for cadastral coordinates may impact on the viability of a coordinated cadastre more than any other technical issue. Too high a confidence interval would make a coordinated cadastre economically unviable, too low a confidence interval would result in unreliable coordinates and so would undermine the reliability of the cadastral system.

It is the recommendation of this project that the Regulations governing a coordinated cadastre should adopt the standard confidence level (i.e. 68% confidence interval) when determining Class and Order of boundary and control points belonging to the coordinated cadastre. The Regulations should also stipulate that Class and Order in the coordinated cadastre should meet the requirements of SP1 for 'Survey Coordination Projects' i.e. Class C, Order 3. (ICSM 2004, p.A-7)

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These recommendations would generally be in keeping with the current requirements of Part 1, Heading 2 of the NSW Surveyor Generals Directions No. 3 titled “Control for Cadastral Surveys” and so would not create a need to make significant changes to the cadastral survey techniques currently practiced in NSW.

This, it is suggested, would assist in maintaining the economic viability of a coordinated cadastre, whilst also ensuring that cadastral information is maintained at an acceptable level of accuracy.

2.6.4 Principles of Equity in a Coordinated Cadastre

The SR2006 obliges cadastral surveyors to increase the density of geodetic control monuments i.e. PMs through the surveys they perform. The Regulations specify how many PMs surveys must connect to when redefining or creating interests in land. [SR2006 Sec 42 (1) (2) (3)] The regulations require that surveyors place new geodetic monuments by stipulating that only two of the PMs contributing to the total number of PM connections required by the survey can have existed before the survey. [SR2006 Sec 42 (4)] It is also a requirement that new PMs be identified to the Surveyor General by a sketch plan which declares the MGA94 coordinates of the mark and an estimate of the marks Class and Order. [SR2006 Sec 44 (1) (c) & (3)]

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This paper has already ascertained that the SR2006 requires surveys be connected to PMs having a horizontal Class of C or better. [SR2006 Sec 12 (2)] Cadastral survey procedures must also be performed to at least a Class C precision as per Part 1, Heading 2 of the NSW Surveyor Generals Directions No. 3 ‘Control for Cadastral Surveys’. However, the Regulations and the Directions make no mention of a minimum requirement for the Order of PMs connected to the cadastre or the Order of the survey. It is important to recognise that Class on its own does not indicate the reliability of MGA94 information associated with a PM.

Accuracy should be the criterion for determining MGA94 coordinates (USQ 2004a, p.1.2), especially if those coordinates are proposed to be used as cadastral evidence.

Figure 2.6 illustrates the potential consequences of connecting a subdivision in a coordinated cadastre to PMs having a high Class but a low Order. The coordinates of the PMs in Diamond Drive were determined by a survey network independent of one that determined the coordinates of the PMs in Emerald Street. Two sets of coordinates for the south east corner of the subdivision are shown. The bold set was calculated using PM52634 as the datum point. The other set was calculated using PM73325 as the datum point.

Table 2.3 shows the maximum allowable semi major axis of the standard error ellipse around the south east corner of Lot 4 when the corner is calculated from PM73325 and PM52634. These results assume each survey was performed to meet the criterion for the highest Class and Order achievable by the PM adopted as a datum.

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For example: when the southeast corner of lot 4 is laid in from PM52634 the following variables are applied to the formula;

$$r = c (d + 0.2)$$

$$d = 0.1310$$

$$c = 30 \text{ (ICSM 2004, p.A-7)}$$

Therefore $r = 30 (0.1310 + 0.2)$

| | Minimally Constrained | Fully Constrained |
|--------------------|-----------------------|-------------------|
| | Adjustment | Adjustment |
| PM73325 | 3mm | 21mm |
| Class B Order 5 | | |
| PM52634 | 10mm | 10mm |
| Class C Order 3 | | |

Table 2.3 Residuals Derived for South East Corner of Lot 4 shown on Figure 2.6

(ICSM 2004, p. A-6 - A-10)

The results of Table 2.3 can be summarised by stating that the network which determined the coordinates of PM73325 & PM65895 in Figure 2.6 was more precise than the one that determined the coordinates of PM52634 & PM64287.

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However, the network that determined PM52634 & PM64287 is a better fit with surrounding coordinate data and is therefore considered to be more accurate.

If the MGA94 coordinates for the south east corner of lot 4 in Figure 2.6 were determined from PM52634 they would theoretically be more accurate than if they were determined from PM73325

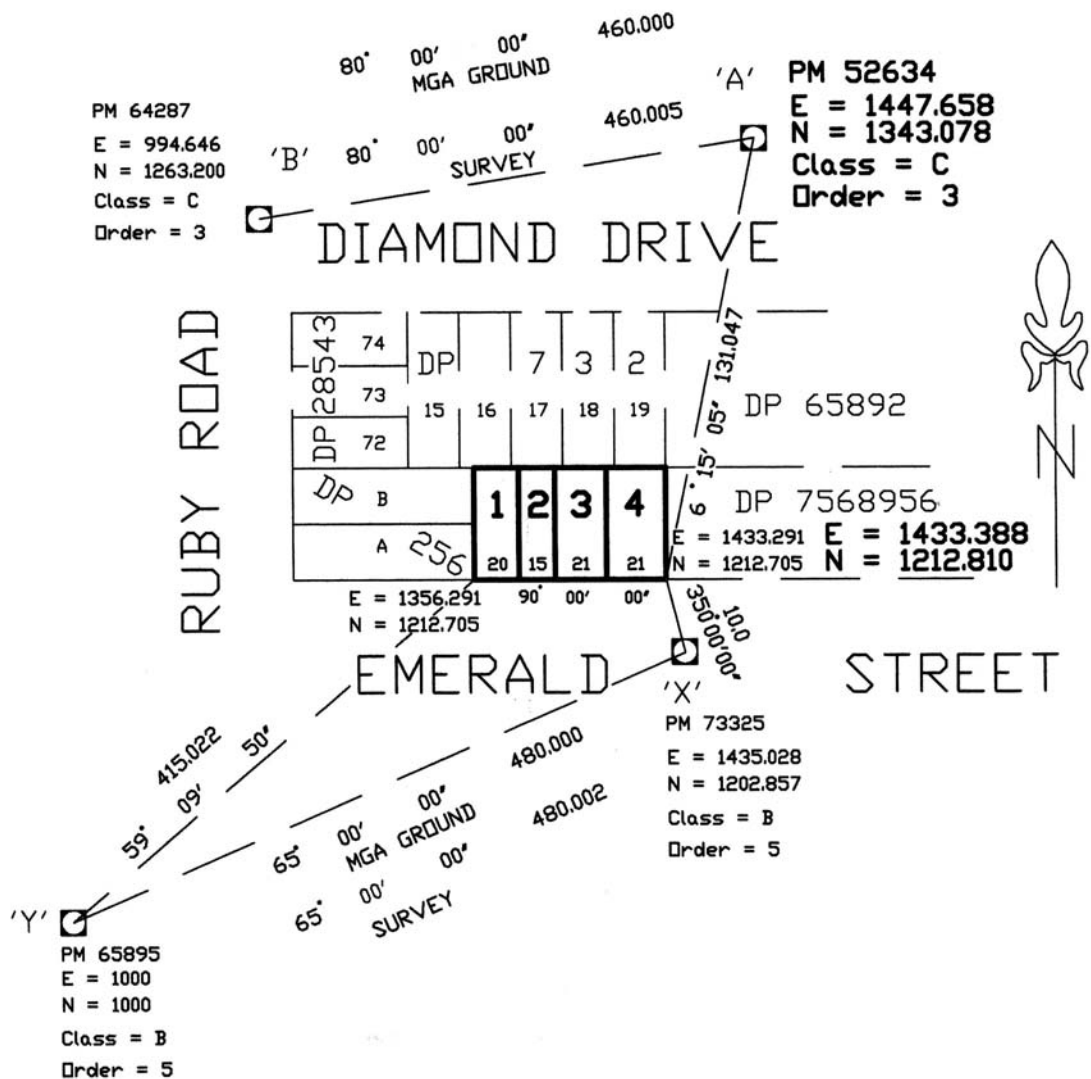


Figure 2.6: Plan Showing Discrepancies Resulting From Survey Connections to Geodetic Monuments Having Low Order

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Based on this scenario, a situation may arise in a coordinated cadastre where the rights of one owner were considered inferior to those of a neighbouring owner, because of the PMs connected to by the individual plans that created each owners interest, regardless of which interest came first. This is an unsatisfactory situation and would certainly be considered to be in conflict with the principles of equity.

To achieve an acceptable level of certainty as to the true location of a land owners rights and obligations on the ground in a coordinated cadastre, the Regulations must reflect the importance of performing surveys that are both internally consistent and spatially accurate.

To achieve this goal the Regulations would need to stipulate the minimum acceptable level of Class and Order for the PMs used as datums by coordination surveys. A coordination survey that adopted a PM having a higher Order than the minimum would have its Order reduced to that of the other points in the cadastre by the application of a successful fully constrained adjustment using the existing coordinated boundaries as constraints to the adjustment.

Therefore, the regulations governing a coordinated cadastre should enforce the adoption of a minimum level of Class for coordination surveys and geodetic control, the adoption of existing adjoining coordinated corners as constraints to new boundary coordinates and the adoption of a minimum level of Order for geodetic control. This would ensure a consistent level of accuracy for coordinated corners throughout the coordinated cadastre.

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In the event that geodetic control of the specified Class and Order was not available in an area, the Regulations would need to stipulate that a suitably dense geodetic control network of the specified Class and Order was to be established prior to allocating coordinates to any boundary corners. This would add significantly to the cost of a project. For whilst a high Class of survey can be achieved on a project site it may be necessary to extend a survey well beyond the external limits of the site to achieve a high Order survey.

It is interesting to note that changes to the Regulations which assign Class and Order to a coordinated boundary corner would represent a fundamental change to the concept of a cadastral corner and a cadastral boundary in NSW.

Previously a corner was considered a singular point at the end a boundary line and a boundary was a line having no width that extended between two corners. Under the procedures used to assign Class and Order a corner will become an ellipse with a semi major axis and a semi minor axis, and a boundary will become a line having a width equal to the semi major axes of the error ellipses at its extents.

2.6.5 Inaccessible Interests in Land

Interests in land are not limited to questions of ownership and possession. A party can have an interest in land which they neither own nor have possession of. This kind of interest is referred to as an easement. An easement is an interest which gives a party the right to use land that is affected by the easement for a specific purpose; or in some cases

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the easement prevents a party, who may be the owner of the land, from performing a specific action on the affected part of the land.

The current Regulations outline how surveys for the purpose of defining interests such as easements are to be carried out. They stipulate what kind of monuments are to be set in place to record the location of these interests and what survey connections must be made between the interests and the surrounding cadastre. [SR2006 Sec18 (1) (2) & (3)]

The Regulations also deal with interests that exist over parts of the land that are inaccessible. For example, a two lot subdivision may create a situation where an existing buried pipeline carries roof water from an existing building to the street and in doing so crosses over land that now belongs to a neighbouring parcel. To provide for this situation an easement over the existing line of underground pipes can be created. [SR2006 Sec 18 (4) (a)] This amounts to an easement which has its location defined by the location of a structure that is protected by the easement.

In other words the structure, which in this example is a pipeline, is protected by the easement and is also the monument that defines the location of the easement.

The position of interests that are inaccessible because they are, for example, buried or contained inside a wall, cannot at this point in time, be adequately defined by coordinates without disturbing the structure or the land in which they are contained. If a coordinated cadastre is to be established in NSW it will still need to rely on monuments and natural features to define the location of some interests.

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Legislation governing the function of a coordinated cadastre would need to determine under what circumstances this was to occur. Table 2.4 lists some circumstances when this paper has suggested it would remain necessary to define the location of interests with monuments or natural features.

-
- | | |
|----|--|
| 1. | Definition of ambulatory boundaries |
| 2. | Easement over existing line of pipes/cables etc |
| 3. | Easement for support |
| 4. | Limitation to internal face of wall (strata plans) |
| 5. | Limitation in height above or depth below |
| 6. | Torrens boundary on face of wall / centre of wall |
-

Table 2.4: Interests Requiring Spatial Definition by Monuments

2.6.6 Changes to the Hierarchy of Evidence

Clause 9 (3) (a) of the SR2006 dictates that surveyors must comply with the NSW Surveyor Generals Directions. Therefore, under the current Regulations, surveyors are bound to attempt to comply with the Hierarchy of evidence depicted by the NSW Surveyor Generals Directions No.7, '*Surveying Regulation Applications*'.

To maintain the stability of boundaries in a coordinated cadastre, the principles of boundary reinstatement applied to the coordinated system would need to adopt a hierarchy of evidence that placed most weight on measurement as a form of cadastral

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evidence. Therefore, the Directions and the Regulations would need to be modified to view measurement as the highest form of cadastral evidence in the coordinated system.

This change would challenge long established principles of common law which view physical boundary evidence such as pegs, reference marks and occupations as the best form of cadastral evidence.

The original surveys must govern, and the laws under which they were made govern, because the land was bought in reference to them; and any legislation, whether State or Federal, that should have the effect to change these, would be inoperative, because of the disturbance to vested rights. (Cooley, cited in ASPLS Standards of Practice Manual 1994, p.3)

The above statement made by Justice Thomas M. Cooley (n.d.) highlights the difficulties that would be faced by a coordinated cadastre that would seek to change the hierarchy of evidence in order to maintain the stability of the coordinate information it consisted of.

It is considered likely that the courts would continue to apply the established principles of common law to a coordinated cadastre, showing favour to monuments as evidence. This would effectively overrule the new Regulations relating to the hierarchy of cadastral evidence. However, any reference to the outcome of a coordinated boundary dispute settled by the courts can only be speculative at this point in time.

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A test case would be needed to determine the reliability of a coordinated cadastre that placed most weight on measurement as a form of cadastral evidence and to determine the sustainability of the Regulations that governed it.

2.6.7 Original Intention

The SR2006 currently enforces the principle that the reinstatement process should place survey marks on the ground at the same location as was done at the time of the original survey. [SR2006 Sec 19 (1)]

‘It is not the job or responsibility of ... [reinstating] surveyors to correct the originals. It is their job to report any discrepancies found.’ (Brown et al. 1995, p. 32)

This principle outlined by Brown is reflected in the NSW Regulations. [SR2006 19 (2) (a) & (b)] For a coordinated cadastre to operate in NSW using coordinates as the primary mode of cadastral evidence, the principles laid down in Clause 19 of the SR2006 relating to original intention would need to be set aside.

The changed Regulations would need to stipulate that corners were no longer fixed by original intentions that were described by direct connections to cadastral monuments. Instead they would be fixed according to coordinates recorded in a cadastral database.

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Adoption of this practice would conflict with the current Regulations which require surveyors to '*measure boundaries by the most direct method reasonably practicable*'. [SR2006 Sec 15]

The location of boundary coordinates on the surface of the Earth will be determined relative to geodetic infrastructure i.e. PMs. The quality of boundary positions fixed on the Earth will be a function of the Class and Order of the geodetic infrastructure connected to during a survey and by the standard of measurements taken. Under a coordinated cadastral system it will be difficult to correct errors or omissions made during the original survey without affecting the spatial rights of abutting owners. This could potentially cause an increase in the volume of land related litigation in NSW.

2.7 Case Studies

It was considered appropriate at this point to briefly discuss two examples of plans that have been registered in NSW.

In example 2.7.1 the location of the relevant interests were described exclusively by MGA94 coordinates. This example was a special case and as such was granted exemptions by the LPI (which was the registering authority at the time of the plans creation) as it did not comply with the 'Surveyors (Practice) Regulation 2001' in effect at the time.

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Example 2.7.2 discusses a conventional survey plan containing a significant measurement error. In this example the adoption of a wall as a monument by the original survey maintained part of the affected interest at its intended location. In essence this is an example of monuments preserving the rights of affected parties in the correct location and of measurements failing to do the same.

2.7.1 A Registered Interest Defined by Coordinates in NSW

The background information for this example was derived from a NSW Roads and Traffic Authority (RTA) Report titled ‘The Kosciuszko Ko-ordinated (sic) Kadastre (sic)’.

Following the coronial inquiry into the events of 1997 that have come to be known as the Thredbo Disaster, control of the roads known as Alpine Way and Kosciusko Road were transferred from the National Parks and Wildlife Service (NPWS) to the Roads and Traffic Authority (RTA). Accordingly it became necessary to establish 120km of new cadastral boundaries encompassing the formation of the two roads, to facilitate their excise from the Kosciusko National Park.

A field survey was completed in relation to the MGA94 using a combination of GPS, photogrammetry and conventional survey techniques. Subsequently plans of the land to be excised from the National Park were prepared and registered. Four sheets from one of these plans are included in Appendix B.

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With the exception of sheet 18 of 18 depicting the control network and the survey locality, all sheets belonging to the plan are similar. Therefore sheets 4 – 17 inclusive are not shown in the appendix.

The plan shows no boundary bearings or distances and there are no direct connections between the new corners and the geodetic monuments constituting the surveys control network. No other monuments refer to the new corners. A note on the plan indicates that none of the new corners were marked.

Therefore, no evidence of these corners exists on the ground and they are not subject to the well defined principles of law governing intention. The only evidence depicting the intention of this survey are the tables of MGA94 coordinates shown on the face of the plan.

Any future reinstatement of the boundaries shown on this plan will not require an interpretation of original intention. However, if an error resulting in an encroachment of the road formation was made during any stage of the survey this error will stand for all time as there is no evidence to refute it.

The circumstances of the survey justify the methods used on this occasion. However, the report prepared by the RTA outlining the survey acknowledges that the ability of this plan to identify cadastral boundaries by coordinates was made possible by a lack of *‘intersecting boundaries and different ownerships’*. The perimeters of most survey plans prepared in NSW are subject to adjacent interests held by a number of other parties.

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If the locations of these interests are themselves defined by monuments, the integrity of the coordinated boundaries could be questioned, as per the hierarchy of evidence and the rules of law. Likewise, in a fully coordinated cadastre any contradictory physical evidence of a corner, such as an old peg, could be used to over-rule recorded cadastral coordinates.

2.7.2 Intention Preserved by Monuments and Lost by Measurement

In September 1994 a plan of easements contained within lots 1 & 2 DP 813828 was created. Under the Torrens Title System '*registration alone gives validity to the transfer or creation of an interest in land*'. (USQ 2004b, p. 2.19) The interests were therefore created on the 30th of December 1994, the date that the easement plan was registered as DP 649949.

In August 2006 another surveyor was given instructions to subdivide the land previously described in DP 649949 as lot 1 DP 813828. During the course of the survey in 2006 a large discrepancy was found between the measurements of the first and second surveys. This discrepancy impacted significantly on the interests created by the easement plan because the location of the easements had been defined by erroneous measurements.

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Two of the easements created by DP 649949, included as part of Appendix B, were for access purposes. A right of carriageway, labelled Q on DP 649949, provided vehicle access from the street, down an access ramp, into an underground carpark situated on lot 2. A right of footway, labelled S on DP 649949, provided pedestrian access into the same underground carpark. Appendix B also contains a photograph of the ramp and footway and a copy of the unregistered plan of subdivision dated 2006. The photograph illustrates the access routes. The plans illustrate the access rights as they currently are and as they should have been.

The easement plan, DP 649949, fixed the northern side of the right of carriageway using the face of a wall as a monument. The southern side of the right of carriageway and the right of footway were fixed in relation to the external boundaries of the allotments, by measurements. The plan also depicts two other walls in the vicinity of the right of footway and the southern perimeter of the right of carriage way.

The plan alludes to the possibility that these interests should have been bounded by the walls. However, this conclusion cannot be drawn as the description '*face of wall*' is not shown at these locations. [SR2006 Sec 64 (2)] As no reference marks fix the location of these interests, their locations are defined by the measurements shown along the frontage of Station Street on the original easement plan i.e. DP 649949.

When the survey for subdivision purposes was performed in 2006 it revealed a discrepancy of 0.91 metres in the measurements along Station Street.

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The end result of the error was that a 0.91 meter wide strip of the access ramp, into the carpark, was not effected by the right of carriageway and the right of footway was shifted laterally so that it was located 0.91 metres north of where it should have been. That is, it covered part of the access ramp not the footpath. This meant that on both occasions the dominant owner had no legal right to use the access structures for the purposes they had been constructed. The northern side of the right of carriageway remained fixed at its intended location because the monument, being the ‘face of wall’ so noted on the easement plan, overruled the measurements shown on the plan.

This example serves as a good illustration for the potential consequences of adopting a cadastral system that relies solely on measurement to define the location of boundaries on the ground.

2.8 Conclusion

Cadastral reforms that adopted coordinates as the primary form of cadastral evidence would provide the opportunity to update the cadastre into a multipurpose LIS. However, physical cadastral evidence is more readily understood by the majority of the community, who are not trained in Spatial Science.

Establishment of a coordinated cadastre in NSW would require changes to the NSW Surveying Regulations. These changes would include the assignment of Class and Order to coordinated cadastral corners.

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To meet the requirements of the new Regulations regarding Class and Order, surveys will need to be performed using control having an appropriate level of precision and accuracy. The coordination surveys would also need to adhere to a set of predetermined standards of practice, or alternatively to standards of practice that could be proven to be equivalent to or better than these.

The preceding chapter recommended that a minimum Class and a minimum Order for geodetic cadastral control be enforced by the Regulations governing the coordinated cadastre and that adjoining coordinated boundaries should be adopted as constraints in a fully constrained adjustment at the standard confidence interval. This would theoretically maintain all spatial rights in the coordinated cadastre at the same level of accuracy.

Cadastral evidence can assume either a physical or documented form. At common law cadastral evidence of a physical nature, such as pegs, reference marks and occupations, is generally considered better evidence of a boundary's location than documented evidence such as survey measurements and coordinates.

It is likely that cadastral marking would still be necessary in a coordinated cadastre in order to indicate the location of a corner on the ground. This coupled with the fact that many owners would erect occupations would ensure that physical evidence, which would on occasion conflict with documented coordinates, continued to exist in a coordinated cadastre.

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It is speculated that even under a coordinated cadastral system the courts would continue to support the doctrine of monuments over measurements. Therefore, until such time as the courts amend the position of measurement in the hierarchy of evidence a proprietor's spatial rights and obligations would be better protected by the placement of accurate survey monuments defining those rights, than by the recording of accurate geodetic coordinates purporting to do the same.

Chapter 3

Procedures for Cadastral Coordination Projects

3.1 Introduction to Coordination Procedures

Ideally all boundary corners belonging to a coordinated cadastre should be assigned the same Order so that no one point can be considered to have greater weight and be used to undermine the rights of an adjacent land owner.

Order is a function of Class and Class is dependant, amongst other things, upon the procedures employed during a survey.

Therefore, it is necessary that surveys which contribute to the proposed coordinated cadastre be performed to a set of predetermined standards of practice, or alternatively, to standards of practice that can be proven to be equivalent to or better than these. The publication SP1, which the Surveying Regulation 2006 adopts as its procedure manual, should be used to set the standards of practice employed during cadastral coordination projects.

In theory surveyors should be employing the standards of practice described by SP1, or alternatively standards of practice that are equivalent or better, when performing control surveys, in order to meet their obligations under the Surveying Regulation 2006.

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The results of the questionnaire distributed to meet the requirements of this paper's Section 1.4 (a) (i) 'Research Methodology' showed however, that 61% of the Surveying Organisations sampled were not familiar enough with the Standards of Practice recommended by SP1 to apply them. Perhaps not surprisingly then, the questionnaire showed that 63% of the survey organisations sampled did not regularly apply the recommendations made by SP1 when conducting control surveys.

Therefore, the following chapter was written to provide a simplified explanation of SP1's recommended procedures for coordination projects, which use conventional terrestrial survey techniques. The procedures outlined by this chapter are intended to be applied to cadastral coordination surveys aimed at achieving a Class C survey. This Class of survey conforms to the requirements of "Survey Coordination Projects" described by SP1 (ICSM 2004, p. A-7) and to the recommendations made by Section 2.6.3 of this paper. The survey procedures recommended in the following chapter are a reflection of the techniques applied to the coordination survey performed in Cambridge Gardens, during the course of this project. These techniques were based upon the recommendations of SP1 and the NSW Surveyor Generals Directions.

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3.2 Searching Procedures

A complete search of public records for relevant cadastral information should be the first task of any cadastral survey. The majority of this task can still be achieved in person at the Land Titles Office located at 1 Prince Albert Road, Queens Square, Sydney. However, often it will be more convenient for a surveyor to engage the services of an organisation that specialises in the performance of cadastral searches, to undertake searching tasks on the surveyor's behalf.

It is recommended that the option of engaging a specialist searching organisation be adopted when completing the cadastral searching requirements of cadastral coordination projects. The NSW Department of Lands website contains a list of approved information brokers at <https://lpi-online.lpi.nsw.gov.au/lpsearch/brokers.html>.

The searching requirements of a cadastral coordination project also necessitate a search of the Survey Control Information Management System (SCIMS) for geodetic control in the form of permanent marks (PMs). The PMs used as geodetic control must have MGA94 coordinates with a minimum Class C and minimum Order 3 to meet the recommendations made by Section 2.6.3 of this paper “Class and Order in a Coordinated Cadastre”.

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For greatest convenience this search should be conducted using the SCIMS online radial coordinate searching facility available at <https://scims.lands.nsw.gov.au>.

This service recalls all PMs situated within a specified radial distance of a specified horizontal coordinate. The approximate MGA94 coordinate at the centre of the survey site should be determined by scale, using a representation of the MGA94 grid which is commonly found overlain onto the pages of street directories and topographic maps. This coordinate should then be input into the online search facility and the appropriate SCIMS Mark Plot and SCIMS Mark Reports retrieved (examples of these documents are included in Appendix E). The SCIMS online radial coordinate search can be refined to allow the search to filter out marks not meeting required criteria such as a minimum Class and Order.

A fuller description of the SCIMS searching facility is provided by the NSW Surveyor General's Directions No 4 "Using the Survey Control Information Management System (SCIMS)". This description includes details of how to make a PM search request by conventional mail or fax.

The searching procedures described above fulfil the requirements of Clause 7 (a) & (b) of the SR2006 and the Surveyor Generals Directions No 7 "Surveying Regulation Applications", in regards to searching requirements for cadastral surveys.

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3.3 Verification of Survey Equipment

To maintain legal traceability of the measurements made during a cadastral coordination survey and to ensure the compatibility of measurements made during independent coordination surveys, a surveyor must regularly verify that the survey equipment used during these surveys is functioning correctly.

The goals of this paper do not include describing the technical procedures a surveyor should follow when verifying the accuracy of equipment used to perform a cadastral coordination project. It is sufficient to acknowledge that it is a requirement of the SR2006 that surveyors *‘not use any equipment in making a survey unless the surveyor knows the accuracy obtained by its use.’* [Sec 14 (2) SR2006]

It is anticipated that a surveyor making reference to this chapter will intend to perform a cadastral coordination survey using conventional terrestrial surveying techniques. It is also anticipated that these techniques would include the measurement of horizontal distances with electronic distance measuring (EDM) equipment and the measurement of horizontal angles with an electronic total station.

Surveyors needing to verify the measuring capabilities of their EDM are referred to Part II of the NSW Surveyor Generals Directions No 4 ‘Verification of Distance Measuring Equipment’. These directions provide surveyors with detailed technical instructions for the verification of EDM equipment. The directions also list the location of 18 pillared

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Test Lines throughout NSW that can be used by surveyors to verify their EDM equipment.

Most inaccuracies associated with angular measurement in a survey network are to be accounted for by the application of corrections to observed horizontal angles and the application of appropriate surveying procedures. These procedures and corrections are discussed further in Section 3.4 ‘Field Procedures’ and Section 3.5 ‘Calculations and Adjustments’.

3.4 Field Procedures

The publication ‘Standards and Practices for Control Surveys (SP1)’ defines the attributes of precision and accuracy through the terms Class and Order respectively.

Class is a function of the planned and achieved precision of a survey network ... Order is a function of the Class of a survey, [and] the conformity of the new survey data with an existing network (ICSM 2004, p. A-6 & A-9)

In other words Class is a measure of the precision of the survey that established the coordinates of a survey mark or that would theoretically establish cadastral coordinates. Order is based upon the Class achieved by the survey and is also a measure of a coordinated point’s accuracy. That is, it is a measure of how well the point fits with known control and in the case of a coordinated cadastre how

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well it fits with abutting cadastral coordinates. Table 3.1 describes the relationship between the Class of a survey and the highest Order the surveyed points can achieve.

| CLASS | ORDER |
|-------|-------|
| 3A | 00 |
| 2A | 0 |
| A | 1 |
| B | 2 |
| C | 3 |
| D | 4 |
| E | 5 |

Table 3.1 Relationship between Class and Order

Source: ICSM, ‘Standards and Practices for Control Surveys’, 2004

Control surveys that are tied to the National coordinate reference frame should be assigned a Class that corresponds to the designed and achieved precision of the survey. Individual points belonging to the survey should be assigned an Order to indicate the accuracy with which their position is described. (ICSM 2004, p.A-5)

Section 2.6.3 of this paper “Class and Order in a Coordinated Cadastre” recommended that the Regulations governing a coordinated cadastre should stipulate that the Class and

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Order of the coordinated cadastre should meet the requirements of SP1 for “Survey Coordination Projects”. This is equivalent to a Class C and Order 3 (ICSM 2004, p.A-7 & A-9). Tables 3.1 and 3.2 illustrate the relationship of Class and Order for ‘Survey Coordination Projects’ as recommended by SP1.

| CLASS | C | Typical Applications |
|-------------------------------|-----|--|
| (for 68% confidence interval) | | |
| 3A | 1 | Special high precision surveys |
| 2A | 3 | High precision National geodetic surveys |
| A | 7.5 | National and State geodetic surveys |
| B | 15 | Densification of geodetic survey |
| C | 30 | Survey coordination projects |
| D | 50 | Lower CLASS projects |
| E | 100 | Lower CLASS projects |

Table 3.2 Assigning Class to Horizontal Control Surveys

Source: ICSM, ‘Standards and Practices for Control Surveys’, 2004

The following paragraphs describe the minimum acceptable field practices for a cadastral coordination project, performed with an electronic total station, aiming to meet the standards of a Class C survey. These practices are derived from the procedure manual SP1 and the Surveyor Generals Directions No.3.

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Typically this kind of survey will consist of two types of measurement, angular measurement and distance measurement. Each of these will be dealt with separately.

3.4.1 Angular Measurement for a Class C Survey

Definitions: Pointing – a single intersect with a target.

Arc – the average of face left and face right pointings.

Zero – the initial circle reading taken to the reference object.

Set – a number of arcs with a different zero for each arc.

(USQ 2004c, p.3.13 – 3.14)

The following numbered points describe the procedures a surveyor should consider employing when performing angular observations as part of a cadastral coordination survey aimed at achieving a Class C precision.

- 1) It is permissible to perform all angular observations associated with a Class C survey over a single day. (ICSM 2004, p. B-7)
- 2) To reduce the effect of horizontal refraction on observed horizontal angles it is advisable to perform these observations '*an hour or two after sunrise and [an hour or two] before and after sunset*' (USQ 2004c, p.3.17). However, angular

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measurements aimed at achieving a Class C survey may be read at any time of the day if appropriate checking procedures are employed. (ICSM 2004, p.B-7) Surveyor's will need to exercise their professional judgment when observing this recommendation, so as to accomplish the desired level of precision whilst ensuring the survey is completed in a reasonable time frame and within budget.

- 3) The instrument used to observe horizontal angles for a Class C survey must be capable of reading angles to 1" of arc or better. (ICSM 2004, p.B-7)
- 4) When measuring angles as part of a coordinated cadastral survey the length of the observation lines will dictate the procedures that should be employed to measure the angles between those lines.

For the majority of lines in a coordinated cadastral survey observation lengths will be less than 1 kilometre. On these occasions a minimum of two arcs of horizontal angles should be read. (Surveyor Generals Directions No.3 2004, p.2)

The need to establish control of Order 3 at the survey site may necessitate the measurement of long lines as part of the coordinated cadastral survey.

For observation lines greater than 1 kilometre in length one set of six arcs should be read at each station setup. A different zero should be read to the reference object for each arc to minimise the effect of any instrumental error associated with the horizontal circle (ICSM 2004, p.B-7). This technique is often referred to as splitting

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the circle. For a set of six observations it is suggested the zeros approximate the examples show in Table 3.3.

| Table of Zeros |
|----------------|
| 00° 00' 10" |
| 30° 11' 50" |
| 60° 03' 30" |
| 90° 15' 10" |
| 120° 05' 50" |
| 150° 18' 30" |

Table 3.3: Table of Zeros

Source: ICSM, 'Standards and Practices for Control Surveys', 2004

The zeros should be read to the reference object, as opposed to being set to the reference object, this will minimise the effect of pointing errors. Because the zeros are read to the reference object their values may be several seconds different to those shown in Table 3.3.

- 5) For the majority of angles belonging to an observation set, the difference between an observed angle and the mean angle of the observation set should be less than or equal to 3"; if this is not the case the observation set should be repeated. If the difference between an observation and the mean of the observation set exceeds 6" the observation should be repeated until the difference is less than or equal to 6". (ICSM 2004, p.B-8).

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- 6) The range of angles within an observation set should usually be less than or equal to 6". If the range of angles within an observation set exceeds 12" the observations outside of this range should be repeated until the range of the observation set is less than or equal to 12". (ICSM 2004, p.B-8)

It should be acknowledged that the standards of practice booklet SP1, upon which procedures 4 & 5 are based, was '*not designed to cover specific issues of cadastral surveys*'. (ICSM 2004, p.A-5)

During the course of a coordinated cadastral survey it may be necessary for a surveyor to measure lines that vary greatly in length. The effect that a residual to the mean of an observation set will have on the positional uncertainty of a surveyed point reduces with a reduction in the length of the observed line. Therefore, whilst it is recommended that the procedures described by points 4 and 5 be followed for observations involving long lines, especially lines longer than 1 kilometre, surveyors should exercise their own professional judgment as to the application of these procedures when observing short lines.

For example: an observation set having an angular range of 13" over a length of 30 meters equates to a positional uncertainty of 1.9mm;

$$\begin{aligned}\text{Positional uncertainty} &= (\sin 13'') \times 30 \text{ metres} \\ &= 1.9 \text{ mm}\end{aligned}$$

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Too strict an adherence to the recommendations of points 4 & 5 in all circumstances may result in a substantial increase to the cost of a survey with very minimal gains in achieved precision and accuracy.

- 7) The following procedures should also be applied to a Class C survey to eliminate systematic instrumental errors associated with angular measurement that will not have been eliminated by the procedures described up to this point. (ICSM 2004, p.B-8)
 - i) The slow motion screw should always be turned into compression to avoid slow motion screw backlash.
 - ii) The intersection point of the cross hairs should be set onto the target for each face left pointing and each face right pointing. This will minimise any error resulting from misalignment of the cross hairs.
- 8) The plate bubble should be checked for ‘wandering’ after each pointing. If any wandering of the plate bubble is noted the number of graduations left of centre and right of centre should be recorded so that a Dislevelment Correction can be applied to the observation during reductions. (ICSM 2004, p.B-8) The plate bubble should be re-levelled at the completion of the arc of observations.

The effect of plate bubble wandering reduces with reductions in the length of observation lines. Therefore whilst this procedure should always be adopted for

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lines greater than 1 kilometre, surveyors should apply their professional judgement when deciding whether or not to apply this correction on shorter lines. In many cadastral survey situations if wandering occurs it may be less troublesome to re-level the instrument and commence the arc of observations again.

3.4.2 Distance Measurement for a Class C Survey

The following numbered points describe the procedures a surveyor should consider employing when performing distance observations as part of a cadastral coordination survey aimed at achieving a Class C precision.

- 1) It is permissible to perform all distance observations associated with a Class C survey over a single day. (ICSM 2004, p.B-4)
- 2) When measuring distances as part of a coordinated cadastral survey the length of the observation lines will dictate the procedures that should be employed to measure the distance of those lines.

For the majority of lines in a coordinated cadastral survey observation lengths will be less than 1 kilometre. On these occasions the distance of a line should be measured in both directions. If the difference between the two measurements is greater than 6mm+30ppm the distances should be measured again to determine which distance to adopt. (Surveyor Generals Directions No.3 2004, p.3)

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For observation lines greater than 1 kilometre in length six to ten measurements should be read between the occupied station and the observation point. The instrument should then be re-pointed at the target and another six to ten measurements read. This process should occur over several minutes. The combination of these two groups of measurements is described by SP1 as a set. Observations should be made at both ends of the line.

To achieve a Class C result over a distance greater than 1 kilometre one full set of measurements is required between occupied stations and observation points. (ICSM 2004, p.B-4)

- 3) Atmospheric readings should be taken at the time of the survey and appropriate corrections applied to the observations. The atmospheric readings are to include estimates of temperature made with a glass mercury filled thermometer, having a graduation interval of less than 1 degree Celsius. An estimate of air pressure should also be made. This estimate should be made to within 0.3hPa with a calibrated barometer. (ICSM 2004, p.B-4)
- 4) Atmospheric observations must be taken at both ends of observed lines greater than 1 kilometre to meet the requirements of a Class C survey (ICSM 2004, p.B-4). However many of the lines measured during a coordinated cadastral survey will be relatively short and so the atmospherics at either end of the line should be similar. The need to measure atmospherics at either end of an observed line must be left to the surveyor's discretion.

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- 5) Distances measured by EDM must meet with National standards regarding traceability. To ensure these requirements are complied with a surveyor should refer to the Surveyor Generals Directions as outlined in Section 3.3 of this paper “Verification of Survey Equipment”. All EDM measuring equipment should be calibrated in accordance with the Surveyor Generals Directions at least annually and immediately after service and repair. [SR2006 Sec 14 (4)]

3.4.3 General Field Requirements for a Class C Survey

Class and Order are assigned to survey points by conducting a minimally constrained adjustment of the survey network and then a fully constrained adjustment of the survey network. Following the adjustments, comparisons of the semi-major axes of the standard error ellipses of the surveyed lines are made against the maximum allowable semi-major axes of corresponding lines. The maximum allowable semi-major axis of each line is determined by the formula;

$$r = c (d + 0.2).$$

(ICSM 2004, p.A-6 & A-9)

In order to perform the minimally constrained least squares adjustment and the fully constrained least squares adjustment the survey network must have redundancy built into it.

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The Survey General's Direction No.3 'Control for Cadastral Surveys' specifies that all permanent marks should be included in a closed survey network. The directions state *'no mark should be left hanging at the end of a radiation'*. Accordingly field techniques such as surveying closed loops and observing points from multiple stations should be employed by surveyors performing cadastral coordination surveys. These techniques will provide the survey network with the redundancy needed to perform a least squares adjustment and hence will facilitate the assignment of Class and Order to the survey network.

3.5 Calculations and Adjustments

The following Sections contain a description of the dislevelment correction that should be applied to angular observations that were noted as being subject to plate bubble wandering. As well as a general description of the adjustment processes that need to be applied to a cadastral coordination survey network in order to establish the Class and Order of the network.

3.5.1 Dislevelment Correction

Point number eight of Section 3.4.1 of this paper "Angular Measurement for a Class C Survey" discusses the field procedures to be applied when it is noted that the plate bubble has been effected by wandering. The following paragraphs describe the correction process to be applied to observations that have been effected by plate bubble wandering.

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As stated in Section 3.4.1 surveyors must use professional judgement to decide the suitability of this correction for the circumstance of the survey. In many cadastral survey situations if wandering occurs it may be less troublesome to re-level the instrument and commence the arc of observations again.

The Dislevelment Correction is expressed in the following formula;

$$c'' = \frac{b(\sum L - \sum R)}{n} \cot ZD$$

c'' = dislevelment correction

L = plate bubble reading divisions left of centre

R = plate bubble reading divisions right of centre

b = value of seconds of division of the plate bubble tube eg 20''

ZD = observed zenith distance

n = number of plate bubble readings. NB for 12 pointings n = 24

because plate bubble readings occur at Left and Right ends of the bubble tube.

(USQ 2004c, p.4.19)

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This correction should be applied to the mean of the observation set.

For example: for an observation set that has the following attributes;

$$\text{Mean} = 172^{\circ} 17' 20''$$

$$b = 20''$$

$$ZD = 105^{\circ} 28'$$

Bubble Readings

| L | R |
|-----------------|----------------|
| 3 | 2 |
| 3 | 2 |
| 4 | 1 |
| <u>4</u> | <u>1</u> |
| $\Sigma L = 14$ | $\Sigma R = 6$ |

$$c'' = 20'' \frac{(14 - 6) \cot 105^{\circ} 28'}{8}$$

$$c'' = -5.53''$$

$$\begin{aligned}\text{Corrected Observation} &= 172^{\circ} 17' 20'' - 5.53'' \\ &= 172^{\circ} 17' 14.47''\end{aligned}$$

(USQ 2004c, p.4.19)

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3.5.2 Assessing Class with a Minimally Constrained Adjustment

References to aspects of this topic were made during previous Sections of this paper. For convenience these aspects were repeated at this point, so that a complete description of the process used to assess the Class of a cadastral coordination survey network was provided.

All examples provided throughout the remainder of this chapter were made in reference to the survey network illustrated by Figure 3.1. This network formed a loop in part of the survey traverse performed over Cambridge Gardens during the course of this project.

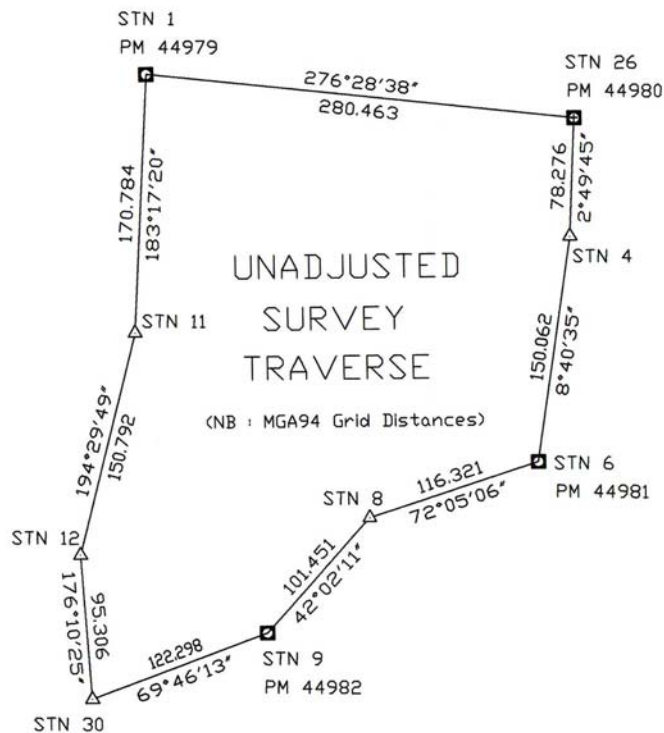


Figure 3.1 Unadjusted Survey Traverse

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As was stated in Section 3.4.3 Class and Order are assigned to survey points by conducting both a minimally constrained adjustment of the survey network and then a fully constrained adjustment of the survey network. When performing a fully constrained adjustment on a cadastral coordination survey network the network is constrained by PMs having MGA94 coordinates. Therefore, the first step in the adjustment process is to apply a combined scale factor (CSF) to the surveyed distances of the network to reduce these from ground distances to grid distances. This is done as follows;

$$\text{Grid Distance} = \text{Ground Distance} \times \text{CSF}$$

Example STN 1 to STN 11:

The combined scale factor (CSF) for the example network was derived from the SCIMS Survey Mark Reports (Appendix E). The CSF = 1.000142. The surveyed ground distance of the line between Station 1 and Station 11 was 170.760. Therefore

$$\text{Grid Distance} = 170.760 \times 1.000142$$

$$\text{Grid Distance} = 170.784$$

This reduction process must be applied to all lines in the survey network prior to performing the least squares adjustment process.

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To assess the Class of the survey network a minimally constrained least squares adjustment must be performed on the survey network that consists of angles and grid distances. Following the adjustment a comparison of the semi-major axis of the standard error ellipse for each line of the network must be made against the maximum allowable semi-major axis for corresponding lines. The maximum allowable semi-major axis is determined by the application of the following formula;

$$r = c (d + 0.2)$$

r = maximum length of semi major axis in mm

c = empirical factor (Table 3.2)

d = distance between control points in KM

(SP1 2004, p. A-6)

Example STN 1 to STN 11:

$d = 0.170784$ (Refer Figure 3.1)

$c = 30$ (Table 3.2)

$r = 30 (0.170784 + 0.2)$

$r = 11.12$ mm

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For the survey to be assigned Class C the results of the comparison must show that the semi-major axes of the standard error ellipses resulting from the minimally constrained adjustment are smaller than the corresponding maximum allowable semi-major axes.

For example Table 3.4 contains the semi-major axes of the standard error ellipses resulting from a minimally constrained adjustment of the network illustrated in Figure 3.1 and the corresponding maximum allowable semi-major axes of the same network. Comparisons of these values show that on each occasion the semi-major axis of the standard error ellipse is smaller than the corresponding maximum allowable semi-major axis. Therefore the survey network achieves a Class C.

| Relative Error Ellipses (metres) 68% Confidence Region | | | | Maximum |
|---|----|------------------------|------------------------|---|
| Stations | | Semi-Major Axis | Semi-Minor Axis | Allowable Semi-Major Axis (r) |
| From | To | | | |
| 1 | 11 | 0.009282 | 0.004460 | 0.011124 |
| 1 | 26 | 0.009894 | 0.000000 | 0.014414 |
| 4 | 6 | 0.009097 | 0.004736 | 0.010502 |
| 6 | 8 | 0.008513 | 0.004149 | 0.009490 |
| 8 | 9 | 0.008471 | 0.003900 | 0.009044 |
| 11 | 12 | 0.009104 | 0.005160 | 0.010524 |
| 12 | 30 | 0.008391 | 0.003707 | 0.008859 |
| 26 | 4 | 0.008194 | 0.002004 | 0.008348 |
| 30 | 9 | 0.008582 | 0.004885 | 0.009669 |

Table 3.4 Comparison of Maximum Allowable Semi-Major Axes & Semi-Major Axes of Standard Error Ellipses Resulting From Minimally Constrained Adjustment of Survey Traverse

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3.5.3 Assessing Order with a Fully Constrained Adjustment

The process used to assess the Order of a survey network is similar to that used to assess Class. Initially Table 3.1 should be consulted to determine the highest Order that can be assigned to the survey based on the achieved Class of the survey.

A fully constrained least squares adjustment must then be performed on the survey network that consists of angles and grid distances. The network should be constrained by PMs connected to the survey network which have an Order that is equal to or better than the survey's target Order and by any adjoining coordinated boundary corners.

Following the adjustment a comparison of the semi-major axis of the standard error ellipse for each line of the network must be made against the maximum allowable semi-major axis of the corresponding line. When assessing the Order of a survey the maximum allowable semi-major axis is determined by applying the same formula used when assessing Class i.e.

$$r = c (d + 0.2).$$

When assessing Order the application of this formula, and the variables used by it are the same as those used when assessing Class.

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For the survey to be assigned Order 3 the results of the comparison must show that the semi-major axes of the standard error ellipses resulting from the fully constrained adjustment are smaller than the corresponding maximum allowable semi-major axes.

For example Table 3.5 contains the semi-major axes of the standard error ellipses resulting from a fully constrained adjustment of the network illustrated in Figure 3.1 and the corresponding maximum allowable semi-major axes of the same network. Comparisons of these values show that on each occasion the semi-major axis of standard error ellipse is smaller than the corresponding maximum allowable semi-major axis. Therefore the survey network achieves an Order 3.

| Relative Error Ellipses (metres) 68% Confidence Region | | | | Maximum |
|---|----|------------------------|------------------------|---|
| Stations | | Semi-Major Axis | Semi-Minor Axis | Allowable Semi-Major Axis (r) |
| From | To | | | |
| 1 | 11 | 0.008125 | 0.003444 | 0.011124 |
| 1 | 26 | 0.000000 | 0.000000 | 0.014414 |
| 4 | 6 | 0.006511 | 0.001452 | 0.010502 |
| 6 | 8 | 0.005837 | 0.001455 | 0.009490 |
| 8 | 9 | 0.005837 | 0.001455 | 0.009044 |
| 11 | 12 | 0.008169 | 0.003580 | 0.010524 |
| 12 | 30 | 0.007502 | 0.002708 | 0.008859 |
| 26 | 4 | 0.006511 | 0.001452 | 0.008348 |
| 30 | 9 | 0.007286 | 0.003366 | 0.009669 |

Table 3.5 Comparison of Maximum Allowable Semi-Major Axes & Semi-Major Axes of Standard Error Ellipses Resulting From Fully Constrained Adjustment of Survey Traverse

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Once the adjustments have been performed and the network has achieved the required levels of Class and Order the adjusted lines should be reduced from grid distances back to ground distances.

The adjusted grid distances are converted back to ground distances as follows;

$$\text{Adjusted Ground Distance} = \text{Adjusted Grid Distance} \div \text{CSF}$$

Example STN 1 to STN 11:

$$\text{Adjusted Ground Distance} = 170.785 \div 1.000142$$

$$\text{Adjusted Ground Distance} = 170.761.$$

Once all adjusted grid distances are reduced to adjusted ground distances, cadastral calculations can be performed to re-establish the location of boundary corners relative to monuments found in the field.

When the surveyor is satisfied with the calculated boundary definition the CSF should again be applied to the survey network, including the cadastral boundaries so that all the ground distances are converted back to grid distances.

At this stage it is possible for the surveyor to determine the MGA94 coordinates of the boundary points which have been assigned a Class C and Order 3.

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3.6 Conclusion

The Inter-Governmental Committee on Surveying and Mapping (ICSM) developed the system that defines the attributes of network precision and accuracy with the terms Class and Order. The workings of this system are described in detail by the publication known as ‘Standards and Practices for Control Surveys (SP1)’.

The preceding chapter provides a basic description of the procedures a surveyor should follow when performing a cadastral coordination survey that is aimed at achieving a precision of Class C and an accuracy of Order 3 using conventional terrestrial surveying equipment.

The information provided in this chapter may assist surveyors who are not familiar with the recommendations of SP1 to develop a better understanding of the recommendations made by the document. However it should not be used as a substitute for SP1.

Surveyors who find themselves performing surveys of any nature to a specified Class and Order should familiarise themselves fully with the standards and practices recommended by SP1.

Chapter 4

Questionnaires

4.1 Introduction to Questionnaires

The specifications of this project required that a cost benefit analysis of the proposal to coordinate the cadastre be made.

To make an accurate determination of the costs and benefits associated with coordinating the cadastre, accurate up to date data was required on a range of issues related to the proposal to coordinate the cadastre. These issues included the current application of cadastral information, the perceived suitability of a coordinated cadastre for current and future applications, user familiarity with coordinate information and coordinate systems and the identification of incentives to encourage the participation of surveyors in the coordination process.

The users and creators of cadastral data were considered the most appropriate source for this information. Hence two questionnaires were designed and distributed to these groups throughout NSW.

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Some of the data collected by the questionnaire was also used for justification of other tasks performed by the project and to establish specific values such as the royalty amount to be applied to the break even analysis performed in Chapter 5.

4.2 Questionnaire Sample Selection

The primary goal of any statistical analysis is to achieve a true account of the characteristics of a population, based on measurements taken of a sample deemed to be representative of the population of interest.

So that this research project would accomplish the goal described above when gathering data for the cost benefit analysis, two questionnaires were distributed across a broad cross section of the spatial science community. The questionnaires were named the ‘NSW Surveying Questionnaire’ and the ‘NSW Spatial Information Questionnaire’ and are included in Appendix C along with the resulting questionnaire response data. The ‘NSW Surveying Questionnaire’ targeted surveying organisations which gather spatial information. The ‘NSW Spatial Information Questionnaire’ targeted organisations that use spatial information to fulfil a land development or land management role. A total of 621 questionnaires were distributed to government and private sector industries in NSW as shown in Tables 4.1 and 4.2.

Chapter 4 – Questionnaires

| | |
|-------------------|-----|
| Council Surveyors | 100 |
| Private Surveyors | 213 |

Table 4.1: NSW Surveying Questionnaire Distribution

| | |
|----------------------------|-----|
| Civil Engineers | 37 |
| Town Planners | 38 |
| Architects | 33 |
| Local Councils | 100 |
| Registered Clients of DCDB | 100 |

Table 4.2: NSW Spatial Information Questionnaire Distribution

Because it was desirable that sample populations were derived from varied sections of the spatial science community it became convenient to use several information sources when selecting members of the sample populations, the processes adopted were as follows.

The Yellow Pages ® was used to select sample populations for Private Surveyors, Civil Engineers, Town Planners and Architects. An online version of the directory found at www.yellowpages.com.au provided the ability to search each professional grouping by

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yellow pages book regions, of which there are 20 in NSW. The location of these regions are illustrated by a map of NSW included in Appendix C. The result of each regional search was then proportioned for each profession, by the total number of listed organisations belonging to the profession in NSW. The number of questionnaires distributed to a region was then calculated based on this ratio.

For example, 79 listings for surveyors were found in Tamworth, the total number of surveyors listed in NSW was 1211. Therefore, the ratio of surveyors belonging to the Tamworth Region was $79/1211$. A total of 200 questionnaires were expected to be sent to Private Surveyors in NSW. Therefore, the number of questionnaires sent to the Tamworth Region was $(79/1211) \times 200 = 13$. Rounding of these numbers meant the final number of questionnaires posted was often one questionnaire higher than the calculated number.

A disproportionate number of Architects (75.8%) were found listed in the Sydney region. Therefore, the ratio of architects for 11 of the 20 regions translated into less than one questionnaire. Questionnaires were not distributed to this profession in these 11 regions. This meant that the sample population throughout NSW was maintained as a true representation of the distribution of the profession across NSW. Also the final statistical results were not significantly biased in favour of the profession, by the inclusion of large numbers of extra questionnaires to represent Architects in all geographic regions. Table 4.3 lists the regions in which Architects were not represented.

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| | | |
|----------------|--------------|-------------|
| Albury/Wodonga | Campbelltown | Nowra |
| Bathurst | Cooma | Wagga Wagga |
| Bega | Dubbo | Windsor |
| Broken Hill | Muswellbrook | |

Table 4.3: Yellow Pages Book Regions Not Represented by Architects in Questionnaire Data

The NSW Department of Local Government website located at www.dlg.nsw.gov.au was used to select sample populations for Council Surveyors and Local Councils. The procedure was similar to that used with the Yellow Pages ®. A Graphics Interchange Format (GIF) Image on the webpage provided the ability to search for local councils by local government regions, of which NSW has 14. Once again the results of this search were then proportioned for each region by the total number of local councils in NSW. The number of questionnaires distributed in a region was then calculated based on this ratio. The phone number for each council was also identified using www.dlg.nsw.gov.au. The two digits following the area code (02), were used to establish which yellow pages book region a council belonged to. This provided a common geographic reference for all members of the sample population.

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A spreadsheet containing a list of organisations with licences for the NSW DCDB was contributed by the NSW Department of Lands for use by this research project.

The spread sheet was used to select a sample population of registered users of the DCDB. The online version of the Yellow Pages directory www.yellowpages.com.au was used to determine the phone numbers of the organisations and again the two digits following the area code (02) were used to establish which yellow pages book region the organisation belonged to.

When it was noted that an organisation was listed in a multiple number of regions the organisation was only selected as a representative for one of those regions.

4.3 Questionnaire Rationales

Both of the questionnaires included in Appendix C were distributed simultaneously, along with letters of introduction outlining the project and the objectives of the questionnaires. The rationale behind the two questionnaires was different as it was anticipated that the effects of the proposal to coordinate the cadastre would be different on the two categories of target populations.

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4.3.1 NSW Surveying Questionnaire Rationales

Question one was answered for the respondents before posting. The question identified which of the twenty NSW yellow pages book regions the questionnaire had been sent to. This information made it possible to identify patterns in questionnaire responses that were attributable to geographic location.

Question two measured the approximate number of surveys that the respondent currently connects to the states geodetic control network at a cost to themselves or their clients.

Question three measured the costs associated with connecting a cadastral survey to geodetic monuments, as opposed to the entire cost of a cadastral survey. The average annual value of these geodetic connections was calculated by combining the responses to questions two and three.

Question four measured the satisfaction rate of surveyors with the current legislative requirements relating to geodetic connections to the cadastre.

Question five determined the willingness of surveying organisations to participate in a programme of cadastral coordination under a royalty scheme. If the Surveying industry was unwilling to participate under a royalty scheme, the coordination programme would become unworkable under such a scheme.

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Question six measured the percentage from each sale of a cadastral coordination plan a respondent believed would be fair compensation for the resources their organisation invested into the creation of the plan. This figure was based on the current sale price of a deposited plan purchased online from the NSW Department of Lands. That price was \$8.50 per image including GST.

Questions seven, eight, nine and ten measured the number of respondents that had used technologies that were complementary to coordinated spatial data in the 7 days prior to responding to the questionnaire. It was believed that asking organisations to indicate whether or not they had used these technologies in the last 7 days would better reveal trends associated with the technology, than asking an organisation if they frequently used a technology. This was because a response that was given to the second style of question would have been subject to the respondent's opinion. It was assumed that if organisations indicated they had used this technology recently they would be likely to benefit from the proposed change to a coordinated cadastre. It was also assumed that if organisations indicated they had not used this technology recently they would not find the change beneficial; in fact, they may experience additional costs resulting from a need to update technology and training.

Question eleven measured the industries familiarity with the document SP1. Question twelve measured the rate at which SP1's recommendations were practiced. During Chapters Two and Three this project suggested that when appropriate the recommendations made by SP1 regarding control surveys should be practiced whilst performing the proposed coordination surveys. Therefore, the surveying industries familiarity with SP1 should be considered in terms of cost and benefit.

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Question thirteen measured the quantity of information already provided to survey clients as MGA94/GDA94 information. A coordinated cadastre would compliment other MGA94 spatial data created by surveyors therefore constituting a benefit to the surveyor and the wider community. Conversely, a coordinated cadastre may negate the need for the services of a surveyor in some situations, thereby constituting a cost to the surveyor.

Whilst an argument can be made that a coordinated cadastre may reduce demand for surveying services in some circumstances, surveyors should not pose this as an argument against coordination of the cadastre. Apart from the ethical reasons behind this statement there is also a very good chance that the development of a coordinated cadastre would lead to other developments, technological or otherwise, which would see an increase in the demand for surveying services in other areas.

Questions fourteen and fifteen identified areas in which the staff of respondent survey organisations would require training that was specific to the understanding and application of MGA94 spatial information. Additional training of this nature would represent a cost to survey organisations. Training is also likely to benefit the organisation by providing staff with the skills necessary to provide different services to the community thereby increasing an organisation's customer base. Alternatively, extra training may simply allow the organisation to provide current services in a more efficient manner.

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Question sixteen measured the perceived ability of a coordinated cadastre to benefit surveying organisations.

4.3.2 NSW Spatial Information Questionnaire Rationales

Question one was answered for the respondents before posting. The question identified which of the twenty yellow pages book regions in NSW the questionnaire had been sent to. This information made it possible to identify patterns in questionnaire responses that were attributable to geographic location.

Question two determined the most popular medium used, by respondents to the questionnaire, when accessing cadastral data. The responses given to this question were used to assist in the determination of an appropriate method for the presentation, storage and dissemination of coordinated MGA94 cadastral information.

Question three measured the volume of a respondent's work that could potentially be effected by the proposal to coordinate the cadastre. Other questions determined if this respondent would gain or lose from the proposal, this question gave an indication of how much gain or loss would be made.

Question four identified whether or not an organisation currently used coordinates when dealing with spatial information. Question five identified whether or not the members of an organisation were familiar with the coordinate systems MGA94 and GDA94. These two questions were intended to give an indication of how large a transition the proposed

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change to a coordinated cadastral system would be for organisations that use cadastral data.

Questions six and seven measured what percentage of an organisation's spatial information is currently stored in an electronic format and in a coordinated form. The questions also identified how much of the data stored in this form was on the MGA94 or GDA94 coordinate systems. This would indicate how compatible the proposed coordinated cadastral information would be with information currently stored by organisations and how compatible the new coordinate information would be with organisations current storage systems.

Questions eight, nine and ten measured the number of respondents that had used technologies that were complementary to coordinated spatial data in the 7 days prior to responding to the questionnaire. It was believed that asking organisations to indicate whether or not they had used these technologies in the last 7 days would better reveal trends associated with the technology, than asking an organisation if they frequently used a technology. This was because a response that was given to the second style of question would have been subject to the respondent's opinion. It was assumed that if organisations indicated they had used this technology recently they would be likely to benefit from the proposed changes. It was also assumed that if organisations indicated they had not used this technology recently they may experience additional costs resulting from a need to update technology and training.

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Question eleven measured the accuracy required of spatial information by the respondent organisations. It was assumed that organisations that used coordinated spatial information and required high accuracies for this information would stand to benefit from the proposal to coordinate the cadastre. Organisations that use coordinated spatial information and that find the lower accuracies that are provided by the current DCDB are sufficient for their needs may stand to lose if the proposed changes were to result in an increase in the cost of coordinated cadastral data which can currently be sourced from the DCDB at lower spatial accuracies.

Question twelve referred to what Section 2.4 of this report “Arguments Supporting a Coordinated Cadastre” suggested should be the long term goal aspired to when coordinating the cadastre. That is the establishment of a cadastre which is in fact a multipurpose LIS that can store and retrieve information relating to land in thematic layers. The question asked respondents if this kind of a cadastre would be more beneficial to their organisation than the current system.

Question thirteen attempted to identify areas in which an organisation’s staff members would require training to work with the proposed change to a coordinated cadastre.

Question fourteen measured the perceived ability of a coordinated cadastre to benefit respondent organisations.

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4.4 Questionnaire Results

The returns total for the questionnaires is illustrated in Table 4.4. As can be seen the response rate from surveyors was significantly less than that of the other professionals. This was disappointing given that the project was being carried out in order to fulfil the requirements necessary to join the ranks of the surveying profession.

Several questionnaires were responded to as ‘Return to Sender’; on these occasions the questionnaire was not included in the returns total. Another small number of questionnaires were returned containing no responses. Similarly these questionnaires were also excluded from the returns total.

Some respondents included a considerable amount of additional information in the form of comments to questions asked. The analysis of the questionnaire data refers to these comments as much as possible.

| | Surveying Questionnaire | Spatial Information Questionnaire |
|----------------------|----------------------------|--------------------------------------|
| Returns Total | 86/313 | 113/308 |
| Percentage of Sample | 27% | 37% |

Table 4.4: Questionnaire Return Rates

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4.4.1 Surveying Questionnaire Results

Generally there appeared to be no regional correlation to the answers given to the Surveying Questionnaire. However a point of interest that was attributable to the location of the questionnaire respondent was that some of the respondents from rural parts of NSW expressed concerns about a royalty system paying a fixed amount per plan. As some of these respondents pointed out, rural sections of the cadastre generally contain fewer parcels than urban sections of a similar size. Under a royalty scheme this characteristic would translate into a smaller customer base per plan for rural surveyors when compared to their urban counterparts. One respondent suggested using different royalty amounts in urban and rural areas to accommodate this characteristic.

Question two established that on average surveying organisations in NSW annually connect 32 cadastral survey plans to the MGA94 via survey connections to geodetic monuments such as state survey marks (SSMs) and permanent marks (PMs).

Question three established that the average fee charged by a surveying organisation for connecting a cadastral traverse to geodetic monuments was \$879.

By combining the results of questions two and three it was shown that on average in NSW the total fees charged annually by one survey organisation for making geodetic connections to the cadastre was \$28128.

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This figure was not the average annual fees charged by surveying organisations in NSW for final plans that are used to create or modify an interest in land. Rather the \$28128 represents the average annual fees charged for connecting the plans to the MGA94.

These connections are currently made to meet the requirements of Clause 43 (1) of the SR2006 and usually provide no real benefit to the party paying the fee for the connections. This is because the fee paying party's goal is the creation or modification of an interest in land, not the creation of coordinated cadastral information.

Therefore, the combined results of question two and three have shown that the methods currently being employed in NSW to connect the cadastre to the MGA94 and provide coordinated cadastral data for technical applications such as GIS are being heavily subsidised by the clientele of surveying organisations. This clientele may therefore stand to benefit from the proposal to implement a programme specifically aimed at coordinating the cadastre.

Question four asked respondents if they were satisfied with the NSW Regulations that require them to make the connections discussed above. 82% of respondents stated they were satisfied with the Regulations currently in place. Although some expressed the opinion that charging surveyors for SCIMS Survey Mark Reports is unjustified, because the surveyors are purchasing them to fulfil NSW legislative requirements that are aimed at, amongst other things, increasing the accuracy of the coordinate data SCIMS reports on.

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Question five asked surveyors if their organisation would be willing to perform cadastral coordination surveys at no cost to the State Government and subsequently derive an income from royalty payments on occasions when their plans were sold by the State Government. An average of 63% of respondents stated ‘no’, their organisation would not be prepared to participate in this kind of programme. Comments made by the majority of the respondents indicated that most believed they would not be able to derive sufficient income from the royalty payments to cover the cost of their investment in a realistic time frame.

A comparison between the answers of question four and question five was made. The comparison revealed there was no relationship between a surveyors willingness to participate in the proposed program of cadastral coordination for royalties and their level of satisfaction with the current Regulations regarding geodetic connections to the cadastre. Figure 4.1 illustrates the relationship between organisations levels of satisfaction with the current Regulations and organisations willingness to conduct coordination surveys for royalties.

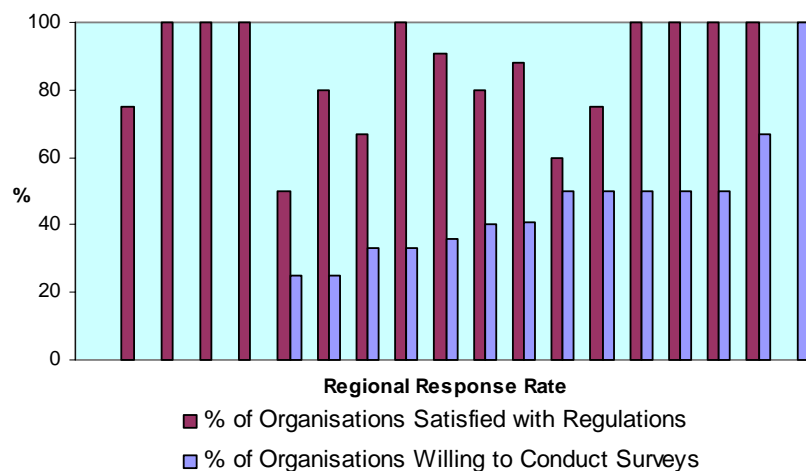


Figure 4.1: Comparison of Willingness to Conduct Surveys and Satisfaction with Regulations

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Question six measured how much income respondents believed they should derive as a royalty payment when their coordinate information was sold electronically by the NSW Department of Lands under the proposed royalty scheme.

Despite a return rate of nearly 27% for the “NSW Surveying Questionnaire” only forty four responses were received to this question, representing 14% of the initial sample population. This means that nearly half of the respondents did not answer question six.

This perhaps reflects one of the biggest problems associated with the royalty scheme proposal. That is, what value to assign to a plan as a royalty? The average response to question six indicated that a royalty fee of \$7.39 would be required as incentive for surveyors to participate in the proposed cadastral coordination program. Upon the exclusion of an outlier this figure was revised to \$3.57.

A fuller discussion of this result is included in Chapter 5 as part of the Break Even Analysis.

It had been expected that an increasing dependence by surveying organisations on technology such as GPS and GIS would stimulate interest amongst surveyors in the proposal to establish a coordinated cadastre.

However, a comparison of the responses obtained from questions five, seven, eight, nine, and ten indicated otherwise. The questionnaire showed that there was no relationship between surveying organisations willingness to create coordinated cadastral

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information for royalties, and the frequency that the organisation uses technology that compliments this type of information.

The conclusion drawn from these observations and the general comments made by responding surveyors was that the incentive to create coordinated cadastral information would come primarily from the ability to profit from the sale of the information. The fact that a surveying organisation was a high user of coordinate based technology did not appear to effect the outcome of the comparison. In retrospect this was perhaps not surprising, as a surveyor is one of the few professionals involved in land management who has the skills necessary to confidently create accurate coordinated information on the ground.

The conclusion that was drawn from questions five, seven, eight, nine, and ten makes the result of the break even analysis performed in Chapter 5 central to the viability of the projects proposal.

Figures 4.2 - 4.5 inclusive, illustrate the relationships that existed between the percentage of survey organisations in a region that were willing to perform coordination surveys for royalty fees and the percentage of organisations that used technology that complements coordinated spatial information.

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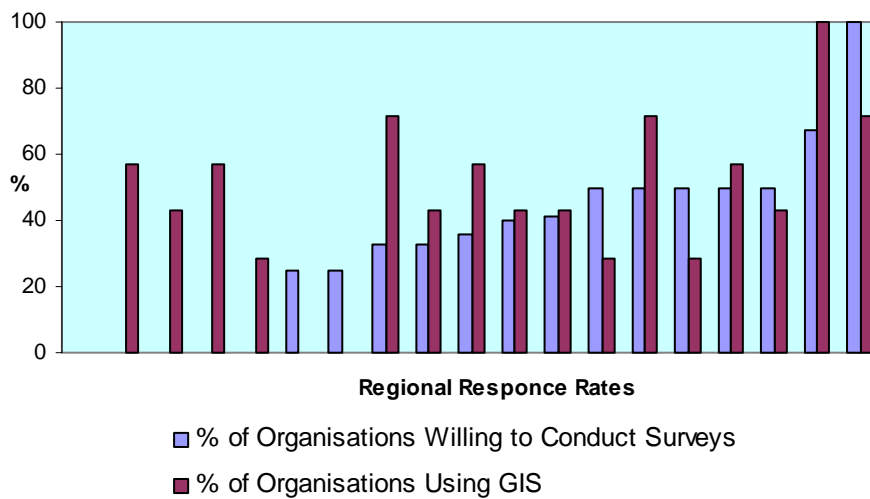


Figure 4.2: Comparison of Willingness to Conduct Surveys and Corresponding GIS Usage

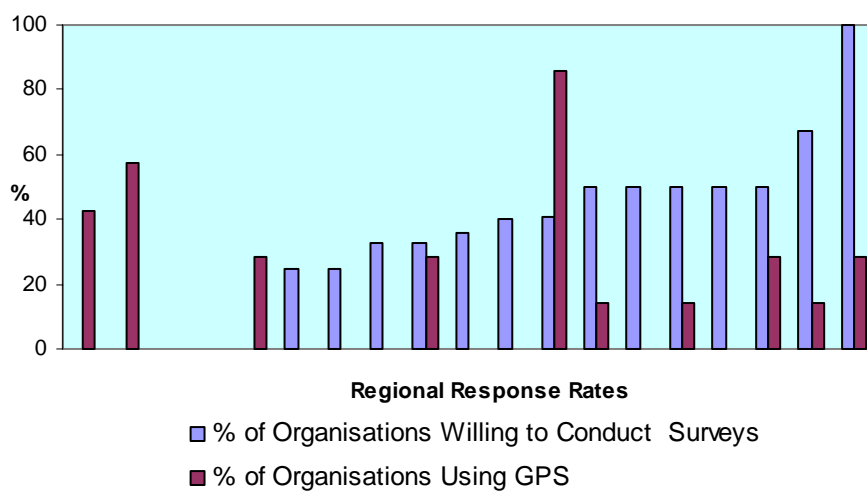


Figure 4.3: Comparison of Willingness to Conduct Surveys and Corresponding GPS Usage

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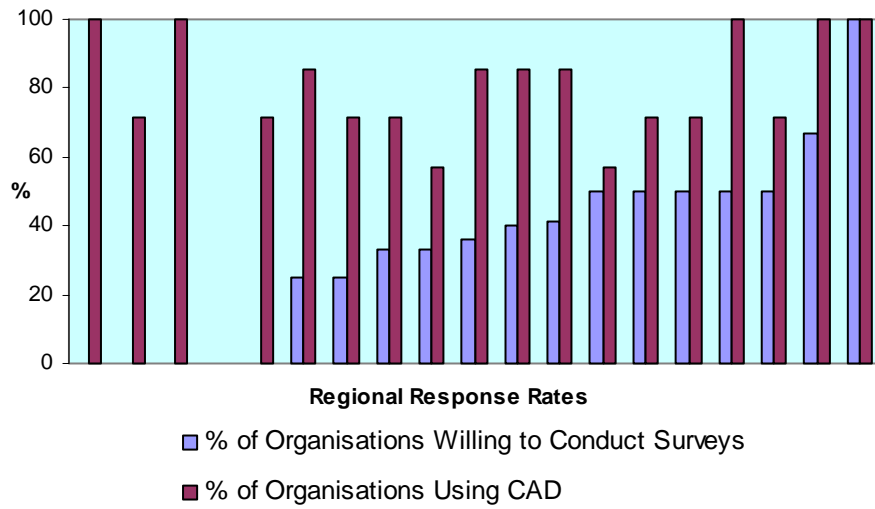


Figure 4.4: Comparison of Willingness to Conduct Surveys and Corresponding CAD Usage

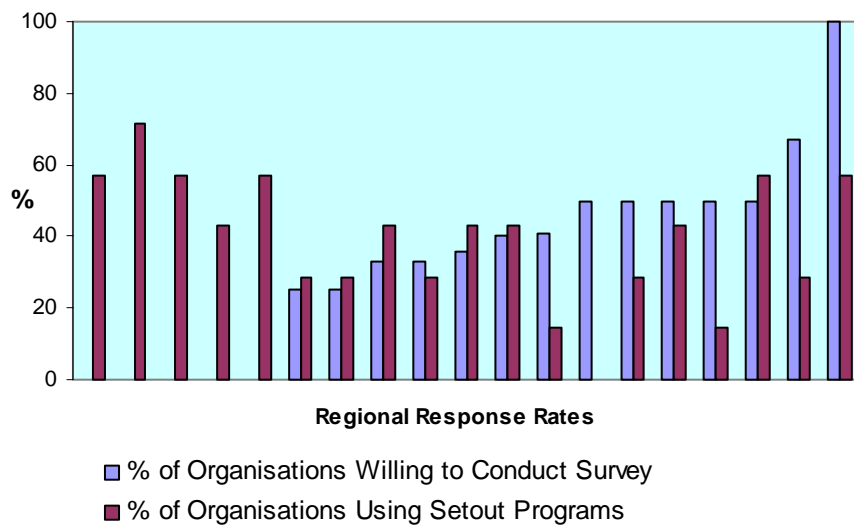


Figure 4.5: Comparison of Willingness to Conduct Surveys and Corresponding Setout Program Usage

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Question eleven asked if survey organisations felt they were familiar enough with the document ‘Standards and Practices for Control Surveys (SP1)’ to be able to implement the recommendations made by it. On average only 39% of the responding organisations throughout NSW felt they had sufficient knowledge of the document SP1 to be able to do this.

A comparison of the responses to questions five and eleven showed a correlation. State wide the answers to questions five and eleven that were given in the affirmative were given at rates of 37% and 39% respectively. An investigation at the regional level showed that in eight of the fourteen regions where organisations stated they would be prepared to conduct cadastral coordination surveys, the percentage of organisations that were familiar with SP1 was equal to or greater than the percentage of organisations willing to perform the coordination surveys for royalties.

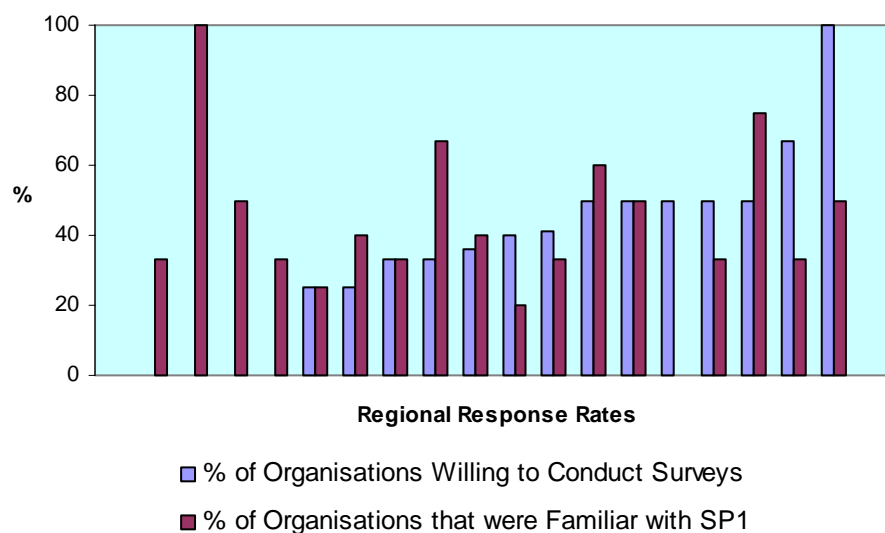


Figure 4.6: Comparison of Willingness to Perform Surveys and Corresponding Knowledge of SP1

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A simple explanation involving allocation of resources may account for this result. Under the proposal to adopt a coordinated cadastre an organisation having insufficient knowledge of the document SP1 would need to invest additional resources into staff training to compete with other organisations that already have that knowledge. This would cost the organisation money they otherwise may have invested elsewhere.

The responses to questions eleven and twelve also justified the outlining of the procedures, in Chapter 3 of this paper, necessary to achieve a Class C Order 3 when performing a cadastral coordination project. Question one shows that on average a survey organisation in NSW will create 32 plans with geodetic connections. However question twelve shows that only 37% of survey organisations making these connections follow the recommendations of SP1. This is problematic as the adoption of varying procedures to create geodetic connections makes it difficult to compare the quality of derived geodetic information with confidence.

Adoption of a coordinated cadastral system that assigned Class and Order to coordinated corners would theoretically oblige all surveyors to adopt similar survey techniques and to perform these techniques to a similar standard. Adoption of this type of system would theoretically make the cadastre a more homogenous land information system.

It had been anticipated that the needs of a survey organisation's clientele would effect the organisation's willingness to participate in cadastral coordination projects.

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Initially this appeared to be true on a state-wide basis. As question thirteen indicated that an average of 38% of NSW survey clients required either MGA94 or GDA94 spatial information, whilst the percentage of organisations willing to conduct coordination surveys for royalties was 37%. However, an investigation that was made at a regional level found that the percentage of organisations in a region that were willing to conduct surveys for royalties did not correlate to the percentage of organisations whose clients required geodetic spatial information. This regional relationship is illustrated by Figure 4.7.

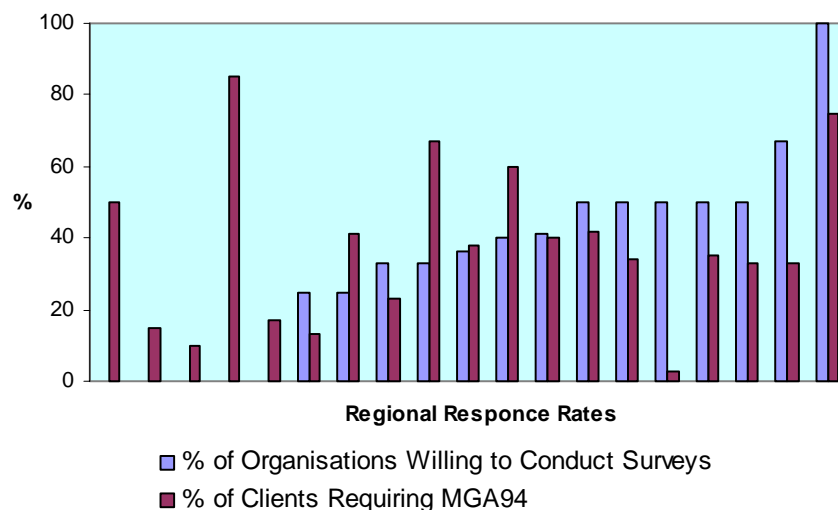


Figure 4.7: Comparison of Willingness to Perform Surveys and Corresponding Client Needs

From this observation it was concluded that the needs of survey clientele were not sufficient motivation to encourage survey organisations to participate in the proposed coordination project for royalty payments.

Questions fourteen and fifteen related to the respondents ability to work with MGA94 information and additional training requirements.

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At a state-wide level there again appeared to be a correlation between the responses given to these questions and the willingness of survey organisations to perform the proposed coordination surveys for royalties. Respondents to question fourteen indicated that 63% of organisations either didn't thoroughly understand the MGA94 coordinate system or were unable to perform calculations on it. This correlates with the 65% of respondents to question fifteen who state their organisation will require extra training to allow organisation members to work with and create coordinate based survey plans. These response rates are very similar to those of question five in which 63% of respondents stated they would not perform cadastral coordination surveys for royalties.

When the results were viewed from the regional perspective eight of the fourteen regions willing to perform coordination surveys for royalties show a correlation between the willingness of organisations to conduct coordination surveys for royalties and their knowledge of and ability to work with the MGA94. This relationship is illustrated by Figure 4.8, the relationship between these two variants for the remaining thirteen regions is however fairly erratic.

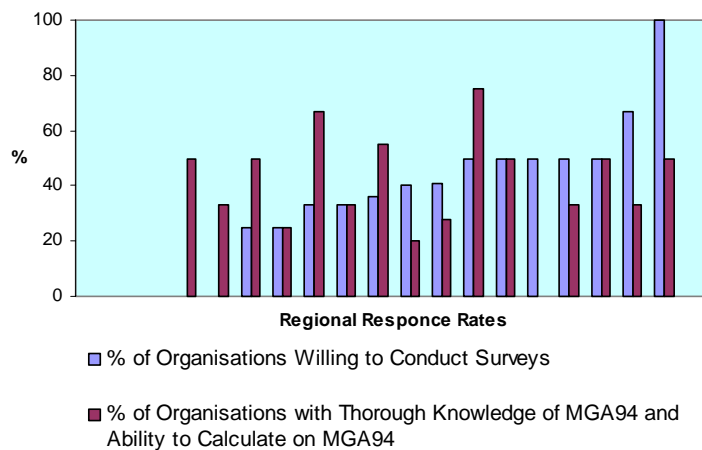


Figure 4.8: Comparison of Willingness to Perform Surveys and Knowledge of/Ability with MGA94

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Question sixteen measured the perceived ability of a coordinated cadastre to benefit surveying organisations. The responses to this question showed that 63% of the respondent organisations believed a coordinated cadastre would benefit their organisation. This is despite the fact that 63% of responding surveying organisations also stated they would not perform cadastral coordination surveys under a royalty system. This suggests that surveying organisations may be more willing to perform these types of surveys if another method of reimbursement was made available to them. For example, a program of cadastral coordination sponsored by the State Government which offered to pay surveyors directly for the services they render toward coordination of the cadastre.

4.4.2 Spatial Information Questionnaire Results

Like the ‘Surveying Questionnaire’ the results to question one of the ‘Spatial Information Questionnaire’ generally revealed no significant regional patterns to responses.

Question two sought to determine the most popular medium used to access cadastral data. It did this by asking respondents what format they purchased cadastral data in. The results showed that 78% of the organisations questioned purchased Deposited Plans to access cadastral information; 64% purchased information from the Digital Cadastral Data Base (DCDB) and 66% purchased other forms of cadastral survey plans.

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The response to question two regarding the purchase of DCDB information would have been biased by the fact one third of the questionnaires were sent to organisations known to hold licences for the DCDB. Therefore, it is believed the State wide result to this question in regard to the DCDB would be lower than the questionnaire indicated.

The questionnaire responses indicated that Deposited Plans (DPs) were a more popular source of cadastral information than the DCDB and other forms of survey plans. The popularity of DPs over the DCDB probably reflects a need for cadastral spatial information having a level of accuracy not currently offered by the DCDB. The popularity of DPs over other forms of survey plans perhaps reflects a desire for cadastral information that has, in a sense, been ratified by the state as being a good representation of what actually exists on the ground.

Regardless of the reasons for the popularity of DPs, the responses to question two led to the conclusion that Deposited Plans are still an adequate method of storing and disseminating cadastral information to the majority of cadastral information users.

Based on this conclusion it was decided to convey the coordinated cadastral information created by the Cambridge Gardens coordination survey using a plan as the storage medium.

Responses to question three indicated that 98% of the respondent organisations were involved in projects associated with the cadastre. On average 66% of the projects these organisations were associated with had a relationship to the cadastre.

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Question four determined that an average of 71% of the organisations questioned used coordinates when working with spatial information.

A comparison between the results of questions three and four indicated that the majority of organisations whose projects were related to the cadastre also related them to a coordinate system. This comparison is illustrated by Figure 4.9.

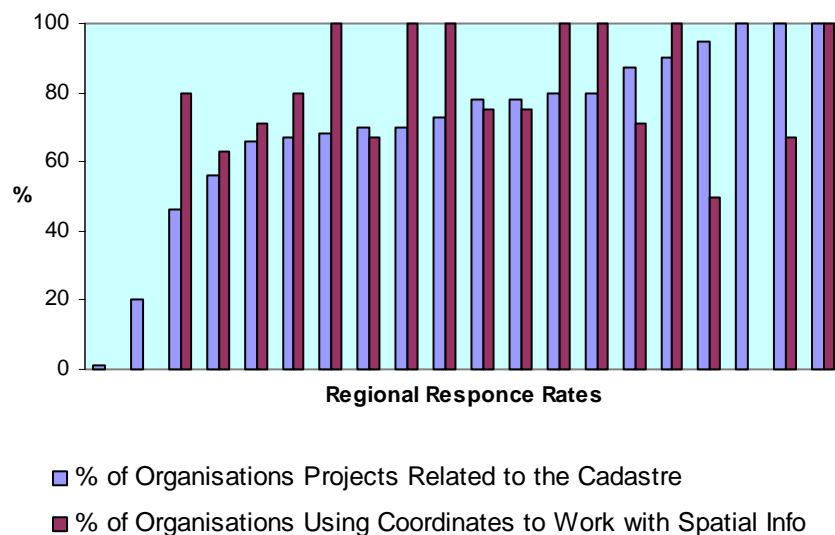


Figure 4.9: Comparison of Projects Related to Cadastre and Use of Coordinate Spatial Information

Question five asked organisations how familiar they were with the Transverse Mercator Projection MGA94 and the spheroidal coordinate system GDA94.

69% of the responses indicated familiarity with MGA94, 59% indicated familiarity with GDA94.

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The responses relating to familiarity with MGA94 were added to the comparison of responses to question three and four. This revealed a strong correlation between the use of coordinates and familiarity with the MGA94. The majority of organisations that indicated they were involved with projects related to the cadastre also indicated familiarity with the MGA94 and indicated that they used coordinates when dealing with spatial information. These comparisons are illustrated in Figure 4.10.

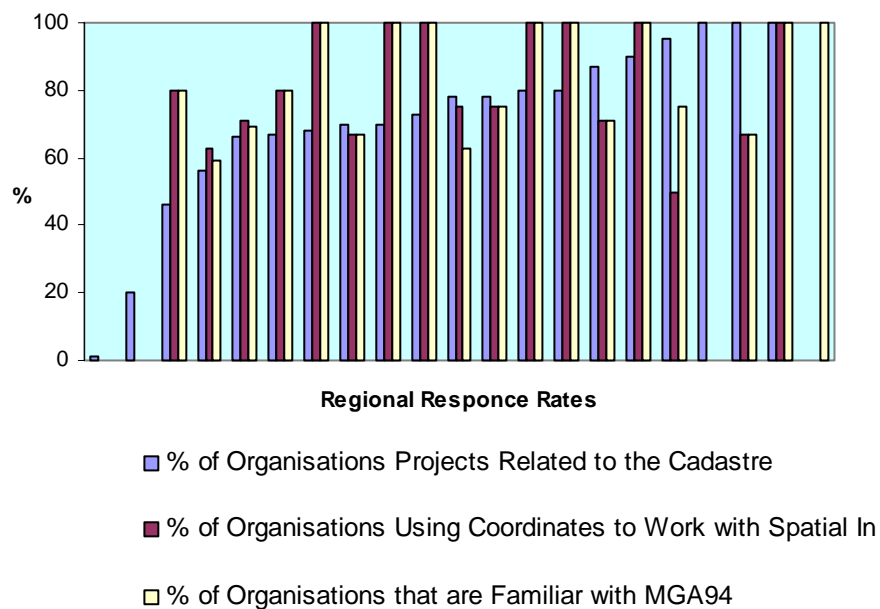


Figure 4.10: Comparison of Projects Related to Cadastre, Use of Coordinate Spatial Information and Familiarity with MGA94

The combined analysis of the responses to questions three, four and five indicated that the proposal to establish a coordinated cadastre, using MGA94 as the reference frame, would be compatible with the practices currently employed by organisations involved with land management and land development in NSW.

Chapter 4 – Questionnaires

Question six and seven sought to establish the ratio of spatial information currently stored electronically on the MGA94 or GDA94 coordinate systems. Respondents to question six indicated that 58% of the spatial information stored by their organisations is stored electronically on either the MGA94 or GDA94 systems. Question seven indicated that 15% of the responding organisations spatial information was stored electronically on another coordinate system. Leaving 27% stored in another format that was either not electronic or did not involve a coordinate system.

These responses indicate that the proposal to create a coordinated cadastre using the MGA94 as a reference frame will result in coordinated cadastral information that is potentially compatible with at least 58% of spatial information currently stored by the respondent organisations. This figure may be increased when it is possible to apply transformation procedures to the electronic information stored on a coordinate system other than MGA94.

Questions eight, nine and ten showed that at the time of the questionnaire 66% of responding organisations used GIS, 83% used CAD and 27% used differential GPS techniques.

The relationship between this group's use of technology and its desire for coordinated spatial information should be different to that of surveyors. Surveyors create spatial information and then try to profit from it.

Chapter 4 – Questionnaires

Managers and developers of land, use information that in most circumstances is created by someone else, to build, design or plan. Most often these groups do not profit from spatial information about land. Instead they profit from the processes, designs etc they make or apply to the land.

Therefore, it was interpolated that an organisation involved in projects associated with the cadastre that also has a high dependency on technology that is coordinate based would stand to benefit from the creation of a coordinated cadastre.

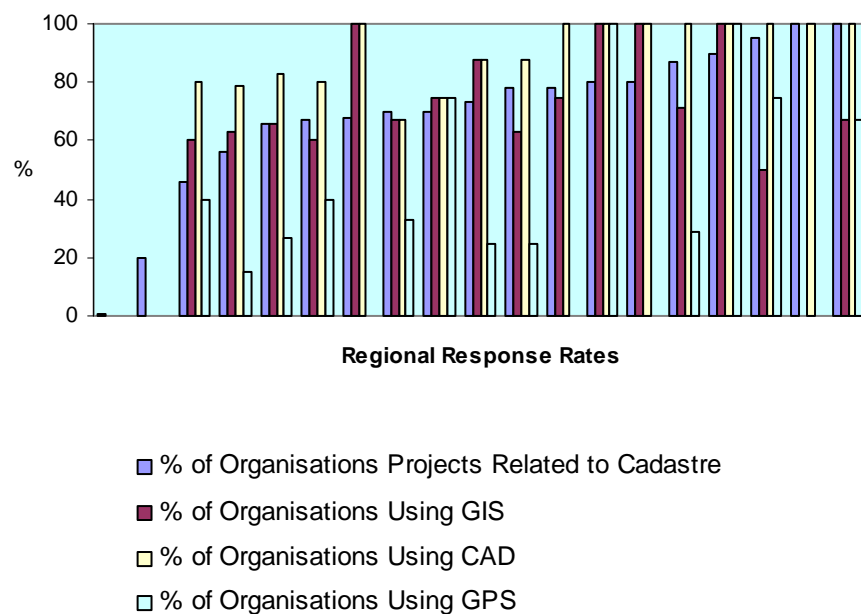


Figure 4.11: Comparison of Projects Related to Cadastre & Use of GIS, GPS and CAD Technologies

As Figure 4.11 illustrates when this assumption is made, all of the sample regions contain a significant proportion of organisations that would benefit from the implementation of a coordinated cadastral system.

Chapter 4 – Questionnaires

Question eleven asked organisations what accuracy they expected of the spatial information they used. To provide for the fact that different projects undertaken by the same organisation will require different levels of accuracy multiple responses were asked for. The results showed that $\pm 1\text{m}$ and $\pm 0.01\text{m}$ were the tolerances most often required for the spatial information used by the respondent organisations. 44% of the responding organisations indicated they had in the past required a tolerance of $\pm 1\text{m}$. 41% indicated they had in the past required a tolerance of $\pm 0.01\text{m}$.

The conclusion drawn from the responses to question eleven was the accuracy needs of many projects are not being met by the DCDB that is currently available in NSW. As the accuracy of the DCDB is currently only suitable for plotting purposes in many areas.

Question twelve established that 84% of the respondents were of the opinion that a cadastral system capable of linking various categories of land information in a single electronic reference system, similar to the system discussed in Section 2.4 of this paper, would benefit their organisation.

Question thirteen, which attempted to measure the additional training that staff members of the respondent organisations would need to work with a coordinated cadastre, appeared to be troublesome to most of the questionnaire respondents. The majority of organisations that responded to the questionnaire either did not respond to this question or stated that the staff of their organisation would require no further training. As a result the data collected by this question was insufficient to use in an analysis of the training topic.

Chapter 4 – Questionnaires

Question fourteen measured the perceived ability of a coordinated cadastre to benefit the respondent organisation compared to the existing system. The responses to this question showed that 73% of the respondent organisations believed a coordinated cadastre would be more beneficial to their organisation than the current system.

4.5 Conclusion

This chapter has outlined the procedures used to distribute two questionnaires which gathered data to assist with the cost benefit analysis required by the project specifications. This chapter also contains an analysis of the data gathered by the two questionnaires.

To assess whether or not the surveying profession would support the establishment of a coordinated cadastre the “Surveying Questionnaire” asked surveying organisations if they would be prepared to perform cadastral coordination surveys and then be reimbursed for their services over a period of time by royalty payments.

Additional comments provided by many surveyors indicated that most believed a royalty scheme would not provide sufficient income to reimburse them for the expense of creating cadastral coordination plans. The manner in which the question outlined above was asked has probably skewed the response by surveyors regarding their willingness to become involved in cadastral coordination surveys.

Chapter 4 – Questionnaires

To accurately gauge whether or not surveyors were prepared to perform cadastral coordination surveys it would have been more appropriate to separate the issue of performing the surveys from the issue of being reimbursed by a royalty scheme.

The response to the final question of each questionnaire showed that the majority of organisations in NSW, both surveying and non surveying, believe that a coordinated cadastre would benefit their organisation. A large percentage of managers and developers of land also indicated that a multilayered cadastral system capable of describing multiple attributes of land would benefit their organisations.

Chapter 5

Break Even Analysis

5.1 Introduction to Break Even Analysis

‘The Surveyor-General is to ensure that the register is made available to the public, subject to such charges as may be prescribed by the regulations, at the head office of the Department’ [The Surveying Act 2002 Sec 7 (3)]

This quotation may hold the solution to some of the questions asked by Section 1.2 of this project i.e. who will invest resources into coordinating the cadastre? Who will reap the benefits? Will the benefits offset the costs?

When a surveyor performs a survey he must present the survey information in a form that is usable by others such as a plan, field notes, a points file or a report. Such presentations constitute original works (Broadfoot 1994, p. 7) and are protected by copyright for a period of 70 years after the death of the author under the Federal Copyright Act 1968, Clause 33 (2). Recognition of these rights by the organisations responsible for maintaining Australia’s land registers has become a contentious issue for surveyors in recent years as the profession has become more aware of its members rights under Copyright laws.

Chapter 5 – Break Even Analysis

Copyright exists to encourage the creation of original material that will benefit society. (McNamara 1997, p. 14) This statement may provide the key to creating a situation in which it is financially viable for surveyors to perform the procedures outlined in Chapter 3 without significant financial input from the State Government.

With the advent of technologies such as GPS & GIS the applications for coordinated spatial information have increased. It is expected that coordination of the cadastre would also further increase the number of applications for cadastral information. As the applications for cadastral information increase so will the market for cadastral information.

It was shown in Section 2.6.1 “Updating the Geodetic Reference” that it is already a legislative requirement that new survey plans be connected to geodetic monuments with known MGA94 coordinates of Class C or better. [SR2006 Sec 12 (2)] This requirement is establishing a link between the cadastre and the MGA94 in newly subdivided areas. However an equivalent link is not being established at the same pace in older areas. Furthermore, in some circumstances the accuracy of the MGA94 information derivable from these links is questionable due to the Order of the PMs connected to under the SR2006.

Establishing a coordinated cadastre and accurate MGA94 infrastructure that provide accurate MGA94 coordinates in all jurisdictions could result in high earnings for the N.S.W Department of Lands. However, the resources required to establish a survey accurate coordinated cadastre in all jurisdictions in the foreseeable future, probably out

Chapter 5 – Break Even Analysis

strip the resources available to the Department of Lands in the current climate of economic rationalisation. Conversely private enterprise contains a significant pool of resources. What is lacking is financial incentive for private enterprise to perform the coordination tasks.

The lack of financial incentive may be addressed if the registering authorities in NSW agreed to pay royalties to surveyors when coordinated cadastral data created by surveyors was sold to third parties.

It is again noted that surveyors may already legally be entitled to these royalties, under the Federal ‘Copyright Act 1968’. The registering authority, who in the case of NSW is the Department of Lands, could offset the expense of these royalties by increasing the charges consumers would pay to access survey accurate coordinated cadastral information, thus creating a user pays situation.

5.2 Objectives of the Break Even Analysis

The objective of this chapter was to determine the commercial viability of the proposal to coordinate the cadastre, using a royalty scheme as the financial incentive to encourage the participation of surveying organisations. This determination was made by performing a Break Even Analysis using the coordination survey performed by this project as a model for the analysis.

Chapter 5 – Break Even Analysis

5.3 The Definition of a Break Even Analysis

The Encarta Dictionary (1999) defines the Breakeven Point as *‘the level of financial activity at which the value of an investment equals its cost’*

A typical break-even analysis identifies the total cost of an exercise at any level of activity through an analysis of the fixed and variable costs of the exercise as illustrated by Figure 5.1.

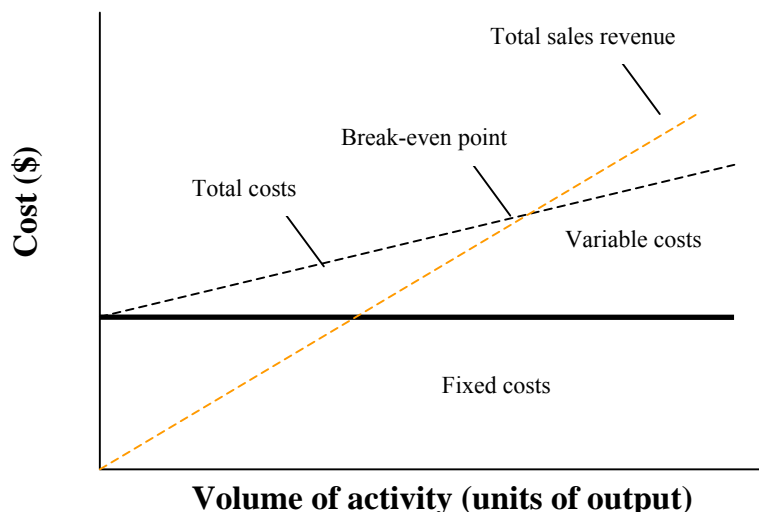


Figure 5.1: Typical Break Even Analysis

Source: Atrill et al, *Accounting an Introduction, Second Edition*

Chapter 5 – Break Even Analysis

5.4 Break Even Analysis Methodology

A cadastral coordination survey was performed in Cambridge Gardens as per Section 1.4 (d) Research Methodology.

The fixed and variable costs of the survey were estimated and combined to determine the total cost of the Cambridge Gardens survey to the surveyor. The completion of the Cambridge Gardens survey project and the theoretical recording of the coordinate information by the Department of Lands represented a point in time when the costs of the project to the surveyor became fixed.

Accordingly the break-even analysis for the Cambridge Gardens Survey considered the final fixed cost of the coordination project across the whole of the analysis.

An estimation of the income the surveyor theoretically derived as royalties from third parties accessing the accurate coordinate information was calculated using statistical data contributed by the NSW Department of Lands and an estimated royalty figure derived from question six of the “NSW Surveying Questionnaire”.

The data contributed by the NSW Department of Lands described the frequency with which the current deposited plans within the survey area of Cambridge Gardens had been accessed during the 18 month period January 2001 to June 2002.

Chapter 5 – Break Even Analysis

An interpolation was performed based on the Department's data, to determine how long it would take a surveyor to recover the costs incurred during the Cambridge Gardens coordination survey. Figure 5.2 illustrates graphically how this process occurred.

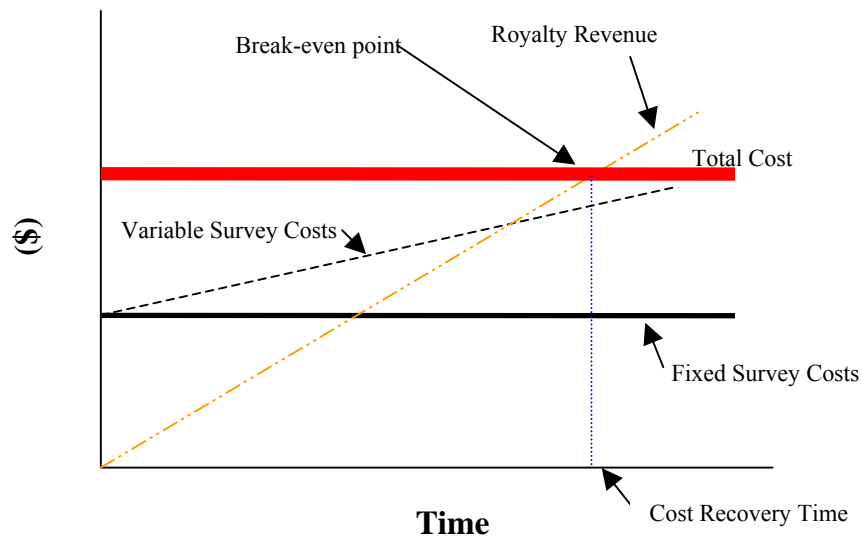


Figure 5.2: Methodology of Cambridge Gardens Break Even Analysis

5.5 Calculation of Variable Coordination Survey Costs

Two primary groups of variable costs were associated with the coordination survey. The first group was labour costs. The Second group was searching costs. Table 5.1 lists and quantifies the variable costs identified for the coordination survey. The paragraphs that follow explain how these variable costs were derived.

Chapter 5 – Break Even Analysis

| | | |
|--|-----------|----------------|
| Labour Costs (Field) | 22 hours | @\$42.54/hr |
| Labour Costs (Calculations & Searches) | 20 hours | @\$24.01/hr |
| Labour Costs (Drafting) | 8 hours | @\$16.59/hr |
| Online Deposited Plan Purchases | 6 plans | @\$8.50/plan |
| Online SCIMS Mark Report (MGA94) | 6 reports | @\$3.50/report |
| Total Variable Costs | | \$1620.80 |

Table 5.1: Variable Costs of Coordination Survey

The labour times shown in Table 5.1 were logged during the course of the coordination survey that was performed to meet the objectives of section 1.4 (d) of the Research Methodology. The hourly rates for field, calculation and drafting costs were determined in accordance with the minimum hourly incomes described by 3 State awards. This process is discussed below.

To simplify the analysis it was decided that its scenario would entail a Registered Surveyor performing all of the survey field work with the assistance of a Field Hand. Subsequently the same surveyor would perform the survey calculations. In other words the Registered Surveyor in this scenario would not instruct another suitably qualified person to perform the survey work under the supervision of the Registered Surveyor. Although, this would have been permissible under Clause 21 (3) (a) & (b) of the NSW “Surveying Act 2002”.

Chapter 5 – Break Even Analysis

Part B, Table 1 of the “Professional Surveyors (Private Industry) (State) Award” states the minimum hourly income of a Registered Surveyor is \$22.03.

Clause 1 (iv) of the “Surveyors' Field Hands (State) Award” states, a First Class Survey Field Hand, *‘[is] an employee who has had two years' experience as a surveyor's field hand’*. Part B, Table 1 of the same award states that a Field Hand of this calibre should earn a minimum hourly rate of \$17.00.

Clause 5.5.3 (a) (ii) of the “Land Surveyors General Award 1998” stipulates, that an employer with a payroll not exceeding \$1 000 000 must contribute 9% of an employees ordinary time earnings as compulsory employer superannuation contributions.

This brought the minimum cost per hour for a Registered Surveyor to a total of \$24.01, and the minimum cost per hour for a First Class Survey Field Hand to a total of \$18.53.

Therefore, the minimum hourly variable cost attributable to the wages of the survey field party was considered to be \$42.54.

The survey calculation work would theoretically be performed by the Registered Surveyor at the same hourly cost to the survey firm as was determined above, that is \$24.01 per hour.

Chapter 5 – Break Even Analysis

The survey drafting was theoretically performed by a draftsman described as such under Clause 1.5.1 (a) (i) of the “Drafting Employees, Planners, Technical Employees, &C. (sic) (State) Award”. Schedule A of the award defines the wage group of this type of employee as Wage Group C10. Clause 5.1.1 (c) of the award states an employee of this level is entitled to a minimum hourly wage of \$15.22.

This variable cost was again increased by a further 9% of the employee’s ordinary time earnings, to provide for compulsory employer superannuation contributions. This brought the minimum cost per hour for the Draftsman to a total of \$16.59.

The variable cost of Deposited Plans purchased online, shown in Table 5.1, is a reflection of the charges imposed by the NSW Department of Lands for plans purchased electronically at www.lands.nsw.gov.au. Appendix D contains a list of the Deposited Plans used for the coordination survey.

Likewise the variable costs of the SCIMS Mark Reports reflect the charges imposed by the NSW Department of Lands for SCIMS Mark Reports purchased online at the Department’s website, www.lands.nsw.gov.au. Appendix E contains copies of the SCIMS Mark Reports purchased online.

Chapter 5 – Break Even Analysis

5.6 Calculation of Fixed Coordination Survey Costs

The fixed costs associated with the coordination survey in Cambridge Garden were based on the equipment and resources actually used to perform the survey. For example the calculation and drafting time spent on the survey totalled 26 hours therefore the electrical utility costs constituting part of the fixed costs for the Cambridge Gardens survey were considered equivalent to 26 hours of the power bill at the address where calculations and plotting occurred. Table 5.2 lists and quantifies fixed costs incurred as a result of the coordination survey.

The total costs for equipment shown in Table 5.2 were derived from an online Survey Equipment Supplier at www.geodetic.com.au or are a reflection of costs actually incurred over a period of time when acquiring equipment and services used to complete the coordination survey. Although all of this equipment was used to complete the survey project it may not have been acquired specifically for the project.

Chapter 5 – Break Even Analysis

| Item | Total Cost (\$) | Life Expectancy (Years) | Depreciation Rate (\$)/ other Service Cost Per Annum |
|---------------------------------------|-----------------|-------------------------------------|--|
| Nikon NPL – 352 | 13970 ϕ | 10 \S | 1397.00 |
| Total Station | | | |
| Tribrach \times 2 | 297 ϕ | 10 \S | 29.70 |
| Tribrach Adaptor \times 2 | 297 ϕ | 10 \S | 29.70 |
| Prism/Target \times 2 | 132 ϕ | 10 \S | 13.20 |
| Mini Prism | 143 ϕ | 10 \S | 14.30 |
| Wooden Tripod \times 3 | 242 ϕ | 10 \S | 24.20 |
| Hi Viz Safety Vest \times 2 | 16.50 ϕ | 2 | 8.25 |
| Traffic Cones \times 3 | 12.10 ϕ | 5 | 2.42 |
| HP 48GX Calculator | 260 | 10 \S | 26.00 |
| Survey Vehicle | 13000 | 12 \S | 1083.33 |
| CivilCad 6 Software & Base Licence | 1045 | 25 \S | 41.80 |
| Desktop Computer | 2360 | 4 \S | 590.00 |
| Office Furniture | 750 | 13 ¹ / ₃ \S | 56.25 |
| Havoc Software | 0 | 0 | 0 |
| Electricity Costs | 355/quarter | NA | 1420.00 |
| Phone Line Costs | 91/month | NA | 1092.00 |
| ISP Fees | 28.95/28days | NA | 377.38 |
| Rental | 285/week | NA | 14820.00 |

Table 5.2: Fixed Costs of Coordination Survey

ϕ : Source: www.geodetic.com.au

\S : Source: Australian Taxation Office 'Unofficial Consolidated Taxation Ruling as at 1 January 2005'

Chapter 5 – Break Even Analysis

Under Section 40.95 of the Federal “Income Tax Assessment Act 1997”, when determining the “Effective Life” of an asset for depreciation purposes a person may either ‘use an effective life determined by the commissioner for a depreciating asset’, or ‘work out the effective life of the asset’ [Sec 40.95 (1) (a) & (b)]

In accordance with the “Income Tax Assessment Act 1997” the life expectancy values marked thus § on Table 5.2, were obtained from Tables A & B of the Australian Taxation Office document “TR 2000/18C8” otherwise known as the “*Unofficial Consolidated Taxation Ruling as at 1 January 2005*”. Other values were calculated based on empirical observations made whilst in the employ of a variety of Private Survey Firms.

The depreciation rates and other fixed costs related to the supply of services, shown in Table 5.2, were calculated on an annual basis. These were then classified as field or office related costs. The number of hours spent in the field and the office were calculated as a ratio of a twelve month period. Respectively this amounted to ratios of $22\text{hours} \div 8760\text{hours} = 0.00251$ and $28\text{hours} \div 8760\text{hours} = 0.00320$.

The depreciation rates and other fixed costs, relating to services, were added together in their classified groups. This amounted to a total fixed cost of \$2628.10 / annum for field related costs and a total fixed cost of \$18397.43 / annum for office related costs.

Chapter 5 – Break Even Analysis

Applying the respective hourly ratios determined the fixed costs of the job as follows.

Fixed cost (field related) = $\$2628.10 \times 0.00251 = \6.60 . Fixed cost (office related) = $\$18397.43 \times 0.00320 = \58.87

These two figures were added together to determine the total fixed cost of the Cambridge Gardens Survey. Total fixed cost = $\$6.60 + \$58.87 = \$65.47$.

It is noted that the depreciation rates shown in Table 5.2 were an over estimation of the rates likely to be experienced. To simplify the exercise it was assumed that all assets had a residual value of \$0. In reality most assets retain some value at the end of their useful life and can be sold to recoup a portion of their initial expense. Also an asset may not have been in use for the whole of the survey process, thus freeing them up for use by other projects. For example office time totalled 28 hours, however, the internet would not have been used solely by this project for the entire 28 hours.

5.7 Calculation of Total Cost for Coordination Project

The completion of the Cambridge Gardens survey project and the theoretical recording of the coordinate information by the Department of Lands represented a point in time when the costs of the project to the surveyor became fixed. This final fixed cost of the Cambridge Gardens survey equated to the addition of the fixed and variable costs calculated in Sections 5.5 and 5.6. Accordingly the final fixed cost of the Cambridge Gardens survey = $\$65.47 + \$1620.80 = \$1686.27$.

Chapter 5 – Break Even Analysis

5.8 Calculation of Royalty Income

According to the results gathered by question six of the ‘Surveying Questionnaire’ (Appendix C) the average royalty payment required by respondents was 87% of the \$8.50 charge currently imposed by the Department of Lands. This equated to a \$7.39 royalty payment when the surveyors coordinate data was sold to a third party. This rate was skewed by the response of one respondent who required a rate of 2000% or \$170 for each sale. This response was treated as an outlier and removed from the data making the average rate 42% or \$3.57. The rate of 42% or \$3.57 was the figure adopted for subsequent calculations.

Statistical data contributed by the NSW “Department of Lands” was used in the Break Even Analysis calculations. The data illustrated the frequency that electronic access was gained to the 6 current Deposited Plans in Cambridge Gardens. The data, shown in Appendix D, was provided verbally by an employee of the Department of Lands and related to the 18 month period between January 2001 and June 2002. No documented confirmation of this data was able to be obtained.

The annual royalty revenue was calculated as follows. The frequency of access statistics provided by the Department of Lands and illustrated in Appendix D were added together. This established that the 6 Deposited Plans in Cambridge Gardens were accessed a total of 38 times between January 2001 and June 2002.

Chapter 5 – Break Even Analysis

This number was subsequently multiplied by the ratio 12 / 18 to interpolate an annual access figure. Therefore, $38 \times 12 \div 18 = 25\frac{1}{3}$ which is the interpolated annual access figure.

The assumption was made that the interpolated annual access figure, $25\frac{1}{3}$, would approximately represent the number of times a new coordinated plan of the same area could be expected to be accessed in the same time period.

To calculate the royalty receivable in a twelve month period the interpolated annual access figure $25\frac{1}{3}$ was multiplied by the desired royalty rate \$3.57, determined by question six of the “NSW Surveying Questionnaire”.

Therefore the interpolated annual royalty payable for access to the new coordinated plan in Cambridge Gardens was $25\frac{1}{3} \times \$3.57 = \90.44 .

5.9 Break Even Calculation

The break even calculation was performed according to the process illustrated earlier by Figure 5.2. The total survey costs were divided by the estimated annual royalty figure to calculate the number of years it would theoretically take for a surveyor to recoup the expenses incurred as a result of the Cambridge Gardens survey.

Chapter 5 – Break Even Analysis

Therefore, the interpolated number of years taken to reach the break even point was $\$1686.27 / \$90.44 = 18.64$ years. The final result is illustrated graphically in Figure 5.3.

An investment return time in excess of 18 years would not be acceptable to organisations which depend on cash receipts to meet their own financial obligations. Several more analyses were made using the procedure outlined above applying different royalty rates. The results of these analyses are also illustrated graphically in Figure 5.3 and do not appear any more satisfactory from the perspective of the surveying organisation. There were simply insufficient sales of the cadastral information to allow the surveyor to recover the survey costs by royalties in a time period that would be considered acceptable.

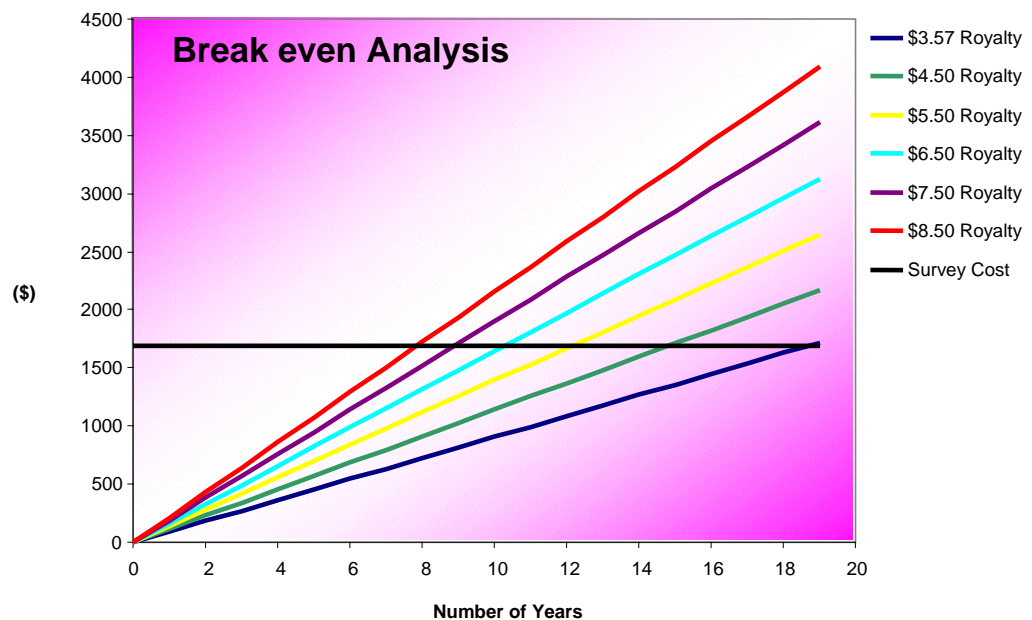


Figure 5.3: Comparison of Break Even Analysis

Chapter 5 – Break Even Analysis

Remarks made by one surveyor responding to the “NSW Surveying Questionnaire” highlighted an issue of importance to the break even analysis. The surveyor stated that with any proposal involving royalties and electronic survey plans the issue is how to *‘ensure the plans are only used once per download, so as to maximise [the] customer base.’* The surveyor went on to suggest that larger one off payments may be a more appropriate way of allowing surveyors to recoup expenses incurred as a result of the proposal. This would avoid issues relating to copyright infringement through ongoing use of the cadastral coordinate information and would allow the surveyor to recover his expenses at a faster rate.

5.10 Conclusions

The Break Even Analysis was based upon information logged during the performance of a coordination survey, information derived from various awards and information sourced from the NSW Department of Lands.

The results of the Break Even Analysis showed that the proposal to use royalty payments to reimburse surveyors for the resources they invest into cadastral coordination surveys was not financially viable on this occasion. This conclusion was based on a royalty amount determined by the surveying organisations that responded to the questionnaires discussed in Chapter 4 of this paper. This result perhaps reflects an underestimation by survey organisations as to the true value of the information they create.

Chapter 5 – Break Even Analysis

The survey performed for this analysis was conducted for research purposes. Therefore, only road frontages were fixed, the costs associated with a real world cadastral coordination project would be expected to be higher; resulting in an even larger break even period.

The finding of this analysis was supported by the opinions of many of the surveying organisations that responded to question five of the surveying questionnaire. Many of these organisations were of the opinion that a royalty scheme would not be capable of reimbursing surveyors for the cost of creating coordinated cadastral data in a realistic time frame.

The conclusion reached by this paper following the performance of the break even analysis is as follows. In order for a program aimed at coordinating the cadastre in all jurisdictions of NSW to succeed, significant Government funding will be required or else a significant increase in the monetary value placed on survey information will need to occur.

Time and monetary considerations were a limiting factor to the testing procedures performed during this project. Further testing of the conclusion drawn by this paper would be justifiable as the conclusion to date is based upon the results of an analysis at one survey site.

Chapter 5 – Break Even Analysis

Any further testing should attempt to incorporate a variety of scenarios into the analysis. These should include choosing multiple survey sites of varying characteristics, for example, hilly sites, heavily vegetated sites, sites with buried survey monuments, rural sites, highly urbanised sites etc. Any further testing should also attempt to make a comparison of the effects of various surveying techniques and equipment on the outcome of the analysis. For example Fast Static GPS surveying combined with conventional terrestrial surveying may prove to be more cost effective in this kind of a survey than conventional terrestrial surveying alone.

Chapter 6

Analysis of Costs & Benefits

6.1 Introduction

The following Chapter contains an analysis of some major costs and benefits that were identified during the course of this project as being associated with coordinating the cadastre. These costs and benefits were not quantified and so a true cost benefit analysis was not performed, consequently a cost benefit ratio was not determined.

The analysis simply acknowledges the existence of the identified costs and benefits and provides some insight into what the author perceives the potential effects of these may be.

It is acknowledged that some of the points listed as benefits by this analysis conflict with other points listed as costs. For example a benefit identified by the analysis was the ability to reinstate boundaries without the need for cadastral monuments. This is at odds with a cost identified by the analysis, being a lack of cadastral monuments resulting in decreased cadastral tangibility especially for laypeople. Conflicts such as this illustrate the diversity of the users of cadastral information.

As applications for cadastral and non-cadastral spatial information continue to grow and diversify, so does the cadastres clientele. Developing a cadastral system capable of satisfying the needs of new cadastral clients, without compromising the needs of pre-existing clients, would pose one of the greatest challenges to any cadastral reform process.

Chapter 6 – Costs & Benefits

6. 2 Identified Costs and Benefits

Some of the major costs and benefits associated with coordination of the cadastre that were identified during the course of this project are illustrated in Tables 6.1 and 6.2. The costs and benefits listed in these tables include examples that are directly connected to finance and examples that have a more intangible nature.

-
- Opportunity to create a homogenous cadastral data set through the enforcement of Class and Order.
 - Common spatial reference system throughout the cadastre from coordination date onwards, would facilitate development of the cadastre as a multi-layered LIS.
 - Modern spatial science information collection, storage and dissemination techniques and technology are well suited to implementation of a coordinated cadastre.
 - Consistent cadastral reinstatement could occur regardless of the existence of local monuments.
 - Cadastral reinstatement would only be subject to matters of fact not matters of opinion.
-

Table 6.1: Benefits Associated with Coordinating the Cadastre

Chapter 6 – Costs & Benefits

-
- Coordination process does not appear to be cost recovering.
Therefore it would be financially expensive for the State.
 - Additional education and training would be required for all users.
 - Cadastral rights would be less recognisable (less tangible) to most laypeople.
 - Original intention would be more difficult to recognise & more difficult to prove from the laypersons perspective.
 - Errors of transcription or omission may result in increased occurrences of land related litigation.
-

Table 6.2: Costs Associated with Coordinating the Cadastre

6.3 Analysis of Benefits Associated with Coordinating the Cadastre

6.3.1 A Homogenous Data Set

The present cadastre consists in part of documented spatial information created over a long period of time, using a variety of techniques and technologies. Modern survey technologies generally achieve survey results that are more precise and more accurate than those achieved with older technologies. Hence the reliability of documented spatial information stored as part of the cadastre is not consistent and can be a function of the technology used at the time of its creation.

For example: all things being equal, a survey that measured distances in hilly country with electronic distance measuring (EDM) equipment would be expected to achieve a better result than a survey that measured the same distances using a steel band and a spring balance.

Chapter 6 – Costs & Benefits

Or: all things being equal, a survey measuring angles with a one second instrument would be expected to achieve a better result than a survey measuring the same angles with a twenty second instrument.

Adoption of a coordinated cadastre would almost certainly entail the classification of network precision and coordinated boundary accuracy through the assignment of Class and Order.

To achieve a common Class coordination surveys would be performed using similar techniques and technology (ICSM 2004, p. A-6) and would be required to achieve a consistent level of precision. The accuracy of coordinated points would also be consistent, as the Order of new coordinated corners would be a function of the coordination surveys Class and the accuracy of the adjoining coordinated corners, which would be used as constraints to the coordination survey. (Refer Section 2.6.4)

This kind of a cadastre would in part address an issue that the current system does not, that is the issue of metadata.

Metadata is often described as data about data; it is usually considered to be *‘information pertaining to [an] entire dataset rather than the objects within the data set’*. (Clarke 2003, p.228) Metadata contains a range of information about a dataset, including information concerning the data’s reliability.

Chapter 6 – Costs & Benefits

To date when documented cadastral information has been used in applications such as GIS a user has been forced to accept that the documented information contained in the cadastre was of a quality suitable for the intended application.

A coordinated cadastre that requires surveys to achieve Class C and Order 3 (Refer Section 2.6.3) would create a homogenous data set and would provide users with a mechanism to assess the quality of documented cadastral information and hence assess its suitability for intended applications.

6.3.2 Common Spatial Reference System

Documented cadastral spatial information that has been created to date will almost without exception be presented in a vector format, i.e. as bearings and distances.

For historical reasons the azimuth that NSW cadastral information is orientated relative to could be one of several. Examples include True North, Magnetic North, ISG or MGA94.

Surveyors generally have the skills and experience necessary to recognise that spatial information contained on a plan has been stored on an azimuth that may be different to that used by an adjoining plan. Surveyors will also generally possess the skills required to convert information in this situation to a common reference system, i.e. a common azimuth.

Chapter 6 – Costs & Benefits

Developments in modern technology have increased the number of applications for spatial information in general, as well as the applications for cadastral spatial information.

Technology has also made it easier to access cadastral information. NSW cadastral plans can now be purchased online from the Department of Lands by anyone with access to the internet and a credit card. In the past there was nothing preventing a person purchasing the same plans on their own behalf. However, the process generally involved a degree of human contact providing the opportunity for consultation and advice.

The increasing number of applications for spatial information and the ease with which this information can be accessed should be considered positive developments for the cadastre. However, these developments may be creating a situation in which a growing number of the users of cadastral information are not as familiar with basic spatial science concepts, such as plan orientation, as they may need to be to avoid costly mistakes and misunderstandings.

Adoption of the recommendations made in Section 2.6.1 of this project “Updating the Geodetic Reference System”, which were subsequently demonstrated in Appendix F, would create a situation whereby the documented information of the coordinated cadastre would always be expressed relative to a single reference system. This would reduce the opportunity for costly errors possibly resulting from increased usage of cadastral information by individuals with minimal spatial science skills.

Chapter 6 – Costs & Benefits

Adoption of the recommendations made in Section 2.6.1, resulting in an ongoing common spatial reference frame, would also facilitate the development of the cadastre into a multilayered LIS such as that outlined in Section 2.4 of this paper, which 84% of the respondents to the Spatial Information Questionnaire stated would benefit their organisations.

6.3.3 Compatibility of Coordinate Data

Coordinates are already widely used by modern spatial science information collection, storage, dissemination techniques and technologies. However current Legislation forces contemporary cadastral plans to continue to adhere to the traditional practice of describing cadastral positions using vector quantities. As a consequence when the spatial science industry and many other industries involved in land management and land development deal with cadastral information *‘there is a continual movement between dimensional data in vector format and coordinate information.’* (Blanchfield & Elfick 2006, p.7)

On many occasions, a coordinated cadastre would provide the ability to input cadastral information directly into many modern technologies which were designed to work primarily with coordinates. Thus halting the need to deconstruct and reconstruct cadastral information between vector and coordinate formats when collecting, storing and transferring the information using these technologies.

Chapter 6 – Costs & Benefits

However, on many other occasions the deconstruction and reconstruction processes would still be necessary. This is in part due to the fact that a large percentage of the population, who have interests in land, have no training in spatial science and no access to the technologies referred to. These people, would on occasion, have need to make reference to documented cadastral information and could be expected to better understand linear forms of spatial information such as vector quantities than coordinate information.

There would also be occasions when it was more convenient for the spatial science professional to work with vector information as opposed to coordinate information. For example, a surveyor designing a subdivision must comply with local government regulations regarding parcel dimensions. This situation would be more suited to vector information as a direct comparison could be made between what had been designed and what the regulations required.

So, whilst data compatibility with modern technology and modern techniques could be considered to be a benefit associated with coordination of the cadastre, it should perhaps be considered a subjective benefit.

6.3.4 Consistent Cadastral Reinstatement

The final two points shown on Table 6.1 are related and so were both dealt with under this sub-heading.

Chapter 6 – Costs & Benefits

When cadastral reinstatement relies on monuments as evidence, situations occur in which the reinstatement process becomes subject to matters of opinion. These situations most frequently arise when cadastral monuments are disturbed or destroyed. In these cases a Registered Surveyor must decide where he or she believes a corner was originally located, based upon the remaining evidence. It is not uncommon to find differing opinions amongst Registered Surveyors as to the true location of a boundary in circumstances where cadastral monuments have been lost. The situation becomes more complex when two surveyors reinstate the same corner at different times.

If the evidence available at the time of the second reinstatement has changed since the first the outcome of the two surveys may vary.

The cadastral evidence of a coordinated cadastre would not be physical in nature and so it would not be subject to the effects of physical disturbance, deterioration or destruction.

The cadastral reinstatement process of a coordinated cadastre would rely solely on measurement for cadastral evidence. These measurements would assume the form of coordinates and would be made relative to the MGA94 or an equivalent geodetic coordinate system available at the time. The reinstatement process would essentially become a process of setting out accurate dimensions recorded as coordinates relative to the Earth's centroid, thus theoretically always providing a consistent reinstatement result.

Chapter 6 – Costs & Benefits

6.4 Analysis of Costs Associated with Coordinating the Cadastre

6.4.1 Direct Financial Cost of Coordinating the Cadastre

Based upon the results of the break even analysis, performed in Chapter 5 of this paper, a project aimed specifically at coordination of the cadastre would not be a cost recovering exercise and therefore would represent a significant cost to the State.

6.4.2 Additional Education and Training for All Users

The surveying questionnaire results, illustrated in tabular format as part of Appendix C, indicate that over 60% of surveying organisations in NSW may not be familiar with the recommendations of SP1 regarding surveying procedures for control surveys. The questionnaire results also reveal that an average of 63% of the respondents to the questionnaire indicated members of their organisation were either unable to perform calculations using the MGA94 projection or lacked an understanding of the MGA94 coordinate system. Adoption of a coordinated cadastre which defines cadastral corners with MGA94 coordinates and which uses Class and Order to indicate the reliability of those coordinates would require the members of surveying organisations in NSW to have a good understanding of both SP1 and the MGA94 coordinate system.

Therefore, adoption of a coordinated cadastre could be expected to result in training expenses for many surveying organisations. The level of training required and hence the cost incurred would be a function of the surveying organisation's skills deficit.

Chapter 6 – Costs & Benefits

A basic education in geodesy would become a requirement for designers, planners and other individuals who would be expected to work with coordinated cadastral information.

Currently measurements are taken on the curved surface of the Earth relative to local cadastral monuments. In NSW it is common for the ground distances of the measured cadastral lines to be recorded on a Deposited Plan; these are then treated as a plane distance.

This practice is acceptable under the present cadastral system in part because measured cadastral distances are usually relatively short; therefore, the effect that curvature of the Earth has on measured cadastral distances is usually small enough to be ignored on a local scale.

This is coupled with the fact that a cadastral line is currently measured relative to a physical monument on the Earth's surface and is theoretically reinstated relative to the same monument. When a line is reinstated on different occasions, using a consistent distance measured from a common datum point, the end point of the line will also be consistent. The type of distance used in this situation is irrelevant to the consistency of the achieved results. This is demonstrated by the fact that cadastral distances can be converted between metric and imperial without effecting the reinstatement result. What is important is that all lines be measured using the same type of distance.

Chapter 6 – Costs & Benefits

A coordinated cadastre however, would not refer corners to monuments. Instead corners would be referred to the Earth's centroid via geodetic coordinates.

In the case of a coordinated cadastre that adopts the MGA94 as a coordinate system, the coordinates will exist on a plane surface, whilst the coordinated corner will exist on the Earth's curved surface. To successfully transfer information between these surfaces conversion processes involving the calculation and application of scale factors would need to occur. Distances calculated between coordinates would be plane distances and would therefore need to be converted to ground distances before they could be applied to problems that existed on the curved surface of the Earth. Measurements made on the ground would need to be converted to plane distances before they could be used to determine MGA94 coordinates.

Designers, planners and other individuals working with coordinated cadastral information would require an understanding of the principles discussed above and the skills necessary to perform the conversion tasks. Therefore, as previously stated a basic education in geodesy would become a requirement for designers, planners and other individuals who would be expected to work with coordinated cadastral information.

6.4.3 Potential for an Increase in Land Related Dispute

The last three points listed in Table 6.2 are interrelated; therefore these points were all dealt with under this sub-heading.

Chapter 6 – Costs & Benefits

One of the primary points to consider when assessing the success of any cadastral system is its ability to prevent land related disputes.

Under the present monument based cadastral system when a boundary corner is created its location is recorded in reference to a cadastral monument, be that a reference mark, a peg, a wall or some other structure. These monuments provide evidence of the location of a boundary that is tangible and readily understood by the layperson. The law considers monuments to be better evidence of the location of a cadastral corner than measurements shown on the face of a plan. This concept, referred to as the doctrine of “Monuments over Measurements”, was reviewed during Chapter 2 of this paper.

As long as the monument exists the spatial rights associated with the land in question are easily recognisable on the ground. In this way the original intentions of parties to an agreement concerning spatial rights are clearly conveyed to all concerned, in a manner that can be understood by all, regardless of their technical background or skills. Whilst the monument exists in an undisturbed state errors of transcription or omission do not effect the location of the referenced corner.

In this way the doctrine of monuments over measurements protects a proprietor’s spatial rights as the proprietor originally intended. This has assisted to minimise land related litigation in NSW.

Chapter 6 – Costs & Benefits

The successful operation of a coordinated cadastre will require that the doctrine of monuments over measurements be overturned and documented evidence in the form of coordinates will be used to fix the location of a boundary, regardless of conflicting physical evidence.

Whilst it is likely that a coordinated cadastre would continue to use marks on the ground, such as pegs, to indicate the location of cadastral corners there would be a subtle difference between an original peg placed in relation to a coordinated cadastre, in which the courts supported a doctrine of measurements over monuments and an original peg placed under the current system which according to the current law fixes the corner regardless of conflicting measurements.

In a coordinated system any survey mark, whether it was an original mark or not would only be an indication of where a surveyor believed a corner was located.

If an error of transcription or omission was to occur when documenting the location of a corner in a coordinated cadastre the location of the corner in question would be subject to the effects of the error. (Refer Section 2.7.2) A marked line that had been adopted and acted upon by all original parties as the boundary, could subsequently, be overturned if it were shown that the markings disagreed with the coordinates recorded on a cadastral plan. In other words the original intention of the parties would be overruled by the measurements shown on a plan.

Chapter 6 – Costs & Benefits

A significant provision to the success of the cadastre is the community's belief that they are treated equably by the system. Adoption of cadastral procedures that fail to recognise original intentions and dispute boundary locations based upon intangible evidence, that many in the community having minimal or no training in spatial science will find difficult to interpret, could be expected to lead to an increase in the occurrence of land related dispute and litigation.

6.5 Conclusion

This chapter has acknowledged the existence of some of the costs and benefits associated with coordinating the cadastre. The chapter also outlines the effects of these as perceived by the author.

The cadastres clientele represents a broad spectrum of the community. The technical skills and the needs of individuals and organisations belonging to this clientele vary greatly. Therefore, change that constitutes a benefit for some may in fact be detrimental to others. The needs of the community as a whole must be considered when determining the suitability of a cadastral reform process.

Chapter 7

Conclusions

7.1 Conclusion

It is the visible object and marks that the surveyor establishes ... which determine the extremities of the property lines for the owner, the engineer, the builder, the fencer and the retracement surveyor. Moreover, it is these objects and marks, or the occupations erected in reliance upon them, that the courts will consider favourably in settling boundary disputes.
(Ticehurst 1994, p.4-64)

Whilst other attributes would require consideration when assessing the viability of any proposed cadastral reform, an ability to maintain spatial rights and obligations as they were originally intended and an ability to communicate intention to all effected parties, should be the primary points of consideration for this kind of an assessment.

The process of interpreting original intention can often be a complex and time consuming one for the reinstatement surveyor. At face value a coordinated cadastre that purports to offer accurate MGA94 coordinates as the primary evidence of boundary locations appears to be a more desirable system than the one currently in use. This is especially so for professions that regularly translate cadastral information into MGA94 coordinate information for use with technology such as GIS, CAD and GPS, all of which are designed to deal with absolute positions, not legal concepts that can be open to interpretation.

Chapter 7 - Conclusion

It should be remembered though, that most laypeople with interests in land are not expert users of technology such as GIS, CAD or GPS. In fact many may not be able to proficiently read the most basic of survey plans. However, most laypeople understand evidence they can see and therefore, usually have no significant issues understanding intention when it is described by physical evidence such as an original survey peg.

This kind of evidence makes the intangible tangible and often best describes the intentions of the original parties to land. As one surveyor who was questioned during the course of this project stated *'property owners have a right to know where you determine their boundary to be and the right to dispute that determination'*. If a proprietor is unclear about the determination a surveyor has made because of the format that new cadastral information is presented in, the proprietor effectively loses their right of dispute.

For this reason it is speculated that even under a coordinated cadastral system the courts would continue to support the doctrine of 'monuments over measurements'. This would create a situation where a defendant proprietor, acting in good faith in relation to coordinated cadastral evidence, may find their spatial rights challenged by other evidence, not contained in the cadastral database which the proprietor had until that time been bound to adhere to. For this reason it is speculated that a proprietor's spatial rights and obligations would be better protected by the placement of accurate survey monuments defining those rights than by the recording of accurate geodetic coordinates purporting to do the same.

Chapter 7 - Conclusion

It is considered that a reform process resulting in an overall reduction to the level of protection afforded to proprietor's spatial rights should not be considered a viable alternative to the current system. Therefore, a coordinated cadastre should not be considered a viable alternative to the current system until such time as the courts review and amend their opinion on the position of measurement in the hierarchy of evidence.

7.2 Achievement of Project Specifications

NSW Legislation and Regulations related to the establishment, monumentation and reinstatement of cadastral boundaries were researched during chapter two of this research project. The Surveying Act 2002 was found to be the primary document governing the control of surveys; however, the Act gives authority to the Surveying Regulation 2006 to make provision for the practices used to conduct surveys in NSW. Therefore, the Surveying Regulation 2006 was the focus of the research which also recommended changes to the Regulations that the author of this project perceived would be necessary to provide for the establishment and governance of a coordinated cadastre.

The document 'Standards and Practices for Control Surveys (SP1)' and the NSW Surveyor Generals Directions, which together constitute current National and State guidelines for control surveys, were researched during the course of this project.

Chapter 7 – Conclusion

These guidelines were used as the basis for the cadastral coordination survey procedures outlined during chapter three of the project.

The procedures outlined in chapter three were applied to a cadastral coordination survey performed to establish the location of road boundaries and the MGA94 coordinates of those boundaries in the suburb of Cambridge Gardens. The plans contained in Appendix F illustrate the results of that survey and have been presented in a format that was considered appropriate for the presentation, storage and dissemination of cadastral MGA94 information. It is anticipated that the MGA94 coordinates illustrated in the tables contained in Appendix F would also be stored in an electronic database. This, combined with the design of the plan, would allow the plan's MGA94 coordinates to be updated when revisions, to account for tectonic drift, are made to the MGA coordinate system, without causing a need to update the plan's diagram.

7.3 Further Research

Although it is believed a coordinated cadastre would result in reduced protection of proprietor's spatial rights, significant technical benefits could be achieved by establishing an accurate DCDB. The coordinates of the accurate DCDB could be determined by conducting cadastral coordination surveys using the techniques outlined in chapter three of this paper.

Chapter 7 – Conclusion

If an accurate DCDB were established using the procedures outlined in chapter 3, as opposed to a coordinated cadastre which attempted to adopt coordinates as the primary form of cadastral evidence, the coordinates resulting from the DCDB would be considered cadastral evidence at the lower end of the hierarchy of evidence and as such could be over ruled by conflicting physical evidence. However, the coordinates may become a tool of great significance to many of the organisations sampled by the questionnaires distributed during the course of this project.

Many of these organisations indicated that they would benefit from coordinated cadastral information and the accurate DCDB would probably be suitable for many engineering and design applications. It may even be plausible for surveyors to conduct some surveys not requiring strict accuracy, such as topographic surveys, using coordinates from the database. Responsibility for the correctness of these surveys would ultimately rest with the surveyor and therefore, it would prudent for surveyors and other professionals using the accurate DCDB to also make reference to other forms of cadastral evidence. An accurate DCDB would also facilitate the creation of a multilayered LIS annexed to the cadastre, which many land managers and land developers indicated would benefit their organisations.

As with any proposal to effect change, cost must be a consideration. The results of the break even analysis performed in chapter five of this research project indicated that the cost of determining accurate MGA94 coordinates of boundary corners over large portions of the cadastre would not be a cost recovering exercise.

Chapter 7 – Conclusion

These results relied heavily upon information provided by the NSW Department of Lands which described the number of times existing cadastral plans of the survey area had been accessed online. Unfortunately this information was limited to an eighteen month period between January 2001 and June 2002 and so it was necessary make an interpolation over a long period of time based upon data that represented only a relatively small period of time.

The results also relied upon the findings of an analysis performed at one site using only terrestrial surveying techniques. Further testing at other sites incorporating other surveying techniques would be justifiable. Further testing should also refer to data from the Department of Lands indicating the number of times plans belonging to test sites are accessed. However when possible this data should represent larger periods of time.

It may also be appropriate for further testing to focus on the amount a purchaser would be willing to pay for coordinated cadastral information, rather than the amount a surveyor believes this information is worth under a royalty scheme.

The project specifications also aimed to complete a cost benefit analysis of the proposal to coordinate the cadastre. A true cost benefit analysis requires that all costs and benefits associated with a proposal be assigned a financial value from which a cost benefit ratio is determined.

Chapter 7 – Conclusion

Limitations of time and resources have prevented this project from determining a cost benefit ratio for the coordination proposal. Therefore, this could also be an area of further research. If further research incorporating a cost benefit analysis were undertaken it should include a comparison of the cost benefit ratio associated with creating an accurate DCDB against the cost benefit ratio associated with establishing a coordinated cadastre which would attempt to establish coordinates as the primary form of cadastral evidence.

Appendix A

Research Project Specification

A1 (Sheet 1): Research Project Specification

Appendix A

University of Southern Queensland
Faculty of Engineering and Surveying
ENG 4111/2 Research Project
Project Specification

FOR: **Wayne Edmund Stoeckl**

TOPIC: Viability of a co-ordinated cadastre

SUPERVISOR: Shane Simmons



ENROLMENT: ENG 4111 – S1, X, 2006
ENG 4112 – S2, X, 2006

PROJECT AIM: The project seeks to;

- a) Assess the commercial viability of converting sections of the existing cadastre into a co-ordinated cadastre
- b) Develop a set of procedures to assist in this task

PROGRAMME: Issue A, 08 March 2006

- 1) Undertake a cost/benefit analysis for the establishment of a co-ordinated cadastre from a commercial and public benefit perspective; i.e. who will benefit from the process, what incentives/disincentives exist for surveyors to undertake these projects.
- 2) Research the current N.S.W Legislation/Regulations relating to the establishment of cadastral boundaries, monumentation of cadastral boundaries and reinstatement of cadastral boundaries. Determine what changes are required to these to provide for the establishment of a co-ordinated cadastre.
- 3) Research current national and state guidelines relating to control surveys and co-ordination projects.
- 4) Develop a general set of procedures to assist surveyors meet the criteria of applicable guidelines and regulations when undertaking a cadastral co-ordination project.
- 5) Determine an appropriate method of presenting, storing and disseminating the MGA information so that it can be used to reinstate the corners of individual parcels in the future.
- 6) Apply the developed procedures while performing a survey to establish the location of road boundaries in Cambridge Gardens and determine the MGA co-ordinates of critical points along the roads i.e. tangent points, intersection points splay corners etc.

AGREED  (Student)  (Supervisor)

(Dated) 21/4/06

Appendix B

Case Studies

B1: Section 2.7.1 – DP1067711 (4 sheets)

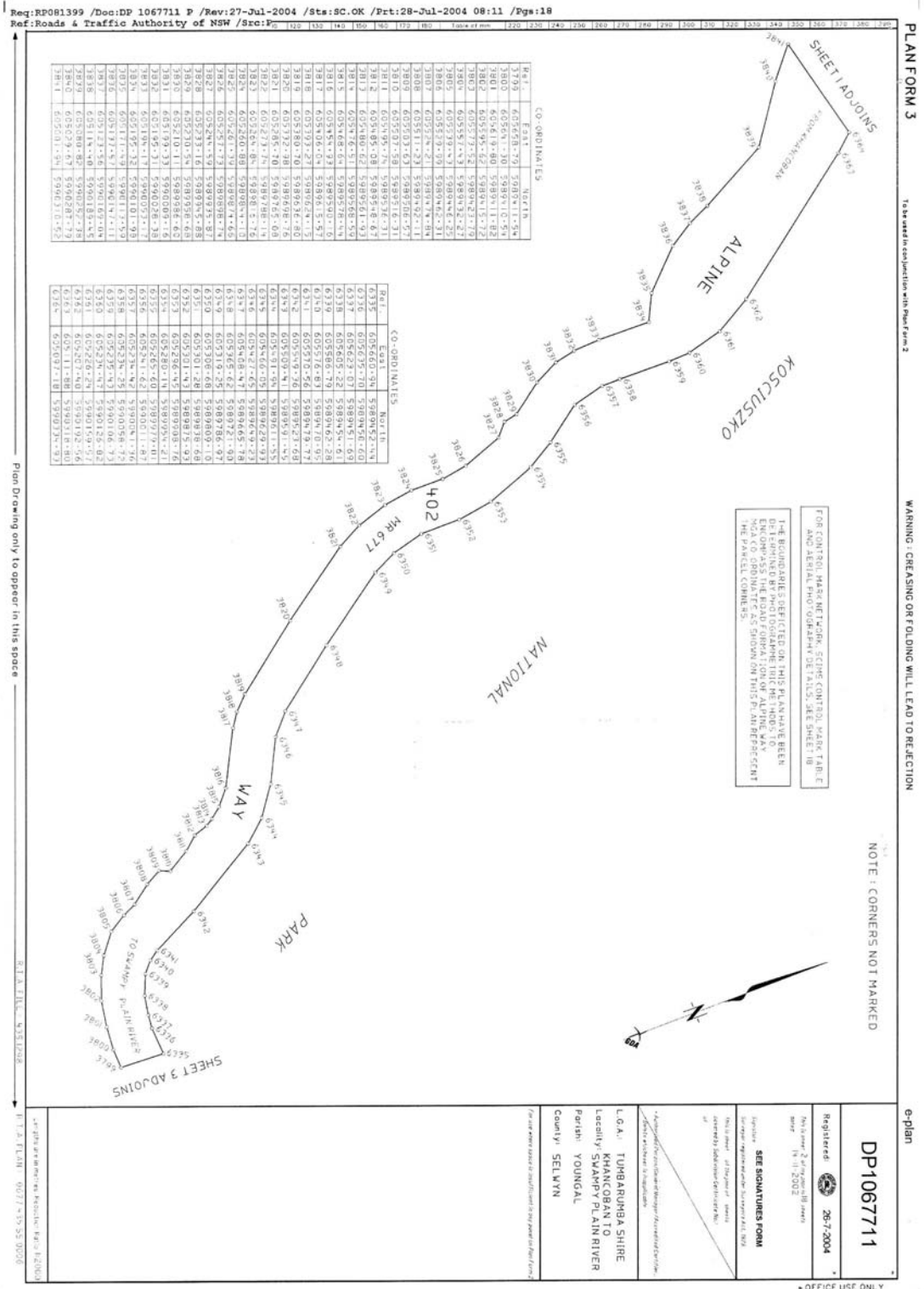
B2: Section 2.7.2 – DP649949 & Draft Plan of Subdivision (2 sheets)

B3: Section 2.7.2 Photograph Access Ramp (1 sheet)

Appendix B

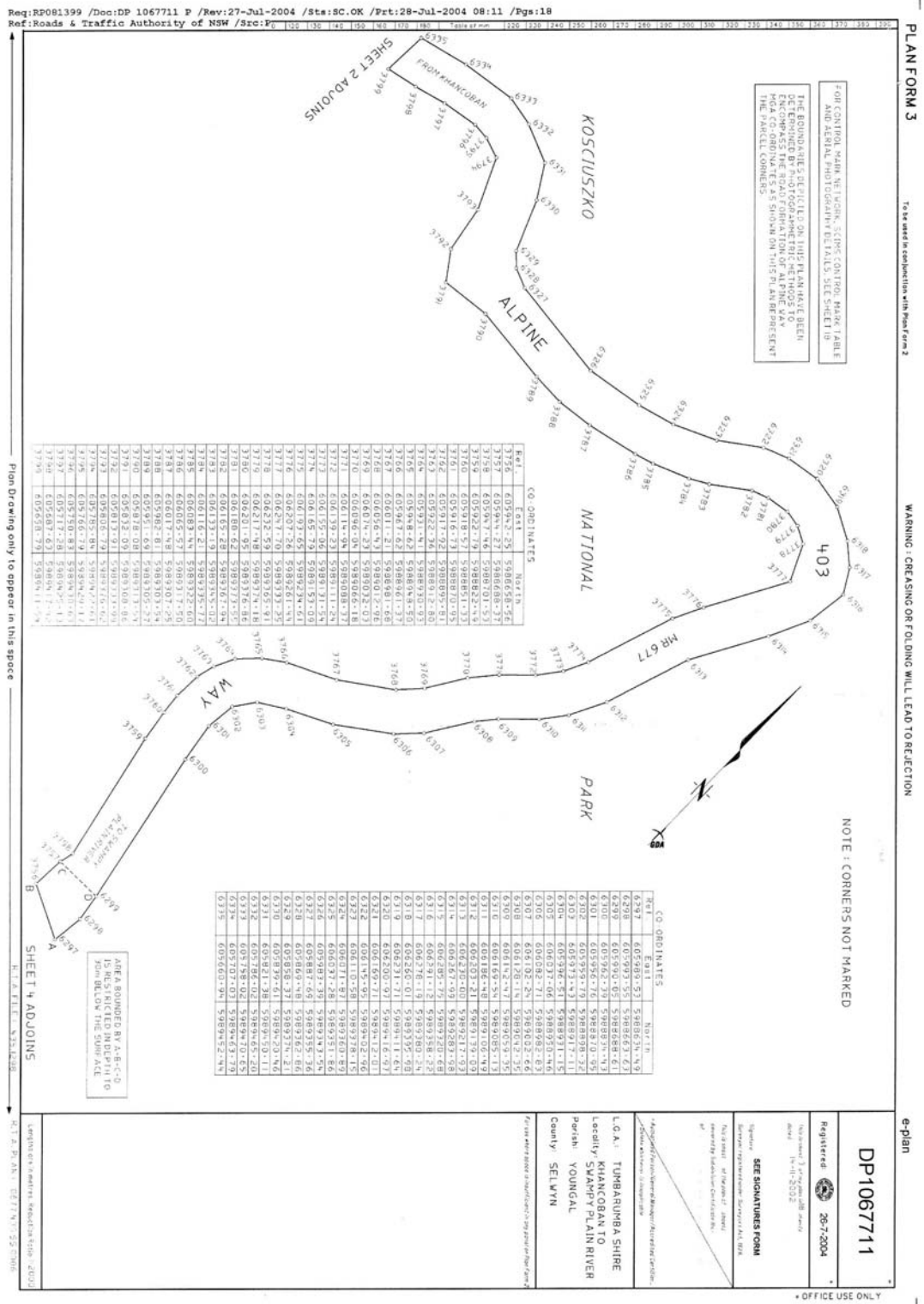
[illegible]

Appendix B



B1 (Sheet 2)

Appendix B



B1 (Sheet 4)

[illegible]

B2 (Sheet 2)

158

Appendix B



B3 (Sheet 1)

Appendix C

Survey Questionnaires

C1: N.S.W Surveying Questionnaire (4 sheets)

C2: N.S.W Spatial Information Questionnaire (3 sheets)

C3: Map of N.S.W Yellow Pages Directory Boundaries (1 sheet)

C4: Surveying Questionnaire Results (5 sheets)

C5: Spatial Information Questionnaire Results (5 sheets)

Appendix C

Wayne Stoeckl
94 Richmond Road
Cambridge Park NSW 2747
(m) 0428122873
email: waynestoeckl@bigpond.com

To the Principle Surveyor,

Dear Sir/Madam,

I am a Surveying student studying for a Bachelor of Surveying by correspondence at the University of Southern Queensland. As part of my final year of studies I am completing a research project. To this end I am seeking your assistance by asking you to answer the enclosed short questionnaire relating to your survey organisation.

My project is investigating the commercial viability of developing sections of the existing cadastre into a cadastral network which has the potential to use survey accurate MGA94 coordinates as evidence of boundary locations. My project proposes that surveyors undertake large scale redefinition plans aimed at fixing road alignments across several blocks of streets. The plans would use available marks and monuments for survey evidence as is the current practice; and would make connections to a network of geodetic monuments of an appropriate class and order. Following a rigorous adjustment process such as the least squares method the MGA94 coordinates of both the existing survey monuments and the critical boundary points of the road alignments (intersection points, tangent points, splay corners etc) would be determined.

The aim of my questionnaire is to obtain statistical data on the current cost of connecting boundaries to geodetic monuments, current industry trends which are sympathetic to working with a coordinated cadastre, the surveying industries interest in participating in a cadastral coordination programme and the industries interest in using royalty payments as a financial incentive for the creation of the proposed coordinate plans.

Please return the completed questionnaire using the prepaid envelope included and feel free to attach any additional information you believe will assist with my project.

Thankyou for supporting me in my efforts to become a Survey Graduate.

If you have any queries please contact myself or my project supervisor Mr Shane Simmons at USQ on 07 4631 2910 or email at simmonss@usq.edu.au

Yours Faithfully

Wayne Stoeckl

C1 (Sheet 1)

Appendix C

N.S.W Surveying Questionnaire:

NB: All answers should relate to the experiences of your surveying organisation not only those of yourself. No attempt will be made to identify individual respondents or their organisations.

- 1) Geographic Region
- 2) In the last year the number of subdivision, redefinition or consolidation plans performed by your organisation which involved connecting a cadastral survey traverse to geodetic monuments such as SSM's and PM's was approximately?

| | | | | |
|--|----------------------------------|----------------------------------|----------------------------------|-----------------------------------|
| <input type="checkbox"/> 0 – 10 | <input type="checkbox"/> 10 – 20 | <input type="checkbox"/> 20 – 30 | <input type="checkbox"/> 30 - 40 | <input type="checkbox"/> 40 – 50 |
| <input type="checkbox"/> 50 –60 | <input type="checkbox"/> 60 – 70 | <input type="checkbox"/> 70 – 80 | <input type="checkbox"/> 80 –90 | <input type="checkbox"/> 90 – 100 |
| <input type="checkbox"/> More than 100 | | | | |
- 3) Please estimate the average fee charged by your organisation for connecting a cadastral traverse to geodetic monuments? (*include searching, field, calculation and drafting costs incurred by your organisation/passed on to your client*).

| | | | |
|--|--|--|---|
| \$0 - \$250 <input type="checkbox"/> | \$250 - \$500 <input type="checkbox"/> | \$500 - \$750 <input type="checkbox"/> | \$750 - \$1000 <input type="checkbox"/> |
| \$1000 - \$1500 <input type="checkbox"/> | \$1500 - \$2000 <input type="checkbox"/> | \$2000 - \$2500 <input type="checkbox"/> | More <input type="checkbox"/> than \$2500 |
- 4) Are you satisfied with the current NSW regulatory requirements regarding geodetic connections to the cadastre? Yes☐ No☐

Comments please.
.....
.....
- 5) Would your organisation be inclined to perform cadastral coordination survey plans at its expense and to submit these plans for registration, if a royalty payment was made to it when the survey information was sold to a third party?

Yes☐ No☐

Comments please
.....
.....
- 6) What percentage of the sale of this information would you expect to receive as a royalty payment? *NB: The current cost of DP's purchased online from the Dept of Lands is \$8.50 per image including GST*
- 7) On how many of the last 7 days have you used a Geographic Information System (GIS) when working with cadastral information?

C1 (Sheet 2)

Appendix C

- 8) On how many of the last 7 days have you used a CAD package when working with cadastral information?
- 9) On how many of the last 7 days have you used GPS to perform a cadastral survey task?
- 10) On how many of the last 7 days have you performed a cadastral survey task with a total stations setout program which used coordinate data that had been uploaded or keyed in?
- 11) Are you familiar enough with the document “Standards and Practices for Control Surveys (SP1)” published by ICSM that you could apply the recommendations made by it? ☐ Yes ☐ No
- 12) Does your organisation regularly apply the recommendations of SP1 when performing control surveys? ☐ Yes ☐ No
- 13) What percentage of your clientele requires survey information presented on the MGA94 or GDA94 coordinate systems?
- 14) Please select one of the following.
- Members of my organisation,
- ☐ a) Have a thorough understanding of the MGA94 coordinate system including the effect of scale factors, false origins and zone overlap. They can perform calculations using the MGA94 projection including transformations between MGA94 and other coordinate systems such as GDA94.
- ☐ b) Are able to perform calculations using the MGA94 projection including transformations between MGA94 and other coordinate systems but don't thoroughly understand the coordinate system.
- ☐ c) Are unable to perform calculations using the MGA94 projection but do have a basic understanding of the coordinate system including things such as the effect of scale factors, false origins and zone overlap
- 15) Please identify any areas in which you believe the members of your organisation would require additional training in order to efficiently create and/or work with the type of coordinate based survey plans described by my proposal.
.....
.....
.....
- 16) Apart from income earned as a result of potential royalty payments would a survey accurate coordinated cadastre benefit your organisation? ☐ Yes ☐ No

C1 (Sheet 3)

Appendix C



Additional comments

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Appendix C

Wayne Stoeckl
94 Richmond Road
Cambridge Park NSW 2747
(m) 0428122873
email: waynestoeckl@bigpond.com

Dear Sir/Madam,

I am a Surveying student studying for a Bachelor of Surveying by correspondence at the University of Southern Queensland. As part of my final year of studies I am completing a research project. To this end I am seeking your assistance by asking you to answer the enclosed short questionnaire relating to your organisation.

My project is investigating the commercial viability of developing survey plans which will use MGA94 coordinates to redefine the location of boundaries. From these survey plans the corners of a parcel of land could potentially be marked on the ground, on a plan, in a CAD system or in a GIS using survey accurate MGA94 coordinates instead of using traditional survey marks and a series of bearings and distances.

My questionnaire is aimed at obtaining statistical data about organisations that are involved in the development and management of land resources and that are not surveying organisations. I will use the data I receive from responses to my questionnaire in a cost benefit analysis of the propositions I am making in my research project.

Please return the completed questionnaire using the prepaid envelope included and feel free to attach any additional information you believe will assist with my project.

Thankyou for supporting me in my efforts to become a Survey Graduate.

If you have any queries please contact myself or my project supervisor Mr Shane Simmons at USQ on 07 4631 2910 or email at simmonss@usq.edu.au

Yours Faithfully

Wayne Stoeckl

C2 (Sheet 1)

Appendix C

N.S.W Spatial Information Questionnaire:

NB: All answers should relate to the experiences of your organisation not only those of yourself. No attempt will be made to identify individual respondents or their organisations.

- 1) Geographic Region
- 2) Does your organisation purchase any of the following types of information?

| | | |
|--|----------------------------------|-----------------------------|
| Deposited Plans (DP's) | (a) <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| Digital Cadastral Data Base (DCDB) | (b) <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| Surveyors Plans which display boundary information | (c) <input type="checkbox"/> Yes | <input type="checkbox"/> No |
- 3) What percentage of the projects that your organisation deals with have some relationship to cadastral boundaries?
- 4) Do the members of your organisation currently use coordinates when dealing with spatial information? ☐ Yes ☐ No
- 5) Are the members of your organisation familiar with the following coordinate systems?

| | | |
|-----------|------------------------------|-----------------------------|
| (a) MGA94 | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| (b) GDA94 | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
- 6) What percentage of your organisations spatial information is stored in an electronic format on the MGA94 coordinate system or the GDA94 coordinate system?
.....
- 7) What percentage of your organisations spatial information is stored in an electronic format on another coordinate system? (Please indicate the name/s of the coordinate system/s)
- 8) Does your organisation use a Geographic Information System?
☐ Yes ☐ No
- 9) Does your organisation use Computer Aided Drafting software (CAD)?
☐ Yes ☐ No
- 10) Does your organisation use differential GPS techniques? i.e. a GPS technique which involves two receivers recording simultaneously; one is located at a point which already has known coordinates. ☐ Yes ☐ No

Please see over for remainder of questionnaire

C2 (Sheet 2)

Appendix C

- 11) What accuracy does your organisation usually expect of the spatial information it uses? NB: in many cases the acceptable tolerance will depend on the task at hand please mark multiple boxes if this is appropriate for your organisation.

| | | | |
|---------------|--------------------------|-----------|---|
| +/- 10 metres | <input type="checkbox"/> | +/- 10 cm | <input type="checkbox"/> |
| +/- 1 metre | <input type="checkbox"/> | +/- 1cm | <input type="checkbox"/> |
| +/- ½ metre | <input type="checkbox"/> | other | <input type="checkbox"/> Please specify |

- 12) Would a cadastral system that was capable of linking various categories of land information in a single electronic reference system be of greater benefit to your organisation than the current system? *(Eg the system might list the following information about a property; its location, dimensions, title description, legal encumbrances, environmental and legislative constraints, zoning description and property value).*

Yes ☐ No ☐

- 13) Please identify any areas in which you believe the members of your organisation would require additional training in order to efficiently work with a coordinated boundary system.

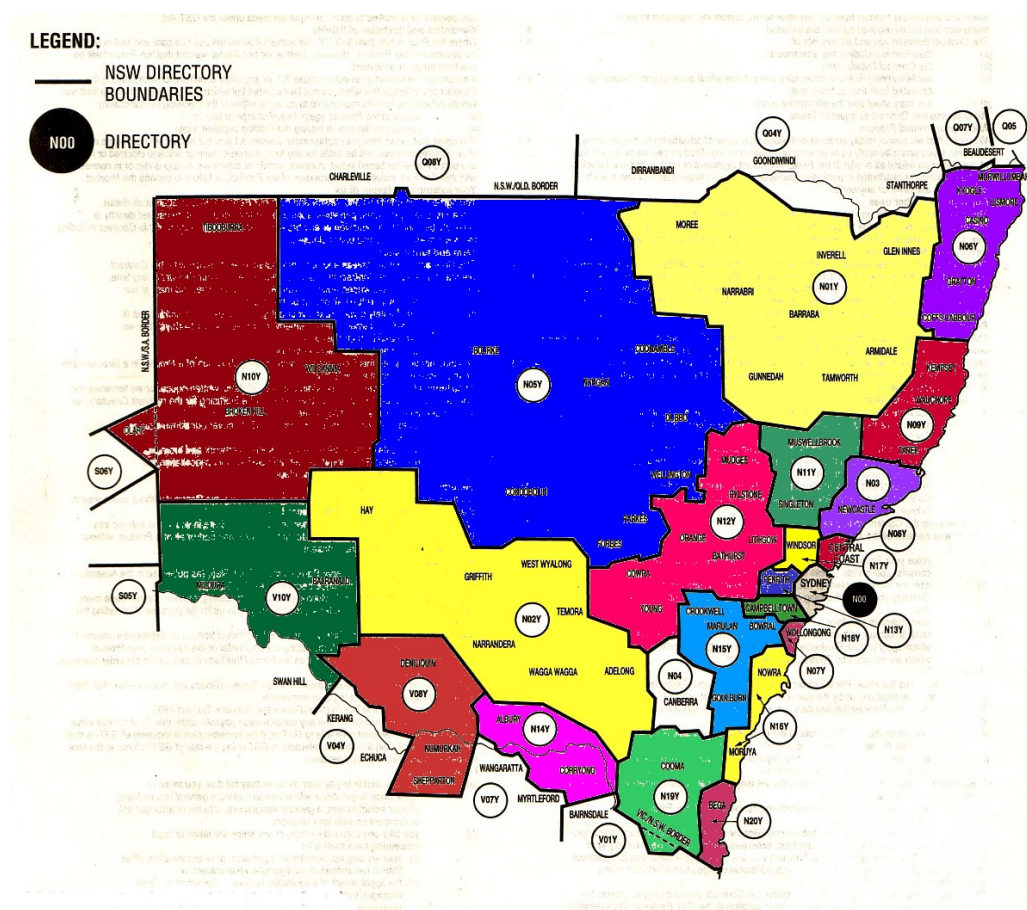
.....

- 14) Would a coordinated boundary system be of greater benefit to your organisation than the current system? Yes ☐ No ☐

Additional comments

.....

Appendix C



| Yellow Pages Book | Regional Book Code | Yellow Pages Book | Regional Book Code |
|-------------------|--------------------|-------------------|--------------------|
| Region | | Region | |
| Sydney | N00Y | Muswellbrook | N11Y |
| Tamworth | N01Y | Bathurst | N12Y |
| Wagga Wagga | N02Y | Penrith | N13Y |
| Newcastle | N03Y | Albury | N14Y |
| Dubbo | N05Y | Goulburn | N15Y |
| Lismore | N06Y | Nowra | N16Y |
| Wollongong | N07Y | Windsor | N17Y |
| Central Coast | N08Y | Campbelltown | N18Y |
| Kempsey | N09Y | Cooma | N19Y |
| Broken Hill | N10Y | Bega | N20Y |

Source: Sensus Australia 'Sydney Yellow Pages 2004-2005'

Appendix C

| Viability of a Coordinated Cadastre Surveying Questionnaire Results ENG4112 Research Project Sheet 1 of 5 | | | | | | |
|--|---|---|---|-----|--|-----|
| | Q2: Average annual number of plans connecting cadastral survey traverse to geodetic monuments? | Q3: Average fee charged for connecting a cadastral traverse to geodetic monuments? | Q4: Satisfied with NSW regulatory requirements regarding geodetic connections to the cadastre | | Q5: Would perform cadastral coordination survey plans at own expense if a royalty payment paid | |
| | | \$ | % | % | % | % |
| | | | yes | no | yes | no |
| NSW | 32 | 879 | 82 | 18 | 37 | 63 |
| Albury | 65 | 1333 | 75 | 25 | 50 | 50 |
| Bathurst | 18 | 1100 | 100 | 0 | 50 | 50 |
| Bega | 35 | 500 | 75 | 25 | 0 | 100 |
| Broken Hill | 10 | 375 | 100 | 0 | 50 | 50 |
| Campbelltown | 45 | 1150 | 60 | 40 | 50 | 50 |
| Central Coast | 28 | 500 | 100 | 0 | 50 | 50 |
| Cooma | 15 | 500 | 100 | 0 | 0 | 100 |
| Dubbo | 15 | 1500 | 0 | 100 | 0 | 100 |
| Goulburn | 30 | 500 | 100 | 0 | 0 | 100 |
| Kempsey | 13 | 1000 | 80 | 20 | 25 | 75 |
| Lismore | 19 | 812 | 80 | 20 | 40 | 60 |
| Muswellbrook | 25 | 917 | 100 | 0 | 0 | 100 |
| Newcastle | 46 | 600 | 91 | 9 | 36 | 64 |
| Nowra | 50 | 1250 | 0 | 100 | 100 | 0 |
| Penrith | 28 | 1333 | 100 | 0 | 67 | 33 |
| Sydney | 29 | 1073 | 88 | 12 | 41 | 59 |
| Tamworth | 20 | 437 | 50 | 50 | 25 | 75 |
| Wagga Wagga | 12 | 417 | 67 | 33 | 33 | 67 |
| Windsor | 50 | 250 | 100 | 0 | NR | NR |
| Wollongong | 75 | 1500 | 100 | 0 | 33 | 67 |
| Total No Responses NSW | 86 | 79 | 84 | | 81 | |
| % of Original Sample | 27 | 25 | 27 | | 26 | |

NR : No Responses

C4 (Sheet 1)

Appendix C

| Viability of a Coordinated Cadastre Surveying Questionnaire Results ENG4112 Research Project Sheet 2 of 5 | | | | |
|--|---|---|---|---|
| | Q6: Average sale % of survey information expected as a royalty payment? | Q7: Average No. days in last 7 that a GIS was used when working with cadastral information? | Q8: Average No. days in last 7 that CAD was used when working with cadastral information? | Q9: Average No. days in last 7 GPS was used to perform a cadastral survey task? |
| | % | Days | Days | Days |
| NSW | 86 | 3 | 6 | 1 |
| Albury | NR | 5 | 5 | 2 |
| Bathurst | 30 | 3 | 5 | 1 |
| Bega | 100 | 4 | 7 | 0 |
| Broken Hill | 10 | 2 | 4 | 1 |
| Campbelltown | 46 | 2 | 7 | 0 |
| Central Coast | 10 | 4 | 5 | 0 |
| Cooma | 100 | 3 | 7 | 3 |
| Dubbo | NR | NR | 0 | 0 |
| Goulburn | NR | 4 | 5 | 4 |
| Kempsey | 519 | 0 | 5 | 0 |
| Lismore | 28 | 3 | 6 | 0 |
| Muswellbrook | 80 | 2 | 5 | 2 |
| Newcastle | 51 | 4 | 6 | 0 |
| Nowra | 60 | 5 | 7 | 2 |
| Penrith | 13 | 7 | 7 | 1 |
| Sydney | 40 | 3 | 6 | 6 |
| Tamworth | 75 | 0 | 6 | 0 |
| Wagga Wagga | 10 | 5 | 5 | 0 |
| Windsor | NR | 0 | 3 | 0 |
| Wollongong | 25 | 3 | 4 | 2 |
| Total No Responses NSW | 44 | 83 | 85 | 85 |
| % of Original Sample | 14 | 27 | 27 | 27 |

NR : No Responses

Appendix C

| Viability of a Coordinated Cadastre Surveying Questionnaire Results ENG4112 Research Project Sheet 3 of 5 | | | | | | |
|--|---|---|-----|--|-----|--|
| | Q10: Average No. days in last 7 that a total station setout program was used for cadastral survey tasks | Q11: Are you familiar enough with 'SP1' that you could apply the recommendation s it makes? | | Q12: Do you regularly apply SP1 to control surveys? | | Q13: Average percentage of clientele requiring survey information on MGA94 / GDA94? |
| | Days | % | | % | | % |
| | | yes | no | yes | No | |
| NSW | 2 | 39 | 61 | 37 | 63 | 38 |
| Albury | 4 | 50 | 50 | 100 | 0 | 34 |
| Bathurst | 3 | 75 | 25 | 60 | 40 | 33 |
| Bega | 4 | 33 | 67 | 0 | 100 | 15 |
| Broken Hill | 0 | 0 | 100 | 0 | 100 | 3 |
| Campbelltown | 1 | 60 | 40 | 60 | 40 | 42 |
| Central Coast | 2 | 33 | 67 | 0 | 100 | 35 |
| Cooma | 4 | 100 | 0 | 100 | 0 | 10 |
| Dubbo | 3 | 0 | 100 | 0 | 100 | 50 |
| Goulburn | 5 | 50 | 50 | 50 | 50 | 85 |
| Kempsey | 2 | 40 | 60 | 67 | 33 | 41 |
| Lismore | 3 | 20 | 80 | 33 | 67 | 60 |
| Muswellbrook | 4 | 33 | 67 | 33 | 67 | 17 |
| Newcastle | 3 | 40 | 60 | 40 | 60 | 38 |
| Nowra | 4 | 50 | 50 | 50 | 50 | 75 |
| Penrith | 2 | 33 | 67 | 0 | 100 | 33 |
| Sydney | 1 | 33 | 67 | 27 | 73 | 40 |
| Tamworth | 2 | 25 | 75 | 25 | 75 | 13 |
| Wagga Wagga | 3 | 33 | 67 | 33 | 67 | 23 |
| Windsor | 1 | 0 | 100 | 0 | 100 | 100 |
| Wollongong | 2 | 67 | 33 | 67 | 33 | 67 |
| Total No Responses NSW | 85 | 85 | | 83 | | 82 |
| % of Original Sample | 27 | 27 | | 27 | | 26 |

NR : No Responses

Appendix C

| Viability of a Coordinated Cadastre Surveying Questionnaire Results ENG4112 Research Project Sheet 4 of 5 | | | | | |
|--|--|---|--|--|-----|
| | Q14a: Members have thorough understanding of the MGA94 coordinate system. They can perform calculations | Q14b: Members are able to perform calculations using the MGA94 projection but don't thoroughly understand the coordinate system. | Q14c: Members are unable to perform calculations on MGA94 but do have an understanding of the coordinate system | Q15: Extra training needed to allow members to create and work with coordinate based survey plans | |
| | % | % | % | % | |
| | Rates represent ratio of affirmative answers/returned questionnaires | | | yes | No |
| NSW | 37 | 32 | 31 | 65 | 35 |
| Albury | 50 | 25 | 25 | 75 | 25 |
| Bathurst | 50 | 50 | 0 | 80 | 20 |
| Bega | 0 | 25 | 75 | 25 | 75 |
| Broken Hill | 0 | 50 | 50 | 50 | 50 |
| Campbelltown | 75 | 25 | 0 | 33 | 67 |
| Central Coast | 33 | 67 | 0 | 33 | 67 |
| Cooma | 0 | 100 | 0 | 0 | 100 |
| Dubbo | 0 | 0 | 100 | 0 | 100 |
| Goulburn | 50 | 50 | 0 | 50 | 50 |
| Kempsey | 25 | 25 | 50 | 100 | 0 |
| Lismore | 20 | 20 | 60 | 100 | 0 |
| Muswellbrook | 33 | 67 | 0 | 100 | 0 |
| Newcastle | 55 | 36 | 9 | 55 | 45 |
| Nowra | 50 | 0 | 50 | 100 | 0 |
| Penrith | 33 | 0 | 67 | 67 | 33 |
| Sydney | 28 | 28 | 44 | 61 | 39 |
| Tamworth | 50 | 25 | 25 | 75 | 25 |
| Wagga Wagga | 67 | 0 | 33 | 67 | 33 |
| Windsor | 0 | 100 | 0 | NR | NR |
| Wollongong | 33 | 33 | 33 | 100 | 0 |
| Total | 84 | 84 | 84 | 81 | |
| % of Original Sample | 27 | 27 | 27 | 26 | |

NR : No Responses

Appendix C

| Viability of a Coordinated Cadastre Surveying Questionnaire Results ENG4112 Research Project Sheet 5 of 5 | | |
|--|---|-----|
| | Q16: Would a survey accurate coordinated cadastre benefit your organisation? | |
| | % | |
| | yes | No |
| NSW | 63 | 37 |
| Albury | 67 | 33 |
| Bathurst | 80 | 20 |
| Bega | 33 | 67 |
| Broken Hill | 0 | 100 |
| Campbelltown | 33 | 67 |
| Central Coast | 33 | 67 |
| Cooma | 0 | 100 |
| Dubbo | 0 | 100 |
| Goulburn | 50 | 50 |
| Kempsey | 100 | 0 |
| Lismore | 100 | 0 |
| Muswellbrook | 100 | 0 |
| Newcastle | 50 | 50 |
| Nowra | 100 | 0 |
| Penrith | 67 | 33 |
| Sydney | 65 | 35 |
| Tamworth | 67 | 33 |
| Wagga Wagga | 50 | 50 |
| Windsor | NR | NR |
| Wollongong | 100 | 0 |
| Total No. Responses NSW | 71 | |
| % of Original Sample | 23 | |

NR : No Responses

Appendix C

| Viability of a Coordinated Cadastre Spatial Information Questionnaire Results ENG4112 Research Project Sheet 1 of 5 | | | | | | | |
|--|---------------------------|-----|-------------------------|-----|--|-----|--|
| | Q2a: Purchases DP's | | Q2b: Purchases DCDB. | | Q2c: Purchases other cadastral survey plans | | Q3: Average % of projects related to cadastre |
| | % | | % | | % | | % |
| | yes | no | yes | no | yes | no | |
| NSW | 78 | 22 | 64 | 36 | 66 | 34 | 66 |
| Albury | 100 | 0 | 100 | 0 | 100 | 0 | 80 |
| Bathurst | 75 | 25 | 75 | 25 | 57 | 43 | 73 |
| Bega | 100 | 0 | 0 | 100 | 50 | 50 | 68 |
| Broken Hill | 100 | 0 | 0 | 100 | 100 | 0 | 1 |
| Campbelltown | 100 | 0 | 100 | 0 | 100 | 0 | 100 |
| Central Coast | 100 | 0 | 67 | 33 | 100 | 0 | 100 |
| Cooma | 100 | 0 | 0 | 100 | 0 | 100 | 20 |
| Dubbo | 100 | 0 | 67 | 33 | 67 | 33 | 70 |
| Goulburn | 100 | 0 | 100 | 0 | 100 | 0 | 90 |
| Kempsey | 100 | 0 | 71 | 29 | 71 | 29 | 87 |
| Lismore | 100 | 0 | 75 | 25 | 86 | 14 | 78 |
| Muswellbrook | 75 | 25 | 100 | 0 | 50 | 50 | 70 |
| Newcastle | 100 | 0 | 50 | 50 | 100 | 0 | 95 |
| Nowra | 0 | 100 | 0 | 100 | 0 | 100 | 100 |
| Penrith | 75 | 25 | 75 | 25 | 75 | 25 | 78 |
| Sydney | 67 | 33 | 58 | 42 | 65 | 35 | 56 |
| Tamworth | 80 | 20 | 100 | 0 | 60 | 40 | 67 |
| Wagga Wagga | 80 | 20 | 80 | 20 | 20 | 80 | 46 |
| Windsor | 100 | 0 | 100 | 0 | 100 | 0 | NR |
| Wollongong | 0 | 100 | 0 | 100 | 0 | 100 | 80 |
| Total No Responses NSW | 113 | | 112 | | 111 | | 100 |
| % of Original Sample | 37 | | 36 | | 36 | | 32 |

NR : No Responses

Appendix C

| Viability of a Coordinated Cadastre Spatial Information Questionnaire Results ENG4112 Research Project Sheet 2 of 5 | | | | | | | |
|--|---|-----|---------------------------------|-----|---------------------------------|-----|---|
| | Q4: Currently use coordinates when dealing with spatial information. | | Q5a: Familiar with MGA94. | | Q5b: Familiar with GDA94. | | Q6: Average % spatial information stored electronically on MGA94 or GDA94. |
| | % | | % | | % | | % |
| | yes | no | yes | no | yes | no | |
| NSW | 71 | 29 | 69 | 31 | 59 | 41 | 58 |
| Albury | 100 | 0 | 100 | 0 | 100 | 0 | 100 |
| Bathurst | 100 | 0 | 100 | 0 | 75 | 25 | 93 |
| Bega | 100 | 0 | 100 | 0 | 50 | 50 | 100 |
| Broken Hill | 0 | 100 | 0 | 100 | 0 | 100 | 0 |
| Campbelltown | 0 | 100 | 0 | 100 | 0 | 100 | 0 |
| Central Coast | 67 | 33 | 67 | 33 | 50 | 50 | 0 |
| Cooma | 0 | 100 | 0 | 100 | 0 | 100 | 0 |
| Dubbo | 67 | 33 | 67 | 33 | 33 | 67 | 50 |
| Goulburn | 100 | 0 | 100 | 0 | 100 | 0 | 100 |
| Kempsey | 71 | 29 | 71 | 29 | 27 | 71 | 48 |
| Lismore | 75 | 25 | 63 | 37 | 50 | 50 | 61 |
| Muswellbrook | 100 | 0 | 100 | 0 | 100 | 0 | 95 |
| Newcastle | 50 | 50 | 75 | 25 | 50 | 50 | 58 |
| Nowra | 100 | 0 | 100 | 0 | NR | NR | 100 |
| Penrith | 75 | 25 | 75 | 25 | 75 | 25 | 73 |
| Sydney | 63 | 37 | 59 | 41 | 58 | 42 | 50 |
| Tamworth | 80 | 20 | 80 | 20 | 60 | 40 | 59 |
| Wagga Wagga | 80 | 20 | 80 | 20 | 100 | 0 | 72 |
| Windsor | 100 | 0 | 100 | 0 | 100 | 0 | 100 |
| Wollongong | 100 | 0 | 100 | 0 | 100 | 0 | 0 |
| Total No Responses NSW | 113 | | 112 | | 111 | | 101 |
| % of Original Sample | 37 | | 36 | | 36 | | 33 |

NR : No Responses

Appendix C

| Viability of a Coordinated Cadastre Spatial Information Questionnaire Results ENG4112 Research Project Sheet 3 of 5 | | | | | | | |
|--|--|------------------|-----|------------------|-----|-----------------------------------|-----|
| | Q7: Average % spatial information stored electronically on neither MGA94 or GDA94. | Q8: Uses GIS. | | Q9: Uses CAD. | | Q10: Uses differential GPS. | |
| | % | % | | % | | % | |
| | | yes | no | yes | no | yes | No |
| NSW | 15 | 66 | 34 | 83 | 17 | 27 | 73 |
| Albury | 0 | 100 | 0 | 100 | 0 | 100 | 0 |
| Bathurst | 6 | 88 | 13 | 88 | 13 | 25 | 75 |
| Bega | 0 | 100 | 0 | 100 | 0 | 0 | 100 |
| Broken Hill | 0 | 0 | 100 | 0 | 100 | 0 | 100 |
| Campbelltown | 80 | 0 | 100 | 100 | 0 | 0 | 100 |
| Central Coast | 0 | 67 | 33 | 100 | 0 | 67 | 33 |
| Cooma | 0 | 0 | 100 | 0 | 100 | 0 | 100 |
| Dubbo | 35 | 67 | 33 | 67 | 33 | 33 | 67 |
| Goulburn | 5 | 100 | 0 | 100 | 0 | 100 | 0 |
| Kempsey | 15 | 71 | 29 | 100 | 0 | 29 | 71 |
| Lismore | 3 | 63 | 38 | 88 | 13 | 25 | 75 |
| Muswellbrook | 5 | 75 | 25 | 75 | 25 | 75 | 25 |
| Newcastle | 20 | 50 | 50 | 100 | 0 | 75 | 25 |
| Nowra | 0 | 100 | 0 | 100 | 0 | 100 | 0 |
| Penrith | 0 | 75 | 25 | 100 | 0 | 0 | 100 |
| Sydney | 16 | 63 | 37 | 79 | 21 | 15 | 85 |
| Tamworth | 11 | 60 | 40 | 80 | 20 | 40 | 60 |
| Wagga Wagga | 32 | 60 | 40 | 80 | 20 | 40 | 60 |
| Windsor | 0 | 100 | 0 | 100 | 0 | 0 | 100 |
| Wollongong | 100 | 100 | 0 | 100 | 0 | 0 | 100 |
| Total No Responses NSW | 100 | 112 | | 113 | | 113 | |
| % of Original Sample | 32 | 36 | | 37 | | 37 | |

NR : No Responses

Appendix C

| Viability of a Coordinated Cadastre Spatial Information Questionnaire Results ENG4112 Research Project Sheet 4 of 5 | | | | | |
|--|--|-------|---------|---------|----------|
| | Q: 11 Require spatial information to have an accuracy of | | | | |
| | ± 10 m | ± 1 m | ± 1/2 m | ± 0.1 m | ± 0.01 m |
| Albury | | | yes | yes | |
| Bathurst | yes | | yes | yes | yes |
| Bega | | | yes | yes | |
| Broken Hill | | | | yes | |
| Campbelltown | | | | | yes |
| Central Coast | yes | yes | yes | yes | yes |
| Cooma | | yes | | | |
| Dubbo | | yes | | | yes |
| Goulburn | | yes | | yes | |
| Kempsey | yes | yes | | yes | yes |
| Lismore | yes | yes | | yes | yes |
| Muswellbrook | yes | yes | yes | | |
| Newcastle | | yes | yes | | yes |
| Nowra | | | | yes | |
| Penrith | | yes | yes | | yes |
| Sydney | yes | yes | yes | yes | yes |
| Tamworth | yes | yes | yes | yes | yes |
| Wagga Wagga | yes | yes | | | yes |
| Windsor | | | | | |
| Wollongong | yes | yes | | yes | |
| Total No Responses NSW | 25 | 50 | 25 | 27 | 47 |
| % of Original Sample | 8 | 16 | 8 | 9 | 15 |

NR : No Responses

Appendix C

| Viability of a Coordinated Cadastre Spatial Information Questionnaire Results ENG4112 Research Project Sheet 5 of 5 | | | | |
|--|---|-----|---|-----|
| | Q12: Multilayered cadastral system would be beneficial. | | Q14: Would a coordinated boundary system be more beneficial to your organisation than the current system? | |
| | % | | % | |
| | yes | no | yes | no |
| NSW | 84 | 16 | 73 | 27 |
| Albury | 100 | 0 | 67 | 33 |
| Bathurst | 100 | 0 | 86 | 14 |
| Bega | 50 | 50 | 100 | 0 |
| Broken Hill | 100 | 0 | 0 | 100 |
| Campbelltown | 0 | 100 | 0 | 100 |
| Central Coast | 100 | 0 | 100 | 0 |
| Cooma | 100 | 0 | 0 | 100 |
| Dubbo | 100 | 0 | NR | NR |
| Goulburn | 100 | 0 | 100 | 0 |
| Kempsey | 86 | 14 | 83 | 17 |
| Lismore | 100 | 0 | 83 | 17 |
| Muswellbrook | 75 | 25 | 100 | 0 |
| Newcastle | 100 | 0 | 50 | 50 |
| Nowra | 100 | 0 | NR | NR |
| Penrith | 67 | 33 | 67 | 33 |
| Sydney | 84 | 16 | 75 | 25 |
| Tamworth | 67 | 33 | 33 | 67 |
| Wagga Wagga | 40 | 60 | 33 | 67 |
| Windsor | 100 | 0 | NR | NR |
| Wollongong | NR | NR | 100 | 0 |
| Total No Responses NSW | 104 | | 89 | |
| % of Original Sample | 34 | | 24 | |

NR : No Responses

Appendix D

Royalties Table

**D1: Table Indicating Frequency of Online Access for Deposited Plans and
Theoretic Royalties Payable (1 sheets)**

Appendix D

| Deposited Plan Number | No. Times Accessed Jan 2001 – Jun 2002 | Annual Royalty Payable (\$) Based on \$3.57 |
|--------------------------|---|---|
| 247363 | 7 | 16.66 |
| 249077 | 9 | 21.42 |
| 245661 | 3 | 7.14 |
| 245691 | 6 | 14.28 |
| 245610 | 7 | 16.66 |
| 246554 | 6 | 14.28 |

Table Indicating Frequency of Online Access and Annual Proposed
Royalty Revenue (\$) for Deposited Plans in Cambridge Gardens Survey

Source: Pers Comm NSW Department of Lands

Appendix E

SCIMS Survey Mark Reports for Cambridge Gardens

E1: SCIMS Mark Plot (1 sheets)

E2: SCIMS Mark Report SSM44985 (1 sheet)

E3: SCIMS Mark Report SSM44981 (1 sheet)

E4: SCIMS Mark Report SSM44982 (1 sheet)

E5: SCIMS Mark Report SSM44984 (1 sheet)

E6: SCIMS Mark Report SSM44979 (1 sheet)

E7: SCIMS Mark Report SSM44980 (1 sheet)

Appendix E

SCIMS
Mark Plot



500 Metre DCDB Plot Centered About Mark:

SS 44981

New Radius: 500 metres

Redraw



Plot Legend

Print Page

<http://scims.lands.nsw.gov.au/FireRender>

1/30/2006

Appendix E

Department of Lands - SCIMS Survey Marks - Mark Report

Page 1 of 1

SCIMS Mark Report



| | | |
|---------------------|-------------|---------------|
| Mark | Date | Time |
| SS 44985 | 08-AUG-2006 | 14:32:55 |
| Station Name | | Status |

Alias

| | |
|-----------------|-------------------|
| Location | Suburb |
| GROUND LEVEL | CAMBRIDGE GARDENS |

| | | | | | | |
|-------|--------------------|---------------------|-----------------|--------------|------------------------|-------------|
| | Latitude | Longitude | Class | Order | Source | Date |
| GDA94 | -33 44 10.52011 | 150 43 23.74093 | B | 2 | 227560 | 24-DEC-2001 |
| | MGA Easting | MGA Northing | MGA Zone | CSF | Convergence | |
| | 289079.118 | 6264758.758 | 56 | 1.000141 | -1° 15' 53" | |

| | | | | | | |
|-------|--------------------|---------------------|-----------------|--------------|------------------------|-------------|
| | Latitude | Longitude | Class | Order | Source | Date |
| AGD66 | -33 44 16.18260 | 150 43 19.55995 | B | 2 | 205796 | 18-APR-1995 |
| | AMG Easting | AMG Northing | AMG Zone | CSF | Convergence | |
| | 288974.591 | 6264568.974 | 56 | 1.000142 | -1° 15' 56" | |
| | ISG Easting | ISG Northing | ISG Zone | CSF | Convergence | |
| | 274249.075 | 1265595.061 | 561 | 0.999941 | -0° 09' 15" | |

| | | | | | |
|-------|---------------|--------------|--------------|------------------------|-------------|
| AHD71 | Height | Class | Order | Source | Date |
| | 48 | U | U | 216443 | 14-NOV-2001 |

| | | |
|--------------------|------------------|----------------------|
| Date Placed | Placed By | Monument Type |
| | NOT AVAILABLE | UNKNOWN |

Print Page

<http://scims.lands.nsw.gov.au/FireRender>

8/08/2006

Appendix E

SCIMS Mark Report



Department of Lands

Reliable from the ground up

Mark

SS 44981

Date

08-AUG-2006

Time

14:30:26

Station Name

Status

Alias

Location

GROUND LEVEL

Suburb

CAMBRIDGE GARDENS

| | Latitude | Longitude | | Class | Order | Source | Date |
|-------|--------------------|---------------------|-----------------|--------------|--------------|------------------------|-------------|
| GDA94 | -33 44 07.76575 | 150 43 18.50270 | | B | 2 | 227560 | 24-DEC-2001 |
| | MGA Easting | MGA Northing | MGA Zone | CSF | | Convergence | |
| | 288942.416 | 6264840.635 | 56 | 1.000141 | | -1° 15' 56" | |
| | Latitude | Longitude | | Class | Order | Source | Date |
| | -33 44 13.42822 | 150 43 14.32172 | | B | 2 | 205796 | 18-APR-1995 |
| AGD66 | AMG Easting | AMG Northing | AMG Zone | CSF | | Convergence | |
| | 288837.890 | 6264650.850 | 56 | 1.000142 | | -1° 15' 58" | |
| | ISG Easting | ISG Northing | ISG Zone | CSF | | Convergence | |
| | 274114.015 | 1265679.556 | 561 | 0.999940 | | -0° 09' 18" | |
| AHD71 | Height | | | Class | Order | Source | Date |
| | 50 | | | U | U | 216443 | 14-NOV-2001 |

Date Placed

Placed By

NOT AVAILABLE

Monument Type

UNKNOWN

Witness Marks

Print Page

Appendix E

SCIMS Mark Report



Department of Lands

Reliable from the ground up

| | | |
|---------------------|-------------|---------------|
| Mark | Date | Time |
| SS 44982 | 08-AUG-2006 | 14:30:43 |
| Station Name | | Status |

Alias

Location
GROUND LEVEL

Suburb
CAMBRIDGE GARDENS

| | Latitude | Longitude | | Class | Order | Source | Date |
|-------|-----------------|-----------------|----------|----------|-------|-------------|-------------|
| GDA94 | -33 44 11.24324 | 150 43 11.47124 | | B | 2 | 227560 | 24-DEC-2001 |
| | MGA Easting | MGA Northing | MGA Zone | CSF | | Convergence | |
| | 288763.800 | 6264729.502 | 56 | 1.000142 | | -1° 16' 00" | |
| | Latitude | Longitude | | Class | Order | Source | Date |
| | -33 44 16.90561 | 150 43 07.29015 | | B | 2 | 205796 | 18-APR-1995 |
| AGD66 | AMG Easting | AMG Northing | AMG Zone | CSF | | Convergence | |
| | 288659.275 | 6264539.718 | 56 | 1.000143 | | -1° 16' 03" | |
| | ISG Easting | ISG Northing | ISG Zone | CSF | | Convergence | |
| | 273933.315 | 1265571.930 | 561 | 0.999940 | | -0° 09' 22" | |
| AHD71 | Height | | | Class | Order | Source | Date |
| | 50 | | | U | U | 216443 | 14-NOV-2001 |

| | | |
|--------------------|------------------|----------------------|
| Date Placed | Placed By | Monument Type |
| | NOT AVAILABLE | UNKNOWN |

Print Page

Appendix E

SCIMS Mark Report



| | | |
|---------------------|-------------|---------------|
| Mark | Date | Time |
| SS 44984 | 08-AUG-2006 | 14:31:00 |
| Station Name | | Status |

Alias

Location
GROUND LEVEL

Suburb
CAMBRIDGE GARDENS

| | Latitude | Longitude | | Class | Order | Source | Date |
|-------|--------------------|---------------------|-----------------|------------|-------|--------------------|-------------|
| GDA94 | -33 44 09.58199 | 150 43 07.14259 | | B | 2 | 227560 | 24-DEC-2001 |
| | MGA Easting | MGA Northing | MGA Zone | CSF | | Convergence | |
| | 288651.253 | 6264778.217 | 56 | 1.000143 | | -1° 16' 02" | |

| | Latitude | Longitude | | Class | Order | Source | Date |
|-------|--------------------|---------------------|-----------------|------------|-------|--------------------|-------------|
| | -33 44 15.24435 | 150 43 02.96146 | | B | 2 | 205796 | 18-APR-1995 |
| AGD66 | AMG Easting | AMG Northing | AMG Zone | CSF | | Convergence | |
| | 288546.728 | 6264588.432 | 56 | 1.000144 | | -1° 16' 05" | |
| | ISG Easting | ISG Northing | ISG Zone | CSF | | Convergence | |
| | 273821.756 | 1265622.807 | 561 | 0.999941 | | -0° 09' 24" | |

| | Height | | Class | Order | Source | Date |
|-------|--------|--|-------|-------|--------|-------------|
| AHD71 | 47 | | U | U | 216443 | 14-NOV-2001 |

| | | |
|--------------------|------------------|----------------------|
| Date Placed | Placed By | Monument Type |
| | NOT AVAILABLE | UNKNOWN |

Print Page

24

Appendix E

Department of Lands - SCIMS Survey Marks - Mark Report

Page 1 of 1

SCIMS Mark Report



| | | |
|---------------------|-------------|---------------|
| Mark | Date | Time |
| SS 44979 | 08-AUG-2006 | 14:29:57 |
| Station Name | | Status |

Alias

| | |
|-----------------|-------------------|
| Location | Suburb |
| GROUND LEVEL | CAMBRIDGE GARDENS |

| | | | | | | |
|--------------|--------------------|---------------------|-----------------|---------------|--------------------|-------------|
| GDA94 | Latitude | Longitude | Class | Order | Source | Date |
| | -33 43 59.20898 | 150 43 08.93158 | B | 2 | 227560 | 24-DEC-2001 |
| | MGA Easting | MGA Northing | MGA Zone | CSF | Convergence | |
| | 288690.231 | 6265098.802 | 56 | 1.000143 | -1° 16' 01" | |
| AGD66 | Latitude | Longitude | Class | Order | Source | Date |
| | -33 44 04.87142 | 150 43 04.75054 | B | 2 | 205796 | 18-APR-1995 |
| | AMG Easting | AMG Northing | AMG Zone | CSF | Convergence | |
| | 288585.704 | 6264909.017 | 56 | 1.000144 | -1° 16' 04" | |
| | ISG Easting | ISG Northing | ISG Zone | CSF | Convergence | |
| | 273866.933 | 1265942.511 | 561 | 0.999941 | -0° 09' 23" | |
| AHD71 | Height | Class | Order | Source | Date | |
| | 46 | U | U | 216443 | 14-NOV-2001 | |

| | | |
|--------------------|------------------|----------------------|
| Date Placed | Placed By | Monument Type |
| | NOT AVAILABLE | UNKNOWN |

Print Page

<http://scims.lands.nsw.gov.au/FireRender>

8/08/2006

Appendix E

SCIMS Mark Report



Department of Lands
Reliable from the ground up

| | | |
|---------------------|-------------|---------------|
| Mark | Date | Time |
| SS 44980 | 08-AUG-2006 | 14:30:10 |
| Station Name | | Status |

Alias

Location
GROUND LEVEL

Suburb
CAMBRIDGE GARDENS

| | Latitude | Longitude | | Class | Order | Source | Date |
|-------|--------------------|---------------------|-----------------|--------------|--------------|--------------------|-------------|
| GDA94 | -33 44 00.43528 | 150 43 19.72552 | | B | 2 | 227560 | 24-DEC-2001 |
| | MGA Easting | MGA Northing | MGA Zone | CSF | | Convergence | |
| | 288968.902 | 6265067.164 | 56 | 1.000141 | | -1° 15' 55" | |
| | Latitude | Longitude | | Class | Order | Source | Date |
| | -33 44 06.09777 | 150 43 15.54464 | | B | 2 | 205796 | 18-APR-1995 |
| AGD66 | AMG Easting | AMG Northing | AMG Zone | CSF | | Convergence | |
| | 288864.375 | 6264877.380 | 56 | 1.000142 | | -1° 15' 58" | |
| | ISG Easting | ISG Northing | ISG Zone | CSF | | Convergence | |
| | 274144.882 | 1265905.484 | 561 | 0.999941 | | -0° 09' 17" | |
| AHD71 | Height | | | Class | Order | Source | Date |
| | 49 | | | U | U | 216443 | 14-NOV-2001 |

| | | |
|--------------------|------------------|----------------------|
| Date Placed | Placed By | Monument Type |
| | NOT AVAILABLE | UNKNOWN |

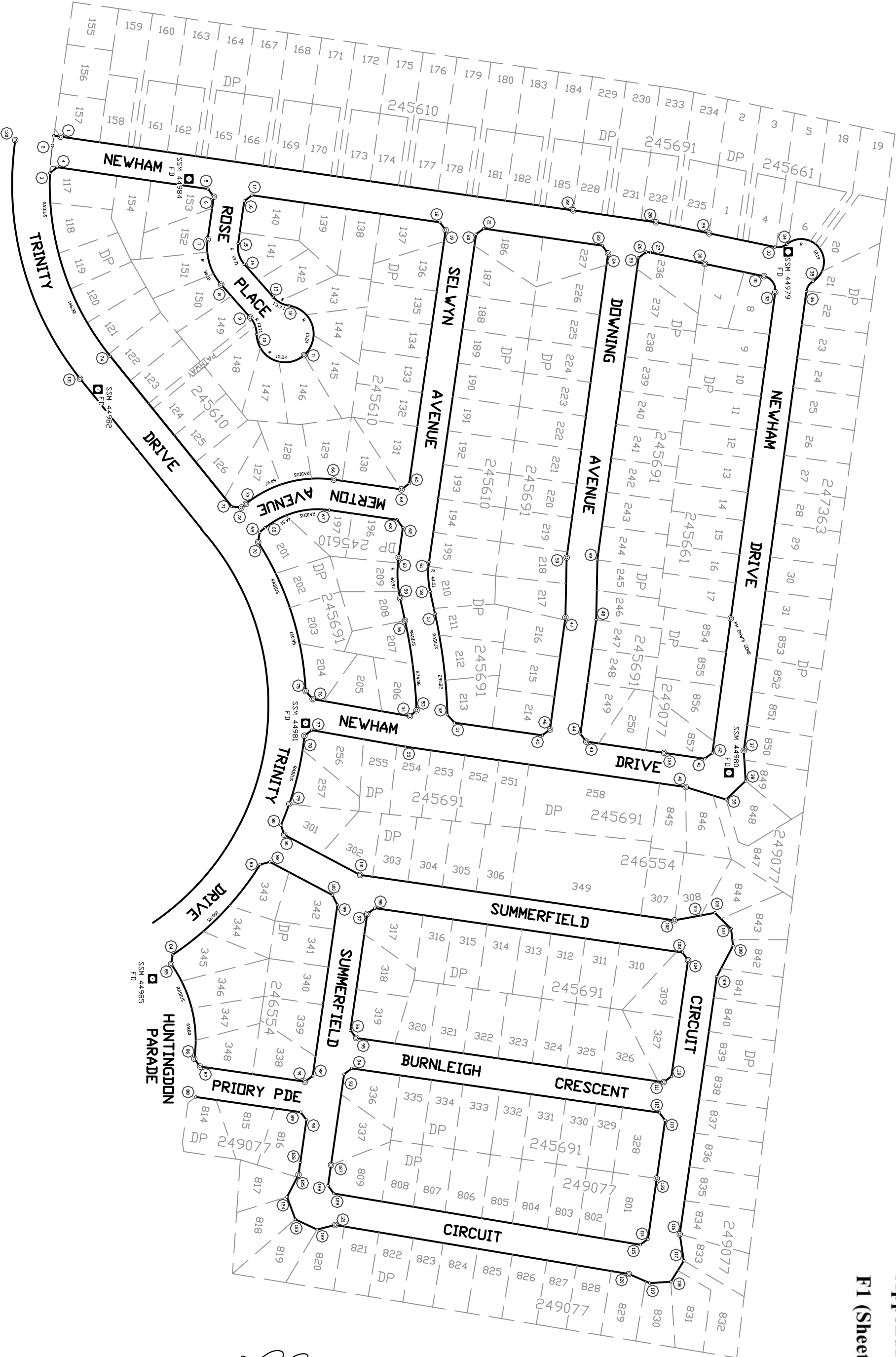
Print Page

Appendix F

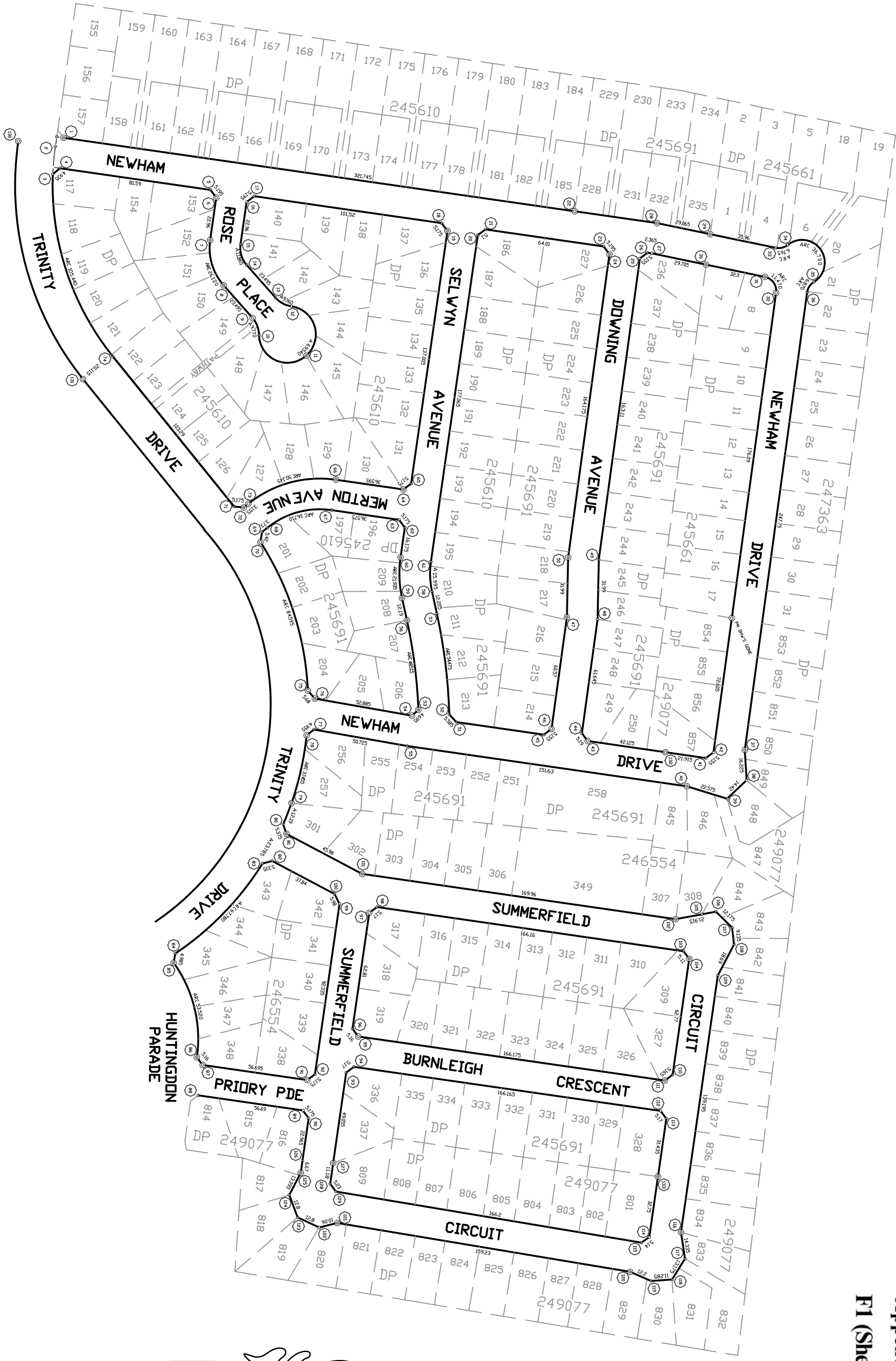
Cambridge Gardens Coordination Plan and Plan Rationale

F1: Coordination Plan (4 sheets)

F2: Cadastral Coordination Plan Rationale (3 sheets)



Plan of Coordinated Road Frontages



Plan Showing Ground Distances

Tables of Reference Marks Found

| | |
|----|---|
| 1 | 276° 50' 50" & 3.580 RM DHW FD <DP 245610> |
| | 276° 40' 17" 12.88 RM DHW FD BY ME <DP 245610> |
| 29 | 188° 20' 50" 3.505 RM DHW FD <DP 245610> |
| | RM GONE <DP 245610> |
| 3 | 188° 10' 17" 3.58 RM DHW FD <DP 245610> |
| | 188° 08' 30" 12.90 RM DHW FD BY ME <DP 245610> |
| 7 | 188° 10' 17" 3.58 RM DHW FD <DP 245610> |
| | 188° 13' 00" 12.895 RM DHW FD BY ME <DP 245610> |
| 8 | 138° 33' 17" 3.58 RM DHW FD <DP 245610> |
| | 138° 38' 25" 12.895 RM DHW FD BY ME <DP 245610> |
| 9 | 188° 33' 17" 3.58 RM DHW FD <DP 245610> |
| | 138° 34' 15" 12.925 RM DHW FD BY ME <DP 245610> |
| 11 | 48° 33' 17" 3.58 RM DHW FD <DP 245610> |
| | RM GONE <DP 245610> |
| 19 | 188° 14' 05" 12.88 RM DHW FD <DP 245610> |
| | 188° 14' 05" 3.595 RM DHW FD BY ME <DP 245610> |
| 22 | 278° 24' 00" 3.57 RM DHW FD <DP 245610> |
| | 278° 24' 00" 12.975 RM DHW FD BY ME <DP 245610> |
| 24 | 188° 10' 15" 12.875 RM DHW FD <DP 245691> |
| | 188° 10' 15" 3.565 RM DHW FD BY ME <DP 245691> |
| 28 | 279° 58' 15" 3.58 RM DHW FD <DP 245691> |
| | 279° 58' 15" 12.98 RM DHW FD BY ME <DP 245691> |
| 29 | 296° 33' 10" 3.655 RM DHW FD <DP 245691> |
| | RM GONE <DP 245691> |
| 38 | 102° 20' 55" 3.47 RM DHW FD BY ME <DP 245661> |
| | 101° 52' 40" 12.805 RM DHW FD BY ME <DP 245661> |
| 31 | 101° 47' 40" 12.805 RM DHW FD <DP 245661> |
| | 101° 45' 45" 3.44 RM DHW FD BY ME <DP 245661> |
| 38 | 187° 45' 25" 3.48 RM DHW FD <DP 245661> |
| | RM GONE <DP 245661> |
| 37 | 355° 52' 15" 3.595 RM DHW FD <DP 249077> |
| | 355° 52' 15" 13.23 RM DHW FD BY ME <DP 249077> |
| 48 | 123° 48' 15" 14.50 RM DHW FD <DP 249077> |
| | 123° 48' 15" 3.985 RM DHW FD BY ME <DP 249077> |
| 59 | 287° 43' 00" 13.11 RM DHW FD <DP 245691> |
| | 288° 08' 20" 3.575 RM DHW FD BY ME <DP 245691> |
| 43 | 278° 10' 15" 3.58 RM DHW FD <DP 245691> |
| | 278° 10' 15" 12.89 RM DHW FD BY ME <DP 245691> |
| 46 | 188° 12' 20" 3.58 RM DHW FD <DP 245691> |
| | 188° 12' 20" 12.94 RM DHW FD BY ME <DP 245691> |

| | |
|-----|---|
| 54 | 279° 04' 15" 3.58 RM DHW FD <DP 245691> |
| | 279° 04' 15" 12.84 RM DHW FD BY ME <DP 245691> |
| 59 | 188° 12' 15" 3.58 RM DHW FD <DP 245691> |
| | 188° 12' 15" 13.05 RM DHW FD BY ME <DP 245691> |
| 76 | 270° 59' 45" 3.55 RM DHW FD BY ME <DP 245691> |
| | 271° 32' 30" 13.135 RM DHW FD BY ME <DP 245691> |
| 73 | 358° 33' 15" 16.61 RM DHW FD <DP 245691> |
| | 358° 33' 15" 3.48 RM DHW FD BY ME <DP 245691> |
| 78 | 6° 33' 15" 16.55 RM DHW FD <DP 245691> |
| | 6° 33' 15" 3.53 RM DHW FD BY ME <DP 245691> |
| 79 | 329° 33' 17" 16.535 RM DHW FD <DP 245691> |
| | 329° 34' 19" 3.485 RM DHW FD BY ME <DP 245691> |
| 72 | 231° 03' 25" 12.88 RM DHW FD <DP 245610> |
| | 230° 49' 35" 3.545 RM DHW FD BY ME <DP 245610> |
| 79 | 231° 03' 17" 12.88 RM DHW FD <DP 245610> |
| | 230° 47' 35" 3.53 RM DHW FD BY ME <DP 245610> |
| 66 | 278° 11' 35" 3.575 RM DHW FD <DP 245610> |
| | 278° 11' 35" 12.88 RM DHW FD <DP 245610> |
| 64 | 278° 11' 35" 3.575 RM DHW FD <DP 245610> |
| | 278° 11' 35" 12.88 RM DHW FD <DP 245610> |
| 60 | 188° 10' 30" 12.955 RM DHW FD <DP 245610> |
| | 188° 10' 30" 3.56 RM DHW FD BY ME <DP 245610> |
| 99 | 167° 33' 15" 12.88 RM DHW FD <DP 245691> |
| | 167° 19' 15" 3.57 RM DHW FD BY ME <DP 245691> |
| 56 | 167° 33' 15" 12.88 RM DHW FD <DP 245691> |
| | 167° 29' 25" 3.57 RM DHW FD BY ME <DP 245691> |
| 131 | 141° 03' 17" 16.535 RM DHW FD <DP 245610> |
| | 140° 49' 50" 3.59 RM DHW FD BY ME <DP 245610> |
| 47 | 184° 28' 25" 12.775 RM DHW FD <DP 245691> |
| | 184° 28' 25" 3.40 RM DHW FD BY ME <DP 245691> |
| 59 | 184° 28' 15" 12.955 RM DHW FD <DP 245691> |
| | RM GONE <DP 245691> |
| 73 | 19° 33' 15" 16.535 RM DHW FD <DP 245691> |
| | 19° 35' 15" 3.505 RM DHW FD BY ME <DP 245691> |
| 81 | 297° 27' 15" 12.955 RM DHW FD <DP 246554> |
| | 297° 47' 15" 3.56 RM DHW FD BY ME <DP 246554> |
| 109 | 278° 10' 15" 3.20 RM DHW FD <DP 246554> |
| | RM GONE <DP 246554> |
| 97 | 16° 42' 15" 3.575 RM DHW FD <DP 246554> |
| | 16° 42' 15" 13.095 RM DHW FD BY ME <DP 246554> |

| | |
|-----|---|
| 96 | 278° 10' 15" 12.955 RM DHW FD <DP 246554> |
| | 278° 10' 15" 3.475 RM DHW FD BY ME <DP 246554> |
| 91 | 278° 10' 15" 3.505 RM DHW FD <DP 246554> |
| | 278° 10' 15" 12.955 RM DHW FD <DP 246554> |
| 89 | 278° 10' 15" 3.505 RM DHW FD <DP 246554> |
| | RM GONE <DP 246554> |
| 86 | 8° 10' 15" 3.505 RM DHW FD <DP 246554> |
| | 8° 10' 15" 12.915 RM DHW FD BY ME <DP 246554> |
| 88 | 330° 10' 15" 3.58 RM DHW FD <DP 246554> |
| | 330° 26' 40" 12.965 RM DHW FD BY ME <DP 246554> |
| 109 | 200° 18' 15" 3.59 RM DHW FD <DP 249077> |
| | 200° 18' 15" 13.27 RM DHW FD BY ME <DP 249077> |
| 127 | 8° 10' 15" 3.50 RM DHW FD <DP 246554> |
| | 8° 10' 15" 12.98 RM DHW FD BY ME <DP 246554> |
| 121 | 87° 19' 15" 3.75 RM DHW FD <DP 249077> |
| | 87° 19' 15" 13.25 RM DHW FD <DP 249077> |
| 109 | 111° 14' 15" 13.15 RM DHW FD <DP 249077> |
| | 111° 14' 15" 6.675 RM DHW FD BY ME <DP 249077> |
| 116 | 351° 27' 15" 3.755 RM DHW FD <DP 249077> |
| | 351° 27' 15" 13.535 RM DHW FD BY ME <DP 249077> |
| 139 | 188° 10' 15" 12.955 RM DHW FD <DP 246554> |
| | 188° 10' 15" 3.47 RM DHW FD BY ME <DP 246554> |
| 111 | 278° 10' 15" 3.505 RM DHW FD <DP 246554> |
| | 278° 10' 15" 12.98 RM DHW FD BY ME <DP 246554> |
| 106 | 188° 10' 15" 3.505 RM DHW FD <DP 246554> |
| | RM GONE <DP 246554> |
| 103 | 256° 25' 15" 13.87 RM DHW FD <DP 246554> |
| | RM GONE <DP 246554> |

Tables of MGA94 Cadastral Points

| | | |
|----|----------------|-----------------|
| 1 | E = 288628.649 | N = 6264709.570 |
| 2 | E = 288633.351 | N = 6264705.202 |
| 3 | E = 288648.139 | N = 6264703.832 |
| 4 | E = 288645.004 | N = 6264707.646 |
| 5 | E = 288656.614 | N = 6264786.415 |
| 6 | E = 288660.789 | N = 6264791.509 |
| 7 | E = 288663.517 | N = 6264788.242 |
| 8 | E = 288707.780 | N = 6264795.469 |
| 9 | E = 288725.393 | N = 6264811.021 |
| 10 | E = 288734.324 | N = 6264814.452 |
| 11 | E = 288745.556 | N = 6264839.782 |
| 12 | E = 288719.031 | N = 6264831.772 |
| 13 | E = 288714.497 | N = 6264823.361 |
| 14 | E = 288696.884 | N = 6264807.810 |
| 15 | E = 288685.860 | N = 6264804.537 |
| 16 | E = 288663.131 | N = 6264807.804 |
| 17 | E = 288659.997 | N = 6264811.948 |
| 18 | E = 288674.444 | N = 6264912.451 |
| 19 | E = 288678.587 | N = 6264915.550 |
| 20 | E = 288680.821 | N = 6264931.860 |

| | | |
|----|----------------|-----------------|
| 21 | E = 288677.827 | N = 6264935.988 |
| 22 | E = 288668.078 | N = 6264983.863 |
| 23 | E = 288686.936 | N = 6264999.354 |
| 24 | E = 288691.082 | N = 6265002.483 |
| 25 | E = 288693.426 | N = 6265018.778 |
| 26 | E = 288690.320 | N = 6265022.895 |
| 27 | E = 288690.656 | N = 6265025.237 |
| 28 | E = 288674.435 | N = 6265028.088 |
| 29 | E = 288680.361 | N = 6265056.547 |
| 30 | E = 288696.713 | N = 6265054.320 |
| 31 | E = 288703.299 | N = 6265085.948 |
| 32 | E = 288711.858 | N = 6265091.891 |
| 33 | E = 288687.693 | N = 6265091.757 |
| 34 | E = 288686.145 | N = 6265098.116 |
| 35 | E = 288706.016 | N = 6265112.162 |
| 36 | E = 288711.582 | N = 6265108.542 |
| 37 | E = 288957.098 | N = 6265075.096 |
| 38 | E = 288973.296 | N = 6265076.071 |
| 39 | E = 288983.197 | N = 6265065.584 |
| 40 | E = 288976.575 | N = 6265043.999 |

| | | |
|----|----------------|-----------------|
| 41 | E = 288961.413 | N = 6265054.201 |
| 42 | E = 288958.311 | N = 6265058.217 |
| 43 | E = 288952.273 | N = 6264990.809 |
| 44 | E = 288948.126 | N = 6264987.685 |
| 45 | E = 288948.879 | N = 6264967.272 |
| 46 | E = 288945.778 | N = 6264971.392 |
| 47 | E = 288885.764 | N = 6264979.652 |
| 48 | E = 288887.050 | N = 6264996.091 |
| 49 | E = 288855.064 | N = 6264996.760 |
| 50 | E = 288853.777 | N = 6264980.321 |
| 51 | E = 288942.100 | N = 6264920.255 |
| 52 | E = 288937.922 | N = 6264916.547 |
| 53 | E = 288935.539 | N = 6264899.991 |
| 54 | E = 288938.674 | N = 6264896.497 |
| 55 | E = 288954.933 | N = 6264893.900 |
| 56 | E = 288887.474 | N = 6264893.819 |
| 57 | E = 288883.928 | N = 6264909.894 |
| 58 | E = 288872.012 | N = 6264907.254 |
| 59 | E = 288875.574 | N = 6264891.181 |
| 60 | E = 288853.770 | N = 6264890.385 |

| | | |
|----|----------------|------------------|
| 61 | E = 288956.111 | N = 6264906.680 |
| 62 | E = 288837.757 | N = 6264892.685 |
| 63 | E = 288833.616 | N = 6264889.582 |
| 64 | E = 288817.321 | N = 6264891.9230 |
| 65 | E = 288814.220 | N = 6264896.067 |
| 66 | E = 288812.106 | N = 6264855.696 |
| 67 | E = 288828.404 | N = 6264853.375 |
| 68 | E = 288837.846 | N = 6264818.966 |
| 69 | E = 288840.191 | N = 6264816.065 |
| 70 | E = 288845.547 | N = 6264815.234 |
| 71 | E = 288826.480 | N = 6264801.096 |
| 72 | E = 288827.026 | N = 6264806.241 |
| 73 | E = 288825.042 | N = 6264808.695 |
| 74 | E = 288746.129 | N = 6264736.168 |
| 75 | E = 288925.220 | N = 6264840.671 |
| 76 | E = 288929.504 | N = 6264844.403 |
| 77 | E = 288946.137 | N = 6264843.934 |
| 78 | E = 288949.142 | N = 6264839.996 |
| 79 | E = 288985.628 | N = 6264831.876 |
| 80 | E = 288996.974 | N = 6264827.429 |

| | | |
|-----|----------------|-----------------|
| 81 | E = 289002.059 | N = 6264829.174 |
| 82 | E = 289016.623 | N = 6264821.499 |
| 83 | E = 289017.995 | N = 6264816.343 |
| 84 | E = 289066.313 | N = 6264769.510 |
| 85 | E = 289071.227 | N = 6264768.664 |
| 86 | E = 289121.945 | N = 6264781.114 |
| 87 | E = 289126.080 | N = 6264784.206 |
| 88 | E = 289142.375 | N = 6264781.860 |
| 89 | E = 289150.454 | N = 6264837.979 |
| 90 | E = 289154.595 | N = 6264841.081 |
| 91 | E = 289134.161 | N = 6264840.328 |
| 92 | E = 289131.063 | N = 6264844.474 |
| 93 | E = 289130.157 | N = 6264861.238 |
| 94 | E = 289127.058 | N = 6264865.379 |
| 95 | E = 289110.762 | N = 6264867.715 |
| 96 | E = 289106.625 | N = 6264864.631 |
| 97 | E = 289044.449 | N = 6264873.598 |
| 98 | E = 289041.351 | N = 6264877.740 |
| 99 | E = 289039.661 | N = 6264857.655 |
| 100 | E = 289034.331 | N = 6264854.946 |

| | | |
|-----|----------------|-----------------|
| 101 | E = 289023.576 | N = 6264869.814 |
| 102 | E = 289047.828 | N = 6265038.059 |
| 103 | E = 289065.061 | N = 6265042.221 |
| 104 | E = 289069.156 | N = 6265045.280 |
| 105 | E = 289045.227 | N = 6265052.130 |
| 106 | E = 289043.843 | N = 6265059.614 |
| 107 | E = 289052.384 | N = 6265068.293 |
| 108 | E = 289061.461 | N = 6265069.321 |
| 109 | E = 289078.016 | N = 6265060.639 |
| 110 | E = 289131.295 | N = 6265036.356 |
| 111 | E = 289134.396 | N = 6265032.223 |
| 112 | E = 289150.690 | N = 6265029.877 |
| 113 | E = 289154.829 | N = 6265032.977 |
| 114 | E = 289218.371 | N = 6265023.852 |
| 115 | E = 289221.385 | N = 6265019.691 |
| 116 | E = 289215.817 | N = 6265040.850 |
| 117 | E = 289229.987 | N = 6265043.016 |
| 118 | E = 289241.170 | N = 6265036.044 |
| 119 | E = 289241.940 | N = 6265024.783 |
| 120 | E = 289237.055 | N = 6265013.599 |

| | | |
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| 121 | E = 289210.818 | N = 6264856.524 |
| 122 | E = 289213.243 | N = 6264846.759 |
| 123 | E = 289207.822 | N = 6264835.162 |
| 124 | E = 289195.826 | N = 6264830.690 |
| 125 | E = 289183.930 | N = 6264836.850 |
| 126 | E = 289177.326 | N = 6264837.803 |
| 127 | E = 289178.716 | N = 6264854.235 |
| 128 | E = 289189.783 | N = 6264852.639 |
| 129 | E = 289193.999 | N = 6264855.738 |
| 130 | E = 288630.481 | N = 6264685.291 |
| 131 | E = 288758.101 | N = 6264719.978 |
| 132 | E = 288958.285 | N = 6265032.506 |
| 133 | E = 289185.949 | N = 6265028.508 |

| | | | | |
|--|----------------|-----------------|---------|---------|
| SSW 44979 | E = 288690.231 | N = 6265098.802 | CLASS B | ORDER 2 |
| SSW 44980 | E = 288968.902 | N = 6265067.164 | CLASS B | ORDER 2 |
| SSW 44981 | E = 288942.416 | N = 6264840.635 | CLASS B | ORDER 2 |
| SSW 44982 | E = 288763.800 | N = 6264729.502 | CLASS B | ORDER 2 |
| SSW 44984 | E = 288651.253 | N = 6264778.217 | CLASS B | ORDER 2 |
| SSW 44985 | E = 289079.118 | N = 6264758.758 | CLASS B | ORDER 2 |
| SOURCE SCIMS 08/08/06 COMBINED SCALE FACTOR 1.000142 | | | | |

Appendix F

Cadastral Coordination Plan Rational

- 1) Every coordinated point is assigned a unique identifier i.e. a point code demonstrated below;



- 2) All MGA94 coordinates are recorded in tables of MGA94 cadastral points annexed to the plan. Coordinates are linked to their respective points via the point codes.
- 3) It is envisaged that coordinates would also be recorded in an electronic database. Coordinates in the electronic database would be assigned a unique identifier consisting of the point code prefixed by the deposited plan number.

For example: point number 263 belonging to deposited plan number 123456 would be recorded in the cadastral database as 123456/263. In this way all corners in the coordinated cadastre would be assigned a unique identifier.

- 4) No bearings are shown on the coordination plans and the north point is only a general north point.

F2 (Sheet 1)

Appendix F

Cadastral Coordination Plan Rational

- 5) Together points 2, 3 & 4 prevent the need to update the coordinated plan's diagram in the future when the MGA is updated, to counter the effects of tectonic drift. Instead a transformation could be applied to the electronic database updating the coordinates to the new MGA.

The combined effect of these points also means that all registered coordinated plans will be on the same orientation and their coordinates will always be fixed relative to the same datum.

Storing the coordinates in an electronic data base will make future coordinate transformations relatively simple.

- 6) Point codes also link corners to the reference marks used to fix the boundary locations prior to coordination. This maintains the chain of evidence through the original coordination plan. Tables of reference marks would not appear on subsequent plans as coordinates would be used to define the location of boundaries for all subsequent surveys.

Appendix F

Cadastral Coordination Plan Rational

- 7) Ground distances are recorded on sheet two of the plan to provide a checking mechanism for coordinate joins following application of the scale factor. The ground distance also provides a description of parcel dimension in a context that is simpler for a layperson to understand.
- 8) No connections are shown between PMs as the coordinates of these points are fixed and are used to constrain the survey along with any surrounding coordinated boundary corners.
- 9) Coordinated cadastral plans actually submitted for registration would be contained in a standardised A2 size planform such as those used for deposited plans in NSW today. In order to include the Cambridge Gardens coordination plans as part of this text it was necessary to create plans that were no larger than an A3 size. Therefore, no planforms have been used with the coordination plans created for this research project.

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