University of Southern Queensland

Faculty of Engineering and Surveying

Evaluation of control for the adjustment of the Digital Cadastral Data Base (DCDB)

A dissertation submitted by

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ABSTRACT

1. Introduction

Cadastral boundaries are the invisible lines that separate land into individual parcels. The Digital Cadastral Data Base (DCDB) is a graphical representation of the cadastral boundaries held in an electronic form. This data forms a base layer in Graphical Information Systems (GIS) however the lack of spatial accuracy may limit the usefulness of the system.

2. Objective

The aim of this project is to estimate the expected accuracies achievable when adjusting the DCDB by using different methods to collect control points.

3. Method

These points will be collected from aerial photos at two different scales, by using Global Positioning System (GPS) to locate fence corners and to coordinate existing survey marks connected to cadastral boundaries. The control points will be used to constrain the adjustments.

To limit the number of variables only a least squares adjustment method has been selected to adjust the DCDB. Several adjustments have been processed using the control points and these results have then been compared and contrasted to establish differences among the accuracies of the resulting DCDB's.

4. Conclusion

It is obvious that the method using coordinated survey marks connected to cadastral boundaries will give the most accurate approximation of the cadastre however it is not always possible to find an adequate density of survey marks to use this method in all cases. This project endeavours to quantify what level of accuracy that might be expected when the DCDB is adjusted. The main problems found were the accuracy of the occupations and the ability to collect quality coordinates of these points. The two other methods possible are an minimally constrained adjustment based on a known point and swing with adequate checks or a multi point GPS adjustment from Occ's.

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Certification

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

My Full Name Wayne Edward Fenwick

Student Number: 0011020281

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Signature

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Date

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LIST OF ACRONYMS

ADC	Armidale Dumaresq Council
AGD66	Australian Geodetic Datum 1966
AHD	Australian Height Datum
AMG	Australian Map Grid
ANS	Australian National Spheroid
DCDB	Digital Cadastral Data Base
DP	Deposited Plan
EDM	Electronic Distance Measurement
GDA94	Geodetic Datum of Australia 1994
GIN	Galvanised Iron Nail
GIS	Geographical Information System
GPS	Global Positioning System
HAVOC	Horizontal Adjustment by Variation Of Coordinates
ISG	Integrated Survey Grid
LEP	Local Environment Plan
MGA	Map Grid of Australia
Occ's	Occupation
PM	Permanent Mark
RTK	Real Time Kinematic
SCIMS	Survey Control Information Management System
SSM	State Survey Mark
SV	Space Vehicle
Trig	Trigonometrical Station
UHF	Ultra High Frequency
UTM	Universal Transverse Mercator
WGS84	World Geocentric Spheroid 1984

CHAPTER 1

INTRODUCTION

The advent of Geographical Information Systems (GIS) has allowed the day to day use of the Digital Cadastral Data Base (DCDB) as a base layer to give spatial meaning and reference to other information. While this has been immensely useful, like so many advances in technology, by solving one problem it has created another. The initial DCDB was captured within both economic and historic technical constraints, therefore restricting the applications for which it can be subsequently used. This has lead to the need to improve the accuracy of the DCDB to enhance its usability and therefore confidence in the product. The problem created is one of how to manage an evolving and shifting DCDB.

There are many approaches to solving this problem such as schematic management, topological management and best estimate management techniques, however, this project will concentrate on evaluating those methods of collecting control points to adjust the DCDB which are driven by the management processes of the best estimate technique.

The reasoning behind this approach is to adjust it once therefore allowing the evolution to occur in the correct location and gain the maximum benefit from the systems that use the data. By assessing the results of this project it will be possible to determine which method of control point collection will provide the appropriate level of control that is required to achieve the desired accuracy of the DCDB.

To achieve this goal this project will use a test site being the village of Hillgrove. This site was chosen due to some historical challenges and would give a representative sample of rural NSW. Control points will be collected by various methods. These points will then be used to constrain several adjustments of the cadastral data collected from the Deposited Plans (DP's). This will supply a set of coordinated values for each corner of the adjustment which in turn will then be compared to the most accurate estimation of the actual position of the corner. The control data will be an adjustment based on the use of existing survey marks.

Now that the broad aims and methodology have been outlined there is a need to explain these in more detail and to assist in this process a brief outline of the dissertation has been supplied to help with the direction of this paper.

Chapter 2 presents the Conceptual Framework underpinning the dissertation and is devoted to setting out the concepts that are needed to appreciate both the problem being researched and the analysis of the data gathered. It will elaborate on the management techniques for GIS and define the problems caused by an evolving DCDB. It will also include a review of literature reporting any previous work pertinent to this project.

Chapters 3 and 4 present a review of the methodological options available to the project to proceed and outlines why the adopted methods were selected, followed by a discussion about the Methodology and the detail behind each method. This will rely on an understanding of the limitations and required processes explained in the conceptual framework.

Chapters 5 and 6 presents a review of the Results will lead to a more detailed discussion about the Comparisons that were able to be made from the analysis of data that were collected.

Chapter 7 presents the Conclusions made about the suitability/acceptability of the chosen methods of collecting control points for the adjustment of the DCDB.

CHAPTER 2

Conceptual Framework

2.1 INTRODUCTION

It is important to have an appreciation of the history in the area that the study has taken place as this has an effect on the results. It is also necessary to understand the concept of relativity and how this affects the management of a GIS. Building on this understanding of relativity, the problem of a dynamic DCDB will be discussed in more detail. Included in that discussion will be the consideration of the different options for the management of spatial systems which will highlight how each method addresses the problems caused by a dynamic DCDB.

Spatial data can be collected in many ways; the traditional surveying methods being well understood while the Global Positioning System (GPS) may require some basic explanation as this is relatively new technology. Another concept is that of *positional uncertainty* (defined in section 2.6) which, although not a recent idea, is now being recognised as an indication of the quality of spatial data.

Other fundamental background knowledge required to understand the constraints and process used in this project are explored, such as the distortions in aerial photos and the precedent of monument over measurement which is a legal requirement in surveying. This precedent came from English common law and would have been present when the first survey was performed in Hillgrove some 70 years after colonisation.

2.2 BRIEF HISTORY OF HILLGROVE

Gold was found at Bakers Creek in 1857 approximately 18 miles (26 Km) to the east of Armidale NSW however it was not until the 1870's that the town was developed. Between 1880 and 1900 the town was at it peak with six hotels, four churches, two schools, a school of arts, a hospital, several banks, a stock exchange, a court house, police station and a cordial factory. There were approximately 3000 people with an unusually high proportion of women and this lead to a very culturally developed society. The town had its own newspaper, Borough Council, Debating Society, Masonic Lodge and recreation ground. (ACC 1994) The electric light came to the town in 1895 from the hydro power station on the Gara River. (NPWS 1994) Hillgrove started to decline from 1900. This is evident as many of the major buildings that burnt down were not rebuilt. By the 1920's the majority of the remaining buildings had been relocated to Armidale and the surrounding area. (ACC 1994) Today the village has a population of no more than 100 people.

The surveying history is much less detailed. Since the surveys in the 1880's there is no record of any survey work until recently. There have been three surveys along the southern edge of the village between the mid 1980's to the early 1990's and none in the northern part of the village. Coincidently this is about the time that the DCDB was created and started to be used in GIS.

2.3 WHAT IS RELATIVITY

What is meant by the word *relative* and the concept of *relativity*? Why is this important to this discussion? The significance of relativity to this discussion is due to the need manage geographical data in a system and the question arises, if an object moves for some reason how should this affect any of the surrounding objects. The immediate and obvious point in case is, if the DCDB could move as a result of an adjustment how will this affect the other objects in the GIS? This question will lead to considering geographical management techniques and why an object might move. These points will be covered in more detail later in the discussion.

The Australian Concise Oxford Dictionary states that *relativity* is the fact of being relative and *relative* is having reference or relating. So from this there can be two arguments put forward. In the context of this discussion these arguments are to be relative to a neighbouring object, which could be described as *local relativity*, or alternatively to be relative to a central point, which could be described as *global relativity*.

The concept of *local relativity* is that one object is a set distance, and offset from, another object and to maintain that relationship both objects must move by the same amount. An example of this is the wheels on a car, no matter where the car goes or which direction the car is facing all of the wheels are in the same relative position to each other. The application of this concept will be explored further in the management techniques of GIS.

In contrast, the concept of *global relativity* is where all points are relative to one fixed point, in both distance and direction, outside the immediate area of concern. An example of this could be the use of GPS. This is where, for all intents and purposes, an object is located and its position is unique within the system and if something nearby should move then it has no affect on the position of the original point.

The two views above can be seen to be contradicting by trying to be different, however, they can also be seen to be saying the same thing, just in two different ways. The key point from this discussion that needs to be clear is that there are two ways to view relativity and neither is wrong, however in GIS the approach adopted will affect the usefulness of the system. To explain a little more about the *global* approach a few fundamentals of GPS will be explored after the problem caused in GIS by a moving DCDB has been considered in more depth.

2.4 GRAPHICAL INFORMATION SYSTEMS

A GIS is made up of many layers of data, for example there could be a roads layer, rivers and creeks layers, a railway layer and utilities layers (water, sewer, stormwater, gas, electricity, etc). There are also layers that are not physical features, such as a historical sites layer or contaminated land layer or archaeological sensitive areas layer, all of which can be known as constraints layers. In a GIS, each layer can be turned on or off as desired. The DCDB is the base layer in a GIS that allows a user of the system to see the relationship of the utility or constraint to the adjacent properties.

2.4.1 The Problem with the DCDB

When the DCDB was first collected, between 1986 and 1994, the data was digitised from existing maps ranging in scale from 1:2,000 to 1:100,000. This was a result of a decision at the time that this was the most cost effective (that is, achievable in a reasonable time) method available. The aim was to digitise every parcel of land in the in state of NSW. It was determined that the project required extra man power, which lead to the engagement of eight contractors, all collecting data. The result was a complete DCDB that was inevitably inaccurate though useable. (Effenberg 2001) In the early systems this was a big step forward as it allowed mapping to occur and data to be collected and placed adjacent to the appropriate parcel.

While being able to locate objects adjacent to the correct parcel is a very valuable tool, problems can emerge when data is collected by a more accurate methods, such as GPS observations, leading to the exposure of inaccuracies within the existing DCDB. This leads to questions of how can the system be improved so that it can be used both more confidently and in more situations. The obvious answer is to increase the accuracy of the DCDB, but the implication of doing this is that all the data placed adjacent to the original DCDB will almost certainly create inconsistencies between layers due to the shifts applied. There is an argument for redrawing the whole DCDB from plans as simply manipulating the existing DCDB into a tightened frame will not remove the errors within the individual blocks. These errors can be as large as 500% in short lines. (An example found in Hillgrove.) In addition there is the consideration of whether or not the data will be moved once or whether the DCDB is to become a dynamic, continually improving dataset. If the dataset is to be continually improving, then how is it possible to maintain the relationships with all the other objects in the system? Many of the datasets within the GIS use the boundaries of the DCDB as a definition of a boundary, an example of this being the Local Environment Plan (LEP). This dataset uses the boundaries of the DCDB to define the shapes in the LEP to a large extent. If the DCDB should move then the LEP needs to move relative to the DCDB to maintain the correct relationship. Another example could be the location of a water service connection. This example will be used to describe the various methods that could be used to manage a GIS.

There are many statements alluding to the merits of DCDB upgrades but little documentation on how to actually perform the task and no documentation was found that covers the work performed in this project. A paper prepared for the AGI Conference UK 1997 (Effenberg & Williamson 1997) reported that countries with cadastral mapping were aiming to have the cadastre accuracy consistent to the current technology used in surveying. Further, a paper prepared for the 1999 New Zealand Institute of Surveyors & FIG Commission VII Conference proposed

> the development of a fully survey accurate spatial database forming a basis for the spatial integration management and use of land based data – a truly multipurpose cadastre. (Bevin 1999, P. 11)

To highlight the associated problem arising from such a development, an article about Spatial Data Infrastructure (Spencer 2004) points out that some authorities will relocate DCDB boundaries without regard for how this affects other utilities that use the data for their own mapping requirements, causing additional work for the utility agencies. Another paper from FIG Working Week and GSDI-8 (Elfick, Hodson & Wilkinson 2005, P. 1) states that 'The utility of spatial data is greatly improved if it is accurate and consistent between layers, especially given the advent of inexpensive GPS devices'.

The current accuracy of the DCDB is approximately 2-4 m in urban areas and over 20 m in rural areas as a result of digitising off plans with scales of 1:2000 and above. While this may have been acceptable ten years ago it is no longer the case, current users desire accuracies in the order of 0.3 m or better in urban areas (Williamson and Hunter 1996) this seems to be the general agreement within the industry. As noted already however, the call for improved levels of accuracy within the DCDB all too often are not matched by advice on how best to go about undertaking such revisions.

To reinforce the problem Figure 2.1 is in the village of Ebor which is not far from Hillgrove and shows the current DCDB road areas as the shaded regions. The line work representing the actual location of the fences and buildings has been digitised from an orthorectified and georeferenced 1:8000 aerial photo. The shift in this case is in the order of 35 metres.

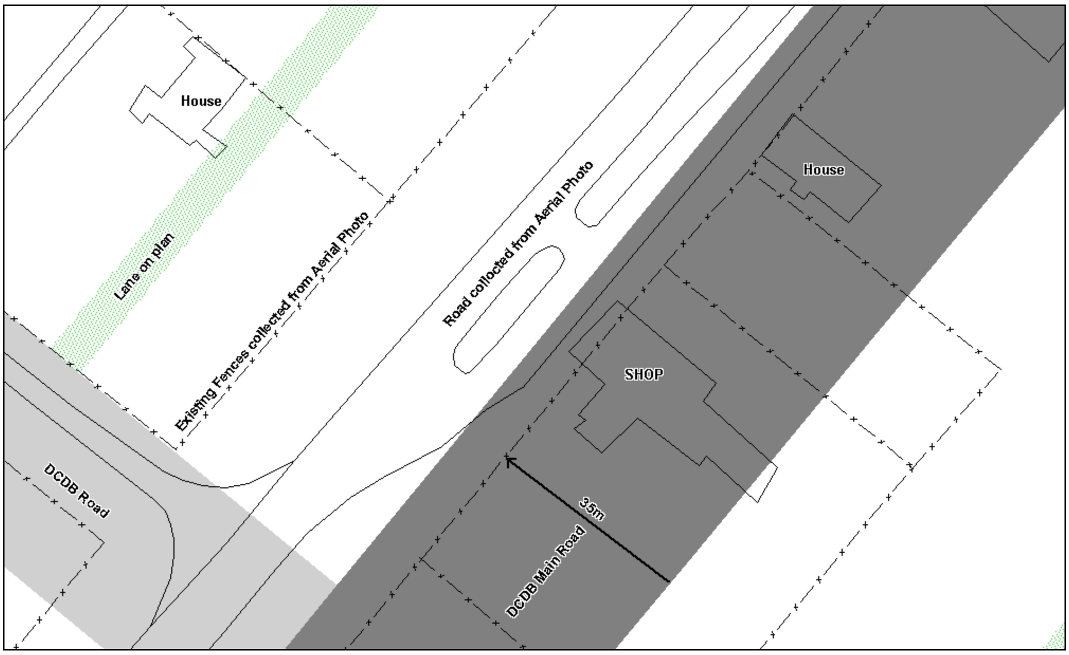

Figure 2.1 The Current DCDB against an Orthorectified Georeferenced Image

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2.4.2 GIS Management (Towards a Solution)

There are three main management techniques available to the GIS professional for maintaining its datasets. Each method has its advantages and disadvantages, and these are very subjective depending on what the system is designed to achieve and the background of the people managing the system. Following will be an outline of the Schematic approach, the Topological approach and the Best Estimate approach to GIS management

2.4.2.1 Schematic Management

The schematic approach creates a spatially inaccurate representation of data and when new spatially accurate data is included it must be made to fit with the existing data, this is achieved by a reduction in accuracy of the new data. This style of GIS does not evolve into a spatially accurate system and is limited in its usefulness. The advantage of this system is data maintains relativity when new data is added to any layer. This management style relies solely on *Local Relativity* between layers within the system. Some obvious disadvantages are that it is very difficult to share the layers between different GIS's because the layers in one system may not align to the layers in any other system. Also each system needs to maintain the DCDB which creates duplicated effort.

Figure 2.2 and Figure 2.3 are an example of a subdivision of a parcel of land that has been incorporated into the schematic GIS. Note that there is no change in the relationships to the water service connections or the size and shape of any other parcels as a result of the new data being added because of the subdivision of Lot E. The changes that are being ignored in this management technique could be the location of the parcel relative to state survey marks or the size of the adjoining parcel that have been surveyed as part of the subdivision process.

Figure 2.2 is the DCDB before the subdivision takes place. Figure 2.3 is depicting the new DCDB after the subdivision.

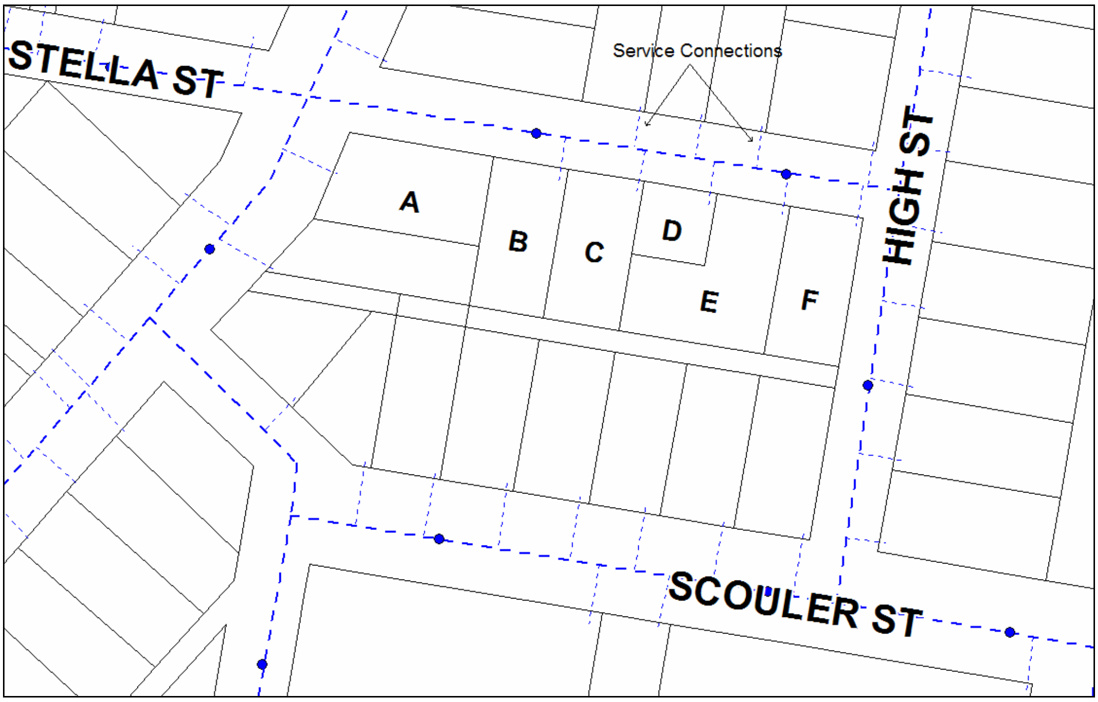

Figure 2.2 Before Subdivision (Schematic Approach)

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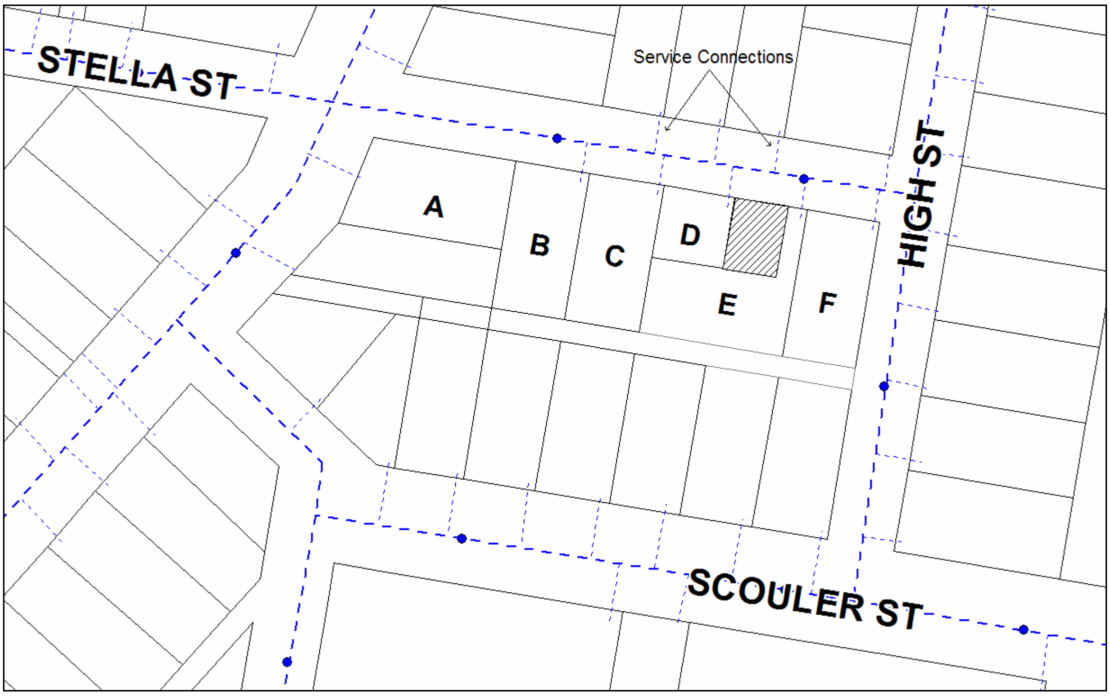

Figure 2.3 After Subdivision (Schematic Approach)

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2.4.2.2 Topological Management

Another approach is the topologically correct technique. This is an evolutionary style of management that starts with spatially inaccurate data that, over a long period of time, might achieve an acceptable level of spatial accuracy. While this might be a desirable outcome, it is not essential to the approach. Rather, the aim of this method is to maintain the spatial relationships amongst all of the objects stored in each layer and between layers in the system regardless if any of them move for any reason. The same example of a subdivision of Lot E using this method would result an accurate DCDB for the lots surrounding the subdivision as a result of using measurements off the subdivision plan. As well, all the service connections will continue to be shown joining to the correct property. This method will be explained in three stages although it is one process in practice. Figure 2.4 below is Stage 1 the starting point, the DCDB before the subdivision.

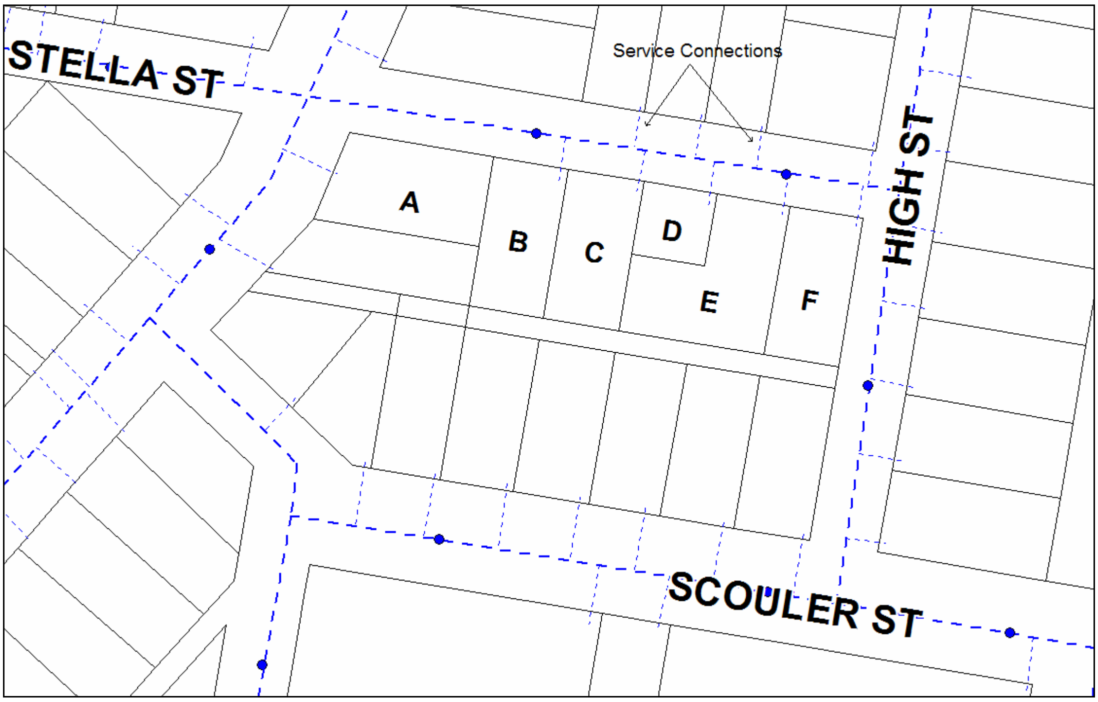

Figure 2.4 Stage 1 Before Subdivision (Topological Approach)

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Figure 2.5 depicts Stage 2 of this process notice that the as a result of the subdivision the boundaries have been moved to be representative of their true distances, i.e. the shape and location of the lots are now accurate. This has resulted in the service connections now relating to the wrong lots. The primary cause of this shift was that Lot B was drawn much wider that it actually is. In stage 3 shown in Figure 2.6 the service connections will be corrected to maintain the correct relationship.

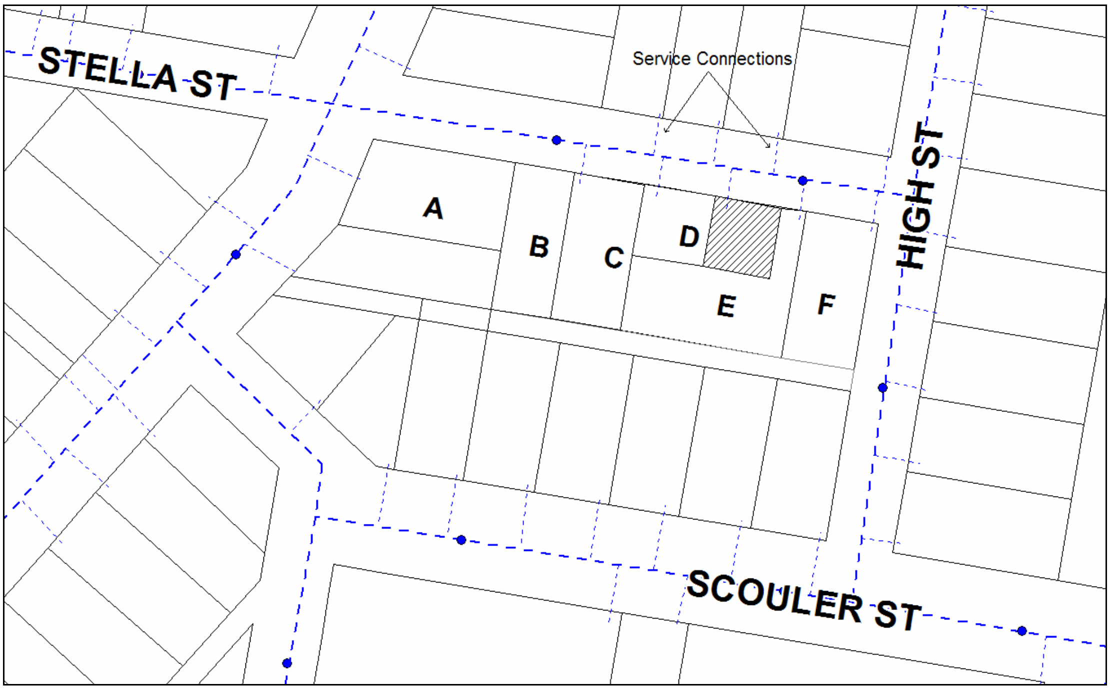

Figure 2.5 Stage 2 (Topological Approach)

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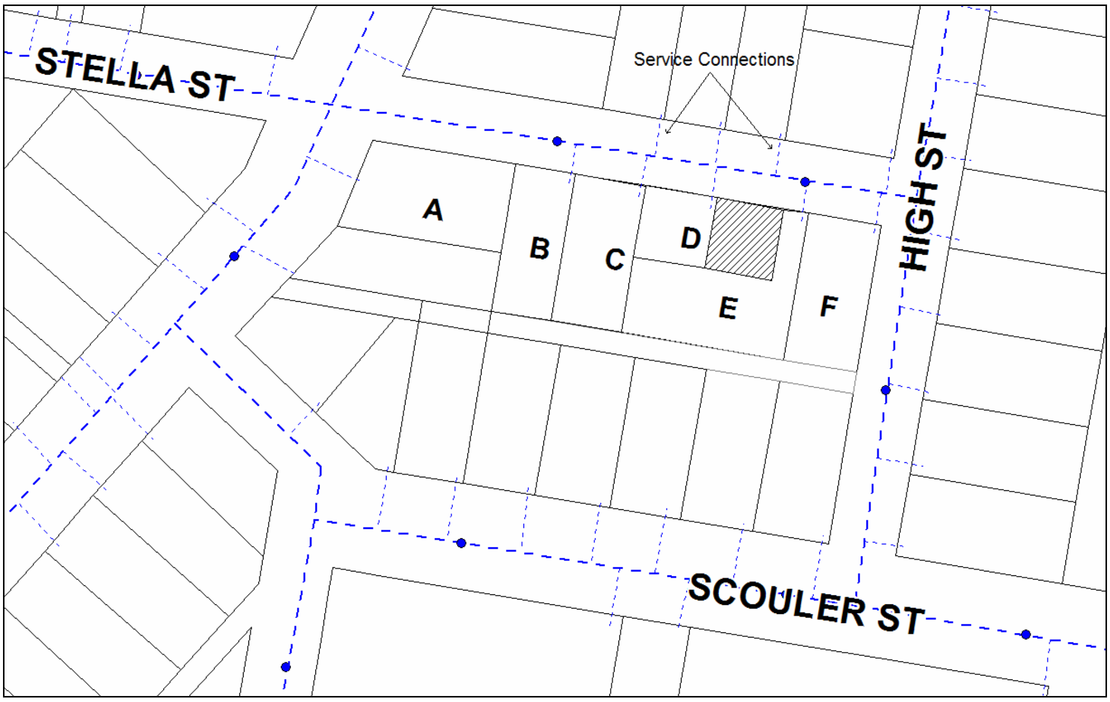

Figure 2.6 Stage 3 End Result (Topological Approach)

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This shift needs to be applied to every layer in the GIS to maintain the correct relativity through out the entire system. While this seems like a simple task how can the GIS manager be sure that all the layers have been amended? That's a discussion for another paper.

2.4.2.3 Best Estimate Management

The aim of a best estimate GIS is to locate objects so that any movement of the object is not significant within the context of the GIS. This could be achieved by locating all objects to the current surveying standards. That is not to imply, however, that extreme measures need to be taken to locate all objects. For example, there is no need to locate a manhole to the nearest 5 mm, because if a manhole of 1 m diameter is located to the nearest 0.3 m and this manhole is located across the boundary of two parcels which is accurate to the nearest 0.1 m then the boundary could move 0.05 m either way and would still appear to be over the manhole. Figure 2.7 shows the extremes of movement which may occur between the manhole and the boundary.

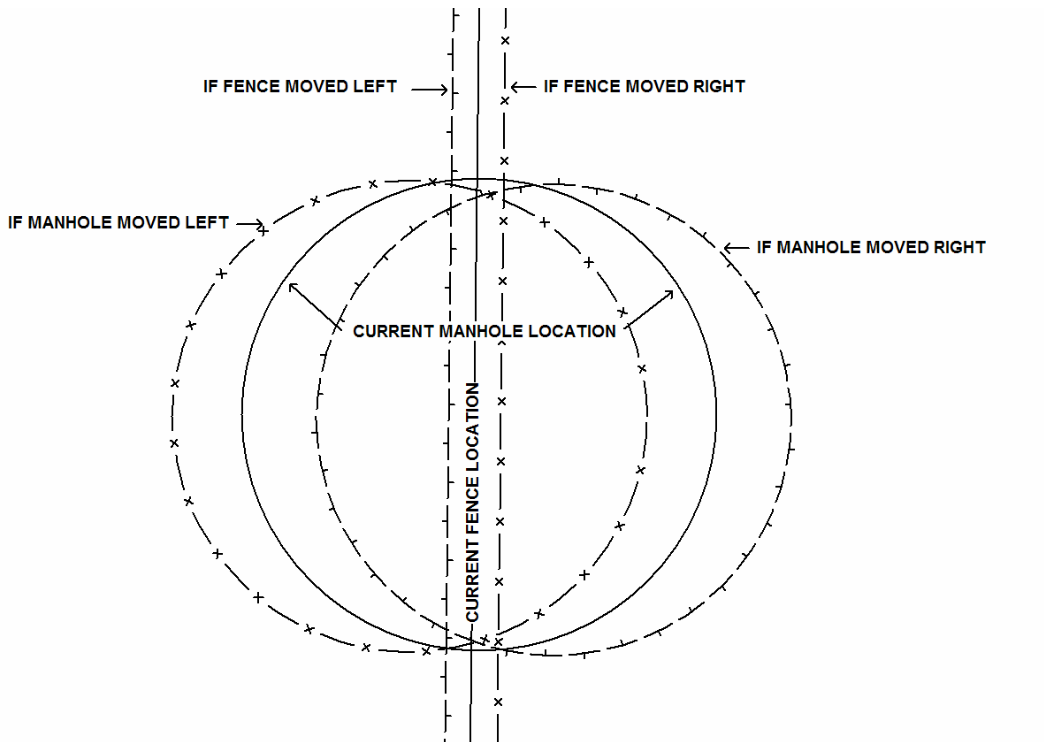

Figure 2.7 Boundary Over Manhole

One advantage of this method is the capability to measure distances between objects to allow management decisions to be made without field work being required eg Is it possible to supply a sewer connection to a property? The utilities manager could measure the distance and obtain the relative height difference from the GIS, then make an informed decision about the feasibility to supply that service. It may be that it could be too close to call allowing for the known tolerances, in which case more accurate field work would be required. However it could be obvious whether there is, or is not, enough fall to allow the connection.

This level of decision making is not available in any other style of GIS management. By using surveying techniques to collect data such as GPS there is the default acceptance of using the concept of *Global Relativity* in this management style.

2.5 GPS BASICS

As stated above use of GPS is ideal for collecting data for GIS applications and will be used in this project to collect control point data. This section will cover some background information relating to the sectors needed for GPS to work, the signal type and their application, this is supplied for completeness and to ensure an understanding of GPS and the jargon used in general discussion. An overview of the models used by GPS and for geodetic survey work and coordinate systems. The later two points will be referred to in the section on positional uncertainty.

2.5.1 GPS Sectors

There are three sectors required for GPS to function these are the space sector, the control sector and the user sector. The Space Sector contains all of the Space Vehicles (SV's) that send out the signals that are received on earth. The Control Sector is made up of five tracking stations that are situated around the equator. These stations monitor and control the SV's to ensure that they are in the correct position and sending out the correct signals. This sector determines the health of the SV's and publishes updates that can be used by the user for planning purposes. The User Sector comprises all the users regardless of what level of accuracy they may be using. (Trimble 2004) Different types of receivers collect data with differing levels of accuracy which in turn determine the nature and quality of the system output.

2.5.2 GPS Measurement

All GPS measurements are determined using a ranging technique and there are two different ways that GPS use ranging. One is Code Ranging which only requires one receiver and uses the L1 signal to determine the time and then calculate the position of the receiver. This method only gives a rough estimate of the location. The other method which is used by survey grade GPS receivers involves determining the difference in the carrier phase cycles to calculate the exact number of wavelengths between the antenna and each SV, between two receivers. This method requires both L1and L2 signals to be read and processed and is much more accurate and reliable. The difference between the signals is the frequency that they are transmitted at and the data carried on each signal. (Trimble 2004) While the signal type received may affect the measurement accuracy, the configuration and number of SV's determines the reliability of the measurements made by the receiver. There is a requirement for a minimum of four SV's and a PDOP of below 6 before measurement can be taken. PDOP is a value given that relates to the geometry of the SV's.

2.5.3 Differential GPS

To achieve better accuracy with GPS requires 2 receivers both reading the same signals from the same SV's. The result is a reading from the base station to the roving receiver just like a radiation measured using traditional surveying techniques. (Trimble 2004) This radiation is an unchecked observation and the most common way to check it is to repeat the observation a few hours later when the SV's are in a different location or have two base stations to allow a comparison between two radiations.

Differential GPS can work in several modes; two have been used in this project. The first mode used for collecting the primary control was Static Survey, this is where two receivers are set up (one on a known point and the other on an unknown point) and allowed to observe the satellites for a long period of time. In this case an hour observation was determined appropriate. After all the observations have been taken the data is processed in the office environment, this is called post-processing. This results in high accuracy coordinates due to the abundance of observed data.

The second process used to collect secondary control and adjustment points was Real Time Kinematic (RTK), which is where a base receiver is set up on a known point and continually tracks the satellites comparing the read position to the known position, calculating a correction factor and then broadcasting this correction via a communication system to the roving receiver. The communication system used in this case was Ultra High Frequency (UHF) radio. The roving receiver receives this broadcast signal and the signals from the same SV's as the base, applies the correction and so supplies the user with a real time corrected position. (Trimble 2004) While this method is far superior to a single unit solution the lack of volume in observed data means that this system is not as accurate however much faster then the static survey method.

To allow GPS to calculate where the receiver is on the earth's surface, the unit requires a model of the earth. There are many models of the earth each with its own advantages. Another name for a model is a R*eference Frame.*

2.5.4 Models of the Earth

The earth is an irregular shape which is difficult to mathematically define and work with. As a result there are many approximations that have been developed and used over the years and one would expect that there are many more to come. An Ellipsoid is an ellipse that is spun through one full rotation on its minor (shortest) axis. A Geoid is the term given to the irregular shape that the earth would be if it were covered with water. This is an equipotential surface formed by the effects of gravity. (Trimble 2004)

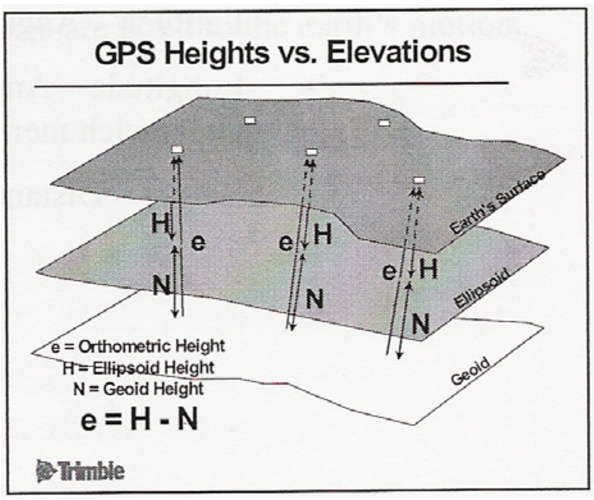

Figure 2.8 Relationship between Models of Earth (Trimble 2004, P. 20)

To map objects located on the earth's surface there needs to be some way to represent the curved surface on a flat surface. This can be achieved in many ways such as using projected coordinate systems.

2.5.5 Coordinate Systems

There are many ways to map the earth onto a flat surface. The three major types of coordinates systems are *Earth Centred Cartesian Coordinates (X,Y,Z), Longitude, Latitude and Ellipsoidal height* and *Projection Coordinates*. (USQ 2003) All of these rely on a mathematical approximation of the earth being an ellipsoid and some need further manipulation such as the projection coordinates which shall be discussed below in more detail as it is the system used in this project.

Taking one of these models and wrapping a cylinder around one meridian of longitude (see Figure 2.9 below) will allow a projection to be formed. This is known as a Transverse Mercator Projection and a particular method has been adopted world wide with 6 degree wide zones and is know as the Universal Transverse Mercator Projection (UTM).

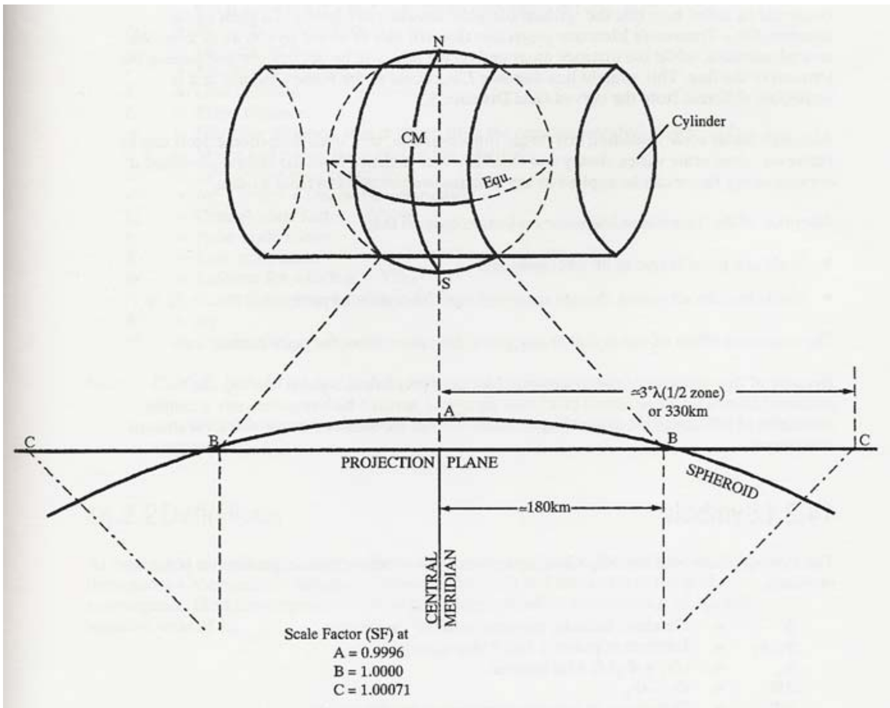

Figure 2.9 Diagram of UTM (USQ 2003, P. 6.4)

Each of these projections are named so it is possible to determine which datum is being used or referenced. Examples of these are the World Geocentric Spheroid 1984 (WGS84) used by GPS, Geodetic Datum of Australia 1994 (GDA94) and the Australian Geodetic Datum 1966 (AGD66) which are used for mapping in Australia, and there are many more. However, these three are the relevant models to this discussion.

To model the earth's surface in a small region such as Australia does not mean that the centre of the ellipsoid has to be coincident with the centre of the earth. This is the case for AGD66 where the centre of the ellipsoid is approximately 200 m from the centre of the earth. This was a deliberate decision to achieve the best possible representation of the earth's surface over this region.

The result of creating a UTM projection coordinate system allows for the mapping and calculation of distances and bearings on the projection. As there are many ellipsoids there are also many projections and each of these have also been named. For example, the projection from the AGD66 datum became the Australian Map Grid (AMG) and that from the GDA94 datum became the Map Grid of Australia (MGA). Figure 2.10 shows the zones across Australia. When using data presented in a projection coordinate system there needs to be an awareness of which zone the data is in as the coordinate numbers are repeated for each zone, based on a false origin for that zone, to remove any negative numbers. Zones are notated as the projection name followed by the zone number eg MGA 56.

In New South Wales each AMG 6 degree zone was split into 2 degree zones to reduce the distortion caused by the projection and this is known as the Integrated Survey Grid (ISG). This is notated by the letters ISG followed by the Zone / Sub-zone. Eg ISG56/1. This project has been completed in ISG56/1 as a result of the aerial photos being georeferenced (spatially located) in this projection.

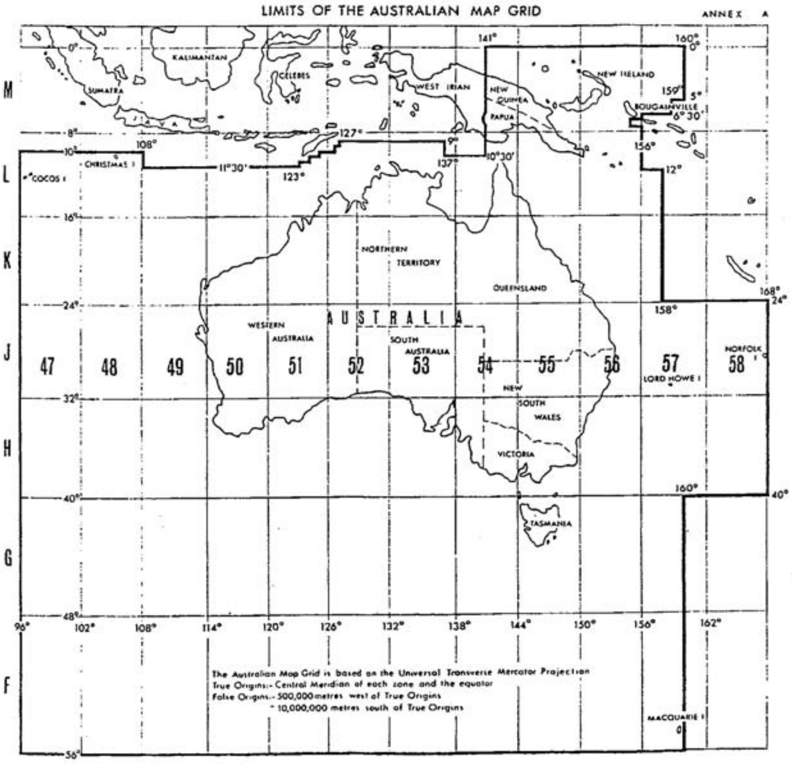

Figure 2.10 Australian Zones (USQ 2003, P. 6.3)

As a result of using GPS to collect the control point data, knowing that this data has been stored as ISG 56/1 coordinates and also knowing that these coordinates are located on the ellipsoid all at the same height, the data from the plans needs to be reduced to the ellipsoid to allow a true comparison of distances. The elevation of the project site is approximately 1000 m above mean sea level and this means that the distance measured on the ground will be longer than the distance required for the comparison.

A brief description of Figure 2.11 will explain the reduction of a distance to ellipsoidal height. Line d_2 is the slope distance from Point A to Point B. At the mean height, the distance has been reduced to a horizontal distance. Due to the converging plumb lines through A and B (affected by gravity) this distance is reduced further to d_3 at the ellipsoid. This process has removed all variation due to elevation and slope in the measured line allowing it to be compared to data gathered by the GPS.

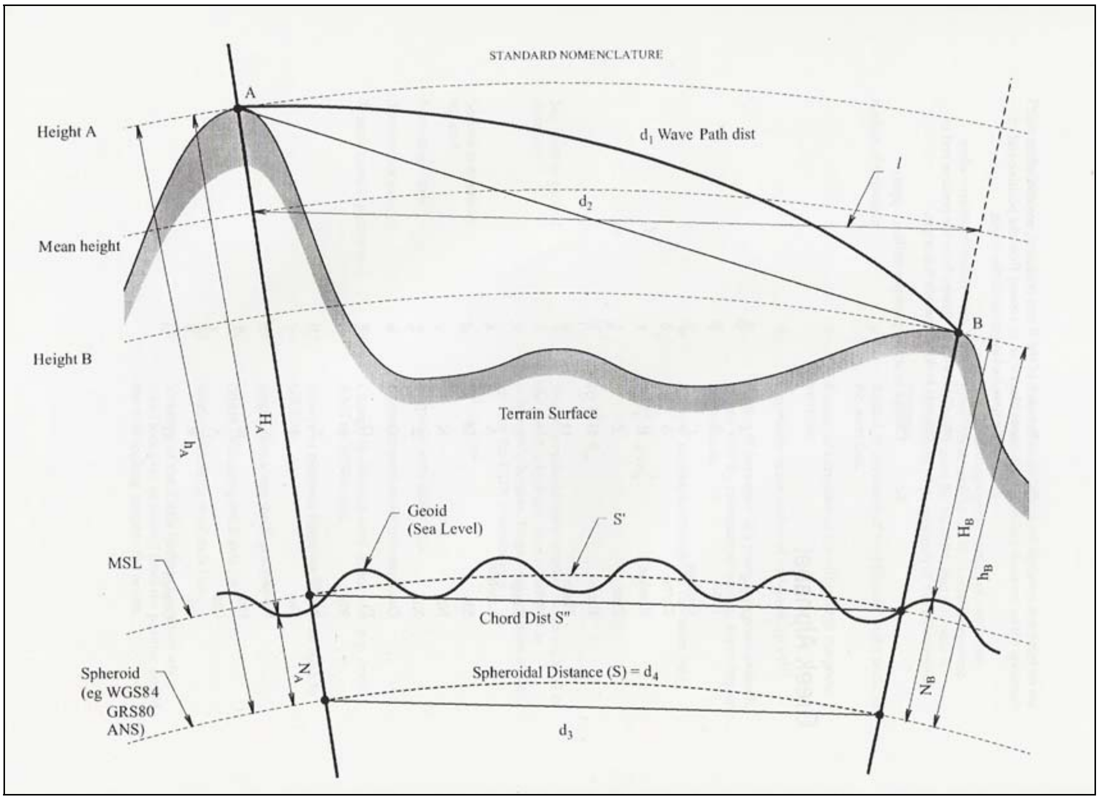

Figure 2.11 Reduction of Distances to the Ellipsoid (USQ 2003, P. 8)

The use of GPS has made some surveying tasks much faster by allowing long distances to be measured in a single observation. While all measurements are directly measured on a ellipsoid and this avoids the need for reduction calculations however, there is still the need to quantify the reliability of the measurements. To this end the term *Positional Uncertainty* is used in surveying and the general concept can be applied to all GIS objects.

2.6 POSITIONAL UNCERTAINTY

When measuring a radiation there needs to be a check to ensure no gross error has occurred however there will always be some amount of error as it is not possible to make a perfect measurement. There is a concept that there always some level of error in all measurement and at some point in time that error may be large enough to cause some problem or at least contribute to a problem. This is a legacy from older measurement systems and in the future measurements taken today will most likely not be of sufficient accuracy for some applications. This is the sense in which the DCDB is best thought of as an artefact that is in evolution. Professionals today, and in the future, need to be aware of the quality of the data they use. *Positional uncertainty* is a term of acceptance that all measurement is subject to some degree of error. In surveying it is possible to quantify the size of errors and there are tolerances that are regarded as acceptable, at least for the moment.

The current *Standard and Practices for Control Surveys* known as SP1 defines the term *positional uncertainty* as;

> *The uncertainty of the coordinates or height of a point, in metres, at the 95% confidence level, with respect to the defined reference frame. (ICSM 2002, P. xiii)*

While this may be applicable for a control survey, a generalisation of the concept is useful also in the context of a GIS. A brief look at the measurement systems used in the past will help to explain some reasons why there is less accuracy in older data.

2.6.1 History of Measurement

In the 1400's the standard of measurement was Rods each Rod is approximately 16.5 feet, in the 1800's measurements were made in Links each link is 8 inches, then in the 1900's Inches were used and now Millimetres are a standard unit of measure. As time progresses accuracy increases and what was formerly acceptable is currently no longer acceptable. An example of this are the survey plans in the 1880's which were drawn with distances shown to the nearest 0.1 of a link (20 mm), then in the early 1900's plans showed distances to a fraction of an inch (1/8 inch equates to 3 mm) and the current convention is to show distances between control points to the nearest millimetre. This is a direct result of gradual improvements in distance measurement technology, from the Gunters Chain measuring in links to Electronic Distance Measurement (EDM) and GPS that can measure to millimetres.

2.6.2 Effects of change

With the introduction of GPS technology in surveying there may be a belief, both within and outside the surveying profession, that it will facilitate the introduction of a coordinated cadastre and this is believed to be an absolute value. However, these coordinates are not absolute values and they will contain some level positional uncertainty. As discussed earlier, coordinates are based on a mathematical model of the earth and as time passes better and better models are and will be achieved. The conversion from one model to the next may or may not be an exact mathematical conversion. Another factor is the quality of the data; by which method the data was observed and does the data contain accumulated errors. To transform data between the AMG56 and MGA56 projections, both model and quality issues are present. The best method of conversion at present is to use the NT2v Grid which can have errors up to 0.1 of a metre in some areas of New South Wales. (Dr T Watson 2005, pers comm., 21 Oct) A similar process would need to used (although a different grid would be required) to transform data from AGD66 to AGD84 due to the data quality issue, both of these projections are based on the same ellipsoid known as the Australian National Spheroid (ANS).

Further GPS measurements are based on the World Geocentric Spheroid 1984 (WGS84) reference frame. The significance of this is a GPS measurement using one of the most accurate devices on a fixed station taken in 1994 using WGS84 coordinates and a measurement on the same station with the same device in 2004 using WGS84 coordinates would be approximately 0.5 metre different due to tectonic plate movements. Therefore some form of transformation is required to happen to display the results in the MGA56 projection or any other projection and this may introduce positional uncertainty, while these amounts are small, accumulated errors are a component of the uncertainty. A practical example of this problem could be that two points which are coordinated in one projection and then transformed to another projection, could have the distance between them change by a small amount even though the distance on the ground will remain the same as neither mark will have been physically moved. This issue has already been confronted and dealt with from a legal perspective by a historical solution. In surveying there is a precedent that a monument takes dominance over a measurement.

2.7 MONUMENT OVER MEASUREMENT

A monument is defined in The Oxford English Dictionary as any object, natural or artificial, fixed permanently in the soil and referred to in a document as a means of ascertaining the location of a tract of land or any part of its boundaries. It would appear that the prerequisite for converting an object into a monument for the purpose of boundary definition is that the object should be referred to in a document. Hallmann (Hallmann 1973) makes the point that the reference does not need to be a direct reference. An indirect reference such as describing the land by reference to a plan would be enough to allow the plan and all the information in the plan to become part of the document. As a result of this linkage the objects in the plan shown in relation to the boundaries would become monuments.

In cadastral surveying the aim is to redefine the original intention of the survey; that is to mark the same position as the first surveyor. If this was done by pure measurement then with the increase in accuracy over time there would either be slithers of unowned land or disputes of ownership when there is not enough land to fulfil the measurements on the plan. Again the issue of positional uncertainty is present and a key factor in understanding why monuments take precedence over measurements. Historically the legal definition of land has been based on monuments this overcomes the issues of excess and shortage of land as described in plans due to the ability to measure consistently. Objects such as fence posts, brick walls, buildings, trees and survey reference marks become monuments. This allows a surveyor to find and identify these objects by measurement and then proportion the available land based on the current measurements to each title to ensure a fair and equitable result based on the original intention.

The DCDB is a graphical representation of the cadastre at mean sea level and the cadastre is based on monuments to fix corners at the local elevation with these measurements represented on a plan. From the discussion above about ellipsoids as models of the earth’s surface, various projections and the resulting concept of positional uncertainty, it is expected that the values in any DCDB will vary slightly from those shown on its related plans and there will be some level of movement over time. The benefit of having the DCDB connected to monuments is that as measurement technology improves, it is possible to coordinate these and therefore adjust the DCDB to achieve a more accurate model of the cadastre. One method of coordinating these monuments could be the use of aerial photography although this too has some limitations which will be discussed in the next section.

2.8 AERIAL PHOTOGRAPHY

In September 2001, Armidale Dumaresq Council had aerial photography flown and orthorectified (corrected). It was decided to get several scales flown over Hillgrove.

Large scale 1:25,000 photos allowing the detail of the mines workings in the gorge to be seen and the small scale 1:8,000 photos allowed 1 m contours to be created in the village itself.

The scale of the image creates some limitation on what pixel size can be obtained although the limiting factor in this case was the requirement for 1 m contours. A pixel is a single square of colour, a digital image being made up of thousands pixels. The smaller each pixel is the better the quality of the image and the closer it is possible to zoom in to see detail. A pixel resolution described as 0.25 m means that each pixel is 0.25 m x 0.25 m as a ground measurement. As an indication of quality at a pixel size of 0.25 m it is possible to see a red or yellow circle on the ground 300 mm in diameter. From the 1:8,000 imagery 0.25 m pixels were created and from the 1:25,000 images 1 m pixels were obtained.

With such small objects being able to be seen in the photos it is often mistaken for being very accurate. Due to the distortions in an image cause by the lens and the variation in height of the ground it is generally accepted that an image after orthorectification is only accurate to 2.5 times the pixel size. It is also impossible to determine the inaccuracy in an uncorrected image as the errors change constantly in both magnitude and direction.

Due to effects of photography all objects that have height above a selected datum will be displaced. In the image any object such as a tree that both the base and the top can be seen, the result will appear as if the tree is laying flat on the ground except the height of the tree will not be correct and in a radial direction from the centre of the image. The diagram below shows the geometry that causes the effect in the image. While the distortions for lens defects and terrain elevation can be minimised through orthorectification the misrepresentation of the tree or a building or fence post cannot be fixed. For this reason the most accurate location of any object will be at ground level.

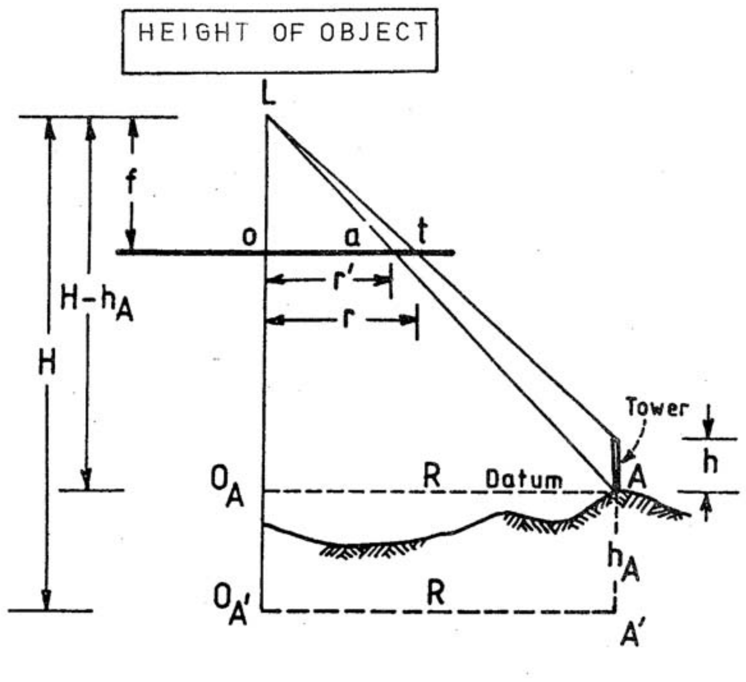

Figure 2.12 Misrepresentation of a Tower (TAFE 1989, P. 106)

2.9 CONCLUSION

Hillgrove grew quickly to be an impressive town for its time, however its decline has left a much smaller village and the ravages of time have removed the evidence of any corners marked in the original surveys. As in many rural areas the lack of durable survey marks has meant that little evidence can be found of previous work. Many years have passed since that time, though relatively recently a DCDB has been created which has evolved into a dynamic record of land information. These changes have lead to the development of new management techniques to deal with the complexities of topology in GIS. GPS technology has made it possible to locate assets and other objects within acceptable limits of tolerance. All that is left is to improve the accuracy of the DCDB to reduce the effort in managing these systems and to improve their useability. This will require the collection of control points by some method to constrain the dataset, however when choosing this method, consideration must be given to the limitations and the effects this may have on the end result.

CHAPTER 3

Methodological Considerations

3.1 INTRODUCTION

To achieve the aim of this project there were several methods available for collecting the coordinates and adjusting the data. The options considered are outlined and the final choice is justified.

3.2 TRADITIONAL SURVEY

A traditional survey would involve using a total station and reflectors to traverse between each of the intermediate stations and would allow several of the points required for coordination to be collected from each intermediate station. This would have been the most accurate method as it is possible to connect to an identified point such as a clout on a fence post. The method would have taken slightly longer in the field although it would have left behind more marks that could be connected into in the future. The traditional survey methods require closed loops to ensure accuracy and quality. An alternative to forming closed loops is to connect onto known points located by another means or from a previous survey. The disadvantage of this is that it is possible to be comparing two surveys of differing accuracy. This makes finding errors much harder. Using this method alone it would be very time consuming to connect into the state survey network.

3.3 GLOBAL POSITIONING SYSTEM (GPS) SURVEY

As a result of the survey control placed in 2001, there are secure known base stations within range to allow RTK GPS survey of each of the points of interest. The advantage of this method is that there is substantially less equipment required to be moved during the collection of points. There is the disadvantage of needing a secure place to set up the base station where it will be safe from theft and disturbance either intentional or accidental.

The RTK GPS survey requires the occupation of each point four times, two from each base station, to ensure that the data collected is of a acceptable quality. If the wrong coordinates are entered into the base the results of a second occupation will appear to confirm the first point collected however once the data from the other base station is collected and compared then it will be obvious that there is a problem. If this should happen it will mean a complete resurvey of all data collected from that base station. In the case of Hillgrove, there are no marks to check onto to ensure that equipment has been set up correctly. Alternatively if only one observation was collected from each base station it would not be possible to determine which observation was incorrect if they didn't agree. With the options to collect survey data now considered, the following options are available to adjust the data.

3.4 THE ADJUSTMENTS

The adjustment itself is not a crucial part of this project. In saying that, the adjustment selected is required to move all the points and maintain connectivity of the lines. The adjustment of data should only be performed on data that has all of the systematic and gross errors removed therefore in an ideal world this process will only be adjusting the random errors within the plans that form the dataset for the adjustment. As this is not and ideal world, unless the error can be isolated beyond reasonable doubt or provided the error is not excessively large, the data will have to be accepted.

When performing a survey it is common practice to determine the accuracy/s of the main traverse routes or loops. This is commonly done by determining the misclose or error which is the amount by which the traverse does not form a perfect closed figure. Then the misclose distance is divided by the total length of the traverse to give a ratio of accuracy. This ratio is normally stated as 1 in 'X' Eg 1 in 8000 or 1:8000 for this discussion 1 in 'X' will be used to avoid confusion with photo scales.

There is the assumption that all the plans are of a sufficient standard and the adjustment will be used to spread any errors through out the DCDB to achieve the most likely coordinates of the property boundaries. One must consider the objective of the adjustment and what the DCDB will be used for. The DCDB is a graphical representation of the cadastral boundaries not the actual cadastral boundaries. While it would be advantageous to have all boundaries that meant to be parallel, actually being parallel it is not essential provided they are close to parallel.

3.4.1 Adjustment Options

There are several methods available to perform adjustments, and some of these are outlined in this discussion. The desired adjustment will be able to adjust complex networks and supply a listing of adjusted values of each line in the adjustment. A Helmet Transformation is a four parameter transformation which will scale, shift in X, Shift in Y and rotate the current model. While this may seem adequate this process has some limitations which will be discussed later in this section.

Rubber Sheeting is a process of stretching the existing dataset between control points on a polynomial approach. For this to be applicable to the DCDB it would require a complete redrafting of the DCDB.

Both of the above mentioned methods could be used however neither of the processes supply any indication of how much adjustment it has applied to any one line. (Dr T Watson 2005 pers comms., 21 Oct) This failing does not supply any indication if a point has been attached to the wrong control point or if anything else has occurred that is undesirable.

The essence of a Bowditch adjustment is a linear adjustment based on the assumption that each line should be adjusted by a proportional amount based on the length of each line divided by the total length of the traverse. This adjustment is then applied to the components of each line changing both the distance and the bearing of each line. The Bowditch Adjustment is not applicable as an adjustment method for this project as it will only adjust one traverse at a time and will not deal with complex network adjustments.

Shift Assist is not and adjustment technique however it is a piece of software written in the MapBasic programming language which can be run within the GIS application MapInfo Professional to shift datasets. After some research it was not possible to determine which adjustment method was used in the application, therefore this is not a suitable solution either.

An adjustment method which would appear to be adequate is the Least Squares Adjustment method which will be discussed in detail.

3.4.2 Least Squares

The main reason to adjust something is to distribute the errors evenly throughout the data set. These errors should not be gross errors but systematic errors, for example, a gross error would be entering 100.00 when the measurement was 10.00. Alternatively a systematic error could be created by the fact that the instrument only measures to the nearest 5 millimetres and 6 seconds (USQ 2002) or, as in the Hillgrove case, the plans are only quoted to a fraction of a link. If gross errors are adjusted it will corrupt good data and create an unreliable outcome.

Another reason to use an adjustment program is that it is an easy way to convert a large amount of data from the local elevation distances to mean sea level distances. This reduction of distances is a function of the software not a direct part of the adjustment process.

As a result of using the least squares adjustment process a list of residuals is produced, this is an indication of the amount of movement that occurred in each line. An example of this could be demonstrated by adjusting a 60/30 right triangle that has the lengths of sides of 3.5, 3.75 and 5.75. The correct answer is a 3, 4, 5 triangle because the triangle is constrained by control along the hypotenuse of the length of 5. The residuals would be -0.5, +0.25 and –0.75 respectively. (See Figure 3.1) A residual is the amount of change that needs to be applied to an object to make it fit into the whole network.

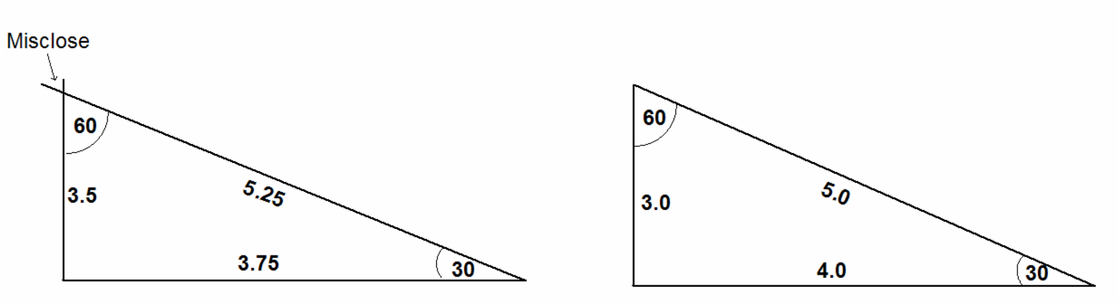

Figure 3.1 Residuals of a Triangle

The aim of least squares is to minimise the sum of the squares of the residuals. That is to say that the variation to each observation will be a minimum. One advantage of this method is that it adjusts all the observations at the same time. On the other hand to perform a Least Squares adjustment there must be redundant observations. A redundant observation is any observation that is above the minimum number of observations required to solve the problem. This requires extra data collection although the method is able to use direct observation such as those read from an instrument and indirect observation which can be derived from the direct observations.

A Frenchman by the name of Adrien Legendre published the principle in 1806. Since that time it has been used to calculate the orbits of planets and many surveying problems such as traverse, GPS levels, resection or intersection. (USQ 2002) It is possible to use different datasets that have different accuracies without corrupting the good data with poorer quality observation by using weightings to identify the quality of each observation. As all observations are adjusted simultaneously the method lends itself to network adjustments.

An example of this method is the software Horizontal Adjustment by Variation Of Coordinates (HAVOC) supplied by the Department of Lands NSW which has been used in this project.

3.5 CONCLUSION

From the above discussion the adjustment process used is not critical to the project however the least squares method is the most common method employed in the surveying profession to adjust networks and appears to allow the best functionality with its ability to weight observations dependant on the age or reliability of each individual observation and supply a listing of the residuals applied to each line in the adjustment.

The selection of field technique was based on the need to set up the base stations to provide coordinates on the state survey control network to allow Hillgrove to be correctly georeferenced within the DCDB. The base stations were time consuming to get access to so the maximum amount of work that could be performed from the minimum number of setups was to be the most efficient use of time and resources. These restrictions lead to the selection of the GPS for the entire project.

CHAPTER 4

METHODOLOGY

4.1 INTRODUCTION

In general terms the process used in this project revolves around placing a primary control network and then using that network to control the collection of points of varying reliability to constrain an adjustment based on the survey data for the village. Several variations of control points have been put though the adjustment process. This resulted in many sets of coordinates of varying degrees of accuracy for each corner of each village block. Then a comparison was carried out and conclusions drawn. Each part of this process will be discussed in more detail below.

4.2 ESTABLISHING CONTROL

In 2001, using static GPS survey methods primary control was brought into Hillgrove for the purpose of suppling photo control for the aerial photos to be flown. This process involve using two Ashtech GSR2300 L1/L2 capable GPS receivers, one as a base station set to record continuously from the time it was setup until it was retrieved at the end of each day. The other unit was used as a rover to record 1 hour duration observations on each of the roving stations. Typically there were three roving stations observed twice each day.

There was a complication caused by the lack of both high quality horizontal positions and vertical control on the trigonometrical stations (Trig) at Gara Trig and Bora Trig. These stations had either no elevation data or poor accuracy data. There was a high precision vertical control survey carried out along Grafton Rd using State Survey Marks (SSM) although none of these marks had horizontal control to an accuracy of better than the nearest 10 metres. This fact made it difficult to locate some of the marks necessitating the identification of substitute marks. Figure 4.1 shows the relative locations of the survey marks used to gain primary control.

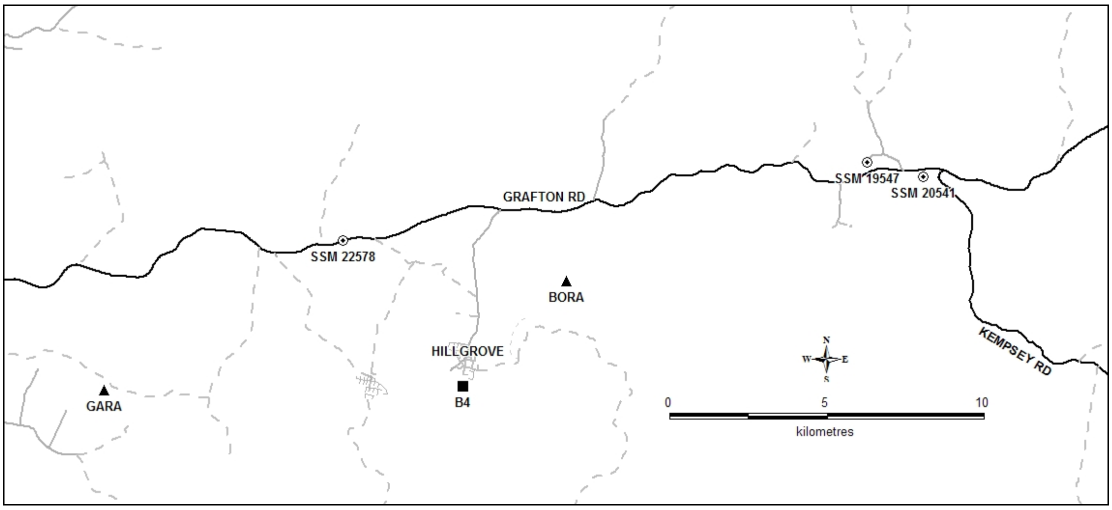

Figure 4.1 Plan of Survey Marks used for Primary Control

(Reproduced with permission from Armidale Dumaresq Council)

After the data collection was complete the data was post processed to improve the accuracy of the observations. This was originally carried out by Sokkia Australia located in Sydney. The outcome of this was the coordination of a station known as B4 located in the Hillgrove Gold and Antimony Mine with accurate Easting, Northing and Australian Height Datum (AHD) Elevation also now both Bora Trig and Gara Trig have better quality heights suitable for supplying photo control.

As the use of this data was necessary in this project, the raw observations were converted from the propriety data format of the GSR2300 to Rhinex to allow the Trimble Office Suite to read the data. This allowed the reprocessing of the data to verify the results obtained in 2001 and to give the station B4 MGA56 coordinates to allow the coordination of the Permanent Marks (PM) in Hillgrove shown in Figure 4.2. This was necessary as both B4 and Bora Trig were to be used as base stations in this project.

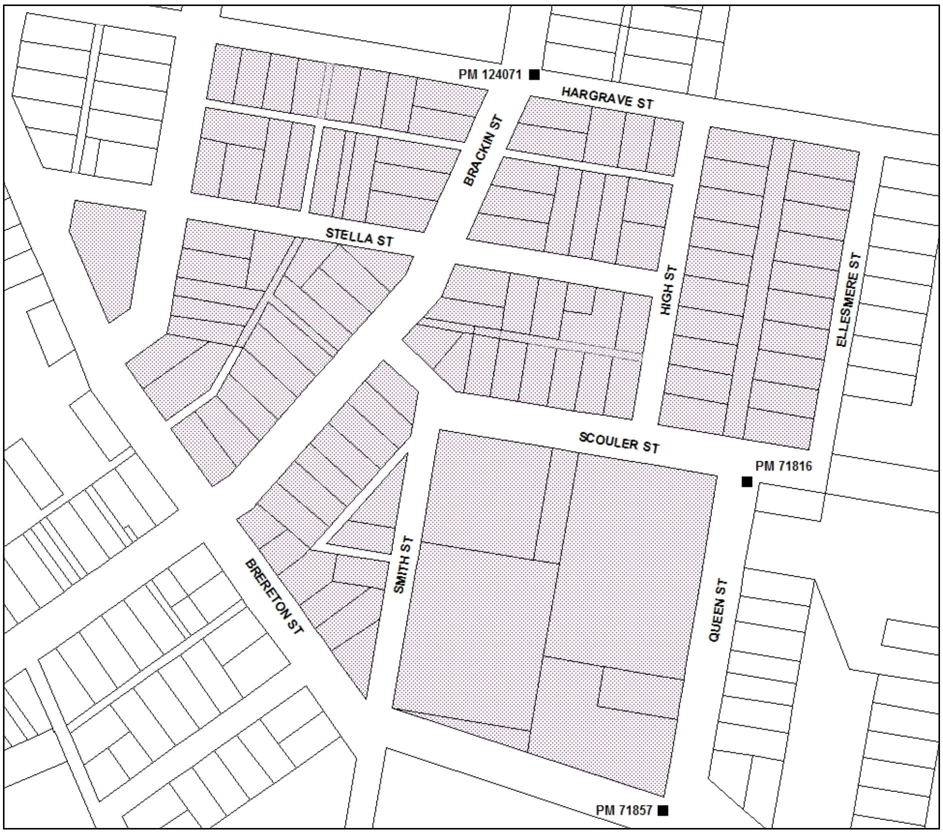

Figure 4.2 Plan of PM’s in Hillgrove

(Reproduced with permission from Armidale Dumaresq Council)

4.3 THE LEAST SQUARES ADJUSTMENT

The inputting of the data into HAVOC seemed initially to be a straight forward process of data entry: how wrong could one be! The plans had very few connections across roads although there was a definite road hierarchy with the main roads being 150 links wide and the minor roads being 100 links wide while the lanes were 30.3 links wide. This lent itself to the process of adopting the connection on the plan if one could be found and if not the hierarchy distance was used. Another interesting occurrence was the number of times an angle fell in the road reserve which meant that there was no direct connection available and a close was required to determine the connection across the road. The quality of the plans prepared in the 1880’s were of a lesser standard than the plans produced today as there were several cases where the sections closed with an accuracy little above 1 in 8000 while the best found was 1 in 22,000. At the other end of the spectrum was section 11 which only achieved an accuracy of 1 in 3800 while two of the portions in this section closed with accuracies just over

1 in 2000. This was the best data available so a network was constructed by closing each section tying the sections together with connections to each of the neighbouring sections at the corners. An example of the input files and plans can be found in Appendix B and Appendix C respectively.

The software requires a unique naming convention for each point in the adjustment. This required the development of a consistent numbering convention to be devised which left enough space between numbers to add any intermediate points required with out disrupting the numbering system. This was also very useful from a surveying perspective as it was now possible to tag each point collected with the respective number to avoid confusion when processing the data in the office. The complete numbering system can be seen in Appendix D.

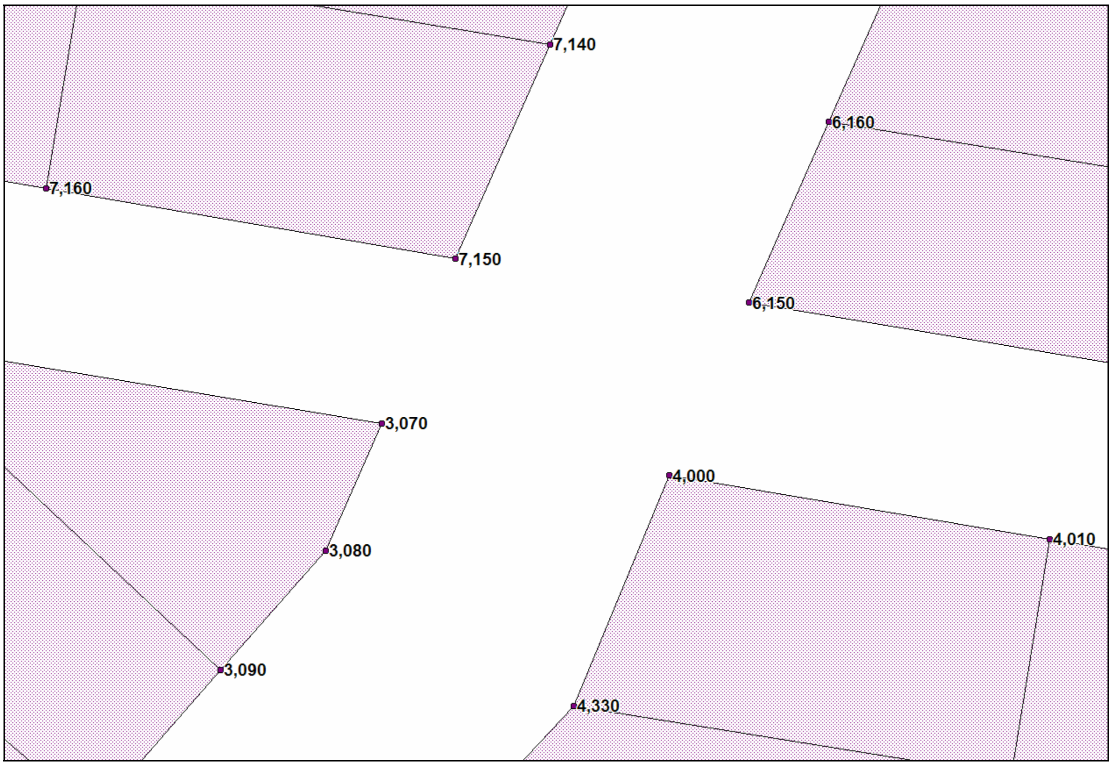

Figure 4.3 Example of Numbering System

(Reproduced with permission from Armidale Dumaresq Council)

The application of the collected control points was to be used to constrain a least squares adjustment. After entering the raw data from the survey plans into HAVOC the coordinates of the control points were entered as necessary for each adjustment. There were many adjustments run in this product, each variation with its own strengths or weaknesses.

The one point and azimuth (direction relative to north) (1PtAz) adjustment relies on the selection of one point with reliability as this point will affect the result of the whole adjustment. From this point the program requires an azimuth to orientate the adjustment. The value of this azimuth was determined by a sun observation found on the 1880 village plan and applied the swing to a line in the adjustment. This adjustment had three variations; the first was a point collected from the 1:25,000 scale photo, the second was a control point from the 1:8,000 photo and the last was a GPS located peg.

The advantages of this minimally constrained adjustment are that it identifies that there are no gross errors in the data input for the adjustment as none of the residuals are excessively large. Other advantages are that only one coordinate is required to run the adjustment so it is a good starting point to assess the suitability of those control points obtained by lesser accurate methods such as locating fence posts from aerial photos. An example of this is there is no way to know if a post is on the corner or some distance away from the actual intersection of the boundaries by looking at the aerial photo or by when collecting the post by GPS when there is no other evidence available. Also this adjustment is equivalent to redrawing the DCDB and floating it as an uncontaminated estimate of the original intention.

The disadvantage of this adjustment is that it is completely reliant on the two initial values being correct. If either one of these values is wrong, then that result will either be shifted in one direction or swung about the fixed point.

The other adjustment type was a multi-point constrained adjustment which requires many points to constrain the adjustment. The aim is to supply control over the entire project to ensure that the adjustment doesn't push out in one area. Sometimes more control does not necessarily lead to better results because if the control is of unknown accuracy, as is the case with the control from Occ's, then the adjustment can't resolve the variances and so it fails. This adjustment was run with control by Occ's from the 1:25,000 photo and the 1:8,000 photo, the GPS Occ's survey and the GPS existing survey marks survey. The following sections describe the collection methods used to obtain the control point values.

4.4 CONTROL BY AERIAL PHOTOGRAPHY

As noted already, in 2001, ADC flew aerial photography and had it orthorectified to preset targets which were surveyed using an RTK GPS method. This imagery was flown at 1:8,000 and 1:25,000 scales and scanned to provide pixel sizes of 0.25 m and 1.0 m respectively.

Having this data available the selection of control points from each of the images was undertaken independently of each other. That is to say, the values determined from the 1:8,000 imagery had no influence on the values determined from the 1:25,000 imagery.

The aim of this method was to select fence posts at the corners of the village sections to use as the control for the adjustment. This is based on the assumption that the fence will represent the actual boundary corner.

Problems identified with this method included the inability to actually see a fence post at these scales, however it was possible to identify the fence lines and where they intersected. Another problem was that vertical objects are displaced in aerial photos due to the angles created from the aircraft, as discussed in section 2.8. This has the effect of potentially picking the wrong point on the image that should represent the base of the fence post and therefore using the wrong value in the adjustment.

Another issue is that an image is apparently only as accurate as 2.5 times the pixel size. This is a rule of thumb accepted in the industry For example a 0.25 m image would have an accuracy of 0.625m. This would obviously limit the results obtained from this method.

As a direct result of the above mentioned constraints and assumptions the multi-point adjustment would not run as the variances were to large. To resolve this situation the control points were culled by a process of running a 1PtAz minimally constrained adjustment and then comparing these result to the control points for the equivalent adjustment and rejecting any points with variances greater than a determined value. This allowed the multi-point adjustment to be run with success to achieve results. A separate adjustment was used for the two different scales of photography. This will be covered in more detail during the discussion of the results (see section 5). Another method for the collection of control points was the use of GPS to collect occupations.

4.5 CONTROL BY GPS SURVEY OF OCCUPATIONS

Collecting control points by using GPS to locate fence posts requires the assumption that the fence post is on the intersection of the boundaries for that parcel. In the case of Hillgrove there has been little survey activity since 1880 and therefore it is very difficult to determine if the post is close to the boundary corner or not. As a result the decision was made to collect any fence post on the corner of the blocks in the assumption that they would be close. Some blocks only had fencing on one side or part of the side so it was not possible locate where the corner might be. Another block had a splay corner in the fence line where there was no splay in the property boundary so an estimate of where the corner might be was made by lining up the fence lines.

The actual surveying process was not as straight forward as was originally thought. The complication was that the GPS antenna is fixed to the top of a 2 m high pole and some of the posts are leaning or have a clout or GIN in them. To take a shot over a clout or leaning post the GPS pole must be lent on an angle and an estimate of when the antenna head is over the mark needs to be made. This is not a repeatable method and as a result there was expected to be some variation in the results. Another restricting variation was that it was not possible to take every shot in the same relative position of the post, such as at the outside edge on the intersection of the two boundaries. This was caused by plants and drainage lines restricting access. These variations were not deemed to be significant in the scheme of the survey although this needs to be considered in the overall accuracy expectations of the project.

As mentioned in the GPS Basics section the limitations of GPS equipment required four shots to be taken at each location to ensure erroneous observations could be removed from the data set before processing. During the processing of these control points for inclusion in the adjustment the same problem with the adjustment failing was found as with the data collected from the aerial photography. The same process was used to cull the control points by comparing them with a 1.5 m variance to the results of a 1PtAz adjustment using a GPS post as the datum point. Typically, this reduced the amount of available control by half and so this improved the result. There is more detail in the discussion about the results.

4.6 CONTROL BY EXISTING SURVEY

At the point of conceptualisation of this project it was intended to do a complete boundary definition of the area of interest using traditional surveying methods. After getting the entire search required for the project and assessing the difficulty of undertaking a full redefinition, and the time this would add to the project against the added benefit and accuracy of just collecting and coordinating existing survey marks, it was decided to do the latter. This will not have a significant effect on the result although the adjustment will not be constrained in the northern section of the village as there are no recent surveys in this area. Given the age of the surveys and the lack of evidence it could be possible that the only way of fixing the boundaries would be to survey the boundaries by dimension from the southern part of the village and see how this fits with the existing fencing. This is effectively the same as putting the bearings and distances in an adjustment, holding the southern part fixed and leaving the northern part floating. Graeme Stewart made a comment that it was possible to spend two weeks doing field work and still not be able to accurately define the corner as originally marked. The purpose of this adjustment is to act as the baseline to assess the accuracy of the other adjustments by comparing the results.

This method requires the use of existing survey marks to determine the location of the corners of the DCDB. This was achieved by using RTK GPS to determine the coordinates of the marks. This survey was performed as part of the collection of fence posts and to achieve quality data through four observations at each location. The base stations were located on a station known as B4 in the Hillgrove Gold and Antimony Mine and the other station used was on Bora Trigonometrical Pillar.

To achieve the desired outcome a complete plan search for the area was required in order to assess the likely places that marks might still exist. As the majority of the village has not had any survey activity since the 1880`s there was little evidence expected to be found.

Some time was spent on an initial investigation to see if any of the three new registered plans had any pegs still visible. This revealed several pegs in the south west and the south east of the village, however there was no evidence in the northern part of the village, probably due to the lack of recent work in this part of the town. During the survey there were several fence posts that had clouts or Galvanised Iron Nails (GIN) in them. As a result of these marks these fence posts were also located.

At point 1020 there was a broad arrow and the number 7 carved into the fence post and there was a peg located 0.5 m away from the post, both of these points were coordinated.

While GPS was chosen as the survey method for this and the previous method, the significant difference between the methods for collecting control points is that this method is connecting to actual cadastral survey marks and the previous method is making the assumption that the fence posts are on the cadastral corners. This difference in collection method is expected to have a profound effect on the accuracy of the end result.

4.7 CONCLUSION

In general terms the initial methodology provided a suitable solution to evaluating the control points for the adjustment of the DCDB. There was the need for slight modification, in the form of the culling process, as the adjustment software was unable to use points that were unreliable and poor estimates of the true location of boundary locations.

CHAPTER 5

RESULTS

5.1 INTRODUCTION

From that data collected and manipulated, three PM's were coordinated and several adjustments were processed. This section will review the findings of these calculations and outline the implications of any decisions made in those calculations. Each adjustment will be discussed in turn and a summary of the results gathered will allow a comparison to occur. The discussion on these results will occur in Chapter 6.

The observed values are available in Appendix E and the results from the adjustments are available in Appendix F. The reduction of the Permanent Marks can be seen in Appendix G. The comparisons to the survey adjustment are located in Appendix H.

5.1.1 One Point and Azimuth

All of the 1PtAz adjustments have the same adjustment statistics as the only change of the value of the starting coordinate. The standard deviations used in the adjustment, which act as the weighting mechanism, were set at 20 seconds for the angles and 2 cm + 20 ppm for the distances. The results from this adjustment show that there are no gross errors in the entered data. This is indicated in Table 5.1 by the small size of the Max and Min residual values

Function	Value
Average Residual	-0.00003
Standard Deviation	0.014
Median Residual	0
Max Residual	0.037
Min Residual	-0.048
Range	0.085
Variance	0.701

Table 5.1 – 1PtAz Statistics

5.1.2 Multi Point 1:8,000 Aerial Photo

The first adjustment with all of the control points collected from the imagery would not run, therefore some culling of the less reliable points was required. The variance adopted was 1.5 m from the results of the minimally constrained adjustment using the 1:8,000 control point as a starting value. After these points were removed the adjustment ran however with very poor results. The standard deviations were increased to 60 seconds and 100 cm + 100 ppm until a reasonable variance was gained. There was little change in the residuals between a variance of 3.7 given by 300 seconds (5 minutes) and 500 cm + 500 ppm and a variance of 1.0 at 480 seconds (8 minutes) and 800 cm + 800 ppm. The variance of 1.0 was adopted as the final result. Table 5.2 show the statistics for this adjustment.

Function	**Value**
Average Residual	0.055
Standard Deviation	0.522
Median Residual	0.075
Max Residual	1.584
Min Residual	-1.337
Range	2.921
Variance	1.056

Table 5.2 – Multi-Point 1:8000 Statistics

5.1.3 Multi Point 1:25,000 Aerial Photo

A similar occurrence was experienced with the 1:25,000 imagery derived control points. The first adjustment would not run so the control was culled to within 3 m from the 1PtAz adjustment using the 1:25,000 control point value. This adjustment ran successfully however the starting deviations were set very high at 480 second and 800 cm + 800 ppm. Another adjustment was run after culling the control down within 2 m from the 1PtAz adjustment. This also ran with the above deviations however yielded a similar variance. It was deemed at this point that the results were not going to improve so further variations were not pursued as the limitations of the software are 999 seconds and 999 cm + 999 ppm. Table 5.3 show the statistics for this adjustment.

Function	Value
Average Residual	0.086
Standard Deviation	0.808
Median Residual	-0.008
Max Residual	2.435
Min Residual	-1.403
Range	3.838
Variance	12.603

Table 5.3 - Multi-Point 1:25000 Statistics

5.1.4 Multi Point GPS Occupations

Again when the adjustment was first run with all the control points wouldn't run. These were culled back to being within 1 m of the minimally constrained adjustment. The standard deviations were loosened until an acceptable variance was achieved and this occurred at 300 seconds and 500 cm + 500 ppm. Results displayed in Table 5.4.

Function	Value
Average Residual	0.054
Standard Deviation	0.650
Median Residual	0.073
Max Residual	1.974
Min Residual	-1.637
Range	3.611
Variance	2.879

Table 5.4 – Multi-Point GPS Occ's Statistics

5.1.5 Multi Point GPS Existing Survey Marks

As this adjustment which was to act as the control for the other adjustments to be compared against, the aim was to keep the standard deviations tight and accept a slightly higher variance. This was achieved at 60 seconds and 90 cm + 90 ppm. Table 5.5 shows this worked reasonably well as the average residual was 37 mm with a standard deviation of 162 mm.

Function	Value
Average Residual	-0.037
Standard Deviation	0.162
Median Residual	-0.014
Max Residual	0.401
Min Residual	-0.620
Range	1.021
Variance	5.939

Table 5.5 – Multi-Point GPS Existing Survey Statistics

5.1.6 Coordination of Permanent Marks

From the data collected to coordinate the PM's, values were collated into groups dependant on which mark they were for and which base station they were measured from. These were then meaned and any measurement over 2 standard deviations from the mean was rejected, the reasoning for this being that when a small dataset is used statical analysis is not really valid because there are insufficient data to ensure statistical regularity. After this culling process, the remaining values were averaged. The adopted values for the coordinated PM's are in MGA56 format for inclusion in the Survey Control Information Management System (SCIMS) and are displayed in the Table 5.6 below.

PM Number	Easting	Northing	AHD Level
71816	395321.964	6617580.659	997.551
71857	395262.050	6617353.066	986.644
124071	395160.050	6617867.695	1001.169

Table 5.6 – Permanent Marks Coordinated

5.1.7 Combined Results

The comparison of all of the adjustments produces the following table. This table is the result of each point in the adjustment having the adjusted value subtracted from the existing survey value. All of these values are summarised in Table 5.7.

Adjustment	Average	Std Dev	Median	Min	Max	Range
1PtAz 8,000	0.614	0.191	0.587	0.360	1.393	1.033
1PtAz 25,000	2.259	0.181	2.233	2.013	2.947	0.947
1PtAz GPS	0.304	0.163	0.288	0	1.029	1.029
MP 8,000	0.901	0.544	0.885	0.108	2.519	2.411
MP 25,000	1.687	0.755	1.575	0.567	3.408	2.841
MP GPS Occ’s	0.584	0.388	0.472	0	1.829	1.829
GPS Occ’s	1.858	3.148	0.884	0	17.395	17.395
Current DCDB	7.035	1.486	7.075	4.292	10.123	5.831

Table 5.7 – Results Compared to Survey Adjustment

5.2 CONCLUSION

Due to the poor estimations of actual boundary corners resulting from the adoption of occupations, the standard deviations used for weighting of the observations in HAVOC needed to be large to allow processing to occur. This is unfortunate but unavoidable. The three PM’s were successfully coordinated to allow the data to be included in SCIMS for future use. From this point the project has yielded results that will allow a comparison to occur.

CHAPTER 6

COMPARISIONS

6.1 INTRODUCTION

With the results available comparisons can be drawn between the various options, this will be achieved by considering each variant in turn to discuss the advantages and disadvantages of the adjustment type and collection method of control points.

6.2 1PTAZ ADJUSTMENT

The use of one known point and a justifiable azimuth as the only constraints in the adjustment yielded good results, as would be expected. Although this all depends on the quality of the known point and the azimuth, the effect of an incorrect point is a constant shift in one direction and the result of an incorrect azimuth is a swing about the known point. This is a high risk option and if used would require a quality check to be performed to ensure that the lateral shift or swing were within acceptable limits. It is interesting to note that there is and average of 0.3 m variation between the GPS Peg adjustment and the adjustment controlled by the existing survey marks. (Shown in Table 6.1) This is surprising considering the majority of the data came from the same plan as the one known point and the azimuth.

Adjustment	Average	Std Dev	Median	Min	Max	Range
1PtAz 8,000	0.614	0.191	0.587	0.360	1.393	1.033
1PtAz 25,000	2.259	0.181	2.233	2.013	2.947	0.947
1PtAz GPS	0.304	0.163	0.288	0	1.029	1.029

Table 6.1 – 1PtAz Comparisons

6.3 CURRENT OCCUPATIONS

These results shown in Table 6.2 are typical for a small village such as Hillgrove or for any rural area that has not had any considerable survey work carried out to identify the quality of the fencing. Having a median of 0.8 m variation between the fencing and the control will have an impact on the ability to achieve a good accuracy using any method that relies on the occupations as an estimate of the actual boundary positions. There are a few outliers in the dataset that skew the average to a higher value of 1.8 m.

Adjustment	Average	Std Dev	Median	Min	Max	Range
GPS Occ's	1.858	3.148	0.884	0	17.395	17.395

Table 6.2 – Current Occupations

6.4 MULTI POINT GPS OCC'S

Considering the variation in the actual occupations, the results of this method are very encouraging as a method of collecting control point data for this style of adjustment. The advantages of this method are the ease of identification of the locations to be collected and the relative simplicity of the equipment to collect these points. The disadvantages of this method are the repetitive nature requiring at least two separate observations from each of the different base stations to ensure quality data is recorded and the difficulty of recording the same point on each post each time due to the configuration of the equipment. If it was possible to substantiate the Occ's used in the adjustment the values in Table 6.3 would be lower indicating a better approximation of the cadastre.

Adjustment	Average	Std Dev	Median	Min	Max	Range
MP GPS Occ's	0.584	0.388	0.472	0	1.829	1.829

Table 6.3 – Multi Point Occupation Adjustment

6.5 MULTI POINT 1:8,000 OCC'S

Again the accuracy of the occupations is a problem; however this method yielded reasonable results for a rural adjustment. It is important to mention that the results in Table 6.4 are outside the acceptable range 0.5 m from actual location (Williamson 1996) for what is deemed an accurate DCDB for a rural area within the industry.

The advantage of this method is that it is an office based solution and once the imagery is obtained the process is relatively quick. The disadvantages of this method are the expense of obtaining the 1:8,000 imagery for large areas would be prohibitive and if this were to be flown specifically for this reason, there is a very large time factor in obtaining orthorectified imagery. The other problem with this method is the pixel size required to allow the identification of the base of the posts to remove the effects of the post being laid flat in the image.

Adjustment	Average	Std Dev	Median	Min	Max	Range
MP 8,000	0.901	0.544	0.885	0.108	2.519	2.411

Table 6.4 - Multi Point 1:8000 Adjustment

6.6 MULTI POINT 1:25,000 OCC'S

While this method does improve the DCDB's accuracy, the amount of improvement is not substantial. An advantage of this method is that 1:25,000 imagery is readily available from state government agencies however the majority is not rectified yet in the western parts of the state. The disadvantages of this method are the ability to obtain a small enough pixel size to allow identification of the actual posts in the imagery. Another problem is the accuracy of the image and the quality of the coordinates derived by this method.

6.7 GPS Coordination of PM's

Even though care was taken when observing these points it can be shown from the data collected that GPS can require a lot of redundancy to achieve good quality results. In this project for the coordination of the PM's any observation over 2 standard deviations (13 mm) from the mean were rejected which was approximately a third of the data collected. While this seems like a large amount of data, the manufacturer's specification is ±10 mm and if this was used more data would have been rejected. With the appropriate amount of data collected RTK coordination of PM's is adequate to create low order values for these marks in SCIMS. A better solution could be achieved by post processing a static survey however this requires observations times in the order of an hour compared to 30 seconds using RTK.

6.8 Conclusion

Accepting that an adjustment using existing survey marks will normally supply the best result, it was interesting to evaluate these other methods to determine which would produce the most reliable results. This revealed the best alternative is the one point and azimuth adjustment based on a GPS located peg. It yielded with an average of 0.3 m and a standard deviation of 0.16 m would almost obtain 95% of the results deemed as accurate in a rural area, provided there were adequate checks in place to verify that the initial point and swing were accurate. The 1PtAz adjustment is usually used to assess the data by comparison before including it in an adjustment to determine if there are any outliners or suspect data. This minimally constrained adjustment could have a duel purpose of acting as a tool of comparison and a uncontaminated estimate of the original intention.

The multi point GPS Occ's adjustment with an average of 0.58 m and a standard deviation of 0.38 m may not meet the desired accuracy in rural areas however this method probably could be used in urban areas with high quality fencing that could be substantiated, although this would require further testing. Again this method also has a reasonable standard deviation and this would indicate a good representation between the actual occupations and the intended boundaries. This could be anticipated to improve with better quality occupations.

The other methods tested degraded in accuracy and reliability and therefore there appears to be questionable benefit in pursuing them in practice. Essentially there are many factors that lead to good result. There is the ability to identify the desired point, the ability to accurately collect this point, the amount and distribution of substantiated control points and the quality of the underlying data being adjusted. If these are all achievable then the result will be acceptable and worthwhile. If this is not possible then a lesser standard may need to be considered as is the case in Hillgrove.

In Figure 6.1 below the adjusted DCDB is show by the dashed thick line while the current DCDB is represented by the thin solid line. Note the relativity of the new DCDB to the fence lines in the background image. While considering this figure take into consideration the inaccuracies of aerial photography and the possible inaccuracies in the fencing. The image was taken in 1943.

Figure 6.1 Comparison of Current DCDB to Adjusted DCDB

(Reproduced with permission from Armidale Dumaresq Council)

CHAPTER 7

CONCLUSIONS

From a dynamic inaccurate DCDB, limited in its application to a solid base of current cadastral data able to support the most complex applications, this is the ultimate in the management of the DCDB. Whilst this is possible to achieve, the question is how to go about it.

With a comprehensive knowledge of the factors that affect the processes that could be used to acquire control to constrain such an adjustment, it is possible to determine a solution. Factors include the distortions and problems associated with aerial photography, the uncertainty of occupations, the effects of transformations from one projection to another and the concept of positional uncertainty. Couple these with a strong understanding of relativity, not only is it possible to manage just the DCDB but also an entire GIS. Without this holistic view of the need to manage the DCDB, one cannot appreciate the importance of why it needs to be accurate.

To obtain an accurate DCDB there needs to be some modification to the existing dataset. The methodology to assess the options for control for this process was to select an adjustment process: this was the mechanism for the change. Next it was necessary to collect control points to constrain this adjustment, then process each option and compare the results.

To compare the result there must be some pre-existing reference point and it is well accepted that the use of existing survey marks to constrain an adjustment will give a superior result. With that known baseline to work from, there were two options worthy of consideration, however they both have limitations and restrictions and so need to be considered with caution. One point and azimuth will supply an acceptable result however this is a high risky option as the whole adjustment hinges around one point: this would require substantial checking mechanisms. The other option to note would be the use of GPS to collect occupations. This is dependent on the quality of the locations of the occupations relative to the boundaries, as this will affect the results of the adjustment. The key to a adjusting the DCDB is quality data and adequate substantiated control points that allow the adjustment to have redundant data.

A point that was made very early in this dissertation is that the only way to improve the accuracy of the whole DCDB is to redraw it from bearing and distance and use this as the basis for any adjustment. This project has concentrated on adjusting the outline of the village section as a test case. To fill in all the individual parcels each lot would be required to become part of the adjustment as the internal measurements all affect the result of the final DCDB. Simply squeezing the existing DCDB into an accurate section will not overcome the problems face by the current DCDB.

From the amount of effort required to perform this project it has become very obvious that there is no quick fix to this problem. The amount of time required to collect control points is similar, regardless of whether they are occupations or existing survey marks. The bulk of the time taken in this process is entering the data into the adjustment. That is to say the time taken to do the job properly is no more than the time taken to half do it.

7.1 FURTHER WORK

This project has looked at the possible ways of collecting control point to adjust the DCDB in a small localised area in order to achieve an improved level of accuracy. The DCDB covers the whole State of NSW and it is not possible to move one small part of it with out creating a problem somewhere else. A detailed study is needed on how far should the effects of this adjustment be applied. This is only topical while the DCDB has large inaccuracies as once it is accurate any shift will be localised.

Another useful project could test the results from a GPS survey collecting occupations in a highly developed area to determine what level of accuracy this would achieve.

APPENDICES

Appendix A

Project Specification

University of Southern Queensland

Faculty of Engineering and Surveying

ENG 4111/4112 Research Project

PROJECT SPECIFICATION

For: Wayne Fenwick

TOPIC:	Evaluation of Control for Adjusting the Digital Cadastral Data Base (DCDB).
SUPERVISERS:	Assoc. Prof. Frank Young and Graeme Stewart (Dept. Lands NSW)
ENROLMENT:	ENG 4111 – S1, X, 2005 ENG 4112 – S2, X, 2005
PROJECT AIM:	To determine the accuracies achievable when adjusting the DCDB by using different methods to provide control.
SPONSORSHIP:	Armidale Dumaresq Council and Department of Lands NSW.
PROGRAMME:	Issue C, 26 September 2005

1. Research prior attempts to define these accuracies.
2. Research different methodologies (software solutions) for doing the adjustment. (To be aware of the alternatives).
3. Design and carry out GPS surveys to place Permanent Marks and link to the state survey control network.
4. Reduce and evaluate the results.
5. Acquire and review property search.
6. Perform adjustments using the four different sets of control coordinates.
7. Critically evaluate and comment the results.

As time permits:

8. Acquire estimates of cost for each method.
9. Prepare a cost verses accuracy relationship.

AGREED:

Wayne Fenwick

(Student):____

Assoc. Prof. Frank Young USQ

(Supervisor):____

Appendix B

HAVOC Input File

MP8000.HAV - Notepad

File Edit Format View Help

```
92SOURCE ID.MP8000
92HILLGROVE
01 561       9999100                  1           5   4 1 2      2 4        157
*grd-4000          4000                386821.21  1616551.92
*grd-4060          4060                386963.235 1616551.92
*grd 1210          1210                386809.689 1616434.184
*
grd-1020          1020                386908.306 1616417.435
*grd-1060          1060                386970.501 1616178.441
*grd-1070          1070                386874.428 1616205.005
*grd-1090          1090                386775.255 1616232.589
grd-1000          1000                386808.975 1616434.707
*grd-2010          2010                386795.167 1616462.011
grd-2000          2000                386769.761 1616482.404
*grd-2270          2270                386664.516 1616368.798
*grd-3190          3190                386655.352 1616400.563
*grd-3200          3200                386648.266 1616395.682
grd-3020          3020                386627.075 1616584.758
grd-7240          7240                386630.490 1616604.151
*grd-4330          4330                386811.475 1616530.791
grd-6100          6100                386963.935 1616547.683
grd-5130          5130                387071.291 1616420.295
grd-5000          5000                387001.961 1616649.377
grd-6040          6040                386982.420 1616653.048
grd-5030          5030                387106.959 1616631.825
*grd-4180          4180                386781.697 1616496.046
*grd-4160          4160                386824.829 1616462.691
*
* AZIMUTH RECORD
*azm 4000           4060          980830     1
*
*BLOCK 4000 / SECTION 20
*
bdsS4000           4060          900000     480  142.025    800  800      93000
bds 4060           4090         1800000           87.568
bds 4090           4160         2700000          125.378
bds 4160           4180         3020800           53.048
bds 4180           4330          320800           42.241
bds 4330           4000          135200           24.341
*
*BLOCK 6000 / SECTION 19
*
bds 6000           6040          900000          110.743
bds 6040           6100         1800000          106.679
bds 6100           6150         2700000          137.056
bds 6150           6000          135200          109.880
*
*BLOCK 5000 / SECTION 18
*
bds 5000           5030          900000          106.679
bds 5030           5130         1800000          214.365
bds 5130           5340         2700000          106.679
bds 5340           5000           00000          214.365
*
*BLOCK 7000 / SECTION 12
*
bds 7000           7090          900000          196.440
bds 7090           7150         1935200          109.900
bds 7150           7240         2700000          170.148
bds 7240           7000           00000          106.679
*
BLOCK 3000 / SECTION 11
*
bds 3020           3070          900000          165.212
bds 3070           3080         1935200           11.990
bds 3080           3190         2120800          192.920
bds 3190           3200         2244600           12.271
bds 3200           3410         3144600          106.679
bds 3410           3420          444600           35.204
bds 3420           3020           00000           83.686
*
*BLOCK 3000 / SECTION 32
*
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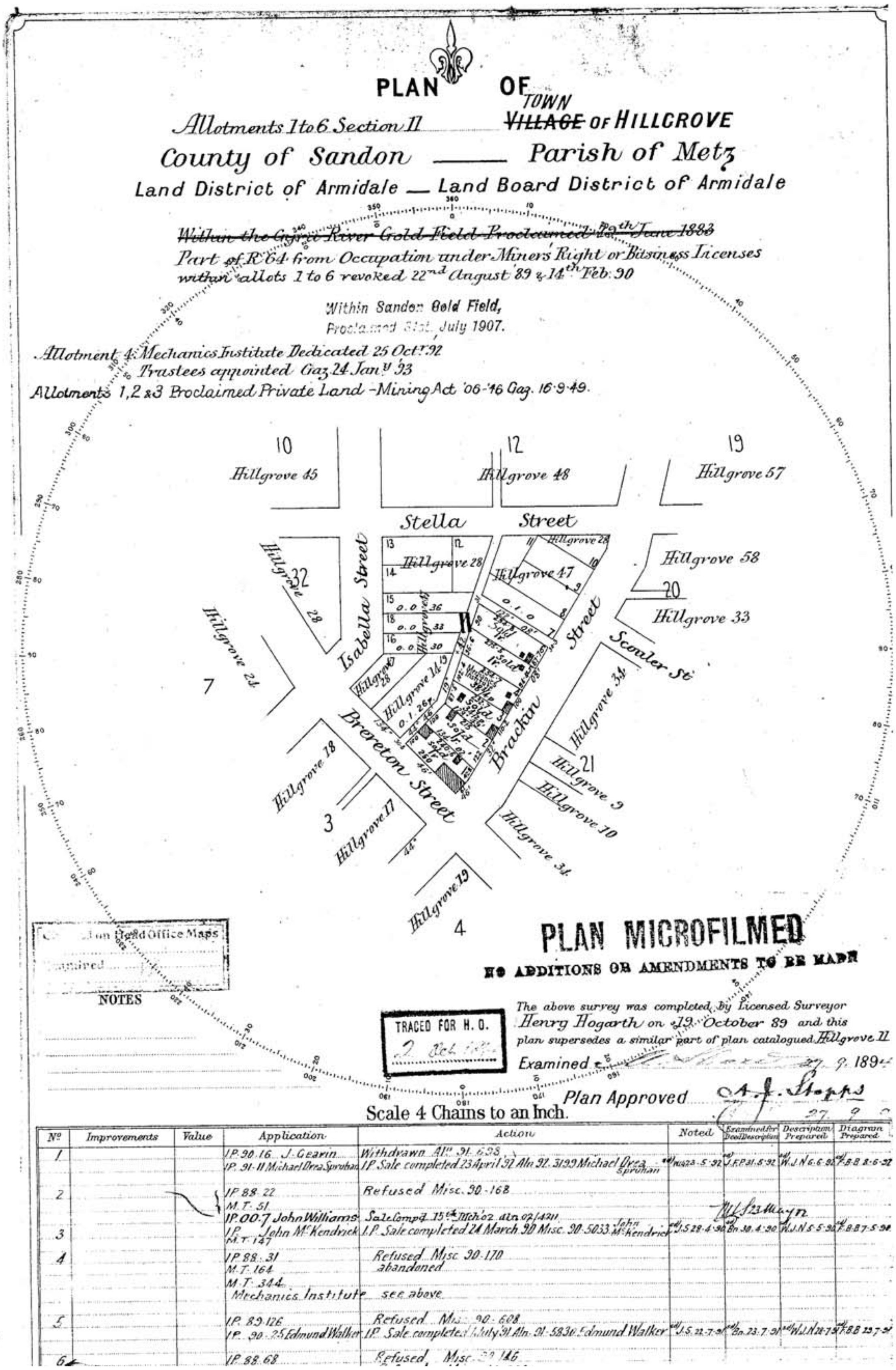
Appendix C

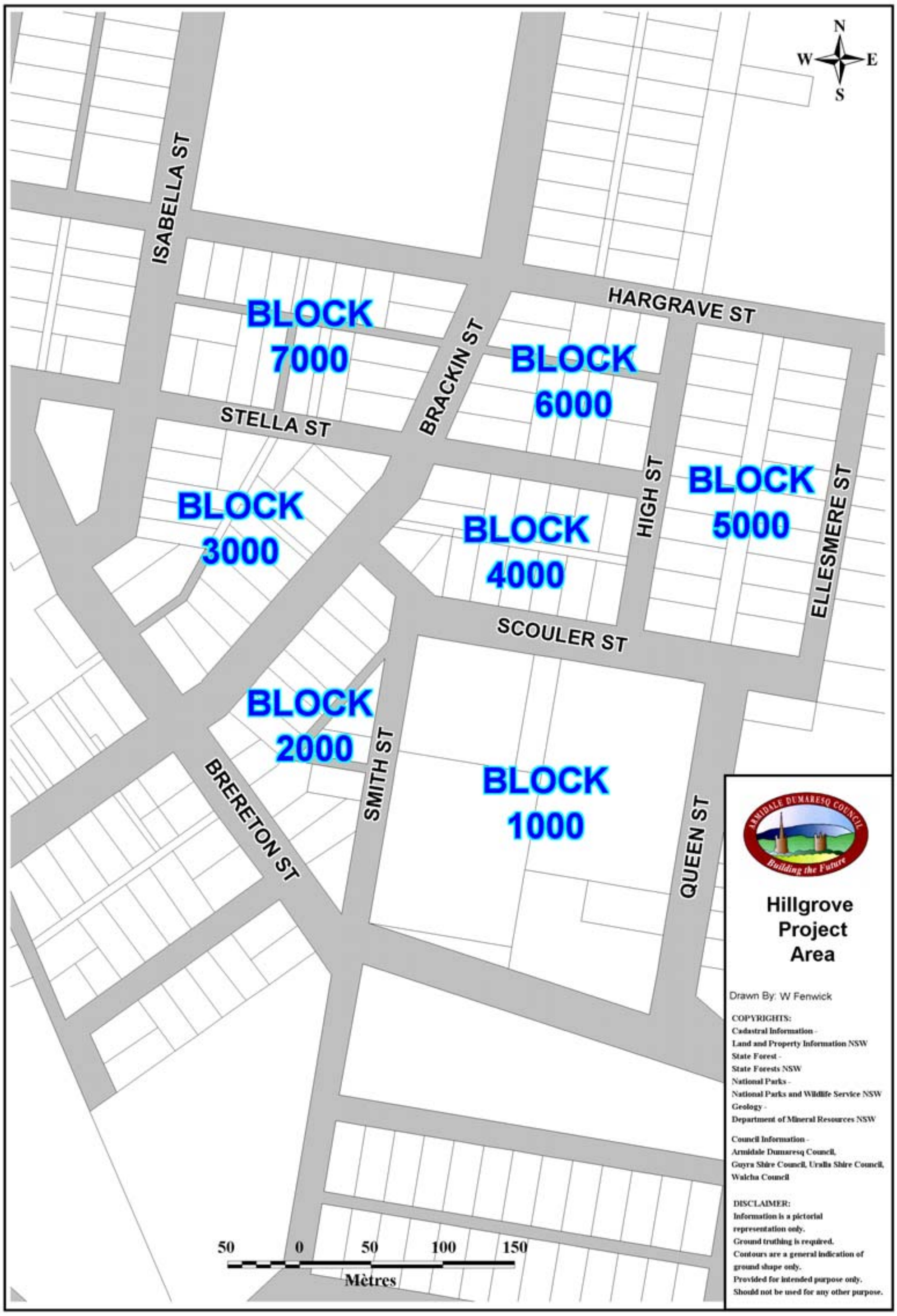
Example of an 1880's Portion Plan


PLAN OF TOWN OF HILLCROVE
Allotments 1 to 6 Section 11
County of Sandon — Parish of Metz
Land District of Armidale — Land Board District of Armidale
Part of R 64 from Occupation under Miners Right or Business Licenses within allots 1 to 6 revoked 22nd August 89 & 14th Feb. 90
Within Sandon Gold Field, Proclaimed 31st July 1907.
Allotment 4: Mechanics Institute Dedicated 25 Oct. 92
Trustees appointed Gaz 24 Jany 93
Allotments 1,2 &3 Proclaimed Private Land - Mining Act '06-'46 Gaz. 16-9-49.
Stella Street
Isabella Street
Brereton Street
Brackin Street
Scoular St
PLAN MICROFILMED
NO ADDITIONS OR AMENDMENTS TO BE MADE
NOTES
TRACED FOR H. O.
The above survey was completed by Licensed Surveyor Henry Hogarth on 19 October 89 and this plan supersedes a similar part of plan catalogued Hillgrove 11
Examined
Plan Approved
Scale 4 Chains to an Inch.
Nº
Improvements
Value
Application
Action
Noted
Description Prepared
Diagram Prepared
Mechanics Institute
see above

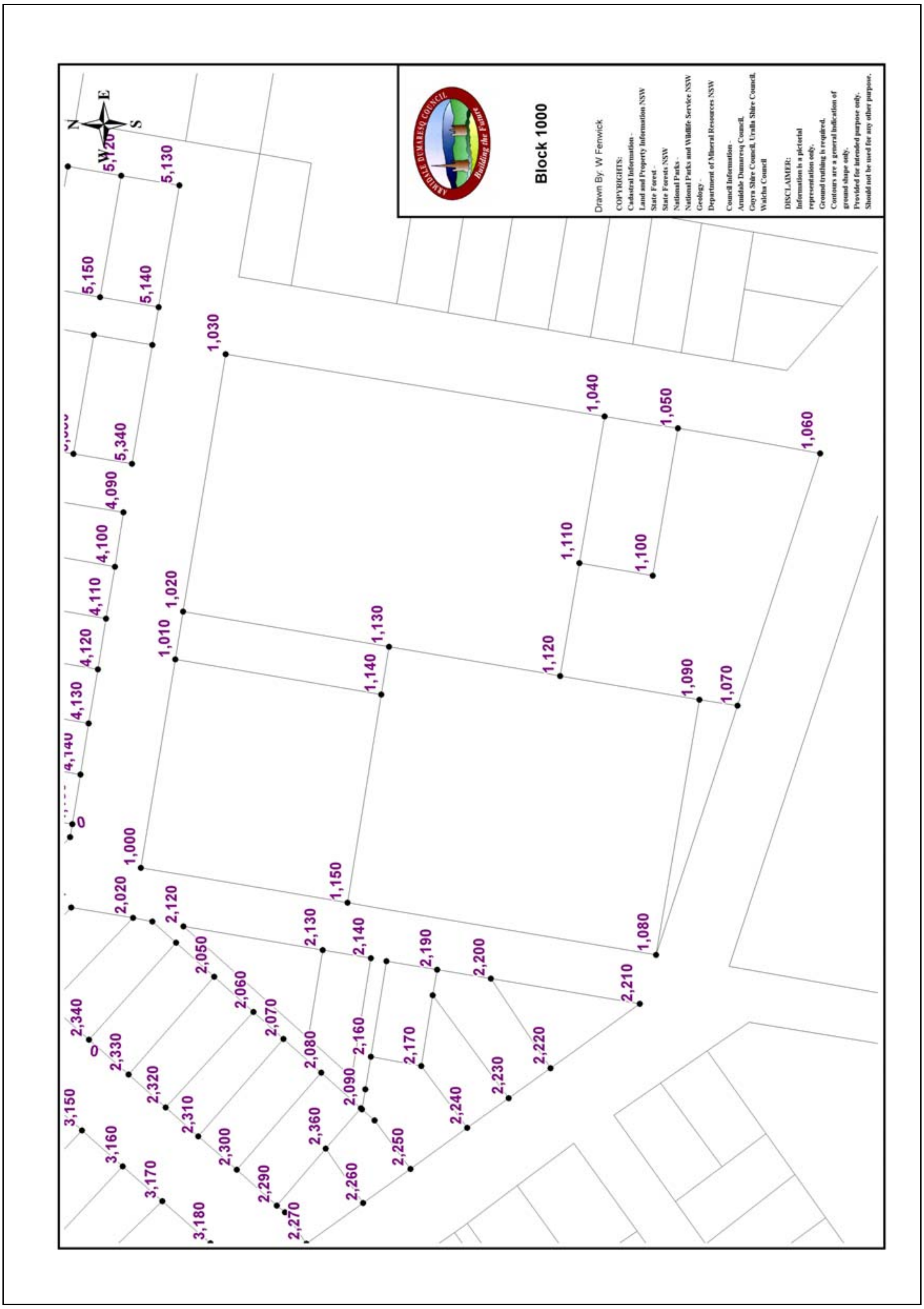
Appendix D

Block Layout and Numbering System

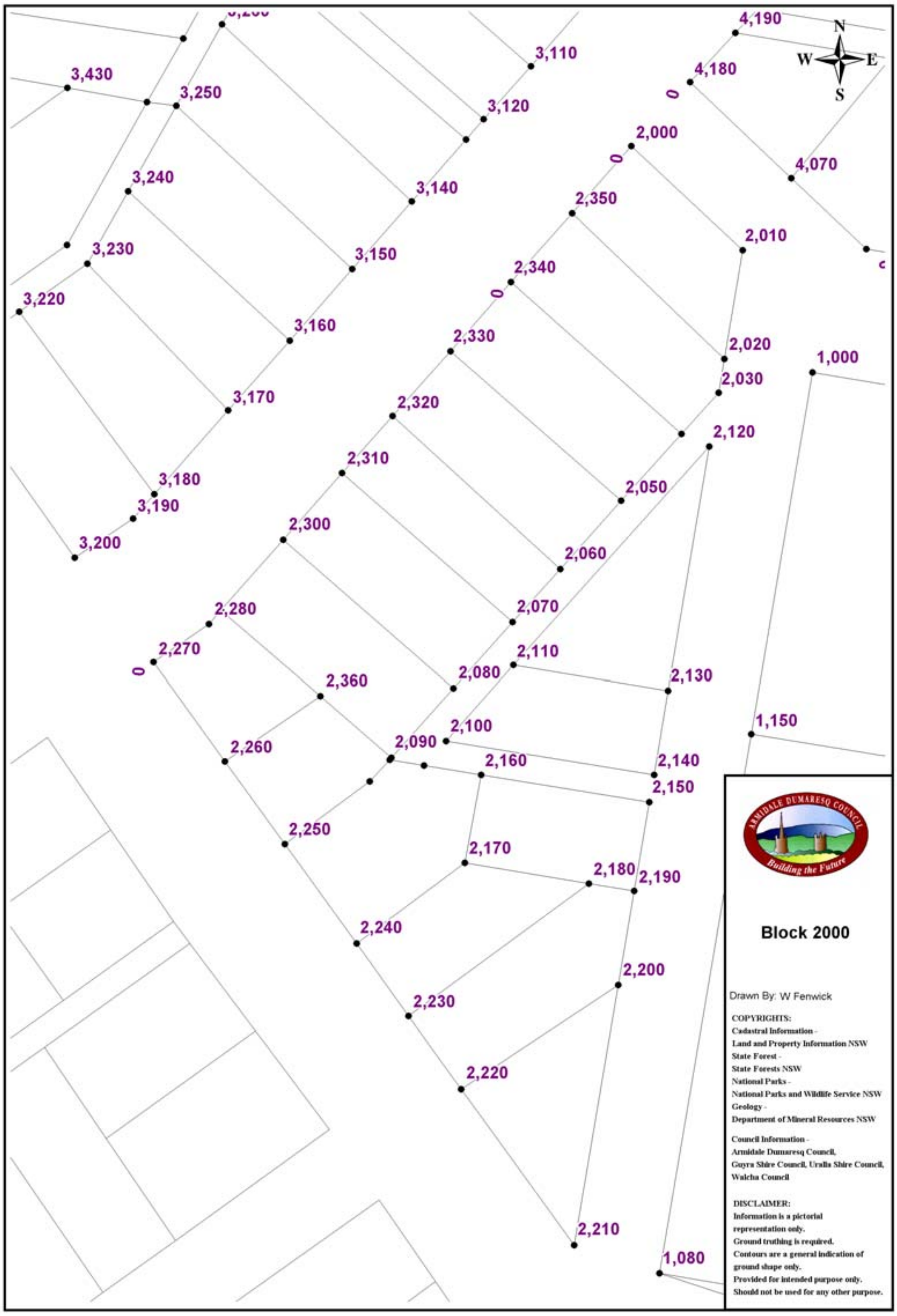
Project Area Block Numbering System.



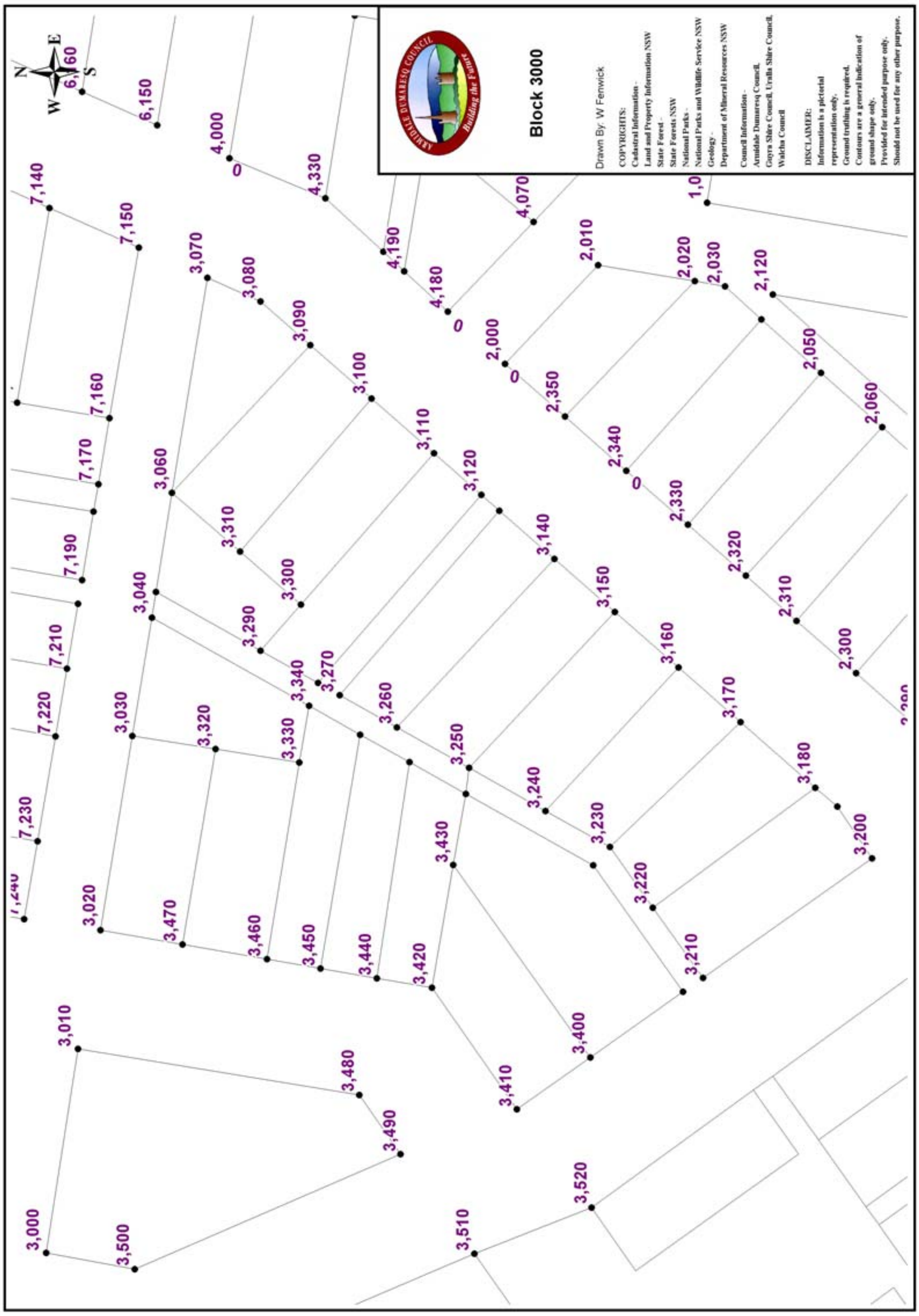
Block 1000 Numbering system for points used in the adjustments.



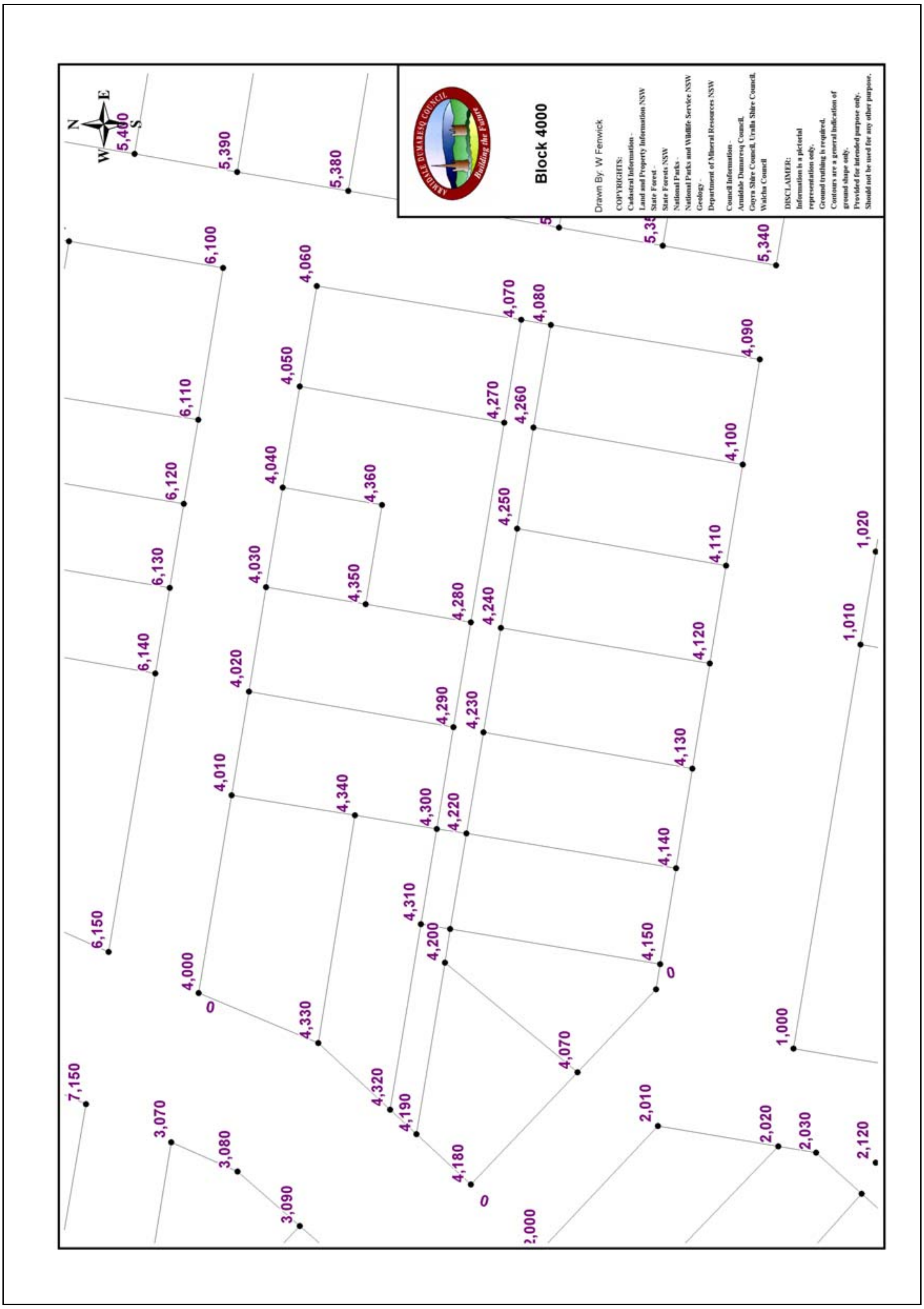
Block 2000 Numbering system for points used in the adjustments.



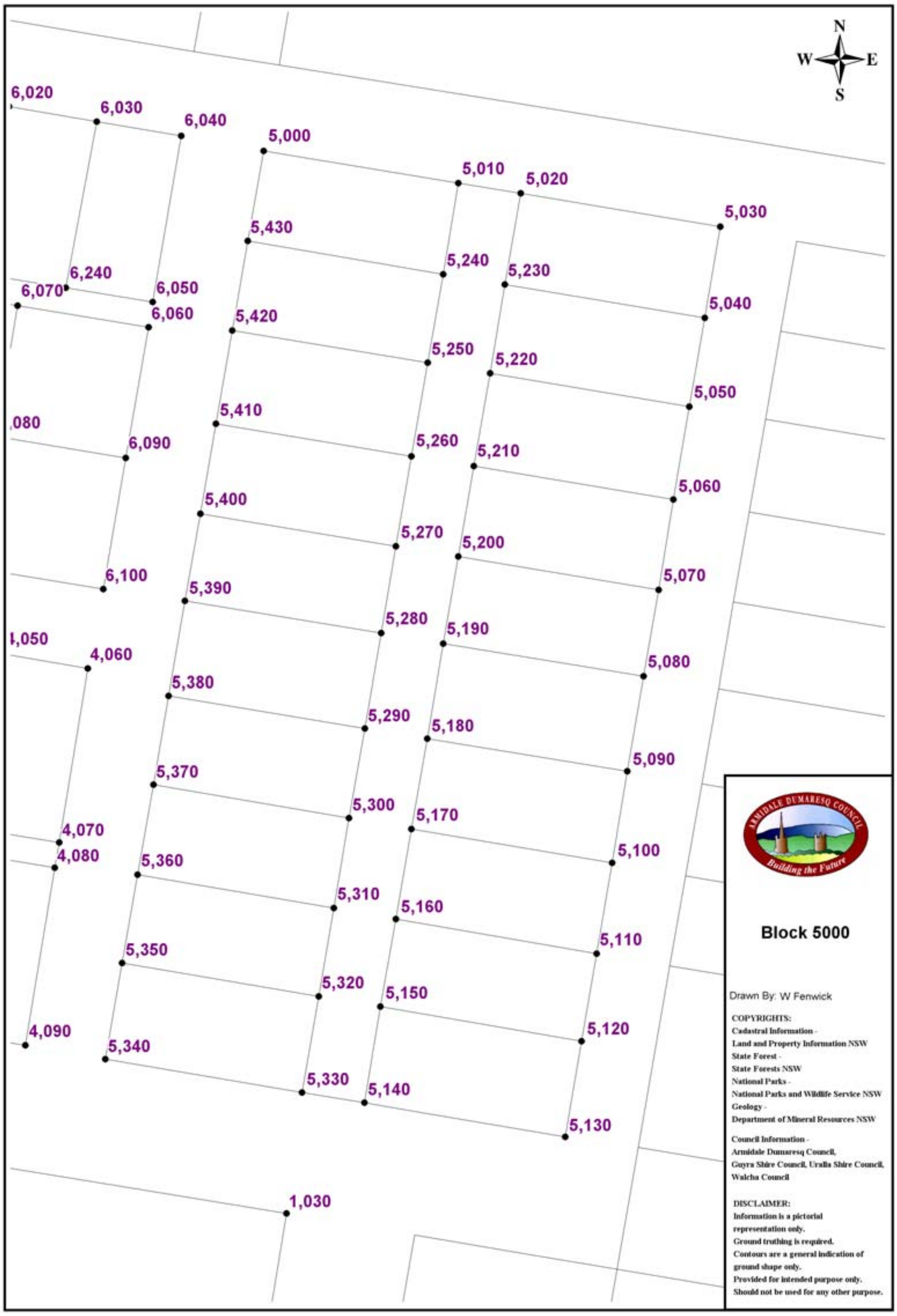
Block 3000 Numbering system for points used in the adjustments.



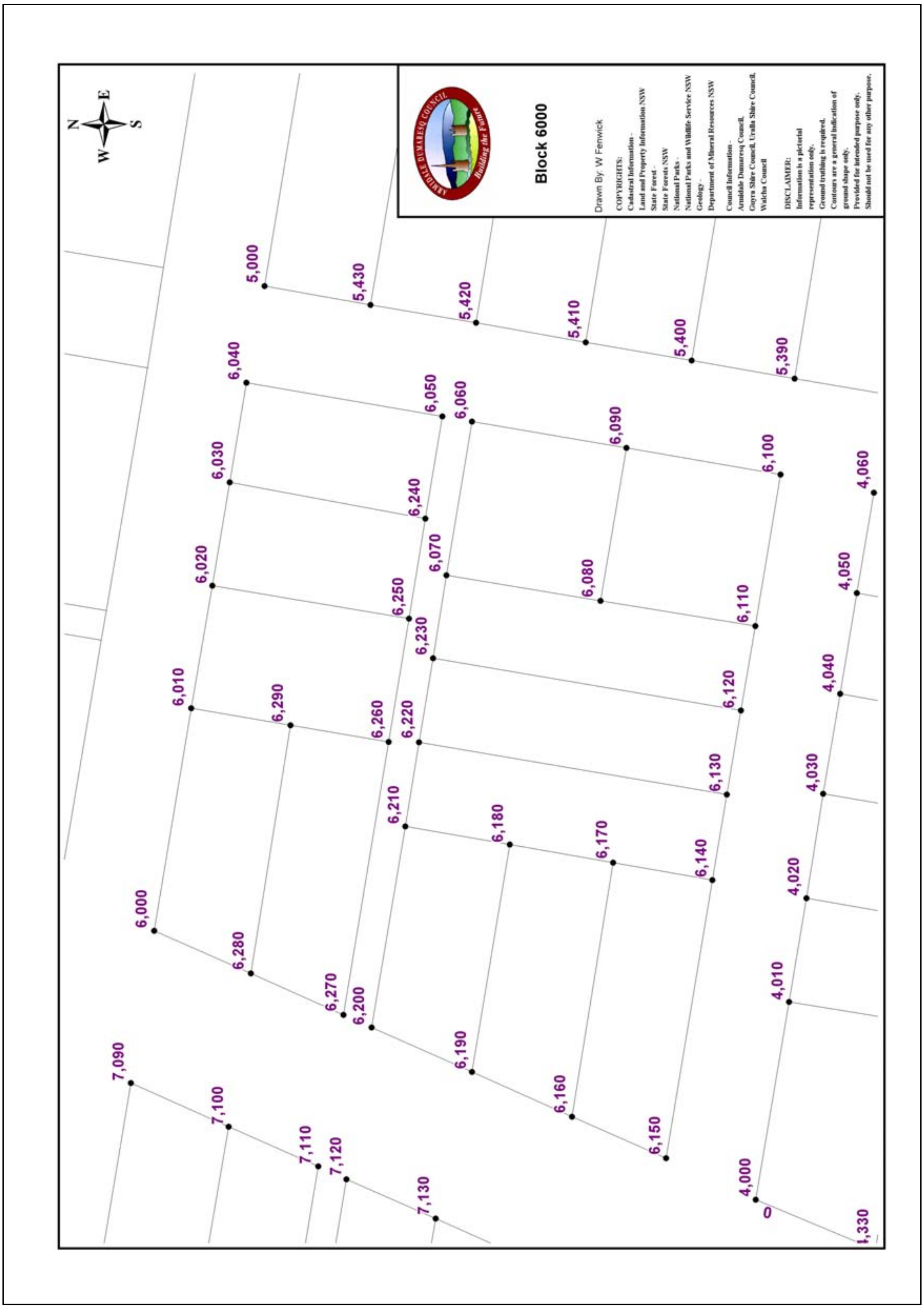
Block 4000 Numbering system for points used in the adjustments.



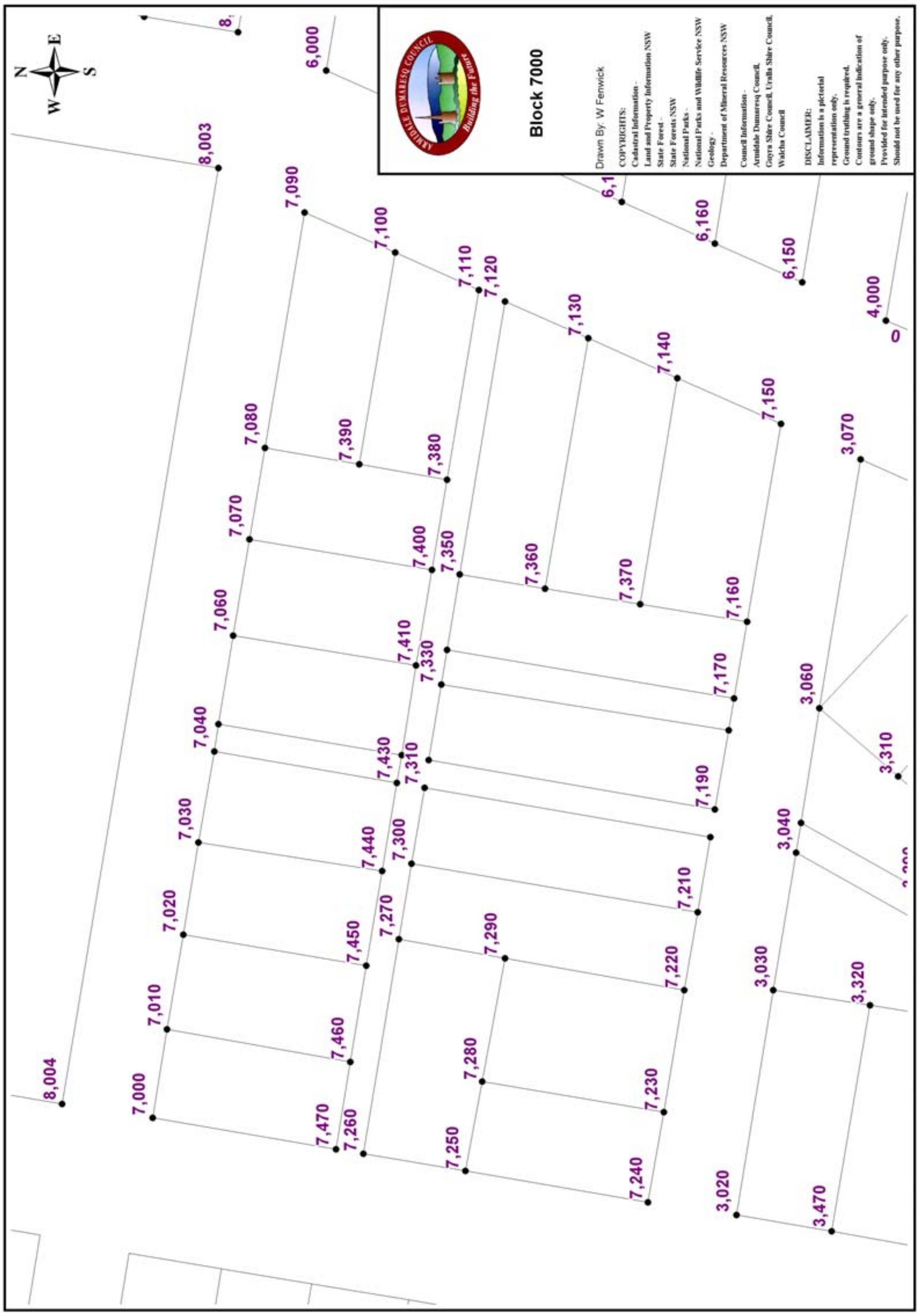
Block 5000 Numbering system for points used in the adjustments.



Block 6000 Numbering system for points used in the adjustments.



Block 7000 Numbering system for points used in the adjustments.



Appendix E

Observed Data

Raw observations in MGA 56.

		Average		**Average**		**Average**	
		Maximum		Maximum		Maximum	
		Minimum		Minimum		Minimum	
		Range	Easting	Range	Northing	Range	RL
ID=9029	**CO=1000**	**395096.874**	395096.841	**6617611.776**	6617611.813	**992.973**	992.924
ID=9081	CO=1000	395096.941	395096.851	6617611.823	6617611.823	993.033	992.909
ID=8022	CO=1000	395096.841	395096.941	6617611.652	6617611.652	992.909	993.033
ID=8075	CO=1000	0.100	395096.862	0.171	6617611.816	0.124	993.027
ID=9021	**CO=1030**	**395296.162**	395296.160	**6617580.880**	6617580.883	**997.063**	997.115
ID=9073	CO=1030	395296.216	395296.216	6617580.933	6617580.840	997.115	997.026
ID=8015	CO=1030	395296.104	395296.104	6617580.840	6617580.864	997.026	997.040
ID=8067	CO=1030	0.112	395296.166	0.093	6617580.933	0.089	997.070
ID=9022	**CO=1060**	**395262.943**	395262.973	**6617358.597**	6617358.573	**986.924**	986.868
ID=9074	CO=1060	395262.973	395262.957	6617358.698	6617358.559	987.006	986.853
ID=8016	CO=1060	395262.885	395262.885	6617358.557	6617358.698	986.853	987.006
ID=8068	CO=1060	0.088	395262.956	0.141	6617358.557	0.153	986.967
ID=9024	**CO=1070**	**395166.253**	395166.255	**6617383.527**	6617383.552	**984.544**	984.501
ID=9076	CO=1070	395166.263	395166.257	6617383.552	6617383.514	984.578	984.536
ID=8019	CO=1070	395166.236	395166.236	6617383.500	6617383.543	984.501	984.578
ID=8071	CO=1070	0.027	395166.263	0.052	6617383.500	0.077	984.560

		Average		**Average**		**Average**	
		Maximum		Maximum		Maximum	
		Minimum		Minimum		Minimum	
		Range	Easting	Range	Northing	Range	RL
ID=9027	**CO=1090**	**395066.835**	395066.781	**6617408.905**	6617408.939	**983.643**	983.606
ID=9079	CO=1090	395066.876	395066.855	6617408.939	6617408.885	983.686	983.618
ID=8021	CO=1090	395066.781	395066.826	6617408.885	6617408.908	983.606	983.686
ID=8073	CO=1090	0.095	395066.876	0.054	6617408.887	0.080	983.662
ID=9002	**CO=124071**	**395160.051**	395160.066	**6617867.697**	6617867.700	**1001.172**	1001.142
ID=9048	CO=124071	395160.066	395160.045	6617867.717	6617867.694	1001.234	1001.169
ID=9049	CO=124071	395160.033	395160.043	6617867.685	6617867.693	1001.138	1001.157
ID=9050	CO=124071	0.033	395160.048	0.032	6617867.692	0.096	1001.138
ID=9099	CO=124071		395160.060		6617867.699		1001.147
ID=8002	CO=124071		395160.054		6617867.699		1001.234
ID=8045	CO=124071		395160.033		6617867.717		1001.167
ID=8095	CO=124071		395160.061		6617867.685		1001.221
ID=9031	**CO=2000**	**395056.861**	395056.821	**6617658.920**	6617658.912	**992.426**	992.399
ID=9083	CO=2000	395056.952	395056.882	6617658.975	6617658.975	992.472	992.372
ID=8026	CO=2000	395056.788	395056.788	6617658.846	6617658.846	992.372	992.472
ID=8077	CO=2000	0.164	395056.952	0.129	6617658.946	0.100	992.459
ID=8092	**CO=3000**	**394816.019**	394815.971	**6617773.392**	6617773.537	**987.695**	987.782
ID=8041	CO=GIN3000	394816.089	394815.950	6617773.537	6617773.379	987.782	987.730
ID=9095	CO=GIN3000	394815.950	394816.067	6617773.309	6617773.341	987.627	987.627
ID=9044	CO=3000GIN	0.139	394816.089	0.228	6617773.309	0.155	987.640

		Average		Average		Average	
		Maximum		Maximum		Maximum	
		Minimum		Minimum		Minimum	
		Range	Easting	Range	Northing	Range	RL
ID=9043	**CO=3010**	**394881.712**	394881.735	**6617763.432**	6617763.439	**987.687**	987.677
ID=9094	CO=3010	394881.735	394881.708	6617763.483	6617763.429	987.763	987.669
ID=8040	CO=3010	394881.682	394881.682	6617763.377	6617763.377	987.639	987.639
ID=8091	CO=3010	0.053	394881.722	0.106	6617763.483	0.124	987.763
ID=9042	**CO=3020**	**394912.684**	394912.676	**6617758.403**	6617758.434	**989.093**	989.080
ID=9093	CO=3020	394912.693	394912.693	6617758.434	6617758.416	989.128	989.041
ID=8039	CO=3020	394912.676	394912.689	6617758.340	6617758.340	989.041	989.123
ID=8090	CO=3020	0.017	394912.677	0.094	6617758.421	0.087	989.128
ID=8036	**CO=3070**	**395077.638**	395077.795	**6617733.376**	6617733.351	**994.953**	995.232
ID=8087	CO=3070		395077.480		6617733.400		994.673
ID=9040	**CO=3190**	**394944.327**	394944.329	**6617575.135**	6617575.126	**988.923**	988.900
ID=9091	CO=3190	394944.343	394944.343	6617575.174	6617575.100	988.979	988.851
ID=8035	CO=3190	394944.294	394944.294	6617575.100	6617575.174	988.851	988.979
ID=8086	CO=3190	0.049	394944.343	0.074	6617575.140	0.128	988.962
ID=9038	**CO=3210E**	**394905.180**	394905.143	**6617608.429**	6617608.528	**986.771**	986.733
ID=9090	CO=3210E	394905.288	394905.138	6617608.528	6617608.431	986.807	986.738
ID=8084	CO=3210E	394905.138	394905.151	6617608.357	6617608.400	986.733	986.807
ID=8034	CO=3210E	0.150	394905.288	0.171	6617608.357	0.074	986.804

		Average		Average		Average	
		Maximum		Maximum		Maximum	
		Minimum		Minimum		Minimum	
		Range	Easting	Range	Northing	Range	RL
ID=9037	**CO=3210W**	**394901.589**	394901.555	**6617613.738**	6617613.684	**986.421**	986.389
ID=9089	CO=3210W	394901.679	394901.548	6617613.878	6617613.681	986.497	986.362
ID=8083	CO=3210W	394901.548	394901.575	6617613.681	6617613.708	986.362	986.437
ID=8033	CO=3210W	0.131	394901.679	0.197	6617613.878	0.135	986.497
ID=9009	**CO=4000**	**395106.701**	395106.698	**6617729.310**	6617729.314	**995.939**	995.926
ID=9064	CO=4000	395106.727	395106.691	6617729.324	6617729.294	996.038	995.871
ID=8008	CO=4000	395106.687	395106.687	6617729.294	6617729.307	995.871	995.922
ID=8054	CO=4000	0.040	395106.727	0.030	6617729.324	0.167	996.038
ID=9012	**CO=4160**	**395112.284**	395112.291	**6617640.184**	6617640.179	**994.389**	994.332
ID=9067	CO=4160	395112.295	395112.295	6617640.245	6617640.169	994.435	994.360
ID=8011	CO=4160	395112.256	395112.256	6617640.141	6617640.245	994.332	994.435
ID=8057	CO=4160	0.039	395112.295	0.104	6617640.141	0.103	994.430
ID=9011	**CO=4180**	**395068.682**	395068.690	**6617672.729**	6617672.750	**992.978**	992.950
ID=9066	CO=4180	395068.690	395068.685	6617672.779	6617672.779	993.018	992.929
ID=8010	CO=4180	395068.676	395068.678	6617672.660	6617672.660	992.929	993.014
ID=8056	CO=4180	0.014	395068.676	0.119	6617672.725	0.089	993.018
ID=9010	**CO=4330**	**395097.659**	395097.622	**6617708.067**	6617708.080	**995.522**	995.510
ID=9065	CO=4330	395097.689	395097.673	6617708.080	6617708.076	995.598	995.421
ID=8009	CO=4330	395097.622	395097.689	6617708.031	6617708.031	995.421	995.598
ID=8055	CO=4330	0.067	395097.651	0.049	6617708.079	0.177	995.560

		Average		Average		Average	
		Maximum		Maximum		Maximum	
		Minimum		Minimum		Minimum	
		Range	Easting	Range	Northing	Range	RL
ID=9018	**CO=5000**	**395285.726**	395285.722	**6617829.784**	6617829.765	**998.178**	998.203
ID=9070	CO=5000	395285.774	395285.715	6617829.795	6617829.795	998.204	998.119
ID=8012	CO=5000	395285.692	395285.774	6617829.765	6617829.794	998.119	998.204
ID=8064	CO=5000	0.082	395285.692	0.030	6617829.783	0.085	998.185
ID=9019	**CO=5030**	**395391.474**	395391.519	**6617813.987**	6617813.971	**992.065**	992.066
ID=9071	CO=5030	395391.519	395391.498	6617814.004	6617813.989	992.112	992.031
ID=8013	CO=5030	395391.383	395391.383	6617813.971	6617814.004	992.031	992.112
ID=8065	CO=5030	0.136	395391.496	0.033	6617813.982	0.081	992.051
ID=9017	**CO=5340**	**395253.725**	395253.752	**6617617.487**	6617617.498	**997.064**	997.028
ID=B5	CO=5340		395253.698		6617617.475		997.099
ID=9004	**CO=6000**	**395155.540**	395155.575	**6617849.752**	6617849.677	**1000.965**	1000.821
ID=9058	CO=6000		395155.575		6617849.864		1001.167
ID=8049	CO=6000		395155.469		6617849.716		1000.906
ID=9005	**CO=6015**	**395209.274**	395209.277	**6617842.076**	6617842.085	**1001.275**	1001.197
ID=9059	CO=6015	395209.289	395209.279	6617842.085	6617842.085	1001.434	1001.434
ID=8004	CO=6015	395209.252	395209.289	6617842.059	6617842.059	1001.197	1001.215
ID=8050	CO=6015	0.037	395209.252	0.026	6617842.076	0.237	1001.252
ID=9006	**CO=6040**	**395266.057**	395266.057	**6617832.914**	6617832.940	**998.945**	998.928
ID=9060	CO=6040	395266.103	395266.054	6617832.944	6617832.922	998.990	998.906
ID=8005	CO=6040	395266.014	395266.103	6617832.849	6617832.849	998.906	998.956
ID=8051	CO=6040	0.089	395266.014	0.095	6617832.944	0.084	998.990

		Average		**Average**		**Average**	
		Maximum		Maximum		Maximum	
		Minimum		Minimum		Minimum	
		Range	Easting	Range	Northing	Range	RL
ID=9007	**CO=6100**	**395249.981**	395249.973	**6617727.675**	6617727.624	**1000.877**	1000.837
ID=9061	CO=6100	395249.997	395249.987	6617727.704	6617727.675	1000.909	1000.873
ID=9062	CO=6100	395249.957	395249.989	6617727.624	6617727.678	1000.837	1000.865
ID=8006	CO=6100	0.040	395249.957	0.080	6617727.694	0.072	1000.901
ID=8052	CO=6100		395249.997		6617727.704		1000.909
ID=9008	**CO=6150**	**395114.168**	395114.182	**6617747.693**	6617747.678	**996.874**	996.800
ID=9063	CO=6150	395114.208	395114.079	6617747.728	6617747.685	997.065	997.065
ID=8007	CO=6150	395114.079	395114.208	6617747.678	6617747.728	996.717	996.912
ID=8053	CO=6150	0.129	395114.203	0.050	6617747.680	0.348	996.717
ID=9046	**CO=7000**	**394935.363**	394935.370	**6617883.099**	6617883.100	**995.672**	995.652
ID=9097	CO=7000	394935.381	394935.356	6617883.116	6617883.109	995.737	995.583
ID=8043	CO=7000	394935.344	394935.381	6617883.070	6617883.070	995.583	995.737
ID=8093	CO=7000	0.037	394935.344	0.046	6617883.116	0.154	995.716
ID=9047	**CO=7090**	**395126.051**	395126.068	**6617854.636**	6617854.644	**1000.084**	1000.037
ID=9098	CO=7090	395126.068	395126.038	6617854.667	6617854.667	1000.143	1000.038
ID=8044	CO=7090	395126.038	395126.042	6617854.604	6617854.604	1000.037	1000.143
ID=8094	CO=7090	0.030	395126.056	0.063	6617854.630	0.106	1000.117
ID=9041	**CO=7150**	**395082.813**	395082.824	**6617751.934**	6617751.917	**995.771**	995.729
ID=9092	CO=7150	395082.833	395082.833	6617751.977	6617751.922	995.814	995.728
ID=8037	CO=7150	395082.776	395082.819	6617751.917	6617751.977	995.728	995.814
ID=8088	CO=7150	0.057	395082.776	0.060	6617751.919	0.086	995.812

		Average		**Average**		**Average**	
		Maximum		Maximum		Maximum	
		Minimum		Minimum		Minimum	
		Range	Easting	Range	Northing	Range	RL
ID=9001	**CO=71816**	**395321.962**	395321.976	**6617580.657**	6617580.659	**997.567**	997.547
ID=9051	CO=71816	395321.976	395321.968	6617580.668	6617580.658	997.616	997.543
ID=9052	CO=71816	395321.940	395321.963	6617580.650	6617580.655	997.511	997.551
ID=9053	CO=71816	0.036	395321.956	0.018	6617580.658	0.105	997.544
ID=9100	CO=71816		395321.969		6617580.668		997.511
ID=8046	CO=71816		395321.940		6617580.650		997.616
ID=8096	CO=71816		395321.973		6617580.653		997.614
ID=8001	CO=71816		395321.952		6617580.657		997.611
ID=9000	**CO=71857**	**395262.050**	395262.052	**6617353.064**	6617353.072	**986.656**	986.629
ID=9054	CO=71857	395262.073	395262.048	6617353.074	6617353.074	986.709	986.630
ID=9055	CO=71857	395262.028	395262.050	6617353.048	6617353.074	986.618	986.648
ID=9056	CO=71857	0.045	395262.044	0.026	6617353.063	0.091	986.635
ID=9101	CO=71857		395262.048		6617353.067		986.618
ID=8047	CO=71857		395262.028		6617353.055		986.709
ID=8097	CO=71857		395262.057		6617353.048		986.702
ID=8000	CO=71857		395262.073		6617353.055		986.679
ID=9096	**CO=7240**	**394915.514**	394915.550	**6617777.922**	6617777.904	**989.976**	989.758
ID=8038	CO=7240	394915.550	394915.478	6617777.959	6617777.913	990.081	990.081
ID=8089	CO=7240	394915.478	394915.499	6617777.904	6617777.959	989.758	990.067
ID=9045	CO=7420	0.072	394915.529	0.055	6617777.910	0.323	989.997

		Average		**Average**		**Average**	
		Maximum		Maximum		Maximum	
		Minimum		Minimum		Minimum	
		Range	Easting	Range	Northing	Range	RL
ID=8023	**CO=BA7 1020**	**395196.545**	395196.508	**6617596.128**	6617596.159	**994.404**	994.469
ID=8058	CO=BA7 1020	395196.570	395196.537	6617596.159	6617596.074	994.469	994.416
ID=9013	CO=BA71020	395196.508	395196.565	6617596.074	6617596.141	994.348	994.348
ID=9068	CO=BA71020	0.062	395196.570	0.085	6617596.139	0.121	994.381
ID=9030	**CO=CLOUT2010**	**395082.081**	395082.008	**6617638.103**	6617638.086	**993.500**	993.469
ID=9082	CO=CLOUT2010	395082.221	395082.048	6617638.130	6617638.085	993.547	993.452
ID=8025	CO=CLOUT2010	395082.008	395082.221	6617638.085	6617638.130	993.452	993.532
ID=8076	CO=CLOUT2010	0.213	395082.045	0.045	6617638.112	0.095	993.547
ID=9033	**CO=CLOUT2270**	**394953.977**	394953.991	**6617543.749**	6617543.736	**988.914**	988.893
ID=9085	CO=CLOUT2270	394953.991	394953.942	6617543.770	6617543.770	988.957	988.862
ID=8027	CO=CLOUT2270	394953.942	394953.985	6617543.735	6617543.754	988.862	988.957
ID=8079	CO=CLOUT2270	0.049	394953.990	0.035	6617543.735	0.095	988.945
ID=9032	**CO=CLOUT2280**	**394968.209**	394968.224	**6617556.253**	6617556.255	**989.078**	989.069
ID=9084	CO=CLOUT2280	394968.224	394968.215	6617556.282	6617556.282	989.135	989.018
ID=8028	CO=CLOUT2280	394968.183	394968.215	6617556.228	6617556.246	989.018	989.135
ID=8078	CO=CLOUT2280	0.041	394968.183	0.054	6617556.228	0.117	989.089
ID=9003	**CO=CLOUT8111**	**395161.432**	395161.404	**6617868.635**	6617868.600	**1001.575**	1001.568
ID=9057	CO=CLOUT8111	395161.479	395161.466	6617868.687	6617868.656	1001.744	1001.744
ID=8003	CO=CLOUT8111	395161.379	395161.479	6617868.595	6617868.687	1001.484	1001.505
ID=8048	CO=CLOUT8111	0.100	395161.379	0.092	6617868.595	0.260	1001.484

		Average		**Average**		**Average**	
		Maximum		Maximum		Maximum	
		Minimum		Minimum		Minimum	
		Range	Easting	Range	Northing	Range	RL
ID=9039	**CO=FCE**	**394846.908**	394846.907	**6617691.985**	6617691.968	**983.933**	983.876
ID=8042	CO=FCE		394846.928		6617692.021		983.974
ID=8085	CO=FCE		394846.889		6617691.965		983.950
ID=9028	**CO=INT2210**	**395047.758**	395047.777	**6617417.238**	6617417.186	**983.820**	983.744
ID=9080	CO=INT2210	395047.838	395047.838	6617417.379	6617417.065	983.871	983.871
ID=8029	CO=INT2210	395047.698	395047.719	6617417.065	6617417.379	983.744	983.830
ID=8074	CO=INT2210	0.140	395047.698	0.314	6617417.320	0.127	983.835
ID=9014	**CO=PEG1020**	**395196.647**	395196.645	**6617595.551**	6617595.522	**994.327**	994.333
ID=9069	CO=PEG1020	395196.655	395196.641	6617595.575	6617595.563	994.356	994.291
ID=8024	CO=PEG1020	395196.641	395196.655	6617595.522	6617595.542	994.291	994.356
ID=8059	CO=PEG1020	0.014	395196.645	0.053	6617595.575	0.065	994.326
ID=9023	**CO=PEG1060**	**395261.564**	395261.574	**6617352.383**	6617352.377	**986.697**	986.668
ID=9075	CO=PEG1060	395261.574	395261.569	6617352.390	6617352.390	986.753	986.644
ID=8017	CO=PEG1060	395261.544	395261.544	6617352.375	6617352.375	986.644	986.722
ID=8069	CO=PEG1060	0.030	395261.568	0.015	6617352.388	0.109	986.753
ID=8070	**CO=PEG1070**	**395164.367**	395164.344	**6617382.368**	6617382.378	**984.451**	984.478
ID=9025	CO=PEG1070	395164.376	395164.374	6617382.378	6617382.365	984.489	984.407
ID=9077	CO=PEG1070	395164.344	395164.376	6617382.355	6617382.355	984.407	984.431
ID=8018	CO=PEG1070	0.032	395164.375	0.023	6617382.374	0.082	984.489

		Average		**Average**		**Average**	
		Maximum		Maximum		Maximum	
		Minimum		Minimum		Minimum	
		Range	Easting	Range	Northing	Range	RL
ID=9026	**CO=PEG1090**	**395068.256**	395068.266	**6617412.062**	6617412.051	**984.331**	984.296
ID=9078	CO=PEG1090	395068.266	395068.261	6617412.086	6617412.056	984.360	984.312
ID=8020	CO=PEG1090	395068.247	395068.248	6617412.051	6617412.086	984.296	984.360
ID=8072	CO=PEG1090	0.019	395068.247	0.035	6617412.053	0.064	984.357
ID=9020	**CO=PEG5130**	**395359.263**	395359.272	**6617601.835**	6617601.824	**998.101**	998.073
ID=9072	CO=PEG5130	395359.272	395359.269	6617601.845	6617601.837	998.151	998.043
ID=8014	CO=PEG5130	395359.244	395359.265	6617601.824	6617601.833	998.043	998.138
ID=8066	CO=PEG5130	0.028	395359.244	0.021	6617601.845	0.108	998.151
ID=9034	**CO=STHCNR**	**394915.441**	394915.497	**6617553.229**	6617553.225	**987.921**	987.911
ID=9086	CO=STHCNR	394915.531	394915.492	6617553.280	6617553.200	987.963	987.901
ID=8030	CO=STHCNR	394915.243	394915.243	6617553.200	6617553.280	987.901	987.963
ID=8080	CO=STHCNR	0.288	394915.531	0.080	6617553.210	0.062	987.908
ID=9035	**CO=STHPEG1**	**394877.697**	394877.693	**6617596.171**	6617596.187	**986.426**	986.414
ID=9087	CO=STHPEG1	394877.703	394877.703	6617596.187	6617596.164	986.467	986.379
ID=8031	CO=STHPEG1	394877.690	394877.703	6617596.162	6617596.171	986.379	986.467
ID=8081	CO=STHPEG1	0.013	394877.690	0.025	6617596.162	0.088	986.443
ID=9036	**CO=STHPEG2**	**394861.618**	394861.625	**6617584.144**	6617584.139	**986.405**	986.388
ID=9088	CO=STHPEG2	394861.625	394861.622	6617584.159	6617584.159	986.451	986.355
ID=8032	CO=STHPEG2	394861.611	394861.611	6617584.139	6617584.139	986.355	986.451
ID=8082	CO=STHPEG2	0.014	394861.613	0.020	6617584.140	0.096	986.425

		Easting		Northing		RL	
	Av Range on PMs	0.038		0.025		0.097	
	Av Range on Peg	0.055		0.034		0.084	
	Av Range at Post	0.081		0.088		0.130	

Excepted Mean MGA 56 Value Converted to ISG 56/1

Point	**MGA Easting**	**MGA Northing**	**AHD Level**	**ISG Easting**	**ISG Northing**
1000	395096.874	6617611.776	992.973	386809.111	1616434.815
1030	395296.162	6617580.880	997.063	387007.879	1616400.376
1060	395262.943	6617358.597	986.924	386970.708	1616178.650
1070	395166.253	6617383.527	984.544	386874.447	1616205.301
1090	395066.835	6617408.905	983.643	386775.465	1616232.448
124071	395160.051	6617867.697	1001.172	386876.841	1616689.651
2000	395056.861	6617658.920	992.426	386769.929	1616482.676
3000	394816.019	6617773.392	987.695	386531.085	1616601.440
3010	394881.712	6617763.432	987.687	386596.611	1616590.313
3020	394912.684	6617758.403	989.093	386627.498	1616584.733
3070	395077.638	6617733.376	994.953	386792.031	1616556.774
3190	394944.327	6617575.135	988.923	386655.891	1616400.877
3210E	394905.180	6617608.429	986.771	386617.330	1616434.871
3210W	394901.589	6617613.738	986.421	386613.833	1616440.244
4000	395106.701	6617729.310	995.939	386821.026	1616552.191
4160	395112.284	6617640.184	994.389	386825.027	1616462.953
4180	395068.682	6617672.729	992.978	386781.997	1616496.277
4330	395097.659	6617708.067	995.522	386811.605	1616531.105
5000	395285.726	6617829.784	998.178	387001.861	1616649.501
5030	395391.474	6617813.987	992.065	387107.343	1616631.824
5340	395253.725	6617617.487	997.064	386966.085	1616437.741
6000	395155.540	6617849.752	1000.965	386872.010	1616671.783
6015	395209.274	6617842.076	1001.275	386925.616	1616663.152
6040	395266.057	6617832.914	998.945	386982.244	1616652.981
6100	395249.981	6617727.675	1000.877	386964.297	1616548.012
6150	395114.168	6617747.693	996.874	386828.820	1616570.444
7000	394935.363	6617883.099	995.672	386652.394	1616709.044
7090	395126.051	6617854.636	1000.084	386842.604	1616677.192
7150	395082.813	6617751.934	995.771	386797.536	1616575.242
71816	395321.962	6617580.657	997.567	387033.678	1616399.694
71857	395262.050	6617353.064	986.656	386969.716	1616173.132
7240	394915.514	6617777.922	989.976	386630.675	1616604.204
BA7 1020	395196.545	6617596.128	994.404	386908.518	1616417.395
CLOUT2010	395082.081	6617638.103	993.500	386794.783	1616461.408
CLOUT2270	394953.977	6617543.749	988.914	386664.985	1616369.315
CLOUT2280	394968.209	6617556.253	989.078	386679.441	1616381.568
CLOUT8111	395161.432	6617868.635	1001.575	386878.239	1616690.564

FCE	394846.908	6617691.985	983.933	386560.533	1616519.473
INT2210	395047.758	6617417.238	983.820	386756.533	1616241.121
Point	**MGA Easting**	**MGA Northing**	**AHD Level**	**ISG Easting**	**ISG Northing**
PEG1020	395196.647	6617595.551	994.327	386908.610	1616416.816
PEG1060	395261.564	6617352.383	986.697	386969.218	1616172.460
PEG1070	395164.367	6617382.368	984.451	386872.540	1616204.175
PEG1090	395068.256	6617412.062	984.331	386776.942	1616235.580
PEG5130	395359.263	6617601.835	998.101	387071.361	1616420.213
STHCNR	394915.441	6617553.229	987.921	386626.612	1616379.481
STHPEG1	394877.697	6617596.171	986.426	386589.625	1616423.099
STHPEG2	394861.618	6617584.144	986.405	386573.331	1616411.356
Av Range on PMs	0.038	0.025	0.097		
Av Range on Pegs	0.055	0.034	0.084		
Av Range at Posts	0.081	0.088	0.130		

Appendix F

Results of Adjustments

Point	1Pt & Azimuth 8000 Easting	1Pt & Azimuth 8000 Northing	1Pt & Azimuth 25000 Easting	1Pt& Azimuth 25000 Northing
1000	386809.147	1616434.210	386808.008	1616435.410
1020	386908.306	1616417.435	386907.167	1616418.635
1030	387007.529	1616400.650	387006.390	1616401.850
1060	386968.946	1616172.696	386967.807	1616173.896
1070	386872.283	1616204.449	386871.144	1616205.649
1080	386776.699	1616235.847	386775.560	1616237.047
1090	386775.623	1616236.028	386774.484	1616237.229
1200	386940.807	1616411.937	386939.668	1616413.137
1210	386789.314	1616437.565	386788.175	1616438.765
2000	386769.252	1616482.894	386768.113	1616484.094
2010	386793.346	1616461.400	386792.207	1616462.600
2210	386756.191	1616241.812	386755.052	1616243.012
2270	386664.157	1616370.221	386663.018	1616371.421
2280	386676.856	1616379.324	386675.717	1616380.524
3000	386547.634	1616597.852	386546.495	1616599.052
3010	386597.206	1616589.466	386596.067	1616590.666
3020	386626.954	1616584.434	386625.815	1616585.634
3070	386789.785	1616556.889	386788.646	1616558.089
3080	386785.001	1616545.870	386783.862	1616547.071
3190	386656.565	1616401.901	386655.426	1616403.101
3200	386646.579	1616394.744	386645.440	1616395.944
3410	386584.415	1616481.461	386583.276	1616482.661
3420	386613.004	1616501.953	386611.865	1616503.153
3480	386585.327	1616519.237	386584.188	1616520.438
3490	386572.980	1616510.387	386571.841	1616511.587
3500	386544.199	1616577.542	386543.060	1616578.742
4000	386820.427	1616551.706	386819.288	1616552.906
4060	386960.445	1616528.020	386959.306	1616529.220
4090	386945.839	1616441.686	386944.700	1616442.886
4160	386822.225	1616462.594	386821.086	1616463.794
4180	386782.642	1616497.904	386781.503	1616499.104
4330	386810.744	1616529.406	386809.606	1616530.606
5000	387001.426	1616649.669	387000.287	1616650.869
5030	387106.597	1616631.878	387105.458	1616633.078
5130	387070.845	1616420.540	387069.706	1616421.740
5340	386965.672	1616438.331	386964.533	1616439.531
6000	386872.429	1616671.493	386871.290	1616672.693
6040	386981.593	1616653.025	386980.454	1616654.225
6100	386963.800	1616547.852	386962.661	1616549.052
6150	386828.677	1616570.711	386827.539	1616571.911
7000	386648.104	1616709.440	386646.965	1616710.640
7090	386841.787	1616676.676	386840.648	1616677.876
7150	386798.036	1616575.894	386796.897	1616577.094
7240	386630.309	1616604.267	386629.170	1616605.467

Point	1Pt & Azimuth GPS Easting	1Pt & Azimuth GPS Northing	Multi Point 8000 Easting	Multi Point 8000 Northing
1000	386809.451	1616433.591	386808.975	1616434.707
1020	386908.610	1616416.816	386908.306	1616417.435
1030	387007.833	1616400.031	387007.339	1616400.277
1060	386969.250	1616172.077	386967.856	1616172.523
1070	386872.587	1616203.830	386871.444	1616204.619
1080	386777.003	1616235.228	386775.859	1616236.439
1090	386775.927	1616235.410	386774.660	1616236.646
1200	386941.111	1616411.318	386940.406	1616411.874
1210	386789.618	1616436.946	386789.590	1616438.066
2000	386769.556	1616482.275	386769.761	1616482.404
2010	386793.650	1616460.782	386793.564	1616461.000
2210	386756.494	1616241.193	386755.508	1616241.352
2270	386664.461	1616369.602	386664.063	1616370.007
2280	386677.160	1616378.705	386676.884	1616379.119
3000	386547.938	1616597.233	386547.796	1616598.494
3010	386597.510	1616588.848	386597.333	1616589.911
3020	386627.259	1616583.816	386627.075	1616584.758
3070	386790.089	1616556.270	386790.378	1616556.469
3080	386785.305	1616545.252	386785.498	1616545.349
3190	386656.869	1616401.282	386656.538	1616401.938
3200	386646.883	1616394.125	386646.460	1616394.774
3410	386584.719	1616480.842	386584.385	1616482.108
3420	386613.308	1616501.334	386612.788	1616502.297
3480	386585.631	1616518.619	386585.169	1616519.698
3490	386573.284	1616509.768	386572.794	1616510.903
3500	386544.503	1616576.923	386544.277	1616578.183
4000	386820.731	1616551.087	386821.216	1616551.126
4060	386960.749	1616527.401	386960.356	1616527.023
4090	386946.143	1616441.067	386945.636	1616442.061
4160	386822.529	1616461.975	386822.240	1616463.437
4180	386782.946	1616497.285	386783.793	1616498.009
4330	386811.049	1616528.787	386811.358	1616528.664
5000	387001.730	1616649.050	387001.961	1616649.377
5030	387106.901	1616631.259	387106.959	1616631.825
5130	387071.149	1616419.921	387071.291	1616420.295
5340	386965.976	1616437.712	386965.450	1616438.628
6000	386872.733	1616670.874	386874.176	1616671.798
6040	386981.898	1616652.405	386982.420	1616653.048
6100	386964.104	1616547.233	386963.935	1616547.683
6150	386828.982	1616570.092	386829.695	1616570.445
7000	386648.409	1616708.821	386648.970	1616710.811
7090	386842.091	1616676.057	386843.338	1616677.141
7150	386798.340	1616575.275	386798.846	1616575.764
7240	386630.614	1616603.648	386630.490	1616604.151

Point	Multi Point 25000 Easting	Multi Point 25000 Northing	Fence Multi Point GPS Easting	Fence Multi Point GPS Northing
1000	386808.942	1616436.198	386809.422	1616434.044
1020	386907.167	1616418.635	386908.518	1616417.395
1030	387006.996	1616402.479	387007.879	1616400.376
1060	386970.156	1616175.003	386969.662	1616173.040
1070	386872.746	1616206.235	386872.800	1616204.738
1080	386777.269	1616236.847	386776.869	1616236.131
1090	386776.692	1616236.941	386776.190	1616236.245
1200	386941.117	1616413.142	386941.370	1616411.550
1210	386789.969	1616439.269	386789.943	1616437.317
2000	386769.696	1616483.301	386769.929	1616482.676
2010	386793.682	1616462.209	386793.969	1616461.280
2210	386758.116	1616242.442	386757.001	1616241.244
2270	386665.364	1616369.918	386664.985	1616369.315
2280	386678.215	1616379.268	386676.376	1616377.500
3000	386546.442	1616597.945	386548.099	1616598.072
3010	386596.069	1616589.913	386597.677	1616589.743
3020	386625.945	1616585.078	386627.498	1616584.733
3070	386790.403	1616558.131	386789.833	1616557.445
3080	386785.575	1616546.792	386784.481	1616545.079
3190	386657.874	1616401.577	386655.730	1616400.418
3200	386647.710	1616394.181	386647.095	1616394.214
3410	386584.168	1616481.510	386584.627	1616481.161
3420	386612.523	1616502.141	386613.594	1616501.973
3480	386584.638	1616519.281	386585.836	1616519.265
3490	386572.436	1616510.402	386573.561	1616510.446
3500	386543.127	1616577.466	386544.669	1616577.653
4000	386820.903	1616553.184	386820.933	1616552.220
4060	386960.134	1616530.647	386961.049	1616528.677
4090	386945.999	1616443.307	386946.328	1616441.060
4160	386822.728	1616463.259	386822.627	1616461.843
4180	386782.882	1616498.297	386782.876	1616497.223
4330	386811.290	1616530.603	386810.624	1616528.401
5000	387002.134	1616650.658	387001.861	1616649.501
5030	387107.426	1616633.618	387107.343	1616631.824
5130	387073.291	1616422.706	387071.361	1616420.213
5340	386967.991	1616439.748	386966.085	1616437.741
6000	386871.863	1616673.251	386872.522	1616671.415
6040	386981.752	1616654.198	386982.244	1616652.981
6100	386963.135	1616549.193	386964.297	1616548.012
6150	386828.434	1616570.906	386828.820	1616570.444
7000	386644.997	1616709.454	386648.296	1616709.087
7090	386841.293	1616677.681	386841.423	1616676.640
7150	386797.968	1616575.904	386797.536	1616575.242
7240	386628.164	1616605.461	386630.675	1616604.204

Point	Surveyed Reference Marks Easting	Surveyed Reference Marks Northing	Actual GPS Fence Post Easting	Actual GPS Fence Post Northing	DCDB Easting	DCDB Northing
1000	386809.988	1616433.462	386809.111	1616434.815	386811.15	1616440.08
1020	386908.61	1616416.816	386908.518	1616417.395	386910.79	1616423.64
1030	387007.747	1616400.149	387007.879	1616400.376	387010.71	1616407.09
1060	386969.218	1616172.46	386970.708	1616178.650	386972.22	1616176.04
1070	386872.54	1616204.175	386874.447	1616205.301	386874.16	1616208.15
1080	386777.52	1616235.3				
1090	386776.942	1616235.58	386775.465	1616232.448	386777.2	1616239.89
1200	386941.201	1616411.371				
1210	386789.901	1616436.847				
2000	386769.759	1616482.598	386769.929	1616482.676	386770.97	1616490.51
2010	386793.974	1616461.026	386794.783	1616461.408	386795.63	1616467.25
2210	386756.941	1616241.472	386756.533	1616241.121	386758.26	1616246.14
2270	386664.763	1616369.894	386664.985	1616369.315	386664.9	1616375.72
2280	386677.437	1616378.99	386679.441	1616381.568	386677.24	1616384.17
3000	386547.991	1616597.346	386531.085	1616601.440	386548.94	1616605.05
3010	386597.568	1616588.991	386596.611	1616590.313	386599.91	1616597.1
3020	386627.31	1616583.979	386627.498	1616584.733	386629.51	1616591.43
3070	386790.143	1616556.522	386792.031	1616556.774	386792.39	1616564.74
3080	386785.377	1616545.526			386786.52	1616551.48
3190	386657.076	1616401.615	386655.891	1616400.877	386660.37	1616407.58
3200	386647.123	1616394.471			386647.44	1616398.93
3410	386584.933	1616481.093			386584.83	1616487.57
3420	386613.423	1616501.541			386615.12	1616508.73
3480	386585.741	1616518.803			386588.41	1616526.9
3490	386573.388	1616509.936			386573.55	1616516.6
3500	386544.572	1616577.054			386544.82	1616582.91
4000	386820.812	1616551.354	386821.026	1616552.191	386822.27	1616559.28
4060	386960.818	1616527.742			386963.97	1616535.63
4090	386946.248	1616441.311			386949.25	1616446.83
4160	386822.688	1616462.164	386825.027	1616462.953	386823.07	1616467.59
4180	386783.034	1616497.499	386781.997	1616496.277	386783.94	1616504.72
4330	386811.152	1616529.064	386811.605	1616531.105	386812.3	1616535.31
5000	387001.752	1616649.374	387001.861	1616649.501	387005.35	1616657.7
5030	387106.972	1616631.638	387107.343	1616631.824	387112.85	1616639.88
5130	387071.361	1616420.213	387071.361	1616420.213	387076.38	1616425.2
5340	386966.128	1616437.961	386966.085	1616437.741	386968.13	1616443.58
6000	386872.715	1616671.125	386872.010	1616671.783	386876.2	1616679.81
6040	386981.884	1616652.722	386982.244	1616652.981	386985.99	1616661.3
6100	386964.159	1616547.565	386964.297	1616548.012	386967.58	1616554.34
6150	386829.038	1616570.336	386828.820	1616570.444	386830.57	1616577.29
7000	386648.366	1616708.937	386652.394	1616709.044	386650.47	1616717.21
7090	386842.054	1616676.293	386842.604	1616677.192	386845.63	1616684.48
7150	386798.37	1616575.504	386797.536	1616575.242	386800.01	1616581.86
7240	386630.645	1616603.773	386630.675	1616604.204	386632.25	1616610.48
8111	386878.239	1616690.564	386878.239	1616690.564	386884.51	1616698.8
8200	386983.422	1616672.84			386988.94	1616681.12
9000	386589.625	1616423.099	386589.625	1616423.099	386589.54	1616428.56
9001	386573.331	1616411.356	386573.331	1616411.356	386573.62	1616417.25
9010	386622.73	1616376.967	386626.612	1616379.481	386623.22	1616382.15

Appendix G

Reduction of PM Observations

Observed Data:

Point	PM Number	Observed Average Maximum Minimum Range	MGA Easting Observed	Observed Average Maximum Minimum Range	MGA Northing Observed
ID=9002	*124071*	***395160.051***	*395160.066*	***6617867.697***	*6617867.700*
ID=9048	124071	395160.066	395160.045	6617867.717	6617867.694
ID=9049	124071	395160.033	395160.043	6617867.685	6617867.693
ID=9050	124071	0.033	395160.048	0.032	6617867.692
ID=9099	124071		395160.060		6617867.699
ID=8002	124071		395160.054		6617867.699
ID=8045	*124071*		*395160.033*		*6617867.717*
ID=8095	*124071*		*395160.061*		*6617867.685*
ID=9001	71816	**395321.962**	395321.976	**6617580.657**	6617580.659
ID=9051	71816	395321.976	395321.968	6617580.668	6617580.658
ID=9052	71816	395321.940	395321.963	6617580.650	6617580.655
ID=9053	71816	0.036	395321.956	0.018	6617580.658
ID=9100	71816		395321.969		6617580.668
ID=8046	*71816*		*395321.940*		*6617580.650*
ID=8096	*71816*		*395321.973*		*6617580.653*
ID=8001	71816		395321.952		6617580.657
ID=9000	71857	**395262.050**	395262.052	**6617353.064**	6617353.072
ID=9054	71857	395262.073	395262.048	6617353.074	6617353.074
ID=9055	71857	395262.028	395262.050	6617353.048	6617353.074
ID=9056	71857	0.045	395262.044	0.026	6617353.063
ID=9101	71857		395262.048		6617353.067
ID=8047	*71857*		*395262.028*		*6617353.055*
ID=8097	71857		395262.057		6617353.048
ID=8000	*71857*		*395262.073*		*6617353.055*
Adopted Values		**Easting**		**Northing**	
PM 124071		395160.050		6617867.695	
PM 71816		395321.964		6617580.659	
PM 71857		395262.050		6617353.066	

Reduction of Eastings:

Point	PM Number	Observed Average Maximum Minimum Range RL	Observed AHD Reduced Level	Base Station Easting Average	Base Station Easting Diff	Base Station Easting Maximum Minimum Range
ID=9002	*124071*	***1001.172***	*1001.142*		*-0.014*	*395160.066*
ID=9048	124071	1001.234	1001.169	395160.052	0.007	395160.043
ID=9049	124071	1001.138	1001.157		0.009	0.023
ID=9050	124071	0.096	1001.138		0.004	
ID=9099	124071		1001.147		-0.008	
ID=8002	124071		1001.234	395160.049	-0.005	395160.061
ID=8045	*124071*		*1001.167*		*0.016*	*395160.033*
ID=8095	*124071*		*1001.221*		*-0.012*	*0.028*
ID=9001	71816	**997.567**	997.547		-0.010	395321.976
ID=9051	71816	997.616	997.543	395321.966	-0.002	395321.956
ID=9052	71816	997.511	997.551		0.003	0.020
ID=9053	71816	0.105	997.544		0.010	
ID=9100	71816		997.511		-0.003	
ID=8046	*71816*		*997.616*	*395321.955*	*0.015*	*395321.973*
ID=8096	*71816*		*997.614*		*-0.018*	*395321.940*
ID=8001	71816		997.611		0.003	0.033
ID=9000	71857	**986.656**	986.629		-0.004	395262.052
ID=9054	71857	986.709	986.630	395262.048	0.000	395262.044
ID=9055	71857	986.618	986.648		-0.002	0.008
ID=9056	71857	0.091	986.635		0.004	
ID=9101	71857		986.618		0.000	
ID=8047	*71857*		*986.709*	*395262.053*	*0.025*	*395262.073*
ID=8097	71857		986.702		-0.004	395262.028
ID=8000	*71857*		*986.679*		*-0.020*	*0.045*
Adopted Values		**AHD**				
PM 124071		1001.169				
PM 71816		997.551				
PM 71857		986.644				

Reduction of Northings and Distance to Average Position:

Point	PM Number	Base Station Northing Average	Base Station Northing Diff	Base Station Northing Maximum Minimum Range	Distance from Base Station Average
ID=9002	*124071*		*-0.004*	*6617867.700*	***0.014***
ID=9048	124071	6617867.696	0.002	6617867.692	0.008
ID=9049	124071		0.003	0.008	0.010
ID=9050	124071		0.004		0.006
ID=9099	124071		-0.003		0.008
ID=8002	124071	6617867.700	0.001	6617867.717	0.005
ID=8045	*124071*		*-0.017*	*6617867.685*	***0.023***
ID=8095	*124071*		*0.015*	*0.032*	***0.019***
ID=9001	71816		0.001	6617580.668	0.010
ID=9051	71816	6617580.660	0.002	6617580.655	0.002
ID=9052	71816		0.005	0.013	0.006
ID=9053	71816		0.002		0.011
ID=9100	71816		-0.008		0.009
ID=8046	*71816*	*6617580.653*	*0.003*	*6617580.657*	***0.015***
ID=8096	*71816*		*0.000*	*6617580.650*	***0.018***
ID=8001	71816		-0.004	0.007	0.005
ID=9000	71857		-0.002	6617353.074	0.004
ID=9054	71857	6617353.070	-0.004	6617353.063	0.004
ID=9055	71857		-0.004	0.011	0.004
ID=9056	71857		0.007		0.008
ID=9101	71857		0.003		0.003
ID=8047	*71857*	*6617353.053*	*-0.002*	*6617353.055*	***0.025***
ID=8097	71857		0.005	6617353.048	0.006
ID=8000	*71857*		*-0.002*	*0.007*	***0.020***
Av					0.010
Max					0.025
Min					0.002
Std Dev					0.0067

Reduction of Reduced Levels and Precision of Observations:

Point	PM Number	Base Station RL Average	Base Station RL Diff	Base Station AHD RL Maximum Minimum Range	Horizontal Precision	Vertical Precision
ID=9002	*124071*		*0.009*	*1001.169*	*0.007*	*0.011*
ID=9048	124071	1001.151	-0.018	1001.138	0.010	0.019
ID=9049	124071		-0.006	0.031	0.007	0.012
ID=9050	124071		0.013		0.007	0.014
ID=9099	124071		0.004		0.006	0.010
ID=8002	124071	1001.207	-0.027	1001.234	0.007	0.009
ID=8045	*124071*		*0.040*	*1001.167*	*0.008*	*0.012*
ID=8095	*124071*		*-0.014*	*0.067*	*0.007*	*0.011*
ID=9001	71816		-0.008	997.551	0.007	0.009
ID=9051	71816	997.539	-0.004	997.511	0.010	0.019
ID=9052	71816		-0.012	0.040	0.007	0.014
ID=9053	71816		-0.005		0.008	0.016
ID=9100	71816		0.028		0.006	0.010
ID=8046	*71816*	*997.614*	*-0.002*	*997.616*	*0.006*	*0.009*
ID=8096	*71816*		*0.000*	*997.611*	*0.006*	*0.010*
ID=8001	71816		0.003	0.005	0.007	0.009
ID=9000	71857		0.003	986.648	0.008	0.011
ID=9054	71857	986.632	0.002	986.618	0.007	0.014
ID=9055	71857		-0.016	0.030	0.007	0.012
ID=9056	71857		-0.003		0.008	0.016
ID=9101	71857		0.014		0.006	0.010
ID=8047	*71857*	*986.697*	*-0.012*	*986.709*	*0.006*	*0.010*
ID=8097	71857		-0.005	986.679	0.006	0.010
ID=8000	*71857*		*0.018*	*0.030*	*0.010*	*0.013*
Av			0.000			
Max			0.040			
Min			-0.027			
Std Dev			0.0150			

Date Time and Base Station for Observation:

Point	PM Number	Date	Time	RMS	Base
ID=9002	*124071*	*18/08/2005*	*11:13:00 AM*	*15.3*	*Bora Trig*
ID=9048	124071	18/08/2005	12:37:00 PM	25.6	Bora Trig
ID=9049	124071	18/08/2005	12:43:00 PM	46.7	Bora Trig
ID=9050	124071	18/08/2005	12:51:00 PM	23.2	Bora Trig
ID=9099	124071	18/08/2005	3:05:00 PM	18.9	Bora Trig
ID=8002	124071	17/08/2005	9:42:00 AM	21.3	B4
ID=8045	*124071*	*17/08/2005*	*11:23:00 AM*	*10.9*	*B4*
ID=8095	*124071*	*17/08/2005*	*1:56:00 PM*	*11.9*	*B4*
ID=9001	71816	18/08/2005	11:07:00 AM	13.3	Bora Trig
ID=9051	71816	18/08/2005	1:07:00 PM	18.9	Bora Trig
ID=9052	71816	18/08/2005	1:12:00 PM	39.6	Bora Trig
ID=9053	71816	18/08/2005	1:17:00 PM	26.8	Bora Trig
ID=9100	71816	18/08/2005	3:12:00 PM	17.1	Bora Trig
ID=8046	*71816*	*17/08/2005*	*11:29:00 AM*	*7.9*	*B4*
ID=8096	*71816*	*17/08/2005*	*2:02:00 PM*	*12.0*	*B4*
ID=8001	71816	17/08/2005	9:37:00 AM	13.9	B4
ID=9000	71857	18/08/2005	10:58:00 AM	18.7	Bora Trig
ID=9054	71857	18/08/2005	1:27:00 PM	14.6	Bora Trig
ID=9055	71857	18/08/2005	1:33:00 PM	24.9	Bora Trig
ID=9056	71857	18/08/2005	1:38:00 PM	22.6	Bora Trig
ID=9101	71857	18/08/2005	3:16:00 PM	11.8	Bora Trig
ID=8047	*71857*	*17/08/2005*	*11:33:00 AM*	*12.3*	*B4*
ID=8097	71857	17/08/2005	2:07:00 PM	13.6	B4
ID=8000	*71857*	*17/08/2005*	*9:31:00 AM*	*37.6*	*B4*

Appendix H

Comparison of Results in Detail

Delta	1Pt & Azimuth 8000			1Pt & Azimuth 25000			1Pt & Azimuth GPS Svy		
Point	Delta E	Delta N	Dist	Delta E	Delta N	Dist	Delta E	Delta N	Dist
1000	0.841	-0.748	1.126	1.980	-1.948	2.778	0.537	-0.129	0.552
1020	0.304	-0.619	0.690	1.443	-1.819	2.322	0.000	0.000	0.000
1030	0.218	-0.501	0.546	1.357	-1.701	2.176	-0.086	0.118	0.146
1060	0.272	-0.236	0.360	1.411	-1.436	2.013	-0.032	0.383	0.384
1070	0.257	-0.274	0.376	1.396	-1.474	2.030	-0.047	0.345	0.348
1080	0.821	-0.547	0.987	1.960	-1.747	2.626	0.517	0.072	0.522
1090	1.319	-0.448	1.393	2.458	-1.649	2.960	1.015	0.170	1.029
1200	0.394	-0.566	0.690	1.533	-1.766	2.339	0.090	0.053	0.104
1210	0.587	-0.718	0.927	1.726	-1.918	2.580	0.283	-0.099	0.300
2000	0.507	-0.296	0.587	1.646	-1.496	2.224	0.203	0.323	0.381
2010	0.628	-0.374	0.731	1.767	-1.574	2.366	0.324	0.244	0.406
2210	0.750	-0.340	0.823	1.889	-1.540	2.437	0.447	0.279	0.527
2270	0.606	-0.327	0.689	1.745	-1.527	2.319	0.302	0.292	0.420
2280	0.581	-0.334	0.670	1.720	-1.534	2.305	0.277	0.285	0.397
3000	0.357	-0.506	0.619	1.496	-1.706	2.269	0.053	0.113	0.125
3010	0.362	-0.475	0.597	1.501	-1.675	2.249	0.058	0.143	0.154
3020	0.356	-0.455	0.578	1.495	-1.655	2.230	0.051	0.163	0.171
3070	0.358	-0.367	0.513	1.497	-1.567	2.167	0.054	0.252	0.258
3080	0.376	-0.344	0.510	1.515	-1.545	2.164	0.072	0.274	0.283
3190	0.511	-0.286	0.586	1.650	-1.486	2.221	0.207	0.333	0.392
3200	0.544	-0.273	0.609	1.683	-1.473	2.237	0.240	0.346	0.421
3410	0.518	-0.368	0.635	1.657	-1.568	2.281	0.214	0.251	0.330
3420	0.419	-0.412	0.588	1.558	-1.612	2.242	0.115	0.207	0.237
3480	0.414	-0.434	0.600	1.553	-1.635	2.255	0.110	0.184	0.214
3490	0.408	-0.451	0.608	1.547	-1.651	2.263	0.104	0.168	0.198
3500	0.373	-0.488	0.614	1.512	-1.688	2.266	0.069	0.131	0.148
4000	0.385	-0.352	0.522	1.524	-1.552	2.175	0.081	0.267	0.279
4060	0.373	-0.278	0.465	1.512	-1.478	2.114	0.069	0.341	0.348
4090	0.409	-0.375	0.555	1.548	-1.575	2.208	0.105	0.244	0.266
4160	0.463	-0.430	0.632	1.602	-1.630	2.285	0.159	0.189	0.247
4180	0.392	-0.405	0.564	1.531	-1.605	2.218	0.088	0.214	0.231
4330	0.408	-0.342	0.532	1.546	-1.542	2.184	0.103	0.277	0.296
5000	0.326	-0.295	0.440	1.465	-1.495	2.093	0.022	0.324	0.325
5030	0.375	-0.240	0.445	1.514	-1.440	2.089	0.071	0.379	0.386
5130	0.516	-0.327	0.611	1.655	-1.527	2.252	0.212	0.292	0.361
5340	0.456	-0.370	0.587	1.595	-1.570	2.238	0.152	0.249	0.292
6000	0.286	-0.368	0.466	1.425	-1.568	2.119	-0.018	0.251	0.252
6040	0.291	-0.303	0.420	1.430	-1.503	2.075	-0.014	0.317	0.317
6100	0.359	-0.287	0.460	1.498	-1.487	2.111	0.055	0.332	0.337
6150	0.361	-0.375	0.521	1.499	-1.575	2.174	0.056	0.244	0.250
7000	0.262	-0.503	0.567	1.401	-1.703	2.205	-0.043	0.116	0.124
7090	0.267	-0.383	0.467	1.406	-1.583	2.117	-0.037	0.236	0.239
7150	0.334	-0.390	0.513	1.473	-1.590	2.167	0.030	0.229	0.231
7240	0.336	-0.494	0.597	1.475	-1.694	2.246	0.031	0.125	0.129

Delta	Multi Point 8000			Multi Point 25000			Multi Point GPS Fce		
Point	Delta E	Delta N	Dist	Delta E	Delta N	Dist	Delta E	Delta N	Dist
1000	1.013	-1.245	1.605	1.046	-2.736	2.929	0.566	-0.582	0.812
1020	0.304	-0.619	0.690	1.443	-1.819	2.322	0.092	-0.579	0.586
1030	0.408	-0.128	0.428	0.751	-2.330	2.448	-0.132	-0.227	0.263
1060	1.362	-0.063	1.363	-0.938	-2.543	2.710	-0.444	-0.580	0.730
1070	1.096	-0.444	1.183	-0.206	-2.060	2.070	-0.260	-0.563	0.620
1080	1.661	-1.139	2.014	0.251	-1.547	1.567	0.651	-0.831	1.056
1090	2.282	-1.066	2.519	0.250	-1.361	1.384	0.752	-0.665	1.004
1200	0.795	-0.503	0.941	0.084	-1.771	1.773	-0.169	-0.179	0.246
1210	0.311	-1.219	1.258	-0.068	-2.422	2.423	-0.042	-0.470	0.472
2000	-0.002	0.194	0.194	0.063	-0.703	0.706	-0.170	-0.078	0.187
2010	0.410	0.026	0.411	0.292	-1.183	1.219	0.005	-0.254	0.254
2210	1.433	0.120	1.438	-1.175	-0.970	1.524	-0.060	0.228	0.236
2270	0.700	-0.113	0.709	-0.601	-0.024	0.601	-0.222	0.579	0.620
2280	0.553	-0.129	0.568	-0.778	-0.278	0.826	1.061	1.490	1.829
3000	0.195	-1.148	1.164	1.549	-0.599	1.661	-0.108	-0.726	0.734
3010	0.235	-0.920	0.950	1.499	-0.922	1.760	-0.109	-0.752	0.760
3020	0.235	-0.779	0.814	1.365	-1.099	1.752	-0.188	-0.754	0.777
3070	-0.235	0.053	0.241	-0.260	-1.609	1.630	0.310	-0.923	0.974
3080	-0.121	0.177	0.214	-0.198	-1.266	1.281	0.896	0.447	1.001
3190	0.538	-0.323	0.628	-0.798	0.038	0.799	1.346	1.197	1.801
3200	0.663	-0.303	0.729	-0.587	0.290	0.655	0.028	0.257	0.259
3410	0.548	-1.015	1.153	0.765	-0.417	0.871	0.306	-0.068	0.313
3420	0.635	-0.756	0.987	0.900	-0.600	1.082	-0.171	-0.432	0.465
3480	0.572	-0.895	1.062	1.103	-0.478	1.202	-0.095	-0.462	0.472
3490	0.594	-0.967	1.135	0.952	-0.466	1.060	-0.173	-0.510	0.539
3500	0.295	-1.129	1.167	1.445	-0.412	1.503	-0.097	-0.599	0.607
4000	-0.404	0.228	0.464	-0.091	-1.830	1.832	-0.121	-0.866	0.874
4060	0.462	0.719	0.855	0.684	-2.905	2.984	-0.231	-0.935	0.963
4090	0.612	-0.750	0.968	0.249	-1.996	2.011	-0.080	0.251	0.263
4160	0.448	-1.273	1.350	-0.040	-1.095	1.096	0.061	0.321	0.327
4180	-0.759	-0.510	0.914	0.152	-0.798	0.812	0.158	0.276	0.318
4330	-0.206	0.400	0.450	-0.138	-1.539	1.545	0.528	0.663	0.848
5000	-0.209	-0.003	0.209	-0.382	-1.284	1.340	-0.109	-0.127	0.167
5030	0.013	-0.187	0.187	-0.454	-1.980	2.031	-0.371	-0.186	0.415
5130	0.070	-0.082	0.108	-1.930	-2.493	3.153	0.000	0.000	0.000
5340	0.678	-0.667	0.951	-1.863	-1.787	2.581	0.043	0.220	0.224
6000	-1.461	-0.673	1.609	0.852	-2.126	2.290	0.193	-0.290	0.348
6040	-0.536	-0.326	0.627	0.132	-1.476	1.482	-0.360	-0.259	0.443
6100	0.224	-0.118	0.253	1.024	-1.628	1.923	-0.138	-0.447	0.468
6150	-0.657	-0.109	0.666	0.604	-0.570	0.830	0.218	-0.108	0.243
7000	-0.604	-1.874	1.969	3.369	-0.517	3.408	0.070	-0.150	0.166
7090	-1.284	-0.848	1.539	0.761	-1.388	1.583	0.631	-0.347	0.720
7150	-0.476	-0.260	0.542	0.402	-0.400	0.567	0.834	0.262	0.874
7240	0.155	-0.378	0.409	2.481	-1.688	3.001	-0.030	-0.431	0.432

Delta	Actual GPS Fce			DCDB		
Point	Delta E	Delta N	Dist	Delta E	Delta N	Dist
1000	0.877	-1.353	1.612	-1.162	-6.618	6.719
1020	0.092	-0.579	0.586	-2.180	-6.824	7.164
1030	-0.132	-0.227	0.263	-2.963	-6.941	7.547
1060	-1.490	-6.190	6.367	-3.002	-3.580	4.672
1070	-1.907	-1.126	2.215	-1.620	-3.975	4.292
1080			0.000			
1090	1.477	3.132	3.463	-0.258	-4.310	4.318
1200						
1210						
2000	-0.170	-0.078	0.187	-1.211	-7.912	8.004
2010	-0.809	-0.382	0.895	-1.656	-6.224	6.441
2210	0.408	0.351	0.538	-1.319	-4.668	4.851
2270	-0.222	0.579	0.620	-0.137	-5.826	5.828
2280	-2.004	-2.578	3.265	0.197	-5.180	5.184
3000	16.906	-4.094	17.395	-0.949	-7.704	7.762
3010	0.957	-1.322	1.632	-2.342	-8.109	8.440
3020	-0.188	-0.754	0.777	-2.200	-7.451	7.769
3070	-1.888	-0.252	1.905	-2.247	-8.218	8.520
3080				-1.143	-5.954	6.063
3190	1.185	0.738	1.396	-3.294	-5.965	6.814
3200				-0.317	-4.459	4.470
3410				0.103	-6.477	6.478
3420				-1.697	-7.189	7.387
3480				-2.669	-8.097	8.526
3490				-0.162	-6.664	6.666
3500				-0.248	-5.856	5.861
4000	-0.214	-0.837	0.864	-1.458	-7.926	8.059
4060				-3.152	-7.888	8.494
4090				-3.002	-5.519	6.283
4160	-2.339	-0.789	2.468	-0.382	-5.426	5.439
4180	1.037	1.222	1.603	-0.906	-7.221	7.278
4330	-0.453	-2.041	2.091	-1.148	-6.246	6.351
5000	-0.109	-0.127	0.167	-3.598	-8.326	9.070
5030	-0.371	-0.186	0.415	-5.878	-8.242	10.123
5130				-5.019	-4.987	7.075
5340	0.043	0.220	0.224	-2.002	-5.619	5.965
6000	0.705	-0.658	0.964	-3.485	-8.685	9.358
6040	-0.360	-0.259	0.443	-4.106	-8.578	9.510
6100	-0.138	-0.447	0.468	-3.421	-6.775	7.590
6150	0.218	-0.108	0.243	-1.532	-6.954	7.121
7000	-4.028	-0.107	4.029	-2.104	-8.273	8.536
7090	-0.550	-0.899	1.054	-3.576	-8.187	8.934
7150	0.834	0.262	0.874	-1.640	-6.356	6.564
7240	-0.030	-0.431	0.432	-1.605	-6.707	6.896
8111				-6.271	-8.236	10.352
8200				-5.518	-8.280	9.950
9000				0.085	-5.461	5.462
9001				-0.289	-5.894	5.901
9010	-3.882	-2.514	4.625	-0.490	-5.183	5.206

Results of comparisons

Delta	1Pt & Azimuth 8000			1Pt & Azimuth 25000			1Pt & Azimuth GPS Svy		
Point	Delta E	Delta N	Dist	Delta E	Delta N	Dist	Delta E	Delta N	Dist
Av			0.614			2.259			0.304
Med			0.587			2.233			0.288
Min			0.360			2.013			0.000
Max			1.393			2.960			1.029
Range			1.033			0.947			1.029
Sdev			0.191			0.181			0.163

Delta	Multi Point 8000			Multi Point 25000			Multi Point GPS Fce		
Point	Delta E	Delta N	Dist	Delta E	Delta N	Dist	Delta E	Delta N	Dist
Av			0.901			1.687			0.584
Med			0.885			1.575			0.472
Min			0.108			0.567			0.000
Max			2.519			3.408			1.829
Range			2.411			2.841			1.829
Sdev			0.544			0.755			0.388

Delta	Actual GPS Fce			DCDB		
Point	Delta E	Delta N	Dist	Delta E	Delta N	Dist
Av			1.858			7.035
Med			0.884			7.075
Min			0.000			4.292
Max			17.395			10.123
Range			17.395			5.831
Sdev			3.148			1.486

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