University of Southern Queensland
Faculty of Engineering and Surveying

A Review of a Cadastral Boundary Adjustment Software Program

A dissertation submitted by

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ABSTRACT

The surveying profession continues to suffer from a shortage of personnel in a time when demand for surveyors is increasing. Concurrently, the ongoing improvements in surveying technology have been proven in making surveys more efficient, thereby passing time savings on to clients and the general public who rely on an accurate system of land ownership.

The current system of re-establishing boundaries in Australia is based on survey monument evidence, and relies on the education and experience of a Registered Cadastral Surveyor to make sense of this evidence. Given the shortage of surveyors, there is concern that surveying services may not be provided in a timely manner, or worse, that extra pressure on surveyors may lead to cases of incorrect boundary re-establishment.

This project aims to investigate the potential for recent software technology to perform the boundary re-establishment process, with a view to alleviating the Registered Surveyors workload.

To achieve this aim, a capable software program will be used to re-establish several general boundary problems, and these answers will be compared to that of a Registered Cadastral Surveyor and long established reinstatement doctrine. Results will show that in some of the tested scenarios the software solutions are the same as the human results, but many were found to be in disagreement. It will be observed that the methods used by the software in solving such problems are, although mathematically sound, not capable of the analysis and reasoning of a Registered Surveyor.

This project will provide a foundation for future research into the programming of boundary reinstatement software, and will enable informed decision making in surveying practices as to the potential for this software to alleviate staff workloads.

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CERTIFICATION

I certify that the ideas, designs and experimental work, results, analysis 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.

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Date

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TABLE OF CONTENTS

Contents **Page**

CHAPTER 3 - METHOD

CHAPTER 4 - DATA ANALYSIS.

APPENDICES

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

The following abbreviations have been used throughout the text and bibliography:-

RS	Registered Surveyor.
GC	GeoCadastre Adjustment Software.
DCDB	Digital Cadastral Data Base.
CCDB	Coordinated Cadastral Data Base.
B/D	Bearing/ Distance.
GM	GeoCadastre Manual (see references).
DHW	Drill-Hole and Wing.
SSM	State Survey Mark (New South Wales).
USQ	University of Southern Queensland.

GLOSSARY

Cadastre:	A public survey, record or map of the value, extent and ownership of land as a basis of taxation. Also *Land* as in *Registered Land Surveyor* (*Registered Cadastral Surveyor).*
Reinstatement:	Also *Re-establishment*, *retracement*, *redefinition* Re-establishing the boundaries of interests in land in their original intended positions using all available survey information.
Least-Squares Adjustment:	A mathematical adjustment procedure that distributes the total error among observed measurements. Different weights can be applied to each measurement to dictate how much that measurement contributes to the adjustment.
Traverse:	A series of surveyed lines whose lengths and angles of intersection are measured at instrument stations.
Metes and Bounds:	A mete is a vector quantity; it is an expression of distance in a direction. A bound is anything referred to in the original description that would determine on the ground the limit to the laterality of the property for that part of its perimeter.
Misclose:	The error found by measuring a closed traverse or plan loop and not finishing on the starting point.
Deed:	(As in *deed distance)* - The original distance of a boundary as given by its survey plan.

CHAPTER 1

INTRODUCTION

"This pursuit is at once an art and a science."

(Hallmann, 1973).

"To be sure, cases may be different…but the more elaborately a computer is programmed, the more the difference in cases can be taken into account."

(Azimov, 1975).

1.1 The Problem.

There is very little published literature addressing the potential for software to replace higher-level tasks performed by surveyors - in particular the task of boundary reinstatement where lost boundary corners are reinstated in their originally intended position. Several software programs exist which can adjust survey plan information and field measurements to derive a solution for the most likely location of boundary corners, and these predominantly use a least-squares adjustment routine to best approximate a boundary reinstatement. The reinstatement process however has never been adequately defined due to the complex level of skill required to correctly assess all the variables involved.

Leininger (2006) raises the question of whether the doctrine of traditional boundary retracement (reinstatement) is 'violated' by the use of least-squares adjustment software. He states that the reliance on measurement and geometry to achieve a solution is seemingly at odds with the long held legal precedent of measurements being low on a hierarchy of importance. Put simply, monuments (such as boundary pegs or creeks) have a greater importance in determining a boundary corner than measurements shown on survey plans. This stance is reflected in the courts as they pay little regard to mathematical solutions. Buckner (1997) agrees by saying

> *"The accurate position is not ... the precise coordinate position resulting from a weighted least-squares adjustment … Truth is only found in where the corner was monumented originally."* (Buckner, 1997).

The views of Leininger (2006) reflect the necessity for this research – that is, to determine just how useful a software adjustment program can be for boundary reinstatements and the ramifications of using one for this task. He also addresses the uncertainty involved in selecting weights for evidence found in a field survey and describes the weight selection process as the essence of boundary reinstatement.

A response to Leininger was voiced by Forkner (2007) who clarifies that the emphasis in least-squares methods does not rest on how to weight the monuments but merely which measurements are more accurate than others. Least-squares adjustment is used in surveying to adjust data based on the relative accuracy of each measurement made in a survey. Measurements deemed more accurate are given more weight in the adjustment and are less likely to be changed. The true nature of least-squares as an analysis and adjustment tool is therefore not based on reinstatement principles as it focuses solely on measurement accuracy.

It is reasonable therefore to suggest that there is some uncertainty as to the proper use (if at all) of least-squares adjustment software in the profession.

1.2 Project Aim

This dissertation aims to analyse the effectiveness of a boundary reinstatement software program by using the software to adjust parcel boundary scenarios and comparing these results with the solutions dictated by documented reinstatement doctrines and those of a Registered Surveyor. Results from this investigation will enable surveying practices to evaluate the benefits of such software with a focus on relieving staff workloads in light of current personnel shortages in Surveying.

1.3 Project Background

1.3.1 Registration

Registered Surveyors are those who have achieved a recognized competency standard which permits them the authority to submit plans which affect land interests in NSW. (All other Australian states and territories have a similar system in place whereby the title 'Registered' may differ but the competency system is equivalent). The role of the Registered Surveyor is essential in maintaining the integrity of underlying property markets and ensuring community interests are protected (Department of Lands, 2008).

Under the Surveyors Act 2002 (NSW) Section 21, a person must not;

> *(a) carry out a land survey for fee or reward, or*
>
> *(b) advertise that he or she is willing to carry out a land survey for fee or reward,*
>
> *unless the person is a registered land surveyor.*
>
> (Surveyors Act 2002 (NSW) Section 21).

Excepted from this clause is any person undertaking a land survey under the immediate supervision of a Registered Land Surveyor. Clearly, no change in land interests relating to boundaries can be finalised without a registered surveyor's authority. Furthermore, ever-increasing property prices and a continuing increase in population have placed greater demands on surveying services and this trend does not appear to be abating.

1.3.2 Surveyor Shortage

Amidst this progress, the surveying profession is suffering from a shortage of registered surveyors. A disproportionately high percentage of those currently registered are nearing retirement age and a decrease in university place enrolments in surveying courses has been observed for several years (DEWR, 2006). DEWR cites a 27% drop in the completion of relevant university courses in the three years to 2005 from the preceding 3 years. Employer surveys in 2005 revealed an average of only 1.3 suitable applicants per job vacancy with registered cadastral surveyor positions being the hardest to fill. Alone, these statistics only serve to point out what could be a periodic cycle at its low point however, the literature continues. Blanchfield & Elfick (2006) observe that there has been a 37% decline in the number of Registered Surveyors from 1991 to 2004 and, although aimed at hydrographic surveying in particular, O'Connell (2006) addresses the surveying profession as a whole when discussing the 'catastrophic' shortage of surveyors in Australia. There does not seem to be any debate as to the seriousness of the situation.

Technology has always had a role in surveying and new adjustment programs using least-squares techniques may play a role in alleviating the shortage of surveyors by assisting or replacing all or part of the task of boundary reinstatement. This may help the Registered Surveyor to overcome backlogged work, reduce the stress caused by being overworked, and postpone the need for more staff to be employed. It will also allow more time to be spent training young professionals, so as to adequately prepare them for higher responsibilities when required.

1.3.3 Software

The least-squares adjustment process is not new to the surveying profession and has traditionally been used to adjust measured control traverses to give a more mathematically correct network of distances and angles. The principle of using this technique to recover boundary corners given survey measurements and original plan dimensions has been incorporated into the GeoCadastre (2008) software program (hereafter referred to as GC).

> *"GeoCadastre is a Windows based cadastral process that allows conversion of metes and bounds derived DCDB data into coordinate accurate parcel networks…This unique process…allows original survey data to be retained creating a complete and precise cadastre."*
>
> (Michael Johnson & Associates 2004).

It is hypothesized that this software may be able to automate the cadastral reinstatement process, thus saving Registered Surveyors' time and money while reducing human error.

1.3.4 Project Expert

The Registered Surveyor acting as an expert in the testing process for the project is employed by Landpartners Built Environment Consultants (LPL), Lismore NSW. He holds a Bachelors degree in Surveying from the University of Newcastle, and is currently registered with the Board of Surveying and Spatial Information NSW (BOSSI) as well as being a Registered Surveyor in Queensland. He is a member of the Institute of Surveyors Australia and NSW, is a founding member of the Spatial Sciences Institute Australia and has over 15 years experience as a Registered Surveyor working predominantly in redefining cadastral boundaries and dealing with land titles.

1.3.5 Rationale

By testing GC over a range of boundary scenarios, not only will its performance be able to be compared to human solutions, but an understanding of its adjustment processes may be gained. GC is naturally a commercial, copyrighted product that can be subjected to financial losses were its programming to be revealed, not to mention the possible breaches in intellectual property law that would occur. It is also likely that any information as to its programming, if disclosed by the proprietors themselves, would not be independently verifiable and therefore will not be sought for this research. Therefore, without knowledge of the software's programming, an empirical testing method must be used to analyse the program.

The empirical method will aid in reducing the mathematical results of the software to more holistic results, which are more congruent with human thought processes. This in turn will enable an assessment of GCs usefulness in a typical surveying office environment. If surveyor numbers continue to reduce in the future, it is foreseeable that surveyors may rely more and more on technology to lighten the burden caused by demand for their skills. The skills and training required to perform boundary reinstatement are critical for the advancement and professional recognition of surveyors, and so it follows that a shortage of those ready to undergo this training will require new solutions.

One solution is to lower the training requirements to become a Registered Surveyor. The advantage of this is a short-term influx of new registrations and a higher proportion of registrations in the long-term. The consequence of this however, is that the standard expected of the Registered Surveyor by the community is lowered. Professional standards are placed by regulatory institutions to protect the community and its trust in the professionals hired to provide invaluable services. This solution is therefore not ideal, and serves to diminish the profession to that of a para-profession only for the sake of meeting the shortage. A far less detrimental solution is to automate higher level decision-making tasks that a surveyor performs.

1.4 Summary

This dissertation aims to compare the ability of a software program to reinstate survey boundaries compared to human solutions. The research conducted will provide a foundation for further research into the usefulness and development of such software in response to the current shortage of surveyors.

Private practitioners will benefit from this unbiased review of the current capabilities of software in the less technologically-exposed area of traditional boundary reinstatement.

A review of literature for this research in Chapter 2 will identify that there are many factors which contribute to the education, experience and decision making skills of the registered surveyor. It will also reveal the segmentation of related topics and a lack of documentation in the wider surveying community concerning the role of software advances in surveying.

Literature that deals with software assisted boundary reinstatement will also be reviewed to understand the development of the concept, and to expand on any previous work in this particular area.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will review the literature to compare a survey boundary reinstatement software program with results obtained via conventional means. There was very little published literature found that actually touched on this topic let alone that which focussed solely on the idea of automating the boundary redefinition process. Rather, the vast majority of published material is concerned with increasing the accuracy of current coordinated cadastres which is not the primary focus of this dissertation.

The aim of the chapter therefore is to gather, correlate and review the literature which relates to the themes of the project, thereby linking previously unconnected ideas together for a topic that has not yet been studied in sufficient detail.

The information under the following chapter sub-headings will analyse the literature that has; impacted on the direction of the project, influenced the method undertaken and provided the background information to justify and set the project foundations. Each theme in this chapter will contribute in providing a solid framework to increase the industry knowledge of the neglected field of automated boundary reinstatement.

Among the researched literature is some debate as to the viability of using such programs to perform higher duties. Accompanying this debate was a noticeable lack of understanding of the principles used in computerised adjustments and subsequently, unwillingness among some to make the leap to the technology.

2.2 History

The only paper to specifically address the task of reinstatement by least-squares methods provides an example as to how the software can be used to support a reinstatement decision. It also includes a recommendation for analysing monument evidence weights as further work.

Harvey (2008) addresses methods of constraining a straight boundary line when survey evidence suggests bends should be introduced in it. The paper focuses not on the correct reinstatement solution, but the ways least-squares adjustments can be calculated to give different solution options. Examples demonstrate how to make the least-squares adjustment results fit the surveyors' reinstatement solution but not how to arrive *at* the reinstatement solution (the methods presented can however be implemented during the reinstatement process). The distinction between altering the adjustment to suit and the adjustment arriving at the solution unaided is an important one which sets this dissertation topic apart from Harvey's focus. Harvey does however relate the adjustment process to more traditional cadastral surveying rather than increasing current GIS database accuracy, the focus of the latter being more commonly found research.

Future work recommends analysis of the effects of different input data weights such as weights due to the variations of reference mark reliability. The approach of assessing evidence weights was originally the goal of this dissertation; the circumstances leading to a change in this direction are explained in later chapters.

An insight into the numerous considerations that arise simply when introducing software to a reinstatement was gained. It is also evident that several disciplines must be researched – that of software, reinstatement principles and the role of improved technology in the professional workplace.

2.3 Technology

There is no question that technology can improve the efficiency of repetitive and error-prone tasks. In surveying, these tasks are mainly in the form of calculations, drafting and measuring, where associated technologies have proven their worth in freeing up time to be spent on less routine matters. The division between proponents of technology and their counterparts may however have created skill gaps in the profession.

Pepling (1996) believes that no amount of technology can replace education and experience but it can make tasks easier and faster. This opinion is expressed in a review of the latest surveying technology for 1996. Although technology has advanced since then, his opinion is still current as the applications of recent technology still provide benefit in the form of increased efficiency. Can newer technology however start to replace a 'careful practitioner and good judgement'? (Pepling, 1996). It is important to note that Pepling does fail to point out any pitfalls of the products in the article and so may exhibit bias towards new technology.

Ghilani (2000) relays how historically, new technologies have divided surveyors and this division had left gaps which less qualified people filled to meet new market needs. The effect of this was educational holes in the industry for both current and new surveyors. He reminds us that surveying has always been a progressive and technologically savvy vocation. This paper has little other relevance but comes from a respected academic in the field.

Blanchfield & Elfick (2006) believe that technology has always benefited surveyors, but also speculate how continually advancing technology has helped support the skills shortage to date without any serious consequences. Blanchfield & Elfick (2006) therefore provide an additional point of view- that the skills shortage may not be such a problem at all in the future. Although Elfick is affiliated with the software under review in this project, he is a prominent expert in the field of coordinated cadastral information system programming.

Regardless of debate, there is no reason to believe that the further advancement of technology cannot continue to relieve the day-to-day burden of tasks to a point where the tasks being automated are actually quite complex.

2.4 Adjustment Software

Software technology can potentially provide the computing power to perform complex reinstatement tasks with considerable gains for the professional.

Lu & Shih (2002), while exploring cadastral overlay improvement with least-squares adjustments, conclude that the benefits of computer-assisted adjustment include speed (leaving more time for other analysis) and greater credibility (owing to the use of objective, scientific methods). Consequently too, surveying efficiency and the public perception of surveyors will increase. This may be applicable for cadastral data overlays but strictly for boundary reinstatement, this may not be the case. Lu & Shih also concede that the magnitude of value weights still require reasoning and verification through repeated adjustment testing.

2.4.1 GeoCadastre

Naturally, the Company who designed and markets the GeoCadastre program endorses many benefits in using cadastral adjustment software including cost and speed savings, and GIS layer compatibility. Independent reports such as the one from Michael Johnson & Associates (2004) can not be verified as being scrutinized and accepted by the professional community and as such, will not be relied upon for technical and academic study. However, it can be used as background information and in understanding the operations of the software.

The Geodata website (The Geodata Cadastral Solution, 2008) provides an overview of the GeoCadastre program. It is designed to be used in the GeoData suite of software which aims to create and manage a “Survey Accurate Coordinated Cadastral Data Base (CCDB)” produced by the input of survey measurements and survey plans.

It is acknowledged on the website that the ‘intuitive’ process of boundary definition ‘cannot be completely replicated in a software package’ but the software ‘should provide a model which is the best approximation of the legal cadastre’. It remains to be seen just how approximate is best and whether this level of approximation is practical for boundary reinstatement applications. The primary intended application of the software (that is, in the upgrade of CCDBs) is then addressed citing successful client case studies. The success of the GeoData software suite in creating accurate CCDBs is not being addressed in this project, nor are the virtues of a CCDB of which much has been written. Of further note is that the GeoCadastre ‘least-squares adjustment engine has been rigorously tested’ and confirmed as reported by the company itself.

It will be seen if GeoCadastre is the program to deliver the technological potential referred to in a reinstatement application. By their own admission, GeoData has prepared us not to expect the replication of the intuitive redefinition process, but a best approximation in its place.

2.5 Least-Squares Adjustment

Caution must be taken when applying weights to survey evidence in a least-squares adjustment. Although assigning a hierarchy for the observed evidence is an essential part of the reinstatement process, the incorrect choice of weights in a software adjustment may yield spurious results. Additionally, could such spurious results be considered in a court case as definitive evidence?

By far the most useful literature found discussing the assigning of weights to problems, if only analogous to boundary redefinition was by Greenfeld (1997). Here he states that the assigning of weights to observations presents a challenge as least-squares will yield the best results only if the observations are weighted appropriately.

In boundary reinstatement, weighting by hierarchy of evidence and experience is the most common method adopted. Furthermore, it is stressed that ‘weights must be assigned with utmost caution and with substantiated reasoning to maintain the integrity of the least-squares results' (Greenfeld, 1997). Such a statement may imply that just as many qualified surveyors are required to operate and analyze the results as were required to perform the reinstatement in the first instance. Even though Greenfelds' opinion of critical weight selection seems to be in line with the general professional view, the application of it is only covered briefly in the paper and more literature would be preferred before adopting this stance.

In mild contrast to his sparse coverage of weights, he then suggests the use of a three or four-parameter transformation approach for solving this scenario without referring to any scientific results which confirm this approach. Instead he refers to his own previous work on the matter.

Greenfelds' rigorous mathematical treatment of the examples covered is thorough and consistent with other least-squares adjustment techniques literature. He also draws from previous work in the same area, which further categorizes him as an authority in the field. It would be desirable to obtain Greenfelds' prior paper on the topic which has proved so far difficult to obtain. This earlier paper may enable a more critical view of any possible bias.

Shih (1995) discusses a dangling line scenario, which does not explicitly apply to this project; however the principles of least-squares are applied to an unknown boundary corner problem. Shih (1995) reports that the objective nature of a mathematical (least-squares) solution maybe more desirable in the handling of land disputes. The emphasis is on providing a fair, objective and logical technique. These principles are an important factor in determining when a least-squares adjustment software package may be of its highest use. Shih (1995) was written in Taiwan to help alleviate problems with missing or inaccurate original cadastral plans so the references are predominantly from that region and are not readily obtainable. In Australia, we have a highly capable titling system, and the status of the registered surveyor is such that he/she is the most accurate tool in boundary reinstatement in the courts eyes. It would not seem that the use of a least-squares adjustment (such as in the case of Shih (1995)) in Australia, would hold more legal weight than a Registered Surveyors solution. Nevertheless, the formulation stated by Shih does provide an objective and logical technique.

Least-squares may play a role in the administration and reinstatement of land boundaries but whilst many are prepared to warn of the critical nature of selecting weights, no attempt at an actual weighting scheme has been offered.

2.6 Boundary Reinstatement

Boundary reinstatement can be a complicated task reliant on significant education and much experience. As such, reinstatement principles are hard to define and have not been comprehensively recorded.

2.6.1 Errors

The process of boundary reinstatement involves assessing errors in the evidence to weigh this evidence and arrive at a conclusive location for the boundary (ACSM, 1997). Such errors are due to the;

1. Availability and condition of reference monuments.
2. Occupation lines differing to plan lines.
3. Ambiguity in plan information and;
4. Positional uncertainty of the measurements

(ACSM, 1997).

The first three can be estimated based on first hand knowledge of the evidence but only Positional uncertainty can be estimated using statistical means in which case appropriate computational procedures to control and adjust random errors should be employed (ACSM, 1997). Although these classifications have been updated since 1997, the principles referred to above have not changed and also apply to surveying in Australia.

2.6.2 Evidence Hierarchy

Humphries (1990) was able to consolidate much of the known literature reporting reinstatement methods back to the 19th Century. Regardless of the intended Queensland focus, it was discovered that there were not many resources that were either current or dealt with the topic thoroughly. It is not the intention of this project to comprehensively research the accepted rules of boundary reinstatement as they exist today as this excellent source contains the pertinent information required. Referring to Brown and Landgraf (1957), Humphries lists nine rules in order of importance for the practice of reinstating boundaries.

1. Control by Intention – where the original intention of the deed always dominates.
2. Control by Lines Marked and Surveyed – where any original marks found prevail.
3. Control by Natural Monuments.
4. Control by Artificial Monuments – which are less stable than natural monuments.
5. Control by Maps and Plans.
6. Control by Adjoiners – Adjacent well established lines are considered natural monuments.
7. Metes and Bounds.
8. Control by Course and Distance – when sufficient evidence can relocate missing monuments.
9. Control by Quantity – area.

These rules are reiterated by Brown (1980) in the same order.

Humphries then refers to Hallmanns' (1973) eight problems that can complicate a boundary reinstatement.

1. Loss of original marks and other monuments.
2. Disturbed monuments.
3. Incorrectly placed monuments.
4. Ambiguously related monuments.
5. Unreliable authority for the monument.
6. Where bearings stated are inaccurate.

7. Where dimensions stated are inaccurate.
8. Where descriptions stated are inaccurate.

In concluding comments, Humphries states the reason that scarce documentation exists on the subject of reinstatement is due to knowledge being passed on primarily via the master/pupil relationship under the articles system. Modern pressures and requirements have passed this training responsibility onto the university system, which has effectively eroded the successful master/pupil knowledge transfer. It is an interesting point to add that Humphries himself is a surveying lecturer at one such university, where one imagines he has an enhanced view of this effect. It would follow then, that any body of knowledge that is not studiously recorded for posterity has the risk of being lost. In this case, I can think of no better institutions than universities to collate and consolidate the dwindling records.

In relation to technological advances, Humphries recognises that laborious tasks are much faster now than they were and subsequently, the field surveyor 'must make decisions with respect to the reinstatement of the boundaries in minutes rather than in hours'. It remains to be seen if this is indeed a practicable expectation.

Humphries (1992) then delves further into the issue by listing some of the documented rules of reinstatement. The word *some* is used owing to the nature of reinstatement knowledge being "performed by convention, without explicit guidance and direction" and having not been "clarified in a Torrens jurisdiction, like Australia". He also quotes Willis (1982);

> *"…[t]he survey investigators must learn to distinguish these by experience as the result of there use of them."* (Willis, 1982).

It is conceded thereby; that there are more rules which could be defined but have not as yet been published (as well as those indefinable, such as the intuition of the practitioner).

The desire to establish well-defined rules to govern the reinstatement process is not endorsed by all. Humphries quotes Hamer (1967);

> *"Unlike some other branches of surveying, the problems encountered in cadastral work do not as a rule fall within certain well-defined limits nor are they governed by any well-established formulae, which if correctly applied, will provide the required answers"* (Hamer, 1967).

Here we are given the implication that debate and contention may have followed the definition of rules throughout history, possibly hindering any consolidation of the knowledge.

Humphries' review of Foxall (1943) exposes a disagreement with Brown and Landgraf (1957) where Foxalls' reinstatement evidence hierarchy is as follows;

1. Natural features.
2. Original marking of grant boundaries, road surveys, alignments or resumption surveys.
3. Monuments.
4. Original marking of private surveys.
5. Occupation.
6. Measurement.

The difference being the ordering of *natural features* above *original marking*. Once again there seems to be debate associated with any consensus. This will not however impact on the testing scheme or results conducted in later chapters. Of most importance to this project is the common concept that measurement is the least controlling of all evidence.

It has been noted by Humphries that Foxall (1943) displayed a 'decided lack of citation of source material' and this discrepancy will be resolved in favour of Brown and Landgrafs hierarchy for the purposes of the study. Humphries sums up the process of reinstatement by saying;

> *"[the evidence]… needs to be appropriately weighed by the surveyor in the field and applied to the circumstance in which the surveyor finds him or herself, taking due account of the law and the mathematics as appropriate"*
>
> (Humphries, 1992).

By using a Registered Surveyor any debate as to hierarchy can be substantially removed, as such a position is formally qualified to be proficient in applying reinstatement rules in practice.

2.6.3 Shortage and Excess

Reinstatement principles can be found in a detailed format in very few documents. It has usually been the case that the evolution of best practice doctrine has occurred via court rulings and in other piecemeal sources such as government directions and dated manuals. Sprott (1989) summarized a logical and simple set of rules to deal with boundary discrepancies between two (or more) adjacent lots where a shortage or excess is found. This short article provides a good framework for testing the software as it only deals with one variable at a time (the three corners measured to, all of equal weight) which simplifies the situation enough to be able to understand the redefinition principles being addressed. More on this will be addressed in Chapter 3. It is also conceded in the article that more complicated scenarios are not so clear cut to decipher, but applying the given principles may make the task easier.

Sprotts' paper is the exception to the rule for defining courses of action during a field reinstatement. Only a general guide to evidence hierarchy and a small number of rules can be found easily, but the lack of consensus as to the entire process of boundary reinstatement does not bode well for the thorough programming of reinstatement software.

2.7 Conclusion

The GeoData software suite has been thoroughly designed and has passed the test in several large scale GIS applications, as reported by GeoData Information Systems themselves. The GeoCadastre component will now be scrutinised in the more rigorous task of boundary reinstatement which may be above and beyond the intention of the programs developers.

Although the process of boundary reinstatement is expertly understood and applied by registered and other recognised surveyors, any consensus on the definition of rules for reinstating boundaries has not been extended to the development of an authoritative standard. Similarly, there is still work to be done on whether technology can provide automated solutions to this process.

A testing structure based on known reinstatement principles will be used to enable a thorough selection of test scenarios. These tests will be conducted in a controlled manner, with software and input variables held fixed while one variable is changed at a time to enable finite analysis steps.

CHAPTER 3

METHOD

3.1 Introduction

In order to obtain data which can readily be compared with conventional reinstatement solutions, a thorough and justified testing scheme must be designed. Also, sufficient detail of the testing process is necessary to enable further research and duplication of the methods applied. Chapter 3 will outline the rationale behind the testing scheme, the principles of boundary reinstatement being adopted for testing, the input of data into GC and provide a summary of the tests performed. Each section is vital to understanding the process of software testing within a known framework of reinstatement principles. This in turn will allow accurate and meaningful analysis of the results.

The aim of the chapter is to document the procedure adopted in satisfying the research objectives listed in 3.2. This was achieved by describing simple reinstatement scenarios that had documented solutions and by devising scenarios that could isolate a specific test variable in accordance with known principles of reinstatement.

3.2 Research Objectives

The basis for research is in the testing and analysis of various survey reinstatement scenarios in the GC software and to compare these to known solutions.

The objectives to be achieved are to;

1. Gain familiarity with the software to the point of understanding all relevant input variables and to accurately interpret results.

2. Choose several simple field survey scenarios that increase in complexity gradually and test these in the software.

3. Compare and analyse each scenario with a correct solution as performed by a registered surveyor or by documented principles.

4. Analyse the effectiveness of the software's algorithms using the results from above and recommend any improvements or future research.

5. Analyse the adjustment process with reference to the traditional doctrines of boundary reinstatement.

3.3 Scenario Choice

A simplified boundary reinstatement can be seen in figure 3.1, with the subject parcel shown as 'LOT', the lower boundary fronting a road and two reference marks shown as 'A' and 'B', each with bearing and distance reference measurements to their corresponding corners. The single lot reinstatement is encountered often in practice, through identification, lot peg-out, construction, sub-division and detail surveys. It is represented here in a generic fashion; that is, just a basic lot shape with no easements or extra survey information usually required for a thorough reinstatement. It has been chosen to allow for the testing of a variety of different measurement observations and complexities while still enabling easy analysis of results. It should be noted that on the occasion that marks A and B are in agreement with each other and the parcel they refer to, there is no difficulty in reinstating the boundaries of the parcel as the corners are exactly where the evidence refers.

Theoretically, with no other survey information present, the doctrine of monuments over measurements (see 3.2) prevails and the reference marks reinstate the lot boundaries. This stance is confirmed by this project's Registered Surveyor. It is only when discrepancies between these reference marks are discovered that the challenge of reinstatement presents itself. In all further testing, it is these discrepancies that will be simulated, that is, when the marks do not mathematically agree to the surveyor's satisfaction.

If additional evidence were to be introduced, there would be many more variations that can affect the reinstatement result. It is the combination of a wide variety of information that allows for the most accurate solution to a reinstatement problem. The situation where two marks with identical characteristics are in positional disagreement can only be solved in reality when considered alongside other pertinent information. Without such additional information, there is no way to decide which of the marks is correct, if any.

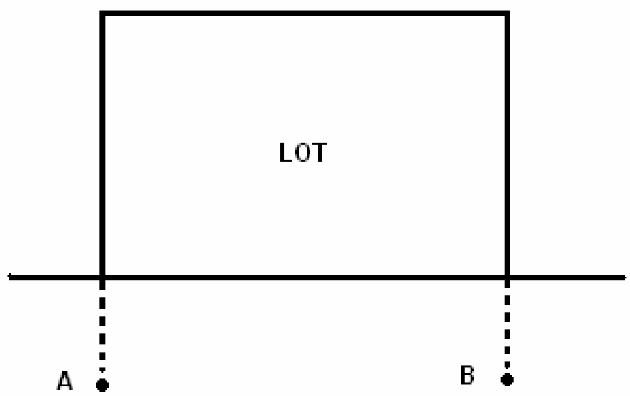

Figure 3.1: Simple Lot Reinstatement with Reference Marks A and B Being the Only Survey Evidence

Even in such a simple case, and excluding all other evidence (that is, A and B are the only surveying evidence present), there are many factors that can complicate the reinstatement. Major factors are listed as follows;

- **Age of marks A and B**
  All else being the same, the oldest mark holds the most weight, as it is most likely to have been placed in reference to where the boundary was intended originally.

- **Condition of marks A and B**

  All else being the same, the least disturbed mark holds the most weight, as it is most likely to be still in its correct position.

- **Type of mark**

  All else being the same, the most permanent type of mark holds the most weight, as it is the least likely to have been disturbed.

Ideally, a reinstatement software package should allow discrimination between these factors based on a user-set weighting scheme. Weight inputs would be to the user's discretion, chosen on a case-by-case basis to reflect the nature of the evidence found. This function however was not available on GC and as such, a more quantitative testing scheme was devised which doesn't discern between survey mark variables.

3.4 Doctrines of Boundary Reinstatement

As condensed from Chapter 2, the rules, as relevant, to be used for this project, are listed as follows;

1. Excess or Shortage is to be proportioned among all lots, on the assumption that the error is consistent.
2. Monuments are to govern over measurements.
3. Monuments control bearings and distances.
4. Errors in distance on the same survey, are to be proportioned over the entire line unless evidence to the contrary can be found
5. Monuments…are presumed superior to distance, angle and area.
6. Where two monuments, otherwise equal, are in conflict, the one in harmony with distance, angle, or area becomes controlling.
7. Coordinates, being based upon calculations that are dependant upon bearing and distance, are presumed inferior to monuments, bearing, and distance, but superior to area.

3.5 The Software

3.5.1 Version

The software version used will be GeoCadastre V4.81 (20 July 2008)

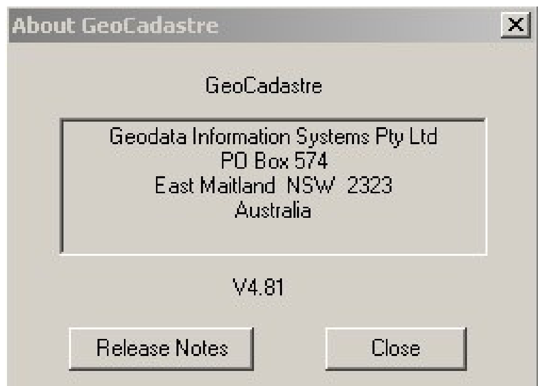

Figure 3.2: GeoCadastre Version Information

3.5.2 Parcel Entry

The cadastral adjustment automatically applies constant weighting to all bearings and distances in the data based on the age of the survey unless the accuracy is entered separately by the user. The GeoCadastre Manual (2007) describes this accuracy as "a number between 1 and 7 indicating the category of the data".

Accuracy	Description	Bearings (Secs)	SD Distances	PPM (Metres)
1	High Acc (1mm)	5	0.001	5
2	High-Medium Acc (10mm)	30	0.010	25
3	Medium Acc (20mm)	60	0.020	50
4	Med-Low Acc (50mm)	120	0.050	125
5	Low Acc (0.2m)	300	0.200	125
6	Digitised Parcels (1m)	3600	1.000	1000
7	Excluded from Adjustment	Unknown Accuracy		

Table 3.1: Accuracy Types for Lot Input in GeoCadastre

With today's instruments, and assuming the competent error minimisation techniques of a field surveyor, setting a high accuracy level of 1 or 2 is not only plausible, but expected in many surveying projects and will be adopted for the remainder of the dissertation. A Higher accuracy setting will also result in the ability to more closely scrutinise the results.

The base lot adopted for testing has an area of $1000m^2$, is rectangular in shape with sides of length 20m and front and back boundaries of length 50m. These dimensions were chosen as it resembles the size and shape of a large number of residential allotments, and is encountered often.

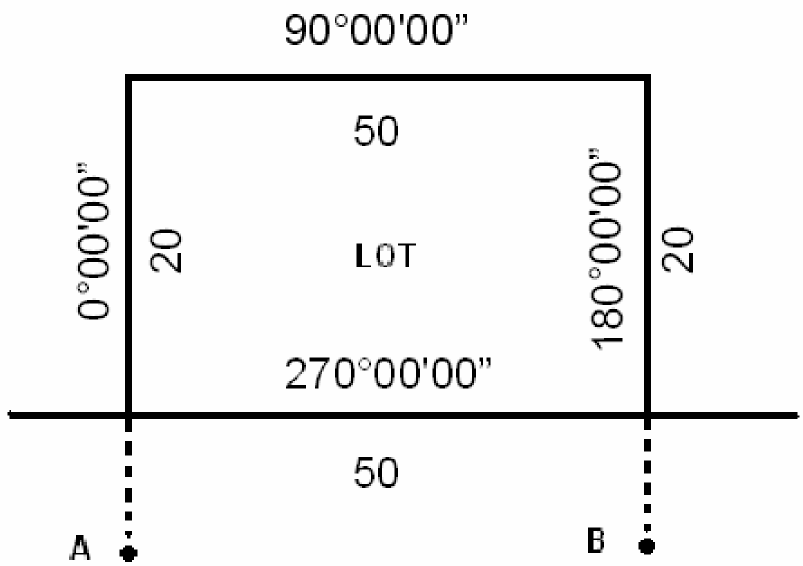

Figure 3.3: Test Lot Dimensions

Control connections (those measurements from marks 'A' and 'B' to the corners) remain fixed as these are the measured values we are adopting for the survey. The forced variation of the connection dimensions will enable us to control any desired discrepancies for each test.

The two control connections are tagged as '995'. This is GC's way of specifying different attributes associated with a parcel or line. The full list is reproduced below;

Tag	**Use**	**Main User**	**Feature**
10	Parcel	LIC in NSW	Dedicated Land
12	Parcel	LIC in NSW	Private Section Plan
13	Parcel	LIC in NSW	Real Property Boundaries
14	Parcel	LIC in NSW	Crown Subdivision

15	Parcel	LIC in NSW	Vacant Crown Land
16	Parcel	Adjustment	Compiled plan
17	Parcel	Adjustment	Compiled plan
21	Line	LIC in NSW	Road Boundaries
22	Line	NT Govt	Connection along road boundary
23	Line	LIC in NSW	Pathway
27	Line	LIC in NSW	Laneway
29	Parcel	LIC in NSW	Closed road
40	Parcel	LIC in NSW	Reserve
42	Line	LIC in NSW	Reservation line (100 ft)
44	Parcel	LIC in NSW	Drainage Reserve
60	Parcel	LIC in NSW	Cemetery
71	Line	LIC in NSW	Tidal Boundary
72	Line	LIC in NSW	Non Tidal Boundary
73	Line	LIC in NSW	Mean High Water Line
74	Line	LIC in NSW	Mean Low Water Line
77	Line	LIC in NSW	Coastline
80	Parcel	LIC in NSW	Railway Land
121	Line	LIC in NSW	State Boundary
233	Line	LIC in NSW	County Boundary
234	Line	LIC in NSW	Parish Boundary
633	Line	LIC in NSW	Mine Subsidence Boundary
838	Line	LIC in NSW	National Park Boundary
841	Line	LIC in NSW	State Forest Boundary
921	Line	Geodata in NSW	Reserved Road
984	Line	NT Government	Right of Way
986	Line	NT Government	Power Line
990	Line	NT Government	Sewerage
991	Line	NT Government	Electricity Supply
992	Line	NT Government	Drainage
993	Line	NT Government	Electronic Communications
994	Line	NT Government	Access
995	Line	CAD30	Precise Connection (control connections)

998	Line	CAD20, 30	Radial lines to centres
999	Line	CAD10, 20, 30	Connections

Table 3.2: GeoCadastre Attribute Tags

Tag 995 is listed as a Precise Connection and is held at accuracy 1 as it is intended to be used as a direct connection to a control point. Tag 999 is assumed to be surveyed and will always stay at the accuracy assigned according to the survey date unless its accuracy is specifically set.

The parcel is shown on screen (using the arbitrary notation of Lot 1 in DP 123456) as follows:

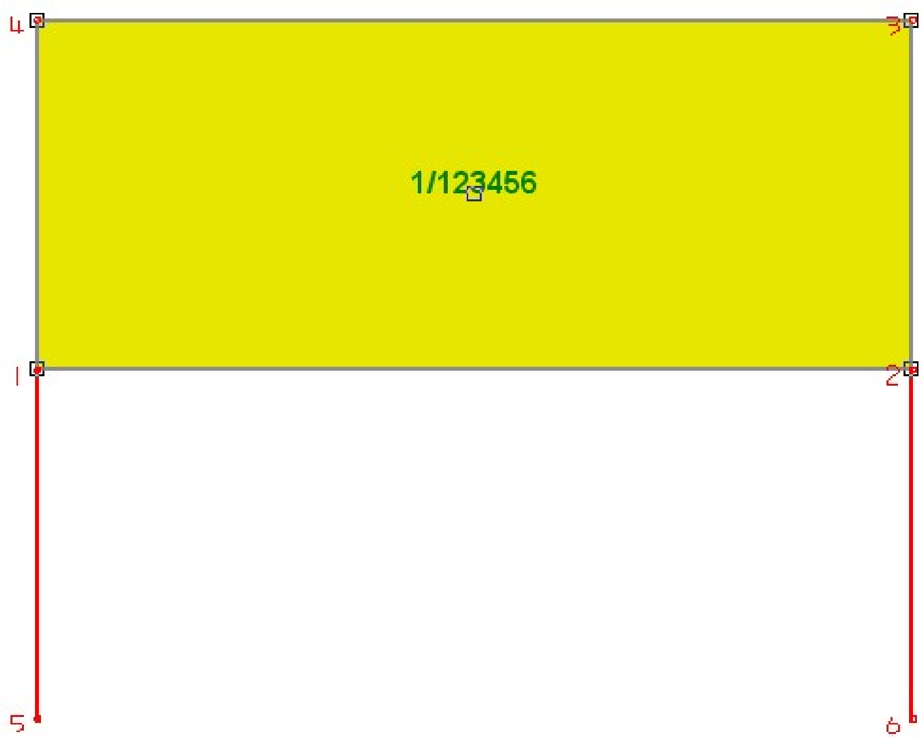

Figure 3.4: Screenshot of Entered Lot Showing Connections

3.5.3 Adjustment.

The adjust function applies a least-squares adjustment to the lot, using any entered station control points as fixed. If the lot corners by plan dimension do not agree with the connections from station coordinates, the program provides a best-fit solution.

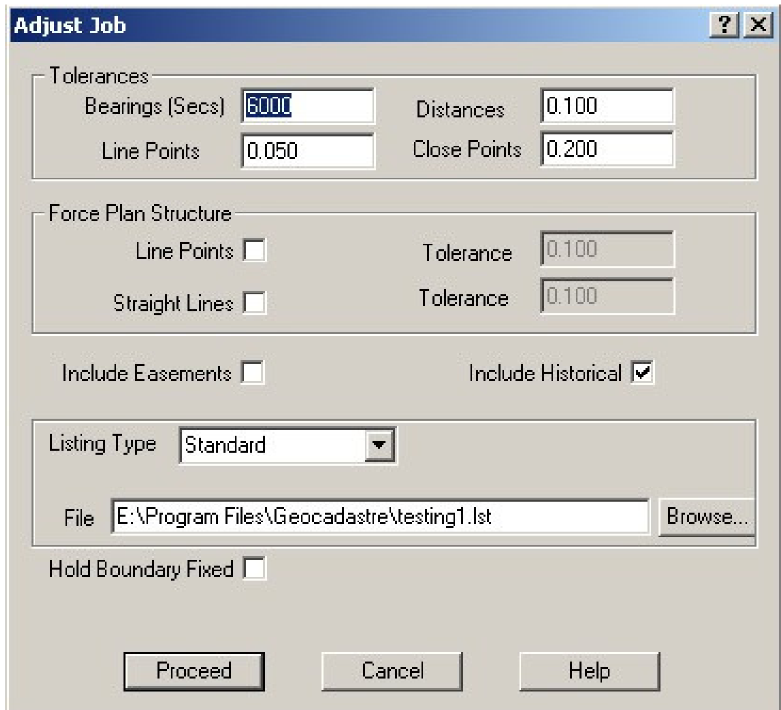

Figure 3.5: Screenshot Displaying Tolerance Fields and 'Hold Boundary Fixed' Checkbox

Tolerances are those values that, if exceeded, halt the adjustment. The 'Hold Boundary Fixed' button will force the original lot dimensions to remain as much as possible. The output of each adjustment is in the form of a text report.

3.6 Testing.

3.6.1 Shortage and Excess.

There are 10 scenarios described by Sprott (1989), which are amended here to create frontage distances of 50 instead of 500.

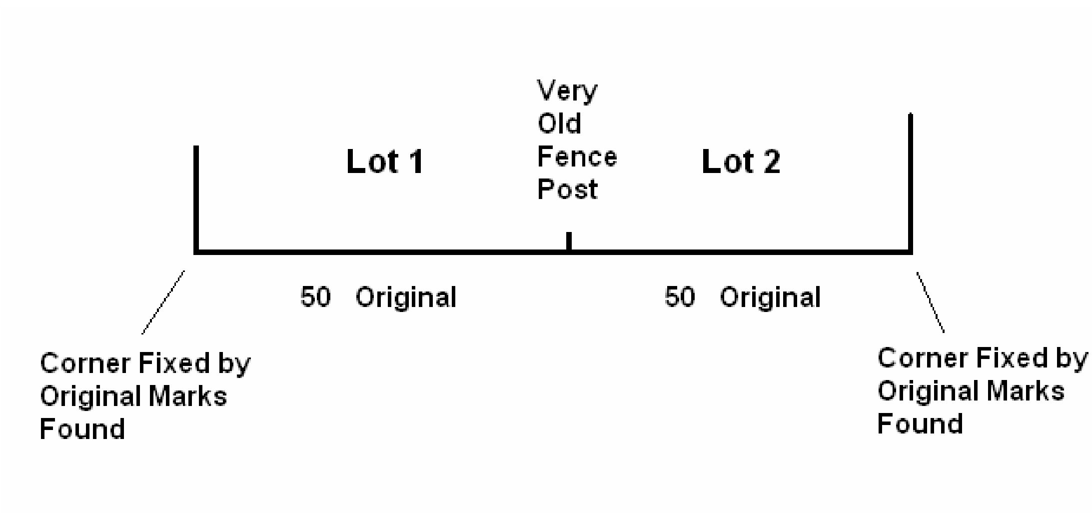

Figure 3.6: Original Distances and Survey Evidence for Shortage and Excess Tests

In each scenario, the two extreme points are fixed by the clearest of evidence, the centre point is a fence line which has been accepted and both owners of Lot 1 and Lot 2 want to maintain their rights (Brown (n.d.), cited in Sprott (1989)). The fixed connections to the extreme points are tagged '995' to minimise adjustment deviation. The connection to the very old fence post can be tagged as '999' to reflect its relative uncertainty compared with the extreme corners.

Sprott has provided an over simplified scenario in order to demonstrate the principles of shortage and excess only. The situation in Fig 3.6 is not sufficient to single-handedly reinstate the frontage boundaries in reality, as other evidence further along the road would be necessary to prove any decisions. Nevertheless each scenario isolates the distance discrepancies in question. Frontages are then measured as follows;

Scenario	Lot 1 Frontage	Lot 2 Frontage
1	50	50
2	50	51
3	50	49
4	51	51
5	49	49
6	51	52
7	49	48
8	49	51
9	49	52
10	48	51

Table 3.3: Sprott (1989)'s Ten Shortage and Excess Examples

Each test will be conducted by altering the control connections (tagged as '995') to the values that will reproduce each scenario. The station coordinates will remain the same. For example, to simulate the scenario where the old fence post is in the position to give 50m on parcel 2 and 51m for parcel 1 we just correct the connections from stations 1-3 to give connections as follows;

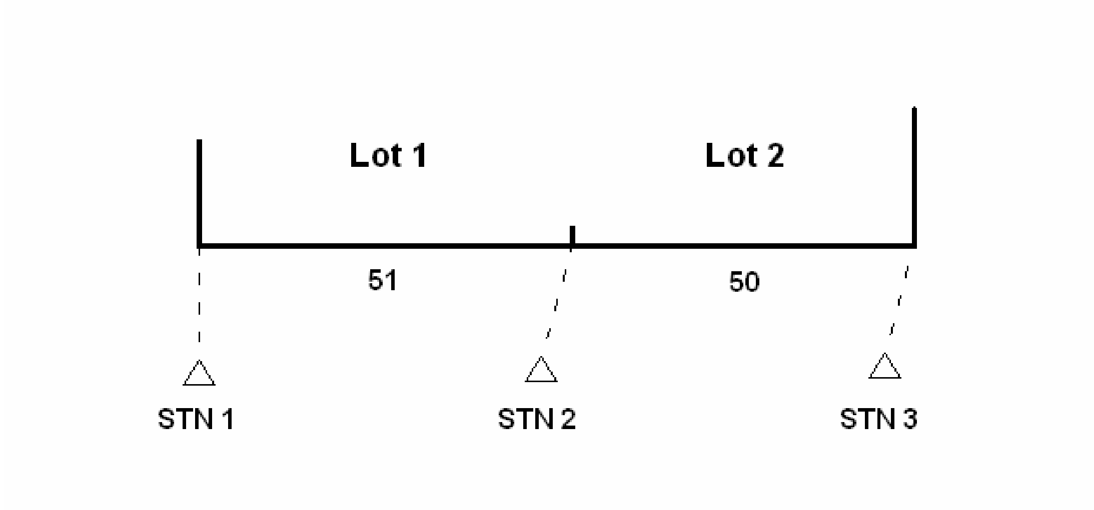

Figure 3.7: Example Shortage and Excess Testing Scenario Demonstrating the Adjusted Station to Corner Connections

Station	To	Connection (B / D)
1	Corner	0°00’00” 20.0m (no change)
2	Corner	2°51’45” 20.025m
3	Corner	2°51’45” 20.025m

Table 3.4: Adjusted Station to Corner Connections from Fig. 3.7

3.6.1.1 Test 1

Both Lot frontages are 50m.

Station	To	Connection (B / D)
1	Corner	0°00’00” 20.0m (no change)
2	Corner	0°00’00” 20.0m (no change)
3	Corner	0°00’00” 20.0m (no change)

Table 3.5: Station to Corner Connections for Test 1

3.6.1.2 Test 2

Lot 1 frontage is 50m, Lot 2 frontage is 51m.

Station	To	Connection (B / D)
1	Corner	0°00’00” 20.0m (no change)
2	Corner	0°00’00” 20.0m (no change)
3	Corner	2°51’45” 20.025m

Table 3.6: Station to Corner Connections for Test 2

3.6.1.3 Test 3

Lot 1 frontage is 50m, Lot 2 frontage is 49m.

Station	To	Connection (B / D)
1	Corner	0°00’00” 20.0m (no change)
2	Corner	0°00’00” 20.0m (no change)
3	Corner	357°08’15” 20.025m

Table 3.7: Station to Corner Connections for Test 3

3.6.1.4 Test 4

Lot 1 frontage is 51m, Lot 2 frontage is 51m.

Station	To	Connection (B / D)
1	Corner	0°00’00” 20.0m (no change)
2	Corner	2°51’45” 20.025m
3	Corner	5°42’38” 20.100m

Table 3.8: Station to Corner Connections for Test 4

3.6.1.5 Test 5

Lot 1 frontage is 49m, Lot 2 frontage is 49m.

Station	To	Connection (B / D)
1	Corner	0°00’00” 20.0m (no change)
2	Corner	357°08’15” 20.025m
3	Corner	354°17’22” 20.100m

Table 3.9: Station to Corner Connections for Test 5.

3.6.1.6 Test 6

Lot 1 frontage is 51m, Lot 2 frontage is 52m.

Station	To	Connection (B / D)
1	Corner	0°00’00” 20.0m (no change)
2	Corner	2°51’45” 20.025m
3	Corner	8°31’51” 20.225m

Table 3.10: Station to Corner Connections for Test 6

3.6.1.7 Test 7

Lot 1 frontage is 49m, Lot 2 frontage is 48m.

Station	To	Connection (B / D)
1	Corner	0°00’00” 20.0m (no change)
2	Corner	357°08’15” 20.025m
3	Corner	351°28’09” 20.225m

Table 3.11: Station to Corner Connections for Test 7

3.6.1.8 Test 8

Lot 1 frontage is 49m, Lot 2 frontage is 51m.

Station	To	Connection (B / D)
1	Corner	0°00’00” 20.0m (no change)
2	Corner	357°08’15” 20.025m
3	Corner	0°00’00” 20.0m (no change)

Table 3.12: Station to Corner Connections for Test 8

3.6.1.9 Test 9

Lot 1 frontage is 49m, Lot 2 frontage is 52m.

Station	To	Connection (B / D)
1	Corner	0°00’00” 20.0m (no change)
2	Corner	357°08’15” 20.025m
3	Corner	2°51’45” 20.025m

Table 3.13: Station to Corner Connections for Test 9

3.6.1.10 Test 10

Lot 1 frontage is 48m, Lot 2 frontage is 51m.

Station	To	Connection (B / D)
1	Corner	0°00’00” 20.0m (no change)
2	Corner	354°17’22” 20.100m
3	Corner	357°08’15” 20.025m

Table 3.14: Station to Corner Connections for Test 10

3.6.2 Angular Discrepancies

A new station (4) is added and now Lot 1 is a corner block on a road intersection.

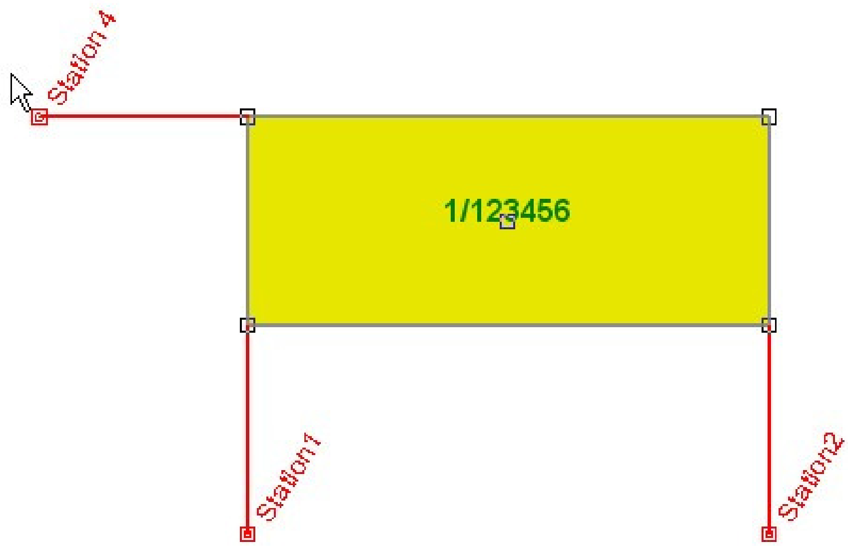

Figure 3.8: Screenshot of Entered Lot Showing New Connection from Station 4

3.6.2.1 Test 11

Stations 1, 2 and 4 are fixed by survey monument, but original dimensions indicate that the parcel is rectangular, and each corner therefore is a right-angle. By lengthening the connection from station 2 to its corner from 20m to 21m, this angle is reduced.

Station	To	Connection (B / D)
1	Corner	0°00'00" 20.0m
2	Corner	0°00'00" 21.0m
4	Corner	90°00'00" 20.0m

Table 3.15: Station to Corner Connections for Test 11

This test was chosen as it most simply demonstrates a discrepancy between an observed angle and the plan angle. The ability to resolve this difference is essential in correctly reinstating boundaries and is given more importance as it is widely known that before electronic distance measurement technology, angles were read with a higher accuracy than were the distances measured. More reliance is therefore placed on plan angles than distances where the survey was conducted in this period.

3.6.2.2 Test 12

All corners are fixed by survey monument, and similar to test 11, the connection from Station 2 is not in agreement with the original angles of the parcel. In addition, the connection from Station 3 provides evidence to support the right angle being adopted as it lines up along the road if the right angle is adopted. This extra information is introduced to provide more weight to the adjustment adopting the plan angle of 90°.

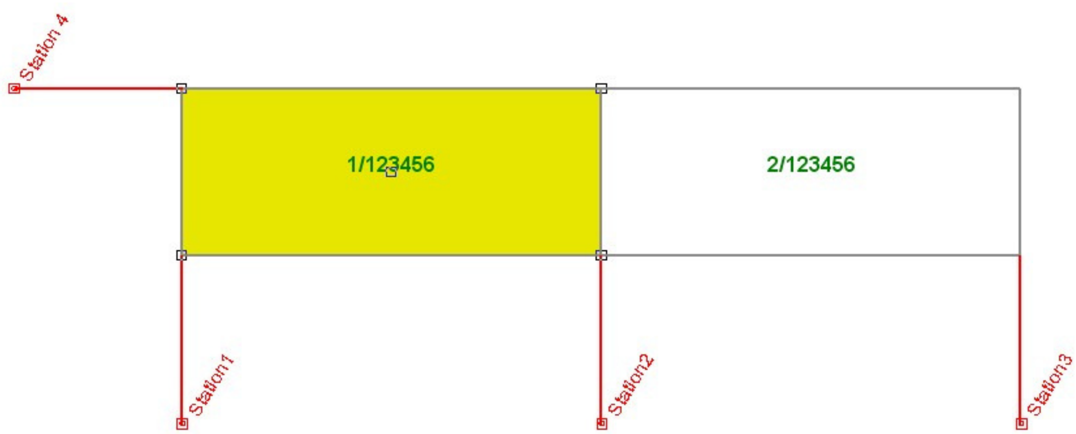

Figure 3.9: Screenshot of Entered Lots for Test 12

Station	To	Connection (B / D)
1	Corner	0°00’00” 20.0m
2	Corner	0°00’00” 21m
3	Corner	0°00’00” 20.0m
4	Corner	90°00’00” 20.0m

Table 3.16: Station to Corner Connections for Test 12

3.6.3 Test 13 - Control Adjustment

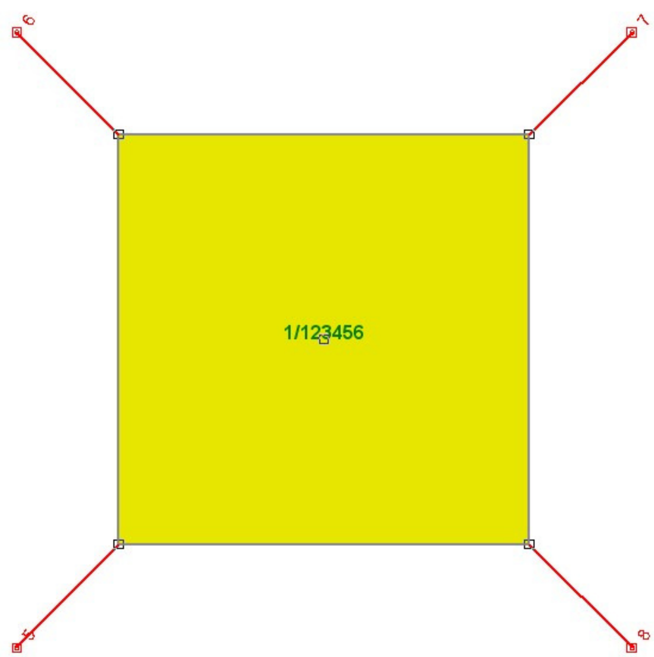

Figure 3.10: Screenshot of Lot for Test 13

A square lot is created with sides 20m long. Survey monuments 5, 6, 7 and 8 are traversed incorrectly, causing a bearing of 90°01’00” instead of 90°00’00” from 8 to 7 which results in a 0.044m misclose at 7. The coordinates of the stations are entered to reflect the incorrect measurement and the connection from 7 is also input with the bearing error added as would result from a measurement taken from 7.

Monument	Easting	Northing	Connection to Corner(B / D)
5	0	0	45°00’00” 7.071m
6	0	30	135°00’00” 7.071m
7	30.044	30	225°00’00” 7.071m
8	30	0	315°00’00” 7.071m

Table 3.17: Monument Coordinates and Connections for Test 13

GC places most weight on station data as their coordinates are derived from survey observations and as such, represents what is on the ground.
This test will reveal whether station coordinates will actually be adjusted if an error is found and if this adjustment will affect the reinstated corner coordinates.

3.6.4 Test 14 - Lot Misclose

The same scenario as in Test 12 is reproduced with no connection discrepancies. A 1m shortage is introduced in the frontage of Lot 1 leading to a 1m misclose at the frontage boundary intersection of Lots 1 and 2. The adjustment is run solely to test the software’s ability to locate and correct (or report) the error.

3.6.5 Real-World Reinstatement

3.6.5.1 Test 15

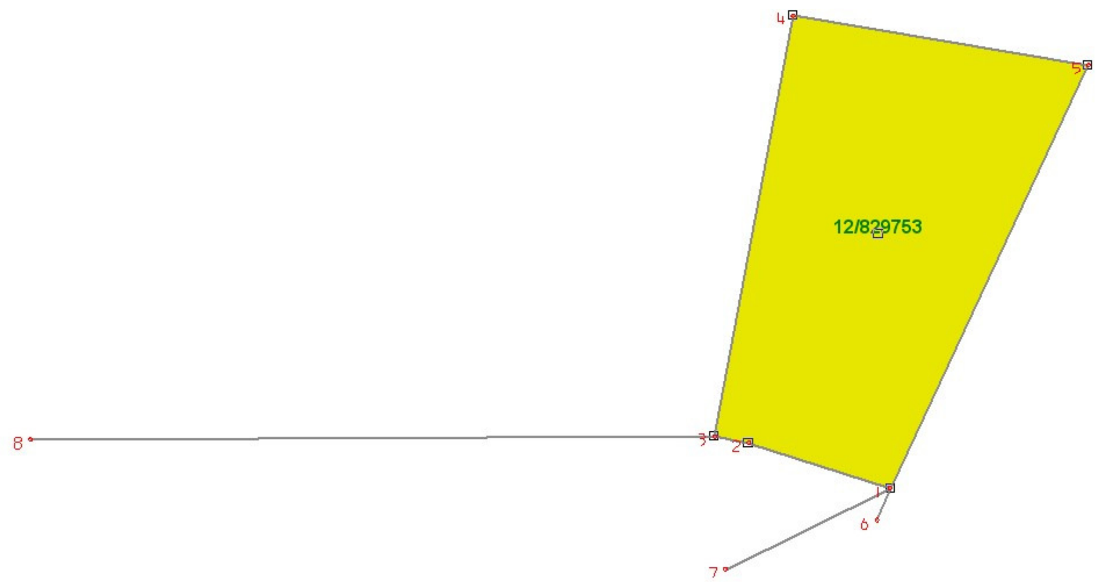

Figure 3.11: Screenshot of Actual Survey Data for Test 14

A redefinition survey was conducted on Lot 12 in DP 829753 by a Registered Surveyor. Three survey marks were used to reinstate the boundaries; two DHW's (Drill-Hole and Wings) and an SSM (State Survey Mark). All three marks were found to be in disagreement with each other by up to 40mm. The comparison between marks is shown in Table 3.17.

In this test the adjustment results can be directly compared to the actual reinstatement solution.

From	To	Plan B / D	Observed B / D	Misclose B / D
DHW1	DHW2	280°34’11” 69.942m	280°35’32” 69.939m	16°48’52” 0.027m
DHW1	SSM	71°57’51” 15.783m	71°55’13” 15.82m	53°49’39” 0.039m
DHW2	SSM	95°25’00” 84.138m	95°25’06” 84.16m	101°45’59” 0.023m

Table 3.18: Survey Mark Comparisons for Test 15

3.7 Conclusion

In order to effectively test and analyse the software results, a series of survey scenarios have been chosen to isolate quantitative factors affecting a boundary reinstatement. These factors are shortage and excess, angular discrepancy, control misclose and lot misclose. Shortage and excess tests have covered all scenarios as documented by Sprott (1989). These ten scenarios provide various levels of complexity in reinstating the corners however the situations are far simpler than would be necessary to perform a thorough and exhaustive reinstatement in reality.

Two angular tests of increasing complexity were included to test GC’s angle preservation capabilities, as well as a control misclose and lot misclose scenario. Finally, a deceptively difficult real life reinstatement has been tested to enable comparison between a Registered Surveyors’ solution and GCs adjustment.

The capacity to weight different survey mark variables was not available and so was not incorporated into the final testing scheme. Where possible the tests have been designed with established reinstatement doctrine in mind. Research objectives 1 and 2 have been satisfied in Chapter 3, that is, to gain sufficient familiarity with the software and to select a variety of test scenarios. The remaining objectives will now be addressed in the following chapters.

CHAPTER 4

RESULTS

4.1 Introduction

The testing of the scenarios described in Chapter 3 has resulted in adjustment data that can now be analysed. The output from GC is an text file detailing all variables and data used in the adjustment process. Each report is up to three pages in length and takes an understanding of the software to make sense of the results. It is therefore necessary to explain and summarise the test results in a meaningful way to ensure knowledge is gained and relayed from the testing process.

This chapter will summarise and explain the relevant adjustment data gained from the tests outlined in Chapter 3.

Each of the test results will be tabulated where possible and will be followed by a summary of the findings. As the adjustment results for each test are numeric and brief, they do not gain great benefit from graphical representation. Comparisons to solutions by conventional means will be included. A detailed discussion of these results can then follow in Chapter 5.

4.2 Results

4.2.1 Test 1

Lot	Distance Original (m)	Distance Observed (m)	Distance after Reinstatement (m)	Distance after Adjustment (m)	Δ Distance (m)
1	50	50	50	50	0
2	50	50	50	50	0

Table 4.1: Test 1 Results

Lot frontages are both measured to be 50m as per original. As there is no discrepancy, the adjustment has not altered the observed corners.

4.2.2 Test 2

Lot	Distance Original (m)	Distance Observed (m)	Distance after Reinstatement (m)	Distance after Adjustment (m)	Δ Distance (m)
1	50	50	50	50.002	0.002
2	50	51	51	50.901	-0.099

Table 4.2: Test 2 Results

The conventional reinstatement leaves the frontage distances as measured, however the adjustment reduces the difference between measured and original values, resulting in a minimal excess for Lot 1 (0.002m) and a lessened excess of 50.901m for Lot 2.

4.2.2.1 Test 2 Holding Boundary Fixed

Lot	Distance Original (m)	Distance Observed (m)	Distance after Reinstatement (m)	Distance after Adjustment (m)	Δ Distance (m)
1	50	50	50	50	0
2	50	51	51	50.907	-0.093

Table 4.3: Test 2 Results with 'Hold Boundary Fixed' Option Checked

Lot 1 frontage has not been changed and the adjusted frontage for Lot 2 is marginally closer to that of the reinstated distance, compared to the results in Table 4.2.

4.2.3 Test 3

Lot	Distance Original (m)	Distance Observed (m)	Distance after Reinstatement (m)	Distance after Adjustment (m)	Δ Distance (m)
1	50	50	50	50	0
2	50	49	49	49.082	0.082

Table 4.4: Test 3 Results

Lot 1 frontage has not been changed and the adjusted frontage for Lot 2 is 0.082m longer than measured.

4.2.4 Test 4

Lot	Distance Original (m)	Distance Observed (m)	Distance after Reinstatement (m)	Distance after Adjustment (m)	Δ Distance (m)
1	50	51	51	50.863	-0.137
2	50	51	51	50.821	-0.179

Table 4.5: Test 4 Results

The 1m excess in both lots has been reduced by 0.137m and 0.179m for Lots 1 and 2 respectively. Scale factors of 1.007594 for Lot 1 and 1.021416 for Lot 2 were applied during adjustment seemingly in order to reduce the common 1m excess.

4.2.5 Test 5

Lot	Distance Original (m)	Distance Observed (m)	Distance after Reinstatement (m)	Distance after Adjustment (m)	Δ Distance (m)
1	50	49	49	49.139	0.139
2	50	49	49	49.144	0.144

Table 4.6: Test 5 Results

The 1m shortage in both lots has been reduced by 0.139m and 0.144m for Lots 1 and 2 respectively. Scale factors of 0.992386 for Lot 1 and 0.977306 for Lot 2 were applied during adjustment in similarity to Test 4 to seemingly correct the overall shortage.

4.2.6 Test 6

Lot	Distance Original (m)	Distance Observed (m)	Distance after Reinstatement (m)	Distance after Adjustment (m)	Δ Distance (m)
1	50	51	51	50.865	-0.135
2	50	52	52	51.685	-0.315

Table 4.7: Test 6 Results

The unequal excess in both lots has been reduced by 0.135m and 0.315m for Lots 1 and 2 respectively. Scale factors of 1.007617 for Lot 1 and 1.035938 for Lot 2 were applied during adjustment. This is similar to results from Test 4.

4.2.7 Test 7

Lot	Distance Original (m)	Distance Observed (m)	Distance after Reinstatement (m)	Distance after Adjustment (m)	Δ Distance (m)
1	50	49	49	49.138	0.138
2	50	48	48	48.222	0.222

Table 4.8: Test 7 Results

The unequal shortage in both lots has been reduced by 0.138m and 0.222m for Lots 1 and 2 respectively. Scale factors of 0.992377 for Lot 1 and 0.961028 for Lot 2 were applied during adjustment.

4.2.8 Test 8

Lot	Distance Original (m)	Distance Observed (m)	Distance after Reinstatement (m)	Distance after Adjustment (m)	Δ Distance (m)
1	50	49	50	49.142	-0.858
2	50	51	50	50.976	0.976

Table 4.9: Test 8 Results

The shortage in Lot 1 and equal excess in Lot 2 have been adjusted by scale factors of 0.992413 and 1.009147 respectively, the first case of opposite scaling being applied to each lot (one smaller, one larger). The reinstated distances are marginally being approached as Lot 1 has increased by 0.142m and Lot 2 has decreased by 0.024m.

4.2.8.1 Test 8 Holding Boundary Fixed

Lot	Distance Original (m)	Distance Observed (m)	Distance after Reinstatement (m)	Distance after Adjustment (m)	Δ Distance (m)
1	50	49	50	50	0
2	50	51	50	50	0

Table 4.10: Test 8 Results with “Hold Boundary Fixed’ Option Checked

Test 8 is the second scenario where checking the ‘Hold Boundary Fixed’ option improves the adjustment. As opposed to Test 2 however, the correct solution is reached is Test 8.

4.2.9 Test 9

Lot	Distance Original (m)	Distance Observed (m)	Distance after Reinstatement (m)	Distance after Adjustment (m)	Δ Distance (m)
1	50	49	50	50	0
2	50	52	51	50.907	-0.093

Table 4.11: Test 9 Results

The 1m shortage for Lot 1 is balanced with the 2m excess in Lot 2. Adjustment results give the reinstated distance of 50m for Lot 1 and a 0.093m shortage to the reinstated distance of 51m for Lot 2.

4.2.10 Test 10

Lot	Distance Original (m)	Distance Observed (m)	Distance after Reinstatement (m)	Distance after Adjustment (m)	Δ Distance (m)
1	50	48	49	49.082	0.082
2	50	51	50	50	0

Table 4.12: Test 10 Results

As with Test 9, the shortage for Lot 1 is balanced with the excess in Lot 2 in Test 10. Adjustment results give the reinstated distance of 50m for Lot 2 and a 0.082m excess to the reinstated distance of 49m for Lot 1.

4.2.11 Test 11

4.2.11.1 Holding Boundary Fixed

Angle Original	Angle Observed	Angle after Adjustment	Δ Frontage Distance (m)	Δ Easting (m)	Δ Northing (m)
90°00'00"	88°51'15"	90°00'00"	0	0	0

Table 4.13: Test 11 Results with "Hold Boundary Fixed' Option Checked

When the 'Hold Boundary Fixed' option is checked, the connection in disagreement is effectively ignored and the Lot's right-angles are maintained. As will be explained in Chapter 5, this result may be right or wrong.

4.2.11.2 Not Holding Boundary Fixed

Angle Original	Angle Observed	Angle after Adjustment	Δ Frontage Distance (m)	Δ Easting (m)	Δ Northing (m)
90°00'00"	88°51'15"	89°16'00"	-0.067	-0.071	0.639

Table 4.14: Test 11 Results without "Hold Boundary Fixed' Option Checked

Using only the observed connections and boundary information the adjusted angle is increased towards the original 90° by approximately 25'. The length of the affected boundary is adjusted to less than the original 50m by 0.067m even though a scale factor of 1.000920 was applied by the adjustment.

4.2.12 Test 12

4.2.12.1 Holding Boundary Fixed

Angle Original	Angle Observed	Angle after Adjustment	Δ Frontage Distance (m)	Δ Easting (m)	Δ Northing (m)
90°00’00”	88°51’15”	89°16’21”	-0.065	-0.069	0.634

Table 4.15: Test 12 Results Without “Hold Boundary Fixed’ Option Checked

Results are similar to those from Test 11. The angle has improved slightly (by 21”) but the location of the corner is almost exactly the same.

4.2.12.2 Not Holding Boundary Fixed

Adjustment failed

4.2.13 Test 13

Monument	Easting Before Adjustment	Easting After Adjustment	Northing Before Adjustment	Northing After Adjustment
5	0	0	0	0
6	0	0.010	30.000	30.011
7	30.044	30.023	30	29.999
8	30	30.011	0	-0.010

Table 4.16: Test 13 Traverse Results

The misclose has been recognised and adjusted through the traverse. The boundary corners have been adjusted to reflect the amended monument coordinates. At most the corners have been adjusted by 0.021m.

4.2.14 Test 14

The adjustment has proceeded despite the Lot misclose. The adjustment results are promising, as the misclosing frontage has been closed, stretching the distance from 49.000m to 49.830m. As is the case in all other tests, each lot has been adjusted by its own scale factor and so the misclose is not isolated in Lot 1 - Lot 2 has compensated for the error also.

The adjustment report has alerted that the corner is ‘suspect’ owing to its large magnitude which is in excess of the error tolerance set by the user.

4.2.15 Test 15

Corner	Reinstated Easting	Easting After Adjustment	Δ Easting	Reinstated Northing	Northing After Adjustment	Δ Northing
1	247.438	247.432	-0.006	103.143	103.128	-0.015
2	233.441	233.432	-0.009	107.636	107.623	-0.013
3	230.079	230.070	-0.009	108.260	108.250	-0.010
4	237.855	237.849	-0.006	149.874	149.876	0.002
5	267.031	267.033	0.002	144.975	144.976	0.001

Table 4.17: Test 15 Results

Corner 2 has the largest adjustment deviation of 0.016m. The least deviation of 0.002m is at corner 5 which is a difference that can be considered to be negligible. A scale factor of 1.000270 has been applied to the lot resulting in the change in length of boundary lines and connections.

Both connections from 7 and 8 have increased in length by 0.025m and 0.013m respectively while the connection from 6 has decreased despite the adjustment scale factor increasing the scale. Its length has been reduced by 0.016m.

4.2.16 Hold Boundary Fixed Option

In assessing the role and importance of the 'Hold Boundary Fixed' option to a reinstatement, the following has been tabulated to display in which tests the option improved results;

Test	Improved Results	Did Not Improve Results
1	-	-
2	●	
3	●	
4		●
5		●
6		●
7		●
8	●	
9	●	
10	●	
11	-	-
12		●
13		●
14		●
15		●

Table 4.18: Whether the 'Hold Boundary Fixed' Option Improved Results or Not

Of the 15 tests;

- Test 1 did not require adjustment.
- Tests 4,5 ,6 ,7 ,13, 14 and 15 did not exhibit any difference in results by using the option.
- Tests 2 and 3 showed minimal improvement.
- Tests 8, 9 showed considerable improvement.
- Test 10 was an improvement but still far from correct.
- Test 11 requires further information to be conclusive.
- Test 12 failed when the option was checked yet identified the gross error.

4.3 Conclusion

Tests 1, 8 and 11 produced results consistent with conventional reinstatement results. All other tests resulted in adjusted corners that did not agree with reinstated measurements. Test 15 incorporated a real world example and resulted in a maximum coordinate difference of 0.016m at the boundary corners.

Several tests resulted in or approached correct solutions as compared with reinstatement principles. Most however resulted in revised boundary lengths and new corner coordinates that would be difficult to justify using the same reinstatement principles.

Included was a table showing the results using the option to hold boundaries fixed. An assessment on the usefulness of this option will now be discussed in the next chapter along with a discussion of results, implications and recommendations.

CHAPTER 5

DISCUSSION, IMPLICATIONS AND CONCLUSIONS

5.1 Introduction

The results described in Chapter 4 have provided a superficial look at how the software performed against the 15 test scenarios. Further analysis is now required to make sense of the test results. Whilst not exhaustive, the tests were devised to cover general types of discrepancy that commonly arise during a reinstatement survey. The tests have revealed a range of results that require further analysis to place them in the context of the project and to derive meaning for the reader.

Chapter 5 will discuss the results in more detail, to provide a thorough analysis of their significance and in doing so; satisfy the remaining research objectives 3, 4 and 5 (see 3.2).

The test results described in Chapter 4 will now be discussed in terms of:

- How the software has performed.
- What software behaviours were identified.
- How these behaviours can provide benefit or cause detriment to the reinstatement process.
- Implications for the reinstatement process and the wider profession.

Each test result will be discussed to convey the authors observations in respect to the accepted boundary reinstatement doctrines described in Chapter 3. The use of variables during the test adjustments will be explained and the effects discussed. Recommendations and further research suggestions will then be made followed by the project conclusions.

5.2 Test Discussion

5.2.1 Test 1

As each land holder receives their entitled frontage, there is no adjustment necessary- the frontage distances are not in question and the measurements show no discrepancies (that is, Δ Distance = 0 for both lots (refer 4.2.1)). In agreement, the GC adjustment forces no amendments – the same result a surveyor would arrive at.

5.2.2 Test 2

A negligible adjustment to Lot 1 has resulted. This is in agreement with the correct reinstatement for scenario 2 as the occupations agree with deed and the land holder has their frontage entitlement. Lot 2 has adjusted to give a frontage of 50.9m. In reality, the full 51m would be given as the frontage for both lots must total the reinstated distance of 101m. GC has attempted to minimise the 1m excess to suit original plan dimensions but this has left a 0.1m discrepancy that cannot be justified.

After selecting the 'Hold Boundary Fixed' option, the negligible adjustment to Lot 1 has been removed, but a similar amended distance for the frontage in Lot 2 remains.

5.2.3 Test 3

A negligible adjustment to Lot 1 has resulted. This is in agreement with the correct reinstatement for scenario 3 results as the occupations agree with deed and the land holder has their frontage entitlement. Lot 2 has adjusted to give a frontage of 49.08. In reality, only 49m could be given as the frontage of both lots must total the reinstated distance for both lots of 99m. As was observed in Test 2, GC has attempted to minimise the 1m shortage to suit original plan dimensions but this has left a 0.08m discrepancy that cannot be justified in reality.

5.2.4 Test 4

Initially the test adjustment failed as the adjustment coordinate departures surpassed 3 times the input error tolerance. The tolerance was then increased to allow the adjustment to continue.

By checking the 'Hold Boundary Fixed' option, Lot 1 was held unchanged at 50m frontage while the overall 2m excess was placed entirely in Lot 2's frontage. The correct solution is for each land holder to keep their frontages of 51m as they both have at least their entitlement of 50m. Un-checking this option allowed the adjustment to continue without repeating this vastly incorrect result.

GC has shared the equal excess in lots 1 and 2 to the magnitude of 50.86m and 50.82m respectively. The fixed corners at the extremities can not be changed from a total distance of 102m so GC has again created discrepancies of 0.14m and 0.18m for Lots 1 and 2 respectively that cannot be justified in reality unless a scale difference could be proven from the original survey. There is no evidence to confirm such a scale factor so scale cannot be considered in the reinstatement. GC has nevertheless applied scale factors to each lot. Furthermore, it is almost inconceivable (even if remotely possible) that a scaling error could legitimately have occurred in any prior survey on the lots to the order of 1 in 50 metres.

5.2.5 Test 5

GC has shared the equal shortage in lots 1 and 2 to the magnitude of 49.14m each. The correct reinstatement solution is for each land holder to keep their measured frontage of 49m as they both have equal frontages - even if it is less than their original entitlement. Both land holders can therefore not lay claim to their neighbours land as they would if the neighbour had more than their entitlement. The fixed extremities can not be changed so GC has again created discrepancies of 0.14m for both Lots 1 and 2 that cannot be justified in reality.

5.2.6 Test 6

The correct solution is similar to scenario 2 where both land holders have their frontage entitlement even though one has less than the other. Frontages should be kept as measured. GC has given Lot 1 50.87m and Lot 2 51.69m. These values give a hint as to the correct course of action for the surveyor but again the adjustment has created discrepancies in an attempt to minimise errors. The cause of the magnitude of the errors is again the different scaling factors applied to each lot, which does not preserve the original plan distances.

5.2.7 Test 7

In this scenario, both holders have unequal shortages, and so both must accept their shortage. The common fence post is still deemed the corner as it is the accepted occupation at the boundary and the unequal shortages should not be apportioned between the land holders. The GC adjustment has given Lot 1 49.14m and Lot 2 48.22m, which, as in Test 6, merely suggests that the frontages should remain as reinstated. Overall though, an excess of 0.36m is created, which cannot be justified without further evidence.

5.2.8 Test 8

To ensure both land holders receive their entitled frontage in scenario 8, it is necessary to move the common corner off the fence post to establish correct frontages. GC initially tries to hold the fence post (as practicable), giving Lot 1 and Lot 2 frontages of 49.14m and 50.98m respectively. When the ‘Hold Boundary Fixed’ option is checked however, the correct entitlements of 50m result and no scaling is applied to the adjustment. This is the correct solution as shown by the reinstated distance in Chapter 4.

5.2.9 Test 9

In scenario 9, where one land holder has shortage and the other a larger excess, the correct solution is to give the minimum frontage entitlement of 50m to the shortage affected lot and the remaining excess to the other. GC nears this solution by giving the 50m minimum to Lot 1 and 50.91m to Lot 2. Here, as in Test 8, the ‘Hold Boundary Fixed’ option must be checked to achieve the most correct result.

5.2.10 Test 10

The correct solution for Scenario 10 is to reduce Lot 2‘s excess to its frontage entitlement, and minimise Lot 1’s shortage by the same amount. When GC performs the adjustment with the ‘Hold Boundary Fixed’ option checked, Lot 1 is given its full 50m entitlement and Lot 2 is given 49.08m – the reverse of the reinstated amendments. GC seems to have given preference to Lot 1 by holding its entitled frontage fixed instead of Lot 2’s. In the absence of any evidence to the contrary, this is nevertheless an equivalent solution mathematically and should still be considered a legitimate adjustment. GC does not know that it is more of an inconvenience to reduce Lot 2‘s frontage by 2m. When the ‘Hold Boundary Fixed’ option is unchecked, Lot 1 and Lot 2 are given 48.29m and 51.05m respectively, which is a closer solution to the reinstated values, but is still not the correct reinstatement.

5.2.11 Test 11

The situation where Lot 1's angular relationship is measured to be in doubt is one that requires additional consideration. On one hand the monuments dictate the location of the corner from Station 2 (see reinstatement rules 2, 3 and 6 in Chapter 2), but the error is very large compared to original dimensions. Based solely on the principle of monuments taking precedence, the right angle should not be held and this roughly agrees with the test results when the hold boundary fixed option is not checked.

Reinstatement rule 7 (Chapter 2) states;

> *"Where two monuments, otherwise equal, are in conflict, the one in harmony with distance, angle, or area becomes controlling."*

When the 'Hold Boundary Fixed' option is checked, the adjustment ignores the errant connection and holds the right angle. Although this result is also a possible solution, more evidence is required to prove that this determination should be adopted.

5.2.12 Test 12

Test 12 simulates the Test 11 scenario but with added evidence to agree with the solution of holding the right angle. Unexpectedly, holding the boundary fixed actually doesn't solve the adjustment as it did in Test 11. It does however alert the user to 'Check observations to point 7' which is the corner in disagreement. The program has picked up what appears to be an incorrect mark, or gross measurement error. A possible correct solution for this scenario, given no other information is to disregard the monument in error by 1m to restore all original parcel dimensions. GC has recognized the anomaly correctly.

Alternatively, by allowing the adjustment to continue unconstrained the results are difficult to analyse. It can be seen in the adjustment report that each parcel has undergone a scaling and rotation operation in the adjustment which has resulted in unexpected corner deviations. It is obvious the adjustment has broken down or degraded with the introduction of extra complexity to the extent that a meaningful reinstatement has not resulted.

Also of interest are the final coordinates of the corner referred to by the errant connection. The coordinates were only slightly different to those from Test 11, signifying the extra information from Lot 2 was considered separately, by adjusting each lot differently, rather than using the new evidence from Lot 2 in conjunction with the evidence from Lot 1 to form a more accurate adjustment.

5.2.13 Test 13

The introduced misclose was adjusted proportionally through the traversed monuments as would be the recommended course of action in the case of a real field survey. A thorough human analysis would reveal the connection from 7 to be equal in distance to the other three connections, and given the lot dimensions (that of a square) it could be presumed to be likely that the traverse error occurred in the one leg from 8 to 7. Without the ability to reason in this fashion, the software has adjusted the data to fit, and the boundaries have been changed (however minimally).

5.2.14 Test 14

The suspect point alert has responded to the input tolerance value which can be increased to disguise such large errors. If the user does however possess an idea as to the expected accuracy of potentially suspect points, this alert could be useful in locating other such misclose errors.

In adjusting the misclose, there is no evidence to suggest that the misclose lies in the deliberately shortened boundary line and not elsewhere in the lot. Naturally, GC has adjusted only the given data as it is not capable of analysing the cause of the error as a human would be.

5.2.15 Test 15

Given the discrepancies found by survey (between 0.023m and 0.039m), it is surprising that the adjusted corners have shifted by no more than 0.016m. In this scenario where no marks agree and without further evidence supporting the adoption one mark or another as correct, a best fit adjustment may be a possible reinstatement solution based on the final coordinate results from this adjustment. The adjusted coordinates do not however agree with doctrines 6 and 7 from Chapter 3;

6. Where two monuments, otherwise equal, are in conflict, the one in harmony with distance, angle, or area becomes controlling.

7. Coordinates, being based upon calculations that are dependant upon bearing and distance, are presumed inferior to monuments, bearing, and distance, but superior to area.

Following these doctrines, the monument or monuments most in harmony with the boundary dimensions should be adopted. When the mark is adopted it is taken to be correct and the connections from it should not change. This has not occurred in the adjustment as each connection distance was changed. Similarly with doctrine number 7, any of the monuments should be adopted before calculated coordinates are which has not occurred.

It was attempted to give the connections from the drill-hole and wings a weighting by assigning the value of 0.02m in the 'Accuracy' input box during data entry. This value was an experienced guess as to the possible variation that may be found in this type of mark. Similarly, for the SSM an accuracy value of 0.005m was assigned as this mark type would have less chance of being disturbed. As the connection type was '995' for each mark, GC did not allow any movement on the coordinates and so the accuracy values were ineffectual.

The 'best approximation' referred to in 2.5.1 has been achieved based on the result being not exact, but very close to the conventional solution. The ability of the software to provide a satisfactory approximation will now be addressed further.

5.3 Interpretation

5.3.1 Scale

During the software adjustment process a scale factor and rotation is applied to the data to obtain a solution that best satisfies the given data geometrically. Scaling is only used in real world reinstatements where a scale factor can be proven in the original survey, or in parcels with much larger distances (thousands of metres) than those encountered in this project. It is therefore necessary to adopt scale factors when using the software for its intended purpose – larger scale coordinated cadastral data sets. On a smaller scale boundary reinstatement, scaling is not practical and results in misleading adjusted coordinates.

When adjusting two adjacent lots (depending on the nature and magnitude of the errors being adjusted), different scale factors were observed to have been applied to each lot. If the two lots being adjusted were created by the same plan, it is desirable to maintain the same factor across the whole plan to ensure consistency between lots, and reduce the distortion across many lots in the same plan.

5.3.2 Hold Boundary Fixed Option

There were no specific software options enabling the separate weighting of input data. One option that was available forced the adjustment to maintain original boundary dimensions where possible. The results from utilising this function throughout testing were difficult to examine as its effects were observed in many grades. These grades ranged from having no discernable effect at all to having a considerable effect on the test results.

When the data has an overall shortage or excess, or the observed survey evidence all disagrees short or long, the scale factor provides the dominant adjustment factor such as in scenarios 4, 5, 6 and 7. Scenarios where one aspect of the data is without discrepancy provide good cause to hold the boundary fixed as in tests 2 and 3 where one lot has correct entitled frontage taken from measured survey data. Tests 8, 9 and 10 benefited from there being approximately equal and opposite errors affecting adjacent lots, meaning the errors are shared consistently during adjustment.

As can be seen in Test 12, by holding the boundary fixed, the errant connection was identified which supports the use of the option in locating blunders and incorrect input data.

Only one test, Test 8, resulted exactly in the correct reinstated solution. This scenario is one that can occur frequently, where two exterior marks agree but one interior mark does not. Where this situation occurs in the course of a real survey, the 'Hold Boundary Fixed' function may be useful in identifying the correct reinstatement decision. All other tests, whether improvement was evident by using the option or not, still resulted in approximations of the correct reinstated solution.

5.3.3 Test Limitations

Test 15 is a good representation of a small-scale boundary reinstatement where located monuments do not agree with each other. The magnitude of the observed discrepancies is not unrealistic, as it is likely that marks can be disturbed this amount by natural or man-made disturbances.

The errors introduced throughout the tests have been exaggerated to isolate and highlight the adjustment effects of the software. Although not uncommon, errors of this magnitude are not realistic in determining the practicality of utilising the software in an everyday sense. Field experience repeatedly demonstrates that discrepancies between survey monuments are usually at most ten times less than the 1m errors applied to many of the tests. As seen in the results of Test 15, smaller input errors will result in smaller adjustment differences, which, in some cases, may be of negligible tolerance. In certain cases it may be acceptable therefore to adopt the adjustment solution.

5.4 Implications

5.4.1 Legal

GeoCadastre has the ability to consider original plan information and observed measurements to arrive at an approximate solution for the reinstatement of the boundary corners. But exactly how legitimate are these results? The traditional reinstatement process, having evolved from legal precedent, has the advantage of a traceable chain of decision steps that the surveyor can recount when argued against. According to Brown and Eldridge (1962);

> *"Software will not provide proof, it may however be used as an evidential tool in the process. Evidence is not proof. A consideration of all evidence and conclusions to be drawn from evidence, in accordance with the law of evidence, may produce proof"*
>
> (Brown and Eldridge, 1962)

Therefore the onus is on the surveyor to provide proof of the boundary location. Any weakness in the surveyor's reinstatement process can then be identified and corrected if necessary. The adjustment results from GC however, do not provide a chain of steps based on surveying principles and as such, cannot carry the weight that traditional methods do in a legal situation.

> *"The location of a boundary on the ground is a question of fact to be determined in the light of the law from all the available evidence. What may be inferred mathematically is only a part of the evidence and may not carry much weight"*
>
> (Hallmann, 1970; p 180)

It is therefore suggested that least-squares adjustment results for boundary reinstatement should not be accepted as legal evidence given the current level of software sophistication.

5.4.2 Skills Shortage

Will the application of GC in the work place help to alleviate the current skills shortage? It would seem not. To obtain the most beneficial results a Registered Surveyor would be required to make sense of the adjustment results in respect to the inputs, and to use these results as an aid in understanding the interplay of a large number of conflicting evidence comparisons. It is feasible however, for a lesser qualified surveyor to input the data, run the adjustment and present the results to the Registered Surveyor, possibly saving computation time. The final decision as to the location of the boundaries however, as always, remains with the Registered Surveyor.

> *"A surveyor…defines the boundary by offering a professional opinion as to where he believes a boundary should be placed."*
>
> (Blume, 1981)

5.4.3 To Use Or Not To Use?

Do the results of this research serve to stand against the ongoing use of cadastral adjustment programs like GeoCadastre? The answer is absolutely not. The benefits of GeoCadastre are proven in large-scale cadastral database projects where the initial spatial accuracy was less than desirable. GC provides a management tool that can and has provided solutions far in excess of most existing database accuracy. The developers claim that the software suite can achieve a survey accurate cadastral database, but many differences between the adjustment process and the traditional redefinition practices have been observed. The application of GC on smaller survey projects and those that require high reinstatement accuracy and process accountability is questionable, and an understanding of the software's use and functions is required before adjustment results should be relied on.

5.5 Further Research and Recommendations

5.5.1 Scaling

Where practicable, the original plan distances should be maintained to ensure land holders are receiving their legally entitled boundary distances. Scaling these increases the departure from the original distances, thus decreasing the accuracy of the result. The option to disable scaling during adjustment may enable more accurate solutions. Scaling may then be enabled when dealing with older surveys where errors of scale are more likely.

Scaling also depends on the inputs for each lot as adjacent lots were observed to have different scale factors applied to each. Where two or more lots have been created on the same plan, dimensional relationships between the two should be maintained, and scaling each differently jeopardises this relationship.

Where a scale factor is applied, the option to maintain the same scale factor across each entire plan is desirable in the software.

5.5.2 Monuments Over Measurements

Reinstatement principals and court precedent has established the doctrine of adopting monuments over measurements. According to Bucknor (1997); the truth is only to be found in the monument location, rather than a least squares adjustment coordinate. This then leads to reinstatements not being solved by best-fit methods or based on mathematical averages. For software to develop to being capable of performing reinstatements, it first must hold the corner from the observed reference mark measurements as fixed. It then will apply the original boundary dimensions and look for inconsistencies. Next, the input weighting of the evidence will be applied to the adjustment incrementally, and boundary inconsistencies can be eliminated systematically. Several iterations of this process will continue until all solvable boundary inconsistencies are solved, and a report will communicate the unsolvable points of conflict. Further programming may recognise frequently unsolvable conflicts and use specific scenarios, drawn from real life and programmed into the software, to complete the solution.

5.5.3 Weighting of Evidence

Leininger (2006) says weight selection is the essence of reinstatement. A thorough examination of the relative weights of survey monuments, based on the physical variables type, condition and age, would be beneficial in planning a strategy for future adjustment software programming that could incorporate this human aspect of the reinstatement process.

5.5.4 Larger Networks

Larger parcel networks have been documented and proven in the GC environment in terms of cadastral database manipulation and accuracy. The techniques applied by this dissertation will provide a framework for adjusting larger data sets from a reinstatement viewpoint. By increasing the knowledge of the software capabilities at this scale, potential benefits can be applied to larger subdivision and development projects.

5.6 Summary

Chapter 5 has established that the GeoCadastre software program provides mixed results in reinstating boundary corners. The least-squares adjustment process fails to incorporate the documented principles of traditional reinstatement, instead resulting in an entirely mathematical approximation.

Implications of the findings included the likely inadmissible nature of software outputs in a court case and that this software can not yet replace trained and qualified survey staff at the reinstatement task. It has been recommended in the future to include the ability for more user control over scaling in the adjustment along with an approach that focuses more on the current accepted redefinition process.

Future research for expansion of the topic has been identified as the ability to incorporate different weights for evidence found in redefinition surveys into the program and to test larger scale projects using the same method as in this dissertation.

5.7 Conclusions

According to GeoData (2008), GeoCadastre aims to provide a model which is the best approximation of the legal cadastre. The results of this dissertation agree in that most cases, an approximation is the result. It is not known if these approximations are "best" however, as in some cases the results are very misleading. It can be concluded then that the software is not capable of "survey accurate" boundary reinstatement while approximations of the magnitude observed are present and documented principles of reinstatement are not incorporated.

It follows therefore that the reinstatement process still requires a Registered Surveyor to ensure it is performed to a professional standard and that GeoCadastre should only be used in a training or support role in small boundary reinstatements. GeoCadstre can therefore not currently be used to alleviate the shortage of surveyors by replacing the boundary reinstatement process. In the future however, this same technology may advance to a point where it could contribute to the shortage solution.

Results from applying a real world example to GeoCadastre, although not exactly correct, were promising. This has lead to the opinion that such technology has potential for further development and success in reinstatement, but is currently more suited to larger-scale GIS applications and developments where it has been tested and proven to deliver benefit.

This dissertation has provided a never-before documented review of a land boundary reinstatement software program. It has linked the traditional techniques of boundary reinstatement with the current technology that can approximate it. As a result this research will initiate the further union of these two areas of study for the future benefit of the surveying profession and the wider public.

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APPENDICES

APPENDIX A

University of Southern Queensland
FACULTY OF ENGINEERING AND SURVEYING

ENG 4111/2 Research Project
PROJECT SPECIFICATION

FOR: BENJAMIN MARC MAYO

TOPIC: A REVIEW OF A CADASTRAL BOUNDARY ADJUSTMENT SOFTWARE PACKAGE

SUPERVISOR: Glenn Campbell (USQ Supervisor)
Peter Gibbings (USQ Supervisor)

PROJECT AIM: This project aims to analyse the effectiveness of a Boundary Adjustment Software Program in re-establishing parcel boundaries as compared with the solution of a Registered Surveyor.
SPONSORSHIP:

PROGRAMME: **Issue A. March 2008**

1. Research legal requirements for cadastral reinstatement and previous published work on numerical solutions of cadastral surveys.

2. Obtain and become familiar with the software package.

3. Choose several simple field survey scenarios that increase in complexity gradually and test these in the software.

4. Compare and analyse each scenario with a solution as performed by a registered surveyor.

5. Using the results from above, analyse the effectiveness of the softwares algorithms and recommend any improvements after discussing least squares adjustment techniques.

6. Analyse any weighting scheme as applies to the adjustment process with respect to the conventional methods of boundary reinstatement.

7. Submit an academic dissertation on the research.

As time permits:

8. Test an entire field survey against a human solution in the software using the now understood software processes from step 3.

9. Repeat testing procedure with second software program and compare results between the two.

AGREED:

__________ (Student) __________, PDG on ADL. (Supervisors)

Dated: 25/3/08 4/4/08 _/_/_

EXAMINER 4/4/08

APPENDIX B1

```
                        Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  E:\Program Files\Geocadastre\ShartageExcess1.lst     06-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 0.50
Easement data   : No
Historical Data : Yes
Hold Boundary   : No
Listing File    : E:\Program Files\Geocadastre\ShartageExcess1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       3
Number of Parcels              =       2
Number of Corners              =       7
Number of Bearings             =       9
Number of Distances            =       9
Number of Unknowns             =      10
Number of Redundant Ob         =       8
Bearings Exceeding Tolerance   =       0
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=  -0.000  N=   0.000 at point 1
 Av shift E=  -0.000  N=   0.000
Mean of Residuals              =    0.00
Standard Deviation of Residuals =    0.00
Range of Residuals             =    0.00
Matrix Size                    =      10
Band Width                     =       8
Number of Terms                =     151


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
1/123456 Line: 1-2  Observation Weight =0.040000
1/123456 Line: 1-2  Line Scale Factor=1.000000  Reduced Length=50.000
1/123456 Line: 1-2  Observation Weight =6400.000000
1/123456 Line: 2-3  Observation Weight =0.040000
1/123456 Line: 2-3  Line Scale Factor=1.000000  Reduced Length=20.000
1/123456 Line: 2-3  Observation Weight =8264.462891
1/123456 Line: 3-1  Observation Weight =0.040000
1/123456 Line: 3-1  Line Scale Factor=1.000000  Reduced Length=53.852
1/123456 Line: 3-1  Observation Weight =6207.261230
1/123456 Line: 5-1  Observation Weight =0.040000
1/123456 Line: 5-1  Line Scale Factor=1.000000  Reduced Length=20.000
1/123456 Line: 5-1  Observation Weight =8264.462891
1/123456 Line: 6-2  Observation Weight =0.040000
1/123456 Line: 6-2  Line Scale Factor=1.000000  Reduced Length=20.000
1/123456 Line: 6-2  Observation Weight =8264.462891
```

```
2/123456 Line: 2-7  Observation Weight =0.001111
2/123456 Line: 2-7  Line Scale Factor=1.000000  Reduced Length=50.000
2/123456 Line: 2-7  Observation Weight =79.012344
2/123456 Line: 7-3  Observation Weight =0.001111
2/123456 Line: 7-3  Line Scale Factor=1.000000  Reduced Length=53.852
2/123456 Line: 7-3  Observation Weight =77.676949
2/123456 Line: 3-2  Observation Weight =0.001111
2/123456 Line: 3-2  Line Scale Factor=1.000000  Reduced Length=20.000
2/123456 Line: 3-2  Observation Weight =90.702950
2/123456 Line: 9-7  Observation Weight =0.040000
2/123456 Line: 9-7  Line Scale Factor=1.000000  Reduced Length=20.000
2/123456 Line: 9-7  Observation Weight =8264.462891

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff



---------- Control Report ----------
              TRANSFORMATION RESULTS
 Point     X           Y          dx       dy      Name     Acc
#   5     1000.000    1000.000     0.000    0.000   Station1
#   6     1050.000    1000.000     0.000    0.000   Station2
#   9     1100.000    1000.000     0.000    0.000   Station3

              Arbitrary Grid

     no.     E  (final)     N          corrections
      1    1000.000     1020.000      -0.000   0.000
      2    1050.000     1020.000      -0.000   0.000
      3    1050.000     1040.000      -0.000  -0.000
      5    1000.000     1000.000    Fixed Point  Station1
      6    1050.000     1000.000    Fixed Point  Station2
      7    1100.000     1020.000      -0.000  -0.000
      9    1100.000     1000.000    Fixed Point  Station3


Plan: 123456  Parcel: 1 Scale:1.000000  Rotation   0 00 00  AccType=1
Misclose  90 00 00  0.000   Acc:High   Computed Area:1000 sqm

  From   Bearing    Distance    To      dE        dN      Dist-err   Gnd dist
     1   90 00 00     50.000    2    0.000     0.000      0.000   50.000
     2    0 00 00     20.000    3    0.000    -0.000     -0.000   20.000
     3  270 00 00     50.000    4                        -0.000   50.000
     4  180 00 00     20.000    1   -0.000    -0.000      0.000   20.000
     5    0 00 00     20.000    1   -0.000    -0.000      0.000   20.000
     6    0 00 00     20.000    2    0.000     0.000      0.000   20.000

Plan: 123456  Parcel: 2 Scale:1.000000  Rotation   0 00 00  AccType=2
Misclose  90 00 00  0.000   Acc:High   Computed Area:1000 sqm

  From   Bearing    Distance    To      dE        dN      Dist-err   Gnd dist
     2   90 00 00     50.000    7    0.000    -0.000     -0.000   50.000
     7    0 00 00     20.000    8                         0.000   20.000
     8  270 00 00     50.000    3    0.000    -0.000     -0.000   50.000
     3  180 00 00     20.000    2    0.000     0.000     -0.000   20.000
     9    0 00 00     20.000    7    0.000    -0.000      0.000   20.000
Acc=1
```

APPENDIX B2.1

```
                        Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  E:\Program Files\Geocadastre\ShartageExcess1.lst     06-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 0.50
Easement data   : No
Historical Data : Yes
Hold Boundary   : No
Listing File    : E:\Program Files\Geocadastre\ShartageExcess1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       3
Number of Parcels              =       2
Number of Corners              =       7
Number of Bearings             =       9
Number of Distances            =       9
Number of Unknowns             =      10
Number of Redundant Ob         =       8
Bearings Exceeding Tolerance   =       1
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=   0.906  N=   0.030 at point 7
 Av shift E=   0.230  N=   0.006
Mean of Residuals              =    0.05
Standard Deviation of Residuals =   0.08
Range of Residuals             =    0.33


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   2/123456 Line: 9-7  Dirn(c-o)=   -2°51'45", Effect=0.999

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff
123456/2        0.000     -0.000      2      7     50.000     0.901
123456/2        0.000     -0.000      7      8     20.000     0.307
123456/2        0.000     -0.000      8      3     50.000     0.766


---------- Control Report ----------
              TRANSFORMATION RESULTS
 Point     X           Y          dx       dy       Name     Acc
#   5     1000.000    1000.000     0.000     0.000   Station1
#   6     1050.000    1000.000     0.000     0.000   Station2
#   9     1100.000    1000.000     0.000     0.000   Station3
```

Arbitrary Grid

no.	E (final)	N	corrections	
1	1000.003	1020.002	0.003	0.002
2	1050.005	1019.996	0.005	-0.004
3	1050.005	1039.997	0.005	-0.003
5	1000.000	1000.000	Fixed Point	Station1
6	1050.000	1000.000	Fixed Point	Station2
7	1100.906	1020.030	0.906	0.030
9	1100.000	1000.000	Fixed Point	Station3

Plan: 123456 Parcel: 1 Scale:1.000018 Rotation 0 00 21 AccType=1
Misclose 90 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	90 00 00	50.000	2	0.001	-0.000	0.002	50.002
2	0 00 00	20.000	3	-0.001	0.000	0.001	20.001
3	270 00 00	50.000	4			-0.000	50.000
4	180 00 00	20.000	1	0.000	0.000	-0.000	20.000
5	0 00 00	20.000	1	0.000	0.000	0.002	20.002
6	0 00 00	20.000	2	0.001	-0.000	-0.004	19.996

Plan: 123456 Parcel: 2 Scale:1.015429 Rotation 359 47 32 AccType=2
Misclose 90 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
2	90 00 00	50.000	7	0.062	0.002	0.901	50.901
7	0 00 00	20.000	8			0.307	20.307
8	270 00 00	50.000	3	0.006	-0.155	0.766	50.766
3	180 00 00	20.000	2	-0.068	0.153	0.001	20.001
9	2 51 45	20.025	7	0.062	0.002	0.026	20.051

Acc=1

APPENDIX B2.2

```
                        Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  E:\Program Files\Geocadastre\ShartageExcess1.lst     06-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 0.50
Easement data   : No
Historical Data : Yes
Hold Boundary   : Yes
Listing File    : E:\Program Files\Geocadastre\ShartageExcess1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       7
Number of Parcels              =       2
Number of Corners              =       8
Number of Bearings             =      10
Number of Distances            =      10
Number of Unknowns             =       4
Number of Redundant Ob         =      16
Bearings Exceeding Tolerance   =       1
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=   0.907  N=   0.030 at point 7
 Av shift E=   0.907  N=   0.030
Mean of Residuals              =    0.05
Standard Deviation of Residuals =   0.08
Range of Residuals             =    0.34


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   2/123456 Line: 9-7  Dirn(c-o)=   -2°51'45", Effect=0.999

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff
123456/2        0.000     -0.000      2      7     50.000     0.907
123456/2        0.000     -0.000      7      8     20.000     0.309
123456/2        0.000     -0.000      8      3     50.000     0.773



---------- Control Report ----------
              TRANSFORMATION RESULTS
 Point     X           Y           dx        dy      Name     Acc
#   5     1000.000    1000.000     0.000     0.000   Station1
#   6     1050.000    1000.000     0.000     0.000   Station2
```

```
#   9     1100.000    1000.000     0.000     0.000   Station3

              Arbitrary Grid

     no.      E  (final)      N          corrections
       1     1000.000     1020.000    Job Boundary Point
       2     1050.000     1020.000    Job Boundary Point
       3     1050.000     1040.000    Job Boundary Point
       4     1000.000     1040.000    Job Boundary Point
       5     1000.000     1000.000    Fixed Point  Station1
       6     1050.000     1000.000    Fixed Point  Station2
       7     1100.907     1020.030       0.907   0.030
       9     1100.000     1000.000    Fixed Point  Station3
Plan: 123456  Parcel: 1 Scale:1.000000  Rotation   0 00 00  AccType=1
Misclose 270 00 00  0.000   Acc:High   Computed Area:1000 sqm

  From   Bearing    Distance    To       dE        dN      Dist-err   Gnd dist
     1   90 00 00     50.000     2    0.000     0.000     0.000   50.000
     2    0 00 00     20.000     3    0.000     0.000     0.000   20.000
     3  270 00 00     50.000     4    0.000     0.000     0.000   50.000
     4  180 00 00     20.000     1   -0.000     0.000     0.000   20.000
     5    0 00 00     20.000     1   -0.000     0.000     0.000   20.000
     6    0 00 00     20.000     2    0.000     0.000     0.000   20.000

Plan: 123456  Parcel: 2 Scale:1.015549  Rotation 359 47 39  AccType=2
Misclose  90 00 00  0.000   Acc:High   Computed Area:1000 sqm

  From   Bearing    Distance    To       dE        dN      Dist-err   Gnd dist
     2   90 00 00     50.000     7    0.063     0.002     0.907   50.907
     7    0 00 00     20.000     8                        0.309   20.309
     8  270 00 00     50.000     3    0.005    -0.156     0.773   50.773
     3  180 00 00     20.000     2   -0.068     0.154     0.000   20.000
     9    2 51 45     20.025     7    0.063     0.002     0.026   20.051
Acc=1
```

APPENDIX B3

```
                        Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  E:\Program Files\Geocadastre\ShartageExcess1.lst     06-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 0.50
Easement data   : No
Historical Data : Yes
Hold Boundary   : Yes
Listing File    : E:\Program Files\Geocadastre\ShartageExcess1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       7
Number of Parcels              =       2
Number of Corners              =       8
Number of Bearings             =      10
Number of Distances            =      10
Number of Unknowns             =       4
Number of Redundant Ob         =      16
Bearings Exceeding Tolerance   =       1
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=  -0.918  N=   0.019 at point 7
 Av shift E=  -0.918  N=   0.019
Mean of Residuals              =    0.05
Standard Deviation of Residuals =   0.08
Range of Residuals             =    0.34


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   2/123456 Line: 9-7  Dirn(c-o)=    2°51'45", Effect=0.999

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff
123456/2        0.000     -0.000      2      7     50.000    -0.918
123456/2        0.000     -0.000      7      8     20.000    -0.319
123456/2        0.000     -0.000      8      3     50.000    -0.798
```

```
---------- Control Report ----------
             TRANSFORMATION RESULTS
 Point     X           Y           dx        dy       Name     Acc
#   5     1000.000    1000.000     0.000     0.000    Station1
#   6     1050.000    1000.000     0.000     0.000    Station2
#   9     1100.000    1000.000     0.000     0.000    Station3

             Arbitrary Grid

     no.      E  (final)     N          corrections
      1     1000.000     1020.000    Job Boundary Point
      2     1050.000     1020.000    Job Boundary Point
      3     1050.000     1040.000    Job Boundary Point
      4     1000.000     1040.000    Job Boundary Point
      5     1000.000     1000.000    Fixed Point  Station1
      6     1050.000     1000.000    Fixed Point  Station2
      7     1099.082     1020.019      -0.918   0.019
      9     1100.000     1000.000    Fixed Point  Station3

Plan: 123456  Parcel: 1 Scale:1.000000  Rotation   0 00 00  AccType=1
Misclose 270 00 00  0.000   Acc:High   Computed Area:1000 sqm

  From    Bearing    Distance    To      dE        dN       Dist-err   Gnd dist
     1    90 00 00     50.000     2    0.000     0.000      0.000    50.000
     2     0 00 00     20.000     3    0.000     0.000      0.000    20.000
     3   270 00 00     50.000     4    0.000     0.000      0.000    50.000
     4   180 00 00     20.000     1   -0.000     0.000      0.000    20.000
     5     0 00 00     20.000     1   -0.000     0.000      0.000    20.000
     6     0 00 00     20.000     2    0.000     0.000      0.000    20.000

Plan: 123456  Parcel: 2 Scale:0.984102  Rotation   0 09 54  AccType=2
Misclose  90 00 00  0.000   Acc:High   Computed Area:1000 sqm

  From    Bearing    Distance    To      dE        dN       Dist-err   Gnd dist
     2    90 00 00     50.000     7   -0.063     0.001     -0.918    49.082
     7     0 00 00     20.000     8                        -0.319    19.681
     8   270 00 00     50.000     3    0.003     0.158     -0.798    49.202
     3   180 00 00     20.000     2    0.060    -0.160      0.000    20.000
     9   357 08 15     20.025     7   -0.063     0.001      0.015    20.040
Acc=1
```

APPENDIX B4

```
                        Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  E:\Program Files\Geocadastre\ShartageExcess1.lst     06-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 1.00
Easement data   : No
Historical Data : Yes
Hold Boundary   : No
Listing File    : E:\Program Files\Geocadastre\ShartageExcess1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       3
Number of Parcels              =       2
Number of Corners              =       7
Number of Bearings             =       9
Number of Distances            =       9
Number of Unknowns             =      10
Number of Redundant Ob         =       8
Bearings Exceeding Tolerance   =       1
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=   1.575  N=   0.151 at point 7
 Av shift E=   0.522  N=   0.068
Mean of Residuals              =    0.30
Standard Deviation of Residuals =   0.33
Range of Residuals             =    0.94


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   2/123456 Line: 9-7  Dirn(c-o)=   -5°42'38", Effect=1.993

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff
123456/2        0.000     -0.000      8      3     50.000     1.458


---------- Control Report ----------
             TRANSFORMATION RESULTS
 Point     X            Y           dx        dy       Name     Acc
#   5     1000.000     1000.000     0.000     0.000   Station1
#   6     1050.000     1000.000     0.000     0.000   Station2
#   9     1100.000     1000.000     0.000     0.000   Station3
```

Arbitrary Grid

no.	E (final)	N	corrections	
1	999.891	1019.907	-0.109	-0.093
2	1050.754	1020.151	0.754	0.151
3	1049.866	1040.080	-0.134	0.080
5	1000.000	1000.000	Fixed Point	Station1
6	1050.000	1000.000	Fixed Point	Station2
7	1101.575	1020.134	1.575	0.134
9	1100.000	1000.000	Fixed Point	Station3

Plan: 123456 Parcel: 2 Scale:1.021416 Rotation 359 28 47 AccType=2
Misclose 90 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
2	90 00 00	50.000	7	0.069	-0.154	0.821	50.821
7	0 00 00	20.000	8			0.583	20.583
8	270 00 00	50.000	3	-0.386	-0.172	1.458	51.458
3	180 00 00	20.000	2	0.317	0.326	-0.051	19.949
9	5 42 38	20.100	7	0.069	-0.154	0.095	20.195

Acc=1

Plan: 123456 Parcel: 1 Scale:1.007594 Rotation 359 36 58 AccType=1
Misclose 270 00 00 0.000 Acc:High Computed Area:1000.0 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	90 00 00	50.000	2	0.412	0.043	0.863	50.863
2	0 00 00	20.000	3	-0.341	-0.179	-0.051	19.949
3	270 00 00	50.000	4			0.038	50.038
4	180 00 00	20.000	1	-0.072	0.136	0.015	20.015
5	0 00 00	20.000	1	-0.072	0.136	-0.093	19.907
6	2 51 45	20.025	2	0.412	0.043	0.140	20.165

APPENDIX B5

```
                         Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  E:\Program Files\Geocadastre\ShartageExcess1.lst     06-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 1.00
Easement data   : No
Historical Data : Yes
Hold Boundary   : No
Listing File    : E:\Program Files\Geocadastre\ShartageExcess1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       3
Number of Parcels              =       2
Number of Corners              =       7
Number of Bearings             =       9
Number of Distances            =       9
Number of Unknowns             =      10
Number of Redundant Ob         =       8
Bearings Exceeding Tolerance   =       1
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=  -1.617  N=  -0.114 at point 7
 Av shift E=  -0.538  N=  -0.009
Mean of Residuals              =    0.31
Standard Deviation of Residuals =    0.34
Range of Residuals             =    0.61


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   2/123456 Line: 9-7  Dirn(c-o)=    5°42'38", Effect=1.993

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff
123456/2        0.000     -0.000      8      3     50.000    -1.545



---------- Control Report ----------
              TRANSFORMATION RESULTS
 Point     X          Y           dx        dy       Name     Acc
#   5     1000.000    1000.000     0.000     0.000   Station1
#   6     1050.000    1000.000     0.000     0.000   Station2
#   9     1100.000    1000.000     0.000     0.000   Station3
```

Arbitrary Grid

no.	E (final)	N	corrections	
1	1000.101	1020.087	0.101	0.087
2	1049.239	1019.886	-0.761	-0.114
3	1050.124	1039.927	0.124	-0.073
5	1000.000	1000.000	Fixed Point	Station1
6	1050.000	1000.000	Fixed Point	Station2
7	1098.383	1020.063	-1.617	0.063
9	1100.000	1000.000	Fixed Point	Station3

Plan: 123456 Parcel: 1 Scale:0.992386 Rotation 0 21 37 AccType=1
Misclose 270 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	90 00 00	50.000	2	-0.413	-0.028	-0.861	49.139
2	0 00 00	20.000	3	0.347	0.166	0.061	20.061
3	270 00 00	50.000	4			-0.035	49.965
4	180 00 00	20.000	1	0.066	-0.139	-0.014	19.986
5	0 00 00	20.000	1	0.066	-0.139	0.088	20.088
6	357 08 15	20.025	2	-0.413	-0.028	-0.124	19.901

Plan: 123456 Parcel: 2 Scale:0.977306 Rotation 0 22 23 AccType=2
Misclose 90 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
2	90 00 00	50.000	7	-0.066	0.165	-0.856	49.144
7	0 00 00	20.000	8			-0.618	19.382
8	270 00 00	50.000	3	0.412	0.165	-1.545	48.455
3	180 00 00	20.000	2	-0.346	-0.330	0.061	20.061
9	354 17 22	20.100	7	-0.066	0.165	0.028	20.128

Acc=1

APPENDIX B6

```
                        Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  E:\Program Files\Geocadastre\ShartageExcess1.lst     06-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 1.00
Easement data   : No
Historical Data : Yes
Hold Boundary   : No
Listing File    : E:\Program Files\Geocadastre\ShartageExcess1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =      3
Number of Parcels              =      2
Number of Corners              =      7
Number of Bearings             =      9
Number of Distances            =      9
Number of Unknowns             =     10
Number of Redundant Ob         =      8
Bearings Exceeding Tolerance   =      1
Distances Exceeding Tolerance  =      0
Close Points Found             =      0
Line Point Errors Found        =      0

Max shift E=   2.445  N=   0.262 at point 7
 Av shift E=   0.743  N=   0.099
Mean of Residuals              =    0.32
Standard Deviation of Residuals =    0.35
Range of Residuals             =    0.93


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   2/123456 Line: 9-7  Dirn(c-o)=   -8°31'51", Effect=2.978

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff
123456/2        0.000     -0.000      2      7     50.000     1.685
123456/2        0.000     -0.000      8      3     50.000     2.165


---------- Control Report ----------
              TRANSFORMATION RESULTS
 Point     X          Y          dx        dy       Name     Acc
#   5     1000.000    1000.000     0.000     0.000   Station1
#   6     1050.000    1000.000     0.000     0.000   Station2
#   9     1100.000    1000.000     0.000     0.000   Station3
```

Arbitrary Grid

no.	E (final)	N	corrections	
1	999.895	1019.909	-0.105	-0.091
2	1050.760	1020.147	0.760	0.147
3	1049.872	1040.077	-0.128	0.077
5	1000.000	1000.000	Fixed Point	Station1
6	1050.000	1000.000	Fixed Point	Station2
7	1102.445	1020.262	2.445	0.262
9	1100.000	1000.000	Fixed Point	Station3

Plan: 123456 Parcel: 1 Scale:1.007617 Rotation 359 37 21 AccType=1
Misclose 270 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	90 00 00	50.000	2	0.414	0.042	0.865	50.865
2	0 00 00	20.000	3	-0.342	-0.179	-0.050	19.950
3	270 00 00	50.000	4			0.038	50.038
4	180 00 00	20.000	1	-0.072	0.137	0.015	20.015
5	0 00 00	20.000	1	-0.072	0.137	-0.090	19.910
6	2 51 45	20.025	2	0.414	0.042	0.136	20.161

Plan: 123456 Parcel: 2 Scale:1.035938 Rotation 359 11 46 AccType=2
Misclose 90 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
2	90 00 00	50.000	7	0.128	-0.145	1.685	51.685
7	0 00 00	20.000	8			0.866	20.866
8	270 00 00	50.000	3	-0.363	-0.320	2.165	52.165
3	180 00 00	20.000	2	0.235	0.466	-0.050	19.950
9	8 31 51	20.225	7	0.128	-0.145	0.184	20.409

Acc=1

APPENDIX B7

```
                        Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  E:\Program Files\Geocadastre\ShartageExcess1.lst     06-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 1.00
Easement data   : No
Historical Data : Yes
Hold Boundary   : No
Listing File    : E:\Program Files\Geocadastre\ShartageExcess1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       3
Number of Parcels              =       2
Number of Corners              =       7
Number of Bearings             =       9
Number of Distances            =       9
Number of Unknowns             =      10
Number of Redundant Ob         =       8
Bearings Exceeding Tolerance   =       1
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=  -2.543  N=   0.180 at point 7
 Av shift E=  -0.772  N=   0.021
Mean of Residuals              =    0.34
Standard Deviation of Residuals =    0.37
Range of Residuals             =    0.87


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   2/123456 Line: 9-7  Dirn(c-o)=    8°31'51", Effect=2.978

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff
123456/2        0.000     -0.000      2      7     50.000    -1.778
123456/2        0.000     -0.000      8      3     50.000    -2.376


---------- Control Report ----------
              TRANSFORMATION RESULTS
 Point     X          Y          dx        dy       Name     Acc
#   5     1000.000    1000.000     0.000     0.000   Station1
#   6     1050.000    1000.000     0.000     0.000   Station2
#   9     1100.000    1000.000     0.000     0.000   Station3
```

```
             Arbitrary Grid

     no.      E  (final)      N          corrections
      1     1000.098     1020.086       0.098   0.086
      2     1049.236     1019.889      -0.764  -0.111
      3     1050.119     1039.931       0.119  -0.069
      5     1000.000     1000.000    Fixed Point  Station1
      6     1050.000     1000.000    Fixed Point  Station2
      7     1097.457     1020.180      -2.543   0.180
      9     1100.000     1000.000    Fixed Point  Station3

Plan: 123456  Parcel: 1 Scale:0.992377  Rotation   0 21 18  AccType=1
Misclose 270 00 00  0.000   Acc:High   Computed Area:1000.0 sqm

  From   Bearing    Distance    To       dE        dN      Dist-err   Gnd dist
     1   90 00 00     50.000     2  -0.414    -0.028     -0.862   49.138
     2    0 00 00     20.000     3   0.347     0.166      0.061   20.061
     3  270 00 00     50.000     4                       -0.035   49.965
     4  180 00 00     20.000     1   0.067    -0.139     -0.014   19.986
     5    0 00 00     20.000     1   0.067    -0.139      0.086   20.086
     6  357 08 15     20.025     2  -0.414    -0.028     -0.121   19.904

Plan: 123456  Parcel: 2 Scale:0.961028  Rotation   0 27 04  AccType=2
Misclose  90 00 00  0.000   Acc:High   Computed Area:1000 sqm

  From   Bearing    Distance    To       dE        dN      Dist-err   Gnd dist
     2   90 00 00     50.000     7  -0.130     0.172     -1.778   48.222
     7    0 00 00     20.000     8                       -0.950   19.050
     8  270 00 00     50.000     3   0.431     0.324     -2.376   47.624
     3  180 00 00     20.000     2  -0.301    -0.497      0.061   20.061
     9  351 28 09     20.225     7  -0.130     0.172      0.115   20.340
Acc=1
```

APPENDIX B8.1

```
                        Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  E:\Program Files\Geocadastre\ShartageExcess1.lst     06-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 1.00
Easement data   : No
Historical Data : Yes
Hold Boundary   : No
Listing File    : E:\Program Files\Geocadastre\ShartageExcess1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       3
Number of Parcels              =       2
Number of Corners              =       7
Number of Bearings             =       9
Number of Distances            =       9
Number of Unknowns             =      10
Number of Redundant Ob         =       8
Bearings Exceeding Tolerance   =       0
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=  -0.752  N=  -0.121 at point 2
 Av shift E=  -0.072  N=  -0.033
Mean of Residuals              =    0.30
Standard Deviation of Residuals =    0.33
Range of Residuals             =    0.32


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff




---------- Control Report ----------
              TRANSFORMATION RESULTS
Point     X           Y            dx        dy       Name     Acc
#   5     1000.000    1000.000     0.000     0.000   Station1
#   6     1050.000    1000.000     0.000     0.000   Station2
#   9     1100.000    1000.000     0.000     0.000   Station3

              Arbitrary Grid
```

no.	E (final)	N	corrections	
1	1000.107	1020.091	0.107	0.091
2	1049.248	1019.879	-0.752	-0.121
3	1050.134	1039.921	0.134	-0.079
5	1000.000	1000.000	Fixed Point	Station1
6	1050.000	1000.000	Fixed Point	Station2
7	1100.224	1019.975	0.224	-0.025
9	1100.000	1000.000	Fixed Point	Station3

Adjustment of Cadastral Parcels

Plan: 123456 Parcel: 2 Scale:1.009147 Rotation 0 04 56 AccType=2
Misclose 90 00 00 0.000 Acc:High Computed Area:1000.0 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
2	90 00 00	50.000	7	0.060	0.159	0.976	50.976
7	0 00 00	20.000	8			0.024	20.024
8	270 00 00	50.000	3	0.398	-0.150	0.059	50.059
3	180 00 00	20.000	2	-0.458	-0.009	0.062	20.062
9	0 00 00	20.000	7	0.060	0.159	-0.024	19.976

Acc=1

Plan: 123456 Parcel: 1 Scale:0.992413 Rotation 0 22 18 AccType=1
Misclose 270 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	90 00 00	50.000	2	-0.412	-0.028	-0.858	49.142
2	0 00 00	20.000	3	0.345	0.166	0.062	20.062
3	270 00 00	50.000	4			-0.035	49.965
4	180 00 00	20.000	1	0.066	-0.138	-0.014	19.986
5	0 00 00	20.000	1	0.066	-0.138	0.092	20.092
6	357 08 15	20.025	2	-0.412	-0.028	-0.132	19.893

APPENDIX B8.2

```
                 Adjustment of Cadastral Parcels                  Page: 1

GeoCadastre 4.81  E:\Program Files\Geocadastre\ShartageExcess1.lst     06-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 1.00
Easement data   : No
Historical Data : Yes
Hold Boundary   : Yes
Listing File    : E:\Program Files\Geocadastre\ShartageExcess1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       7
Number of Parcels              =       2
Number of Corners              =       8
Number of Bearings             =      10
Number of Distances            =      10
Number of Unknowns             =       4
Number of Redundant Ob         =      16
Bearings Exceeding Tolerance   =       0
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=  -0.000  N=   0.000 at point 7
 Av shift E=  -0.000  N=   0.000
Mean of Residuals              =    0.00
Standard Deviation of Residuals =    0.00
Range of Residuals             =    0.00


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff




---------- Control Report ----------
              TRANSFORMATION RESULTS
Point     X            Y           dx        dy       Name     Acc
#   5     1000.000     1000.000     0.000     0.000    Station1
#   6     1050.000     1000.000     0.000     0.000    Station2
#   9     1100.000     1000.000     0.000     0.000    Station3

              Arbitrary Grid
```

no.	E (final)	N	corrections
1	1000.000	1020.000	Job Boundary Point
2	1050.000	1020.000	Job Boundary Point
3	1050.000	1040.000	Job Boundary Point
4	1000.000	1040.000	Job Boundary Point
5	1000.000	1000.000	Fixed Point Station1
6	1050.000	1000.000	Fixed Point Station2
7	1100.000	1020.000	-0.000 0.000
9	1100.000	1000.000	Fixed Point Station3

Plan: 123456 Parcel: 2 Scale:1.000000 Rotation 0 00 00 AccType=2
Misclose 90 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
2	90 00 00	50.000	7	0.000	0.000	-0.000	50.000
7	0 00 00	20.000	8			-0.000	20.000
8	270 00 00	50.000	3	0.000	0.000	-0.000	50.000
3	180 00 00	20.000	2	0.000	0.000	0.000	20.000
9	0 00 00	20.000	7	0.000	0.000	0.000	20.000

Acc=1

Plan: 123456 Parcel: 1 Scale:1.000000 Rotation 0 00 00 AccType=1
Misclose 270 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	90 00 00	50.000	2	0.000	0.000	0.000	50.000
2	0 00 00	20.000	3	0.000	0.000	0.000	20.000
3	270 00 00	50.000	4	0.000	0.000	0.000	50.000
4	180 00 00	20.000	1	-0.000	0.000	0.000	20.000
5	0 00 00	20.000	1	-0.000	0.000	0.000	20.000
6	357 08 15	20.025	2	0.000	0.000	-0.025	20.000

APPENDIX B9

```
                         Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  E:\Program Files\Geocadastre\ShartageExcess1.lst     06-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 1.00
Easement data   : No
Historical Data : Yes
Hold Boundary   : Yes
Listing File    : E:\Program Files\Geocadastre\ShartageExcess1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       7
Number of Parcels              =       2
Number of Corners              =       8
Number of Bearings             =      10
Number of Distances            =      10
Number of Unknowns             =       4
Number of Redundant Ob         =      16
Bearings Exceeding Tolerance   =       0
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=   0.907  N=   0.030 at point 7
 Av shift E=   0.907  N=   0.030
Mean of Residuals              =    0.05
Standard Deviation of Residuals =   0.08
Range of Residuals             =    0.34


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff
123456/2        0.000     -0.000     2      7     50.000     0.907
123456/2        0.000     -0.000     7      8     20.000     0.309
123456/2        0.000     -0.000     8      3     50.000     0.773

---------- Control Report ----------
              TRANSFORMATION RESULTS
 Point     X          Y          dx       dy       Name     Acc
#   5     1000.000    1000.000    0.000    0.000    Station1
#   6     1050.000    1000.000    0.000    0.000    Station2
#   9     1100.000    1000.000    0.000    0.000    Station3

              Arbitrary Grid
```

no.	E (final)	N	corrections
1	1000.000	1020.000	Job Boundary Point
2	1050.000	1020.000	Job Boundary Point
3	1050.000	1040.000	Job Boundary Point
4	1000.000	1040.000	Job Boundary Point
5	1000.000	1000.000	Fixed Point Station1
6	1050.000	1000.000	Fixed Point Station2
7	1100.907	1020.030	0.907 0.030
9	1100.000	1000.000	Fixed Point Station3

Plan: 123456 Parcel: 1 Scale:1.000000 Rotation 0 00 00 AccType=1
Misclose 270 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	90 00 00	50.000	2	0.000	0.000	0.000	50.000
2	0 00 00	20.000	3	0.000	0.000	0.000	20.000
3	270 00 00	50.000	4	0.000	0.000	0.000	50.000
4	180 00 00	20.000	1	-0.000	0.000	0.000	20.000
5	0 00 00	20.000	1	-0.000	0.000	0.000	20.000
6	357 08 15	20.025	2	0.000	0.000	-0.025	20.000

Plan: 123456 Parcel: 2 Scale:1.015549 Rotation 359 47 39 AccType=2
Misclose 90 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
2	90 00 00	50.000	7	0.063	0.002	0.907	50.907
7	0 00 00	20.000	8			0.309	20.309
8	270 00 00	50.000	3	0.005	-0.156	0.773	50.773
3	180 00 00	20.000	2	-0.068	0.154	0.000	20.000
9	2 51 45	20.025	7	0.063	0.002	0.026	20.051

Acc=1

APPENDIX B10

```
                      Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  E:\Program Files\Geocadastre\ShartageExcess1.lst     06-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 1.00
Easement data   : No
Historical Data : Yes
Hold Boundary   : Yes
Listing File    : E:\Program Files\Geocadastre\ShartageExcess1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       7
Number of Parcels              =       2
Number of Corners              =       8
Number of Bearings             =      10
Number of Distances            =      10
Number of Unknowns             =       4
Number of Redundant Ob         =      16
Bearings Exceeding Tolerance   =       1
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=  -0.918  N=   0.019 at point 7
 Av shift E=  -0.918  N=   0.019
Mean of Residuals              =    0.05
Standard Deviation of Residuals =   0.08
Range of Residuals             =    0.34


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   1/123456 Line: 6-2  Dirn(c-o)=    5°42'38", Effect=1.993

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff
123456/2        0.000     -0.000     2      7     50.000    -0.918
123456/2        0.000     -0.000     7      8     20.000    -0.319
123456/2        0.000     -0.000     8      3     50.000    -0.798
---------- Control Report ----------
              TRANSFORMATION RESULTS
 Point     X           Y           dx        dy      Name     Acc
#   5     1000.000    1000.000     0.000     0.000   Station1
#   6     1050.000    1000.000     0.000     0.000   Station2
#   9     1100.000    1000.000     0.000     0.000   Station3

              Arbitrary Grid
```

no.	E (final)	N	corrections
1	1000.000	1020.000	Job Boundary Point
2	1050.000	1020.000	Job Boundary Point
3	1050.000	1040.000	Job Boundary Point
4	1000.000	1040.000	Job Boundary Point
5	1000.000	1000.000	Fixed Point Station1
6	1050.000	1000.000	Fixed Point Station2
7	1099.082	1020.019	-0.918 0.019
9	1100.000	1000.000	Fixed Point Station3

Plan: 123456 Parcel: 1 Scale:1.000000 Rotation 0 00 00 AccType=1
Misclose 270 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	90 00 00	50.000	2	0.000	0.000	0.000	50.000
2	0 00 00	20.000	3	0.000	0.000	0.000	20.000
3	270 00 00	50.000	4	0.000	0.000	0.000	50.000
4	180 00 00	20.000	1	-0.000	0.000	0.000	20.000
5	0 00 00	20.000	1	-0.000	0.000	0.000	20.000
6	354 17 22	20.100	2	0.000	0.000	-0.100	20.000

Plan: 123456 Parcel: 2 Scale:0.984102 Rotation 0 09 54 AccType=2
Misclose 90 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
2	90 00 00	50.000	7	-0.063	0.001	-0.918	49.082
7	0 00 00	20.000	8			-0.319	19.681
8	270 00 00	50.000	3	0.003	0.158	-0.798	49.202
3	180 00 00	20.000	2	0.060	-0.160	0.000	20.000
9	357 08 15	20.025	7	-0.063	0.001	0.015	20.040

Acc=1

APPENDIX B11.1

```
                        Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  e:\program files\geocadastre\angle.lst               27-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 0.50
Easement data   : No
Historical Data : Yes
Hold Boundary   : Yes
Listing File    : e:\program files\geocadastre\angle.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       6
Number of Parcels              =       1
Number of Corners              =       7
Number of Bearings             =       7
Number of Distances            =       7
Number of Unknowns             =       3
Number of Redundant Ob         =      11
Bearings Exceeding Tolerance   =       0
Distances Exceeding Tolerance  =       1
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=   0.000  N=   0.000 at point 0
 Av shift E=   0.000  N=   0.000
Mean of Residuals              =    0.00
Standard Deviation of Residuals =   0.00
Range of Residuals             =    0.00


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   1/123456 Line: 6-2  Distance(c-o)=-1.000

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff
123456/1       -0.000     -0.000      6      2     21.000    -1.000


Error vectors at Inactive Control Points
========================================
Point   Bearing  Distance  Name
   20   90 00 00    0.000  Station 4
```

---------- Control Report ----------

TRANSFORMATION RESULTS

	Point	X	Y	dx	dy	Name	Acc
#	5	1000.000	1000.000	-0.000	0.000	Station1	
#	6	1050.000	1000.000	0.000	0.000	Station2	
#	5	1100.000	1000.000	-0.000	0.000	Station3	
	20	980.000	1040.000	-0.000	0.000	Station 4	

Arbitrary Grid

no.	E (final)	N	corrections
1	1000.000	1020.000	Job Boundary Point
2	1050.000	1020.000	Job Boundary Point
3	1050.000	1040.000	Job Boundary Point
4	1000.000	1040.000	Job Boundary Point
5	1000.000	1000.000	Fixed Point Station1
6	1050.000	1000.000	Fixed Point Station2
20	980.000	1040.000	0.000 0.000

Plan: 123456 Parcel: 1 Scale:1.000000 Rotation 0 00 00 AccType=1
Misclose 270 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	90 00 00	50.000	2	-0.000	0.000	-0.000	50.000
2	0 00 00	20.000	3	0.000	0.000	0.000	20.000
3	270 00 00	50.000	4	-0.000	0.000	0.000	50.000
4	180 00 00	20.000	1	-0.000	0.000	0.000	20.000
5	0 00 00	20.000	1	-0.000	0.000	0.000	20.000
6	0 00 00	21.000	2	-0.000	0.000	-1.000	20.000
20	90 00 00	20.000	4	-0.000	0.000	-0.000	20.000

APPENDIX B11.2

```
                        Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  E:\Program Files\Geocadastre\angle.lst               06-
Oct-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 0.50
Easement data   : No
Historical Data : Yes
Hold Boundary   : No
Listing File    : E:\Program Files\Geocadastre\angle.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       2
Number of Parcels              =       1
Number of Corners              =       5
Number of Bearings             =       5
Number of Distances            =       5
Number of Unknowns             =       7
Number of Redundant Ob         =       3
Bearings Exceeding Tolerance   =       0
Distances Exceeding Tolerance  =       1
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=  -0.153  N=   0.639 at point 2
 Av shift E=  -0.074  N=   0.358
Mean of Residuals              =    0.17
Standard Deviation of Residuals =    0.18
Range of Residuals             =    0.44


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   1/123456 Line: 6-2  Distance(c-o)=-1.000

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff
```

Error vectors at Inactive Control Points

Point	Bearing	Distance	Name
20	0 00 00	0.000	Station 4

---------- Control Report ----------

TRANSFORMATION RESULTS

	Point	X	Y	dx	dy	Name	Acc
#	5	1000.000	1000.000	0.000	0.000	Station1	
#	6	1050.000	1000.000	0.000	0.000	Station2	
#	5	1100.000	1000.000	0.000	0.000	Station3	
	20	980.000	1040.000	0.000	0.000	Station 4	

Arbitrary Grid

no.	E (final)	N	corrections	
1	1000.000	1020.000	-0.000	0.000
2	1049.929	1020.639	-0.071	0.639
4	999.847	1040.435	-0.153	0.435
5	1000.000	1000.000	Fixed Point	Station1
6	1050.000	1000.000	Fixed Point	Station2

Plan: 123456 Parcel: 1 Scale:1.000920 Rotation 359 32 16 AccType=1
Misclose 270 00 00 0.000 Acc:High Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	90 00 00	50.000	2	-0.080	0.018	-0.067	49.933
2	0 00 00	20.000	3			0.000	20.000
3	270 00 00	50.000	4	0.044	0.200	0.000	50.000
4	180 00 00	20.000	1	0.035	-0.217	0.435	20.435
5	0 00 00	20.000	1	0.035	-0.217	0.000	20.000
6	0 00 00	21.000	2	-0.080	0.018	-0.361	20.639
20	90 00 00	20.000	4	0.044	0.200	-0.148	19.852

APPENDIX B12.1

```
                 Adjustment of Cadastral Parcels                  Page: 1

GeoCadastre 4.81  E:\Program Files\Geocadastre\angle.lst              27-
Sep-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 0.50
Easement data   : No
Historical Data : Yes
Hold Boundary   : No
Listing File    : E:\Program Files\Geocadastre\angle.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       3
Number of Parcels              =       2
Number of Corners              =       8
Number of Bearings             =      10
Number of Distances            =      10
Number of Unknowns             =      12
Number of Redundant Ob         =       8
Bearings Exceeding Tolerance   =       0
Distances Exceeding Tolerance  =       1
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=  -0.080  N=   0.634 at point 2
 Av shift E=  -0.027  N=   0.086
Mean of Residuals              =    0.20
Standard Deviation of Residuals =   0.22
Range of Residuals             =    0.64


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   1/123456 Line: 6-2  Distance(c-o)=-1.000

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff


Error vectors at Inactive Control Points
========================================
Point   Bearing  Distance  Name
   20    0 00 00    0.000  Station 4
```

---------- Control Report ----------

TRANSFORMATION RESULTS

Point	X	Y	dx	dy	Name	Acc
# 5	1000.000	1000.000	0.000	0.000	Station1	
# 6	1050.000	1000.000	0.000	0.000	Station2	
# 9	1100.000	1000.000	0.000	0.000	Station3	
20	980.000	1040.000	0.000	0.000	Station 4	

Arbitrary Grid

no.	E (final)	N	corrections	
1	1000.000	1020.000	-0.000	0.000
2	1049.931	1020.634	-0.069	0.634
3	1049.920	1040.001	-0.080	0.001
4	1000.000	1039.799	0.000	-0.201
5	1000.000	1000.000	Fixed Point	Station1
6	1050.000	1000.000	Fixed Point	Station2
7	1100.015	1019.998	0.015	-0.002
9	1100.000	1000.000	Fixed Point	Station3

Plan: 123456 Parcel: 2 Scale:0.999390 Rotation   0 17 39 AccType=2
Misclose 90 00 00 0.000   Acc:High   Computed Area:1000.0 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
2	90 00 00	50.000	7	0.115	-0.046	0.088	50.088
7	0 00 00	20.000	8			0.033	20.033
8	270 00 00	50.000	3	-0.115	-0.287	0.083	50.083
3	180 00 00	20.000	2	-0.000	0.333	-0.633	19.367
9	0 00 00	20.000	7	0.115	-0.046	-0.002	19.998

Acc=1

Plan: 123456 Parcel: 1 Scale:0.995869 Rotation 359 34 59 AccType=1
Misclose 90 00 00 0.000   Acc:High   Computed Area:1000 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	90 00 00	50.000	2	0.000	0.302	-0.065	49.935
2	0 00 00	20.000	3	0.133	-0.247	-0.633	19.367
3	270 00 00	50.000	4	0.006	-0.087	-0.080	49.920
4	180 00 00	20.000	1	-0.139	0.031	-0.201	19.799
5	0 00 00	20.000	1	-0.139	0.031	0.000	20.000
6	0 00 00	21.000	2	0.000	0.302	-0.366	20.634
20	90 00 00	20.000	4	0.006	-0.087	0.001	20.001

APPENDIX B12.2

```
                 Adjustment of Cadastral Parcels                  Page: 1

GeoCadastre 4.81  E:\Program Files\Geocadastre\angle.lst               27-
Sep-08
  ADJUSTMENT FAILED



Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   1/123456 Line: 6-2  Distance(c-o)=-1.000
*** Zero on diagonal in column 4
at point number 7. Check observations to it
Aborting adjustment.

Failure to form Normal Equations
```

APPENDIX B13

```
                    Adjustment of Cadastral Parcels                 Page:
1
GeoCadastre 4.81  E:\Program Files\Geocadastre\testing1.lst           05-
Oct-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 0.10
Easement data   : No
Historical Data : Yes
Hold Boundary   : Yes
Listing File    : E:\Program Files\Geocadastre\testing1.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       4
Number of Parcels              =       1
Number of Corners              =       8
Number of Bearings             =       8
Number of Distances            =       8
Number of Unknowns             =       9
Number of Redundant Ob         =       7
Bearings Exceeding Tolerance   =       0
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=   0.000  N=  -0.000 at point 7
 Av shift E=   0.000  N=   0.000
Mean of Residuals              =    0.00
Standard Deviation of Residuals =   0.00
Range of Residuals             =    0.00


Close Points Report - Test Distance = 0.200
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff


Error vectors at Inactive Control Points
========================================
Point   Bearing  Distance  Name


    5  137 12 08    0.000  5
    6   43 02 20    0.015  6
    8  133 01 12    0.015  8
    7  268 03 04    0.021  7
```

---------- Control Report ----------

TRANSFORMATION RESULTS

Point	X	Y	dx	dy	Name	Acc
5	0.000	0.000	-0.000	0.000	5	
6	0.000	30.000	-0.010	-0.011	6	
8	30.000	0.000	-0.011	0.010	8	
7	30.044	30.000	0.021	0.001	7	

Arbitrary Grid

no.	E (final)	N	corrections	
1	5.004	5.000	Job Boundary Point	
2	25.011	4.993	Job Boundary Point	
3	25.018	25.001	Job Boundary Point	
4	5.010	25.007	Job Boundary Point	
5	0.000	-0.000	0.000	-0.000
6	0.010	30.011	-0.000	-0.000
7	30.023	29.999	-0.000	0.000
8	30.011	-0.010	0.000	0.000

Plan: 123456 Parcel: 1 Scale:1.000370 Rotation 0 01 10 AccType=1
Misclose 270 00 00 0.000 Acc:High Computed Area:400.0 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	90 00 00	20.000	2	-0.000	-0.000	0.007	20.007
2	0 00 00	20.000	3	-0.000	-0.000	0.007	20.007
3	270 00 00	20.000	4	-0.000	0.000	0.007	20.007
4	180 00 00	20.000	1	0.000	-0.000	0.007	20.007
5	45 00 00	7.071	1	0.000	-0.000	0.003	7.074
6	135 00 00	7.071	4	-0.000	0.000	0.003	7.074
7	225 01 00	7.071	3	-0.000	-0.000	0.003	7.074
8	315 00 00	7.071	2	-0.000	-0.000	0.003	7.074

APPENDIX B14

```
                     Adjustment of Cadastral Parcels               Page:1

GeoCadastre 4.81  E:\Program Files\Geocadastre\angle.lst               07-
Oct-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 0.50
Easement data   : No
Historical Data : Yes
Hold Boundary   : No
Listing File    : E:\Program Files\Geocadastre\angle.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       3
Number of Parcels              =       2
Number of Corners              =       8
Number of Bearings             =      10
Number of Distances            =      10
Number of Unknowns             =      12
Number of Redundant Ob         =       8
Bearings Exceeding Tolerance   =       0
Distances Exceeding Tolerance  =       1
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=  -0.170  N=  -0.120 at point 2
 Av shift E=  -0.034  N=  -0.014
Mean of Residuals              =    0.10
Standard Deviation of Residuals =    0.11
Range of Residuals             =    0.30


Close Points Report - Test Distance = 0.050
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============
   1/123456 Line: 1-2  Distance(c-o)=1.000

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff
123456/1       -1.000     -0.000      1      2     49.000     0.830



Error vectors at Inactive Control Points
========================================
Point   Bearing  Distance  Name
   20    0 00 00    0.000  Station 4
```

```
---------- Control Report ----------
              TRANSFORMATION RESULTS
 Point      X            Y           dx        dy       Name     Acc
#   5     1000.000     1000.000     0.000     0.000    Station1
#   6     1050.000     1000.000     0.000     0.000    Station2
#   9     1100.000     1000.000     0.000     0.000    Station3
   20      980.000     1040.000     0.000     0.000    Station 4

              Arbitrary Grid

     no.      E  (final)      N          corrections
      1     1000.000     1020.000      -0.000   0.000
      2     1049.830     1020.054      -0.170   0.054
      3     1049.953     1040.003      -0.047   0.003
      4     1000.000     1039.880       0.000  -0.120
      5     1000.000     1000.000    Fixed Point  Station1
      6     1050.000     1000.000    Fixed Point  Station2
      7     1100.048     1019.995       0.048  -0.005
      9     1100.000     1000.000    Fixed Point  Station3

Plan: 123456  Parcel: 2 Scale:1.002553  Rotation   0 02 17  AccType=2
Misclose  90 00 00  0.000   Acc:High   Computed Area:1000 sqm

  From    Bearing    Distance    To       dE        dN      Dist-err   Gnd dist
     2    90 00 00     50.000     7    0.024     0.017     0.218   50.218
     7     0 00 00     20.000     8                        0.034   20.034
     8   270 00 00     50.000     3    0.043    -0.060     0.085   50.085
     3   180 00 00     20.000     2   -0.067     0.043    -0.051   19.949
     9     0 00 00     20.000     7    0.024     0.017    -0.005   19.995
Acc=1

Plan: 123456  Parcel: 1 Scale:1.006253  Rotation 359 56 14  AccType=1
Misclose 270 00 00  1.000   Acc:1/139   Computed Area:989.9 sqm

  From    Bearing    Distance    To       dE        dN      Dist-err   Gnd dist
     1    90 00 00     49.000     2    0.043     0.105     0.830   49.830
     2     0 00 00     20.000     3    0.043    -0.071    -0.051   19.949
     3   270 00 00     50.000     4    0.041    -0.139    -0.047   49.953
     4   180 00 00     20.000     1   -0.126     0.105    -0.120   19.880
     5     0 00 00     20.000     1   -0.126     0.105     0.000   20.000
     6     0 00 00     20.000     2    0.043     0.105     0.054   20.054
    20    90 00 00     20.000     4    0.041    -0.139     0.000   20.000
```

APPENDIX B15

```
                        Adjustment of Cadastral Parcels
Page: 1
GeoCadastre 4.81  e:\program files\geocadastre\829753 take 2.lst       04-
Oct-08
  ADJUSTMENT COMPLETED SUCCESSFULLY

Project Option Settings
=======================
Project Units   : Meter
Plane Coordinate System

Check Tolerances:
        Bearings     1°40'00"
        Distances 0.10
Easement data   : No
Historical Data : Yes
Hold Boundary   : No
Listing File    : e:\program files\geocadastre\829753 take 2.lst

Adjustment Statistical Summary
==============================
Number of Control Points       =       3
Number of Parcels              =       1
Number of Corners              =       5
Number of Bearings             =       5
Number of Distances            =       5
Number of Unknowns             =       5
Number of Redundant Ob         =       5
Bearings Exceeding Tolerance   =       0
Distances Exceeding Tolerance  =       0
Close Points Found             =       0
Line Point Errors Found        =       0

Max shift E=   0.005  N=  -0.004 at point 1
 Av shift E=   0.005  N=  -0.003
Mean of Residuals              =    0.00
Standard Deviation of Residuals =   0.00
Range of Residuals             =    0.00


Close Points Report - Test Distance = 0.200
===================
No close points found

Line Points Report - Test Distance = 0.050
===================
0 Line Point Errors found

Parcel Lines
============

Suspect Points and Lines (exceed three sigma)
========================
Plan/Parcel   Parcel misclose    Point     dx       dy

Plan/Parcel     Parcel misclose   From     To     Length      Diff



---------- Control Report ----------
Point     X           Y           dx        dy       Name     Acc
#   6      246.154     100.000     0.011     0.011    SSM   0.005
#   8      162.370     107.947     0.004     0.001    DHW2   0.02
#   7      231.117      95.091    -0.015    -0.013    DHW   0.02

              Arbitrary Grid
```

no.	E (final)	N	corrections	
1	247.432	103.128	0.005	-0.004
3	230.070	108.250	0.004	-0.002
6	246.154	100.000	Fixed Point	SSM
7	231.117	95.091	Fixed Point	DHW
8	162.370	107.947	Fixed Point	DHW2

Plan: 829753 Parcel: 12 Scale:1.000270 Rotation 0 00 46 AccType=2
Misclose 220 58 02 0.002 Acc:1/88944 Computed Area:1036 sqm

From	Bearing	Distance	To	dE	dN	Dist-err	Gnd dist
1	287 47 55	14.700	2			0.004	14.704
2	280 30 00	3.420	3	0.000	0.000	0.001	3.421
3	10 35 05	42.335	4			0.012	42.347
4	99 31 55	29.585	5			0.008	29.593
5	205 05 55	46.195	1	0.000	0.000	0.012	46.207
6	22 13 00	3.395	1	0.000	0.000	-0.016	3.379
7	63 45 44	18.162	1	0.000	0.000	0.025	18.187
8	89 43 55	67.687	3	0.000	0.000	0.013	67.700

APPENDIX C

Req:R057580 /Doc:DP 0829753 P /Rev:14-May-1993 /Sts:OK.OK /Prt:28-Oct-2008 22:48 /Pgs:ALL /Seq:1 of 1
Ref:LandPartners Limited /Src:P