# Re-establishment of cadastral boundaries following the 2010-2011 Canterbury earthquakes

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## ABSTRACT

Between September 2010 and June 2011, the Canterbury region of New Zealand was subjected to 3 major earthquakes with magnitudes between 6.3 and 7.1 and thousands of aftershocks with magnitudes as high as 5.6 on the Richter scale.

The initial September 2010 event caused significant physical damage to land, buildings and infrastructure in the Christchurch urban area, and the surrounding rural area, but fortunately there were no fatalities. The February 2011 event caused multiple fatalities and more severe physical damage to buildings, infrastructure and land in Christchurch City. In June 2011 another major earthquake caused further damage to land, buildings and infrastructure.

Both vertical and horizontal survey control marks were subject to movements well in excess of accuracy requirements by each of the three events and the position of Cadastral boundaries and boundary points have been affected by land movement due to the earthquakes.

Few international examples of solutions for boundary re-establishment after such an event that were applicable to New Zealand could be located.

This paper describes the effects of the earthquakes on cadastral boundaries in the region. It then discusses the steps that are being taken to provide certainty in cadastral boundary re-establishment by surveyors.

**KEYWORDS:** Cadastral boundaries, earthquakes, regulatory intervention, Cadastral systems

## 1 INTRODUCTION

### 1.1 Canterbury earthquakes

The Canterbury region of New Zealand was subjected to a magnitude 7.1 earthquake, at 4:35am on 4 September 2010, causing significant physical damage to land and buildings in the Christchurch and Kaiapoi urban areas and surrounding rural area. Miraculously for an event of this size there was no loss of life.

Further significant land and property damage resulted from a magnitude 6.3 earthquake on 22 February 2011. Although the magnitude of the 22 February 2011 earthquake was less than the 4 September 2010 earthquake, the consequences were more devastating due to the location being closer to Christchurch City, the shallow depth, and much higher than normal ground accelerations (the highest ever recorded in New Zealand). Many commercial buildings, which were occupied at the time (12:37 pm), were severely damaged accounting for most of the 181 deaths as a result of this earthquake.

Another pair of aftershocks measuring 5.6 and 6.3 on 13 June 2011 caused further damage to land and property but fortunately no further deaths.

The physical effects of the earthquakes on the certainty of Cadastral boundaries were manifested in a number of ways:

- shearing of up to 4 metres in rural areas where a fault line passed through land parcels
- extension, compression and distortion close to a fault line
- block movements and rotations throughout the Canterbury area

- irregular deformation and surface flow (lateral spreading) due to liquefaction of subsoils
- Landslips and rock falls in the hill suburbs.

Despite frequent seismic activity in New Zealand there had been no major earthquake affecting the cadastral boundaries of a large urban area since the Hawke's Bay (Napier) earthquake in 1931.

Few international examples of solutions for boundary re-establishment after such an event that were applicable to New Zealand could be located.

## 1.2 Location of Christchurch

Christchurch, population 390,000, is the second largest city in New Zealand and is situated approximately midway down the eastern coast of the South Island at 43°32'S, 172°38'E.

The Canterbury region surrounding Christchurch is principally alluvial plains with small townships as residential commuter towns for Christchurch or supporting agricultural or horticultural activities on the Canterbury plains.

The City of Christchurch is largely built on a low lying plain through which meander two small rivers – the Heathcote and the Avon. The suburbs to the south-east extend up the steep slopes of the Port Hills and over those hills is the port of Lyttleton on the southern slopes. To the north of Christchurch the town of Kaiapoi is also located on a low lying area about the Kaiapoi River.

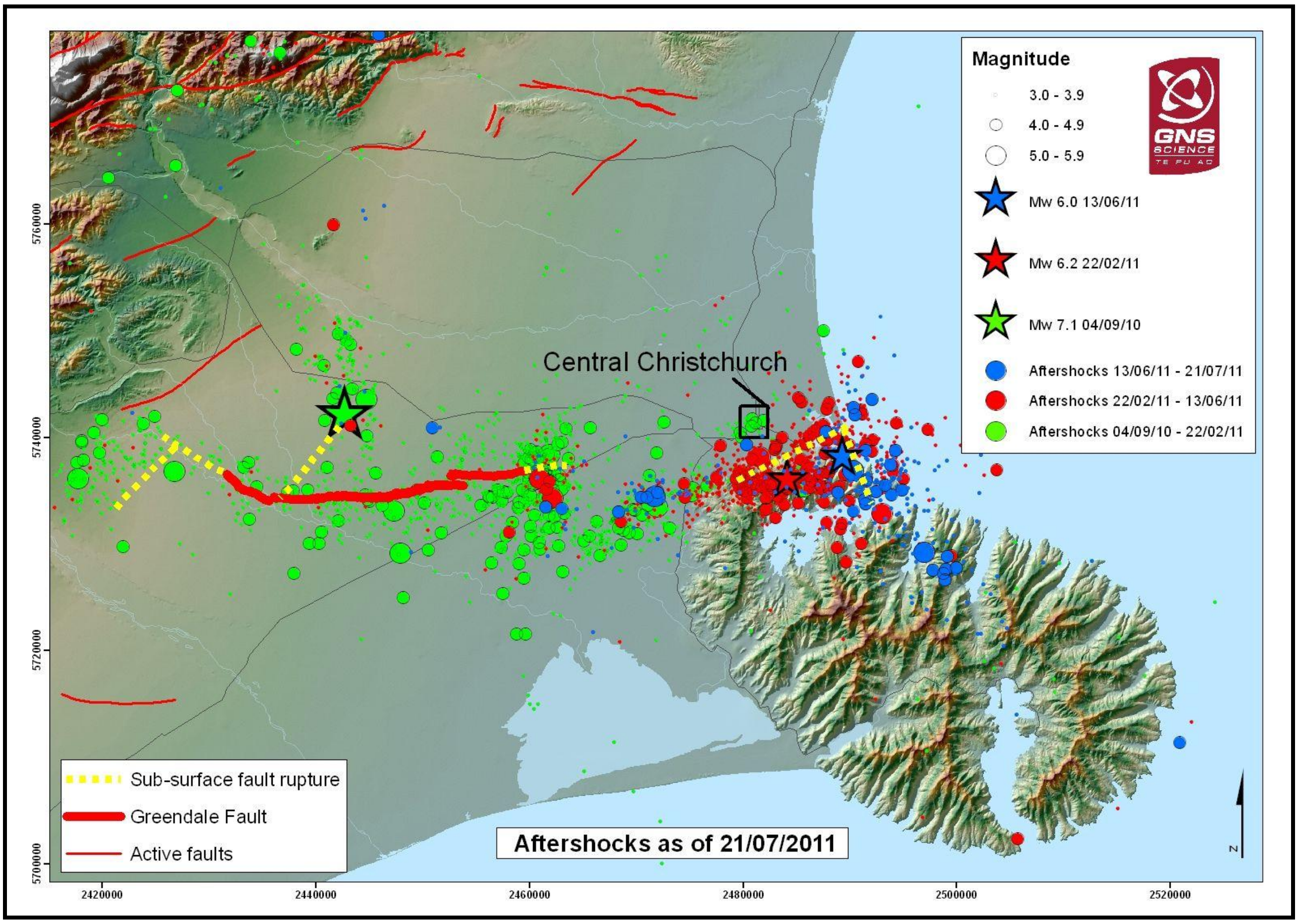


*Figure 1 – Location of faults and earthquake epicentres (Map –GNS Science)*

## 1.3 Location of the earthquakes

The epicentre of the 4 September 2010, magnitude 7.1, earthquake was located approximately 40 km west of Christchurch City near the town of Darfield and has been officially named the Darfield earthquake. A 28 km fault surface rupture, associated with the September 2010 earthquake, between the districts of Rolleston and Greendale, 10 km south of Darfield, has been named the Greendale fault.

The 22 February 2011 magnitude 6.3 earthquake was centred only 10 km south east of the Christchurch central business district, near the port of Lyttelton. Scientists have identified a 10 km long sub-surface fault rupture running ENE between the Christchurch suburbs of Halswell and Sumner, associated with this earthquake (GNS Science, 2011)

The June 2011 magnitude 5.6 and 6.3 earthquakes were centred 10 km east of Christchurch central business district.

Collectively, the three earthquake events and their associated aftershocks can be referred to as the Canterbury earthquakes.

The location of the epicentre of the earthquakes, the location of the aftershocks and the fault lines are illustrated in Figure 1.

# 2 PHYSICAL EFFECTS OF THE CANTERBURY EARTHQUAKES

Major earthquake events can cause disturbance to the land surface together with damage to buildings and their accompanying structures, as well as to surface and below ground utility infrastructure. Cadastral survey marks and geodetic survey control marks are deemed to be part of the utility infrastructure of the nation.

## 2.1 Damage to Structures caused by the Canterbury earthquakes

### 2.1.1 Building and property damage

A large number of buildings in the centre of the city were damaged by the shaking effect of the earthquakes and many more sustained damage due to underlying soil disturbance. Demolition is progressing and approximately 900 buildings in the CBD are expected to be demolished. Some of these buildings are physically repairable but it not is economical to do so.

A large number of residential suburban homes were severely damaged by shaking, by rock falls and by localised areas of liquefaction and surface flow (lateral spreading) due to liquefaction. The liquefaction and effects on the land is discussed later in this paper. To date, about 5000 homes have been identified as being on land which is uneconomic to rehabilitate and these properties will be purchased by the government. A further 10,000 homes are on land with moderate to severe damage and are subject to further assessment to determine whether they must also be abandoned.

### 2.1.2 Damage to Utility Infrastructure

All commercial, industrial and residential areas of the city were fully reticulated with utility services and serviced with high quality roads and footpaths. Mainly due to the liquefaction and subsequent surface flow elements of the earthquake, many road surfaces were rippled, concrete kerbs and channels distorted, bridges now higher than adjoining roads, stormwater and sewerage pipe work broken, and manholes raised through the road surface, electricity cables stretched and severed, gas lines ruptured, and water services destroyed. Christchurch is a flat city which relies heavily on pumps to operate the stormwater and foul sewerage systems and riverside pumping stations were tilted and made inoperative.

Most surveying reference marks are placed within the road corridors of the city, and where the road surfaces were disturbed by liquefaction, these marks were moved from their original positions.

Figure 2 illustrates the extrusion of a stormwater manhole structure through the road surface due to the effect of liquefaction.

*Figure 2 – A storm water manhole raised by liquefaction (Photo - Wikipedia)*

## 2.2 Disturbance to Land caused by the Canterbury Earthquakes

### 2.2.1 Fault Shear

The 4 September 2010 Darfield earthquake resulted in a fault shear visible on the land surface. Parcels of land astride the 28 kilometre long fault line were offset in places by up to 4 metres. Fences, water races and road formations clearly show the extent of the offset. The differential movement on either side of the fault is principally horizontal but with some local areas of vertical movement.

The surface fault rupture passes through approximately fifty separate cadastral land parcels in a rural area used primarily for agriculture and horticulture.

Figures 3 and 4 illustrate the effect of the fault rupture on a water race, a fence and a road formation, all of which were previously straight.


*Figure 3 – Effects of fault rupture on previously straight fence and water race. (Photo - Survus Consultants)*

*Figure 4 – Effects of fault rupture – previously straight road (Photo - Survus Consultants)*

### 2.2.2 Distortion adjacent to the fault

Following survey it is expected that parcel boundaries of land close to the fault will be shown to exhibit distortion reflecting the east-west direction of the fault. To date only one post earthquake dataset (DP440446) which crosses the fault has been received.

### 2.2.3 Liquefaction effects

Property damage was caused by the liquefaction effects of the earthquakes, mostly in urban areas, where almost 200,000 tonnes of water-borne fine silt was extruded out of the subsoil to the surface. Surface supported structures and infrastructure tended to settle into the subsurface void created by the extrusion of the liquefied material. The liquefaction thus caused surface and structural damage due to vertical movement but also caused shallow surface movement (lateral spreading) towards features of topographic weakness. For example, where a land parcel was close to a river bank or a terrace, the surface layer of that parcel could move towards the river bank. This surface movement could carry survey boundary monuments, fences and walls erected on boundaries and survey control monuments.

Figure 5 is an example of a rift between buildings and paving which were originally adjacent. This rift was caused by surface flow of material as a result of liquefaction.

*Figure 5 – Displacement due to liquefaction (Photo- Eliot Sinclair and Partners)*

Figure 6 is a photograph of a gate at the rear of a property giving access to a riverside recreation area. The white peg at the base of the post is a legal boundary monument. These features appear undisturbed yet after the earthquake they had moved 2.8 metres away from the roadside which was only 80 metres away.

*Figure 6 – Boundary point has moved 2.8 metres due to lateral spreading as a result of liquefaction (Photo - Eliot Sinclair and Partners)*

### 2.2.4 Block shift

Measurements of survey control stations following the September 4 earthquake completed by GNS Science and Land Information New Zealand (LINZ) showed that the whole region had been subjected to a deep seated block shift in terms of previous positions. The average shift of all points was about 100mm with the direction varying across the region. This deep seated movement in most cases is relatively uniform in relation to individual parcels of land.

Figure 7 shows the horizontal displacement vectors following the September 2010 quake. Measurements of survey control stations were repeated following the February 2011 and June 2011 earthquakes but over a smaller area as preliminary results showed little new movements to the west and north of the Christchurch suburban area.

Figure 8 shows the total displacements in the central areas due to all earthquake activity between September 2010 and mid-June 2011.

### 2.2.5 Vertical Movement

Figure 7 also shows the extent of vertical movement measured following the September 2010 earthquake. Figure 8 shows the total displacements measured between pre-September 2010 and post June 2011. Local government authorities maintain their own level networks about the city for infrastructure purposes and many of the benchmarks were the invert levels of sewer manholes. Liquefaction caused considerable changes to the levels of many of these manholes which are not reflected in the LINZ survey control displacement vectors.

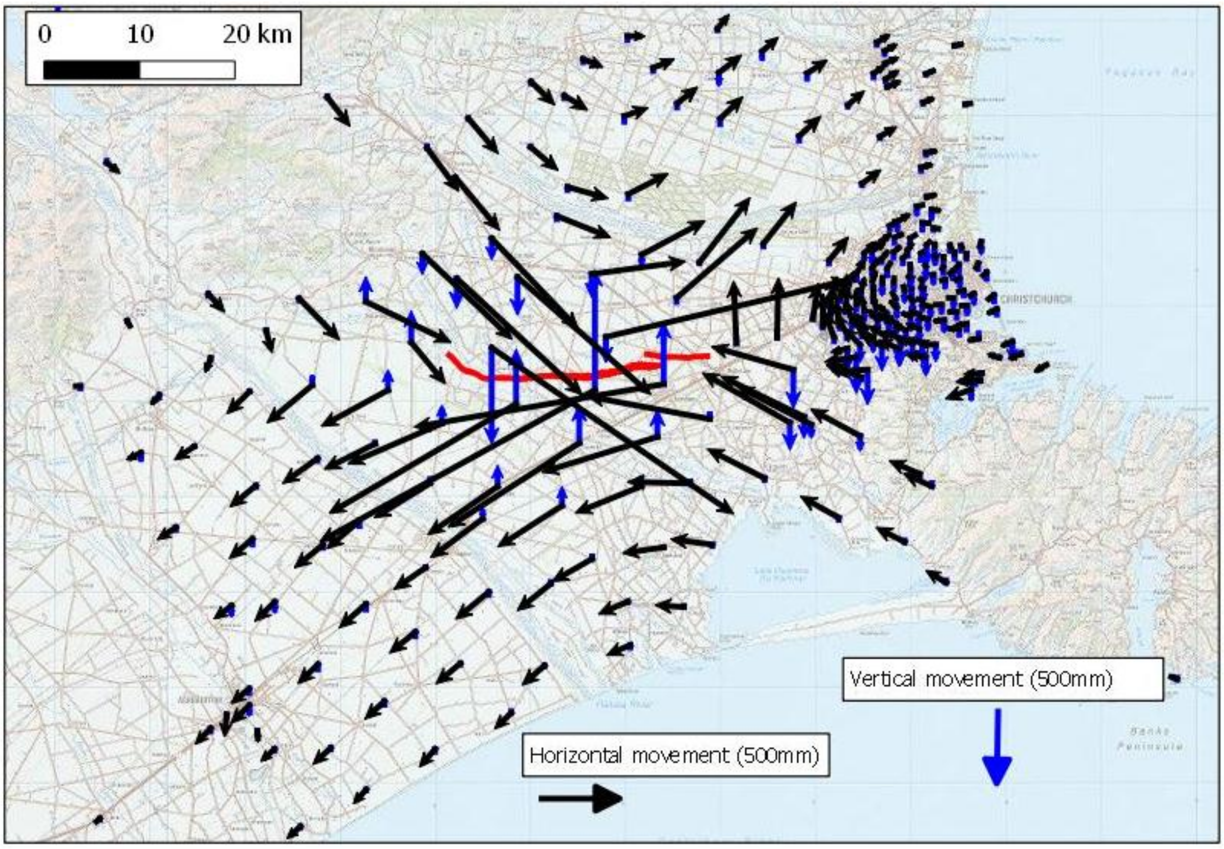


*Figure 7 – Horizontal and vertical ground displacements – Post September 2010 (Map – LINZ)*

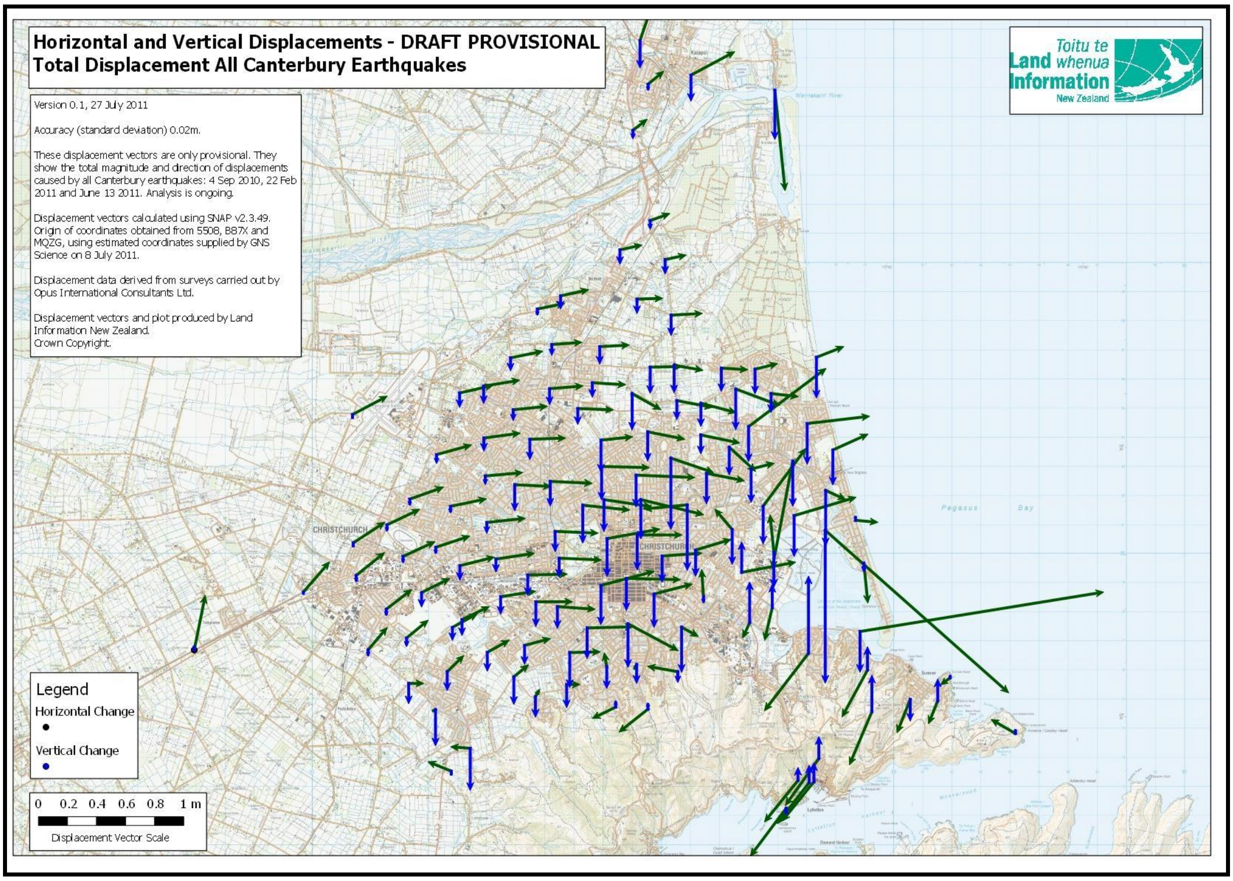


*Figure 8 – Total horizontal and vertical ground displacements – Post June 2011 (Map – LINZ)*

### 2.2.6 Rock fall Damage

The February earthquake caused large volumes of rock to detach from previously stable suburban cliff faces resulting in land damage at the top and bottom of the cliffs. Figure 9 illustrates the loss of support for a dwelling built above a cliff face.


*Figure 9 – Cliff collapse – Sumner (Photo courtesy Ross Becker, Photographer)*

## 3 THE EFFECT OF THE CANTERBURY EARTHQUAKES ON CADASTRAL BOUNDARIES

### 3.1 New Zealand Cadastral System

The New Zealand cadastral system supports a Torrens title system with a state guarantee of title. The survey system is supported by a strong network of survey control marks to which boundary points and monuments are connected. All boundary surveys are undertaken by private sector surveyors operating under the Cadastral Survey Act 2002 and the Rules for Cadastral Survey 2010. The Rules for Cadastral Survey 2010, which came into effect 24 May 2010, have the status of statutory regulations. Most of the guiding principles for the re-establishment of boundaries come from common law which has established a hierarchy of evidence for the re-establishment of boundaries and boundary points. The two highest levels in this hierarchy are natural boundaries followed by the location of an existing boundary monument in the position in which it was originally placed.

### 3.2 Inadequacy of Existing Law

New Zealand had no prescriptive law or regulation for the re-establishment of boundaries following earthquakes or landslip. There is also a lack of common law to assist surveyors with precedents for re-establishing boundaries following an earthquake. Moreover, the movement experienced following the recent Canterbury earthquakes causes difficulty with the hierarchy of evidence when a boundary monument may appear undisturbed from its originally placed position but has in fact moved considerably. See Figure 6 above. When submitting a Cadastral Survey Dataset (CSD) for integration into the cadastre, a licensed surveyor is required to certify that the survey and dataset are in accordance with the Cadastral Survey Act 2002 and the Rules for Cadastral Survey 2010. The Rules require a surveyor, when defining a boundary by survey, to interpret all evidence found in accordance with all relevant enactments and rules of law [rule 6.1 RCS2010].

### 3.3 Previous New Zealand Earthquake experience

The 1931 Hawke's Bay earthquake was the last significant earthquake in New Zealand which impacted upon major residential and commercial districts. A further result of that earthquake was the loss by fire of all official title and survey records for the district. Fortunately that has not been a consequence of the Canterbury earthquakes. The Hawke's Bay Earthquake Act 1931 and the Land Transfer (Hawke's Bay) Act 1931, inter alia, made provision for the reconstruction of records. The Napier Alignment Regulations 1932 provided for standard traverses to re-establish fixed width road alignments. These provisions are of little relevance to the re-establishment of Canterbury boundaries post 2010.

Other significant earthquakes in New Zealand, Inangahua 1968 and Edgecumbe 1987, have been in largely rural areas, and Fiordland 2009 was in a wilderness area largely within a National Park. Where boundaries have been re-established following those earthquakes decisions have been made by cadastral surveyors and where necessary discussed with and endorsed by LINZ (or predecessor departments) staff on a case-by-case basis. The number of boundaries affected by the Canterbury earthquakes precluded a similar approach being taken although the principles used for the re-establishment of boundaries are generally consistent.

### 3.4 Overseas precedents

In 2004 the Surveyor General commissioned a study to synthesize international best practices in re-defining parcel boundaries following a deformation event (Ballantyne 2004). The study found there is a lack of rigorous principles to deal with such movement which could assist in preparing similar response for New Zealand. Two useful examples are the 1964 Anchorage, Alaska, earthquake and the 1971 San Fernando, California, earthquake. In those cases special legislation was used to deal with the effects of the earthquakes and while not directly relevant to the Canterbury situation, similar principles, where relevant, have been applied to the re-establishment of boundaries since the Canterbury events.

## 4 MANAGING THE SPATIAL CADASTRE

### 4.1 The New Zealand Spatial Cadastre

For 70% of land parcels, covering most urban and intensively-used rural areas, New Zealand has a survey-accurate digital spatial cadastre. For these parcels, boundary dimensions have been captured from vectors on historic survey plans, and subsequently new digital survey data, and adjusted in terms of the official geodetic datum to generate accurate coordinates. Generally these coordinates have a network (absolute) accuracy of 0.20m in urban areas and 0.50m in rural areas at the 95% confidence level. New Zealand has a monument and observation-based cadastre, so these coordinates do not legally define property boundaries. However the spatial cadastre that these coordinates represent is used by LINZ and surveyors to find marks and check the quality of new survey data. It is also used widely by the geospatial community, where it forms an important base layer to aid land management and other decision-making.

The movements caused by the Canterbury earthquakes are significant enough to require the updating of a large number of coordinates to realign the digital spatial cadastre.

### 4.2 Re-measurement required

Before the digital spatial cadastre can be realigned and new values for points produced, it is necessary to update the geodetic survey control system in the affected area. Three separate types of geodetic survey are required to update the control system so that the spatial cadastre can be updated. For full details on the re-establishment of the control system following the earthquake, refer to Donnelly et al (2011).

### 4.2.1 Initial Deformation Survey

In the week following the Darfield earthquake, GNS Science (New Zealand's geological research organisation) carried out a survey of 70 control marks in the area expected to have been affected. These 70 marks all had accurate pre-September earthquake coordinates to enable a reliable estimate of deformation to be determined. This survey was repeated one month later to assess the extent of ongoing post-seismic deformation. While GNS did carry out surveys following the next two earthquakes for scientific purposes they were not as extensive.

### 4.2.2 Regional Control Survey

Based on the results of the initial GNS Science deformation surveys, LINZ surveyed a further 250 marks in October 2010. This survey provided additional information about the extent of displacements as illustrated in Figure 7. In particular, this survey focussed on re-surveying control in urban areas, such as Christchurch city. Fewer marks were resurveyed following the February and June earthquakes as the magnitude was smaller. These later surveys concentrated on the greater Christchurch urban area.

### 4.2.3 Denser Localised Deformation Control Survey

Denser geodetic surveys will be required in areas in the vicinity of the Darfield fault rupture. These will be completed after movement due to significant aftershocks has ceased. Denser control in areas of liquefaction and the Christchurch Central Business District is also required. Completion of control in the CBD is delayed until demolition makes this area safe for survey work. Denser control in areas of liquefaction can be planned but awaits Canterbury Earthquake Recovery Authority's (CERA) determination of streets or suburbs which will be purchased by the Crown and on which re-development will not take place.

## 4.3 Re-adjustments required

To update the spatial cadastre without resurveying every affected point, a model of the earthquake movements is used. This model is based on one developed by GNS Science, modified by LINZ so that it can be used to update cadastral data. A description of the general procedure used to update New Zealand's deformation model after an earthquake is given in Winefield et al (2010).

In areas of localised deformation (such as areas affected by liquefaction), the movements are generally so non-uniform that full least squares adjustment, rather than a model, will be required to achieve the required accuracy. Until updated cadastral data is collected, the accuracy may be comparatively low, but the results of the adjustment will be used to assign appropriate accuracy orders.

As shown in Table 1, the number of coordinates needing to be updated is likely to be at least several hundred thousand, and could be up two million if measurements show that updates are required up to 200km from the epicentre.

*Table 1 – Number of geodetic and cadastral marks potentially requiring update*

| Maximum Range (km) | Geodetic marks (order 5 or better) | Cadastral control (order 6 or better) | Total marks |
|---|---|---|---|
| 0-20 | 223 | 4816 | 56835 |
| 20-40 | 1269 | 49538 | 565892 |
| 40-60 | 3176 | 28632 | 387606 |
| 60-80 | 673 | 3681 | 143593 |
| 80-100 | 487 | 2182 | 103995 |
| 100-120 | 701 | 5256 | 141675 |
| 120-140 | 1388 | 6771 | 206350 |
| 140-160 | 1683 | 2924 | 131968 |
| 160-180 | 1359 | 2115 | 109825 |
| 180-200 | 1314 | 3162 | 151680 |
| **TOTAL (up to 200km)** | **12273** | **109077** | **1999419** |

### 4.4 Timing of the spatial cadastre update

To avoid the confusing situation of having a combination of pre and post-earthquake coordinates in the Landonline database, geodetic control and cadastral coordinates will be updated at the same time, once the necessary geodetic survey work has been completed. For most surveyors, doing surveys over a small area, the pre-earthquake coordinates are still in terms with each other, so the fact that post-earthquake coordinates are not made available immediately is usually not a problem.

Until the update occurs, coordinate changes due to the earthquakes are being provided to surveyors and local government officials who request them.

While this update was initially expected to occur in the first half of 2011, due to the February and June 2011 earthquakes and the additional work now required, it is now expected that the coordinate update will occur in mid 2012 assuming there are no further significant aftershocks during that time period.

## 5 STATUTORY AND REGULATORY RESPONSE

### 5.1 Canterbury Earthquake Response and Recovery Act 2010

Following the 4 September 2010 earthquake, the Government of New Zealand determined that to facilitate the response to the earthquake, and to provide adequate statutory power to assist with the response, some relaxation of requirements in existing statutes would be required and allowance made for circumstances where the compliance with existing legislation could not be reasonably met as a result of the earthquake.

As a result the Canterbury Earthquake Response and Recovery Act 2010 was passed on 14 September 2010. The Act allowed for Orders in Council to be issued allowing exemptions, modifications or extensions of certain Acts including the Cadastral Survey Act 2002.

### 5.2 Rules for Cadastral Survey (Canterbury Earthquake) 2010

#### 5.2.1 Meeting with Surveyors

Following the earthquake, the Surveyor-General, and other LINZ representatives, attended a meeting of Canterbury surveyors to discuss post earthquake survey issues and to determine how LINZ could assist with the earthquake response and recovery effort. At the time some indicative surveys had been carried out on areas exhibiting the greatest movements due to liquefaction surface flow and reports were available as to the slip movement across the Greendale fault.

#### 5.2.2 Issue of Bulletin

With information gained from the surveyors and from local government authorities and from visiting sites with geotechnical advisors to the Earthquake Commission, a Bulletin was issued to surveyors in the region on 18 October 2010 providing guidance for the definition of boundaries in the affected areas. A point of contact with a Surveyor-General's staff member located in Christchurch was also provided. Very few surveys were being carried out in this period but the Bulletin was available to minimise any dislocation to work in progress.

#### 5.2.3 Special Rules for Cadastral Survey.

The Surveyor-General used the powers provided by the Canterbury Earthquake (Cadastral Survey Act) Order 2010, made under the Canterbury Earthquake Response and Recovery Act 2010, to prepare the Rules for Cadastral Survey (Canterbury Earthquake) 2010 (CEQ Rules). The Order allowed these Rules to be prepared without the extensive consultation normally required for statutory regulations. However feedback was sought from the Canterbury Branch of the New Zealand Institute of Surveyors and representatives of the Institute of Cadastral Surveying.

The CEQ Rules are only temporary and were to expire on 16 December 2011, in accordance with the Order in Council, unless superseded by new rules before then. The expiry date has now been extended to 31 December 2012 by the Canterbury Earthquake Recovery Act 2011. LINZ is proposing to develop longer term rules, with national application, for dealing with the effects of land movement due to earthquakes before the temporary rules expire. This will involve full consultation with surveyors, and other stakeholders, as required by the Cadastral Survey Act 2002.

### 5.2.4 Provisions of the Rules for Cadastral Survey (Canterbury Earthquake) 2010.

The Rules for Cadastral Survey (Canterbury Earthquake) 2010 (CEQ Rules) and a corresponding Guideline were published 23 December 2010 came into effect 31 January 2011. These Rules and Guideline apply to surveys for the re-establishment of boundary points, and boundaries, which have been affected by movement due to the Canterbury earthquakes. They apply in conjunction with the existing Rules for Cadastral Survey 2010 (RCS2010).

Where there has been deep-seated movement due to the earthquake then cadastral boundaries are deemed to have moved with the resulting land surface movement which can be displacement or deformation due to a fault rupture or relatively uniform block shift.

The CEQ Rules state that re-established boundary points and related boundaries affected by deep seated movement must hold the same relationship to physical evidence, including survey marks and boundary occupation, as they did prior to the earthquake.

Where the deep-seated movement results in a relatively uniform block shift of an entire land parcel, then the relative positions of the parcel's boundaries to survey marks will remain the same as before the earthquake.

Where a parcel boundary has been displaced or distorted by deep-seated movement, such as a fault rupture, that exceeds the applicable accuracy tolerances of the RCS2010, the re-established boundary must reflect that displacement or distortion. This may require the creation of new boundary angle points.

Conversely the case of shallow surface movement, due to liquefaction and surface flow, is considered analogous to land slip in which case survey and legal precedents indicate boundaries will normally be reinstated to their original positions after taking into account any deep-seated block movement.

The CEQ Rules also provide for some relaxation of the normal requirements for orientation of surveys and for adoption of boundaries from existing cadastral records in certain circumstances.

No Rules were formulated for those boundaries affected by rock falls. Firstly, this was not an issue after the September 2010 earthquake, and secondly common law supports the re-establishment of boundaries back in their original relative positions as for avulsion of water boundaries.

In a particular case where compliance with the rules is impractical or unreasonable the Surveyor-General can grant an exemption from the requirements, or specify alternative requirements, as provided for by section 47(5) Cadastral Survey Act 2002.

The CEQ Rules and Guideline can be accessed from the Canterbury Earthquake page on the LINZ web site (LINZ 2010)

## 5.3 Effect of the Rules for Cadastral Survey (Canterbury Earthquake) 2010

The CEQ Rules have provided some authority for the re-establishment of boundaries affected by the earthquake. Cadastral surveys have been small in number following the earthquake and the CEQ rules have not been comprehensively tested in practice to date. The large number of re-establishment surveys expected as building owners replace or repair their buildings had not commenced at the time of writing this paper.

The provisions of the CEQ Rules have allowed the licensed surveyors to confidently certify the datasets, for compliance with the Rules, and facilitate their integration into the cadastre.

In general, boundaries will only need to be resurveyed for the purpose of subdivision, or reconstruction of buildings close to boundaries, therefore it may be decades before many of the boundaries affected by movement due to the earthquake are resurveyed.

The purchase by the government of properties in the worst affected areas means that re-establishment of boundaries in these areas may not be required. Where land damaged by liquefaction is being remediated all structures will probably be removed first and boundaries will be re-established in their original positions in conjunction with the land remediation work.

### 5.4 Canterbury Earthquake Recovery Act 2011

On 18 April 2011 the Canterbury Earthquake Recovery Act 2011 was passed into law replacing the Canterbury Earthquake Response and Recovery Act 2010.

Particular features of this Act affecting boundary definition include:

- Extension of the expiry date of the Rules for Cadastral Survey (Canterbury Earthquake) 2010 until 31 December 2012 (s90).
- Permit the CE of CERA to require the CE of LINZ to approve a CSD which does not comply fully with the Rules for Cadastral Survey. Such direction can only be made after the CE of CERA has consulted with the Surveyor-General;
- Exempting the certifying surveyor of such a dataset from the liability for non-compliance with the Rules to the extent that the non-compliance was necessary for the purposes of the CERA Act.
- Provision for the issue of a title limited-as-to-parcels resulting from a survey dataset which the CE of CERA directed to be approved and for which adjoining owners approvals have not been obtained.

These reserve powers are considered likely to only be used as a last resort in cases where they will allow recovery efforts to proceed without being unduly delayed by uncertainty over boundary location, while still protecting the enduring rights of adjoining property owners.

## 6 NEW ZEALAND INSTITUTE OF SURVEYORS RESPONSE TO EARTHQUAKE RELATED CADASTRAL ISSUES.

The Canterbury Branch of the New Zealand Institute of Surveyors held a Cadastral issues workshop in August 2011 to discuss the issues arising from the earthquakes and the extra work surveyors will be required to do in determining cadastral boundaries in Canterbury in the future. The outcomes of this workshop will become available from the New Zealand Institute of Surveyors.

## 7 CONCLUSION

The CEQ Rules developed in response to the September 2010 earthquake provide some certainty for surveyors when certifying datasets but are yet to be fully tested for reasonableness and for comprehensiveness to cover all the cadastral definition issues resulting from the earthquakes.

This may not occur until the return of land development and reconstruction of buildings in the region. This may not occur in any volume until 2012 when the effect of decisions as to the retreat from parts of the city is complete.

Landowners will normally not require a definition or re-definition of their property boundaries unless they are subdividing or developing their land or have a dispute with their neighbour. Therefore, the effect of the Canterbury earthquakes on some property boundaries may not be discovered for decades ahead.

## ACKNOWLEDGEMENTS

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## REFERENCES


Ballantyne, B, 2004, *Managing the New Zealand cadastre after deformation events: Applying grit to a slippery slope*, LINZ research report.

Canterbury Earthquake Recovery Authority (CERA) ( http://www.cera.govt.nz )

Donnelly, N, Ritchie, J, and Amos, M, 2011, *Re-establishment of the New Zealand Survey Control System following the 2010 Darfield (Canterbury) Earthquake*, in Proceedings of FIG Working Week, May 18-22, Marrakech, Morocco. Available at: http://www.fig.net/srl/

GNS Science, 2011, *Canterbury earthquake - Most damaging quake since 1931,* media release web page, (http://www.gns.cri.nz)

LINZ 2010, *Canterbury Earthquake,* web page, (http://www.linz.govt.nz/survey-titles/cadastral-surveying/canterbury-earthquake/index.aspx)

LINZ 2010, *Rules for Cadastral Survey (Canterbury Earthquake) 2010 – LINZS65001* Available at LINZ Canterbury earthquake web page – see above

LINZ 2010, *Guideline for Rules for Cadastral Survey (Canterbury Earthquake) 2010 – LINZG65702* Available at LINZ Canterbury earthquake web page – see above

Quigley, M, 2010, *Science update on Darfield earthquake for press and public*, web page (http://drquigs.com/)

Smith M, Thompson M, Donnelly N, Grant D, 2011, *Re-establishment of cadastral boundaries following the 2010 earthquake in Canterbury, New Zealand*, in Proceedings of FIG Working Week, May 18-22, Marrakech, Morocco. Available at: http://www.fig.net/srl/

Tonkin & Taylor, 2010, *Darfield Earthquake 4 September 2010 Geotechnical Land Damage Assessment & Reinstatement Report – Stage 2*, Earthquake Commission Report (http://canterbury.eqc.govt.nz/publications/2010/11/stage2)

Winefield, R. Crook, C. and Beavan, J, 2010, *The Application of a Localised Deformation Model after an Earthquake*, in Proceedings of XXIV FIG Congress, April 11-16, Sydney, Australia. Available at: http://www.fig.net/srl/