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TRANSMITTAL MEMORANDUM

TO: Kim Reed

RE: Verizon Proposal

DATE: August 31, 2018

received 9/4/18

Dear Kim:

The materials on property value impact which the Gemmetts submitted contained links to several publications, some of which were provided by them. Enclosed for the ZBA's record are two of the articles which were referenced by link but not provided by them.

- The 2005 Appraisal Journal Article by Bond, et al.
- The July 25, 2014 article from *Realtor* magazine.

Please do not hesitate to contact me if you have any questions.

Very truly yours,

Michael L. Donovan

Enclosures

Cell Towers, Antennas Problematic for Buyers

July 25, 2014

An overwhelming 94 percent of home buyers and renters surveyed by the National Institute for Science, Law & Public Policy (NISLAPP) say they are less interested and would pay less for a property located near a cell tower or antenna.

What's more, of the 1,000 survey respondents, 79 percent said that under no circumstances would they ever purchase or rent a property within a few blocks of a cell tower or antennas, and almost 90 percent said they were concerned about the increasing number of cell towers and antennas in their residential neighborhood.

The survey, "Neighborhood Cell Towers & Antennas—Do They Impact a Property's Desirability?" also found that properties where a cell tower or group of antennas are placed on top of or attached to a building (condominium high-rise, for instance) is problematic for buyers.

"A study of real estate sales prices would be beneficial at this time in the Unites States to determine what discounts home buyers are currently placing on properties near cell towers and antennas," says Jim Turner, chair of NISLAPP.

Feedback

The NISLAPP survey echoes the findings of a study by Sandy Bond of the New Zealand Property Institute and past president of the Pacific Rim Real Estate Society (PRRES). "The Impact of Cell Phone Towers on House Prices in Residential Neighborhoods," which was published in The Appraisal Journal in 2006, found that buyers would pay as much as 20 percent less for a property near a cell tower or antenna.

Source: "Neighborhood Cell Towers & Antennas—Do They Impact a Property's Desirability? <http://electromagnetichealth.org/electromagnetic-health-blog/survey-property-desirability/>" *National Institute for Science, Law & Public Policy (June 2014)*

Trouble Spots for Buyers:

- Home Owners Object to Cell Tower Installations </daily-news/2012/11/19/home-owners-object-cell-tower-installations>

- Field Guide to Cell Phone Towers <http://www.realtor.org/field-guides/field-guide-to-cell-phone-towers>

- 6 Ways a Home May Turn Off Buyers </daily-news/2013/06/11/6-ways-a-home-may-turn-off-buyers>

- 6 Ways to Turn Off Buyers at Open Houses </node/16422>

Feedback

Comment </daily-news/2014/07/25/cell-towers-antennas-problematic-for-buyers#disqus_thread>

Recent Stories in This Section

The Impact of Cell Phone Towers on House Prices in Residential Neighborhoods

abstract

This article examines whether proximity to cellular phone towers has an impact on residential property values and the extent of any impact. First, a survey approach is used to examine how residents perceive living near cellular phone base stations (CPBSs) and how residents evaluate the impacts of CPBSs. Next, a market study attempts to confirm the perceived value impacts reported in the survey by analyzing actual property sales data. A multiple regression analysis in a hedonic pricing framework is used to measure the price impact of proximity to CPBSs. Both the survey and market sales analysis find that CPBSs have a negative impact on the prices of houses in the study areas.

by Sandy Bond, PhD, and Ko-Kang Wang

The introduction of cellular phone systems and the rapid increase in the number of users of cellular phones have increased exposure to electromagnetic fields (EMFs). Health consequences of long-term use of cellular phones are not known in detail, but available data indicates that development of nonspecific health symptoms is possible.[1] Conversely, it appears health effects from cellular phone equipment (antennas and base stations) pose few, if any, known health hazards.[2]

A concern associated with cellular phone usage is the siting of cellular phone transmitting antennas (CPTAs) and cellular phone base stations (CPBSs). In New Zealand, CPBS sites are increasingly in demand as the major cellular phone companies there, Telecom and Vodafone, upgrade and extend their network coverage. This demand could provide the owner of a well-located property a yearly income for the siting of a CPBS.[3] However, new technology that represents potential hazards to human health and safety may cause property values to diminish due to public perceptions of hazards. Media attention to the potential health hazards of CPBSs has spread concerns among the public, resulting in increased resistance to CPBS sites.

Some studies suggest a positive correlation between long-term exposure to the electromagnetic fields and certain types of cancer,[4] yet other studies report inconclusive results on health effects.[5] Notwithstanding the research results, media reports indicate that the extent of opposition from some property owners

1. Stanislaw Szmigielski and Elizbieta Sobiczewska, "Cellular Phone Systems and Human Health—Problems with Risk Perception and Communication," *Environmental Management and Health* 11, no. 4 (2000): 352–368.
2. Jerry R. Barnes, "Cellular Phones: Are They Safe?" *Professional Safety* 44, no. 12 (Dec. 1999): 20–23.
3. R. Williams, "Phone Zone—Renting Roof Space to Ma Bell," *The Property Business* 12 (April 2001): 6–7.
4. C. M. Krause et al., "Effects of Electromagnetic Field Emitted by Cellular Phones on the EEG During a Memory Task," *Neuroreport* 11, no. 4 (2000): 761–764.
5. Independent Expert Group on Mobile Phones, *Mobile Phones and Health* (Report to the United Kingdom Government, 2000), http://www.iegmp.org.uk.

affected by the siting of CPBSs remains strong.[6] However, the extent to which such attitudes are reflected in lower property values for homes located near CPBSs is not known.

Understanding the impact of CPBSs on property values is important to telecommunications companies both for planning the siting of CPBSs and for determining likely opposition from property owners. Similarly, property appraisers need to understand the valuation implications of CPBSs when valuing CPBS-affected property. The owners of affected property also want to understand the magnitude of any effects, particularly if compensation claims or an award for damages are to be made based on any negative effects on value.

The research here uses a case study approach to determine residents' perceptions towards living near CPBSs in Christchurch, New Zealand, and to quantify these effects in monetary terms according to an increasing or decreasing percentage of property value. The case study uses both an opinion survey and an econometric analysis of sales transaction data. A comparison of the results can be used to help appraisers value affected property as well as to resolve compensation issues and damage claims in a quantitative way. Further, the results provide a potential source of information for government agencies in assessing the necessity for increased information pertaining to CPBSs.

The following provides a brief review of the cellular phone technology and relevant literature. Then, the next section describes the research procedure used, including descriptions of the case study and control areas. The results are then discussed, and the final section provides a summary and conclusion.

Cellular Telephone Technology[7]

Cellular (mobile) telephones are sophisticated two-way radios that use ultrahigh frequency (UHF) radio waves to communicate information. The information is passed between a mobile phone and a network of low-powered transceivers, called mobile phone sites or cell sites. As mobile sites are very low powered they serve only a limited geographic area (or "cell"), varying from a few hundred meters to several kilometers; they can handle only a limited number of calls at one time. When a mobile phone user on the move leaves one cell and enters another, the next site automatically takes over the call, allowing contact to be maintained.

When a mobile phone call is initiated, the phone connects to the network by using radio signals to communicate with the nearest mobile phone site. The mobile phone sites in a network are interlinked by cable or microwave beam, enabling phone calls to be passed from one cell to another automatically. A mobile phone site is typically made up of a mast with antennas connected to equipment stored in a cabinet. Power is fed into the cabinet by underground cable. The antennas are designed to transmit most of the signal away horizontally, or just below horizontal, rather than at steep angles to the ground.

Mobile phone sites can only accommodate a limited number of calls at any one time. When this limit is reached, the mobile phone signal is transferred to the next nearest site. If this site is full or is too far away, the call will fail.

Cell site capacity is a major issue for telecommunication companies. As the number of people using mobile phones grows, more and more cell sites are required to meet customer demand for reliable coverage. At the end of March 2002, Telecom had more than 1.3 million mobile phone customers and more than 750 mobile phone sites throughout New Zealand. Vodafone had over 1.1 million mobile phone customers.[8] In areas, such as Auckland (the largest city in New Zealand, with close to a third of the NZ population), where almost complete coverage has been achieved, the main issue is ensuring that there is the capacity to handle the ever-increasing number of mobile phones and calls.

Locating Cellular Phone Sites

For cellular phone service providers, the main goals when locating cell sites are (1) finding a site that provides the best possible coverage in the area without causing interference with other cells, and (2) finding a site that causes the least amount of environmental impact on the surrounding area. Service providers usually attempt to locate cell sites on existing structures such as buildings, where antennas can be mounted on the roof to minimize the environmental impact. If this is not possible, a mast will need to be erected to support the antennas for the new cell site.

6. S. Fox, "Cell Phone Antenna Worries Family," *East & Bays Courier,* November 8, 2002, 1.

7. The information in this section was sourced from Telecom, http://www.telecom.co.nz; New Zealand Ministry for the Environment, http://www.mfe.govt.nz; and New Zealand Ministry of Health, http://www.moh.govt.nz.

8. Vodafone, "Cell Sites and the Environment," http://www.vodafone.co.nz/aboutus/vdfn_about_cellsites.pdf (accessed December 19, 2002) and "Mobile Phones and Health," http://www.vodafone.co.nz/aboutus/vdfn_about_health_and_safety.pdf (accessed December 19, 2002): and Telecom, "Mobile Phone Sites and Safety," http://www.telecom.co.nz/content/0,3900,27116-1536,00.html (accessed December 19, 2002).

Service providers prefer to locate cell sites in commercial or industrial areas due to the "resource consent" procedure required by the Resource Management Act 1991[9] for towers located in residential areas.

Despite the high level of demand for better cell phone coverage, the location of cell sites continues to be a contentious issue. The majority of people want better cell phone coverage where they live and work, but they do not want a site in their neighborhood. Thus, cell sites in or near residential areas are of particular concern. Concerns expressed usually relate to health, property values, and visual impact.[10]

In general, uncertainties in the assessment of health risks from base stations are presented and distributed in reports by organized groups of residents who protest against siting of base stations. When the media publishes these reports it amplifies the negative bias and raises public concerns. According to Covello, this leads to incorrect assessment of risks and threats by the public, with a tendency to overestimate risks from base stations and neglect risks from the use of cell phones.[11]

Assessment of Environmental Effects

Under the Resource Management Act 1991 (RMA), an assessment of environmental effects is required every time an application for resource consent is made. Information that must be provided includes "an assessment of any actual or potential effects that the activity may have on the environment, and the ways in which any adverse effects may be mitigated."[12] An assessment of the environmental effects of cell sites would take into consideration such things as health and safety effects; visual effects; effects on the neighborhood; and interference with radio and television reception.

Radio Frequency and Microwave Emissions from CPBSs

According to the Ministry for the Environment, the factors that affect exposure to radiation are as follows:

- Distance. Increasing the distance from the emitting source decreases the radiation's strength and decreases the exposure.

- Transmitter power. The stronger the transmitter, the higher the exposure.
- Directionality of the antenna. Increasing the amount of antennas pointing in a particular direction increases the transmitting power and increases the exposure.
- Height of the antenna above the ground. Increasing the height of an antenna increases the distance from the antenna and decreases the exposure.
- Local terrain. Increasing the intervening ridgelines decreases the exposure.[13]

The amount of radiofrequency power absorbed by the body (the dose) is measured in watts per kilogram, known as the specific absorption rate (SAR). The SAR depends on the power density in watts per square meter. The radio frequencies from cellular phone systems travel in a "line of sight." The antennas are designed to radiate energy horizontally so that only small amounts of radio frequencies are directed down to the ground. The greatest exposures are in front of the antenna so that near the base of these towers, exposure is minimal. Further, power density from the transmitter decreases rapidly as it moves away from the antenna. However, it should be noted that by initially walking away from the base, the exposure rises and then decreases again. The initial increase in exposure corresponds to the point where the lobe from the antenna beam intersects the ground.[14]

Health Effects

According to Szmigielski and Sobiczewska, the analogue phone system (using the 800–900 megahertz band) and digital phone system (using the 1850–1990 megahertz band) expose humans to electromagnetic field (EMF) emissions: radio frequency radiation (RF) and microwave radiation (MW), respectively. These two radiations are emitted from both cellular phones and CPBSs.[15]

For years cellular phone companies have assured the public that cell phones are safe. They state that the particular set of radiation parameters associated with cell phones is the same as any other ra-

9. The Resource Management Act 1991 is the core of the legislation intended to help achieve sustainability in New Zealand; see http://www.mfe.govt.nz/laws/rma.

10. Szmigielski and Sobiczewska; and Barnes.

11. Vincent T. Covello, "Risk Perception, Risk Communication, and EMF Exposure: Tools and Techniques for Communicating Risk Information," in *Risk Perception, Risk Communication and Its Application to EMF Exposure: Proceedings of the World Health Organization and ICNIRP Conference*, ed. R. Matthes, J. H. Bernhardt, M. H. Repucholi, 179–214 (Munich, Germany, May 1998).

12. Section 88(4), (b), Resource Management Act 1991.

13. Ministry for the Environment and Ministry of Health, *National Guidelines for Managing the Effects of Radiofrequency Transmitters*, available at http://www.mfe.govt.nz and http://www.moh.govt.nz (accessed May 21, 2002).

14. Ibid.; and Szmigielski and Sobiczewska.

15. Szmigielski and Sobiczewska.

dio signal. However, reported scientific evidence challenges this view and shows that cell phone radiation causes various effects, such as altered brain activity, memory loss, and fatigue.[16]

According to Cherry, there is also strong evidence to conclude that cell sites are risk factors for certain types of cancer, heart disease, neurological symptoms and other effects.[17] The main concerns related to EMF emissions from CPBSs are linked to the fact that radio frequency fields penetrate exposed tissues.

Public concern regarding both cell phones and CPBSs in many countries has led to establishment of independent expert groups to carry out detailed reviews of the research literature. Research on the health effects of exposures to RF are reviewed by, for instance, the NZ Radiation Laboratory, the World Health Organization, the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the Royal Society of Canada, and the UK Independent Expert Group on Mobile Phones. The reviews conclude that there are no clearly established health effects for low levels of exposure. Such exposures typically occur in publicly accessible areas around radio frequency transmitters. However, there are questions over the delayed effects of exposure.

While present medical and epidemiological studies reveal weak association between health effects and low-level exposures of RF/MW fields, controversy remains among scientists, producers, and the general public. Negative media attention has fuelled the perception of uncertainty over the health effects from cell phone systems. Further scientific or technological information is needed to allay fears of the public about cell phone systems.

Radio Frequency Radiation Exposure Standards

International Standards. The reviews of research on the health effects of exposures to RF have helped establish exposure standards that limit RF exposures to a safe level. Most standards—including those set by the ICNIRP, the American National Standards Institute (ANSI), and New Zealand—are based on the most-adverse potential effects.

The 1998 ICNIRP guidelines have been accepted by the world's scientific and health communities; these guidelines are both consistent with other stated standards and published by a highly respected and independent scientific organization. The ICNIRP is responsible for providing guidance and advice on the health hazards of nonionizing radiation for the World Health Organization (WHO) and the International Labour Office.[18]

The New Zealand Standard. In New Zealand, when a mobile phone site is being planned, radio frequency engineers calculate the level of electromagnetic energy (EME) that will be emitted by the site. The level of EME is predicted by taking into account factors such as power output, cable loss, antenna gain, path loss, and height and distance from the antenna. These calculations allow engineers to determine the maximum possible emissions in a worst-case scenario, i.e., as if the site was operated at maximum power all the time. The aim is to ensure that EME levels are below international and NZ standards in areas where the general public has unrestricted access.

All mobile phone sites in New Zealand must comply in all respects with the NZ standard for radio frequency exposures.[19] This standard is the same as used in most European countries, and is more stringent than that used in the United States, Canada, and Japan. Some local communities in New Zealand have even lower exposure-level standards; however, in reality mobile phone sites only operate at a fraction of the level set by the NZ standard. The National Radiation Laboratory has measured exposures around many operating cell sites, and maximum exposures in publicly accessible areas around the great majority of sites are less than 1% of the exposure limit of the NZ standard. Exposures are rarely more than a few percent of the limit, and none have been above 10%.

Court Decisions

Two court cases in New Zealand have alleged adverse effects due to CPBSs: *McIntyre v. Christchurch City*

16. K. Mann and J. Röschke, "Effects of Pulsed High-Frequency Electromagnetic Fields on Human Sleep," *Neuropsychobiology* 33, no. 1 (1996): 41–47; Krause et al.; Alexander Borbely et al., "Pulsed High-Frequency Electromagnetic Field Affects Human Sleep and Sleep Electroencephalogram." *Neurosci Let*, 275, no. 3 (1999): 207–210; L. Kellenyi et al., "Effects of Mobile GSM Radiotelephone Exposure on the Auditory Brainstem Response (ABR)," *Neurobiology* 7, no. 1 (1999): 79–81; B. Hocking, "Preliminary Report: Symptoms Associated with Mobile Phone Use," *Occup Med* 48, no. 6 (Sept. 1998): 357–360; and others as reported in Neil Cherry, *Health Effects Associated with Mobil Base Stations in Communities: The Need for Health Studies*, Environmental Management and Design Division, Lincoln University (June 8, 2000); http://pages.britishlibrary.net/orange/cherryonbasestations.htm.

17. Cherry.

18. Ministry for the Environment and Ministry of Health.

19. NZS 2772.1:1999, "Radiofrequency Fields Part I: Maximum Exposure Levels – 3kHz to 300GHz." This standard was based largely on the 1998 ICNIRP recommendations for maximum human exposure levels to radio frequency. The standard also includes a requirement for minimizing radio frequency exposure. See National Radiation Laboratory, *Cell Sites* (March 2001). 7; available at http://www.nrl.moh.govt.nz/CellsiteBooklet.pdf.

Council[20] and *Shirley Primary School v. Telecom Mobile Communications Ltd.*[21] Very few cell site cases have actually proceeded to Environment Court hearings. In these two cases the plaintiffs claimed that there was a risk of adverse health effects from radio frequency radiation emitted from cell phone base stations and that the CPBSs had adverse visual effects.

In *McIntyre*, Bell South applied for resource consent to erect a CPBS. The activity was a noncomplying activity under the Transitional District Plan. Residents objected to the application. Their objections were related to the harmful health effects from radio frequency radiation. In particular, they argued it would be an error of law to decide, based on the present state of scientific knowledge, that there are no harmful health effects from low-level radio frequency exposure. It was also argued that the Resource Management Act contains a precautionary policy and also requires a consent authority to consider potential effects of low probability but high impact in reviewing an application.

The Planning Tribunal considered residents' objections and heard experts' opinions as to the potential health effects, and granted the consent, subject to conditions. It was found that there would be no adverse health effects from low levels of radiation from the proposed transmitter, not even effects of low probability but high potential impact.

In *Shirley Primary School*, Telecom applied to the Christchurch City Council for resource consent to establish, operate, and maintain a CPBS on land adjacent to the Shirley Primary School. This activity was a noncomplying activity under the Transitional District Plan. Again, the city council granted the consent subject to conditions. However, the school appealed the decision, alleging the following four adverse effects:

- Risk of adverse health effects from the radio frequency radiation emitted from the cell site
- Adverse psychological effects on pupils and teachers because of the perceived health risks
- Adverse visual effects
- Reduced financial viability of the school if pupils withdraw because of the perceived adverse health effects

The court concluded that the risk of the children or teachers at the school developing leukemia or other cancers from radio frequency radiation emitted by the cell site is extremely low, and the risk to the pupils of developing sleep disorders or learning disabilities because of exposure to radio frequency radiation is higher, but still very small. Accordingly, the Telecom proposal was allowed to proceed.

In summary, the Environmental Court ruled that there are no established adverse health effects from the emission of radio waves from CPBSs and no epidemiological evidence to show this. The court was persuaded by the ICNIRP guidelines that risk of health effects from low-level exposure is very low and that the cell phone frequency imposed by the NZ standard is safe, being almost two and one-half times lower than that of the ICNIRP.

The court did concede that while there are no proven health effects, there was evidence of property values being affected by both of the health allegations. The court suggested that such a reduction in property values should not be counted as a separate adverse effect from, for example, adverse visual or amenities effects. That is, a reduction in property values is not an environmental effect in itself; it is merely evidence, in monetary terms, of the other adverse effects noted.

In a third case, *Goldfinch v. Auckland City Council*,[22] the Planning Tribunal considered evidence on potential losses in value of the properties of objectors to a proposal for the siting of a CPBS. The court concluded that the valuer's monetary assessments support and reflect the adverse effects of the CPBS. Further, it concluded that the effects are more than just minor as the CPBS stood upon the immediately neighboring property.

Literature Review

While experimental and epidemiological studies have focused on the adverse health effects of radiation from the use of cell phones and CPBSs, few studies have been conducted to ascertain the impact of CPBSs on property values. Further, little evidence of property value effects has been provided by the courts. Thus, the extent to which opposition from property owners affected by the siting of CPBSs is reflected in lower property values is not well known in New Zealand.

Two studies have been conducted to ascertain the adverse health and visual effects of CPBSs on property values. Telecom commissioned Knight Frank (NZ) Ltd to undertake a study in Auckland in 1998/

20. NZRMA 289 (1996).
21. NZRMA 66 (1999).
22. NZRMA 97 (1996).

99 and commissioned Telfer Young (Canterbury) Ltd to undertake a similar study in Christchurch in 2001. Although the studies show that there is not a statistically significant effect on property prices where CPBSs are present,[23] the research in both cases involves only limited sales data analysis. Further, no surveys of residents' perceptions were undertaken, and the studies did not examine media attention to the sites and the impact this may have on saleability of properties in close proximity to CPBSs. Finally, as the sponsoring party to the research was a telecommunication company it is questionable whether the results are completely free from bias. Hence, the present study aims to help fill the research void on this contentious topic in an objective way.

CPBSs are very similar structures to high-voltage overhead transmission lines (HVOTLs); therefore it is worthwhile to review the body of literature on the property values effects of HVOTLs. The only recently published study in New Zealand on HVOTLs effects is by Bond and Hopkins.[24] Their research consists of both a regression analysis of residential property transaction data and an opinion survey to determine the attitudes and reactions of property owners in the study area toward living close to HVOTLs and pylons.

The results of the sales analysis indicate that having a pylon close to a particular property is statistically significant and has a negative effect of 20% at 10–15 meters from the pylon, decreasing to 5% at 50 meters. This effect diminishes to a negligible amount after 100 meters. However, the presence of a transmission line in the case study area has a minimal effect and is not a statistically significant factor in the sale prices.

The attitudinal study results indicate that nearly two-thirds of the respondents have negative feelings about the HVOTLs. Proximity to HVOTLs determines the degree of negativity: respondents living closer to the HVOTLs expressed more negative feelings towards them than those living farther away. It appears, however, from a comparison of the results, that the negative feelings expressed are often not reflected in the prices paid for such properties.

There have been a number of HVOTLs studies carried out in the United States and Canada. A major review and analysis of the literature by Kroll and Priestley indicates that in about half the studies, HVOTLs have not affected property values and in the rest of the studies there is a loss in property value between 2%–10%.[25] Kroll and Priestley are generally critical of most valuer-type studies because of the small number of properties included and the failure to use econometric techniques such as multiple regression analysis. They identify the Colwell study as one of the more careful and systematic analyses of residential impacts.[26] That study, carried out in Illinois, finds that the strongest effect of HVOTLs is within the first 15 meters, but the effect dissipates quickly with distance, disappearing beyond 60 meters.

A Canadian study by Des Rosiers, using a sample of 507 single-family house sales, finds that severe visual encumbrance due to a direct view of either a pylon or lines exerts a significant, negative impact on property values; however location adjacent to a transmission corridor may increase value.[27] This was particularly evident where the transmission corridor was on a well-wooded, 90-meter right-of-way. The proximity advantages include enlarged visual field and increased privacy. The decrease in value from the visual impact of the HVOTLs and pylons (on average between 5% and 10% of mean house value) tends to be cancelled out by the increase in value from proximity to the easement.

A study by Wolverton and Bottemiller[28] uses a paired-sale analysis of home sales in 1989–1992 to ascertain any difference in sale price between properties abutting rights-of-way of transmission lines (subjects) in Portland, Oregon; Vancouver, Washington; and Seattle, Washington; and those located in the same cities but not abutting transmission line rights-of-way (comparisons). Subjects sold during the study period were selected first; then a matching comparison was selected that was as similar to the subject as possible. The study results did not support a finding of a price effect from abutting an HVTL right-of-way. In their conclusion, the authors

23. Mark Dunbar, Telfer Young research valuer, personal communication with Bond. 2002. The results of these studies have not been made publicly known. The study by Knight Frank of Auckland was conducted by Robert Albrecht.

24. S. G. Bond and J. Hopkins, "The Impact of Transmission Lines on Residential Property Values: Results of a Case Study in a Suburb of Wellington, New Zealand," *Pacific Rim Property Research Journal* 6, no. 2 (2000): 52–60.

25. C. Kroll and T. Priestley, "The Effects of Overhead Transmission Lines on Property Values: A Review and Analysis of the Literature," Edison Electric Institute (July 1992).

26. Peter F. Colwell, "Power Lines and Land Value," *Journal of Real Estate Research* 5, no. 1 (Spring 1990): 117–127.

27. François Des Rosiers, "Power Lines, Visual Encumbrance and House Values: A Microspatial Approach to Impact Measurement," *Journal of Real Estate Research* 23, no. 3 (2002): 275–301.

28. Marvin L. Wolverton and Steven C. Bottemiller, "Further Analysis of Transmission Line Impact on Residential Property Values," *The Appraisal Journal* (July 2003): 244–252.

warn that the results cannot and should not be generalized outside of the data. They explain that

limits on generalizations are a universal problem for real property sale data because analysis is constrained to properties that sell and sold properties are never a randomly drawn representative sample. Hence, generalizations must rely on the weight of evidence from numerous studies, samples, and locations.[29]

Thus, despite the varying results reported in the literature on property value effects from HVOTLs, each study adds to the growing body of evidence and knowledge on this (and similar) valuation issue(s). The study reported here is one such study.

Opinion Survey Research Objectives and Methodology

Research by Abelson;[30] Chalmers and Roehr;[31] Kinnard, Geckler and Dickey;[32] Bond;[33] and Flynn et al.,[34] recommend the use of market sales analysis in tandem with opinion survey studies to measure the impact of environmental hazards on residential property values. The use of more than one approach provides the opportunity to compare the results from each and to derive a more informed conclusion than obtained from relying solely on one approach. Thus, the methods selected for this study include a public opinion survey and a hedonic house price approach (as proposed by Freeman[35] and Rosen[36]). A comparison of the results from both of these techniques will reveal the extent to which the market reacts to cell phone towers.

Public Opinion Survey

An opinion survey was conducted to investigate the current perceptions of residents towards living near CPBSs and how this proximity might affect property values. Case study areas in the city of Christchurch were selected for this study. The study included residents in ten suburbs: five case study areas (within 300 meters of a cell phone tower) and five control areas (over 1 kilometer from the cell phone tower). The five case study suburbs were matched with five control suburbs that had similar living environments (in socioeconomic terms) except for the presence of a CPBS.

The number of respondents to be surveyed (800) and the nature of the data to be gathered (perceptions/personal feelings towards CPBSs) governed the choice of a self-administered questionnaire as the most appropriate collection technique. Questionnaires were mailed to residents living in the case study and control areas.

A self-administered survey helps to avoid interviewer bias and to increase the chances of an honest reply where the respondent is not influenced by the presence of an interviewer. Also, mail surveys provide the time for respondents to reflect on the questions and answer these at their leisure, without feeling pressured by the time constraints of an interview. In this way, there is a better chance of a thoughtful and accurate reply.

The greatest limitation of mail surveys is that a low response rate is typical. Various techniques were used to help overcome this limitation, including careful questionnaire design; inclusion of a free-post return envelope; an accompanying letter ensuring anonymity; and reminder letters. An overall response rate of 46% was achieved for this study.

The questionnaire contained 43 individual response items. The first question acted as an identifier to determine whether the respondent was a homeowner or tenant. While responses from both groups were of interest, the former was of greater importance, as they are the group of purchasers/sellers that primarily influence the value of property. However, it was considered relevant to survey both groups as both are affected by proximity to a CPBS to much the same extent from an occupiers' perspective, i.e., they both may perceive risks associated with a CPBS. It was hypothesized that tenants, being less-permanent residents, would perceive the effects in a similar way, but to a much lesser degree.

Other survey questions related to overall neighborhood environmental desirability; the timing of

29. Ibid., 252.

30. P. W. Abelson, "Property Prices and Amenity Values," *Journal of Environmental Economics and Management* 6 (1979): 11–28.

31. James A. Chalmers and Scott Roehr, "Issues in the Valuation of Contaminated Property," *The Appraisal Journal* (January 1993): 28–41.

32. W. N., Kinnard, M. B. Geckler, and S. A. Dickey, "Fear (as a Measure of Damages) Strikes Out: Two Case Studies Comparisons of Actual Market Behaviour with Opinion Survey Research" (paper presented at the Tenth Annual American Real Estate Society Conference, Santa Barbara, California, April 1994).

33. S. G. Bond, "Do Market Perceptions Affect Market Prices? A Case of a Remediated Contaminated Site," in *Real Estate Valuation Theory*, ed. K. Wang and M. L. Wolverton, 285–321 (Boston: Kluwer Academic Publishers, 2002).

34. James Flynn et al., "Survey Approach for Demonstrating Stigma Effects in Property Value Litigation," *The Appraisal Journal* (Winter 2004): 35–45.

35. A. Myrick Freeman, *The Benefits of Environmental Improvement: Theory and Practice* (Baltimore: John Hopkins Press, 1979).

36. Sherwin Rosen, "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy* 82, no. 1 (Jan/Feb 1974): 34–55.

the CPBS's construction and its proximity in relation to the respondent's home; the importance placed on the CPBS as a factor in relocation decisions and on the price/rent the respondent was prepared to pay for the house; how a CPBS might affect the price the respondent would be willing to pay for the property; and the degree of concern regarding the effects of CPBSs on health, stigma, aesthetics, and property values. The surveys were coded to identify the property address of the respondent. This enabled each respondent's property to be located on a map and to show this in relation to the cell site.

Eighty questionnaires[37] were distributed to each of the ten suburbs (five case study and five control areas) in Christchurch. Respondents were instructed to complete the survey and return it in the free-post, self-addressed envelope provided. The initial response rate was 31%. A month later, a further 575 questionnaires with reminder letters were sent out to residents who had not yet responded. A total response rate of 46% was achieved. Response rates from each suburb ranged from 33% (Linwood) to 61% (Bishopdale).

The questionnaire responses were coded and entered into a computerized database.[38] The analysis of responses included the calculation of means and percentage of responses to each question to allow for an overview of the response patterns in each area.

Case Study and Control Areas

The suburbs of Beckenham, Papanui, Upper Riccarton, Bishopdale, and St Albans were selected for the case study because there is at least one CPBS within each of these communities. Census data, providing demographic and socioeconomic characteristics of geographic areas, was used to select the control suburbs of Spreydon, Linwood, Bromley, Avonhead, and Ilam.[39] The control areas are located further away (over 1 kilometer) from the CPBS in their matched case study area. As well as matching demographic and socioeconomic characteristics, each suburb was selected based on its similarity to its matched case study area in terms of living environment and housing stock, distance to the central

business district, and geographic size; the only dissimilarity is that there are no CPBSs in the control areas. (See Appendix I for a location map.)

Demographic statistics show that Bromley and Ilam comprise a younger population (median age about 33), with Bishopdale and Upper Riccarton having an older population (median age about 40). The ethnic breakdown of each suburb indicates that Papanui and Spreydon have the highest proportion of Europeans (about 90%), Bromley has the highest proportion of both Maoris and Pacific Islanders (13.9% and 8.5% respectively), while Ilam, Avonhead, and Upper Riccarton have the highest proportion of Asians (16.1% to 18.5%).[40]

Median household and median family incomes (MHI and MFI) are highest in Ilam and Avonhead (MHI: $34,751NZ, $53,405NZ; MFI: $51,530NZ, $65,804NZ, respectively) and lowest in Linwood and Beckenham (MHI: $22,275NZ, $26,398NZ; MFI: $29,673NZ, $33,847NZ respectively).[41] Residents of St Albans West have the highest levels of education (21.7% have a degree or a higher degree) followed by Upper Riccarton (18.7%), Ilam (16.7%), and Avonhead (16.2%). These same suburbs have the highest proportion of professionals by occupational class (20.3% to 27.3%). Residents of Bromley have the lowest education (40% have no qualification) and the lowest proportion of professionals (5.5%).[42]

In summary, the socioeconomic data shows that Ilam is the more superior suburb, followed by Avonhead, Upper Riccarton, St Albans West, and Papanui. The lower socioeconomic areas are, in decreasing order, Spreydon, Bishopdale, Bromley, Beckenham, and Linwood.

Survey Results

A summary of the main findings from the survey is presented in Appendix II, and the survey results are discussed in the following.

Response Rates

Of the 800 questionnaires mailed to homeowners and tenants in the case study and control areas (400 to each group), 50% from the case study area and 41%

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37. Approved by the University of Auckland Human Subjects Ethics Committee (reference 2002/185).

38. The computer program SPSS was selected as the appropriate analytical tool for processing the data.

39. The census is conducted in New Zealand every five years, and the data used to define the control areas is from the latest census conducted in 2001, see Christchurch City Area Unit Profile, 2001 at http://www.ccc.govt.nz/Census/ChristchurchCityAreaUnitProfile.xls.

40. Christchurch City Area Unit Profile statistics.

41. $1NZ = $0.65US, thus, $34,751NZ = $22,588US.

42. The median house price for Christchurch city in August 2003 was $185,000NZ/$120,000US (New Zealand national median house price at this time was $215,000NZ/$140,000US), http://www.reinz.co.nz/files/HousingFacts-Sample-Pg1-5.pdf (accessed March 17, 2004). Median house prices in each individual suburb could not be obtained as the median sales data from the Real Estate Institute of NZ (REINZ) contains more than one suburb in each location grouping.

from the control area were completed and returned. Over three-quarters (78.5%) of the case study respondents were homeowners compared to 94% in the control area.

Desirability of the Suburb as a Place to Live

More than half (58.3%) the case study respondents have lived in their suburb for more than five years (compared to 65% in the control group) and a quarter (25%) have lived in their suburb between 1 and 4 years (compared to 28% in the control group).

Around two-thirds (65% of the case study respondents and 68% of the control group respondents) rated their neighborhoods as either above average or superior as a place to live when compared with other similar named suburbs. The reasons given for this include close proximity to amenities (shops, library, medical facilities, public transport, and recreational facilities) and good schools.

Reasons given for rating the case study neighborhoods inferior to other similar neighborhoods include lower house prices, older homes, more student housing and lower-income residents. The reasons given by the control group respondents for an inferior rating include distance from the central business district (Avonhead); smell from the sewerage oxidation ponds and composting ponds (Bromley); and lower socioeconomic area and noise from the airport (Linwood).

Feelings About a CPBS as an Element of the Neighborhood

In the case study areas, a CPBS had already been constructed when only 39% of the respondents bought their houses or began renting in the neighborhood. Some responded that they were not notified that the CPBS was to be built, that they had no opportunity to object to it, and that they felt they should have been consulted about its construction. For the respondents who said that proximity to the tower was of concern to them, the most common reasons given for this were the impact of the CPBS on health, aesthetics, and property values. Nearly three-quarters (74%) of the respondents said they would have gone ahead with the purchase or rental of their property anyway if they had known that the CPBS was to be constructed.

In the control areas nearly three-quarters (72%) of the respondents indicated they would be opposed to construction of a CPBS nearby. The location of a CPBS would be taken into account by 83% of respondents if they were to consider moving. As with the case study respondents, the control group respondents who were concerned about proximity to a CPBS were most often concerned about the effects of CPBSs on health, aesthetics, and property values.

Impact on Decision to Purchase or Rent

In the case study areas, the tower was visible from the houses of 46% of the respondents, yet two-thirds (66%) of these said it was barely noticeable, and one-quarter said it mildly obstructed their view. When asked in what way the CPBS impacts the enjoyment of living in their home, 37% responded that its impact was related to health concerns, 21% said it impacted neighborhood aesthetics, 20% said it impacted property value, and 12% said it impacted the view from their property.

When asked about the impact that the CPBS had on the price/rent they were prepared to pay for their property, over half the case study respondents (53.1%) said that the tower was not constructed at the time of purchase/rental, and 51.4% of the respondents said the proximity to the CPBS did not affect the price they were prepared to pay for the property. Nearly 3% said they were prepared to pay a little less, 2% said they were prepared to pay a little more. For the control group respondents, 45% of the respondents would pay substantially less for a property if a CPBS were located nearby, over one-third (38%) were prepared to pay just a little less for such a property, and 17% responded that a CPBS would not influence the price they would pay.

Only 10% of the case study respondents gave an indication of the impact that the CPBS had on the price/rent they were prepared to pay for the property; one-third of these felt it would decrease price/rent by 1% to 9%. For the control group, over one-third (38%) of the respondents felt that a CPBS would decrease price/rent by more than 20%, and a similar number (36%) said they would be prepared to pay 10% to 19% less for property located near a CPBS. The responses are outlined in Table 1.

Table 1 Impact of a CPBS on Purchase/Rental Price Decision

Price/Rent Effect	Percent of Case Study Respondents (Control Group Responses)
20% more	5% (3%)
10–19% more	10% (2%)
1–9% more	14% (2%)
1–9% less	33% (19%)
10–19% less	24% (36%)
20% or greater reduction in price/rent	14% (38%)

Interestingly, it would seem that those living farther away from the CPBSs (the control group) are far more concerned about proximity to CPBSs than those living near CPBSs (the case study group); they indicated that a CPBS would have a greater price/rent effect. The possible explanations for this are discussed in the survey results section.

Concerns About Proximity to the CPBS

Most case study respondents were not worried about the effects of proximity to a CPBS related to health (50%), stigma (55%), future property value (61%), or aesthetics (63%). About one-quarter to one-third of these respondents were somewhat worried about the impact of proximity to a CPBS on health (38%), stigma (34%), future property value (25%), or aesthetics (25%). From the list of issues, respondents were most worried about future property value, but only 13.5% of the respondents responded this way.

Here again, control group respondents were much more concerned about the effects of proximity to a CPBS than their case study counterparts. Of the possible concerns about CPBSs on which respondents were asked to comment, control group respondents were most worried about the negative effects on future property values and aesthetics. Nearly half the respondents were worried a lot about these issues. Similar responses were recorded for the possibility of harmful health effects in the future from CPBSs (42% were worried a lot about this) and stigma associated with houses near CPBSs (34% were worried a lot). The responses regarding concerns about living near a CPBS are shown in Table 2.

In both the case study and control areas, the issue of greatest concern for respondents was the impact of proximity to CPBSs on future property values. The main concerns related to CPBSs were the unknown potential health effects, the possible socioeconomic implications of the siting of CPBSs, and how CPBSs affect property values. There also were concerns that the city council was not notifying the public about the possible construction of CPBSs.

Discussion of the Survey Results

The results were mixed, with responses from residents ranging from having no concerns to being very concerned about proximity to a CPBS. In general, those people living in areas farther from CPBSs were much more concerned about issues related to proximity to CPBSs than residents who lived near CPBSs.

Over 40% of the control group respondents were worried a lot about future health risks, aesthetics, and future property values compared with the case study areas, where only 13% of the respondents were worried a lot about these issues. However, in both the case study and control areas, the impact of proximity to CPBSs on future property values is the issue of greatest concern for respondents. If purchasing or renting a property near a CPBS, over a third (38%) of the control group respondents said a CPBS would reduce the price of their property by more than 20%. The perceptions of the case study respondents were again less negative, with a third saying they would reduce the price by only 1%–9%, and 24% saying they would reduce the price by 10%–19%.

The lack of concern shown by the case study respondents may be due to the CPBSs being either not visible or only barely visible from their homes. The CPBSs may be far enough away from respondents' properties (as was indicated by many respondents, particularly in St Albans West, Upper Riccarton, and Bishopdale) or hidden by trees and consequently not perceived as affecting the properties. The results may have been quite different had the CPBS being more visually prominent.

Alternatively, the apparent lower sensitivity to CPBSs of case study residents compared to the control group residents may be due to cognitive dissonance reduction. In this case, respondents may be unwilling to admit, due to the large amounts of money already paid, that they may have made a poor purchase or rental decision in buying or renting property located near a CPBS. Similarly, the homeowners may be unwilling to admit there are concerns about CPBSs when the CPBSs were built

Table 2 Concerns about Living Near a CPBS*

Concern	Does not worry me	Worries me somewhat	Worries me a lot
Possibility of harmful health effects	50% (20%)	38% (38%)	12% (42%)
Stigma effect	55% (21%)	34% (45%)	12% (34%)
Effect on future property values	61% (15%)	25% (37%)	13% (47%)
Aesthetics	63% (18%)	25% (37%)	11% (45%)

* Percent of case study respondents having that concern (control group respondents). All numbers are rounded.

after they had purchased their homes, because to do so might have a negative impact on property values.

Regardless of the reasons for the difference in responses from the case study and control groups, the overall results show that residents perceive CPBSs negatively. In both the case study and control areas, the impact of proximity to CPBSs on future property values was the issue of greatest concern for respondents. Overall, respondents felt that proximity to a CPBS would reduce value by from 10% to over 20%. The second part of the study outlined below, involving an econometric analysis of Christchurch property sales transaction data, helps to confirm these results.

Respondents' comments added at the end of the survey indicate that residents have ongoing concerns about CPBSs. Although some people accepted the need for CPBSs, they said that they did not want them built in their back yard, or they preferred that they be disguised to blend better with their environment.

Market Study Research Objectives and Methodology

A market study was undertaken to test the hypothesis that in suburbs where there is a CPBS it will be possible to observe discounts to the selling price of homes located near these structures. Such discounts would be observed where buyers of proximate homes view the CPBSs in negative terms due to a perceived risk of adverse effects on health, aesthetics, and property value.

The literature dealing specifically with the measurement of the impact of environmental hazards on residential sale prices (including proximity to transmission lines, landfill sites, and ground water contamination) indicates the popularity of hedonic pricing models, as introduced by Court[45] and later Griliches,[44] and further developed by Freeman[45] and Rosen.[46] The more recent studies, including those by Dotzour;[47] Simons and Sementelli;[48] and Reichert,[49] focus on proximity to an environmental hazard and demonstrate that this reduces residential house prices by varying amounts depending on

the distance from the hazard.[50] However, there are no known published studies that use hedonic housing models to measure the impact of proximity to a CPBS on residential property values.

As in the previous residential house price studies, the standard hedonic methodology was used here to quantify the impact of a CPBS on sale prices of homes located near a CPBS. The results from this study in tandem with the opinion survey results will help test the hypothesis that proximity to a CPBS has a negative impact on property value and will reveal the extent to which the market reacts to CPBSs.

Model Specification

A hedonic price model is constructed by treating the price of a property as a function of its utility-bearing attributes. Independent variables used in the model to account for the property attributes are limited to those available in the data set and known, based on other well-tested models reported in the literature and from valuation theory, to be related to property price. The basic model used to analyze the impact on sale price of a house located near a CPBS, is as follows:

$$P_i = f(X_{1,i}, X_{2,i} \ldots \ldots \ldots \ldots \ldots X_{n,i})$$

where:

P_i = property price at the i th location

$X_{1,i} \ldots X_{n,i}$ = individual characteristics of each sold property (e.g., land area, age of house, floor area, sale date, construction materials, house condition, CPBS construction date, etc.)

The more recent hedonic pricing studies that demonstrate the effects of proximity to an environmental hazard use different functional forms to represent the relationship between price and various property characteristics.[51] In hedonic housing models the linear and log-linear models are most popular. The linear model implies constant partial effects between house prices and housing characteristics, while the log-linear model allows for nonlinear price effects and is shown in the following equation:

43. A. T. Court, "Hedonic Price Indexes with Automotive Examples," in *The Dynamics of Automobile Demand* (New York: General Motors, 1939).

44. Zvi Griliches, ed. *Price Indexes and Quality Change* (Cambridge, Mass.: Harvard University Press, 1971).

45. Freeman.

46. Rosen.

47. Mark Dotzour, "Groundwater Contamination and Residential Property Values," *The Appraisal Journal* (July 1997): 279–285.

48. Robert A. Simons and Arthur Sementelli, "Liquidity Loss and Delayed Transactions with Leaking Underground Storage Tanks," *The Appraisal Journal* (July 1997): 255–260.

49. Alan K. Reichert, "Impact of a Toxic Waste Superfund Site on Property Values." *The Appraisal Journal* (October 1997): 381–392.

50. Only Dotzour found no significant impact of the discovery of contaminated groundwater on residential house prices. This was likely due to the nonhazardous nature of the contamination where the groundwater was not used for drinking purposes.

51. See for example L. Dale et al., "Do Property Values Rebound from Environmental Stigmas? Evidence from Dallas," *Land Economics* 75, no. 2 (May 1999): 311–326; Dotzour; Simons and Sementelli; and Reichert.

$$\ln P_i = b_0 + b_1 \times X_{1,i} + b_2 \times X_{2i} + b_3 \times X_{3i}$$
$$\ldots \ldots \ldots + b_n \times X_{n+1} + a_0 \times D_0 +$$
$$\ldots \ldots + a_m \times D_m + e_0$$

where:

$\ln P_i$ = the natural logarithm of sale price

b_0 = the intercept

$b_1 \ldots b_n$; $a_0 \ldots a_m$ = the model parameters to be estimated, i.e., the implicit unit prices for increments in the property characteristics

$X_1 \ldots X_n$ = the continuous characteristics, such as land area

$D_0 \ldots D_m$ = the categorical (dummy) variables, such as whether the sale occurred before (0) or after (1) the CPBS was built

Sometimes the natural logarithm of land area and floor area is also used. The parameters are estimated by regressing property sales on the property characteristics and are interpreted as the households' implicit valuations of different property attributes. The null hypothesis states that the effect of being located near a CPBS does not explain any variation in property sale prices.

The Data

Part of the process for selecting appropriate case study areas was identifying areas where there had been a sufficient number of property sales to provide statistically reliable and valid results. Sales were required for the period before and after the CPBS had been built in order to study the impact of the CPBS on the surrounding properties' sale prices.

Further, due to the multitude of factors that combine to determine a neighborhood's character, such as proximity to the central business district, standard of schooling, recreational facilities provided, standard of housing, proximity to amenities, and the difficulty in allowing for these separately, sales located in areas with comparable neighborhood characteristics were preferred.

Four of the suburbs in the survey case study met the criteria for the market study: St Albans, Beckenham, Papanui, and Bishopdale. No sales data was available for Upper Riccarton after the CPBS was built in this suburb, hence this suburb was not included in the market analysis study. As each CPBS was built at a different date, the sales from each suburb were sepa-

rately analyzed. The uniformity of locational and neighborhood characteristics in each of these suburbs allows the analysis to be simplified and to focus on the properties' physical attributes. The relative homogeneity of housing, locational, and neighborhood attributes was verified through field inspections.

The dependent variable is the property sale price. The data set includes 4283 property sales that occurred between 1986 and 2002 (approximately 1000 sales per suburb).[52]

The independent data set was limited to those variables that correspond to property attributes known and suspected to influence price. These variables are floor area (m^2); land area (ha); age of the house (the year the house was built); tower (a dummy variable indicating whether the sale occurred before or after the CPBS was built); sale date (month and year); time of sale based on the number of quarters before or after the CPBS was built (to help control for movements in house prices over time); category of residential property (stand-alone dwelling, dwelling converted into flats, ownership unit, etc); quality of the principal structure (as assessed by an appraiser); and roof and wall materials. The number of bedrooms was not available in the data set, but would not have been included as an independent variable since the number of bedrooms is highly correlated with floor area.

Since the GIS coordinates of properties for the initial analysis were not available, street name was included as an independent variable instead. To a limited extent, street name helped to control for the proximity effects of a CPBS. It was suspected that houses on a street close to a CPBS may, on average, sell for less than houses on a street farther away from the CPBS.

While views, particularly water views, have been shown in previous empirical studies to be an important attribute affecting sale price, in the present study the flat contour of the landscape where the homes are located, together with the suburban nature of the environment surrounding these, precluded any significant views. Thus, views were not included in the analysis. Further, due to the large number of sales included in the analysis, inspections of each individual property were not made to determine the view, if any, of a CPBS from each house. It was felt that it is not merely the view that may impact on price, but also proximity to a CPBS due to the potential effect this may have on health, cell phone coverage, and neighborhood aes-

52. These sales were obtained from Headway Systems Ltd, a data distribution and system development company. Headway is the major supplier of property market sales information to New Zealand's valuation profession; it is jointly owned by the NZ Institute of Valuers (NZIV) and PT Investments, a consortium of 28 shareholders from within the property industry.

thetics. Hence, view of a CPBS was not included as an independent variable. The variable descriptions are listed in Table 3. Variable codes are shown in Appendix III and basic descriptive statistics for selected quantitative variables are shown in Appendix IV.

Table 3 Variable Descriptions

Variable*	Definition
SLNETX	Sale price of the house (NZ$)
SITSTX	Street name
CATGYX2	Category of dwelling: D, E, etc.[†]
CATGYX4	Quality of the structure: A, B, C[†]
TIMESOLD.Q	Using the time the cell phone tower was built as a baseline quarter, the number of quarters before (–) and after (+) it was built
AGE	Year the house was built
LANDAX	Land area (ha)
MATFAX	Total floor area (m²)
WALLCNX	Wall construction: W, B, C, etc. [†]
ROOFCNX	Roof construction: W, B, C, etc. [†]
TOWER	An indicator variable: 0 if before the cell phone tower was built, or 1 after it was built

* Sale price is the dependent variable.

† See Appendix III for explanation of variable codes.

Market Study Results

An econometric analysis of Christchurch property transaction data helped to confirm the opinion survey results. In the analysis of selected suburbs, the sales data from sales that occurred before a CPBS was built was compared to sales data from after a CPBS was built to determine any variance in price, after accounting for all the relevant independent variables.

Empirical Results

The model of choice is one that best represents the relationships between the variables and has a small variance and unbiased parameters. Various models were tested and the results are described in the next section. The following statistics were used to help select the most appropriate model: the adjusted coefficient of determination (adjusted R^2); the standard error of the regression equation; the AIC[53] and BIC[54] statistics; and t-test of significance of the coefficients and F-statistic.

Significance of Variables and the Equation: St Albans

As hedonic prices can vary significantly across different functional forms, various commonly used functional forms were examined to determine the model specification that best describes the relationship between price and the independent variables. Also, to test the belief that the relationship between *Price* and *Land Area* is not a linear function of *Price,* the variable *LANDAX* (land area) was transformed to reflect the correct relationship. Several transformations were tested including: linear of *SLNETX* (sale price) and log of *LANDAX*; log of *SLNETX* and linear of *LANDAX*; and log of *SLNETX* and log of *LANDAX*. All dummy variables remained in their linear form in each model.

It was found that the best result was obtained from using the log of *SLNETX* and log of *LANDAX*, and the linear form of all the dummy variables. Taking the log of an independent variable implies diminishing marginal benefits. For example, an extra 50 square meters of land area on a 550-square-meter site would be worth less than the previous 50 square meters. The log-log model shows the percent change in price for a one-percent change in the independent variable, while all other independent variables are held constant (as explained in Hill, Griffiths, and Judge).[55]

In the semilogarithmic equation the interpretation of the dummy variable coefficients involves the use of the formula: $100(e^{b_n} - 1)$, where b_n is the dummy variable coefficient.[56] This formula derives the percentage effect on price of the presence of the factor represented by the dummy variable and is advocated over the alternative, and commonly misused, formula of $100 \cdot (b_n)$. The resulting model included all the available variables as follows:

$$\begin{aligned} \log(SLNETX) = \alpha &+ \beta_1 \times TOWER + \beta_2 \times SITSTX \\ &+ \beta_3 \times CATGYX2 + \beta_4 \times CATGYX4 \\ &+ \beta_5 \times TIMESOLD \times Q + \beta_6 \times AGE \\ &+ \beta_7 \times \log(LANDAX) \\ &+ \beta_8 \times MATFAX \\ &+ \beta_9 \times WALLCNX \\ &+ \beta_{10} \times ROOFCNX \end{aligned}$$

53. AIC is the Akaike Information Criterion, and is a "goodness of fit" measure involving the standard error of the regression adjusted by a penalty factor. The model selected is the one that minimizes this criterion (Microsoft SPSSPC Online Guide, 1997).

54. The BIC is the Bayesian Information Criterion. Like the AIC, BIC takes into account both how well the model fits the observed data, and the number of parameters used in the model. The model selected is the one that adequately describes the series and has the minimum SBC. The SBC is based on Bayesian (maximum-likelihood) considerations. (Microsoft SPSSPC Online Guide, 1997).

55. R. Carter Hill, William E. Griffiths, and George G. Judge. *Undergraduate Econometrics* (New York: John Wiley & Sons, 1997).

56. See Robert Halvorsen and Raymond Palmquist, "The Interpretation of Dummy Variables in Semi-Logarithmic Equations," *American Economic Review* 70, no. 3 (1980): 474–475.

From the regression output, the variables *ROOFCNX* and *WALLCNX* were found to be insignificant so these were removed from the model and the regression was rerun. The table in Appendix V summarizes these results. The F-statistic (123) shows that the estimated relationship in the model is statistically significant at the 95% confidence level and that at least one of the coefficients of the independent variables within the model is not zero.

Table 4 summarizes the model selection test statistics. Based on the AIC and BIC, the regression that excludes the variables *ROOFCNX* and *WALLCNX* is superior to the regression that includes them (AIC and BIC are minimized). For this reason, the model excluding these variables was selected for analysis, and it is discussed next.

Table 4 Test Statistics — St Albans

	Adjusted R^2	AIC	BIC
Full Model	0.82	-118.38	36.55
Sub Model	0.82	-121.64	5.95

Tests for normality, heteroskedasticity, and multicollinearity generally indicated that the model was adequately specified and that the data were not severely ill conditioned (heteroskedasticity and multicollinearity were diminished when the data were transformed).

The coefficient of determination (R^2) indicates that approximately 82% of the variation in sale price is explained by the variation in the independent variable set. All variable coefficients had the expected signs,[57] except for *TOWER*, which was positive. The positive coefficient for *TOWER* shows that, when all the other variables are held constant, after the installation of a CPBS in St Albans, the price of a house would increase by $e^{0.1153} \approx 1.12$ (12%). A possible explanation is that cell phone technology was quite new at the time (1994), and as there had been little in the media about possible adverse health effects from CPBSs, people may have perceived it as a benefit as they were likely to get better cell phone coverage.

The most significant variables were *TIMESOLD.Q* (the quarter in which the sale occurred before or after the CPBS was built), $log(LANDAX)$ (log of land area), and *MATFAX* (total floor area) and all have a positive influence on price. The positive *TIMESOLD.Q* indicates that the market was increasing over time since the CPBS was built (1994), but only to a limited extent (1.38%). The positive log of land area and total floor area shows that prices increase with increasing size.

The regression coefficient on $log(LANDAX)$ is 0.3285, which indicates that, on average, a 10% increase in *LANDAX* will generate a 3.285% increase in price. The positive coefficient for *MATFAX* indicates that, when all the other variables are held constant, for each additional m² the price would increase by $e^{0.0022514} \approx 1.0022314$ (0.22% increase).

Significance of Variables and the Equation: Papanui

The same functional form used for St Albans was used for Papanui. From the regression output, the variable *CATGYX2* was found to be insignificant so it was removed from the model and the regression was rerun; Appendix VI summarizes the results. The F-statistic (152) shows that the estimated relationship in the model is statistically significant at the 95% confidence level and that at least one of the coefficients of the independent variables within the model is not zero.

Table 5 summarizes the model selection test statistics. Based on the AIC and BIC, the regression that excludes the variable *CATGYX2* is superior to the regression that includes it (AIC and BIC are minimized). For this reason, the model excluding this variable was selected for analysis, and is discussed next.

Table 5 Test Statistics — Papanui

	Adjusted R^2	AIC	BIC
Full Model	0.87	-509.91	-371.99
Sub Model	0.87	-510.57	-381.56

The coefficient of determination (R^2) indicates that approximately 87% of the variation in sale price is explained by the variation in the independent variable set. This would be considered high in comparison with the amount of explanation obtained in similar hedonic house studies reported in the literature.[58] All variable coefficients had the expected signs.

The most significant variables were *TIMESOLD.Q*, *MATFAX* (total floor area), and *TOWER*. The former two have a positive influence on price. The positive *TIMESOLD.Q* indicates that the

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57. Note that the variable *AGE* is positive as this variable indicates the year the house was built; therefore, the higher the year, the younger the home. Newer houses have less wear and tear than older homes and sell, on average, for more than older homes.

58. For example, Reichert obtained an adjusted R^2 of 84%; Simons and Sementelli, 78%; Abelson, 68%; Dotzour, 56%–61%.

market was increasing over time since the CPBS was built (2000), but only by 1.4% per quarter. The positive coefficient for *MATFAX* indicates that, when all the other variables are held constant, the price would increase by $e^{0.0042576} \approx 1.00427$ (0.43%), with increasing size. The negative coefficient for *TOWER* shows that, when all the other variables are held constant, after the installation of a CPBS in Papanui, the price of a house would decrease by $e^{-0.2540} \approx 0.79$ (21% decrease).

Significance of Variables and the Equation: Beckenham

The same functional form used for Papanui and St Albans was used for Beckenham. From the regression output, the variable *ROOFCNX* was found to be insignificant so it was removed from the model and the regression was rerun; Appendix VII summarizes these results. The *F*-statistic (214) shows that the estimated relationship in the model is statistically significant at the 95% confidence level and that at least one of the coefficients of the independent variables within the model is not zero.

Table 6 summarizes the model selection test statistics. Based on the AIC and BIC, the regression that excludes the variable *ROOFCNX* is superior to the regression that includes it (AIC and BIC are minimized). For this reason, the model excluding this variable was selected for analysis.

Table 6 Test Statistics — Beckenham

	Adjusted R^2	AIC	BIC
Full Model	0.89	-819.00	-641.39
Sub Model	0.89	-818.66	-650.66

The coefficient of determination (R^2) indicates that approximately 89% of the variation in sale price is explained by the variation in the independent variable set. Again, as with the model for Papanui this amount of explanation would be considered high.

The most significant variables were *TIMESOLD.Q*, *MATFAX*, and *TOWER*. The former two have a positive influence on price. The positive *TIMESOLD.Q* indicates that the market was increasing over time since the CPBS was built in 2000, but only by 1.91% per quarter. The positive coefficient for *MATFAX* indicates that, when all the other variables are held constant, the price would increase by $e^{0.0042054} \approx 1.00421$ (0.42%), with increasing size. The negative coefficient for *TOWER* shows that, when all the other variables are held constant, after the installation of a

CPBS in Beckenham, the price of a house would decrease by $e^{-0.25019} \approx 0.793$ (20.7% decrease).

Significance of Variables and the Equation: Bishopdale

The same functional form used for the other three suburbs was used for Bishopdale. From the regression output, the variables *ROOFCNX* and *CATGYX* were found to be insignificant so these were removed from the model and the regression was rerun; Appendix VIII summarizes these results. The *F*-statistic (122) shows that the estimated relationship in the model is statistically significant at the 95% confidence level and that at least one of the coefficients of the independent variables within the model is not zero.

Table 7 Test Statistics — Bishopdale

	Adjusted R^2	AIC	BIC
Full Model	0.79	-927.48	-775.71
Sub Model	0.79	-929.32	-796.52

Table 7 summarizes the model selection test statistics. Based on the AIC and BIC, the regression that excludes the variable *ROOFCNX* and *CATGYX* is superior to the regression that includes it (AIC and BIC are minimized). For this reason, the model excluding these variables was selected for analysis.

Again, the most significant variables were *TIMESOLD.Q* and *MATFAX*; the variable of interest, *TOWER*, was not a significant variable in the model so it is not discussed further. The former two variables have a positive influence on price. The positive *TIMESOLD.Q* indicates that the market was increasing over time since the CPBS was built in 1994, but only at 0.98% per quarter. The positive coefficient for *MATFAX* indicates that, when all the other variables are held constant, the price would increase by $e^{0.0059665} \approx 1.004$ (0.40%), with increasing size.

Summary of Results

The above analysis shows that the most significant variables and their impact on price were similar between suburbs. This indicates the relative stability of the coefficients between each model. Interestingly, the impact of *TOWER* on price (a decrease of between 20.7% and 21%) was very similar in the two suburbs where the towers were built in the year 2000. This may be due to the much greater media publicity given to CPBSs after the two legal cases in Christchurch (*McIntryre* and *Shirley Primary School*

in 1996 and 1999, respectively). The two suburbs where *TOWER* was either insignificant or increased prices by around 12%, were suburbs where towers had been built in 1994, prior to the media publicity.

Limitations of the Research

The main limitation affecting this survey was in the selection of the case study areas. Specifically, the areas selected had CPBSs that were not highly visible to residents. If more-visible CPBSs had been selected, the results may have been quite different. Thus, caution must be used in making generalizations from this study or applying the results directly to other similar studies or valuation assignments. Factors that could affect results are the distance of homes from the CPBS, the style and appearance of the CPBS, how visible the CPBS is to residents, the type of home (single family, multifamily, rental, etc.), and the socioeconomic make-up of the resident population.

To help address the proximity factor, a study is in progress examining the role of distance to the CPBSs and price effects; that study uses GIS analysis to determine the impact this has on residential property prices. It is expected that this will provide a more precise estimation of the impact of a CPBS on price.

It must be kept in mind that these results are the product of only one case study carried out in a specific area (Christchurch) at a specific time (2003). The above results indicate that value effects from CPBSs may vary over time as market participants' perceptions change. Perceptions toward CPBSs can change either positively or negatively over time. For example, as the World Health Organization's ten-year study of the health effects from CPBSs is completed and becomes available, consumers' attitudes may become more positive or negative depending on the outcome of that study. Consequently, studies of the price effects of CPBSs need to be conducted over time.

Areas for Further Study

This research has focused on residents' perceptions of negative effects from proximity to CPBSs and how these impact property values, rather than the scientific or technological estimates of these risks. The technologists' objective view of risk is that risk is measurable solely in terms of probabilities and severity of consequences, whereas the public, while taking experts' assessments into account, view risk more subjectively, based on other factors. Further, the results of scientific studies about the health effects of radio frequency and microwave radiation

from CPBSs are not consistent. Residents' perceptions and assessments of risk vary according to a wide range of psychological, social, institutional, and cultural processes, and this may explain why their assessments differ from those of the experts.

Given the public concerns about the potential risks arising from being located nearby a CPBS, it is important for future studies to focus more attention on the kinds of risks the public associates with CPBSs and the level of risk perceived. How far away from the CPBS do people feel they have to be to be safe? What CPBS design, size, and surrounding landscape would help CPBSs to be more publicly acceptable? What social, economic, educational, and other demographic variables influence how people perceive the risks from CPBSs? Do residents that are heavy users of cell phones have a different perception of CPBSs than residents who make little use of this technology? Are these perceived risks reflected in property values and to what extent? Do these perceived risks vary over time and to what degree?

Answers to these questions, if shared among researchers and made public, could lead to the development of a global database to assist appraisers in determining the perceived level of risk associated with CPBSs and other similar structures.[59] Knowledge of the extent that these risks are incorporated into property prices and how they vary over time will lead to more accurate value assessments of properties in close proximity to CPBSs and other similar structures.

Summary and Conclusions

Focusing on four case study neighborhoods in Christchurch, New Zealand, this article presents the results from both an opinion survey and market sales analysis undertaken in 2003 to determine residents' perceptions towards living near a CPBS and how this may impact property prices. From the results, it appears that people who live close to CPBSs perceive the sites less negatively than those who live farther away.

The issue of greatest concern for survey respondents in both the case study and control areas is the impact of proximity to CPBSs on future property values. Overall, respondents would pay from 10%–19% less to over 20% less for a property if it were in close proximity to a CPBS.

The opinion survey results were generally confirmed by the market sales analysis using a hedonic house price approach. The results of the sales analysis show prices of properties were reduced by around 21% after a CPBS was built in the neighborhood. How-

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59. For example, high-voltage overhead transmission lines.

ever, this result varies between neighborhoods, with a positive impact on price being recorded in one neighborhood, possibly due to the CPBS being built in that suburb before any adverse media publicity about CPBSs appeared in the local Christchurch press.

Research to date reports no clearly established health effects from radio frequency emissions of CPBSs operated at or below the current safety standards, yet recent media reports indicate that people still perceive that CPBSs have harmful effects. Thus, whether or not CPBSs are proven to be free from health risks is only relevant to the extent that buyers of properties near CPBSs perceive this to be true. Even buyers who believe that there are no adverse health effects from CPBSs, knowing that other potential buyers might think the reverse, will probably seek a price discount for a property located near a CPBS.

The comments of survey participants indicate the ongoing concerns that residents have about CPBSs. There is the need to increase the public's understanding of how radio frequency transmitting facilities operate and the strict exposure-limit standards imposed on the telecommunication industry. As more information is discovered that refutes concerns regarding adverse health effects from CPBSs, and as information about the NZ safety standards are made more publicly available, the perception of risk may gradually change, eliminating the discounts for neighboring properties.

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Additional Reading

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Appendix I Location Map
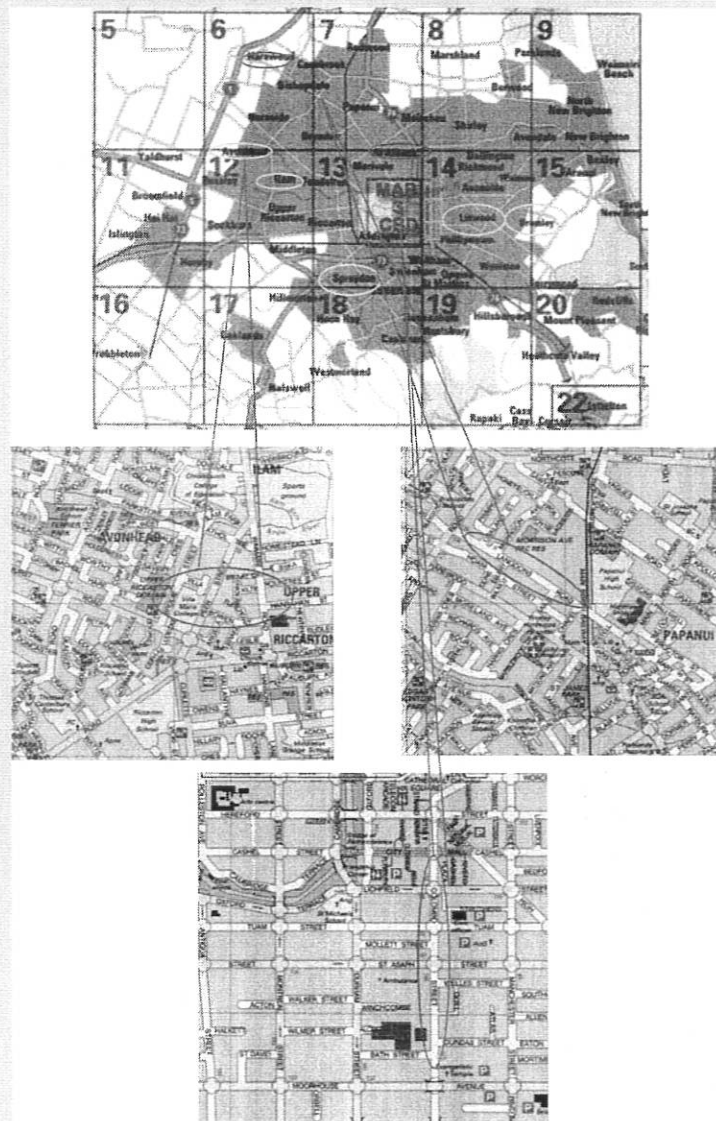
Areas circled in white at the top are without a cell phone tower, while areas circled in the bottom three maps have a cell phone tower.
Source: http://www.ccc.govt.nz/maps/Wises/

Appendix II Summary of the Survey Results

Variable	Responose	Valid Percent (%)	
		Case Study	Control
Occupancy	Homeowner	78.5	94.2
	Tenant	21.5	5.8
How long have you lived there?	Less than 6 months	8.0	2.6
	6 months–1 year	8.6	4.5
	1–4 years	25.1	27.7
	More than 5 years	58.3	65.2
How would you rate the desirability of your neighborhood?	Superior	27.4	30.9
	Above Average	37.4	36.8
	Average	28.5	27.0
	Below Average	5.6	4.6
	Inferior	1.1	0.7
Would you be opposed to construction of a cell phone tower nearby?	Yes		72.1
	No		27.9
When you purchased/began renting was the cell phone tower already constructed?	Yes	39.3	
	No	60.7	
Was the proximity of the cell phone tower a concern to you?	Yes	20.0	
	No	80.0	
Would you have gone ahead with rental/purchase if you had known a cell phone site was to be constructed?	Yes	73.9	
	No	26.1	
Is location of a cell phone tower a factor you would consider when moving?	Yes		83.4
	No		16.6
Is the cell phone tower visible from your house?	Yes	45.7	
	No	54.3	
If yes, how much does it impact on your view?	Very obstructive	9.6	
	Mildly obstructive	24.5	
	Barely noticeable	66.0	
In what way does it impact on the enjoyment of living in your house?	Views	11.8	
	Aesthetics	20.6	
	Health concerns	36.8	
	Change in property value	19.9	
	Other	11.0	
Effect a nearby cell phone tower would have on the price/rent you would pay for the property	Tower wasn't constructed	53.1	
	Pay substantially more	0.0	0.0
	Pay a little more	2.3	0.0
	Pay a little less	2.8	37.6
	Pay substantially less	0.6	45.4
	Not influence price	51.4	17.0
% Effect a nearby cell phone tower would have on the price/rent you would pay for the property	20% higher or more	5	3.2
	10–19% more	10	1.6
	1–9% more	14	2.4
	1–9% less	33	19.2
	10–19% less	24	36.0
	20% or a greater reduction	14	37.6
Concern about the possibility of harmful health effects in the future	Does not worry me	50.3	19.9
	Worries me somewhat	38.0	38.4
	Worries me a lot	11.7	41.7
Concern about the stigma associated with houses near the cell phone sites	Does not worry me	54.6	20.8
	Worries me somewhat	33.9	45.0
	Worries me a lot	11.5	34.2
Concern about the affect on your properties value in the future	Does not worry me	61.3	15.4
	Worries me somewhat	25.4	37.2
	Worries me a lot	13.3	47.4
Concern about the aesthetic problems caused by the tower	Does not worry me	63.3	18.2
	Worries me somewhat	25.4	37.0
	Worries me a lot	11.3	44.8

Appendix III Variable Codes

Category of Dwelling

Code	Definition
D	Dwelling houses are of a fully detached or semi-detached style situated on their own clearly defined piece of land.
E	Converted dwelling houses that are now used as rental flat.
F	Ownership home units which may be single storey or multi-storey and which do not have the appearance of dwelling houses.
H	Home and income. The dwelling is the predominant use, and there is an additional unit of use attached to or associated with the dwelling house that can be used to produce income.
R	Rental flats that have been purpose built.

Quality of the Principal Structure

Code	Definition
A	Superior design and quality of fixtures and fittings is first class.
B	The design is typical of its era and the quality of the fixtures and fittings is average to good.
C	The design is below the level generally expected for the era, or the level of fixtures and fittings is barely adequate and possibly of below average quality.

Building Materials: Walls and Roof

Code	Definition
W	Wood
B	Brick
C	Concrete
S	Stone
R	Roughcast
F	Fibrolite
M	Malthoid
P	Plastic
I	Iron
A	Aluminium
G	Glass
T	Tiles
X	*

Appendix IV Descriptive Statistics

Variable	Mean	Std. dev.	Median	Minimum	Maximum	Range
St Albans:						
Sale Price ($)	221,957	110,761	200,000	42,000	839,000	797,000
Land Area (ha)	0.0658	0.0331	0.0579	0.0261*	0.3794	0.3533
Floor Area (m²)	161	70.40	150	50	450	400
Beckenham:						
Sale Price ($)	116,012	50,037	111,000	21,500	385,000	363,500
Land Area (ha)	0.0601	0.0234	0.0553	0.0164*	0.2140	0.1976
Floor Area (m²)	115	32.50	110	40	340	300
Papanui:						
Sale Price ($)	127,661	51,114	119,000	43,000	375,000	332,000
Land Area (ha)	0.0685	0.0289	0.0675	0.0310	0.3169	0.2859
Floor Area (m²)	122	34.60	110	56	290	234
Bishopdale:						
Sale Price ($)	136,786	41,390	134,500	56,000	342,000	286,000
Land Area (ha)	0.0679	0.0163	0.0653	0.0400	0.2028	0.1628
Floor Area (m²)	125	31.20	118	64	290	226

* These small land areas are related to apartments or units in a block of apartments/units that have the land area apportioned on a pro rata basis.

Appendix V Regression Model: St Albans

log(SLNETX) = TOWER + CATGYX2 + CATGYX4 + TIMESOLD.Q + AGE + log(LANDAX) + MATFAX + SITSTX

Residuals:	Min	1Q	Median	3Q	Max
	-0.72855	-0.15032	0.01593	0.14263	0.72047

Coefficients:	Estimate	Std. Error	t-value	Pr(> |t|)	
(Intercept)	9.1781868	0.6769096	13.559	< 2e-16	***
TOWER	0.1133186	0.0318188	3.561	0.000395	***
CATGYX2D	0.1846417	0.0702520	2.628	0.008776	**
CATGYX2O	0.0334663	0.1008594	0.332	0.740134	
CATGYX4B	-0.1551409	0.0245485	-6.320	4.75e-10	***
CATGYX4C	-0.1483169	0.0722959	-2.052	0.040600	*
TIMESOLD.Q	0.0136663	0.0008208	16.650	< 2e-16	***
AGE	0.0016408	0.0003521	4.660	3.81e-06	***
log(LANDAX)	0.3285367	0.0283610	11.584	< 2e-16	***
MATFAX	0.0022314	0.0001962	11.373	< 2e-16	***
SITSTXAIKMANS RD	0.4029259	0.0533671	7.550	1.41e-13	***
SITSTXBEVERLEY ST	0.2330787	0.0803137	2.902	0.003827	**
SITSTXBRISTOL ST	-0.1706840	0.0521716	3.272	0.001124	**
SITSTXBROWNS RD	0.2492536	0.0720854	3.458	0.000579	***
SITSTXCOX ST	0.3055798	0.0581672	5.253	2.00e-07	***
SITSTXGORDON AVE	0.0823422	0.0679833	1.211	0.226236	
SITSTXKNOWLES ST	0.1690979	0.0558911	3.025	0.002576	**
SITSTXMANSFIELD AVE	0.2954242	0.0652983	4.524	7.16e-06	***
SITSTXMCDOUGALL AVE	0.3303105	0.0623720	5.296	1.60e-07	***
SITSTXMURRAY PL	0.3613773	0.0629166	5.744	1.40e-08	***
SITSTXOFFICE RD	0.3681146	0.0543368	6.775	2.71e-11	***
SITSTX Other	0.0618491	0.0736629	0.840	0.401416	
SITSTXPAPANUI RD	0.1940369	0.0560474	3.462	0.000570	***
SITSTXRANFURLY ST	0.1701716	0.0617504	2.756	0.006012	**
SITSTXST ALBANS ST	0.1458665	0.0571172	2.554	0.010873	*
SITSTXWEBB ST	0.1895432	0.0725061	2.614	0.009143	**
SITSTXWESTON RD	0.2084419	0.0527555	3.951	8.60e-05	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.2175 on 677 degrees of freedom
Multiple R-Squared: 0.8253, Adjusted R-squared: 0.8186
F-statistic: 123 on 26 and 677 DF, p-value: < 2.2e-16

Appendix VI Regression Model: Papanui

ln(formula = log(SLNETX) ~ TOWER + SITSTX + TIMESOLD.Q + AGE + log(LANDAX) + MATFAX + WALLCNX + ROOFCNX + CATGYX4, data = Papanui.final)

Residuals:	Min	1Q	Median	3Q	Max
	-0.484987	-0.098006	0.003859	0.106253	0.563126

Coefficients:	Estimate	Std. Error	t-value	Pr(> |t|)	
(Intercept)	5.9482316	0.6998186	8.500	< 2e-16	***
TOWER	-0.2339640	0.0240908	-9.712	< 2e-16	***
SITSTXHOANI ST	-0.1966982	0.0265429	-7.411	4.26e-13	***
SITSTXLANGDONS RD	-0.1192547	0.0281242	-4.240	2.58e-05	***
SITSTXLEANDER ST	0.0305555	0.0449437	0.680	0.496853	
SITSTXMATSONS AVE	0.0949636	0.0292461	3.247	0.001231	**
SITSTXMORELAND AVE	-0.0892332	0.0397622	-2.244	0.025183	*
SITSTXMORRISON AVE	-0.1984492	0.0289772	-6.848	1.84e-11	***
SITSTXOther	-0.1543194	0.0337436	-4.573	5.83e-06	***
SITSTXSAILS ST	-0.0761412	0.0433455	-1.757	0.079490	.
SITSTXSAWTELL PL	0.1840793	0.0393904	4.673	3.66e-06	***
SITSTXSAWYERS ARMS RD	0.0872393	0.0201388	4.332	1.73e-05	***
SITSTXST JAMES AVE	0.2497688	0.0289940	8.615	< 2e-16	***
TIMESOLD.Q	0.0138914	0.0004137	33.575	< 2e-16	***
AGE	0.0029307	0.0003512	8.345	4.85e-16	***
log(LANDAX)	0.0904764	0.0270812	3.341	0.000886	***
MATFAX	0.0042576	0.0002410	17.664	< 2e-16	***
WALLCNXC	0.0054100	0.0200666	0.270	0.787558	
WALLCNXF	-0.0980851	0.0464442	-2.112	0.035106	*
WALLCNXO	-0.1158407	0.0468334	-2.473	0.013655	*
WALLCNXR	-0.0670051	0.0244382	-2.742	0.006291	**
WALLCNXW	-0.0679166	0.0192628	-3.526	0.000454	***
WALLCNXX	-0.0571365	0.0358369	-1.594	0.111381	
ROOFCNXI	0.1502973	0.1139845	1.319	0.187810	
ROOFCNXO	0.0870092	0.1164152	0.747	0.455111	
ROOFCNXT	0.0954874	0.1138506	0.839	0.401965	
CATGYX4B	-0.0623758	0.0343487	-1.816	0.069872	.
CATGYX4C	-0.3669901	0.0905659	-4.052	5.74e-05	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.1579 on 604 degrees of freedom
Multiple R-Squared: 0.8718, Adjusted R-squared: 0.8661
F-statistic: 152.2 on 27 and 604 DF, p-value: < 2.2e-16

Appendix VII Regression Model: Beckenham

ln(formula = log(SLNETX) ~ TOWER + SITSTX + CATGYX4 + TIMESOLD.Q + AGE + log(LANDAX) + MATFAX + WALLCNX + CATGYX2, data = Beckenham.final)

Residuals:	Min	1Q	Median	3Q	Max
	-0.64490	-0.09026	0.01142	0.10112	0.40993

Coefficients:	Estimate	Std. Error	t-value	Pr(> |t|)	
(Intercept)	9.2062865	0.4725194	19.483	< 2e-16	***
TOWER1	-0.2301918	0.0182774	-12.594	< 2e-16	***
SITSTXBECKENHAM ST	0.1648069	0.0515406	3.198	0.001436	**
SITSTXBOON ST	-0.0616738	0.0484966	-1.272	0.203817	
SITSTXBRADFORD AVE	0.0923843	0.0494942	1.867	0.062300	.
SITSTXCOLOMBO ST	0.0623765	0.0467234	1.335	0.182223	
SITSTXDEVON ST	-0.0959430	0.0457562	-2.097	0.036299	*
SITSTXDUNN ST	-0.0207886	0.0427676	-0.486	0.627031	
SITSTXFISHER AVE	0.2271245	0.0400288	5.674	1.90e-08	***
SITSTXLONGFELLOW ST	-0.0186953	0.0451597	-0.414	0.678990	
SITSTXOTHER	-0.0222126	0.0467607	-0.475	0.634888	
SITSTXPERCIVAL ST	-0.0347190	0.0517740	-0.671	0.502663	
SITSTXROXBURGH ST	0.1029109	0.0466753	2.205	0.027729	*
SITSTXSOMERFIELD ST	0.0186495	0.0428968	0.435	0.663851	
SITSTXSOUTHAMPTON ST	-0.0243265	0.0402926	-0.604	0.546171	
SITSTXSOUTHEY ST	-0.0324513	0.0429880	-0.755	0.450520	
SITSTXSTRICKLAND ST	-0.0819418	0.0407196	-2.012	0.044494	*
SITSTXTENNYSON ST	0.1165007	0.0393410	2.961	0.003147	**
SITSTXWEMBLEY ST	0.0648226	0.0458033	1.415	0.157359	
CATGYX4B	0.0275481	0.0373405	0.738	0.460864	
CATGYX4C	-0.1168640	0.0469787	-2.488	0.013049	*
TIMESOLD.Q	0.0189904	0.0003396	55.928	< 2e-16	***
AGE	0.0010988	0.0002426	4.530	6.74e-06	***
log(LANDAX)	0.1546535	0.0195655	7.904	8.19e-15	***
MATFAX	0.0042054	0.0002138	19.674	< 2e-16	***
WALLCNXC	-0.0208433	0.0378338	-0.551	0.581833	
WALLCNXF	-0.1171637	0.0394091	-2.973	0.003031	**
WALLCNXO	-0.0445073	0.0399745	-1.113	0.265849	
WALLCNXR	-0.1119164	0.0235736	-4.748	2.41e-06	***
WALLCNXW	-0.0629968	0.0222366	-2.833	0.004718	**
WALLCNXX	-0.0992564	0.0398493	-2.491	0.012933	*
CATGYX2D	0.1445276	0.0399650	3.616	0.000316	***
CATGYX2F	0.3069113	0.0744524	4.122	4.11e-05	***
CATGYX2R	0.2927391	0.1222453	2.395	0.016847	*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.1515 on 864 degrees of freedom
Multiple R-Squared: 0.8911, Adjusted R-squared: 0.8869
F-statistic: 214.2 on 33 and 864 DF, p-value: < 2.2e-16

Appendix VIII Regression Model: Bishopdale

ln(formula = log(SLNETX) ~ TOWER + TIMESOLD.Q + AGE + log(LANDAX) + MATFAX + WALLCNX + SITSTX, data = Bishopdale.final)

Residuals:	Min	1Q	Median	3Q	Max
	-0.53633	-0.08893	0.01446	0.08850	0.49048

Coefficients:	Estimate	Std. Error	t-value	Pr(> |t|)	
(Intercept)	9.0005033	0.6988891	12.878	< 2e-16	***
TOWER	0.0262575	0.0182796	1.436	0.151259	
TIMESOLD.Q	0.0097887	0.0004834	20.251	< 2e-16	***
AGE	0.0013236	0.0003598	3.679	0.000249	***
log(LANDAX)	0.1357753	0.0333622	4.070	5.16e-05	***
MATFAX	0.0039665	0.0001855	21.389	< 2e-16	***
WALLCNXC	-0.0169935	0.0108641	-1.564	0.118160	
WALLCNXO	0.0785660	0.0336688	2.333	0.019863	*
WALLCNXR	-0.0693225	0.0300511	-2.307	0.021313	*
WALLCNXW	-0.0815210	0.0230110	-3.542	0.000420	***
SITSTXCARDOME ST	0.0610536	0.0314227	1.943	0.052360	.
SITSTXCHEDWORTH AVE	0.0330487	0.0317738	1.040	0.298589	
SITSTXCLOTILDA PL	0.2252988	0.0420078	5.363	1.06e-07	***
SITSTXCOLESBURY ST	0.0528749	0.0302668	1.747	0.081018	.
SITSTXCOTSWOLD AVE	0.0604953	0.0286474	2.112	0.035012	*
SITSTXEASTLING ST	0.0551537	0.0319833	1.724	0.085003	.
SITSTXFARRINGTON AVE	-0.0001768	0.0238544	-0.007	0.994087	
SITSTXHAREWOOD RD	0.0204412	0.0252674	0.809	0.418753	
SITSTXHIGHSTED RD	0.0391760	0.0253953	1.543	0.123302	
SITSTXKILBURN ST	-0.0176756	0.0366951	-0.482	0.630155	
SITSTXKINGROVE ST	-0.0052772	0.0375965	-0.140	0.888406	
SITSTXLEACROFT ST	0.1058243	0.0333633	3.172	0.001571	**
SITSTXMURMONT ST	0.1825316	0.0365287	4.997	7.12e-07	***
SITSTXNEWMARK ST	-0.0342136	0.0272490	-1.256	0.209621	
SITSTXOTHER	0.0525437	0.0253634	2.072	0.038612	*
SITSTXRALEIGH ST	0.0470151	0.0314032	1.497	0.134740	
SITSTXSTACKHOUSE AVE	0.0235719	0.0278844	-0.845	0.398165	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.137 on 821 degrees of freedom
Multiple R-Squared: 0.7946, Adjusted R-squared: 0.7881
F-statistic: 122.1 on 26 and 821 DF, p-value: < 2.2e-16