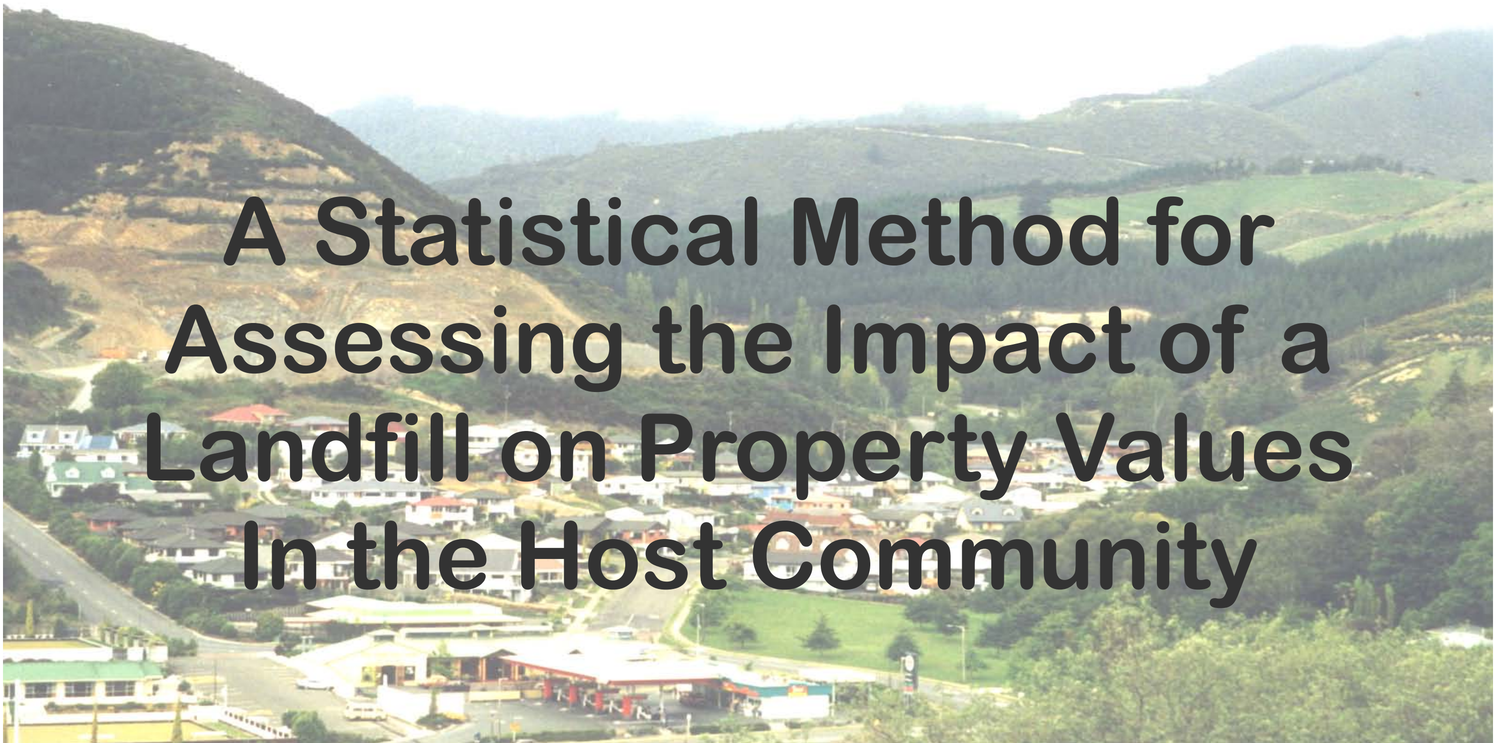
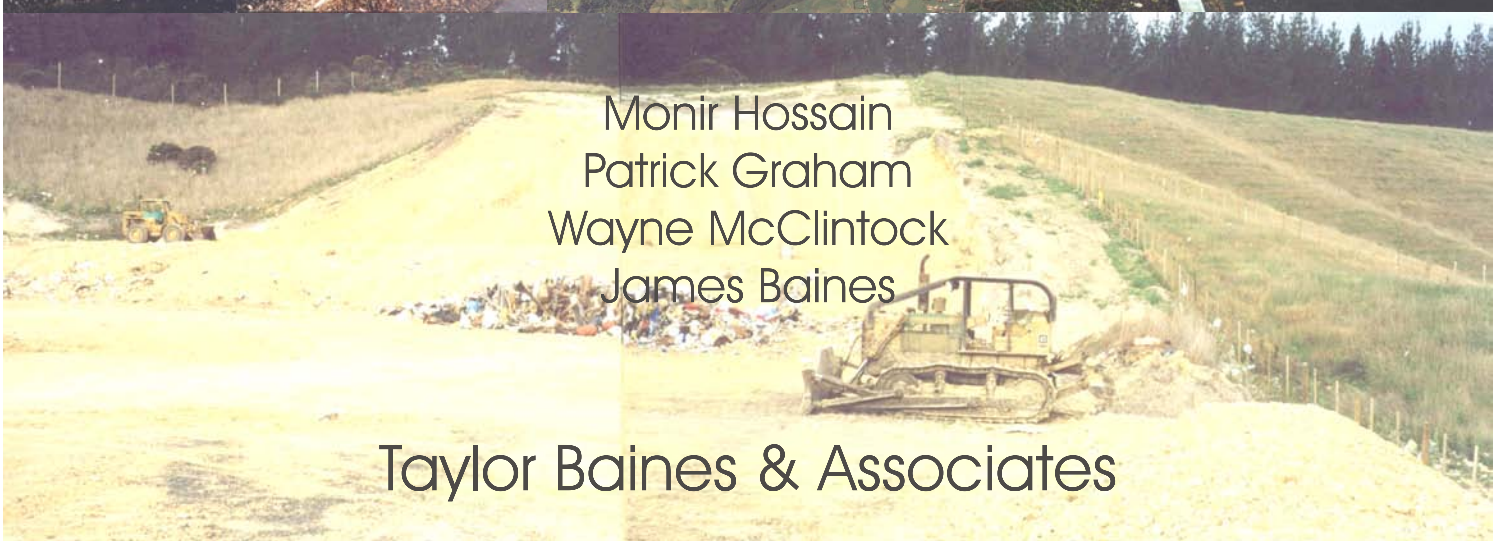
Host Communities: siting and effects of facilities



A Statistical Method for Assessing the Impact of a Landfill on Property Values In the Host Community



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Host Communities:
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A Statistical Method for Assessing the Impact of a Landfill on Property Values in the Host Community

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Working Paper FS#35
Public Good Science Fund Contract TBA X0002

October 2002

Acknowledgments

Monir Hossain and Patrick Graham undertook the statistical analysis in this study, while Wayne McClintock and James Baines of Taylor Baines coordinated the research activities, assisted with the development of the methodology and prepared the introductory and concluding sections of the paper.

The research team wishes to thank Judith Hopkins for her valuable advice which assisted in developing a methodology for this study. They are also grateful to Mark Dow, and other staff from Quotable Value (QV) Valuations for their help with the collection of property data that was used in the statistical analysis, and for their comments on an earlier version of this working paper.

The research team also acknowledges the financial support provided for this programme by the Foundation for Research, Science and Technology.

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1 THE RESEARCH PROGRAMME

1.1 Public Good Science Fund Research

Since 1997 Taylor Baines and Associates has been funded by the Foundation for Research, Science and Technology to study the siting and social impacts of a range of facility types. From 1997 to 2001 this research focussed on landfills and transfer stations, and wastewater treatment plants. Currently, other facilities such as cell phone towers, prisons and shopping centres are being investigated.

The research programme has received strong support from Local Government New Zealand, the New Zealand Water and Wastes Association, the Ministry for the Environment and several territorial local authorities.

1.2 Reasons for this research programme on solid waste facilities and their host communities

The assessment of the effects of solid waste facilities at the time a site is being selected is often a contentious process. The debates associated with such assessments are just as likely to be informed by hearsay and prejudice as they are by well-founded evidence. This research programme addresses the issues of possible social bias in site selection, and the lack of empirically based information relevant to New Zealand communities. It has been conducted in settings removed from the tensions of the resource consent proceedings by a team of independent researchers who have no organisational affiliations with the developers of these solid waste facilities, or the host communities.

1.3 Case studies of landfills - brief summary of purpose/methodology

Seven case studies of landfills and transfer stations were undertaken as part of this research programme. They were carefully selected to provide a range of facilities from relatively recent metropolitan landfills and a transfer station, to the types of facilities more prevalent in smaller cities and rural districts. Social impact assessment was used to compile accurate descriptions of the effects experienced by host communities. This was achieved by canvassing a wide range of observations from local people, by examining other data sources to corroborate the observations of neighbours, and by feeding back preliminary findings for validation by people participating in the studies.

The primary emphasis of the case study of the Redvale Landfill near Auckland, like the other six case studies, was to record the experience of members of the host community. Their experience of the off-site effects such as noise, litter, odour, dust and traffic will be useful to assist other New Zealand communities considering the siting of a new landfill. There are however also some off-site effects such as risks to groundwater quality that are not likely to be informed by the experience of neighbours as they are less detectable to casual observation. The research method was based on the approach to social assessment as described by Taylor *et al.* (1995), and included identifying the time frame and communities of interest, profiling the community, surveying nearby residents and business people, interviewing key informants, and examining documents.

1.4 Outputs of this research programme

Outputs from this research programme have been publicly presented at conferences and workshops, and are also available in a variety of other formats. They include a series of working papers, conference papers, and abbreviated summaries of each case study. All of them are available from Taylor Baines & Associates[1] on request. Full case study reports are available for the cost of reproduction and postage, while conference papers and abbreviated summaries for each case study are available free of charge and can be downloaded from the Taylor Baines website - www.tba.co.nz.

1.5 The research provider - Taylor Baines & Associates

Founded in 1989 as an independent research and consulting firm, Taylor Baines and Associates is a provider of social science research, social assessment consultancy services, and training in social assessment methods. The social science focus has frequently been applied to natural resource management, and exploring relationships between communities and their environment. Taylor Baines has specific experience relating to urban development issues including the siting and effects on host communities of wastewater treatment plants, prisons and large retail outlets.

[1] Taylor Baines & Associates, PO Box 8620, Riccarton, Christchurch. www.tba.co.nz. ph/fax 3433-884.

2 INTRODUCTION TO THIS STUDY

2.1 Reasons for selecting the Redvale Landfill

The Redvale Landfill was selected for this study of the impact of a solid waste facility on property values for a number of reasons. First, it is a modern sanitary landfill serving the Auckland metropolitan area but situated in a rural locality. Operated and managed by the private sector, it was subject to planning scrutiny under the Resource Management Act as well as earlier legislation. Second, it was the subject of a previous *ex ante* study by Dean (1994) who assessed the potential effect of the proposed Redvale Landfill on the values of neighbouring properties during the planning process. Third, a limited amount of property valuation data was analysed by researchers from Taylor Baines and Associates during the case study of the Redvale Landfill.

2.2 Description of the Redvale Landfill and its host community[2]

Since its opening in August 1993 the Redvale Landfill has been one of the main refuse disposal facilities for the Auckland region. The landfill covers an area of 80 hectares, and is located six kilometres south of Silverdale at Dairy Flat, and about 25 kilometres north of Auckland City. It is owned and operated by Waste Management NZ Ltd. The land for the facility was purchased in 1988, and part of the site is occupied by a lime quarry which has been operating for over 20 years (Baines and Buckenham, 2000: 6).

Other features of land use in the vicinity of Dairy Flat which have major effects on the host community include state highway 1 and the North Shore aerodrome. Although much of the land around Dairy Flat is still devoted to agricultural and horticultural production, rural subdivision in the early 1980's began to attract people with alternative lifestyles to the locality. Initially these newcomers from the Auckland metropolitan area were interested in larger lifestyle properties which allowed them to pasture animals, but later arrivals were more interested in purchasing smaller properties. As a result of these developments over the last two decades the community of Dairy Flat comprises several distinct groups - 'locals', lifestylers, and itinerants. Community activity concentrates at a number of places around Dairy Flat. The main places where community activity occurs are the shops and commercial premises at the junction of SH1 and Kahikatea Flat Road, the Dairy Flat Primary School and the North Harbour Trotting Club which are both near the landfill and quarry, and the Dairy Flat Tennis Club and Community Hall on the corner of SH1 and Postman Road (Baines and Buckenham, 2000: 16-21).

2.3 Previous study by Dean

Dean (1994) describes the methodology used by the valuer as part of the planning process to assess the effect that the establishment of the Redvale Landfill would have on property values in the surrounding area. The methodology assumes that as there had been significant speculation about the use of the site for a proposed landfill for six years prior to the planning hearing, it would have

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2 The community of residents and businesses in close proximity to the landfill (Baines and Buckenham, 2000: 3).

been already evident in property sales in the locality given this period of public knowledge. The valuer developed three distinct methods to analyse the changes in property values.

The first method required a computer search of all property sales within a 1.5 kilometre radius of the facility over a period of eight years. Then the sample was further refined to identify which properties had sold more than once during this period. The changes in value between the two sale dates were measured and compiled as a profile of property value increases. This sample of property value increases in the vicinity of the Redvale landfill was then compared on a monthly and annual basis with a control sample of properties in locations of a similar type yet sufficiently far from the facility to ensure they could not be affected. The results for both samples were remarkably similar.

The second method used government valuation data. The valuer took a cross section of government valuation data for properties within a 1.5 kilometre radius of the facility over three valuation cycles and compared it on a monthly and annual basis with those for properties over five kilometres away. Again there was a remarkable similarity for both samples.

For the third method the valuer took a sample of sales within close proximity of the facility and then found comparable sales (in terms of land area, house size, use etc.) in other locations to determine if there were any price differences. This method compared seven properties near the facility with similar properties within a control area, and found there were no measurable differences between sale prices for the two areas. Dean (1994: 29) observes that the planning tribunal after examining this analysis concluded that the effect on property values from the proposed landfill would be benign.

2.4 Preliminary analysis of property data during the case study of the Redvale Landfill

As part of the case study of the Redvale Landfill, researchers from Taylor Baines analysed data provided by a resident of Dairy Flat[3] for the capital value of eight properties in the host community from valuation rolls in 1989, 1992 and 1995. The researchers also obtained corresponding data for these properties for 1998 from Quotable Value NZ. Then they aggregated the data to 'near' and 'far' locations in terms of the distance of the properties from the landfill. Their analysis of this limited data revealed that the six properties 'near' the landfill appeared to have lost value relative to the two 'far' properties even before operations commenced in 1993. Although property values had been increasing since 1992, the gap between 'near' and 'far' properties seemed to have widened (Baines and Buckenham, 2000: 62).

The findings from this preliminary analysis by Taylor Baines researchers are at variance with the finding by Dean (1994) that there were remarkable similarities between the sale prices and government valuations of properties within 1.5 kilometres of the landfill site, and 'control' properties sufficiently far away that the facility would have no effect on their value. Thus further investigation was required to resolve the issue of the Redvale Landfill's effect on property values in the host community.

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[3] It should be noted that this was not a random sample. The resident had assembled the data for the purposes of preparing evidence for a statutory hearing.

2.5 The Effect of NIMBY on Property Values - other New Zealand research

Hopkins (1999) has examined the effect of the NIMBY (Not in my back yard) syndrome on the valuation of property. She concluded from a review of the international literature that the majority of studies used multiple regression analysis to isolate the effect of the NIMBY variable from other variables that may affect property values. She notes that while a small sample size of sales creates a difficulty in isolating the effect, there is a high level of statistical confidence in the final equation. Hopkins used this method for two case studies she conducted in New Zealand.

The first case study examined the effects of high voltage overhead transmission lines on the values of residential properties in the suburb of Newlands in Wellington. Hopkins used prices for 330 property sales, and adjusted for the effects of distance by taking the reciprocal of distance times a hundred to both the nearest transmission lines and pylons. She reports that the effect of having a pylon close to a property was significant with a negative effect of 20 per cent between 10 and 15 metres from the pylon. This negative effect declined to a negligible amount at a hundred metres from the pylon. By contrast the presence of the transmission lines in Newlands had a minimal effect of less than negative one per cent for properties directly under a line, and was not statistically significant in the sales price (Hopkins, 1999: 4-5).

In the second case study Hopkins chose four community houses owned by Community Housing Limited that provide social services or accommodation for people with disabilities in three suburbs in Auckland and one suburb in Palmerston North. Each community house was located in a neighbourhood that comprised mainly owner occupied, single family homes. Two of the community houses had a lot of adverse publicity about the nature of the social service they were providing. The number of property sales in the vicinity of each community house varied, and these data were collected for a four-year period: two years prior and two years after the time the community house was purchased by Community Housing Limited. The results revealed that none of the four community houses had any statistically significant effect on the property values of other houses in their localities. Furthermore, there appeared to be no difference on property values in the neighbourhood between the two community houses that had experienced adverse publicity, and those whose presence in the neighbourhood was less controversial (Hopkins, 1999: 6-10). Hopkins (1999: 10) qualifies her findings from both studies by acknowledging that the small database of property sales close to these types of facilities, and the need for a 'line of sight' variable to measure visibility, present problems for this kind of statistical analysis.

Evidence presented by Daly (nd) as part of an appeal to the Environment Court by the Department of Corrections reports findings about the effects of establishing a range of correctional, residential care, and medical facilities on the property values of neighbouring houses. She concludes that negative effects on property values are not sustained over the long term:

> "History has shown that effects on value resemble a trough shaped curve following the announcement of the location of an unpopular use. Initially, media publicity fuels concerns however once such a use has quietly persisted over a period of time without causing disruption or a breach of peaceful and quiet enjoyment to surrounding property owners, concerns seem to settle down (Daly, nd: 16)."

For one of the correctional facilities, a probation office and periodic detention centre in Newtown (Wellington), Daly investigated the effects on residential property values around the facility by tracking median sale prices on the valuation roll from January 1995 to November 1998. She compared the median sale prices of residential properties within the valuation roll for the immediate area around the facility with those from the valuation rolls in the wider area for the same period, and found that both sets of sale prices moved at a similar rate. A similar exercise examining the median sale prices of commercial and industrial properties within the same valuation roll and comparing them with those from the valuation rolls for the wider area, indicated that movements in prices over the period were unlikely to have been influenced by the establishment of the correctional facility. Daly also used multiple regression analysis to ascertain whether the proximity of a residential property to the correctional facility influenced its value. Her results were statistically insignificant as few properties close to the facility were sold (Daly, nd: 18-20).

3 METHODOLOGY

3.1 Consultation with Judith Hopkins

During the first phase of this study of the impact of a landfill on property values, advice about an appropriate methodology was sought from Judith Hopkins whose research about the effects of NIMBY on property values was described in the previous section. The leader of the research team initially corresponded with her by email when she was at Massey University, and later another member of the team interviewed her in Christchurch.

The consultation with Judith Hopkins enabled the research team to explore several issues before the methodology for the study was finalised. A number of principles were established during these discussions which helped the development of the methodology.

Firstly, the actual sale price of individual properties rather than government valuation was considered to provide a better basis for measuring this type of effect[4]. The use of actual sale prices was also recommended by a manager from QV Valuations during subsequent discussions with the research team.

Secondly, the actual sale prices of properties should be collected just prior to it becoming public knowledge that a facility was to be established in a host community. Sometimes this public knowledge exists for some years before the final decision about the siting of the facility is made.

Thirdly, it would be necessary to adjust the actual sales prices of individual properties in terms of the CPI index so all sales are recorded in constant dollars. Any effects, such as location and noise, would be allowed for within the equation by creating a dummy variable.

Fourthly, a control area of similar properties which is sufficiently distant from the facility as to be unlikely to experience any effects from its operations is required for comparative purposes. Such a control area needs to be selected carefully; probably with the assistance of field staff from Quotable Value New Zealand (QVNZ) who have local knowledge of the area. Even so, it is difficult to isolate the effect that the facility has had on changes in property values, from other factors that also influence the property market in that locality. One way of addressing this issue would be to use the local knowledge of the field staff of QVNZ to identify other factors influencing the movement of sale prices in the area. These factors could then be discussed when examining the changes in property values, and some assessment made as to their significance when compared with the effect of the facility.

Finally, in addition to measuring changes in property values, it would be useful to measure (1) changes in the average time it takes a house to be sold once it has been placed on the market, and (2) changes in the rate of turnover of properties. These two indicators, however, can only be collected from the records of real estate agents, and require a lot of time and effort in sifting through non-computerised records.

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4 Although actual sale prices are considered better than government valuations for measuring the effects of property values, they present analytical difficulties when few properties have changed ownership during the time period being considered.

3.2 Further development of the methodology

Researchers from Taylor Baines used these principles to develop a basic method for compiling data to measure the effects of a facility on nearby properties. This method had several components:

(1) The identification of all residential properties within X kilometres of a facility that had been sold over a specified period of time. This period of time would preferably begin before the selection of the site was public knowledge, and end when the facility has been in operation for several years.

(2) The identification of a control group of residential properties relatively distant from the facility that share similar characteristics with residential properties within X kilometres of the facility.

(3) The collection of data regarding actual sales prices, the number of times properties were sold, relevant indices of inflation to adjust individual prices, and overall market trends for the residential property during the specified period of time.

(4) The analysis of actual sale price data by distance (or some transformation of distance) from the facility boundary, with the properties being sorted into bands of distance (e.g. 500 metres to 1 kilometre) from the site. This analysis would address three questions: (i) how have sales prices changed over time for the different groupings/bands of properties? (ii) is there any indication that such changes over time are influenced by proximity to the facility? (iii) if the answer to the previous question is "yes", is the distance effect statistically significant?

(5) The analysis of property turnover data by distance using the same bands as established for the analysis of sale prices and addressing similar issues as described above.

This basic method for measuring the effects of a facility on nearby properties was then discussed with two statisticians with the objective of applying it to the question of whether the development and operation of the Redvale Landfill has had an impact on property values in its host community. The major points arising from these discussions were:

(1) The analysis of changes in property values requires a complex model that would be developed as the data was analysed by the statisticians through an interactive process. Thus the data should be collected from QVNZ before the statisticians developed the method. The distance of the properties from the facility should be kept continuous, rather than cluster the individual properties into bands of distance from the site.

(2) The analysis of property turnover data would use a Poisson distribution, a commonly employed value for count data.

(3) Data would be obtained from QVNZ for all properties within a specified distance from the Redvale Landfill. The specified distance would need to encompass and extend beyond the area where actual effects were recorded during the field research. The properties to be included would be in all directions according to the specified radius. The extra distance is required to allow for the perceptions of potential buyers which may differ from the actual experiences of residents.

(4) The same data would also be required for a control area of properties of similar characteristics, and with a similar sample size to the properties nearby the Redvale Landfill. Advice from Quotable Value NZ would be sought to help identify this control area.

(5) There was some uncertainty as to what date the time series data should be collected from. Although the dates the land was purchased for the Redvale Landfill (1988) and commencement of operations (August 1993) were well known, there was considerable uncertainty as to the time when it became public knowledge among the residents of the host community that a landfill may be established there. The preferred option was to collect data from the year before the proposed landfill became public knowledge, but if there was no clear indication of the time that occurred it was decided to start from 1986 (i.e. the year before the landfill site was purchased) as the default option.

3.3 Data collection

Next researchers from Taylor Baines and the statisticians met with a manager from QV Valuations (a division of QVNZ) to establish the boundaries for the host community of the Redvale Landfill, and for a control area, and to consider the data requirements for the statistical analysis. At that meeting the boundary of the host community was established, but it was agreed that advice be sought from staff of QV Valuation's Auckland office to assist selection of the control area. It was agreed that the control area adjoin the host community, and that it be further divided between an area directly adjoining the host community, and an area further afield.

QV Valuations was then contracted to supply three sets of data from its records as follows:

(1) Data on every property sold from 1 January 1986 to 1 September 2001 comprising the selling price each time a property was sold, the date of sale of the property, and the land and floor (where appropriate) areas of the property.

(2) Data of properties with multiple sales.

(3) Roll valuations of each property within the area every three years from 1986 including the land and floor area of the property[5].

QV Valuations sorted this data into four groups; the host community, the control area that directly adjoins the host community, a control area further afield, and all other properties on the valuation roll. Furthermore, staff at QV Valuations measured distances from the centre of the Redvale landfill site to the furthest boundary of each property within the host community, and also for each property in the control area that directly adjoins the host community. All this data in electronic form, together with maps of the host community and control areas, was forwarded to the statisticians for analysis.

3.4 Review of findings

After the statistical analysis was completed the findings were discussed by members of the research team and a draft paper prepared. The draft paper was then sent to Judith Hopkins and QV Valuations where it was read by four valuers, three of whom were from the Auckland region. Their comments on the draft paper were forwarded to the research team who revised the paper for final publication.

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[5] It was decided to extract the roll valuations of each property as a back up in case the number of property sales in either the host community or control area was too small.

4 STATISTICAL ANALYSIS

4.1 General approach

A statistical modelling approach to the analysis was adopted. Statistical modelling involves fitting competing statistical models to data, determining the 'best' model in terms of a trade-off between the model complexity and how closely a model fits the data and, finally, interpreting the implications of the 'best' model for the problem at hand. The concept of 'fit' refers to the proximity of predictions from the model to the observed data, and a modelling exercise aims to identify models that provide a good fit to the data, without being unduly complex. In order to guide model selection, approximate Bayes factors based on the Bayesian Information Criterion (BIC) (Kass and Raftery, 1995) were computed. The Bayes factor for comparing two models, M1 and M2, say, is the ratio of the probability for the data under M1 to the probability for the data under M2. Thus, the Bayes factor quantifies how much more likely are the observed data under M1 than M2. The BIC contains an explicit trade-off between model fit and model complexity and provides a convenient means of approximating Bayes factors, which are, in general, difficult to compute exactly[6].

4.2 Distance Classification

Because actual distance from each property to the landfill was available from Quotable Value New Zealand data for both host and control area properties were grouped into five distance bands, within 500 m from the landfill site, between 500 m and 1 km from the site, between 1 km and 2 km from the site, between 2 km and 3 km from the site and greater than 3 km from the site. This classification of properties by distance facilitated investigation of localised effects, while simplifying the presentation of results. The distribution of host and control area sites is shown in Table 1.

Table 1: Frequency distribution of plots by distance and group (host and control area)

Distance	Host area	Control area
< 500 m	15	0
500 m - 1 km	28	0
1 km - 2 km	86	8
2 km - 3 km	24	51
≥ 3 km	4	20

Unsurprisingly, in all analyses, the host/control classification did not contribute to the fit of models after accounting for distance band. Consequently results are presented below using the five distance bands given above.

6 Although the approximation based on the BIC is fairly rough, it is probably adequate in terms of the broad categories suggested by Kass and Raftery (1995) for interpreting Bayes factors. Kass and Raftery suggest that Bayes factors between 0 and 3, provide negligible support for M1 versus M2, Bayes factors between 3 to 20 suggest some positive evidence for M1 versus M2, while Bayes factors between 20 and 150 indicate strong support for M1 with larger values indicating even stronger support.

4.3 Analysing sales price data

In order to study the effects of distance from the landfill and time trends on prices, a hierarchical modelling approach, which accounted for the fact some properties were sold several times over the study period, was adopted. At the first level of the hierarchical model, logarithmically transformed sale prices per hectare, were regressed against the time of sale. The influence of time of sale was modelled via a linear trend variable with additional indicators representing the post purchase, pre operations and post-operations time periods. These indicator variables represent the change in prices during the corresponding time period over and above the underlying trend. The model was implemented using the SAS procedure Proc Mixed. Further technical details are outlined in the Appendix.

4.4 Analysing data on turnover rates

Annual turnover rates were defined as the ratio of the total number of sales in a particular time-period and area to the total number of property-years for that time-period and area, where the number of property-years is defined as the number of properties in a study area, multiplied by the number of years in a study period. That is, the annual turnover rate for a given area and period is given by

$$T = \frac{\sum \text{sales}}{(\text{number of years}) \times \sum \text{properties}}$$

A Poisson regression model was employed to model the effect of distance and time period on turnover rate and was fitted using the GEE algorithm (Liang and Zeger, 1986) within the SAS procedure GENMOD. The GEE algorithm accounts for the statistical complications arising from the fact some properties were sold several times during the study period. Further details can be found in the Appendix.

4.5 Interpreting the models

For the analysis of both sale price and turnover, the fitted models yield estimates of relative effects comparing expected prices or turnover for each time-period or distance band with the expected price or turnover in a reference time period or distance band. For comparisons by distance, the area within 500 m of the landfill served as the reference area. For time-period comparisons, the period prior to purchase of the landfill can be viewed as the reference period. However, the time-period effects can also be interpreted as representing the ratio of the expected sales price (or turnover rate) in a given time period to that expected in the absence of the landfill that is, the prices (or turnover rate) predicted from the underlying trend. It is this latter interpretation of the time-period effects which is emphasised below.

In addition to reporting point estimates of relative expected prices and turnover rates, 95% confidence intervals and approximate probabilities for the relative expected prices and turnover rates exceeding one, are also reported. A relative expected price of one indicates no effect. The probability that the relative effect (price or turnover) exceeds one is a measure of the strength of evidence for an association with low probabilities indicating strong evidence of a negative effect and

high probabilities indicating strong evidence of a positive effect. Further details concerning the interpretation of the models can be found in the Appendix.

4.6 Results

Effect on Prices

The overall trends in property prices over the study period, 1986-2001 are shown in Figure 1 where a modest increasing trend is apparent over most of the period. Prices are presented as logarithmically transformed prices per hectare in order to standardize for variation in property size and to facilitate graphical display, in view of the substantial variation in prices remaining after accounting for variation in property size. The relationship between average price per hectare (logarithmically transformed) and distance from the landfill for all sales between 1986 and 1991 is studied in Figure 2. A slight negative trend is apparent. It should be noted that Figure 2 includes data from the period prior to purchase of the landfill site when no affect of the landfill on prices would be expected, though prices could of course vary with distance from the site for other reasons.

Figure 1: Time trend in log−transformed net sales price per hectare.

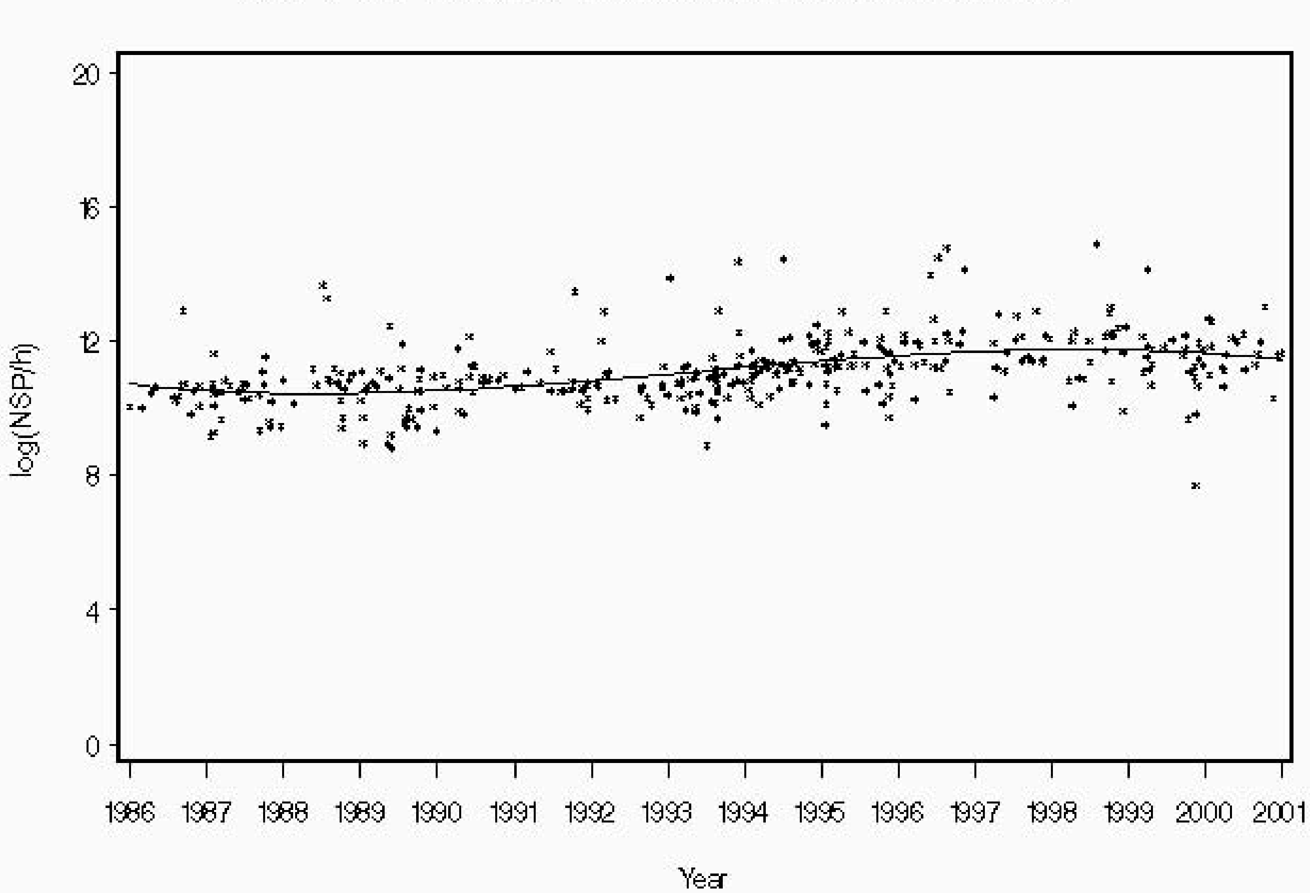
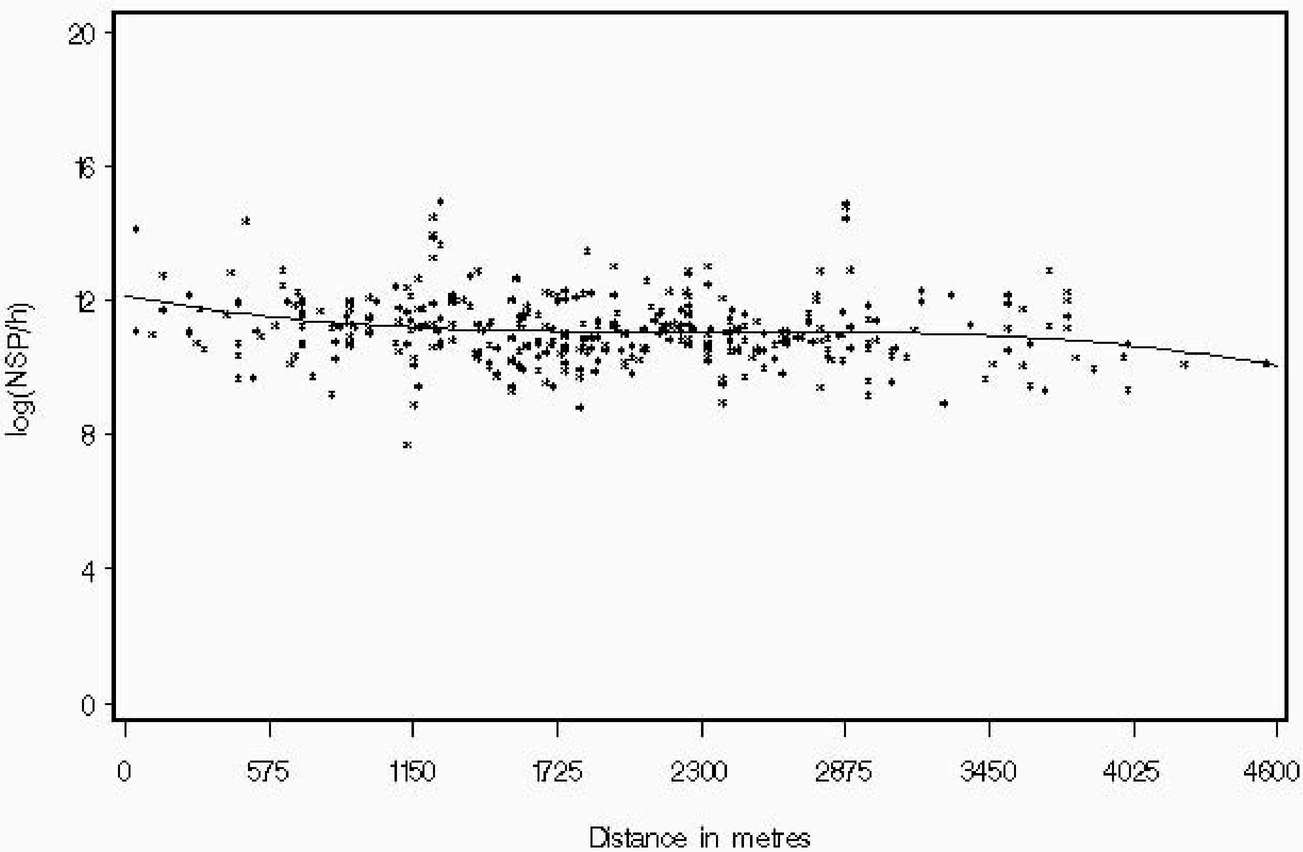


Figure 2: Variation of average price (log-transformed price per hectare) with distance from the landfill site.



Since any impact of the landfill on property prices is unlikely to have been apparent prior to purchase of the landfill site and to be stronger in areas closer to the site, it is important to look simultaneously at variation in prices over time and by distance from the landfill. This is explored, descriptively, in Table 2 where average prices per hectare are presented for five distance bands (within 500 m, 500 m to 1 km, 1 km to 2 km, 2 km to 3 km and greater than 3 km) for the periods prior to purchase of the landfill site, the period between purchase and commencement of operations and the period post-operation. The data reported in Table 2 do not support the hypothesis that the landfill had a negative impact on property prices. For example, consider the data for the properties less than 500 m from the site and between 500 m and 1 km from the site. Whereas any effect of the landfill would be expected to stronger in the area immediately adjoining the landfill, average post - landfill purchase prices actually increased more rapidly in the area within 500 m of the landfill than in the area between 500 m and 1 km from the landfill. In the area closest to the landfill, the average sale price per hectare in the periods between purchase of the landfill site and commencement of operations and post commencement of operations were, respectively 44% and 871% higher than in the pre-purchase period. In contrast the corresponding increases for properties between 500 m and 1 km from the landfill were much more modest, 6% and 69% respectively.

Part of the observed increases in price per hectare may be attributable to sub-division of larger properties: Average size for properties sold declined by 38% in the area closest to the landfill, and by 48% in the area more than 3 km from the landfill. Average property size amongst properties sold increased in the other distance bands. Average total prices (not adjusted for size) also increased for

all distance bands, though less dramatically than prices per hectare: percentage increases ranged from 76% for the area more than 3 km from the landfill to 308% for properties between 500 m and 1 km from the landfill.

Table 2: Average (standard deviation) net sale price per hectare by time period and distance from the landfill

Distance from landfill	Number of properties[1]	Pre-purchase time period	Purchase date to operation date	Post- operation date
<=500 m	15	48,144 (17,011)	69,514 (57,416)	467,613 (600,142)
500 m - 1 km	28	66,329 (52,595)	70,453 (71,571)	112,311 (76,158)
1 km - 2 km	94	32,601 (11,932)	107,895 (218,092)	182,340 (399,125)
2 km - 3 km	75	58,439 (89,625)	50,165 (28,248)	225,819 (527,725)
3 km	24	16,966 (6,079)	37,653 (43,548)	115,870 (94,457)

[1] Number of properties at the start of the study period.

The data reported in Table 2 do not account for the underlying trend in property prices over the study period and it would certainly be incorrect to attribute the observed increases to the purchase of the landfill site or to commencement of landfill operations. It is possible that the price increases reported in Table 2 conceal negative effects of purchase or commencement of operations. That is the observed price increases may in fact have been greater had the landfill not been placed in Redvale. In order to test this proposition we fitted a model to the price data which included a time trend variable in addition to indicator variables for the periods between purchase of the landfill and commencement of operations and post commencement of operations. These indicator variables represent the difference between the expected price in the corresponding period and the price that would have been expected in the absence of the landfill, that is the average price predicted from the underlying trend. Thus the indicator variables represent the effect of the post-purchase, pre-operations and the post-operations periods on prices over and above the underlying trend.

It was found that a model in which period effects were allowed to vary with distance from the landfill fitted somewhat better than a model assuming constant period effects across all five distance bands (the approximate Bayes factor based on the BIC was 4.7 indicating that the data were 4.7 times more likely under the model allowing for distance varying period effects than the model assuming common period effects for all distance bands). The model-based estimates of the period effects are presented in Tables 3 and 4 as estimated relative expected prices comparing average prices in the post-purchase, pre-operations period and post-operations period with average prices for the same time period, in the absence of the landfill. A relative expected price of one represents no period effect over and above the underlying trend, while relative expected prices less than one indicate a negative effect and estimates greater than one indicate a positive effect.

The results reported in Table 3 suggest that in the period post-purchase but pre-commencement of operations, prices were generally lower than expected on the basis of the underlying increasing trend. However it seems unlikely that this can be attributed directly to the purchase of the landfill because the effect appears greater in the area between 500 m and 1 km from the site than in the area within 500 m of the site. Indeed the results for the latter area are consistent with a model in which there is no effect of landfill purchase date; the confidence interval for the post-purchase, pre-operations effect includes one and the approximate probability that the relative expected price exceeds one is close

to 0.5. In contrast, the probability that the relative expected price in the area between 500 m and 1 km from the landfill was less than one is approximately 82%.

The hypothesis that the landfill adversely affected property prices is weakened further by the results reported in Table 4 for the relative expected price comparing prices in the post operations period with those expected for the same period in the absence of the landfill. From Table 4, it can be seen that for properties within 500 m of the landfill the prices in the post-operations period were approximately 75% greater than expected on the basis of the underlying trend, although there is considerable statistical uncertainty concerning this parameter (95% confidence interval 0.67 to 4.58). With the exception of the area more than 3 km from the site, the evidence for a positive impact of the post operations period on prices, over and above the underlying trend, is stronger in the area closest to the landfill than for any other distance band. Thus, although any negative effect on property prices would be expected to be strongest close to the landfill, the data suggest that, if prices in this area were affected at all by the post-operations period, then the effect was positive.

Table 3: Relative expected prices comparing the expected post-purchase, pre-operations period sales prices with the prices expected in the absence of the landfill, by distance from the landfill

Distance	Relative Price	95% Confidence interval	Pr(relative price >1)
< 500 m	0.921	0.368 - 2.302	0.43
500 m - 1 km	0.654	0.264 - 1.620	0.179
1 km - 2 km	1.041	0.708 - 1.530	0.58
2 km - 3 km	0.856	0.596 - 1.202	0.176
3 km	1.099	0.511 - 2.364	0.596

Table 4: Relative expected prices comparing the expected post-operation sales prices with the prices expected in the absence of the landfill, by distance from the landfill

Distance	Relative Price	95% Confidence interval	Pr(relative price >1)
< 500 m	1.748	0.668 - 4.575	0.872
500 m - 1 km	0.722	0.278 - 1.877	0.252
1 km - 2 km	1.238	0.726 - 2.111	0.783
2 km - 3 km	1.074	0.647 - 1.784	0.609
3 km	2.142	0.919 - 4.992	0.961

<u>Effect on turnover</u>

Annual turnover rates are shown in Table 5, for each distance band and time period. The area closest to the landfill recorded a substantial decline in annual turnover rate in the period immediately following purchase of the landfill, followed by an increase in the rate so that post-operation and pre-purchase annual turnover rates were very similar. With the exception of the area between 2 km and 3 km from the landfill, all other areas recorded a steady increase in turnover during the study period. However, it should be noted that the results for the area within 500 m from the landfill are based on

only 20 sales and once statistical uncertainty is taken into account, it becomes clear that the apparent difference in time trend between the area closest to the landfill area and the other areas is not a significant source of variation in the data. A model in which time trends were allowed to vary with distance from the landfill was decisively rejected in comparison with a model assuming a common trend across all areas (the approximate Bayes factor indicated the data were over 50 times more likely under the constant time trend model than the model allowing for time trends which varied with distance). Thus while turnover clearly declined in the area closest to the landfill in the period immediately post-purchase, when taken in context with the data as whole, it appears that the observed decline is within the range of variation expected under a model for long-run turnover rates (the hypothetical rate that would be observed as the number of properties becomes large) which posits a common time trend for all distance bands.

Table 5: Annual turnover rate by time period and distance from the landfill

Distance from landfill	Number of sales	Pre-purchase time period	Purchase date to operation date	Post-operation date
< 500 m	20	0.1	0.048	0.107
500 m - 1 km	40	0.036	0.064	0.123
1 km - 2 km	156	0.074	0.099	0.118
2 km - 3 km	125	0.12	0.102	0.105
3 km	35	0.063	0.089	0.103

Under the model assuming a common time- trend, the relative turnover rate comparing prices in the post-purchase pre-operations period with the rate expected in the absence of the landfill was 1.08 with a 95% confidence interval 0.756 to 1.545. The relative rate for the post-operations period was 1.327 (95% confidence interval 0.937 to 1.880). Thus, as suggested by Table 5, it appears that while turnover generally increased across the study area subsequent to the purchase and commencement of operation of the landfill, the evidence for a substantial change in turnover over during the study period is weak.

Relative annual turnover rates by area are shown in Table 6. These relative rates compare expected turnover in each distance band with expected turnover in the area closest to the landfill, based on the model assuming constant time-trends across areas. This model can also be interpreted as assuming constant distance effects over time. It appears that the annual turnover rate was lower in the area closest to the landfill, than in areas more distant from the site, however the evidence for this effect becomes moderately strong only for the distance bands between 1 km and 2 km from the landfill and 2 km to 3 km from the landfill, where the approximate probability that the relative turnover rate is greater than one exceeds 97%.

Table 6: Relative annual turnover rate by distance from the landfill, using properties less than 500 m from the landfill as the reference group

Distance	Relative turnover rate	95% Confidence interval	Pr(relative turnover rate >1)
< 500 m	1		
500 m - 1 km	1.066	0.785 - 1.448	0.659
1 km - 2 km	1.27	0.986 - 1.635	0.968
2 km - 3 km	1.29	0.992 - 1.676	0.971
3 km	1.118	0.841 - 1.486	0.778

While the fact that turnover appears lower in the area within 500 m from the landfill than in areas further from the landfill could be taken as evidence of an effect of the landfill, the modelling analysis suggests that the proposition that this pattern of turnover rates held prior to purchase cannot be ruled out and, in fact, is more strongly supported by the data than a model where the relative positions of the distance bands with respect to turnover rates changes over time.

5 CONCLUSION

The statistical analysis undertaken as part of this study does not support the hypothesis that the establishment and operation of the Redvale Landfill had a negative effect on property values. On the contrary the data suggest that, if prices in the area closest to the landfill (within 500 metres) were affected at all during the post-operations period, then that effect was positive. The subdivision of properties within the area closest to the landfill has undoubtedly contributed to significant increases in average sale prices since the landfill was purchased, and is itself inconsistent with a negative effect of the landfill on property values.

However, there are several other factors that may also have influenced the movement of property values in the vicinity of the Redvale Landfill that were identified during the earlier case study by Baines and Buckenham (2000) and by valuers from the Auckland region who are familiar with this location. The presence of a long established quarry next to the landfill site, which operates under less stringent conditions required under legislation prior to the RMA, may have accustomed residents to noise, dust and traffic effects that are in excess of those permitted for the landfill's operations. A new motorway extension providing access from Albany to Orewa was opened in December 1999. It has reduced traffic volumes on the state highway, enhanced the rural atmosphere around Dairy Flat, and contributed to the increasing subdivision of properties in the area. Aspect, privacy and views also influence the buying decisions of purchasers of lifestyle blocks in rural areas like Dairy Flat. Thus if the landfill is not within the line of sight of a dwelling then a purchaser may not perceive it as having a negative effect on the property. As only the contour to the east of the Redvale Landfill is relatively level, some properties on the other boundaries where the terrain is undulating to easy hill country do not have line of sight of the landfill. Furthermore, a contour obscuring the view of the landfill may also reduce the negative effects of noise, dust and odour.

As this discussion of the area around the Redvale Landfill reveals, there may be a multiplicity of factors that may influence the movement of property values after a landfill commences operations in a specific locality. Although the statistical methods used in our analysis do not support the hypothesis that the establishment of the Redvale Landfill has had a negative effect on property values in close proximity to the site, it is possible that a study of a landfill at a different location and in different circumstances, using the same statistical methods may support this hypothesis.

Further application of the methods used in this study would not only increase our knowledge of the effects of landfills, or other types of facilities, on property values in their vicinity, but also assist in the process of applying this type of statistical analysis to impact assessment.

REFERENCES

Baines, J. and Buckenham, B. (2000). An analysis of host community experience of the Redvale Landfill (Auckland Region). Working Paper FS8, Public Good Science Fund Contract TBA 802, Taylor Baines & Associates, Christchurch.

Burton, P.R.; Gurin, L.C. and Campbell, M.J. (1998). Clinical significance not statistical significance: A simple Bayesian alternative to p values. *Journal of Epidemiology and Community Health*, 52, 318-323.

Daly, L. (nd). Statement of Evidence as part of an appeal by the Department of Corrections to the Environment Court in Gisborne. (circa 1999)

Dean, S.N. (1994). Value Implications of a Proposed Landfill Site. New Zealand Valuers' Journal. December: 27-29.

Hopkins, J. (1999). The Effect of NIMBYs on Property Values: A New Zealand Case Study. Paper presented to the Sixth European Real Estate Conference, Athens, Greece, 22-25 June 1999.

Kass, R.E. and Raftery, A. (1995) Bayes Factors. *Journal of the American Statistical Association*, 90, 773-795

Liang, K.Y. and Zeger, S.L. (1986) Longitudinal data analysis using generalized linear models *Biometrika,* 73, 13-22.

SAS Institute Inc., (1999), *SAS/STAT User's Guide, Version 8*, Cary, NC, SAS Institute Inc.

Taylor, C.N.; Goodrich, C.G. and Bryan, C.H. (1995). Social Assessment: theory, process and techniques. 2nd Edition. Taylor Baines & Associates, Christchurch.

APPENDIX: Statistical Method - Technical Details

Sales price model: In order to model the effect of the landfill on property sales prices, while accommodating the correlation structure of the sales data, resulting from multiple sales for some properties, we adopted a 2-level hierarchical model. The outcome variable of interest is, Y_{ij}, indicating the logarithm of net sale price per hectare for the $i-th$ plot at the $j-th$ sale, where $i = 1,\cdots,236$ and $j = 1,\cdots,n_i$. The first level of the model relates sales price to time trend and has the form:

$$y_{ij} = \beta_{0i} + \beta_{1i}x1_{ij} + \beta_{2i}x2_{ij} + \beta_{3i}d_{ij} + \varepsilon_{ij}$$

The covariates $X1$ and $X2$ are indicator variables for the date from landfill land purchase date (01/01/1988) to landfill operation date (01/08/1993) and the date after the landfill operation date. The covariate D is a continuous variable, indicating day of study and day zero is taken to be 01/01/1986. The error terms, ε_{ij}'s are assumed to be normally distributed with mean 0 and variance ^{2}

At the second level of the hierarchy, the level-one regression coefficients are related to characteristics of the property itself. Two models were considered

Model 1: $$\beta_{0i} = \alpha_{00} + \alpha_{02}d1_i + \alpha_{03}d2_i + \alpha_{04}d3_i + \alpha_{05}g_i + \upsilon_{0i}$$

$$\beta_{1i} = \alpha_{10} + \upsilon_{1i}$$

$$\beta_{2i} = \alpha_{20} + \upsilon_{2i}$$

$$\beta_{3i} = \alpha_{30} + \upsilon_{3i}$$

$$\beta_{4i} = \alpha_{40} + \upsilon_{4i}$$

Model 2: $$\beta_{0i} = \alpha_{00} + \alpha_{01}d1_i + \alpha_{02}d2_i + \alpha_{03}d3_i + \alpha_{04}d5_i + \alpha_{05}g_i + \upsilon_{0i}$$

$$\beta_{1i} = \alpha_{10} + \alpha_{11}d1_i + \alpha_{12}d2_i + \alpha_{13}d3_i + \alpha_{14}d5_i + \upsilon_{1i}$$

$$\beta_{2i} = \alpha_{20} + \alpha_{21}d1_i + \alpha_{22}d2_i + \alpha_{23}d3_i + \alpha_{24}d5_i + \upsilon_{2i}$$

$$\beta_{3i} = \alpha_{30} + \upsilon_{3i}$$

$$\beta_{4i} = \alpha_{40} + \upsilon_{4i}$$

The second level covariates, $D1$, $D2$, $D3$ and $D5$ are the indicator variables for the distance bands, and represent the areas 0.5 km to 1 km, 1 km to 2 km, 2 km to 3 km and more than 3 km from the landfill. The area within 500 m of the landfill serves as the reference area. The other covariate G is a group indicator variable, coded '1' for the host area and '0' for the control area. The errors, υ_{ki}'s are assumed to have a zero mean normal distribution for $k = 0,\cdots,4$.

Model 2 permits the time period effects to vary with distance from the landfill, while model 1 assumes common time period effects across the distance bands.

Turnover model: To model the effect of landfill on turnover, we split the data into three time periods: the period before the landfill land purchase date, the period from landfill land purchase date to landfill operation date and the period after the landfill operation date. The variable of interest, T_{ij}, is the number of sales for the $i-th$ property during the $j-th$ time period, where $i = 1,\cdots,236$ and $j = 1,2,3$. The models assume a Poisson distribution for T_{ij} with mean parameters given by

Model 1: $\ln(E(T_{ij})) = \ln(L_j) + \gamma_0 + \gamma_1 d1_i + \gamma_2 d2_i + \gamma_3 d3_i + \gamma_4 d5_i + \gamma_5 x1_{ij} + \gamma_6 x2_{ij}$

Model 2:

$$\begin{aligned}\ln E(T_{ij}) = \ln(L_j) &+ \gamma_0 + \gamma_1 d1_i + \gamma_2 d2_i + \gamma_3 d3_i + \gamma_4 d5_i + \gamma_5 x1_{ij} + \gamma_6 x2_{ij} + \gamma_7 d1_i \times x1_{ij} \\ &+ \gamma_8 d2_i \times x1_{ij} + \gamma_9 d3_i \times x1_{ij} + \gamma_{10} d5_i \times x1_{ij} + \gamma_{11} d1_i \times x2_{ij} \\ &+ \gamma_{12} d2_i \times x2_{ij} + \gamma_{13} d3_i \times x2_{ij} + \gamma_{14} d5_i \times x2_{ij}\end{aligned}$$

The factor L_j is the length of the jth time period and $\ln(L_j)$ is used in the model as an offset to account for the different lengths of the time periods. The covariates, $D1$, $D2$, $D3$, $D5$, $X1$ and $X2$ are defined as before.

Because each property contributed three observations to the data (one for each time period) the standard assumption of mutual statistical independence for all observations is not tenable. Consequently we adopted a generalised estimating equation (GEE) approach to model fitting (Liang

and Zeger, 1986). The GEE approach generates consistent parameter estimates and precision estimates for the model parameters without assuming independence for the repeated sales counts. A drawback to the GEE approach to model fitting is that because it is not fully based on likelihood theory, likelihood based approaches to model selection such as those based on the Bayesian Information Criterion (BIC) are, strictly speaking, unavailable. However, as an approximation, we computed the BIC and the corresponding approximate Bayes factors (Kass and Raftery, 1995) based on a conventional maximum likelihood analysis, ignoring the correlation structure of the data. Parameter estimates, confidence intervals and approximate posterior probabilities were based on the GEE analysis.

Interpretation of the Models. We adopted a quasi-Bayesian approach to interpreting the results of the models, based on uniform prior distributions and normal approximations to posterior distributions. Under this set-up results depend only on the observed data and inferences follow from a normal approximation to the likelihood function. Consequently 95% confidence intervals are viewed as approximations to Bayesian 95% credible intervals and can be interpreted as probability statements concerning the parameter of interest. In addition, other posterior probabilities can be approximated such as a parameter value (e.g., relative price or turnover) exceeding some null value (such as one for relative measures of effect) can be approximated. This approach to inference generalises the approximate Bayesian perspective of Burton, Gurin and Campbell (1998).