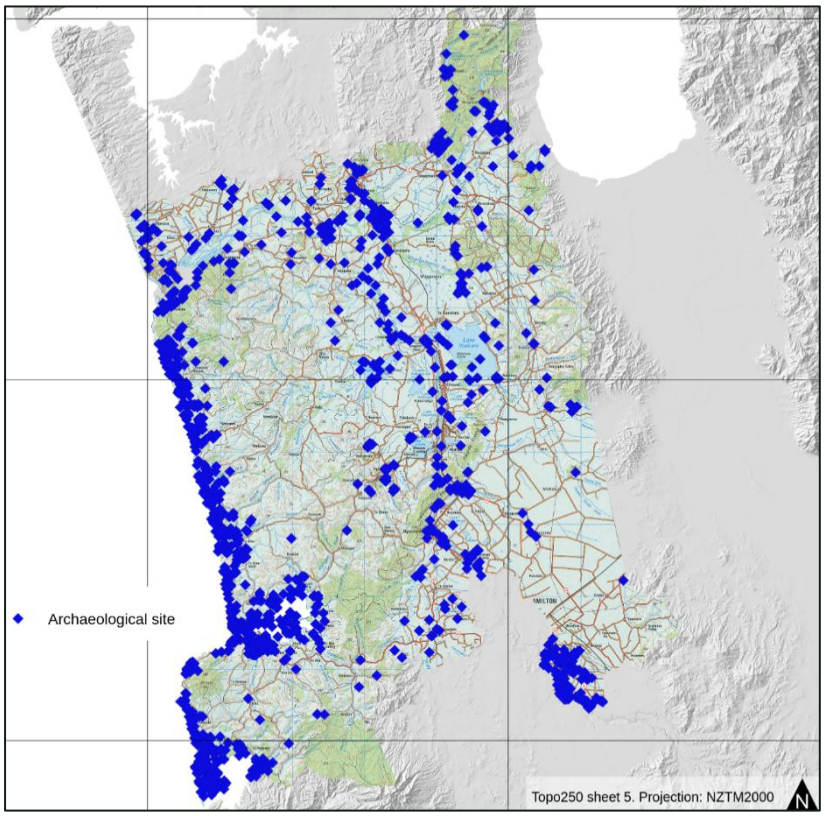
Waikato District Plan Review

Archaeological Heritage Project Phase I



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Executive Summary

Waikato District Council is currently drafting a single district plan and is required to recognize and provide for the protection of New Zealand's historic heritage under the Resource Management Act 1991. The plan review creates an opportunity to provide archaeological site information to local land owners and other WDC residents about the 1,378 archaeological sites recorded in the District.

The purpose of the WDC Archaeological Heritage project is to identify recorded archaeological sites, unrecorded traditional Maori garden sites and archaeologically sensitive urban areas in Waikato District and make this information accessible to Council staff and the public on WDC's web site "intra maps".

This is achieved by the delivery of an archaeological heritage “alert layer” to the Council’s GIS division. The alert layer takes the form of a shapefile containing cadastral parcels affected by proximity to archaeological sites and overlays for towns in the district.

This is the Phase I completion report. It introduces the project, provides background information on the nature and distribution of recorded archaeology in the Waikato District and explains how the selection of cadastral parcels for the alert layer was made. It also provides a Waikato Riverside alert layer that indicates the potential for archaeological sites. The Waikato Riverside alert was included at the request of planning department staff members. The Riverside alert layer indentifies parcels close to the River where unrecorded archaeological sites are known to exist or believed to exist based on predictive modelling.

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Introduction

The WDC archaeological project is a multi-phased project designed to update the archaeological information in the existing WDC plan commencing with Phase I. This report documents the development and delivery of Phase 1 of the Waikato District Plan Review archaeological heritage alert project by Simmons and Associates Ltd.

The report is divided into two parts. The first is project management information:

- Background information and project purpose
- The scope and intention of the Phase I project,
- The tasks completed and
- Project risk analysis.

The results of Phase I are summarised and recommendations included.

The second part of the report provides an overview of archaeology in the Waikato District. It introduces the NZ Archaeological Site Recording Scheme, and discusses the limitations of the dataset. It also explains the methodology developed to select parcels for the alert layer, and how this was implemented. The sections in this part of the report are:

1. Overview of archaeology in the Waikato District
2. A short history of the Site Recording Scheme
3. Quantifying uncertainty in the archaeological data
4. Methodology

Archaeological Heritage Project; Background Information

The Waikato District currently contains 1,378 archaeological sites recorded in the New Zealand Archaeological Association (NZAA) Site Recording Scheme (the Scheme). Less than 1 percent of these sites are registered in the Waikato or Franklin District operative plans. Most of the landowners in the district are unaware of the recorded and unrecorded archaeological sites on their property. Waikato District Council is currently drafting a single district plan and is required to recognize and provide for the protection of New Zealand's historic heritage under the Resource Management Act 1991. The plan review creates an opportunity to provide archaeological site information to local land owners and other WDC residents.

The purpose of the WDC Archaeological Heritage project is to identify recorded archaeological sites, unrecorded traditional Maori garden sites and archaeologically

sensitive urban areas in Waikato District and make this information accessible on WDC's web site "intra maps".

During the course of Phase I it was determined the best method for alerting property owners to the potential for archaeological sites on their land was to develop a property parcel overlay layer. The identification of recorded site locations on property parcels will provide existing and future district property owners and council staff with the ability to manage effects to archaeological sites.

All archaeological sites in New Zealand are protected under the *Heritage New Zealand Pouhere Taonga* Act, 2014 regardless of whether they are recorded or not. An archaeological site is defined in the Act (S6) as:

> (a) any place in New Zealand, including any building or structure (or part of a building or structure), that--
>
> (i) was associated with human activity that occurred before 1900 or is the site of the wreck of any vessel where the wreck occurred before 1900;
>
> and
>
> (ii) provides or may provide, through investigation by archaeological methods, evidence relating to the history of New Zealand; and
>
> (b) includes a site for which a declaration is made under section 43(1).

Phase I of the Archaeological Heritage Project

Phase I of the project involved the design of the GIS data layer and delivery of an initial dataset providing alerts for existing archaeological sites recorded in the Site Recording Scheme. It was agreed at the project inception meeting that a shapefile would be supplied, containing cadastral parcels which are affected by proximity to recorded archaeological sites. Each shapefile record would contain not only the spatial geometry, but also tabular fields recording the appellation (legal description) and the NZAA identifiers for sites affecting that parcel. The intention of the project design is to provide the capability to notify interested parties of archaeological sites on or near property parcels. It is not intended to provide comprehensive archaeological data about the individual sites.

Phase I Tasks Undertaken

As specified in the Archaeological Heritage Inception Report the following were carried out:

1. An immediate meeting with GIS staff to determine the structural content took place on 23 February;
2. Follow up meetings to ensure any unforeseen problems in the information and system are solved took place on 9 and 18 March;
3. Data compilation;
    a. Preparation of a report documenting the Phase I work, including the methodology used to construct the alert layer and a list of the sites included in the Phase I alert layer by number, type and GIS location data; and
4. Obtaining a list of Heritage New Zealand Select Archaeological Sites from the WDC planning department.

Meetings

In total, three meetings were held between Council and Simmons and Associates during Phase I:

1. February 23. The inception meeting.
   This was the meeting referred to in task 1, in which the nature and purpose of the project were discussed, and an agreement reached that delivery would take the form of a shapefile.

2. March 9.
   This was the first of two follow-up meetings referred to in task 2. A copy of a shapefile containing property parcels affected by proximity to archaeological sites had been sent to Eunice Karauria earlier. Malcolm Hutchinson presented an A3 map (included as Appendix 2) indicating the parcels in the shapefile, and discussed the methodology used to select parcels for inclusion in the alert layer. It was suggested that a way be found to offer protection to sites along the river known to exist but not yet recorded in the Scheme.

3. March 18.
   The second of two meetings referred to in task 2. The purpose of this meeting was to answer some of the questions raised by the telephone call of 14 March between Malcolm and Eunice. It was determined that a shapefile would form

the final delivery format, and that it should make accommodation for sites along the river, which are known from remote-sensing data but are not yet recorded. The riverside parcels were to be delivered as a separate file.

Other communications

Other communications preceded and followed meetings. Any project-related email correspondence sent from Malcolm was carbon-copied to the team members:

Damon Mathfield, WDC Senior Policy Planner
Jenni Vernon, WDC Leader of the Strategic Planning and Resource Management Team,
Betty Connolly, Senior Policy Planner
Eunice Karauria WDC GIS Officer,
Alexy Simmons, Simmons and Associates Senior Archaeologist

Email and phone calls

1. March 10
   An email from Malcolm Hutchinson to Eunice Karauria in which I explained the method by which the individual property parcels had been selected, and something of the uncertainty inherent in the location of sites in the Site Recording Scheme (discussed in greater detail in Part 2).

2. March 11
   Eunice's response, raising the following issues:
   a. Checking the terms and conditions of the agreement with the NZAA with regard to publishing their data on Council's website,
   b. Complications around maintaining two sets of data, when one (the alert layer) is derived from sets already in Council possession,
   c. The planners preference in how the layer is displayed,
   d. District plan layers are static as any change to the Plan requires a documented process.

3. March 14
   Phone call between Malcolm and Eunice, discussing matters around the dynamic nature of the underlying datasets, whether the alert layer would be inserted into the District plan, and whether a shapefile is the appropriate delivery format. Also discussed was the potential issue of the agreement with

NZAA with respect to making data available on the public website. This phone call was followed up by email on 15 March.

4. March 15
   Email from Malcolm to Damon Mathfield requesting the second meeting (held on 18 March), and explaining the reason for the request.

Copies of email correspondence mentioned above are included as Appendix 1.

Data compilation

Task 3 of Phase I refers to the compilation of a shapefile by selecting cadastral parcels according to their proximity to recorded archaeological sites.

The process by which cadastral parcels are selected for inclusion in the alert layer is explained in detail in Part 2 of this report. It involves an analysis of the underlying NZAA archaeological dataset, the identification of certain issues which lead to uncertainty in the spatial location of archaeological sites, and the formulation of a methodology to overcome these limitations.

The methodology required a 100 m buffer around each recorded archaeological site in the District. Cadastral parcels were then selected where they intersected with one or more of these buffered areas. Parcels recording road or hydro (rivers, streams) were excluded from the initial selection. During discussion at meeting 2, it was suggested that many of the road parcels represent unformed or paper roads, which would be better included in the selection.

In order to provide protection for clusters of archaeological sites known to exist along the banks of the Waikato River, but not yet recorded, a buffer of 1,000 m was applied to Hydro parcels representing the River, and parcels intersecting with this buffer were included in the selection.

As specified in task 3, a list of 1,378 recorded archaeological sites, with NZAA identifier, site type and NZTM coordinates is supplied as a Comma Separated Values (CSV) file with the data delivery.

Task 3 also required that a report explaining the method used to derive the alert layer. This report answers that requirement, with particular reference to Part 2.

Changes in the Phase I Scope of Work

At the second meeting (March 9) it was suggested that a way be found to protect the sites along the river which are known to exist but are not yet recorded. A predictive model should be used to select parcels likely to be affected by these sites.

It was pointed out by Eunice that the terms of the arrangement between the Council and the NZ Archaeological Association may preclude the supply of information within the Site Recording Scheme to the public. I undertook to discover the correct person within the Association with whom to discuss the matter of public distribution of archaeological data, or data derived from archaeological data.

Risk Register

The risk register has been adapted from that supplied with the inception report. Additional risks were identified during phase work and added to the end of the Phase I risk register (Table 1). The risk register was used as a tool for addressing several issues relating to the Phase I project design. For example the potential for bad outcomes caused by the absence of field work from the project scope, and by data quality limitations, has been addressed by the formulation of a methodology to cope with uncertainty in the archaeological data, with particular reference to the locations. (Part two of this report provides a short history of the Site Recording Scheme, and discusses in some detail the factors which cause this uncertainty.)

Table 1. Risk register for Phase I.

Risk statement	Rank 1-5		Treatment plan
	Likelihood	Consequence	
Bad outcome caused by table top study versus field work.	2	2	Archaeologists and a researcher with experience in the Waikato will source the data used to inform the table top research. The constraints intrinsic to the base data will be clearly stated and identified in the phase reports. An advice note will be included in the phase reports and on the web site requesting WDC be advised of information errors, such as the location of sites. This will facilitate the opportunity for a fieldwork or research based checked and updated. This has been addressed by the compilation of part 2 of this report.
Bad outcome caused by failure to communicate data sharing requirements	2	2	Meetings to be carefully conducted and minutes taken and shared between participants and edited as necessary. Model dataset to be delivered to Council GIS staff before final deadline, giving an opportunity (and time in the schedule) to address format and structure issues. This has been addressed with a schedule of meetings between the Council and Simmons and Associates. Also, email correspondence was engaged when necessary.
Bad outcome caused by data quality limitations, e.g. incorrectly located sites, sparse	3	3	The limitation of the NZAA SRS data set will be stated and identified in the phase report. An advice note will be included in the

archaeological records or errors in the records.			phase report and on the web site requesting WDC be advised of information errors. This will facilitate an opportunity for follow up fieldwork or research to verify the information and update the data base. Addressed in Part 2 of this report.
Bad outcome caused by human analysis errors.	1	1	Archaeologists with experience in the Waikato will analysis the research data. An advice note will be included in the phase reports and on the web site requesting WDC be advised of information errors so they can be investigated. Addressed as stated above.
Bad outcome caused by human errors during data entry.	1	1	Experienced WDC personnel will be inserting the data into WDC's GIS data base. An advice note will be included in the phase reports and on the web site requesting WDC be advised of information errors. Addressed as stated above.
Bad outcome caused by an illness incapacitating senior archaeologists involved in the project for more than a week.	1	1	Revision of the phase deadlines. Employment of senior archaeologists with a similar skill set. Not necessary in Phase 1.

Results of Phase I

Three electronic data files have been delivered. These are:

1. the primary alert layer, a shapefile containing cadastral parcels affected by proximity to archaeological sites;
2. the Waikato River side alert, a shapefile containing property parcels within 1,000 m of the river; and
3. a CSV file containing the list of archaeological sites recorded within the boundaries of the District.

A shapefile was developed by selecting parcels from the LINZ cadastral layer which are affected by proximity to one or more recorded archaeological sites. This shapefile contains one record for each relationship between cadastre and sites. A parcel affected by five archaeological sites will be recorded in the shapefile five times. Similarly, a site will be listed once for each parcel it affects.

The shapefile contains three attribute columns: an integer identifier, the parcel appellation, and the NZAA identifier. The geometry column contains the polygon shape of the land parcel.

Cadastral parcels were selected according to a basic method of buffering each archaeological site by 100 m, in an attempt to compensate for uncertainty in the location of sites recorded in the Scheme. It is recognised that this is a very basic methodology, which does not guarantee that only parcels affected by archaeological sites will be selected. It does, however, provide for some measure of protection for known archaeological sites in the District. It is thought that the methodology might be refined with further research.

An updated map depicting the shapefile is included as Appendix 3.

Data delivery

A draft of the shapefile was delivered by email to Eunice on the morning of March 9. This was addressed at the meeting later that afternoon, at which a map of the District, illustrating the shapefile, was presented (This map is attached as Appendix 2 and the updated version is Appendix 3).

A final copy of the shapefile, produced using a modified methodology which included non-formed road parcels and a second shapefile identifying parcels subjected to unrecorded sites along the river have also been supplied.

In addition to the shapefiles, the list of 1,378 recorded archaeological sites within the District, with their site types and NZTM coordinates has been supplied as a comma-separated values (CSV) file.

Recommendations

It is recommended that the Waikato District Council Project Steering Committee (PSC) consider the following matters associated with use and management of the archaeological alert layer:

- who sees the archaeological alert layer;
- providing a list of Heritage New Zealand identified special or select archaeological sites to WDC GIS staff so these can be flagged in the WDC archaeological data base; and
- how frequently GIS staff update the archaeological alert parcel layer;

The Phase I Overview of Archaeology in the Waikato District

Introduction

Here we provide some background about the recorded archaeology in the Waikato District, explore the history of the NZ Archaeological Association's Site Recording Scheme (the Scheme) and discuss some of the shortcomings inherent in the data collected in it, with particular reference to uncertainty over site locations. Following the background information sub-section the methodology for selecting cadastral parcels is explained.

Recorded Archaeological Sites in the Waikato District

The New Zealand Archaeological Association maintains the national database of archaeological sites, the Site Recording Scheme. In it are over 67,000 records of archaeological sites across New Zealand. The scheme records 1,378 archaeological sites within the boundaries of the Waikato District. Figure 1 shows the distribution of these sites throughout the district.

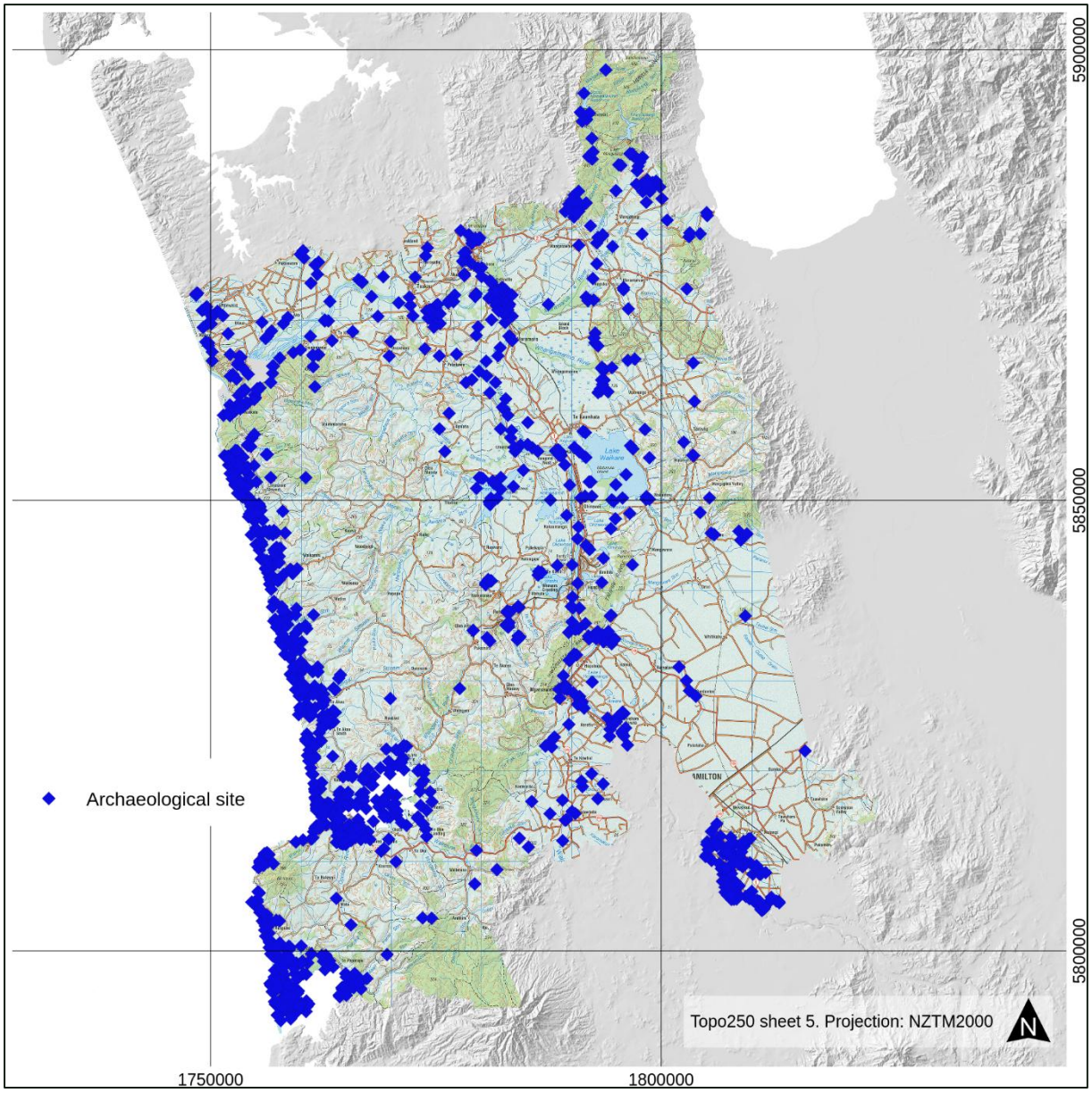

Figure 1. Archaeological site distribution in the Waikato District.

The Site Recording Scheme contains records for places of human activity dating to after 1900 as well as those precisely fitting the legal definition.

The sites within the Waikato District are classified into 34 types, being associated with pre-European Maori occupation and with later Maori and Pakeha activities. The site types recorded in the District can be seen in Table 2, below.

Table 2. Archaeological sites by type within the Waikato District.

site type	count
Agricultural/ pastoral	22
Art	3
Artefact find	24
Botanical evidence	2
Burial/ cemetery	37
Cave/ rock shelter	7
Cement/ lime works	1
Commercial	4
Fishing	2
Flax milling	5
Flour milling	5
Health care	2
Historic - domestic	21
Historic - land parcel	1
Industrial	7
Maori horticulture	131
Midden/Oven	226
Military (non-Maori)	51
Mining - coal	31
Mining - gold	1
Mission station	6
Pa	317
Pa - gunfighter	5
Pa - island/ swamp	1
Pit/Terrace	401
Recreation	1
Religious	1
Shipwreck	5
Source site	4
Timber milling	1
Traditional site	1
Transport/ communication	11
Unclassified	35
Working area	6

By far the most common type is "Pit/Terrace" with 401 individual sites recorded. Next most common are Pa, with 323 known in the district (the combined total of records for "Pa", "Pa - gunfighter" and "Pa - island/swamp"). Sites of type "Midden/oven" and "Maori horticulture" are the only two others with numbers above one hundred.

Together numbering 1,081, these pre-European Maori sites constitute 78 percent of the sites recorded in the District.

The relative numbers of sites by type can better be seen in Table 3, below, ordered from most common to least:

Table 3. Archaeological sites by type within the Waikato District, sorted from most to least common.

site type	count
Pit/Terrace	401
Pa	317
Midden/Oven	226
Maori horticulture	131
Military (non-Maori)	51
Burial/ cemetery	37
Unclassified	35
Mining - coal	31
Artefact find	24
Agricultural/ pastoral	22
Historic - domestic	21
Transport/ communication	11
Cave/ rock shelter	7
Industrial	7
Mission station	6
Working area	6
Pa - gunfighter	5
Shipwreck	5
Flour milling	5
Flax milling	5
Source site	4
Commercial	4
Art	3
Botanical evidence	2
Health care	2
Fishing	2
Cement/ lime works	1
Historic - land parcel	1
Pa - island/ swamp	1
Timber milling	1
Mining - gold	1
Recreation	1
Religious	1
Traditional site	1

Proximity of sites to waterways

One of the first things to notice about the distribution of archaeological sites in the Waikato District is the way they cluster towards the coast (including the two harbours, Raglan and Aotea) and the river, leaving a large area in the western hills seemingly without recorded archaeology.

Table 4 records the number of sites found within 1 km, 2½ km and 5 km from the coast, and from the river. Also listed is the percentage of the total number of sites in the District represented by each count.

Table 4. Number of sites by proximity to coast or river.

Location	1.0 km	2.5 km	5.0 km
Coast	507	963	763
	36.8%	70.0%	55.4%
River	277	377	460
	20.1%	27.4%	33.4%

We see here that just over half of the archaeological sites recorded in the District are within 5 km of the coast, and another third are known within a similar distance from the Waikato River. Over one third of all recorded sites in the District occur within a thousand metres of the coast. One fifth of all sites are within a kilometre of the river.

If we add the river and the coast together we see percentages for proximity to the major waterways in the District in Table 5.

Table 5. Number of sites by proximity to coast and river.

	1.0 km	2.5 km	5.0 km
No. sites	779	1040	1166
Percentage	56.5%	77.5%	84.6%

This indicates that 85 percent of all archaeological sites recorded in the District are within five kilometres of the coast, or of the Waikato River. Nearly half of the recorded sites are within 1,000 m.

Figures 2, 3 and 4 show this proximity in a visual sense. In these figures, the black dots represent recorded archaeological sites, while the coloured polygons are the areas enclosed by buffers of different distances.

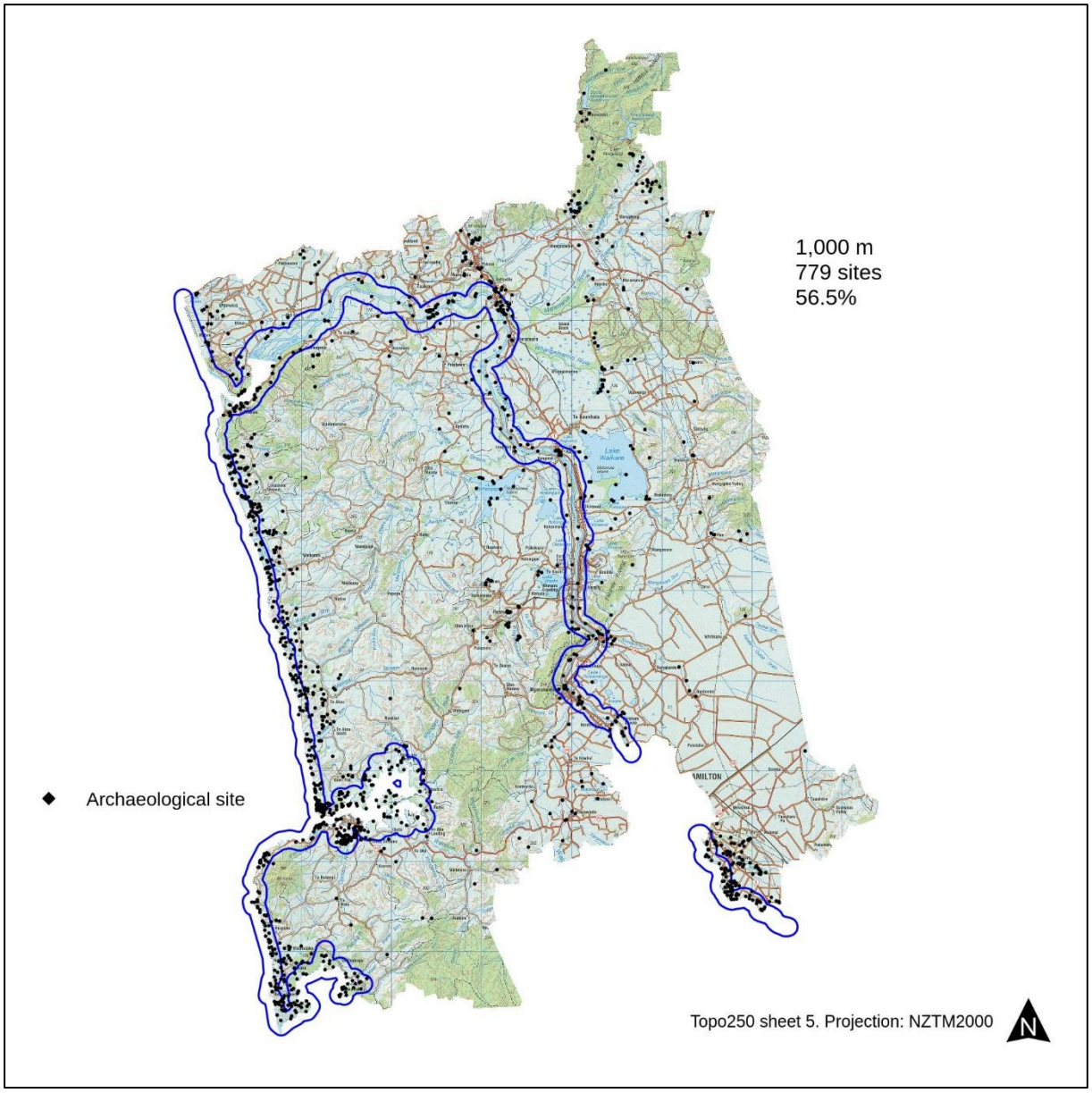

Figure 2. Archaeological sites within 1,000 m of the coast or of the Waikato River.

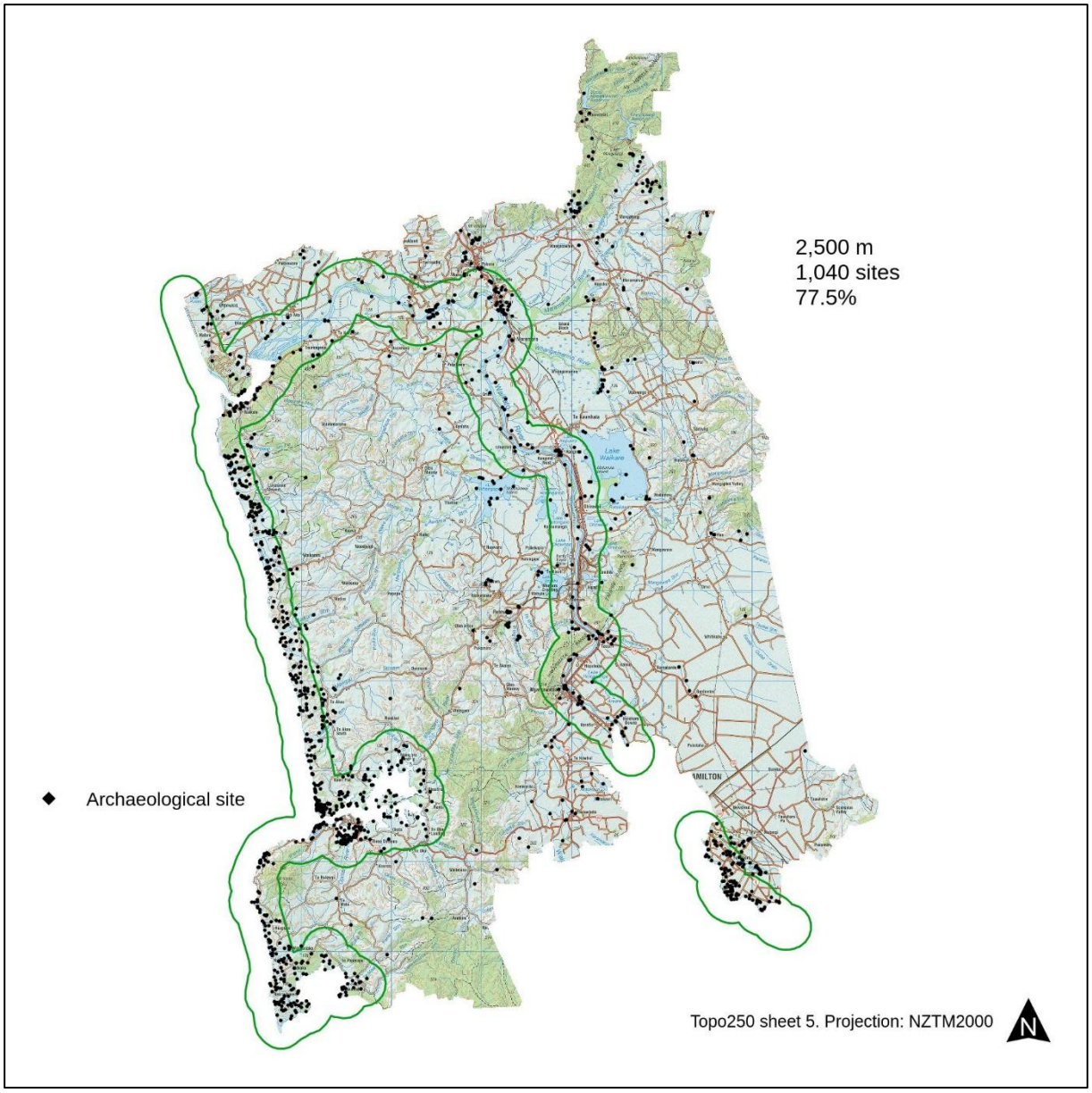

Figure 3. Archaeological sites within 2,500 m of the coast or of the Waikato River.

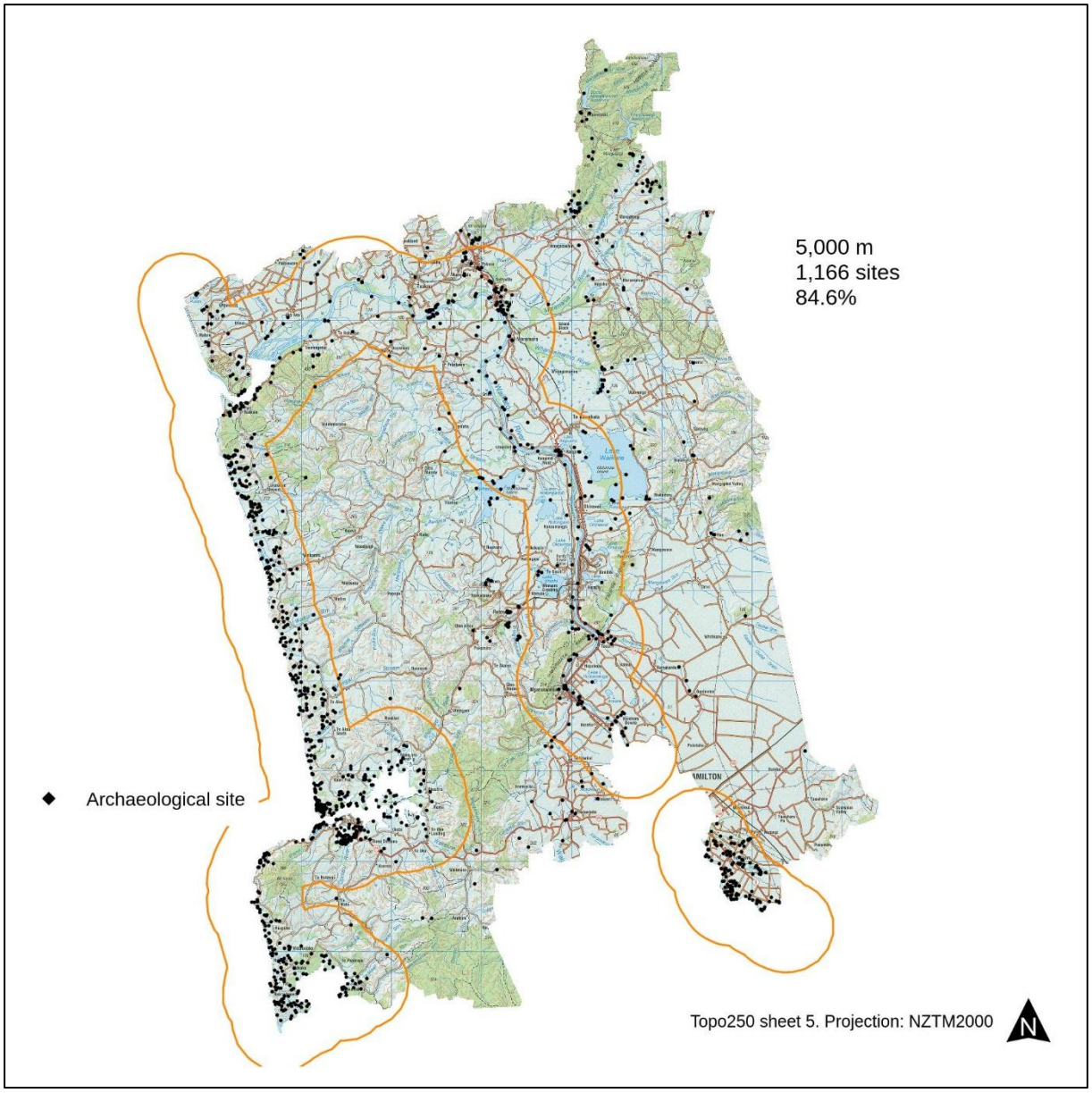

Figure 4. Archaeological sites within 5,000 m of the coast or of the Waikato River.

This would support the hypothesis that further unrecorded archaeological sites might be predicted in greater numbers in proximity to the Waikato River and along the coast.

A Short history of the NZAA Site Recording Scheme

This history is necessarily very brief. Following a broad background of how the Scheme came to be, I concentrate for the greater part on the way the locations of sites have been recorded, that being the subject most relevant to the current project.

The Scheme started in 1951, when the Hawkes Bay branch of the Royal Society was given a grant to establish a suitable scheme whereby sites related to early Maori occupation might be recorded in a simple but systematic way (Mumford 1959, p. 8). The scheme devised by Mr J. Buchanan consisted of a simple form recording details of a site, which would be held in a filing cabinet locally, and duplicated into another file in Wellington.

The original purpose of the scheme was "to encourage the recording and surveying of archaeological remains by setting up and operating a National Site Recording Scheme". The objective was to create files of information about archaeological sites. Such information was to be used for archaeological research and to promote the protection and conservation of archaeological sites (Walton 2007, p. 2-3).

The 1 inch to 1 mile series (NZMS 1) of topographic maps would be the basis for cataloguing archaeological sites, the major divisions of the record files being the sheet numbers of the map series. File N 56 would refer to sheet 56 of the North Island (Ngaruawahia). Figure 5 is a detail from the earliest edition of this map showing Ngaruawahia and environs.

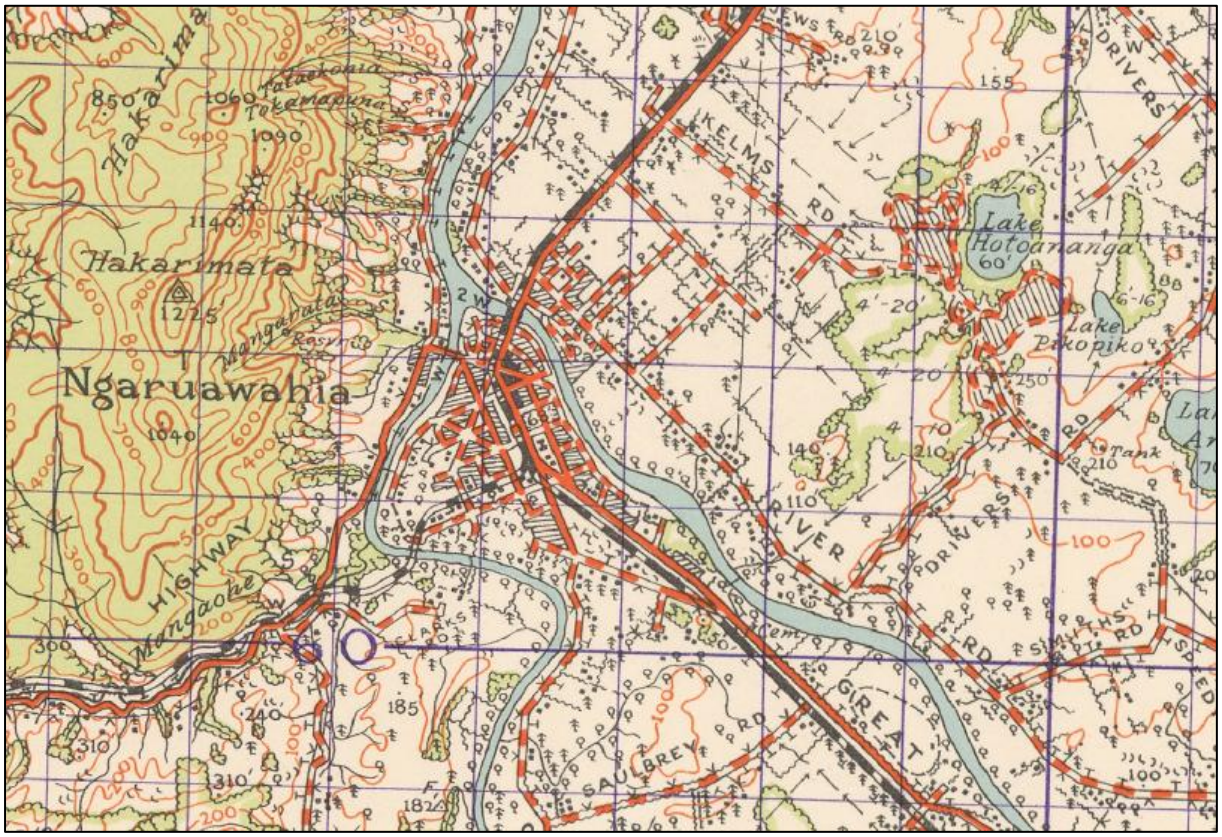

Figure 5. Detail from NZMS1 sheet N56, Ngaruawahia, printed 1944. Map sourced from mapspast.org.nz.

A field investigator would fill in a form describing the site and giving its location on the NZMS 1 map. The form would be handed into a local filekeeper who would check the details and assign the site a number.

New Zealand had been divided into eleven districts, the borders of which coincided with the edges of NZMS 1 map sheets. Each district had a filekeeper, whose job it was to maintain the files, making them available to members of the Association and interested others, and ensuring the quality and accuracy of the files in their possession. A duplicate set of files was always kept in Wellington in what became known as the central file.

In 1960, the scheme was given an overhaul, with provision to list sites as threatened or (to be) scheduled (Daniels, Mumford, Smart 1960, p. 33). This was early recognition that the scheme could help to manage and hopefully conserve the archaeological resource.

By 1962, there were 295 recorded sites in the Auckland file, but only 13 in the Waikato one. In 1963, Daniels reported 21 sites in the Waikato file and by 1972, there were 123 Waikato sites (Daniels 1962, p. 253, Daniels 1963, p. 140, Daniels 1972, p. 144).

By 1982, the Scheme had grown to 28,842 sites in all, with 1,877 of them being in the Waikato file[1]. It was also in the 1980s that the Department of Conservation (DOC) established the Computerised Index to New Zealand Archaeological Sites (CINZAS). This was a simple text-only database recording an index of site records in the central file.

In the first decade of the 21st Century it became obvious that the paper-based filing system was not going to be able to keep up with demand, both for access to archaeological records, and for creating new ones. Neither was it well suited to its growing role as a means of informing regulatory decisions (Law 2007, p. 58).

The NZ Archaeological Association embarked on a project to scan the large number of paper records held in the central file in Wellington, and to make these available on a website. The result was ArchSite. This has now effectively replaced the paper-based system with an entirely electronic means of capturing and distributing archaeological records.

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[1] It should be noted that the Waikato site file comprised records falling on any of 14 NZMS map sheets -- an area much larger than the Waikato District.

Imperial to metric conversion

New metric maps, with a new projection and new coordinate system, were introduced during the 1970s and 1980s. It was decided that a conversion of the Scheme was needed, and work was undertaken to rename the sites according to the new NZMS 260 map sheet index. It was also necessary to transform the coordinates from imperial feet in the North- or South- Island projection into metres on the NZ Map Grid.

An excellent treatment of how this was accomplished and what it meant for the accuracy of location data in the Scheme was given by Sheppard, who explained a grid reference like this:

> Contrary to popular belief, a grid reference actually defines a square on the map, not a point on the ground. The NZAA site recording scheme uses the most precise grid reference appropriate to its maps; defining a 100 yard square on NZMS1 maps, or a 100 m square on maps of the NZMS260 series. These squares, if drawn on the maps, would be of 1.6 mm sides and 2 mm respectively.
> (Sheppard 1985, p. 188).

The conventional method of citing a grid reference -- printed in the margins of all topographic maps -- is to quote the significant digits of the grid square the site is in. This means giving the coordinates for the south-west corner of that square.

This is likely to cause confusion today, with the prevalence of high-precision GPS handsets. A GPS reading is commonly understood to represent a single point, which is somewhat different from a grid reference. If the site is in the north-west corner of that 100 m square, Going to the grid reference with a GPS might put you at a location up to 141 m away (the diagonal length of a 100 m square).

The conversion from imperial to metric is not straightforward. The fact that a grid reference refers to a square area rather than a point can, in certain circumstances, cause an automatic calculation to throw the site location out by quite a distance. Sheppard illustrated this (in Figure 6) by laying an indicative metric grid over an imperial one and describing a situation "having an extreme effect on the calculation of an equivalent NZMS260 (metric) grid reference".

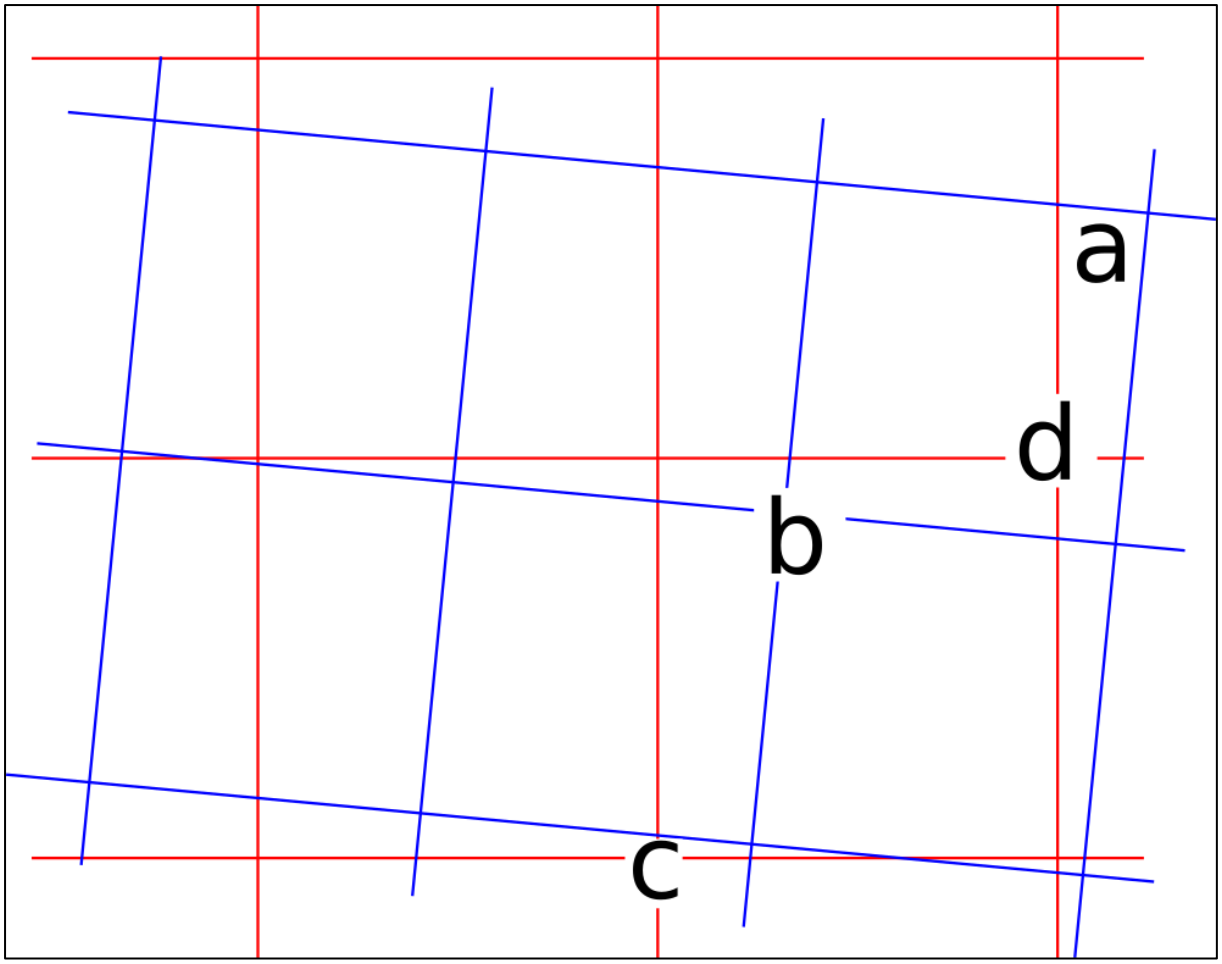

Figure 6. Metric grid (red) and imperial grid (blue), after Sheppard 1985. Differences between the grids are exaggerated.

A site at "a" is in the north-west corner of the 100 yard imperial grid (blue), and its location would be given as "b". On the metric map (red), the square containing "b" is defined by the coordinates of "c" when the site should in fact be in the square defined by "d". In this case, the computed coordinates at "c" would be well over 100 m distant from the site's actual location as might be given today by a GPS handset.

Qualifying uncertainty in the archaeological data

This section has been included to address the risk to Phase I identified as "bad outcome caused by data quality limitations, e.g. incorrectly located sites, sparse archaeological records or errors in the records". It answers the treatment plan by providing an explanation of the limitations of the NZAA Site Recording Scheme dataset.

Given what we know of the age of earlier records in the Scheme, and the way their positions were recorded by estimating grid references from topographic maps, it is useful to understand how these things affect the determination of where an archaeological site is, how extensive it is, and which property parcels around it will be affected by proximity to it.

We can do this by examining some of the sites in the district. The precise locations of pa are often easier to detect using modern remote sensing data, and pa are frequently limited in extent, with fairly clearly-defined boundaries.

The Waikato Regional Aerial Photography Service (WRAPS) provides high-accuracy aerial imagery of the region. These come as tiles, already referenced to their geographic location.

Using the aerial images, we can spot the locations of certain pa, and compare them with the stated locations in the Scheme.

The Unnamed Pa S14/26, recorded by Steve Edson in 1979 (therefore recorded under the Metric system) is located at NZTM 1787142 5822752. When we plot this point on the map, however, we find it lying in the middle of the Waipa River. This is not, in fact the correct location. The pa actually stands on a low hill on the right bank of the river, just below a sharp bend to the left. This is visible on the WRAPS 2012 image, as shown in Figure 7.

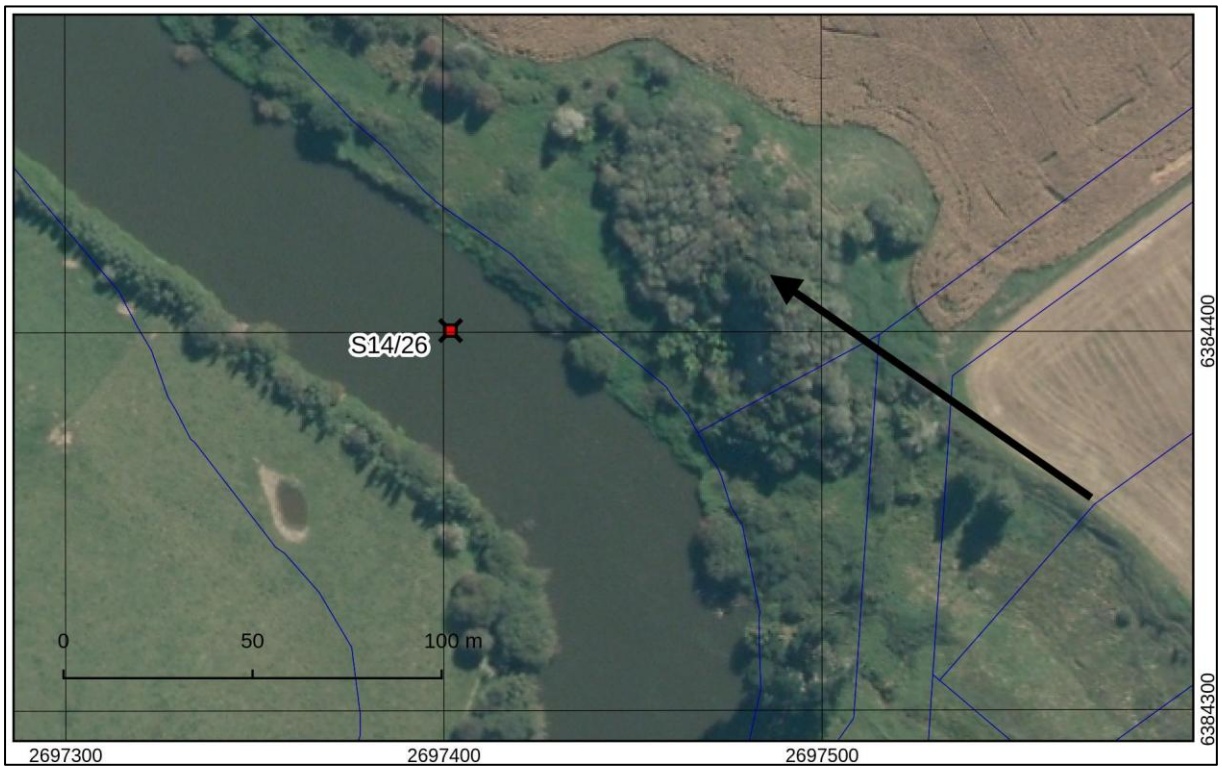

Figure 7. The given location for the unnamed pa S14/26 (symbol), and the actual location (arrow), separated by ~85 m. The blue lines are cadastral boundaries.

There is a trick to this figure, because it is projected to the NZ Map Grid 1949 -- the projection used on the NZMS260 series of topographic maps. The location of the site falls at the south-west corner of a 100 m grid square. The lightly wooded area indicated by the arrow approximates the extent of the pa, so we see how Steve Edson used the grid reference convention to describe the location of this site.

Another pa, a little further down the Waipa River from S14/26 is S14/122, recorded by Janet Leatherby and P.H. Morgan in 1985. It illustrates the difficulty of locating archaeological sites from desktop-only methods. This is shown in Figure 8.

Figure 8. The given location for the unnamed pa S14/122 (symbol). The blue lines are cadastral boundaries, the projection is NZMG49.

Once again we see the stated location being (close to) the south-west corner of a 100 m square, according to the site recording convention. The modern aerial image, however, has nothing to tell us about where the pa may actually be located. Given the skill and experience of Leatherby and Morgan, it would be expected somewhere in the square to the north and east of the symbol. Only a field visit would enable certainty.

Even for sites recorded recently with high-accuracy remote sensing datasets, the grid reference given in the site file will not adequately describe the extent of a site.

Maori horticulture sites, of which the mid-Waikato valley has an abundance, serve to illustrate this point. These are highly visible in remote-sensing data, because of the presence of subcircular sand-mines (called borrow pits). S14/317 is a Maori horticulture site recorded in 2013 from historic aerial photography and modern remote-sensing data. Its position is given in the site record as NZTM 1804906 5810500.

Figure 9 shows the extent of this site, as indicated by borrow pits spotted on the historic photographs (and marked with black circles).

Figure 9. The Maori horticulture site S14/317 is recorded at the centre of a cluster of borrow pits. The projection is NZMG49.

The point location is given at the centre of a cluster of some 20 borrow pits. Going only from the location of the borrow pits, the site occupies some 15 ha, and extends up to 300 m from the given point. It also blends into the site S14/316 to the south east, and there is no realistic way of knowing where one site ends and the next begins. Cadastral parcels have been included on this illustration to show how a single site can affect several properties, and not just the one the point location resides in.

Interestingly, the location for the pa S14/117 does not fall on the corner of a 100 m square on the NZMG grid. This site was recorded by Morgan in 1985, and the location was updated to a more precise reference by another researcher after that date.

Methodology

The grid reference locations of archaeological sites given in the scheme are inadequate for determining which properties will be affected by proximity to an archaeological site.

For the greatest part of the operation of the Scheme, locations were given to the highest precision appropriate to the maps available. These had a resolution of 100 yards for very early records and 100 m for records filed after metric maps were introduced in the 1970s. Conversion from imperial to metric coordinates necessarily generated errors which cannot be easily identified or corrected.

Also, no archaeological site may be described by a single point; all have extent in horizontal space. Some may be very small - some middens are known as single, highly localised expression of marine shell on the surface. But some archaeological sites may be extensive. We have seen how Maori horticulture sites can occupy hundreds of metres of riverbank.

Clearly, a method for compensating for the shortcomings in the data and the nature of archaeological sites, is required in order to have confidence in the selection of parcels for an alert layer. The objective is to minimise the number of false negatives -- parcels which are affected by archaeological sites but are not selected -- while not making the criteria so loose as to select many parcels unaffected by archaeological sites.

It was thought that a good start for developing this methodology was to place a 100 m buffer around all archaeological sites, and select parcels which intersect with one or more of these buffers. 100 m was chosen because this is the precision with which early records were located.

Methodological weakness

It is acknowledged that this is a crude way of identifying affected parcels. On any short inspection of individual sites, it will quickly become apparent that the 100 m buffer will not correctly identify all affected parcels, and that it will incorrectly identify some parcels. We have seen in the case of the Maori horticulture site S14/317 that a 100 m buffer may not identify all the parcels affected by such an extensive site.

Also, some site records are of a trivial nature, recording the location of a single find spot with no other archaeological evidence. Some, like S14/9 (figure 10), have been assessed by the filekeeper to be of limited value as the informant proved unreliable.

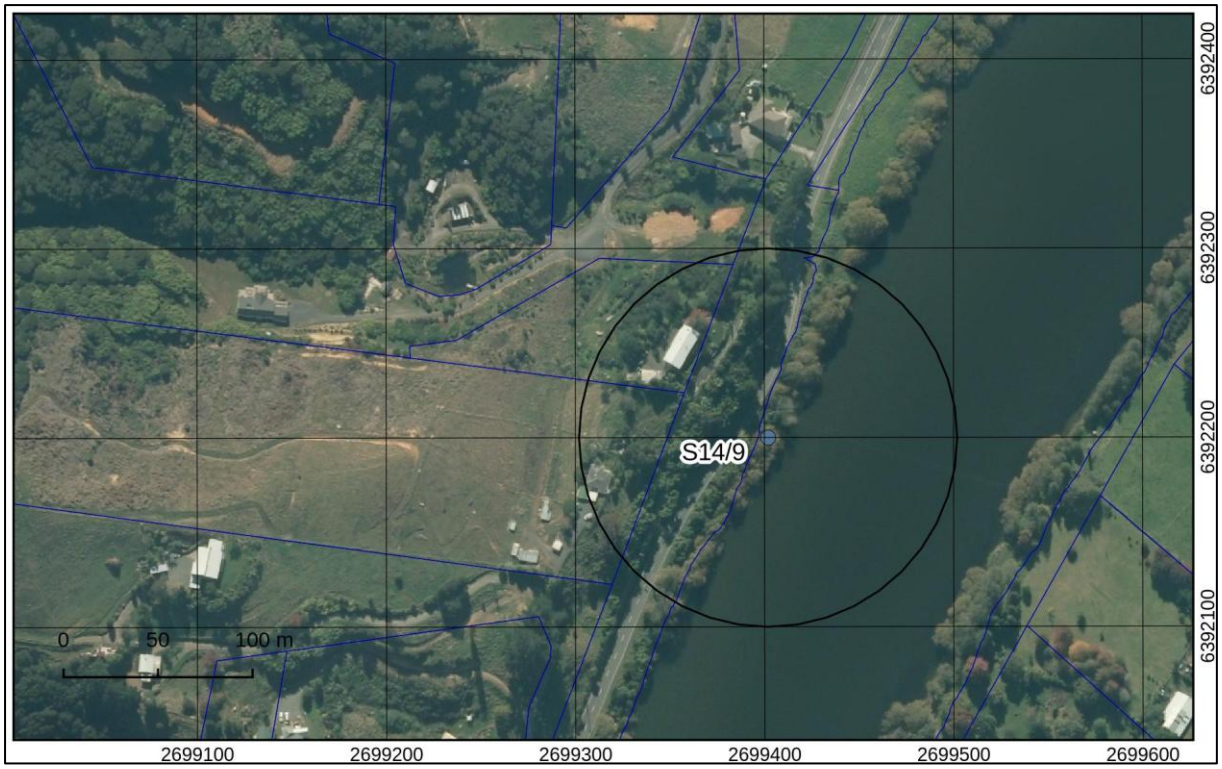

Figure 10. A 100 m buffer around the trivial site S14/9. Projection is NZTM2000.

Placing a 100 m buffer around this location triggers three property parcels unnecessarily.

These shortcomings could be addressed by a number of methods. It may be possible to draw buffers of varying size around sites according to type. Sites in heavily developed areas may already be subject to disturbance, and hence deserve a smaller buffer. Certain individual site records may be examined in detail and a buffer applied on a studied basis.

All of these methods will require further research and testing.

The predictive model

We have seen in the archaeological background above that the majority of sites recorded in the District cluster closely to the coastline and to the Waikato River. It is not unreasonable to assume that further archaeological evidence remains undiscovered in these areas of high known density.

Also, we have evidence of unrecorded Maori horticulture sites lining the river from Hamilton down nearly as far as Meremere. Many of these unrecorded sites were

identified by Simmons and Associates in previous work for the Council (Simmons, Hutchinson, 2014)

It was felt by Council that a means of recognising these unrecorded sites and offering some manner of protection for them would be a necessary part of the project. Therefore, a further set of cadastral parcels should be identified.

All of the parcels affected by archaeological sites along the coast have already been identified by the original method. This left those along the Waikato River. These were selected as those intersecting with a 1,000 m buffer around the river parcels. This distance was chosen as just over 20 percent of all archaeological sites known in the District fall within 1,000 m of the river. Phases 2 and 3 of this project are intended to record archaeological sites known to exist, and this layer may no longer be necessary when that work is completed.

The banks of the Waipa River is much less densely populated with recorded and unrecorded archaeological sites, and was excluded from selection in the riverside alert. If it is considered necessary, parcels along the banks of the Waipa River can be included as well.

Source datasets

Computation of the alert layer required the acquisition of three primary or source datasets.

1. The cadastral layer of property parcels from Land Information New Zealand (LINZ).
   LINZ provide the opportunity to select subsets of vector layers on territorial authorities, so the Waikato District was chosen as a crop area. The data were downloaded into Geopackage/SQLite database file, providing 18.7 Mb of data. These records were then uploaded into the project database.
2. The territorial authority boundaries from Statistics NZ.
   Statistics NZ supply geographic data describing the boundaries of territorial authorities. These were downloaded as shapefiles and injected as a table into the project database. The Waikato district was selected, and the others discarded.
3. The NZAA national database of archaeological sites.
   These data come from a copy of the national archaeological database downloaded into my own database systems. Individual site records are recovered from ArchSite by an automated process which brings in all the

tabular data available for a site record, and copies of attached documents including scans of the original paper records. These constitute the full archaeological record for each site, and are stored in a table within the PostGIS database cluster. Attached scans of paper sheets are stored in a disc-based filesystem, with pointers to them in the database.

A subset of the NZAA dataset containing only those sites recorded within the Waikato District Boundary was then extracted, using a spatial query combining the boundary of the district with the NZAA data.

These datasets were all acquired in early March 2016.

The selection

A Standard Query Language (SQL) statement was written which generated the buffers around the archaeological sites, and selected cadastral parcels which intersect with one or more of the buffers. The statement selected out parcels representing streams (hydro) or roads, except those identified as unformed.

A second statement was written to select parcels along the riverbank, in response to a request made to include presently-unrecorded sites known to exist there. This layer was created by buffering cadastral parcels describing the Waikato River by 1,000 m, and selecting those parcels which intersect with this buffer.

The two shapefiles supplied to Council in service to the requirements outlined in the inception report are illustrated by the map included as Appendix 3.

Glossary

NZAA	New Zealand Archaeological Association
NZMG	NZ Map grid. The coordinate system used with the NZMS260 metric series topographic maps.
NZMS1	The original 1 foot to 1 mile imperial topographic map series. Replaced by NZMS260 metric maps.
NZMS260	Metric topographic maps in the 1:50,000 scale. Replaced by Topo50 maps.
NZTM	NZ Transvers Mercator. The map projection and coordinate system used with modern Topo50 maps.
SQL	Standard Query Language. A language used in databases to define data and to perform search and sort operations.
SRS	Site Recording Scheme. The NZAA archaeological database.
Topo50	The latest official series of metric topographic maps in the 1:50,000 scale.
WDC	Waikato District Council.

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Appendices

1. Email correspondence.
2. Waikato District Council Heritage alert overlay Draft 1. March 9. A3 map.
3. Waikato District Council Heritage alert overlay Phase 1. March 31. A3 map.
4. Visual representation of the archaeological alert layer
5. Visual representation of the Riverside alert layer
6. Indication of the NZAA sites file.

RE: WDC Heritage Alert project. Request for another meeting

From: Damon Mathfield <Damon.Mathfield@waidc.govt.nz>
To: Malcolm Hutchinson <malcolm@archaeography.co.nz>
Date: Tue, 15 Mar 2016 16:08:02 +1300

Ok sure

From: adventuremalcolm@gmail.com [mailto:adventuremalcolm@gmail.com] **On Behalf Of** Malcolm Hutchinson
Sent: Tuesday, 15 March 2016 7:31 a.m.
To: Damon Mathfield
Cc: Jenni Vernon; Betty Connolly; Eunice Karauria; Alexy Simmons
Subject: WDC Heritage Alert project. Request for another meeting

Good morning Damon

Yesterday I had a conversation with Eunice about some of the technical matters touched on during our meeting last Wednesday (9 March). We talked about how the shapefile is not really the correct form to deliver the alert layer in, and how we might be able to determine what the best way is. Eunice suggested that what the planners require is what we should deliver. We have assumed that this is a layer, but this may not be the case.

I thought that in order to understand exactly what form the delivery would take it would be helpful to meet again to have a discussion about how the system will be used by the planners (and others).

I wonder if it would be possible to arrange such a meeting for later in the week? In talking with Alexy, Thursday any time or Friday afternoon seems preferable.

Regards
Malcolm

RE: Waikato district heritage alert project

From: Eunice Karauria <Eunice.Karauria@waidc.govt.nz>
To: Malcolm Hutchinson <malcolm@archaeography.co.nz>
Cc: Alexy Simmons <historynz@gmail.com>, Betty Connolly <Betty.Connolly@waidc.govt.nz>, Damon Mathfield <Damon.Mathfield@waidc.govt.nz>, Jenni Vernon <Jenni.Vernon@waidc.govt.nz>
Date: Fri, 11 Mar 2016 15:46:52 +1300
Attachments: 1

Hey Malcolm

Thank you for your email and thorough explanation. Your metadata and history behind the NZAA dataset is much appreciated along with your thoughts about the issues inherent with this sort of exercise. This early on in the project, I'm just identifying any potential issues that may hinder the end objective.

My comments from your email:

- main concern would be checking the Terms and Conditions of NZAA with regard to publishing *their* data on *our public* website
- as you mentioned, maintaining two sets of data is not a preference and we could manipulate the data as you suggested
- good thoughts on polygon vs point geometry, ultimately Planners' preference on how the layer appears in the Plan
- currently all district plan layers are static (not dynamic) as any change to the plan, requires a documented process.

As requested, I've attached the paper roads (.tab). Note that it is difficult for us to determine which roads are paper roads and which are not. There is no data source that defines a paper road and we utilise a combination of formed roads and land parcels to approximate the paper roads. Any problems, please let me know.

Cheers

Eunice Karauria
GIS Officer
Waikato District Council
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From: adventuremalcolm@gmail.com [mailto:adventuremalcolm@gmail.com] **On Behalf Of** Malcolm Hutchinson

Malcolm Hutchinson
Sent: Thursday, 10 March 2016 1:50 p.m.
To: Eunice Karauria
Cc: Alexy Simmons; Betty Connolly; Damon Mathfield; Jenni Vernon
Subject: Re: Waikato district heritage alert project

Dear Eunice

At yesterday's meeting it was decided I should write you a letter explaining how the shapefile I delivered to you was derived. In this letter I should outline some of the issues with the shapefile and a discussion of how they might be addressed.

I have attached a PDF copy of the map I used to illustrate my talk at the meeting. I will be referring to this map at times during this letter.

Before I get into that, however, Betty has suggested I could ask if you have a set of the unformed road parcels you could supply to me. For reasons explained below, I have removed road parcels from the selection, but this has also removed many paper roads which would be better included.

How the shapefile was made

The file I delivered to you contains a set of cadastral parcels within the Waikato District which are affected by proximity to an archaeological site. It is computed in a spatial database using data downloaded from LINZ (the cadastre), and from the NZ Archaeological association (the point locations for archaeological sites).

The intention is that staff at the Council, and possibly the public via the Council's website, will be alerted to potential archaeological issues when they query a cadastral parcel.

There may be more than one instance of a particular parcel. A record in that file is generated for each archaeological site affecting a parcel. In each record you get the appellation, the cadastral geometry and the NZAA site identifier.

This is illustrated on the map by transparency in the orange parcel shapes. The more opaque a parcel is, the larger the number of archaeological sites it is affected by.

The computation I used to produce the shapefile is printed near the bottom of the page. This is an SQL command on a PostgreSQL database, with PostGIS spatial extensions installed.

In selecting cadastral parcels I have applied a 100 m buffer to archaeological sites. Any parcel touching (intersecting with) one of these buffer areas will be recorded in the output.

The buffer is an attempt to compensate for some of the known inaccuracies in the NZAA dataset, and to account for the fact that archaeological sites, although recorded as a point location in the dataset, in fact occupy areas. I will discuss this in more detail below.

I have removed from the selection any record referring to a road, railway or hydro parcel. This is a policy decision which was discussed briefly at the meeting and which will require refinement. One suggestion is that unformed roads should be included and not selected out.

Issues with the shapefile

The file I supplied to you is a draft. It is an example of the dataset we are attempting to supply.

Broadly speaking, I see two main issues with the shapefile:

1. Problems with the underlying NZAA dataset which require a structured methodology to correct (or to compensate for).

2. Theoretical computer science considerations which suggest a static shapefile is not the correct answer to this problem.

The first set of problems are to do with the nature of the NZ Archaeological Association's site recording scheme and of the archaeological sites it attempts to record. The scheme has been going for a long time and many of the records are unreliable, particularly with reference to the point locations. It is necessary to develop a methodology to compensate for the uncertainty inherent in these data.

The second set of problems refers to the idea that a single static file cannot accurately represent the changing nature of the underlying data. The file as presented is not structured to permit efficient and accurate queries in the manner that a well-designed database system can.

I will discuss each of these issues separately below.

Issues with the NZAA dataset

The Site Recording Scheme has been in existence since about 1957. It was originally conceived as a research resource for archaeologists, and there was no intention that it be used to inform regulatory decisions.

There are 1,387 archaeological sites recorded within the District. Many were recorded on the old NZMS1 topographic map series, with coordinates given in feet. Coordinates for site locations were recorded as an estimate from the topographic maps, and these estimates were often not more precise than 100 yards or so.

When the NZMS 260 series of metric topographic maps was introduced, the imperial coordinates in the Site Recording Scheme were converted to metres on the NZ Map Grid. This conversion introduced spatial errors which compounded the low precision of the original locations.

Until the relatively recent introduction of hand-held GPS units, site locations were recorded to the nearest 100 m, using the convention described on the NZMS 260 map sheets. This would place the location at the south west corner of a 100 m square, with the site being somewhere inside this square.

Later, all metric coordinates in the scheme were again transformed to the NZTM projection we now use, introducing further errors and uncertainty.

So when the SRS says a site is at a particular location as stated in eastings and northings, we cannot be certain that the site is actually there. It might be up to 100 m away given the recording convention. And if the field researcher was careless or unskilled, the site may be even further away. In many cases it is impossible to determine the true location of a site other than by physically visiting it.

Another characteristic of archaeological sites which makes their precise location difficult is the fact that a site does not occupy a single point in geographic space. All archaeological sites have horizontal extent, and the size of that extent is peculiar to the individual site. Some Maori horticulture sites, for example, occupy hundreds of metres of riverbank, while middens can be small and highly localised.

A point location also implies that a site is *not* somewhere. A property owner can say "well I don't have to worry about it, the record says the site is not on my property."

In order to accurately determine which property parcels should carry an archaeological alert, a methodology to identify and compensate for these errors and inaccuracies is needed. The 100 m buffer around each archaeological site is the crudest expression of this methodology.

The methodology may be refined, by providing differently-sized buffers for sites of different type, or (as was suggested in the meeting) by reducing the size of buffers for sites in highly-developed urban areas.

The shapefile is not the right answer

The shapefile is a static thing, a snapshot in time of the state of the underlying datasets. From a computer science point of view, it does not accurately model the problem.

It is also apparent to me (from Damon, in yesterday's meeting) that managing an extra dataset is not something you necessarily want to be doing.

The correct model is a many-to-many relationship between cadastral parcels, and archaeological sites with an appropriate buffer. This is modeled in the database with a link table, recording unique identifiers for cadastral parcels with NZAA site identifiers. The presence of one or more records in the link table carrying the cadastral identifier is the trigger for the alert to be applied to that parcel.

I think the computation identifying parcels should be performed inside the Council's database. If this were the case, the alert layer would automatically update each time the cadastral set is re-acquired, or new archaeological sites are recorded.

The methodology for identifying parcels can be periodically revisited and refined if necessary. The Council would be able to do this (presumably in consultation with an archaeologist) at their own convenience.

Summary

I have tried to present a broad understanding of the NZAA archaeological sites dataset and the limitations inherent in the records within it, particularly of the point location data. I believe that a simple point is not sufficient to adequately identify the heritage risks to property owners, developers and planners.

A methodology is necessary to compensate for these limitations. I have suggested that a start for developing this methodology is to buffer each archaeological site by 100 m. The figure is not entirely arbitrary, as the convention for recording sites before GPS receivers became available was to capture coordinates from a topographic map with a precision of 100 m.

I have also suggested that a static shapefile, or other form of supplying an additional layer of data is not the correct approach to solving the problem of providing a heritage alert capacity. From my background as a computer programmer and database designer, I understand that a better way of modeling the problem is to have a link table, in the Council's database, identifying relationships between cadastral parcels and archaeological sites.

I suggest this computation would best be performed in the Council's computer systems, by applying a spatial query to the datasets the Council already manages, rather than adding a new, derived, dataset.

I hope this letter has been helpful, both in conveying something of the nature of the problem as I see it, and in providing clear suggestions as to how the objective might be achieved. I would certainly like to hear your thoughts on the matter.

Regards,
Malcolm

On Tue, Feb 23, 2016 at 2:40 PM, Eunice Karauria <Eunice.Karauria@waidc.govt.nz> wrote:

Hi Malcolm

Thanks for your email. It was really nice meeting you and Alexy too. Your email outlines what I understood was discussed at the meeting, ultimately the supply of a shapefile (prior to the next meeting as suggested by you would be great). I'll have a chat with Anton Marais (my Team Leader) to see if there are any points he could contribute to the discussion.

Cheers
Eunice Karauria
GIS Officer
Waikato District Council
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requirements and check the location of public utilities all by entering your address.

From: adventuremalcolm@gmail.com [mailto:adventuremalcolm@gmail.com] **On Behalf Of** Malcolm Hutchinson
Sent: Tuesday, 23 February 2016 1:55 p.m.
To: Eunice Karauria
Cc: Alexy Simmons; Betty Connolly; Damon Mathfield; Jenni Vernon
Subject: Waikato district heritage alert project

Good afternoon Eunice

It was a pleasure meeting you this morning. I have put together some notes from our discussion.

Firstly, it is my understanding that I am to supply a shapefile containing cadastral parcels within the District, which are affected by proximity to an archaeological site. Each parcel is to have one or more site numbers, indicating which site or sites that parcel is affected by.

Cadastral parcels will be identified by applying a buffer of varying sizes to the point location of NZAA recorded sites. The buffer is necessary to overcome the limitations inherent in the NZAA dataset -- that being sites which have geographic locations set to much lower precision than we commonly deal with today, and the fact that a point does not adequately describe an archaeological site. An archaeological site may be recorded as being inside one parcel, but it may be extensive enough to affect several parcels.

I understand that the cadastral layer is very dynamic, and that the Council updates its copy of the layer weekly. Therefore, any static file we supply can be expected to date rapidly. At this early stage in the project, we identify this as a risk to the integrity of the data supplied. I have some ideas for how the dynamic nature of the underlying datasets can be addressed, but I feel that this is outside the scope of Phase I of the project.

As I understood it, we are to have a second meeting in the week starting 8 March. I will supply a sample dataset, which should enable you to test it. If I supply this to you several days in advance of our meeting, you should have time to examine it and to construct useful feedback.

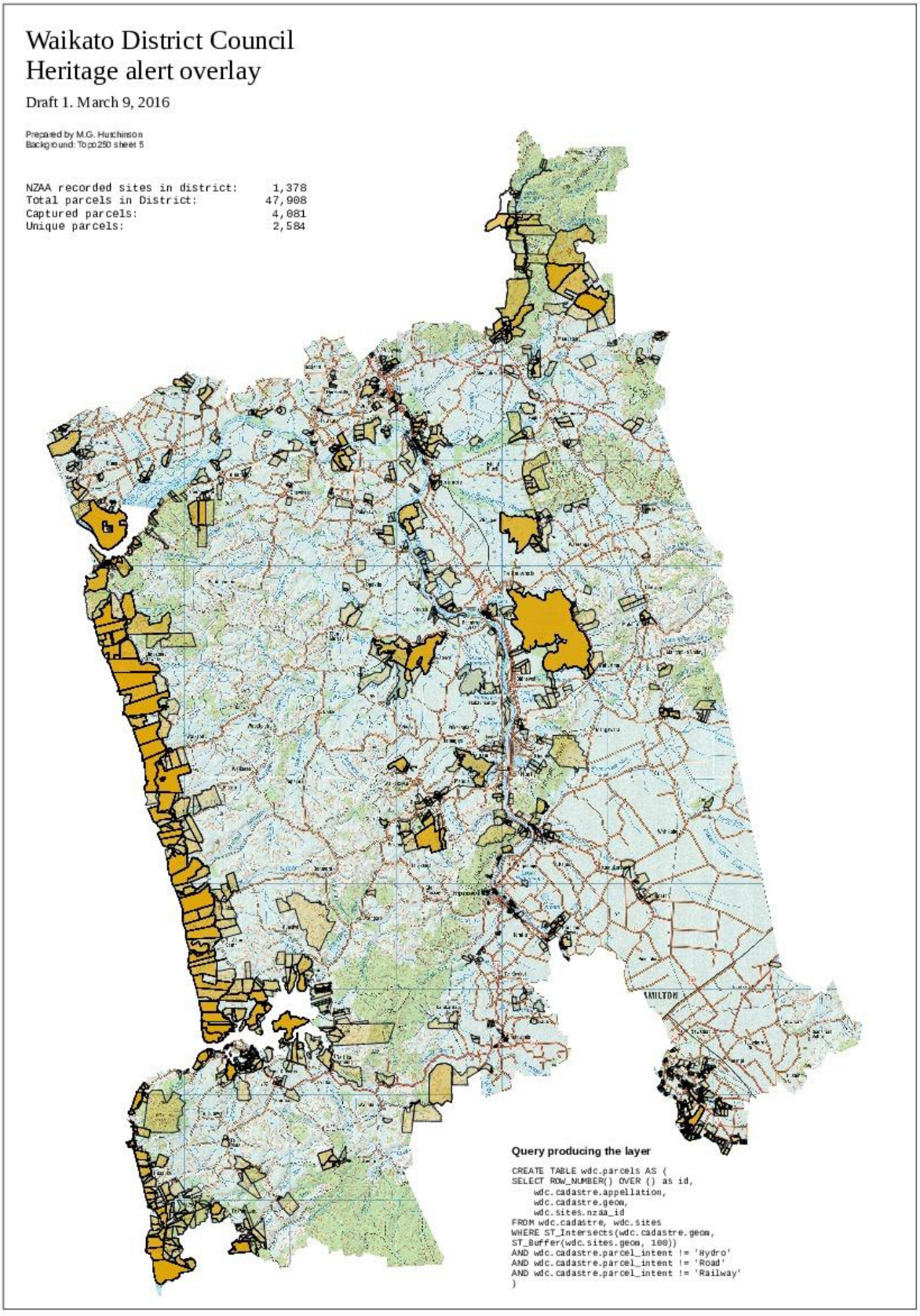
Thank you for your time today, and I look forward to working with you.

Regards
Malcolm

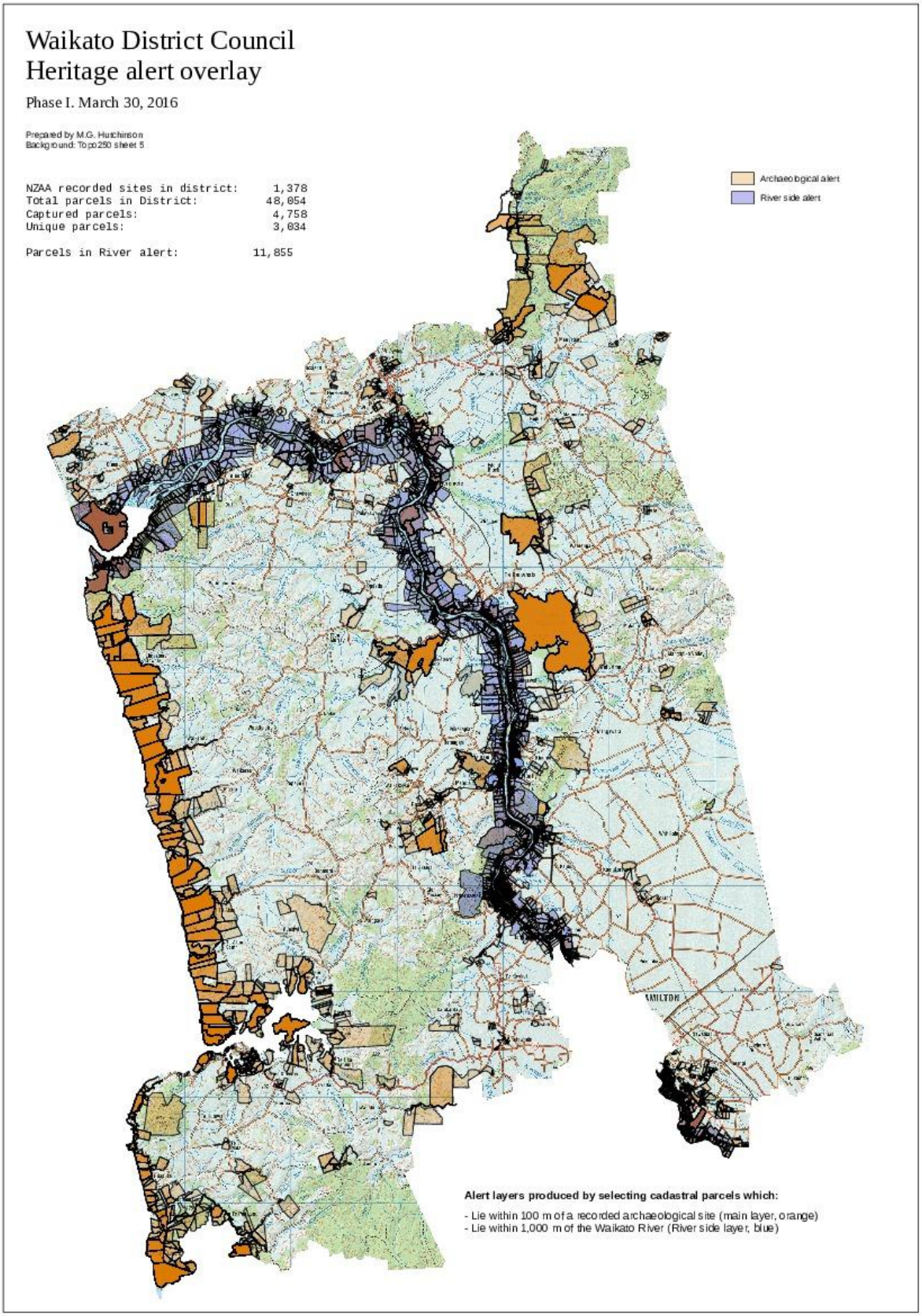
Attachments

Name	Size
road_paper_prog.zip (road_paper_prog.zip)	422.1 kB

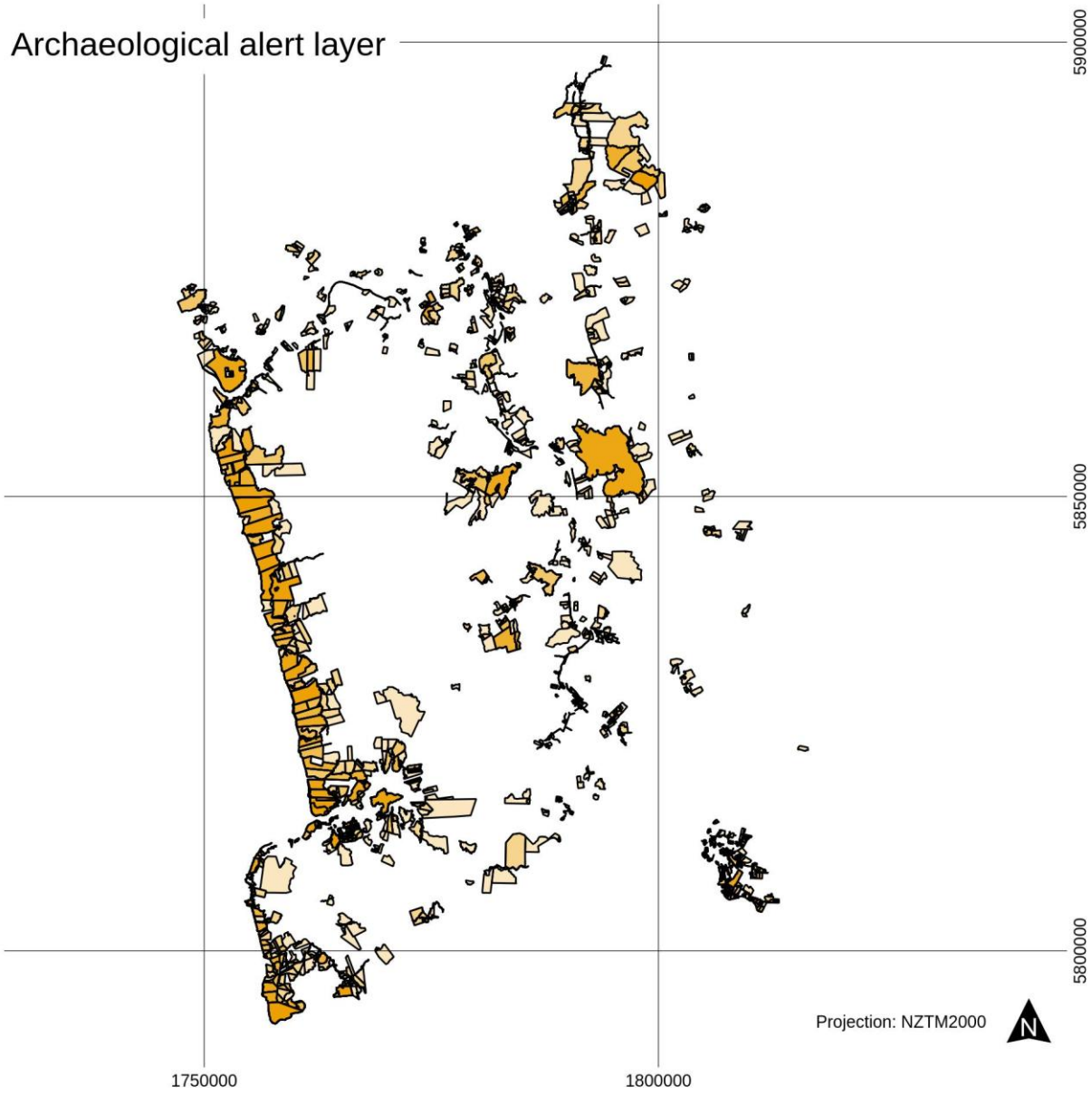
Appendix 2


Waikato District Council
Heritage alert overlay
Draft 1. March 9, 2016
Prepared by M.G. Hutchinson
Background: Topo250 sheet 5
NZAA recorded sites in district: 1,378
Total parcels in District: 47,908
Captured parcels: 4,081
Unique parcels: 2,584
Query producing the layer
CREATE TABLE wdc.parcels AS (
SELECT ROW_NUMBER() OVER () as id,
wdc.cadastre.appellation,
wdc.cadastre.geom,
wdc.sites.nzaa_id
FROM wdc.cadastre, wdc.sites
WHERE ST_Intersects(wdc.cadastre.geom,
ST_Buffer(wdc.sites.geom, 100))
AND wdc.cadastre.parcel_intent != 'Hydro'
AND wdc.cadastre.parcel_intent != 'Road'
AND wdc.cadastre.parcel_intent != 'Railway'
)

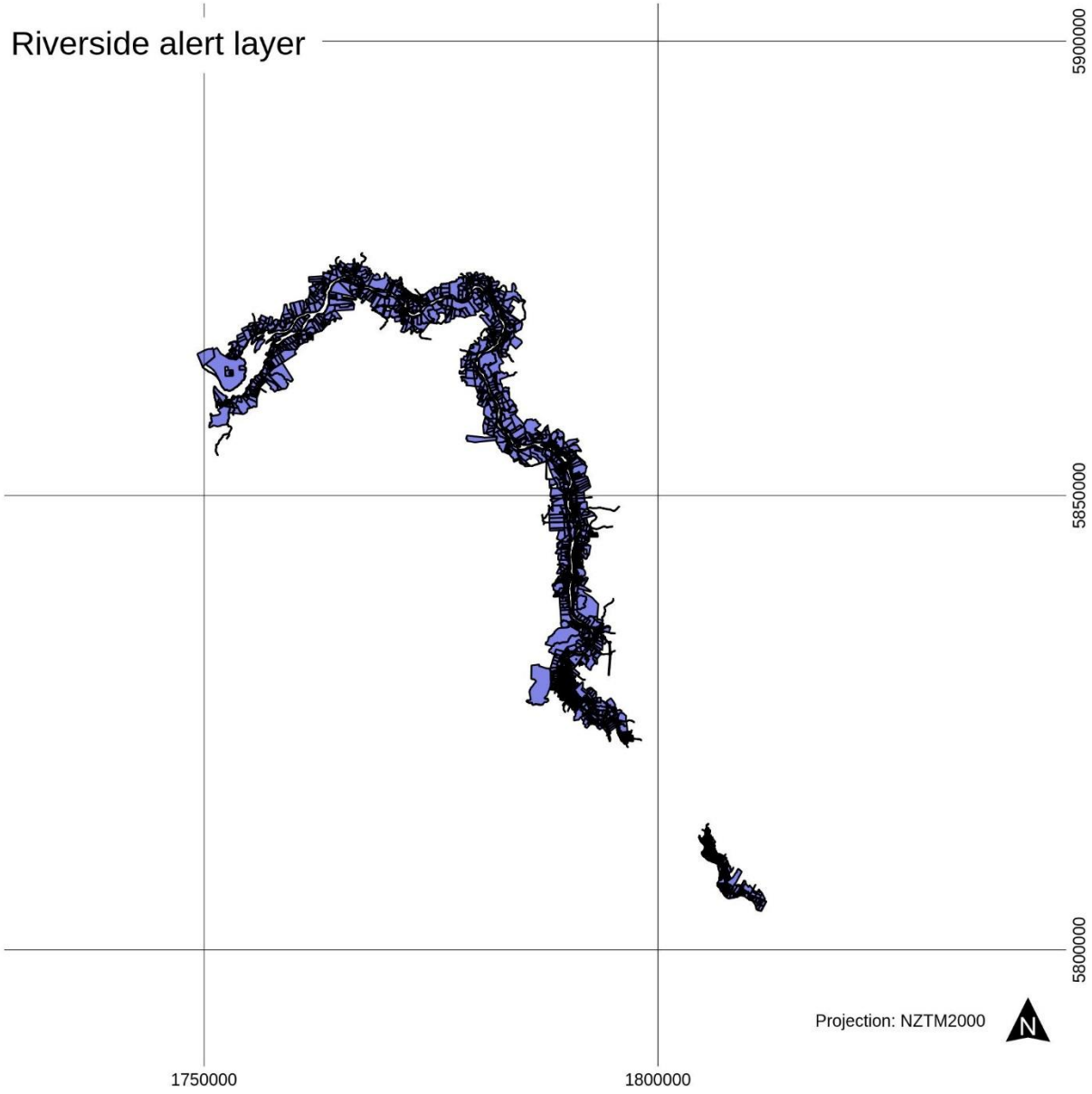
Appendix 3


Waikato District Council
Heritage alert overlay
Phase I. March 30, 2016
Prepared by M.G. Hutchinson
Background: Topo250 sheet 5
NZAA recorded sites in district: 1,378
Total parcels in District: 48,054
Captured parcels: 4,758
Unique parcels: 3,034
Parcels in River alert: 11,855
Archaeological alert
River side alert
Alert layers produced by selecting cadastral parcels which:
- Lie within 100 m of a recorded archaeological site (main layer, orange)
- Lie within 1,000 m of the Waikato River (River side layer, blue)

Appendix 4


Archaeological alert layer
5900000
5850000
5800000
1750000
1800000
Projection: NZTM2000
N

Appendix 5


Riverside alert layer
5900000
5850000
5800000
1750000
1800000
Projection: NZTM2000
N

Appendix 6

NZAA id	Site type	easting	northing
R09/1124	Midden/Oven	1755695	5869769
R12/64	Pa	1760247	5877710
R12/90	Pa	1761581	5876142
R12/91	Pa	1761978	5876446
R12/92	Pa	1760348	5876910
R12/93	Pit/Terrace	1759947	5877310
R12/94	Pit/Terrace	1769152	5874826
R12/104	Pit/Terrace	1779540	5878920
R12/105	Pa	1779045	5878845
R12/127	Midden/Oven	1756763	5868804
R12/128	Pa	1763227	5872080
R12/129	Pa	1763061	5869915
R12/135	Pit/Terrace	1748556	5872989
R12/136	Pa	1748456	5872989
R12/140	Pa	1779456	5872945
R12/141	Military (non-Maori)	1772158	5871632
R12/142	Pa	1765761	5868739
R12/143	Pa	1767856	5872624
R12/144	Pa	1768560	5870425
R12/145	Pa	1762661	5869915
R12/146	Pa	1749259	5871191
R12/147	Pa	1750160	5870392

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For 1,378 sites. Supplied as a Comma Separated Values (CSV) file.