

**CROWN LIGHTENING TRIALS:  
INSTALLATION REPORT**

**J.A. TURNER, J.D. TOMBLESON  
& J.P. MACLAREN**

**Report No. 43    May 1998**

# **FOREST & FARM PLANTATION MANAGEMENT COOPERATIVE**

## **EXECUTIVE SUMMARY**

### **CROWN LIGHTENING TRIALS: INSTALLATION REPORT**

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Crown lightening, or the reduction of a tree's "sail area" by pruning, is becoming increasingly common as a method of reducing toppling, particularly on fertile farm sites. This report documents the installation of six toppling trials aimed at quantifying the influence of crown lightening on tree growth, stability, root development, stem straightness and silvicultural costs.

Two crown lightening trials were installed in June 1996 at Horohoro (Rotorua) and Sefton (Canterbury). A further four trials were installed in April and May 1997 at Waikatea Forest (Wairoa), Kumeroa Valley (Woodville), Glenledi Forest (Milton) and Dipton (Southland). All six trials contained a crown lightening treatment, which involved removing approximately 30% of the crown, and a control. The Horohoro trial incorporated an additional clear bole pruning treatment which removed 30% of the crown from the base of the tree. The Glenledi trial incorporated an additional crown lightening treatment comprising removal of complete whorls. Treated trees will be compared for growth and any incidence of toppling with an untreated control.

Root collar diameter and total height were measured for the treatment and control trees. Percentage reduction of crown profile removed was quantified using a digital camera for crown lightened trees at Waikatea Forest, Kumeroa Valley and Dipton. Trials will be annually remeasured for growth and assessed following any incidence of toppling.

## BACKGROUND

"Toppling" (the wind throw of trees aged 2 to 3 years) can have serious economic implications for forest and woodlot growers throughout New Zealand. Toppling results in more stems having butt sweep so reducing potential volume recovery of valuable clearwood, a reduced selection ratio at time of thinning and a reduced possibility of achieving an acceptable final crop stocking (Menzies 1975). For example, a stand in which 80% of trees toppled more than 15° at age two years could suffer a 31% loss in clearwood production (Mason & Trewin 1987). A further cost of toppling is the increased susceptibility of older trees to wind throw due to poor root architecture (Burdett *et al* 1986). The incidence of toppling may be increasing due to the high rate of new land planting, the high proportion of inexperienced planters, and the forestry move to fertile farm sites (Ray *et al* 1994).

In 1995/96 members of the Forest & Farm Plantation Management Cooperative awarded the highest ranking to a project proposal to evaluate three treatments aimed at reducing the incidence of toppling. Treatments to be evaluated included quantifying the affect of crown lightening, severe lateral root trimming and topping of nursery seedlings on subsequent stability, tree growth, and stem straightness of seedlings. A sample of the trial sites will also be quantified in terms of their risk to toppling using computer-based air flow models.

There are several ways to avoid, mitigate or remedy the incidence of toppling:

1. Nursery practice eg. minimum root conditioning, topping, improved root trimming;
2. Good site preparation eg. careful use of cultivation and weed control;
3. Correct planting techniques;
4. Choice of planting stock. Physiologically-aged cuttings, seedling age;
5. Stability pruning (crown lightening);
6. Choice of site;

Considerable research has been carried out in the areas of site preparation, improved planting techniques and choice of planting stock. This trial series primarily addresses points one, five and six listed above and specifically details the installation of crown lightening trials.

## TRIAL LOCATIONS AND DESCRIPTIONS

For trials investigating the effectiveness of various treatments as means of reducing the incidence of toppling to provide meaningful results, they must be located in areas where toppling is likely to occur. The macro- and micro-climatic factors which, in conjunction with soil characteristics and forest management practices, have the greatest effect on the likelihood of toppling at a particular site are:

1. the general wind climate of the area,
2. the location of the site with respect to the surrounding topography (ie., its exposure) and,
3. the frequency of occurrence of strong winds from the opposite direction to that of the prevailing wind,
4. the incidence of high rainfall associated with strong winds.

In order to find the most suitable sites for the installation of crown lightening trials, an investigation was carried out to characterise each potential trial site in terms of the general wind climate that it is exposed to, as well as its exposure with respect to local topography (Turner, Moore & Tombleson 1997). The results of this characterisation process and general comments relating to history of previous toppling at the site, condition of planting stock, and access, are summarised in Table 1 and Table 2.

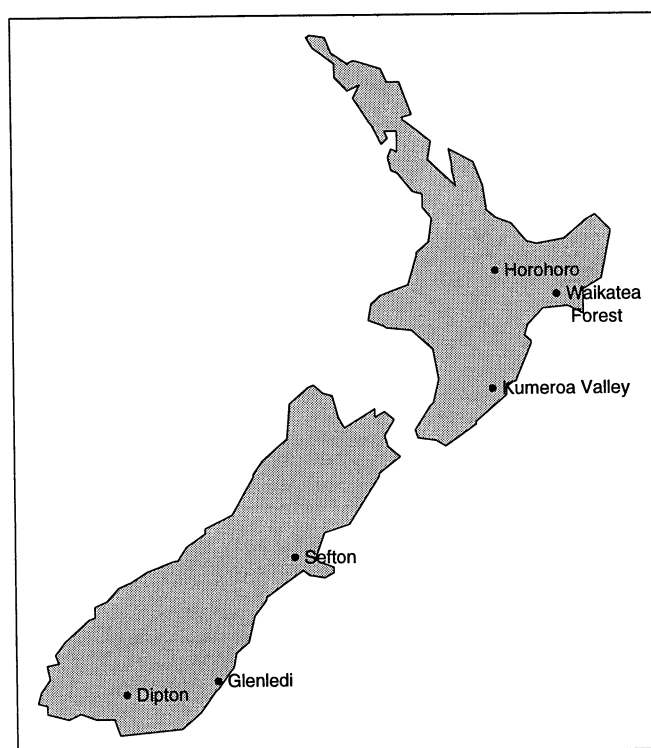
**Table 1: Windiness score, and prevailing wind speed (m/ s) and direction. The prevailing wind direction is that direction from which the wind most frequently originates. Sites labelled in bold were the six trial sites selected.**

Trial Site	Windiness Score	Prevailing Wind	
		Direction	Average Speed
<b>Kumeroa Valley</b>	7.1	NW	10.4
<b>Waikatea Forest</b>	15.5	N	5.0
<b>Dipton</b>	11.2	NW	5.1
<b>Glenledi</b>	10.6	na	5.5
<b>Horohoro</b>	4.3	SW	4.4
<b>Sefton</b>	9.9	NE	4.5
Takapu Farm Forest	10.9	na	10.5
Ti Toki Forest	17.0	NW	6.4
Stuart Brown's Property	16.0	NW	6.4
Donald James' Property	14.2	NW	6.4
Kiteroa Station	13.5	SW	1.8
Moonlight Forest	13.9	N	5.0

**Table 2: Suitability of access, planting stock and evidence of toppling for enabling the installation of a crown lightening trial. A ✓ indicates the site is suitable in relation to the particular characteristic.**

<b>Trial Site</b>	<b>Access</b>	<b>Planting Stock</b>	<b>Toppling</b>
<b>Kumeroa Valley</b>	✓	✓	✓
<b>Waikatea Forest</b>	x	✓	✓
<b>Dipton</b>	x	✓	unknown
<b>Glenledi</b>	✓	✓	✓
<b>Horohoro</b>	✓	✓	x
<b>Sefton</b>	✓	✓	x
Takapu Farm Forest	x	✓	✓
Ti Toki Forest	✓	✓	✓
Stuart Brown's Property	na	✓	unknown
Donald James' Property	na	✓	unknown
Kiteroa Station	✓	✓	x
Moonlight Forest	x	✓	x

The locations of the trial sites are shown below (Figure 1). Specific location and contact details are provided in Appendix I.



**Figure 1: Location of crown lightening trial sites.**

### **Sefton**

This trial was located on a relatively flat, fertile farm site 100 metres from the Carter-Holt-Harvey MDF plant. The soil type is a Mainaki yellow-grey-earth. The stand has been established to enable the possibility of effluent disposal from the mill, and has been planted in clonal rows in order to examine the interaction effects of genetics and

varying levels of boron application. The trees were planted in June 1994, thus the trial was installed in a two year old plantation. Tree spacing is at 2.4 x 2.6 m, or 1602 stems per hectare. There has been no understorey grazing.

A single application of herbicide had suppressed the grass sufficiently for good establishment. One row was accidentally missed with herbicide, and survival and growth has been greatly compromised. One block of trees was sprayed (with various herbicide treatments) twice in the two year period. The effect of this was a considerable increase in height and diameter growth, but also a noticeable increase in toppling. This block has been used as a pilot trial for the main study, which will take place on the single-sprayed rows in winter 1997. It was not possible to install the trial on the single-sprayed rows in winter 1996, because of insufficient tree height growth which averaged only 1 m, compared to 1.6 m for the double-sprayed block.

The presence of an existing trial layout (clonal treatments, boron application, herbicide rates) is unsatisfactory, but may not matter as there is adequate replication in the trial and if the treatment effects are sufficiently strong.

### **Horohoro**

This trial is located south of Rotorua on a fertile farm site of rolling topography. Relative to the wet clay soils of Northland etc, the Taupo sandy silt<sup>1</sup> derived from Taupo Ash is not considered to be highly prone to toppling. However the Horohoro site is subject to occasional wind storms which can result in a high incidence of toppling. This trial may not be subject to any wind storms over the following two years, however the trial will yield valuable information on the affect of crown lightening on tree growth. The trial was installed in a two year old plantation of GF23 physiologically aged cuttings which has received no understorey grazing to date thus the trees have full lateral growth to ground level. The plantation was established into rips created by a winged ripper. The initial spacing was 5 x 3.5m amounting to 500 stems per hectare. The plantation is currently almost at its established stocking ie very little mortality has occurred since establishment. No toppling was evident at the time of trial installation.

### **Waikatea Forest**

The Waikatea Forest (Wairoa) trial is located on an ex-farm site with steep, undulating topography (Figure 2), however, the individual plots are situated on areas of more gently sloping topography. The trial was installed in April 1997 in a rising two year old plantation (Compartment 9.02) of GF16 seedlings planted at 1250 stems/ ha. This site has Mokau sand loams<sup>1</sup> (117c) derived from sandstone. No soil cultivation was performed prior to planting. The site has received no understorey grazing to date thus the trees have full lateral growth to ground level. No toppling was evident at the time of trial installation.

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<sup>1</sup> General Survey of the Soils of North Island, New Zealand.



**Figure 2: Waikatea Forest trial location**

### **Kumeroa Valley**

The Kumeroa Valley trial is located near Woodville on a fertile ex-farm site (SI=30 m) of steep, undulating topography. Two of the plots are located on flat areas, with the other two on steeper slopes, one with a westerly aspect, the other with a southerly aspect. The trial was installed in April 1997 in a rising two year old plantation of GF 17-19 seedlings planted at 1000 stems/ ha. The seedlings range in height from 0.5 to 2 m. The site has very variable growth, with slower growth in wet areas, areas of grass competition, and erosion patches. No soil cultivation was performed prior to planting. While there was minimal evidence of toppling at this trial site, there has been extensive toppling from a NW wind on the more exposed opposite face of the valley (aspect NE) in a rising 5 year old plantation. The site has Takapau heavy silt loams<sup>1</sup> (75a) derived from alluvium from greywacke and volcanic ash on the flats (Replicates 1 and 2). On the steeper slopes (Replicates 3 and 4) the soils are Whangamomona silt loams<sup>1</sup> (116) derived from sandy mudstone and sandstone.

### **Glenledi**

The Glenledi trial is located near Milton in Compartment 40 Tokoiti Forest, owned by City Forests Ltd. The pasture site is located on a ridge fully exposed to all wind directions and overlooks the ocean. Site preparation incorporated double-ripping, and spot spraying, with trees planted between the double rips. The trees were planted 2.5 m along the rows and 4.5 m between rows (888 stems/ ha). The site has Raurekai silt loams and Taratu silt loam/ sandy loam on the ridge tops. Soils on steeper sites off the ridge tops are classified as Taratu hill soils (Soil Map of Bruce County, Scale 1:100 000, NZ Soil Bureau Map 159). A meteorological station operated by City Forests Ltd. is located 3 km from the trial site.

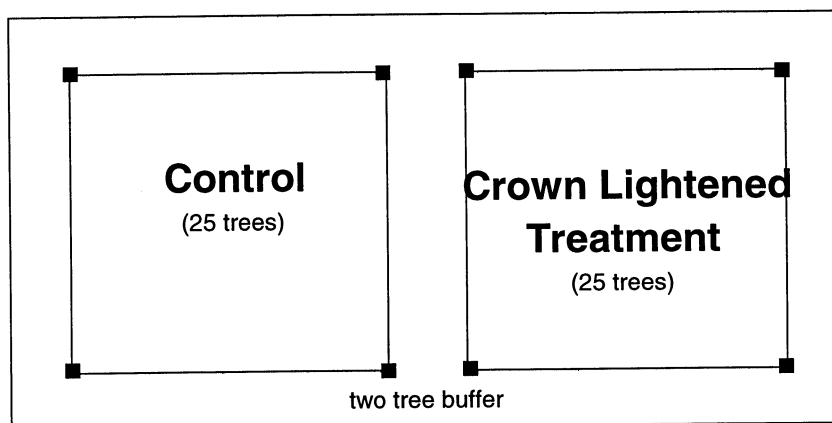
### **Dipton**

The Dipton trial is located on a fertile ex-farm site adjacent to the Dipton Forest owned by the Southland District Council. The site has Mossburn yellow brown earth soils which are prone to saturation of the A horizon. The site is approximately 240 m a.s.l. and is exposed to both the north westerly, and southerly winds. The site

was ripped to a depth of 600 mm prior to being planted with GF 19 seedlings in 1994. The rising three year old stand was planted at a spacing of 3.6 by 3.0 m (925 stems/ ha). The current stocking is 900 stems/ ha. The average tree height is 1.5 metres. The site has received no understory grazing to date thus the trees have full lateral branch growth to ground level.

## TRIAL LAYOUT

Trials located at Dipton, Kumeroa Valley, and Waikatea Forest, are comprised of the following trial layout. Four paired plots (Figure 3), with each plot containing either 25 crown lightened trees (treatment), or 25 non-crown lightened trees (control). All four corners of each plot are marked with 50 x 50 mm treated pegs painted yellow. Each plot is surrounded by a two-tree buffer. Buffer trees associated with the treatment (crown lightened) plots have been crown lightened. Each of the four paired plots was located on a different site within the trial location to cover various aspects and topography.



**Figure 3: Paired-plot layout.**

The trial at Sefton comprised only 90 trees, subdivided into three replicates of the stability pruning treatment and three replicates of the control. There was no space for buffer trees. The trial was marked on all four corners by a treated 50 x 50 mm painted stake. All trees were numbered with plastic cattle tags attached to branches. Two colours of tags were used: red and yellow, and the latter was selected randomly to be stability pruned. Tags occur in contiguous blocks of 15 trees of the same colour.

The trials at Glenledi and Horohoro were comprised of a similar layout to the trials at Kumeroa Valley, Dipton, and Waikatea Forest, however an additional crown lightening treatment (detailed below) was added to each plot.



## CROWN LIGHTENING TREATMENTS

All treatments aimed to remove approximately one-third of the crown area, via shortening of the laterals using secateurs, to form a cylinder (Figure 4). However, variations to this treatment were applied at each trial, as follows. At the trials in Kumeroa Valley, and Waikatea Forest, approximately one-third of each branch length was removed for all whorls below the first whorl from the top of the tree. At the Dipton trial, the same method was applied with the exception that up to half of the branch length was removed where branches exceeded 40 cm in length. The crown lightening treatment applied to the trials at Horohoro and Sefton involved shortening the branches to remove 30% of the crown by cutting branches to the inside of the second order laterals. Branch clusters in the top third (approximately) of the tree did not generally contain any second order laterals and were not generally shortened. All double leaders were also removed. The Horohoro trial received an additional clear bole pruning treatment which aimed to remove 30% of the crown. The trial at Glenledi received two crown lightening treatments. The first treatment shortened the branches down to the lowest second order branch. The second treatment involved complete removal of the two largest whorls. For all crown lightening treatments all stem needles were removed to prevent subsequent fascicle growth. At all trial sites where there were double leaders, the smaller of the leaders was treated like a branch.

## MEASUREMENTS

All trees were measured for total height, degree of any lean, and root collar diameter (trees at Horohoro were approximately 3 m tall, therefore dbh was measured rather than root collar diameter). To provide a measure of exposure to the wind, each paired-plot was assessed using the topographic exposure index called *topex* which is calculated by measuring the angle of inclination from a point to the skyline within 3 km for the eight compass directions. Negative angles of inclination were recorded as zero. Specific combinations of these measurements were used to derive aspect, valley shape and valley direction multipliers. An elevation multiplier was also included. These multipliers were assigned the appropriate weightings, as determined by Quine and White (1993), and summed to give a score which gave a quantitative estimate of the effect of local topography on the site windiness.

### Digital Images

For the trials installed at Dipton, Kumeroa Valley, and Waikatea Forest crown lightened trees were assessed for percentage of crown removed using digital imaging techniques. Photographs were taken using a digital camera to quantify the reduction of canopy profile before and after crown lightening. Computer image assessment techniques were used to calculate and compare the profile of foliage in each image and thereby quantify the change caused by the treatment. The assessment technique and the software programs used were first developed to assess shelterbelt optical porosity as described in Horvath *et al.* (1996).

### Camera Settings

Using a Canon Powershot 600 Digital Camera, all images were captured as black and white, 'CRW' non-formatted images. The 'CRW' format allows for the highest resolution with this camera, while the B&W format allows for smaller computer file size and ease of assessment.

The desired image is a dark tree silhouette against a light coloured background. Exposure control at levels of +1/3 or +2/3 were used in order to create a brighter backdrop and therefore a stronger silhouette type image. On grey, overcast days a higher exposure setting was required to allow more backdrop light. A white backdrop cloth was used to screen the background and also to increase the silhouette nature of the images. The backdrop consisted of a 3 x 3 m sheet of nursery frost cloth with a horizontal wooden pole at the top and bottom.

The camera was located as close to the tree as possible, so that the tree filled the entire picture area. This allowed the maximum amount of pixel data in an image to be used to determine the sail-area of the tree. The camera was mounted on a tri-pod and maintained in the same position until the second photograph was taken following the application of crown lightening. This also ensured that the before and after photos are of the same scale.

### Image Assessment

Images were edited so that only the tree is in the image; all background features were removed. The images were then converted to black and white images in a 'LINEART' format and stored as 'WINDOWS BITMAPS' (BMP). The program COREL PHOTOPAINT was used for editing and format conversion (Figure 4).



'Before' treatment image



Converted 'Lineart' image



'After' treatment image



Converted 'Lineart' image

**Figure 4: Before and after digital images using 'lineart' conversions.**

The assessment of each image involved counting pixels, determining their colour-black or white, and calculating a percentage of black in the image. The area of black represents the "sail area" of the tree. A comparison of the profile 'before' and 'after' was then calculated and expressed as a percentage of the foliage removed.

Foliage removed was assessed at the Horohoro and Sefton trials using video imaging techniques only. To quantify the amount of foliage removed as a result of applying the crown lightening treatments a sample of trees was videoed before and after the removal of branches. At the Horohoro trial a sample of five trees was randomly selected for each of the two crown lightening treatment plots times four replications giving a total sample of 20 trees for each of the two crown lightening treatments. At the Sefton trial every tree was videoed, including the controls. Each tree was videoed for a period of up to five seconds before and after crown lightening was carried out using a white backdrop. These images were then digitised using software located at the Resource Monitoring Unit at *Forest Research*. The difference in the crown profile 'before' and 'after' was then calculated and expressed as a percentage of the original crown area.

### **Data Storage**

Measurement data from the Horohoro, Kumeroa Valley, Waikatea Forest, and Dipton trials, are contained in an Excel spreadsheet "*D:\James\Topple\Crown Lightening Trials\1997 Trial Installation Data.xls*" held by James Turner. The original digital images used to quantify percentage of foliage removed are held on CD by James Turner. Data for the Sefton and Glenledi trials is held by Piers Maclaren. All data from the trials is also contained on the *Forest Research* Permanent Sample Plot (PSP) system listed under experiment numbers FR309 and FR102/1/94 (Dipton).

## **FUTURE MEASUREMENT AND MANAGEMENT**

Following any significant incidence of toppling, angle of tree lean is to be measured, for the purpose of quantifying any subsequent recovery of stem straightness. The trials will also be re-measured annually for the first 5 years, then once every two years to assess any differences in tree growth. One year after trial installation approximately 5% of trees (amounting to two treatment and 1 control tree) on each site will be excavated to assess rooting habit and to determine if crown removal results in decreased root production. Any difference in root/ shoot ratio between the treatment and control will also be assessed.

Root characteristics of a sub-sample of the trees will be measured three years after treatment using the 'Menzies' scoring system to assess the effect of crown lightening on root growth and orientation. A sub-sample of crown lightened and control trees will be excavated, separated into tree components, oven dried and weighed. The objective is to determine if crown removal results in decreased root production and a change in root/shoot ratio.

Soil characteristics will also be assessed on all four trial sites, including: soil type, soil horizons, soil fertility and soil moisture immediately following any major storm events to quantify the influence of site factors and their possible contribution to the incidence of toppling. Finally, the model WASP which predicts airflow over complex terrain will be used to predict the areas of peak wind speed enhancement through terrain interactions to quantify the wind risk at the trial sites. The aim will be to assess the wind risk of at least one or two sites per year (including the severe lateral root pruning trials (Turner, Tomblison & Brown 1997)) for a period of four years. Priority will be given to assessing the crown lightening trials.

Silvicultural management of the trials will be in keeping with the standard management practices scheduled by each of the plantation owners. It is anticipated that each trial will be pruned to a height of approximately 6 m which will enable juvenile straightness of the butt log to be assessed using a straight edge on any sites which may topple. On such sites, plantation owners have been requested to provide approval for a sample of toppled trees to be retained in the final crop. This will enable comparisons of juvenile and mature sinuosity. Sawing studies of toppled trees is also a possibility at the rotation end.

## ACKNOWLEDGMENTS

The authors gratefully acknowledge Blair Haggitt, Wilson and Associates; Matt Pannell, City Forests Ltd., Roger Allen, Juken Nissho Ltd.; and Carter Holt Harvey Forests Ltd. for providing sites for the installation of these trials. Also to Tony Smith, Form Consulting Group Ltd.; Glen Johnston and Greg Herick, Earnslaw One Ltd.; Dave Elliott, Forest and Woodlot Consultants (NZ) Ltd.; Robert Hill, Trustwood Forests; Maree Candish and Colin Maunder, P.F. Olsen & Co. Ltd; Stuart Brown; Donald James; Andy McCord and Peter Ballantyne, Carter Holt Harvey Forests Ltd.; Leon Idoine; and Peter Mcleod, Franklin Rural Management, for kindly offering potential sites and making information available for the selection of the best sites for the installation of the crown lightening trials. Finally it is recognised that the installation of these trials would not have been possible without the able assistance of Gaspar Horvath, Shane Major, Iain McInnes and Myles Carter of *Forest Research*. John Moore also provided invaluable expertise in wind-flow modelling to enable the identification of appropriate trial locations in terms of their level of windiness.

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## **APPENDIX I: TRIAL LOCATIONS AND CONTACTS**

### **Horohoro FR309/1**

#### ***Location***

Rotorua/ Atiamuri highway

NZMS 260 Map Sheet U16 NZMG 6325 2787

Latitude: 38°15'S. Longitude: 176°10'E

Altitude: 180 m

#### ***Contact***

Jeff Tombleson,

Plantation Management,

Forest Research Institute Ltd.,

Ph: (07) 347-5649 or (025) 586 507

FAX (07) 347-5332

***Date Trial Installed:*** 9 June 1996

### **Sefton FR309/2**

#### ***Location***

adjacent to CHH MDF plant, Sefton

NZMS 260 Map Sheet M34 NZMG 5771 2480.

Latitude: 43°16'S. Longitude: 172°38'E

Altitude: 30 m

#### ***Contact***

Piers Maclaren,

Plantation Management,

Forest Research Institute Ltd.,

***Date Trial Installed:*** 9 June 1996

**Waikatea Forest FR309/3**

***Location***

Poverty Bay region, Wairoa

NZMS 260 Map Sheet X19 NZMG 6242 2915

Latitude: 38°56'S. Longitude: 177°41'E

Altitude: 500 m

***Contact***

Roger Allen  
Juken Nissho Ltd,  
PO Box 1239,  
Gisborne.

Ph: (06) 867-8398

FAX: (06) 867-0579

***Date Trial Installed:*** 28 - 30 April 1997

**Kumeroa Valley FR309/4**

***Location***

Wairarapa Region, Woodville

NZMS 260 Map Sheet T24 NZMG 6188 2769.

Latitude: 40°23'S. Longitude: 176°03'E

Altitude: 200 m

***Contact***

Blair Haggitt  
Wilson and Associates,  
PO Box 217,  
1st Floor Carters Building Supplies,  
Rangitikei St.,  
Palmerston North.

Ph: (06) 357-6096 or (025) 445 646

FAX (06) 356-2517

***Date Trial Installed:*** 21-24 April 1997



**Glenledi FR309/5**

***Location***

Otago region, Tokoiti Forest

NZMS 260 Map Sheet H45 NZMG 814 418

Latitude: 46°11'S. Longitude: 170°02'E

Altitude: 70 m

***Contact***

Phil Taylor  
City Forests Ltd.,  
PO Box 2225,  
Dunedin.

Ph: (03) 455-5512

FAX: (03) 455-5501

***Date Trial Installed:*** May 1997

**Dipton FR309/6**

***Location***

Southland region, Dipton

NZMS 260 Map Sheet E45 NZMG 5464 2153

Latitude: 45°56'S. Longitude: 168°22'E

Altitude: 120 m

***Contact***

Mark Dean,  
Plantation Management,  
New Zealand Forest Research Institute Ltd,  
Private Bag 3020,  
Rotorua.

Ph: (07) 347-5675

FAX: (07) 347-5332

***Date Trial Installed:*** 1 - 3 May 1997

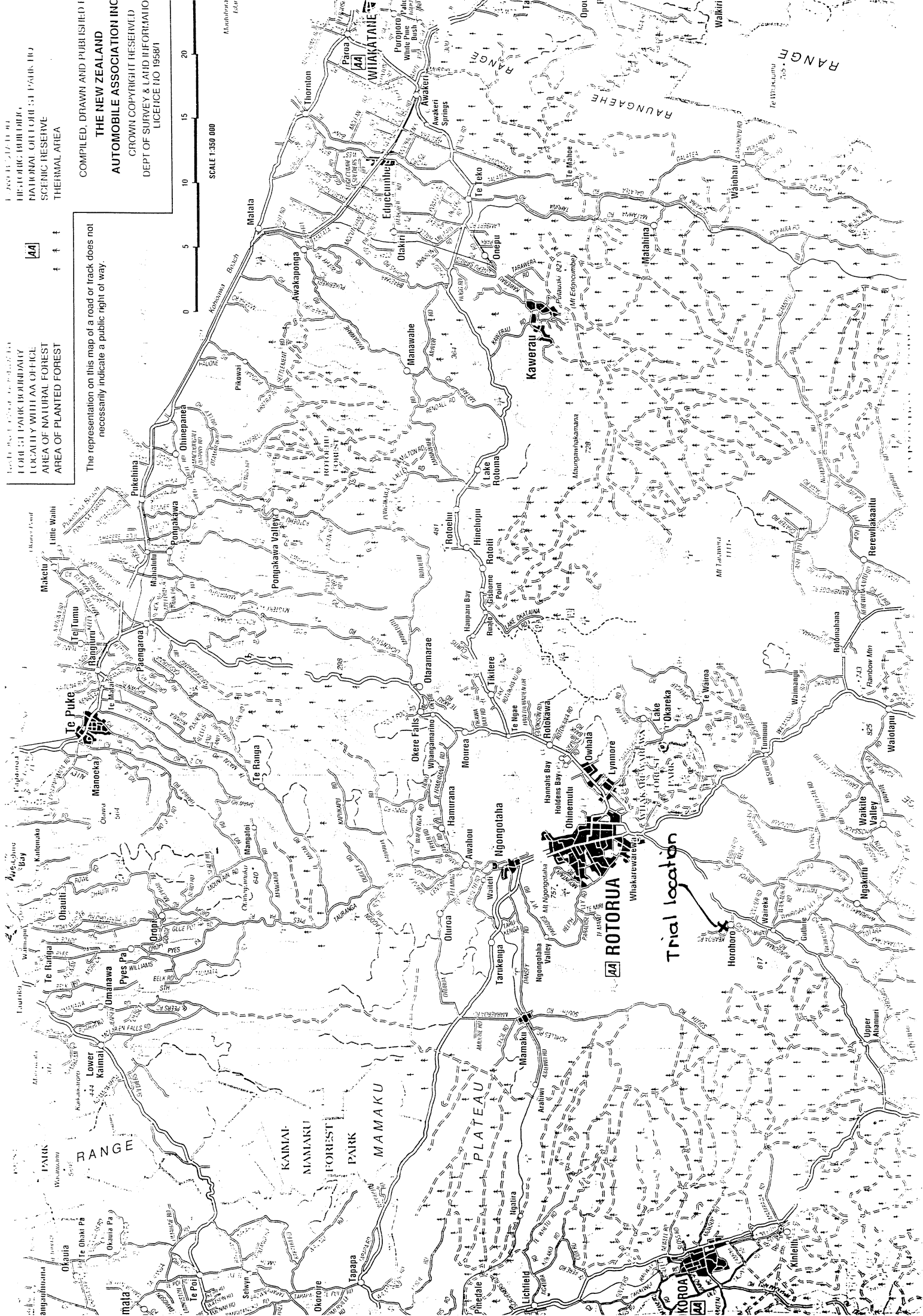
**HOROHORO FR309/ 1**

**THE NEW ZEALAND**

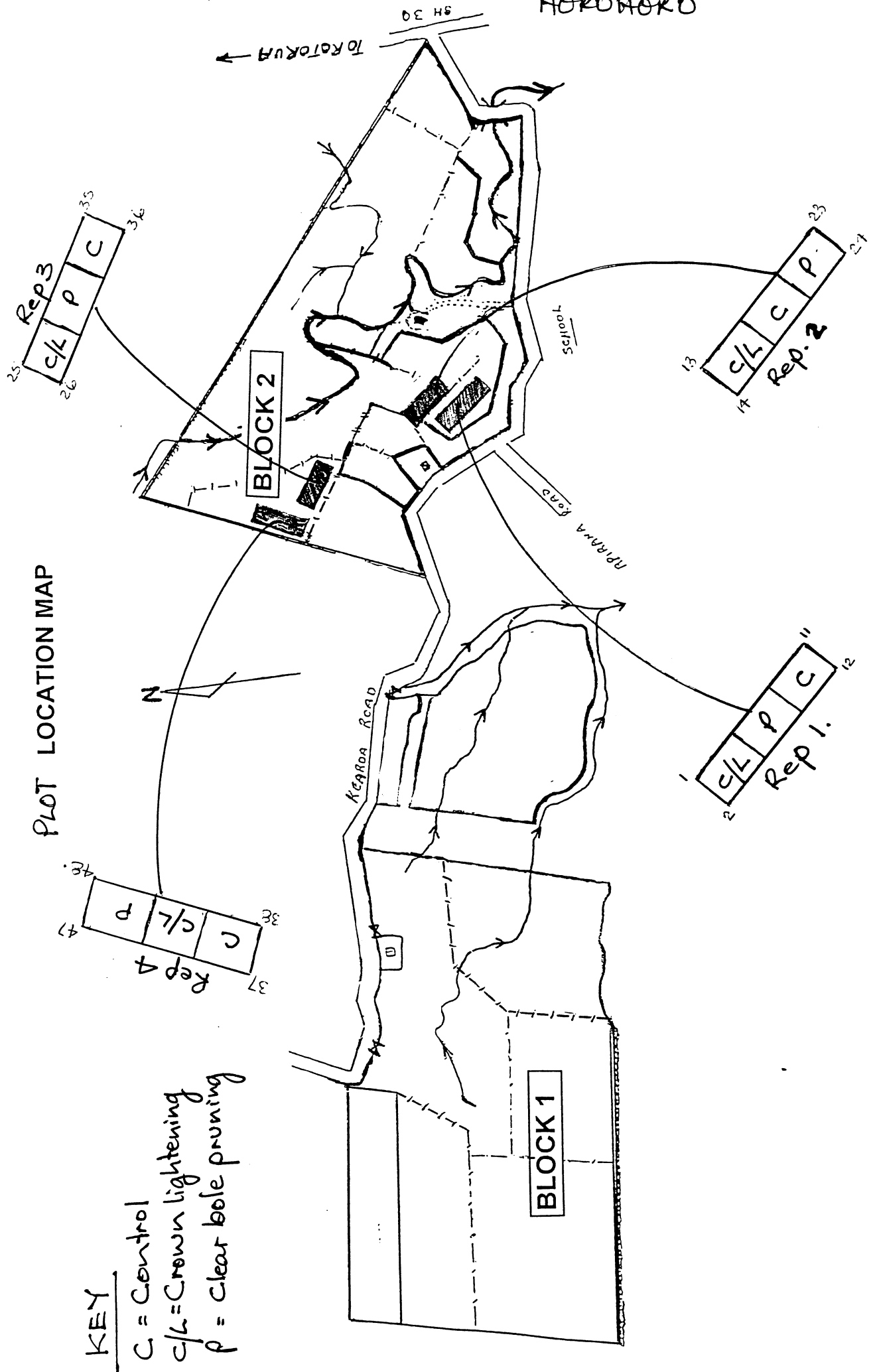
AUTOMOBILE ASSOCIATION

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DEPT OF SURVEY &amp; LAND INFOR



# TRIAL LOCATION MAP HOROHORO

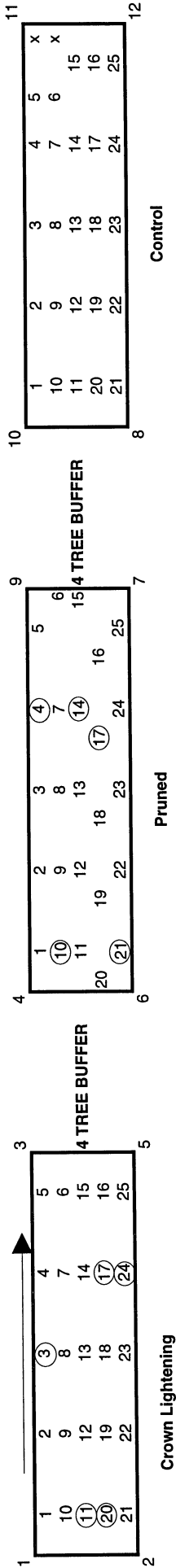


PLOT LAYOUT FOR CROWN LIGHTENING TRIAL AT HOROHORO

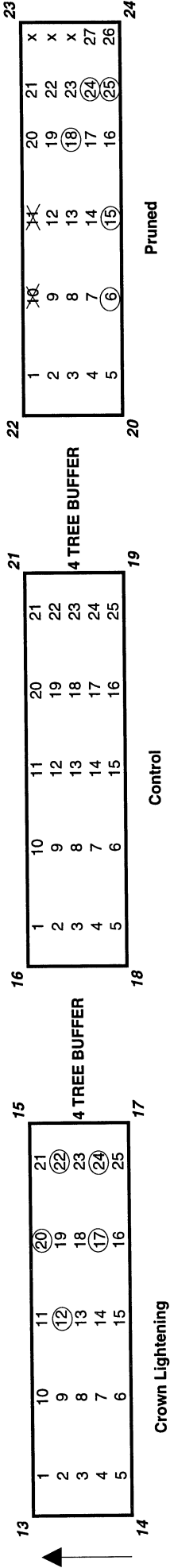


the arrow indicates the direction of planting rows and starts from the baseline for the plot  
the circle indicates those trees which have been measured for green crown removed

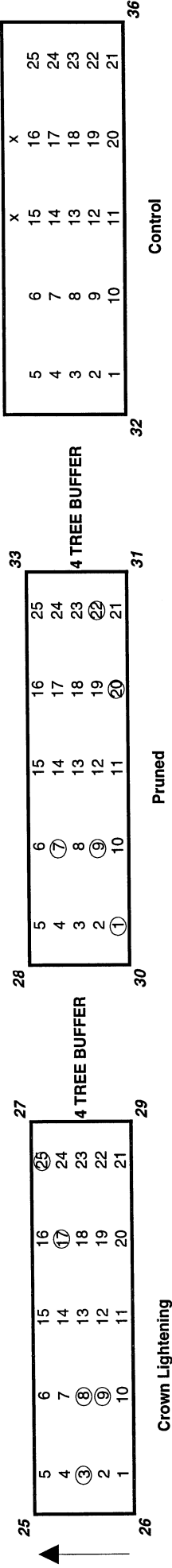
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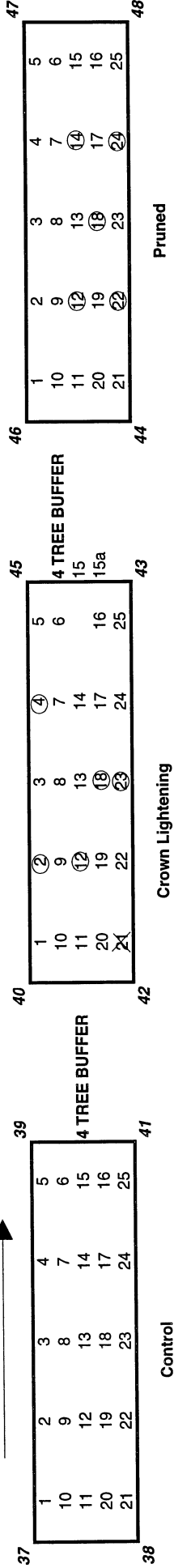
REPLICATION 2



REPLICATION 3

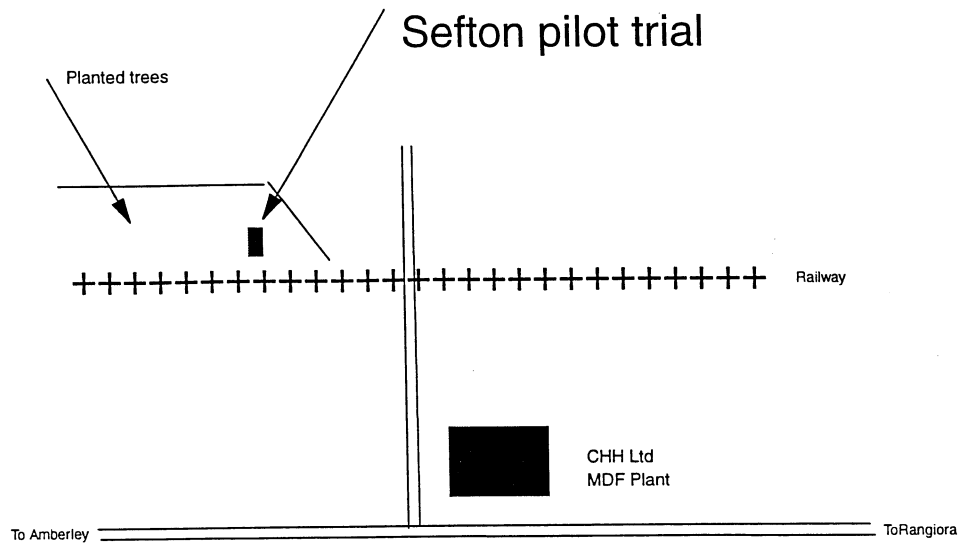


REPLICATION 4



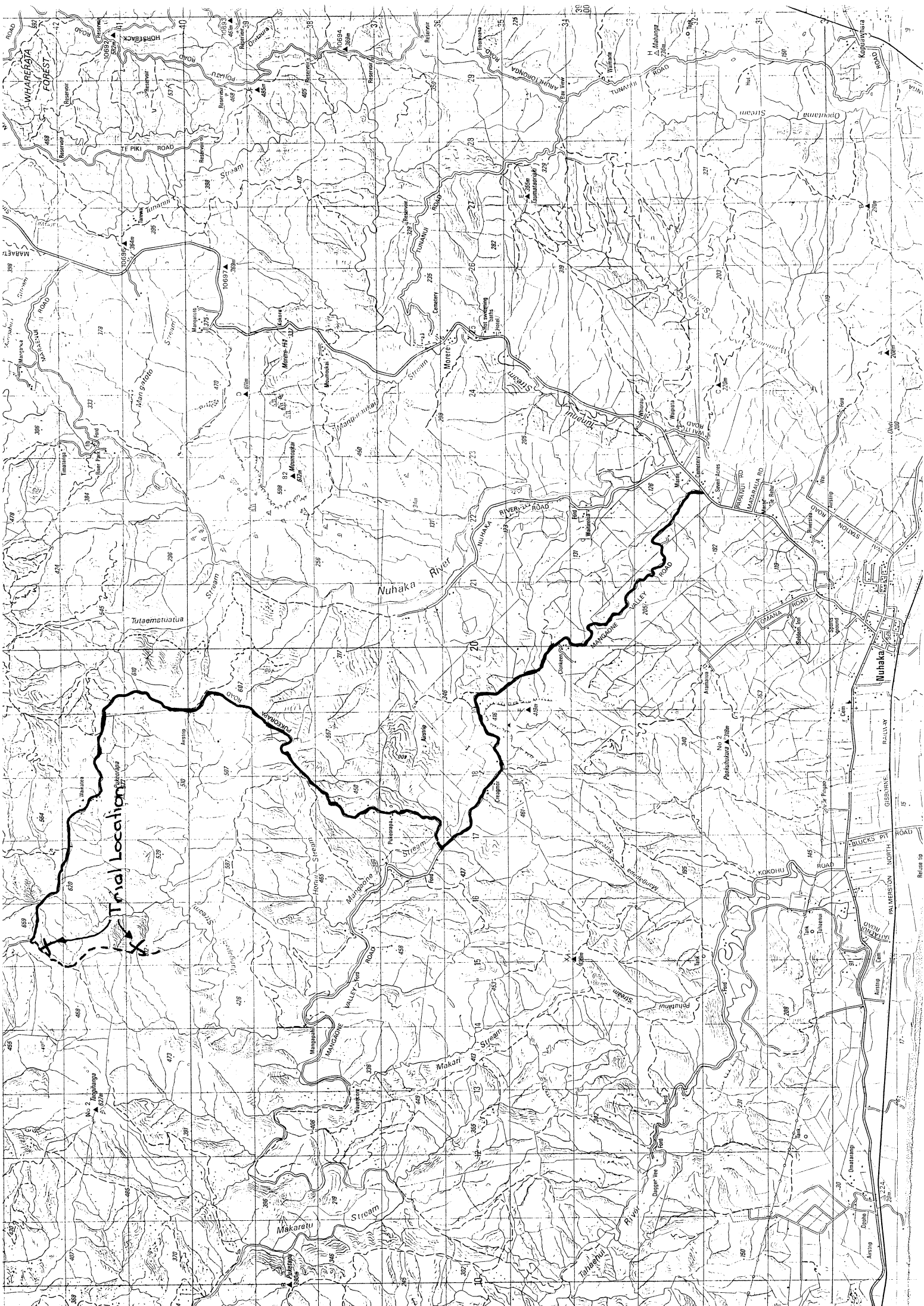
**SEFTON FR309/ 2**

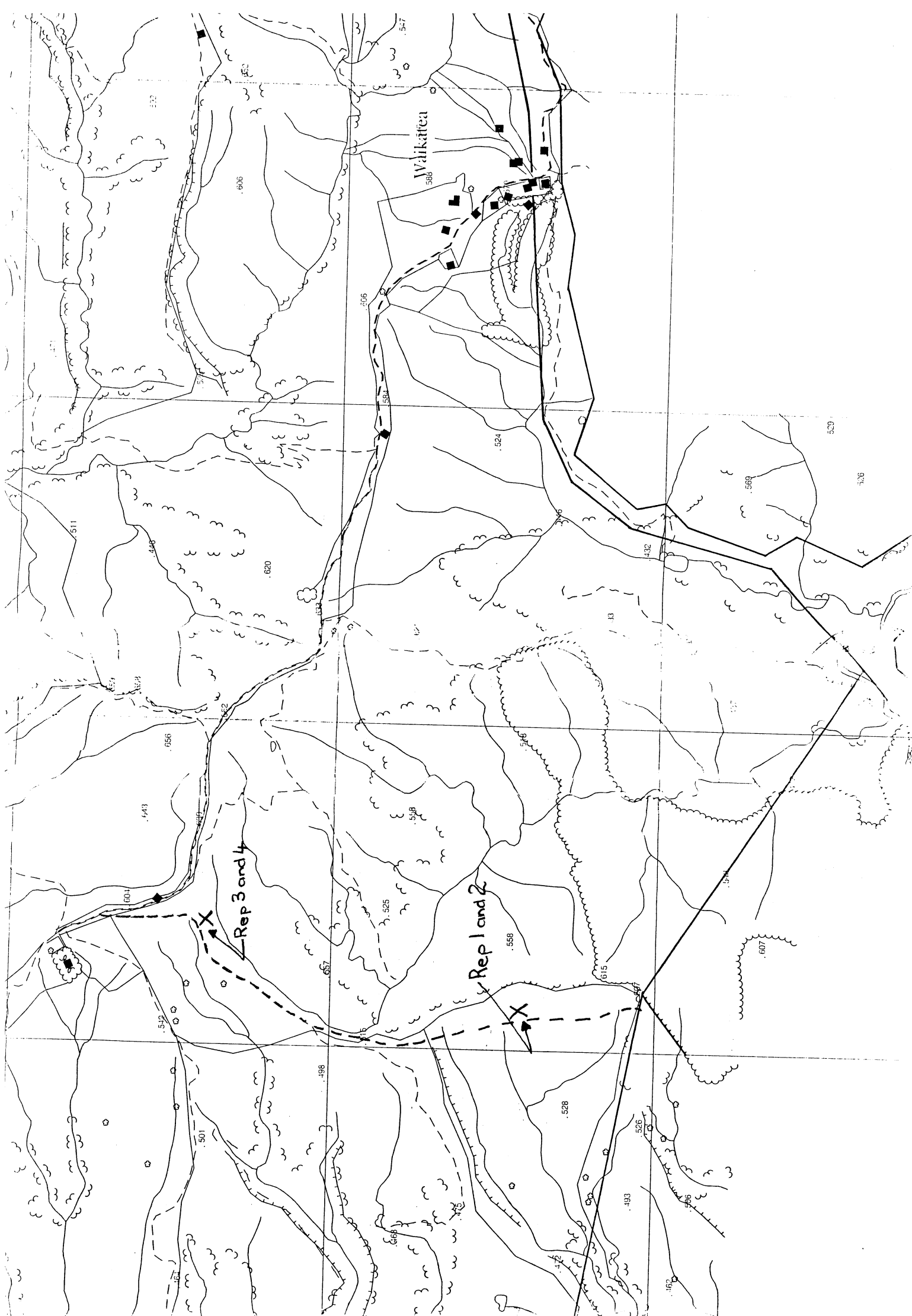
## APPENDIX 1 — location of the Sefton trial



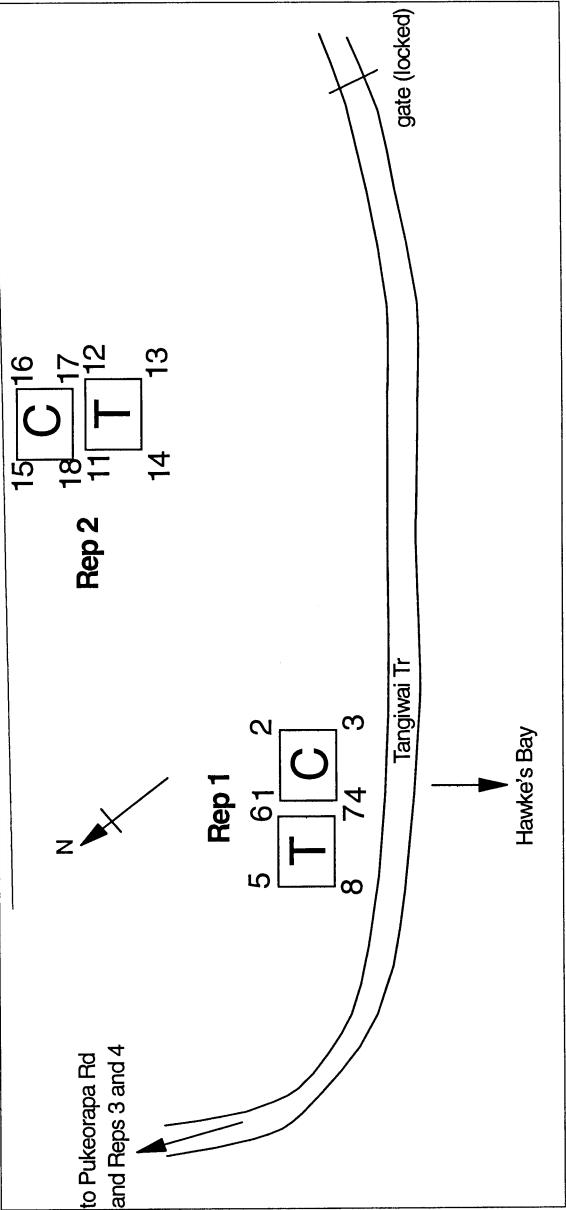
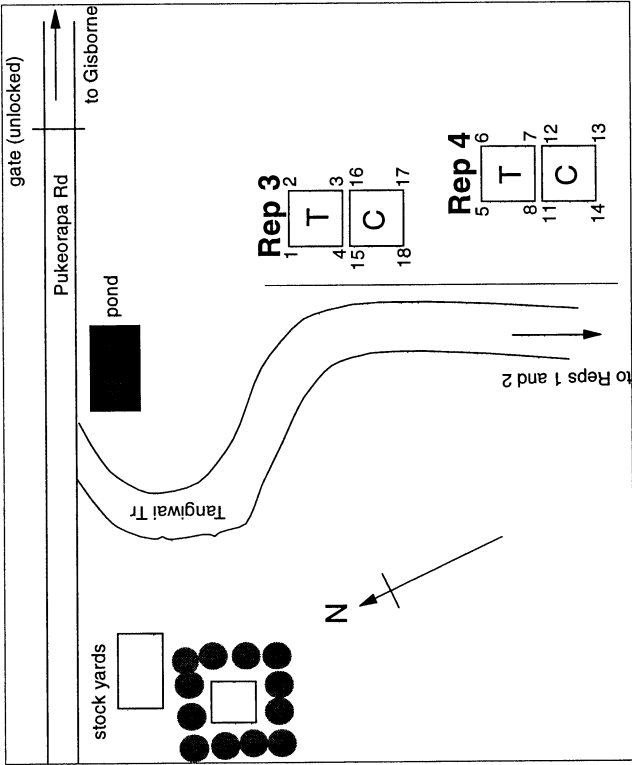
## **WAIKATEA FOREST FR309/ 3**







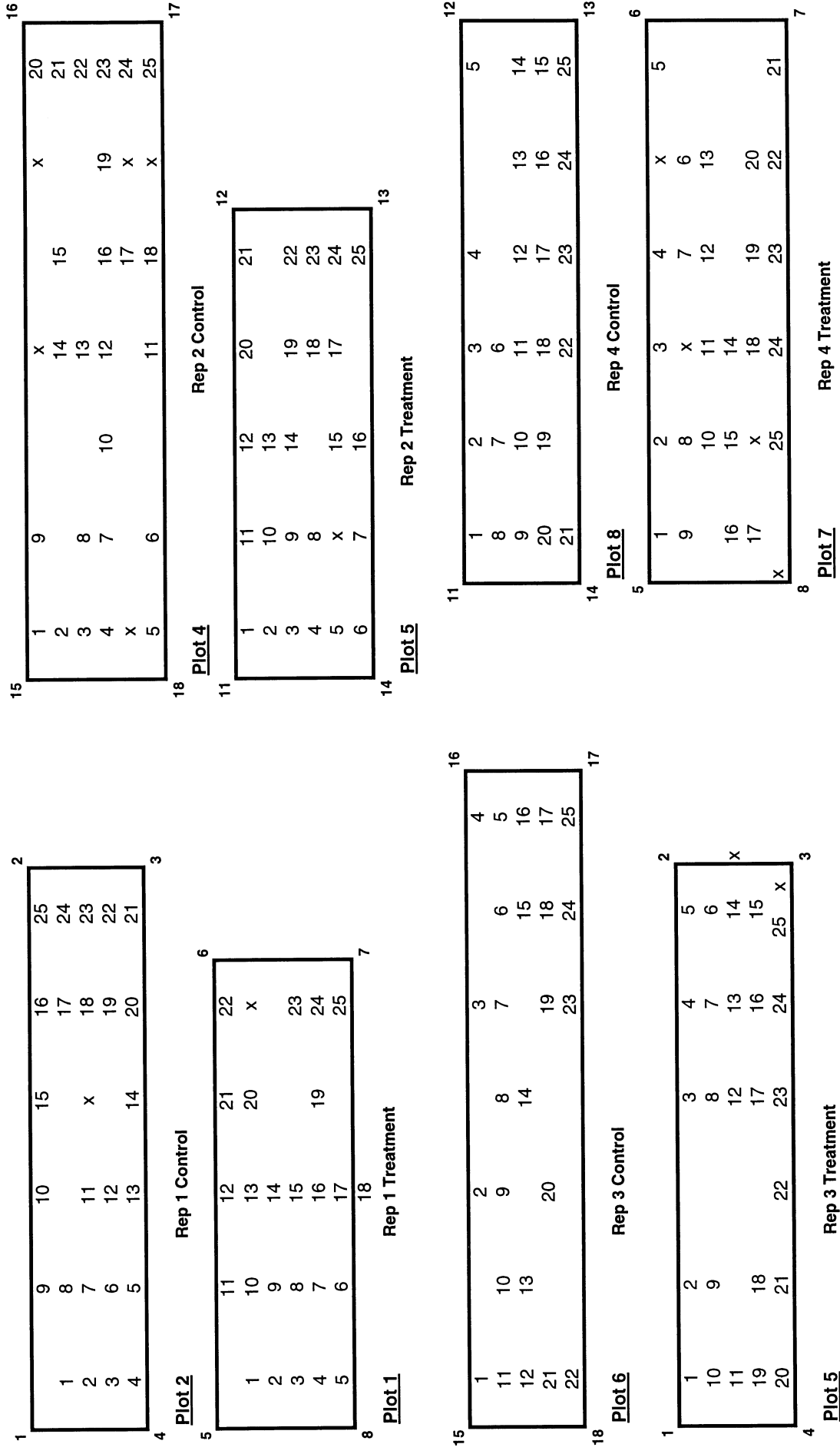
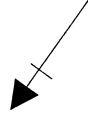
Waikatea Forest



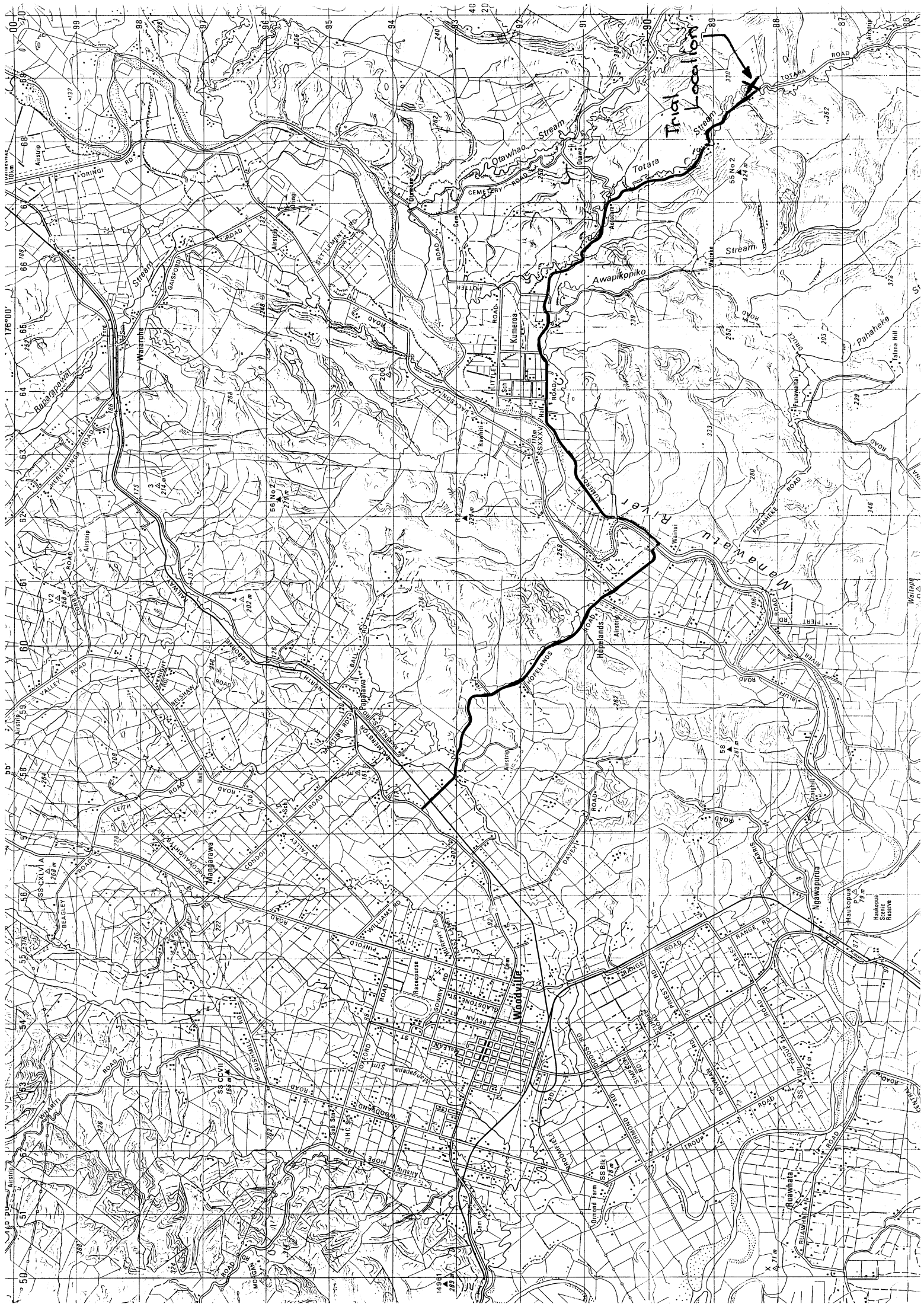
# Waikatea Forest

## Plot Layouts

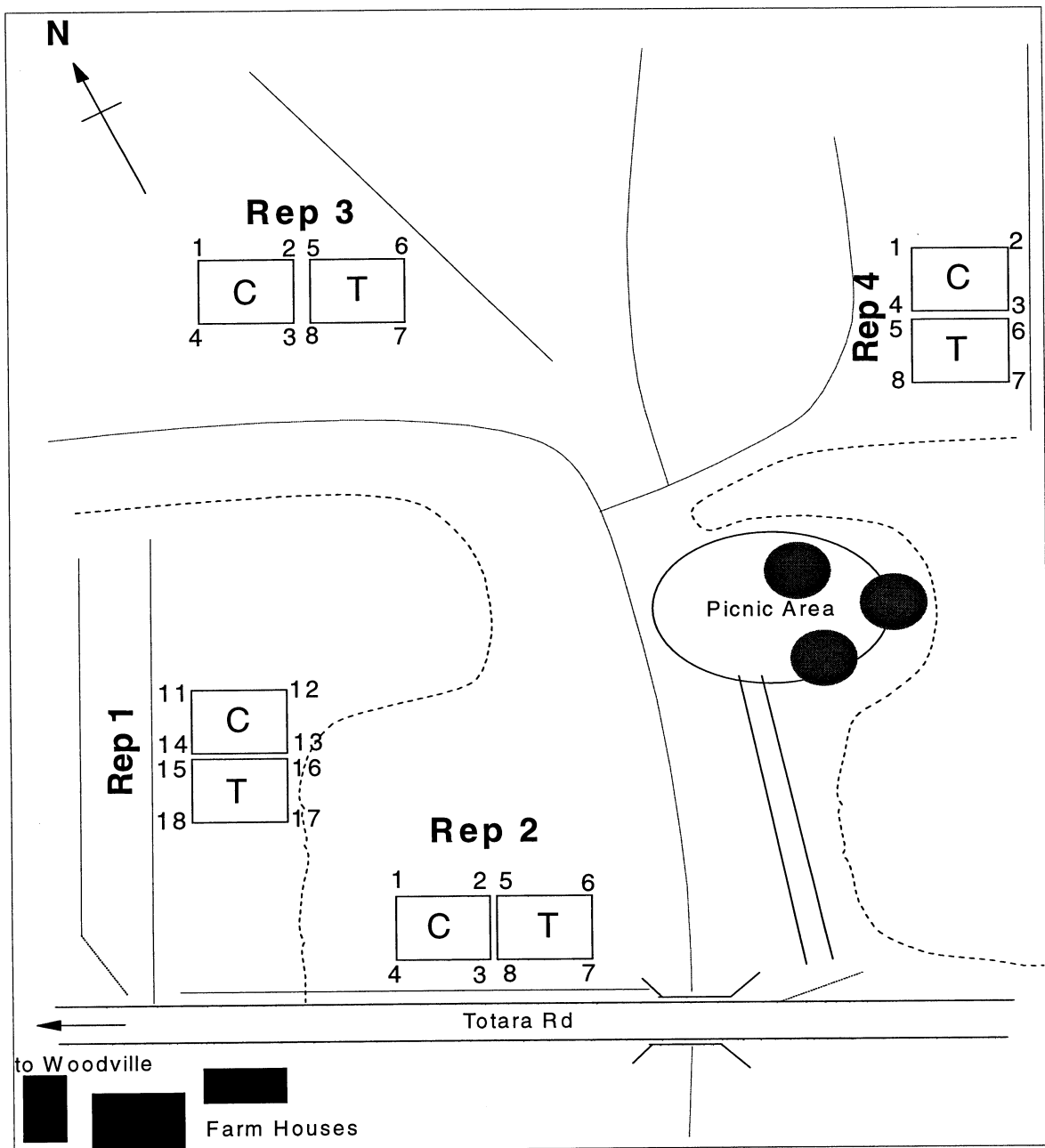
**Z**



## **KUMEROA VALLEY FR309/ 4**

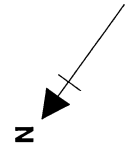


# Kumeroa Valley



Plot Layouts

**Kumeroa Valley**



11	12	13
1	11	12
2	10	13
3	9	14
4	8	15
5	7	16
	6	x
		17
		20
		19
		18
		x
		x
		24
		23
		22
		21

14	15	16	17
<u>Plot 2</u>	Rep 1 Control		
1	10	11	x
2	9	12	20
x	8	13	19
3	7	14	18
x	6	15	17
4	5	16	x
			21
			22
			23
			24
			25

1	2	3
<u>Plot 1</u>	Rep 1 Treatment	
1	10	11
2	9	12
3	8	13
4	7	14
5	6	15
		16
		17
		18
		19
		20
		21
		22
		23
		24
		25

4	5	6	7
<u>Plot 6</u>	Rep 3 Control		
1	11	12	20
2	10	13	x
3	9	14	19
4	8	15	18
5	7	x	x
6		16	17
			21
			22
			23
			24
			25

8
<u>Plot 5</u>
Rep 3 Treatment

1	2	3
<u>Plot 4</u>	Rep 2 Control	
1	10	11
2	9	12
3	8	13
4	7	14
5	6	15
		16
		17
		18
		19
		20
		21
		22
		23
		24
		25

5	6	7
<u>Plot 3</u>	Rep 2 Treatment	
1	10	11
2	9	x
3	8	12
4	7	13
		14
		15
		16
		17
		18
		19
		20
		21
		22
		23
		x
		24
		25

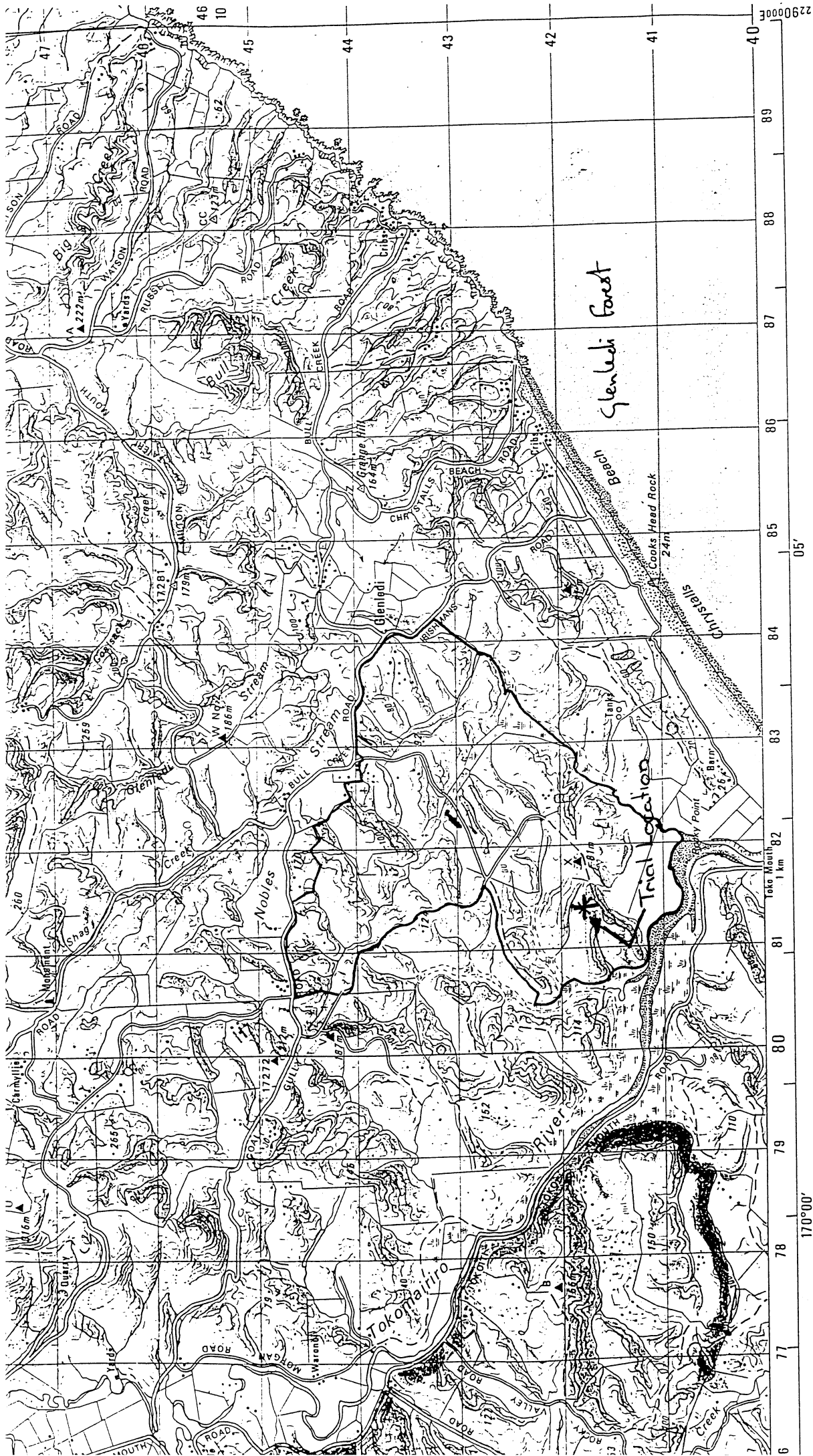
1	2	3
<u>Plot 8</u>	Rep 4 Control	
1	8	17
x	7	9
2	6	10
3	5	11
4		12
	x	13
		14
		15
		16
		18
		19
		20
		21
		22
		23
		24
		25

4	5	6	7
<u>Plot 7</u>	Rep 4 Treatment		
1	10	11	x
2	9	x	20
3	x	12	19
4	8	13	18
	7	14	17
	6	15	16
			21
			22
			23
			24
			25

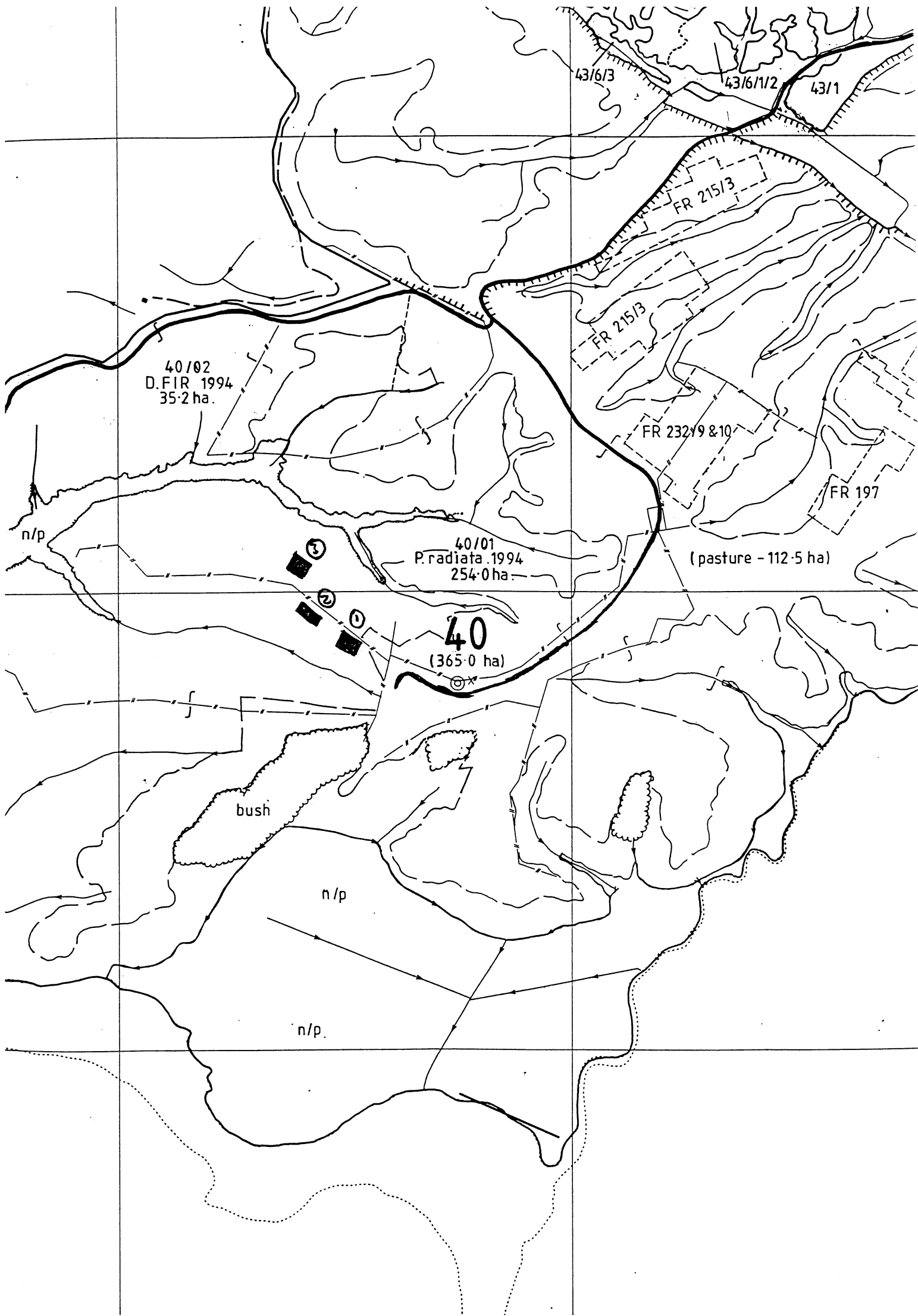
8
<u>Plot 7</u>
Rep 4 Treatment



**GLENLEDI FR309/ 5**



Refer to this map as -  
NZMS 260 H45  
MILTON  
EDITION 1



**DIPTON FR309/ 6**





