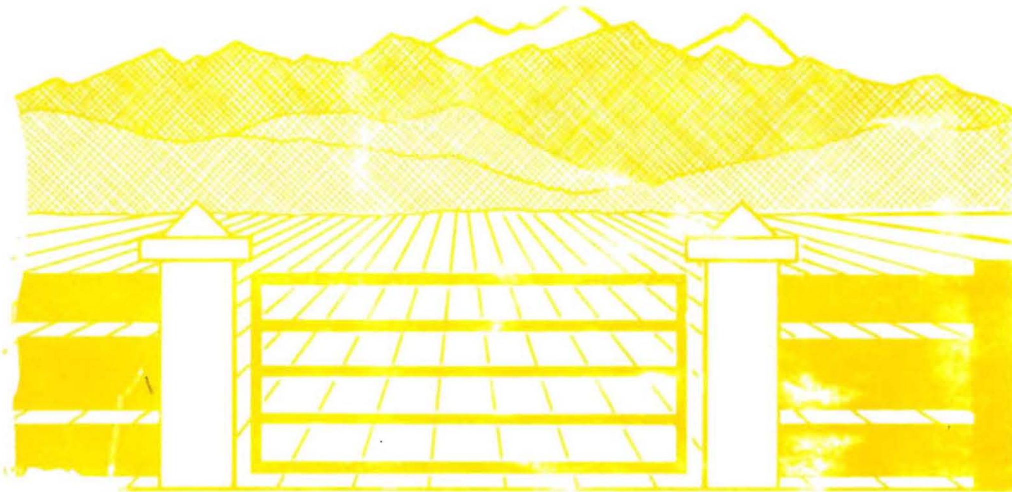
Lincoln College

Farm Management and Rural Valuation Department

1981 Farm Budget Manual



Part 1 Technical (Volume 2)

1981 FARM BUDGET MANUAL

Part 1: TECHNICAL

Volume 2 Sections 16–25

Edited by R.J.DIPROSE
Senior Lecturer in Farm Management
Department of Farm Management and Rural Valuation
Lincoln College,
Canterbury N.Z.

SECTION 16

FARM FORESTRY

16. FARM FORESTRY

Prepared by A. Allen (NZFS) November 1980

16.1 PLANNING

Points to consider in planning to establish a woodlot, and governing choice of species:-
(i) Extent and location of area.
(ii) Purpose of planting e.g. Timber, fencing material, erosion control, shelter, firewood.
(iii) Site factors e.g. present vegetation cover, climate, soil altitude, topography.
(iv) Access for extraction of forest produce.
(v) Market demand.
(vi) Source of tree stocks.
(vii) Whether or not adequate silvicultural treatment can be given once stand is established.
(viii) Restrictions on forestry under district schemes.

16.2 SITE FACTORS

16.2.1 Climate

Temperature and rainfall are the main constraints. *Pinus radiata* will grow throughout New Zealand, but is damaged by heavy snowfalls. *Pinus muricata* is a similar species more resistant to snow. Douglas fir, *Eucalyptus delegatensis* and *Eucalyptus regnans* require 750 mm rainfall for good growth. Douglas fir and *Eucalyptus regnans* are susceptible to out-of-season frosts so they are better grown on hill country in colder areas. For inland South Island areas with a severe climate, Doublas fir, Larch, *Pinus nigra, Pinus muricata* (blue strain), *Pinus penderosa, Eucalyptus delegatensis, Eucalyptus saligna* and *Eucalypus botryoides* require a warm climate. Most species are harmed by salt-laden winds, but *Pinus radiata, Cypressus macrocarpa,* and *Eucalyptus botryoides* are tolerant.

16.2.2 Altitude and Aspect

Radiata pine will grow well up to 900 m in the central North Island, down to 600 m in Canterbury and 500 m in Southland. *Pinus muricata,* Douglas fir, *Pinus nigra* will, nevertheless, often do better on a moist southerly aspect at lower altitudes. Douglas fir prefers a southerly aspect, and shelter from drying north - west wind in the South Island.

16.2.3 Soils

Physical condition is more important than nutrient content. Poor drainage is the most important limiting factor. A hard rain may impair growth. Poplars will grow in a wet soil, but require fertility and not too acid. Pines, cypresses and cedars will tolerate dry soils. Eucalypts are more sensitive to variations in fertility than pines. Fertilizers are not generally needed for satisfactory tree growth, but may be required on some infertile soils particularly in Northland and Westland (fertile soils require both drainage and fertilizer).

16.2.4 Vegetative Cover

Can influence species choice and subsequent management. If rapid regrowth of weeds will occur, a faster growing species can compete better e.g. radiata pine compared to Douglas fir on a gorse-infested site. Hormone sprays can be applied at a light rate over radiata pine for releasing from gorse and broom, but not over Eucalypts. Control of gorse before planting is desirable, as a gorse-infested stand can be an expensive and unattractive proposition for tending.

16.2.5 Site Index

This is defined as the dominant height of radiata pine at age 20. It gives a measure of the relative productivity of a site for growing trees.

Area description	Site index m (± 2 m)
High altitude stands in the more arid parts of Marlborough, South Canterbury and Otago; stands subject to stong winds and saltspray along the ocean foreshore: stands on nutrient-deficient sites without fertilizing.	20 or less
Canterbury plains and lower foothills; Marlborough sounds; some of the better sites in inland Otago(?)	22
Southland Conservancy (excluding inland Otago): South Canterbury hill country (?); Kaingaroa plains above 500 m; East Coast hill country above 500 m(?); coastal sands in the Manawatu and Canterbury	24
Central Marlborough; Nelson and foothills (fertilizer applied where appropriate); inland Manawatu;	

16.3 SPECIES

Species	Site Requirements	Natural Durability	Wood Characteristics	Uses	General
Pinus radiata	Will tolerate most sites except poorly drained or high altitude.	Non-durable	Easily treated. Moderate strength and density. Sawing seasoning, machining, painting and staining properties very good.	Posts, poles. Building timber - framing, boards, laminated beams, plywood veneers, furniture. Pulp and paper.	The primary general purpose timber in New Zealand.
Corsican pine	Will tolerate colder and wetter sites than radiata.	Non-durable	Similar to radiata. Suitable for round produce because of fine branches and regular form.	Mainly posts and poles. Little planted now except where conditions could be too severe for radiata.	
Pinus muricata (blue strain) Bishop pine	Similar to radiata, but more resistant to snow because of stiffer branching habit, and shows better growth at higher altitudes.	Non-durable	Similar to radiata.	Similar to radiata.	An alternative to radiata in heavy snow areas.
Douglas fir	Prefers a moist, cool site, requires 750mm and annual rainfall. Evenly distributed, for good growth. More intolerant of wet ground than pines. Does not stand coastal conditions. Is damaged by exposure to high winds. Not suitable for northern N.I. Will stand snow well but can be badly damaged by out-of-season frosts so is better with good air drainage.	Heart moderately durable. Can be used un-treated in most low-hazard situations.	Difficult to treat. Cannot be treated by ordinary pressure treatment. Strong. Does not machine or take paint well.	Framing and construction timber, particularly where high strength is required, so long as knots are small.	A valuable timber because of high strength and the fact that it can be used untreated for many purposes.

Cupressus macrocarpa	Will tolerate a wide range of sites but requires a reasonably fertile, moist (but not wet) site for good growth. Tolerates coastal conditions.	Heart fairly durable.	Treatment as for Douglas fir. Good strength, density. Good sawing, seasoning, machining and painting properties stable. High proportion of heart.	Framing, flooring, weatherboards, joinery, turnery, boat-building. Furniture. General-purpose farm timber.	A vuluable general-purpose timber. Very variable in form so requires careful selection of seed source.
C. lusitanica Mexican cypress	Warmer N.I. sites, away from the sea. Moderately fertile and well drained.	Less durable than macrocarpa.	Similar to macrocarpa.	All-round building timber. Joinery and turnery.	Similar to macrocarpa, for warm climates.
Eucalyptus species - Ash Group *E. delegatensis* Alpine Ash	Cool climate, 1000 mm and rainfall. Will grow in warmer, drier climates but prone to later failure. One of the hardiest eucalypts.	Non-durable Difficult to treat.	Light, strong, pale coloured. Prone to warping, and to collapse when drying. *E. delegatensis* also prone to internal cracks which limit its use. Difficulties can be overcome by quarter-sawing of large logs, and by steam reconditioning.	Veneers, decorative pannelling, furniture, turnery, joinery. Short-fibred pulp.	
E. fastigata Brown barrel	Reasonably moist sites, less hardy than *E. delegatensis*.	Non-durable Difficult to treat.			Has a rough branching habit.
E. regnaus Mountain Ash	Cool, moist climate with good cold air drainage, 750 mm of rainfall.	Non-durable			The most desirable ash-type eucalypt.
B. Gum group *E. Saligna* - Sydney Blue Gum	Warmer N.I. and northern S.I. districts, 750 mm of rainfall.	Moderate to good.	Tough, strong, hard-wearing. Reddish-brown. Sawing and seasoning difficulties as for ash group.	General building and farm use including fencing. Also veneers, furniture, panelling.	The best eucalypt for warmer climates.
E. botryoides - Southern mahogany	Similar to *E. Saligna* will tolerate wetter soils and coastal conditions.	Moderate to good.	As for *E. saligna*	As for *E. Saligna*	Growth and form inferior to *E. saligna*

Factors affecting choice of species:
(i) Site factors
(ii) Land preparation needs
(iii) Availability of tree stocks and relative cost
(iv) Management requirements.
(v) Market demand or other end-use.
(vi) Rotation Lengths
(vii) Aesthetic value.

16.3.1 Rotation Length

Pinus radiata	25-35 years
Pinus muricata	25-35 years
Pinus nigra	40-50 years
Douglas fir	about 50 years
Macrocarpa	about 50 years
Eucalypts	about 40 years

16.4 LAND PREPARATION

Inadequate site preparation can lead to poor stocking, need for blanking (replacement planting), costly release clearing, unthrifty trees, and reduced management options.

16.4.1 Techniques of Land Preparation

(i) **Pasture.** Graze close prior to planting. Grass control is desirable, especially in fertile improved pastures where grass can compete strongly with tree for moisture. Spot or line spraying is a popular and efective technique. Some sprays can be applied over pines after planting.
(ii) **Gorse and Broom.** Gorse sites are among the most expensive and difficult to prepare. Burning followed by planting is often unsuccessful as gorse regrowth beats trees, and access for tending is difficult. It is preferable to control gorse before planting. A combination of burning, bulldozing, cultivation, heavy stocking and or one or more spray applications may be required. Preparation may take up to two years.
(iii) **Scrub.** For small scrub, crush and burn or bulldozing or cutting lines is suitable. For taller scrub, bulldoze clear, crush or fell and burn.

(iv) **Compacted stony or clay soils.** Ripped lines allow easier planting and better establishment.
(v) **Frosty areas.** Bare ground (sprayed or cultivated) lessens the effect of heavy or out-of-season frosts.
(vi) **Cutover sites.** Window and/or burn, although it is possible to plant directly into cutovers.

16.5 PLANTING

16.5.1 Tree Stocks

The ideal seedling is short and fat - about 200 mm short length and 100-120 mm root. Best ages are:-

Pinus radiata	- 1½ year-old or well-grown 1-year old
Other conifers	- 2 year-old
Eucalypts	- 1 year-old - potted stock is preferable.

16.5.2 Care of Tree Stocks

Most trees are now dispatched in plastic bags - these should be stored one layer deep in a cool shady spot, with roots downwards so that condensation runs down. Bags should not be left in the sun to heat up.

If seedlings are bare - rooted they should be heeled in, in overlapping rows until required for planting.

16.5.3 Planting Technique

A grubber with blade about 180 x 100 mm is the best tool in compacted or stony ground. In friable or cultivated soil a spade is preferable because of the larger hole it makes, allowing better spread of roots. Roots should be well spread and directed downwards. Tree should be upright and deeper into the ground than it was in the nursery. Soil should be compacted around the tree so that no air pockets are left. Cutting away a patch of turf to provide a bore planting spot ('screefing') is recommended in grass, unless spot spraying is to be done.

It is desirable to ensure correct spacing of planting lines by setting two rows of holes with two or say, every 5th line. Other holes can be sighted in from these two bud lines.

16.5.4 Spacing

Will depend on:- species, competing vegetation, degree of land preparation, prospects for sale of thinnings, need for grazing within the stand, etc. Generally close spacing is preferable.

Spacing is normally varied by varying the spacing between rows, with spacing in the line kept at 2 m (2 paces.)

Common spacings are:-

Radiata pine - 2.5 x 2 or 3 x 2m, most commonly 3 x 2 m (1667 stems/ha)
Other pines - 2 x 2 up to 3 x 2
Douglas fir - 2.5 x 2 or 3 x 2 m
Eucalypts - 2.5 x 2.5 m for even crown development.
Cypressess - 2 x 2 up to 3 x 2m

Close spacing results in earlier canopy closure, suppression of weeds or grass, smaller branches, restriction of diameter growth (unless thinning is done early), better form and more choice for selection of crop trees.

Wide spacing results in later canopy closure and suppression of weeds or grass, larger branches (hence more expensive pruning), less restriction of diameter growth, rougher form, less choice for selection of final crop trees, and more scope for grazing within stand.

16.5.5 Blanking (replacement of dead seedlings)

This is normally done the year following planting. If mortality, assessed the autumn following planting, is uniformly distrubuted and less than about 15% blanking is not required. If over 15% or concentrated in patches blanking is necessary. Trees planted later to fill in gaps rarely form part of the final crop.

16.5.6 Fertilizer

Fertilizer application is not normally required for conifers, and can be disadvantageous by boosting top growth of pines and making young trees prone to toppling. May be necessary on phosphate - deficient or low - fertility soils in some districts.

Eucalypts will benefit from application of nitrogenous fertilizer (urea, blood and bone, diammonium phosphate) in spade slit 15-20 cm from tree (not uphill), at time of planting.

16.6 RELEASING

It may be necessary to cut back competing grass, weeds or scrub hardwoods from young trees. Bracken and gorse and broom are among the most troublesome weeds.

Common methods:

Physical - hand (curved slasher etc)
- mechanical (rotary slasher inter-row)

Chemical - spot or strip ground spraying for grass
- blanket aerial or ground spraying for grass or weeds.

Pines and Douglas fir are tolerant to a number of grass sprays, and also to 245T at light rates, if applied when trees are not in flush of growth.

For sensitive species such as eucalypts, or when in doubt, trees can be shielded with a cone or tube for spraying.

Releasing is a poor substitute for good land preparation.

16.7 TENDING REGIMES

16.7.1 Boards and Veneers

Pruning is necessary to produce clear (knot-free) timber. Logs capable of producing clear timber particulary decorative veneers, are likely to command a premium and the objective of the private grower should be to grow this type of wood where possible. Management should be to prune as early as possible to keep knotty core to a minimum and early thinning to take best advantage of pruning by rapid diameter growth.

16.7.2 Framing Timber

Strength and stiffness are essential. Douglas fir is the ideal timber, but radiata pine is satisfactory for most purposes. Knots are acceptable provided they are kept small. Management should be to keep trees closely spaced in early stages, to suppress branch growth, unless pruning is to be carried out. This will mean later thinning than in board regime with consequent longer time to reach utilizable size. A high and even initial stocking will also be necessary.

Should only be considered as a management objective when tending for clear wood is precluded by difficulty of access, shortage of finance etc.

16.7.3 Roundwood (posts and poles)

Can be a profitable outlet for thinnings or for clearfelling of small trees. Demand fluctuates. Thinning for production of roundwood is not usually worthwhile unless easy, and there is a market available. It is generally better to thin to waste than to delay thinning and restrict growth of final crop trees in to the hope of profit from sale of thinnings.

16.7.4 Pulpwood

As a primary management objective, pulp or chipwood is unlikely ever to be profitable to the smaller grower. It can be useful for thinnings or otherwise unsalable wood from clearfelling, providing the cost of cutting and extraction is less than that of thinning to waste.

16.7.5 Wide Spaced Planting and Grazing

An opportunity for combined land use. Initial spacing 4 x 2m, 5 x 2 m or wider. On time pruning will be essential if timber above box-grade is to be obtained. Thinning will be done earlier than usual to maintain a grass sward as long as possible. There is some doubt that satisfactory final crop stocking can be obtained with a very wide initial spacing.

16.7.6 Sample Management Plans.

Radiata Pine

1. Good site. Final crop only (grazing possible)

Planting at 3.5 m x 2.0 m (1400 stems/ha)

Height of dominants (m)	Approx. age (years)	Prune (m)	Thin to approx. (stems/ha)
5 - 6	4 - 6	0 - 2	750 (best 2 in 4).
7 - 8	6 - 8	2 - 4	370 (best 2 in 4).
10 - 11	8 - 10	4 - 6	200 (best 2 in 4).

Clear fell when the trees reach an average diameter at breast height outside bark (d.b.h.o.b.) of about 60 cm. This is a severe regime, and for maximum return the remaining 200 trees should be systematically pruned to 11 m in two additional lifts.

2. Good site. Intermediate yields

Planting at 3.0 m x 2.0 m (1700 stems/ha)

Height of dominants (m)	Approx. age (years)	Prune (m)	Thin to approx. (stems/ha)
5 - 6	4 - 6	0- 2	All stems that obviously will not yeild a post-not less than 1000.
7 - 8	6 - 8	2 - 4	370, when average butt log will yield a 15 cm post (best 2 in 5).
10 - 11	8 - 10	4 - 6	250, when average d.b.h.o.b. of trees to be thinned is 33 - 35 cm (best 2 in 3).

Clear fell when final crop trees reach about 60 cm diameter at breast height outside bark.

3. Good site. Thin for posts only

Planting at 3.0 m x 2.0 m (1700 stems/ha)

Height of dominants (m)	Approx. age (years)	Prune (m)	Thin to approx. (stems/ha)
5 - 6	4 - 6	0 - 2	All stems that will not make a post - down to 1000 (best 3 in 6).
7 - 8	6 - 8	2 - 4	450, when average d.b.h.o.b. is 15 cm (best 3 in 7). Extract post material.
10 - 11	8 - 10	4 - 6	250 (best 5 in 9). Extract post material.

4. Difficult site. Framing regime

Planting at 2.5 m x 2 m (2000 stems/ha)

Height of dominants (m)	Approx. age (years)	Thin to approx. (stems/ha)
15 - 18	12 - 15	400 (best 1 in 5).

In such situations, clear fell when required after the average stand diameter at breast height outside bark reaches 46 cm.

16.8 PRUNING

The objective of pruning is to produce clear wood, generally on the first 6 metres of the stem, although it may be worth pruning up to 12 metres on best sites.

16.8.1 Selection

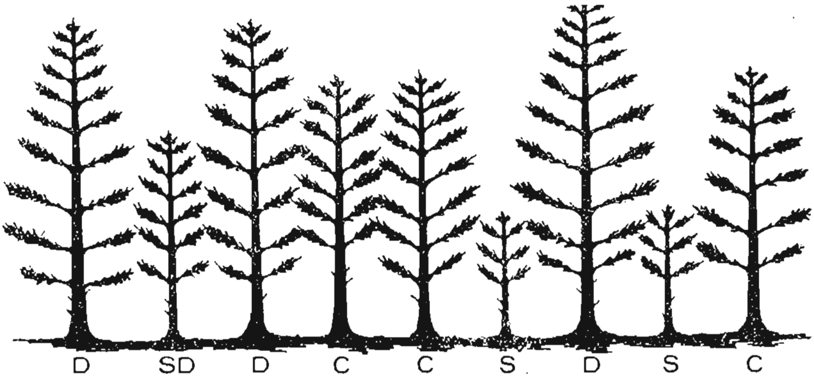
Pruning should be restricted to those trees that will form the final crop leaving a fairly wide margin to account for losses through disease, changes in dominance and windthrow etc.

(a) Points to look for when selecting trees for tending are:

relative dominance and vigour
condition of leader
straightness of main stem
erectness
spacing in relation to other selected crop trees
branch size.

The trees to select for pruning are dominant and co-dominant. Qualities to look for are: Tree's height, width and depth of crown, and diameter in relation to the surrounding trees. These points are visually assessed.

(b) Determining Dominance Class.



Relative dominance: D — dominant; C — co-dominant; SD — sub-dominant; S — suppressed

Dominant - Tallest trees
- Above average crown size and diameter

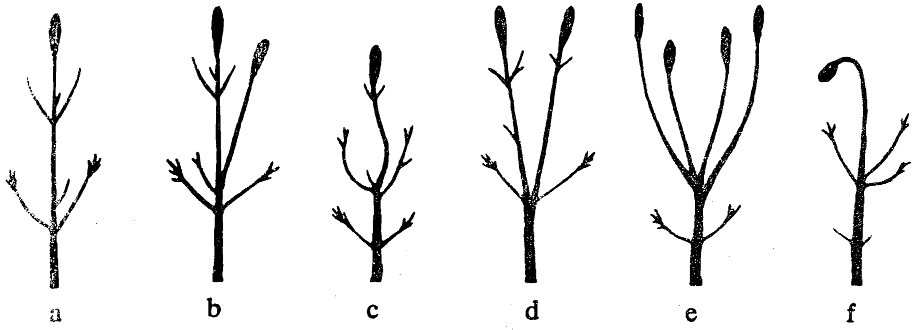
Co-Dominant - Average height but not as tall as dominants
- Crowns shorter and narrower than those of dominant.
- Diameter is average.

Subdominants - Markedly shorter than co-dominants.
- Crowns short and narrow and below general canopy level.
- Diameter is below average.

Suppressed - Smallest in stand
- Crowns almost overwhelmed by crowns of trees about them.
- Diameter is well below average.

(c) Condition of Leader.

By noting the condition of the leader i.e. top two metres of the tree, it is possible to assess the growth potential of the tree.



Leader forms

(a) Single, straight, live, healthy leader.	Highly desirable
(b) Forked leader in which one fork is more vigorous and dominant.	Acceptable
(c) Single leader developed after death	Acceptable
(d) Equally vigorous forked leader	Not acceptable
(e) Multi-forked leader	Not acceptable
(f) Dead leader	Not acceptable

(d) Straightness of Main Stem.

It is desirable to have a straight main stem or trunk although a slight degree of curving or kinking is acceptable providing the tree is in otherwise good condition. As a general guide, if an imaginary line drawn down the first 6 in keeps within the stem, the tree is acceptable.

(e) Erectness

Upright trees are preferable to those with a lean. Acceptable degrees of leaning are no more than 12 cm out from the vertical at a point 1.4m from the ground.

(f) Spacing

The number of trees tended in the first pruning is approximately 750 per hectare (range 600 - 1000). The average spacing for this number of trees is 4 m, the selected trees being not closer than 2 m or not further apart than 6 m. For the second and third stage prunings, the spacing should be, average 6 m, not closer than 2 m or further apart than 10 m to give 200 - 300 stems per hectare.

(g) Branch Size

Small branches growing at right angles to the main stem are ideal branching habit. The greater the number of branches, the smaller the diameter of individuals. This is important as the stubs of small branches will heal over more quickly than those of larger ones.

16.8.2 Timing

Pruning is usually done outside the winter and early summer months as this is when tasks such as planting and release clearing are carried out. It is generally confined to Radiata pine where the fast growth makes the operation economic.

Pruning is generally carried out in three stages; the first pruning is done when the height is about 6 m or about four to six years old, to keep the knotty core as small as possible.

Although the medium pruning is sometimes omitted, it is important to prune branches before they die as dead branch stubs will produce bark-encased knots, and this in turn will produce timber of a lesser value.

An example of a Pruning Schedule. (Radiata Pine)

Stage	Pruned Height (m)	No. of trees pruned (permissible range) in brackets)	Height of Dominants (m)	Approx age (yrs)
Low pruning	0-2	750 (600-1,000)	5-6	4-6
Medium pruning	2-4	370 (240-440)	7-9	6-9
High pruning	4-6	250 (170-300)	10-12	8-11

16.8.3 Method and Tools

(i) Method

Branches should be cut off as close as possible to the stem but without damaging the stem, in order to encourage quick healing and the least possible grain distortion and knot formation. Branches should be pruned while still alive.

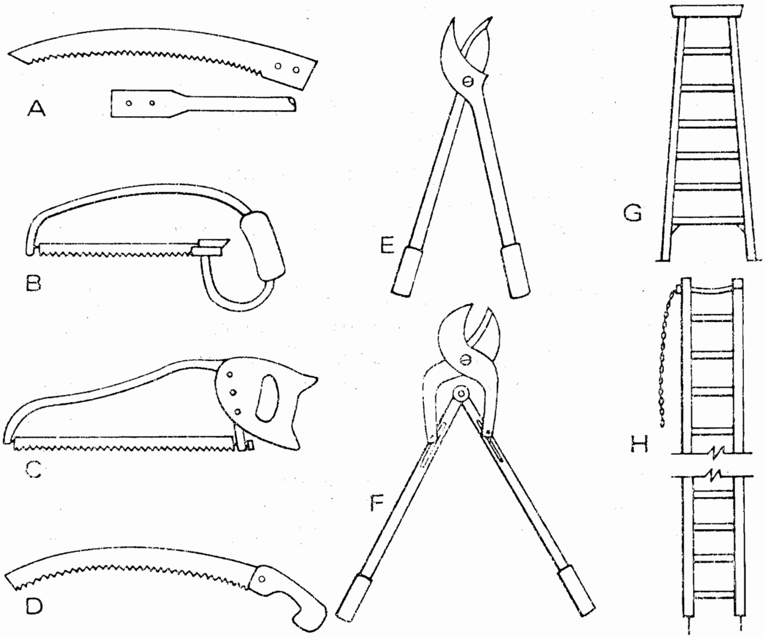
No more than one half of the living crown should be removed as this may retard the tree's development and encourage unpruned trees near by to over-take it and sometimes suppress it.

In the later stages of pruning (i.e. 2nd and 3rd) remove new growth that has formed on the stem, (epicormic shoots) as these are likely to cause knots.

(ii) Tools

For low pruning long-handled secateurs are generally used as they keep sharp longer than saws.

For medium and high pruning either curved pole-mounted saws (used from ground level) or ladders and jack-saws are most commonly used.



A: Swedish curved blade and handle. Mounted on metal or wood handle 1-4 metres long.
B: Commercial jack saw. Very light frame weight.
C: Kaingaroa modified jack saw. Added weight. Now produced commercially - has superceeded (B).
D: Pistol grip saw: Limited to small branch size, very light, no hand protection.
E: Shear type pruners. Point cut, suited to small branches.
F: Shear type pruners. Lever action, able to cope with larger branches up to 65mm in diameter, two sizes.
G & H: Ladder. For medium and high pruning. 4 m aluminium ladder for high pruning. 2.2 m ladder for medium pruning.

16.9 THINNING

In the early stages of a woodlot, stocking will be fairly dense. This is to suppress weeds, restrict branch development and helps to protect and control the form of the main stem. Later it becomes necessary to thin in order to open the stand out giving more room for roots and crowns which will in turn encourage greater diameter growth.

16.9.1 Pruned Stands - 2nd Thinning

Normally done at 9 - 12 m height.
(i) Leave all high-pruned trees, and medium pruned trees if necessary, to achieve the desired stocking of 200-300 stems per hectare.
(ii) Fell all trees that are within 2-5 m of a high pruned tree.
(iii) Fell all malformed trees.
(iv) Fell all trees that are bigger than an adjacent high pruned tree.
(v) An otherwise unacceptible tree may be left to fill in a large gap.
(vi) Maximum spacing between trees should be 10 m.

16.9.2 Unpruned Stands

Thinning will aim to produce acceptable framing timber. May only be done once and should be delayed until lower branches are dead up to 3 or 4 m.
(i) Thin to leave large, straight trees with light branching at spacing to achieve the desired stocking.
(ii) Remove small and malformed trees unless required to fill a canopy gap.

16.9.3 Douglas Fir

Thinning will normally aim to produce good framing and beam material from unpruned stands. The following schedule is suggested:
(i) Thin to about 700 stems per hectare when branches are dead up to 5 m.
(ii) Thin to about 350 stems per hectare when branches are dead up to 10 m. This thinning should produce small sawlogs and round produce.

16.9.4 Eucalypts

Should be kept closely spaced in first few years, then thinned progressively to maintain a crown space equivalent to at least 15 times the d.b.h. Eucalypts are much more sensitive to crown competition than conifers and therefore less tolerant of crowding.

16.9.5 Thinning - General

(i) Aim to leave large, well - formed trees and remove small or badly formed trees.
(ii) Form is more important than spacing.
(iii) All hang-ups should be put in the ground.
(iv) Stumps should be kept low and felled trees completely severed from the stump.
(v) Damage to crop trees should be avoided.

16.9.6 Timing

Determing factors are:
(i) Objects of management
(ii) Species
(iii) Initial spacing
(iv) Difficulty of access (undergrowth, terrain etc.)
(v) Availability of markets for thinings
(vi) Availability of labour
(vii) Stability - danger of windthrow following thinning. Unless there is a market for round produce, thinning will be to waste so should be done as soon as possible to concentrate growth on crop trees.

16.9.7 Selection (Radiata Pine)

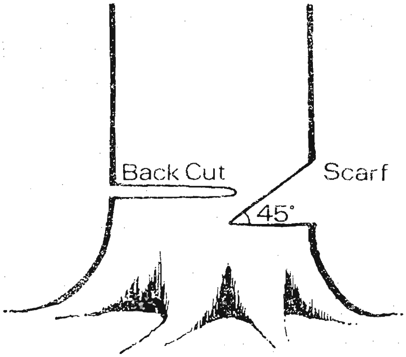
Pruned stands - 1st thinning
Normally done at 5-6 m height.
(i) Leave all pruned trees, and unpruned trees if necessary, to achieve the desired crop stocking of 600-1000 stems per hectare.
(ii) Fell all malformed trees
(iii) Fell all trees that are within 2.5 m of a pruned tree.
(iv) Fell all trees that are bigger than an adjacent pruned tree.
(v) Spacing should be no more than 6 m between trees.

16.9.8 Technique

The most suitable and widely used tools are power saws, although slashes are used for the very young trees.

Trees for cutting should be marked beforehand to avoid mistakes unless the operator is experienced in selection. Stumps should be kept as low as possible and for small trees, a straight sloping, or v-cut should be made using a slasher. When using a power saw for trees up to about 20 cm diameter. One cut from the back is sufficient. For larger trees, cut horizontaly ⅓ depth of tree on the felling direction side, then cut slightly above the first cut level on the opposite side of the tree until the two cuts almost meet and the tree falls.

Scarf is used on bigger trees where necessary.



Cuts for felling larger trees.

16.10 PROTECTION

16.10.1 Fire

Fire risk is high after thinning, as the open stands will be dryer than before thinning, and more intensive protective measures should be taken at this stage.

Fire breaks are important around, larger stands. These should be up to 10 metres wide depending on the danger factor. A wider fire break is advisable when the trees boarder on scrub.

16.10.2 Animals

Opossums can be a problem in some conifers, poplars, willows and eucalypts, especially when the woodlots border on scrub or bush. Extensive damage can lead to death and malformation of young trees.

Hares and rabbits are also a problem causing damage by nipping off the leading shoots of young trees leaving them deformed, or causing retarded growth.

The owner can control these animals himself or approach the Agricultural Pests Distruction Council through any local Authority.

16.11 DISEASE

A fungus, causing Pine needle blight *(Dothistroma pini)* is fairly common, living on the tissue of the pine needles causing them to eventually die and drop off. The disease causes a decided decline in the tree's vigour and seriously hinders the tree's growth, sometimes re-occuring year after year resulting in death. Ideal conditions which encourage the disease are moist, mild climates. The disease is not present in Canterbury or Otago.

Dothistroma can be controlled by aerial spraying.

The Forest Service should be contacted for advice on methods.

Phaeocryptopus (swiss needle-cast fungus) affects Douglas Fir only. It is a wide-spread needle disease particularly apparant in the Central North Island. It can be recognised by the sooty appearance on the underside of the needles and an abnormal needle cast.

Armillaria is a root rot causing death of foliage in both Pines and Douglas Fir although the latter seems slightly less susceptible. The tree may eventually die.

It is usually only a problem in land converted from native bush.

Poplar rust has procluded planting of poplars for timber production, although some clones are only moderately affected in drier climates. It is expected that rust-resistant strains suitable for timber will become available in due course.

16.12 HARVESTING AND SALE

18.12.1 Methods of Sale

The two main options open to the owner are (i) Block sales or (ii) sales of prepared wood.

With block sales, the trees are sold as they stand, which means that the buyer must harvest and transport them to the saw mill or wherever his destination may be. Assessing the value of the timber is done in one of two ways: either (a) lump sum sales or (b) log scaled sales.

(i) Block Sales

(a) Lump sum slae.

An agreement is reached between the owner and buyer specifying details such as the sum, period to fell, and method of payment.

The value of the timber is calculated by multiplying the assessed volume by the unit value.

When using this method of sale it is important to get an accurate assessment of wood value and therefore it would be advisable to seek professional advice. But it is initially up to the buyer to make sure that the quality and quantity of the timber he is buying, is worth the amount he is paying out.

In using this method of sale, the owner cuts down on expenses such as paying for log measurements and can receive all, or part of, the money before logging begins.

(b) Log scaled sale.

This system seems a fairer way of selling, where the actual payment is calculated on the individual measurement of the felled logs.

The disadvantage, is that although the volume is measured accurately, a log scaler needs to be present while logging, to carry this out. Logs may also be measured by weight when truck loads can be put over a weigh-bridge. This is satisfactory providing the seller is satisfied that all output will be accounted for.

(c) Sales of Prepared Wood

By sorting the timber into various qualities and/or preparing it in some way before it goes to the buyer, the owner can ask more money over and above the initial stumpage value of this trees.

Sorting the produce into catagories such as saw-logs, peeler logs, posts, poles and chipwood means the owner can sell the produce individually and will receive more payment for his extra effort, than he would it selling as a stand.

The unit-volume price is agreed on before hand, and payment is based on wood delivered to the point of sale.

It is advisable only when there is a demand for his various wood qualities and when time and expertise are taken in ensuring logging to carried out properly, and the wood is correctly sorted according to size and quality.

(d) Sale by Sawn Output.

This is when the owner is paid for the amount of finished product produced, usually sawn timber. In this way the owner does not have much control over the milling and logging of his wood and so waste is likely.

This method should therefore be avoided unless for some reason, other types of sale are impossible.

16.12.2 Conditions of Sale.

The purpose of drawing up conditions is to protect your interests. Matters to be considered are:

(a) Access - specify access road to avoid damage to farm roads and pasture. A buyer can be requested to construct an access road.

(b) Removal of equipment and cleaning up - It is wise to stipulate the removal and cleaning up of debris. If necessary - burning. A date should be made for this, and fences repaired etc.

(c) Protection of stock and farm poultry

(d) Prevention of erosion

(e) Indemnity - any accident or damage to people or property

(f) Logging waste - buyer does not leave any saleable produce in woodlot.

(g) Dates by which logging must be commenced and wood must be removed.

16.13 ASSESSMENT OF VOLUME

To find the volume of standing trees two measurements must be considered (a) Height and (b) Diameter.

(a) To find average height

The instruments to use are an abney level, a blume leiss or a suuntro hypsometer. These use angles to determine height. It is not necessary to measure each height so take the average height of each diameter class.

(b) To find diameter.

This is measured with a steel diameter tape which has one side in cm and diameter equivilent cm on the other. Standing trees should be measured at breast height which is 1.4 metres above the ground, on uphill side of the tree.

Tree form, sloping ground and litter build-up affect the point at which breast height is measured.

These measurements should be obtained by measuring a sample portion of the trees and the results applied to the crop as a whole. For small stands it may be preferrable to measure all trees.

Sample Plots.

The volume is measured on a number of plots chosen as random throughout the stand. The area covered in sample plots should be not less than 20% for plantations of 2-10 hectares or 10% for plantations of over 10 hectares, and with a minimum of 200 stems in each stand.

The most accurate and simplest method of finding the volume of standing trees is to use the Tree Volume Tables provided by the New Zealand Forest Service. Such tables vary from district to district.

REFERENCES

Selling Produce From Your Plantation.
New Zealand Forest Service. Information series no 76.

Radiata Pine - a basis for selection of trees for pruning and thinning.
New Zealand Forest Service. 4th edition 1976.

Utilisation of Woodlots.
New Zealand Forest Service. Information series no. 20.

Management of Woodlots.
New Zealand Forest Service. Information series no. 19

Forestry Handbook 1977.
New Zealand Institute of Foresters.

Establishing a Woodlot.
New Zealand Forest Service. Information series number 18.

SECTION 17

SOILS AND FERTILIZERS

17. SOILS AND FERTILIZERS

17.1 THE SOILS OF NEW ZEALAND

Soils are formed by the action of environmental factors such as climate, vegetation and topography on rocks and sediments over a period of time. In New Zealand, because of the great diversity of different kinds of rocks and sediments, ranging in age from a few hundred years to hundreds of thousands of years, the soil pattern is very complex. In addition the climate covers a wide range of temperatures from cold alpine to sub-tropical and moisture regimes vary from almost dessert, to continuously wet in the mountains. Forest scrub, tussock and other forms of vegetation as well as varied topography and landform history add to the complexity. Nevertheless there are some broad patterns which have been identified and mapped by soil scientists. These patterns exist because there are broad geographic zones where climate, vegetation, parent material, landform and duration of soil formation are similar.

17.1.1 Zonal Soils

There are five principal zones in New Zealand and the soils associated with them are called ZONAL SOILS. These zonal soils are found on parent materials such as loess, (wind-blown deposits), greywacke etc which are largely made up of silica, feldspar and mica.

Brown-grey earths occur in the dry inland areas of the South Island. The soils are sandy with clayey subsoils, relatively fertile but droughty. *Yellow-grey earths* are widespread from Southland to Hawkes Bay and are formed mainly on loess covered downs and hills under a sub-humid climate. These soils are silty with a dense fragipan and sometimes with a claypan as well in the subsoil. They require small quantities of fertilizers and some need artificial drainage.

Yellow-brown earths are extensive from Southland to North Auckland and up to the snowline on the mountains. They are formed under humid climates where leaching removes soluble products of weathering. These soils require significant quantities of fertilizers to maintain productivity. They are friable, free-draining, silty to loamy textured but clayey versions occur extensively in Northland.

Podzols are formed under forest vegetation under extremely high rainfall; they occur in super-humid regions such as Westland. These soils are acid, very strongly leached and have low fertility. They require large amounts of fertilizer and lime for productive use.

Gley podzols occur mainly on terraces in superhumid regions where soils have become waterlogged after podzolisation. The gley podzols of Westland are extensively leached and have very poor internal drainage. Fertilizer and careful management are required to maintain productivity of these soils.

Over 40% of New Zealand consists of steeplands where the zonal soils occur as part of a complex pattern which includes young soils and fresh slope deposits.

17.1.2 Interazonal Soils

In some parts of the country the soils differ from zonal soils because of the unusual effects of some rocks such as volcanic ash, limestone, and sands on soil formation. These, as well as those soils formed in wet low-lying situations are called INTRAZONAL SOILS.

Yellow-brown pumice (young) and *Yellow-brown loams* (older) are the most extensive of these soils which are formed on volcanic ash in the central North Island. They have loamy, friable, free-draining profiles and contain allophane clays which absorb large quantities of phosphate. Some are deficient in trace elements and low in potassium.

Brown granular loams and clays are a complex group of soils formed on andesitic rocks and occur as small patches from Southland to Northland. Their fertility is highly variable but many are highly productive when nutrient deficiencies are corrected.

Rendzinas are dark fertile soils formed on limestone.

Yellow-brown sands are leached soils on coastal dunes.

Gley soils are poorly drained soils of swamps grading into *peats* in the wettest places.

17.1.3 Azonal Soils

AXONAL SOILS are young soils without well-developed sub-soils, formed in recent floodplains, sand dunes, ash deposits etc.

Recent soils occur on the younger surfaces of valleys and plains. They usually fertile but physical properties, soil moisture and drainage are highly variable.

Regosols occur on fresh sand deposits.

Litholsols on coarse rock waste in the mountains.

Table 1 shows the areas of the main soil groups on flat to rolling, hilly, and steep terrain.

Table 1 Soil Groups in New Zealand.

Common Name	Area (000 hectares)		
	Rolling and Flat	Hill Soils	Related Steepland Soils
ZONAL SOILS	162	41	101
Brown-grey earths			
Yellow grey earths	1,418	405	1,012
- in association with rendzinas	28	20	
- related shallow and stony soils	608		
High country yellow-brown earths	405	405	1,823
Subalpine gley soils and gley podzols		405	911
Southern and central yellow-brown	608	1,823	3,240
earths	57	81	2,734
Southern and central podzolised yellow-brown earths and podzols			
Southern and central gley podzols	304	41	
Northern yellow-brown earths	203	304	203
- in association with rendzinas	20	41	
Northern podzolised yellow-brown earths and podzols	203	122	
INTRAZONAL AND AZONAL SOILS			
Yellow-brown sands	203	16	
Yellow-brown pumice soils	810	810	1,012
Yellow-brown loams	1,215	405	
Brown granular loams and clays, and red brown loams	304	203	405
Organic soils	203		
Gley soils	304		
Recent soils from alluvium	810		
Recent soils from volcanic ash	41	101	203

17.1.4 Mapping

Depending on the scale adopted by the soil surveyor, soil maps can show soil patterns of countries, regions, districts or farms. A country-wide map is useful for showing general trends in soil patterns and will often show a large unbroken area covered by one soil group or type. However, a detailed survey of a small section within such an area would reveal a more complex picture of the soils. Thus most farms have soils of more than one group and these may have quite different fertility and management requirements.

Soil maps are useful for the identification of soils and problem areas and as an aid to decisions regarding land use and land management. The Soil Bureau of the D.S.I.R. is responsible for the surveying and mapping of New Zealand soils.

17.2 ESSENTIAL ELEMENTS

There are 16 elements that are essential for the growth of plants.

They are:

Elements	
Carbon (C) Hydrogen (H) Oxygen (O)	These 3 elements are drawn from the air and water.
Nitrogen (N) Phosphorus (P) Potassium (K)	These 3 major elements are drawn from the soil. Nitrogen in specific instances, is first fixed from the atmosphere by bacteria e.g. in the case of legumes.
Sulphur (s) Calcium (Ca) Magnesium (Mg)	These 3 elements are the secondary elements.
Iron (Fe) Copper (Cu) Zinc (Zn) Manganese (Mn) Boron (B) Chlorine (Cl) Molybdenum (Mo)	These are the trace elements

Growth and yield of crops are determined to a large extent by the nutrient element that is present in the smallest quantity to the plants' requirements.

17.3 SOIL TESTING

The amount of fertilizer required by crops and pastures depends on the ability of the soil to supply the essential plant nutrients. The more that can be supplied to plants from the soil, the less has to be applied as fertilizer. One guide to the ability of the soil to provide nutrients may be obtained from knowledge of previous management and cropping. For instance crops grown during the first season out of a well balanced grass/clover pasture rarely respond to applications of fertilizer nitrogen. However, if cropping is continued in successive years the supply of nitrogen from the soil falls and nitrogen fertilizer requirements increase. Thus, a guide which used knowledge of previous cropping is of limited value.

An alternative and more reliable technique for predicting fertilizer requirements is soils testing. This approach is based on the idea that a laboratory analysis of the soil can provide an INDEX or RATING of the ability of the field soil to release and supply essential plant nutrients.

In order to develop these tests and to make worthwhile predictions it is necessary to establish the relationship between soil test values and the response to fertilizer additions. This is done by carrying out pot tests and field trials in different parts of the country. In this way it is possible to take account of the effects of variations in soils and climate around the country. It must be emphasised, however, that for a variety of reasons, soil tests cannot provide an exact measure of the amount of nutrient available in the soil or the amount of fertilizer required. Rather the index obtained by testing is used as an indicator of the *likelihood of response* to added fertilizer. Thus a low soil test index value would indicate that a response to fertilizer is very unlikely whilst a high soil test index value would indicate that response to fertilizer is unlikely.

The reasons why the values obtained by soil testing require careful interpretation are as follows:

1. The amount of soil analysed is minute compared with the amount in the paddock and there is considerable natural variation even in the soil of one paddock. Thus whilst the test sample is analysed very accurately it may not be truly representative of the whole paddock.

   To overcome this problem several spots are sampled (usually at least 15 sites sampled to a depth of 75 mm using a 25 mm diameter tube) and then bulked together before sending for analysis. When taking samples, areas such as gateways, fertilizer or lime dumps, stock camps etc, must be avoided since they can give very misleading results.

   If a small area within a paddock is of interest then it should be sampled separately.

2. Because the interpretation of the test results are based only on the probability of likelihood of response there are

a small number of soils for which the tests will give the wrong answer. Thus some soils giving a high test index may still show responses to fertilizer and some soils giving a low test index may not.

Continued refinement of the interpretation of soil testing and local knowledge will help to minimise these occurences.

3. The ability of the soil to provide nutrients is only one of a large number of factors which govern crop production. Other factors such as rainfall, temperature sunlight etc. are equally important. Often, for example, a soil test may indicate a likely response to fertilizer. This may occur in one season and not the next. High rainfall, favourable temperatures etc. in the first season may have promoted growth so the crop or pasture needed more available nutrient, but in the next season conditions for growth may have been less favourable so the demand for nutrients was less and no fertilizer response was obtained.

   When interpreting the test values, all production limiting parameters such as climate, disease, insect pests and weed competition must be considered. If any one of these is limiting then it is possible that no growth response will be obtained regardless of the soil test value, and fertilizer use.

Other management policies may be significant when interpreting soil tests. For instance on hill properties with extensive grazing, the marginal cost of fertiliser to produce near maximum yields may well be greater than the value of the extra production. Consequently if soil tests were in the low range, fertilizer may not be applied although the routine recommendation would be to do so. In the reverse situation, the risk of losing production in an intensive cropping system or horticulture may mean that fertilizer may be applied even at high soil test values because the extra yield which may occur in some years is economically justified.

Currently the main soil testing programme available to farmers is through the Ministry of Agriculture and Fisheries Farm Advisory Service. The soil test covers the nutrients phosphorus, potassium, calcium and magnesium and soil pH is also measured.

A soil test for nitrogen presents particular problems and is not included in the routine soil testing service. However, tests are being developed for arable crops such as wheat and maize. One such test for predicting the nitrogen fertilizer requirements of wheat is carried out by the Ravensdown Fertilizer Co-operative Ltd.

17.4 FERTILIZER AND LIME REQUIREMENTS FOR PASTURES IN NEW ZEALAND

17.4.1 North Island

The following section is based on a paper delivered at the 1975 Ruakura Farmers' Conference by C. During and M.B. O'Connor. The paper is entitled "Fertilizers for North Island Sheep and Cattle Farms".

The authors believe that many farmers, particularly those on well-established, well-topdressed properties, use more fertilizer than is necessary. The soils of the North Island can be divided into 3 main groups acording to rainfall and their phosphate retention properties.

Group 1: Mean annual rainfall 750–1 000mm, low-medium P retention.

- occur mainly in Hawke's Bay, Wairarapa and Manawatu.
- classified as Central Yellow Grey Earths, and related intergrades.
- carrying capacity seldom exceeds 17 S.U./ha.

Group 2: Mean annual rainfall 1 000mm–2 000mm high phosphate retention.

- derived from volcanic ash (NOT from recent pumice falls of the Central Plateau.
- occur in Taranaki, King Country 'Mairoa ash', Karaka soils south of Auckland, light friable soils in the Waikato basin.
- have good physical properties, but tend to dry out readily.
- carry more than 20 S.U./ha on well-developed properties.

  NOTE: a sub-group, the volcanic and semi-volcanic soils of North Auckland are inferior to the abovementioned soils, seldom carrying more than 18 S.U./ha.

Group 3: Mean annual rainfail 1 000mm–2 000mm, P retention variable but not high.

- soils derived from mudstones, limestone and sandstones, including greywacke; and the pumice soils of the Central Plateau, Bay of Plenty, Gisborne/Wairoa, peats, North Auckland clay and gumland soils, and the relatively slow-draining soils of the Waikato basin/South Auckland area.

There are two other ways of grouping soils, apart from the rainfall and phosphate retention. The first is the potential yield or carrying capacity of pasture. The potential is affected by physical factors such as slope and moisture. The amount of fertilizers needed to produce any given yield will be lower on the soil with the higher potential; or, inversely, the same yield can be obtained with less fertilizer on the high-producing site.

The second way of grouping soils is on the basis of phosphate status. A site with high status will require less phosphate, other things being equal, than a site with low status.

Recommendations for Fertilizer Application:-

Before discussing the three main soil groupings that were outlined before, there are some important points to note. Carrying capacities are given as stock units (S.U.) per hectare. A S.U. is assumed to consume 600kg dry matter per annum. This is quite a generous conversion ratio found with medium efficient farming. Annual topdressing rates are given as kg P/ha, 12kg P being equivalent to about 125kg superphosphate. The farms on which this study was performed have been topdressed regularly for 10 to 15 years and have passed the initial phase of fertility build-up.

Group 1: The trial results have shown that on these soils, 12kg/ha/ annum can maintain about 16 S.U./ha. Under commercial farming, about 17–18 S.U. will be the top carrying capacity, made possible by the application of about 20–24 kg P/ha/annum. On soils of easy contour, the ratio of 1kg P/annum per 1 S.U. can be used as a rough guide. These soils have relatively good pasture production potential. The soils with physical handicaps such as steep slopes, poor drainage or more than average droughtiness, cannot be expected to reach this potential. This also applies where the farmer is pushing production to maximum limits.

Group 2: Although rates of fertilizer required on these soils are higher than on the soils in Group 1, the amount of phosphate needed may not be high at common stocking rates. At stocking rates of up to 17.5 S.U./ha on soils of easy contour, 24 kg P/ha/annum maintains the soil phosphate level at an acceptable level. This represents a ratio of 1.4kg P/S.U.

After the first 24kg P/ha, the increase in D.M. production to higher rates of application slows down, and peak or near-peak pasture production is usually reached between 48 and 72kg P/ha/annum.

These high rates of P application result in P accumulation in the soil, as the animals do not remove an equivalent amount in their carcasses or to stock-camps, gateways and trees.

The response of pasture on strongly-rolling and hilly land in this soil group to fertilizer application is much different to that on land of easy contour. The ratio of fertilizer input to pasture production is much worse, as pasture production is limited by excessive dryness or shade and by transfer of fertility.

Group 3: Most hill soils in this group produce no more than 8 000 kg D.M./ha/annum and carry no more than 12–13 S.U./ha. Once phosphate fertility has been improved, the carrying capacity can be held by 15–18kg P/ha, a ratio of 1.3kg P/S.U. Most North Auckland clay and gumland soils tend to reach maximum carrying capacity at 16–18 S.U./ha, and 15–16 S.U. requires an annual input of some 24kg P/ha. Note that these figures apply to farms that have been regularly topdressed for some time.

The soils of the Waikato and the Bay of Plenty have good drainage and physical properties, and an estimate of 24kg P/ha/annum supporting 20 S.U. is rather conservative in the light of some production figures of farms in these areas.

Effects of Nil Fertilizer Application:-

The effects of no fertilizer application on the soils of the three main groups was also investigated and reported by During and O'Connor. In Group 1 soils, in Hawke's Bay for example, the omission of topdressing with phosphate for one year has relatively little effect on pasture production, provided the paddocks have been regularly (but not excessively) topdressed in the past. A 5% drop in pasture production was observed.

In Group 2 soils, the loss in production was more significant, with an average of 16% drop. Coupled with a loss of 30–35% in production, this reduction seriously affects animal production, unless the property is grossly understocked. Land that has been newly-broken in suffers the most, as the phosphate build-up is negligible. In soils of this group that have a high soil test level, the fall of pasture production was not appreciable in the first year, but it is rare on sheep and beef farms to have high soil tests in this group of soils.

Group 3 soils, intermediate between groups 1 and 2, have varying responses to omission of P application. On soils with high test levels, the drop in pasture production is very slight. On soils with medium test levels, a drop of about 10% is common, although this varies according to the soil pH and the degree of phosphate retention.

The omission of potassic topdressing on farms that are deficient in potassium will have a much more serious effect than the omission of phosphatic fertilizer. This is due to the low amounts of accumulated potassium compared with phosphorus that is available.

Sulfate applied in superphosphate accumulates in some soils and not in others. Most soils cannot accumulate large amounts of sulfur, and this is only a disadvantage in areas where the mean annual rainfall is high. The gumland soils of North Auckland and the pumice soils of the Central Plateau are prone to sulfur deficiencies, but the problem is only well recognized in the latter situation. During and O'Connor recommend that the gumland soils should be topdressed with elemental sulfur every 12 months, along with sulfur-fortified superphosphate every year.

17.4.2 South Island

This section is based on a paper given at the 1976 Lincoln College Farmers' Conference by T.E. Ludecke, M.J. Batey, and W.H. Risk. The paper is entitled "Maintenance Lime and Fertilizer Requirements for South Island Pastures". The authors agree with Messrs. During and O'Connor that in the past, many farmers in New Zealand have been too keen to topdress their pastures with superphosphate. But in other cases, the application of fertilizer has been insufficient. The problem that the farmers face is how much lime and fertilizer should they apply to their pastures to maintain levels of production. Messrs. Ludecke, Batey and Risk relate their paper to grazed ryegrass and white clover pasture on land that has been developed for 10 years with adequate dressings of fertilizer and lime over that period.

Soil acidity has a large role to play in the production from pastures. There are six main reasons why plants fail on acid soils. These are in order of decreasing importance:

(i) **Deficiencies of Molybdenum** which affect particularly white clover. Mo is the only trace element which becomes more available as the pH rises through the application of lime. Mo deficiencies are likely to occur at a pH of 5.6 and below.

(ii) **Toxicity of Aluminium and Manganese.** The solubility of Al and Mn decreases as the pH drops, and they become more toxic to plants especially white clover. Toxic effects are unlikely at pH's above 5.6.

(iii) **Survival of** *Rhizobium trifolii*, the organism responsible for the nodulation of white clover. This is only a problem when the pH is less than 5.6 the need for lime can be overcome by inoculation and pelleting of the clover seed.

(iv) **Impaired Biological Activity.** At pH's around 6.0 to 6.5, the soil organisms responsible for the breakdown of organic nitrogen, sulfur and phosphorus are at a maximum and hence better grass growth is obtained.

(v) **Impaired Soil Structural Conditions.** The aggregation of sand, silt and clay into good structural aggregates is caused by the production of gums from the decomposition of organic matter. Ryegrass/white clover pastures could fail on acid soils due to poor structural conditions but this is likely to be rare.

(vi) **Deficiencies of Calcium.** These are rare except on extremely acid soils.

The following table shows the low, medium and high pH values, Olsen P, and K values for Ministry of Agriculture and Fisheries soil tests under pasture.

Table 2:

	pH	Olsen 0.5hr Phosphorous	Potassium
Low	less than 5.5	less than 10	less than 3
Medium	5.6 – 6.0	11 – 20	3 – 6
High	greater than 6.0	greater than 21	greater than 7

The authors feel that there is no advantage gained from raising the soil pH above 6.0, and that this pH could be maintained on most soils by an annual topdressing of 2.5 tonnes of lime/hectare every 5 years. This may need to be increased in areas of higher rainfall.

Molybdenum should be used judiciously on all soils. The suggested maintenance dressing is 100g per hectare of sodium molybdate every 3–4 years. Except on soils where the available copper status is very low, these dressings are unlikely to have any deleterious effects on animal health.

As mentioned by During and O'Connor, the phosphate retention capacity of a soil is very important, but cannot be significantly altered by topdressing with phosphatic fertilizers.

P retention values for soils can be easily determined – if you do not know the values for a particular farm, consult the local advisory officer, or D.S.I.R., Soil Bureau Bulletins.

The plant-available phosphate status can be altered by application of fertilizer. The Olsen 0.5 hour test for P status is used by the M.A.F. to give a reliable indication of the phosphate status. The Olsen test values are given in Table 1. With a knowledge of phosphate retention data and the Olsen soil test values, the maintenance superphosphate requirements of pastures can be determined, as shown in Table 2.

Table 3: Maintenance Superphosphate Requirements for Pasture for Near Maximum Pasture Production (kg/ha)

Phosphate Retention Percentage	Phosphorus Status Low	Medium	High
	0 – 10	11 – 20	21 +
Low (0 – 30)	Variable	125	less than 125
Medium (31 – 60)	375	250	125
High (61 – 85)	500	375	190
Very High (86 – 100)	625	440	250

A farm should be soil tested every four years, in the same month it was tested previously. This is particularly important in relation to pH.

White clover growth is limited on many South Island soils by the lack of sulfur especially in soils that are in the early stages of development. No responses to sulfur have been found in many parts of the island that have been regularly topdressed with superphosphate for many years. In every tonne of superphosphate, there are 88kg of phosphorus and 112kg of sulfur.

The form of sulfur in soils that is available to white clover is mineral or inorganic sulfate sulfur. The levels of mineral sulfur in soils increase markedly with increasing soil development, and also with agricultural development, particularly in the top 60cm. The loss of sulfur from soils is very slight; it has been estimated that in grazing systems, the loss is about 10% of that ingested. Messrs. Ludecke, Batey and Risk draw two major implications from their findings. These are:

(i) Increase the use and manufacture of high analysis phosphate fertilizer such as double superphosphate which contain little or no sulfur. This would eliminate considerably the pressure in fertilizer works for acidulation facilities.

(ii) Mixtures of calciphos and superphosphate could be used with considerable monetary savings. Calciphos is calcined or heated C grade Christmas Island phosphate. The C grade rock is unsuitable for the manufacture of superphosphate due to the high sesquioxide content. The calciphos has the disadvantage of having a talc-like texture and thus creating distribution problems. Chemists at the Southland Phosphate Company are confident they have perfected a way of adding calciphos to superphosphate without any chemical reaction and forming a granule which breaks down easily. Trials by M.A.F. have shown that a mixture of 25% calciphos and 75% superphosphate has given responses equal to superphosphate alone.

The amount of potassium in the soil varies with the soil type. There is a lot of 'fixed' potassium (K retained in the structure of the clay colloids) in the drier, colder soils of the South Island derived from greywacke and schist, but there is little 'fixed' potassium in the soils formed in the wetter, warmer areas.

The other forms of K in the soil are exchangeable K on the surfaces of humus and clay colloids, and the K in solution. The soil test currently used for potassium only measures these two types of K. Fixed potassium becomes available to plants slowly. This leads to erroneous soil test results in many parts of Marlborough, Canterbury and Otago where low test values are obtained, and yet there is no response to potassium fertilizers. If potassium is required on grazed pastures, a dressing of 125– 180kg per hectare will be sufficient on the majority of soils and the maintenance dressings will be much less than this. The potassium soil test values are given in Table 1.

SECTION 18

IRRIGATION AND FARM WATER SUPPLY

18. IRRIGATION AND FARM WATER SUPPLY.

18.1 MEASUREMENT.

The unit for depth of irrigation is the millimetre.

1mm (depth) = 1 litre/m^2 = 10 m^3/ha

The speed of application and infiltration should be in millimetres per hour (1 mm/h = 1 litre/m^2/h.)

The units used in farm water supplies are generally cubic metres per hour, litres per hour and litres per second.

18.1.1 Useful Conversions.

The following is a list of conversions useful for farm water supplies and irrigation.

(a) **Volume Rates of Flow**

Cubic metres per hour (m^3/h)	1 m^3/h = 220 gal/h = 3.67 gal/min 1000 gal/h = 4.546 m^3/h
litres per hour (1/h)	1 l/h = 0.22 gal/h 1 gal/h = 4.546 l/h 1 gal/min = 272.765 l/h
Litres per second (l/s)	1 l/s = 0.0353 cubic feet per second (cusec). 1 cusec = 28.32 l/s

(b) **Volume per Area**

litres per hectare (l/ha)	1 l/ha = 0.089 gal/ac = 0.72 pint/ac 1 gal/ac = 11.234 l/ha 1 pint/ac = 1.404 l/ha 1 fl oz/ac = 70.2 ml/ha

18.1.2 Commonly Used Units for Farm Water Supply Projects.

Quantity	Unit	Symbol	Typical Application
Volume	cubic metre	m^3	Storage capacity of farm dams, excavated tanks. Volumes of earthwork, concrete and solids generally.
	litre	l	Fluid volume, volumes of small tanks, pressure vessels, fluid containers generally.
Velocity	kilometre per hour	km/h	Vehicular speeds, wind speeds.
	metre per second	m/s	Stream flow velocity, velocity in pipes, drains, channels.
Volumetric flow rate	cubic metre per second	m^3/s	Flow rates in large pipes, channels, streams, drains.
	litre per second	l/s	Flow rates in pipes, bores, pumping rates.
	millilitre per second	ml/s	Flow rates for trickle irrigation outlets.
Mass	tonne	t	Mass of large quantities of materials.
	kilogram	kg	Mass of quantities of materials generally
Pressure	kilopascal	kPa	Water and air pressure, sprinkler nozzle ratings.
Power	kilowatt	kW	Power of engines, pumps, electric motors, tractors.
Density	kilogram per cubic metre	kg/m^3	Mass per unit volume of materials such as concrete, earth, clay.
Rate of consumption of water	cubic metre per day	m^3/day	Irrigation draft from dams, bores, rivers. Stock draft at excavated tanks.
	litre per day	l/day	Water consumption per person or per head of cattle or sheep.
Linear Dimensions	kilometre	km	Stream lengths, catchment area lengths, large distances generally.
	metre	m	Pipe and channel lengths, reservoir and well depths, hydraulic head.
	millimetre	mm	Pipe diameters, depth of irrigation applied, rainfall, runoff, evaporation, thickness of materials, small dimensions generally.
Area	hectare	ha	Areas of land, catchment areas for small dams, ponded areas.
	square metre	m^2	Cross sectional area of channels, large pipes, embankments.
	square millimetre	mm^2	Cross sectional areas of small pipes, steel sections.

18.1.3 Metric-Imperial Equivalents

The units shown are those most commonly applied to Farm Water Supply projects, together with equivalents in metric and imperial units.

Quantity	Metric Unit	Symbol	Equivalents
Long distances	kilometre	km	1 km = 1 000m = 0.62 miles
Dimensions generally, hydraulic head	metre	m	1 m = 3.280 8ft. = 1 000 mm 1 m head = 3.280 8 ft head. = 9.8 kPa = 1.42 lb/in^2
Small dimensions, rainfall run-off, irrigation applied	millimetre	mm	25.4 mm = 1 inch (1 mm water applied to 1 hectare = 10 m^3)
Large areas	hectare	ha	1 ha = 2.47 acres
Small areas	square metre	m^2	1 m^2 = 0.0001 ha = 10.76 ft^2
Volumes – Earthwork, concrete, water storage	cubic metre	m^3	1 m^3 = 35.3 ft.^{3} = 1.31 yd.^{3} (1 234 m^3 = 1 acre foot)
Fluid volumes, small containers for fluids	litre	l	1 l = 0.001 m^3 = 0.22 gallons
Water pressure, air pressure	kilopascal	kPa	1kPa = 0.145 lb/in^2 = 0.102 m head
Power	kilowatt	kW	1 kW = 0.746 Horsepower
Flows in drains, channel streams, very large pipe	cubic metre per second	m^3/s	1 m^3 = 1 cumec = 35.3 ft ^{3}/s (cusec) = 2.91 ac. ft. per hour = 13 197 gallons per minute
Flow in pipes, pump rate	litre per second	l/s	1 l/s = 13.2 gallons per min. = 791 gallons per hour

18.2 WATER REQUIREMENTS

18.2.1 Average Rates of Demand

Average consumption figures may be used as a basis for preliminary planning. They may also be used to calculate time patterns of demand for the design of minor storages, provided that these time patterns are computed for the appropriate critical storage period.

18.2.2 Peak Rates of Demand

Peak consumption figures should be used for the design of pumps, distribution systems, and spray irrigation layouts. They should not be used for storage design, except in the case of trickle-inflow storages for irrigation use.

18.2.3 Quantity and Time Patterns

In storage design, the use of average consumption figures for estimating reservoir demand may lead to under-design, particularly if the critical storage period is more than one year and includes two summers. A quantity-and-time pattern of demand must therefore be calculated. This is particularly important in the design of major irrigation storages, for which a detailed monthly analysis of irrigation requirements over a critical storage period of known severity is essential.

18.3 AVERAGE AND PEAK WATER REQUIREMENTS FOR FARM WATER SUPPLY.

18.3.1 Average Daily Stock Water Requirements.

Investigations carried out in Britain and U.S.A. have resulted in the publication of observed rates of water consumption by livestock. Because of the nature of the factors influencing stock water consumption, there exists quite a divergence of opinion on this matter. The following figures are put forward as a reasonable basis for design.

	Litres/head/day
Dairy cattle, in lactation	70
dry	45
Beef cattle	45
Calves	25
Horses, working	55
grazing	35
Sheep, dry pastures	7
irrigated pastures	3½
Lambs, dry pasture	2
irrigated pastures	1
Sows	25
Pigs	11
Poultry, per 100 birds per day	30
Turkeys, per 100 bird per day	55

18.3.2 Average Daily Domestic Consumption

The following figures are suggested as reasonable.

Household use including Septic system	180 litres per person per day
Household use excluding Septic system	135 litres per person per day

18.3.3 Average Daily Garden Consumption

(To be used for the design of pumping and reticulation equipment)

Lawns and gardens for the growing of flowers, fruit and vegetables are an essential part of every farm homestead and require much larger quantities of water than are used in the house.

The quantity of water used each day on the house garden can be obtained by relating the consumption to the evapotranspiration as given in the expression C = 8000 Et

Where C = consumption in litres per day per hectare
Et = Daily evapotranspiration for pasture in millimetres for the month of January.

In deriving this relationship it was assumed that the quantity of water used on the average house garden would be only 60 per cent of the evapotranspiration for completely vegetated surfaces having a plentiful supply of water.

In view of the quantity of water used on a house garden it is most essential that the area of the garden that is actually watered be carefully measured.

18.3.4 Average Consumption on General Farming Activities.

Water, in addition to being required for household and stock purposes, must also be provided for other farming activities. It is required in the dairy for the cleansing of equipment and the washing down of bails; in the piggery for washing down purposes; on the fruit farm for spraying; and on the grazing property for dipping purposes.

It should also be provided for use when required as a protection against fire. This important aspect is generally neglected and there is no doubt that if satisfactory supplies had been available, much of the loss in human lives, stock and farm buildings that has occurred from time to time could have been averted.

The quantities of water given below are suggested as being suitable for carrying out the above farming activities –

(i) **Dairy:** Cooling, cleansing of equipment and washing down of bails and other areas – 70 litres per head per day.

(ii) **Piggery:** Washing down of pens – 1500 litres per day per 100 sq.m of area to be cleaned.

(iii) **Sheep Dip:** The quantity used varies with the method of dipping and is generally carried out once a year.

Spray Dip – 1.6 litres per sheep for sheep 2 weeks off shears.
– 2.5 litres per sheep for sheep 2 to 6 weeks off shears.
– 5 to 7 litres per sheep for sheep over 6 weeks off shears (capacity of sump 1000 to 2000 litres)

Plunge Dip– Because of the greater wastage the above figures should be increased by 25 to 50 per cent (capacity of average dip 5000 to 7500 litres)

(iv) **Insecticide Spraying:** Citrus – 18 litres per tree 4 to 5 times a year (average size of spraying vat 350 to 550 litres)

Other fruit – 9 – 14 litres per tree 8 to 12 times a year (average size of spraying vat 350 to 550 litres)

(v) **Fire Fighting:** 1200 litres per 10 m^2 of buildings

18.3.5 Long Term Demands in Domestic and Stock Supplies.

The source of supply for a stock and domestic scheme will be either a permanent watercourse, a well, a bore or a dam. Where the supply comes from a dam there must be sufficient capacity to meet the stock and domestic requirements for the longest period between replenishment from surface runoff. For most of New Zealand it can be assumed that the dam will be replenished once a year.

The average daily consumption of water in the house is more or less constant throughout this period, as is to a certain extent, the consumption of water in general farming activities. Consumption of water by livestock will vary to some extent because of changes in climatic conditions and the ages of the animals. It is suggested therefore that the long term requirements for stock be determined on the basis that the daily consumption for the period between replenishments is 75 to 80 per cent of the average daily requirements in the case of sheep and 80 to 85 per cent in the case of other stock.

The quantity of water used on the house garden over any period extending beyond several months and in different localities varies between wide limits. A greatly exaggerated figure is obtained for the long term demand if the total consumption for the period between replenishments is based solely on an average daily consumption.

It is considered therefore that the actual quantity of water needed to produce satisfactory growth of the garden during this period should be determined having regard to location and rainfall and this can be done by using the expression –

$$C = 10000\ (0.8\ Et - R)$$

where C = total consumption in litres per hectare

Et = monthly evapotranspiration for pasture in millimeters for each month of the growing season.

R = Three quarters of the sum of the average monthly rainfall for the particular locality and growing season.

18.3.6 Storage Provision of Tanks and Dams Filled by Pumping or Gravity From a Source of Supply.

(i) For windmill operated pumps, three to five days

(ii) For pumps operated by other forms of power, the storage to be provided in case of breakdown depends mainly on the interruption that the breakdown will cause to stock watering. If other water supplies are available and stock can be moved to these supplies without great inconvenience then no storage is necessary. On the other hand if no alternative supply exists, at least two days supply should be kept in storage. This storage should be isolated from the main supply as often the breakdown is not noticed until all storage in the system is used and the troughs are dry.

18.3.7 Pumping Rates for Filling Storages from Supply

To determine the pumping rate to replenish a storage tank or dam, consideration should be given to:

(i) Type of pumping equipment to be used;

(ii) Nature of the supply, especially where withdrawal rates could approach low flows;

(iii) Accessibility of pumping equipment;

(iv) Possibility of using off-peak power at special rates.

The following points are listed for design purposes and as a general guide.

(i) For trunk mains to storage reservoirs, tanks etc. by power driven pump, discharge rate to be based upon filling storage in approximately 12 hours. However, in the case of an electrically operated pump and a large storage tank there is no reason why a pumping period of 24 hours cannot be used.

(ii) For trunk mains to storage reservoirs, tanks etc. by windmill driven pump.

Min. discharge litre/hour = 1/10 to 1/8 total daily demand in litres depending upon make of mill.

18.3.8 Maximum Rates of Consumption for Domestic and Stock Purposes.

(i) Household Supplies

To calculate the maximum flow rate to a house it is first necessary to list all the outlet points in the house and then to make a rational estimation of how many of these points are likely to be used simultaneously during peak periods.

The discharges of various outlet points within a household are as follows:

Shower, bath, laundry	14 litres/min
Toilet cistern	7 litres/min
Kitchen sink	11 litres/min

For example in a household of two adults and two children it would be reasonable to assume that around tea time the shower, kitchen sink and toilet cistern could be in use simultaneously hence the total flow would be

Shower	14 litres/min
Toilet	7 litres/min
Kitchen sink	11 litres/min
	32 litres/min

(ii) Stock Supplies

The lack of definite information on stock drinking habits makes any estimate of peak rate of demand to stock supply points open to argument.

It is suggested that peak demands be determined on the basis that the average daily consumption is used on a period 3 to 4 hours in case of set stocking in large area paddocks and 10–12 hours for intensive stocking on small sub-division paddocks.

(iii) General Farm Supplies

Suggested values for the maximum rates at which water will be used in general farming activities are outlined below:

(a) Dairy – cleansing	11 litres/min per outlet
washing down	14 litres/min per outlet
(b) Piggery	14 litres/min per outlet
(c) Insecticide spraying	70 to 90 litres/min into the spraying vat or at such a rate that this can be filled in a period of 5 to 7 minutes
(d) Fire fighting	100 to 150 litres/min at a head of 25 to 35 m.

(iv) Garden Supplies

The maximum rate at which water is used on a house garden depends mainly upon the size of the garden. Most house gardens today are watered by garden sprinkler. A normal garden sprinkler on a 13 mm garden hose has a flow rate of approximately 15 litres/min. For a very large garden it may be necessary to operate two sprinklers simultaneously, hence the required flow rate would then be 30 litres/min.

18.4 FACTORS INFLUENCING COST OF IRRIGATION SYSTEM

(i) The soil type and depth.
(ii) The crop to be grown.
(iii) The shape and dimensions of the area to be irrigated.

(iv) The distance from the water source to the edge of the irrigated area.
(v) The maximum height of the area above the level of the water source.
(vi) The topography of the irrigated area.
(vii) The existence of any restriction on daily pumping time.
(viii) The availability of electricity.

18.5 ESTABLISHING THE WATERING CYCLE

In establishing the watering cycle, several factors must first be accounted for:

(i) The frequency of irrigation
(ii) Maximum net application (millimetres)
(iii) Efficiency of application
(iv) Application rate

18.5.1 Frequency of Irrigation

The frequency of irrigation is the maximum interval between irrigations under peak crop requirements for the crop and soil type under consideration, assuming that no natural precipitation occurs in that interval. If the irrigation plant is adequate to cope with this situation, it should be more than adequate to cope with crop requirements at all other stages.

Frequency of irrigation is obtained by dividing the net available water in the crop root zone by the peak daily water usuage of the crop. To allow for a safety margin, approximately 70 to 80 per cent of this time is taken as the maximum cycle under peak conditions.

18.5.2 Net Available Water

This ranges from 40 to 60 per cent of the total available moisture, the higher figure in general applying to the light soils. The figure normally used is 50 per cent.

18.5.3 Total Available Water

This is obtained by multiplying the total available water per metre of soil by the depth of the effective root zone.

18.5.4 Total Available Water per metre of Soil

A table of total available water capacities per decimetre of soil for various typical irrigation soil types is given. These figures are for soils of uniform texture throughout the effective root zone of the crop being considered. No allowance is made for the presence of a permanent or perched water table within this root zone.

18.6 SPRINKLER IRRIGATION DESIGN DATA

18.6.1 Mean Available Water-Holding Capacities of Soils of Various Textural Classes

Table 1

	Water available	
	Up to 0.3 metre (12in)	Below 0.3 metre
Soil Texture	Millimetres per decimetre	Millimetres per decimetre
Sand	150	50
Loamy Sand	180	110
Sandy Loam	230	150
Fine Sandy Loam	220	150
Silt Loam	220	150
Clay Loam	180	110
Clay	175	110
Peat	200 to 250	At least 200 to 250

NOTE 1 – Before Table 1 is applied to the soils of an area a sufficient number of earth auger test holes shall be put down to determine variations in the depth and textural class of the soil within the effective crop root depth.

NOTE 2 – Where detailed determinations of the water-holding capacities of soils have been made, the values so obtained shall be used in place of Table 1.

Where no determinations have been made but the classification of the soil to be irrigated is known in terms of the main soil groups defined by the New Zealand Soil Bureau, the available water-holding capacity of the soil may be predicted from the known properties of these groups rather than from Table 1. Mean values of measured available water-holding capacities for several of these soil groups are set out in Table 2, including soils formed on volcanic ash, pumice or basalt.

18.6.2 Mean Available Water-Holding Capacities of Soil Groups in New Zealand

Table 2

Soil Group	Water available Millimetres per decimetre depth soil — Depth from surface: Up to 0.3m	Below 0.3m
Northern Yellow brown earths	17.5	11
North podzols and podzolized soils	22	9
Brown loams on basalt	13	7.5
Brown Granular clays (North Auckland)	17.5	15
Brown Granular loams (South Auckland)	16	7.5
Yellow brown loams	20	12
Yellow brown pumice soils	26	22
Central and Southern yellow brown earths	20	11
Yellow grey earths	22	11
Brown grey earths	18	
Organic soils (peat)	20 to 25	At least 20 to 25

18.6.3 A Guide to Soil Textures

(i) **Coarse Sand.** Many of the individual grains are 2mm in diameter or larger and can be easily seen and felt. When moist, the cast crumbles easily.

(ii) **Sand.** This is similar to a coarse sand in texture and appearance, except that the individual grains are much smaller.

(iii) **Sandy loam.** The individual sand grains can be seen and felt but the silt and clay content is sufficient to give some stability to a cast made from the moist soil.

(iv) **Fine sandy loam.** This is intermediate in texture and appearance between a sandy loam and a loam.

(v) **Loam.** This contains sand, silt and clay in such proportions that none of the fractions is easily distinguished by sight or feel. The dry soil slips easily through the fingers, but the moist soil feels smooth (not sticky) and a cast can be handled quite freely without breaking.

(vi) **Sandy clay loam.** When dry, a clay loam is inclined to be cloddy unless the organic matter is high. When moist, it is slightly sticky and a thin ribbon, formed under pressure between the fingers, breaks easily. The cast of moist soil is quite stable.

(vii) **Light clay.** This is intermediate between a clay loam and a clay.

(viii) **Clay.** Clay soils are usually lumpy when dry and sticky when wet. A thin ribbon of moist soil is quite flexible and can frequently be bent into a circle without breaking.

18.6.4 Crop Root Zone

Crop root zone is the depth of soil which contains the bulk of the roots (80 to 90 per cent) of a crop. The table that follows is a guide to these depths for some selected crops and while the roots of some may be traced to much greater depths, the contribution made by the deeper roots to the plant's water requirements may be neglected.

Table 3
EFFECTIVE CROP ROOT DEPTHS UNDER IRRIGATION

Crop	Root depth Metres	Crop	Root depth Metres
Vegetables		**Fruit Crops**	
Asparagus	1.83	Apples	.76–1.22
Beans	.46–.61	Apricots	.61–1.37
Beetroot	.31–.46	Berry Fruits	.31–.76
Broccoli	.46–.61	Cherries	.76–1.22
Brussels sprouts	.46–.61	Chinese gooseberries	.31–.46
Cabbages	.46–.61	Citrus	.61–1.22
Carrots	.46–.61	Grapes	.46–.91
Cauliflowers	.46–.61	Passion fruit	.31–.46
Celery	.61	Peaches	.61–1.22
Cucumbers	.46–.61	Pears	.61–1.22
Globe artichokes	.61–.91	Plums	.76
Lettuces	.15–.46	Strawberries	.31–.46
Onions	.31		
Parsnips	.62–.91	**Field Crops**	
Peas	.46–.61	Barley	.91–1.1
Potatoes	.61–.91	Lucerne	1.22–1.83
Potatoes (sweet)	.61–.91	Maize	.61–.91
Pumpkins	.91–1.22	Oats	.61–.76
Radish	.31	Rice – sprinkler irrigated	.61.91
Rock melons or canteloups	.61	Sorghum (grain & sweet)	.61–.91
Spinach (silver beet)	.46–.61	Tobacco	.61–1.22
Squash	.61–.91	Wheat	.76–1.1
Swedes	.61–.91		
Sweet Corn	.61–.91	**Pasture and fodder crops**	
Tomatoes	.61–1.22	Choumoellier	.46–.61
Turnips (white)	.31–.61	Fodder beet	.46–.61
Water melons	.61–.91	Lucerne	1.22–1.83
		Millett – fodder	.31–.61
		Pastures – annual	.31–.76
		Pastures – perennial	.31–.76
		Rape	.46–.61
		Sorghum alum	.91–.122

18.6.5 Maximum Net Application

Maximum net application is the amount of water required to replace that removed from the soil by the crop under peak water conditions during the irrigation cycle.

In quantity, it is equivalent to the net available water.

18.6.6 Efficiency of Application

For sprinkler irrigation systems, efficiencies within the range 80 to 90 per cent can be achieved with good equipment correctly used.

For high temperature, low humidity and moderate wind conditions (2.2–4.4 km/h), the figure of 80 per cent should be used. For low temperature,high humidity and light wind conditions (less than 2.2 km/h), the figure of 90 per cent should be used. Efficiency of sprinkler systems should be estimated for the peak use period.

For surface irrigation, lower efficiencies of application may fall as low as 60 per cent. For heavier (finer textured) soils, it is possible to achieve efficiencies of the order of 70 to 80 per cent.

EFFICIENCY OF APPLICATION FOR VARIOUS IRRIGATION METHODS

Method of Application	Application Efficiency %
Spray –	
(i) Night watering	90
(ii) Average day watering	80
(iii) Day watering in hot, windy weather	60
Control flooding –	
(i) Border check	75
(ii) Border ditch.	70
(iii) Contour check	75
Semi-controlled flooding –	
(i) Contour ditch	60
(ii) Keyline system	65
(iii) Wild flooding, little or no land preparation and no spreader banks	50

18.6.7 Application Rate

Application rate should be varied according to the infiltration rate of the soil, the average slope of the irrigated area, the degree of plant cover, the soil surface phenomena and the total application.

For spray irrigation systems, application rate determines the time necessary to apply the required depth of water. This in turn, will govern the interval between shifts and thus the number of shifts possible per day. The greater the daily pumping time that can be utilized, the smaller the discharge rate required from a pumping unit for a particular gross apllication area and irrigation cycle. Therefore, wherever it is suitable, select the rate which will require the highest possible daily pumping time, but which still allows two shifts to be made per day. For medium pressure systems, rates from 6 to 20mm per hour are normally recommended. The rate used should not exceed the maximum rates specified in Table 4.

Table 4

ESTIMATED MAXIMUM WATER APPLICATION RATES FOR DESIGN

Soil groups based on texture and profile	Slopes* 0-8°	Slopes* 9°-12½°	Slopes* over12½°
	mm per hr	mm per hr	mm per hr
Sands and light sandy loams uniform in texture to 6ft (1.82m) pumice	31.8	25.4	20.3
Sandy loams to 2ft (.61m) overlaying a heavier subsoil	20.3	16.5	12.7
Medium loams to sandy clays over a heavier subsoil	16.5	12.7	10.2
Clay loams over a clay subsoil	12.7	10.2	7.6
Silt loams and silt clays	10.2	7.6	5.1
Clays	6.4	5.1	3.8
Peat	16.5		

* 0–8° – level to undulating.
** 9°–12½° slope – undulating to low hills
*** Over 12½° slope – low to steep hills.

NOTE 1 – The above figures are intended for guidance only. Where detailed soil surveys and infiltration experiments have been carried out, or where reliable application rate data are available for a similar soil, the figures so established for application rates shall be used.

NOTE 2 – For bare cultivation such as undertree watering of orchards and watering of vegetables, the above rates shall be reduced by up to 50 percent (to avoid soil loss or damage to structure).

NOTE 3 – Lighter application rates shall be used when pastures and crops are being established.

For flood irrigation, the amount applied per watering, rather than application rate, will determine the area which can be watered in the irrigation cycle from a given water supply or with a given size of pumping plant. This is because infiltration rates are relatively high in the initial stages of application, but as watering continues, a more or less steady, much lower, rate of infiltration occurs. Thus for a particular soil, it may take 1 hour to apply 25mm but 3 or 4 hours to apply 50mm.

18.7 TRICKLE IRRIGATION

It is a simple, efficient method of delivering water to plants. Permanent drops such as berryfruit, fruit and ornamental trees are most suited to trickle irrigation.

Advantages:

(i) Low cost of installation, maintenance and materials;
(ii) Low labour imput in operation functioning;
(iii) Foliage and fruit are not continually wet - plant disease not such a risk;
(iv) Efficient use of water provided management is correct. Able to maintain a high degree of control on water application. Water stress should not be experienced;
(v) Generally lower pressures are required, and a smaller water source may be used;
(vi) Little hindrance to normal horticultural activities;
(vii) Evidence from overseas indicates better yields and an improved standard of saleable products.

Disadvantages:

(i) Filtration may be difficult in some areas;
(ii) Unable to be used for frost protection as sprinkler is;
(iii) Overwatering may occur unless system is carefully regulated.

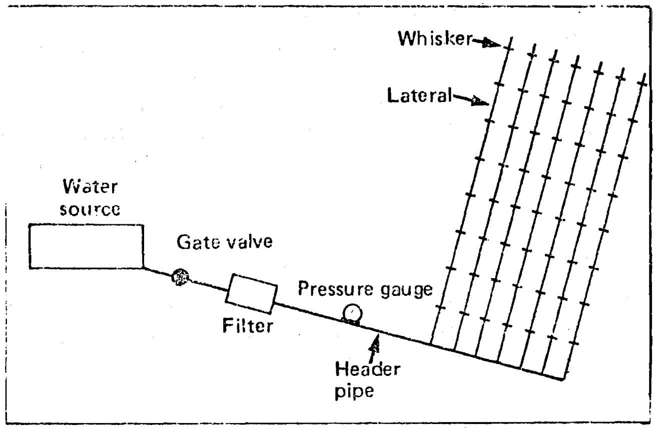
18.7.1 Water Sources

Almost any is suitable for trickle irrigation as the system works on lower flow rates than conventional. The pressure frequently required may vary from 1-40 m head (10-400 kPa) although 6-12 m head (60-120 kPa) is recommended).

18.7.2 Components

Filtration: Water analysis is essential to test total solids, hardness, phosphate and iron in the water. Can be arranged by M.A.F.

Blockages occur easily in small microtubes and suibable filters should be incorporated. Microtube and drippers have small



: Basic components of trickle irrigation.

holes to control water flow which tends to block up. When pumping from a dam, site the pump intake well clear of the bottom yet fairly deep to avoid weed and algae.

Minimum filtration would be in a line strainer of B.S. 100 mesh (150 microns), for algae B.S. 50 mesh (300 microns), filter before B.S. 100 mesh filter.

The element must pass the required flow and the filter body able to withstand the operating pressures. Use a stainless steel element which clogs from the outside.

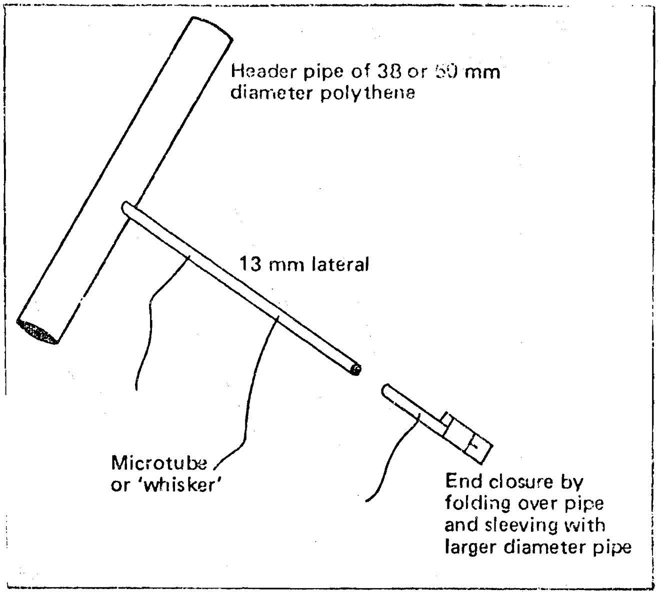
Fit a pressure gauge each side of the filter. Any significant drop in pressure indicates the filter is blocked. All gauges used should be 0-250 kPa range. Mount the gauges side by side so the pressure difference can be seen at a glance. Gauges are turned on only when being read.

Gravel-sand filters are used where suspended solids or iron particules must be removed. Screen or ceramic filters are suitable for reasonable quality water and relatively cheap.

18.7.3 Pipes

Each system - own design. Components used:- header pipes, laterals, and outlets.

Sub-main or header pipes are usually 38-50 mm commercial grade, low density, polythene pipes; but smaller dimensions are suitable in some circumstances. P.V.C. header pipes may also be used. Laterals - thin walled polythene pipes 10, 13, or 16 mm in diameter. They are normally laid out on top of the ground so 'whiskers" can be easily checked.

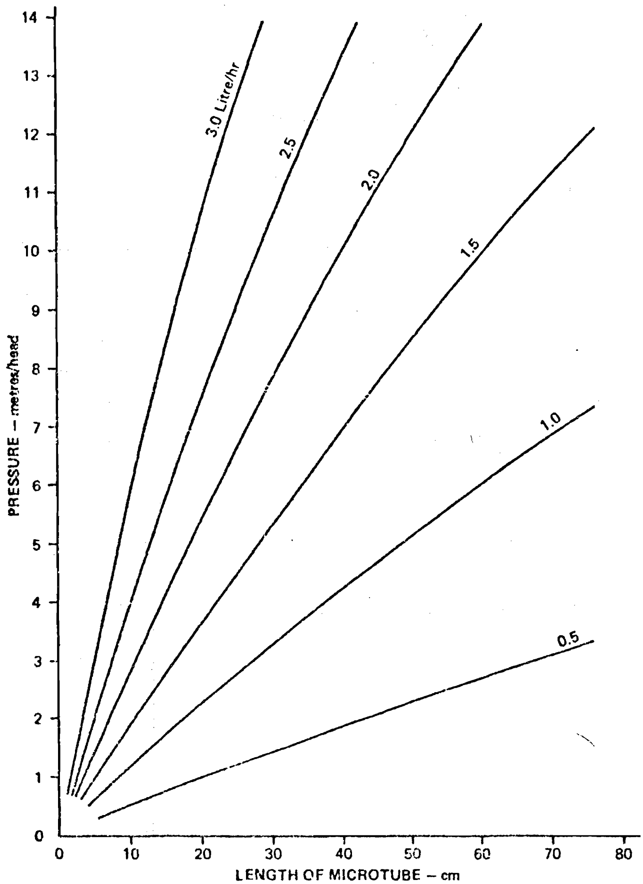


Microtube layout.

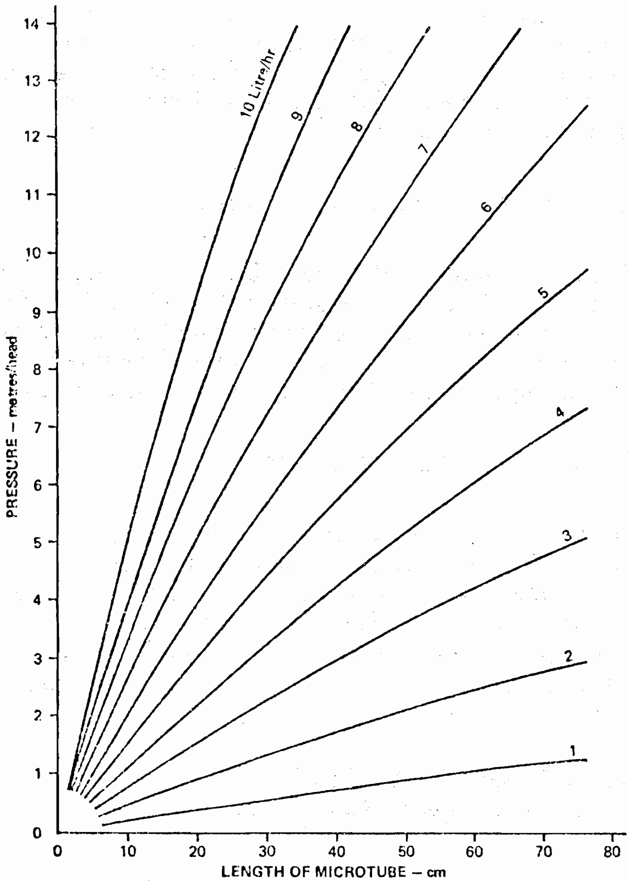
Commonly used microtubes or whiskers sizes re 0.5 and 0.9 mm.

Microtubes are installed as the last step of the system.

Pressure/discharge/length curves of 0.54 mm diameter microtube.



Pressure/discharge/length curves for 0.89 mm diameter microtube.



18.7.4 Watering Rate

The actual rate varies according to climate and the physical properties of the soil and the property layout. For berry fruits and small shrubs 1 litre/hour is often adequate and for larger trees and shrubs 4.5 litres/hour.

18.7.5 Water Distribution

Trickle irrigation in New Zealand is supplementary to natural rainfall, therefore, distribution to the rooting zone is not as important. However, as much of the rooting area as possible should be watered and the number of whiskers used depends on plant size and soil type.

18.7.6 Daily Water Requirements

Total daily water intake depends on plant size, and the level of evapotranspiration. Approximately 3.5 litres/m^2 of foliage/day is the peak water requirement during December, January and February. For example, a tree 14 m^2 will require 49 litres/day as a peak requirement. These figures are an approximate guide.

18.7.8 Fertiliser Requirements

Often extra growth due to a response to water in plants needs extra fertiliser. It may be essential through lack of rainfall to apply fertiliser through the system. They are most efficient applied in a soluable form to prevent blockages.
It is strongly recommended that expert advice is obtained before installing a trickle irrigation in a commercial scheme greater than 2.3 ha.

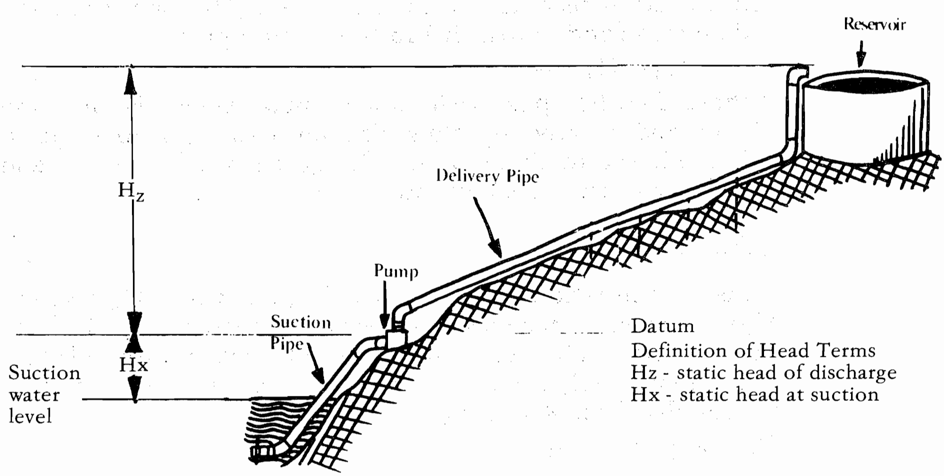
18.8 PUMP CHARACTERISTICS

18.8.1 Pump Total Head, H_T

Various terms are used to describe the pressure output for a particular pump. The correct term is pump **total head (H_T)** which is 'the head imparted to the liquid by the pump'. '**Head**' is pressure expressed in terms of the vertical height (in metres) of a water column which will give rise to an equivalent pressure:

1 m head water = 9.81 kPa

Diagram Portraying Various Definitions



Pump total head is the difference between the total head at the discharge flange (H_D) of the pump and the total head at the suction flange (H_S).

$$H_T = H_D - H_S$$

Total suction head (H_S) may be positive or negative. If a datum is taken through the centreline of the pump (refer to diagram), then if H_S is below this datum, H_S is negative, and if above will be positive.

Total discharge head H_D is the sum of the following terms:

(i) Static head H_Z: this is the vertical height above the datum to the point of discharge (see diagram);

(ii) Friction head h_L: this is the loss in pressure, between the pump and point of discharge, due to friction in pipes and fittings at a particular flow rate(Q);

(iii) Velocity head (H_V) : this is pressure expressed in terms of the velocity (v) of the water ($H_V = V^2/2g$);

(iv) Residual head (H_R) : this is the gauge pressure required at the point of discharge. It may be the head required to operate a device such as a sprinkler or nozzle or trough valve.

In summary:

$$H_D = H_Z + h_L + H_V + H_R$$

Very often H_V is small and can be ignored.

Total suction head; H_S., is the static head (H_X) on the suction side minus friction loss (h_S) in the suction pipe.

$$H_S = H_X - h_S$$

Where H_X will be positive if the suction water level is above the datum and negative if below. Friction loss, h_S, is loss due to friction in the suction pipe and fittings such as foot valves and bends. hs is often insignificant.

Example:

Consider a situation as in the above diagram, where $H_Z = 30$ m, $H_X = 2.5$ m. Requires a residual head at the reservoir (H_R) of 1.5 m to operate a valve. The flow rate is 120 litres/minute and pipe size is 40 mm polythene, the length of pipe is 400 m. Suction is 50 mm diameter, 4 m long.

Discharge head H_D

(i) $H_Z = 30$ m

(ii) Friction head - from polythene pipe friction loss curves, friction loss of 120 litres/minute is 9 m/100 m. Equivalent length for fitting is 6 m thus:

$$h_L = 9 \times 4.06$$
$$= 36.5 \text{ m}$$

(iii) Velocity head - velocity at 120 litres/minute in 40 mm pipe = 1.8 m/second.

$$V^2/2g = 1.8^2/2 \times 9.8 = 0.16 \text{ m - ignore}$$

(iv) $H_R = 1.5$ m

Therefore: $H_D = H_Z + h_L + H_R$

$$30 + 36.5 + 1.5$$
$$= 68 \text{ m}$$

Suction head: H_S

$H_X = -2.5$ i.e., is negative

From pipe chart

hs = .08 m

$H_S = H_X - h_S$

$= -2.58$ m (say -2.6 m)

Pump total head $H_T = H_D - H_S$

$H_T = 70.6$ m

18.8.2 Pump Discharge, Q

Pump discharge is the flow rate of water from the pump outlet and is expressed as volumn per unit times, e.g. m^3/hour, litres/sec., litres/minute.

The flow rate required will depend on the purpose of the pump system.

18.8.3 Water Power (W.P.)

The water power output from a pump can be expressed in terms of the pump total head, H_T, and pump discharge, Q as in the following equation:

$$W.P. = K \times Q \times H_T$$

Where K is a constant which depends on the density of water and the units of Q, P and W.P. If water density is taken as 1000 kg/m^3 then the value of K will be as follows:

	Units of		Value of K
W.P.	Q	H	
kW	cumec	m	9.81
W	l/sec	m	9.81
W	m^3/hr	m	2.72
W	l/min	m	0.16

Where kW is kilo Watts
W is Watts
cumec is m^3 per sec
l is litres
m is metres

Example:
In the previous example
H_T = 70.6 m
Q = 120 l/minute

Therefore:

W.P. = 0.16 x 70.6 x 120
= 1346 Watts
= 1.36 kW

18.8.4 Pump Efficiency

The power delivered by an electric motor or engine to the shaft of a pump is known as the brake power (P_b). Pump efficiency is the ratio of the water output (W.P.) from the pump to the brake power P_b or power input to the pump.

$$\text{Efficiency \%} = \frac{W.P.}{P_b} \times 100$$

Therefore, if efficiency and W.P. is known, then P_b can be estimated by rearranging the above question, i.e.:

$$P_b = \frac{W.P. \times 100}{\text{Efficiency \%}}$$

If, as in the previous example, W.P. is 1.36 kW and efficiency is say 65% (which is common for a centrifugal pump) then,

$$P_b = \frac{1.35 \times 100}{65} = 2.1 \text{ kW}$$

The pump's efficiency, for a given duty, (duty being the head and discharge) should be available from the pump's manufacturer.

For a pump powered with an electric motor, the power consumed by the electric motor and hence the running cost, can be estimated if the efficiency of the electric motor is known. If, in the example, electric motor efficiency is 85%, and motor is directly couple to the pumping (i.e., coupling efficiency 100%), the power consumed by the electric motor will be:

$$\frac{2.1}{85} \times 100 = 2.5 \text{ kW}$$

18.8.5 Suction Capacity

All pumps have a limited suction capacity, and this capacity should be specified by the manufacturer. The maximum theoretical vertical life a pump can achieve is 10m, however, in actual practice problems such as cavitation and reduced performances arise if pumps are subjected to lifts greater than about 6 m.

18.8.6 Pump Selection

There are various types of pumps designed to perform specific functions. Most commonly used for farm water supply and irrigation are:

(i) Positive displacement pumps

(i) piston pump

(ii) helical rotor pump

These pumps are suitable for water supply schemes requiring a relatively low flow rate and high pressure output;

(ii) Centrifugal pumps

These pumps are more suitable for irrigation schemes where high flow rates and moderate discharge pressures are required;

(iii) Axial flow pumps

These pumps are most suited to duties of very high flow rate and very low discharge pressures such as might be required in a large drainage scheme.

The three basic criteria in pump selection are:

(i) Hydraulic capabilities:

This is the pump's capacity to meet the required hydraulic duty, namely, the required head and discharge. The pump's efficiency at the operating duty should be considered as this relates to its running cost. The higher the efficiency the less the running costs. Other factors to consider would be the pump's suction capacity, overloading characteristics and shape of pump curve.

(ii) Mechanical reliability:

The importance of mechanical reliability will depend on the particular circumstances. A pump on a site with difficult access may need to be particularly reliable. The quality of water being pumped will effect reliability particularly with respect to seals and bearings. Other pump speed, coupling method, motive power and priming requirements.

(iii) Cost:

18.9 SPRAY IRRIGATION SYSTEMS

18.9.1 Pumps

	Surface	Submersible
Limitations	7.5 metre depth	Any depth Well diameter restricts Pumps size.
Maintenance	Simple	More difficult
Costs	-	Approx. double
Electricity cost	-	Much less
Efficiency	-	Higher

* No detailed comparisons can be made as the correct choice of pump depends on the individual situation.

USEFUL CONVERSIONS (APPROX.)

1 acre inch (1 inch/ac) = 22,500 gal = 102,150 litres
1 gallon/minute (G.P.M.) = 0.0758 litre/sec.
1 pound/square inch (P.S.I.) = 6.895 kilopascals kPa
1 cubic foot/sec (Cusec) = 374.4 G.P.M.
1 cubic metre/sec m^3/sec (Cumec) = 35.3 Cusec
1 litre = 0.22 gallon
1,000 litre = 1 Cubic metre
1 inch of rain = 100 points = 25 mm.
Electricity 1 horsepower (H.P.) = 0.75 kilowatt (KW)
1 KW uses 1 unit of Electricity/hour

18.9.2 Irrigation Analysis

TYPE	Hand Shift	End Tow	Side Roll	Centre Pivot
Range of crops	Most crops Not tall crops	Mainly pasture not above 30 cm	Most crops up to 70 cm bigger wheels up to 100 cm	All
Output litre/ sec	-	-	13 - 14	-
Pressure)kPa at) Sprinkler) PSI	200 - 300 30 - 45	200 - 300 30 - 45	200 - 300 30 - 45	400 - 600 60 - 90
(1) Area/ shift (ha)	0.9 ha	1.5 ha	1.8 ha	4 - 60
Area/ day (ha)	1.8	3.0-4.5	3.6-5.5	66 hours/ roatation
(2) Wetted width	9m (30 ft)	15m (50ft)	18m (60ft)	-
Gross Appln per 22 hr run	N/A	N/A	N/A	40mm/66 hr 1.6 inch
Cost (Approx)	Cheap 2nd hand avail.	$6,000 2nd hand avail.	$11,000	$83,000
Labour	High	1 hr/shift & Tractor	1/3 - ½ hour/ shift	NIL
Other	Good for v. small area. Obsolete	Best suited for pasture.	No tractor regd, 4 man hours to shift paddocks. Easy to put Nitrogen through line. Suits rectangular paddocks, fences can be problem. Can be shifted in the dark.	60 metre spans. Needs square area with no obstructions. Small models can be towed from paddock to paddock.

(1) 400 metre sprayline
(2) Typical width

18.9.3 Travelling Irrigators

	Big Gun	Ohmme	Roto-Rainer	Turbo-Rainer	Fixed Boom LHW
Company	Andrews & Beaven	Harvin	Briggs	Homersham	Southern Cross
Range of Crops	All	All	All	All	All
Output Litre/Sec	10 - 44	11 - 23	7 - 42	up to 40	up to 40
Pressure) kPa	400 - 600	300 - 400	200 - 280	70	280
at) Sprinkler) PSI	60 - 90	45 - 60	30 - 40	10	40
Area/400m run ha	2.5 - 4	up to 3	1.2 - 4	2.8 - 3.6	4
Ac	6 - 10	7.5	3 - 10	7 - 9	10
Run width (metre)	60 - 100	75	60 - 100	70 - 90	100
Gross Appln mm	33 - 90	40 - 65	up to 90	5 - 95	30 - 90
22 hr run (inch)	1.3 - 3.5	1.6 - 2.5	3.5	0.2 - 3.8	1.2 - 3.5
Cost Approx $	20,000	21 - 24,000	28 - 30,000	28,000	28,000
Labour per shift	½ hour	½ hour	½ - 1 hour	1 hour	½ - 1 hour
Tractor required	yes	yes	yes	yes	yes
Boom operation	-	fixed	rotating	fixed	fixed
Ground wheels travel on	wet or dry	dry	wet	dry	?

Caution if strong following wind dry land can get wet in front of wheels.

	Big Gun	Ohmme	Roto-Rainer	Turbo-Rainer	Fixed Boom LHW
Other	Easily affected by wind. High pressure.	No winch. Follows hose round curves. 3 speeds, good for crops	Big droplet size. Travel geared to rotating boom. Good for pasture.	Ultra low pressure. Requires smaller mainline. Least wind affected. New 1980	Piston driven. Even speed travel. New 1980

18.10 WORKING LIVES FOR FARM WATER SUPPLY EQUIPMENT

18.10.1 Storages:

Wells and bores	25 years
Windmill	20 years
Pumphouse or shed	20 years

18.10.2 Pumps:

Deep-well turbine pump:	
Bowl	16 000 hour or 8 years
Column etc.	32 000 hours or 16 years
Centrifugal pump	30 000hours or 15 years
Low lift, high discharge, axial flow pump	30 000 hours or 15 years

18.10.3 Motors:

Electric motor	50 000 hours or 25 years
Diesel engine 900 rpm or more	28 000 hours or 14 years
less than 600 rpm	50 000 hours or 15 years
Petrol engine air cooled	8 000 hours or 4 years
water cooled (1200 rpm +)	28 000 hours or 14 years
water cooled (< 1200 rpm)	20 000 hours or 20 years

18.10.4 Miscellaneous:

Asbestos-cement pipeline	20 years
Aluminium sprinkler line	15 years
Galvanized sprinkler line	15 years
Sprinkler head	8 years
Earth irrigation ditches	15 years
Concrete irrigation ditches	20 years
Catch drains	15 years

SECTION 19

PEST CONTROL

A pest as defined by the Pesticides Act 1979 is:

(a) Any unwanted mammal, bird, reptile, amphibian, fish, insect, arthropod, mollusc, nematode or other worm, plant, or fungus, not being an organism livng on or in man or any livestock; and

(b) Any bacterium or virus affecting plants; - and includes any other organism from time to time declared under section 6 of this Act to be a pest for the purposes of this Act.

19 PEST CONTROL

19.1 WEED CONTROL

19.1.1 Introduction

This section deals with the chemical control of weeds, listing by crop the suitable chemicals (common and trade names), some of the weeds they are expected to control, their rates of application of product per hectare and the time of application. There are accompanying comments that are relevant to the chemical's use, e.g. "Do not use on legumes" and "Safe on all cereals". This section is intended as a guide only. Some of the chemical's are only tentatively recommended, e.g. ethofumesate (Nortron) for annual weed control. These chemicals have not been registered in New Zealand as suitable control agents for the weeds considered, although they are verylikely to be accepted in the near future.

In some instances preferential endorsement of a product is indicated on the basis of trial use and farmer use. Criticism of similiar products is not normally implied.

Trade names for chemicals are used only to acquaint the reader with some of the available chemicals and their matching common name. We do not intend any preferential endorsement of any product. Nor is criticism of similar products implied.
Note that rates of product per hectare may depend on weed size and age, growth conditions and soil conditions; and on the formulation of proprietary chemicals used. The label recommendation of the chosen product should always be followed. If in doubt, seek advice from the local Ministry of Agriculture and Fisheries Advisory Officer or the chemical company Field Representative. Unless otherwise state, chemicals should be applied in 200 - 250 litres of water per hectare.

Remember to:

Read the instructions on the chemical container and follow carefully.
Take suitable precautions against contact with chemicals.

Wash affected skin with water as soon as possible.

Prevent poisoning, especially of children, by storing chemicals in a locked shed and preventing access to the material in the field when applying.

Be aware of the first aid measures to take if someone is accidentally poisoned.
This section has been revised by J.H.B. Butler and F.C. Allen, Research Division, M.A.F. Lincoln.

19.1.2 Weed Control

Crop	Chemical Names: Common	Chemical Names: Trade	Used for Controlling	Rates of Application of product/hectare	Time of Application	Comments
Brassicas, oil seed rape	trifluralin	Treflan	A wide range of annual broadleaf and grass weeds in all brassicas.	2–3 litres	Preplant spray. and soil incorporated	Will not control wild turnip, shepherd's purse, black nightshade, mallow, storksbill or perennial weeds. Used in all brassicas.
	nitralin	Planavin 75	as for trifluralin	1.1–1.5kg	as for trifluralin	as for trifluralin
	nitrofen	Tok E	Annual weeds, e.g. spurrey, fathen, willow weed.	8–12 litres	when weeds are small seedlings. 10–14 days after crop has struck.	can be used on all brassicas.
	chlornitrofen + picloram	Fodderkleen	Californian thistle and other annual weeds. Does not control storksbill	4–6 litres	best results with low rates of application to young weeds.	Toxic to legumes. Will not control storksbill. Will check and may distort soft turnips and swedes if crop is under water stress. Do not plant potatoes or legumes within 2 years. Do not use on oil-seed rape.

Crop	Chemical Names Common	Trade	Used for Controlling	Rates of Application of product/hectare	Time of Application	Comments
	desmetryne	Semeron	annual weeds, red root, willow weed at later stages of growth than would be controlled with nitrofen.	1.0kg	when crop has at least 4 true leaves	Only used on kale. Do not spray in hot weather or if crop is u/s with pasture species. Do not use on swedes or oil seed rape.
	dicamba	various	Californian thistle, fathen, willow weed, & other annual weeds	0.7–1.5 litres	when crop has 4–8 true leaves.	Toxic to legumes. Brassica crops are only partially tolerant to dicamba.
	dicamba + nitrofen	Fodagard	as for nitrofen and dicamba	4–6 litres	when crop has 4–8 true leaves.	as for dicamba
Cereals: Wheat, Oats Barley, Ryecorn	MCPA	various	Black nightshade, Californian thistle, docks, fathen, hedge mustard, penny cress, stinging nettle shepherd's purse, tares, wild turnip.	2.25–4 litres	**Oats:** after 3 leaf stage. **Barley & Ryecorn:** after 4 leaf stage; **Wheat:** after 5 leaf stage. Do not spray after 2nd node has appeared.	Toxic to legumes, but safe to use on all cereals.
	2,4-D amine	various	all MCPA – susceptible weeds plus cornbind & willow weed.	2–4 litres	Wheat, barley & ryecorn between 5 leaf and early boot stage.	Do not use ester formulations. Do not use on oats.
	MCPB	various	as for MCPA but less effective against shepherd's purse, tares and wild turnip.	2.25–4 litres	After 2 leaf stage and before 3rd joint is detectable.	Use if crop is u/s with legumes but not lucerne.

Crop	Chemical Names: Common	Chemical Names: Trade	Used for Controlling	Rates of Application of product/hectare	Time of Application	Comments
Cereals contd.	2,4-DB	various	as for MCPA plus cornbind, willow weed.	2.5–4 litres	as for MCPB	Use if crop is u/s with white clover or lucerne.
	MCPA + bromoxynil	Brominal M Buctril M	MCPA–susceptible weeds plus daisy weeds, wireweed, willow weed and cornbind	1.5-2 litres	From 4 leaf stage to early jointing. Best results on seedling weeds.	Cereals tolerate this mixture better than MCPA + dicamba.
	Mecoprop + bromoxynil + loxynil	Axall	as for MCPA bromoxynil	2.5-3.0 litres		
	MCPA + bromoxynil + 3,6 - dichloropicolinic acid	Lontrel Cerel	As for MCPA + bromoxynil. Better control of thistles, but poor control of chickweed and spurrey.	3.0 litres.		
	MCPA + dicamba	Bandamine M Bandone M	MCPA - susceptible weeds, chickweed, cornbind & spurrey.	2.5–3 litres + up to 150g a.i. of dicamba	between 5 leaf stage and jointing	Toxic to legumes. Clean equipment thoroughly after use
	MCPA + TBA	Pestco 18-15	MCPA - susceptible weeds plus cleavers and mayweed	5–6 litres	as for MCPA/ dicamba.	Toxic to legumes. Safe on wheat and barley. Clean equipment thoroughly after use.
	mecoprop	Mec 40	MCPA - susceptible weeds plus chickweed, cleavers & fumitory	5–8 litres	Between 2 leaf stage and jointing	Safe on all cereals. Toxic to legumes.
	dichlorprop	Dyprop	MCPA - susceptible weeds plus spurrey, cornbind, willow weed and wireweed	5–6 litres	Between 3 leaf stage and early jointing.	Toxic to legumes. Safe on all cereals.

Crop	Chemical Names: Common	Chemical Names: trade	Used for Controlling	Rates of Application of product/hectare	Time of Application	Comments
Cereals contd.	prometryn	Gesagard	Annual weeds including willow weed, wire weed, spurrey, yellow gromwell and fumitory.	0.75–1.5 litres	3–4 leaf stage when weeds are small	Do not use on u/s crops. If Californian thistle is a problem as well, use 1 litre of prometryn + 1.5 litres of MCPA.
	methabenz-thiazuron	Tribunil	Most annual weeds. MCPA required for thistles	2–2.5 litres	5 leaf stage to jointing.	Moist soil surface conditions required for best results.
	Mixtures:					
	dichlorprop-based	Tricornox Special		4.5–6 litres		
		Trident		3 litres		
		Super Cearex		4 litres		
		Dichlormix M		4 litres	All these products should be applied between the 5 leaf stage and jointing.	All these products are toxic to legumes. They control a wide spectrum of weeds – there is little to choose between them.
	mecoprop-based	Mecomix M		5 litres		
		Cearex		4 litres		
		York Mecomix		4 litres		

Crop	Chemical Names Common	Trade	Used for Controlling	Rates of Application of product/hectare	Time of Application	Comments
Cereals contd. Wild oats control	barban	Neoban	Wild oats in barley and wheat.	800ml–1 litre	At 1½–2½ leaf stage of wild oats.	Use 90 litres of water/ha at 3–400 kPa. Toxic to legumes.
	tri-allate	Avadex BW	Wild oats in spring wheat and in barley	3.5 litres	Preplant spray. Incorporate into soil immediately after spraying.	Less reliable in autumn/winter-sown crops.
	diclofop-methyl	Hoegrass	Wild oats in wheat only; also *Phalaris minor*	2.5–3 litres	2½–4½ leaf stage of wild oats.	
	difenzoquat	Avenge	Wild oats	5 litres	2½–5 leaf stage of wild oats.	Safe on all cereals except oats. Wetting agent required.
	flamprop-methyl	Mataven	Wild oats	6–9 litres	3½ leaf stage to jointing.	Suitable for wheat only.
	benzoylprop-ethyl	Suffix	Wild oats	8–9 litres	Fully tillered to jointing stage of wild oats.	Use in wheat only
	trifluralin	Treflan	Wild oats and broad leaved weeds	2 litres	Preplant spray. Incorporate into soil immediately after spraying.	Use in barley only.

Crop	Chemical Names		Used for Controlling	Rates of Application of Product/hectare	Time of Application	Comments
	Common	Trade				
Maize & Sweetcorn	2, 4-D amine	various	Californian thistle, docks, field bindweed, greater bindweed (convolvulus)	2 –2.5 litres	When maize is 15–25 cm high	Only recommended for perennial weeds
	atrazine	various	Annual broadleaved weeds. Preferred chemical	1 –1.5 kg a.i. (both solid and liquid formulations are available).	Pre- or post-emergence sprays	Not suitable for controlling grass weeds.
	EPTC + antidote	Eradicane	Grass weeds, red-root & black night-shade.	6–8 litres	Preplant spray, soil incorporated.	Use where bristle grass, witch grass, summer grass, couch and barnyard grass are present.
	alachlor	Lasso	Grass weeds and some annual broad-leaved weeds	7 litres	Spray onto soil surface immediately after sowing. Do not incorporate into soil.	Usually applied with atrazine for general weed control.
	metolachlor +atrazine	Primextra 500	Grass and broad-leaved annual weeds	7–9 litres	As for alachlor	
	cynanazine + alachlor	Herbitrol + Lasso	Grass and broad-leaved annual weeds	2–3kg/5.5–7 litres	Apply within 7 days after sowing	General weed control.
	butylate	Sutan T	As for EPTC	6–8 litres	Preplant spray, soil incorporated.	

Crop	Chemical Common	Names Trade	Used for Controlling	Rates of Application of Product/hectare	Time of Application	Comments
Grass seed	MCPA or 2,4-D	various	Thistles, docks, hedge mustard, wild turnip & other annual broadleaved weeds	2.5–3 litres	Seedling docks and annuals: 6–8 weeks after drilling; Scotch & nodding thistle: autumn; Californian thistle and established docks: 1–2 weeks after closing for seed.	In crops such as fescue where clover is a weed, 60g a.i. dicamba may be added.
	MCPB or 2,4-DB	various	Annual broadleaved weeds (see cereal notes)	3–3.5 litres	As for MCPA/2,4-D	Substitute for MCPA when clover is required.
	bentazone	Basagran	Mayweeds, chamomiles, storksbill and other annual weeds	2.5–3 litres	Preferably on small seedlings or short-regrowth.	Warm temperatures required at spraying for reliability. Good coverage required for effective contact action.
	dicamba + MCPA	Bandamine + various	MCPA-susceptible weeds & improved control of thistles and docks.	2–3 litres	Do not apply after the boot stage	Do not use if u/s with clovers
	benzoylprop -ethyl	Suffix	Wild oats	8–9 litres	Apply after closing crop before the boot stage.	Apply in autumn at 3–5 leaf stage of wild oats for yield response in heavy infestations.
	flamprop-methyl	Mataven	Wild oats	6–9 litres	As for benzoylprop-ethyl.	Tentative recommendation only. As for benzoylprop-ethyl.

Crop	Chemcial Names		Used for Controlling	Rates of Application of Product/hectare	Time of Application	Comments
	Common	Trade				
Clover seed	paraquat	various	Grass competition & annual weeds.	1–2 litres	Short-graze pasture & apply in dull humid conditions, September and October.	Used on white clover. May be inactivated if dirty water is used or if it is sprayed onto dirty foliage.
	MCPB or 2,4-DB	various	thistles, plantains, docks & annual broadleaved weeds.	3 litres	Spray biennial thistles when as small as possible. Allow Californian thistle & docks to develop fresh foliage before crop is shut up & spray before clover buds show in base of crop.	Do not spray 2, 4-DB on red clover, nor after mid-December.
	carbetamide	Carbetamex 70	Many grass weeds and sheep sorrel	3–4 kg	Apply mid to late winter in mature stands.	
	propyzamide	Kerb 50	As for carbetamide	2.5 kg	As for carbetamide	
	2, 4-D ester	Weedone 57 2, 4-D ester	Thistles, plantains, hawksbeard, some annual clovers in white clover only	4–5 litres	Apply after a series of hard frosts before August.	Do not apply to growing clover. Tentative recommendation only.
	bentazone	Basagran	Mayweeds, storksbill, chamomiles and other annual weeds	2-3 litres	Apply to small seedlings or to short regrowth.	Temperatures must be warm at application. For general broadleaved weed control, add MCPB. Ensure good spray coverage.

Crop	Chemical Names: Common	Trade	Used for Controlling	Rates of Application of Product/hectare	Time of Application	Comments
Lucerne: seedling	2,4-DB	various	Annual weeds & thistles	3–4 litres	Spray as soon as possible after first trifoliate leaf appears on lucerne and thistles have germinated.	Do not spray autumn sown lucerne if there are resistant winter-growing weeds present.
	MCPB	various	Where nodding thistle is principal weed.	3–4 litres	as for 2, 4-DB	Spray while weeds & crops are actively growing.
	trifluralin	Treflan	General broadleaf and grass weed control	2–3 litres	Preplant spray. Soil incorporation is necessary.	Preferred chemical for annual weeds in pure-sown stands. Not effective against daisy weeds brassica weeds or storksbill.
	EPTC	Eptam	Grass weeds including couch, fathen and nightshade.	5 litres	As for trifluralin	Warm soil conditions are essential.
	bentazone + MCPB	Basagran various	Nodding thistle, storksbill.	2.5 litres MCPB, 2 litres bentazone	Apply at 3–5 leaf stage of lucerne.	Apply in mild to warm conditions favourable for growth.
	dinoseb-amine	various	Storksbill, & various annual weeds.	1–kg a.i.	Apply at 2–5 leaf stage lucerne.	Apply in mild conditions to avoid damage to lucerne. Temperature must not exceed 23°C

Crop	Chemical Names: Common	Trade	Used for Controlling	Rates of Application of Product/hectare	Time of Application	Comments
Lucerne: mature	2,2-DPA	Dalapon various	Barley grass, brown top, creeping bent, fog and other grass weeds.	5–6 kg	Very early spring after growth has commenced	Do not use when grasses are sown with lucerne. Treatment will delay or reduce the following cut, but subsequent growth may offset this loss.
	paraquat	various	fibrous-rooted grasses including Yorkshire fog, *Poa annua* & other annual grasses, annual broadleaved weeds including storksbill & chickweed.	1/5–3 litres in 200 plus litres of water with wetting agent.	While lucerne is dormant.	Only effective against small seedlings of barleygrass. It checks browntop. Spray in dull humid weather avoiding dust and dirt contamination of water or foliage.
	paraquat + simazine or atrazine	various various various	as for paraquat plus browntop, barleygrass & shepherd's purse.	1 kg a.i. simazine 900 a.i. atrazine paraquat as above.	While lucerne is dormant.	As above for application conditions.
	terbacil	Sinbar	Couch & other grass weeds, annual weeds	2 kg	While lucerne is dormant	Do not use on sandy or stony soils
	cyanazine	Herbitrol	Browntop, grass weeds and annual weeds.	2 kg	While lucerne is dormant	
	paraquat + metribuzin	various Sencor	As for cyanazine	2–3 litres of paraquat + 0.5 kg metribuzin	While lucerne is dormant	When paraquat is not used, use 1 kg Sencor.

Crop	Chemical Names Common	Trade	Used for Controlling	Rates of Application of Product/hectare	Time of Application	Comments
Lucerne: mature contd.	propyzamide	Kerb 50	Grass weeds	2–3 kg	While lucerne is dormant	Pre- or post-emergence for seedling lucerne also.
	carbetamide	Carbetamex	As for propyzamide especially barley-grass	3–4 kg	as for propyzamide	As for propyzamide
	asulam	Asulox	docks	3–4 litres	Apply in September or following the last cut in autumn.	Docks must have adequate leaf for good results.
	lexazine	Velpar	Annual Weeds nodding thistle	1.0-1.5 kg	Oct/Nov after grazing or mowing.	Tentative recommendation.
Lupins	trifluralin	Treflan	Annual broad leaved and grass weeds.	2-4 litres	Preplant, soil incorporate	
	attrazine or simazine	various	As for tirfluralin	2-3 litres/ha (50%) 1.2 - 1.8kg/ha (80%)	pre-emergence.	Needs a moist soil surface or rain after application to work effectively.
	Chloroxuron	Tenovan 50.	fathen.	1-2 kg	5-10 cm crop.	Add wetting agent 1.0% v/v. Only controls fat hen at this rate.
Peas	trifluralin	Treflan	Wide range of annual broadleaved and grass weeds, including wild oats.	2–3 litres	Preplant spray. Soil incorporation is necessary.	Preferred treatment if Californian thistle is not present, or if crop is u/s. Not effective against storksbill or brassica weeds.

Crop	Chemical Names: Common	Chemical Names: Trade	Used for Controlling	Rates of Application of Product/hectare	Time of Applciation	Comments
Peas contd.	dinoseb (DNPB) :amine	various	Annual weeds, especially black nightshade, wild turnip, fumitory, fathen, etc.	various	Spray as soon as possible after weeds show. Kill is better if growing conditions are good.	Not suitable for red-root or spurrey control. Extremely poisonous. Can cause scorching at high temperatures, but effectiveness is reduced at less than 18°C. Can be used in crops u/s with clover or lucerne
	:acetate	Aretit, Dinotate		5 litres		
	MCPB	Various	Californian thistle, redroot & other MCPA-susceptible weeds	2–4 litres	Annual weeds as seedlings; perennial in full leaf state.	Not effective against willow weed, fumitory & black nightshade. Use if crop is u/s with clovers.
	MCPB+ dinoseb	various various	Redroot, black nightshade, thistles, wireweed & other annual weeds.	2–3 litres MCPB + 1.5–2 litres of dinoseb	As for MCPB	Observe pre-cautions for dinoseb. Add the ingredients to water separately.
	methabenz-thiazuron	Tribunil	Fathen, black night shade, cornbind, willow weed, red-root, spurrey wire-weed	2-2.5 kg	Seedling weeds when peas at 4–7 node stage.	Do not mix methabenzthiazuron with MCPB. Thistles are resistant.
	metribuzin	Sencor	Annual broadleaved weeds	0.5 kg	As for methabenz-thiazuron.	Can be mixed with 1.5 litres MCPB or with methabenz-thiazuron

Crop	Chemical Names Common	Chemical Names Trade	Used for Controlling	Rates of Application of Product/hectare	Time of Application	Comments
Peas contd.	terbutryn + MCPB	Igran various	annual broadleaved weeds & Californian thistle.	0.8kg 1.5 litres	When weeds are small & thistles have emerged	Do not use in dry conditions.
	bentazone + MCPB	Basagran various	Annual broadleaved weeds including mayweeds	2 kg 2.5 litres	As for terbutryn + MCPB	Apply in mild to warm conditions Tentative recommendation
	cyanazine + MCPB	Herbitrol various	As for metribuzin	2.5–3 kg 1–1.5 litres	As for terbutryn + MCPB	Peas must be higher than 5cm
	diclofop-methyl	Hoegrass 36	Wild oats	3 litres	2–4 leaf stage	
Fodderbeet & Mangolds	chloridazon	Pyramin	Seedling weeds	5 kg.	Pre-emergence or after beet has its first true leaf	Reliable as post-emergence spray if applied in good growing conditions.
	phenmedipham + desmedipham	Betanal AM11	Annual weeds but not wireweed	6 litres	Best applied as a split application 3-5 days apart, the first (3 litres) at Cotyledon stage of the beet.	Does not control wireweed, redroot, willow weed
	lenacil	Venzar	Annual weeds except black nightshade and redroot.	2–3 kg	Preplant spray, soil incorporated.	Better control if lenacil is followed by chloridazon or phenmedipham

Crop	Chemical Names Common	Chemical Names Trade	Used for Controlling	Rate of Application of Product/hectare	Time of Application	Comments
Fodderbeet & Mangolds contd.	cycloate	RoNeet	Wide range of annual weeds but not wireweed	6–8 litres	Preplant spray, soil incorporated	Used with lenacil for wider weed spectrum control
	ethofume -sate	Nortron	Clover and annual grasses	5-10 litres	When beet has 1–2 true leaves	Can be mixed with chloridazon and Betanal.
	metamitron	Goltix	Wide range of annual weeds	6 kg	Early pre-emergence	Tentative recom-mendation.
	2,2-DPA	various	Volunteer cereals, wild oats and grasses	7kg	Post-emergence	2kg may be added to Betanal AM11 to increase control of wireweed.
	diclofop-methyl	Hoegrass 36	Wild oats	3 litres	2–4 leaf stage of wild oats	
Linseed	MCPA	various	Annual broadleaved weeds, docks, Californian thistle	2–2.5 litres	After 6 true leaf stage & before the first signs of buds	Toxic to clovers & lucerne
	MCPA + atrazine	various various	MCPA-susceptible weeds plus corn-bind, fumitory, daisy weeds, spurrey, willow weed & wire-weed.	1.5 litres MCPA + 850g atrazine	When weeds are small & linseed is at 10–20 leaf stage	Toxic toclovers & lucerne. Wettable powder atrazine is more selective.
	MCPA + bromoxynil	Buctril M Bromimal M	MCPA-susceptible weeds plus cornbind wireweed, daisy weeds & willow weed.	1.5–1.75 litres	As for MCPA + atrazine	Does not control fumitory

Crop	Chemical Names Common	Chemical Names Trade	Used for Controlling	Rates of Application of Product/hectare	Time of Application	Comments
	MCPB	various	MCPA-susceptible weeds	2.5 litres	After 6 true leaf stage & before signs of flowering.	Use on crops u/s with clover or lucerne
	tri-allate	Avadex BW	Only wild oats	3.5–4 litres	Preplant spray, soil incorporated	
	diclofop-methyl	Hoegrass 36	Only wild oats	3 litres	At 3–4 leaf stage of wild oats.	Tentative recommendation.
Potatoes	linuron	Afalon Linuron	Broadleaved weeds & some grass weeds	2 kg	After moulding, before haulms have emerged.	Will not control fumitory or perennial weeds
	monolinuron	Aresin	Seedling grasses; less effective against broad leaved weeds than linuron	1.1–1.7 kg a.i.	As for linuron	Linuron/ monolinuron mixture gives wider control spectrum
	prometryn	Gesagard	Annual broadleaved weeds	2–3 kg	As for linuron	
	terbutryn + linuron	Igran + various	Annual broadleaved weeds	1.6–2 kg terbutryn + 1 kg linuron	As for linuron	

Crop	Chemical Common	Names Trade	Used for Controlling	Rates of Application of Product/hectare	Time of Application	Comments
Potatoes contd.	cyanazine + linuron	Herbitrol + various	As for terbutryn + linuron	2kg cyanazine + 1kg linuron	As for linuron	
	metribuzin	Sencor	Annual weeds and many grass weeds	1.5 kg	Pre- or post-emergence (10% emergence)	Preferred treatment for general weed control.
	MCPA	various	Californian thistle	2 litres	Pre- or early post-emergence. Apply before flowering.	Crop will be checked
Potatoes: Pre-harvest dessication	diquat	Reglone	Grass and broad-leaved weeds	3 litres + wetting agent in 300 plus litres of water	Pre-harvest	Some tuber damage may occur in hot, dry conditions. Do not spray when haulms are wilting.
	paraquat	Paraquat Gramoxone	Grass & broad-leaved weeds	1.5–2 litres in 200 plus litres of water	After haulms are dead	Do not apply to live haulms. Best results follow spraying in overcast humid conditions.
abeans	alachlor	Lasso	Most annual weeds	6-7 litres	pre-emergence	Use either alachlor + linuron or trifluralin or metrabuzin then follow up with bentazone or chloroxuron to control weeds resistant to pre-emergence herbicide.
	linuron	various	Most annual weeds	3-4 kg	pre-emergence	
	trifluralin	Treflan	Annual Weeds	2-3 litres	pre-plant	
	metribuzin	Sencor	Annual weeds	0.7 - 1.0 kg	pre-emergence	
	bentazone	Basagran	Annual weeds	2-3 litres	2 leaf stage	

Crop	Chemical Names Common	Trade	Used for Controlling	Rates of Application of Product/hectare	Time of Application	Comments
	chloroxuron	Tendran 50	Annual weeds	3.0 litres	post emergence 1-2 leaf stage	Add surfactant
Sunflowers	trifluralin	Treflan	Annual weeds	2-3 litres	pre-plant soil incorporated	
	E.P.T.C.	Eptan	Annual weeds	6-8 litres	pre-plant soil incorporated	Requires warm soils for effective use.
	alachlor	Lasso	Annual grasses, some broad leaved weeds.		pre-emergence	
	prometryn	Gesagard	Broadleaf weeds	2.0 kg	pre-emergence	Soil-surface must be moist at application or rain after application for herbicide activation.
Tick Beans	trifluralin	Treflan	Annual weeds	2-3 litres	pre-plant soil incoroprate	
	simazine	various	Annual weeds	1.2-1.5 kg (80%) 2.5-3.0 litres (50%)	pre-emergence	Preferred treatment
	dinoseb amine	various	Annual weeds	2.5-3.0 litres	post emergence, 5 node stage	Salvage treatment only
	diclofop methyl	Hoegrass	Wild oat. Phalaris minor	3.0 litres	wild oats 2–4 leaf	

19.1.3 Pastures - General Principles

The most effective weed control in pastures is obtained by the development of a vigorous uniform sward of clovers and grasses. For this reason, good pasture management, including correct use of fertilizers and stock manipulation, is the best way of maintaining weed-free pastures. Weeds usually only invade pastures in weak spots, where pasture vigour is reduced. This can be caused by insect damage, drought, over-grazing or by winter pugging. Once weeds have become estabished in pastures they can be difficult to eliminate by pasture management and it may be necessary to resort to herbicide application. In some instances hard grazing with sheep can reduce or even eliminate weed problems. Examples are the suppression of ragwort by sheep and the control of barley grass by hard spring grazing with sheep. Even anual weeds, once established, tend to persist despite strong pasture competition, because the parent plants die off in the summer and leave gaps in the pasture suitable for germination and establishment of their offspring. For this reason, weed control in new pastures is often useful in preventing possible future problems.

Newly sown pastures

Weeds in new pastures can retard pasture establishment, especially of the slower developing pasture components. Correct use of fertilisers, good seed bed preparation and even distribution of sown seed all help to reduce the effects of weeds. Quick, intense grazing of newly established pasture eliminates many weeds, but spraying should be considered if potentially serious weeds, such as thistles, are present.

When the clover seedlings reach the first or second true (trifoliate) leaf stage, new pastures can be safely sprayed with MCPB at 1 kg/ha. This will successfully control a wide range of broadleaf weeds. However, 2,4-DB at 1-2 kg/ha is more effective on black nightshade, cornbind, fumitory, willow weed, wild turnip and wireweed, but can also cause damage to seedling red and subterranean clover.

MCPB or 2,4-DB should be applied during fine weather and only after ground cover of pasture species and weeds is fairly complete.

Established pastures

Dairy pastures tend to be more open and more heavily pugged than sheep pastures. In addition, cattle are more selective than sheep in their grazing habits so that dairy pastures are commonly more weedy than sheep pastures.

Mowing or topping of tall-growing weeds such as thistles, docks, buttercups and ragwort makes pastures or swards less unsightly and helps stock gain access to them but rarely helps weed eradication. Barley grass seed cause physical damage to lambs, and if these are mown off before the seeds harden, then the cause of damage is removed.

Grubbing of thistles and grubbing or pulling of ragwort gives temporary control but ragwort can regrow from root fragments left in the soil and some kinds of thistle will regrow if not cut off at least 5 cm below ground level.

Herbicides which can be used economically for selective weed control in pastures containing clover are few in number. 2,4-DB and MCPB are the only materials which will do very little harm to pastures whenever they are applied. At the most they will reduce pasture production slightly for a few weeks following application. Unfortunately they have their limitations becuase they are generally more effective on weed seedlings than on large plants and because the range of weeds which they kill is limited. None-the-less, if susceptible weeds are present, one of these chemicals should be used in preference to anything else. Death, even of susceptible weeds, tends to be slow. 2,4-D and MCPA are commonly used, and often abused, for broadleaf weed control in pastures. Both cause fairly severe damage to white clover. Red and subterranean clovers are more tolerant MCPA but both are affected by 2, 4-D. Within a month of spraying, pasture production falls by 10 - 40% depending on how much clover was present initially. After this, the grasses respond to reduced competition and to the release of additional nitrogen so that total pasture yields are not usually affected for long, but it takes four to ten months after spraying before the clover balance is fully restored. Clovers are most susceptible to 2, 4-D or MCPA damage during the spring and autumn flushes of growth. Recovery is slower after autumn spraying than after spring spraying. Clovers are least affected when their growth is slow - during dry summer or in cold winters. Close-grazed clover is such less severely damaged by spraying than is rank clover, therefore, in order to keep clover damage to a minimum, spraying should be carried out between late autumn and early spring. At this time, annual weeds are usually present, but are small, and susceptible to these herbicides.

Dicamba and picloram are both very effective weed killers and are also very damaging to all clovers. They both persist in the soil after spraying. Even though there are no toxic residues left in the soil three months after applying up to 1.0 kg/ha, initial clover kill is so complete that it may be up to two years before the natural/clover balance is fully restored. Over-sowing clovers into sprayed pasture will help to speed this process up. However, the use of dicamba and picloram should generally be restricted to spot application, for weeds difficult to kill or where legumes do not occur.

References to other herbicides which can be used in pastures will be found in the Aglink on 'Control of specific weeds in pastures'. It is very important that due consideration be given to possible reductions of pasture yield and quality before deciding when and how to control pasture weeds with herbicides.

19.1.4 Noxious Plant Control

Introduction

The Noxious Plant Act 1979 replaced the Noxious Weed Act 1959 and is designed principally to protect agricultural and horticultural land against invasion of undesirable plants, but with the basic premise that it is the land owners responsibility to do so and to bear the cost. Only one weed, Johnson grass, has been gazetted as the Government's responsibility. But in each region, money may be spent to clear weeds that are of limited distribution, and could present a problem in the future e.g. Cottsfoot in the Arthurs Park region.

If a plant is delcared noxious in anyone area the landowner is obliged to clear the land of that weed and in only a few instances, weeds such as gorse, broom, blackberry, sweet briar, barbery, nodding and Varigated thistle, ragwart, giant buttercup and barley grass may qualify for some financial assistance. Normally gorse, broom, and blackberry are the only subsidised weeds. The amount of subsidy is based on a proportion of a herbicide cost. This subsidy may be paid for non-herbicide clearance of weeds.

Any herbicide registered for use on that particular noxious weed in pasture may be used. Herbicides are listed for each of the major noxious plants.

Plant Species	Herbicide Name Common	Herbicide Name Trade	Product Rate	Time of Application	Comments
Gorse	245T	Various	10 litres/ha (72%)	Oct/early Nov.	Even coverage is essential. The addition of 10% diesel helps activity. Best used for spot application. The addition of diquat (reglone) dicamba (Ban 750) has seldom shown any advantage. Pasture improvement is a necessity. Damage clover, but is recommended by some to get control of gorse seedlings in young improved pasture.
Broom	245T t pictoram	Tordan brushkiller 520	20-30 litres/ha	Oct/early Nov.	
	245T	Various	1.5 litres/ha (72%)	Oct/early Nov.	
Sweet briar	245T	Various	1:200	growing season	Basal application in diesel. Not generally recommended by aerial application without associated pasture improvement.
	245Tt pictoram	Tordan Brush Killer 520	30 litres/ha	late spring	
	lexazinone	Velpar	2gm/bush	late Spring early summer	"Spot gun" technique for control of individual bushes.
Nodding thistle	M.C.P.B.	Various	2.5-5 litres	April/early May	Pasture recommendation.
	M.C.P.B. + 3, 6 D.C.P.A.	Various Lontrel Pasture	2-4 litres 1-1.5 litres	May or Sept.	Pasture recommendation but note that pasture damage will occur.
Blackberry	245Tt pictoram	Tordan brush-Killer 520	1:100 dilution	before fruit set	spot application only - not reliable.
	fasamine	krenite	1:100 12 litres/ha	Feb-April	Complete coverage is required. Preferred treatment.

Plant Species	Herbicide Name Common	Trade	Product Rate	Time of Application	Comments
	glyphosate	roundup	1:100 9 litres/ha	Nov-March	Good Coverage required
Barberry, Boxthorne	245T lexazinone	Various Velpar	1:10 in diesel 2 gm/bush	Cut the bush down, then apply solution	"Spot gun" treatment. Bulldozing at bushes only other method.
Variegated thistle	M.C.P.B.	Various	2.5-5 litres	Winter/Spring Apply to seedlings	
Giant buttercup	M.C.P.B.	Various	2.5-5 litres	early Spring	Complete control is difficult to achieve.

19.1.5 Farm Forestry and Shelter Belts

Some useful combinations of herbicides used in tree growing are given below. The best treatment is preplant weed control (can be cultivation), followed by a post plant, over the top, or directed and shielded spray, followed, 12 months later, with a tree release spray if required.

Chemical Names Common	Trade	Used for Controlling	Rates of Application of Product/hectare	Time of Application	Comments
Amitrole + 2,2 DPA + Simazine	Permazol S.D.A.	Vegetation Knockdown	4-5 kg	preplant	Do not use post plant on any species.
paraquat + terbulthylazine + terbumeton	paraquat + caragard	Vegetation Knockdown	4 litres 10 litres	preplant or shielded post plant	Can be used on all species

glyphosate with terbulthylazine + terbumeton or with simazine	Round up + caragard	Vegetation Knockdown	4-6 litres 10 litres	preplant or shielded post plant	All species
		Vegetation Knockdown	4 litres	preplant or shielded post plant	All species
terbulthylazine terbumeton	Caragard	Vegetation Knockdown	10-14 litres	post-plant directed	All species except potted Eucalypts
lexazinone	Velpar	Vegetation Knockdown	2-4 kg/ha	pre-plant or post-plant	Pinus radiata only
Simazine and atrazine	Eliminex	Vegetation Knockdown		tree release	Pinus radiata only

19.1.6 Weed Control in Orchards and Vineyards

This information should help growers to choose and apply the most suitable herbicide for their particular requirement. The products listed are those which in trials and commercial practice have proved to be the most reliable and effective for use in orchards and vineyards at the present time.

General Considerations

1. Always read and follow specific warnings, directions and dosage suggestions printed on product labels to ensure effective weed control with the minimum risk of plant injury.
2. Purchase spray equipment designed for herbicide application and keep it for that purpose only.
3. Contact type herbicides (e.g. paraquat) applied in insufficient water to heavy weed growth may result in poor control from inadequate wetting of weed leaf surfaces.
4. Application of pre-emergence herbicides (e.g. simazine) over freshly mown grass clippings or existing weed or straw mulch may prevent an effective dose from reaching the soil where it is required.
5. Inefficient tank agitation of a **wettable powder** herbicide suspension will result in material settling out with resultant dosage being either too weak or too strong. Agitation of some kind is essential with wettable powder herbicides, e.g. simazine (Gesatop 80 W).
6. Use low pump pressure, 275 kPa (40 p.s.i.) and flat spray (fan) tip nozzles giving a coarse droplet size to minimise herbicide drift.
7. Accurate dosage rates of chemical per hectare are important to achieve even control and avoid build up of persistent herbicides in the soil.
8. The aim of herbicide spraying should be a spray to wet weed foliage or soil surface without excessive run-off.

Quantity of Water per Sprayed Hectare (A sprayed hectare = 10,000 m^2 (2.5 acres) of ground actually sprayed).

Water is merely the carrier for the herbicide so that the amount of water applied per sprayed hectare can vary as long as the amount of herbicide product applied per sprayed hectare remains approximately the same. Several factors influence the quantity of water required.

9. The following is a guide to quantities of water necessary to cover one **sprayed** hectare.

Boom Spraying continuous or intermittent strip:

Bare ground or sparse weed cover:	330-560 litres per sprayed hectare (30-50 gals./acre)
Dense, rank weed growth:	670-900 litres per sprayed hectare (60-80 gals./acre)

Spot Spraying with hand gun or wand:

Bare ground or sparse weed cover:	1680-2250 litres per sprayed hectare (150-200 gals./acre)
Dense, rank weed growth:	3370-4500 litres per sprayed hectare (300-400 gals./acre)

10. 'Knockdown' or post emergence herbicides such as Gramoxone, Preeglone, Amitrole TL require sufficient water to cover existing weed foliage but without excess run-off. The more dens and rank the weed growth the more water is necessary.

11. Soil Sterilent or pre-emergence type herbicides such as simazine are applied alone to bare ground. If applied to short sparse weed growth simazine must be combined with one of the knockdown herbicides.

12. To achieve best results with Roundup (glyphosate) herbicide it is essential to apply it as a fine 'dewlike' spray cover using only 200-600 litres water per hectare.

13. Boom spray application along the rows to give continuous or intermittent strips of treated ground. This is the preferred and most accurate method of herbicide application for pre-emergence herbicides in particular also for Roundup. Requires much less water per sprayed hectare compared to spot treatment with a hand wand.

14. Spot treatment with a hand gun or wand. Difficult to achieve accurate dosage application per sprayed hectare. Still necessary in some situations of rank weed growth or uneven ground surface. Requires more water per sprayed hectare than boom spraying.

15. The use of additional wetting agents with 'knockdown' type herbicides improves cover of weed foliage which means less water is necessary. (Additional wetting agent is already incorporated in Gramoxone, Preeglone, Roundup).

    Where extra wetting agent is required any non-ionic product is suitable.

Herbicides Suggested for Orchards and Vineyards

PRODUCT NAME (common name)	Usual product rate per treated hectare ($10{,}000 m^2$)	Used with apparent safety around these fruit crops but check product label.	REMARKS The following abbreviations are used in column 3: B: Brambles, C: Citrus, G: Grapes, K: Kiwifruit, P: Pipfruit, R: Raspberries, S: Stonefruit.
AMITROLE TL (amitrole and ammonium thiocyanate)	6 - 11 litres	G P S	Good general knockdown of annual and some perennial weeds. No pre-emergence control. Do not apply around trees less than 3 years old. Do not apply between fruitset and harvest to avoid all risk of residues in the crop. Caution around apricots on light soils.
ASULOX 40 AC (asulam)	3 - 4 litres	B C G P R S	Very good but slow (6 weeks or more) knockdown control of docks. No pre-emergence control. Do not combine with Gramoxone or Preeglone as no control of docks may result from this mixture.
GESATOP 80W (simazine)	3kg	B C G P R S	Good long term (6-9 months) control of many germinating weed seeds when applied to bare soil. No knockdown control but may be combined with Amitrole TL. Preeglone or similar to control existing weeds. Do not apply around trees less than 3 years old.
GRAMOXONE (paraquat)	6 - 8 litres	B C G K P R S	Rapid knockdown of annual weeds, best on grasses. Short term control, repeat as necessary. No pre-emergence control. No soil residues or uptake by plant roots. No good against most deep rooted perennial weeds such as docks, couch etc.
HYVAR X (bromacil)	2 - 4kg	C	Can cause injury if used around most fruit crops. Citrus appear to tolerate Hyvar but avoid excessive repeated use around citrus. Do not apply around citrus trees less than 3 years old.

KRENITE 48 AC (ammonium ethyl carbamoyl phosphonate)	10 litres	G P S	For control of blackberry only. Spot application only during the 2 month period before leaf discolouration of blackberry, this is late flower to late fruit stage, usually mid February to late April. Effect not seen until following spring. Any regrowth should be sprayed at the same time in the following year. Rain within 24 hours of spraying may reduce effect. Avoid spray drift onto desirable plant stems and leaves.
KROVAR WP	6kg	C	Can cause injury if used around most fruit crops. Citrus appear to tolerate but avoid excessive repeated use around citrus. Do not apply around citrus trees less than 3 years old. Check ACB registration status before use.
PREEGLONE EXTRA (paraquat + diquat)	6 - 8 litres	B C G K P R S	Rapid knockdown of annual weeds both broadleaf and grass weeds. Other comments as for Gramoxone.
PREFIX 7.5G (chlorthiamid)	90 - 140 kg	B P R	General weed control. Expensive compared to most wet spray alternatives. Main use where other herbicides not effective or not safe for use. Results can be variable dependent on rainfall and cool temperatures after application for best effect. Avoid excessive application close against tree and vine trunks or injury may result. Caution around raspberries, or suppression of early sucker growth can result. Check label directions.
REGLONE (diquat)	6 - 8 litres	B C G K P R S	Rapid knockdown of annual broadleaf weeds but not grasses. Other comments as for Gramoxone.
RONSTAR 25 EC (oxadiazon)	6 litres	G	Controls many broadleaf weeds and annual grasses. Apply to bare soil beneath vines before budburst or after vines have developed 10 leaves per shoot. Do not disturb soil surface after application Consult your Federation Fieldman before use.
ROUNDUP 36 AC (glyphosate)	4 - 6 litres	C G K P S	Very effective against a wide range of problem weeds including couch, paspalum, kikuyu. Does not persist in soil. No pre-emergence control. Requires most careful timing and application as a fine droplet spray for best results. Can cause plant death or

			injury if used incorrectly. Follow label directions and consult your Federation Fieldman on current experience with Roundup in your district. Do not apply around trees less than 3 years old.
SHELL SIMAZINE 50SC (simazine)	4.8 litres	B C G P R S	A liquid formulation of simazine. Other comments as for Gesatop 80W.
SIMAZOL 80W (simazine)	3kg	B C G P R S	Comments as for Gesatop 80W.
SINBAR 80WP (terbacil)	2 - 3 kg	see remarks	May be used around apple but not pear trees and around peach trees but caution around apricots and plums as damage may result. Do not apply around trees less than 3 years old. Avoid use on light sandy soils. Sinbar gives excellent long term (6-9 months) control of many germinating weed seeds together with some knockdown effect on existing short open weed growth. Where existing weed growth is dense or above 15-20 cm high, combine with Amitrole TL, Preeglone or similar for best results.
WEEDAZOL TL (amitrole and ammonium thiocyanate)	6 - 11 litres	G P S	Comments as for Amitrole TL, NOTE: Do not apply between fruit set and harvest.

19.1.7 Herbicides for Commercial Vegetable Crops

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application	
				Crop	Weeds
All crops					
Glyphosate	1.5-2.0	Roundup	4.2-5.6 litres	pre-sow and pre-transplant	post-em
Paraquat	0.5-1.0	various	2.5-5.0 litres	pre-em	post-em
Diquat	0.5-1.0	Reglone	2.5-5.0 litres	pre-em	post-em
Paraquat/diquat	0.5-1.0	Preeglone Extra	2.8-5.6 litres	pre-em	post-em
Mineral oil	90-180 litres	various	450-900 litres	pre-em	post-em
Sulphuric acid	10%		1000 litres	pre-em	post-em

Contact pre-emergence treatments can be applied to all crops and are worth while when a substantial number of weeds have emerged before the crop. If the soil is prepared some time before sowing or planting, contact herbicides can often be used to great effect (stale seedbed or delayed planting techniques).
Paraquat is active against grasses; diquat controls broadleaf weeds.

Some species (e.g. fumitory, wireweed) are more easily killed when seedlings have attained true leaves.
Glyphosate can be worth while where perennial weeds have emerged in a stale seedbed, or prior to establishing a crop with minimum cultivation.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Asparagus, established					
Diuron	1.5-3.0	various		pre-em	pre-em
Simazine	1.0-2.0	various		pre-em	pre-em
Linuron	0.5-1.0	various		pre-em	pre- and post-em
Amitrole-T	2.0-4.0	Weedazol TL	10-20 litres	post-harvest	post-em
Asulam	1.5	Asulox	3.8 litres	post-harvest	post-em
2,4-D	1.0-2.0	various		post-harvest	post-em
MCPB	1.0-2.0	various		post-harvest	post-em
Tentative treatments					
Prometryn	0.5-1.0	Gesagard	1.0-2.0 kg	pre-em	pre- and post-em
Propazine	1.0-1.5	Gesamil, Propazol	2.0-3.0 kg	pre-em	pre-em
Terbacil	1.0-2.0	Sinbar	1.2-2.4 kg	pre-em	pre-em
Bromacil	1.0-2.0	various		pre-em, post-harvest	pre-em
Trifluralin*	0.8-1.5	Treflan	2.0-3.8 litres	pre-em, post-harvest	pre-em
Oxadiazon	1.5	Ronstar	6.0 litres	pre-em, post-harvest	pre- and post-em
Metribuzin	0.4	Sencor	0.6 kg	post-harvest	pre- and post-em
Glyphosate	1.5-2.0	Roundup	4.2-5.6 litres	post-harvest	post-em

Residual chemicals can give good control of germinating weeds in spring. Bromacil and terbacil have given promising results against summer grasses when applied after harvest.

Trifluralin can be incorporated in the soil each side of the row when the crop is cultivated.

Perennial weed problems can be tackled after harvest, and after cutting down the fern in autumn, with spot treatments of amitrole-T (docks and couch), 2,4-D and MCPB (thistles), asulam (docks) and oxadiazon (convolvulus).

Glyphosate is useful against most perennial weeds but should only be used, with great care, as a spot treatment in autumn or winter.

None of the chemicals should be applied during the cutting season.

Asparagus, seedling

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Diuron	1.0	various		pre-em	pre-em
Aziprotryne	1.5	Brasoran	3.0 kg	pre- and post-em	pre- and early post-em
Linuron	0.5	various		pre- and post-em	pre- and post-em
Methabenzthiazuron	1.5	Tribunil	2.1 kg	pre- and post-em	pre- and post-em
Tentative treatments					
Simazine	0.4	various		pre-em	pre-em
Metribuzin	0.4	Sencor	0.6 kg	pre-em	pre- and post-em

Some crop damage may occur from pre-emergence application of materials other than diuron, especially on light soils and under wet conditions.

Mixtures of metribuzin with diuron or methabenzthiazuron, applied pre-emergence, have given good results.

Beans, broad

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Simazine	1.0	various		post-sow	pre-em
Tentative treatments					
Chlormethazole	1.0	Probe	1.3 kg	post-sow	pre-em
Diuron	0.5	various		post-sow	pre-em
Linuron	0.8-1.0	various		post-sow	pre-em
Methabenzthiazuron	2.0	Tribunil	2.9 kg	post-sow	pre-em
Monolinuron	0.8-1.0	Aresin	1.6-2.0 kg	post-sow	pre-em
Prometryn	0.8-1.0	Gesagard	1.6-2.0 kg	post-sow	pre-em
Dinoseb acetate	1.5	Aretit	3 litres	pre- and post-em	pre- and post-em

On particularly light or wet soils some damage may be caused by the chemicals. Sow beans uniformly at 5–7 cm depth to minimise the risk. Chlorpropham, at 1 kg/ha, can be added to diuron in broad beans, especially for the control of fumitory.
Dinoseb should be applied after the second pair of leaves are present; some damage may occur.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Cabbages, brussels sprouts					
Dinitramine*	0.4-0.6	Cobex	1.7-2.5 litres	pre-transplant	pre-em
Trifluralin*	0.8-1.0	Treflan	2.0-2.5 litres	pre-sow and pre-transplant	pre-em
Sulfallate	5.0	Vegedex	10.4 litres	pre-em	pre-em
Alachlor	1.5	Lasso	3.0 litres	pre- and post-em	pre-em
Propachlor	4.0-5.0	various		pre- and post-em	pre-em
Aziprotryne	1.5-2.0	Brasoran	3.0-4.0 kg	pre- and post-em	pre- and early post-em
Nitrofen	1.5-2.0	Tok E25	6.2-8.3 litres	pre- and post-em	pre- and early post-em
Simazine	0.4	various		post-em	pre-em
Desmetryn	0.3	Semeron	1.2 kg	post-em	post-em
Terbutryn	0.3-0.4	Igran	0.6-0.8 kg	post-em	post-em
Tentative treatment					
Pendimethalin*	0.8-1.0	Stomp	2.4-3.0 litres	pre-sow and pre-transplant	pre-em

Chlorpropham, at 0.5 kg/ha, has been added to pre-em applications of sulfallate and nitrofen to increase their usefulness.

Simazine is not recommended under wet conditions or on light soils.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Carrots, parsnips					
Trifluralin*	1.0	Treflan	2.5 litres	pre-sow	pre-em
Propazine	1.0-1.5	Gesamil, Propazol	2.0-3.0 kg	post-sow	pre-em
Linuron	0.8-1.0	various		pre- and post-em	pre- and post-em
Prometryn	0.8-1.0	Gesagard	1.6-2.0 kg	pre- and post-em	pre- and post-em
Metribuzin	0.2	Sencor	0.3 kg	post-em	post-em
Mineral oil	90 litres	various	450 litres	post-em	post-em
Tentative treatments					
Alachlor	1.5	Lasso	3.0 litres	post-em	pre-em
Asulam	1.5	Asulox	3.8 litres	post-em	post-em
Metoxuron	3.5	Dosanex	4.4 kg	post-em	post-em

Metribuzin suppresses yarrow, but should not be used on parsnips. Half doses of linuron and/or prometryn applied before and after crop emergence often give good results, especially under rapid growing conditions. After crop emergence, neither of these herbicides should be applied until the two true-leaf stage has been attained.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Cauliflowers, broccoli					
Dinitramine*	0.4-0.6	Cobex	1.7-2.5 litres	pre-transplant	pre-em
Trifluralin*	0.8-1.0	Treflan	2.0-2.5 litres	pre-sow and pre-transplant	pre-em
Sulfallate	5.0	Vegedex	10.4 litres	pre-em	pre-em
Alachlor	1.5	Lasso	3.0 litres	pre- and post-em	pre-em
Propachlor	4.0-5.0	various		pre- and post-em	pre-em
Nitrofen	1.5-2.0	Tok E25	6.2-8.3 litres	pre- and post-em	pre- and early post-em
Simazine	0.4	various		post-em	pre-em
Tentative treatment					
Pendimethalin*	0.8-1.0	Stomp	2.4-3.0 litres	pre- sow and pre-transplant	pre-em

Chlorpropham, at 0.5 kg/ha, has been added to pre-em applications of sulfallate and nitrofen to increase their usefulness.

An experimental use of aziprotryne, at 1.5 kg/ha, followed by irrigation to wash the chemical off the crop foliage has been successful against weeds pre-emergence.

Simazine is not recommended under wet conditions or on light soils.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Celery					
Trifluralin*	1.0	Treflan	2.5 litres	pre-transplant	pre-em
Linuron	0.8-1.0	various		post-em	pre- and post-em
Prometryn	0.8-1.0	Gesagard	1.6-2.0 kg	post-em	pre- and post-em
Tentative treatments					
Alachlor	1.5	Lasso	3.0 litres	post-em	pre-em
Chloroxuron	4.0	Tenoran	8.0 kg	post-em	pre-em

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Garlic, leeks					
Diuron	0.5-1.0	various		post-transplant	pre-em
Simazine	0.5-1.0	various		post-transplant	pre-em
Aziprotryne	1.5-2.0	Brasoran	3.0-4.0 kg	post-transplant and post-em	pre- and early post-em
Chlormethazole	0.5-0.7	Probe	0.7-0.9 kg	post-transplant	pre- and post-em
Linuron	0.5-1.0	various		post-transplant and post-em	pre- and post-em
Methabenzthiazuron	1.5-2.0	Tribunil	2.1-2.9 kg	post-transplant and post-em	pre- and post-em
Monolinuron	0.5-1.0	Aresin	1.0-2.0 kg	post-transplant and post-em	pre- and post-em
Prometryn	0.5-1.0	Gesagard	1.0-2.0 kg	post-transplant and post-em	pre- and post-em
Ioxynil	0.6	Totril	2.4 litres	post-em	post-em

Use the higher rates of these herbicides only after planting garlic; in leeks, and post-emergence in garlic, use the lower rates. Plant at a uniform depth of no less than 5 cm to minimise the risk of crop damage on light soils or under wet conditions. Chlorpropham, at 1 kg/ha, can be added to diuron in garlic, especially for the control of fumitory.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Kumaras					
Alachlor	2.0-3.0	Lasso	4.0-6.0 litres	post-planting	pre-em
Tentative treatment					
Paraquat	0.1-0.2	various	0.5-1.0 litres	post-planting	early post-em

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Lettuce					
Chlorpropham	1.0-2.0	Chloro IPC	2.5-5.0 litres	post-sow and pre-transplant	pre-em
Sulfallate	5.0-7.0	Vegedex	10.4-14.6 litres	post-sow, pre-transplant and post-em	pre-em
Propyzamide	1.5	Kerb	3.0 kg	post-sow, pre-transplant and post-em	pre-em
Tentative treatment					
Trifluralin*	0.8	Treflan	2.0 litres	pre-transplant	pre-em

Lettuce is sensitive to most herbicides. Chlorpropham can cause damage on light soils or under wet conditions. Mixtures of chlorpropham and sulfallate at the lower rates have given good results.

Propyzamide works best under cool, moist conditions and can be quite persistent.

Trifluralin has given good results when watered, rather than incorporated, into the soil.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application	
				Crop	Weeds
Onions					
Chlorpropham	1.0-2.0	Chloro IPC	2.5-5.0 litres	post-sow	pre-em
Chlorthal	5.0-10.0	Dacthal	6.7-13.3 kg	post-sow	pre-em
Chloridazon/ chlorbufam	2.0-2.7	Alicep	4.4-6.0 kg	pre- and post-em	pre-em
Propachlor	4.0-5.0	various		pre- and post-em	pre-em
Alachlor	1.5	Lasso	3.0 litres	post-em	pre-em
Chloroxuron	3.0-4.0	Tenoran	6.0-8.0 kg	post-em	pre-em
Chlormethazole	1.0-1.5	Probe	1.3-2.0 kg	post-em	pre- and early post-em
Aziprotryne	1.5-2.0	Brasoran	3.0-4.0 kg	post-em	pre- and early post-em
Methabenzthiazuron	1.5	Tribunil	2.1 kg	post-em	pre- and post-em
Bentazone	1.0	Basagran	2.0 kg	post-em	post-em
Ioxynil	0.6	Totril	2.4 litres	post-em	post-em
Linuron	0.4	various		post-em	post-em
Prometryn	0.4	Gesagard	0.8 kg	post-em	post-em
Sulphuric acid	10%		1000 litres	post-em	post-em
Terbutryn	0.4	Igran	0.8 kg	post-em	post-em
Tentative treatments					
Ethofumesate	1.5-2.0	Nortron	7.5-10 litres	pre-em	pre- and early post-em
Diclofop-methyl	1.0-1.5	Hoe-Grass	2.8-4.2 litres	post-em	post-em

Chlorpropham should be used only at the lower dose on light soils or under moist, warm conditions when there is a risk of crop damage. Experimentally it has been successfully used at 0.8 kg/ha at the crop 'loop' stage.

At the crop 'flag' stage the addition of a wetting agent to chloridazon/chlorbufam gives control of small seedling weeds. Use the lower rate on light soils. To minimise the risk of damage, post-em herbicides generally should be applied only after the onion two true-leaf stage.

Bentazone controls cleavers and chamomiles.

Chlormethazole controls wireweed.

Chlorthal controls speedwells.

Ethofumesate controls poa annua.

Diclofop-methyl controls barnyard grass and ryegrass.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Peas					
Tri-allate*	1.4-1.7	Avadex	3.5-4.3 litres	pre-sow	pre-em
Trifluralin*	0.6-0.8	Treflan	1.5-2.0 litres	pre-sow	pre-em
Aziprotryne	1.5-2.0	Brasoran	3.0-4.0 kg	pre- and post-em	pre- and early post-em
Cyanazine	1.5-2.0	Herbitrol	3.0-4.0 kg	post-em	pre- and post-em
Methabenzthiazuron	1.5	Tribunil	2.1 kg	post-em	pre- and post-em
Bentazone	1.0	Basagran	2.0 kg	post-em	post-em
Dinoseb acetate	1.5-2.0	various		post-em	post-em
Dinoseb ammonium	0.8-1.0	various		post-em	post-em
MCPB	1.0-1.5	various		post-em	post-em
Prometryn	0.5-0.8	Gesagard	1.0-1.6 kg	post-em	post-em
Terbutryn	0.3-0.4	Igran	0.6-0.8 kg	post-em	post-em
Tentative treatments					
Dinitramine*	0.6	Cobex	2.5 litres	pre-sow	pre-em
Diclofop-methyl	1.0	Hoe-Grass	2.8 litres	post-em	post-em
Difenzoquat	0.8-1.2	Avenge	4.0-6.0 litres	post-em	post-em
Metribuzin	0.3	Sencor	0.4 kg	post-em	post-em

MCPB is mixed with dinoseb ammonium or bentazone, particularly for controlling thistles and cornbind. Do not apply diclofop-methyl within a week of any other spray application.

Diclofop-methyl, dinitramine, difenzoquat, tri-allate and trifluralin are active against wild oats.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Potatoes					
Cyanazine	1.0	Herbitrol	2.0 kg	pre-em	pre- and post-em
Linuron	1.0-1.5	various		pre-em	pre- and post-em
Prometryn	1.0-1.5	Gesagard	2.0-3.0 kg	pre-em	pre- and post-em
Terbutryn	1.0	Igran	2.0 kg	pre-em	pre- and post-em
Methabenzthiazuron	1.5-2.0	Tribunil	2.1-2.9 kg	pre-em	pre- and post-em
Metribuzin	0.5	Sencor	0.7 kg	pre- and post-em	pre- and post-em
Tentative treatment					
Bentazone	1.0	Basagran	2.0 kg	pre- and post-em	post-em

Alachlor, at 1 kg/ha, can be used in mixtures with other pre-emergence materials, especially for control of grasses.

Bentazone has been used particularly for control of cleavers.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Pumpkins, squash, cucumbers, gherkins, marrows					
Tentative treatments					
Alachlor	1.5	Lasso	3.0 litres	pre-em	pre-em
Chlormethazole	1.0-1.5	Probe	1.3-2.0kg	pre-em	pre- and post-em

Cucumbers and gherkins are particularly sensitive to herbicides. They are not tolerant to chlormethazole. Alachlor may cause reduction in vigour.

Good results have been obtained with a mixture of alachlor, at 1.0 kg/ha, and chlormethazole on pumpkins, squash and marrows.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Rhubarb					
Tentative treatments					
Chlorpropham	1.0-2.0	Chloro IPC	2.5-5.0 litres	post-harvest	pre-em
Simazine	1.0-1.5	various		post-harvest	pre-em

These herbicides can be used safely when the crop is dormant.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Silver beet, spinach					
Chloridazon	3.0-4.0	Pyramin	3.8-5.0 kg	pre-em	pre-em
Lenacil	0.8	Venzar	1.0 kg	pre-em	pre-em
Tentative treatments					
Ethofumesate	1.5	Nortron	7.5 litres	pre- and post-em	pre- and post-em
Desmedipham/ phenmedipham	0.8	Betanal AM 11	4.8 litres	post-em	post-em

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Swedes, turnips					
Trifluralin*	0.8-1.0	Treflan	2.0-2.5 litres	pre-sow	pre-em
Nitrofen	2.0-3.0	Tok E25	8.3-12.5 litres	post-sow	pre-em
Nitrofen	1.0-1.5	Tok E25	4.2-6.2 litres	post-em	early post-em
Tentative treatments					
Dinitramine*	0.3	Cobex	1.2 litres	pre-sow	pre-em
Pendimethalin*	0.8-1.0	Stomp	2.4-3.0 litres	pre-sow	pre-em
Alachlor	1.5	Lasso	3.0 litres	pre-em	pre-em
Propachlor	4.0-5.0	various		post-em	pre-em

Some of these treatments have not been widely tested; there may be varietal differences in susceptibility.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application: Crop	Time of application: Weeds
Sweetcorn					
Butylate*	4.0-5.0	Sutan	5.5-6.9 litres	pre-sow	pre-em
EPTC/antidote*	4.0-5.0	Eradicane	5.5-6.9 litres	pre-sow	pre-em
Simazine	1.0-2.0	various		post-sow	pre-em
Alachlor	2.0-3.0	Lasso	4.0-6.0 litres	pre-em	pre-em
Atrazine/ metolachlor	1.5-3.0	Primextra 500 FW	3.0-6.0 litres	pre-em	pre-em
Atrazine	1.0-1.5	various		pre- and post-em	pre- and early post-em
Propachlor	4.0-6.0	various		pre- and post-em	pre- and early post-em
Tentative treatment					
Linuron	0.5-1.0	various		post-em	pre- and post-em

Simazine and atrazine are most effective against broadleaf weeds. EPTC, butylate, alachlor, propachlor and metolachlor control germinating grasses. To avoid damage from linuron, apply as a directed spray to the base of the crop plants. The contact effect of atrazine can be improved by addition of a wetter. Atrazine with 20 litres/ha of an 'all purpose spraying oil' has given good results post-emergence.

Common name	Dose (kg/ha a.i.)	Product name	Dose (per ha)	Time of application	
				Crop	Weeds
Tomatoes					
Trifluralin*	0.8-1.0	Treflan	2.0-2.5 litres	pre-transplant	pre-em
Sulfallate	5.0	Vegedex	10.4 litres	post-transplant	pre-em
Metribuzin	0.3-0.4	Sencor	0.4-0.6 kg	post-em	pre- and post-em
Tentative treatments					
Trifluralin*	0.8-1.0	Treflan	2.0-2.5 litres	pre-sow	pre-em
Pebulate*	4.0	Tillam	5.3 litres	pre-sow and pre-transplant	pre-em
Dinitramine*	0.5-0.6	Cobex	2.1-2.5 litres	pre-transplant	pre-em
Metribuzin	0.3-0.4	Sencor	0.4-0.6 kg	pre-em	pre-em
Alachlor	1.5	Lasso	3.0 litres	post-transplant	pre-em

In direct-sown seedbeds, damage may occur if metribuzin is applied pre-em under wet conditions or post-em before the tomato four true-leaf stage.

In experiments, alachlor, at 1.8 kg/ha, or metribuzin, at 0.6 to 0.9 kg/ha, have been safe and effective when applied to stale seedbeds 4 weeks before sowing.

19.1.8 Susceptibility of Common Weeds to Herbicides

Response:
R: Resistant
MR: Moderately resistant, temporary suppression
MS: Moderately susceptible, growth checked
S: Susceptible

pre-em: pre-emergence
post-em: post-emergence

Herbicide	Dose (kg/ha a.i.)	Time of application to weeds	Redroot	Shepherd's purse	Fathen	Twin cress	Summer grass	Scrambling fumitory	Toad rush	Annual grass	Wire weed	Willow weed	Wild portulaca	Docks	Groundsel	Black nightshade	Spurrey	Chickweed	Clovers	Annual nettle	Speedwells
Alachlor	1.5	pre-em	S	S	MR	MS	S	MS	S	S	R	R	S	MR	MR	S	S	MR	S	MS	S
Atrazine	1.0	pre- and early post-em			S	S	S	S					S		S	S	S	S		MS	
Aziprotryne	1.5	early post-em	MS	S	S	MR	MS	MS	S	S	MS	MS		MS	MS	S	S	S	MS	S	S
Bentazone	1.0	post-em	MR	S	MR	MR	R			R	R	MS	S			S	S	S	R	S	R
Bromacil	1.2	pre and early post-em			S	S	MS	S		S						S					
Chlorbufam/ chloridazon	2.2	pre-em		S	S	MR		MS	S	MS	S	MS		S	S			S	MS	S	S
Chloridazon	3.0	pre-em	MR	S	MR	MS			S	MS		S			MS			MS		MS	
Chlormethazole	1.5	pre- and early post-em	S	S	S	S		R		S	S	MS	S	S.		S	S	S	S	S	MR
Chloroxuron	3.0	pre- and early post-em	MR		MS	S	MR	MR	S			MR		S		S	MS	S	MS	MS	
Chlorpropham	1.0	pre-em		MS	MS	R		MS		S	S	MS	MS		R	R	S	S		S	MS
Chlorthal	8.0	pre-em		R		R	S	R			S	MR				MS					
Cyanazine	1.5	pre- and early post-em	S	S	S	S	R			S	MS	S		S	MS	S	S	S	S	S	S
Cycloate	3.5	pre-em	R	MR	MS	R				S			MS			MR		MS			
Desmedipham/ phenmedipham	0.8	post-em	S		S	MS	MS			MR			S			S					S
Desmetryn	0.3	post-em			S	MS	R	MS	MS	MR	R	S	S	MS	MR	S	S	S	MS	S	S
Dinitramine	0.6	pre-em	S	MR	S	R		MS	MS	S	S	MR		S	MR	MS	MS	MS	MR	MS	S
Dinoseb acetate	1.5	post-em	MR	S	MS	S		S	S	R		MS		S	MS	MS	S	S		S	S
Diuron	1.0	pre-em		S	S	S		R	S	S		MR	MS	S	MS	S	S	MS	S	S	S
EPTC	5.0	pre-em	MR	R	MS	MR	S	S	MR	S	S	MS	MS	MR	R	R	MS		MS	S	
Ethofumesate	2.0	post-em	MS	MR	MR	MS	MS	R	MS	S		MS	MS			MS				MS	
Ioxynil	0.6	post-em		S	S	S		MS	MS	R	MS	S		R	S	S	MR	S		MS	MS
Lenacil	1.0	pre-em	R	S	MS	S		S	S	S	S	MR			MS	MR	MS	S		MS	MR
Linuron	1.0	pre- and post-em	MS	S	MS	S		R	S	MR	MR	S	S	MS	MS	MS	S	S		S	MS
Metamitron	6.0	post-em	S	S	S	MS	MS	S		S	S	S	S		S	S		S		S	S
Methabenzthiazuron	1.5	post-em	MS	S	MR	S		S	S	MS	MR	MS		MS		S	S		MR	S	
Metoxuron	3.5	post-em	MR	S.	S	MS	MR	MS	MS	MR	S	MS		MS	S	S	S	S	S	S	MS
Metribuzin	0.4	post-em	S	S	S	S	MR	S		S	MR	S	S	S	S	R	S	S	S	S	S
Monolinuron	1.0	pre- and post-em	MS	S	MS	S		R	S	S		MS	S	MR	MS	MS	S	S		S	MS
Nitrofen	1.5	post-em		R	MS	R	MR	MS	S	R	S	S			R	S	MS	R		S	S
Pebulate	4.0	pre-em		R	MR	MR			S	S		MS	MS	R		R	MS	MS	MR		MR
Pendimethalin	1.5	pre-em	S		MS	MR						R		S		R	MS		MR		
Prometryn	1.0	pre- and post-em		S	S	MS		S	S	MS	MR	MS	MS	MS	S	MS	S	S		S	MS
Propachlor	4.0	pre-em	MS	S	MS	MR	S	R	S	S	MR	MR	S	MR	S	MS	S	MR		S	S
Propazine	1.5	pre-em			S	S	R	S		S		S			S	S	S		S		S
Propyzamide	1.5	pre-em	R	MS	S	MR		S	S	S	S	S	MS	MR	R	S	S	S	MR	S	S
Simazine	1.0	pre-em		S	S	S	MS	S	S	S	MR	MS		S	S	S	S	S	S	S	S
Sulfallate	4.0	pre-em		R	MR	R		MS		S		R	MS	R		R	R				
Terbacil	1.0	pre-em			MS	S	S	S				S	MS		S	S	S	S	S		
Terbutryn	0.4	post-em	S		MS	S	MR	S	S	MR	MR	S		S		S	S	S		S	
Trifluralin	1.0	pre-em	S	R	S	R		MS	R	S	S	MR	MS	S	R	R	MS	S	R	S	

19.2 INSECT CONTROL

19.2.1 Introduction

The most common method of controlling insect pests is some form of chemical control. This section deals with this aspect but it must be realized that there are other methods of control available that do not rely solely on chemicals.

The lists that follow deal with the most important agricultural insect pests, and the most commonly used chemicals for their control.

As with the weed control section, the mention of a chemical does not constitute an endorsement of the product by Lincoln College, nor does it constitute an endorsement over other chemicals not mentioned.

This section is based on the book "New Zealand Insect Pests", D.N. Ferro (ed.) published by Lincoln College in 1976. Readers of this Manual should consult this book for further information on the pests dealt with, and also for other insect pests that affect deciduous trees, subtropical fruits, glasshouse and ornamental plants or have importance as medical or household pests.

In conjunction with this book, the various publications by the New Zealand Agricultural Chemicals Board should be consulted.

In the preface to "New Zealand Insect Pests", Dr. Ferro wrote:

"It must be emphasised that local conditions may require the usage of special chemicals, techniques or control strategies. Also if a pest occurs on several different crops this does not necessarily mean that the same chemical and methods of application can be used on all crops. Therefore, local advisory personnel should be contacted regularly to assure the most recent and (or) appropriate control strategies are being employed.

...Many of the insects described are only occasionally pests and seldom reach large enough numbers to be classified as pests. It is up to every farmer to become familiar with the pest complex of each crop, and to recognize when an insect is present in sufficient numbers to warrant pest status and subsequent control. Too often farmers and, maybe more importantly, farm advisors, are dependant on prophylactic techniques to take care of pest problems. Hopefully, the information contained in this book will help the farmer to become more informed and therefore more independant in making decisions on pest control."

NOTE:
Some chemicals which could be used for control of the various pests are listed on the following pages. This list is by no means exhaustive and it is important to consult local advisory personnel as to conditions prevailing in your district and the availability of alternative chemicals. Where alternatives to chemical control are feasible, these should be discussed with advisory personnel, as should be correct timing of spray applications for the various pests.

ALWAYS READ THE LABEL

19.2.2 Berry Fruit Pests.

Pest	Chemical	Product Rate*	Remarks
Blackcurrant Aphid	demeton-s-methyl dimethoate	0.02% 0.03%	Growing tips should be closely inspected at regular intervals for aphids. Observe waiting periods.
Blackcurrant Bud Mite	endosulfan	0.15%	For moderate to heavy infestations, repeat after 3 weeks at 0.15% if necessary. Permit required unless used according to special conditions. Observe waiting period.
	endrin	0.05%	Permit required, observe waiting period. Very toxic, should only be used where no other chemical available.
Black Vine Weevil	dieldrin lindane	3.5 kg a.i./ha 2 kg a.i./ha	May be applied to soil prior to planting but not with a spinner. In established beds apply to soil in autumn and early winter. Permits required.
	carbofuran	2.5 kg a.i./ha	Care must be taken to get the material onto the soil under the polythene mulch.
Bugs	carbaryl dichlorvos	0.15% 0.02%	Spray late in the evening. Found to be successful on strawberries.
	parathion	0.02%	Most satisfactory but long waiting period. Permit required. Very hazardous material.
	mevinphos	0.04%	Highly hazardrous, 5 day waiting period on strawberries.
Currant Clearwing	azinphos - methyl	0.05%	Apply immediately post harvest and 2 and 4 weeks later.
Fuller's Rose Weevil	aldrin	2 kg a.i./ha	Highly effective when applied to the soil; only warranted in exceptional circumstances. Permit required.
Garden Weevil	azinphos-methyl chlorpyrifos methiocarb	0.05% 0.03% 0.07%	Observe waiting periods. Suggested chemicals only.
Grape Erineum Mite	parathion	5.00 ml a.i./ha	Apply at bud burst

Pest	Chemical	Product Rate*	Remarks
	demeton-s-methyl	0.02%	Effective against existing leaf infestations.
	lime sulphur	1%	At late dormant to early bud swell.
Grape Mealy Bug	methyl parathion	0.04%	Permit required, use only on severe infestations.
	parathion + oil	0.04% + 1% oil	Very hazardous. Avoid high temperatures when applying oil sprays.
	chlorpyrifos	0.03%	Less hazardous than above. Use on low and moderate infestations.
	methiocarb	0.07%	
	phosmet	0.08%	
Grapevine Moth	azinphos-methyl	0.05%	Only after flowering
	carbaryl	0.12%	Applied before or after flowering, not very persistant.
Grass Grub	dieldrin	3.5 kg a.i./ha	May be applied to soil prior to planting but not with a spinner. In established beds apply to soil in autumn and early winter. Permits required.
	lindane	2 kg a.i./ha	
	diazinon	2 kg a.i/ha	Less persistent than above, timing critical.
	fensulfothion	2 kg a.i./ha	
Leafhoppers	carbaryl	0.12%	Suggested chemicals only.
	demeton-s-methyl	0.02%	
	dimethoate	0.03%	
Leafroller	azinphos - methyl	0.05%	Frequency of application depends on crop. Consult local advisors.
Passionvine Hopper	Cabaryl	0.1%	Low persistence
Raspberry Aphid	demeton-s-methyl	0.02%	Observe waiting period.
	dimethoate	0.03%	
Raspberry Bud Moth	azinphos-methyl	0.03%	Used in place of carbaryl post-harvest.
	carbaryl	0.15%	Short term control.
	DDT	0.03%	Permit required, use only in September or at leaf fall on berry fruits and not to be applied between flowering and harvest.
Raspberry Sawfly	carbaryl	0.1%	Suggested chemical only.

Pest	Chemical	Product rate*	Remarks
Root Nematodes	parathion	0.01%	Soak roots of valuable plants in solution.
Strawberry Aphid	demeton-s-methyl dimethoate	0.02% 0.03%	Observe waiting period.
Strawberry Root Weevil	dieldrin lindane	3.5 kg a.i./ha 2 kg a.i./ha	May be applied to soil prior to planting but not with spinner. In established beds apply to soil in autumn and early winter. Permits required.
	carbofuran	2.5 kg a.i./ha	Care must be taken to get the material onto the soil under the polythene mulch.
Two-spotted Spider Mite			See local advisory officers as availability of compounds and the incidence of resistance varies markedly between districts.

*Unless otherwise stated the rate is given as the percentage active ingredient to be applied. It is assumed that for dilute applications 2000–3000 litres of solution are applied per hectare or for 3x concentrate 670–1000 litres are applied.

However, the same amount of toxicant is applied per hectare with a dilute or 3x concentrate application. The concentrations listed above are for dilute application.

19.2.3 Apples and Pears

(N.Z. Fruit Growers Fed. Ltd, Bulletin 5 and 6)

Because of many variable factors the New Zealand Fruit Growers' Federation Ltd cannot be held responsible for any down grading or loss of crop resulting from the use of the following information. It is a guide only.

Pest	Chemical	Product Rate (per 100 litres water)	Remarks
Codling Moth Leaf Roller	Gusathion 50 W.P.	100 g 75 g 50 g	Most effective, 75 g usually adequate. Good persistence.
	Imidan 75 W. (apples)	100-150 g	Not as effective as gusathion for leaf roller. Can russet sensitive varieties if used before December.
	Lorsban 50 W. (apples)	50-75 g	For codling moth - may not be adequate. Consult Federation Fieldman for time and use.
	Matacil 75 W.P.	100-150 g	Effective against mealy bug also. May increase russet. Note: can be highly toxic to *T. pyri* mite predators.
	Septan 80 W.	150 g	Inferior for leafroller. Short persistence. Useful close to harvest. Waiting period 1 day.
Mealy Bug	Folidol m 50 EC. (pears mainly - apples before blossom)	76 ml	Apply with 2.5% at spray at bud burst.
	Folimat 50 N.A.C.	125 ml	Active. Also for woolly aphis, scale crawlers, mites. Apply as a dilute spray. Do not apply to stone fruit.
	Lorsban 50 W. (apples)	50-75 g	Minimum of 2 consecutive sprays mid Nov - mid Dec. suggested to follow Tokuthion, Folidol or Lorsban treatment.
	Matacil 75 w.p.	100-150 g	Effective. Use as required or alternate with Gusathion.
	Phosdrin Conc. 99 AC. (mainly pears)	32 ml	Emergency clean up spray. 3 day waiting period.
	Rogor E 40 AC.	80 ml	Apply as dilute spray. Slow drying. Evening spray best.

(Mealy Bug continued)	Setpan 80 W.P.	150 g	Less toxic to handle, less effective alternative to Phosdrin.
	Tokuthion 50 EC.	100 ml tentative 60 ml tentative	Subject to registration. Consult your Federation Fieldman.
Mite	Citrason 20 EC	180 ml	Control of European Red Mite. *T. pyri* predator mite survives treatment. Does not control Two Spotted Mite.
	Dibrom 8 EC. (mainly apples)	39-63 ml	Emergency control near harvest only. Do not exceed 2 l/ha.
	Folimat 50 N.A.C.	102 ml	Dilute spray. Mites resistant to Folimat, now present in most districts.
	Kelthane 35	100 g	Mainly from December - 2 sprays, 10 days apart.
	Morestan 25 W.P. (apples)	50 g	Can russet fruit unless carefully used. Consult Federation.
	Morocide 50 W.P. (apples)	50-75 g	Two Spotted Mite. Control of European Mite not good.
	Neoron 50 E.C. (apples)	190 ml	Effective control summer populations. Complete coverage essential.
	Omite 30 W.P. (apples)	200 g	Summer knockdown. Non-systemic - good coverage essential. Do not apply within 30 days of an oil spray.
	Peropal 25 W.P.	Petal fall onwards I.M.C. Programme 50-75 g Non I.M.C. using 4000 l water per hectare 50-75 g (Non I.M.C. using 3000 l water/ha) 75-100 g	Effective. Non-systemic. Variation in dosage rate necessary, especially where intergrated mite control (I.M.C.) is not practised. Consult Fed. Fieldman on dosage and timing.

(Mite continued)	Plictran 50 W.P.	Petal fall onwards I.M.C. programmes 25-37 g Non I.M.C. using 4000 l water/ha 25-37 g Non I.M.C. using 3000 l water/ha 37-50 g	Effective, slow action against mobile stages. Best used before mite numbers get too high. *T-pyri* predator mite survives this treatment. Variation in dosage rates necessary to ensure adequate production/ha.
	Spidex 50 W.P.	75-100 g	Controls summer eggs, and mobile mites. Non effective on Kelthane and Tedion resistant mites.
	Vydate 24 N.A.C. (experimental)	200-250 ml	Short persistence, pre harvest. Highly hazardous - use full protective clothing.
	Oils - dormant and greentip use: Mobil Red Oil Shell Red Oil	4 l	Apply during the month before bud burst. Dilute application.
	Mobil 663 oil Shell late winter	2-2.5 l	Alternative to Red oils. Ensure thorough coverage. Dilute application in calm weather, essential.
	Oils - summer use Shell universal Mobil superior No. 5	1 l	Use only if summer miticides not effective. Avoid captan difolation or sulphur residues on trees to be sprayed. Two sprays 7 days apart. Dilute drenching spray essential.
Woolly Aphids	Folimat 50 EC (apples)	102 ml	Dilute spray.
	Kilval 40 A.C. (apples)	125 ml	Specific single application.

(Wooly aphids continued)	Lindane 50 W.P. (apples)	100 g	Apply if injury visible.
	Lorsban 50 W.P.	50 g	Effective when used in a schedule.
Aphids	Lindane 50 W.P.	100 g	Apply before leaves are distorted. Not over bloom, toxic to bees.
	Malathion 25 W.P.	200 g	Late summer use only. Other chemicals more effective.
	Metasystox i	102 ml	Systemic very effective once leaves distorted, or as preventative.
	Rogor E	76 ml	Systemic very effective once leaves distorted, or as preventative. If dry, irrigate, as many cause leaf drop.
Thrips	Metasystox i 25 E.C.	100 ml	To prevent deformed and scarred fruit. Apply promptly. Pre-bloom sprays sometimes applied also.
	Basudin 50 W.P.	100 g	Waiting period: 14 days
	Dibrom 87 E.C.	40 ml	Waiting period: 4 days Caution - russet
	Folidol M 50 E.C.	76 ml	Waiting period: 14 days - hazardous
	Gusathion 50 W.P.	75 g	Waiting period: 14 days - smooth skin, 21 days other.
	Malathion 50 W.P.	150 g	Waiting period: 3 days
	Septan 80 W.P.	100 g	Waiting period: 1 day
Peach Silver mite	Lime sulphr (peaches and nectarines)	5 l	Should give full season control.
	Rogor E. (peaches and nectarines)	76 ml	Alternative to lime sulphur.

19.2.4 Cereal Crop Pests

Pest	Chemical	Product Rate (a.i./ha)	Remarks
Argentine Stem Weevil	diazinon methomyl oxamyl	2–3kg 1–2kg 1–2kg	Must be applied before breeding cycle begins. Generally is not needed in cereal crops if cereals are planted at right time of year. Important only for protecting seeding plants against larval attack.
Armyworms	fenitrothion methomyl diazinon	1kg 500g 0.65 kg/ha.	Apply to cereals as soon as damage is apparent.
Cereal Aphid	demeton-s-methyl	750g	Organophosphorus spray or systemic granules topdressed in August prevent secondary virus spread.
	disulfoton phorate	1kg 1kg	Systemics applied as granules at time of sowing.
Cereal Leaf Aphid	demeton-s-methyl	500–750g	Seldom needs to be sprayed.
Grain Aphid	demeton-s-methyl	500–750g	Apply as a foliar spray to immature wheat when 30% or more of the heads are infested.
Greasy Cutworm	carbaryl methomyl	250g 250g	Applied as a bait. Applied as foliar spray.
Wheat Bug	diazinon	1kg	Apply as a foliar spray when bugs become noticeable in wheat heads and grains are in the 'milk-ripe' state.

19.2.5 Forage and Seed Crop Pests

Pest	Chemical	Product Rate (a.i./ha)	Remarks
Australian Crop Mirid	carbaryl maldison	1–2kg 1–1.5kg	Spray on appearance and repeat at 2–3 week intervals.
Clover Casebearers	bromophos	500g	Apply in the evening or early morning as a foliar spray. A permit is required to spray clover in bloom. Check on Apairies Protection Regulations.
Clover Mites	dicofol omethoate	300g 75g	Apply as a foliar spray. Both are toxic to bees.
Cocksfoot Midge	diazinon	1kg	Apply when flowers are in full head. Do not normally need to spray for this pest if seed crop is properly managed.
Cocksfoot Thrips	diazinon	1kg	Apply at flowering.
Potato Mirid	carbaryl maldison	1–2kg 1–1.5kg	Spray on appearance and repeat at 2–3 week intervals.
Red Clover Thrips	bromophos dichlorvos	500g 75g	Spray in evening or early morning. Note Apiaries Protection Regulations.

19.2.6 Livestock Pests

Pest	Chemical	Product Rate*	Remarks
Blow Flies	chlorfenvinphos	0.025%	Jetting as a preventive measure.
	diazinon	0.02%	
	fenchlorphos	0.05%	Creams or solutions for individual treatment.
Cattle Lice	crotoxyphos	0.125%	Dip or shower for lactating cattle.
	famphur	13%	Pour on treatment.
	fenthion	12%	
Cattle Tick	chlorfenvinphos	0.05%	Gives 2–3 weeks protection on sheep and 2–3 days on cattle.
	coumaphos	0.05%	
	phosalone	0.05%	
Chorioptic Mange Mite	lindane	0.1%	Applied as a foot bath for leg mange and as a cream for scrotal mange.
Follicle Mites	lindane	0.1%	Applied as a cream to infested parts.
Horse Bot Flies	trichlorphon	10%	Applied as a drench according to body weight.
Pig Louse	coumaphos	0.05%	Applied as a dip or shower.
	famphur	13%	Pour on treatment
	fenthion	12%	
Sheep Itch Mite	lime sulphur	1%	Applied as a dip or shower.
Sheep Ked	fenchlorphos	0.025%	Applied as a dip or shower.
Sheep Lice	coumaphos	0.05%	Applied as a dip or shower.
	diazinon	0.02%	
	lindane	0.1%	Foot bath for foot louse. Sheep must not be dipped in lindane.
Sheep Nasal Bot Fly	trichlorphon	10%	Applied as a drench according to body weight.
Stable Fly	dichlorvos	–	Pesticide strips hung in buildings.
	dichlorvos	0.1%	Sprayed on buildings in places where flies rest.

*Percentage active ingredient

19.2.7 Pasture Pests

Pest	Chemical	Product Rate (a.i./ha)	Remark
Argentine Stem Weevil	carbofuran	1–2kg	Sidedressed along seed lines for control in maize.
	phorate	1–2kg	
	methomyl	1–2kg	For controlling larvae in grass pastures.
	oxamyl	1–2kg	
Armyworm	diazinon	0.65 kg a.i./ha.	Apply to pastures as soon as damage is apparent.
	fenitrothion	1kg	
	methomyl	500g	
Australian Solder Fly	carbofuran	2kg	Underdrilled in pastures or sidedressed along seed lines in maize.
	phorate	2kg	
Black Beetle	fensulfothion	2–3kg	Applied as granules in late November-early December to control larvae, or in September to control adults.
	ethoprophos	2kg	
	isazophos	2kg	
	fensulfothion	2kg	Applied as a band above maize seed at time of planting to control adults.
	phorate	2kg	
Black Field Cricket	Maldison	125 g	Applied as bran and molasses bait at 10 kg/ha.
Blue-green Lucerne Aphid	demeton-s-methyl	100 g a.i./ha	Apply at first signs of damage.
Pea aphid-as for BGLA	pirimicarb	100 g a.i./ha	
	fenvalerate	25 g a.i./ha	
Blue Oat Mite	maldison	500g	
Grass Grub	diazinon	2kg	All should be applied as granules. Diazinon is NOT recommended on heavy soils or soils high in organic matter.
	fensulfothion	2kg	
	ethoprophos	2kg	

Pest	Chemical	Product Rate (a.i./ha)	Remarks
	lindane	1.5kg	For sheep and beef farms only, and can only apply from April to June–must have permit.
Greasy Cutworm	methomyl	250g	Applied as a foliar spray.
Lucerne flea	maldison	500g	Should be applied in early autumn.
Lucerne Stem Nematode	aldicarb dazomet		Applied as soil fumigant. Generally too expensive to use except on high value crops.
Porina	diazinon fenitrothion	1–2kg 750g–1kg	Apply as a foliar spray when larvae are still actively feeding. Should be used instead of above chemicals if conditions become cold and wet.
Red-Legged Earth Mite	azinphos-ethyl	200–300kg	Applied as a spray when visible damage occurs.
Scarab Beetles			See grass grub recommendations.
	DDT	1kg	For nursery stock and home gardens.
Sitona Weevil	azinphos-methyl fenitrothion	200–300g 300g	Applied as a foliar spray to control adult weevils.
Slugs	metaldehyde methiocarb		Incorporated into baits; if contaminate produce must respect withholding periods.
Tasmanian Grass Grub	diazinon fenitrothion	1–2kg 1kg	Applied as a foliar spray while the larvae are still actively feeding.
Whitefringed Weevil	carbofuran oxamyl methomyl fenitrothion	1–2kg 1–2kg 1–2kg 1–2kg	Applied as a foliar spray to kill adult weevils.

19.2.8 Stored Products Pests

The major consideration in control of stored products pests is the type of commodity and its future use rather than the species of insect. The rates given are for temperatures between 16–20°C and for concrete or steel structures.

Compound	Rate	Commodity	Remarks
Fumigants:			
methyl bromide	1.25kg/20 tonnes 1.25kg/24 tonnes 1.25kg/23 tonnes for 24 hr	Barley Wheat Maize } Stored in bulk	The gas should be recirculated if possible and after fumigation removed by aeration of the grain.
	25g/m³ for 24 hr	Bagged grain	
	35g/m³ for 24 hr	Milled cereals and nuts in impermeable containers	Recirculate gas
methyl bromide (reduced pressure)	40g/m³ for 3 hr	Bagged grain, nuts, spices and dried fruits.	Sustained vacuum (25 to 100mm mercury).
	50g/m³ for 3 hr at 20 to 25°C	Milled cereals in permeable containers	
	35g/m³ for 24 hr	Nuts, shelled or in the shell	
hydrogen cyanide	As for methyl bromide	Barley Wheat Maize } Stored in Bulk	As for methyl bromide. Highly hazardous compound.
hydrogen cyanide (reduced pressure)	40g/m³ for 3 hr at 20°C	Bagged grain, nuts, spices, milled cereals	Sustained vacuum (20 to 150mm mercury). Highly hazardous compound.
	85g/m³ for 4 hr at 20°C	Tobacco	
aluminium phosphide	90 tablets/20 tonnes 90 tablets/24 tonnes 90 tablets/24 tonnes for 4 days	Barley Wheat Maize } Stored in bulk	After fumigation the gas should be removed by aeration.
	45 tablets/30m³ for 4 days	Bagged grain and spices	

Compound	Rate	Commodity	Remarks
ethylene dichloride-carbon tetrachloride mixture (3:1 ratio)	5 litres/65 tonnes 5 litres/ 8 tonnes 5 litres/12.4 tonnes for 7 days	Barley Wheat Maize } Stored in Bulk	
	$500 g/m^3$ for 24 hr at 20°C	Bagged grain	
chloropicrin	1kg/20 tonnes 1kg/24 tonnes 1kg/23 tonnes for 24 hr	Barley Wheat Maize } Stored in bulk	Aerate after 24 hours.
	$50 g/m^3$ for 24 hr at 20°C	Bagged grain, nuts	Thorough aeration required.
Insecticides:			
bromophos	50g a.i./5 litres water/$100m^2$	Walls and floors of storage facilities.	
maldison	500g a.i./20 litres water	Storage facilities	Observe 12 hour withholding period.
	100g a.i./120 litres water/10 tonnes	Bulk grain	Maximum residue 2ppm by weight. Minimum quantity to be treated 10 tonnes.
baythion	10g/a.i./10 litres water/$100m^2$	Walls and floors of storage facilities	

NOTE: If the surface to be sprayed is porous the rates given in the table should be doubled.

19.2.9 Vegetable Crop Pests

Pest	Chemical	Product Rate (a.i./ha)	Remarks
Aphids	demeton-s-methyl dimethoate maldison	200g 200g 1–1.5kg	Foliar sprays – spray on appearance. Repeat 2–3 weeks later.
	disulfoton phorate	1.5–2.5kg 1–1.5kg	Granular application – for potatoes apply in bands at base of furrows when planting.
	pirimicarb	125 g a.i/ha	
Beet Leafminer	trichlorphon	1kg	Apply at first sign of damage. Repeat at 2 week intervals up until 2 weeks before harvest.
Carrot Rust Fly	diazinon disulfoton fensulfothion	2.2kg 2.2kg 2.2kg	Incorporate granules into soil prior to sowing. Diazinon only effective at soil temperatures below 16°C.
Caterpillars *Green Looper* *Tomato Fruitworm* *Greasy Cutworm*	carbaryl permethrin	1–2kg 50 g a.i/ha	Spray on appearance. Repeat at 2–3 week intervals.
Diamondback month	carbaryl diazinon permethrin fenvalerate	1–2kg 1kg 50 g a.i/ha 150 g a.i/ha	Apply when damage becomes noticeable. Repeat at 2 week intervals.
Green Vegetable Bug	carbaryl trichlorphon	1–2kg 1kg	Spray on appearance. Repeat at 10–14 day intervals.
Potato Moth	azinphos-ethyl endosulfan	500g 750g	Repeat at 10–14 day intervals.
Slugs and Snails	metaldehyde	3kg	Do not apply to edible parts.
Thrips	demeton-s-methyl maldison	200g 1.5kg	Spray on appearance. Repeat at 10–14 day intervals.

Tomato Russet Mite	demeton-s-methyl zineb	200g 2kg	Apply when mites first appear. Repeat at 10–14 day intervals.
Tomato Stem Borer	carbaryl diazinon	1.5–2kg 750g	Spray on appearance and ensure thorough coverage on base of stems. Repeat at 10–14 day intervals.
Weevils (Larvae and Adults)	azinphos-ehtyl carbaryl	400–500g 1.–5.2 kg	Foliar sprays – spray on appearance. Repeat at 10 - 14 day intervals.
White Butterfly	carbaryl diazinon permethrin fenvalerate	1–2kg 750g 50 g a.i/ha 150 g. a.i/ha	Spray on appearance. Repeat at 10–14 day intervals.
Wireworms	phorate	1–1.5kg	Incorporate granules into soil prior to sowing.

19.3 DISEASE CONTROL IN CROPS

19.3.1 Introduction

Most plant diseases can be placed conveniently into three groups, based on their main method of spread; from crop to crop and from season to season. The three groups are as follows:

- Seed-borne
- Air-borne, including splash dispersal and spread by insects
- Soil-borne

Information on these aspect of the life cycle of plant diseases is essential in determining the strategies that can be used for their control.

In considering control programmes, there are four aspects of importance:

(i) Reduce or eradicate the sources of plant diseases. This is primarily concerned with hygiene, and is based on the old adage that "prevention is better than cure". Rotation of crops is also important here.

(ii) Where practical, alter the environment (soil, crop and storage) in favour of the host plant, so reducing the chances of diseases becoming established and/or slowing down their rate of spread in crops.

(iii) Use resistant cultivars. Most plant breeding programmes have, as one of their aims, the development of new cultivars that are more resistant to diseases than those they are to replace. This is the best method of control and for many diseases there are good resistant cultivars.

(iv) Protection of the host plant.
There has been some successes with the use of biological control of plant diseases, i.e., using a non-pathogenic species to inhibit or retard the development of disease-causing organisms.

In general, it is still necessary to rely on chemicals for protection. These are applied in a number of ways to crops, e.g., as seed treatments, as sprays or dusts, and as granules (often applied into the soil). The chemicals that are available are of three types:

(a) protectant - applied to outside surfaces of the plant and interfere with germination and infection of the plant by pathogens (disease-causing organisms); for example, copper oxychloride, captan, thiram.

(b) eradicant - these, as well as protecting, have limited movement into the plant to eradicate established infections, e.g. dodine (Melprex, etc.) used for black spot control in apples.

(c) systemics - these have been developed since 1965, and will act both as protectants and eradicants, as well as being able to move through the plant in upwards direction, that is in the xylem, or water transport pathway. There are a number of different compounds available, e.g., benomyl, carboxin, thiabendazole, triadimefon, etc.

There are two difficulties associated with the use of systemics. Most have a narrow spectrum of activity, inhibiting some fungal organisms and not others. Thus it is essential to know the range of organisms that are affected by each, and in order to obtain effective control of two or more diseases it may prove necessary to use mixtures of two systemics, or mixtures of a systemic with a protectant. The other disadvantage of systemics is that a number of fungal organisms can develop resistance to their action. This breakdown of effectiveness can be avoided by a number of methods such as alternating the use of a systemic with a protectant, or using systemics from different groups.

NOTE 1

The various chemicals used in plant disease control are listed by their common name with the main trade name or names in brackets. The list is not complete and the use of alternative chemicals should be discussed with your local advisory people, as well as considering the correct time of application of sprays for maximum control of diseases. With all chemicals READ THE LABEL for notes on rates of use and hazards associated with their use.

NOTE 2

In order to explain control of cereal diseases, it is necessary to understand the growth stages of cereals. This diagrammatic key is reproduced on the following pages.

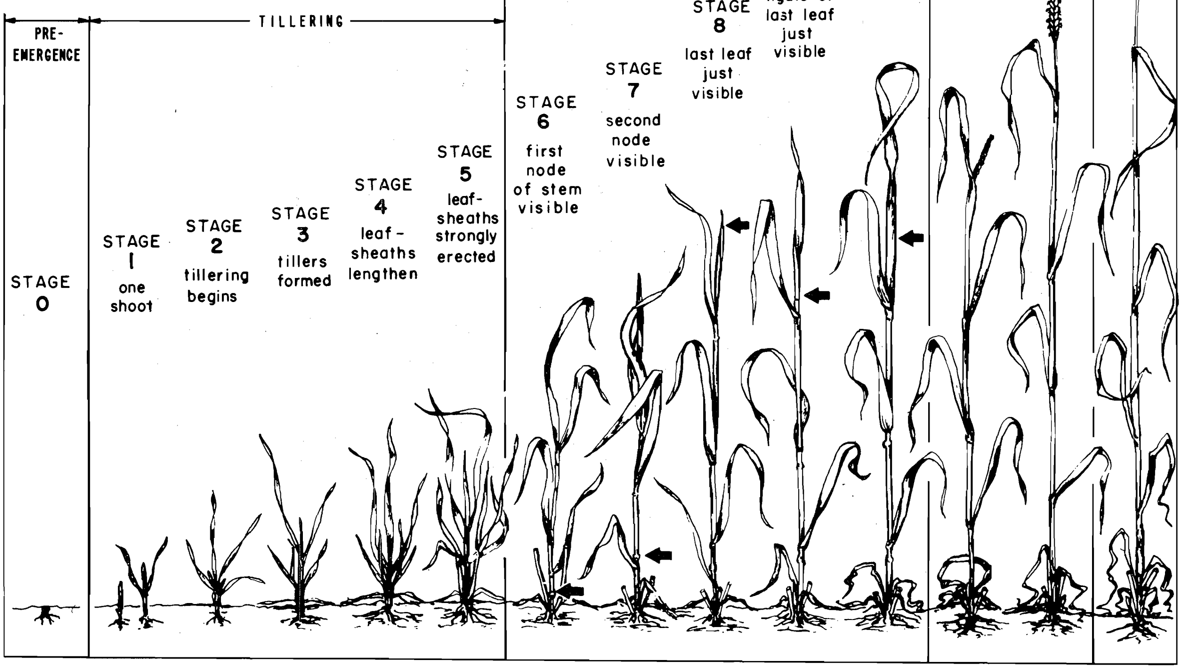
GROWTH STAGE KEY FOR CEREALS

(Sometimes referred to as the Feekes scale)

Stage	
1	One shoot (number of leaves can be added) = "brairding".
2	Beginning of tillering
3	Tillers formed, leaves often twisted spirally. In some varieties of winter wheats, plants may be "creeping" or prostrate.
4	Beginning of the erection of the psuedo-stem, leaf sheaths beginning to lengthen
5	Pseudo-stem (formed by sheaths of leaves) strongly erected.
6	First node of stem visible at base of shoot
7	Second node of stem formed, next-to-last leaf just visible
8	Last leaf visible, but still rolled up, spike beginning to swell.
9	Ligule of last leaf just visible
10	Sheath of last leaf completely grown out, spike swollen but not yet visible.
10.1	First spikes just visible (awns just showing in barley, spike escaping through split of sheath in wheat or oats)
	10.2 Quarter of heading process completed
	10.3 Half of heading process completed
	10.4 Three-quarters of heading process completed
	10.5 All spikes out of sheath
	10.5.1 Beginning of flowering (wheat)
	10.5.2 Flowering complete to top of spike
	10.5.3 Flowering over at base of spike
	10.5.4 Flowering over, kernel watery ripe
11.1	Milky ripe
11.2	Mealy ripe, contents of kernel soft but dry
11.3	Kernel hard (difficult to divide by thumb-nail)
11.4	Ripe for cutting. Straw dead

(After E.C. Large. 1954. Plant Pathol. 3:128-129)

GROWTH STAGES IN WHEAT, OATS, BARLEY, RYE



19.3.2 Cereals - Wheat, Barley, Oats and Maize

(i) Seed-borne Diseases

All cereal grain for sowing must be treated with an approved fungicide such as:

Wheat - Orthocide 75, Dithane M45, Vitaflo 200, Baytan F17
Barley - Dithane M45, Vitaflo 200, Baytan F17
Oats - Dithane M45, Vitaflo 200, Baytan F17
Maize - Vitaflo 200, benomyl/thiram, benomyl/captan.

The purpose of seed treatment is to control disease-organisms **on or in** the seed, as well as to protect the seedlings against soil-borne pathogens. Some fungicides, e.g. Baytan F17, can protect plants against some air-borne pathogens (e.g. powdery mildew), when these are present in the young crop.

The diseases that must be controlled by seed treatment are the stinking and covered smuts, and where loose smut is a problem, a systemic product should be used, such as Vitaflo 200 or Baytan F17.

In barley, net blotch can be serious, but it is effectively controlled by the use of Dithane M45, Vitaflo 200 and by Baytan F17.

In maize, head smut (both seed and soil-borne) is partially controlled by seed treatment, using carboxin + thiram (Vitaflo 200) and benomyl/captan or benomyl/thiram mixtures. In fields with high levels of smut, grown alternative crops to reduce levels of smut in soil.

(ii) Soil-borne Diseases

Take-All - in wheat and barley (and couch/twitch)	Rotate crops, burn or destroy stubble. Avoid areas where couch is present or has been killed by round-up.
Eyespot - in wheat	Can be a problem in 2nd or 3rd crops. Rotate crops, burn or destroy stubble, good weed control sowing rate less than 150 kg, use

of partially resistant cvs. (Takahe, Aotea). Chemical - spray benomyl at growth stage 7-8. (see growth stage key).

Root Rots of Maize - May be severe in some areas. Such areas should not be used for future maize sowings.

(iii) Air-borne diseases

Barley and yellow dwarf virus (BYDV) spread by the cereal aphid.

Wheat - autumn-sown - sow in late May early June to avoid the aphid flights.

Spring (September) sown wheat - BYDV is of much less importance, though in some trials yield losses have been prevented by the use of a granular O.P. insecticide at sowing followed six weeks later by an O.P. spray.

Barley - because of its faster growth rate, seems much less affected by BYDV. However, virus-infected plants can sometimes be seen as markedly yellow in colour and scattered throughout crops.

Oats - sown in autumn for greenfeed, are often severely infected, showing the typical reddish-purple colouration of the leaved. Infected plants often contain high levels of nitrate which may affect health of grazing stock. Oats, sown for grain, when infected show blasting of the head.

Leaf Rust; Stripe Rust (in wheat only) These can appear late in wheat crop growth (at or after flowering). Grain size is reduced, because the leaf area is less, and so there is less assimilates for the grain. If more than 50% of the flag leaf and leaf 2 are infected at this stage (G.S. 10.5 to 10.5.4) then the crop should be sprayed with triadimefon (Bayleton).

Stem Rust - this also occurs late in crop development - infecting the stem below the ear and reducing the movement of water and assimilates to the developing grain. Stem rust is not often a problem in New Zealand, but in some seasons and in some localities, spraying with Bayleton may be necessary.

Speckled Leaf Blotch - can occur early in growth of autumn (May-June) sown wheat. Spray from early to late August, when the disease can be found infecting at least half the first leaves of seedling wheat. Best time of application is probably G.S. 3-4, using benomyl (Benlate) of triadimefon (Bayleton).

This disease can occur later in crop development (at flowering) when sprays for leaf rust control will also provide control.

As the fungus survives on crop debris, burn or destroy wheat stubble as soon as possible after harvest.

Powdery Mildew - occurs on wheat and barley, though the races on each are distinct, the one on wheat will not infect barley and vice versa. In susceptible cultivars, some losses of yield have been recommended, the responses obtained in trials when spraying only for mildew control, have not been worthwhile economically. With some cultivars (such as Hilgendorf) spraying may be worthwhile, use triadimefon (Bayleton).

Net Blotch of Barley - mainly controlled through the use of effective seed treatment chemicals. However, the disease also can spread into barley crops from outside sources such as stubble and volunteer plants. These sources must be destroyed before spring sowing of barley commences.

Maize - Northern Leaf Blight - a common disease, generally severe in some areas of the Waikato causing losses in yield. The fungus survives in the debris from the previous crop, so plough stubble early to reduce this carry-over of disease. Resistant cultivars are an effective means of control.

19.3.3 Potatoes

	Spread By	Control: Cultural	Control: Chemical
Late Blight	Tubers and air	Destroy volunteer plants and piles of discarded tubers. Most certified seed is free of tuber infection.	Spray at first appearance of blight, with maneb, (various) mancozeb (various) propineb (Antaco) chlorothalonil (Bravo) metalazyl (Ridomil) tin compounds (Brestan and Duter) spray every 10-14 days only if weather continues warm and moist.
Early Blight	Air	Occurs generally late in season, more common in dry weather.	Above spray programme provides control.
Black Scurf *Rhizoctonia*	Mainly by Tuber (on outside), Soil	Rotate crops. Plant shallow in warm soil to ensure rapid emergence.	Treat seed tubers by dipping or dusting with benomyl, captan, thiabendazole.
Skin spot, sliver scurf, dry rot, and gangrene (storage problems).		Rotate crops	Treat seed and table tubers soon after harvest with thiabendazole spray. Cure at 15°C for 3 weeks before transferring to storage temperature.
Viruses Mild mosaic (PVX)	Tubers and SAP	Present in many cultivars, though most of the new cvs are resistant.	
Severe mosaic (PVY)	Tubers and APHIDS	Only a problem in some cvs such as King Edward, Eqicure, Jersey Bennes, Blen Ilam.	
Leaf Roll (PLRV)	Tubers and APHIDS	Occurs in all cultivars, most are very susceptible, though Katahdin shows resistance to infection. This virus is frequently the main cause of seed potato degeneration. Spread can be prevented by controlling aphids, during early plant growth, by means of granular O.P. insecticides applied at planting time, e.g. disulfoton (Disyston) or phorate (Thimet).	

In general, potato viruses are controlled through seed potato certification. The standard for Group 1 is less than 0.1% virus, less than 0.5% for Group 2, and less than 1% for Group 3.

Verticillium wilt -	Tubers and Soil	Rotate with crops that are not susceptible to the wilt fungus. Tuber treatment with thiabendazole appears to provide some degree of control.	

Common Scab *Actinomyces scabies*	Tubers and Soil	Provide acid soil conditions, rotate crops, do not plant scab-infected seed, use irrigation during tuber initiation and early tuber growth. (Scab is much more severe under dry conditions).

19.3.4 Peas

	Spread By	Control
Pea Mosaic Virus	Aphids	Resistant cultivars
Pea Top Yellows Virus	Aphids	Resistant cultivars
Fusarium Wilt	Soil-borne	Resistant cultivars
Bacterial Blight	Seed, in Crop Debris, and by machinery.	Seed certification of all field peas. Not usually detected in garden peas.
Damping off *(Pythium* spp)	Soil-borne	Use seed treated with a fungicide. Orthocide 65 generally used.
Foot Rot *(Fusarium* supp)	Soil-borne	
Ascochyta complex	Seed-borne Air-borne	Seed testing, use seed lots (lines) with low level of infection.
Aphanomyces root rot	Soil borne	Avoid areas known to be infected. Rotate crops.

19.3.5 Brassicas

Turnips, Swedes, Marrow-stemmed Kale, Rape.

	Spread By	Control	
		Cultural	Resistance
Dry Rot	Air-borne - from crop	Rotate crops	Cultivars available - swedes - Doon Major, Doon Spartan, Wilhelmsburger.
Clubroot	Soil-borne	Rotation - spores survive in soil 6 years known location of previous outbreaks.	Many cultivars available: Moana-Tape Calder-swede Kiri-swede Most Kale and turnip cultivars.

Viruses	
Turnip mosaic virus - Aphids Cauliflower mosaic virus - Aphids	Now only occassionally. Important in turnips - Kapai is a resistant cultivar.

19.3.6 Lucerne

There are a number of air-borne and soil-borne diseases that can affect these crops, and seriously reduce yield.

Soil-borne diseases

Bacterial Wilt - use resistant cultivars
Phytophthora root rot - use resistant cultivars
Verticillium wilt - some cultivars are partially resistant.

Air-borne diseases

Common leaf spot *Stemphylium* leaf spot Pepper spot Spring black stem & leaf spot and other fungal leaf spots.	use resistant cultivars. With susceptible cultivars, spray with benomyl especially crops being used for seed production.

Seed Treatment

Seed is not generally treated with fungicides because they may interfere with, or inhibit the nodulation process. However, thiram and benomyl and some others, when used, have not affected nodulation.

19.3.7 Pasture

Head Smut Prairie grass	Treat all seed with thiram, or carboxin, or beneomyl. Benomyl at 5 g a.i per kg seed is preferred.
Leaf Rust of Ryegrass	Can cause yield losses and/or reduce the palatability of grass especially in the autumn. Use resistant cultivars such as Ariki, L.S. Ariki.
Facial eczema	Caused by ingestion of spores of the fungus *Pithomyces chartarum.* Control by (1) stock management so that animals are prevented from eating dangerous levels of spores, e.g. graze on "safe" crops - maize, lucerne, kale, rape, or feed hay and silage. (2) Spray pastures early February and March - 10 days before using them - with either benomyl (Benlate) or thiabendazole (Tecto 45), or thiophanate methyl (Sporex).

SECTION 20

FARM STRUCTURES

20. FARM STRUCTURES

20.1 SHEEP YARDS

20.1.1. Introduction

Sheep yards are vital part of any sheep farm, and so must be of the most suitable design and construction possible. Otherwise, the advantages of structures that assist in the handling of sheep are lessened. This causes inefficient, and hence costly, stock handling.

In this section we present some relevant facts, figures and hints on the design and building of sheep yards.

There is no such thing as an "ideal"yard, because the requirements and existing conditions vary widely from farm to farm.

There are several points to consider when you are thinking of building a new set of yards:

(i) List all the handling activities which must be done – shearing, crutching, drafting, culling, vaccinating, drenching, dipping, footbathing, and so on.

(ii) Decide the location of the yards in the light of access, drainage, shelter, and supply of electricity and water.

(iii) Decide where the holding pens should be and their size.

(iv) Carefully plan the handling area, bearing in mind that sheep move more willingly up a slope and that shadows should not be cast ahead of them. If the handling area is outdoors, a roof is recommended.

(v) Decide the features of the handling race(s) – type of floor, raised or at ground level, construction method, length and method of adjusting the width.

(vi) Lay out the forcing, holding and receiving pens – possibly incorporating existing yards or woolshed.

(vii) Draw up the plan to scale.

(viii) Construct the yards in temporary form, using posts, hurdles and netting to test whether the design will work satisfactorily in your particular circumstances.

The yards should be situated in a central position as much as possible to avoid driving the sheep long distances. There should be some shade in the yards if they are not covered. This is appreciated by man and beast alike in hot weather. Trees should not be planted alongside races as the sheep tend to stop in the shady patches. Water should be available to the sheep in the holding pens, especially if they are to be held overnight because the mob size prevents a job being completed in one day.

20.1.2 Yard Size

The size of any set of yards will vary according to particular conditions. The first consideration is the number of sheep and the number of separate mobs most likely to be yarded at the same time. An average of $0.5\,m^2$ of yard space should be allowed for each sheep. This gives ample space for working any but the largest sheep.

Cost is often the limiting factor. A nucleus of well-built, good-quality, long-lasting yards is much more economical than a set made of low quality materials and erected in haste. If the site and the arrangement of the nucleus is chosen carefully, future expansion is much easier.

20.1.3 Yard Shape

The most common shape is the rectangular yard, but there are others, such as the wedge-shaped, the circular, the "bugle", and many other "freak" yards. The diagram on page 15/5 illustrates the main components of a set of yards.

It could serve as the basis for any set of yards, but should be tailored for each individual situation. Several small holding yards alongside the main set are a good asset, as mobs can be held there to empty out before being taken into the yards for example, at shearing. This reduces the fouling of the yards.

Large drafting yards usually consist of the following sections:

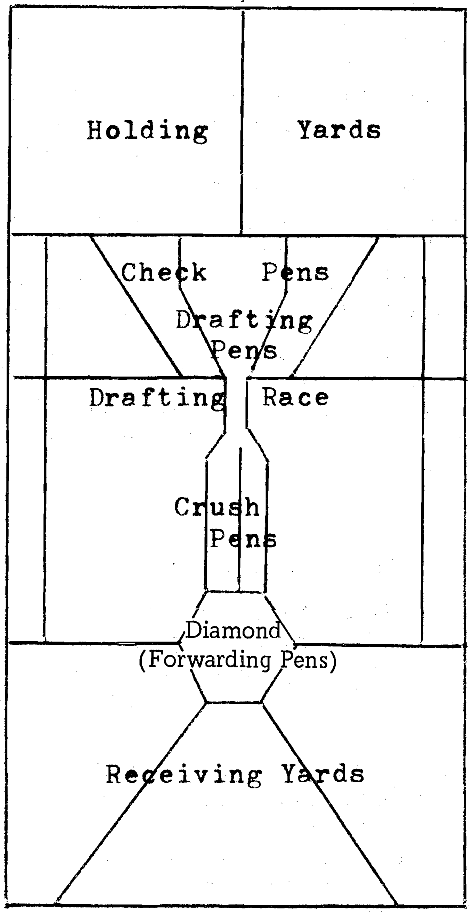
(i) **Receiving yards** –
large capacity; first yard entered by sheep. They communicate with the

(ii) **Forwarding pens** –
smaller, often diamond-shaped. They lead into the

(iii) **Crush or forcing pens** –
one or two long, small pens, tapering at one end. They hold about 50 sheep and communicate by way of a 2-way gate with the

(iv) **Drafting race** –
long and narrow, wide enough for one sheep. It is used to divide a mob into several smaller groups, this being done

Figure 1: Components of a Sheep yard (not to scale)



by one or more drafting gates at its exit which guide the sheep into the

(v) Drafting pens –
small pens to accommodate the drafted groups of sheep. If there are only two, they communicate directly with the holding yards, but often they lead into the

(vi) Check pens –
used for checking for mistakes in drafting, and for any treatments that need to be carried out. They are usually small and open into larger

(vii) **Holding yards** –
correspond in size to the receiving yards.

In a small set of yards it is not necessary to have all the components mentioned above. The race and its immediate adjoining yards are the nucleus and form the main part of small yards. It should also be noted that the various components do not have to be arranged in a straight line. Their actual arrangement is immaterial as long as their sequence is followed.

Several other factors influence the layout of yards. These are the possible use in conjunction with a shearing shed and/or sheep dip, the land available for the yards (area and topography), the lie of the land and fencing requirements.

The aim when building the yards is to have as many straight unbroken sections of fence as possible, as this saves the work and expense of putting in extra strainer and corner posts, stays, etc. The pens or fences should be designed to serve a dual purpose wherever possible.

20.1.4. Yard Construction

The first step is to remove any obvious obstructions from the site that are liable to injure sheep. Level off the ground as much as possible. From the plan, distances should be measured and pegged off. Any logs or stumps should be removed from near gateways.

There are several methods of construction available, but whichever is decided upon the material should be of adequate strength. In the early days, timber was the most common material used in fence construction, but in places like Central Otago where timber was scarce, the wood had to be packed in from other areas or stones were used to build the yards. Timber is still used a lot today, but the cost has risen markedly in the past few years. The durability of timber of posts etc. depends on a lot of factors. Sapwood generally lasts for less time than does heartwood; there are differences between varieties of the same species; the wood may have been rapidly grown and therefore fairly light, or it may be compact, slow-grown wood; the soil type at the site has a great effect on the life of the posts. Chemical treatments are available to assist in prolonging the timber's useful life. The New Zealand Forest Service has a series of long term trials at the Forest Research Institute at Rotorua examining the durability of different timbers that have been treated in many different ways.

Full information on preserving timber can be obtained from the Forest Service and from other sources, but the following is a brief outline of the main points:

(ii) Short-lived posts are a continuing liability. Replacement costs are high and recurring labour costs for repairs are uneconomic.

(ii) The principle of preserving non-durable woods is to render them poisonous to decay organisms.

(iii) A complete protective envelope of treated wood should be created. Any sawing, trimming or cutting should be done before treatment, not afterwards.

(iv) Whole round posts give the best results from preservative treatments. The sapwood soaks up the preservative, forming an envelope around the heartwood.

(v) All bark must be removed to allow complete penetration.

(vi) Wood should be properly seasoned before treatment, as green timber will rot internally after treatment. Seasoned timber does not split as easily and it allows better penetration of the chemicals.

(vii) Water-soluble preservatives are unsuitable for posts.

Post and rail fences are strong and durable, but are often expensive. The most common method is to have the rails spiked or wired to the posts. Round timber is best as it lasts longer and is less likely to bruise the sheep. Split timber should be avoided as splinters can injure the animals.

Timber and wire fences are used a lot, with more posts, battens and wires being used than in the normal farm fence. Eight or ten closely-spaced wires are used, and often a strip of wire netting can be used at the bottom of the fence to keep lambs in. Metal droppers with concrete posts can be used as substitutes for timber. A lighter type of fencing very often can be used for the outer yards where the fences are not subject to rought wear and strains as in the smaller pens. Wire netting can be used for the outer fences, with a rub rail at a suitable height to prevent damage, and also to make the fence more visible to the sheep.

Steel posts and droppers may be preferred in some areas where timber is more expensive, or where the climate is harder on timber as in Central Otago. Wooden battens may be used with steel posts.

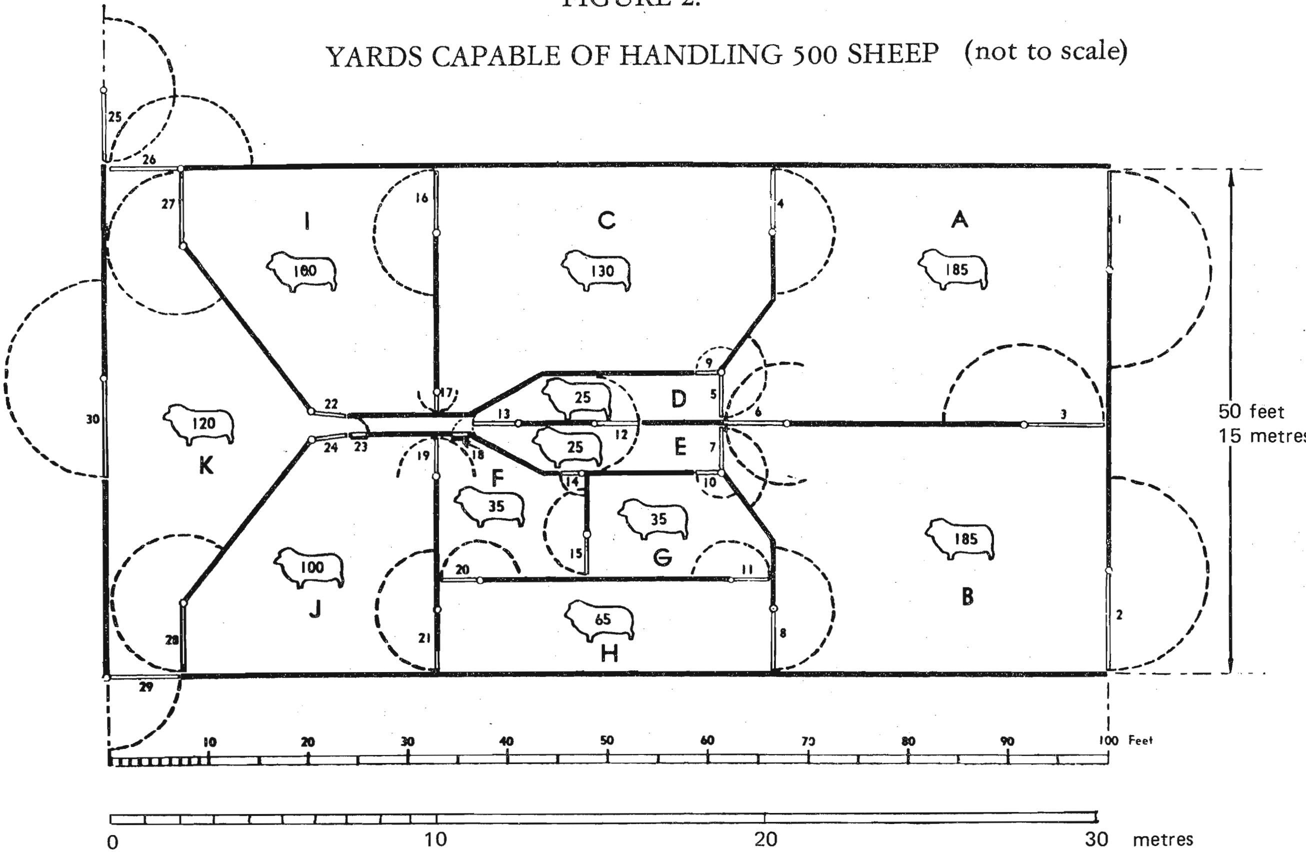
Concrete fence posts and strainers are versatile fencing materials, but they are prone to structural failure if certain guidelines are not followed in their construction. The concrete must be mixed thoroughly; the posts must be given time to mature before use; reinforcing must be adequate and correctly placed. Concrete has very great compressive strength, but will stand very little tensile stress. Reinforcing rods are used to overcome this weakness. Light rods in each corner of a post are much better than a thick rod placed in the center of the post. The steel must be covered by at least 20mm of concrete to prevent its rusting and the covering of concrete must be thicker at the top of the post to allow for weathering. Concrete posts may be bought or made on the site as required.

Pre-stressed posts are much stronger than home-made ones and they are considerably lighter. Concrete posts and strainers may be used in conjunction with wood, metal or concrete railings.

The height of fences is determined by such things as cost, the breed of sheep, the slope of the land and the position of the fence in the yards. External fences should be higher than internal ones, to prevent sheep jumping them and escaping.

FIGURE 2:

YARDS CAPABLE OF HANDLING 500 SHEEP (not to scale)



Materials Required for Sheepyards:

Figure 2 – Yards capable of handling 500 sheep.

Fences:

Length of outer fence = 78.0 m
Length of inner fences= 67.7 m
Total length (ex. gates)= 145.7 m

If five 100mm x 30mm rails are used for fences, a total of 728.5 lineal metres of this timber will be required.

Crush and Race:

End panels of the crush on both sides are close boarded with dressed 150mm x 25mm planks = 4.87m x 6 = 29.22 lineal metres.

Sides of the race are close boarded with dressed 150mm x 25mm planks = 7.31m x 6 = 43.86 lineal metres.

Gates:

If common swing gates are constructed, the following timber will be required –

For 3 x 3.05m, 1 x 2.43m, 5 x 2.13m, 5 x 1.83m, 1 x 1.52m, 3 x 1.37m, 4 x 1.21m, 2 x 0.76m, 2 x 0.60m gates, a total of 384 lineal metres of 100mm x 25mm timber for stiles and stays of all gates, and rails of gates under 2.13m, plus 111.25m of 100mm x 30mm timber for rails of gates 2.13m or wider. Total gates = 30.

Total Timber:

100mm x 25mm = 384 lineal metres
100mm x 30mm = 839 lineal metres
150mm x 25mm = 73 lineal metres

Posts:

A total of 101 posts will be required, and of these 27 need to be heavy enough to act as gateposts.

FIGURE 3:

YARDS CAPABLE OF HANDLING 1 000 SHEEP (not to scale)

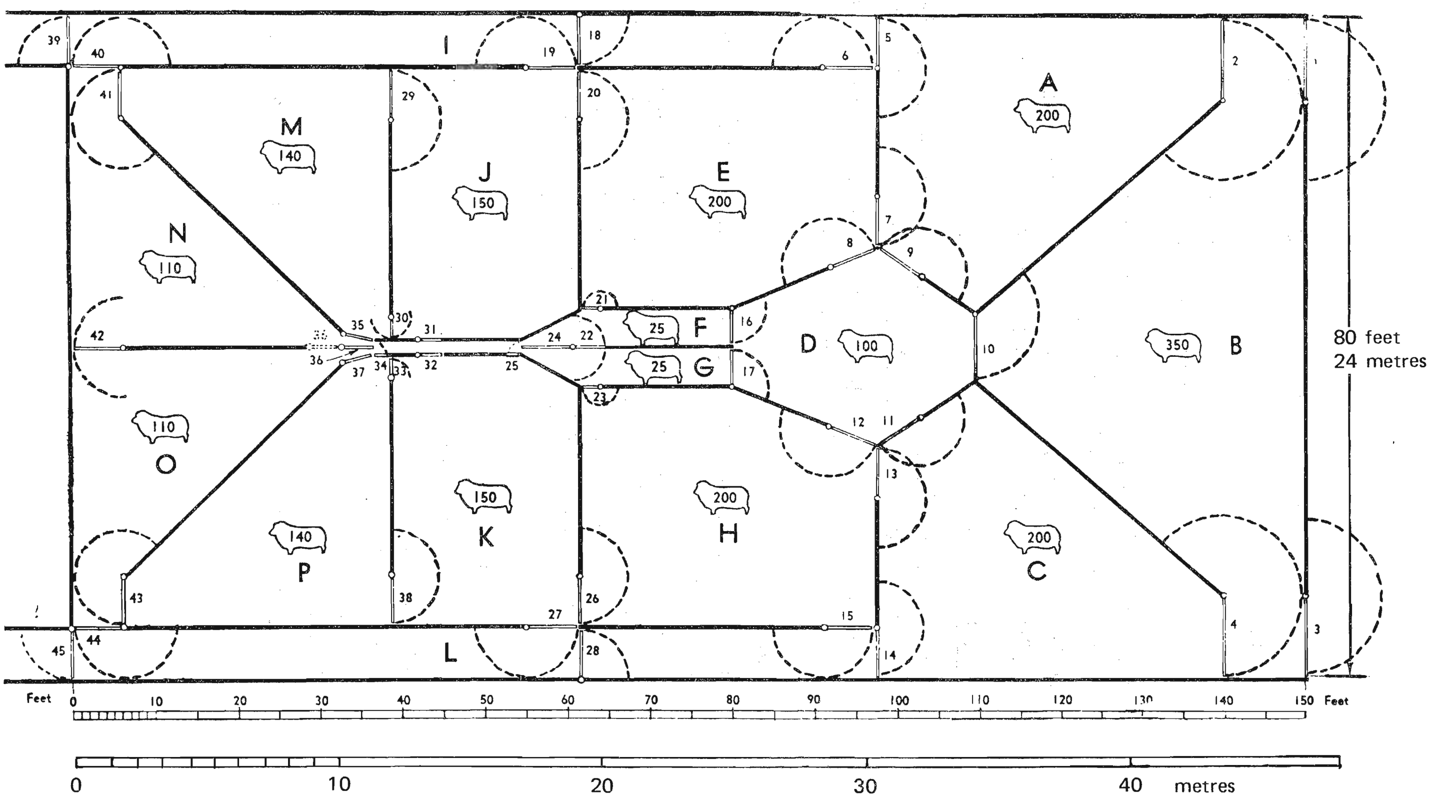


Figure 3 – Yards capable of handling 1 000 sheep.

Fences:

Length of outer fence = 130.4m
Length of fence around diamond= 13.2m

Length of other internal fences= 162.4m
Length of all fences (ex. gates)= 306.0m

If five 100mm x 30mm rails are used for fences, a total of 1 530m of this timber will be required.

Crush and Race:

End panels of the crush on both sides are close boarded with dressed 150mm x 25mm planks = 5.18m x 6 = 31.08m.

Sides of the race are close boarded with dressed 150mm x 25mm planks = 9.14m x 6 = 54.86m.

Gates:

If common swing gates are constructed, the following timber will be required –
For 4 x 3.05m, 1 x 2.43m, 26 x 1.83m, 3 x 1.37m, and 4 x 0.60m gates a total of 670m of 100mm x 25mm timber for stiles and stays of all gates, and rails of all gates 2.13m and under, plus 73.15m of 100mm x 30mm timber for rails of gates 2.13m or wider. Total gates = 45.

Total Timber:

100mm x 25mm = 670 metres
100mm x 30mm = 1 603.2 metres
150mm x 25mm = 85.94 metres

Posts:

A total of 180 posts will be required and of these at least 45 need to be heavy enough to act as gateposts.

20.1.5 Gates

Several types of gates are used in yards. They may be classified under 5 main headings:-

(i) Ordinary swing gates.
(ii) Lift-up gates.
(iii) Slide-back gates.
(iv) Tip-up gates.
(v) Freak or unusual gates.

Before discussing each of the above types of gates, there are several general points worthy of mention.

Gates should be bolted rather than nailed together, as the gate is much stronger and, if broken, the wooden parts can be replaced much more easily. The ordinary carriage bolt with a small square section below the rounded head should not be used, as when the thread gets rusty the square shoulder is quite insufficient to prevent the bolt from turning when an attempt is made to unscrew the bolt. Use hexagonal-headed bolts. Bolts and nuts should be well painted to prevent rust, or preferably galvanized ones should be used. The width of a gate is determined by the amount of traffic it will have to handle. Usually a 3 metre wide gate is ample.

Avoid hanging gates on strainer posts, as there is a greater possibility of the post getting out of plumb. A separate gatepost should be used. However, gates may be hung on a post that is part of a post and rail fence.

The merits and disadvantages of the 5 main types of gates are as follows:-

(i) **Common swing gate**

Advantages
- relatively cheap and easy to construct
- the most practical for wide openings; double swing gates are useful for very wide openings
- low maintenance requirement
- easily removable from its hinges
- can be used as a sweep to push sheep into a crush

Disadvantages
- a lot of space is needed for its swing
- it is difficult to open or close when animals are leaning against it

- it must be fastened when shut, and may get broken by the wind if left swinging
- extra wide ones tend to sag

(ii) **Lift-up (and Lift-swing) gate**

The lift-up gate opens by sliding up a vertical pipe or in grooves cut into the supporting timbers. The best type is held up when lifted by a counter-weight. This is essential for the lift-swing gate.

Advantages
- the gate takes up little space laterally
- it is easy to work if properly constructed
- it is unaffected by the wind
- it is not subject to jamming by sheep pressing up against it of the lift-swing type
- the main advantage of the lift-swing type is that it can be lifted up, swung over the backs of the sheep in the pen, lowered again behind them and used as sweep to push them forward.

Disadvantages
- it is difficult to construct and requires good workmanship
- there is limited head-room with the lift-up gate
- the lift-up gate is less useful than the swing type for other purposes as listed above

(iii) **Slide-back gate**

This type slides back from the opening it covers. The fence at this point is usually double with a 150mm gap between. The gate runs on wheels on a steel rail below (or above) and in a channel guide above (or below).

Advantages
- it takes up very little working room
- it is easy to work if made properly
- it cannot be jammed when slid back into the gap
- it needs no fastening when shut and is not affected by the wind

Disadvantages
- it needs to be built well
- it gets out of order more easily then other types as small stones and dirt get into the groove

– sheep can jump and hit the cross rail on which it runs.

(iv) **Tip-up gate**

This type is less common than the others mentioned. It is usually hinged on a single bolt passing through one of the bottom corners and swings upward and backward alongside the fence.

Advantages
- it is cheap and easy to construct
- it works fairly well even if roughly constructed
- it takes up less space than other types, except the slide-back type
- head-room is unlimited
- it is not easily jammed in the open position
- it is not affected by the wind
- it does not need a fastener

Disadvantages
- it is harder to open or close than other types as there is more weight to lift
- it tends to get broken, as it is hinged at one corner only

There are numerous "freak" or unusual gates that have been built over the years, often to suit some purpose that the more conventional gates could not fulfill. There are self-closing gates where one hinge is closer to the gatepost than the other; there are triangular gates, 2 of which are used to bridge a wide gap; and many others.

Just as there are many types of gates, there are numerous types of gate-fastenings.

20.1.6 The Crush

The function of the crush is to make it easier to force the sheep through into the race. The pen is usually long and narrow, holding not more than 50 sheep at a time. The end of the pen should taper into the mouth of the drafting race. The angle of the taper should be about 30° and where possible one side should be straight. The arrangement of the dividing gate in double crush pens is a matter for personal preference. The height of the crush pen walls does not vary much – in most situations it is about 85-90cm high. The tapering section adjoining the entrance to the race should be close-boarded to prevent sheep seeing the man at the drafting gates which is likely to cause them to baulk before entering the race.

20.1.7 The Drafting Race

The drafting race is the most important component of the sheepyards and it must be designed well. It should be wide enough for a sheep to move along it in comfort without being able to turn around, and it must be close-boarded. The length of the race depends on the number of ways the sheep will be drafted. About 10 metres is the maximum practical length. Width can vary a lot, between 30 and 45 centimetres being common. Some races are wider at the top of the walls than at the bottom.

The height of the sides varies a lot (between 80 and 105cm) and depends on the type of sheep handled. The sides should not be too high so as to prevent handlers reaching over and clearing a blockage. The floor should not be earth as this rapidly hollows with use and becomes unpleasant in wet weather. Concrete is the best flooring material, but cleated wooden floors are just as practicable. A gap should be left between the bottom board of the walls and the floor to allow dirt, etc. to escape and prevent accumulation. Concrete should be fanned out to the sides and at the end of the race rather than ending abruptly into the drafting pens.

Adjustable races are quite useful as the width can be varied according to the size of the sheep being drafted. The most common is where the movable side is hinged at the bottom and the floor width is constant. The most suitable width of race is 27cm at the bottom and 54-59cm at the top (with a vertical height of 80cm). This will accommodate most sizes of sheep quite comfortably.

It is often useful to have a by-pass race alongside the drafting race that connects the crush pens with the pens beyond the drafting race. This allows sheep to be rapidly transferred rather than via the narrow race.

The number of gates in the drafting race can vary from one, which divides the sheep into two separate mobs, to 5 which creates six mobs. Three gates are the most one man can operate at one time, but with two more further down the race operated by another person, the drafting can be more complex. Usually these gates are fully boarded, but some people prefer openbarred gates. Drafting gates must swing freely on their hinges and be level, so they can be left in their correct position while the operator clears a blockage in the race, if working single-handed. All drafting gates must be smooth with no projecting nails, bolts, etc. so as to prevent injury to the sheep being drafted.

20.1.8 Drafting Pens

These vary in number according to the ways the sheep can be drafted.

Often they are omitted and the sheep transfer directly into checking pens. However, drafting pens allow the man working in the checking pen to do his job counting out, raddling, etc. without interference from fresh sheep continually coming in from the race. The check pen should be the same capacity as the drafting pen.

20.1.9 Check Pens

The number of check pens corresponds to the number of drafting pens. They can be of any shape, but should not be too large. A capacity of about 100 sheep per pen is a good upper limit to their size to facilitate catching sheep and removing them. If they are made too small, any gain from easier catching of sheep will be nullified by the need for frequent filling and emptying of them.

20.1.10 Foot-rot Baths

While not always incorporated as a part of sheepyards, foot-rot baths are quite commonly associated with them. After the overgrown hoof has been trimmed, either in the woolshed or in the yards themselves (the shed is better because the battens on the floor help to partially clean the hooves and the conditions are less dusty than in the yards), it is necessary to have the hooves immersed in the formalin solution for only a comparatively short period.

Most installations usually take the form of a race with a trough in the bottom or a small pen with a watertight concrete floor with raised edges to hold the solution. The affected sheep should be kept away from the main set of yards as this assists in the control of the disease. If the separation is not possible, all sheep could enter the yards via a foot-rot bath of large capacity.

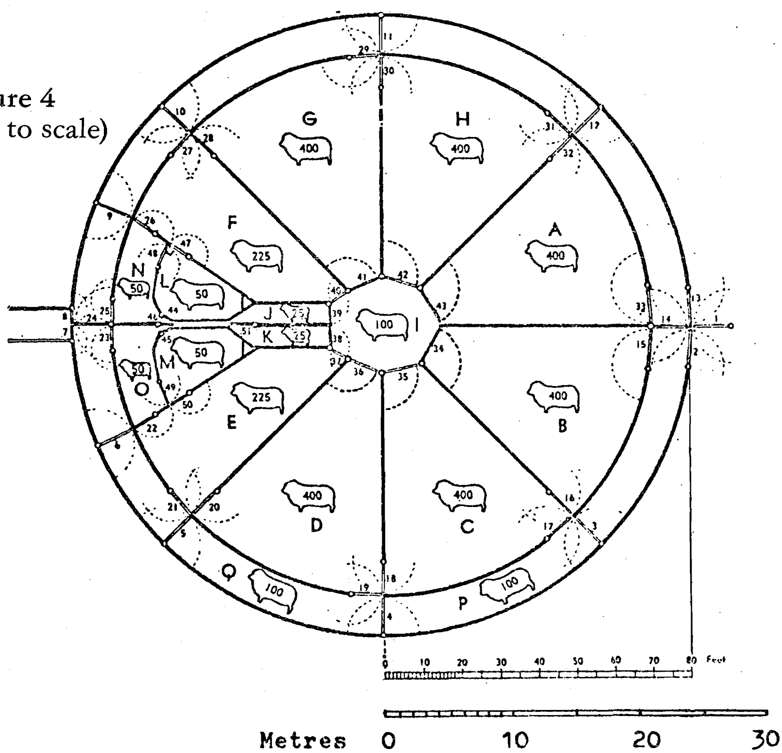
If the foot-rot solution is to be kept for some time in the bath or trough, a roof must be provided to stop dilution by rainwater. It is also a good idea to close-board the bottom 30cm or so of the surrounding fence to prevent undue loss by splashing. It also stops formalin being splashed on any person that may be standing next to the pen.

20.1.11 Circular Sheepyards

Circular stockyards are easy to design, easy to erect, easy to work stock in, and cheaper. Because of the reduction in panels needed to hold a given number of stock, the cost of constructing circular yards can be about 13% below the cost of rectangular yards. There is a better economy of space in circular yards and there is less cost involved in internal fencing.

When planning a circular set of yards, allow enough room for the crush, the race, and the drafting pens, as well as part of the diamond between the centre and the outside fence of the yards. The diagram below illustrates the near-minimum size of a set of yards capable of handling 2000 sheep.

Figure 4
(not to scale)



The central diamond pen can be used to great advantage in circular yards and is really an essential part of the design. In this case it communicates with not fewer than 10 different pens. The outside race or alleyway also serves as a connecting link between the majority of pens. There could be any number of entrances at convenient places around the outside ring fence other than the two shown in the above diagram.

Four-way drafting is a feature of the design and circular yards lend themselves to this.

As with rectangular yards, there are numerous variations on the basic theme. There are fully circular yards, and there are the semi-circular types. The basic design concept of circular yards is that sheep should move freely towards the operator rather than being forced and that they should keep moving on a single pathway without the opportunity to turn back. They should preferably move around curves, especially as they approach the operator. Traditional, rectangular yards often allow the sheep to see the operator and turn back. Blind corners and jamming in the race are common problems which can be avoided by providing a curved access to the race.

The diagram below shows a set of circular sheep yards, incorporating a shower dip and a double working race.

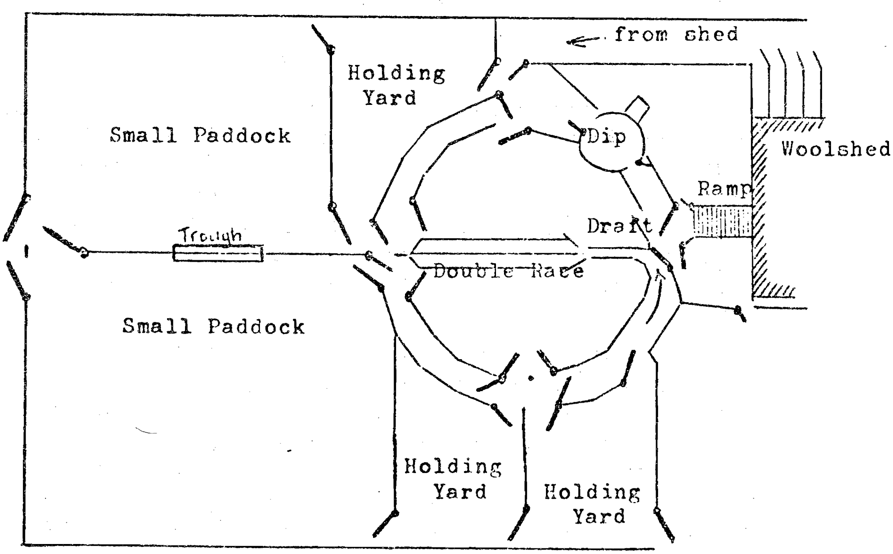


Figure 5 (not to scale)

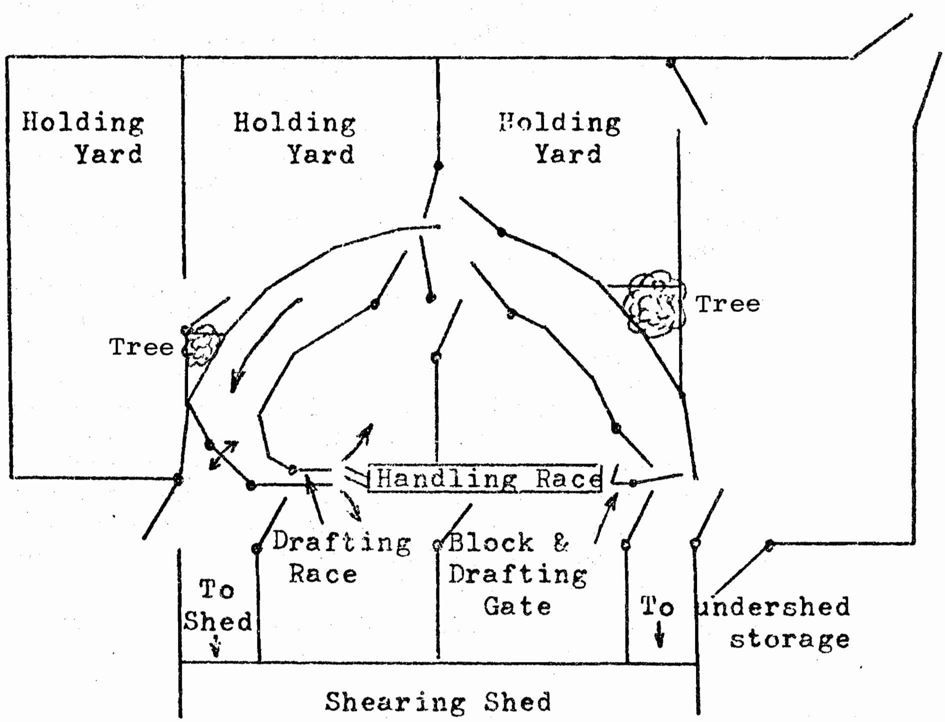


Figure 6 (not to scale)

The set of yards illustrated above retains the sheep flow principles of circular designed sheepyards. Note that the sides of the forcing pen are in this case parallel until the sheep commence the relatively sharp turn into the drafting race. There is 3-way drafting at this point and sheep leaving the long, single handling race can be further sorted into any two of five pens by using a single drafting gate and altering the positions of three other gates.

The design below has a similar working area to that in Figure 6 but the general layout is tailored to the requirements of smaller flocks and for auxiliary yards. The forcing pen is bugle-shaped and there is 3 way drafting before the sheep get to the handling race and they can be directed into any two of four pens as they leave it. This plan could be adapted reasonably easily to existing yards. More storage pens could be added and a double handling race could be incorporated.

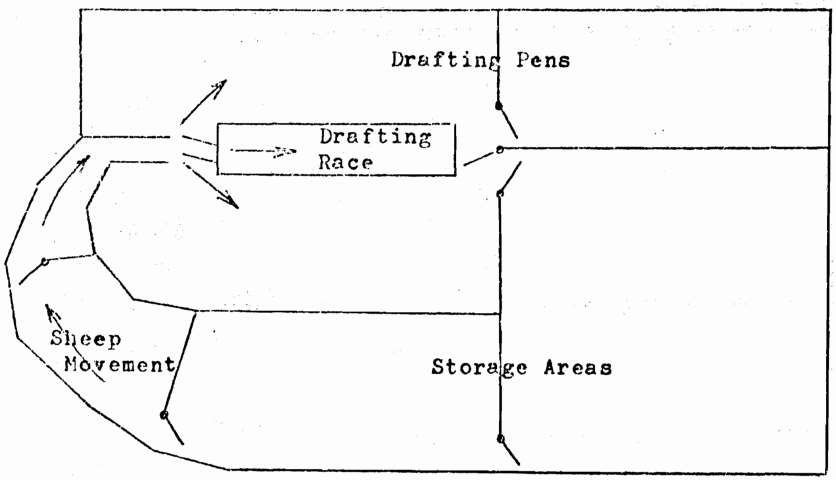


Figure 7 (not to scale)

A further development from the bugle-shaped forcing pens is a double working race and a separate drafting race. The main drafting gate only gives two way drafting.

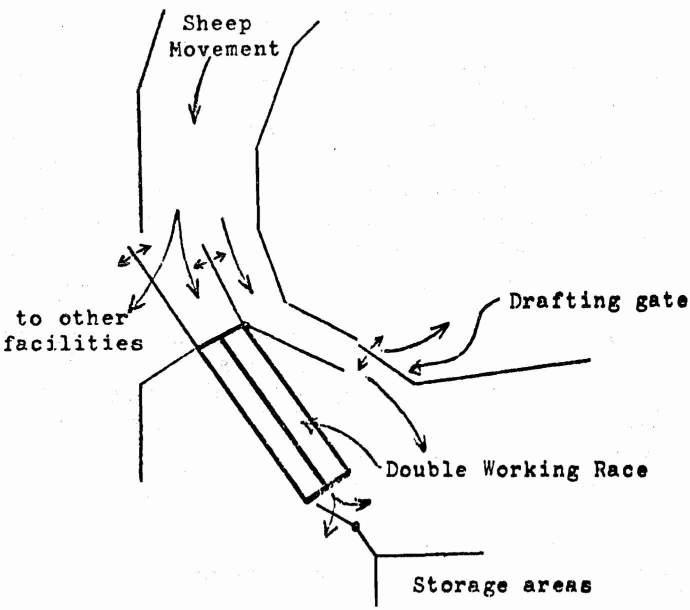


Figure 8 (not to scale)

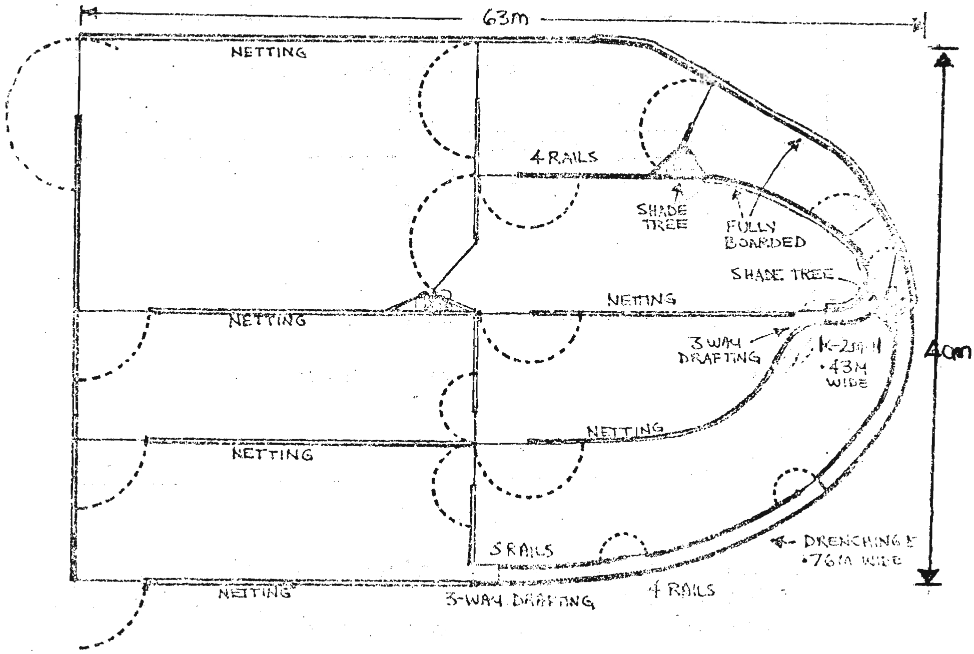


Figure 9. Circular yards designed and used by J. Gallagher

The above design also follows the basic principles of sheep flow through circular yards.
One half is constructed as a semicircle. The forcing area, drafting and drenching races are located on the outside of the semicircle. Latter parts of the forcing race are boarded in, thus allowing the sheep to run better and also cater for the pressure. Holding pens are made of posts and wire. Post spacings vary from 1.2m to 2.4m, depending on need of extra strength.

In this design there are 2, 3-way drafting points, one at the drafting race itself and the other, the end of the drenching race. Drafting race is 2m long, V-shaped, averaging 43 cm wide. Drenching race is 76 cm wide, holding 140 ewes. It has 2 gates to hold the sheep tight. Gate assemblies in holding pens swing either way to allow maximum flexibility for sheep.

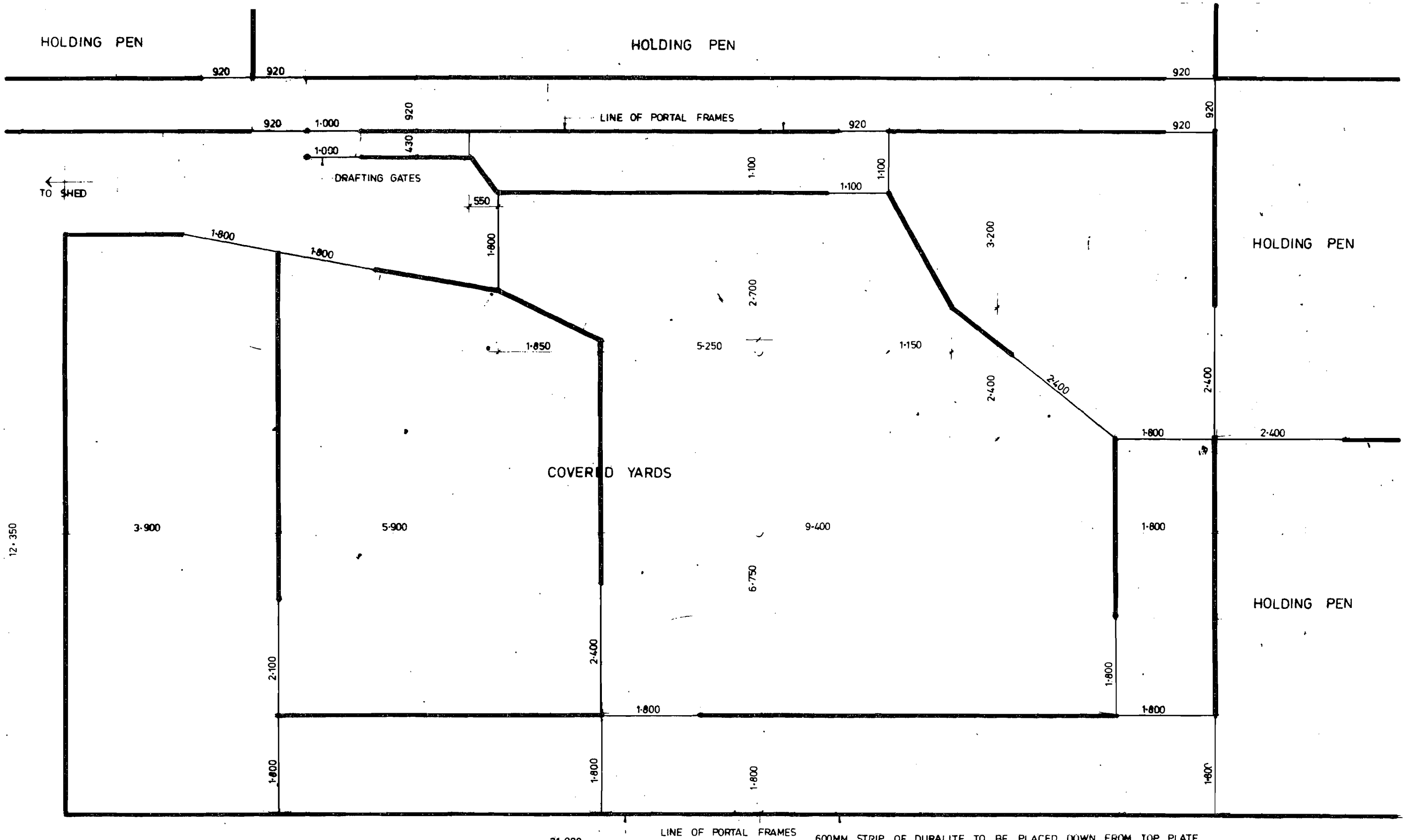
20.1.12. Covered Yards

There are three main points to consider when incorporating covered yards:

(1) Under normal conditions space should be provided to house about ⅓ of the flock.

(ii) The crush pens, drafting race, and general handling facilities should be located on the warm open side. Generally the South or cold side is closed in, but lit with translucent sheets. This allows sheep to remain away from rain drift and easily provides both outside and inside drafting.

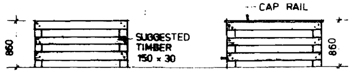
(iii) Drafting - 3 - ways is common, but in some plans sheep can be directed about 10 ways with a 3-way draft under cover. By using exit gates large mobs can be drafted. Generally yard floor is left as is. Some success has been achieved with wood chips, sawdust or small gravel.



COVERED YARDS [21·000 x 12·350]

OVERNIGHT TO HOUSE 500 WOOLLY EWES

NORMAL WORKING 800 WOOLLY EWES



SUGGESTED RAIL HEIGHTS

600MM STRIP OF DURALITE TO BE PLACED DOWN FROM TOP PLATE ALONG TOTAL WALL IF SOUTH WALL COVERED TO GROUND

OUTLET GATES CAN BE PLACED ON SOUTH &/OR WEST WALL IF REQUIRED

SOUTH SIDE COVERED TO GROUND — OPTIONAL

ROOF LINED WITH BUILDING PAPER ON WIRENETTING

M.A.F.
Y1

20.2 CATTLE YARDS

20.2.1 Introduction

The main purpose for which cattle yards will be used will influence their design and construction. For example, on breeding properties, good facilities are required for calf handling – drafting, marking, dehorning, inoculating, drenching, and spraying. Where A.I. is used, there must be suitable provision for the veterinarian to inseminate the cows in safety.

Where the farm enterprise is mainly buying stores and fattening, then drafting, holding and loading facilities are most important.

On dairy farms, where yards are used more often, there are special requirements. They must be easily cleaned with a good supply of clean water and an efficient waste disposal system.

20.2.2 Designing the Yards

Most of the points mentioned in relation to sheepyards in 15.1 are applicable to cattle yards as well. It is very important to plan the facilities carefully as the cost of a set of cattle yards is considerable. Step 1 is to estimate holding capacity with regard to expected future needs. The yards can be made larger from the outset (depending on the financial situation) with the elimination of some of the internal structures that are not needed immediatley.

The yards do not necessarily have to handle every animal on the property at the same time. Capacity will vary according to the property enterprise and scale of operation. Step 2 is to calculate yard size by allowing about 2.5 m^2 of yard space for each animal in the receiving yard. The forcing yard should be designed to hold about one third of the number accommodated in the holding yard. The basic components of a cattleyard are much the same as for sheepyards. Crush length should provide about 1.7 m for each adult animal, while 2 m^2 per animal is sufficient in the drafting pens. These pens are used infrequently and only for a relatively small number of cattle. For large mobs of cattle, design the yard so that larger pens can be used in conjunction with the drafting pens if necessary.

Cattle, like sheep have no colour vision so every item is seen in terms of black, white and grey. Contrasts in dark and bright sufaces can cause cattle to baulk. Covered yards should be lit with fluorescent lights rather than incandescent bulbs.

Loading ramps should not face into the early-morning or late-afternoon sun as cattle find it difficult moving down such ramps.

The social order within a group of cattle works against a free movement of the animals at points of constriction in yards and races and the lead up to a crush should be a slow one with no abrupt angles.

A good cattle race limits the side vision of a cattle beast and directs it to the area ahead. This is of little use if the cow is required to walk into a blind alley. Cattle will stop 6–8m from a blind end. The gates ahead should be of the grill type so the stock can see straight ahead.

Any lead-in to a crush should have a curved approach, though if the angle of the curve is greater than 15°, a straight portion the length of a cow should be built immediately before the crush.

Single file alleyways should be not longer than 7.5m without a curve or bend, though bends should not deflect at an angle greater than 15°. Sharp turning corners of 30° or greater should be avoided.

Overhead walkways frighten cattle; catwalks should be on the side of the races at waist-height so men can reach over and contact cattle. At this height arms cannot be crushed and most of the time the operator is out of sight of the animal. Rubber rollers on the side or bottoms of gates, the areas which will come into contact with a beast if it decides to rush past, will allow the cow to push past without bruising it. This is especially important where the doors are compressed-air controlled.

New concrete floors should have a 1cm deep grove 2cm wide on a 10cm grid pattern worked into them and older floors can have grooves cut into them about 60cm apart when they are repaired. The positions of drains should not impede flow of cattle. If cattle have to unload downhill, steps are preferable to ramps which soon become slippery with dung and urine. Stair steps 8cm in rise and 35cm in run work well for cattle.

Step 3 is to draw the design, making any alterations as necessary. The main consideration when designing yards is to ensure the safety of the operator(s) at all times.

To this end, the 'working area' (i.e. forcing pens, drafting race and head bail) should be sited on the outside rails of the yard. This allows a 'free' area beyond, to protect the operator. Under all circumstances, the operator and assistants working in or adjacent to the race must be assured that they are not going to be obstructed or molested by excited cattle. By the same token, any equipment that may be set out for any reason on a table, on the ground, or held by someone will be safe and not damaged or soiled and will be available when required.

The handling of cattle, particularly under high-country conditions, can be carried out without excessive disturbance or danger to animals or operators if careful planning of the yards is made before building or alteration begins. After the plan has been decided on, construction can begin.

20.2.3. Yard Construction

Cattleyards must be constructed from sturdy, long-lasting materials. Wire netting, although suitable under some circumstances for sheep, is definitely unsuitable for cattle. The most commonly used materials are timber, steel piping or concrete.

The height of cattleyards is usually 2.4m, although this can vary according to the conditions and personal preference.

The types of gates used in cattle yards are generally fewer than those used in sheepyards. The most common is the simple swing gate which is very useful as a sweep for pushing cattle into a pen. It needs to be strongly built, as is the case with all gates used in cattle yards. Lift-up gates are not used much, neither are tip-up gates, as they are both heavy and cumbersome to operate. Slide-back gates are quite useful as they are less prone to damage by the animals, although they cannot be used as a sweep. The lift-swing gate, if constructed of light, strong materials would be useful in this respect, but it is not used in many cattleyards. Gate fastenings for cattleyards are best of the sliding bar or bolt type. Hooks on chains that drop into steel eyes should be avoided as they take much longer to secure than the sliding bar. (Diagram of Standard Cattle Yard over page).

20.2.4. Circular Cattleyards

Circular cattle yards have contributed a lot to the cattle industry in recent years as they are reasonably inexpensive when compared with their capacity and ease of handling cattle.

As with sheep yards, their cost can be as much as 13% lower than the cost of rectangular yards to accomodate the same number of cattle.

The basic steps of planning and design are much the same as for rectangular yards; once the yard size required has been calculated the approach changes somewhat. The next step is to determine the radius of a circle which would enclose that area. If 2.5 m^2 is

STANDARD CATTLE YARD PLAN.

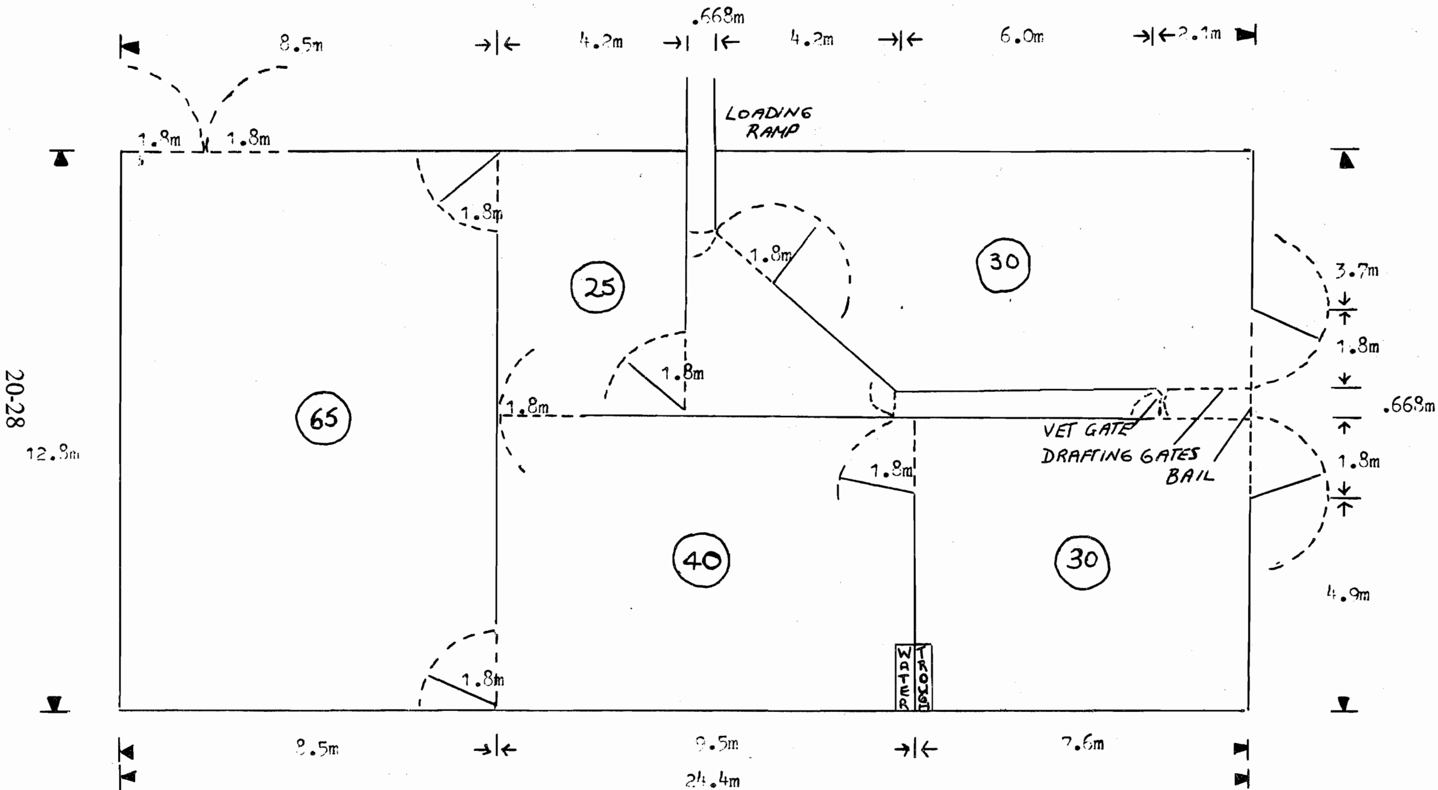


FIGURE 11

SCALE - 2.5cm = 3.0m

allowed for each animal, a yard of radius of 19.9m will provide sufficient room for handling 500 head. If the internal fencing is to be done in panels of 2.5m, then it is better that the radius is some multiple of 5. In this example, the radius is made equal to 20m, or 8 panels of 2.5m.

Drawing the yard outline is the next step, and it is best done on graph paper. The arrangement of the different components of a set of yards is up to the individual. However, just as with the rectangular yards, the working area should be situated on the outside perimeter fence for the safety of the operators. The diagrams that follow illustrate two types of circular cattleyards that are recommended by the Ministry of Agriculture and Fisheries.

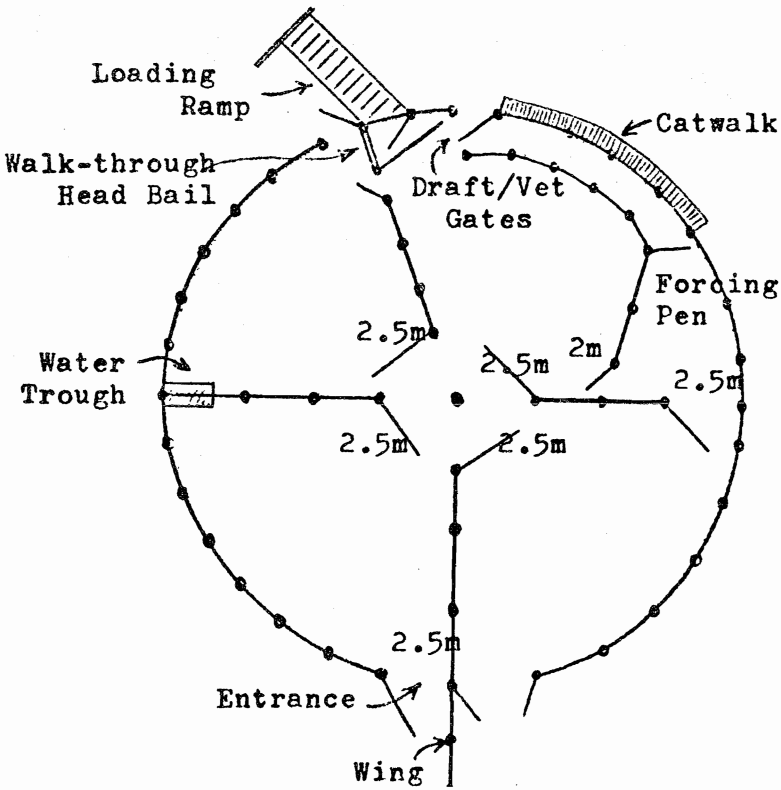


Figure 12 (not to scale)

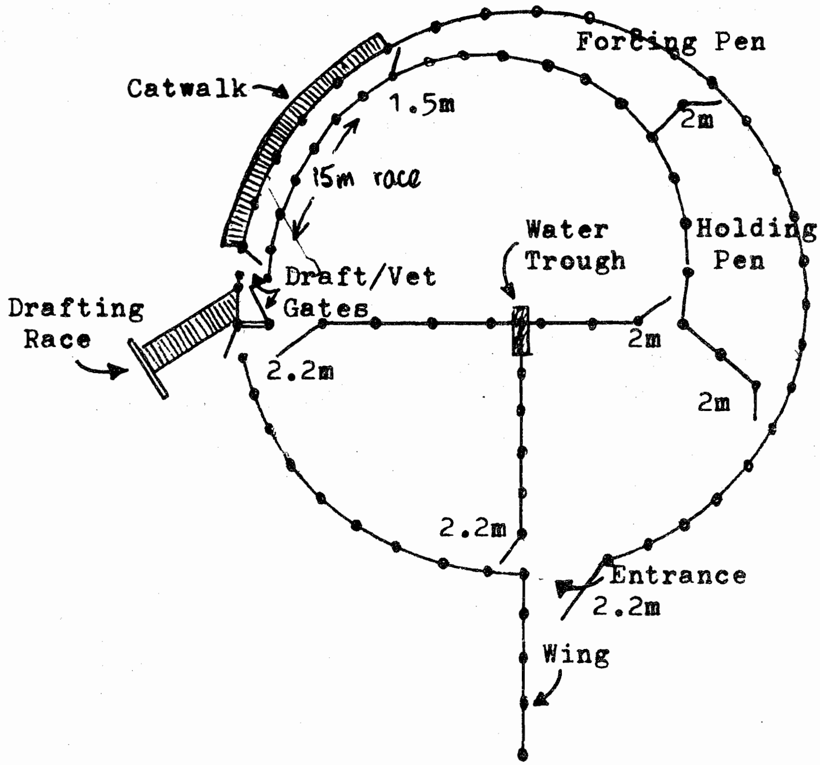


Figure 13
(not to scale)

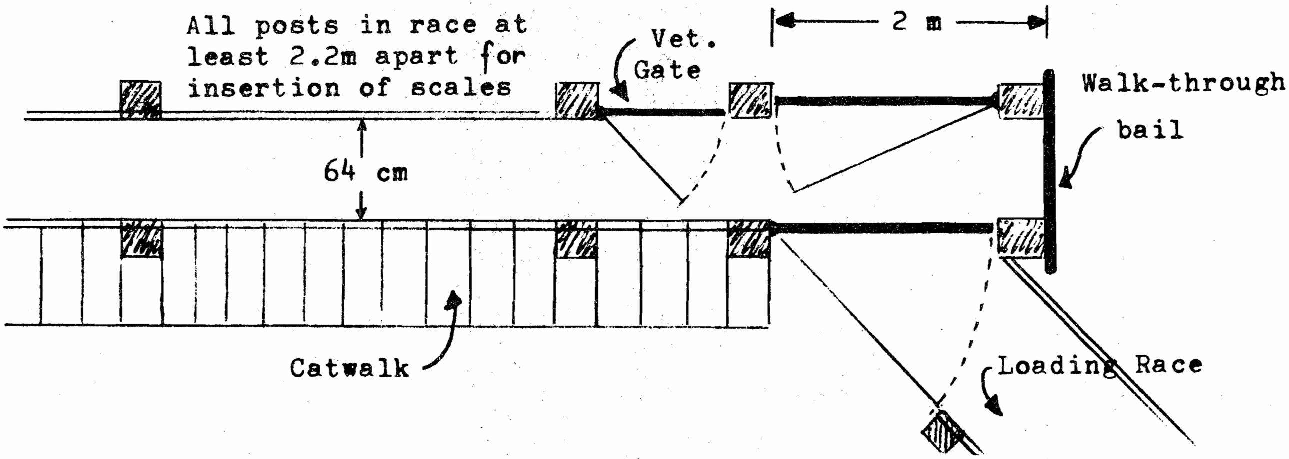


Figure 14 Race and Bail Arrangement
(not to scale)

20.3 CATTLESTOPS

Cattlestops are very useful on farms, preventing animals entering an area which vehicles frequently use and where a gate across the entrance would be inconvenient.

There are several designs for cattlestops that have proved useful over the years. Three are described in the following section.

The first can be made to either railway irons or pipe rails; the latter is preferred by some farmers because they cause less injury to stock that get stuck in the cattlestop. The most common length is 3.6m, with the width varying from 1.5m (where it is needed to deter only the occasional wandering animal) to 2.5m. The pipes (50mm diameter) are welded to two RSJ or channel steel bearers at least 15cm deep and positioned under the wheel tracks. The gaps between the pipes can vary from 95mm to 125mm depending on personal preference. The ends of the pipes are welded into the inside angle of lengths of 50 x 50 x 9mm angle steel resting in small steps in the end wall of the concrete surround.

There are short spacers of 12mm pipe welded between the rails above the RSJ bearers to prevent the pipes from rolling under the immense force of a heavy, braking vehicle. Some people weld steel strips across the top of the rails but sheep often try to walk across them.

The concrete surrounding wall should be 10cm thick provided it has plenty of steel reinforcement. There should be a tolerance of at least 40mm between the steel frame and the concrete. The floor of the cattlestops is of concrete 50mm thick and 37cm below the level of the rails. If a cattle beast steps through the rails, it can stand on the bottom of the pit.

The need for intermediate concrete foundations under the bearers depends on the expected loadings and on the size of the bearers.

Another design, adaptable for either pipes or rails, involves steel strips welded across the pipes. Expansion links join them with bolts through oversized holes in fishplates. The rails rest directly on intermediate concrete bearers at wheeltrack positons. They are securely welded to steel strips at the ends but these are made of flat steel rather than angle iron. Where rails are used, short spacers are welded at their base as well as steel strips being welded on the top. Pipe of 50 x 76mm diameter is suitable for this design.

The pit is 1.5m across and all concrete walls are 20cm thick. The pit is deeper than in the first design with a drainage hole two-thirds up the wall. This means that there is usually some water in the pit, adding to the visual barrier effect.

A slight modification to the standard design is to lay the rails at about

25° instead of right-angles to the approaches. This means that a car 'ripples' rather than bumps across. The gap between the rails needs to be as wide as possible, with 50mm pipe being used instead of railway irons.

20.4 DEER YARDS

20.4.1. Requirements

There is no such thing as a 'standard' deer yard. Most successful yards have some, or all, of the following points in common.

(i) A long lead-in race, close boarded for about 9m out from the yards. Ideally, this should not be straight, but should offer an indirect approach so that the yards are hidden from the animal's view until the last minute.

(ii) The whole working area, or at least some of the pens of main handling area, should be completely roofed-in and darkened. Whether roofed-in or not, all walls should be close boarded and at least 2.1m high for Red deer, or 2.6 for Fallow.

(iii) Sheet or corrugated iron should be avoided as it is noisy.

(iv) Plywood is well supported on framing to avoid 'drumming' on impact.

(v) A central, circular crush pen with two centrally placed swing gates is common in many designs. Farmers often use them more for directing stock into lateral pens, rather than as a crush. Five metres is a suggested maximum diameter.

(vi) Small pens (the actual number depends on herd size) for working with small numbers at close quarters. Large uncovered areas can be used for holding large numbers.

A floor covering of sand, wood chips or coarse saw-dust.

(viii) Storage facilities for equipment.

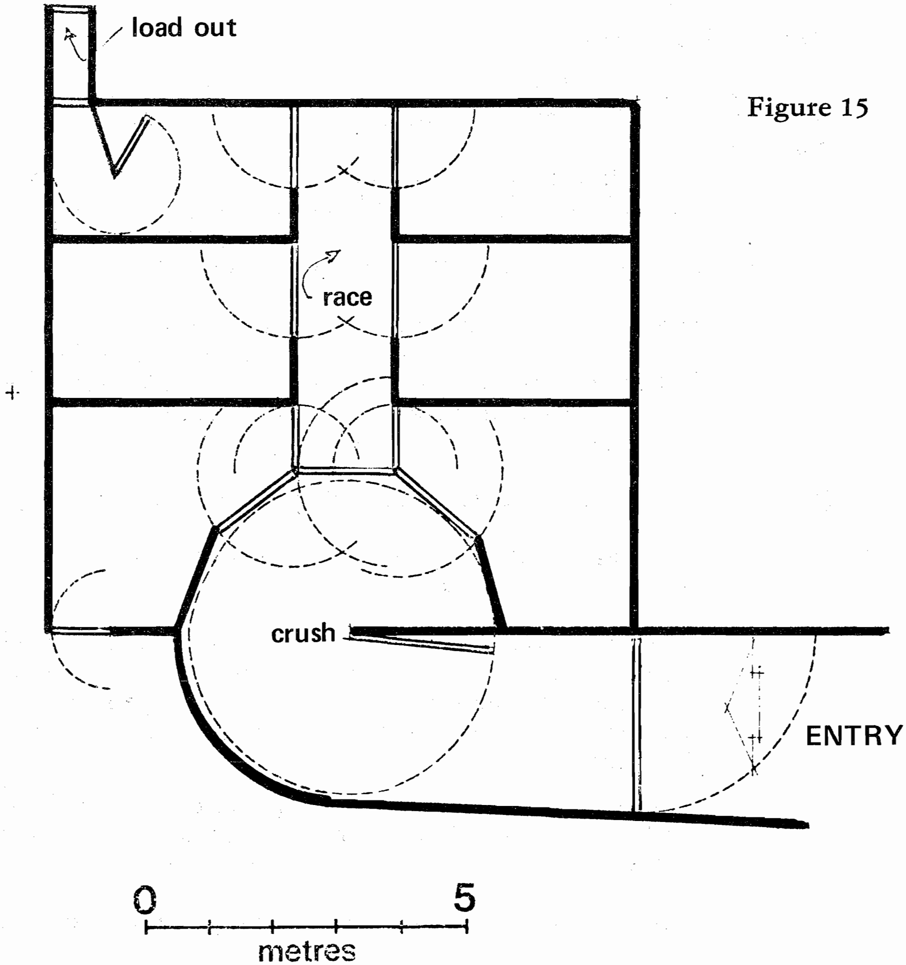
(ix) Usually sheep-type drafting gates do not work, hand drafting is easier.

(x) Long narrow raceways should be avoided.

(xi) Corners should be avoided.

The accompanying plans are based on existing yards and exhibit the great variation to show structural details or precise dimensions. The drawings are intended merely as a guide to layout design. Unless otherwise stated they are intended for handling Red deer.

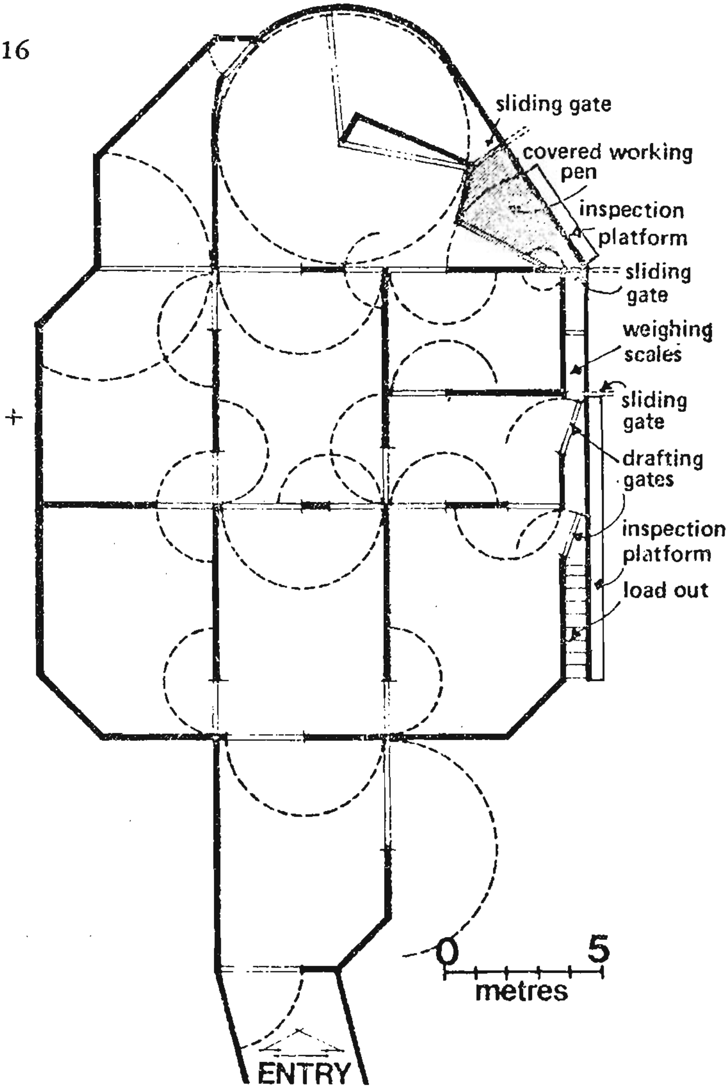
Figure 15



B. Simmons, Rerewhakaaitu

A small, inexpensive design that would suit many small herds. It holds up to 100 animals and yet has the basic requirements of a circular crush pen and small pens leading off a central race. Although these yards are built in a totally enclosed shed, additions and alterations would be relatively simple. Large holding pens could be added around the shed.

Figure 16



Invermay Research Centre

These yards are used as a research facility and some components, e.g., the crush, are larger than necessary for red deer because wapiti are also handled here. A separate working pen or crush was included because the V formation of gates in the circular pen was too narrow and deer tended to climb on each other. Animals can be worked outwards from the circular pen.

The system is very flexible and provides for multi-way drafting (particularly important fro research purposes). The working pen is covered and one side can be used as a crush. The covered area is to be extended to include the whole circular pen and working area at the top end of the plan. The race incorporates fixed weighing scales. The working area has a raked concrete floor. Catwalks are provided along the top of internal partititions and inspection platforms are attached to the external wall of the working race.

The entry race, which approaches the yards obliquely, downhill through a pine plantation, is fenced with 150mm stay netting and has a breast railing.

20.5 WOOLSHEDS

Smaller wool sheds with covered yards have become popular. However, the covering of sheep is secondary to the main functions of a woolshed, which are quick and easy pen filling with good operational facilities for both shearing, wool handling and classing. An older shed can be brought up to a higher standard by adding a raised board, and catching pens with a 1.8m race behind. Additional gates to allow side filling is a great improvement as it cuts down sheep movement and shed hands' time. Poor light can be simply and cheaply corrected by placing a strip of corrugated translucent sheeting about 61cm side down from the top plate.

A big advance in woolshed design in recent times is the concentration of filling catching pens from the front and side and the placement of all pens, so that they lead directly into the catching pens.

An allowance of .37 square metres should be made for holding sheep overnight, and comfortable space provided in covered yards.

The chute shed design is still the most popular and efficient.

The curved or U-shaped boards are gaining popularity and give excellent wool handling facilities.

Board measurements are of vital importance.

20.5.1. Regulations:

Certain requirements are necessary and some details are now mandatory, for satisfactory working conditions.

(i) All catching pen doors must be padded at point of shearer contact.

(ii) Any new or altered shed must have one catching pen door per shearer.

(iii) Each woolshed must have a hand basin and water. If accommodation is not supplied - hot water must be.

(iv) Toilets provided within easy access.

(v) A smoko compartment isolated from the board furnished with tables and chairs must be incorporated.

(vi) The shed must be in a clean state before shearing.

(vii) It is also mandatory to have all sheep skins removed from catching pen areas.

(viii) Counting sheep into catching pens is not allowed, counting out pens or recognised automatic counters must be used.

(ix) All machinery must be checked and in good working order.

(x) A first aid kit should be placed in a convenient position.

20.5.2. Wool Rooms:

(i) Adequate space for wool handling and storage is important.

(ii) A minimum of 5.2m must be allowed between the raised board edge and the wool room.

20.5.3. Notes

Build or Renovate - Assess potential of present building, e.g. state of repair, size, access to farm, financial position, gates and light situation.

Size - Depends on number of sheep and stands, whether covered yards are incorporated or not.

Capacity - Allow 4 square feet ($0.37 m^2$) per sheep.

Types of Woolsheds -

(i) Porthole. Out of date but can be renovated to either chute or return race type.

(ii) Return Race. Excellent for keeping sheep warm after shearing and for general working of sheep at other than shearing time but requires more length to get races in. In wet conditions, shorn sheep take up valuable space that could be used for unshorn animals.

(iii) Chute. Most popular as sheep can be automatically counted and go straight out after shearing. All available space can be used. Catching pens can be side filled and space between stands can be cut to a minimum for woolhandling.

Chutes must be constructed to *correct measurements* for ease of working. Chute sheds must be sited to the best advantage re wind up chute.

Raised Board. - Measurements 5'6" (1.7m) wide x 2'6" (0.76m) high.

Savings ⅓ of walking compared with flat board.
Site -Dry, central, access to power and road.

Building material - This does not affect the work ability of a shed and cost must be considered, although it is possible to build a shed with a variety of materials with a similar cost. If steel portal frames are used they could be desirable for strength, ease of construction and general appearance.

Height above ground. - Lorry height 3'9" (1.1m).
Many sheds now have concrete woolroom floors 12" (.31m), then raised board at 2'6" (0.7m) to give grating height of 3'6" (1.06m). Bale loading is achieved by backing lorry into a position about 2' (0.7m) below concrete block 12" (.31m) high if concrete woolroom is incorporated. Height above ground depends mainly on personal preference.

Stud Height - Minimum 8'6" (2.6m), maximum 9' (2.7m). With raised board woolroom 9' (2.7m) grating 6'6" (1.99m).

Lighting - Most important, if sheep are to run well. Corrugated plastic sheets placed in roof tend to give light *spots* so 2' (0.7m) strips should be placed down from top plate to effect light at important positions in the shed. Windows provide the rest.

Sarking - Black building paper is too dark. Silver sizalation is better, but timber sarking is best and strongest.

Ventilation - 3' (.91m) 5 blade loovres excellent if placed in position to give maximum light and encouragement to draw sheep.
Roof vents good.

Gratings - Spacing ⅝" (15mm) bevelled on one side. Width depends on personal preference. Suggest 1¼" to 1½" (32mm to 37 mm) x 1½" (32mm) deep. Bevel to face away from oncoming sheep. Grating to be changed if necessary to suit progress of sheep.

Gates - Lift and swing type is the most popular, followed by lift, then tip or swing types.

Landing and Ramp - Woolroom loading block no bigger than 6' x 3" (1.8m x .91m). Sheep ramp-steps 12" x 6" (.30m x .15m) or 10" x 5" (.25m x .13m), steps very effective for sheep and man.

Pens and Partitions - Depends on breed of sheep. Height for Romneys or Corriedales 2' 10" (.86m). Rub rails staggered to stop sheep seeing through. Catching pens should hold about 15 sheep.

Wool Rooms - Allow minimum of 17' (5.2m) between edge of raised board or board wall and outside wall for wool room. This gives room for wool table, bins etc. Allow approximately 48" (1.3m) x 2'6" (.76m) for a bale of wool while a pack holder should measure 39" (.99m) x 27" (.69m). This fits inside the pack.

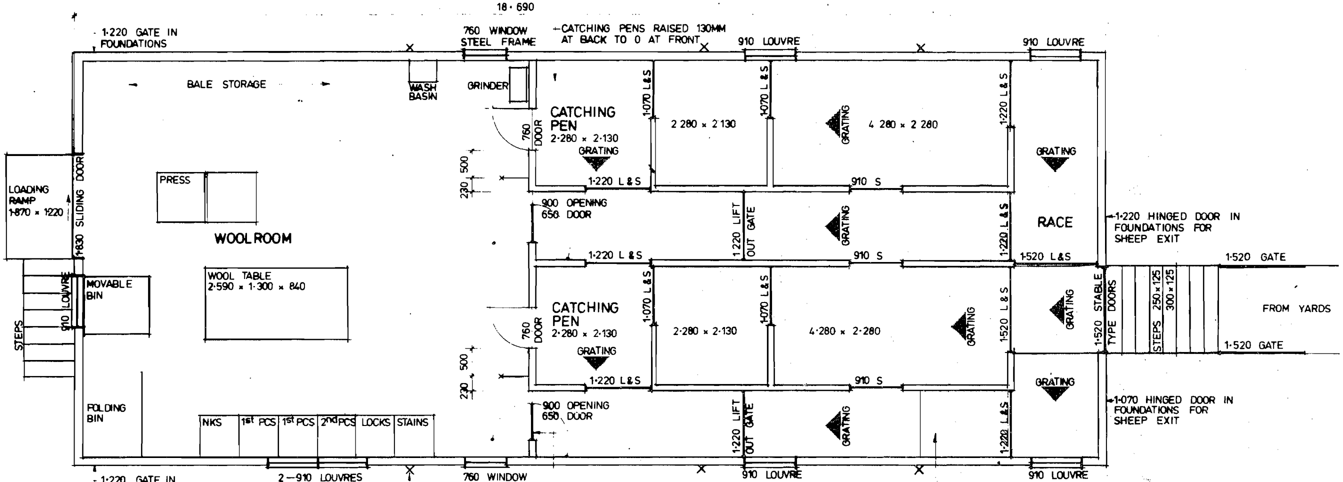
Wool Tables - Rectangular measurements 8'6" (2.6m) x 4'3" (1.3m) x 2'9" (.84m) high. Circular diameter should be 7' (2.1m). Battens are suitable at 1¼" (32mm) x 1¼" (32mm).

Board Layout - Very important.
If chute is used it must jut into the board 6" (.15m) and be attached to the bottom of the foist to give a drop of 4" (.10m). This allows the front feet of the sheep to drop straight into the chute with no risk of returning. Chute to be at 45° angle for 3'6" (1.1m) then a walkoff at 25°.

L. Galloway, Sheep and Beef Officer,
Ministry of Agriculture,
Christchurch.

TWO STAND RETURN RACE WOOLSHED

CAPACITY TOP FLOOR = 200



DOORS ATTACHED TO HOOK BY CHAIN. 650 DOOR CAN ALSO SWING BACK WHEN OFF CHAIN TO BOLT IN WOOLROOM FLOOR TO GUIDE SHEEP INTO RETURN RACE

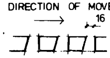
SECTION OF GRATING ON FLOOR TO BE LET DOWN WHILE SHEARING OR CRUTCHING

1·220 HINGED CLOSED IN DOORS TO BE SET IN PLACES MARKED 'X' IN CONCRETE BLOCK FOUNDATIONS FOR CLEANING OUT AND VENTILATION

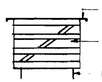
7·410

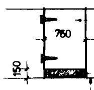
20-40

DIRECTION OF MOVEMENT →



GRATING BEVEL TO FACE AWAY FROM ONCOMING SHEEP





KEY TO GATES

L	LIFT
S	SWING
L&S	LIFT & SWING

HEIGHT FROM GROUND LEVEL TO WOOLROOM FLOOR LEVEL = 1·290

2–910MM LOUVRES TO BE PLACED IN APEX OF ROOF OPPOSITE EACH OTHER. THESE LOUVRES ARE NOT SHOWN ON THE PLAN.

HEIGHT OF BOARD WALL TO BE 1·220 FROM BOARD LEVEL

HEIGHT OF PARTITIONS 860MM ABOVE GRATING

APPROX 4 SHEETS OF MATERIAL TO BE USED IN WALLS FOR LIGHTING & TO BE PLACED IN POSITION WHEN SHED POSITION IS DECIDED

STUD HEIGHT 2·400 IN WOOLROOM

ROOF PREFERABLY SARKED WITH 12MM TREATED PINE

1·500METRE CONCRETE STRIP OF FOUNDATION TO BE PLACED IN EACH CORNER FOR STRENGTH

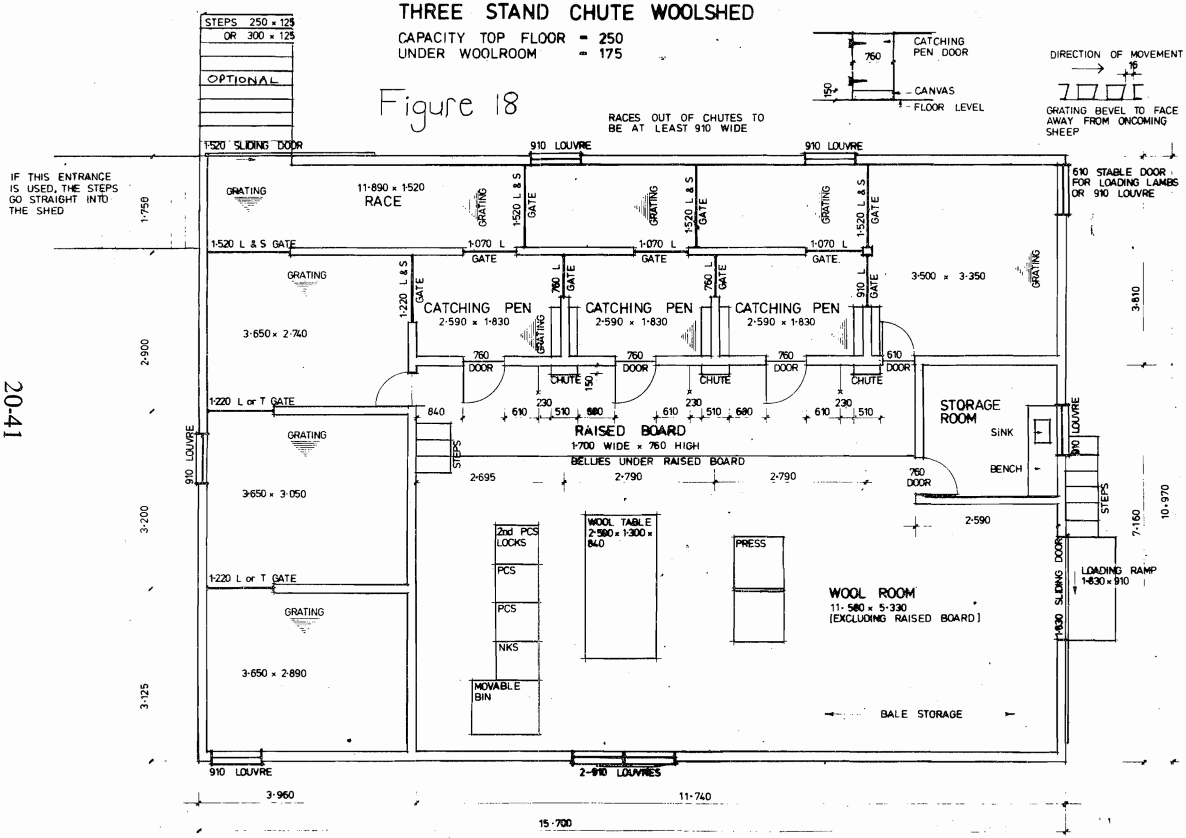
M.A.F.
6

Figure 17

THREE STAND CHUTE WOOLSHED

CAPACITY TOP FLOOR = 250
UNDER WOOLROOM = 175

Figure 18



HEIGHT FROM GROUND LEVEL TO BE AT LORRY HEIGHT - 1·140, HIGHER IF STOCK UNDER WOOLROOM

2-910 LOUVRES TO BE PLACED IN APEX OF ROOF OPPOSITE EACH OTHER. THESE LOUVRES ARE NOT SHOWN ON THE PLAN.

HEIGHT OF BOARD WALL TO BE 1·220 FROM BOARD LEVEL

HEIGHT OF PARTITIONS 860MM ABOVE GRATING LEVEL

STUD HEIGHT 2·700 IN WOOLROOM

STUD HEIGHT 1·920 IN GRATING AREA

ROOF PREFERABLY SARKED WITH 12MM TREATED PINE OR LINED WITH BUILDING PAPER ON WIRENETTING

APPROX 4 SHEETS OF MATERIAL TO BE USED IN WALLS FOR LIGHTING & TO BE PLACED IN POSITION WHEN SHED LOCATION IS DECIDED

610MM STRIPS OF DURALITE TO BE PLACED 610MM DOWN FROM TOP PLATE WHERE IT IS REQUIRED

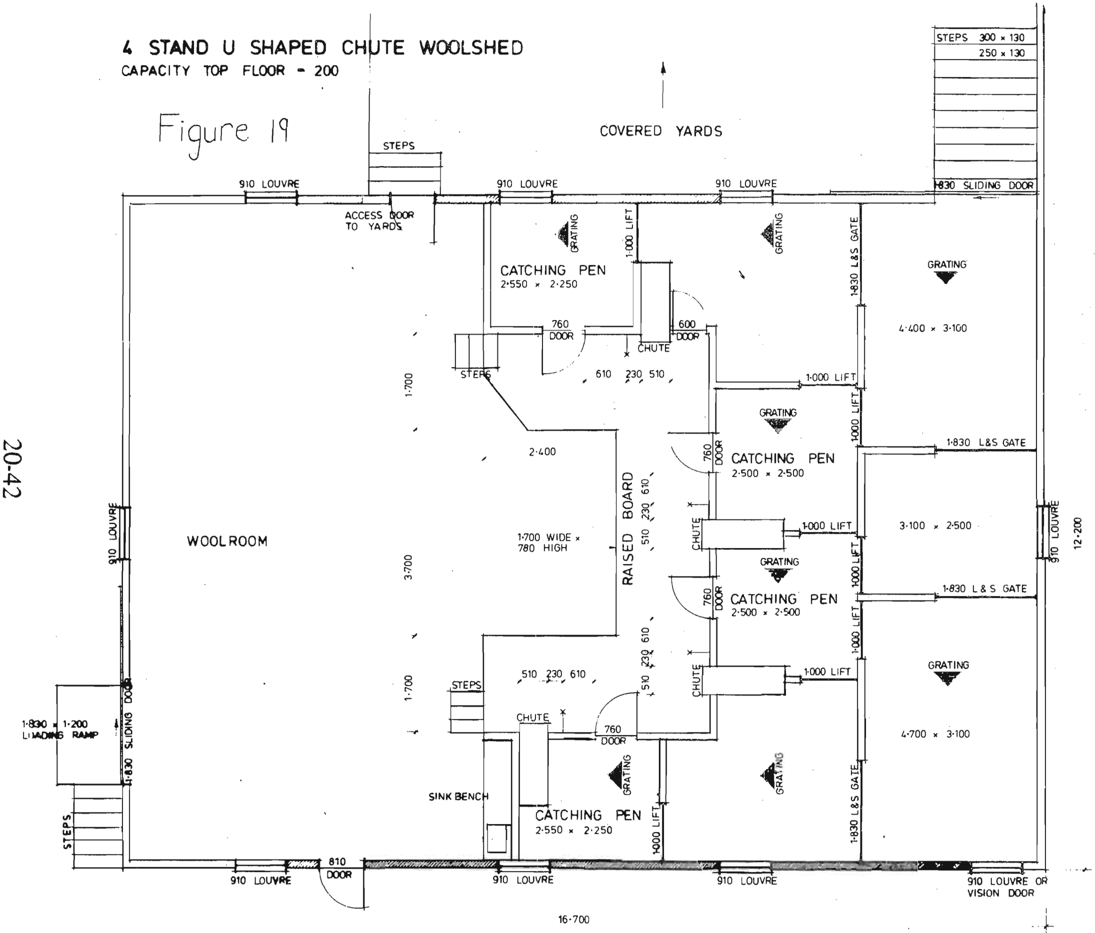
1·500 METRE STRIP OF CONCRETE FOUNDATION TO BE PLACED IN EACH CORNER FOR STRENGTH

M.A.F.
8

4 STAND U SHAPED CHUTE WOOLSHED

CAPACITY TOP FLOOR - 200

Figure 19



LEGEND

610MM STRIPS OF DURALITE PLACED DOWN FROM TOP PLATE

L & S — LIFT & SWING GATE

DIRECTION OF MOVEMENT →

16

GRATING BEVEL TO FACE AWAY FROM ONCOMING SHEEP

CATCHING PEN DOOR

760

150

CANVAS

FLOOR LEVEL

HEIGHT FROM GROUND LEVEL TO WOOL ROOM FLOOR LEVEL = 1·290

2–910MM LOUVRES TO BE PLACED IN APEX OF ROOF OPPOSITE EACH OTHER. THESE LOUVRES ARE NOT SHOWN ON THE PLAN.

HEIGHT OF BOARD WALL TO BE 1·220 FROM BOARD LEVEL

HEIGHT OF PARTITIONS 860MM ABOVE GRATING

STUD HEIGHT 2·700 IN WOOLROOM

ROOF PREFERABLY SARKED WITH 12MM TREATED PINE

1·500 METRE STRIP OF CONCRETE FOUNDATION TO BE PLACED IN EACH CORNER FOR STRENGTH

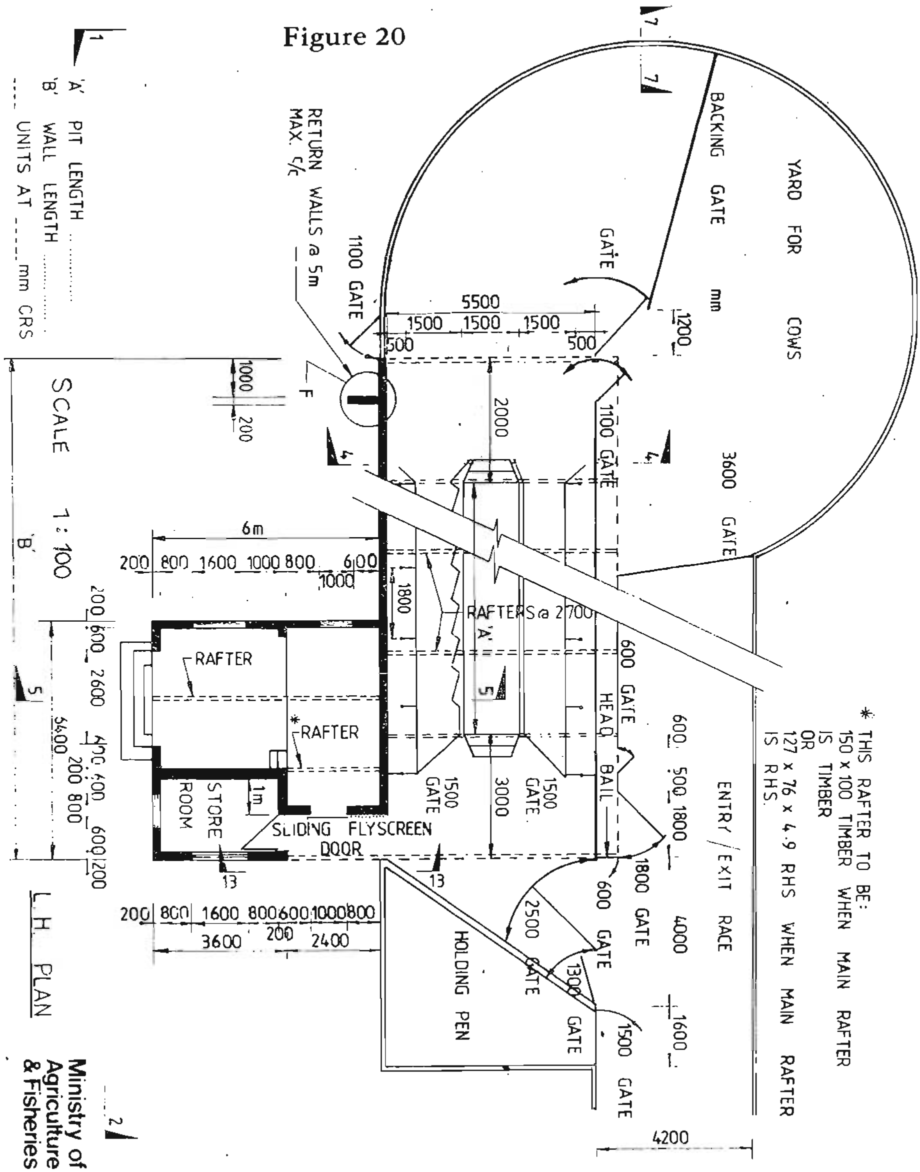
APPROX 4 SHEETS OF MATERIAL TO BE USED IN WALLS FOR LIGHTING & TO BE PLACED IN POSITION WHEN SHED POSITION IS DECIDED

M.A.F.
10

20.6 DAIRY SHEDS AND YARDS

Elevations and floor plans for a standard Herringbone Dairy are given (figure 20) as is further information, and structural notes can be obtained from the Ministry of Agriculture and Fisheries, dairy design service.

Figure 20



SOURCES: The information presented in this section on farm structures was derived from the following sources:

(i) Sheepyards – "Design and Construction of Sheep-drafting yards" by J.E. Duncan. A N.Z. Department of Agriculture Bulletin No.353 (1962)
– N.Z. Farmer May 23, 1974; Jan.8, 1976; Nov.25, 1976; Oct.13, 1977, May 24 1979

(ii) Covered yards - M.A.F., N.Z. Farmer Oct 1980.

(iii) Cattleyards - N.Z. Farmer July 25, 1974; April 14, 1977.

(iv) Cattlestops - N.Z. Farmer May 13, 1976.

(v) Deer yards - M.A.F. Ag Links F.P.P. 251,252.

(vi) Woolsheds - N.Z. Farmer October 1980, M.A.F. Standard plans.

(vii) Dairy - M.A.F. Standard plan.

NOTE: There are other well-produced bulletins and information booklets available from the Ministry of Agriculture and Fisheries, and other sources, dealing with the above-mentioned subjects. We suggest that these are consulted for more detailed information.

The Ministry of Agriculture and Fisheries plans, used in this section can be obtained from them, in a larger form.

20.7 HAYBARNS

The following table lists the capacities of various sizes of haybarns.

Eave Height (m)	Length (m)	Building Capacity (bales) 6m gable	9m gable
2.4	9.1	800	1 400
	13.7	1 200	2 100
	18.3	1 700	2 800
	22.8	2 100	3 500
	27.4	2 500	4 200
3.0	9.1	1 000	1 600
	13.7	1 500	2 500
	18.3	2 000	3 300
	22.8	2 500	4 200
	27.4	3 100	5 000
3.6	9.1	1 200	1 900
	13.7	1 800	2 900
	18.3	2 400	3 800
	22.8	3 000	4 800
	27.4	3 600	5 700
4.2	9.1	1 300	2 100
	13.7	2 000	3 300
	18.3	2 700	4 300
	22.8	3 500	5 400
	27.4	3 900	6 500

NOTE: The capacities are calculated allowing 5 bales per cubic metre.

20.8 GRAIN STORAGE BUILDINGS

20.8.1 Galvanised Steel Silos

Diameter (m)	Eave Height (m)	Tonnes Capacity Barley	Maize	Wheat
3.7	2.4	18.5	21	22
	4.9	36	40	43
4.6	3.3	39	44	47
	4.1	48	54	58
	4.9	57	64	69
5.5	4.1	70	79	84
	5.7	96	108	116
	7.3	122	137	147
6.4	4.1	97	109	117
	5.7	133	148	149
	7.3	168	188	202
7.3	4.1	129	144	154
	5.7	175	196	210
	7.3	221	248	266

20.8.2. Steel Mesh Silos

Silos can be made from steel mesh lined with hessian scrim, and situated in an existing shed. The most common size is 15.5m circumference, 4.5m diameter, with height of 2.3m. A silo of these dimensions has a capacity of about 37m^3 or 34 tonnes. The mesh is joined by "U" bolts and clips. To prevent fermentation, a 3m x 2.4m sheet of wire mesh lined with hessian is used as an air tube into the centre of the silo. This tube can also be made from galvanized sheet steel. These silos should be ALWAYS filled or emptied from the centre.

20.9 CONCRETE

To estimate the quantities of materials required for a particular job, it is necessary to first calculate the volume of concrete (normally in cubic metres) which will be required.

The following table gives suggested mixes for different types of jobs.

Type of Job		Cement (parts)	Sand (parts)	Coarse Aggregate (parts)	Water (litres/bag cement)
Concrete:	thin reinforced walls, columns, fence posts, heavy duty floors	1	1½	3	20
	: floor slabs, tanks, drives, retaining walls, garage floors	1	2½	4	24
	: foundations, road bases, mass concrete	1	3	5	30
	: topping floors and paths	1	1	2	20
Plaster:	tanks, dairy walls	1	2½		20
	: walls, roughcasting and stucco	1	3		20

NOTE: Average weights – Cement = 40kg (standard bag weight)
– Sand = 1 450kg/m^3
– Coarse Aggregate = 1 400kg/m^3

Proportions	Materials to make 1m^3 of mixture: Cement bags	Sand m^3	Aggregate m^3	Yield of mixture per bag of cement (m^3)	Water per bag of cement (litres)
1:1:2	14	0.40	0.80	0.071	20
1:1½:3	10½	0.42	0.85	0.095	24
1:2½:4	8	0.53	0.85	0.125	30
1:3:5	7	0.54	0.90	0.143	15
1:2½	15½	1.00	–	0.065	20
1:3	13½	1.00	–	0.074	20

NOTE: No allowance for waste has been made in these quantities, nor any allowance for irregularities in the subgrade of slabs. When ordering materials, it is wise to allow at least 5% for wastage.

20.10 TIMBER

Timber sections are described in millimetres and standard lengths in metres. The super foot is no longer used. Sales are based on the linear measure for a known end section or by volume (cubic metre).

To calculate the volume contents of sawn timber, multiply the width (mm) by the thickness (mm), divide the result by 1 000^2 and multiply by the length (m). The volume will be expressed in cubic metres.

DIMENSIONS
Preferred Range of Call Sizes in mm

Call Dimensions THICKNESS	Call Dimensions – WIDTH								
	50	75	100	125	150	200	225	250	300
25	X	X	X	X	X	X	X	X	X
30			X		X				
40	X	X	X	X	X	X	X	X	X
50	X	X	X	X	X	X	X	X	X
75			X	X	X	X	X	X	X
100			X	X	X	X	X	X	X

PREFERRED LENGTHS
(in metres)

1.8	3.3	4.8
2.1	3.6	5.1
2.4	3.9	5.4
2.7	4.2	5.7
3.0	4.5	6.0

Finished Dimensions in mm

Call Dimension	Finished Dimension: Green Gauged Timber	Finished Dimension: Dry Dressed Timber
25	–	19
30	–	25
40	37	35
50	47	45
75	69	65
100	94	90
125	119	115
150	144	140
200	194	180
225	219	205
250	244	230
300	294	280

20.11 OTHER FARM BUILDINGS

There are many other types of farm buildings that have not been mentioned in this section, such as milking sheds, implement sheds, etc. Because of the many different types of construction of these buildings, it is not possible to discuss them in any great detail. Further information on their construction and other relevant data can be obtained from sources such as the Ministry of Agriculture and Fisheries, stock and station agents and other commercial organizations that either produce or distribute the materials.

However, before building any new shed or other structure, it is necessary to follow the few simple rules that were discussed in Section 20.1

(i) List all the activities that are to take place in or near the building.

(ii) Decide on the location in the light of drainage, access, shelter, water and electricity supply.

(iii) Carefully plan the building.

(iv) After these rules have been followed, then commence building, checking as you go.

The companion volume, "Financial Budget Manual" contains information on most materials used in the construction of farm buildings. This should be consulted for relevant details.

NOTE: The above comments apply to fencing requirements as well.

SECTION 21

FARM MACHINERY

21. FARM MACHINERY

21.1 POWER TERMS

Kilowatt (kW) is a unit of power measurement. It expresses the amount of work a machine will do in a given time and equals 1000 joules per second. (1kW = 1.34 horse-power).

Indicated Power is the power available at the piston heads of an engine and equals the brake power plus the friction power.

Friction Power accounts for the power used by an engine to overcome the friction of moving parts plus pumping losses. These power losses occur even at no load and increase with speed and added load.

Brake Power generally means the engine power available for productive work at the crankshaft or flywheel. It equals the gross power available when the engine is not driving power-consuming ancillary equipment such as hydraulic pumps, generators, water pumps, and net power when this equipment is functioning. Belt and P.T.O. power are 2 to 4 percent less than net power.

Rated Power is the power generated under a particular condition and engine speed as quoted by the manufacturer, or is some quoted percentage of the maximum power. (Usually about 85% maximum brake power or 75% maximum drawbar power).

P.T.O. Power is the power available at the P.T.O. When tractors have completely separate belt and P.T.O. drives, the P.T.O. is usually designed to transmit 95% of the maximum power.

Maximum P.T.O. Power is the maximum power, more or less continuously available at the P.T.O.

Drawbar Pull is the force exerted by a tractor when pulling a load attached to the drawbar or 3-point linkage. In official tests, the pull is measured on a line parallel to the ground surface.

The maximum pull that can be exerted by a given tractor is critically dependant on the interaction between:-

(a) The maximum torque which can be developed by the engine.

(b) The gear ratio in which the tractor is operated.

(c) The ability of the ground surface to withstand the thrust applied by the drive wheels. In most practical situations, this ability will depend on the soil type, compaction and moisture content, and on the nature of the plant growth present (if any).

(d) The number and nature of driving wheels (or tracks) in use.

(e) The total weight carried by the driving wheels, or tracks while actually working (**not** the static weight carried by the driving axles). This total weight may be affected by:
   (i) Basic tractor weight.
   (ii) Ballast (water in tyres, wheel weights, front frame weights).
   (iii) Weight transfer from linkage-mounted equipment (or, with appropriate accessories, from drawbar-hitched equipment).
   (iv) Weight transfer (as from front axle to rear axle of an ordinary 2 - wheel drive tractor) resulting from the draw bar pull which is being developed.

Drawbar Power is directly related to drawbar pull and travel speed. (see 16.2 Useful Formulae). Hence the drawbar power which can be developed by a given tractor depends on all the factors (a) to (e) discussed under "Drawbar Pull" **and** on the actual travel speed in work, which is dependant on:

(a) Engine speed,
(b) Gear ratio, and
(c) Percentage wheelslip, which in turn is also influenced by all the factors discussed under (c) to (e) in relation to "Drawbar Pull".

NOTE At most "official" tractor testing stations (such as those in Britain, Germany, and the U.S.A.) the drawbar pull and drawbar power are determined, for various reasons, under conditions which are quite unrealistic from an agricultural viewpoint. The tractors are tested on artificial tracks (concrete or tar sealed), and the amount of ballast carried is far greater than would be used on most farms.

Most of the drawbar performance claims made in tractor advertising will be based, quite logically, on official test reports. It is probably quite reasonable to use such claims as a basis for comparing tractors with one another in a general way - but not for relating to the field operating requirements of various impliments. For a reliable comparison between tractors on the basis of published specifications, consider:

(a) Power take-off power (particularly at standard P.T.O. speed of 540 r.p.m. on 1000 r.p.m.), and
(b) Specific feul consumption in litres or grammes per kilowatt - hour, at maximum power and at reduced power (see section 16.3).

21.2 USEFUL FORMULAE

Work = Force in Newtons (N) x Distance moved in metres (m) = Joules (J).

$$\text{Power} = \frac{\text{work}}{\text{time}} = \frac{\text{joules}}{\text{Second}} = \text{watts (W)}$$

Torque = Force in newtons (N) x Distance to centre of rotation in metre = newton metres (Nm).

Maximum torque usually occurs at 60 to 75% of rated engine speed.

$$\text{Power (kW)} = \frac{\text{work}}{\text{time}} = \frac{\text{Pull (N) x Distance (m)}}{\text{1000 x time (seconds)}} = \frac{\text{Pull (N) x speed (km/h)}}{3600}$$

$$\text{Shaft Power (kW)} = \frac{\text{Torque (Nm) x Speed (r.p.m.)}}{9549}$$

Brake Power (kW) = Shaft power as above for equivalent crankshaft speed and torque.

Rated Brake Power = 85% of maximum Brake power at rated engine speed power.

$$\text{Drawbar Power (kW)} = \frac{\text{Pull (N) x Speed (km/h)}}{3600}$$

$$\text{Wheelslip (\%)} = \frac{\text{Distance travelled (with load) x}}{\text{Distance travelled (no load)}} \quad \frac{100}{1}$$

("Distance" in each case being measured for the same number of drive wheel revolutions).

As a rough guide, the speed of an implement (km/h) = number of paces per minute divided by 20.

21.3 ESTIMATED FUEL AND OIL CONSUMPTION OF TRACTORS

The average fuel consumption per kW/hour shown in the table below is for new tractors. The rate for older tractors may be higher. The average load on the engine varies according to the way the machine is used, the size and type of the implement attached, speed of travel and condition of the soil.

The fuel consumption per kW/hour increases as the load on the engine decreases.

21.3.1 Average Specific Fuel Consumption per kW/hour for a Sample of New Tractors

	Type of Engine and Fuel	
Engine loading % of max. power	Petrol litre/kWh.	Diesel litres/kWh.
100	0.261	0.180
75	0.292	0.193
50	0.366	0.217
35	0.468	0.254
25	0.573	0.319

Approximate fuel consumption in litres per hour can be estimated by multiplying S.F.C. by power in kW produced at a particular engine loading.

21.3.2 Fuel Consumption in Litres/Hr for Different Sizes and Loads of Tractor Engines

Type of Engine	Maximum Engine Power		Load on Engine (% of maximum power) 75%		50%		35%		25%	
Petrol	(H.P.)	(kW)	gals/hr	litre/hr	gals/hr	litre/hr	gals/hr	litre/hr	gals/hr	litre/hr
	30	22.4	1.93	8.77	1.62	7.36	1.45	6.59	1.27	5.77
	35	26.1	2.26	10.27	1.89	8.59	1.69	7.68	1.48	6.81
	40	29.8	2.58	11.73	2.16	9.82	1.93	8.77	1.69	7.68
	45	33.5	2.90	13.18	2.43	11.05	2.17	9.91	1.90	8.63
	50	37.3	3.22	14.64	2.70	12.27	2.42	11.01	2.11	9.59
	55	41.0	3.55	16.14	2.97	13.50	2.66	12.09	2.32	10.54
	60	44.7	3.87	17.59	3.24	14.73	2.90	13.18	2.54	11.55
	65	48.5	4.19	19.05	3.51	15.96	3.14	14.27	2.75	12.50
	70	52.2	4.52	20.55	3.78	17.18	3.38	15.37	2.96	13.45
	75	55.9	4.84	22.00	4.05	18.42	3.62	16.46	3.17	14.41
	80	59.6	5.16	23.46	4.32	19.64	3.86	17.54	3.38	15.37
	85	63.4	5.48	24.91	4.59	20.88	4.12	18.73	3.59	16.32
	90	67.1	5.80	26.37	4.86	22.09	4.35	19.78	3.80	17.27

Type of Engine	Maximum Engine Power		Load on Engine (% of maximum power)							
			75%		50%		35%		25%	
	(H.P.)	(kW)	gals/hr	litre/hr	gals/hr	litre/hr	gals/hr	litre/hr	gals/hr	litre/hr
Diesel	30	22.4	1.28	5.82	0.96	4.36	0.79	3.59	0.71	3.23
	35	26.1	1.50	6.82	1.12	5.09	0.92	4.18	0.82	3.73
	40	29.8	1.71	7.77	1.28	5.81	1.05	4.78	0.94	4.27
	45	33.5	1.92	8.73	1.44	6.55	1.18	5.36	1.06	4.82
	50	37.3	2.14	9.73	1.60	7.27	1.31	5.95	1.18	5.36
	55	41.0	2.35	10.68	1.76	8.00	1.44	6.55	1.29	5.86
	60	44.7	2.56	11.64	1.92	8.73	1.58	7.18	1.41	6.41
	65	48.5	2.78	12.64	2.08	9.45	1.71	7.77	1.53	6.96
	70	52.2	2.99	13.59	2.24	10.18	1.84	8.36	1.65	7.50
	75	55.9	3.21	14.59	2.40	10.91	1.97	8.95	1.76	8.00
	80	59.6	3.42	15.55	2.56	11.64	2.10	9.55	1.88	8.55
	85	63.4	3.63	16.50	2.72	12.36	2.23	10.13	2.00	9.09
	90	67.1	3.85	17.50	2.88	13.09	2.36	10.72	2.12	9.64
	95	70.8	4.06	18.46	3.04	13.82	2.49	11.32	2.23	10.14
	100	74.6	4.28	19.46	3.20	14.55	2.63	11.95	2.35	10.68
	105	78.3	4.49	20.41	3.36	15.28	2.76	12.54	2.47	11.23
	110	82.0	4.70	21.37	3.52	16.00	2.89	13.14	2.59	11.77
	115	85.7	4.92	22.37	3.68	16.73	3.02	13.73	2.70	12.27
	120	89.5	5.13	23.32	3.84	17.46	3.15	14.31	2.82	12.82
	125	93.2	5.34	24.27	4.00	18.18	3.28	14.91	2.94	13.36
	130	96.9	5.56	25.27	4.16	18.91	3.41	15.51	3.06	13.91
	135	100.7	5.77	26.23	4.32	19.64	3.54	16.10	3.17	14.41
	140	104.4	6.00	27.28	4.48	20.37	3.68	16.73	3.29	14.95

21.3.3 Oil Consumption

Average oil consumption in tractors is 2.5 to 3 per cent of the fuel consumption. The engine oil may be changed every 250 hours, and transmission oil may be changed every 1 000 hours. Oil filters are usually changed at each oil change.

21.4 WORK CAPACITY OF FARM MACHINERY AND IMPLEMENTS

21.4.1 Cultivation

Area covered by cultivation implements in a given time depends on:

(i) size of implement
(ii) size of traction unit
(iii) nature of country – general steepness of the contour
(iv) type and condition of soil – compare light, stony, heavy and clay soil, in wet or dry condition.
(v) type of work
(vi) breakage and general skill of operator. An experienced man knows the speed at which he gets maximum use out of the implement.
(vii) size and shape of paddock

21.4.2 Harvesting

Area covered by harvesting machinery in a given time depends on:

(i) bulk of the crop – heavy or light yields
(ii) type of crop – wheat or peas, or clovers etc.
(iii) conditions of crop – ease of threshing – lodged oats or ryegrass
(iv) weather – hot and dry, vs. damp and cool
(v) whether the crop has been windrowed (e.g. peas, ryegrass, clover, oats) or is being direct headed
(vi) nature of ground surface – flat or sloping, smooth or rough

21.5 FIELD CAPACITY AND EFFICIENCY

21.5.1 Field Capacity

Field capacity is a measure of the relative productivity of a machine under field conditions. It accounts for failure to utilize the theoretical operating width of the machine, operator capability and habits, operating policy and field characteristics. The following activities account for a majority of the time loss in the field:

- (i) turning and idle travel
- (ii) materials handling (e.g. seed, fertilizer, chemicals, water, harvested material)
- (iii) cleaning clogged equipment
- (iv) machine adjustment
- (v) lubrication and refuelling over daily service
- (vi) waiting for other machines
- (vii) other field time interruptions

Travel to or from a field, major repairs, preventative maintenance, and daily service activities are not included in field time or field efficiency. Field efficiency is not a constant for a particular machine, but varies with size and shape of the field, pattern of field operation, crop yield, moisture and crop conditions.

21.5.2 Effective Field Capacity

Effective field capacity may be determined from the following equation:

$$C = \frac{S.W.E.}{10}$$

where
C = effective field capacity, hectares per hour
S = field speed, km per hour
W = theoretical machine width, metres
E = field efficiency

Theoretical field capacity can be determined from the above equation by using a field efficiency of 100%. Typical ranges of field efficiency and operating speed are listed below:-

Machine	Range in Field Efficiency (%)	Speed km/h
Cultivator, field	75 – 90	4.8 – 8.0
Cultivator, row crop	75 – 90	2.4 – 8.0
Disc Harrow	75 – 90	5.6 – 9.6
Plough	75 – 90	5.6 – 8.0
Rotary Cultivator	75 – 90	1.8 – 7.2
Harrow (spike-tooth)	70 – 85	4.8 – 9.6
Grain Drill	60 – 80	4.0 – 6.4
Maize Planter	60 – 80	5.6 – 9.6
Combine Header	65 – 80	3.2 – 5.6
Maize Picker	55 – 70	4.0 – 5.6
Mower	75 – 80	5.6 – 8.8
Rake	75 – 90	5.6 – 8.0
Hay baler	55 – 80	3.2 – 8.0
Forage Harvester	50 – 75	3.2 – 6.4
Sprayer	55 – 65	4.8 – 9.6

21.6 EXAMPLES OF WORKING OUT TRACTOR HOURS
(Typical Mixed Cropping Farm Implements and 37–48 kW Tractor)

These figures should be interpreted in the light of their deficiencies i.e. paddock condition, soil type, crop type, the yield of the crop, the amount of research data available and how applicable it is to New Zealand conditions. Where implements are combined in 'gangs' some rationalization is necessary. Consequently the following figures are, as near as possible, an average assessment of hours per hectare for a 37 to 48 kW (50 to 60 hp) tractor operating on flat ground cultivating and harvesting an average yielding crop.

21.6.1 Heavy Soils

(i) Preparation for Peas

August	hrs/ha
Grub	0.6
Grub, Harrow and Roll	0.7
Plough	1.7
Roll	0.5
Harrow and Roll	0.3
Disc, Roll and Harrow	0.2
Disc and Roll	0.6
Harrow and Roll	0.3
Dutch Harrow	0.4
Drill	0.9
TOTAL Cultivation	6.7
Harvesting (Yield 3000 Kg/ha)	2.0

(ii) Preparation for Wheat

January	hrs/ha
Plough	2.8
Roll	0.5
Disc	0.6
Grub and Harrow	0.5
Grub	0.4
Harrow and Roll	0.4
Drill	0.6
TOTAL Cultivation	5.8
Harvesting (Yield 3300 Kg/ha)	1.5

(iii) Preparation for Barley

August	hrs/ha
Grub	0.4
Grub, Harrow and Roll	0.4
Harrow and Roll	0.2
Plough	1.4
Roll and Disc	0.6
Harrow and Roll	0.3
Harrow and Roll and Disc	1.7
Harrow and Roll	0.3
Drill	0.8
TOTAL Cultivation	6.1
Harvesting	1.5
Plough headland	0.1

(iv) Preparation for Grass

March	hrs/ha
Disc	1.2
Harrow and Roll	0.5
Drill	1.1
Spread Fertilizer	0.5
TOTAL Cultivation	3.3

This paddock is sown for 3 years, so cost of establishment is divided by 3 to find the annual cost.

(v) Preparation for Tama Ryegrass

	hrs/ha
Disc and Harrow	0.6
Roll and Disc	0.2
Roll	0.4
Disc	0.6
Harrow and Roll	0.4
Disc and Harrow	0.6
Roll	0.3
Disc and Harrow	0.5
Harrow and Roll	0.4
Drill	1.0
Spread Fertilizer	1.5
TOTAL Cultivation	6.5

(vi) Preparation for Clover Seed

	hrs/ha
Spray	0.4
Heavy Roll	0.8
Mow	1.5
TOTAL Cultivation	2.7
Thresh	2.5

21.6.2 Medium Soils

(i) Old Grass – Peas

	hrs/ha
Deep Plough	3.3
Roll	0.8
Disc (2x)	2.0
Grub (3x)	2.5
Harrow (2)	1.0
Roll (2)	1.6
Drill	1.0
Roll	0.8
Harrow	0.5
TOTAL Cultivation	13.5
Harvest – Mow	1.6
Head	1.3

(ii) Peas – Wheat

	hrs/ha
Disc (2)	2.0
Deep Plough	3.3
Grub (3)	2.5
Drill	1.0
Roll	0.8
Harrow	0.5
TOTAL Cultivation	10.1
Harvesting	0.9

(iii) Wheat – Barley

	hrs/ha
Disc (2)	2.0
Deep Plough	3.3
Grub (2)	1.6
Harrow (2)	1.0
Roll (2)	1.6
Drill	1.0
Harrow	0.5
TOTAL Cultivation	11.0
Harvesting	1.2

(iv) Barley – Greenfeed – Summer fallow – new grass

	hrs/ha
Grub	2.5
Roll	0.8
Drill	1.0
Plough (Oct.)	3.3
Grub (4)	3.3
Harrow (4)	2.0
Roll (4)	3.3
Drill	1.0
Roll	0.8
TOTAL Cultivation	18.0
Harvesting Ryegrass	1.6

21.6.3 Miscellaneous

Windrowing	0.5	(4.3 metres cutting width).
Forage harvesting	1.0	(20 tonnes per hour).
Direct Drilling	0.3	(using a Triple Disc 2.5m width)
Power harrows	2.0	(using a Roterra 2.5m width).
Beet lifter	2.0	

SECTION 22

WEIGHTS AND MEASURES

22. WEIGHTS AND MEASURE

References: *"Metrics on the Land", 1973 F.J. Peake (ed.)*
Information Services, M.A.F.
"Conversion to Metric Units (S.I.)", 1973.
Dr. J.G.H. White, Plant Science Dept., Lincoln College.
"Agricultural Chemicals and Metrication", 1974.
Ag. Chem. and Animal Remedies Manuf. Fed., M.A.F. and N.Z. Grain, Seed & Produce Merchants Fed.

22.1 THE S.I. SYSTEM

22.1.1 Introduction

New Zealand has 'gone metric'. Since January 1974, most agriculturally related industries have been using metric measures for their products.

The International System (SI) of units is used in most countries of the world. This uniformity of measure is preferable to several different systems, which require tedious conversions.

It is clumsy to think in the old imperial system and convert into metric or vice versa. It is better to 'THINK METRIC' in the first place.

This section is designed to assist those people who have not completely changed over to the metric system.

Some useful conversion tables are reproduced in Section 22.3.

22.1.2 S.I. Units

Only a small proportion of the total S.I. units are needed for everyday use. These are:

Quantity	Unit	Symbol
LENGTH	millimetre	mm
	centimetre	cm
	metre	m
	kilometre	km
AREA	square centimetre	cm^2
	square metre	m^2
	hectare	ha
VOLUME	cubic centimetre	cm^3
	cubic metre	m^3
	millilitre	ml
	litre	l or litre

MASS (weight)	gram	g
	kilogram	kg
	tonne	t
VELOCITY	metres per second	m/sec
	kilometres per hour	km/h
FORCE	newton	N
PRESSURE	kilopascal	kPa
TEMPERATURE	degrees Celsius	°C

22.1.3. The Prefixes of S.I. Units

There is a unit common to each quantity – for example, the unit in length is the metre. The prefixes "milli", "centi", and "kilo" denote how many parts of the basic unit a measurement is. For example, a centimetre is one-hundredth of a metre, and a kilometre is one thousand times a metre. All metric units in each quantity are related to each other in multiples of 10. The most common prefixes are:

Prefix	Symbol	Meaning
mega	M	one million times
kilo	k	one thousand times
hecto	h	one hundred times
deca	da	ten times
deci	d	one-tenth
centi	c	one-hundredth
milli	m	one-thousandth
micro	μ	one-millionth

22.1.4 Special Names

Although the basic unit and the metric prefix are used for most measures, some special names are given to commonly used quantities. For example:

1 000 kilograms = 1 tonne

10 000 sq. metres = 1 hectare

A cubic decimetre is called a litre when liquid capacity is measured. One-thousandth of this volume is called either a cubic centimetre (cm^3) or, when liquid capacity is measured, a millilitre (ml).

Pascal is the name given to a pressure of 1 newton per square metre.

22.1.5 Rules of Style

There are some important rules that should be followed when writing values and symbols. These include:

(a) Capitals – **No** initial capital for any S.I. unit written in full, e.g. metre **NOT** Metre.

Capitals only for symbol if unit is derived from a proper name, e.g. newton = N, **or** for numerical prefixes T, G and M, e.g. megagram Mg.

(b) Plurals – **NEVER** with symbols. Where necessary with full name. Decimal fractions are always singular.

e.g. 35 kilometres OR 35 km **NOT** 35 kms
1.5 grams OR 1.5 g **NOT** 1.5gs
0.5 grams OR 0.5 g **NOT** 0.5gs

(c) Number grouping – In numbers of more than four digits, place in groups of 3 with a space in between. No commas should be used, e.g.

3 578 963 **NOT** 3,578,963
1 673.576 **NOT** 1,673.576

(d) Full Stops – A full stop is **NOT** used after a symbol, except at the end of a sentence.

(e) The Decimal Point – May be placed either on the line or in a mid-line position, e.g. 28.76 OR 28·76

(f) The Word "PER" – When the word "per" forms part of the name of a unit (e.g. metres per second), an oblique stroke should be used. Such things as k.p.h. for kilometres per hour are **NOT ALLOWABLE.**

e.g. 25 metres per second = 25m/s

An alternative method is to use the notation whereby km/h is written as km h^{-1}.

22.1.6 Precision and Conversion

If an article is still manufactured according to imperial standards, imperial measures should be used until the manufacturer changes to metric,

e.g. if a pipe is precision-made to a diameter of 6.00 inches, it should be referred to by that measure and not 152.4 mm. When the manufacturer changes to metric, the pipe may become 150 cm.

Where legal or definitive specifications are involved they should be used in the form in which they are given,

e.g. if it is a legal requirement for a house to be 15 feet from a boundary, the imperial measure must be used until the legislation is changed to metric.

22.1.7 Metric and Imperial Listings

Where you use metric units, **do not** give imperial conversions alongside them. Give a list of imperial equivalents in an appendix. If you **must** use imperial units for any reason, such as in 22.1.6 put the metric equivalent in brackets. THINK METRIC!

22.2 AGRICULTURAL APPLICATIONS OF THE S.I. SYSTEM

22.2.1 Agricultural Chemicals

The labels on agricultural chemicals should list the following information:

(a) Active ingredient (a.i.)
(b) Rates of application, and
(c) Net contents.

The Active Ingredient statement is expressed in grams per litre (g/litre) for liquid formulations (mineral oil a.i. is expressed in ml/litre) and as g/kg for solids. In each case, the percentage figure will also be included, so there should be no confusion.

For example, normal strength 2,4,5-T butyl ester will be shown as:

"360 g/litre (36%) 2,4,5-T as the butyl ester in the form of an emulsifiable concentrate".

Simazine 80 wettable powder will be shown as:

"800 g/kg (80%) simazine in the form of a wettable powder".

Rates of Application are most commonly expressed as kg/ha and g/ha for solids, and ml/ha and litres/ha for liquids. When a product is recommended to be diluted with water the diluent will be given in litres/hectare.

A typical expression will be:

"Apply 2 kg of product in 170 – 220 litres of water per hectare".

For gun spraying, product amounts will normally be given for 200 litre drums (i.e. 44 gallon drums), and the drum should be thought of as containing 200 litres. Note that some labels give rates on a 100 litre basis. Additives such as stickers and wetting agents will normally be recommended to be added on a 100 or 150 litre basis.

For example: "Add 12 ml of surfactant per 100 litres of spray mix".

Net Contents of commercial packs will be in litres or kilograms.

Before applying chemicals with a boom sprayer the applicator will need to know –

(a) the area of paddock to be treated – in hectares
(b) the tank size – in litres
(c) the output from the boom – in litres per hectare

The paddock size and the tank size can be found by using the conversion tables in section 22.3. There are 3 variables that influence the output from the boom:

(a) the nozzle size and spacing along the boom
(b) the forward speed, and
(c) the spraying pressure.

The standard nozzle spacings are 355mm and 380mm.

The forward speed is expressed in km/h. Note that 1 km/h equals 16.5 m/minute.

The spraying pressure is expressed in kilopascals (kPa). An approximate conversion factor is 1 lb/sq.in. = 7 kPa.

There is a convenient method for checking output from a spray boom. It assumes that –

(a) the forward speed is uniform,
(b) the pressure is uniform, and
(c) the output from each nozzle is the same.

Fill the spray tank with water, marking the level on a dip stick (calibrated in litres) and spray at the selected speed and pressure along the distance listed in the following table for the width of your boom. For example, if your boom is 3.7m, spray 270m.

Measure the amount of water used (in litres) and multiply by 10 to obtain the number of litres applied per hectare.

Width of Boom	Distance to Spray
2.4 m	417 m
2.7	370
3.0	333
3.4	294
3.7	270
4.0	250
4.3	233
4.6	217
4.9	204
5.2	192
5.5	182
5.8	172
6.1	164
6.4	156
6.7	149
7.0	143
7.3	137
7.6	132
9.1	110
10.7	93
12.2	82
13.7	73
15.2	66
16.8	60
18.3	55

Example – A 4.9m boom uses 27 litres to spray 204m. The output from the boom = 27 x 10
= 270 litres/hectare.

22.2.2 Animal Remedies

The majority of animal remedies are sold in metric measures, and most equipment – such as drenching guns – is graduated in the same way. Non-metric equipment should be recalibrated or replaced with correctly calibrated equipment. Note that 1 cc (now written cm^3) = 1ml.

Various measures you will need to know are:

Quantity	In metric Terms
Volume of doses	millilitres (ml)
Volume of plunge and shower dips	litres (l)

Weight of ingredients and livestock	grams (g) and kilograms (kg)
Pressure	kilopascals (kPa)
Concentration of dips and drenches	grams per litre (g/litre)

If in any doubt about what to do, consult your veterinarian.

22.2.3 Dairying

Dairy companies now measure milk by the litre and farm-separated cream by the kilogram. Payment for milk and cream is based on kilograms of milkfat. Milkfat is shown on advice notes as kilograms per litre (kg/litre) for milk and kilograms per kilogram (kg/kg) for cream. Percentage figures are also used, and are given as % w/v (percent weight by volume) for milk and % w/w (percent weight for weight) for cream.

For example:

4.5 % w/v = 0.045 kg/litre
4.5 % w/w = 0.045 kg/kg

For town milk supply, milk is purchased by the litre.

Temperature for the primary cooling of milk = 18.5°C

Temperature of refrigerated milk = 7° to 13°C

Volume of water needed per set of cups = 10 litres

Minimum distance of dairy from the road = 45m

Minimum clearance of roof above milk vat = 1.0m

Normal milking vacuum = 500 kPa

22.2.4 Fencing

Most fencing equipment has been converted to the nearest metric equivalent, as in the case of fence posts, gates etc. The old 'gauge' measurement of fencing wire has been replaced by mm measures, e.g. No. 8 = 4mm; No.10 = 3.2mm; and No.12½ = 2.4mm. Fencing costs are calculated on a per kilometre basis.

22.2.5 Fertilizers

Fertilizers are sold from the works either in 50 kg bags or by the tonne. Recommendations for application are given in kilograms per hectare or tonnes per hectare. An easily remembered conversion is that 1 hundred-weight per acre (1 cwt/ac.) = 125 kilograms per hectare (125kg/ha).

22.2.6 Grain and Seed

Grain, seeds and produce are measured in kilograms and tonnes. The bushel weight should no longer be used. Where weight for a given volume is required to measure quality, kilograms per hectolitre is used instead of pounds per bushel. One hectolitre equals 100 litres.

Merchants sell grain and seeds in the following metric packs:

Clover, ryegrass, browntop, dogstail, timothy, fescue, brassicas and lucerne	50kg
Cocksfoot and prairie grass	35kg
Field peas	75kg
Garden peas	50kg
M/D seed wheat, seed lupins, tares, ryecorn and maize	75kg
M/D seed barley	70kg
M/D seed oats	60kg
M/D seed beans (small seed)	50kg
(large seed e.g. Scarlet, Broad)	40kg

Sack sizes are measured in millimetres but designated in centimetres. The actual sizes remain unchanged from imperial.

1220 x 670mm (48" x 26½")	122cm sack
1170 x 585mm (45" x 23")	116cm sack
1040 x 585mm (41" x 23")	104cm sack
940 x 585mm (37' x 23")	94cm sack

One bale holds 250 of 116cm, 104cm or 94cm sacks.

Sack capacities are as follows

Perennial ryegrass		122cm sack	45 kg F/D	(5 bu)	
			63.5 kg M/D	(7 bu)	
Italian, Manawa		122cm sack	36 kg F/D	(4 bu)	
			55 kg M/D	(6 bu)	
Cocksfoot		122cm sack	27 kg F/D	(60 lb)	
			45 kg M/D	(100 lb)	
Phalaris	Double	116cm sack	64 kg M/D	(140 lb)	
	Single	116cm	55 kg F/D	120 lb)	
Timothy	Double	116cm sack	64 kg M/D	(140 lb)	
	Single	116cm	45 kg F/D	(100 lb)	
Clover &	Double	116cm sack	73 kg M/D	(160 lb)	
Lucerne	Single	116cm	55 kg F/D	(120 lb)	
Wheat		116cm sack	82 kg F/D	(3 bu)	
Barley		116cm sack	79 kg F/D	(3½ bu)	
Oats		116cm sack	64 kg F/D	(3½ bu)	
Field Peas		116cm sack	82 kg F/D	(3 bu)	
Garden Peas		116cm sack	68 kg F/D	(2½ bu)	
Lupins		116cm sack	82 kg F/D	(3 bu)	
Linseed		116cm sack	76 kg	(1¼ cwt)	
Potatoes		122cm sack	73 kg	(160lb)	14 sacks per tonne

Seed Boxes

A box is deemed to hold 13 sacks of grass seed (roughly 530 kg F/D seed) and/or 18 sacks of grain (roughly 1225 kg F/D)

Most new seed drills are equipped with metric calibration equipment, but conversion kits are available for most recent model drills. Older drills could be converted by an engineer.

22.2.7 Horticulture

Metrication in horticulture is very similar to metrication in the grain and seeds industry. Fruit and vegetable sizing will be in millimetres.

22.2.8 Meat: Sheep and Cattle

Meat grades are determined on kilograms liveweight. These weights are recorded to the nearest 0.5 kg, with cut-off points at 0.25 kg. For details of the meat grading system, refer to Sections 2 and 4 in this volume.

22.3 METRIC & IMPERIAL CONVERSIONS

22.3.1 Area

Metric to Imperial

1 cm^2	= 0.155 square inch
1 m^2	= 10.76 square feet
1 m^2	= 1.196 square yards
1 m^2	= 0.039 54 perch
1 ha	= 2.471 acres
1 km^2	= 0.386 1 square mile
(1 km^2 =	100ha. 1 ha = 10 000 m^2)

Imperial to Metric

1 square inch	= 6.452 cm^2
1 square foot	= 0.092 90 m^2
1 square yard	= 0.836 1 m^2
1 perch	= 25.29 m^2
1 acre	= 0.404 7 ha
1 square mile	= 2.590 km^2

Quick Conversions:

square inches x 20/3 = cm^2
square yards x 5/6 = m^2
perches x 25 = m^2
acres x 4/10 = ha
square miles x 5/2 = km^2

22.3.2 Density

Metric to Imperial

1 g/cm²	= 0.036 13 pound/cu.inch
1 g/cm²	= 62.43 pound/cu.foot
1 kg/m³	= 0.062 43 pound/cu. foot
1 g/litre	= 0.160 4 ounce/gallon
1 g/litre	= 0.010 02 pound/gallon

Imperial to Metric

1 pound/cu.inch	= 27.68 g/cm³
1 pound/cu.foot	= 0.016 02 g/cm³
1 pound/cu.foot	= 16.02 kg/m³
1 ounce/gallon	= 6.236 g/litre
1 pound/gallon	= 99.78 g/litre

Quick Conversions:

pounds per cubic foot x 16 = kg/m³
ounces per gallon x 6 = g/litre
pounds per gallon x 100 = g/litre

22.3.3 Energy

Metric to Imperial

1 kJ/kg	= 0.108 3 kilocalorie/pound
1 kJ	= 0.238 8 kilocalorie
1 kJ	= 0.948 Btu
1 kW	= 1.341 horsepower
1 MJ	= 9.48 x 10^{-3} therm

Imperial to Metric

1 kilocalorie/pound	= 9.230 kJ/kg
1 kilocalorie	= 4.187 kJ
1 Btu	= 1.06 kJ
1 horsepower	= 0.745 7 kW
1 therm	= 106 MJ

Quick Conversions:

kilocalories x 4 = kJ
horsepower x 3/4 = kW

Note: the watt is the power used when work is done or energy expended at the rate of one joule per second.

22.3.4 Length

Metric to Imperial

1mm	= 0.039 37 inch
1 cm	= 0.393 7 inch
1 m	= 3.281 feet
1 m	= 1.094 yards
1 m	= 0.049 71 chain
1 m	= 0.004 971 furlong
1 km	= 0.621 4 mile

Imperial to Metric

1 inch	= 25.4mm
1 inch	= 2.54 cm
1 foot	= 0.304 8 m
1 yard	= 0.914 4 m
1 chain	= 20.12 m
1 furlong	= 201.2m
1 mile	= 1.609 km

Quick Conversions:

inches x 10/4 = centimetres
feet x 3/10 = metres
yards x 9/10 = metres
chains x 20 = metres
miles x 8/5 = kilometres

22.3.5 Mass

Metric to Imperial

1 g	= 0.035 27 ounce
1 g	= 0.002 204 pound
1 kg	= 2.204 6 pounds
1 kg	= 0.157 5 stone
1 kg	= 0.019 68 hundred weight
1 t	= 0.984 2 long ton
1 t	= 1.102 3 short tons
(1 t	= 1 000 kg)

Imperial to Metric

1 ounce	= 28.35 g
1 pound	= 453.6 g
1 pound	= 0.453 6 kg
1 stone	= 6.350 4 kg
1 hundredweight	= 50.803 kg
1 long ton	= 1.016 t
1 short ton	= 0.907 2 t

Quick Conversions:

ounces x 30 = g
pounds x 4/9 = kg
hundredweights x 50 = kg
long tons x 1 = t

22.3.6 Mass per Unit Area

Metric to Imperial

1g/m^2	= 0.029 49 ounce/sq.yard
1 g/m^2	= 8.922 pounds/acre
1 kg/ha	= 0.892 2 pound/acre
1 t/ha	= 7.97 hundredweight/acre

Imperial to Metric

1 ounce/sq.yard	= 33.91 g/m^2
1 pounds/acre	= 0.1121 g/m^2
1 pound/acre	= 1.121 kg/ha
1 hundredweight/acre	= 0.125 5 t/ha
1 ton/acre	= 2.5t/ha

Quick Conversions:

ounces per square yard x 100/3 = g/m^2
pounds per acre x 11/100 = g/m^2
pounds per acre x 11/10 = kg/ha
tons per acre x 10/4 = t/ha

22.3.7 Mass per Unit Length

Metric to Imperial

1 kg/m	= 0.056 pound/inch
1 kg/m	= 0.672 pound/foot

Imperial to Metric

1 pound/inch	= 17.86 kg/m
1 pound/foot	= 1.488 kg/m

Quick Conversions:

pounds per foot x 3/2 = kg/m
pounds per inch x 18 = kg/m

22.3.8 Pressure

Metric to Imperial

1 kPa	= 0.145 pound force/sq.inch
1 kPa	= 20.885 pound force/sq.ft
1 kPa	= 0.294 1 inch Mercury

Imperial to Metric

1 pound force/sq.in	= 6.895 kPa
1 pound force/sq.ft	= 0.0479 kPa
1 inch Mercury	= 3.4 kPa

Quick Conversions:

pounds force per square inch x 7 = kPa
inches of Mercury x 3.5 = kPa

Note: **Atmospheric pressure** is given in millibars.

1 millibar (mb) = 0.029 53 barometer inch Mercury
1 bar = 10 kpa
1 pascal = pressure or stress arising when a force of one newton is applied uniformly over an area of one square metre.

22.3.9 Temperature

Temperature is measured in degrees Celsius (°C)

To convert temperatures 9/5 x °C + 32 = °Farenheit
5/9 x (°F – 32) = °Celcius

22.3.10 Velocity

Metric to Imperial

1 m/s	= 3.281 feet/second
1 m/s	= 2.237 miles/hour
1 km/h	= 0.911 3 foot/second
1 km/h	= 0.621 4 mile/hour

Imperial to Metric

1 foot/second	= 0.304 8 m/s
1 mile/hour	= 0.447 m/s
1 foot/second	= 1.097 3 km/h
1 mile/hour	= 1.609 km/h

Quick Conversions:

feet per second x 3/10 = m/s
miles per hour x 8/5 = km/h

22.3.11 Volume

Metric to Imperial		Imperial to Metric	
1 cm^3	= 0.061 cubic inches	1 cubic inch	= 16.387 cm^3
1 m^3	= 35.32 cubic foot	1 cubic foot	= 0.028 32 m^3
1 m^3	= 1.308 cubic yards	1 cubic yard	= 0.764 6 m^3
1 ml	= 0.035 2 fluid ounces	1 fluid ounce	= 28.41 ml
1 litre	= 1.760 pints	1 pint	= 0.568 3 litre
1 litre	= 0.220 gallon	1 gallon	= 4.546 litres
1 litre	= 0.035 31 cubic feet	1 cubic foot	= 28.3167 litres

Quick Conversions:

cubic inches x 16 = cm^3
cubic inches x 16 = cm^3
cubic feet x 3/100 = m^3
cubic yards x 3/4 = m^3

fluid ounces x 30 = ml
pints x 6/10 = litre
gallons x 9/2 = litre

22.3.12 Volume per Unit Area

Metric to Imperial		Imperial to Metric	
1 millilitre/ha	= 0.014 2 fluid ounce/acre	1 fluid ounce/acre	= 70.2 millilitres/ha
1 litre/ha	= 0.7121 pint/acre	1 pint/acre	= 1.404 litres/ha
1 litre/ha	= 0.089 02 gallon/acre	1 gallon/acre	= 11.23 litres/ha

Quick Conversions:

pints per acre x1.4 = litres per hectare
gallons per acre x 11 = litres per hectare

22.3.13 Volume per Unit Time (Volume rate of flow)

Metric to Imperial		Imperial to Metric	
1 m^3/s	= 35.31 cubic feet/second	1 cubic foot/second	= 0.028 32 m^3/s
1 m^3/h	= 0.009 810 cubic foot/sec.	1 cubic foot/sec.	= 101.0 m^3/h
1 m^3/h	= 219.97 gallons/hour	1 gallon/hour	= 0.004 546 m^3/h
1 litre/s	= 0.035 31 cubic foot/second	1 cubic foot/second	= 28.32 litres/s
1 litre/h	= 0.003 666 gallon/minute	1 gallon/minute	= 272.8 litres/h
1 litre/h	= 0.220 gallon/hour	1 gallon/hour	= 4.546 litres/h

Quick Conversions:

gallons per hour x 9/2000 = m^3/h
gallons per minute x 3/11 = m^3/h
gallons per hour x 9/2 = litres/h

cusecs x 30 = litres/s
(1 **cumec** = 1 cubic metre per second)

22.4 MISCELLANEOUS MEASURES

22.4.1 Cost Conversions

Cost per kilogram	= Cost per pound x 2.2
Cost per kilogram	= cost per hundredweight/50
Cost per tonne	= cost per ton x 1
Cost per litre	= cost per gallon/4.5
Cost per hectare	= cost per acre x 2.5
Cost per metre	= cost per yard x 1.1
Cost per metre	= cost per chain/20
Cost per kilometre	= cost per mile/1.6

22.4.2 Crop Yields

Yield tonnes/ha	Wheat Peas Ryecorn Lupins Clovers Lucerne Beans 60 lb/bus 36.7 bus/t 27.2 kg/bus	Linseed Maize 56 lb/bus 39.4 bus/t 25.4 kg/bus	Barley 50 lb/bus 44 bus/t 22.7 kg/bus	Oats 40 lb/bus 55 bus/t 18.1 kg/bus	Ryegrasses Grass seed 20 lb/bus 110 bus/t 9.1 kg/bus
	bus/ac	bus/ac	bus/ac	bus/ac	bus/ac
6	89.3	95.6	107.1	133.9	267.7
5.5	81.8	87.6	98.2	122.7	245.4
5.0	74.4	79.7	89.3	111.6	223.1
4.5	67.0	71.7	80.3	100.4	200.8
4.0	59.5	63.7	71.4	89.2	178.5
3.5	52.1	55.7	62.5	78.1	156.2
3.0	44.6	47.8	53.6	66.9	133.8
2.5	37.2	39.8	44.6	55.8	111.5
2.0	29.8	31.8	35.7	44.6	89.2
1.5	22.3	23.9	26.8	33.5	66.9
1	14.8	15.9	17.8	22.3	44.6

Examples:

1) Wheat, std bushel wgt = 60 lb/bus = 36.7 bus/t = 27.2 kg. A crop yielding 3.5 t/ha = 52.1 bus/ac

2) Lucerne, std bushel wgt = 60 lb/bus = 36.7 bus/t = 27.2 kg. A crop yielding 3.0 t/ha = 44.6 bus/ac

3) Barley, std bushel wgt = 50 lb/bus = 22.7 kg/bus. A crop yeilding 4.5 t/ha = 80.3 bus/ac

22.4.3 Distance

1 international nautical mile = 1 852 m

22.4.4 Rainfall

10 points	= 2.54 mm
1 inch	= 25.4 mm

Note: Rainfall is now measured in millimetres.

22.4.5 Temperature

Freezing point	= 0°C
Blood Heat	= 36.6°C
Cold Water (tap)	= 10°C
Warm water	= 50°C
Hot water	= 70°C
Boiling water	= 100°C
Absolute temperature (°K)	= °C + 273.16

22.4.6 Velocity

1 knot = 1 nautical mile per hour = 0.514 m/s

22.4.7 Volume

1 teaspoonful	= 3.5 ml
1 dessertspoonful	= 7 ml
1 tablespoonful	= 14 ml
1 milk bottle	= 600 ml
1 large milk bottle	= 740 ml
5 gallon drum	= 22 litres
44 gallon drum	= 200 litres

22.4.8 Volume per unit Area

1 pound per acre	= 1.1 kg/ha
1 hundredweight per acre	= 125 kg/ha
1 ton per acre	= 2.5 t/ha

22.4.9 Application rate conversion chart

KNOWN

WANT TO KNOW	KG AI PER HA	LB AI PER ACRE	LT PER HA	PT PER ACRE	KG PER HA	LB PER ACRE	FL OZ PER ACRE	ML PER HA
KG AI PER HA		x 1.12	x $\frac{\%AI}{100}$	x $\frac{1.4 \times \%AI}{100}$	x $\frac{\%AI}{100}$	x $\frac{\%AI}{0.89 \times 100}$	x $\frac{1.4 \times AI}{2000}$	x $\frac{\%AI}{10000}$
LB AI PER ACRE	x 0.89		x $\frac{0.89 \times \%AI}{100}$	x $\frac{\%AI}{80}$	x $\frac{\%AI}{1.12 \times 100}$	x $\frac{\%AI}{100}$	x $\frac{\%AI}{1600}$	$\frac{0.89 \times \%AI}{100000}$
LITRES PER HA	x $\frac{100}{\%AI}$	x $\frac{1.12 \times 100}{\%AI}$		x1.4	x 1	x 1.12	x .07	$\frac{1}{1000}$
PINTS PER ACRE	x $\frac{100}{1.4 \times \%AI}$	x $\frac{80}{\%AI}$	x 0.7		X 0.7	x 0.8	x 0.5	$\frac{0.7}{1000}$
LB PER ACRE	x $\frac{0.89 \times 100}{\%AI}$	x $\frac{100}{\%AI}$	x 0.89	x 1.25	x 0.89			
KG PER HA	$\frac{100}{\%AI}$	x $\frac{1.2 \times 100}{\%AI}$	x 1	x 1.4		x 1.2		
FL OZ PER ACRE	x $\frac{2000}{1.4\%AI}$	x $\frac{1600}{\%AI}$	x 14	x20				x $\frac{14}{1000}$
ML PER HA	x $\frac{100000}{\%AI}$	x $\frac{112000}{\%AI}$	x 1000	x 1400			x 70	

SECTION 23

ELECTRICITY

23. ELECTRICITY

23.1 DEFINITION OF ELECTRICAL TERMS.

Ampere......... the unit in which the strength of an electrical current is measured.

Ohm............ the unit in which resistance to the flow of an electric current is measured.

Volt .... the unit of electric 'pressure'. A 'pressure' of 1 volt is required to 'force' a current of 1 amp through a resistance of 1 ohm.

Watt............ the unit of power, or rate of doing work. Watts = Volts x Amperes.

Kilowatt-hour ... for commercial purposes, electrical energy is charged for in units of 1 000 watt-hours, or kilowatt-hours.

$$\text{kWh for D.C. current} = \frac{\text{Volts x Amperes x hours}}{1\,000}$$

$$\text{kWh for A.C. current} = \frac{\text{Volts x Amperes x hours x power factor}}{1\,000}$$

23.2 USEFUL FORMULAE AND EQUIVALENTS.

1 kilowatt = 1 000 watts
= 1.341 Horsepower
= 56.869 British Thermal Units (Btu) per minute.

$$\text{No. of kilowatts to heat water in 1 hour} = \frac{\text{Litres x Temperature rise (°C)}}{\text{8.586 x Efficiency percentage}}$$

NOTE: With water at an average tap temperature of 10°C, 1 kW will boil 9.54 litres/hour at 100% efficiency.

1 kilowatt-hour = 3 412 Btu

1 Btu = heat required to raise 1 pound of water by 1° Farenheit

1 calorie = heat required to raise 1 gram of water by 1° Celsius

1 Therm = 29.34 kW/hour
= 100 000 Btu

1 Horsepower = 745.7 watts
= 42.407 Btu/minute

NOTE: The reader should be aware that the above mentioned Imperial units, e.g. Btu, horsepower, Farenheit, etc. have been disregarded in New Zealand, and that it is advisable to think and work in metric units, to avoid possible complications when trying to convert metric back to Imperial units.

23.3 ELECTRICITY CONSUMPTION – UNIT PERFORMANCE DATA.

Note: Such data can be used only as a guide, as actual electricity consumption will vary considerably throughout the year according to scale of production, air temperature and other factors.

23.3.1 Dairy:

Application	Description & Type	Herd Size	Motor Rating	Unit Performance	Average kWh Consumption per Annum
Milk Cooler (Water)	400 l/hr (2 can) 20m centrifugal pump	30–100	0.20 kW	–	40
	500 l/hr (3 can)	Over 100	0.20 kW	–	50
Milking Machine	Required pump capacity – l/min				
2 single units	350–450	10– 30	0.75 kW	15–25 kWh per cow per 10–month lactation	400–600
3 single units	450–500	30– 40	0.75 kW	15–25 kWh per cow per 10–month lactation	600–800
4 single or 2 double	500–600	40– 60	0.75 kW	15–25 kWh per cow per 10–month lactation	800–1 000
6 single or 3 double	650–750	60– 80	1.00 kW	15–25 kWh per cow per 10–month lactation	1000–1200
8 single or 4 double	750–900	80–100	1.50 kW	15–25 kWh per cow per 10–month lactation	1400–1600
10 single or 5 double	900–1 000	100 +	1.50 kW	15–25 kWh per cow per 10–month lactation	1600–1800
Water Heater	80 l storage (65 l draw-off)	30 (20–40)	1 000 watt	60 kWh/cow/annum (700 l hot water/cow/ annum)	1 800 40 kWh/450 l (65°C)
	100 l storage (80 l draw-off)	60 (over 40)	1 200 watt	60 kWh/cow/annum (700 l hot water/cow/ annum)	3 600 (65°C)

23.3.2 General:

Application	Description & Type	Rating of Motor	Average kWh Consumption per annum	Unit Performance
Air Compressor	0.09m³/min. 165 kg/cm²	0.35 kW	Variable	0.50 kWh per hr.
Battery Charger	Electric fence	100 watts	30	1.00 kWh per charge
Chaff Cutter	2–blade–heavy type	2.25 kW	360	3.00 kWh per tonne
	3–blade–heavy type	3.75 kW	300	2.00 kWh per tonne
Drill (portable)	6 mm drill (170 watts)	0.20 kW	Variable	0.20 kWh per hour
Emery wheel grinder	150–200 mm wheel	0.35 kW	10	0.25 kWh per hour
Grindstone	550–750 mm	0.20 kW	10	0.25 kWh per hour
House (average farm)	Lighting, minor appliances, refrigerator and hot water service	–	6 000	–
Irrigation–Pumps		0.2–3.75 kW	–	2 700–6 000 l/kWh (depending on total head)
15 m vertical head	27 300 l/hr	3.75 kW	6 000	0.50 kWh/4 550 l
30 m vertical head	35 400 l/hr	5.60 kW	7 000	0.75 kWh/4 550 l
30 m vertical head	54 500 l/hr	7.45 kW	8 000	1–1.5 kWh/4 550 l
100 m (sprays) (25 m head)	27 200 l/hr	3.75 kW	6 000	20 kWh/cm/hectare
100 m (sprays) (45 m head)	27 300 l/hr	7.45 kW	10 000	30 kWh/cm/hectare
Saw bench (wood)	600 mm Saw	3.75 kW	150 kWh	5 kWh per tonne
Sheep shearing	–	0.05–0.35 kW	–	–
Soldering iron	25 mm diameter bit	180 watts	Variable	0.2 kWh per hour
Water Supply	Pressure system 1 150 l/hr	0.2–0.35 kW	50 kWh per annum	1 kWh per 4 550 l
Water Supply	Overhead tank system 2 250 l/hr	0.2 kWh	50 kWh per annum	0.5 kWh per 4 550 l

SECTION 24

METEOROLOGICAL DATA

24. METEOROLOGICAL DATA

24.1 ANNUAL RAINFALL

The following table is a summary of rainfall from April 1974 to March 1978 gathered from main centres throughout the North and South Islands.

	Rainfall in mm				
District	1974/75	1975/76	1976/77	1977/78	Normal
Whangarei	1495	1921	1754	1172	1492
Hamilton	1179	1295	1388	1153	1197
Taumaranui	1696	1628	1503	1388	1432
Gisborne	1456	1014	1171	1406	1034
Napier	1087	1038	777	951	780
Waipukurau	1144	892	843	899	839
Palmerston North	1080	1062	1152	778	1002
Masterton	1257	1054	1137	1092	964
Blenheim	827	706	732	587	664
Christchurch	940	794	727	806	632
Highbank	1203	992	897	868	985
Ashburton	989	738	683	679	776
Taieri	787	574	751	734	687
Gore	825	938	857	858	841
Invercargill	859	1058	996	1083	1044

Source: New Zealand Meteorological Service.

24.2 WEATHER FORECASTING

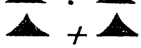
24.2.1 Symbols

The following symbols are employed for marking the positions of fronts and allied phenomena on charts. This is a monochromatic method of representation:-

 Cold front at the surface

 Cold front above the surface

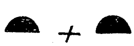
 Cold front - frontogenesis

 Cold front - frontolysis

 Warm front at the surface

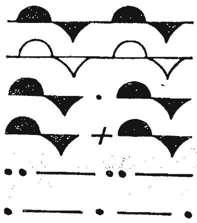
 Warm front above the surface

 Warm front - frontogenesis

 Warm front - frontolysis

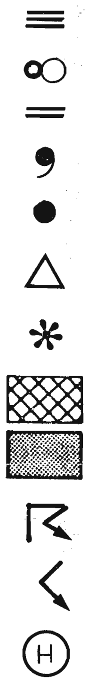
 Occluded front at the surface

 Occluded front above the surface

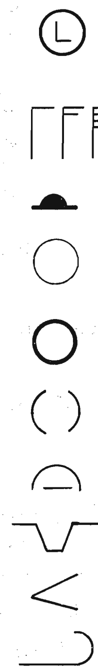


Quasi - stationary front at the surface
Quasi - stationary front above the surface
Quasi - stationary front - frontogenesis
Quasis - stationary front - frontolysis
Instability line
Shear line

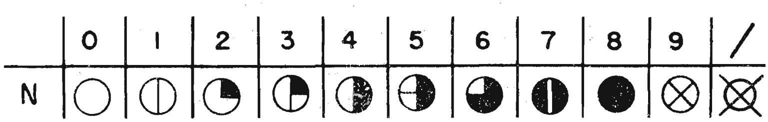
"At the surface" - intersection of the front with the surface, depicted by the chart.
"Above the surface" - implies the vertical projection of a frontal intersection at a higher level on to the surface depicted by the chart.



Fog
haze
mist
drizzle
rain
hail
snow
continuos Precipitation
thunderstorms
lightning
High pressure Anticyclone

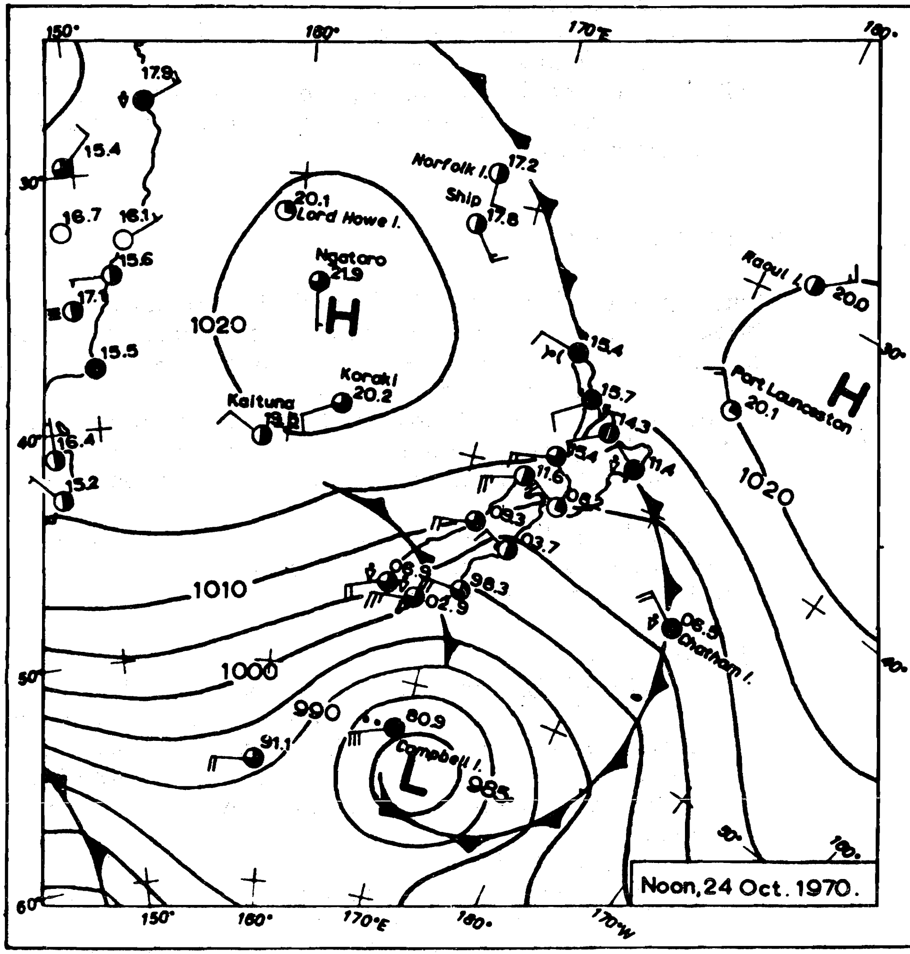


low pressure - cyclone. depression,
various strength winds
dew
clear sky
calm
visibility, exceptional
cumulus cloud
stratus
alto stratus
cirrus



N = the fraction of the cellestial dome covered by cloud.

24.2.2 Example of a Weather Map



An abbreviated form of plotting. At each situation:-

(i) The arrow indicates the direction of the wind, number of barbs the speed. Each barb is equivalent to 10 knots.

(ii) The amount of cloud is shown by the proportion of the station circle (blacked in).

(iii) Full lines are isobars and labelled with sea level pressures e.g. 1020, sea-level pressure = 1020 millibars.

(iv) Anticyclone over Tasman sea, light winds blowing in counter-clockwise direction. A second anticyclone lies northeast of the North Island.

(v) A deep depression is centred near Campbell Island, with closely packed isobars and strong winds blowing in a cockwise direction aound it.
(vi) A cold front is moving across Chatham Island and over the North Island with showers.
(vii) A minor cold front in the west - southwest airflow is moving over the southern parts of the South Island with showery weather.

24.2.3 Surface Charts

One of the important steps in the analysis, consists of drawing isobars, lines along which the atomospheric pressure (corrected to sea-level) has the same value. On large area charts, they are drawn at intervals of 5 millibars.

Meteorologists have discovered that the wind blows along isobars with a speed depending on how closely they are spaced. Isobars, close together shows a strong wind, wide apart, a light wind.

A westerly wind means lower pressure to the south, while an easterly wind means lower pressure to the north.
Four important features:-

(i) Anticyclone
A region of high pressure. In New Zealand wind blows in a counter-clockwise direction around an anticyclone. The central region is an area of light variable winds, usually accompanied by a spell of fine weather or cloudiness, scattered drizzle or fog. Normally moving from West to East.
(ii) Depressions & Fronts
A depression is a region of low pressure, a cyclone. The winds blow in a clockwise direction and are often strong. In New Zealand, regional depressions generally move towards the southeast or east. Rain is usually concentrated in quite distinct parts of a depression. Many depressions are composed of two distinct airmasses, one warm and the other cold. The boundaries between these are fronts. A line along which warm air is advancing and displacing cold air is a warm front, and vice-versa. Most of the cloud and precipitation in a depression is concentrated on the fronts. Their passage is often marked by a clearance or change in weather and wind direction. Often in a deep depression, a cold front may overtake a warm front, forming a single front, called an occlusion.

(iii) Troughs of low pressure

Sometimes an area of low pressure in an elongated form extends across the chart as a narrow region, along which atomospheric pressure is lower than directly on either side. This is known as a trough of low pressure. It often extends from the southeast towards the northwest. As the depression passes south of New Zealand, the trough moves from the southwest to northeast across the country. An anticyclone is usually located on either side of the trough. Within the trough, there is often a cold front, preceded by northwest winds and a belt of cloud and rain, followed by southwest winds, lower temperatures and showers.

(iv) Ridges of high Pressure

Between two depressions or troughs of low pressure, there often is a ridge of high pressure. An elongated area, the same as the trough, except that atmospheric pressure is higher than in the immediate vicinity on either side. This is generally accompanied by a brief period of fine weather, similar to an anticyclone.

24.2.4 Prognostic Charts and Forecasting.

Analysis of the current weather situation is a necessary prerequisite to forecasting. The first step is the construction of a "progrostic chart" for 24 hours after the latest analysis. The future locations of anticyclones, depressions, troughs, ridges and fronts are decided by the meteorologist from weather pattern trends over the last few hours and days. Locations of "jetstreams" (ribbons of very strong wind at altitudes of 9-12 km), temperature changes, land masses and cold or warm oceans are also noted. Atmospheric conditions are very complicated, and weather forecasting can never be simple. Patterns of flow, fronts and their associated weather are always changing.

Topography has a strong influence resulting in cloud and heavier rain on the windward side of mountain ranges, and dry weather on the lee-side.

An over estimate of cloud or wind at night, may lead to fog or frost being omitted from the forecast.

Reference: N.Z. Meteorological Service, Misc. Pub. 138.

24.3 SUMMARIES OF CLIMATOLOGICAL OBSERVATIONS AT NEW ZEALAND STATIONS TO 1970.

24.3.1 Introduction

This section contains summaries of the climatological observations made at stations administered by the New Zealand Meteorological Service in New Zealand,

In most cases the tables are based on observations made once a day. The observation hour since 1 January 1950 in New Zealand has normally been 0900 hours New Zealand Standard Time (NZST) but prior to this was 0930 hours NZST. Any deviations from these times are noted in the tables. NZST is 12 hours ahead of GMT.

The summaries relate to the present sites of most currently operating stations. Unless the tables specify otherwise, site changes involving little if any discontinuity are ignored in compiling the data. When for a particular station sites not strictly comparable have been used, the data for the extremes of temperature, rainfall and sunshine are usually taken from observations made at all sites.

24.3.2 Notes on the Tables

(i) Station Details

The latitude and longitude of each station are given in degrees and minutes and the height in metres.

The code number listed before each station name is allocated by the New Zealand Meteorological Service for its own purposes.

(ii) Rainfall

The standard New Zealand Meteorological Service rain-gauge has a funnel diameter of 12.7 cm and is installed with the rim 30 cm above ground. Rainfall is measured to 0.1 mm.

Highest monthly annual total: The highest rainfall recorded during the period indicated.

Normal: The normal refers to the standard 30 year period 1941–70, and is the average rainfall over this period. At many stations the observations are not complete over this period and the normal is obtained by adjusting the actual rainfall recorded to the standard 1941–70 period. This is done by comparing the actual rainfall at the station with the rainfall at nearby stations for which a true 1941–70 normal is available. The normal rainfalls are adjusted for changes in the observation site (where applicable) and relate to the current observation site.

Lowest monthly/annual total: The lowest rainfall recorded during the period indicated.

Average number of days with rain: The average number of days (0900 hours NZST to 0900 hours NZST) during which at least 1.0mm of rain was recorded.

Maximum 1-day rainfall: The highest rainfall recorded in the 24 hours ending at 0900 hours NZST during the period indicated.

(iii) Water Balance

The data on water balance are based on the relationship between the estimated daily potential evapotranspiration (assessed from the mean monthly evapotranspiration) and the daily rainfall, assuming that the soil is capable of holding a maximum of 75 mm of water.

Average runoff: Runoff occurs when the rainfall less the potential evapotranspiration exceeds the moisture capacity of the soil which is assumed to be not more than 75 mm. The average runoff during the period indicated is the average runoff per month or year, after allowance is made for the soil moisture capacity of 75 mm.

Average deficit: A deficit occurs when the combined rainfall and available soil moisture is less than the potential evapotranspiration. The average deficit during the period indicated is the average deficit per month or year after allowance has been made for the available soil moisture.

(iv) Temperatures

Dry and wet bulb, maximum and minimum thermometers are exposed in screens 1.3 metres above the grassed surface. The thermometers used are mainly of the sheathed pattern.

Highest maximum: The highest temperature recorded during the period indicated.

Mean monthly/annual maximum: The average of the highest temperature recorded in each month or year during the period indicated.

Mean daily maximum: The average of the highest temperature recorded each day during the period indicated. This is approximately the average early afternoon temperature.

Normal: The normal refers to the standard 30 year period 1931–60, and is obtained by averaging the mean daily maximum and mean daily minimum temperatures for this period. At many stations the observations started after 1931, and in these cases the normal is obtained by adjusting the actual temperatures to the standard 1931–60 period. This is done by comparing the actual temperature with the temperature at nearby stations for which a true 1931–60 normal is available. The normal temperatures are adjusted for changes in the observation site (where applicable) and relate to the current observation site. The normal temperatures given here are slightly different from those which would be obtained using hourly observations over the 24 hour day. Such temperatures are available on request.

Mean daily minimum: The average of the lowest temperature recorded each day during the period indicated. This is approximately the average early-morning temperature.

Mean monthly/annual minimum: The average of the lowest temperatures recorded in each month or year during the period indicated.

Lowest minimum: The lowest temperature recorded during the period indicated.

Mean daily grass minimum: The average of the lowest grass temperatures recorded each day during the period indicated
temperatures recorded each day during the period indicated.
The grass minimum thermometer is exposed horizontally 2.5 cm above a level grass surface.

(v) **Days with Frost**

Ground frost: Data on ground frost are obtained from the readings of grass minimum thermometers which are exposed horizontally 2.5 cm above a level grass surface. A day with ground frost occurs when the grass minimum temperature is -1.0°C or lower. The data given are the average number of days with ground frost in a month or year, during the period indicated.

Frost in screen: A day with screen frost occurs when the temperature in the screen (1.3 metres above a grassed surface) is below 0°C. The data given are the average number of days with screen frost in a month or year, during the period indicated.

(vi) **Earth Temperature**

Earth temperatures are measured at 0900 hours NZST. Bent-stem thermometers with the bulbs sunk into bare soil are used at depths of 0.10 and 0.20 metres. At depths of 0.30 and 0.91 metres lagged thermometers are used, these being suspended inside steel tubes sunk into the ground. At shallow depths the 0900 hours earth temperature is close to the minimum earth temperature for the day, but at depths of 0.30 metres or more the diurnal range is negligible, and such earth temperatures at 0900 hours are close to the mean daily earth temperatures at these depths. The data give the average 0900 hours earth temperature for various depths during the period indicated.

(vii) **Relative Humidity**

The average relative humidity at 0900 hours NZST is calculated from the average dry and wet bulb temperature observations made at 0900 hours. At the stations equipped with hygrographs a mean relative humidity over 24 hours is also given. This is found by averaging the value for each hour scaled from the hygrograph charts. The data given are over the period indicated.

(vii) **Vapour Pressure**

The vapour pressure is a measure of the water vapour content of the air. The average vapour pressure at 0900 hours NZST is calculated from the average dry bulb temperature observations made at 0900 hours and the average relative humidity calculated (as above) for 0900 hours. The data given are averages over the period indicated.

Note: Water vapour, like other gases, exerts a pressure, which is called a vapour pressure. Near the ground water vapour can exert a pressure of about 5 to 30 millibars and in New Zealand average vapour pressures vary from about 7 millibars to 18 millibars. The relative humidity at a specific time may be expressed as the actual vapour pressure at that time divided by the vapour pressure necessary for saturation.

(ix) **Sunshine**

The duration of "bright sunshine" is given for stations equipped with Campbell-Stokes pattern sunshine recorders.

Owing to topographical features there are few stations at which all possible sunshine would be recorded.

Highest: The highest duration of bright sunshine for the month or year during the period indicated.

Average: The average duration of bright sunshine for the month or year during the period indicated.

% of possible: The highest/average/lowest duration of bright sunshine expressed as a percentage of the total possible bright sunshine, i.e. the astronomically possible sunshine, less half an hour for each day.

Lowest: The lowest duration of bright sunshine for the months or years during the period indicated.

(x) Wind

The daily wind run in km per day is given for those stations equipped with a Robinson Cup anemometer, the cups of which are usually exposed 6 metres above the ground. For an open exposure the wind run recorded at 6 metres is approximately 10 percent less than the wind run at 10 metres.

Wind gusts: At stations equipped with Dines or Munro recording anemometers, detailed information about fluctuations in wind speed and direction are available. From these records are given the average number of days in the month or year with gusts of 34 knots or more, and 52 knots or more.

(xi) Special Phenomena

The frequency of special phenomena is given as the average number of days per month or year on which they are observed.

Note: It is difficult to obtain reliable data on some special phenomena because some observers fail to record all occurrences especially when they happen at night. The data should therefore be treated with caution. Data given are the **average number of days** per month or year, over the period indicated, of **snow, hail and thunder.**

159234 ALEXANDRA — LAT. 45 16S LONG. 169 23E HT. 141 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1922-1970*	96	137	103	90	68	55	57	53	63	93	96	70	496
NORMAL	1941-1970	46	38	38	28	28	20	15	15	20	28	33	30	339
LOWEST MONTHLY/ANNUAL TOTAL	1922-1970*	8	2	2	5	2	2	1	0	3	1	5	1	211
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1928-1970	6	5	6	6	5	5	4	4	4	5	6	6	64
MAXIMUM 1-DAY RAINFALL MM.	1928-1970	58	45	36	39	26	28	20	20	34	50	41	35	58
ESTIMATED WATER BALANCE														
AVERAGE DEFICIT (MM)	1929-1970	53	53	38	15	5	.	.	.	5	13	41	66	289
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1928-1970	37.2	33.7	32.1	27.7	23.1	19.8	19.9	20.3	22.6	27.8	31.7	33.4	37.2
MEAN MONTHLY/ANNUAL MAXIMUM	1928-1970	31.2	30.3	28.4	23.7	19.1	15.1	14.8	16.9	20.6	24.3	27.1	29.5	32.0
MEAN DAILY MAXIMUM	1929-1970	23.1	23.0	20.8	16.7	11.6	7.9	7.2	11.1	14.8	17.8	19.9	22.1	16.3
NORMAL	1931-1960	16.9	16.7	14.4	10.8	6.2	3.3	2.4	5.3	8.7	11.6	13.8	15.9	10.5
MEAN DAILY MINIMUM	1929-1970	10.7	10.3	8.2	4.7	0.8	-1.3	-2.2	-0.6	2.4	5.3	7.5	9.8	4.6
MEAN MONTHLY/ANNUAL MINIMUM	1929-1970	4.4	3.8	1.7	-1.6	-5.2	-6.2	-7.2	-5.0	-3.2	-0.8	0.9	3.4	-7.7
LOWEST MINIMUM	1929-1970	1.4	0.7	-0.8	-4.6	-7.1	-10.0	-11.7	-8.4	-5.6	-3.4	-1.8	0.6	-11.7
MEAN DAILY RANGE	1929-1970	12.4	12.7	12.6	12.0	10.8	9.2	9.4	11.7	12.4	12.5	12.4	12.3	11.7
MEAN DAILY GRASS MINIMUM	1929-1970	6.9	6.6	4.4	1.0	-2.6	-4.1	-5.0	-4.0	-1.8	0.9	3.2	6.1	1.0
DAYS WITH FROST														
GROUND FROST AVERAGE	1963-1970	1.0	2.4	2.3	11.6	15.6	25.1	27.3	25.0	17.4	10.6	6.1	2.5	146.9
FROST IN SCREEN AVERAGE	1963-1970	.	.	.	2.0	10.1	21.3	25.1	15.4	5.2	1.6	0.4	.	81.1
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1963-1970	16.3	15.4	13.1	8.6	4.7	1.9	1.3	2.7	5.9	9.5	12.6	15.7	9.0
AVERAGE AT 0.30 METRES	1963-1970	17.5	17.6	15.6	11.8	7.4	4.2	3.1	4.8	7.9	11.2	13.7	16.4	10.9
AVERAGE AT 0.91 METRES	1963-1970	16.4	17.0	16.2	13.9	10.6	7.5	5.7	6.1	7.9	10.4	12.8	15.1	11.6
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1963-1970	63	66	74	78	85	90	91	84	73	62	57	59	74
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1963-1970	11.1	11.1	10.6	9.0	6.8	6.0	5.5	6.1	7.2	8.2	9.2	10.7	8.5
SUNSHINE. HOURS														
HIGHEST	1935-1970	284	246	232	198	188	131	141	185	208	254	287	294	2343
AVERAGE	1935-1970	232	200	192	154	123	99	107	151	172	206	210	227	2073
% OF POSSIBLE	1935-1970	50	51	51	48	43	38	39	49	50	51	48	47	48
LOWEST	1935-1970	166	139	146	116	79	54	72	110	122	163	154	162	1862

WIND														
DAILY WIND RUN (KILOMETRES)	1963-1970	169	172	145	116	85	76	63	89	114	185	200	217	136
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1928-1970	.	.	.	.	0.5	1.1	1.4	0.6	0.4	0.3	0.1	.	4.4
AVERAGE NO. OF DAYS WITH HAIL	1928-1970	0.2	0.1	0.1	.	0.1	0.1	.	0.1	0.1	0.2	0.3	.	1.3
AVERAGE NO. OF DAYS WITH THUNDER	1928-1970	0.6	0.5	0.1	0.1	.	.	.	.	.	0.2	0.6	0.5	2.6

* includes observations from rainfall station

H31971 ASHBURTON LAT. 43 54S LONG. 171 45E HT. 101 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1909-1970*	182	255	256	224	248	166	229	204	182	154	257	243	1147
NORMAL	1941-1970	64	66	76	66	71	56	61	61	51	61	69	74	776
LOWEST MONTHLY/ANNUAL TOTAL	1909-1970*	8	3	6	5	8	2	7	9	2	4	16	5	382
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1927-1970	7	7	8	7	8	7	8	7	7	7	8	8	90
MAXIMUM 1-DAY RAINFALL MM.	1927-1970	56	121	105	67	71	61	62	72	59	56	74	66	121
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1927-1970	5	8	10	10	20	30	43	36	23	13	10	10	218
AVERAGE DEFICIT (MM)	1927-1970	33	28	15	10	.	.	.	.	.	.	5	18	109
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1930-1970	38.4	36.4	36.0	30.7	26.2	23.0	21.2	22.3	26.0	29.1	33.8	33.3	38.4
MEAN MONTHLY/ANNUAL MAXIMUM	1930-1970	31.5	31.6	29.2	25.3	21.1	17.3	17.1	19.4	22.4	25.4	27.5	29.5	32.9
MEAN DAILY MAXIMUM	1930-1970	22.4	22.2	20.2	17.0	13.4	10.7	10.1	12.0	14.7	17.4	19.6	21.2	16.7
NORMAL	1931-1960	16.6	16.5	14.7	11.9	8.4	5.9	5.2	6.9	9.3	11.7	13.8	15.4	11.3
MEAN DAILY MINIMUM	1930-1970	10.4	10.4	8.9	6.1	2.9	0.5	-0.2	1.2	3.4	5.6	7.3	9.4	5.5
MEAN MONTHLY/ANNUAL MINIMUM	1930-1970	4.1	3.9	1.8	-0.4	-3.2	-4.7	-5.6	-4.4	-2.2	-0.5	0.9	3.2	-6.0
LOWEST MINIMUM	1930-1970	0.3	-0.4	-0.9	-2.8	-6.0	-7.1	-11.6	-7.8	-4.8	-3.0	-2.6	-1.5	-11.6
MEAN DAILY RANGE	1930-1970	12.0	11.8	11.3	10.9	10.5	10.2	10.3	10.8	11.3	11.8	12.3	11.8	11.2
MEAN DAILY GRASS MINIMUM	1930-1970	7.9	7.7	6.1	3.2	0.2	-2.7	-3.2	-1.8	0.3	2.7	4.8	6.9	2.7
DAYS WITH FROST														
GROUND FROST AVERAGE	1929-1970	0.3	0.5	1.7	6.0	14.3	21.3	22.8	19.1	12.7	6.5	2.6	0.8	108.6
FROST IN SCREEN AVERAGE	1927-1970	.	.	0.1	1.4	7.0	14.6	16.7	11.8	5.3	1.4	0.4	.	58.7
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1951-1970	18.9	17.8	14.7	10.9	6.6	3.4	2.6	4.3	7.7	11.9	15.4	17.8	11.0
AVERAGE AT 0.30 METRES	1951-1970	19.3	18.8	16.4	12.9	8.9	5.8	3.7	6.0	8.8	12.3	15.3	17.8	12.2
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1928-1970	64	68	74	77	79	79	79	74	69	64	61	64	71
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1931-1970	12.5	12.8	12.3	10.6	8.2	6.7	6.4	7.0	8.4	9.5	10.5	11.6	9.7
SUNSHINE. HOURS														
HIGHEST	1935-1970	265	218	243	186	164	168	178	192	230	238	263	254	2039
AVERAGE	1935-1970	200	166	157	140	121	115	124	145	157	182	188	191	1886
% OF POSSIBLE	1935-1970	43	43	41	44	41	44	44	46	45	45	43	40	44
LOWEST	1935-1970	136	107	82	97	85	81	89	81	97	138	111	106	1647

WIND														
AVERAGE NO. OF DAYS WITH														
GUSTS 34 KNOTS OR MORE	1943-1954**	3.8	3.9	3.4	3.4	2.4	4.2	2.9	1.7	3.7	4.9	4.8	3.6	42.7
GUSTS 52 KNOTS OR MORE	1943-1954**	0.1	0.2	0.2	0.3	.	0.2	0.1	0.1	0.3	0.1	0.4	.	2.0
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1929-1970	.	.	.	.	0.1	0.3	0.8	0.4	0.5	0.3	.	.	2.4
AVERAGE NO. OF DAYS WITH HAIL	1929-1970	0.2	0.2	0.1	0.3	0.1	0.1	0.2	0.1	0.2	0.4	0.3	0.2	2.4
AVERAGE NO. OF DAYS WITH THUNDER	1929-1970	0.5	0.3	0.2	0.2	.	.	.	.	0.1	0.2	0.5	0.5	2.5

* includes observations at rainfall station
** refers to observations at Ashburton Aerodrome

G13592 BLENHEIM LAT. 41 31S LONG. 173 57E HT. 4 M.

	Period	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1930-1970*	141	129	108	173	183	155	166	157	192	115	147	123	922
NORMAL	1941-1970	51	43	51	53	76	58	66	61	53	53	48	51	664
LOWEST MONTHLY/ANNUAL TOTAL	1930-1970*	2	2	3	6	13	9	10	5	3	2	5	1	398
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1941-1970**	5	5	6	6	7	7	8	8	7	8	7	7	80
MAXIMUM 1-DAY RAINFALL MM.	1941-1970**	75	76	63	76	95	55	48	76	48	46	44	53	95
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1941-1970**	3	.	.	5	20	25	36	36	15	13	5	3	161
AVERAGE DEFICIT (MM)	1941-1970**	51	38	28	13	3	.	.	.	.	.	10	30	173
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1932-1970**	34.8	33.3	31.9	28.6	24.4	20.8	19.4	19.9	24.0	30.1	29.4	34.2	34.8
MEAN MONTHLY/ANNUAL MAXIMUM	1932-1970**	30.8	29.8	28.2	24.9	20.8	17.8	16.7	18.0	20.9	24.2	26.7	29.0	31.7
MEAN DAILY MAXIMUM	1932-1970**	23.7	23.5	21.8	18.8	15.5	12.9	12.3	13.5	15.8	18.0	20.3	22.4	18.2
NORMAL	1931-1960	17.7	17.8	15.9	13.2	9.9	7.3	6.7	8.1	10.3	12.3	14.4	16.6	12.5
MEAN DAILY MINIMUM	1932-1970**	11.9	12.1	10.3	7.6	4.6	1.8	1.4	2.9	4.9	7.0	8.7	10.9	7.0
MEAN MONTHLY/ANNUAL MINIMUM	1932-1970**	5.4	5.1	3.2	0.8	-1.8	-3.5	-3.3	-2.7	-1.3	0.2	2.1	4.1	-4.1
LOWEST MINIMUM	1932-1970**	2.5	1.7	-1.1	-4.1	-4.9	-8.8	-6.0	-5.2	-4.0	-3.6	-2.9	-0.2	-8.8
MEAN DAILY RANGE	1932-1970**	11.8	11.4	11.5	11.2	10.9	11.1	10.9	10.6	10.9	11.0	11.6	11.5	11.2
MEAN DAILY GRASS MINIMUM	1932-1970**	8.3	8.9	6.9	4.1	1.1	-1.6	-1.9	-0.6	1.3	3.3	5.4	7.5	3.6
DAYS WITH FROST														
GROUND FROST AVERAGE	1947-1970	0.2	0.1	1.0	4.2	11.6	17.6	19.1	15.8	12.6	5.5	1.4	0.5	89.6
FROST IN SCREEN AVERAGE	1947-1970	.	.	0.1	0.3	2.7	9.4	11.4	7.0	2.3	0.5	.	.	33.7
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1948-1970	19.4	18.4	15.6	11.5	7.9	4.8	4.3	5.7	8.6	12.6	16.2	18.6	12.0
AVERAGE AT 0.30 METRES	1948-1970	19.8	19.7	17.7	14.3	10.9	7.9	6.8	8.0	10.3	13.3	16.2	18.4	13.6
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1947-1970	63	65	71	78	82	84	85	81	73	66	62	63	73
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1947-1970	13.8	13.9	13.2	11.4	9.3	7.5	7.3	8.1	9.3	10.6	11.4	13.0	10.7
SUNSHINE. HOURS														
HIGHEST	1935-1970**	335	298	281	239	202	205	231	212	242	300	307	308	2673
AVERAGE	1935-1970**	262	225	215	189	164	155	157	175	197	226	239	245	2449
% OF POSSIBLE	1935-1970**	58	59	57	59	55	57	55	55	57	56	56	53	57
LOWEST	1935-1970**	200	160	147	92	115	104	121	129	131	142	175	196	2241

SPECIAL PHENOMENA

AVERAGE NO. OF DAYS WITH SNOW	1932-1970**	.	.	.	.	.	.	0.1	.	.	.	.	.	0.1
AVERAGE NO. OF DAYS WITH HAIL	1932-1970**	.	.	.	.	.	.	0.1	.	.	.	0.2	0.1	0.4
AVERAGE NO. OF DAYS WITH THUNDER	1932-1970**	0.4	0.5	0.2	0.2	0.2	0.2	.	0.2	0.2	0.2	0.4	0.6	3.3

* includes observations from rainfall station
** includes observations at various sites

H32451 CHRISTCHURCH AIRPORT LAT. 43 29S LONG. 172 32E HT. 30 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1943-1970	99	144	147	188	198	168	140	136	123	138	140	148	861
NORMAL	1941-1970	46	45	53	56	81	56	61	53	43	43	43	48	626
LOWEST MONTHLY/ANNUAL TOTAL	1943-1970	8	7	8	13	13	6	5	5	8	3	8	5	382
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1945-1970	6	5	7	6	8	7	8	6	6	6	7	6	81
MAXIMUM 1-DAY RAINFALL MM.	1945-1970	30	31	51	74	62	41	43	51	73	33	35	80	80
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1946-1970	.	.	3	10	20	20	30	23	13	8	3	.	130
AVERAGE DEFICIT (MM)	1946-1970	51	43	25	10	3	.	.	.	.	.	15	36	183
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1953-1970	35.4	34.3	33.3	29.7	26.1	21.7	21.2	22.8	24.8	28.6	32.0	32.6	35.4
MEAN MONTHLY/ANNUAL MAXIMUM	1953-1970	32.3	31.7	29.0	25.7	20.8	17.8	17.2	20.1	21.7	25.3	28.0	29.9	33.1
MEAN DAILY MAXIMUM	1953-1970	22.3	22.0	19.7	17.2	13.6	11.2	10.3	12.1	14.3	17.0	19.5	20.6	16.7
NORMAL	1931-1960	16.2	16.1	14.1	11.6	8.3	5.7	4.9	6.5	8.8	11.0	13.2	15.0	10.9
MEAN DAILY MINIMUM	1953-1970	12.0	11.7	10.3	6.9	4.0	1.1	0.6	1.8	4.0	6.4	8.4	10.7	6.5
MEAN MONTHLY/ANNUAL MINIMUM	1953-1970	5.8	5.8	3.8	0.6	-2.1	-3.8	-4.5	-3.4	-1.8	0.1	2.4	4.9	-4.6
LOWEST MINIMUM	1953-1970	3.1	3.5	-0.1	-2.2	-4.2	-5.2	-6.7	-5.1	-3.7	-4.1	-0.3	2.8	-6.7
MEAN DAILY RANGE	1953-1970	10.3	10.3	9.4	10.3	9.6	10.1	9.7	10.3	10.3	10.6	11.1	9.9	10.2
MEAN DAILY GRASS MINIMUM	1953-1970	9.8	9.7	8.3	4.6	1.9	-1.3	-1.7	-0.6	1.2	3.5	5.4	8.5	4.1
DAYS WITH FROST														
GROUND FROST AVERAGE	1953-1970	.	.	0.6	3.6	8.7	17.5	19.1	15.8	10.1	5.6	2.3	0.3	83.6
FROST IN SCREEN AVERAGE	1953-1970	.	.	0.1	0.3	4.0	12.0	14.3	9.5	3.9	1.1	0.1	.	45.3
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1959-1970	18.1	17.1	14.6	11.0	7.5	4.4	3.9	4.8	7.4	11.0	14.3	17.1	10.9
AVERAGE AT 0.30 METRES	1959-1970	19.2	18.7	16.4	13.2	9.6	6.4	5.4	6.5	8.8	11.9	14.9	17.7	12.4
AVERAGE AT 0.91 METRES	1959-1970	18.0	18.1	16.9	14.6	11.5	8.5	6.9	7.3	8.9	11.3	13.9	16.3	12.7
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1953-1970	68	73	80	81	86	86	87	85	79	71	64	68	77
MEAN OVER 24 HOURS	1960-1969	72	74	78	80	83	83	84	80	78	72	70	73	77
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1953-1970	13.5	13.6	13.1	10.1	8.7	7.0	6.8	7.6	9.0	10.1	10.8	12.3	10.2
SUNSHINE. HOURS														
HIGHEST	1949-1970	288	228	227	192	143	160	172	195	220	236	265	264	2198
AVERAGE	1949-1970	211	180	160	147	121	119	123	150	164	198	206	205	1984
% OF POSSIBLE	1949-1970	46	46	42	46	41	45	44	48	47	49	48	43	46
LOWEST	1949-1970	167	112	92	95	93	83	98	114	90	149	151	124	1846

WIND														
AVERAGE NO. OF DAYS WITH														
GUSTS 34 KNOTS OR MORE	1942-1970	5.7	4.9	4.4	4.1	4.1	3.2	3.2	2.6	4.4	6.0	6.6	5.0	54.2
GUSTS 52 KNOTS OR MORE	1942-1970	0.2	0.2	0.3	0.4	0.2	0.2	0.2	.	0.3	0.4	0.3	0.1	2.8
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1953-1970	.	.	.	.	0.3	0.1	0.6	0.3	0.5	0.2	.	.	2.0
AVERAGE NO. OF DAYS WITH HAIL	1953-1970	0.4	0.2	0.1	0.3	0.3	0.4	0.7	0.3	0.6	0.5	0.4	0.1	4.3
AVERAGE NO. OF DAYS WITH THUNDER	1953-1970	0.4	0.2	0.3	0.1	0.1	0.1	.	.	0.1	0.2	0.5	0.2	2.2

H32412 DARFIELD LAT. 43 29S LONG. 172 8E HT. 195 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL, MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1919-1970	180	242	195	221	336	203	245	228	178	178	178	189	1100
NORMAL	1941-1970	69	66	74	69	81	58	66	64	56	66	69	76	814
LOWEST MONTHLY/ANNUAL TOTAL	1919-1970	17	1	6	6	18	11	12	8	10	5	8	5	499
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1939-1970	8	6	8	7	9	7	8	8	7	8	8	8	93
MAXIMUM 1-DAY RAINFALL MM.	1939-1970	48	84	117	65	88	61	51	56	75	57	45	77	88
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1939-1970	3	8	8	15	33	28	48	43	25	23	13	10	257
AVERAGE DEFICIT (MM)	1939-1970	23	25	13	8	3	.	.	.	.	.	3	13	88
TEMPERATURE, DEGREES CELSIUS														
HIGHEST MAXIMUM	1939-1970	36.3	36.1	33.6	28.4	23.9	19.3	19.9	22.4	25.7	29.1	31.9	33.9	36.3
MEAN MONTHLY/ANNUAL MAXIMUM	1939-1970	31.4	32.0	29.2	24.9	20.2	16.5	16.5	18.6	21.9	25.3	27.6	30.3	32.9
MEAN DAILY MAXIMUM	1939-1970	22.9	22.9	20.5	17.1	13.2	10.4	9.9	11.9	14.9	17.3	19.7	21.5	16.9
NORMAL	1931-1960	16.2	16.2	14.3	11.6	7.9	5.6	4.8	6.4	9.0	11.1	13.1	14.9	10.9
MEAN DAILY MINIMUM	1939-1970	10.0	10.0	8.5	5.8	3.0	0.7	0.1	1.2	3.2	5.2	6.9	8.8	5.3
MEAN MONTHLY/ANNUAL MINIMUM	1939-1970	4.0	3.4	2.0	-0.3	-2.4	-3.7	-4.4	-3.7	-2.1	-0.8	0.5	2.9	-5.0
LOWEST MINIMUM	1939-1970	0.9	-0.4	-0.4	-2.6	-5.3	-7.4	-9.0	-6.1	-4.8	-3.5	-2.6	0.1	-9.0
MEAN DAILY RANGE	1939-1970	12.9	12.9	12.0	11.3	10.2	9.7	9.8	10.7	11.7	12.1	12.8	12.7	11.6
MEAN DAILY GRASS MINIMUM	1944-1970	8.1	8.2	6.4	3.0	0.2	-2.3	-2.9	-2.0	0.2	2.6	4.4	6.7	2.7
DAYS WITH FROST														
GROUND FROST AVERAGE	1944-1970	.	0.1	0.9	5.5	14.0	21.2	22.8	19.1	13.3	6.4	2.9	0.4	106.6
FROST IN SCREEN AVERAGE	1939-1970	.	.	0.1	1.2	5.7	12.8	16.1	11.9	5.1	1.7	0.5	.	55.1
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1939-1970	67	70	78	82	85	84	84	82	77	70	65	66	76
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1939-1970	12.6	12.6	12.2	10.3	8.3	6.8	6.5	7.2	8.4	9.7	10.6	11.9	9.8
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1939-1970	.	.	.	0.1	0.4	0.7	1.3	0.7	0.6	0.5	0.1	.	4.4
AVERAGE NO. OF DAYS WITH HAIL	1939-1970	0.2	0.1	0.1	0.1	0.1	.	0.1	0.1	0.2	0.3	0.2	0.1	1.6
AVERAGE NO. OF DAYS WITH THUNDER	1939-1970	0.4	0.3	0.1	0.1	.	.	.	.	0.1	0.3	0.6	0.5	2.4

A53982 **DARGAVILLE EXP. FARM** LAT. 35 57S LONG. 173 50E HT. 20 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1943-1970*	199	337	231	217	245	285	328	211	153	349	166	233	1790
NORMAL	1941-1970	66	84	79	104	132	150	132	137	97	109	84	79	1253
LOWEST MONTHLY/ANNUAL TOTAL	1943-1970*	4	5	17	30	45	46	43	76	26	26	13	15	911
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1943-1970*	7	7	9	12	16	17	17	17	13	13	10	9	147
MAXIMUM 1-DAY RAINFALL MM.	1943-1970*	49	102	75	82	98	120	92	94	72	205	53	71	205
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1943-1970*	10	20	13	25	79	114	114	91	51	48	20	23	608
AVERAGE DEFICIT (MM)	1943-1970*	25	33	18	3	.	.	.	.	.	.	.	.	79
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1943-1970*	31.8	31.6	32.1	26.7	24.0	21.2	21.1	21.1	21.7	25.6	27.3	28.4	32.1
MEAN MONTHLY/ANNUAL MAXIMUM	1943-1970*	27.8	28.3	26.9	24.4	21.5	19.3	18.4	18.7	19.9	22.0	23.7	25.7	28.9
MEAN DAILY MAXIMUM	1943-1970*	23.3	24.1	22.8	20.3	17.8	15.7	14.9	15.3	16.4	17.8	19.5	21.4	19.1
NORMAL	1931-1960	17.7	18.4	17.3	15.8	13.1	11.1	10.3	10.7	11.9	13.4	15.0	16.9	14.3
MEAN DAILY MINIMUM	1943-1970*	13.6	13.8	12.9	11.1	9.2	7.6	6.2	6.9	8.0	9.7	10.7	12.2	10.2
MEAN MONTHLY/ANNUAL MINIMUM	1943-1970*	7.8	7.6	5.5	3.4	1.4	-0.1	-1.3	-0.5	1.3	3.4	4.9	6.2	-2.2
LOWEST MINIMUM	1943-1970*	4.4	1.7	0.0	0.2	-3.3	-3.3	-5.0	-3.3	-1.9	1.1	2.2	1.2	-5.0
MEAN DAILY RANGE	1943-1970*	9.7	10.3	9.9	9.2	8.6	8.1	8.7	8.4	8.4	8.1	8.8	9.2	8.9
MEAN DAILY GRASS MINIMUM	1943-1970*	10.8	11.2	10.6	8.4	6.5	4.9	3.5	4.2	5.0	6.8	8.2	9.7	7.5
DAYS WITH FROST														
GROUND FROST AVERAGE	1951-1970	.	.	0.1	0.4	0.9	0.3	2.2	4.2	0.4	0.2	0.1	..	8.8
FROST IN SCREEN AVERAGE	1951-1970	.	.	.	.	0.3	0.3	1.0	1.5	0.1	.	.	.	3.2
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1951-1970	20.9	20.6	18.6	15.6	12.9	10.9	9.5	10.3	12.2	14.9	17.7	19.8	15.3
AVERAGE AT 0.30 METRES.	1951-1970	21.2	21.4	19.7	16.9	14.2	12.2	10.8	11.4	13.0	15.2	19.5	21.8	16.4
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1951-1970	76	81	84	86	82	83	82	82	84	80	76	76	81
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1951-1970	17.6	18.8	17.6	15.3	13.2	11.7	10.7	11.3	12.5	13.4	14.7	16.3	14.4
SUNSHINE. HOURS														
HIGHEST	1943-1970*	269	233	216	183	178	136	148	182	169	209	245	254	2181
AVERAGE	1943-1970*	216	191	181	142	125	105	120	142	149	169	203	205	1948
% OF POSSIBLE	1943-1970*	49	51	48	43	40	36	40	43	43	43	49	46	45
LOWEST	1943-1970*	151	119	155	108	86	60	99	118	127	132	163	114	1848

SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH HAIL	1951-1970	.	.	.	.	0.2	0.3	0.4	0.6	0.1	0.2	.	0.1	1.9
AVERAGE NO. OF DAYS WITH THUNDER	1951-1970	0.5	0.5	0.4	0.4	1.2	1.3	0.5	0.5	0.3	0.6	0.8	0.4	7.4

* includes observations at various sites

D87692 GISBORNE AERODROME LAT. 38 40S LONG. 177 59E HT. 4 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1937-1970	233	242	376	283	343	247	321	294	190	238	224	204	1431
NORMAL	1941-1970	74	61	91	91	109	112	112	117	74	71	58	64	1034
LOWEST MONTHLY/ANNUAL TOTAL	1937-1970	4	3	12	8	18	26	19	38	8	20	3	8	717
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1937-1970	7	7	9	10	11	11	12	13	9	9	8	8	113
MAXIMUM 1-DAY RAINFALL MM.	1937-1970	116	152	78	105	113	97	121	113	54	61	104	92	152
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1937-1970	8	8	13	30	56	74	91	86	41	23	13	8	451
AVERAGE DEFICIT (MM)	1937-1970	41	30	15	8	.	.	.	.	.	.	5	28	127
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1937-1970	37.7	35.4	32.8	27.9	24.3	22.6	21.2	22.0	25.4	30.6	32.4	34.5	37.7
MEAN MONTHLY/ANNUAL MAXIMUM	1937-1970	31.3	30.2	28.4	25.4	21.8	19.2	18.6	19.0	21.6	24.7	27.6	29.2	32.4
MEAN DAILY MAXIMUM	1937-1970	24.4	24.3	22.5	19.8	16.9	14.5	13.7	14.5	16.5	18.7	21.1	23.0	19.2
NORMAL	1931-1960	18.3	18.7	16.8	14.6	11.9	9.5	8.9	9.7	11.3	13.2	15.4	17.2	13.8
MEAN DAILY MINIMUM	1937-1970	12.8	13.2	11.7	9.6	7.2	4.9	4.4	5.3	6.5	8.1	9.9	11.7	8.8
MEAN MONTHLY/ANNUAL MINIMUM	1937-1970	6.6	6.7	5.0	3.2	0.9	-1.2	-1.1	-0.4	1.0	2.0	3.5	5.3	-1.9
LOWEST MINIMUM	1937-1970	4.4	3.8	2.1	-0.7	-1.2	-3.3	-3.4	-1.9	-1.9	-0.6	-0.6	3.1	-3.4
MEAN DAILY RANGE	1937-1970	11.6	11.1	10.8	10.2	9.7	9.6	9.3	9.2	10.0	10.6	11.2	11.3	10.4
MEAN DAILY GRASS MINIMUM	1942-1970	10.0	10.4	8.8	6.4	4.3	2.1	1.5	2.1	3.0	4.8	6.7	8.8	5.7
DAYS WITH FROST														
GROUND FROST AVERAGE	1942-1970	0.1	.	0.1	1.2	3.9	8.6	10.2	8.9	6.3	3.3	1.0	0.2	43.8
FROST IN SCREEN AVERAGE	1937-1970	.	.	.	.	0.2	2.2	1.9	1.0	0.2	0.2	.	.	5.7
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1942-1970	20.6	20.0	17.5	13.8	10.5	7.8	7.0	8.1	10.4	13.8	17.1	19.6	13.8
AVERAGE AT 0.30 METRES	1937-1970	21.2	20.9	18.9	15.7	12.4	9.7	8.8	9.6	11.6	14.1	17.1	19.8	15.0
AVERAGE AT 0.91 METRES	1937-1970	19.2	19.8	18.8	16.8	14.3	11.9	10.7	10.8	11.9	13.6	15.6	18.8	15.2
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1937-1970	64	68	73	77	81	81	82	80	74	69	64	64	73
MEAN OVER 24 HOURS	1962-1969	72	74	77	78	81	80	81	78	77	75	70	75	77
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1937-1970	15.3	16.1	15.2	13.4	11.5	9.6	9.2	9.8	10.6	11.8	12.3	14.2	12.4
SUNSHINE. HOURS														
HIGHEST	1937-1970	306	260	298	228	191	190	181	196	218	264	311	327	2439
AVERAGE	1937-1970	249	209	197	163	139	131	131	148	176	207	225	240	2215
% OF POSSIBLE	1937-1970	56	55	52	50	45	47	44	46	51	52	54	53	52
LOWEST	1937-1970	159	146	151	107	59	87	76	91	116	121	158	164	1987

WIND														
DAILY WIND RUN (KILOMETRES)	1945-1970*	249	237	224	212	211	216	216	227	237	251	267	253	233
AVERAGE NO. OF DAYS WITH														
GUSTS 34 KNOTS OR MORE	1942-1970	3.0	2.2	2.8	3.0	4.2	4.6	4.5	4.3	4.7	5.4	6.0	3.6	48.3
GUSTS 52 KNOTS OR MORE	1942-1970	0.1	0.1	.	.	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	1.3
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1937-1970	.	.	.	.	.	.	.	.	.	.	.	.	.
AVERAGE NO. OF DAYS WITH HAIL	1943-1970	.	.	.	.	0.4	0.1	0.2	0.2	0.2	0.3	0.2	0.2	1.8
AVERAGE NO. OF DAYS WITH THUNDER	1937-1970	1.2	0.4	0.6	0.6	0.3	0.1	0.2	0.2	0.4	0.8	1.4	0.9	7.1

* refers to observations at Manutuke

I68191 GORE LAT. 46 6S LONG. 168 56E HT. 72 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL, MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1943-1970	134	128	139	177	183	145	122	97	134	118	130	163	1074
NORMAL	1941-1970	76	69	76	79	76	79	56	48	53	69	81	79	841
LOWEST MONTHLY/ANNUAL TOTAL	1943-1970	34	25	17	24	14	25	21	7	4	21	32	24	622
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1943-1970	11	10	12	12	12	13	11	9	10	12	13	12	137
MAXIMUM 1-DAY RAINFALL MM.	1943-1970	52	47	39	34	32	31	30	26	28	39	40	52	52
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1907-1965*	8	8	10	23	36	48	41	28	20	20	20	10	272
AVERAGE DEFICIT (MM)	1907-1965*	8	8	5	3	.	.	.	.	.	.	.	3	27
TEMPERATURE, DEGREES CELSIUS														
HIGHEST MAXIMUM	1943-1970	35.0	32.8	31.8	27.2	23.3	20.0	18.3	23.9	23.9	27.2	28.9	32.6	35.0
MEAN MONTHLY/ANNUAL MAXIMUM	1943-1970	29.8	29.3	27.3	22.9	18.8	15.0	14.9	17.8	20.8	23.7	26.0	27.6	30.8
MEAN DAILY MAXIMUM	1943-1970	20.9	20.8	18.9	15.8	12.3	9.3	9.1	11.6	14.2	16.4	18.0	19.6	15.6
NORMAL	1931-1960	14.8	14.8	13.2	10.7	7.3	5.0	4.4	6.3	8.7	10.8	12.3	14.0	10.2
MEAN DAILY MINIMUM	1943-1970	9.2	8.8	7.8	5.3	2.5	1.1	0.2	1.3	3.3	5.1	6.5	8.1	4.9
MEAN MONTHLY/ANNUAL MINIMUM	1943-1970	3.4	2.5	1.4	-0.4	-2.8	-3.7	-4.5	-3.3	-1.7	-0.4	0.7	2.2	-5.2
LOWEST MINIMUM	1943-1970	0.2	0.0	-0.8	-3.3	-6.1	-6.6	-7.8	-8.9	-4.7	-2.8	-1.7	-0.3	-8.9
MEAN DAILY RANGE	1943-1970	11.7	12.0	11.1	10.5	9.8	8.2	8.9	10.3	10.9	11.3	11.5	11.5	10.7
MEAN DAILY GRASS MINIMUM	1943-1970	6.7	6.4	5.4	3.0	0.4	-1.3	-2.3	-1.7	0.3	2.3	4.1	6.0	2.4
DAYS WITH FROST														
GROUND FROST AVERAGE	1943-1970	0.6	1.0	2.1	4.5	12.4	17.7	22.1	17.8	12.3	6.6	2.5	0.7	100.3
FROST IN SCREEN AVERAGE	1943-1970	.	.	0.1	0.9	5.8	9.4	10.5	9.0	3.3	0.9	0.3	0.1	40.3
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1945-1970	14.9	14.0	12.2	9.1	5.9	3.8	2.7	3.8	6.2	9.1	12.8	14.0	9.0
AVERAGE AT 0.30 METRES	1943-1970	16.2	15.7	14.3	11.3	8.1	5.6	4.3	5.4	7.8	10.4	12.8	13.7	10.5
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1943-1970	75	77	84	83	87	86	86	82	77	71	70	73	79
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1943-1970	12.3	12.0	11.4	9.6	7.9	6.8	6.4	6.9	8.0	9.1	10.2	11.7	9.4
SUNSHINE, HOURS														
HIGHEST	1943-1970	244	201	194	153	136	122	155	162	189	194	242	233	1839
AVERAGE	1943-1970	187	163	144	115	105	80	100	133	141	169	172	186	1695
% OF POSSIBLE	1943-1970	40	42	38	36	37	31	37	43	41	41	39	39	39
LOWEST	1943-1970	125	134	99	52	76	59	58	94	100	106	128	145	1454

WIND														
DAILY WIND RUN (KILOMETRES)	1942-1970	237	219	200	187	175	174	164	174	200	227	240	240	203
AVERAGE NO. OF DAYS WITH														
GUSTS 34 KNOTS OR MORE	1960-1964**	5.8	3.0	6.0	1.0	4.8	3.7	2.7	0.3	2.3	6.0	7.2	5.8	48.6
GUSTS 52 KNOTS OR MORE	1960-1964**	.	.	0.2	.	.	.	.	.	.	.	0.5	0.2	0.9
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1943-1970	.	.	.	.	0.4	1.1	0.9	0.6	0.8	0.3	0.3	.	4.4
AVERAGE NO. OF DAYS WITH HAIL	1943-1970	0.2	0.1	0.1	0.1	0.3	0.2	0.2	0.3	0.6	0.4	0.6	0.3	3.4
AVERAGE NO. OF DAYS WITH THUNDER	1943-1970	0.3	0.3	0.1	.	.	.	.	.	0.1	0.1	0.4	0.6	1.9

* refers to observations at East Gore
** refers to observations at Gore Aerodrome

F21422 GREYMOUTH — LAT. 42 28S LONG. 171 12E HT. 4 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1947-1970	391	488	367	579	408	330	332	348	388	422	423	438	2998
NORMAL	1941-1970	198	203	193	216	224	196	193	191	201	224	236	213	2488
LOWEST MONTHLY/ANNUAL TOTAL	1947-1970	58	72	97	80	59	54	81	22	72	82	93	60	2005
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1947-1970	12	11	13	14	15	14	14	14	15	17	16	14	169
MAXIMUM 1-DAY RAINFALL MM.	1947-1970	127	160	141	121	134	88	107	138	79	91	71	131	160
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1947-1970	104	109	132	165	216	170	165	165	122	165	173	124	1810
AVERAGE DEFICIT (MM)	1947-1970	.	.	.	.	.	.	.	.	.	.	.	.	.
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1947-1970	28.8	26.7	27.7	24.5	21.2	17.6	18.1	19.3	21.5	23.2	23.8	26.1	28.8
MEAN MONTHLY/ANNUAL MAXIMUM	1947-1970	24.0	23.4	23.5	20.5	18.0	15.3	14.9	16.2	17.8	19.0	20.1	22.4	25.6
MEAN DAILY MAXIMUM	1947-1970	19.6	19.5	18.7	16.5	14.3	12.0	11.6	12.7	13.9	15.2	16.4	18.2	15.7
NORMAL	1931-1960	15.8	16.0	14.9	12.8	10.8	8.4	7.9	8.8	10.2	11.8	13.2	14.7	12.1
MEAN DAILY MINIMUM	1947-1970	12.6	12.8	11.8	9.4	7.4	5.2	4.5	5.3	6.8	8.7	9.8	11.6	8.8
MEAN MONTHLY/ANNUAL MINIMUM	1947-1970	8.0	7.7	6.4	4.6	2.2	0.4	-0.3	1.2	1.6	3.6	5.6	6.8	-0.9
LOWEST MINIMUM	1947-1970	5.7	3.7	3.2	1.1	-2.2	-1.8	-1.9	-0.5	0.0	-0.7	2.8	2.9	-2.2
MEAN DAILY RANGE	1947-1970	7.0	6.7	6.9	7.1	6.9	6.8	7.1	7.4	7.1	6.5	6.6	6.6	6.9
MEAN DAILY GRASS MINIMUM	1947-1970	10.2	10.2	9.0	6.5	4.4	2.0	1.6	2.2	3.8	6.2	7.3	9.0	6.0
DAYS WITH FROST														
GROUND FROST AVERAGE	1947-1965	.	0.1	0.2	0.9	3.7	7.2	9.2	6.5	3.7	0.7	.	.	32.2
FROST IN SCREEN AVERAGE	1947-1965	.	.	.	.	.	0.6	1.2	0.4	.	.	.	.	2.2
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1947-1965	80	84	84	84	84	84	83	82	82	82	81	80	83
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1947-1965	15.5	16.0	14.4	12.3	10.5	8.9	8.3	8.9	10.4	11.9	13.0	14.2	12.0
SUNSHINE. HOURS														
HIGHEST	1947-1970	265	217	188	187	163	145	156	194	210	214	231	244	1918
AVERAGE	1947-1970	192	161	149	131	107	95	106	134	141	142	158	178	1694
% OF POSSIBLE	1947-1970	42	42	39	40	36	35	37	42	41	35	37	38	39
LOWEST	1947-1970	114	100	99	94	78	64	61	78	86	88	95	113	1415
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1947-1965	.	.	.	.	.	.	.	.	.	.	.	.	.
AVERAGE NO. OF DAYS WITH HAIL	1947-1965	.	.	0.1	0.3	0.2	.	0.3	0.2	0.3	0.2	0.1	0.2	1.9
AVERAGE NO. OF DAYS WITH THUNDER	1947-1965	0.4	.	0.6	0.6	0.8	0.1	0.4	0.4	0.3	0.3	.	0.2	4.1

D96681 <u>HASTINGS</u> LAT. 39 39S LONG. 176 51E HT. 14 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1892-1966*	297	289	204	340	237	283	262	199	210	177	205	193	1514
NORMAL	1941-1970	58	58	61	56	79	84	79	86	48	51	46	61	767
LOWEST MONTHLY/ANNUAL TOTAL	1892-1966*	2	0	4	2	11	11	12	18	1	4	1	1	516
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1928-1966	7	6	7	7	9	8	10	9	8	7	8	7	93
MAXIMUM 1-DAY RAINFALL MM.	1928-1966	246	122	81	194	114	108	73	56	64	38	152	61	246
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1928-1970	8	10	5	10	25	36	56	48	20	5	8	3	234
AVERAGE DEFICIT (MM)	1928-1970	51	46	28	15	3	.	.	.	.	.	13	41	197
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1930-1966	36.6	36.4	32.8	31.1	26.8	23.3	23.9	22.8	27.7	31.8	33.9	32.8	36.6
MEAN MONTHLY/ANNUAL MAXIMUM	1930-1966	31.9	31.2	28.9	26.9	22.6	20.1	18.7	19.9	22.5	26.3	28.5	30.2	32.8
MEAN DAILY MAXIMUM	1930-1966	25.4	25.1	23.1	20.4	16.8	14.3	13.4	14.7	16.9	19.7	22.0	23.9	19.6
NORMAL	1931-1960	18.8	18.9	16.8	14.4	11.0	8.5	7.8	9.1	10.9	13.3	15.4	17.5	13.6
MEAN DAILY MINIMUM	1930-1966	12.4	12.6	10.6	7.9	5.1	2.6	2.4	3.4	4.8	7.0	8.9	11.1	7.4
MEAN MONTHLY/ANNUAL MINIMUM	1930-1966	6.2	6.2	3.1	1.0	-1.4	-3.2	-3.1	-2.3	-1.1	0.6	2.5	4.7	-3.8
LOWEST MINIMUM	1930-1966	3.3	2.4	0.0	-3.0	-5.6	-5.9	-5.0	-3.9	-3.3	-3.1	-1.1	2.2	-5.9
MEAN DAILY RANGE	1930-1966	13.0	12.5	12.5	12.5	11.7	11.7	11.0	11.3	12.1	12.7	13.1	12.8	12.2
MEAN DAILY GRASS MINIMUM	1930-1966	9.9	10.2	7.9	5.2	2.3	-0.3	-0.5	0.3	1.6	4.1	6.3	8.7	4.6
DAYS WITH FROST														
GROUND FROST AVERAGE	1928-1965	.	.	0.8	2.1	9.0	14.6	15.5	13.4	9.7	3.8	0.6	0.2	69.7
FROST IN SCREEN AVERAGE	1928-1965	.	.	.	0.3	3.0	8.0	9.5	5.6	2.6	0.5	0.1	.	29.6
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1942-1965	20.3	19.8	16.8	12.9	9.4	6.2	5.7	6.8	9.6	13.1	16.6	19.3	13.0
AVERAGE AT 0.30 METRES	1928-1965	21.8	21.6	19.2	15.8	11.8	8.7	7.6	8.7	11.2	14.5	17.6	20.4	14.9
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1928-1965	65	70	74	80	82	83	83	79	74	68	63	64	74
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1928-1965	15.5	15.9	14.5	12.7	10.2	8.4	8.0	8.7	10.0	11.5	12.7	14.6	11.9
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1929-1965	.	.	.	.	.	.	.	0.1	.	.	.	.	0.1
AVERAGE NO. OF DAYS WITH HAIL	1929-1965	.	.	.	.	.	.	.	0.1	0.1	0.1	0.1	.	0.4
AVERAGE NO. OF DAYS WITH THUNDER	1929-1965	0.1	0.1	.	0.1	.	.	.	.	0.1	0.1	0.4	0.2	1.1

* includes observations at rainfall station

H31572 HIGHBANK POWER STN   LAT. 43 35S LONG. 171 44E HT. 336 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL, MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1953-1970	161	125	179	197	219	150	255	135	100	154	187	185	1195
NORMAL	1941-1970	89	81	86	91	81	61	79	74	66	86	97	94	985
LOWEST MONTHLY/ANNUAL TOTAL	1953-1970	36	24	32	13	29	5	15	14	21	16	25	34	665
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1953-1970	9	8	10	9	10	7	9	8	7	8	10	10	104
MAXIMUM 1-DAY RAINFALL MM.	1953-1970	62	52	59	102	75	34	62	43	40	58	54	61	102
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1954-1970	10	3	13	25	56	38	76	41	23	18	23	18	344
AVERAGE DEFICIT (MM)	1954-1970	13	10	5	.	.	.	.	.	.	.	.	3	31
TEMPERATURE, DEGREES CELSIUS														
HIGHEST MAXIMUM	1953-1970	35.7	32.2	30.1	25.8	21.6	18.8	18.3	19.7	22.9	25.7	30.4	30.0	35.7
MEAN MONTHLY/ANNUAL MAXIMUM	1953-1970	29.3	28.8	27.0	23.3	19.1	16.6	15.9	17.1	19.4	22.4	24.2	26.9	30.6
MEAN DAILY MAXIMUM	1953-1970	21.4	21.0	18.9	16.1	12.6	10.7	9.4	11.0	13.3	15.7	17.5	19.5	15.6
NORMAL	1931-1960	15.2	15.1	13.7	11.4	8.2	7.0	5.3	6.4	8.9	10.7	12.3	13.9	10.7
MEAN DAILY MINIMUM	1953-1970	10.6	10.4	9.4	7.0	4.4	2.7	1.9	2.8	4.5	6.4	7.8	9.2	6.4
MEAN MONTHLY/ANNUAL MINIMUM	1953-1970	5.1	4.7	4.2	1.5	-0.6	-1.6	-2.3	-1.2	-0.2	0.9	2.1	3.9	-2.9
LOWEST MINIMUM	1953-1970	1.9	1.2	1.3	0.0	-4.2	-5.6	-4.4	-3.9	-3.2	-1.1	0.1	1.6	-5.6
MEAN DAILY RANGE	1953-1970	10.8	10.6	9.5	9.1	8.2	8.0	7.5	8.2	8.8	9.3	9.7	10.3	9.2
MEAN DAILY GRASS MINIMUM	1953-1970	8.7	8.7	7.1	4.4	1.2	-0.7	-1.3	-0.2	2.0	3.9	5.7	7.4	3.9
DAYS WITH FROST														
GROUND FROST AVERAGE	1953-1970	.	0.1	0.5	2.5	9.5	15.6	18.1	13.7	7.8	4.1	1.5	0.3	73.7
FROST IN SCREEN AVERAGE	1953-1970	.	.	.	.	2.1	4.7	8.9	4.0	0.9	0.4	.	.	21.0
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1953-1970	71	73	77	73	76	68	72	71	69	64	65	68	71
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1953-1970	12.2	11.8	11.3	9.1	7.6	6.1	5.9	6.3	7.3	8.2	9.4	10.8	8.8
SUNSHINE, HOURS														
HIGHEST	1954-1970	279	235	189	195	164	173	170	224	243	246	264	267	2198
AVERAGE	1954-1970	220	181	160	160	136	135	136	164	174	206	212	209	2093
% OF POSSIBLE	1954-1970	48	47	42	50	46	51	48	52	50	51	49	44	49
LOWEST	1954-1970	163	129	111	102	98	96	108	127	111	164	167	123	1867
WIND														
DAILY WIND RUN (KILOMETRES)	1954-1970	306	288	269	274	256	253	246	275	298	332	351	309	288
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1953-1970	.	.	.	0.2	0.5	0.6	1.8	0.8	0.9	0.5	0.3	0.1	5.7
AVERAGE NO. OF DAYS WITH HAIL	1953-1970	0.1	0.1	0.2	0.1	.	0.2	0.2	0.1	0.3	0.2	0.5	0.1	2.1
AVERAGE NO. OF DAYS WITH THUNDER	1953-1970	0.9	0.3	0.3	0.2	0.2	0.1	.	0.1	0.1	0.5	0.6	0.3	3.6

A53291 <u>KERIKERI</u> LAT. 35 14S LONG. 173 57E HT. 73 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1935-1970	361	390	356	494	427	380	406	351	280	307	223	213	2768
NORMAL	1941-1970	76	124	112	142	178	178	183	196	142	114	99	104	1648
LOWEST MONTHLY/ANNUAL TOTAL	1935-1970	11	1	4	15	46	69	33	104	40	21	19	24	1126
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1947-1970	7	9	9	10	13	14	14	16	12	12	9	9	135
MAXIMUM 1-DAY RAINFALL MM.	1947-1970	84	132	154	122	113	137	95	93	90	114	57	74	154
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1947-1970	23	56	43	76	117	147	152	163	94	61	38	33	1003
AVERAGE DEFICIT (MM)	1947-1970	15	18	10	5	3	.	.	.	.	.	.	3	54
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1945-1970	34.3	31.9	29.4	27.6	25.2	21.0	20.6	21.4	23.5	26.4	27.3	30.3	34.3
MEAN MONTHLY/ANNUAL MAXIMUM	1945-1970	28.4	28.0	26.7	24.8	21.8	19.7	18.7	19.2	20.9	23.1	25.1	27.0	29.1
MEAN DAILY MAXIMUM	1945-1970	24.5	24.6	23.4	21.2	18.3	16.1	15.4	16.1	17.5	19.4	21.3	23.0	20.1
NORMAL	1931-1960	18.3	18.8	17.9	16.1	13.7	11.6	10.7	11.1	12.3	13.9	15.3	17.1	14.7
MEAN DAILY MINIMUM	1945-1970	13.2	14.3	12.9	11.0	9.1	7.0	6.0	6.5	7.3	8.9	10.1	12.1	9.9
MEAN MONTHLY/ANNUAL MINIMUM	1945-1970	8.0	8.6	7.4	5.6	3.3	1.2	0.6	1.0	2.0	3.7	4.9	6.2	-0.3
LOWEST MINIMUM	1945-1970	4.8	5.3	3.6	1.9	-0.3	-1.4	-2.0	-0.8	-0.8	1.7	3.2	3.3	-2.0
MEAN DAILY RANGE	1945-1970	11.3	10.3	10.5	10.2	9.2	9.1	9.4	9.6	10.2	10.5	11.2	10.9	10.2
MEAN DAILY GRASS MINIMUM	1945-1970	10.0	11.4	9.6	7.4	5.4	3.1	2.1	2.8	3.6	5.5	6.8	9.0	6.4
DAYS WITH FROST														
GROUND FROST AVERAGE	1951-1970	.	.	.	0.2	1.8	4.5	8.6	6.5	3.0	0.8	0.2	0.1	25.7
FROST IN SCREEN AVERAGE	1945-1970	.	.	.	.	.	0.3	0.5	0.2	0.1	.	.	.	1.1
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1947-1970	20.5	20.6	20.6	16.1	13.2	10.9	9.7	10.3	12.0	14.8	17.2	19.3	15.4
AVERAGE AT 0.30 METRES	1947-1970	20.9	21.1	21.6	17.6	16.4	12.8	11.5	11.8	13.5	15.6	17.7	19.6	16.7
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1945-1970	72	76	78	82	88	90	89	86	80	76	74	71	80
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1945-1970	17.3	18.3	17.9	16.4	13.9	12.6	11.9	11.8	12.4	13.5	14.3	16.0	14.7
SUNSHINE. HOURS														
HIGHEST	1938-1970	314	241	217	217	167	169	178	185	208	229	241	287	2308
AVERAGE	1938-1970	223	175	169	150	133	124	137	145	157	179	206	213	2011
% OF POSSIBLE	1938-1970	51	47	45	45	42	43	45	44	45	45	50	48	47
LOWEST	1938-1970	143	111	127	79	76	93	92	111	104	142	153	134	1778

SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1945-1970	.	.	.	.	.	.	.	.	.	.	.	.	.
AVERAGE NO. OF DAYS WITH HAIL	1945-1970	.	.	.	.	.	0.2	.	0.4	0.1	.	0.1	0.1	0.9
AVERAGE NO. OF DAYS WITH THUNDER	1945-1970	0.5	0.2	0.1	0.8	0.8	0.8	0.4	0.6	0.3	0.2	0.5	0.1	5.3

E05622 LEVIN   LAT. 40 39S LONG. 175 16E HT. 46 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1949-1970	209	160	107	172	163	195	201	200	213	218	166	206	1400
NORMAL	1941-1970	76	76	76	84	104	109	107	97	84	99	84	99	1095
LOWEST MONTHLY/ANNUAL TOTAL	1949-1970	28	33	27	19	34	42	48	48	18	25	24	30	826
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1949-1970	8	7	8	10	12	12	13	11	10	12	11	11	125
MAXIMUM 1-DAY RAINFALL MM.	1949-1970	71	72	48	46	39	50	68	49	41	55	46	68	72
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1949-1970	15	8	3	13	46	71	79	69	36	38	30	28	436
AVERAGE DEFICIT (MM)	1949-1970	8	13	8	3	.	.	.	.	.	.	.	3	35
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1949-1970	28.5	29.3	27.4	24.8	22.2	20.2	19.3	19.3	21.2	26.1	27.1	26.6	29.3
MEAN MONTHLY/ANNUAL MAXIMUM	1949-1970	25.7	26.6	25.6	21.9	19.5	17.1	16.0	16.7	19.0	20.8	22.2	24.1	27.3
MEAN DAILY MAXIMUM	1949-1970	21.3	21.8	20.6	17.8	15.3	12.9	12.1	13.3	14.7	16.4	17.9	19.9	17.0
NORMAL	1931-1960	16.5	16.7	15.6	13.4	11.1	9.0	8.2	8.8	10.4	12.2	13.7	15.2	12.6
MEAN DAILY MINIMUM	1949-1970	12.6	12.9	11.8	9.3	7.2	5.2	4.2	5.2	6.8	8.6	10.1	11.7	8.8
MEAN MONTHLY/ANNUAL MINIMUM	1949-1970	6.5	6.5	5.3	2.4	0.7	-0.9	-1.1	-0.4	1.0	2.5	3.2	5.4	-1.6
LOWEST MINIMUM	1949-1970	4.2	3.4	1.2	-0.7	-1.0	-2.7	-2.7	-2.2	-1.0	-0.5	-0.8	2.8	-2.7
MEAN DAILY RANGE	1949-1970	8.7	8.9	8.8	8.5	8.1	7.7	7.9	8.1	7.9	7.8	7.8	8.2	8.2
MEAN DAILY GRASS MINIMUM	1949-1970	10.3	10.2	8.8	6.1	3.9	1.8	0.9	1.8	3.4	5.9	7.6	9.4	5.8
DAYS WITH FROST														
GROUND FROST AVERAGE	1949-1970	.	.	0.2	2.1	5.6	10.1	13.5	9.6	5.9	2.0	0.6	0.1	49.7
FROST IN SCREEN AVERAGE	1949-1970	.	.	.	0.1	0.3	2.0	3.6	1.3	0.2	0.1	.	.	7.6
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1949-1970	17.2	18.3	16.4	5.7	10.0	7.7	6.4	7.4	9.8	12.8	15.2	17.4	12.0
AVERAGE AT 0.30 METRES	1949-1970	19.8	19.8	18.5	15.5	12.4	9.9	8.5	9.3	11.3	13.7	16.1	18.2	14.4
AVERAGE AT 0.91 METRES	1960-1970	18.6	19.2	18.8	17.2	14.7	12.3	10.6	10.4	11.5	13.2	15.2	17.1	14.9
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1949-1970	73	75	76	81	83	85	86	82	78	76	74	73	79
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1949-1970	15.1	15.5	14.6	12.8	10.9	9.4	8.8	9.4	10.5	11.7	12.5	14.0	12.1
SUNSHINE. HOURS														
HIGHEST	1955-1970	284	247	233	188	162	126	149	190	240	200	222	278	2054
AVERAGE	1955-1970	211	192	175	150	121	107	115	132	146	164	177	194	1884
% OF POSSIBLE	1955-1970	47	50	46	46	40	39	40	41	42	41	42	42	44
LOWEST	1955-1970	142	148	122	112	83	74	59	91	97	132	119	143	1770

WIND														
DAILY WIND RUN (KILOMETRES)	1954-1970	196	172	172	169	185	188	188	190	209	217	220	192	192
AVERAGE NO. OF DAYS WITH														
GUSTS 34 KNOTS OR MORE	1967-1970	1.3	0.8	1.3	2.5	2.5	2.5	1.5	1.8	2.3	5.8	3.8	1.8	27.9
GUSTS 52 KNOTS OR MORE	1967-1970	.	.	.	0.3	0.3	0.3	.	.	.	.	0.3	.	1.2
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1949-1970	.	.	.	.	.	.	0.2	0.1	0.1	.	.	.	0.4
AVERAGE NO. OF DAYS WITH HAIL	1949-1970	0.1	.	0.1	0.3	0.2	0.8	0.4	0.5	0.2	0.3	0.1	0.2	3.2
AVERAGE NO. OF DAYS WITH THUNDER	1949-1970	0.8	0.4	0.3	0.6	0.6	1.4	0.7	0.8	0.4	0.6	0.6	0.7	7.9

H32641 LINCOLN LAT. 43 39S LONG. 172 28E HT. 11 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1881-1970	139	233	179	204	197	199	209	236	142	133	150	192	986
NORMAL	1941-1970	56	56	66	58	76	58	58	56	46	48	53	58	689
LOWEST MONTHLY/ANNUAL TOTAL	1881-1970	7	0	5	10	11	9	4	8	7	3	12	3	338
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1881-1970	7	6	7	7	8	8	9	8	7	7	8	7	88
MAXIMUM 1-DAY RAINFALL MM.	1881-1970	98	102	92	79	79	106	81	60	47	65	51	69	106
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1881-1970	.	3	3	5	18	28	46	30	18	8	5	3	167
AVERAGE DEFICIT (MM)	1881-1970	41	36	23	10	3	.	.	.	.	.	5	28	146
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1881-1970	37.9	36.3	33.9	29.4	27.2	22.7	20.6	22.2	31.1	30.7	32.8	36.9	37.9
MEAN MONTHLY/ANNUAL MAXIMUM	1881-1970	31.1	30.7	29.0	25.3	20.9	17.4	16.6	18.6	21.8	25.0	26.7	29.4	32.5
MEAN DAILY MAXIMUM	1881-1970	22.1	21.9	20.0	17.3	13.7	11.1	10.3	11.8	14.4	17.1	19.0	20.9	16.6
NORMAL	1931-1960	16.0	15.8	14.1	11.4	8.1	5.6	4.8	6.4	8.5	10.9	12.8	14.8	10.8
MEAN DAILY MINIMUM	1881-1970	10.7	10.8	9.3	6.8	4.0	1.7	1.2	2.2	4.2	6.2	7.6	9.6	6.2
MEAN MONTHLY/ANNUAL MINIMUM	1881-1970	4.2	4.0	2.2	-0.3	-2.2	-3.9	-4.0	-3.3	-1.7	-0.3	1.3	3.2	-4.9
LOWEST MINIMUM	1881-1970	0.1	0.3	-1.9	-4.4	-6.1	-7.3	-11.6	-6.9	-7.2	-5.9	-2.7	-1.2	-11.6
MEAN DAILY RANGE	1881-1970	11.4	11.1	10.7	10.5	9.7	9.4	9.1	9.6	10.2	10.9	11.4	11.3	10.4
MEAN DAILY GRASS MINIMUM	1881-1970	7.9	7.9	6.4	3.6	0.9	-1.2	-1.6	-0.7	1.1	3.2	4.7	6.6	3.2
DAYS WITH FROST														
GROUND FROST AVERAGE	1881-1970	0.3	0.4	2.0	5.7	11.4	16.7	18.3	15.7	9.9	5.5	2.5	1.0	89.4
FROST IN SCREEN AVERAGE	1881-1970	.	.	0.1	1.0	4.6	9.7	11.4	7.8	3.2	1.1	0.3	.	39.2
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1943-1970	17.3	16.6	14.2	11.1	7.5	4.6	3.9	5.1	7.5	10.7	13.8	16.4	10.7
AVERAGE AT 0.30 METRES	1943-1970	17.8	17.7	15.8	12.8	9.7	6.9	5.8	6.7	8.7	11.3	13.9	16.4	12.0
AVERAGE AT 0.91 METRES	1943-1970	16.3	16.7	15.7	13.9	11.4	9.0	7.4	7.5	8.7	10.6	11.6	14.8	12.0
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1944-1970	65	66	75	80	84	84	85	82	74	68	64	65	74
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1944-1970	13.0	13.1	12.9	11.1	9.2	7.3	7.1	8.0	9.0	10.1	11.0	12.2	10.3
SUNSHINE. HOURS														
HIGHEST	1935-1970	294	238	270	185	190	158	174	191	225	250	270	278	2255
AVERAGE	1935-1970	222	187	176	143	122	114	119	145	166	198	209	215	2016
% OF POSSIBLE	1935-1970	48	48	46	44	42	43	42	46	48	49	48	46	47
LOWEST	1935-1970	178	126	117	76	80	71	83	67	89	142	135	110	1683

WIND														
DAILY WIND RUN (KILOMETRES)	1964-1970	327	325	288	293	251	222	230	254	296	323	311	323	287
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1881-1970	.	.	0.1	.	0.1	0.6	0.8	0.5	0.3	0.1	0.1	.	2.6
AVERAGE NO. OF DAYS WITH HAIL	1881-1970	0.3	0.1	0.2	0.1	0.3	0.5	0.6	0.5	0.6	0.5	0.4	0.3	4.4
AVERAGE NO. OF DAYS WITH THUNDER	1881-1970	0.7	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.6	0.6	3.3

H32791 ONAWE,AKAROA LAT. 43 46S LONG. 172 56E HT. 46 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1934-1970	171	248	256	431	328	197	415	310	276	141	165	377	1595
NORMAL	1941-1970	64	58	74	102	124	99	112	89	66	58	66	81	993
LOWEST MONTHLY/ANNUAL TOTAL	1934-1970	15	11	15	10	21	20	19	26	12	13	10	1	547
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1934-1970	7	7	8	10	11	11	12	10	9	9	9	8	112
MAXIMUM 1-DAY RAINFALL MM.	1934-1970	99	83	75	206	112	59	109	107	186	52	53	217	217
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1934-1970	8	8	13	33	69	74	91	66	38	13	10	15	438
AVERAGE DEFICIT (MM)	1934-1970	30	25	23	5	.	.	.	.	.	.	5	18	106
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1937-1970	35.0	35.6	32.8	31.1	26.2	22.3	19.6	21.0	24.2	29.1	29.4	32.2	35.6
MEAN MONTHLY/ANNUAL MAXIMUM	1937-1970	30.5	30.8	28.8	25.2	21.2	17.1	16.6	18.7	21.8	24.3	26.3	28.8	31.9
MEAN DAILY MAXIMUM	1937-1970	22.0	22.1	20.1	17.1	13.9	11.3	10.4	11.9	14.6	17.0	19.1	20.5	16.7
NORMAL	1931-1960	16.9	16.9	15.3	13.0	10.1	7.7	6.7	8.1	10.1	12.2	14.1	15.7	12.2
MEAN DAILY MINIMUM	1937-1970	12.1	12.2	11.0	8.9	6.7	4.4	3.6	4.3	6.0	7.6	9.1	10.9	8.1
MEAN MONTHLY/ANNUAL MINIMUM	1937-1970	7.0	6.9	5.9	3.7	2.0	0.1	-0.6	-0.1	1.1	2.6	3.8	5.8	-0.9
LOWEST MINIMUM	1937-1970	3.3	5.0	2.8	-0.6	-1.1	-2.6	-1.8	-2.1	-0.9	0.0	0.0	4.4	-2.6
MEAN DAILY RANGE	1937-1970	9.9	9.9	9.1	8.2	7.2	6.9	6.8	7.6	8.6	9.4	10.0	9.6	8.6
MEAN DAILY GRASS MINIMUM	1937-1970	8.1	7.9	7.0	4.5	2.3	-0.2	-0.7	-0.1	1.5	3.8	5.6	7.5	3.9
DAYS WITH FROST														
GROUND FROST AVERAGE	1937-1970	0.5	0.6	0.3	1.7	6.7	14.3	15.1	14.8	7.7	2.6	0.6	.	64.9
FROST IN SCREEN AVERAGE	1937-1970	.	.	.	0.1	0.1	0.7	1.7	0.8	0.1	.	.	.	3.5
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1937-1970	67	68	73	75	78	79	81	78	70	67	67	68	73
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1937-1970	13.9	14.0	13.3	11.5	9.5	8.2	7.8	8.4	9.0	10.4	11.8	13.0	10.9
SUNSHINE. HOURS														
HIGHEST	1939-1970	286	232	252	213	139	145	142	178	222	256	252	278	2081
AVERAGE	1939-1970	219	184	171	135	99	93	98	130	163	193	205	205	1895
% OF POSSIBLE	1939-1970	47	48	45	42	34	35	35	41	47	48	47	43	44
LOWEST	1939-1970	139	132	102	86	65	58	56	64	108	118	140	122	1668
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1937-1970	.	.	.	.	.	0.3	1.0	0.2	0.1	0.1	.	.	1.7
AVERAGE NO. OF DAYS WITH HAIL	1937-1970	0.2	0.4	0.4	0.6	1.3	1.9	1.6	1.0	1.2	1.3	0.8	0.3	11.0
AVERAGE NO. OF DAYS WITH THUNDER	1937-1970	0.7	0.5	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.4	0.7	1.0	4.5

E05363 PALMERSTON NORTH DSIR — LAT. 40 23S LONG. 175 37E HT. 34 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1928-1970	245	192	216	155	222	263	151	204	165	187	191	219	1299
NORMAL	1941-1970	84	69	74	74	86	99	91	84	69	89	79	104	1002
LOWEST MONTHLY/ANNUAL TOTAL	1928-1970	25	9	16	24	13	15	29	30	13	15	27	24	713
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1928-1970	9	8	8	10	12	13	12	12	11	12	11	11	127
MAXIMUM 1-DAY RAINFALL MM.	1928-1970	82	92	85	69	74	49	59	51	46	37	47	63	92
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1928-1970	13	8	8	5	36	66	58	61	30	30	20	23	358
AVERAGE DEFICIT (MM)	1928-1970	13	18	13	5	.	.	.	.	.	.	.	3	52
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1918-1970*	30.0	30.6	29.5	27.8	23.4	20.9	19.3	22.8	21.7	26.2	27.7	31.7	31.7
MEAN MONTHLY/ANNUAL MAXIMUM	1928-1970	27.0	27.4	25.8	23.1	19.7	16.9	15.8	17.2	19.1	21.1	23.6	25.7	28.1
MEAN DAILY MAXIMUM	1928-1970	21.8	22.2	20.9	18.1	14.9	12.5	11.8	13.0	14.7	16.6	18.5	20.6	17.1
NORMAL	1931-1960	17.1	17.4	16.1	13.7	10.7	8.4	7.8	8.9	10.6	12.4	14.2	16.0	12.8
MEAN DAILY MINIMUM	1928-1970	12.6	12.6	11.5	9.4	6.7	4.6	3.8	4.8	6.4	8.1	9.7	11.5	8.5
MEAN MONTHLY/ANNUAL MINIMUM	1928-1970	6.2	6.3	3.9	2.3	-0.3	-1.9	-1.9	-1.6	-0.1	1.6	3.5	5.6	-2.6
LOWEST MINIMUM	1918-1970*	1.7	1.4	0.0	-3.3	-3.9	-5.0	-5.3	-6.0	-3.9	-2.0	0.6	0.0	-6.0
MEAN DAILY RANGE	1928-1970	9.2	9.6	9.4	8.7	8.2	7.9	8.0	8.2	8.3	8.5	8.8	9.1	8.6
MEAN DAILY GRASS MINIMUM	1928-1970	9.0	9.0	7.8	5.7	2.9	1.0	0.2	1.1	2.8	4.8	6.4	8.1	4.9
DAYS WITH FROST														
GROUND FROST AVERAGE	1928-1970	0.2	0.4	1.0	2.9	7.2	11.2	14.0	11.4	6.7	3.3	1.1	0.1	59.5
FROST IN SCREEN AVERAGE	1928-1970	.	.	.	.	1.3	4.0	5.3	3.0	0.9	0.2	.	.	14.7
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1939-1970	18.7	18.3	16.4	13.2	10.2	7.7	6.7	7.6	9.9	12.6	15.2	17.6	12.8
AVERAGE AT 0.30 METRES	1928-1970	19.2	19.1	17.6	14.8	11.7	9.2	8.0	8.7	10.8	13.1	15.7	18.1	13.8
AVERAGE AT 0.91 METRES	1928-1970	18.2	18.6	17.9	16.1	13.6	11.2	9.7	9.6	10.9	12.7	14.7	16.8	14.2
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1928-1970	73	74	77	81	83	85	85	81	78	75	73	73	78
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1928-1970	15.2	15.4	14.7	12.7	10.8	9.3	8.7	9.3	10.4	11.6	12.8	14.3	12.1
SUNSHINE. HOURS														
HIGHEST	1935-1970	302	252	226	184	161	132	147	182	223	236	263	280	2020
AVERAGE	1935-1970	210	185	171	138	116	94	105	126	139	158	175	194	1811
% OF POSSIBLE	1935-1970	47	49	45	42	38	34	36	39	40	39	41	42	42
LOWEST	1935-1970	149	124	114	91	62	59	54	88	101	101	118	149	1556

WIND														
DAILY WIND RUN (KILOMETRES)	1961-1970	286	286	261	256	222	220	211	225	267	298	332	285	262
AVERAGE NO. OF DAYS WITH														
GUSTS 34 KNOTS OR MORE	1940-51/65 - 70 **	4.4	3.6	2.8	3.9	3.2	3.2	2.1	3.2	4.3	6.2	6.3	4.8	48.0
GUSTS 52 KNOTS OR MORE	1940-51/65 - 70 **	.	0.1	0.1	0.3	0.1	0.1	.	0.2	0.2	0.2	0.3	0.3	1.9
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1928-1970	.	.	.	.	.	.	.	.	.	.	.	.	.
AVERAGE NO. OF DAYS WITH HAIL	1928-1970	.	.	.	.	0.1	0.3	0.1	0.2	0.2	0.1	0.2	.	1.2
AVERAGE NO. OF DAYS WITH THUNDER	1929-1970	.	.	.	.	0.2	0.5	0.1	.	.	0.2	0.3	0.4	1.7

* refers to observations at various sites in Palmerston North
** refers to observations at Palmerston North Aerodrome

G12191 RIWAKA,MOTUEKA LAT. 41 6S LONG. 172 58E HT. 8 M.

	Period	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL, MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1943-1970	182	365	266	509	354	223	303	298	327	304	311	212	1880
NORMAL	1941-1970	74	99	104	127	155	119	145	140	117	112	89	91	1372
LOWEST MONTHLY/ANNUAL TOTAL	1943-1970	11	10	4	4	34	11	47	22	21	6	6	12	919
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1956-1970	6	5	8	8	10	9	10	10	11	10	8	8	101
MAXIMUM 1-DAY RAINFALL MM.	1956-1970	98	199	109	115	124	89	146	85	95	77	114	72	199
TEMPERATURE, DEGREES CELSIUS														
HIGHEST MAXIMUM	1956-1970	31.7	31.2	28.9	26.0	21.6	19.4	18.5	19.4	21.7	27.2	27.2	29.3	31.7
MEAN MONTHLY/ANNUAL MAXIMUM	1956-1970	28.2	27.7	26.3	23.7	19.9	17.9	16.9	18.0	19.5	22.8	24.7	26.7	29.1
MEAN DAILY MAXIMUM	1956-1970	23.2	23.3	21.6	18.8	15.7	13.5	12.5	13.7	15.5	17.9	19.8	21.8	18.1
NORMAL	1931-1960	16.7	16.7	15.6	13.0	10.1	7.6	6.9	8.2	10.1	12.1	14.2	16.1	12.3
MEAN DAILY MINIMUM	1956-1970	11.6	11.7	10.6	7.3	4.5	1.7	1.3	2.5	4.6	6.6	8.5	10.7	6.8
MEAN MONTHLY/ANNUAL MINIMUM	1956-1970	6.3	5.5	4.9	1.4	-1.2	-2.5	-3.2	-2.5	-0.8	0.9	3.4	5.1	-3.4
LOWEST MINIMUM	1956-1970	4.7	2.2	1.8	-0.6	-3.3	-3.4	-4.4	-4.0	-2.3	-1.8	1.5	2.5	-4.4
MEAN DAILY RANGE	1956-1970	11.6	11.6	11.0	11.5	11.2	11.8	11.2	11.2	10.9	11.3	11.3	11.1	11.3
MEAN DAILY GRASS MINIMUM	1956-1970	9.1	9.1	7.6	4.1	1.5	-1.4	-1.6	-0.4	1.8	3.7	5.6	8.0	3.9
DAYS WITH FROST														
GROUND FROST AVERAGE	1956-1970	.	0.1	0.3	4.1	10.2	17.6	18.3	15.9	9.5	3.7	0.5	0.2	80.4
FROST IN SCREEN AVERAGE	1956-1970	.	0.1	.	0.1	2.7	9.0	12.3	6.9	1.7	0.3	.	.	33.1
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1956-1970	19.4	18.7	16.0	11.8	7.8	4.6	3.9	5.6	8.7	12.3	15.7	18.2	11.9
AVERAGE AT 0.30 METRES	1956-1970	21.0	20.8	18.3	14.1	10.2	6.7	5.7	7.4	10.4	13.7	16.7	19.4	13.7
AVERAGE AT 0.91 METRES	1956-1970	19.1	19.7	18.6	16.3	13.1	10.0	8.2	8.6	10.4	12.8	15.2	17.4	14.1
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1956-1970	66	70	77	80	85	88	94	83	76	67	64	65	76
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1956-1970	14.6	15.1	14.0	11.7	9.4	7.8	7.4	8.3	9.6	10.6	11.6	13.4	11.1
WIND														
DAILY WIND RUN (KILOMETRES)	1957-1970	163	151	135	122	113	103	105	121	136	159	180	172	139
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1956-1970	.	.	.	.	.	0.2	0.1	0.1	0.1	.	.	.	0.5
AVERAGE NO. OF DAYS WITH HAIL	1956-1970	.	.	.	0.1	0.1	.	.	0.1	0.1	0.1	0.2	0.2	0.9
AVERAGE NO. OF DAYS WITH THUNDER	1956-1970	0.6	0.4	0.9	0.3	0.6	0.3	0.1	0.2	0.5	0.3	0.9	0.3	5.4

C75731 RUAKURA,HAMILTON LAT. 37 47S LONG. 175 19E HT. 40 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1905-1970	315	324	215	255	262	323	243	227	240	209	211	212	1650
NORMAL	1941-1970	71	81	84	99	112	132	117	117	97	107	91	89	1197
LOWEST MONTHLY/ANNUAL TOTAL	1905-1970	6	6	8	20	23	23	40	41	30	20	11	14	829
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1907-1970	8	7	8	10	12	14	13	13	12	12	11	10	131
MAXIMUM 1-DAY RAINFALL MM.	1907-1970	91	148	82	126	64	106	103	80	66	60	67	55	148
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1946-1970*	5	23	18	28	61	114	99	84	46	58	36	28	600
AVERAGE DEFICIT (MM)	1946-1970*	13	28	20	5	.	.	.	.	.	.	.	.	66
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1930-1970	32.2	33.1	29.1	27.4	22.9	20.2	18.8	20.0	22.1	26.6	27.7	34.7	34.7
MEAN MONTHLY/ANNUAL MAXIMUM	1930-1970	27.7	28.0	26.3	24.0	20.3	18.0	16.8	17.8	19.7	21.6	24.0	26.4	28.8
MEAN DAILY MAXIMUM	1930-1970	23.5	24.0	22.6	19.8	16.5	13.9	13.3	14.5	16.2	17.9	19.9	22.0	18.7
NORMAL	1931-1960	17.3	17.8	16.3	13.8	11.0	8.7	8.1	9.2	10.7	12.6	14.2	16.0	13.0
MEAN DAILY MINIMUM	1930-1970	11.5	12.0	10.6	8.3	5.7	3.7	3.0	4.1	5.4	7.3	8.9	10.6	7.6
MEAN MONTHLY/ANNUAL MINIMUM	1930-1970	4.9	5.3	3.1	0.7	-2.0	-4.0	-4.1	-3.2	-1.2	0.8	2.5	3.8	-4.8
LOWEST MINIMUM	1930-1970	1.1	1.7	-2.0	-3.9	-5.0	-9.9	-5.9	-5.5	-4.1	-2.2	-0.6	-2.2	-9.9
MEAN DAILY RANGE	1930-1970	12.0	12.0	12.0	11.5	10.8	10.2	10.3	10.4	10.8	10.6	11.0	11.4	11.1
MEAN DAILY GRASS MINIMUM	1930-1970	8.3	8.7	7.1	5.1	2.4	0.5	-0.4	0.6	1.8	4.1	5.8	7.4	4.3
DAYS WITH FROST														
GROUND FROST AVERAGE	1939-1970	0.1	0.2	0.8	2.8	5.5	8.7	10.8	9.1	6.0	3.0	1.1	0.6	48.7
FROST IN SCREEN AVERAGE	1939-1970	.	.	0.8	0.4	1.7	4.1	5.0	3.1	1.2	0.2	.	0.1	16.6
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1936-1970	19.0	18.9	17.3	14.4	11.3	8.8	7.8	8.8	10.9	13.5	15.8	17.8	13.7
AVERAGE AT 0.30 METRES	1946-1970	19.8	20.1	18.8	16.3	13.3	10.9	9.5	10.1	11.8	14.2	16.4	18.4	15.0
AVERAGE AT 0.91 METRES	1921-1970	18.2	18.8	18.5	17.2	15.1	12.9	11.3	11.0	11.9	13.4	15.2	16.8	15.0
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1928-1970	73	76	79	84	88	88	88	85	81	77	73	73	80
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1928-1970	16.2	16.6	15.5	13.7	11.3	9.6	9.0	9.9	11.1	12.4	13.5	15.2	12.8
SUNSHINE. HOURS														
HIGHEST	1936-1970	315	247	227	191	187	151	161	184	203	236	261	263	2193
AVERAGE	1936-1970	227	188	179	156	127	109	120	142	162	175	203	215	2003
% OF POSSIBLE	1936-1970	51	50	47	48	41	39	40	44	46	44	49	48	47
LOWEST	1936-1970	124	136	134	83	95	53	77	104	107	104	155	137	1781

WIND														
DAILY WIND RUN (KILOMETRES)	1936-1970	182	172	158	150	153	150	156	171	180	193	196	188	171
AVERAGE NO. OF DAYS WITH														
GUSTS 34 KNOTS OR MORE	1945-1952**	0.4	0.9	1.8	1.6	2.1	2.2	2.0	2.6	2.0	2.4	2.2	2.4	22.6
GUSTS 52 KNOTS OR MORE	1945-1952**	.	.	.	.	0.2	.	0.2	0.1	.	0.1	.	.	0.6
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1923-1970	.	.	.	.	.	.	.	.	.	.	.	.	.
AVERAGE NO. OF DAYS WITH HAIL	1923-1970	.	.	0.1	0.1	0.2	0.3	0.2	0.5	0.3	0.4	0.2	0.2	2.5
AVERAGE NO. OF DAYS WITH THUNDER	1923-1970	1.2	0.9	1.0	0.7	0.8	1.0	0.5	1.0	0.8	1.0	1.2	1.3	11.4

* refers to observations at Rukuhia
** refers to observations at Hamilton Aerodrome

E94333 STRATFORD DEM.FARM LAT. 39 20S LONG. 174 18E HT. 311 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1960-1970	259	234	232	285	303	378	338	498	440	426	405	259	2691
NORMAL	1941-1970	135	147	137	150	206	221	221	213	183	201	165	170	2149
LOWEST MONTHLY/ANNUAL TOTAL	1960-1970	66	53	21	49	102	151	84	112	76	14	67	46	1644
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1960-1970	27.3	26.8	26.6	24.0	18.8	16.1	16.6	16.5	17.8	21.6	22.1	27.8	27.8
MEAN MONTHLY/ANNUAL MAXIMUM	1960-1970	25.0	24.9	24.4	20.5	17.2	15.1	14.3	14.9	16.6	19.0	20.8	23.5	26.0
MEAN DAILY MAXIMUM	1960-1970	20.5	20.7	19.4	16.6	13.8	11.4	10.8	11.6	13.2	15.3	16.6	19.1	15.7
NORMAL	1931-1960	15.1	15.3	14.6	12.3	9.7	7.5	6.7	7.2	9.0	10.6	12.6	14.0	11.2
MEAN DAILY MINIMUM	1960-1970	10.9	11.0	10.5	8.0	6.0	4.2	3.4	4.2	5.4	6.6	7.8	9.6	7.3
MEAN MONTHLY/ANNUAL MINIMUM	1960-1970	5.7	5.4	4.3	1.8	0.0	-1.0	-2.2	-1.3	-0.2	0.9	2.0	3.8	-2.4
LOWEST MINIMUM	1960-1970	4.0	3.1	1.4	-0.3	-1.4	-2.8	-3.9	-2.1	-1.6	-1.6	-0.6	1.7	-3.9
MEAN DAILY RANGE	1960-1970	9.6	9.7	8.9	8.6	7.8	7.2	7.4	7.4	7.8	8.7	8.8	9.5	8.4
MEAN DAILY GRASS MINIMUM	1960-1970	7.8	7.6	7.0	4.3	2.3	-0.5	0.1	2.4	2.3	3.1	4.5	6.5	4.0
DAYS WITH FROST														
GROUND FROST AVERAGE	1960-1970	.	0.1	0.7	4.4	9.2	12.3	15.2	13.0	8.8	6.4	2.1	0.9	73.1
FROST IN SCREEN AVERAGE	1960-1970	.	.	.	0.2	1.0	2.4	4.8	2.5	1.4	0.4	0.1	.	12.8
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1960-1970	17.3	17.2	15.5	12.3	12.1	6.9	5.9	6.8	8.8	11.6	13.6	16.6	12.0
AVERAGE AT 0.30 METRES	1960-1970	18.2	18.1	16.8	14.1	11.1	8.8	7.6	8.3	9.9	12.3	14.3	16.9	13.0
AVERAGE AT 0.91 METRES	1960-1970	16.0	16.7	16.6	15.9	13.7	11.7	10.1	9.6	10.2	11.3	12.9	14.6	13.3
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1960-1970	79	80	83	84	87	88	88	86	82	79	78	78	83
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1960-1970	15.2	15.3	14.8	12.5	12.1	9.4	8.8	9.3	10.2	11.4	12.1	14.1	12.1
WIND														
DAILY WIND RUN (KILOMETRES)	1963-1970	259	248	229	243	238	227	225	278	278	280	315	303	260
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1960-1970	.	.	.	.	0.1	0.2	0.2	0.1	.	.	.	.	0.6
AVERAGE NO. OF DAYS WITH HAIL	1960-1970	.	.	0.1	0.2	0.6	0.6	0.6	0.5	1.3	1.0	0.4	0.4	5.7
AVERAGE NO. OF DAYS WITH THUNDER	1960-1970	1.5	0.2	1.4	0.1	0.9	0.6	0.4	0.4	0.6	0.8	1.2	1.3	9.4

150831 TAIERI INVERMAY LAT. 45 51S LONG. 170 22E HT. 24 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1943-1970	166	123	196	260	191	169	132	71	185	117	134	126	882
NORMAL	1941-1970	69	53	69	61	61	61	53	41	43	51	64	61	687
LOWEST MONTHLY/ANNUAL TOTAL	1943-1970	23	15	18	18	19	8	5	9	4	14	30	18	488
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1943-1970	10	9	8	9	8	8	8	8	8	10	11	11	108
MAXIMUM 1-DAY RAINFALL MM.	1943-1970	70	43	73	64	77	47	62	31	50	37	36	39	77
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1943-1971	5	3	5	10	20	25	23	13	13	5	5	3	130
AVERAGE DEFICIT (MM)	1943-1971	18	18	10	5	3	.	.	.	.	3	3	3	63
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1942-1970	33.7	34.6	34.2	28.9	24.3	20.4	19.8	22.3	24.3	27.9	30.8	30.7	34.6
MEAN MONTHLY/ANNUAL MAXIMUM	1942-1970	29.2	29.7	28.0	24.0	20.2	16.4	16.5	18.5	21.6	24.0	26.0	27.3	31.3
MEAN DAILY MAXIMUM	1942-1970	20.3	20.4	18.7	16.0	12.8	10.3	10.0	11.8	14.1	16.1	17.7	18.9	15.6
NORMAL	1931-1960	14.6	14.4	13.1	10.6	7.6	5.7	4.8	6.3	8.3	10.3	12.2	13.5	10.1
MEAN DAILY MINIMUM	1942-1970	9.0	8.6	7.6	5.0	2.4	0.8	-0.1	0.9	2.8	5.0	6.5	8.1	4.7
MEAN MONTHLY/ANNUAL MINIMUM	1942-1970	3.1	1.9	1.2	-1.3	-4.0	-4.7	-5.6	-3.8	-2.8	-1.2	0.4	2.0	-6.1
LOWEST MINIMUM	1942-1970	-0.1	-1.0	-2.1	-3.9	-8.4	-7.3	-8.4	-6.4	-5.0	-3.5	-1.9	-1.1	-8.4
MEAN DAILY RANGE	1942-1970	11.3	11.8	11.1	11.0	10.4	9.5	10.1	10.9	11.3	11.1	11.2	10.8	10.9
MEAN DAILY GRASS MINIMUM	1943-1970	6.8	6.3	5.0	2.4	-0.4	-1.9	-2.6	-2.0	0.0	2.2	4.0	5.9	2.1
DAYS WITH FROST														
GROUND FROST AVERAGE	1943-1970	0.5	1.0	2.8	7.1	15.1	20.0	22.4	20.0	14.1	7.9	3.1	1.3	115.3
FROST IN SCREEN AVERAGE	1943-1970	.	0.1	0.4	2.5	8.1	11.8	15.6	11.6	5.5	1.6	0.6	0.1	57.9
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1945-1970	15.1	14.4	12.5	9.3	6.2	3.9	2.9	3.9	6.3	9.3	11.9	14.1	9.1
AVERAGE AT 0.30 METRES	1945-1970	16.0	15.9	14.3	11.4	8.3	6.2	4.5	5.5	7.7	10.3	12.7	14.8	10.6
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1942-1970	67	71	76	79	82	80	82	79	72	67	64	66	74
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1942-1970	11.9	12.2	11.5	9.7	7.9	6.7	6.4	6.9	7.9	9.0	9.9	11.2	9.3
SUNSHINE. HOURS														
HIGHEST	1950-1962	248	188	177	178	141	123	111	156	187	189	222	237	1890
AVERAGE	1950-1962	188	161	138	124	107	92	102	129	151	166	160	171	1689
% OF POSSIBLE	1950-1962	40	41	36	39	37	36	37	42	44	41	36	35	39
LOWEST	1950-1962	129	127	115	77	80	62	85	100	99	124	115	109	1549

WIND														
AVERAGE NO. OF DAYS WITH														
GUSTS 34 KNOTS OR MORE	1940-1965	5.2	5.0	4.3	4.1	4.1	4.2	2.8	3.1	4.7	5.8	6.1	5.0	54.4
GUSTS 52 KNOTS OR MORE	1940-1965	0.2	0.1	0.1	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.4	0.2	2.7
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1943-1960	.	.	.	0.2	0.3	1.4	1.4	0.7	0.8	0.2	0.1	.	5.1
AVERAGE NO. OF DAYS WITH HAIL	1942-1960	0.3	0.3	0.4	0.5	0.5	1.0	0.4	0.7	1.0	1.2	1.2	1.3	8.8
AVERAGE NO. OF DAYS WITH THUNDER	1943-1960	0.9	0.3	0.1	0.2	0.1	.	.	0.1	0.2	0.4	1.7	1.4	5.4

I49591 TARA HILLS,OMARAMA LAT. 44 32S LONG. 169 54E HT. 488 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1949-1970	136	133	120	154	115	91	88	130	204	110	137	148	770
NORMAL	1941-1970	64	56	53	43	41	30	28	30	36	48	48	56	533
LOWEST MONTHLY/ANNUAL TOTAL	1949-1970	18	5	7	3	7	3	7	5	3	2	11	7	391
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1949-1970	6	6	7	6	7	5	5	6	6	7	7	7	75
MAXIMUM 1-DAY RAINFALL MM.	1949-1970	87	47	29	66	52	31	39	49	53	42	45	58	87
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1950-1970	3	.	.	3	5	13	18	20	13	10	5	3	93
AVERAGE DEFICIT (MM)	1950-1970	36	33	25	15	3	.	.	.	.	3	13	33	161
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1949-1970	34.4	32.4	30.0	27.2	20.6	17.2	15.2	19.2	21.0	26.4	29.7	32.3	34.4
MEAN MONTHLY/ANNUAL MAXIMUM	1949-1970	30.4	29.4	27.1	22.2	17.6	14.0	12.7	15.2	19.2	23.4	25.1	28.6	31.4
MEAN DAILY MAXIMUM	1949-1970	23.0	22.7	19.8	15.8	10.8	7.4	6.3	9.3	13.4	16.7	18.7	21.3	15.4
NORMAL	1931-1960	15.7	15.4	12.7	9.3	5.2	2.3	1.3	3.7	6.7	9.6	12.0	14.1	9.0
MEAN DAILY MINIMUM	1949-1970	8.6	8.4	6.8	3.2	0.1	-2.6	-3.8	-1.8	0.7	3.1	5.1	7.3	2.9
MEAN MONTHLY/ANNUAL MINIMUM	1949-1970	2.3	1.7	-0.2	-3.3	-6.0	-7.8	-9.0	-6.6	-4.8	-2.8	-1.3	0.7	-9.5
LOWEST MINIMUM	1949-1970	-0.2	-1.7	-4.1	-6.1	-9.4	-11.2	-17.9	-10.8	-8.2	-5.6	-4.2	-1.7	-17.9
MEAN DAILY RANGE	1949-1970	14.4	14.3	13.0	12.6	10.7	10.0	10.1	11.1	12.7	13.6	13.6	14.0	12.5
MEAN DAILY GRASS MINIMUM	1949-1970	6.6	6.4	4.9	1.0	-2.0	-4.8	-5.6	-3.8	-1.6	0.6	2.7	5.4	0.8
DAYS WITH FROST														
GROUND FROST AVERAGE	1949-1970	0.7	0.6	3.0	11.3	20.1	26.5	28.9	26.6	19.5	12.8	5.4	1.9	157.3
FROST IN SCREEN AVERAGE	1949-1970	0.1	0.2	1.3	6.6	15.3	23.5	27.1	22.9	13.3	6.2	2.4	0.4	119.3
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1949-1970	16.7	15.8	12.8	8.3	3.9	1.1	0.2	1.8	4.8	9.2	12.9	15.9	8.6
AVERAGE AT 0.30 METRES	1949-1970	18.4	17.8	15.2	10.8	6.2	2.9	1.6	3.1	6.3	10.3	13.7	16.6	10.2
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1949-1970	59	63	70	75	83	84	87	83	71	62	58	58	71
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1949-1970	10.6	10.9	10.2	8.3	6.6	5.3	5.1	5.9	6.9	7.8	8.5	9.7	8.0
WIND														
DAILY WIND RUN (KILOMETRES)	1949-1970	304	282	246	230	193	180	167	182	232	285	315	315	244
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1949-1970	0.1	0.1	0.3	0.6	1.0	2.1	2.3	1.2	1.3	0.8	0.3	0.1	10.2
AVERAGE NO. OF DAYS WITH HAIL	1949-1970	0.1	.	0.1	0.1	.	0.1	0.1	.	0.1	0.2	0.2	0.3	1.3
AVERAGE NO. OF DAYS WITH THUNDER	1949-1970	1.1	0.4	0.5	0.4	0.2	0.1	.	0.1	0.4	0.6	0.6	1.1	5.5

SPECIAL PHENOMENA

AVERAGE NO. OF DAYS WITH SNOW	1947-1970	.	.	.	.	.	.	.	0.1	0.1	.	.	.	0.2
AVERAGE NO. OF DAYS WITH HAIL	1947-1970	.	.	0.1	.	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	1.2
AVERAGE NO. OF DAYS WITH THUNDER	1947-1970	1.0	0.4	0.3	0.3	0.4	0.3	0.1	0.3	0.2	0.4	0.7	0.9	5.3

* includes observations from rainfall sites

B76621 TAURANGA AERODROME LAT. 37 40S LONG. 176 12E HT. 4 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1898-1970*	532	343	297	383	311	381	348	247	256	357	285	447	2049
NORMAL	1941-1970	84	84	114	114	137	132	137	137	107	114	84	104	1348
LOWEST MONTHLY/ANNUAL TOTAL	1898-1970*	1	8	5	10	13	19	2	14	16	11	14	4	779
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1941-1970	7	7	9	9	11	11	12	13	10	11	9	9	118
MAXIMUM 1-DAY RAINFALL MM.	1910-1970*	134	160	96	239	116	164	135	97	156	130	105	163	239
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1910-1970*	18	30	30	53	79	104	107	97	63	66	30	36	713
AVERAGE DEFICIT (MM)	1910-1970*	20	23	15	3	.	.	.	.	.	.	3	5	69
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1913-1970*	33.3	31.1	30.3	27.9	23.9	21.9	22.8	20.0	24.7	25.6	28.3	30.6	33.3
MEAN MONTHLY/ANNUAL MAXIMUM	1941-1970	28.5	27.5	25.9	23.5	20.2	18.2	17.3	17.7	19.7	21.7	24.2	26.3	29.1
MEAN DAILY MAXIMUM	1941-1970	23.6	23.8	22.4	19.9	16.9	14.7	14.1	14.7	16.2	17.9	20.1	21.9	18.8
NORMAL	1931-1960	18.5	18.8	17.3	15.0	12.1	9.9	9.2	10.0	11.4	13.3	15.2	17.1	14.0
MEAN DAILY MINIMUM	1941-1970	13.6	14.2	12.8	10.1	7.7	5.4	4.6	5.6	7.0	8.9	10.4	12.4	9.4
MEAN MONTHLY/ANNUAL MINIMUM	1941-1970	7.7	8.0	6.0	4.3	1.0	-0.7	-0.9	-0.2	1.2	2.9	4.4	6.6	-1.6
LOWEST MINIMUM	1913-1970*	3.3	1.7	0.7	-0.6	-5.3	-4.6	-4.2	-3.4	-4.6	-2.3	0.6	-0.3	-5.3
MEAN DAILY RANGE	1941-1970	10.0	9.6	9.6	9.8	9.2	9.3	9.5	9.1	9.2	9.0	9.7	9.5	9.4
MEAN DAILY GRASS MINIMUM	1941-1970	9.9	10.5	8.9	5.9	3.8	1.5	0.7	1.7	2.7	4.7	6.4	8.7	5.5
DAYS WITH FROST														
GROUND FROST AVERAGE	1929-1970*	0.2	0.1	0.5	0.2	7.6	12.0	14.0	11.8	7.9	4.0	1.1	0.4	59.8
FROST IN SCREEN AVERAGE	1913-1970*	.	.	.	.	0.6	2.0	3.0	1.4	0.5	0.1	.	.	7.6
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1964-1970	19.4	19.1	17.8	14.5	11.2	8.8	7.8	9.1	10.9	13.3	15.8	18.3	13.8
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1931-1970*	70	72	75	79	82	83	84	81	76	73	71	71	76
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1931-1970*	16.2	16.7	15.7	14.0	11.8	10.1	9.6	10.3	11.1	12.4	13.7	15.3	13.1
SUNSHINE. HOURS														
HIGHEST	1935-1970*	328	252	272	237	209	191	197	203	220	268	304	304	2478
AVERAGE	1935-1970*	251	209	204	179	156	138	150	162	181	201	226	240	2297
% OF POSSIBLE	1935-1970*	57	56	54	55	51	49	50	50	52	50	54	53	54
LOWEST	1935-1970*	163	151	159	80	107	84	91	113	117	116	157	175	2022

WIND														
AVERAGE NO. OF DAYS WITH														
GUSTS 34 KNOTS OR MORE	1942-58/64-65/68-70	1.8	0.9	2.1	3.2	3.7	4.3	2.8	4.6	3.6	4.4	3.8	2.9	38.1
GUSTS 52 KNOTS OR MORE	1942-58/64-65/68-70	.	0.1	.	0.3	0.1	0.1	0.2	0.1	0.1	0.1	.	0.1	1.2
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH HAIL	1913-1970	.	.	.	.	0.1	0.1	0.1	0.3	0.1	0.3	0.3	0.1	1.4
AVERAGE NO. OF DAYS WITH THUNDER	1913-1970	0.8	0.6	0.6	0.6	0.7	0.5	0.3	0.9	0.4	0.9	1.0	0.6	7.9

* refers to observations at various sites

E15102 WALLACEVILLE LAT. 41 8S LONG. 175 3E HT. 56 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1924-1970*	253	275	256	246	389	317	259	250	323	280	336	253	1757
NORMAL	1941-1970	86	91	89	86	137	132	135	119	104	117	102	97	1295
LOWEST MONTHLY/ANNUAL TOTAL	1924-1970*	4	8	3	11	27	15	30	24	15	7	12	25	776
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1939-1970	7	7	9	10	13	13	14	13	11	11	11	10	130
MAXIMUM 1-DAY RAINFALL MM.	1939-1970	121	127	83	94	76	70	75	65	73	74	97	110	127
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1940-1970	20	23	15	23	86	104	107	91	61	66	48	23	667
AVERAGE DEFICIT (MM)	1940-1970	8	8	5	3	.	.	.	.	.	.	.	.	24
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1939-1970	29.1	30.7	28.9	25.9	23.0	19.2	18.3	20.0	22.7	25.9	25.8	29.3	30.7
MEAN MONTHLY/ANNUAL MAXIMUM	1939-1970	26.4	26.5	25.4	22.1	19.5	16.7	15.7	16.5	18.8	20.4	22.6	24.8	27.4
MEAN DAILY MAXIMUM	1939-1970	21.5	21.5	20.2	17.5	14.7	12.4	11.8	12.6	14.5	16.1	17.9	20.1	16.7
NORMAL	1931-1960	15.9	16.2	14.7	12.3	9.9	7.4	6.9	8.4	9.6	11.2	13.0	14.8	11.7
MEAN DAILY MINIMUM	1939-1970	11.5	11.6	10.2	7.9	5.5	3.4	2.7	3.6	5.4	7.3	8.9	10.6	7.4
MEAN MONTHLY/ANNUAL MINIMUM	1939-1970	4.1	3.6	2.0	-0.2	-2.1	-3.9	-3.8	-3.4	-1.9	-0.2	1.0	3.1	-4.6
LOWEST MINIMUM	1939-1970	0.6	0.9	-0.9	-3.1	-4.9	-7.2	-6.1	-6.7	-5.5	-2.5	-1.5	-0.3	-7.2
MEAN DAILY RANGE	1939-1970	10.0	9.9	10.0	9.6	9.2	9.0	9.1	9.0	9.1	8.8	9.0	9.5	9.3
MEAN DAILY GRASS MINIMUM	1939-1970	8.7	8.8	7.2	4.8	3.0	0.8	0.0	0.7	2.4	4.6	6.3	7.9	4.6
DAYS WITH FROST														
GROUND FROST AVERAGE	1939-1970	0.4	0.6	2.1	5.0	8.6	12.3	14.7	13.1	22.7	5.3	2.0	1.1	87.9
FROST IN SCREEN AVERAGE	1939-1970	.	.	0.1	1.1	3.6	7.9	10.1	7.4	3.8	1.2	0.2	.	35.4
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1939-1970	15.6	15.9	15.8	12.8	9.8	7.3	6.2	7.1	9.4	12.2	14.8	15.5	11.9
AVERAGE AT 0.30 METRES	1939-1970	19.1	18.9	17.4	14.7	11.7	9.3	8.1	8.7	10.7	13.1	15.3	17.6	13.7
AVERAGE AT 0.91 METRES	1939-1970	18.1	18.4	17.6	15.7	13.2	10.9	9.6	9.4	10.7	12.7	14.7	16.6	14.0
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1939-1970	69	72	77	81	84	85	85	83	77	73	70	70	77
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1939-1970	14.5	14.8	14.0	12.3	10.5	8.9	8.5	9.0	10.0	11.1	12.0	13.5	11.6
SUNSHINE. HOURS														
HIGHEST	1939-1970	281	263	228	192	155	147	132	174	235	222	252	300	2057
AVERAGE	1939-1970	226	194	183	147	113	97	98	125	151	169	192	212	1907
% OF POSSIBLE	1939-1970	50	51	48	45	38	36	34	39	43	42	45	46	44
LOWEST	1939-1970	157	127	142	93	72	52	60	83	106	102	115	160	1616

WIND														
DAILY WIND RUN (KILOMETRES)	1955-1970	229	214	187	187	188	164	169	183	203	235	266	235	205
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1939-1970	.	.	.	.	.	0.2	0.2	.	0.1	0.1	.	.	0.6
AVERAGE NO. OF DAYS WITH HAIL	1939-1970	0.1	.	0.1	0.2	0.4	0.7	0.3	0.2	0.3	0.4	0.2	.	2.9
AVERAGE NO. OF DAYS WITH THUNDER	1939-1970	0.3	0.1	0.3	0.3	0.2	0.7	0.4	0.3	0.4	0.4	0.5	0.2	4.1

* includes observations at rainfall station

E95902 WANGANUI LAT. 39 56S LONG. 175 3E HT. 22 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL. MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1890-1970*	189	216	159	237	243	250	209	186	141	187	178	185	1243
NORMAL	1941-1970	69	64	61	74	86	91	81	76	58	81	69	89	899
LOWEST MONTHLY/ANNUAL TOTAL	1890-1970*	0	8	7	13	8	8	15	17	12	10	18	7	635
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1937-1970	8	7	8	9	11	12	12	11	9	11	9	10	117
MAXIMUM 1-DAY RAINFALL MM.	1937-1970	91	89	54	60	43	52	41	47	38	46	51	65	91
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1937-1970	8	8	.	5	30	53	53	48	23	28	15	15	286
AVERAGE DEFICIT (MM)	1937-1970	18	25	20	8	.	.	.	.	.	.	3	5	79
TEMPERATURE. DEGREES CELSIUS														
HIGHEST MAXIMUM	1937-1970	30.1	30.1	30.4	31.1	24.2	19.7	19.8	20.5	22.1	26.8	29.3	29.4	31.1
MEAN MONTHLY/ANNUAL MAXIMUM	1937-1970	27.1	27.5	26.4	24.2	20.5	17.6	16.8	17.9	19.9	21.9	24.3	25.9	28.6
MEAN DAILY MAXIMUM	1937-1970	21.8	22.2	20.9	18.3	15.5	13.1	12.4	13.5	15.1	16.7	18.7	20.5	17.4
NORMAL	1931-1960	17.6	18.0	16.6	14.4	11.6	9.4	8.5	9.4	11.1	12.9	14.7	16.6	13.4
MEAN DAILY MINIMUM	1937-1970	13.6	13.8	12.7	10.3	7.9	5.9	4.8	5.7	7.4	9.1	10.7	12.5	9.5
MEAN MONTHLY/ANNUAL MINIMUM	1937-1970	8.1	8.1	6.8	4.3	2.0	0.1	-0.5	0.2	1.7	3.7	5.3	7.5	-1.1
LOWEST MINIMUM	1937-1970	5.6	5.0	3.0	1.6	-1.2	-1.7	-1.9	-1.5	-0.4	0.7	2.1	3.4	-1.9
MEAN DAILY RANGE	1937-1970	8.2	8.4	8.2	8.0	7.6	7.2	7.6	7.8	7.7	7.6	8.0	8.0	7.9
MEAN DAILY GRASS MINIMUM	1937-1970	11.3	11.3	10.5	8.3	6.1	4.1	3.1	4.0	5.2	6.9	8.5	10.4	7.5
DAYS WITH FROST														
GROUND FROST AVERAGE	1937-1970	.	.	.	.	0.7	2.4	4.4	2.3	0.8	0.2	0.1	.	10.9
FROST IN SCREEN AVERAGE	1937-1970	.	.	.	.	0.1	0.7	2.2	0.6	0.2	.	.	.	3.8
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1963-1970	19.1	18.7	16.9	13.1	9.6	7.4	6.4	7.6	9.7	12.5	15.4	18.3	12.9
AVERAGE AT 0.30 METRES	1937-1970	20.7	20.4	18.6	15.3	12.0	9.2	8.2	9.1	10.9	13.7	16.6	19.1	14.5
AVERAGE AT 0.91 METRES	1937-1970	19.5	19.8	19.0	16.8	14.1	11.7	10.1	10.0	11.2	13.1	16.5	17.8	15.0
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1937-1970	67	70	73	77	80	83	83	79	79	70	66	67	75
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1937-1970	14.7	15.3	14.4	11.5	10.8	9.4	8.8	9.2	10.6	11.2	12.1	13.7	11.8
SUNSHINE. HOURS														
HIGHEST	1937-1970	303	275	244	230	174	141	159	191	224	258	281	290	2319
AVERAGE	1937-1970	243	206	190	163	133	110	120	148	163	188	215	229	2108
% OF POSSIBLE	1937-1970	54	54	50	50	44	40	41	46	47	47	51	50	49
LOWEST	1937-1970	185	141	104	105	69	68	68	106	106	138	140	165	1825

WIND														
DAILY WIND RUN (KILOMETRES)	1937-1970	286	267	246	241	240	246	227	238	256	286	301	296	261
AVERAGE NO. OF DAYS WITH														
GUSTS 34 KNOTS OR MORE	1955-1970**	5.9	4.3	5.4	5.4	8.0	8.0	6.1	6.3	6.1	7.9	9.3	6.3	79.0
GUSTS 52 KNOTS OR MORE	1955-1970**	0.2	0.1	0.3	0.9	1.1	0.9	0.8	0.6	0.6	0.4	0.6	0.6	7.1
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1937-1965	.	.	.	.	.	.	0.1	.	.	.	.	.	0.1
AVERAGE NO. OF DAYS WITH HAIL	1937-1970	0.1	0.1	.	0.2	0.3	0.4	0.4	0.7	0.4	0.2	0.3	.	3.1
AVERAGE NO. OF DAYS WITH THUNDER	1937-1970	0.3	0.3	.	0.3	0.4	0.6	0.1	0.4	0.4	0.2	0.4	0.3	3.7

* includes observations at rainfall site
** refers to observations at Wanganui Aerodrome

C75801 WHATAWHATA LAT. 37 49S LONG. 175 5E HT. 104 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL, MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1952-1970	184	369	294	321	249	467	261	239	293	261	332	255	2346
NORMAL	1941-1970	81	112	109	135	150	191	163	157	127	150	119	114	1608
LOWEST MONTHLY/ANNUAL TOTAL	1952-1970	21	27	23	27	107	56	83	95	42	36	37	69	1326
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1952-1970	8	8	10	12	14	16	15	15	13	14	12	11	147
MAXIMUM 1-DAY RAINFALL MM.	1952-1970	60	142	111	99	68	78	74	72	79	95	70	59	142
TEMPERATURE, DEGREES CELSIUS														
HIGHEST MAXIMUM	1952-1970	32.1	29.7	30.6	25.7	22.9	20.6	20.4	21.7	22.9	22.3	24.6	28.1	32.1
MEAN MONTHLY/ANNUAL MAXIMUM	1952-1970	27.1	27.9	26.7	23.4	20.1	18.0	16.8	17.6	19.7	20.8	23.1	25.6	28.6
MEAN DAILY MAXIMUM	1952-1970	23.0	23.7	22.1	19.4	16.2	13.8	13.1	14.2	15.7	17.2	18.9	21.3	18.2
NORMAL	1931-1960	17.8	18.1	16.8	14.2	11.4	9.0	8.4	9.6	11.0	12.9	14.6	16.4	13.3
MEAN DAILY MINIMUM	1952-1970	12.8	13.4	12.0	9.7	7.5	5.5	4.4	5.6	6.9	8.7	10.2	12.0	9.0
MEAN MONTHLY/ANNUAL MINIMUM	1952-1970	6.6	7.4	5.4	2.9	0.1	-1.6	-1.9	-1.3	0.8	2.6	3.7	5.8	-2.7
LOWEST MINIMUM	1952-1970	2.4	5.3	1.7	-1.1	-2.9	-3.3	-3.4	-3.3	-1.0	-0.3	0.6	2.9	-3.4
MEAN DAILY RANGE	1952-1970	10.2	10.3	10.1	9.7	8.7	8.3	8.7	8.6	8.8	8.5	8.7	9.3	9.2
MEAN DAILY GRASS MINIMUM	1952-1970	9.8	10.3	8.9	6.3	4.3	2.3	0.9	2.3	3.6	5.7	7.5	9.2	5.9
DAYS WITH FROST														
GROUND FROST AVERAGE	1952-1970	0.1	.	0.5	1.9	5.5	9.2	12.0	8.7	5.2	1.6	0.6	0.1	45.4
FROST IN SCREEN AVERAGE	1952-1970	.	.	.	0.2	0.9	3.3	4.4	2.3	0.4	.	.	.	11.5
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1952-1970	19.7	19.6	17.6	14.2	11.4	9.0	7.7	8.8	10.7	13.3	15.8	18.3	13.8
AVERAGE AT 0.30 METRES	1952-1970	20.1	20.3	19.1	16.6	13.8	11.6	10.2	10.8	12.3	14.2	16.4	18.6	15.3
AVERAGE AT 0.91 METRES	1952-1970	17.8	18.5	18.4	17.4	15.8	14.0	12.4	12.1	12.7	13.6	15.1	16.5	15.4
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1952-1970	74	78	80	83	87	88	88	85	82	79	75	75	81
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1952-1970	16.5	17.2	16.0	13.7	11.8	10.1	9.4	10.1	11.2	12.6	13.6	15.5	13.1
SUNSHINE, HOURS														
HIGHEST	1952-1970	290	231	204	186	165	126	146	170	181	232	250	246	2060
AVERAGE	1952-1970	217	180	171	147	112	97	109	127	148	168	190	203	1869
% OF POSSIBLE	1952-1970	49	48	45	45	36	34	37	39	42	42	45	45	43
LOWEST	1952-1970	131	151	139	77	86	71	67	103	102	99	151	113	1723

WIND														
DAILY WIND RUN (KILOMETRES)	1952-1970	261	235	229	220	204	217	200	225	253	277	285	270	240
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1952-1970	.	.	.	.	.	.	.	.	.	.	.	.	.
AVERAGE NO. OF DAYS WITH HAIL	1952-1970	0.1	0.1	0.1	0.2	0.5	0.4	0.6	0.7	0.3	0.6	0.5	0.1	4.2
AVERAGE NO. OF DAYS WITH THUNDER	1952-1970	1.3	0.5	1.2	0.9	1.5	1.3	0.1	1.0	0.9	1.0	1.5	1.7	12.9

H31883 WINCHMORE LAT. 43 48S LONG. 171 48E HT. 160 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL, MILLIMETRES														
HIGHEST MONTHLY/ANNUAL TOTAL	1947-1970	144	134	158	219	243	143	175	132	87	120	253	150	948
NORMAL	1941-1970	61	64	74	66	74	56	61	61	51	61	66	76	771
LOWEST MONTHLY/ANNUAL TOTAL	1947-1970	18	7	20	5	20	3	14	12	11	9	13	12	491
AVERAGE NUMBER OF DAYS WITH RAIN 1.0 MILLIMETRES OR MORE	1947-1970	8	6	8	7	8	6	8	7	6	7	8	8	86
MAXIMUM 1-DAY RAINFALL MM.	1947-1970	49	95	84	73	58	49	62	51	50	53	62	56	95
ESTIMATED WATER BALANCE														
AVERAGE RUNOFF (MM)	1947-1970	3	5	5	18	20	18	48	33	13	15	13	5	196
AVERAGE DEFICIT (MM)	1947-1970	33	28	13	10	.	.	.	.	.	.	5	13	102
TEMPERATURE, DEGREES CELSIUS														
HIGHEST MAXIMUM	1949-1970	35.9	34.0	31.4	27.9	23.9	19.3	19.7	21.1	23.2	26.4	31.6	31.1	35.9
MEAN MONTHLY/ANNUAL MAXIMUM	1949-1970	30.8	30.4	28.1	23.9	19.6	16.6	16.4	18.2	21.0	23.7	26.2	28.5	31.8
MEAN DAILY MAXIMUM	1949-1970	21.8	21.5	19.2	16.2	12.7	10.4	9.8	11.4	13.9	16.4	18.7	20.1	16.0
NORMAL	1931-1960	15.4	15.3	13.4	10.7	7.6	5.1	4.7	6.1	8.2	10.4	12.4	14.2	10.3
MEAN DAILY MINIMUM	1949-1970	9.9	9.9	8.5	5.7	2.7	0.3	-0.2	1.1	3.1	5.2	6.7	8.8	5.1
MEAN MONTHLY/ANNUAL MINIMUM	1949-1970	3.8	3.6	1.8	-0.4	-3.5	-4.9	-5.2	-4.5	-2.7	-0.8	0.4	3.0	-6.0
LOWEST MINIMUM	1949-1970	1.7	1.6	-0.4	-3.1	-8.4	-7.8	-7.7	-7.2	-6.2	-4.2	-2.1	0.7	-8.4
MEAN DAILY RANGE	1949-1970	11.9	11.6	10.7	10.5	10.0	10.1	10.0	10.3	10.8	11.2	12.0	11.3	10.9
MEAN DAILY GRASS MINIMUM	1949-1970	7.8	7.7	6.2	3.4	0.3	-2.5	-3.0	-1.9	0.3	2.5	4.2	6.7	2.6
DAYS WITH FROST														
GROUND FROST AVERAGE	1949-1970	0.3	0.2	1.4	6.2	13.7	21.0	22.8	19.9	13.2	7.7	3.9	0.9	111.2
FROST IN SCREEN AVERAGE	1949-1970	.	.	0.1	1.1	6.6	14.5	16.8	12.2	4.7	2.0	0.3	.	58.3
EARTH TEMPERATURES (DEGREES C)														
AVERAGE AT 0.10 METRES	1949-1970	16.6	15.7	13.3	10.1	6.4	3.6	2.8	3.9	6.7	10.2	13.3	15.4	9.8
AVERAGE AT 0.30 METRES	1949-1970	17.4	17.2	15.3	12.3	8.8	5.7	4.6	5.6	8.1	11.0	13.7	15.8	11.3
AVERAGE AT 0.91 METRES	1949-1970	16.7	16.9	15.9	13.7	10.7	7.8	6.1	6.4	8.2	10.6	13.1	15.1	11.8
RELATIVE HUMIDITY (%)														
AVERAGE AT 9 A.M.	1949-1970	65	69	77	80	83	81	81	80	73	68	62	66	74
VAPOUR PRESSURE (MBS)														
AVERAGE AT 9 A.M.	1949-1970	12.4	12.6	12.1	10.5	8.2	6.4	6.2	7.2	8.3	9.6	10.1	11.6	9.6
WIND														
DAILY WIND RUN (KILOMETRES)	1949-1970	330	311	283	269	253	230	241	264	296	330	357	346	293
SPECIAL PHENOMENA														
AVERAGE NO. OF DAYS WITH SNOW	1949-1970	.	.	.	.	0.2	0.4	0.8	0.5	0.7	0.2	0.1	.	2.9
AVERAGE NO. OF DAYS WITH HAIL	1949-1970	0.1	0.1	.	.	0.1	0.1	0.2	.	0.3	0.4	0.5	0.4	2.2
AVERAGE NO. OF DAYS WITH THUNDER	1949-1970	0.6	0.3	0.3	0.1	.	.	.	.	0.1	0.4	0.6	0.7	3.1

SECTION 25

INDEX

A

B

C

D

E

F

G

H

I

K

L

M

N

O

P

Q

R

S

T

U

V

W

X/Y/Z

Purchase orders to: Accounts Office,
Lincoln College,
Canterbury,
New Zealand.