Plan for Neridup Creek catchment Neridup Soil Conservation Group

Martyn G. Keen
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1. **Introduction**

This report was initiated at the request of the Neridup Soil Conservation Group as an aid to overcoming the degradation problems of the catchment known as the Neridup Creek Catchment.

Work was commenced on collecting data about the catchment in May 1990 and has continued on a part-time basis as workload has permitted.

This report outlines the physical details of the catchment, predicts runoff peak flows and contains recommendations as a framework for stable land use within the catchment.

Attached to this report are: a set of maps of physical details, a set of plans related to individual degradation problems requiring solutions and two Land Management Plans completed as examples of integrating this report's recommendations.

The solutions to the degradation problems of the Neridup Creek Catchment lie in Land Management Planning for individual properties. The recommendations in this report can be incorporated into these plans. Individual Land Management Plans will need to be finalized by the landholders but any design work for drainage, contouring or waterway defining will need to be done by the Department of Agriculture. Landcare Technician, contractors, surveyors or consultants can implement the designs on site with additional help from the Department of Agriculture where necessary.

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**Martyn G. Keen**  
**LAND CONSERVATION OFFICER**  
**DEPARTMENT OF AGRICULTURE, ESPERANCE**  
**06/01/92**
2. Catchment Description

2.1 Location (See Maps 1, 2 and 4).
The Neridup Creek has its origins 65 kilometres north-east of Esperance (see figure 1) and flows in a south westerly direction towards the southern ocean. It enters the inundated plain 15 kilometres north east of Esperance which is also the termination place of the Coramup Creek and the main Bandy Creek. On the southern side of the inundated plain are Wheatfield, Station, Mullet and Ewans Lakes with a continuation of Bandy Creek from Station Lake to the Southern Ocean. The main Neridup Creek from its origins to the inundated plain is marked "A" on map 4.

Flowing parallel to the Neridup Creek on its westerly side is another smaller catchment marked "B" on map 4. This flows to Plowman's Lake on Location 126 and hence to the Neridup Creek. During wetter years water from Plowman's Lake also flows via an old channel and an eroded firebreak into another catchment. This catchment is marked "C" on map 4. Flows from catchment "C" collect in a lake on locations 25 to 28 in the south west corner of this catchment and from there would overflow into Bandy Creek.

On the eastern side of Neridup Creek is a series of small catchments flowing to Tyrell's Lake on Location 132. The catchments are marked D, E and F on map 4. It is possible for Tyrell's Lake to overflow into the Neridup Creek. Some flows from Neridup Creek are capable of entering Tyrell's Lake depending on the rainfall event (see figure 2 for location of Plowman's and Tyrell's lakes).

A small internally drained catchment marked "G" on map 4 lies adjacent to the Neridup Creek.

2.1.1 Catchments - Areas (See Map 4 - Codes and Map 5 - Vegetation)
The area of each catchment or sub-catchment was calculated from micro-station digitized maps. With reference to map 4 the areas are:

<table>
<thead>
<tr>
<th>Area</th>
<th>Area in hectares</th>
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<tbody>
<tr>
<td>A</td>
<td>26826.24</td>
</tr>
<tr>
<td>B</td>
<td>4527.06</td>
</tr>
<tr>
<td>C</td>
<td>4566.35</td>
</tr>
<tr>
<td>D</td>
<td>2342.29</td>
</tr>
<tr>
<td>E</td>
<td>6564.54</td>
</tr>
<tr>
<td>F</td>
<td>2150.83</td>
</tr>
<tr>
<td>G</td>
<td>713.95</td>
</tr>
</tbody>
</table>

Catchments A & B flow together and have a total area of 31353.3 hectares. Of this area 82% is farming land the remainder is Crown Land. Of the farming land most is
cleared with the percentage of land cleared of native vegetation being as high as 99% on several locations. Likewise catchments D, E and F flow together and have a total area of 11057.66 hectares and 99.4% being farming land the remainder being Crown Land. Generally a larger percentage of the farming land here is uncleared as there are numerous lakes and swamps.

 Catchment C is 96.5% farming land but contains many swamps and lakes. Catchment G is 100% farming land with several large swamps. Both Catchments C and G therefore contain a percentage of uncleared land.

2.2 **Topography** (See Map 3)
Topographic/cadastral maps have been produced for the Neridup Creek area by the Department of Land Administration, Perth to a scale of 1:50,000. The contour interval is plotted on these at 10 metre intervals from stereo interpretation.

The highest topographic feature of the Neridup Creek area is Mount Burdett with an elevation of 260 metres. From here the land falls rapidly at an average grade of 2% to the 150 metre elevation. Many grades in this area can be greater than 4% especially adjacent to the Neridup Creek’s head waters.

Below the 150 metre interval the landscape slopes at a grade of 0.16% to the 100 metre interval, from there at a grade of 0.33% to the 80 metre interval and from here at a grade of 0.43% to the edge of the inundated plain at the 30 metre interval.

2.3 **Natural Drainage** (See Map 2).
The Neridup Creek has a main stream length of approximately 48 kilometres from the edge of the inundated plain to its origins near Mt. Burdett. Its mainstream and tributaries are quite well defined where the landscape slopes at grade of 0.4% and above. These grades occur in the areas of the creek’s head waters and leading into the inundated plain.

The middle section of the creek is poorly defined and can be divided into two parts. The upper middle section which is Crown Land is a series of inundated clay flats, salt lakes and swamps. The area immediately below this is a series of parallel waterways across a wide flood plain.

The whole system has now become overloaded by increased runoffs associated with the clearing of the landscape for agriculture. The main channel is deeply eroded on locations 135 and 146. In saline areas the main channel is bare of vegetation and exhibits the potential for erosion during high runoff events. The main channel is only double fenced for 2% of its total length, the remainder being open to stock. In most places the main channel was cleared for agricultural use.
The two subcatchments running parallel to the Neridup Creek also have ill-defined main waterways which cannot contain the increased runoff associated with clearing.

Green’s Road and Backman’s Road have both modified the flows of the subcatchments. Nearly all of the waterways in the subcatchments were cleared for agricultural use.

2.4 Geology (see map 7: Geological Sheet SI/51-6).
The Neridup Creek Catchment area was mapped geologically between 1965 and 1967 as part of the 1:250,000 Geological Sheet (SI/51-6). The Geological Sheet has explanatory notes titled Esperance-Mondrain Island.

The geology of the Esperance area can be summarised as:

1. The deposition of a thick pile of geosynclined sediments (into a trough) which were subsequently intruded by basic dykes and sills.

2. A period of regional metamorphism took place during which these sediments were metamorphosed to a heterogeneous gneissic migmatite; heterogeneous in that there was substantial metamorphic differentiation within the unit. This was associated with intense folding and shearing.

3. The emplacement of granite to the east of Esperance with the development of a wide zone of migmatite along the contact with the gneissic migmatite. The migmatite lies north-south through Esperance varying in width from 10-30 kilometres. The geological age of these formations is Proterozoic. (See figure 1a).

4. The above was overlain with Werrilup Formation of grey foraminiferal clayey sandstones and dark grey carbonaceous siltstones and sandstones. The Werrilup Formation was then overlain by yellow to grey claystones, siltstones, silty sandstones and sponge mollusca fossils of the Palinup Formation. The age of these formations is thought to be Tertiary with the sea level at this time being 250 metres higher than its present level.

5. A lowering of the sea level stripped inland surfaces, exposed deeper zones of weathering and rejuvenated drainage lines.

6. Further deposition took place in the Pleistocene period to form sandplain deposits and red soil plains etc., with foredunes, coastal dunes and coastal hill dunes etc. being deposits in the recent period (Figure 1b shows the landscape in cross section).
Diagram 1a. LOCATION OF BASEMENT ROCK

Diagram 1b. CROSS SECTION OF LANDFORM THROUGH NERIDUP CREEK.
(Looking North-East)
From the Geological mapsheet it is possible to discern the composition of Mount Burdett and the Wittenoom Hills as Migmatite. Also the exposed rock on location 292 is granite. Migmatite is marked as being present over a large area on locations 283 and 287 along with its basic dykes. Similarly migmatite and basic dykes are marked on locations 109 and 110. On the ground both areas exhibit large bedrock high and dyke induced salinity.

2.5 Atlas of Australian Soils (see map 8)
The soils of the Neridup Creek Catchment area are described on Sheet 5 of the Atlas of Australian Soils and detailed in the Explanatory Data for the same sheet.

The sheet shows associations of soils generally delineated by landscape, with descriptions of each landscape together with component soils being given in the Explanatory Data. The soils being classified according to "A Factual Key to the Recognition of Australian Soils".

The three landscapes detailed for the Neridup Creek Catchment area are Xd1, Ya29 and a small unit of Ca26.

Unit Xd1 is described as a gently undulating plain with small granite hills; with some flats, seasonal swamps and lakes; and some more strongly undulating land adjacent larger waterways. The main soils of this unit are sandy neutral duplex soils with yellow mottled clays – Dy 5.82 containing variable amounts of ironstone (lateritic) gravel. Grading into this soil are uniform soils of leached sands, sometimes containing lateritic gravel – Uc2-21 and Uc2-22.

Associated soils of unit Xd1 are on the plain – Dy 5.84, in season swamps – Dy 5.43, in shallow valleys – Dy 5.42, in depressions – Dy 2.42 and Dy 2.43 and in some seasonally waterlogged areas – Ug 5.2 and Ug 5.5.

Unit Ya 29 is described as a gently undulating plain with seasonal lakes and clay pans, lunettes and dunes. Calcrete underlies the soils in places and acid clay commonly occur at depths. The main soils are sandy alkaline duplex soils with yellow mottled clays – Dy 4.43, Dy 4.83, Dy 5.43 and Dy 5.83. Hard setting surface soils Dy 2.43, Dy 2.83, Dy 3.43 and Dy 3.83 are also common.

Associated soils of the Ya 29 unit are on the plains Gc1.12; and on dunes and lunettes – Uc 2.21 and Uc 1.23.

The unit Ca 26 is an area of leached sands – Uc 2.22 associated with the Wittenoom Hills and Mount Burdett.

From the above the classification Dy 5.82 can be expanded into:

1. Duplex soil with yellow mottled "B" horizon.
3. Few peds evident in "B" horizon.
4. A₂ horizon present and conspicuously bleached.
5. No continuous layer of laterite or boulders between "A" and "B" horizons.
6. Neutral soil reaction trend (Ph).

Soils with local names Fleming gravelly sand, Fleming sand and some sandplain soils fall into this classification.

Likewise the classification Dy 4.83 can be expanded into:

1. Duplex soil with yellow whole coloured "B" horizon.
3. Few peds evident in "B" horizon.
4. A₂ horizon evident and conspicuously bleached.
5. No continuous laterite or boulder layer between "A" and "B" horizons.
6. Alkaline soil reaction trend (Ph).

The locally named soil Circle Valley Sand falls into this classification.

Further information can be obtained from the Bulletin 4230 - "An Introduction to Soils of the Esperance Advisory District" compiled by T.C. Stoneman, T.D. Overheu and P.G. Muller published by the W.A. Department of Agriculture.

3. **Land Degradation and Suggested Treatments**

Flooding, Waterlogging, Water Erosion and Salinity were listed by the landholders as the main degradation problems of the catchment. Wind erosion of flooded or waterlogged areas during dry periods was listed as a secondary degradation problem.

Some of the areas suggested as waterlogged by landholders are in fact flooded areas. Waterlogging could best be described as saturated soil. These areas may be on level ground or sloping ground. Flooding can be as a sheet of water moving across flat or sloping land or as a static pool with water having flowed from sloping land to fill a depression.

3.1 **Treatment of Degradation Problems Caused by Flooding.**

The main flows down the Neridup Creek cause flooding of farming land on both sides of the creek. In many places the land used for farming has encroached too close to the creek. In other places the creek is too ill defined to contain the present flows. The bed of the Neridup Creek is also unstable for most of its length. Many smaller
creeks also flood similarly and many of these have been completely cleared for farming.

These flooding problems can be overcome by the setting aside of a designed width of land about the natural depression where water floods and using this as a waterway. Levees need to be constructed to confine the water flows to the designed width. The waterway can then be treated with pasture species if grass cover is insufficient and trees can be planted both sides of the waterway outside of the levees or designed width. The whole can then be double fenced to exclude stock and maintain stability. The fire risk for the fenced off waterway can be reduced by short periods of grazing.

Flooding of depressions can be reduced by scraper drains or "W" drains connecting the depression to a stable waterway. This will allow revegetation of the depression to combat wind erosion. The flood level of small lakes and swamps can be regulated with scraper drains so as to maintain water in the lake or swamp but reduce the damage to vegetation or revegetation around the lake or swamp.

Flooding of lower areas of the catchment can be controlled to a large extent by construction of contour grade banks discharging into stable waterways in the upper catchment. This regulates the time of concentration of water flooding from the sloping land by lengthening the time taken by a given flood to move from the top of the catchment to the flatter land below.

3.2 Treatment of Waterlogging
Waterlogged areas on sloping land can be treated by interceptor grade banks which discharge into stable waterways. Those areas on flatter land can be treated by contour grade banks on the sloping land above. This diverts the water flooding onto the flatter land.

"W" drains and scraper drains constructed into waterlogged flatter areas can slump causing erosion and silting. Therefore drainage of this type should be shallow with gentle batters leading into the drainage. Pastures can then be promoted on drainage channels and batters.

3.3 Treatment of Water Erosion
Water erosion is present in creek lines on both sloping and flatter lands and in paddocks on sloping lands. Erosion of waterways can be controlled by double fencing and stabilizing the waterways channel with pasture species. While erosion of paddocks can be controlled by the construction of contour grade banks. Grade banks also regulate flooding from sloping land.

3.4 Treatment of Salinity
Salinity is caused by excess soil water mobilizing salts stored in the soil. This expresses itself on the land surface once the ground watertable has risen to within 2
metres of the land surface by affecting plant growth. The rise in ground watertable is caused by rainwater infiltrating past the root zone of shallow rooted annual crops and pastures which have replaced the deep rooted perennial natural vegetation with the advent of farming the area.

Geology also has an effect on salinity as areas of higher bedrock have less storage available for ground water. Bedrock highs and dykes also force ground water closer to the land surface if they act as a barrier to ground water movement.

Salinity is treated by restoring the balance between ground water recharge and plant water use. This is achieved by the maintenance of 20%-25% of a farming property to high water use vegetation (native vegetation, planted trees, fodder trees and shrubs etc). For properties with an annual average rainfall below 500 mm, 20% revegetation is suggested and for properties with annual average rainfalls above 500 mm, 25% revegetation is suggested.

The revegetation of areas of land which are: unsuitable for farming, effected by salinity, with shallow soil to rock, deep sand, deep gravel, adjacent to lakes and swamps, adjacent to natural waterways or are adjacent to man made waterways can be used to make up the 20-25% area required. Also areas around swamps and lakes, along property boundaries, adjacent to laneways and below contour grade banks can also be used to make up the percentage of revegetation. Areas affected by salinity can be planted to salt tolerant forage species.

4. 1989 Rainfall Event

4.1 Rainfall for 1989
From property rainfall records in the Neridup Creek area total rainfall for 1989 was 20% above average annual rainfall for the upper part of the catchment and 25% above average for the lower part of the catchment. The above average rains fell during the months April through July of that year.

The wettest month was June when between 115 and 160 millimetres fell on the catchment; most of this falling during the four days 14th-17th June. This followed a period of little rain from 1st June until 13th June. Rainfall continued from 17th June generally with falls of 20 to 25 mm over one to three day periods approximately at weekly intervals, until the first week of August.

4.2 Flooding from 1989 Rainfall Event
The above average rainfall commencing in April of 1989 quickly produced run-off on all soil types; filled depressions, swamps and lakes; and produced flows in creeks that flooded adjacent countryside.
Shire Roads were flooded adjacent to lakes and where creeks crossed at floodways or culverts. Many roads were closed for long periods of time and several creek crossings were badly damaged. Numerous sections of the main Neridup Creek were also badly eroded and previously eroded areas were further damaged. Paddock erosion also took place on the sloping lands in the upper catchment.

Water leaving Ploughman's Lake diverted down an eroded firebreak on the boundary of locations 126 and 134, flowed across Plowman's Road and flooded many properties below. Location 131 was flooded over nearly a third of the properties area by water flowing towards Tyrell's Lake. (see plan 2). The small internally drained catchment that is on location 118 was flooded to about a quarter of its area. (see plan 5).

4.3 Surveys and Recommendations Initiated by the 1989 Rainfall Event

4.3.1 Visit by M.G. Keen August 1989
I visited the catchment during the week 7-11th August 1989 at the request of the Officer in Charge of the Esperance Agricultural Centre on behalf of the Neridup Conservation Group. The main rainfall events had passed but many road were still cut and properties flooded.

Several properties were visited and recommendations were made regarding minor works. Recommendations were also given on the redefining of the waterway parallel and to the west of Green's Road so as to relieve the flows down this road. The problem of waters escaping from the Neridup Catchment via the eroded firebreak on the boundary of locations 126 and 134 was addressed. A site for a temporary diversion back into the Neridup Creek was chosen and the construction work completed the following week.

An aerial survey of the catchment showed how widespread the flooding problems to be and that the problem could only be addressed on a whole catchment approach.

4.3.2 Survey and Recommendations by G. Gath February 1990.
A survey of the Neridup's Catchment south of Plowman's Lake was initiated by the Neridup Soil Conservation Group in late 1989. The survey was undertaken by Graham Gath Surveys of Esperance and completed in February 1990.

The survey included the measuring of grades; assessing of cross sections and flows; assessing of damages; and designing of works to contain flooding and flows of the size of those experienced during the winter of 1988. Recommendations related to the Neridup Creek at and below Plowman's Lake.
FIGURE 2  LOCATION OF PLOWMAN'S AND TYRELL'S LAKES
5. Formulae Used to Estimate Runoff, Channel Flows and Waterway Dimensions.

5.1 Runoff Estimation
It is necessary to determine the runoff from the Neridup Catchment to assist with the evaluation of natural waterways, existing drainage works and drainage proposals. Peak runoff values can be determined for storms with return intervals of 2, 5, 10, 20 and 50 years. It is then possible to calculate from these peak runoff values the width of waterways and drains for various soil types. The peak runoff values can also be compared with information gathered from waterway cross sections, flow depth and velocities after a storm. This gives a comparison with return intervals when rainfall intensities for that storm are not available.

5.1.1 Runoff Formulae
Several different methods can be used to estimate peak runoff from a catchment. Each requires geographic, rainfall and physical data of the catchment. Each method has separate formulae for different locations within Australia and the correct formula must be used for the desired location.

It is possible to calculate peak runoff for the Neridup Catchment using; the Main Roads Department of Western Australia Method; The Flood Index Method; and the Rational Method from Australian Rainfall and Runoff. Australian Rainfall and Runoff outlines the use of Flood Index and Rational Methods to calculate peak flows for small and medium sized catchments. Small catchments having an upper area limit of 25 km² while the upper limit for medium sized catchments being 250 to 1000 km². The Neridup Catchment area falls within the limits of the medium sized catchments with an area of 313.54 km².

The formulae for the various methods used to calculate peak flows for the Neridup Catchment are:

(1) **MRD Method**

\[ Q_Y = 0.08A^{0.13} \times 10^{0.0052CL} \]

\[ C_{10} = \frac{0.278 \times 0.01}{10 \times 10} \times C_{10} \times C_{10} \times I_{ty} \times A \]

(2) **Flood Index Method**

\[ Q_5 = 3.04 \times 10^{-1} \times A^{0.60} \times 10^{0.0052CL} \]

(3) **Rational Method (Aust. Rainfall and Runoff)**

\[ C_{10} = 1.06 \times 10^{-1} \times L^{-0.32} \times 10^{0.0042CL} \]
and \[ Q_y = 0.278 \times C_{10} \times C_{10} \times I_{tcy} \times A \]

where \( C_{10} \) = 10 year return period coefficient
\( C_y \) = return period coefficient for \( y \) years
\( Q_5 \) = peak flow for 5 year return
\( Q_y \) = peak flow for \( y \) years
\( A \) = area of catchment
\( L \) = mainstream length
\( CL \) = area of catchment cleared as a percentage
\( I_{tcy} \) = design average rainfall intensity for a return interval of \( y \) years and duration \( tc \).
\( tc \) = time of concentration.

Both MRD and Rational Methods require calculations for time of concentration by the formula \( tc = 0.76cA^{0.38} \).

Peak flows for the Neridup Creek catchment were calculated using all three of the above methods for comparison. The results give estimates of peak flows at the lower end of Neridup Creek itself for 2, 5, 10 and 20 year return periods. These are the peak flows from the two catchments marked A and B on map 3 which flow together near Flowman's Road and hence to the lower end of the catchment. The total area of A and B catchments is 313.54 km² (see 2.1.1 Catchments-Areas).

**TABLE OF CALCULATED PEAK FLOWS**

<table>
<thead>
<tr>
<th>Return Interval</th>
<th>MRD</th>
<th>Flood Index</th>
<th>Rational</th>
<th>(Aust. Rainfall and Runoff)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>9.86</td>
<td>14.92</td>
<td>11.25</td>
<td>m³/sec</td>
</tr>
<tr>
<td>5</td>
<td>21.59</td>
<td>29.83</td>
<td>24.28</td>
<td>m³/sec</td>
</tr>
<tr>
<td>10</td>
<td>50.82</td>
<td>52.50</td>
<td>48.32</td>
<td>m³/sec</td>
</tr>
<tr>
<td>20</td>
<td>95.14</td>
<td>90.98</td>
<td>78.28</td>
<td>m³/sec</td>
</tr>
</tbody>
</table>

Each method gives similar results. The main differences being in the Flood Index Method 2 and 5 year returns and the 20 year return for the Rational Method (Aust. R and R). Australian Rainfall and Runoff suggests the rational method as an efficient form of regional flood frequency analysis as the method uses rainfall intensity of each region as an independent variable. It is thought to be less liable to errors in extrapolation where some of the input data may be beyond observed limits. It's results are similar to the other two methods with the Flood Index method being used in design work done by the Western Australian Department of Agriculture.
Most conservation structures are designed for a 20 year return period. The peak flows from the main Neridup Creek would be massive in the advent of a 20 year period. If structures are designed for a 2 year period with no allowance for larger return periods they can be damaged by the larger peak flows and in certain cases a greater degradation problem may result than the original one thought to have been solved.

With such a large catchment, allowance must be made for peak flow of at least a 20 year return period. Preferably these flows should be across a wide area and with a shallow depth. Small confining structures with a freeboard of 0.2 metres should be used, thus greater flows can wash over the confining structure and cause minimal damage. Narrow deep drains may contain the peak flow from a large storm but will erode when the flow’s depth exceeds design depth as velocity increases with depth.

5.2 Formula Used To Determine Flows From Existing Waterways And Channels.
The formula used to determine flows during and after an event is Manning’s formula. Manning’s Formula is expressed as:

\[ V = \frac{2}{n} R^{\frac{1}{2}} S^{\frac{1}{2}} \]

where \( V \) = average velocity of flow (ms\(^{-1}\))
\( R \) = hydraulic radius = \text{cross sectional area (m}^2\) / wetted perimeter (m)
\( S \) = slope of channel bed
\( N \) = Mannings roughness coefficient.

The velocity can easily be calculated and multiplied by the cross sectional area of the creek bed. This will give the volume in m\(^3\)s\(^{-1}\).

Using cross sectional areas, wetted perimeters, measured slopes of channel bed and roughness coefficients for soil types and grass cover, it was possible to calculate volumes of flow in channels of the Neridup Creek at Plowman’s lake and Fisheries Road. The depth of flow and cross sections were measured for flows during the week 7-11 August 1989. This was after the main event.
The volumes calculated are:

Neridup Creek at Fisheries Road  2.088 m$^3$s$^{-1}$
Neridup Creek on Location 134  1.264 m$^3$s$^{-1}$
Overflow from Plowman's Lake  2.256 m$^3$s$^{-1}$
(Which bypassed Neridup Creek)

Useful information; at that time if the overflow from Plowman's lake was diverted into Neridup Creek the volume of flow at Fisheries Road would be:

$$2.088 + 2.256 = 4.344 \text{ m}^3\text{s}^{-1}.$$ 

Using the same formula and cross section, depth etc. from gullies in locations 1406 and 136, flows were assessed as 10.90 m$^3$s$^{-1}$ and 9.50 m$^3$s$^{-1}$ respectively.

5.3 Formulae used for Determining Waterway Dimensions.
The method for determining waterway dimensions uses calculated peak flows, Manning's formula and maximum permissible velocities for soil types and vegetative cover.

Two waterway computer design programmes exist; Waterway (Dept. of Agriculture WA.) and Newway (Dept. of Agriculture W.A.) - D. Stanton and M. Brown. Both give calculations of waterway depth, velocity and width for different soil types and vegetation cover. The programmes can calculate the above information quickly and for ease of operation the Newway computer programme was used for all waterway calculations relating to solutions for individual soil conservation problems described later. This programme uses the Flood Index Method of peak flow estimation.


6.1 Neridup Creek
Taking calculated peak flows of various return period for catchment A & B (see 5.1.1) and comparing these with the estimated flows from stream-bed measurements (see 5.2) it is possible to deduce that flows for 1989 approximately duplicated peak flows for a two year return period. Storms of larger return periods and wetter winters that duplicate flows of larger return periods can be expected.

Trying to contain flows for 5, 10 and 20 year returns in deep scraper drains and allowing flows of these magnitudes to flow down unvegetated channels will result in massive erosion on steeper grades, with associated silting of eroded materials in flatter areas. More channels are usually created around areas of silting thus the degradation problems will grow.
The defining of the main Neridup Creek channel is best achieved by the removal of silt barriers and the construction of small confining levees so as to achieve a designed waterway width. The whole can be double fenced and a mixture of perennial and annual pastures can then be encouraged to stabilize the waterways width.

Where the Neridup Creek has an eroded channel, the sides of the channel can be battered back to a slope of 1:3 if deeply eroded or to flatter slopes if not deeply eroded. This can then be sown to perennial and annual pastures and double fenced.

Keeping the Neridup Creek width shallow and heavily grassed will lessen the chances of erosion of the main channel when very large flows occur. Exceptional flows can overtop the levees without causing excessive damage. The Neridup Creek will continue to flow and will eventually remove the flooding from outside the levees.

The width required to confine flows from a 20 year return period storm at the lower end of the Neridup Creek is 208 metres. The levee height would be 0.5 metres containing a depth of 0.3 metres of flows.

This is the shape that is most economical to construct and one which is easy to maintain. A structure could be made in the form of a channel 40 metres wide and 1.55 metres deep, once again heavily grassed. This would be satisfactory but the cost would be prohibitive.

The design of the main channel for the Neridup Creek will need to be calculated at each place work is required. The further north - the smaller the catchment area and smaller the flow. Also existing depression cross section must be taken into consideration. These factors can reduce the need for a wide waterway.

6.2 Green's Road Drain
This scraper drain flows from location 282 through locations 114, 115, 116 and 117 before entering Plowman's Lake and hence the Neridup Creek. It has a width of 2.4 metres, is unfenced and has no grass cover. The area of its catchment is 4527.06 hectares. (see 2.1.1)

In the event of a 20 year return period storm the drain would need to be 14.69 metres wide and 1.55 metres deep to contain the expected flow. However the 2.4 metres width will suffice if the depth of the channel does not exceed 1.55 metres. The 20 year return period flow must already be dispersed across the land adjacent to the drain so that the depth of water from the top of the flow to the bottom of the channel does not exceed 1.55 metres.
The cross section of this drain and adjacent land should be checked and if the 20 year return period flow depth will be exceeded, the drain should be widened at that point so that the new cross section will accommodate the flow without exceeding the 1.55 metre depth.

Once again the drain will only be stable if heavily grassed and double fenced. The waterway through location 126 also needs double fencing up to Plowman's Lake. A wide shallow "W" drain in this area would remove flooding. The overflow from Plowman's Lake to the Neridup Creek needs double fencing and grasses need encouraging over the full length of the waterways and channels on location 126.

It should be noted that depending on the rainfall event and the level of water in Plowman's Lake, the overflow channel from the lake may be overloaded and water may again escape southwards from the lake and enter catchment C. To be assured that a 20 year flow would remain contained inside the overflow channel it would need to be 32.5 metres and not 2.4 metres wide. This is based on the fact that the overflow channel is 0.7 metres deeper than the southern overflow point.

The depth of the overflow channel is less than 0.7 metres for its length except at the entrance to the channel at the lunette on the edge of Plowman's Lake. Water can flood both sides of the channel once through the lunette.

Using the calculated peak flow for the 1989 rainfall went of 5.88 m³/sec calculating the cross sectional area of that flow at 3.38 m² we will find that the cross sectional area of the channel entrance at the lunette to be smaller by 20%. Therefore some water will still overflow into catchment C even in a repeat of the 1989 rainfall event.

To overcome this and to cater for a larger return period of 20 years the overflow channel's entrance at the lunette will need enlarging to a cross sectional area of 22.75 m² below the level of the lake - full watermark.

Once again the whole of the overflow channel needs double fencing with grasses established to maintain stability. Plowman's Lake and its surrounding vegetation is an important wetland and should be fenced to exclude stock.

6.3 Backman's Road

6.3.1 Catchment E.

The catchment marked E on map 5 flows south east from location 291 across Backman's Road and into location 146. From there the flow is via a drain to a lake and hence into a series of lakes on location 148. From surveys it appears the flow would then leave the lakes, enter
location 145 and cross Lake and Backman's Roads before joining the flow which runs parallel to Backman's Road. The combined flow eventually crosses Scaddan Road and enters Scaddan Road via location 131.

There has been some concern over the drainage direction on location 146 and the expected direction of flow on location 148. The natural drainage lines have been investigated by Landcare Technicians surveying of the area and the approximate direction of flow is marked on plan 1. This natural flow is preferred as it is via a system of lakes which act as retention basins and reduce peak flows. The lakes did reduce flooding in 1989 and did not overflow into location 145 during that year. Allowance should be made for an undisturbed grassed waterway through these locations with leveeing where necessary. (see plan 1).

Concern has also been expressed at the design of drainage across Lake and Backman's Roads at Reserve 26319. The culverting here is hardly sufficient for the expected flows of 18.6 m$^3$/sec for a 20 year return if the whole of this part of the catchment flows or 14.0 m$^3$/sec if the lakes do not overflow during the same return period. Also stresses will occur trying to turn water at right angles into and out of the culverting.

The culverting should be removed and culverting and/or floodways constructed on Lake and Backman's Roads so as to allow water to flow via the natural depression south east of the tennis club on Reserve 16519. This depression can be cleared, grassed and leveed to create a stable waterway. Some drainage on location 145 will need realigning to bring the waterflows to the culverting/floodway leading the waterway. The waterway width will need to be 37.6 metres with a levee height of 0.5 metres or less depending on existing natural depression shape (see map 14 and plan 6).

The flooding through locations 292 to 296, 298 and 131 needs confining to a grassed waterway in the natural depression with levees constructed where necessary. This waterway's location will be in the depression denoted by the flooding marked on plan 2 and a floodway and/or culverting will need placing through Scaddan Road to conform with this flow. Landcare Technician surveyed contour lines are marked on plan 2 showing the location of the depression in the area north of Scaddan Road.

The above waterway will need to be 82.8 metres wide with levees 0.5 metres high at Scaddan Road depending on the existing cross section of the natural depression. But will need designing for all cross sections along its full length. The waterway must be double fenced and heavily pastured. The design peak flow for a 20 year return period would be 37 m$^3$/s.
The sloping land of locations 292 and 296 can be contoured by grade banks so as to reduce flooding from these hills. The grade banks will feed into the above waterway.

6.3.2 Catchment D.
The catchment marked D on map 4 also flows to Tyrell's Lake after flowing through Scaddan Road. These flows can be confined in a waterway 43.5 metres wide with levees 0.5 metres high. This is at its crossing of Scaddan Road. Such a waterway will confine flows of 21.8 m³/sec for a 20 year return period.

The waterway will need designing for all cross sections along its length and will need to be heavily pastured and double fenced. Any sloping land within the catchment will need contouring with grade banks to combat erosion and help reduce peak flows.

6.3.3 Tyrell's Lake
There is a concern that if Tyrell's Lake fills extensive flooding would result and to alleviate this a drain should be constructed through location 133 to Neridup Creek so as to lower the level of the lake (see plan 7).

The line of the proposed drain is the natural overflow from Tyrell's Lake and from surveying there would need to be 3 times the 1989 volume of water in the lake before it would overflow. The area inundated above the lake would be confined to the inlet waterways a location 132. (see plan 8).

The cost of alleviating this inconvenience by the construction of an overflow drain would be great as the area of the natural overflow is flat and to achieve any depth to receive benefit from the drain, a drain of great length would need to be planned.

The inconvenience is probably better accepted and a grassed area left to take overflows to Neridup Creek in the event of exceptionally wet years.

6.4 Location 284 (see plan 3)
The drainage proposal for this location is unsound. The deep excavator drains to combat salinity that will be dug down the waterways will release saline water onto the adjoining location 285. The deep excavator drains will eventually slump and cause deposition of silt on areas and properties below.

The water erosion problems on this location must be dealt with by a grade bank system discharging into double fenced waterways. The salinity problem must be dealt with by revegetation of the saline areas and the inclusion of vegetation up slope. Farming to soil type and land capability is also important.
Location 284 has similar characteristics to location 283 which is the property used as the example Land Management Plan 1. Therefore Land Management Plan 1 can be used as a guide to land conservation and revegetation work on location 284. (see attachment 1).

6.5 Location 115 (see plan 4)
The proposed drainage of the flooded areas on this location is sound. The use of a scraper built channel to connect the flooded depressions will allow the revegetation and stabilizing of those depressions. However the scraper drain should only remove surface flooding and not tap the saline underground water. The saline underground water should be dealt with by revegetation of the area around the depressions.

The scraper drain can be constructed towards Green's Road Drain but must enter a constructed grassed waterway so as to flow over the steeper sloping land without causing erosion. The grassed waterway will be 12 metres wide with levees of 0.5 metres high both sides. The waterway, scraper drain, the original flooded depressions and the revegetation must be double fenced.

6.6 Location 118 (see plan 5)
This location contains the enclosed catchment marked G on map 4. Removal of flooding from the catchment is difficult and if it is possible to remove any flooding, assistance and permission from adjoining downstream landholders will need to be sought.

Drainage towards Neridup Creek via Plowman's Road and location 126 may be possible for some small areas. Drainage of some small areas is also possible towards Bandy Creek via location 110. Both proposals should be investigated by levelling between the flooded areas and the discharge points.

The proposal to drain towards Bandy Creek will need careful planning to negotiate the steep slopes leading to Bandy Creek. Once a scraper drain leaves the areas of cut at the rim of the enclosed catchment it will have to discharge into a grassed and leved waterway. The area of cut and the leved waterway must be double fenced.

6.7 Location 283 (see plan 9)
The proposed drainage work on this property is unsound. Recommendations regarding erosion control and salinity control are contained in attachment 1 (Land Management Plan 1).

6.8 Location 129 (see plan 10)
This location is traversed by the main Neridup Creek and there is a proposal to confine the flooding from the main creek to a smaller waterway. Silt is also deposited in
the remaining vegetated area of the creek adjacent to the properties downstream boundary.

To confine the main creek flows a leved waterway will need constructing through the property at the present creek's location. The waterway will need to be 138.5 metres wide and have a levee height of 0.5 metres to contain the 62.3 m³/sec expected from a 20 year return period.

Silt deposits can be removed by graders or scrapers and grass cover encouraged over the length of the waterway.

The drain proposed to remove flooding from depressions on the western side of the creek is sound but the planned location is level or uphill to the creek allowing for the depth of this proposed drainage. Therefore water will flow from Neridup Creek into the flooded areas via the proposed drain.

This proposed drain needs resiting so as to have about one metre or more fall to the creek. This can be achieved by siting the drain so as to intersect the creek at an acute angle - by crossing the boundary into location 128. The neighbour's assistance and permission will be required.

6.9 **Locations 109 and 110 (see plan 11)**
The proposed drainage on location 110 would best be achieved by a "W" drain rather than deeper scraper or excavator drains. The area of concern around this proposed drain is saline and should be revegetated to combat salinity.

The proposed drainage on location 109 of the flooded area by scraper drain is sound. It will run into a depression and hence to Bandy Creek.

6.10 **Location 114 (see plan 12)**
The proposed work along the boundary of Scaddan Road is possible with two alternatives. To use a system of scraper drains and leved grassed waterways to take flows to Green's Road Drain. These would be parallel to Scaddan Road and inside the boundary of location 114. Alternatively the flows could cross Scaddan Road and enter into the drainage system on location 282. Assistance will be needed from the Shire of Esperance and the landholder of location 282. In either case the small lakes should be retained as lakes with only the flooding surrounding the lakes removed.

The proposed work in the south west corner of the property is sound if it can be incorporated into the system on location 112 but after that system is fully stabilized.
6.11 **Location 116 (see plan 13)**
The proposed work on location 116 is sound. The flooded depressions will be connected to Green's Road Drain via a scraper drain. The flooded depressions may not revegetate and would be better planted to trees outside of the edge of the depressions. This will halt wind erosion.

6.12 **Location 282 (see plan 14)**
The direction of the proposed drain on this location is across Green's Road, into Reserve 27388 (Conservation for Flora and Fauna) and would also flow uphill. The drainage would be better located so as to flow into other drainage in a southerly direction. The whole system flows into the Green's Road Drain.

Care should be taken with removing water from this property. Removal of saline water will jeopardize revegetation work in or alongside the Green's Road Drain as saline water will scorch any vegetation. A revegetation programme is urgently needed on this property to combat salinity. The main drains on the property need double fencing as should many of the larger flooded depressions and saline areas. These can be fenced wider to allow 4-6 rows of salt tolerant trees to be planted inside of the double fencing. Revegetation or high water use fodder species (tagasaste, salt tolerant acacias, etc.) plantings need promoting over 20% of the area of this property.

6.13 **Location 1448 (see plan 15)**
The proposal for drainage on this property is related to erosion and flooding of the main Neridup Creek. The recommendations are as in point 6.1 (Neridup Creek).

7. **Land Management Planning**
To integrate the preceding recommendations into a farm layout a Land Management Plan is needed for that property. Such a plan can incorporate designed surface water control, landuse, revegetation, refencing and management. Financial and economic assessments need to be incorporated into the whole Land Management Plan as the plan must pay for itself and produce income to make the business enterprise sustainable.

The first step in undertaking a Land Management Plan is to assess all the physical features of the property to be planned. These include soil types, degradation problems, and existing property improvements. These are then marked on a plan or aerial photo enlargement of the property and for the basis for the planning exercise.

The land degradation problems need to be addressed firstly. As mentioned previously most problems caused by uncontrolled excess water can be alleviated by earthworks. These earthworks need planning by competent staff as they represent a major investment in the property. The planned earthworks must be marked on the
plan even if their construction is to be of a lower priority or at a later stage.

Planning can now take place around the proposed earthworks based on soil types where those soils would need to be managed by different methods or where those soils could be used for different production or rotations. This is the start of defining Land Management units which are areas of land that can have specific or similar uses.

A Land Management Unit may an area of duplex soil type with sufficient 'A' horizon depth to grow lupins and wheat in rotation while a similar duplex soil type with a shallow 'A' horizon is better suited to a wheat pasture rotation. An area that has been treated by contour grade banks may be a unit as a different paddock working style is required. An area of waterlogging that cannot be treated by earthworks may be a unit growing perennial pastures between rows of waterlogging tolerant trees, the unit then being used for grazing. Saline areas may be units used for autumn grazing with atriplex species.

Once these areas have been defined a fence layout can be drawn recognising the need to double fence earthworks of major importance and the need to fence to Land Management Units. It is then possible to divide the remainder of the property on convenience with consideration given to access. Other areas such as remnant vegetation or land unsuitable for agriculture can fenced out on the plan.

Comparing the new layout with the existing layout it is possible to see the fencing changes that need to be made. The Land Management Plan will now show proposed earthworks and proposed land management units as paddocks. It is now important to define what treatments are needed to get the fullest potential from each unit or paddock. For example an area of deeper sandy soil set aside as a Land Management Unit for grazing only may be treated with perennial pastures. Areas identified as having a high water table with the potential of salinity may be treated with rows of trees to reduce the water table, with perennial pastures between it would be a good unit for grazing.

Now it is possible to analyse the plan from an economic point of view, setting priorities and designing a budget. Financial returns from completing various parts of the plan can be calculated to assist is setting priorities. Some works may give almost immediate financial returns and pay for themselves in a short period of time. For example:
(1) A 'W' drain to treat flooding in a lowing area that is usually used for pastures only may now produce good crops.
(2) Refencing around a sandy rise to exclude it from a
good grazing paddock may raise productivity by removing the need to shift stock if the sandy rise became bare from grazing while feed was still available in the rest of the paddock.

Other works may give financial returns after a several years. For example:
(1) A salt affected area unsuitable for any farming use may produce good autumn feed for stock in the second year after planting.
(2) A area of deep sand recharging ground water planted to trees may eventually increase the productivity of an adjacent lowlying waterlogged area.

Some works may provide more than one avenue to financial return. For example:
(1) An area of deep wind erodable sand planted with wide spaced trees with perennial pastures between may produce good sheltered pasture in the short term as well as a source of saleable timber for firewood, building, chipping or eucalypt oil production in the long term.

In summary a Land Management Plan is the only way to properly integrate catchment recommendations, farm requirements and economic considerations into a package that will lead to sustainable agriculture.

8. **Agronomy Of Land Management Units.** (Jeremy Lemon - Advisor, Department of Agriculture, Esperance.)
Eight major Land Management Units have been identified for the Neridup Creek Catchment defined on soil type, depth, land slope, frequency of flooding and frequency of waterlogging. Agronomic uses have been suggested for each unit as a guide to realising each units full potential. Each is listed below under a common name.

8.1 **Winter Wet Flats**

The distinguishing feature is poor winter drainage within the soil profile and waterlogging to the surface in wet seasons.

These soils are unsuitable for frequent cropping due to the risk of waterlogging. They may be cropped to oats or barley occasionally. Early sowing of cereals allows a nodal root system to develop enabling crops to tolerate periods of waterlogging.

<table>
<thead>
<tr>
<th>Suggested Crops</th>
<th>Suggested Pastures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oats</td>
<td>Sub. clover cv Trikkala</td>
</tr>
<tr>
<td>Barley</td>
<td>Annual Ryegrass</td>
</tr>
<tr>
<td></td>
<td>Phalaris</td>
</tr>
<tr>
<td></td>
<td>Fescue</td>
</tr>
<tr>
<td></td>
<td>Tall Wheat Grass</td>
</tr>
<tr>
<td></td>
<td>Balansa</td>
</tr>
</tbody>
</table>
Adequate phosphate and grazing management will maintain annual pastures, especially on shallower soils with surface gravel.

Rotations include:
Permanent annual pastures
Permanent perennial pastures
Long term pasture phases with occasional cereal crops.

8.2 Medium Depth Sandplain
Undulating Fleming Gravely Sand and Fleming Sand.

This unit is drained with slope but can have subsurface waterlogging on the clay layer in wet seasons. Water repellance develops with longer term pastures.

<table>
<thead>
<tr>
<th>Suggested Crops</th>
<th>Suggested Pastures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>Subclover</td>
</tr>
<tr>
<td>Oats</td>
<td>Annual Ryegrass</td>
</tr>
<tr>
<td>Wheat</td>
<td>Balansa</td>
</tr>
<tr>
<td>Canola</td>
<td>Plalaris</td>
</tr>
<tr>
<td></td>
<td>Fescue</td>
</tr>
</tbody>
</table>

These soils are too shallow for reliable lupin production, gravelly profiles reduce water storage even further. Early sown cereals grow well, the nodal root system enables cereals to tolerate periods of waterlogging. Subclover performs well on these soils and regular cropping reduces the water repellance. Herbicides or intensive grazing management generates clover dominant pasture suitable for wheat cropping. Otherwise barley or oats tolerate the take-all risk after grassy pasture. Perennial pastures limit the opportunity for cropping this unit.

Rotations include:
Rotational cropping - P:P:P:Cereal or P:P:Cereal
Continuous annual pasture
Continuous perennial pasture.

8.3 Flooded
Flat Fleming Gravely Sand and Fleming Sand.
The unit is characterized by regular winter flooding. Drainage can be used if safe and legal disposal is available to make this unit more like Winter Wet Flats.

<table>
<thead>
<tr>
<th>Suggested Crops</th>
<th>Suggested Pastures</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Subclover - Trikkala</td>
</tr>
<tr>
<td></td>
<td>Phalaris</td>
</tr>
<tr>
<td></td>
<td>Tall Wheat Grass</td>
</tr>
<tr>
<td></td>
<td>Annual Ryegrass</td>
</tr>
<tr>
<td></td>
<td>Kikuyu</td>
</tr>
<tr>
<td></td>
<td>White Clover</td>
</tr>
<tr>
<td></td>
<td>Slender Serradella</td>
</tr>
</tbody>
</table>
Flooded areas are suitable for tree establishment and limited grazing access. 
Rotations: 
Permanent pasture.

8.4 Deep Sand
Well drained flat and undulating deep sand.

These soils have a deep well drained sand profile with yellow sand at depth. Potassium levels are low. Phosphate leaches slowly throughout the profile to the yellow sand layers. Manganese is required for lupin and lucerne production. Water repellance is a problem. Cereals respond to cultivation.

<table>
<thead>
<tr>
<th>Suggested Crops</th>
<th>Suggested Pastures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lupins</td>
<td>Serradella</td>
</tr>
<tr>
<td>Wheat</td>
<td>Subclovers (if K levels adequate)</td>
</tr>
<tr>
<td>Barley</td>
<td>Veldt Grass</td>
</tr>
<tr>
<td>Oats</td>
<td>Fescue</td>
</tr>
<tr>
<td>Canola</td>
<td>Love Grass</td>
</tr>
<tr>
<td></td>
<td>Lucerne</td>
</tr>
</tbody>
</table>

The well drained nature of this unit allows frequent cropping. Lupins allow high yielding cereal crops to be grown successfully. Deep rooted plants are able to use the phosphate buildup at depth. Furrow sowing with press wheels helps crop establishment. Annual pastures degenerate in time due to water repellance and changing composition. Rotations should be aimed at avoiding this problem. Perennial pastures produce reliably when water repellance has developed.

Rotations include: 
Continuous crop L:W or L:W:B
Phased cropping P:P:P:B:L:W

Planned shelterbelts and stubble retention crop sowing systems reduce the risk of wind erosion.

8.5 Deep Sand Dunes
Sloping exposed areas of deep sand.

This unit has very deep and exposed sand. There is little colour in the soil profile up to 2 metres. Water repellance, low nutrient status, poor ground cover and exposure to wind make this unit unsuitable for normal agricultural practises.

<table>
<thead>
<tr>
<th>Suggested Crops</th>
<th>Suggested Pastures</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Serradella</td>
</tr>
<tr>
<td></td>
<td>Veldt Grass</td>
</tr>
<tr>
<td></td>
<td>Love Grass</td>
</tr>
</tbody>
</table>

These areas should be excluded from paddocks and used for
trees and shrubs. The exclusion of stock will allow ground cover to develop. The areas can then be used for animal browse and shelter.

Small areas in deep sand units can be topdressed with extra fertiliser to encourage more uniform crop and pasture growth in the paddock.

8.6 Mallee Duplex
Undulating and sloping Circle Valley Sands and sloping sand over domed clay.

Neutral to alkaline sands over alkaline subsoil clays. The topsoils vary in depth from a few centimetres to 30cm and surface texture can be loamy. Sloping sites have high runoff and grade banks will reduce erosion risk to enable safe cropping.

<table>
<thead>
<tr>
<th>Suggested Crops</th>
<th>Suggested Pastures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>Subclover</td>
</tr>
<tr>
<td>Barley</td>
<td>Annual Ryegrass</td>
</tr>
<tr>
<td>Oats</td>
<td>Medics (if pH &gt; 5.5 CaCl₂)</td>
</tr>
<tr>
<td>Peas - on shallower sites</td>
<td>&lt; 10cms</td>
</tr>
<tr>
<td>Lupins - on deeper sites</td>
<td>&gt; 25cms</td>
</tr>
<tr>
<td>Canola</td>
<td></td>
</tr>
</tbody>
</table>

Shallow soils can have subsoil clay mixed to the surface with deep cultivation. This promotes hard setting and poor surface drainage. Gypsum amelioration reduces these problems. Direct drilling is an advantage on these soils for retention of surface structure, infiltration and reduced runoff.

Many rotations are possible on this unit including:
P (medic):W
P:P:Cereal
B:Peas:Canola:W

8.7 Crabhole
Soils are crabhole clays.

Characterised by gilgai micro relief the soil has an alkaline pH 7 - 8 (CaCl₂)

The crabhole relief makes cropping difficult during wet periods. Often small areas are scattered through other units.

<table>
<thead>
<tr>
<th>Suggested Crops</th>
<th>Suggested Pastures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>Medic</td>
</tr>
<tr>
<td>Barley</td>
<td>Phalaris</td>
</tr>
<tr>
<td>Oats</td>
<td>Annual Ryegrass</td>
</tr>
<tr>
<td>Peas</td>
<td>Fescue</td>
</tr>
</tbody>
</table>
Possible rotations are:
Permanent annual pasture
Permanent perennial pasture
Medic:Cereal.

9. Land Drainage

9.1 Legal Aspects of Land Drainage
This topic is covered in the Western Australian Department of Agriculture Farmnote No. 79 of 1986 titled Legal aspects of land drainage by Ken Cole, Senior Advisor, Irrigation and Water Resources Branch. The Farmnote briefly outlines the laws relating to land drainage, the laws being a complex combination of common law and statute law.

A few rules of drainage are:

1. Natural watercourses must not be obstructed or diverted.

2. Surface water must not be collected and diverted to land that would not naturally receive it.

3. The point of entry of surface water onto a lower property must not be changed.

4. A landholder cannot accelerate the flow of water to the material damage of a property below.

Government departments and local government authorities have regulations covering the drainage of water onto their lands. Written permission must be obtained prior to undertaking any drainage onto land under their control.

9.2 Land Drainage Regulations
This subject is covered in Western Australian Department of Agriculture Farmnote No. 15 of 1991 titled Notification of draining or pumping saline land. Briefly the Farmnote outlines the requirement for owners or occupiers of land to notify the Commissioner of Soil Conservation at least 90 days before a new drainage or pumping scheme (set up because of the salinity of the water) discharges water on to other land or into a watercourse.

Drainage is being increasingly used to treat land salinization. However, drainage of land can have significant deleterious off-site effects. Pumping or drainig saline water and then discharging it on to other areas or into a waterway may degrade surrounding land or public land and utilities. Land or waterways further away may also be significantly salinized by the discharge water or made unnaturally wet.
The saline water can be considered a noxious effluent causing a nuisance downstream. Other damage from the saline water can be a loss of private or public amenities, such as the degradation of natural vegetation or damage to roads or culverts, or an increase in soil erosion.

When considering drainage, a land user must be aware of obligations and responsibilities to neighbours and the general community.
10. **References**


Attachment 1.

Sample Land Management Plan 1 (Neridup Location 283).
Neridup location 283 is located in the top of the Neridup Creek Catchment in the area of steeply sloping lands. The whole of the locations 1139.5 hectares area has been used for farming and it now shows signs of salinity in large areas with water erosion present in many paddocks. A plan of the present farm layout is attached.

The salinity problems are caused by saline ground water build up in areas of shallow soil over rock and also where bedrock highs impede ground water movement. There is also insufficient native or planted vegetation to use recharged water.

The attached Land Management Plan describes a fence layout based on defining the areas of salinity, control of surface water and protection of waterways. The plan also describes areas for revegetation.

The contour grade banks will control water that causes soil erosion and will also regulate heavy run off during storms by increasing the time of concentration and reducing peak flows in waterways. The natural waterways need double fencing and these then form the boundaries of many of the paddocks.

Revegetation of waterways and the saline areas with salt tolerant trees where they will grow clear of the scalded areas will help combat ground water discharge. The scalded areas can be planted to salt tolerant forage species and used for areas of controlled grazing in a parkland type situation. Further tree plantings can take place across the slope of the land below contour grade banks. These plantings will intercept ground water movement and can be incorporated into paddock subdivision on the contour.

This plan can be used as a guide to Land Management Planning in the areas of sloping land north of Scaddan Road and within the Neridup Catchment.
Attachment 2.
Sample Land Management Plan 2 (Neridup Location 112)
Neridup location 112 lies to the west of the Neridup Catchment adjacent to the area of numerous parallel ill defined waterways that are the distinguishing feature of the middle of the catchment. This location is situated alongside and to the east of Wittenoom Hills Road. It is connected to other locations of the same owner by a lane on its eastern side.

Nearly all of the properties 739.5 hectares is cleared with only one small area of native vegetation left standing. Flooding and wind erosion of a chain of cleared paperbark swamps is one of the main degradation problems. Also wind erosion is present as blowouts on several of the sand ridges in the centre of the property. Saline ground water is also present at the surface in the area of the old paperbark swamps and in low lying areas between the sand ridges.
ATTACHMENT 3
MAPS 1-14
RELATIONSHIP OF FLOODING AND WATERLOGGING TO SALINITY
FIGURE 3 LEGEND USED FOR INDIVIDUAL PLANS