3. CATCHMENT RISKS

3.1 Salinity and groundwater

Shahram Sharafi

3.1.1 Groundwater trends

There are 159 bores with reasonably rich salinity and water level historical data within the study area. There are 21 bores with fresh water (EC < 90 mS/m), 12 bores with marginal salinity (90-270 mS/m), 40 bores with moderate salinity (270-900 mS/m), and 51 bores with highly saline water (900-5500 mS/m). There are 35 bores with no salinity measurements available.

Groundwater trends in the study area are variable. Sustained watertable rise is displayed where watertables are deep (> 8 m below ground level). In some parts of the landscape, rates of rise are likely to continue unabated for many years. Rates of rise beneath hill slopes vary between 0.15 and 0.30 m/yr (Ghauri 2004).

Variations in groundwater salinity are not highly correlated with rates of rise, meaning that groundwater rise is occurring as a result of both local recharge processes and regional groundwater rise.

Bores in the West Avon Catchment have the highest rate of rise (1.45 m/yr). All falling trends appear associated with declining rainfall and possible intervention located in lower landscape or valley positions and/or proximal to discharge areas. Reduced in situ rainfall recharge and runoff contributions from slopes explain this phenomenon.

Most of the bores in the South Avon sub catchment show a falling trend reflecting the revegetation activities in the area.

Table 3.1 Rates of rise and fall of bores within the Avon Hotham sub catchments

<table>
<thead>
<tr>
<th>Sub Catchment</th>
<th>Bore name</th>
<th>Rising rate (m/yr)</th>
<th>Bore name</th>
<th>Falling rate (m/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Avon</td>
<td>YB4801</td>
<td>1.45</td>
<td>YB4803</td>
<td>-0.47</td>
</tr>
<tr>
<td>Hotham</td>
<td>YN27</td>
<td>0.86</td>
<td>BW011</td>
<td>0.2</td>
</tr>
<tr>
<td>South Avon</td>
<td>WD10</td>
<td>0.03</td>
<td>WN10</td>
<td>-0.85</td>
</tr>
</tbody>
</table>

Groundwater bores located in lower slope or valley/discharge areas have reached local equilibrium. These bores usually have shallow watertable (< 2 m below ground), and display only seasonal responses to rainfall. There are some areas where revegetation has occurred and effectively causing groundwater to fall or stabilised mainly in the South Avon sub catchment.
Figure 3.1. Groundwater trends in the Avon Hotham study area.
3.1.2 Current extent of salinity

The study area has 47,000 hectares of saline land (2.5 per cent) mostly in valley floors, based on Land Monitor\(^1\) data (Figure 3.2).

In a recent survey farmers rated salinity occurring at the change of slope as the biggest problem. This indicates where salinity is currently developing and where management options can be applied. Salinity is likely to expand in low-lying areas adjacent to existing salinity however this expansion is highly dependent on elevation, slope and soil type.

3.1.3 Potential salinity risk

Land-height information from the Land Monitor project indicates that approximately 306,000 hectares (16 per cent) of the study area is located in low-lying hazard areas could become waterlogged and/or saline if watertables rise sufficiently.

Salinity in the main valley of the Avon Hotham is approaching equilibrium and the saline area is not expected to significantly expand. Additional salinisation that will take place is expected to occur in the tributary valleys that lie perpendicular to and converge into the Avon Hotham valley. These flat areas will be more prone to lateral expansion of salinity because of poor surface drainage and ponding of water. Reducing surface water inundation of these tributary valleys using earthworks should reduce the area affected by salinity in these areas.

Of the more than 110,000 km of roads in the study area, about 135 km (5 per cent) of the sealed highways and main roads and more than 2,300 km (4 per cent) of local and unclassified roads are located in salt affected areas.

Almost 49 per cent or 1,370 km of sealed highways and main roads and over 15,800 km or 30 per cent of unsealed roads are within low-lying areas and may be susceptible to flooding, waterlogging and salinity. The annual cost of repairs and maintenance due to salinity is assessed to be almost $20,000 per kilometre for highways and main roads and around $6,600 per kilometre for local and unclassified roads (Kingwell 2003).

\(^{1}\) Details about the Land Monitor project can be found by visiting www.landmonitor.wa.gov.au. Accuracy statements of the data sets can be found in CSIRO Mathematical and Information Services (CMIS) Report No. 01/111.
Figure 3.2. Salinity map.
Figure 3.3. Low lying areas/valley floors.
3.2 Soil and land degradation

*Claire Robertson*

The major land degradation hazards are subsurface compaction and acidification. Current lime application (ABS data) to neutralize acidification averages 44 per cent (from 1994 to 2001) of that required to maintain pH in the study area (appendix Figure A3.1.).

Other hazards include wind erosion and water repellence. Soil structure decline is also likely to be a significant issue within the West Avon and Hotham sub catchments. These less visible forms of land degradation affect larger areas than salinity. However, they often go unnoticed and untreated (Nulsen 1993).

A site analysis and farming system appraisal should be undertaken for recommendations for each degradation hazard as they are site specific (Moore 1998).

Land management hazards described in Table 3.2, are based on land qualities attributed to soil-landscape mapping conducted by the Department of Agriculture (Van Gool et al. 2001). Hazards are also detailed for each of the Avon and Hotham sub catchments in Table A2.1 and A2.2.

**Table 3.2. Land management hazards - Total study area**

<table>
<thead>
<tr>
<th>Threat</th>
<th>Area at risk hectares</th>
<th>Soil supergroup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsurface compaction</td>
<td>70% 1,330,000</td>
<td>Deep sand and sandy earths. Soils with less than 5% clay content are most at risk.</td>
</tr>
<tr>
<td>Subsurface acidity</td>
<td>66% 1,254,000</td>
<td>Deep sands, sandy earths and ironstone gravelly soils. Sandy soil with low levels of organic matter is most susceptible.</td>
</tr>
<tr>
<td>Wind erosion</td>
<td>58% 1,102,000</td>
<td>All soils with loose and bare surfaces, but especially deep sands and sandy earths.</td>
</tr>
<tr>
<td>Water repellence</td>
<td>53% 1,007,000</td>
<td>Deep sands, sandy earths and gravelly soils.</td>
</tr>
<tr>
<td>Phosphorous export</td>
<td>37% 703,000</td>
<td>Wet and waterlogged soils, sandy and loamy duplex soils situated on valley floors, flow lines and areas susceptible to flooding.</td>
</tr>
<tr>
<td>Soil structure decline</td>
<td>35% 665,000</td>
<td>Shallow and deep loamy duplex soils, loamy earths and non-cracking clays.</td>
</tr>
<tr>
<td>Waterlogging</td>
<td>13% 247,000</td>
<td>Wet and waterlogged soils, loamy duplex soils and particularly sandy duplexes on valley floors and lower slopes.</td>
</tr>
</tbody>
</table>
3.3 Agricultural production

Susie Murphy White

3.3.1 Biophysical risks

Biophysical risks such as subsurface compaction, subsurface acidity, wind erosion and salinity will require a high level of investment, of both time and money, to prevent further degradation. Those issues difficult to reverse will result in changes to farming systems to accommodate the altered landscapes. The treatment of biophysical risks is outlined in Table 4.1.

The area at greatest risk to salinity is valley floors and adjacent slopes. This part of the landscape may see changes in enterprise distribution to include more salt bush, salt tolerant perennial pastures and shrubs. Over time the changes in enterprise distribution may include an increase in the proportions of livestock on farm and a decrease of cropping area.

There would be an estimated loss of $247 million if subsoil compaction was left untreated. It is expected that 70 per cent of the study area is at moderate to high risk of subsurface compaction. Treating sub surface compaction involves changes in land management practices over the longer term to reduce the risk of agricultural production decline. The amelioration package will cost $102/ha to implement in the first year, the package involves applying gypsum (2.5 t/ha depending upon soil type) at $75/ha and deep ripping to 40 cm at $27/ha. The longer term management is then needed to maintain the benefits of amelioration.

3.3.2 Capacity to invest

The cost of investing in an activity such as natural resource management is often seen as more costly and risky than investing in land. It should also be considered that the capacity for farmers to invest in conservation works is generally driven by high income producing years that provide cash surpluses and improved equity. Figure 3.3 shows that there have been no surplus funds on a year in, year out basis between 1998 and 2002.

![Surplus / Deficit after all Expenses](chart.png)

Figure 3.3. Surplus and deficit after all expenses. (Source: BankWest benchmarks.)

The trend for investment into conservation works has been conservative with all farmers investing $1 per effective hectare since 1999/00 financial year. As funds are continuing to be invested into conservation works the equity is being reduced from the property on a short term basis.
3.4 Surface water risks

Harry Lauk and Ian Wardell-Johnson

The Study area is situated mainly within the Rejuvenated Drainage Zone, eastern and western sections of the Darling Range Zone to the west of the study area and sections of the south eastern Avon and Mortlock Rivers are within the Ancient Drainage Zone. In the Gingin area there is a small section of the Dandaragan Plateau Zone and just to the south a small section of the Pinjarra Zone.

Surface water risks in the Study area can be summarised in conjunction with the slopes as follows (Figure 3.4).

3.4.1 Slopes of 0-1 per cent

Fourteen per cent of the study area has slopes between 0-1 per cent these are mainly in the eastern to south eastern portion of the study area mainly within the Ancient Drainage Zone.

Having low gradients, the lower landscape is generally poorly drained with frequent waterlogging in the central eastern areas and becoming less frequent further to the east. Flooding on these slopes can be experienced if surface flows are obstructed. Salt accumulation on the soil surface can be a consequence from flooding and waterlogging. Change of slope salinity can be a consequence of water accumulation.

3.4.2 Slopes of 1-3 per cent

Thirty five per cent of the study area has slopes between 1-3 per cent this is mainly in the middle to the eastern portion of the study area within the Rejuvenated and Ancient Drainage Zones.

There is a potential risk of water erosion on these slopes due to the higher rainfall (compared to the eastern wheatbelt) and also from run-off from the steeper slopes and run-on on to the lower slopes. Waterlogging is an issue where there are clayey and duplex soils (low permeable subsoils) and where the surface drainage is poor such as the lower 1 per cent slopes and there is the run-on effect from the slopes above.

3.4.3 Slopes of 3-10 per cent

Forty per cent of the Avon Hotham has slopes between 3-10 per cent this runs mainly on the western portion of the study area within the Darling Range and Rejuvenated Drainage Zones.

There is a potential risk of water erosion with a high risk in the higher rainfall areas, i.e. western areas. Waterlogging is also a big risk in the western areas especially on the lower slopes where there are duplex soils with less permeable subsoils and concave slopes. Flooding is less of an issue in the western areas due to the steeper landscape surface being better drained.

3.4.4 Slopes greater than 10 per cent

Eleven per cent of the Study area has slopes greater than 10 per cent these are mainly in the western portion of the study area within the Darling Range and Rejuvenated Drainage Zones, with many of the eastern steep slopes being mallet hills. There is a very high risk of water erosion in the higher rainfall areas of the western part of the study area.
Figure 3.4. Per cent slope map.
3.4.5 Surface water risks specific to soil type

The surface water risks affecting the soil types can be described by specific regions within the Study area.

The western, north south alignment of the West Avon sub catchment has most of the steep slopes, particularly around and west of Toodyay and south of Bindoon. Toodyay and other areas are also where the high concentration of small landholders (200 ha or less) are located. The issues are:

- soil and water erosion from runoff events, especially on the steeper slopes;
- erosive soils at mallet hilltops or breakaways;
- waterlogging, especially south western, higher rainfall areas on the lower slopes and around the tributaries of the valley floor;
- small hillside seeps fresh and saline;
- landuse changes and clearing issues and
- cross boundary conservation issues, i.e. soil erosion.

The eastern and south eastern part of the Avon catchment, have the lower gradient slopes (0-3 per cent) with most of the heavier soils (loams and clays). The main problems are:

- flooding/waterlogging on the poorly drained duplex soils in the valley floor to the south east (upstream from Beverley in the Avon River and upstream from about the junction of the Mortlock River and Mortlock River East tributaries);
- rising saline watertables in the valley floors and
- water supplies, dams/bores going saline (those not on scheme water).

The eastern part of the Hotham sub catchment have the lower gradient slopes (0-3 per cent) with most of the heavier soils (loams and clays). The issues here are:

- flooding/waterlogging in the poorly drained duplex soils in the valley floor, with the main area (small compared to southeast Avon area) between Yornaning and South of Pingelly;
- rising saline watertables in the valley floors and
- water supplies, dams and bores going saline (those not on scheme water).

3.4.6 Water Management and the Law

There is legislation regarding the clearing of native vegetation, groundwater drainage and pumping for salinity control and interfering with a watercourse. Contact the appropriate organisation for further information:

- **Clearing** – Department of Environment, [www.environment.wa.gov.au](http://www.environment.wa.gov.au)
- **Drainage and pumping** – Department of Agriculture, Soil and Land Commissioners Office, [www.agric.wa.gov.au](http://www.agric.wa.gov.au)
Landholders who wish to extract groundwater for salinity control, either by drainage or pumping, are required to submit a Notification of Intent to Drain to the Office of the Soil and Land Conservation at the Department of Agriculture. There are penalties for failing to do so. Soil and Land Conservation Regulations to control the drainage of saline land in Western Australia were introduced in 1990. The Regulations require landholders intending to drain or pump water from under the land surface to notify the Commissioner of Soil and Land Conservation at least 90 days before work commences.

Un-notified drainage poses many risks to the landscape. They include:

- Threat to downstream infrastructure such as roads and culverts. Often culverts have been eroded away or silted up.
- Threat to downstream agricultural productivity and natural resources.
- Deep drains are in the lowest part of the landscape where they are very vulnerable to high rainfall events. They can have a very high maintenance cost. Best Management Practice Standards state that deep drains should be installed in small catchments up to 2500 hectares, where the services of a civil engineer are not required.
- Uncoordinated planning - Can create difficulties when planning and constructing other earthworks up slope.
- Social issues and ill feeling can occur when downstream neighbours are not notified or given the opportunity to comment on drainage plans.
- Litigation is possible – i.e. Structures should not interfere with, divert or diminish the natural flow characteristics of any flow path (Common Law).
- The appropriate agencies are not notified of the proposal, therefore not allowing chance for comment, increasing the risk of further litigation.

Work Safe Western Australia have a Code of Practice for excavations for all work places, where a person is required to work in an excavation or other opening that is at least 1.5 metres deep.

**3.5 Avon and Hotham River Basins**

*Brendan Oversby, Department of Environment, Northam*

The salinity of both the Avon and Hotham Rivers has risen substantially since the clearing of the native vegetation from their catchments. The estimated original salinity of these rivers is between < 100 mS/m and 550 mS/m (fresh to brackish). The Avon’s salinity has increased to an average fluctuation of between 1,000 mS/m and 4,500 mS/m (saline to hyper saline) while the Hotham has increased to an average fluctuation of between 400 mS/m and 2,500 mS/m (brackish to saline). Most of the major tributaries entering into the Avon are also now salt affected.

This increase in salinity has resulted in a major change to the two river’s ecosystems, affecting both the flora and fauna, as well as indirectly increasing the movement of sediment throughout the system. Many species sensitive to saline water have been lost, or have had their range greatly reduced, while other species, including a number of weed species tolerant to the current conditions, are increasing their range. The current Avon River ecosystem is still quite biodiverse, but is now composed mainly of much more salt tolerant species. The reason for the
Avon River, and to some extent the Hotham River, being able to undertake this shift is that it they have a number of naturally saline waterways and lakes within their catchments. These have provided the necessary seeding material to recolonise the river.

The soils of the Avon River Basin and Hotham catchment are naturally low in nutrients. The rivers have adapted to this over millennium, resulting in an ecosystem based around the organic matter produced by riparian vegetation rather than being an algae-driven system that relies on high nutrient inputs. Following the removal of native vegetation and leaf litter (a form of natural fertiliser), and the subsequent introduction of broad scale agriculture, the type and flow of nutrients through the rivers has radically changed. Additional nutrients, especially phosphorus and nitrogen from chemical fertiliser and animal manures, have been washed from the surrounding catchment into the riparian areas and the river itself. These excess nutrients have had two main effects on the river environment. The first is the increased growth of weed species in the riparian zone. The extra nutrients give the weeds a competitive advantage over native species, as the weed species are better adapted to higher nutrient soils. Often these weed species are grasses, which can further increase the fire risk to the river.

The second impact of excess nutrients is the eutrophication river water. This commonly results in algal blooms, especially during summer months when the water temperature increases. These algal blooms can often result in the death of fish and other aquatic fauna; either from toxins produced by the algae and from the deoxygenation of water as the algae decomposes.

### 3.6 Remnant vegetation risks

**Sally Phelan**

#### 3.6.1 Remnants at risk from salinity

Currently only 0.6 per cent of remnant vegetation is affected by salinity or waterlogging (Land Monitor data). This figure includes naturally saline environments such as salt lakes and samphire vegetation.

Vegetation most at risk of salinity and waterlogging in the future are those remnants located in valley floors. These are usually areas of woodland vegetation. Seven per cent of remaining vegetation in the Study area is located in low-lying or valley floor areas, and may be affected by salinity and waterlogging in the future.

The dominant vegetation types in valley floor areas of the sub-catchments are:

- **Hotham** – Medium woodland; marri and wandoo (3,618 ha).
- **South Avon** – Medium woodland; York gum, wandoo and salmon gum (3,261 ha).
- **West Avon** – Medium woodland; marri and wandoo (4,793 ha).

#### 3.6.2 Fragmentation and biodiversity risks

The fragmentation of native vegetation has major impacts on biodiversity and ecosystem function in the landscape. Isolation of habitats and insufficient habitat size will impact differently on different species, depending on their size and ability to move between remnants (Parsons et al. 2003). In the study area, the average remnant size is 10.6 ha, with over 8 per cent of the total study area being less than 10 ha in size. There are many small remnants and only a few
large viable remnants. This fragmentation of vegetation and resultant lack of connectivity between remnants, together with small size of many remnants is limiting the ability of many flora and fauna species to sustain viable populations.

Wandoo (*Eucalyptus wandoo*), usually known as white gum is a dominant species in the remnant vegetation of the study area and is affected by crown decline commonly referred to as Wandoo decline (Wandoo Recovery Group, 2004). This canopy decline can be observed in the upper and outermost part of the crown with the tree responding by sprouting new leaves from dormant buds (epicormic shoots) along the trunk and limbs to replace lost foliage. Some of the contributing factors to Wandoo decline include insect damage, fungal infection, reduced rainfall, altered fire regimes, salinity and waterlogging. Further study into the causes of Wandoo Decline is being investigated by the Wandoo Recovery Group.

*Phytophthora cinnamonmi* commonly called Jarrah dieback or Cinnamon fungus, poses a risk to the remnant vegetation in the study area. In areas with greater than 400 mm rainfall the fungi can kill a wide range of susceptible plant species, from the banksia, heath, hibbertia, and pea families (Hussey and Wallace 1993). It has been recently calculated that at least 800 plant species are highly susceptible to infection by Cinnamon fungus within the South-west of Western Australia (Shearer et.al. 2004). The root fungi live in the soil and plant roots and their spores are spread by the movement of water along drainage lines and flooded areas. The fungus is also spread through the movement of infected soil on vehicles and machinery, footwear and stock.

The risk to remnant vegetation from Jarrah dieback will result in the loss of:

- honey producing plants therefore loss of nectar eaters such as honey possums, insects and birds resulting in fewer flowers for commercial harvest or tourism;
- loss of utilisable timber;
- lack of regeneration and reduced diversity of plant species.

In addition to waterlogging, salinity, disease, habitat loss and fragmentation, the loss of biodiversity is also continuing at risk due to the following factors:

- Livestock grazing in unfenced remnants;
- Decreased fire frequency or altered fire regimes;
- Introduced predators such as fox and cat;
- Weed invasion from agriculture; and
- Herbicide, pesticide and fertiliser drift.