Nature Glenelg Trust

# Hydrological restoration options for Square Waterhole Swamp, Hesperilla Conservation Park.

*A case study for Fleurieu Peninsula swamp restoration in the SA Murray Darling Basin NRM Region.*

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## Executive summary

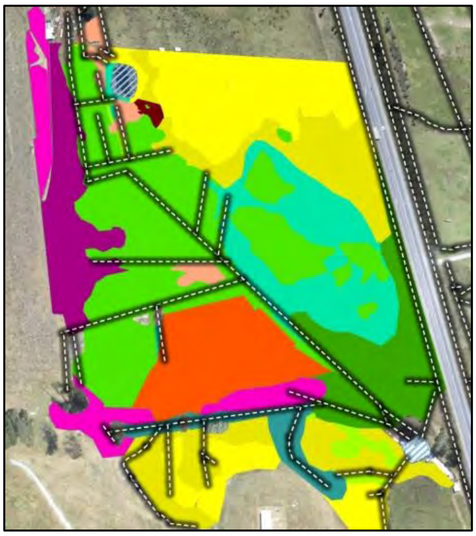
Natural Resources SA MDB commissioned this eco-hydrological study for Square Waterhole Swamp, within Hesperilla Conservation Park, near Mt Compass, South Australia in 2016. This 11 hectare reserve provides a small but significant example of a recovering, remnant area of a Fleurieu Peninsula swamp – a nationally threatened ecological community – and an important site for the nationally endangered Mount Lofty Ranges Southern Emu-wren (*Stipiturus malachurus intermedius*).

The objective of this project was to assess the hydrological restoration options for Square Waterhole Swamp, by providing a detailed investigation of:

- Current hydrology;
- Restoration options; and
- Likely eco-hydrological consequences of restoration actions.

This report is the culmination of a 12 month process of site visits, discussions with experts and community members, historical research and meetings with neighbours. It turns out that Square Waterhole Swamp is entrenched in the early historical memory of the district in a way that is unusual for a natural feature of this type (i.e. in 1800s era thinking - a 'worthless swamp') because of where it was located. Square Waterhole was an early inn, on the transport route between Adelaide and Victor Harbor, which brought this wetland into contact with country travellers since the earliest days of settlement in South Australia.

The main road that was eventually developed through the swamp has probably acted as both a 'curse' – for initially facilitating (1860s) then deepening (1950s) local drainage – and later, an inadvertent 'blessing', for then also acting a partial levee bank, helping to regulate outflows and moderate the effects of adjacent downstream drainage (to the east of the main road). Over more recent decades, the road and fixed culvert invert level on the outlet drain have probably prevented further drainage as the peat subsided, drains slumped and the surface in this part of the swamp started to become saturated with groundwater again.



Despite the apparent obstruction to flow afforded by the road, active drains that pass through and around this remnant of the former swamp are still having an impact. Indeed a closer inspection of the drains and vegetation association maps together (right) clearly shows how the drains continue to shape the ecology of this wetland, as it has recovered after apparent subsidence. This relationship is not a coincidence; it is clear case of *cause and effect* and illustrates in detail how manipulating flows over the long-term directly shapes and defines wetland floristics and ecology. It all starts with water regime – something that can be proactively managed into the future – and that is where the concept of wetland restoration through hydrological management comes into the equation.

**Restoration Goal:**

> To restore the peat system's processes, ecology and habitat quality, and, if possible, recover some of the former footprint (size) of Square Waterhole Swamp, through implementing measures that will slow down water movement through the site.

**Measures of Success:**

Specific objectives which need to be met, in order to successfully meet this goal are:

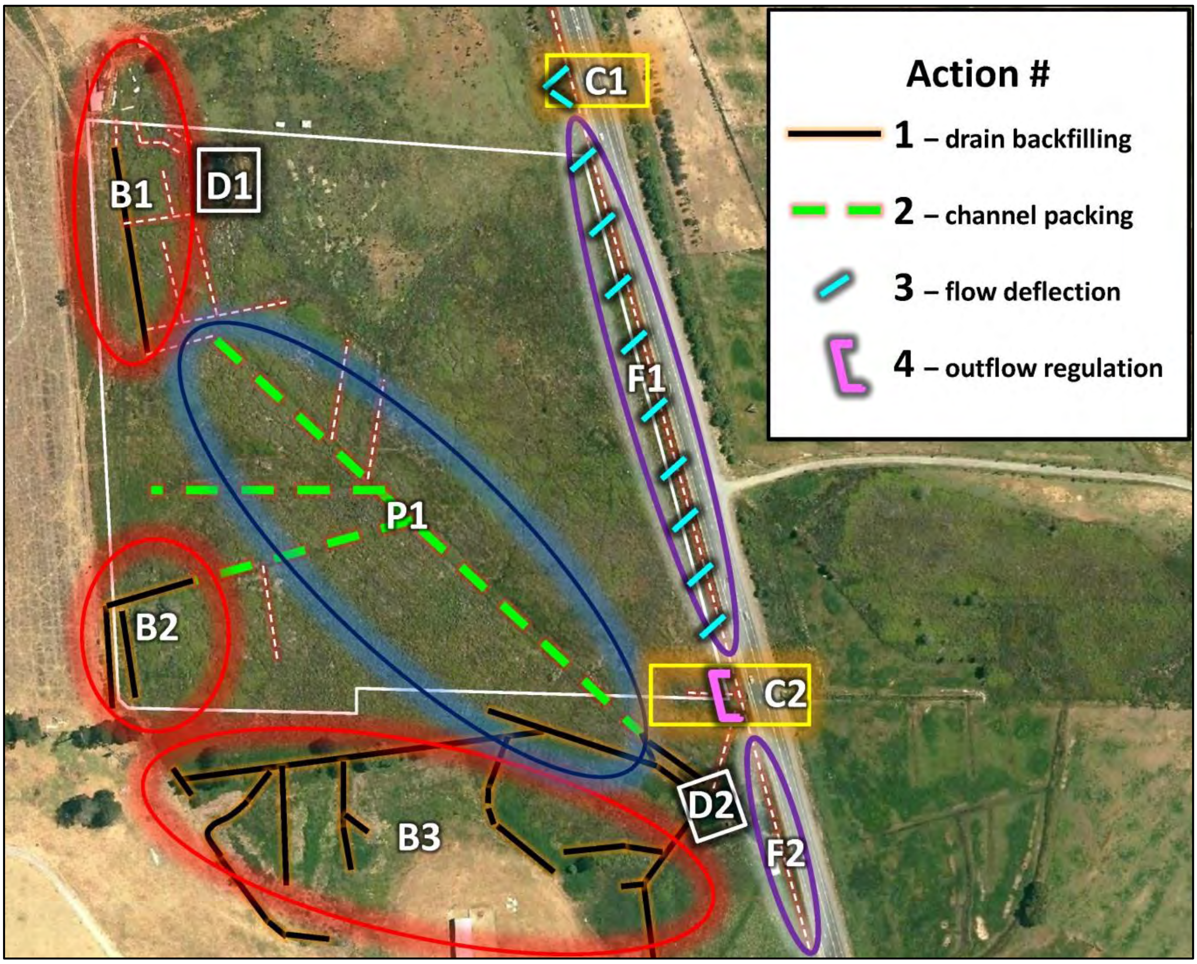
- an increase in soil moisture retention in the elevated slopes of the western and south-western areas of the swamp, aiming to restore year-round saturation of peat;
- to use methods that result in the lowest possible disturbance to the most in-tact areas of the peat bed;
- to cause a positive shift in the trajectory of biological and/or hydrological indicators;
- to enhance regeneration of any expected but absent water dependent vegetation types; and
- to involve interest groups and the wider community in planning and works.

Four key on-ground actions are recommended to achieve a staged process of comprehensive hydrological restoration of the site. These actions are listed below (with primary zone for works in brackets) and are displayed in the site map over the page.

**ACTION 1:** Mechanical drain backfilling to re-saturate banks (B1, B2, B3)
**ACTION 2:** Channel packing to maximise peat re-hydration (P1)
**ACTION 3:** Roadside flow deflection and regulation to minimise drawdown (C1, F1)
**ACTION 4:** Outflow regulation (C2)

Additional recommended actions include:

- Woody weed control during drainage works and fencing rationalisation (B3).
- Further evaluation of the options for managing southern catchment inflows via the roadside catch drain (F2), in consultation with the private landowner.
- Working through the options for managing the future status of an existing easement over part of the swamp (for access to the dam at D1).




**Implementation notes:**

Actions 1 and 3 are independent:

- Action 1 should be completed before Actions 2 and 4, but will require sufficient funding for earthworks and the agreement of the private owners where applicable.
- Action 3 is largely independent of other tasks and could be completed at any time. Sufficient resources (especially time) should be provided for the consultation and design discussions required with Alexandrina Council and the Department of Planning, Transport and Infrastructure (DPTI).

Actions 2 and 4:

- Should follow Action 1, but in that order.
- If completed manually, Action 2 will be time consuming and labour intensive.
- If conducted as a trial, Action 4 is likely to be relatively inexpensive and simple to complete, but does require sufficient time to be provided for the consultation and design discussions required first with DPTI.

# Contents

# 1 Project Background

The swamps of the Fleurieu Peninsula include a range of different wetland types associated with high rainfall areas of the southern Mt Lofty Ranges and straddle two NRM regions (SA MDB and AMLR); specifically those situated within the Tookayerta, Hindmarsh, Parawa, Myponga, Yankalilla, Onkaparinga, Currency Creek and Finniss catchment areas. The original extent of these swamps is estimated to have exceeded 2000 hectares, but over half of this area has either been lost through reclamation (drainage and development) or is severely degraded. Those sites which remain are typically quite small (< 5 ha) (Littlely and Cutten, 1994), degraded and often highly fragmented and isolated. Given the high degree and intensity of human disturbance on the Fleurieu Peninsula, combined with ongoing and demonstrable threats, the swamps of the Fleurieu Peninsula were listed by the Australian Government as a critically endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999* (EBPC Act) in March 2003. Based on past research investigating the condition of remnant swamps, 53% are degraded, 21% are in moderate condition and only 2% are considered to be in a near-pristine state (Harding, 2005). In the Mt Compass and Finniss areas, remnant swamp communities primarily exist as relatively narrow bands of wetland vegetation in the valleys along natural and artificial drainage lines or seepage discharge areas, often straddling multiple smaller landholdings.

Scientists and environmental managers have been researching, and evaluating reasons for, the apparent ongoing decline in condition of the swamps, particularly as habitat for the endangered Mt Lofty Ranges Southern Emu-wren. Previous work has been undertaken by the Fleurieu Peninsula Swamps Recovery Team investigating vegetation community trajectories in response to ecological disturbances (such as fire) and removal of disturbance (such as grazing). This has been both strategic (via trials and transect establishment) or opportunistic (R. Duffield, pers. comm.). More recently there has also been a growing awareness of the need to investigate and address hydrological changes to swamps and their catchment areas. It is widely recognised that water management and disturbance dynamics are key drivers of wetland condition.

With this background in mind, a restoration plan was recently developed for one of the most significant remaining Fleurieu Peninsula swamps, Glenshera Swamp in Stipiturus Conservation Park, situated near Mt Compass (Bachmann and Farrington, 2016), where initial on-ground works have since commenced in 2017. As a result of this first restoration project, there is a growing awareness among NRM practitioners of the need to address potential hydrological threats at other high-value sites. Hence, Natural Resources SA MDB (project manager, Nicola Barnes) have commissioned this eco-hydrological study for Square Waterhole Swamp, within Hesperilla Conservation Park. The investigation has a particular focus on understanding and evaluating the elements capable of negatively influencing hydrology, identifying those that can be actively managed (such as artificial drainage), and suggesting remedial works aimed at minimising or eliminating these impacts into the future.

### 1.1 Project objective

The overall objective of this report and the body of work it summarises is to outline an assessment of hydrological restoration options for Square Waterhole Swamp in Hesperilla Conservation Park, by providing a detailed investigation of:

- Past environmental conditions and values;
- Current eco-hydrological condition and function; and,
- The range of available restoration options.

### 1.2 Requirements

Information requested to be included either in this restoration plan, or considered in its development, include:

- An overview of Hesperilla Conservation Park and the intent of the restoration plan.
- A land tenure assessment of the full wetland extent.
- Reviewing the history of drainage, diversions, and land-use change.
- Evaluation of background material and other existing information on native vegetation, landscape context, habitat for threatened species.
- Completion of digital terrain modelling (based on LiDAR data capture).
- Compilation and assessment of eco-hydrological features and data.
- Assessment of climatic trends.
- Assessment of the natural regeneration capacity of the site.
- Consultation with key stakeholders, including neighbours.
- Field visits to validate desktop findings.
- Providing advice on suitable restoration options and steps required towards their implementation.
- Seeking peer review of the plan.

### 1.3 Project deliverables

- Electronic copies of the final report
- Electronic copies of any literature cited (papers, fact sheets, etc.)
- Presentation of the restoration options to Natural Resources, SA MDB.

## 2 Considerations for Wetland Restoration Planning

For an overview of the *Logic of Wetland Restoration as a Conservation Tool*, please refer to Section 3 (pages 7-11) in the first Fleurieu Swamps restoration planning case study: ***Hydrological Restoration Options for Glenshera Swamp*** (Bachmann and Farrington, 2016).

# 3 Site history assessment

## 3.1 Site description

Hesperilla Conservation Park is named after the Golden Haired Sedge-skipper (*Hesperilla chrysotricha*), see Figure 3.1, a now extremely rare butterfly of the southern Fleurieu Peninsula district, only recorded locally in a few swamps.

***Figure 3.1: Golden Haired Sedge-skipper Butterfly (Hesperilla chrysotricha).***
*Photo by Bryan Haywood*

The park is located approximately 50 km south of Adelaide and two kilometres south of the township of Mount Compass (Figure 3.2), adjacent to (west of) the Victor Harbor Road.

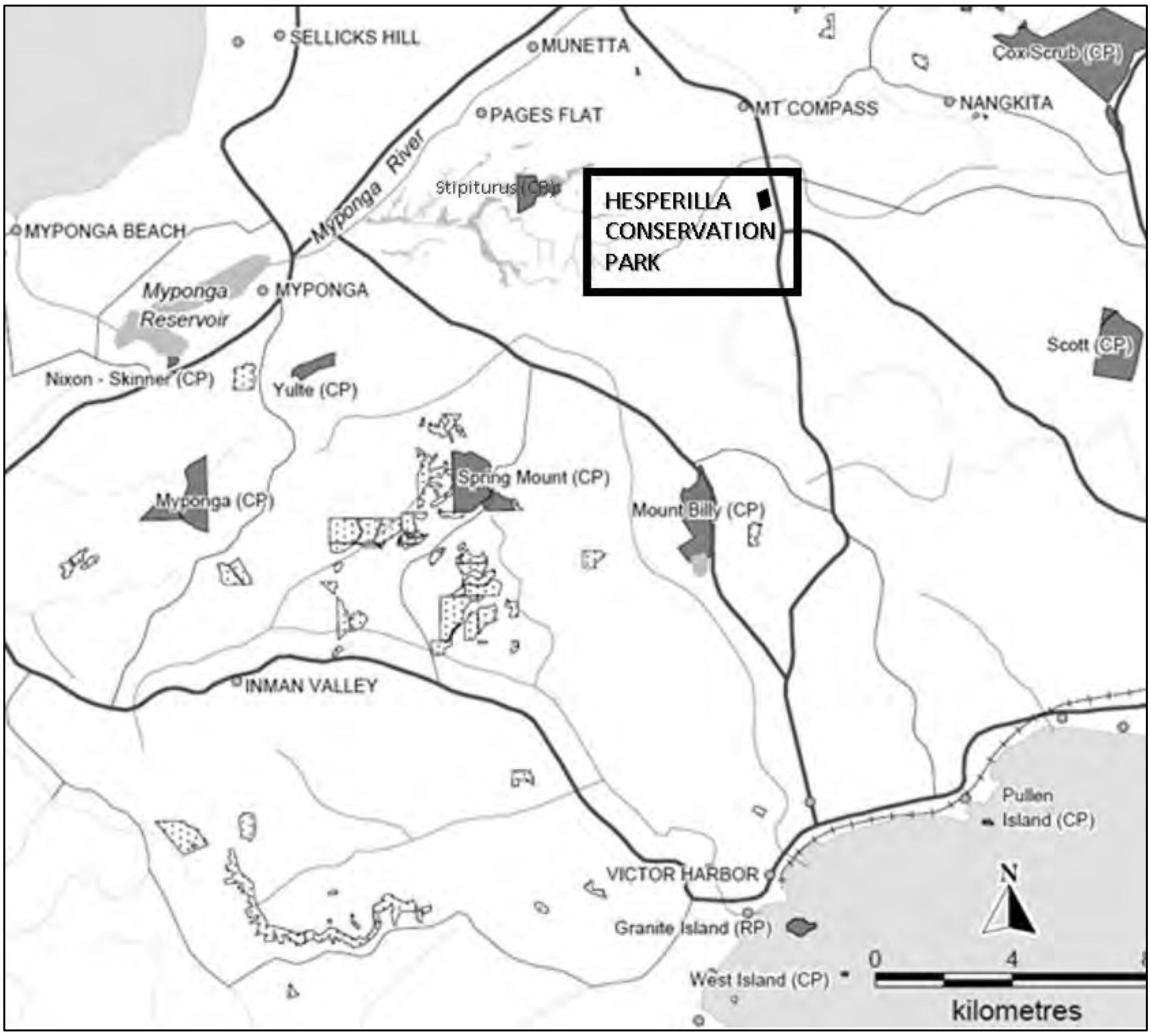



***Figure 3.2: The location of Hesperilla Conservation Park.***

Square Waterhole Swamp, which forms a central wetland feature and occupies almost all of the 11 hectare parcel that makes up the park (Figure 3.3), is regarded as a good example of a peat swamp community in the Mt Compass uplands (Harding, 2005), despite extensive previous drainage works and an intensive grazing history. The site slopes gently downhill from the north-western to south-eastern corners and is bordered to the west by sandy slopes of moderate gradient.

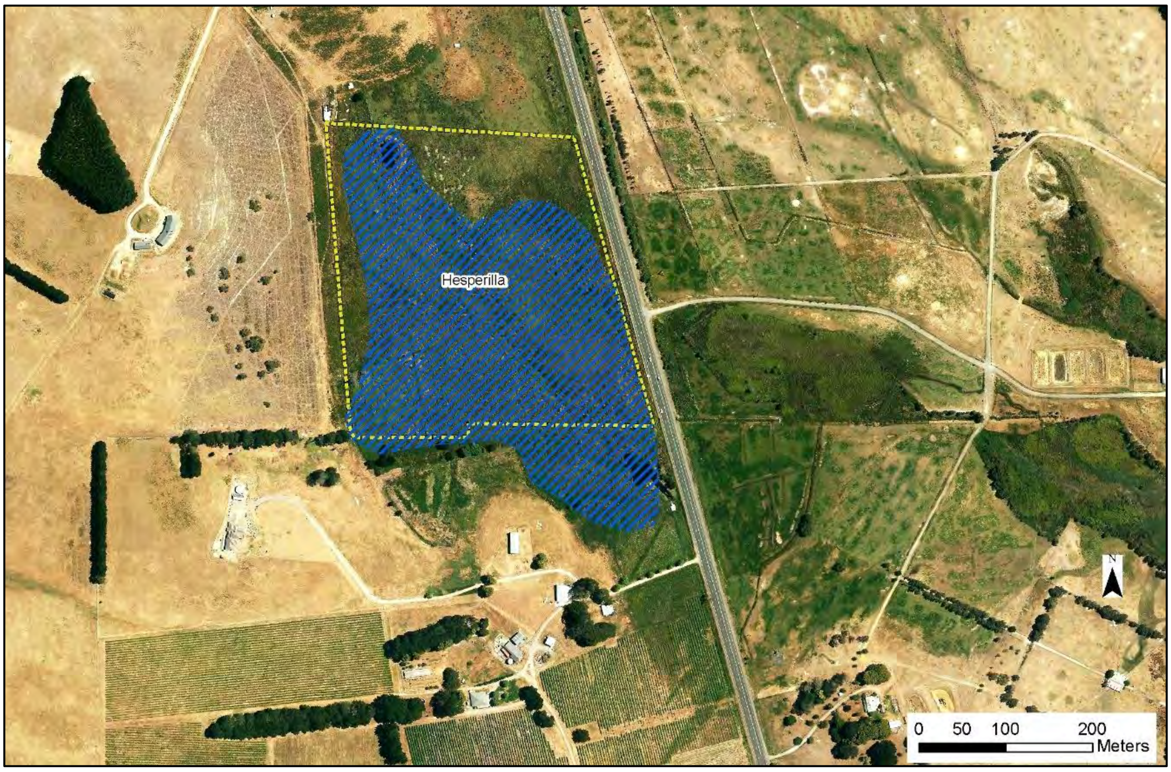



***Figure 3.3: Hesperilla Conservation Park (outlined in yellow), showing the current mapped extent of Square Waterhole (blue shading) in the DEWNR GIS wetland layer.***

The north-eastern corner of the site is of a slightly higher elevation and contains a mixture of open rushland and introduced grasses while the north western corner contains an excavated dam, the remains of old pumping equipment and a dense network of channels and culverts which modify natural inundation patterns through this portion of the wetland. The main wetland area is covered in dense, low-shrub and sedgelands which provide habitat for a population of the nationally endangered Mount Lofty Ranges Southern Emu-wren (*Stipiturus malachurus intermedius*) (M. Pickett, pers. comm. 2017). Indeed the presence of this population was a major reason the state government chose to purchase the site in 2007 (after an incidental prompt from Marcus Pickett when the land came up for sale) and for its eventual proclamation as a Conservation Park in February 2010. Despite its reserved status, the park is yet to have a management plan prepared or adopted under the *National Parks and Wildlife Act 1972*. Hence this restoration feasibility assessment provides the first detailed investigation of the site, its values, ecology and history, and should provide a useful consolidated information resource if and when a park management plan is developed in the future.

## 3.2 Land tenure and management considerations

Although predominantly situated within Hesperilla Conservation Park, Square Waterhole Swamp (as currently mapped in the DEWNR wetland layer – albeit with some inaccuracies) does straddle the park boundaries, as shown in Figure 3.4. However, the full wetland extent is somewhat masked by artificial drains that also extend into additional parcels of adjacent private land situated to the north-west and south-west of the mapped area.

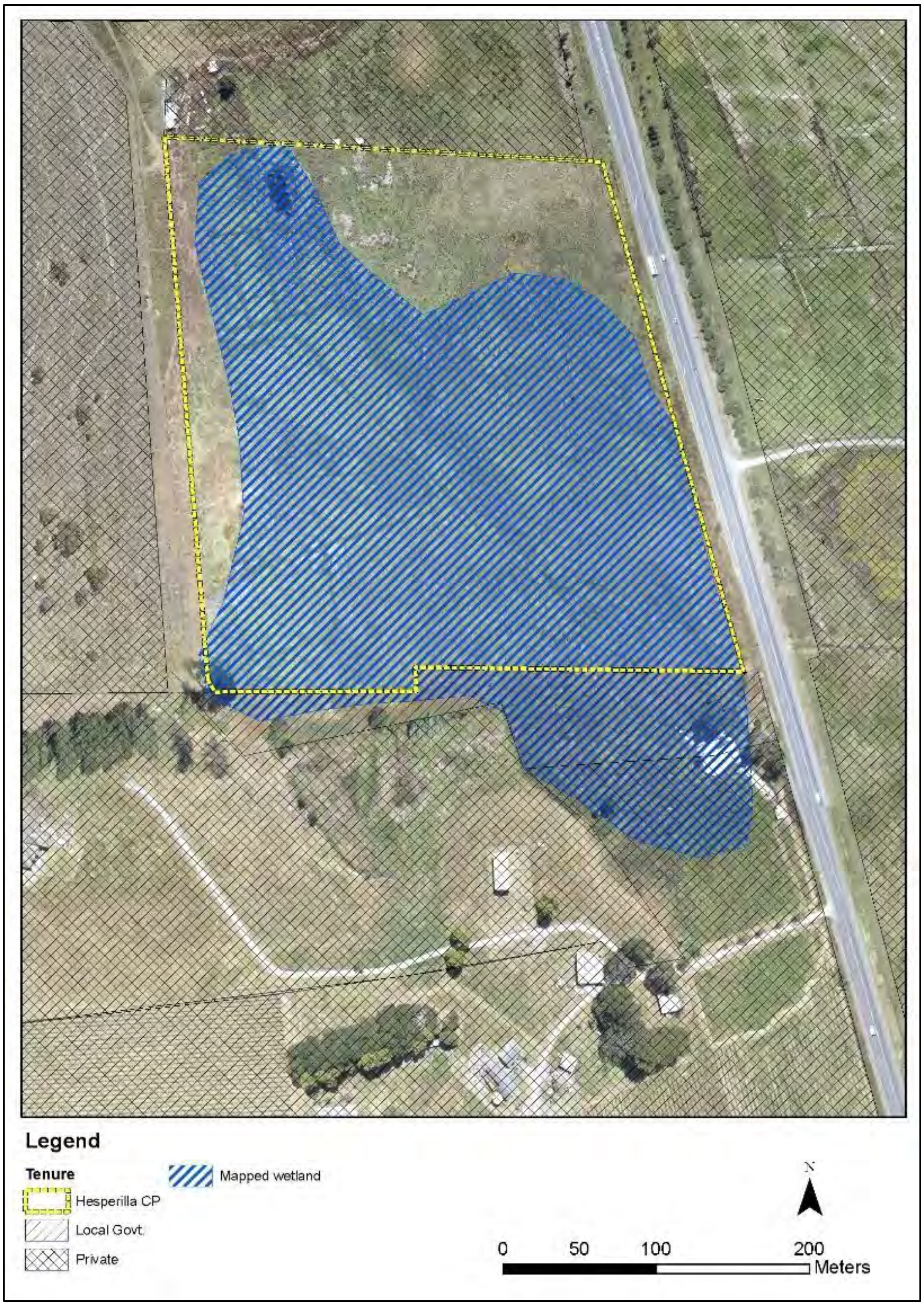



*Figure 3.4: Location of the present (slightly inaccurate) mapped extent of Square Waterhole Swamp*

Those three parcels of private land (one to the north and two to the south), and additional areas of Public Land adjacent to the formal Conservation Park, are indicated in the land tenure map shown in Figure 3.5.

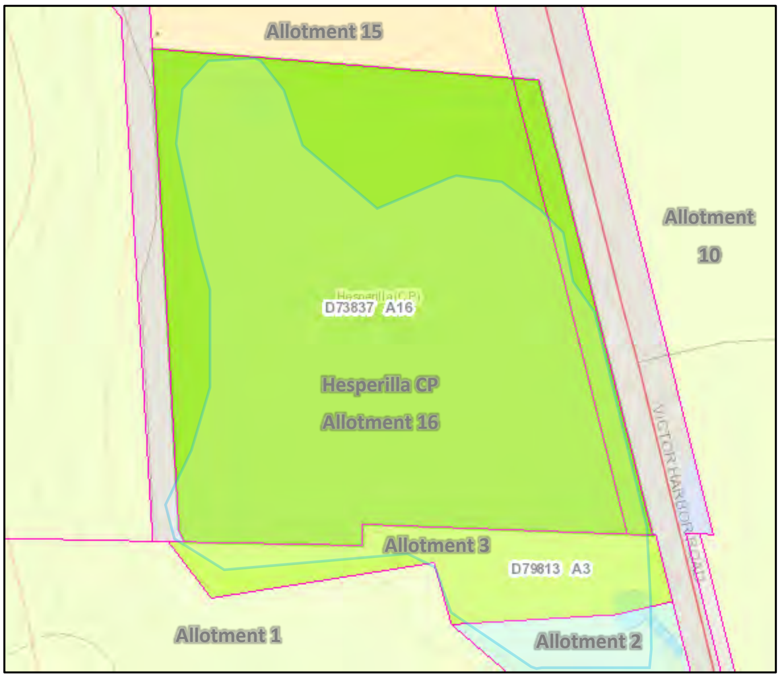



***Figure 3.5: Topographic map showing cadastral boundaries and land tenure surrounding Hesperilla Conservation Park. DEWNR wetland polygon is lightly shaded.***
*__Key:__ Dark Green – Hesperilla Conservation Park; Light Green – Local Government Reserve; Grey – Road Reserves; Other colours – Privately owned properties*

### *3.2.1* Public land managers

Despite not yet having a Park Management Plan in place, the primary focus for the managers of Hesperilla Conservation Park is to maintain a healthy ecosystem that supports the values for which the areas was purchased and proclaimed; namely, the local Mount Lofty Ranges Southern Emu-wren population, the diversity of the threatened swamp ecological vegetation community, and other species of conservation significance. Contact has been maintained throughout the project with the public land manager (Senior Ranger with DEWNR, Stuart Hicks).

Contact has also been maintained throughout the project with the Alexandrina Council Environmental Officer, Lisa Kirwan. This local government body is responsible for the management of land immediately adjacent to the Conservation Park on three sides:

1. **To its south** is an irregular shaped parcel (A 3) that has been a reserve vested under the care and control of Alexandrina Council since 2009 – marked light green in Figure 3.5. The creation of Allotment 3 resulted from a land swap negotiation between a previous private owner and the Council. The owner approached Council in 2005 after they discovered part of a building on their property had been constructed over the previous

road reserve. The boundary reconfiguration (Figure 3.6) and land exchange was finalised in 2008 (L Kirwan, pers. comm.).

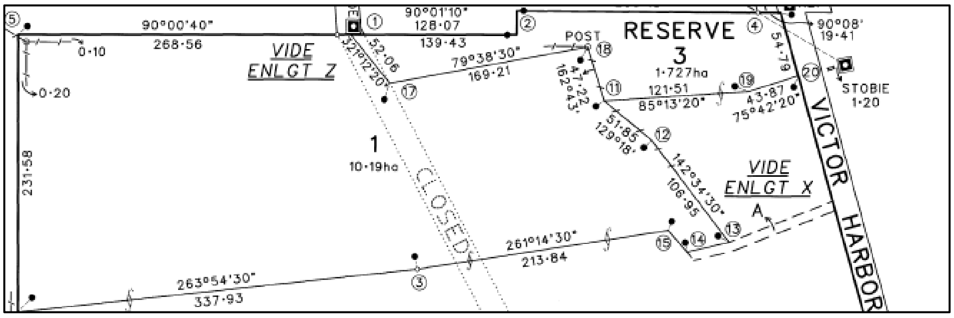



*Figure 3.6: The reconfigured parcels and closed road along the southern boundary of Hesperilla CP*

2. **To the west** of the Conservation Park lies an unmade road reserve, under the care and control of Alexandrina Council – marked grey in Figure 3.5.

3. Finally, **to the east** of the Conservation Park is the main Victor Harbor Road from Mt Compass – also marked grey in Figure 3.5. This is a DPTI managed road, meaning that day-to-day management responsibilities are shared between the South Australian State Government (the road pavement and verge between the marker posts) and Alexandrina Council (the road reserve outside the marker posts).

The public land managers (both DEWNR and Alexandrina Council) are supportive of the restoration planning process outlined in this report. However, should the actions in this report be implemented, then additional consultation with DPTI will be required.

### 3.2.2 Adjacent private landholders

Peripheral zones of the wetland, which occur on private land to the north and south of the park, are currently subjected to low-intensity grazing by domestic stock. A dam that straddles public and private land in the south-eastern corner of the wetland is also used as a water source for irrigation of nearby vineyards.

Through the process of undertaking this restoration feasibility assessment, Nature Glenelg Trust staff have approached and met with neighbours who own peripheral parts of the wetland. Contact has been made and/or maintained with private owners of the two parcels of land to the south (Allotments 1 and 2, DP 79813), the owner of the parcel to the north of the Conservation Park (Allotment 15, DP 73837) and the private land (Allotment 10, DP 73678) on the downstream property to the west of the Victor Harbor Road.

General attitudes throughout the investigation process from private neighbours have been supportive and are compatible with the some form of future hydrological restoration occurring within the Park, with initial support for some of this work also extending into private land to the south of the Park.

### 3.2.3 Wider consultation

In addition to discussing and understanding the expectations of neighbours regarding future management, the wider community has been kept informed of project progress, and asked for their input, at two publicly advertised community presentations held in Mt Compass, in December 2016 and April 2017.

Communication has also been maintained with government agency staff, NGO's, research organisations, volunteer interest groups and other individuals who have a stake in ongoing surveys, research and conservation management in the park. We have also met with local residents with detailed knowledge of the agricultural history of the site and its past management.

A series of discussions have been held on-site with these experts beginning in September 2016 (e.g. Figure 3.7), followed up with presentation of our early conceptual understanding of the site at a Fleurieu Peninsula Swamps Recovery Team meeting (at Willunga) in November 2016, a technical workshop (in Mt Barker) in April 2017 (Figure 3.8), and additional sites visits in April and May 2017 to verify site characteristics.

***Figure 3.7: Catching up with experts in the field – <u>left</u>:*** *Tim Vale (CCSA) and Nicola Barnes (Project Manager with DEWNR), and* ***<u>right</u>:*** *Marcus Pickett (CCSA), who was originally involved in identifying the potential of the site for purchase, due to its value for the MLR Southern Emu-wren*

This has been an iterative process coupled with NGT's investigation as it has unfolded. In this way, participants in these discussions have learned about the site as new information and insights have emerged, helping us to build and share a collective understanding of the site and its history, while talking over potential options for future management.

*Figure 3.8: A workshop with experts in April 2017 at the Natural Resources Centre in Mt Barker.*

However, after going through this consultation process, it is noteworthy that, compared to a recent similar process undertaken at nearby Stipiturus CP (see Bachmann & Farrington 2016), the level of knowledge among experts we have consulted with, regarding the history and biodiversity values of Hesperilla CP, is significantly less advanced. Despite being a smaller site and located next to the main Victor Harbor Road, the site has not experienced the same level of past research and visitation by professional or amateur ecologists, either before or since its reservation. As a result, the information presented in this report should provide a useful platform, and impetus for further study.

A draft version of this report was also circulated for comment and peer review in June 2017.

We are extremely grateful for the following individuals and groups for sharing their knowledge of the site and wider catchment, contributing to (or reviewing) the report and/or meeting with us to discuss future management options:

- Nicola Barnes, ecology (DEWNR)
- Marcus Pickett, avian ecology (CCSA)
- Warren Jacobs, community member
- John Gitsham, ecology and private land management (GWLAP)
- Stuart Hicks, public land management (DEWNR)
- Rebecca Duffield, ecology (CCSA)
- Julie Schofield, ecology (CCSA)
- Tim Vale, ecology (CCSA)
- Lisa Kirwan, public land management (Alexandrina Council)
- Tessa Roberts (NGT/CCSA Graduate Intern)
- Clive & Claire Chesson, flora (Friends of Parks)
- Leo Davis (NOSSA)
- Rick Davies, flora (DEWNR)
- Tim Jury, flora (NCSSA)
- Mardi Van Der Wielen, water planning (DEWNR)
- Kylie Moritz, ecology (DEWNR)
- Doug Bickerton, ecology (DEWNR)
- Jason Higham, ecology (DEWNR)
- The MLRSEW/FPS Recovery Team

## 3.3 Property history and development

### 3.3.1 Square Waterhole – a feature, locality and wider district

Before we explore the history of Square Waterhole Swamp in detail, it is worth clarifying the reasons why the name 'Square Waterhole' is so commonly found and repeated in many early references, but not always in relation to the wetland area that now falls within Hesperilla CP. The reasons for this can be understood by reviewing how the name became connected over time with, and used as a reference point for, a number of different things. In short, the name and term "Square Waterhole" is inter-twined with both the history of the site and the early visitation to, and development of, the surrounding district.

***Square Waterhole – The physical feature and locality:***

First and foremost, Square Waterhole was a real, physical feature, created by excavation of peat to be dried and burned as domestic fuel on-site (RMCD, 1946); at the location of an early, at that time highly remote, stopover on the overland transport route between Adelaide (via Willunga) and the south coast. This early reference from the South Australian Register (1856) is one of the first to Square Waterhole and illustrates the conditions there in the mid-1850s, after the establishment of a new public house at the site in 1855:

> From Myponga-road to the Square Waterhole the road is an unmitigated scrub, toilsome alike to man and beast. At the Square Waterhole a very welcome public-house has recently been erected by Mr. Lush. It is a primitive slab building, but is clean and comfortable. Application has been recently made to the Government to remit the usual licence-fee for the first year in the case of this wayside inn, on the ground that the traffic past it is too small at present to prove very remunerative, while the desirableness of encouraging the maintenance of a hostelry in this lonely and desolate spot is very great. There is always abundance of water in the swamp here even in the height of summer in the very driest seasons. It is by no means brackish, though it has a metallic taste. No cultivation of any sort is carried on, the attempts at it having failed perhaps from want of proper drainage. There is plenty of feed around for a good flock of sheep, and by yarding the flock at night over a few acres of ground it would soon be possible to change the character of the soil, and make successful tillage possible. At present all the hay and corn has to be brought up from a distance of 10 miles, and fresh vegetables are not to be [illegible]. The turf from the swamp, cut out and dried, resembles the peat from the Irish bogs, and burns well as fuel. At the Square Waterhole two roads diverge—that to the left leading to Currency Creek, and the other taking to Encounter Bay. Journeying along the latter, I found the road to be not quite so sandy, though more hilly than the first half of this miserable scrub. It

This excavated waterhole and the public house named after it (which due to limited traffic couldn't afford the fee to maintain a licence to serve alcohol by 1860), were located near the junction where the two roads to the south coast diverged (i.e. the tracks to Currency Creek/Goolwa and Encounter Bay/Victor Harbor), skirting the south-western edge of the swamp. An early survey map of the site from 1855 or 1856 is highly suggestive of the original location of both features, with an unidentified small black square marked on the map reproduced in Figure 3.9 (see super-imposed red arrow). While we may never be certain, there is a strong possibility that this indicates the precise location of the recently (in 1855) established inn, with the physical waterhole located nearby.

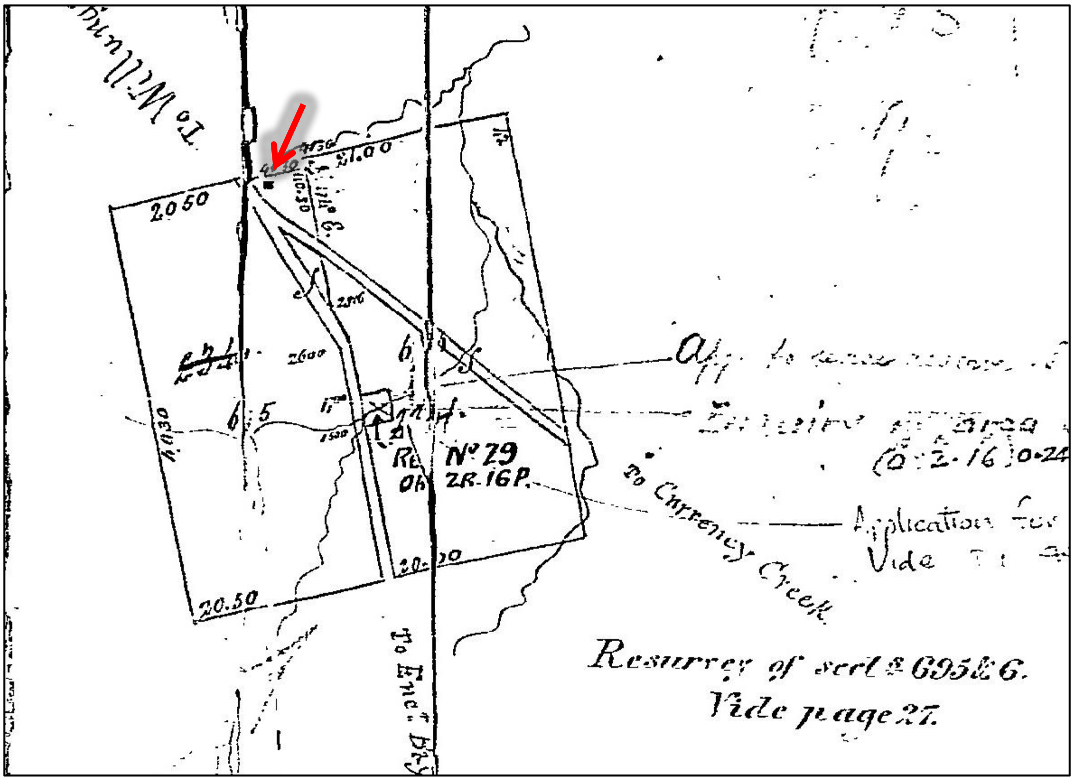



***Figure 3.9: 1855 survey diagram of the "Square Waterhole sections" – Sections 695 and 696, Hundred of Nkangkita***

This specific location for Square Waterhole (at the base of the hill, which today is near the end of a row of pine trees planted up the hillside) is corroborated by other available evidence, including a detailed description in Jacobs (2005) that also recounted a site visit in 1985 with the previous manager of the dairy on the property, Keith Blakely. Mr Blakely had found some evidence associated with the inn at this same location in the past, after broken bottles and other items were found when tilling the soil. His wife, Ella Blakely, also later recalled that her husband had found what he thought to be the original (room-sized) waterhole, lined with timbers, at the edge of the swamp near this same location decades earlier when constructing or maintaining artificial drains through the swamp (Jacobs 2005). More recent accounts and site inspections suggest that the original waterhole is now overgrown and/or partially filled in, as its precise location has not been accurately verified.

However, the one key correction that can be made to Jacobs' 2005 account, is that it would now almost certainly appear that the previous Crown Land Reserve (No. 29), situated nearby, does <u>not</u> mark the precise location of the original Square Waterhole. Close inspection of the map in Figure 3.9 clearly indicates that this reserve was located over a rise and within the next minor valley to the south. As shown on the map, this small reserve was sited along the seasonal watercourse that flows north-east into the swamp from the direction of Mt Jagged, not at the margin of the swamp or near the site of the original inn.

**Square Waterhole - The wider district:**

Being remote and the only resting place for a considerable distance, the term Square Waterhole quickly took on a wider geographic meaning that extended far beyond the physical waterhole or the site of the first public house. As illustrated in Figure 3.10, a map of the County of Hindmarsh from May 1854, the sections of land made available for the Square Waterhole inn were highly isolated from other sections of land that had been taken up for closer settlement by that time.


*Figure 3.10: Portion of a map of the County of Hindmarsh from May 1854, by Robert Stephenson, Surveyor. The "Square Waterhole sections" are clearly visible (see arrow) and highly isolated.*

Indeed this pattern of development, or lack thereof, in the vicinity of Square Waterhole was to persist for decades to come; hence the early descriptions of the wider district are littered with similar, geographically vague references. Terms like "Square Waterhole Swamps" or "Square Waterhole Country" were often used to describe the entire surrounding undeveloped district, extending to present day Mt Compass, Nangkita and the Black Swamp. To illustrate, see this typical early reference from the South Australian Register (1889):

The "Square Waterhole Country," which is seen on the first of these routes, is exceedingly interesting as having attracted so little attention for over thirty years, although capable of supporting, according to competent opinion, quite a large population. A network of swampy ground stretches along the country at the head waters of the River Finniss and along towards the road which leads to Willunga. This peculiar conformation of country may be understood to some extent by inspecting the River Finniss at the place where it is crossed by the railway to Goolwa. The bed of the river is a large wide channel of swampy ground, varying from 100 yards to perhaps half a mile in width and spreading out in places into large broad swampy areas full of rich rank soil with peat and bog, examples of such areas being the Sqaure Waterhole itself and the Hungry and Black Swamps.

The origin of this remarkable conformation seems to be that the waters collected from the large areas of sandy ground near Mount Magnificent and Mount Jagged pass underground by percolation from the sand and have converted large tracts of country into spongy wet soil.

### 3.3.2 A brief history of the development of the Hundred of Nangkita

Square Waterhole and the majority of what was referred to as "Square Waterhole Country" is located within the Hundred of Nangkita (originally spelt Nkangkita), which was defined and proclaimed by South Australian Colonial Secretary, A. M. Mundy, in 1846 (Adelaide Observer, 1846):

6. *Hundred of Nkangkita.*

Bounded on the west by the range between Wood Cone and Mount Compass, which separates the Myponga from Longmarsh; thence from Mount Compass by a continuous range to Mount Observation; thence along the most direct spur to the north-west corner of section No 2363; thence down the River Finniss, keeping midchannel to the Goolwa; thence along the midchannel of the Goolwa to the north east of Hindmarsh Island, to the channel which finds its way to the sea mouth of the Murray, to the east of Hindmarsh and Mundoo Islands; thence to follow that channel to the sea mouth of the Murray; thence to follow the sea coast to a point south of a trigonometrical station south east of section No 2209, and by that station to the midchannel of the Goolwa; thence up the Goolwa to Currency Creek; thence up Currency Creek to a road which crosses it at the south-west corner of section No 2011; thence following that road through sections Nos 2011, 2015, 2005, between sections Nos 2017, 2018, 2031, and 2032, through 2018, 2036, 2034, and 2096, and from the north-west corner of the latter section (2096) passing up a spur which separates the waters of the Long Swamp and the Finniss from Currency Creek, and continuing along this spur to Mounts Jagged and Wood Cone,

Despite its early proclamation and proximity to both Adelaide and busy early trading locations at Goolwa and Victor Harbor, much of the Hundred escaped closer settlement over the subsequent 40 years, due to its perceived lack of suitability for agricultural development: consisting of large tracts of what was considered inferior stringybark scrub over sandy soils on the hills, and impenetrable tea-tree swamps in valleys lacking natural drainage. A detailed description of a journey through the area in the Adelaide Observer in 1887, paints a picture of a remote wilderness, with very few inhabitants:

NO. II.—FROM WILLUNGA TO PORT VICTOR.

After a night's rest at the clean and comfortable hostelry known as the "Bush Inn," we started early, with a bright cool morning, for Port Victor, for the purpose of inspecting and forming an opinion of the capabilities of the intervening country for cultural occupation. The famous Square Waterhole, the infamous Black Swamp, the wrongly named Hungry Swamp, and many historical places exist upon this route. Once there was an accommodation house at the Square Waterhole, where the accommodation was next to nothing and the civility usually expected at such places was altogether absent. Afterwards there was an inn, which was a little better, but the inducements to travellers that way were insufficient and the place is now deserted. There are only two inhabited cottages visible from the road upon the whole route, and one of these, occupied by a stationman under the Road Board is likely to be empty soon. The first house is near Mount Compass, a mile or two west of Square Waterhole. The other is several miles further on, at Hungry Swamp, where George Gaultier occupies a selection of nearly 1,000 acres at an annual rental of £3 10s.

As indicated here, by 1887 the former Square Waterhole Inn was deserted, and the only dwelling situated near present day Mt Compass was the residence of the Road Board's "Stationman" at the time and local pioneer – George Waye – who had been living there with his family since June 1874. His job was to maintain and repair 11 miles of the Willunga road along its new route, after its 1860s realignment (see Figure 3.11). As an elderly man in 1925, when recalling the first 15 years of working there under the Road Board (before transfer to the District Council), he said, "at that time, Mount Compass was all scrub, hundreds and thousands of acres of it. The road was simply a bush track." He also said that he "used to patrol the roads for days on end and never see a single soul" (Victor Harbor Times, 1925).

The following article from the Evening Journal in 1889 details how "*the Crown is still the owner of nearly two-thirds of the land*" in the Hundred of Nangkita, in stark contrast to the adjacent Hundreds (also described below) at that time:

**In the Hundred of Goolwa, running from the Hindmarsh River to Currency Creek and up to Mount Jagged, there are no blocks, and the same may be said of the next four hundreds to be mentioned. Goolwa includes 55,040 acres, of which 16,590 are under lease. Some of the land chiefly comprised is what is known as the Square Waterhole country, amounting to 3,340 acres, is still in the hands of the Government. But the bulk of this unsold country is included in the Hundred of Nangkita, which is bounded by the River Finniss on the east, and runs away up towards Willunga. It embraces no less than 23,080 acres of Crown lands, and 24,295 acres which are held on lease; so that in this hundred, out of 74,880 acres, the Crown is still the owner of nearly two-thirds of the land. But after leaving the Finniss and proceeding as far as Strathalbyn and Bull's Creek, we find that the case is very different in the hundred known as Kondoparinga. There are no vacant Crown lands, and only 12,916 acres are held upon lease.**

However, with the land being surveyed into smaller blocks for closer settlement during this period (the 1880s and early 1890s), as shown in Figure 3.11, the state government was responding to community pressure, ultimately resuming the pastoral and/or miscellaneous leases and making the land available for more intensive agriculture. From that point forward, the dramatic change in land-use that had already swept across neighbouring districts was now about to unfold in the "Square Waterhole Country".


***Figure 3.11: Paving the way for closer settlement: An identical view of surveyed parcels in the "Square Waterhole Country", Hundred of Nangkita, between 1854 (left) and 1894 (right). Also note the realignment of the road.***

The process began with intensive market garden style developments, especially on small land-holdings, leading to the rapid growth of a township at the present-day location of Mt Compass and establishment of the Nangkita settlement in the 1890s. This form of agriculture during a time of economic depression was extremely labour intensive, relying on manual drainage and clearing of the swamps to grow produce in the fertile peat soil. In the early days of settlement, this immense task was completed using basic hand tools.

For the next few decades until the 1930s, development focussed largely on making the swamps of the district productive for market garden style developments, with the higher slopes (of less fertile soils) only used as rough pastoral country for grazing livestock. This headline of an article in the Register in 1915 perfectly summarises local attitudes and the style of development that was generally being promoted at the time:

THE BLACK SOIL COUNTRY.

MT. COMPASS AND THE PEAT FLATS.

THE PROFITABLE 10-ACRE BLOCK — FORTUNES IN MARKET GARDENING.

However, with time, rapid advances in agricultural technology in the 1920s and 1930s – including mechanisation and new equipment, fertilisers, trace elements, new pasture varieties and changes in farming practices – made it possible for more of the land to be opened up, more quickly. Crucially, active development was now pushing beyond the margins of the "peat flats" and into scrub country previously considered unproductive. The results, as shared in the following excerpt from an article by a travelling party inspecting development in the district around Mt Compass in 1935, were enough to encourage others to expand their activities or take up land and follow suit (Chronicle, 1935).

We made an inspection of three of the paddocks and, at a point where one of these joined the land that had not been cleared, were able to witness a remarkable comparison between the country in its natural state and that developed. On one side of the fence there was nothing but a dense mass of scrub, heath, black grass and useless bush, with insufficient feed to fatten a rabbit, and, on the other, we were standing in clover and rye grass above our boot tops, although four sheep to the acre were being grazed thereon.

In short, the "Square Waterhole Country" was about to witness an explosion in rates of land clearance of the high country and slopes that would transform the land and set in train the sequence of events that explain the present-day condition and pattern of development across the Hundred of Nangkita.

### 3.3.3 History of Square Waterhole Swamp prior to 1940

For the purposes of this report, from this point we'll refer to the wetland in the immediate vicinity (to the north-east) of the original Square Waterhole sections, as "Square Waterhole Swamp". Square Waterhole Swamp originally straddled multiple sections of land, as shown in Figure 3.12, forming the broad, groundwater-discharge fed headwaters of the Tookayerta Creek, which then flows in an easterly direction before discharging into Black Swamp and ultimately the Finniss River.

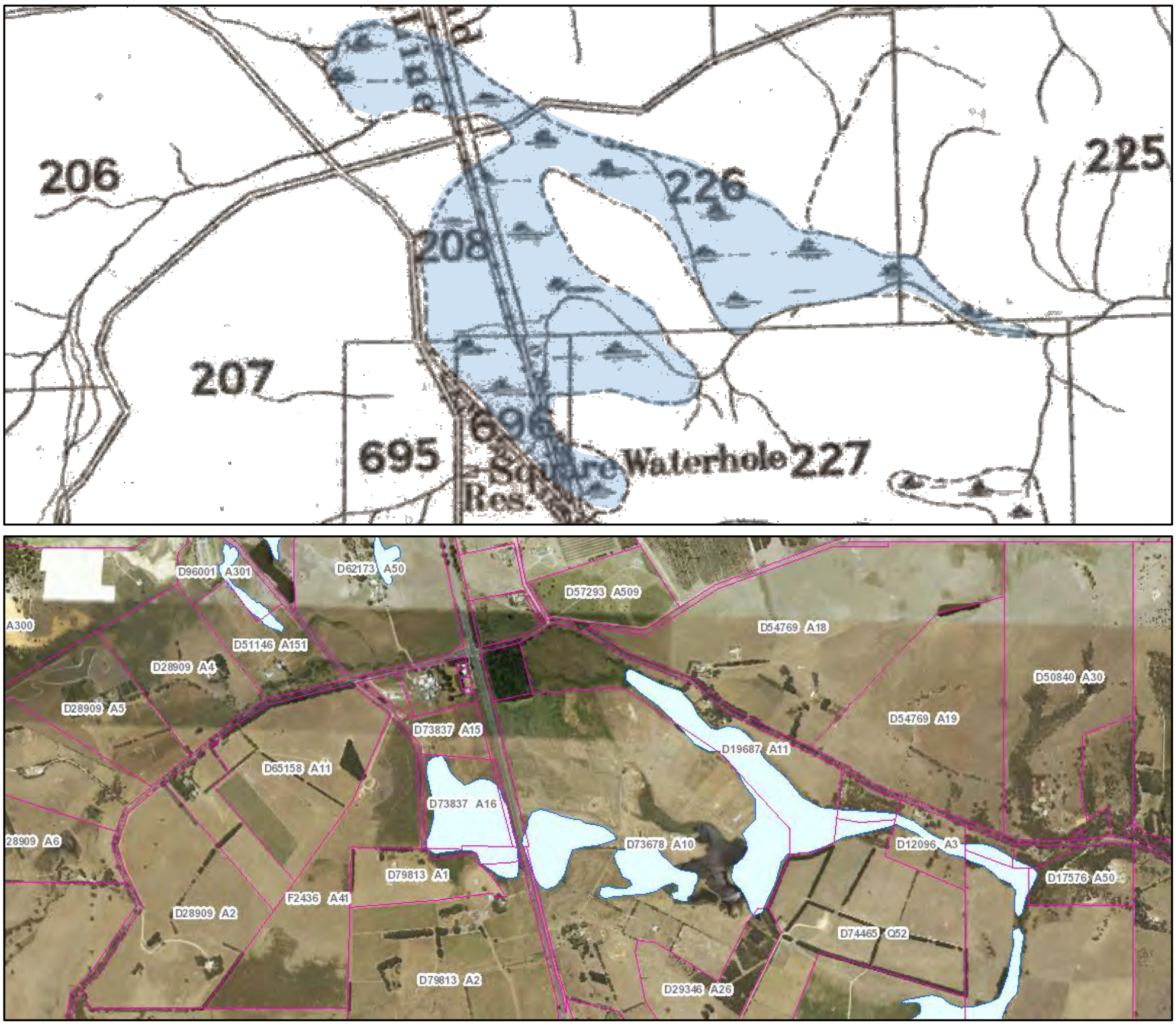



***Figure 3.12: Square Waterhole Swamp, with wetland areas shaded***
***1894 map based on survey diagrams (above) and the same view today (below – with present DEWNR wetland layer polygons) for comparison.***

At a glance, it is clear that present day Hesperilla CP, which falls entirely within what was previously Section 208, represents only a fraction of the original wetland area. While the fate of the wider wetland complex will be explored later in this report, the most striking aspect of this map, relevant to the early (pre-1940) history of the site and with repercussions today, is the 1894 illustration of the new alignment of the road from Willunga. Previously skirting the edge of the wetlands at the base of the hills, the new road bisects a significant portion of Square Waterhole Swamp.

**1860s - The 'South Road'**

In the mid-late 1850s, several accounts of the treacherous nature of the journey on the original 'South Road' appeared, often coupled with pleas for action to address the state of the track (Adelaide Observer, 1856):

present summit. Nothing can well be worse than the present route to Encounter Bay; whether it is the deep sand extending for miles to the Square Waterhole, the rise and fall of Mount Jagged, with its deeply water-worn surface, the wretched crossing of the Hungry Swamp, or the execrable Cut Hill descending to the Bay—all alike is bad, and I fear hopelessly so, unless an amount of money for its improvement be forthcoming, which I apprehend it would appear quite fabulous to speak of."—*Adelaide Observer*, February 22, 1856.

By 1859, a detailed report of notes from a special meeting of the Central Road Board (reproduced below from the South Australian Register, 1859) explained the logic of abandoning the old undulating track in favour of a new route with better gradients:

**Report on proposed new Main Road from Willunga Hill to Hindmarsh Valley.**

Adelaide, September 14, 1859.

Gentlemen—In pursuance of your instruction I have the honour to lay before you a report with estimated cost of cutting and forming a road 20 feet wide, commencing at the top of the newly cut road (Willunga Hill), and terminating at the bottom of Cut Hill, Hindmarsh Valley, being 15 miles and 33 chains. The proposed new line of road, on leaving Willunga Hill, bears to the south-east, and crosses Mount Compass Range about one mile east of the Mount; from thence it passes along the eastern sides of the sandhills, and the Square Waterhole Swamp. It also leaves the Hungry Swamp about one mile to the west, and keeps a southerly direction until it forms a junction with the new road, Hindmarsh Valley.

My reasons for proposing to abandon the old track are—The new line proposed escapes almost all the heavy sandhills, runs along the sides of stony hills, from whence road metal can be easily obtained, and offers much better gradients than those on the old track, without increasing the distance.

The quantity of excavation entered in the estimate is sufficient to make side-ditches, all necessary outfall drains, and form an embankment entirely across the swamp, twenty feet wide and three feet high, with side slopes, one to one as shown in the diagram below. The earth to be excavated, as far as can be ascertained, appears to be (for about two feet deep) sand mixed with vegetable matter, resting upon clay. This, if properly drained, would make an embankment in every respect as regards solidity equal to those lately made in Hindmarsh Valley. The side ditches would be five feet deep, nine feet wide at top, and four feet at bottom.

I have, &c.,

J. T. MANTON.

With this simple report, we have the earliest evidence of plans that would begin the process of hydrological, and hence ecological, change at Square Waterhole Swamp. The Road Board now had a plan for a continuous north-south "*embankment entirely across the swamp, twenty feet wide and three feet high*", with "*side ditches that would be five feet deep*".

While plans had been made, evidence of tenders to build the road, or at least sections of it, still appear in 1865, suggesting these works didn't occur until the early to mid-1860s, despite the survey, designs and costings having been completed several years earlier.

To illustrate the change that did ultimately occur when the road was built, Figure 3.13 shows the change in road alignment, passing through the almost continuous peat swamps that extended between Mt Compass and Square Waterhole.

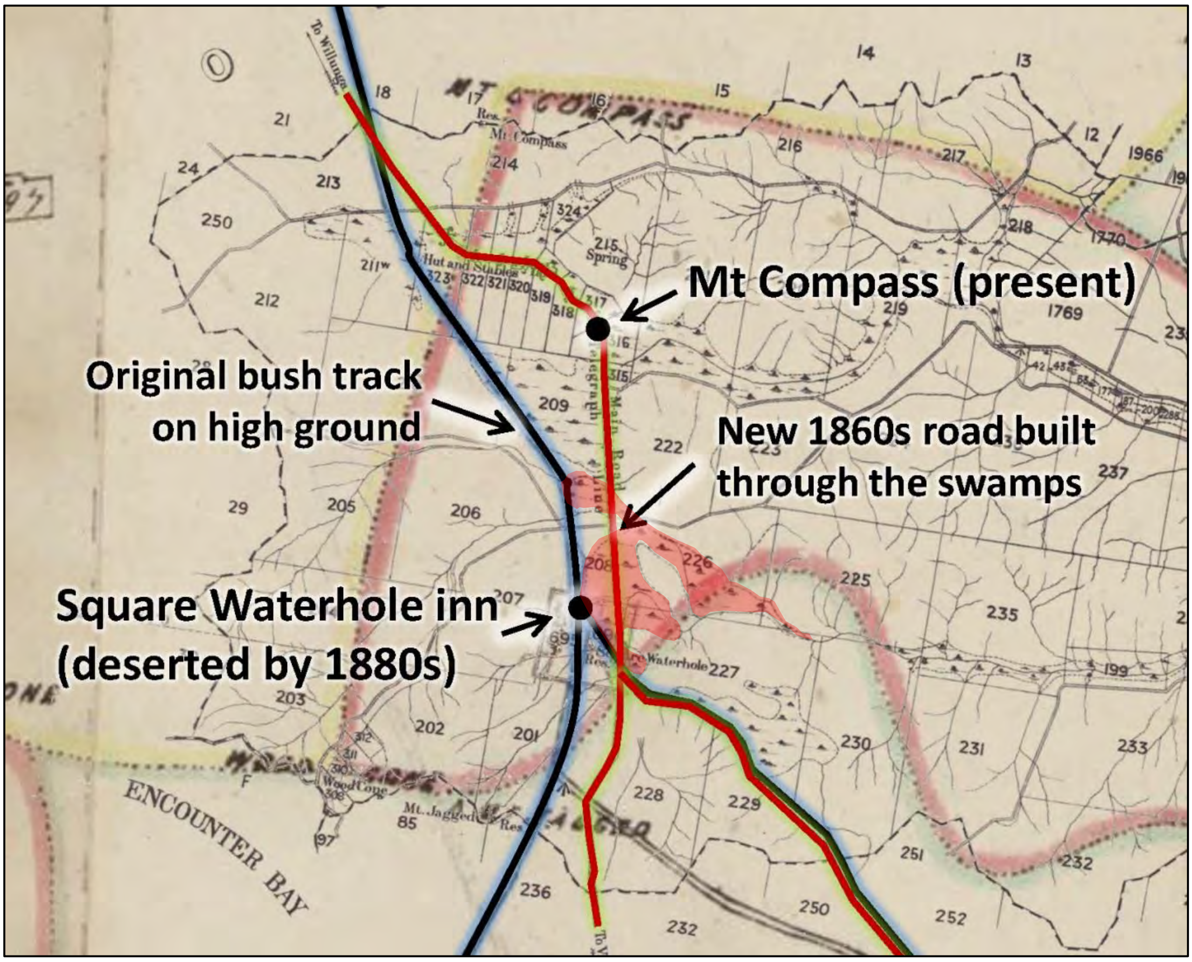



***Figure 3.13: An overlay created from the maps shown in Figure 3.11, highlighting the change in road location. The original extent of Square Waterhole Swamp is shaded red.***

Correspondence of the Central Road Board indicates that the first "stationman" based near present-day Mt Compass (said to be two miles north of Square Waterhole) was Thomas J. O'Callaghan from some time before 1865 (as cited in the SA Weekly Chronicle, 1865). This timing would certainly make sense as this was around the time the new road alignment was being cleared, cut and formed. His residence, a thatched roof timber cottage, burned to the ground in 1871 (Adelaide Observer, 1871), and three years later the Road Board moved him to another station, after work-related complaints against him were considered in April 1874.

He was replaced by George Waye in June 1874, who remained in Mt Compass for over 50 years and witnessed the development of the township and the wider district.

On the 18th of August 1881, the South Australian Government held an auction where a large number of recently surveyed, unoccupied sections of land in the Hundreds of Myponga and Nangkita were offered for sale under Miscellaneous Lease. Section 208 (the location of present day Hesperilla CP) was among the many Sections of land offered and taken up, with someone by the name of M. Stuckey obtaining the lease over this parcel of land (the only parcel successfully obtained by this individual at the auction) (Adelaide Observer, 1881):

**Hundred Nangkita.**
**Section 208, 54 acres, M. Stuckey, £2 9s. 6d.**

Later, in 1887, an excellent general description of swamps in the Mt Compass appeared in the Adelaide Observer (1887). It said they:

> "*are covered with melaleuca, leptospermums, cladiums, and the various plants that are always found upon "teatree swamps," and the soil is rich black peaty humus, with a yellow calcareous clay beneath. This was observed, wherever a trench has been cut across or alongside the swamp*".

Later in the same article a particular mention is made of the specific conditions and original native vegetation of Square Waterhole Swamp (and surrounds) at that time:

At the Square Waterhole there are a number of poplars growing to a considerable height. There is a settler in the neighbourhood named Hailstones, but he was not visible. The swamp is of considerable width here, and is densely covered with teatree of several varieties, sedges, rushes, cladiums, and the like to a height of 3 to 5 feet. As the place is reported to be swarming with tiger snakes, black snakes, and the like, we were rather cautious in our movements, especially as one of the three forming the party could see a snake or a snake's hole at every few steps. A roadman at about 3 miles back stated that the swamp swarmed with snakes, and this information caused all of us to shiver when tramping through the swamp. There was a ditch dug across the swamp here, which showed a depth of about a foot of sandy peat much intermixed with roots of teatres, rushes, sedges, &c., and beneath this was a yellowish calcareous clay. Upon the higher lands we noted Eucalyptus amygdalina, with which is always associated E. Guunii. There was also the "Beautiful mallee" (E cosmophylla) in this locality, and upon the valley running down from Mount Jagged were the two stringybarks and another eucalypt, which was too far off to identify. Upon leaving the Square Waterhole we came to a rise with sand and yellow clay upon a substratum of sandstone intermixed with veins of quartz. Higher up was slate ironstone and quartz, with probably a little gold in the neighbourhood. The trees were stringybark, scrub sheoak, grasstrees, scrub honeysuckle (Banksia ornata), bracken ferns, &c. Just beyond we found a great number of the curious marianthus bignonaceus upon a piece of burnt scrub.

The ditches, culverts and drain out-falls associated with the first road through the swamp and other associated early drainage works of that era initiated an ongoing process of road-related flow alteration that continues to influence the site today. Hence unlike other many other swamps in the Hundred of Nangkita that escaped drainage impacts until the 1890s, Square Waterhole Swamp was one of the first wetlands in the district to be hydrologically modified – as shown in more detail in Figure 3.14.

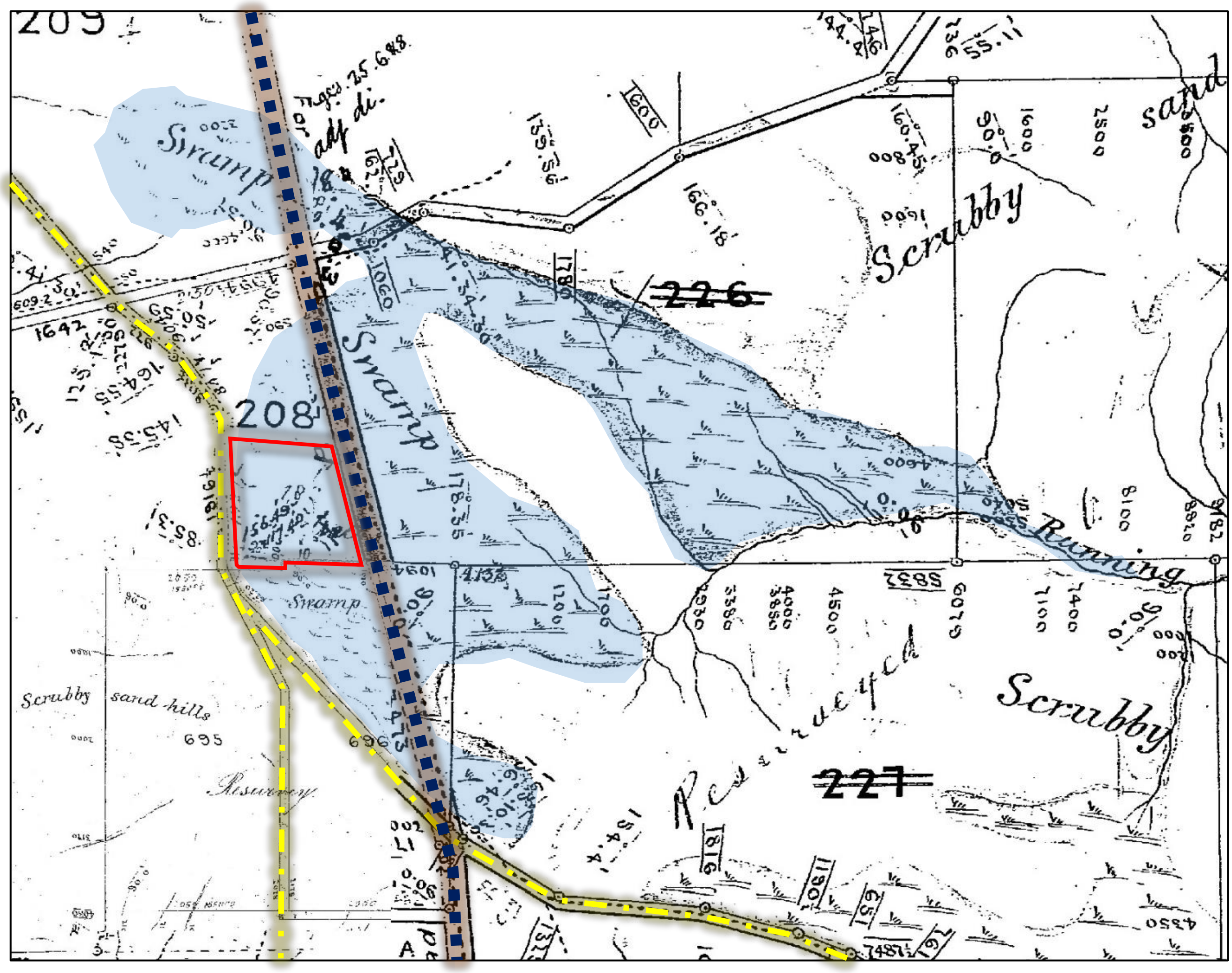



***Figure 3.14: Stitched 1880s survey diagrams showing how the road constructed in the 1860s (dark blue dashed with red shading), still in use today, crossed the bed of the western end of Square Waterhole Swamp. The original sandy bush track (shaded in yellow), skirted the swamp edge (shaded blue). As a portion of the original Section 208, present day Hesperilla CP is outlined in red.***

Despite this early influence to hydrology, the comprehensive drainage of the swamp didn't immediately follow as one might have expected. In fact, it appears very little else happened to the area initially beyond the local impact of those residing there when the site sustained a vegetable garden and animals associated with the inn on the Square Waterhole sections (695 and 696). To illustrate the situation at this specific location in 1893, after the property (at that time named "Crohane" and including adjacent sections of land surrounding the Square Waterhole parcels) was taken up by the Reverend Alfred T. Honner (1835-1909; Church of England rector for congregations at Magill, Norton's Summit and Campbelltown (Advertiser, 1898)), this description was given in the South Australian Register (1893):

The property includes two sections, the only two sold some forty years ago in that hundred. It is now known as Crohane, a name given to it by Mr. Honner after an ancestral possession in County Cork. The property had lain neglected, and become a pasture for kangaroos and stray cattle, which were drawn to it by the abundance of water and sweet herbage. Surprising accounts are given of the fruit and vegetables grown there by early tenants. Almost in the centre of this property, and divided by the main road, is a semicircular swamp, nearly surrounded by high lands which undulate towards it. The swamp is covered with a deposit of first-class peat of various depths. From assays made it contains 75 per cent. of present carbon and only 6·5 per cent. of ash, showing it to be an excellent fuel for steam and other purposes.

In 1899, Augustus Honner (1870-1903; son of the Reverend Alfred Honner) obtained the first freehold title over Section 208 (location of present-day Hesperilla CP), the land next door to the Square Waterhole Sections owned by his father. There is some evidence of additional early drainage works at Square Waterhole Swamp occuring during the time that the Honner's were in possession of these parcels of land. In addition to the road drainage works previously described is the following account from the Field Naturalists' Annual Tour of this precise area, on the 7th of November 1903:

> "*The land is drained to some extent, but the soil is still moist in places, and provides a favourable habitat for many flowers of a different type from those seen within a radius of 30 miles of the city (of Adelaide). The flora somewhat resembles that found in Tasmania.*" (Register, 1903)

The property, which had grown in size as a result of the amalgamation of a number of Sections into a single farm and by 1920 was being called "Square Waterhole Estate", appears to have changed hands a few times since it was re-occupied in the early 1890s. This later article advertising the sale of the property clearly indicates that despite early drainage works described, the swamp was still yet to be fully "reclaimed" (Register, 1920):

SQUARE WATERHOLE ESTATE.

FOR SALE BY AUCTION.

Messrs. Bennett & Fisher.

LIMITED,

have received instructions from the Mortgagees (Messrs. K. DeL. and C. R. Cudmore, under Mortgage registered No. 619675), to sell by public auction, on the

27th OF APRIL,

AT THEIR WILLUNGA MARKET,

The above Property, situated EIGHT MILES from the WILLUNGA RAILWAY and 13 miles from a good market at VICTOR HARBOUR.

1425 ACRES 1 ROOD 32 PERCHES, FREEHOLD.

Being Sections Nos. 695, Part Section 696, Closed Roads Sections 695, 696, Sections 208, 236, 230, 240, 225, 227, Part Section 376, Part Section 377, situated in the HUNDRED OF NANGKITA, COUNTY OF HINDMARSH.

The IMPROVEMENTS comprise a Five (5) Roomed Stone House, Engine House, large quantity of Piping, large Shed and Troughs in first-class condition, Stock and Sheep Yards, good Wood-and-iron Stable (81 ft. x 36 ft.), Implement Shed (39 ft. x 18 ft.), Six-pail Milking Shed, Piggery, Tanks, &c. There is a good amount of fencing on the property, but in poor order.

The above Property is excellently watered, and comprises a good area of rich swamp lands, adjoining the main road, which only require drainage to make them productive to the fullest degree. The fertility of the swamps is unquestioned and after reclamation should be ideal for vegetables, potatoes, onions, &c., for which there is a ready market at Victor Harbour.

The advertisement indicates that by 1920, Square Waterhole Estate had been consolidated into a 1425 acre sheep grazing entrerprise; but, on the basis of this being a mortgagee sale, had clearly fallen on hard times. It also shows that despite the potential of the peat flats already being realised by subdivision and closer settlement at nearby Mt Compass and Nangkita by this time, Square Waterhole Swamp was yet to experience this form of co-ordinated and comprehensive artificial drainage.

However, a search of the original titles indicates that the property didn't sell in 1920, leading the mortgagees to place a series of caveats on the title for Section 208 throughout April in 1920. On the basis of a subsequent advertisement several years later, the owners at the time (William Rickard, Thomas Rickard and Harold Grigg) must have pressed ahead with their efforts to increase the value of the property, prior to it again being offered for sale, presumably to clear their debt to the mortgagee (News, 1926):

**Farm at Mount Compass**

Situated within one mile of Mount Compass, and on the main Adelaide-Victor road, is a property of approximately 1,425 acres, which possesses unusual possibilities for profitable development. The outstanding feature of this holding is about 180 acres of drained peaty swamp land, ideal for onion and potato growing. This flat has been specially channelled at great expense, and is now thoroughly drained and ready for the plough.

The position of the property from a transport point of view is excellent, owing to the first-class motor services between Adelaide and Victor Harbor.

The quality of the soil is demonstrated by the prolific growth of flowers and vegetables on the neighboring properties, best known of which are possibly the gardens of Messrs. W. and D. Wright, which adjoin the main road. There are extensive improvements on the property, including three small houses, huge stables, and cowshed, pumping house, and piping.

Full particulars may be obtained from the adjoining owner, Mr. Whittington, of Clelands Gully, Messrs. Symon, Mayo Murray & Cudmore, or from the auctioneers, Wilkinson, Sando & Wyles, Limited, 20 Waymouth street. The property is to be sold by auction at the Wool Exchange on Wednesday, February 10.

This article clearly states that during those six years the first intensive drainage works took place, with Square Waterhole Swamp "*specially channelled at great expense*" and "*now thoroughly drained and ready for the plough*". A year later, in 1927, Square Waterhole Estate was purchase by Adelaide barrister, Edward Erskine Cleland (Figure 3.15) – after whom nearby 'Clelands Gully' was named – the youngest son of notable early South Australian, John Fullerton Cleland (the Registrar of Births, Deaths and Marriages in Adelaide from 1853 to 1885).

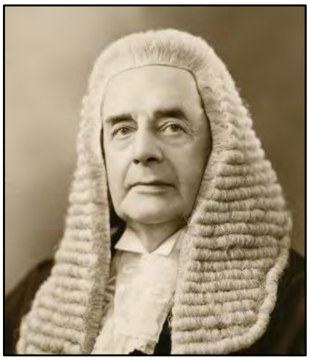


***Figure 3.15: E. E. (Edward Erskine) Cleland***

E. E. Cleland, invested in the development of the property for sheep grazing for ten years, and appears to have either employed, or leased the property to, his new neighbour Mr. Whittington (referred to in the 1926 article above), on the basis of an article that appeared in the Chronicle in 1928, which stated that Mr Whittington was 'in charge':

**DEVELOPMENT OF SCRUB COUNTRY.**

Commendation is due to those settlers who have realised the potential grazing values of much of the State's scrub lands in the higher rainfall areas and are establishing subterranean clover pasture. To the average thinking man who is at all interested in the future welfare and prosperity of South Australia, a visit to the district extending from Myponga to Port Elliot, and via Ashbourne to Currency Creek, is interesting, yet puzzling. Here is an area of hundreds of thousands of acres of scrub land carrying a comparatively few sheep up to the last year or so. Top-dressing, subterranean clover, and the rye grasses are now beginning to revolutionise it. The large area of practically unbroken scrub is well on the way to being a thing of the past. In view of the buoyant wool market it behoves the progressive sheep man to pay attention to this corner of the State.

**A Clover Inspection.**

Some of the existing clover lands were visited on Thursday by about 50 local landholders and visitors, under the auspices of the local branch of the Agricultural Bureau. Messrs. R. Hill, C. R. Scott (superintendent of experimental work), and H. J. Apps (chief dairy expert of the department) were present. The first property visited was that of Mr. E. E. Cleland, where excellent stands of subterranean clover were seen. Mr. Whitington, who is in charge, conducted the party and explained the seeding and cultural methods adopted in each paddock. The

Cleland eventually sold (in May 1936) to a younger barrister whom he most likely met through his work, P. B. Angus Parsons. This transfer occurred soon after Cleland's appointment as a Justice of the Supreme Court in SA (in March 1936). With a new owner and a rapid expansion in the dairy industry about to occur, the further intensive development of Square Waterhole Swamp was set to begin.

### *3.3.4* Development of Square Waterhole Swamp after 1940

Philip Brendon (P. B.) Angas Parsons (1905-1984), Figure 3.16, was a successful lawyer who came from a family that directly connected him to the very foundation of South Australia.

*Figure 3.16:*
***P. B. (Philip Brendon) Angus Parsons at 23 years of age in 1928, a young lawyer just admitted as a practitioner to the Supreme Court. (Advertiser, 1928)***

His great, great grandfather was George Fife **Angas** (1789-1879) – after which Angas Street in Adelaide and Angaston in the Barossa Valley are named – the founder and first Chairman of the South Australia Company. Among numerous achievements in the foundation of South Australia, George Fife Angas both triggered and supported (through his negotiations) the first wave of migration of free German settlers seeking religious freedom from Prussia to South Australia, which lead to the development of settlements like Klemzig near Adelaide and the various early German settlements in the Barossa Valley.

His great grandmother, Rosetta French **Angas Johnson** (1813-1898), and grandmother, Rosetta **Angus Johnson Parsons** (1846-1876) retained the Angus name through two generations of marriage. His father, Sir Herbert **Angus Parsons** (1872-1945) was a lawyer, who later became a politician and ultimately a Judge of the South Australian Supreme Court from 1921-1945. In 1900, his father married Mary Elsie **Bonython**, the daughter of Sir John Langdon **Bonython** (1848-1939); another prominent figure in South Australian history (after whom Bonython Hall and Bonython Park are named).

Having the privilege of this family background and profession, it is perhaps therefore not surprising that P. B. Angus Parsons was able to eventually secure approximately 3000 acres of farmland in the Mt Compass district, including the Square Waterhole Estate, making him a major regional landholder and joining another prominent figure already developing land in the area at the time, Fred N. Simpson (who owned approximately 6000 acres nearby, the Glenshera property) (Bachmann & Farrington, 2016; T. Blakely, pers. comm.).

Indeed in 1940, both men are listed as entrants in the Mt Compass Show, having won first prize (Simpson) and second prize (Angus Parsons) for the sheep section, indicating that by this time P. B. Angus Parsons was already establishing himself in the district (Chronicle, 1940):

# MOUNT COMPASS SHOW

## Stock Entries Improve

**By YATTALUNGA**

In spite of the extreme heat residents of Mount Compass and Nangkita districts presented an excellent display of farm produce and stock at the annual show on Saturday. The display of dairy cattle showed a marked improvement on that of last year, while the sheep entries, although in some classes deficient in numbers, lacked nothing in quality.

Flowers are usually a feature of this show but a dry summer and the excessive heat prevented a good exhibition, although some very creditable blooms were exhibited. Vegetables also showed a decline in entries due to seasonal conditions, but here, too, the quality was excellent.

Great interest was again shown in the schoolchildren's potato growing competition for which each entrant is given a pound of seed to plant. There were 14 entries, and first prize went to Don Jacobs, who produced 434 lb. of commercial potatoes. Second prize and first award for the best displayed exhibit went to Stanley Owen, with a production of 344 lb. Linton Jacobs, winner over a period of seven years, produced just over a ton of potatoes from seven pounds of seed.

The sheep section was judged by Mr. C. W. Ness. The first prize for two crossbred ewes suitable for breeding export lambs was won by Mr F. N. Simpson, with Mr P. B. Angas Parsons in second place. Mr. J. H. Sneyd scored both awards for fat lambs, and Mr M. J. Meyer was first with fat wethers, first and second with fat ewes, first and second with Corriedale ram and ewe, and second with comeback ewe. First prize for comeback ewe went to Mr. W. G. Hunt, and Mr. C. E. Verco gained all the awards for Southdown ram and ewe. With attractive Ryeland rams and ewes, Mr. A. S. Kidman secured the awards for this breed, and in the Romney Marsh classes, Mr. F. E. Shepherd gained first for ram and first and second for ewe, while Mr D. Coombe was second in the male class.

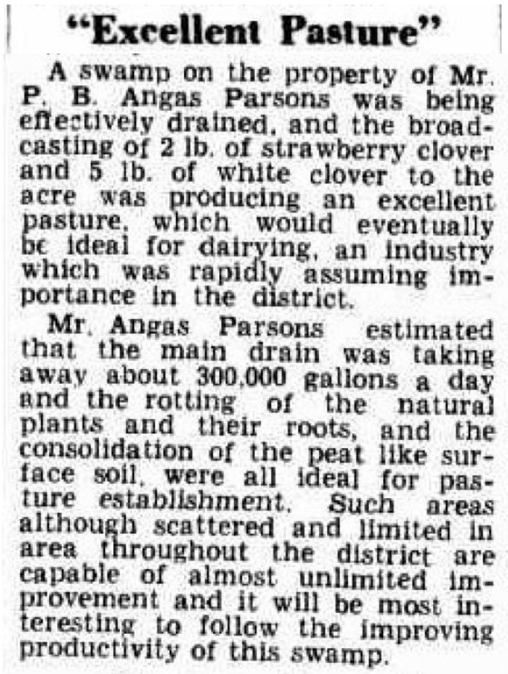
The article also lists a young Linton Jacobs in the schoolchildren's potato growing competition, author of the local history book *Where the Compass Leads You* (Jacobs, 2005); which has been an invaluable reference for the historical investigation that has formed part of this restoration assessment.

As owner of the land, P. B. Angus Parsons entered into an arrangement with Keith Blakely (as a share-farmer) to live at Square Waterhole and run the dairy there, while his sheep and cattle grazing operations over the wider property were managed by Verne McIntosh and later, after he retired, Reg Whiteman (T. Blakely, pers. comm.). During that time, Keith Blakely was responsible for a further attempt at comprehensive drainage (of what remained) of Square Waterhole Swamp on Section 208, a task he initially undertook by hand in the 1940s (A. Peresano, pers. comm.; T. Blakely, pers. comm.).

The result of the combined efforts at drainage up until that point was captured in the first aerial imagery available for the swamp, from 1949, as shown in Figure 3.17.

***Figure 3.17: The first aerial photograph of Square Waterhole Swamp – post-drainage – in April 1949. The boundary of present-day Hesperilla CP is indicated in red.***

We are fortunate that further insights of the time are possible, because a couple of years before this image was taken, an article appeared in the Chronicle (1947), after P. B. Angus Parsons made his property available for a field day on pasture development in the Mt Compass district (right). He also shared some interesting observations about the amount of water being carried away from the swamp by the drains at that time. The sheer amount of physical work involved in building those drains, can be appreciated upon closer inspection – a vast network for such a small area, directing flows to the main drain culvert under the Victor Harbor Road, at the south-eastern corner of the present-day park. For an accurate representation of the number of drains constructed across the site in the 1940s, please see the before and after images in Figure 3.18.



**"Excellent Pasture"**

A swamp on the property of Mr. P. B. Angas Parsons was being effectively drained, and the broadcasting of 2 lb. of strawberry clover and 5 lb. of white clover to the acre was producing an excellent pasture, which would eventually be ideal for dairying, an industry which was rapidly assuming importance in the district.

Mr. Angas Parsons estimated that the main drain was taking away about 300,000 gallons a day and the rotting of the natural plants and their roots, and the consolidation of the peat like surface soil, were all ideal for pasture establishment. Such areas although scattered and limited in area throughout the district are capable of almost unlimited improvement and it will be most interesting to follow the improving productivity of this swamp.

***Figure 3.18: The isolated portion of Square Waterhole Swamp to the west of the main road.***
***Left:*** *in April 1949, with the boundary of present-day Hesperilla CP is indicated in white.*
***Right:*** *the same image with the drains highlighted – the two parallel road verge drains are highlighted a different colour (red/black) to those dug across the swamp (yellow/red).*

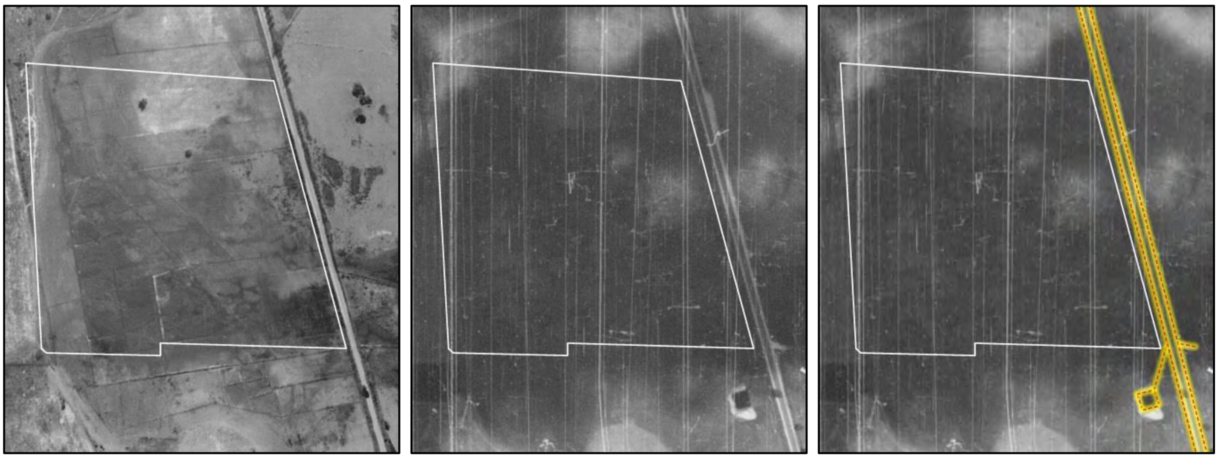
However, as commonly occurs when a significant depth of peat is de-watered, the drained ground rapidly sinks (through a combination of physical and chemical processes, as the peat subsides, compresses and breaks down), drainage channels slump, and areas of the swamp slowly become subject to inundation again. Although never recovering to its pre-drainage extent, this process is why so many small fragments of the original extent of Fleurieu

Peninsula Swamps (including Square Waterhole Swamp), despite being so heavily targeted for development, have managed to retain some of their original biodiversity values.

It is also the reason why many individual swamps of the Fleurieu Peninsula appear to only occupy a fraction of the previous extent first mapped by government surveyors, as the inundated extent or wetted edge (i.e. upslope saturated zone) around a wetland significantly contracts with each attempt at more comprehensive drainage; reducing the moisture holding capacity of what becomes a shrinking core area of saturated peat. For an example of this process at Square Waterhole Swamp, please refer again closely to the pre and post-development wetland extent (shaded) images in Figure 3.12. In some places, the original wetland extended upslope where it becomes extremely hard to imagine wetland vegetation growing today – but that is itself a symptom of this 'landscape dehydration' process.

It is also worth reminding ourselves when viewing the 1949 image in Figure 3.18, that the swamp encountered and further drained by Keith Blakely in the 1940s was already modified. It had been partially drained at least twice previously (when the road was built in the 1860s and again sometime after 1893 but prior to 1903), and had been also subjected to sheep grazing since the 1890s. Beyond comprehensive drainage from the 1920s (and completed in the 1940s), as a result of the subsidence process previously described, over his tenure Keith Blakely had the drainage network periodically maintained, extended or deepened, consistent with farming practices where peatlands have been drained for agriculture (T. Blakely, pers. comm.).

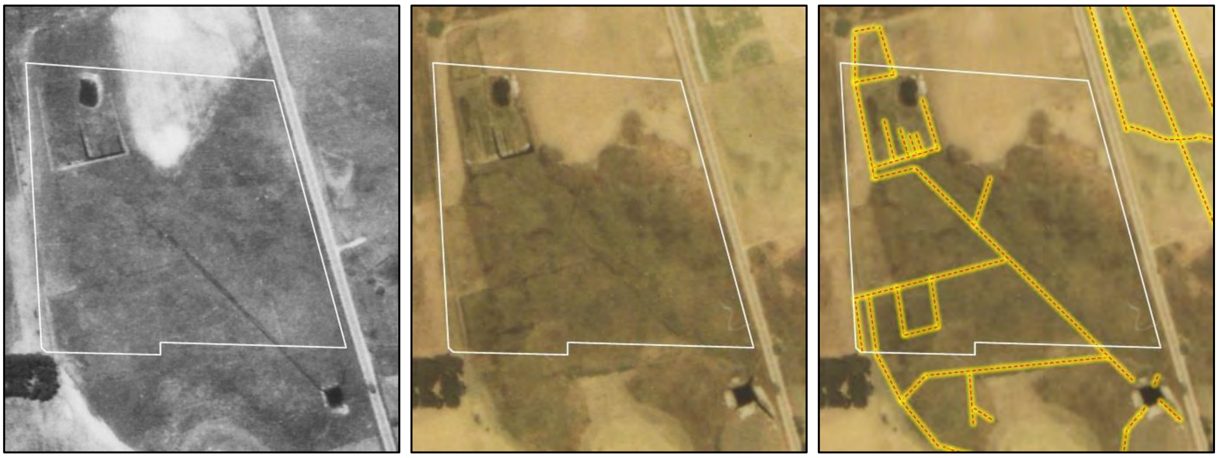
This process, along with a number of other changes can be seen by evaluating the aerial imagery take of the site since 1949, as shown in the following sequence. Firstly, as illustrated in Figure 3.19, the Victor Harbor Road was upgraded during the 1950s, resulting in deepening of the original road-side drains and placement of new culverts.



***April 1949*** ***Dec 1960*** ***Dec 1960 – marked-up***

***Figure 3.19: The changes at Square Waterhole Swamp between 1949 and 1960, with 1960 changes highlighted in the final image.***

While the works were being done and machinery available, Keith Blakely decided to have the large, groundwater-fed dam near the road – still visible today and often erroneously mistaken (as a result of its square shape) for being the original Square Waterhole itself – constructed at the same time (T. Blakely, pers. comm.). In Figure 3.20, drain maintenance and construction in the 1970s and 80s is clearly visible, including a major, comprehensive network of surface drains in the downstream portion of the swamp, to the east of the road.



***Jan 1972*** ***Feb 1984*** ***Combined mark-up***

***Figure 3.20: The changes at Square Waterhole Swamp since 1960, between 1972 and 1984***

Also evident in the previous sequence of images is the pre-1972 construction of a further dam, situated in the north-western corner of the present-day Conservation Park, along with a network of drains that appear to have been constructed to either supply additional flow to, or reduces losses from, the dam.

The dam was used as a reliable supply of large quantities of water to the milk products factory on the hill, a short distance to the north of the swamp, on the balance portion of the former Section 208, Hundred of Nangkita.

Erected in 1954 and 1955, and situated on land purchased from P. B. Angus Parsons out of the Square Waterhole Estate in March 1946, the factory was the largest milk powder drying plant in the southern hemisphere at the time (T. Blakely, pers. comm.). The factory operated for 40 years until 1996, with this article (right), from September 1955 (Victor Harbor Times), describing its imminent opening in 1956.

**MT. COMPASS FACTORY**

The dairy factory built in the milk producing centre of Mount Compass by United Co-operative Dairymen Ltd. is nearing completion and it is hoped the £150,000 plant will be working shortly.

When complete the factory will handle up to 20,000 gallons of milk daily, with the staff working full shift.

A feature of the factory will be a modern spray drying plant, the only one of its kind. This can be used for whole or skim milk powders. A separate division has been built for making butter.

The milk products factory, whose name changed to Dairy Vale in 1977 – see Figure 3.21, handled local Fleurieu Peninsula milk for processing, including from the small dairy at Square Waterhole Swamp only a few hundred metres to the south. The factory site is now used for other purposes.


***Figure 3.21: What remains today of the former Dairy Vale milk products factory on Woodcone Road, immediately north of Square Waterhole Swamp; like Hesperilla CP, this is situated on a parcel of land derived from Section 208, originally part of the Square Waterhole Estate.***

However, despite the factory site no longer drawing water from the present-day Conservation Park, an easement (T2501308) to protect the ability of the milk factory to access the swamp for water was included in the first title in 1946 (see Figure 3.22).

After the construction of the dam, this feature and a realigned easement was included on both affected titles when reissued in 1964 (see Figure 3.22). A construction date around this latter date is also consistent with the aerial imagery presented in Figure 3.20.

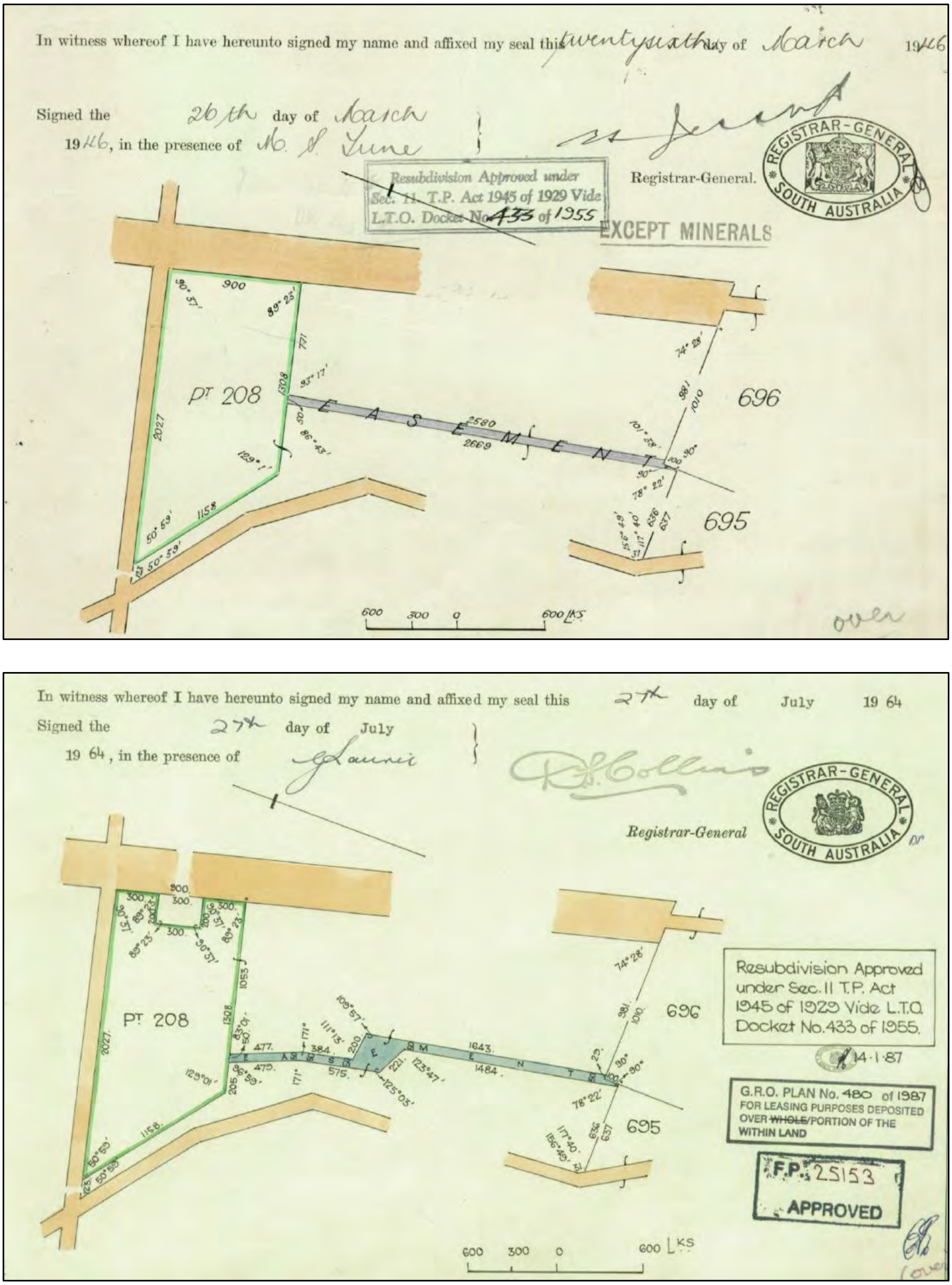



***Figure 3.22: Milk Factory site title plans, issued to Kondoparinga Co-operative Dairymen Limited in 1946 (above) and later to United Co-operative Dairymen Limited 1964 (below), showing the change in configuration of the easement after the dam was constructed.***

This easement through the swamp and covering the northern dam "*for the purpose of storing and conveying water in and over portion of the said land*" remains in place today as a legal instrument registered on the most recent (2007) plan of subdivision (DP 73837) – from which Hesperilla CP, Allotment 16, was created. An overlay of the plan is shown with a recent aerial image to illustrate its location relative to other features in Figure 3.23.

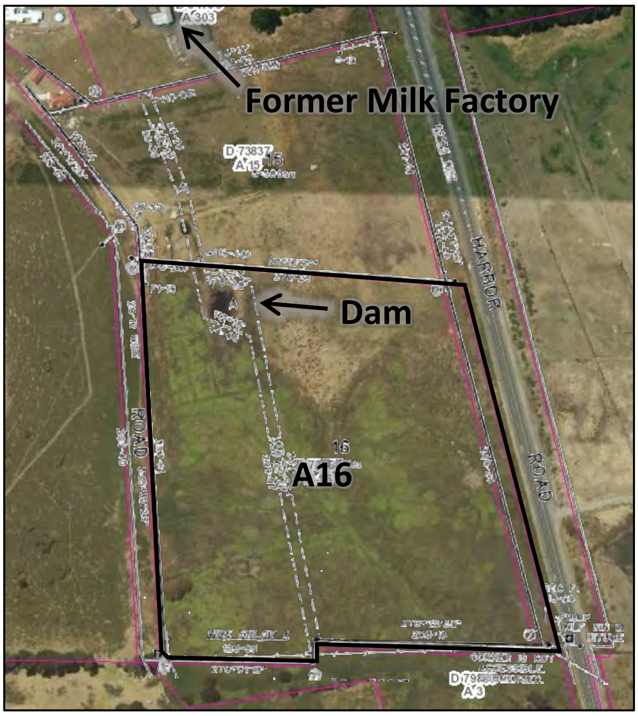



***Figure 3.23: Water access easements super-imposed on a recent aerial image. Hesperilla CP is outlined in black.***

The current appearance of the dam and what appears to be a concrete foundation for the former pumping station on the bank next to it, are shown in Figure 3.24 and Figure 3.25 respectively.

***Figure 3.24: The current appearance of the dam in the north-western corner of Hesperilla CP***

*Figure 3.25: A concrete foundation still remains of what appears was the former pumping station*

Over more recent decades drainage maintenance frequency at the swamp has reduced, as shown in Figure 3.26, and as a result physical changes to the swamp have slowed, commencing the present phase of swamp recovery.

**Oct 1995** | **Oct 1995 – Marked-up** | **Nov 2003**

*Figure 3.26: The changes at Square Waterhole Swamp since 1984, between 1995 and 2003*

While some major drain deepening works occurred on the private property to the south of present-day Hesperilla CP between 1984 and 1995, there have been no significant works since. Figure 3.27 shows the most recent aerial view of the swamp.

*Figure 3.27: Square Waterhole Swamp in October 2015.*

P. B. Angus Parsons maintained ownership of present day Hesperilla CP until it was sold on the 17th of February 1976 to a dairy farmer from Myponga (Mario Di Ionno), resulting in Keith Blakely then also leaving the property after three decades of share-farming (T. Blakely, pers. comm.).

Keith Blakely continued to live and work in the Mt Compass District as a general contractor doing work on farms. P. B. Angus Parsons retained a formal interest in the land (as mortgagee) over subsequent years, including through further ownership changes, until his mortgage over the title was finally discharged in August 1982. Mr Angus Parsons died on the 30th of August 1984, while Mr Blakely died on the 25th of April 1987.

The significant area of land that had once comprised the Square Waterhole Estate changed hands and was eventually sold off as smaller parcels, leading to the present mixed land-use pattern of farming, hobby farming and lifestyle properties now found in the vicinity of what remains of Square Waterhole Swamp today. Further, as a result of the SA Government purchase of Allotment 16 in 2007, a portion of the original Square Waterhole Swamp has now been managed for nature conservation for the past decade, with proactive management of water resources to sustain and, if possible, recover its biodiversity values the subject of this report.

# 4 Eco-hydrological assessment

## 4.1 Changes in regional, catchment and site vegetation cover

While large parts of the Fleurieu Peninsula had already been cleared by 1945, the rate of development accelerated through upscaling of mechanised land clearance after World War II. The result for the remnant biodiversity of the Mt Lofty Ranges was drastic, leading to the loss of over 60% of the native vegetation that still remained in 1945, by just 35 years later in 1980 (see Figure 4.1).

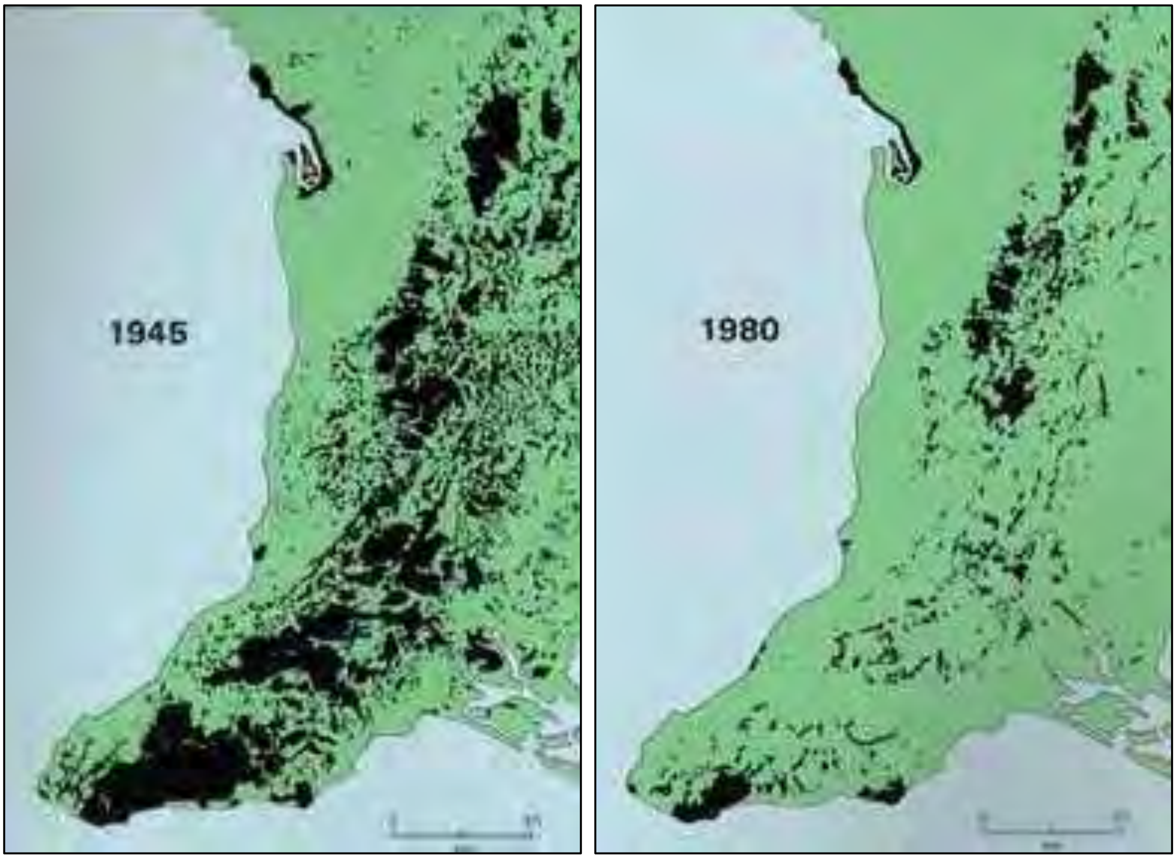



***Figure 4.1: Of 240,000 hectares of native vegetation present in the Mt Lofty Ranges in 1945, only 90,000 hectares remained in 1980, a decline of 62.5%.***

Imagery from 1950 reveals that vegetation clearance had already occurred through much of the catchment around Square Waterhole prior to 1950. However, a comparative view of the wider catchment area around Square Waterhole, using 1950 and 2014 aerial imagery (Figure 4.2) shows significant vegetation clearance in the vicinity of Mt Jagged, an area from which surface and groundwater flows towards Square Waterhole originate.

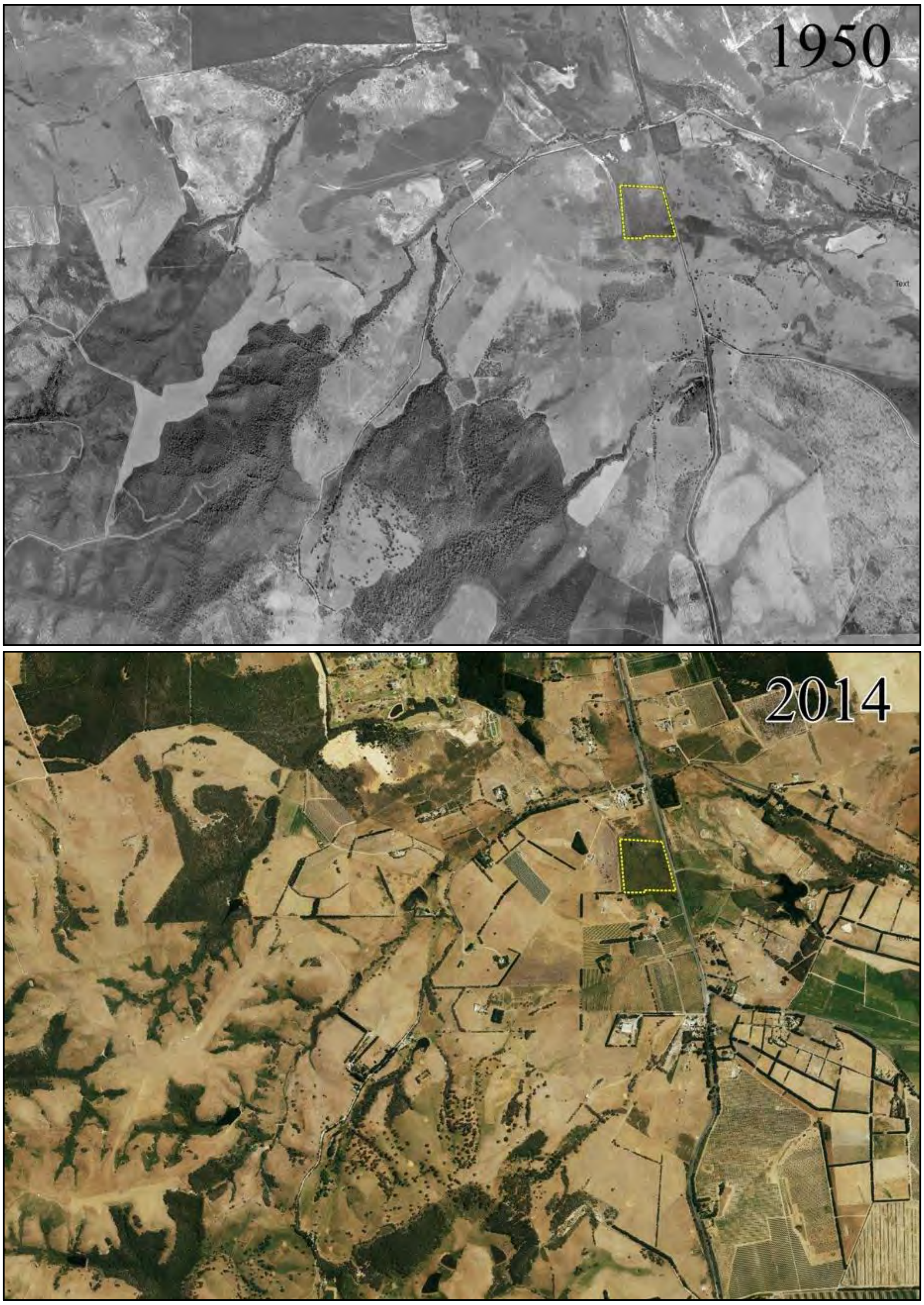



***Figure 4.2: An aerial view of the greater catchment adjacent to Square Waterhole, showing areas of vegetation clearance from 1950 to present.***

A summary of an analysis we have undertaken of decadal vegetation change (Figure 4.3), illustrates that the bulk of clearing in this area had already occurred by 1960, although some further clearance occurred to the south prior to 1972 and to the north-west between 1972 and 1984.

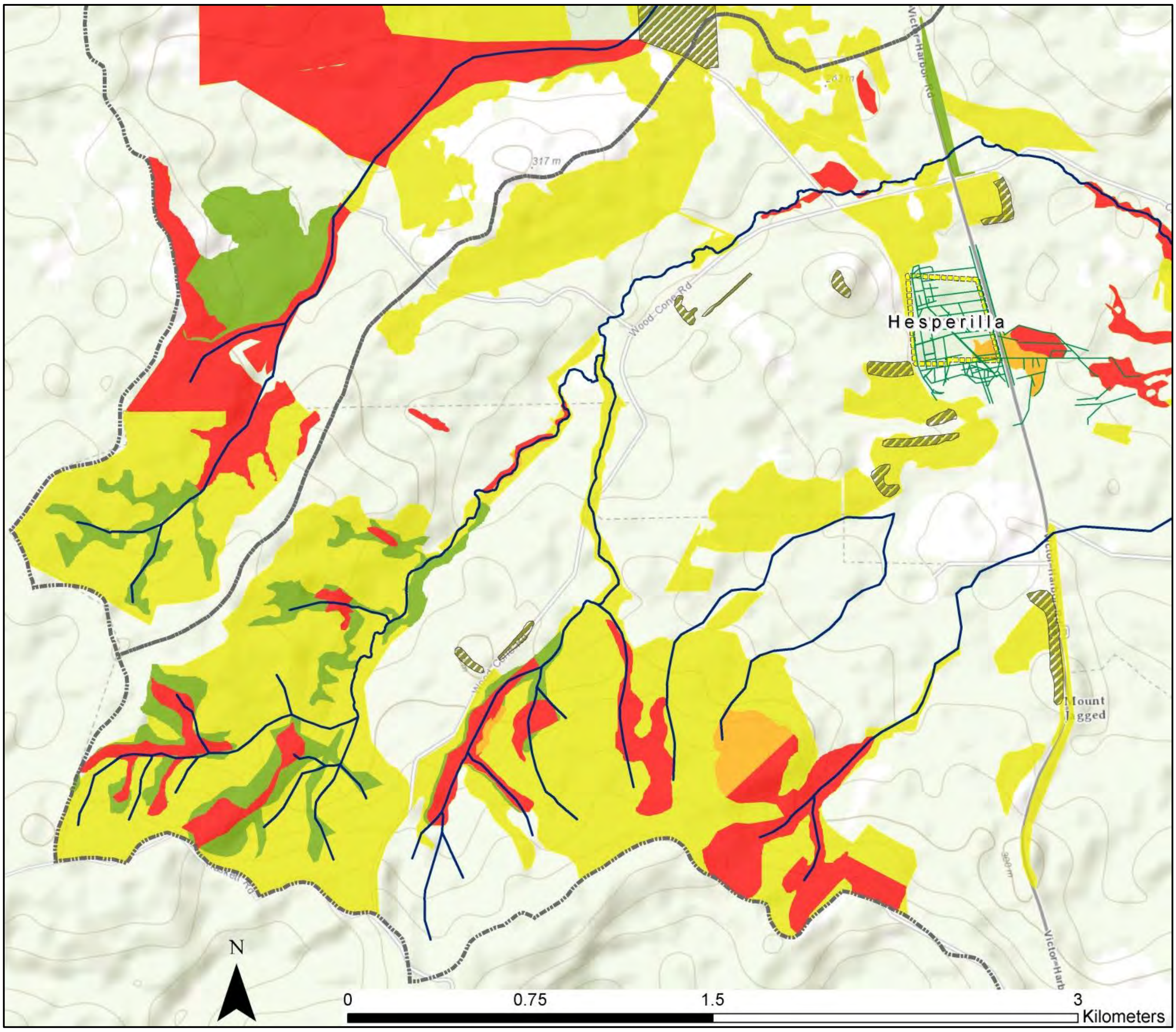
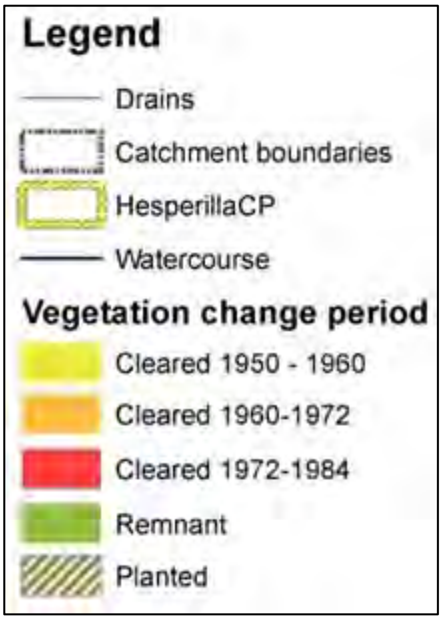



**Figure 4.3: A timeline of modifications to vegetation cover in the catchment of Square Waterhole. Blank areas inside catchment boundary were cleared prior to 1950.**




In contrast to this general pattern of vegetation loss, Square Waterhole Swamp has experienced a degree of wetland vegetation recovery over the aerial photographic record from 1950 through to the present day (Figure 4.4). Significant areas of native vegetation cover that are absent in 1950 have partially or fully recovered by the 1990s. More recent management practices, including stock exclusion, are causing an expansion of native vegetation cover in the north-eastern corner of the Reserve – an area that local residents have advised was still being cut for hay two decades ago.

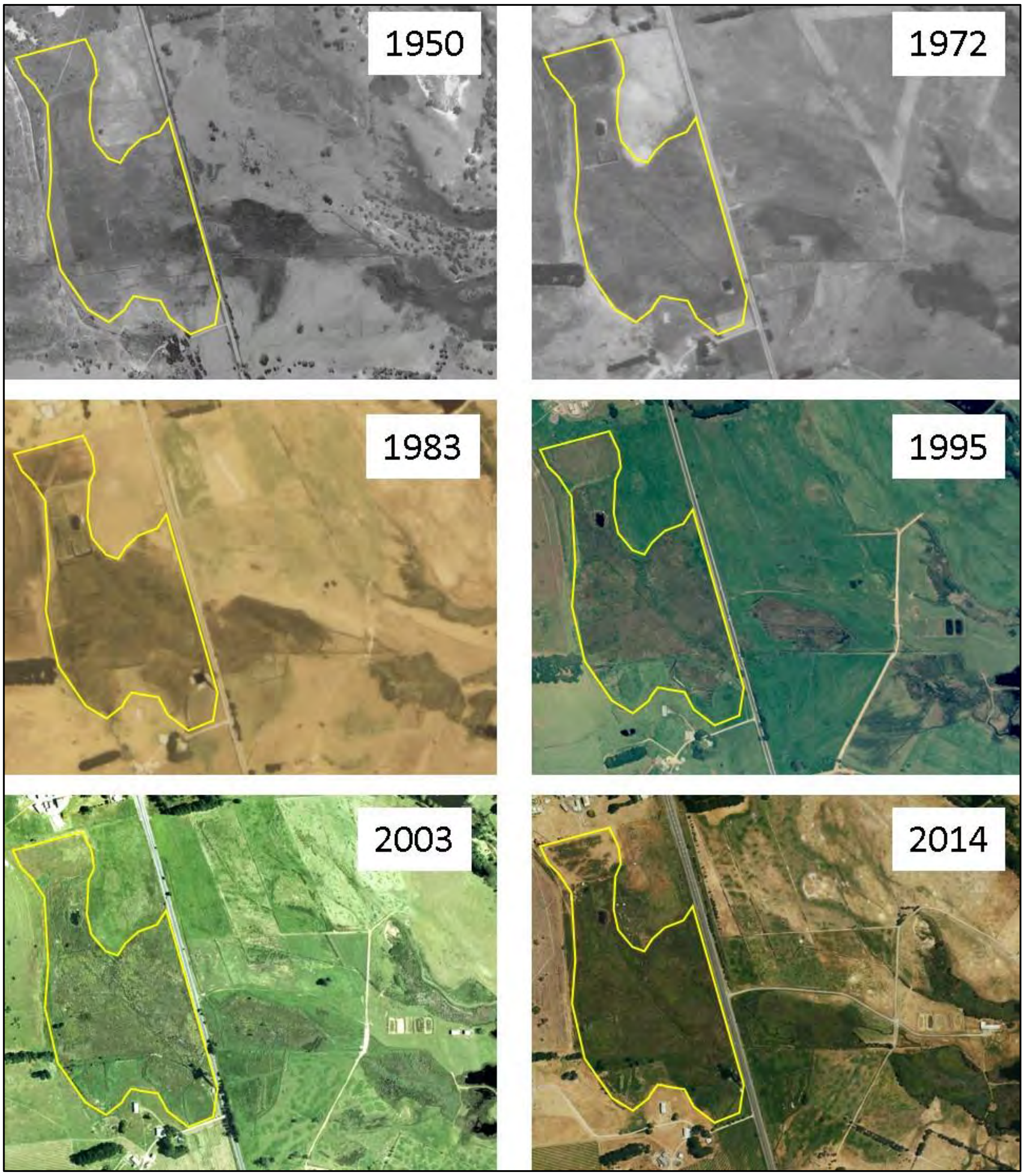



***Figure 4.4: Vegetation recovery in the vicinity of Hesperilla CP***

## 4.2 Conservation values

### *4.2.1* Investment by the Fleurieu Swamps Recovery Project

Over recent years, Hesperilla CP has been the subject of on-ground investment by the Fleurieu Swamps Recovery Project, delivered by the Goolwa to Wellington LAP (GWLAP) with the funding support of Natural Resources SA MDB. Efforts have focussed on restoring conservation values of the site through woody weed control and revegetation, with 3000 indigenous tube stock planted since 2014/15 in the more degraded (previously cleared) northern portion of the park (J. Gitsham, person comm.).

### *4.2.2* Native vegetation associations present today

Typical of remnant Fleurieu Peninsula Swamp communities today and broadly consistent with earlier historic accounts, Square Waterhole Swamp now contains dense swamp vegetation growing on waterlogged peat, peat silt and black clay soils (DEH, 2007). Contemporary vegetation assemblages however within the reserve are currently mostly dominated by long-lived species capable of persisting with high competition but potentially limiting the recruitment of additional swamp specialist flora (R. Duffield, pers. comm.).

A sparse overstorey of *Leptospermum continentale* occurs over a *Baumea* sedge dominated understorey in both the north-western and southern zones (Figure 4.5) while the middle and eastern sections can contain a predominantly *Baumea* sedge rich layer (Figure 4.6).

***Figure 4.5: Leptospermum continentale over a Baumea sedge dominated understorey***

***Figure 4.6: Baumea sedge dominated habitat***

Dense *Gleichenia microphylla* growth occurs along the edges of drainage channels, on the higher elevation zones formed by spoil banks (Figure 4.7), while *Blechnum minus* occurs interspersed within sedge and tea-tree/sedge zones (Figure 4.8).

***Figure 4.7: Gleichenia microphylla growing along a spoil bank***

***Figure 4.8: Blechnum minus interspersed within the sedge zone***

Bracken *Pteridium esculentum* occurs along the higher elevation, sandy western boundary (Figure 4.9) and extends into the park boundary at the head of major west-east running drains.

***Figure 4.9: Pteridium esculentum on the higher elevation, sandy western boundary of the swamp***

A drier, more disturbed zone of former swamp containing sparse grading to scattered *Juncus* rushes over exotic grasses (Figure 4.10) occurs to the north east and also northern edges of the park, up to the northern boundary of the Conservation Park. This area is where the majority of revegetation effort by the GWLAP in the park has so far taken place.

***Figure 4.10: Sparse to scattered Juncus rushes over exotic grasses***

Consistent with community feedback received during our consultation process for the project, there is clear evidence that this more elevated, upslope zone of the former saturated swamp margin (Figure 4.11) was still being cut for hay shortly before the park was created. Hay bales are actually visible in the aerial imagery of the area in December 2004, and the new boundary fence is in place 2½ years later in 2007, as shown in Figure 4.12.

***Figure 4.11: Looking west along the northern boundary of Hesperilla CP (ungrazed, left of fence) – this boundary was created as part of the sub-division that resulted in the creation of the park.***

***31st Dec 2004 – still being cut for hay***
*Blue line was the swamp margin in the late 1800s*
*Orange line was swamp margin in 2004*

***12th May 2007 – the Park boundary in place***
*Dashed yellow lines are corners of the park*
*Arrow is the location of the photo in Figure 4.11*

***Figure 4.12: The northern boundary zone of Hesperilla CP between 2004 and 2007***

This substantial area of what was originally mapped as swamp vegetation, clearly associated with an area of upslope saturation and seepage, provides a clear reminder of just how much this portion of the wetland has changed since it was mapped in the late 1800s. It also illustrates the process of downward migration of the saturated swamp margin after drainage (also represented later, in Figure 4.25).

Finally, a mid-dense thicket of shrubs occurs near the dam in the north-west, as shown in Figure 4.13.

***Figure 4.13: A mid-dense thicket of shrubs near the dam in the north-west of Hesperilla CP***

A spatial overview of these assemblages is shown over the page in Figure 4.14.

A breakdown of dominant vegetation, according to wetland functional groups (Casanova and Zhang, 2007; Vanlaarhoven and van der Wielen, 2009) delineates two zones containing those which are moisture dependent (Ate) and more terrestrial (Tda). Amphibious tolerator dominated communities occupy most of the conservation park with sharp transition to Tda communities along the high elevation south east corner and also along the upslope region of the western boundary. However there appears to be intrusion of a bracken dominated (Tda) community into the main wetland area, midway along the western boundary. This coincides with the location of a west-east running drain. Site observations stemming back to 2008 suggest a decline in amphibious fluctuator species (Duffield pers. comm. 2017) which may indicate less protracted inundation durations (i.e. they require 8 to 10 months inundation) or altered ecological processes in the absence of grazing.

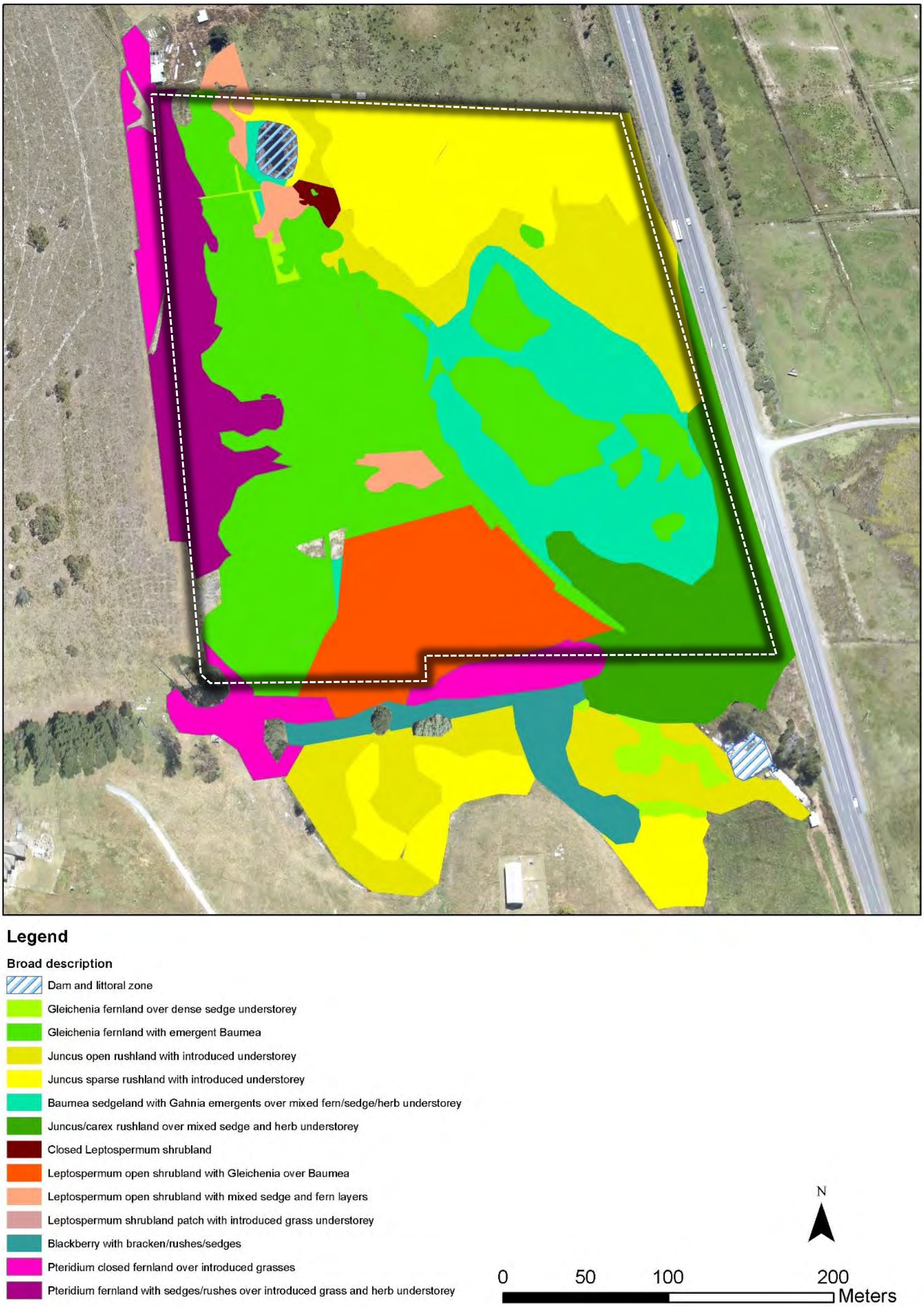



*Figure 4.14: Broad vegetation assemblages found across the remnant western portion of Square Waterhole Swamp, derived from combined field survey and aerial photographic analysis*

### *4.2.3* Significant fauna

**Birds**

Hesperilla Conservation Park was proclaimed primarily to protect and conserve habitat for an important population of the Mount Lofty Ranges Southern Emu-wren (*Stipiturus malachurus intermedius*, as identified (as site #15) in the recovery plan for the species (MLR SEW&FPS Recovery Team, 2007). The vegetation associations occurring on-site, including dense, low vegetation dominated by Prickly Tea-tree (*Leptospermum continentale*), Red-fruit Cutting-grass (*Gahnia sieberiana*), sedges (e.g. *Baumea* spp., *Lepidosperma* spp.) and ferns (e.g. *Blechnum minus*, *Gleichenia microphylla*) are regarded as optimal for the species (Littlely and Cutten 1994). Early records of the Southern Emu-wren in the Mt Compass district, and Square Waterhole specifically, date back to the days previously recounted when the area was not yet opened up for farming and Square Waterhole was a remote roadside stopover location. One such unusual record is from the South Australian Advertiser in 1869, describing an albino Southern Emu-wren, shot by F. W. Andrews (an avid naturalist and collector of that era) at Square Waterhole and sent to the South Australian Museum for their collection:

> A very interesting ornithological specimen was shot by Mr. F. W. Andrews on Thursday last, on the South-road, at the Square Waterhole. Mr. Andrews, who has been collecting for the Museum for some years, was travelling to Town by this road, ween his attension was drawn to this specimen, which he describes as a white emir wren (*stipiturus malacurus*). White magpies, hawks, swans, and other birds described as rare birds, and albinos have been collected, preserved, and may be seen amongst the rare collection of the feathered tribe in our museum, but this trophy of the fowling-piece is about the greatest curiosity of them all. The eyes have no pink appearance peculiar to albinos. The bird is now mounted, and may be seen at the Museum.

As one of the last, relatively large, areas of native vegetation to be developed so close to Adelaide, the birds of the Mt Compass district feature in the observations of several other South Australian naturalists of the late 1800s and early 1900s. One of those was a local, Albert Waye, the youngest son of the former Road Board stationman George Waye, who grew up in the area before the land was closely settled and developed, and hence gained a great appreciation and understanding of his local environment and observed the detrimental impacts of land development on wildlife presence and abundance.

This background and his special interest in native birds, led Albert Waye to contribute a section called "A Study of Local Fauna" in the book that celebrated 100 years of history and development of the Mt. Compass district (RMCD, 1946). In it, he recounted that: "*The dainty Emu Wren with its distinctive tail may occasionally be seen flitting about the ti tree in uncultivated swampland.*"

**Butterflies**

Despite the significance of the park to the Southern Emu-wren, it is actually named after the Golden Haired Sedge-skipper (*Hesperilla chrysotricha*), see Figure 2.1, another habitat-restricted species of the southern Fleurieu Peninsula district. In order of abundance of skippers of wetlands in this area, the Donnysa Skipper (*Hesperilla donnysa*) is still most commonly encountered, followed by the much rarer Flame Skipper (*Hesperilla idothea*), and finally the Golden Haired Sedge-skipper, which has only a handful of records in the area, including one from Square Waterhole Swamp in the 1980s (M Pickett, pers. comm.).

**Aquatic fauna**

In terms of aquatic species of interest recorded at the site, Aquasave Consultants (now Aquasave – NGT) staff surveyed the aquatic habitat at the site for native freshwater fish as part of the Eastern Mt Lofty Ranges Fish Inventory on 30th of March 2004 (Hammer, 2004; Aquasave – NGT database, 2017). The survey resulted in the capture of 20 Mountain Galaxias (*Galaxias olidus*) in the main drain near the culvert and upstream in the adjacent flow. Forty Southern Pygmy Perch (*Nannoperca australis*) were also recorded in the large dam by the road (south of the present Conservation Park boundary), sheltering under the cover of vegetation by the edge. The population was noted to have good size structure.

### *4.2.4* Flora

Despite the site supporting an important remnant area of a critically endangered vegetation community and potential habitat for a range of listed species, the currently known flora for Hesperilla CP does not include any nationally threatened species. Seven species listed as Rare under the Schedules of the *National Parks and Wildlife Act 1972* have been recorded (Table 4.1), and four of them are threatened in the Eastern Mt Lofty Ranges sub-region.

***Table 4.1: State listed flora recorded in Hesperilla CP***

| **Species** | **Common Name** | **SA Rating** | **Sub-regional Rating** |
|---|---|---|---|
| *Baumea acuta* | Pale Twig-sedge | R | VU |
| *Drosera binata* | Forked Sundew | R | VU |
| *Gleichenia microphylla* | Scrambling Coral-fern | R | RA |
| *Melaleuca squamea* | Swamp Honey-myrtle | R | RA |
| *Myriophyllum amphibium* | Broad Water-milfoil | R | VU |
| *Viminaria juncea* | Golden Spray, Native Broom. | R | VU |
| *Xyris operculata* | Tall Yellow-eye | R | RA |

Despite their listings, more as a result of the rarity of their preferred swamp habitat, none of these species are currently of major conservation concern. The current (incomplete) flora species list for Hesperilla CP and surrounds is presented in the Appendix in Section 10.

## 4.3 Biological threats and disturbances

### *4.3.1* Weeds of significance

Being adjacent to dwellings and a transport route, and having a long history of disturbance, means that there are many introduced flora species recorded in Hesperilla Conservation Park. A small number are highlighted here.

***Gorse***

Gorse (*Ulex europaeus*) was already established on the property at the time of reservation, and has been the subject of past weed management works at the site by the GWLAP. Since control works of larger infestations were undertaken (Figure 4.15 - A), a smaller number of scattered recruits continue to emerge from soil stored seed (Figure 4.15 - B).

*Figure 4.15: (A) remains of dense gorse patch; (B) isolated gorse plant in the swamp*

***Blackberry***

When considering the whole remnant swamp area beyond Hesperilla CP, including surrounding public and private land, Blackberry (*Rubus spp.*) is probably the most significant introduced woody weed threatening the values of the swamp. The species is particularly dominant on the elevated, well-drained spoil banks associated with the large, deeper drains situated on both the public (local government reserve) and private land south of the Conservation Park, given past investment in control by the GWLAP within the park. This area is mapped in Figure 4.14 and an image representative of this zone is shown in Figure 4.16.

*Figure 4.16: Looking east along a large Blackberry covered spoil bank to the south of the Conservation Park (which is in the left of the image)*

***Other Weeds***

Several other woody weeds which occur on and adjacent to the site are still quite isolated and therefore should be quite feasible to eradicate. These include Aleppo Pine, Pampas Grass and Willow, as shown in Figure 4.17. Of these species, mature pine trees within the existing Conservation Park have been subject to past control through ring-barking.

**Aleppo Pine**

**Pampas Grass**

**Willow**

*Figure 4.17: Low intensity occurrences of these weeds at the site are feasible for eradication*

### 4.3.2 Stock grazing and trampling

Unrestricted stock access to the swamp was a long-term threat to the site that was largely removed in 2007, when the SA Government purchased the bulk of what remains of this portion of Square Waterhole Swamp. This was an important step in the conservation management of the site as there are multiple aspects to the damage caused by grazing, particularly in peat wetlands which remain saturated year-round and are especially sensitive. These include physical damage to both the vegetation (caused by browsing) and the peat sediment (through pugging and trampling), as well as causing dual impacts on water quality and weeds; as a result of all excrement being nutrient enriched, while manure specifically provides a potential incursion pathway for weed seeds. Smaller fringing areas of wetland on private land to the north and south of the site continue to experience low intensity grazing by domestic livestock (e.g. see vegetation density change in Figure 4.11). Despite the clear threat posed by unrestricted grazing, it is also important to note that the complete exclusion of all forms of disturbance can also result in homogenous vegetation communities or the rapid expansion of problematic species (such as *Phragmites australis,* noted elsewhere in this catchment). As a result, disturbance ecology is a current area of priority research for the Fleurieu Swamps Recovery Program (R. Duffield, pers. comm.).

## 4.4 Hydro-geological context

Square waterhole resides in the upper section of the Tookayerta catchment, which forms part of the wider Eastern Mount Lofty drainage division. The catchment is dominated by two ancient glacial valleys that have been infilled by the Cape Jervis Formation, consisting primarily of medium quartz sand with intermittent silty clay layers. Reworking of these Permian sands during the Tertiary period has resulted in areas of higher clay and iron contents than occurs in the relatively clean Permian deposits (Banks et al. 2006) (Figure 4.18). Fleurieu Peninsula Swamps occurring on Permian Sands form in the lowest parts of the landscape, in valleys and depressions, where they are in direct contact with groundwater. Surface runoff over landscapes underlain by Permian Sand is generally low, with lateral groundwater movement providing almost all of the wetland water requirements (Deane et al. 2010). The primary sources of inflow correlate with seepage zones along the western and north-western boundaries.

Watershed analysis, combined with existing watercourse mapping suggests that the only defined surface flow accumulation would have historically entered the southern edge of Square Waterhole Swamp from the direction of Mt Jagged. These seasonal flows are now captured by the drain that runs along the western side of the road and are directed towards the main culvert that also drains the swamp.

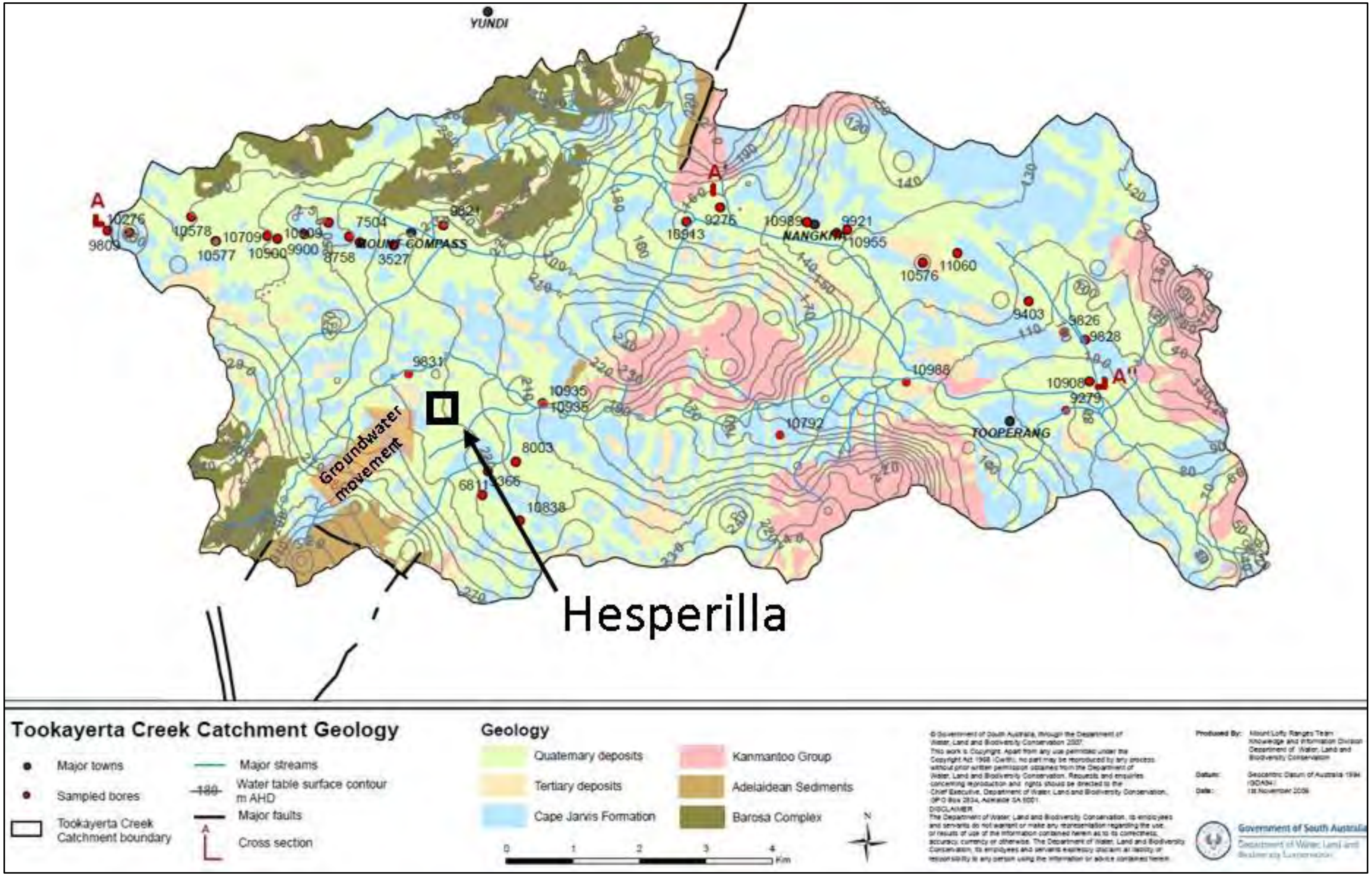



*Figure 4.18: The location of the Hesperilla CP and geology of the Tookeyerta catchment (from Banks* et al. *2006).*

## 4.5 Climatic context

Because most summer rainfall is lost to evaporation in a temperate Mediterranean climate, winter rainfall (April–October) is a more reliable indicator of the water balance in a catchment than average annual rainfall (Barnett and Rix, 2006), and therefore a better way of gaining some insight into the likely maintenance of recharge-driven groundwater base flows.

Figure 4.19 provides an overview of rainfall trends, at the closest BOM weather station (Mount Compass) across these months and suggests that the catchment had been experiencing a deficit from average rainfall since 2004, with eight of the past twelve years yielding below average rainfall.

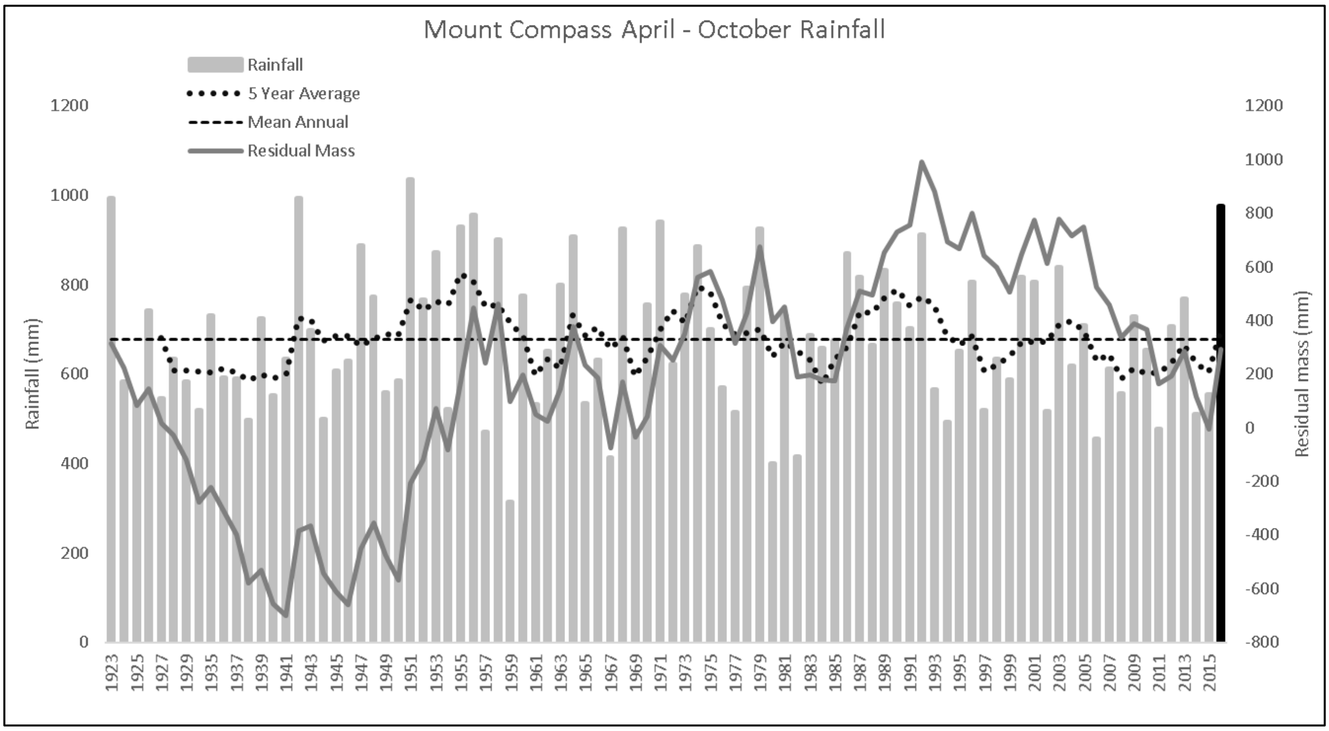



*Figure 4.19: Effective (April – October) rainfall average for Mount Compass BOM station (23735), 1923 – 2016. Residual mass is the cumulative departure from the average over time.*

The 2016 period represents the fourth wettest period on record and, despite following on from two low rainfall years in a row (2014 and 2016) has brought longer term trends back within the order of average conditions. Observation well data reveals that groundwater levels close to drainage lines and swamps have remained stable over the past ten years, which suggests baseflows are currently being maintained (Barnett, 2016, DEWNR, 2016). Despite declining rainfall and over-allocation of water resources within the catchment, limited available metering data suggests that there is not yet overuse (i.e. licensees are not using their full allocations), which helps explain the present maintenance of baseflow (M. van der Wielen, pers. comm.).

However, with climate projections suggesting winter-spring rainfall will decline by between 15 to 30 percent by 2070 (Siebentritt et al. 2014) and likely increased use of allocations, future baseflow decline is a risk worth taking into account for future management decisions in the catchment. With this in mind, it is important to note that the type of eco-hydrological restoration approach advocated in this report is capable of building natural resilience to buffer the ecological community against the predicted detrimental effects of reduced discharge and climate change.

## 4.6 Summary of artificial drainage

A combination of on-ground assessment, aerial photographic interpretation and analysis of the digital elevation model (based on LiDAR), has resulted in the production of a site map showing the modern drains that are still impacting on the hydrology of the site (Figure 4.20). Despite the amount of native vegetation recovery across the site, these drains, which are typically deeper and mostly still defined visibly on the ground, continue to discharge flows at an artificially accelerated rate through and out of the site.

***Figure 4.20: Highlighting the most significant drains still impacting upon the hydrology of the site. The arrows indicate culvert locations.***

An additional combined overview of all past drainage works is shown in Figure 4.21, created by analysing the sequence of historical aerial imagery shown previously in Figure 3.19 - Figure 3.27, starting the first image from 1949.

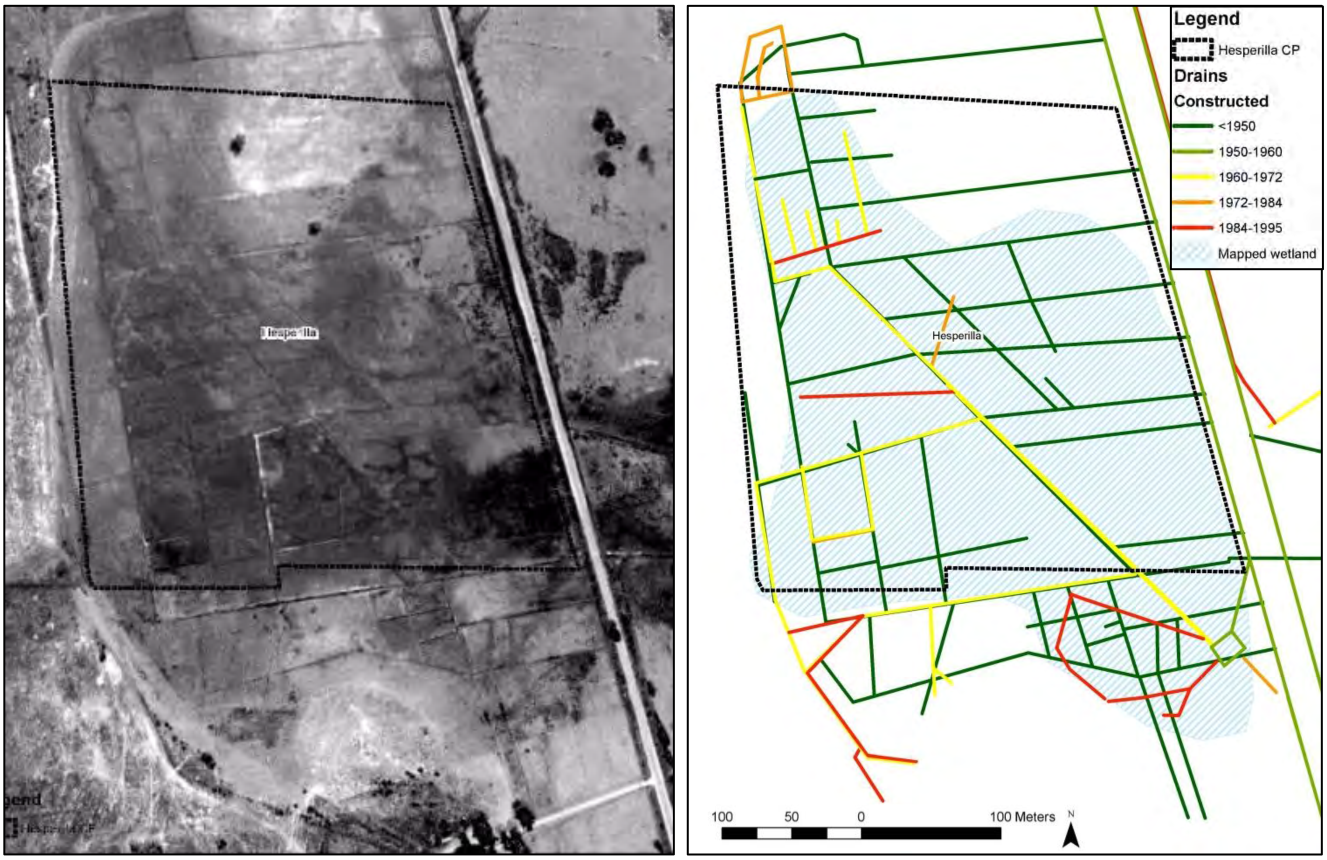



***Figure 4.21: The earliest aerial view of Square waterhole in 1949 (left) and a composite of all drains constructed based on this image and the sequence of aerial imagery since then (right)***

## 4.7 Gradients of existing, active artificial channels

Elevation data, collected using LiDAR and estimated from derived Digital Elevation Models, indicate the approximate slope of identified channels across the wetland area (Figure 4.22).

Whilst in dense vegetation types this data must be interpreted with a degree of caution owing to false signals (failure to penetrate to true ground level due to thick vegetation growth), this analysis does indicate the general slope of each channel and confirms the direction of flow.

This information is also vital for building a picture of how the drains are interacting with the peat bed and for helping to determine both the appropriate restoration response and relative priority of actions – topics that will be addressed in subsequent sections of this report.

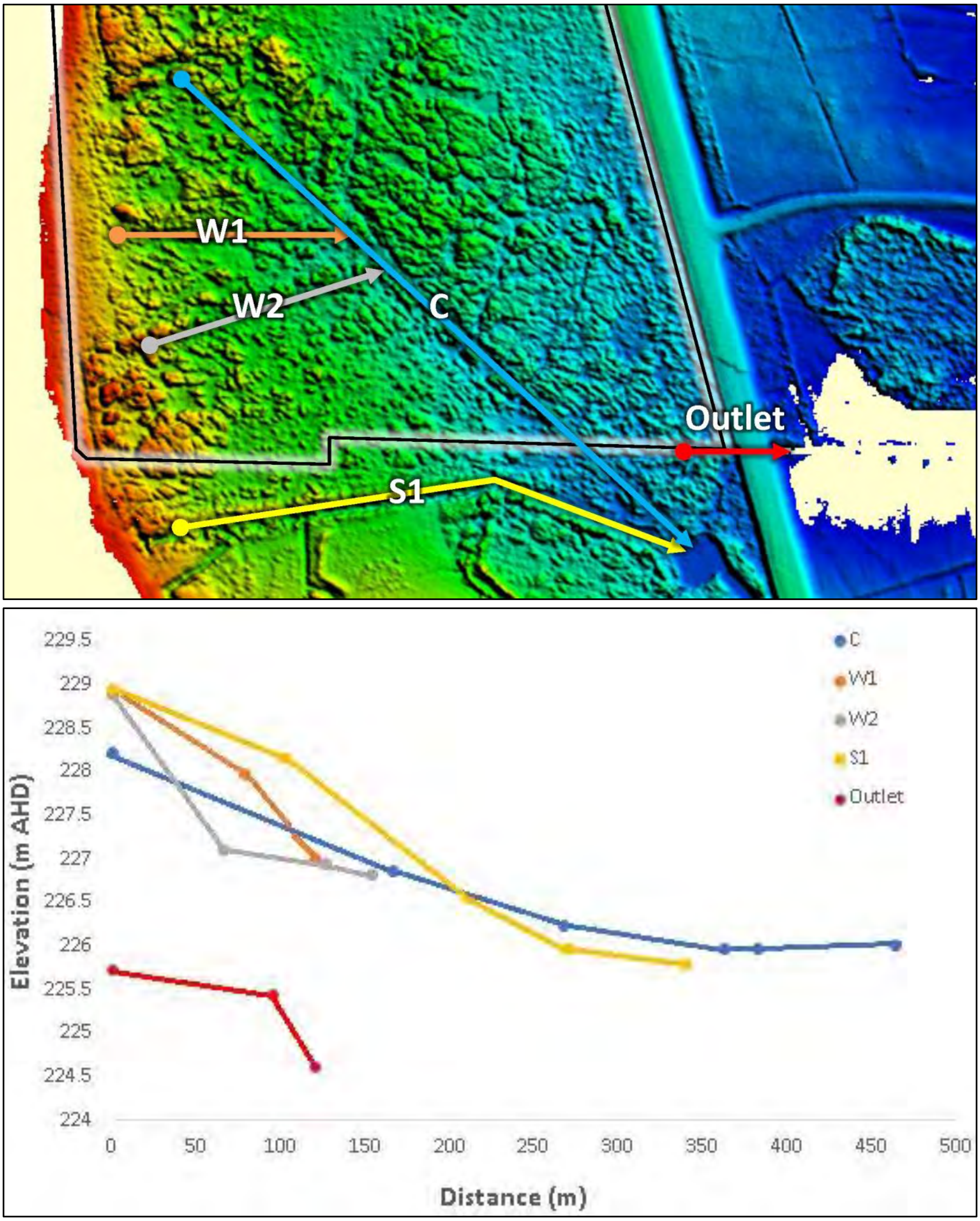



*Figure 4.22: Digital Elevation Model and inferred drainage gradients*

The calculated slopes also agree with observations of flow, with higher flow velocity occurring in steeper sections of the main central (**C**) channel and the artificial outlet (**Outlet**) for all drain flows. They also confirm the relatively large change in elevation across the site (up to 4.5m) and a significant fall on the downstream side of the culverts that flow under the road (a sudden fall of 1 m).

## 4.8 Recent flow observations

A conceptual understanding of how water currently moves through the site, based on observation of flows in visits from spring 2016 to autumn 2017, is provided in Figure 4.23. The only surface watercourse enters the southern end of the swamp via the roadside catch drain (see blue arrow), before discharging away from the main wetland area under the road.

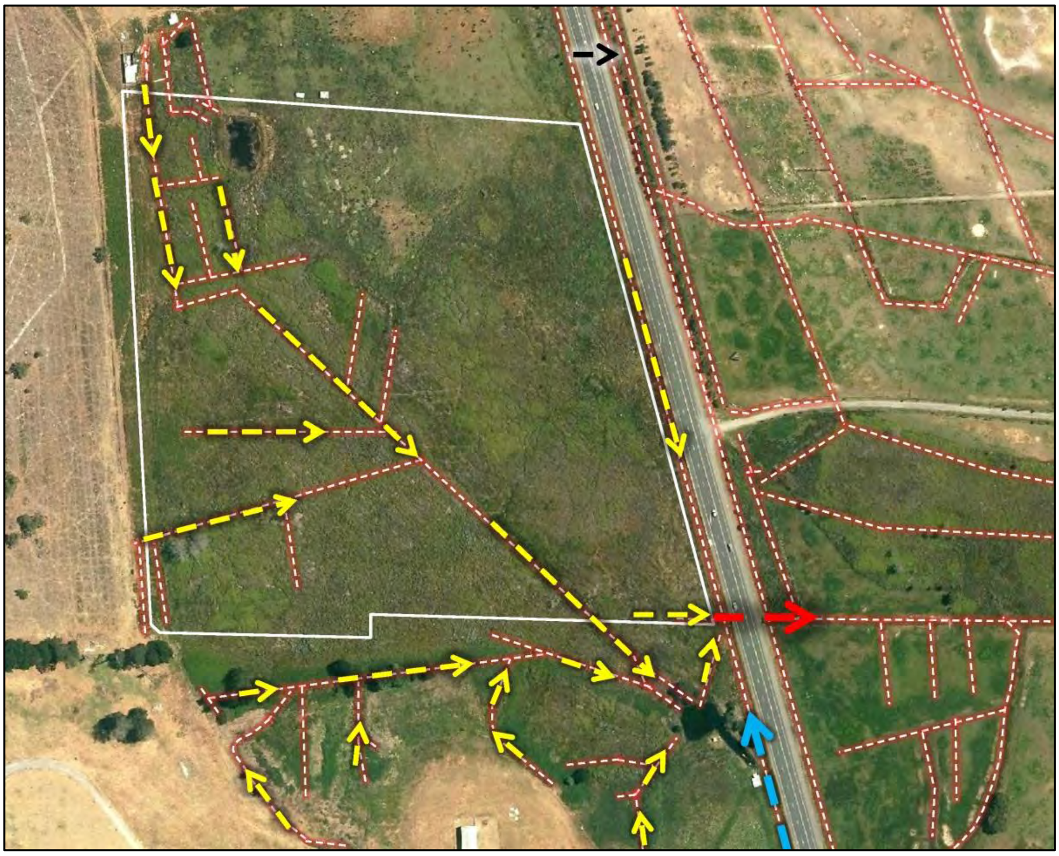


***Figure 4.23: Location of current prominent drains and flow direction (yellow arrows).***

***Notes:*** *The only location with especially high flow velocity was at the culvert under the road (red arrow), as a result of significant fall in the drain downstream. The second culvert is at a higher elevation (black arrow), while the southern section of the catch-drain next to the road (blue arrow) also captures and directs a nearby seasonal surface catchment towards the main drain / culvert.*

More primary (and permanent) sources of inflow appear to correlate with groundwater seepage zones along the southern, western and northern boundaries. Active drains around the margins of the swamp, but especially those arising in in the north-west, feed the main diagonal drain across the swamp with permanent groundwater flows.

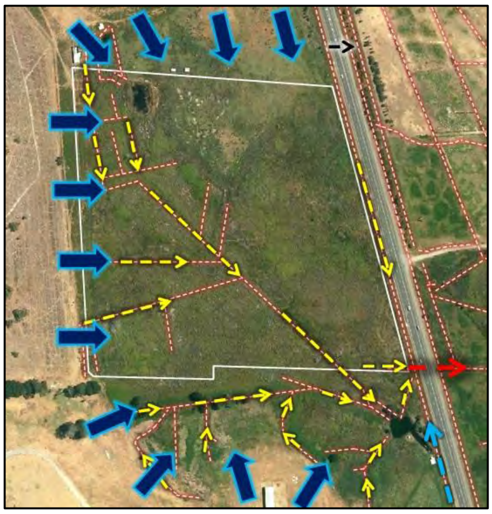


***Figure 4.24: Groundwater discharge from the surrounding hills forms the primary source of water for the swamp. Flow direction indicated by blue arrows.***

## 4.9 Eco-hydrological changes induced by drainage

Including early impacts associated with roadside drains constructed in the 1860s, what remains of the original extent of Square Waterhole Swamp has now experienced over 150 years of hydrological modification; a process that, as a result of closer settlement and agricultural development from the 1890s, greatly intensified throughout the 20th century. The decisions being made over that period, whether that be through the eyes of a road engineer or farmer, were driven by a simple objective: to dry the peat out and move water out of the swamp as effectively and efficiently as possible.

However, it turns out that for the swamp, the development of the road has probably acted as both a 'curse' – for initially facilitating (1860s) then deepening (1950s) local drainage – and an inadvertent 'blessing', for then also acting a partial levee bank, helping to regulate outflows and moderate the effects of drawdown associated with downstream drainage (to the east) over more recent decades, as represented in Figure 4.25. This is because:

1. with a restricted number of culverts under the road (see arrows in Figure 4.20) and the slope across the site, the majority of water leaving the swamp can only exit at a single location, rather than via multiple drainage outfalls; and,
2. with that outflow constriction playing a role, it would appear that as the level of the peat has subsided in the swamp, relative to the level of the road embankment and drains, more of the peat surface has re-saturated.

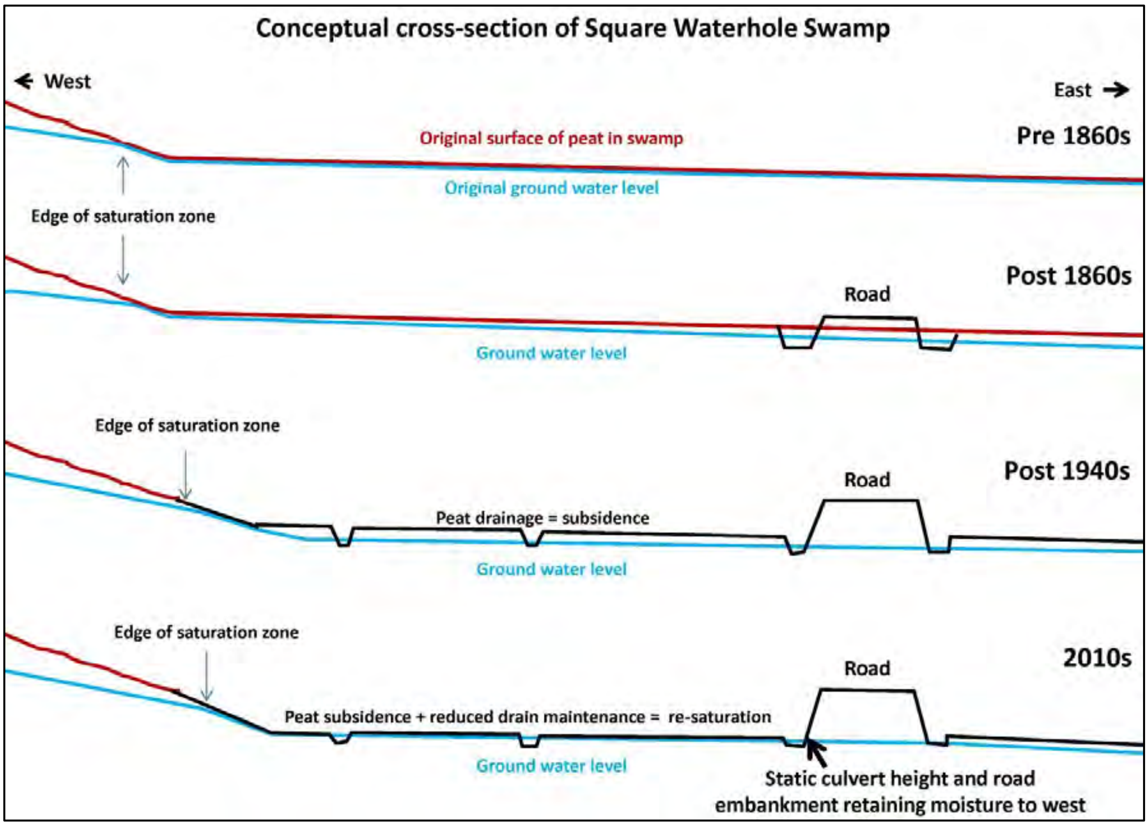



*Figure 4.25: Vertically exaggerated cross-section to represent the changes to swamp surface elevation, ground water level, and the development of the road and drains since the 1860s.*

The role of the road embankment as a factor in driving gradual swamp vegetation recovery, given the subtleties involved in water movement and retention in peat systems, should not be underestimated, and is supported by the nature of observed flows under the road at the main drain and the significant immediate gradient (fall) in the channel on the downstream (eastern) side of the culvert. The invert of the concrete culvert under the road has set the upstream sill level for outflows.

This means that, if the road wasn't present, this main drain could (and probably would) otherwise have been significantly deepened over the years when farm drain maintenance work took place. If this had occurred, significant additional dehydration of the wetland west of the road would have resulted and the remnant swamp as we know it today may not exist.

Does this limiting factor explain why drain maintenance activities reduced on the property over the past few decades, or was it simply driven by a change in land-ownership, land-use or management practices? Whatever the reason, the combined effects of these changes since settlement (in conjunction with the reliability and volume of groundwater discharge) are significant and explain why the remnant swamp persists, appearing as it does today.

The physical extent of the swamp has shrunk, even within the present-day Conservation Park, which was, according to early survey maps, almost entirely once covered by swamp vegetation prior to development. The more water that has been drawn out of the system via drainage and the greater the degree of peat dewatering and subsidence, the greater the extent of dehydration also expected up slope and around the fringe of the swamp. After all, this is precisely what drainage was intending to do and has achieved, an impact that was particularly successful in the balance of Square Waterhole Swamp to the north, and on the property to the east of the road which is more deeply and comprehensively drained. To help further visualise this drainage impact, the Digital Elevation Model for the site is a most useful tool (Figure 4.26).

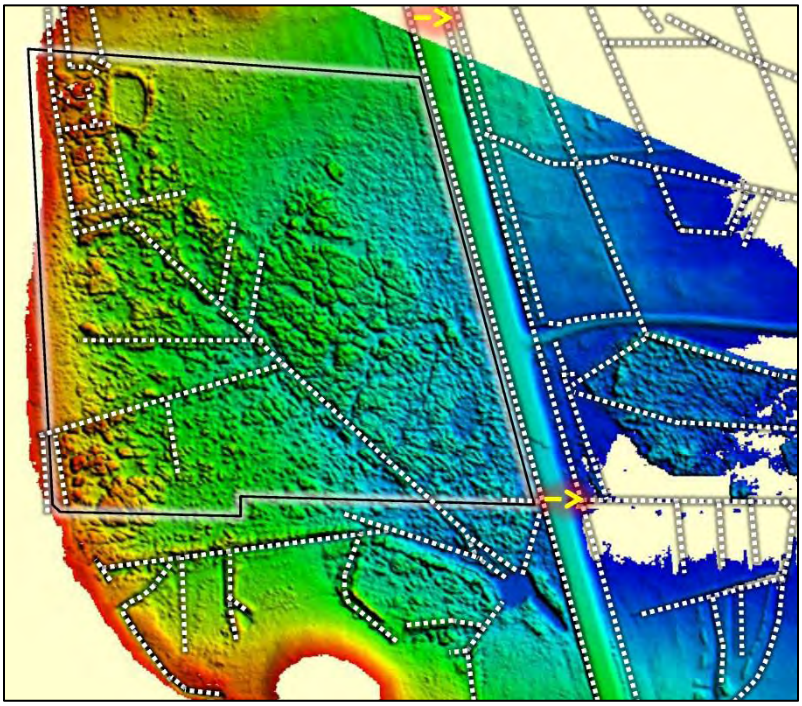


*Figure 4.26: Digital Elevation Model: coloured shading illustrates the change in gradient from the original edge of the saturation zone (red/orange) through the lowest parts of the swamp (blue).*

The natural contours and slope of the site would ordinarily cause water, through gravity, to move downslope from areas coloured red, to orange, then yellow, green and finally blue. At any location, this is how a groundwater discharge direction (Figure 4.27) can be inferred.

However, artificial drains are now super-imposed on top of, and interacting with, that original gradient, across and through what was originally a continuous peatland (Figure 4.28).

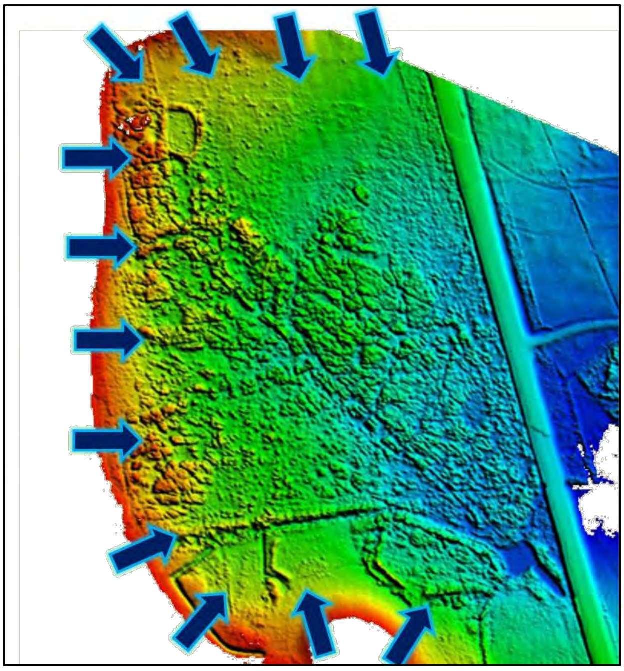


*Figure 4.27: Digital Elevation Model for Square Waterhole Swamp illustrating inferred groundwater flow direction.*

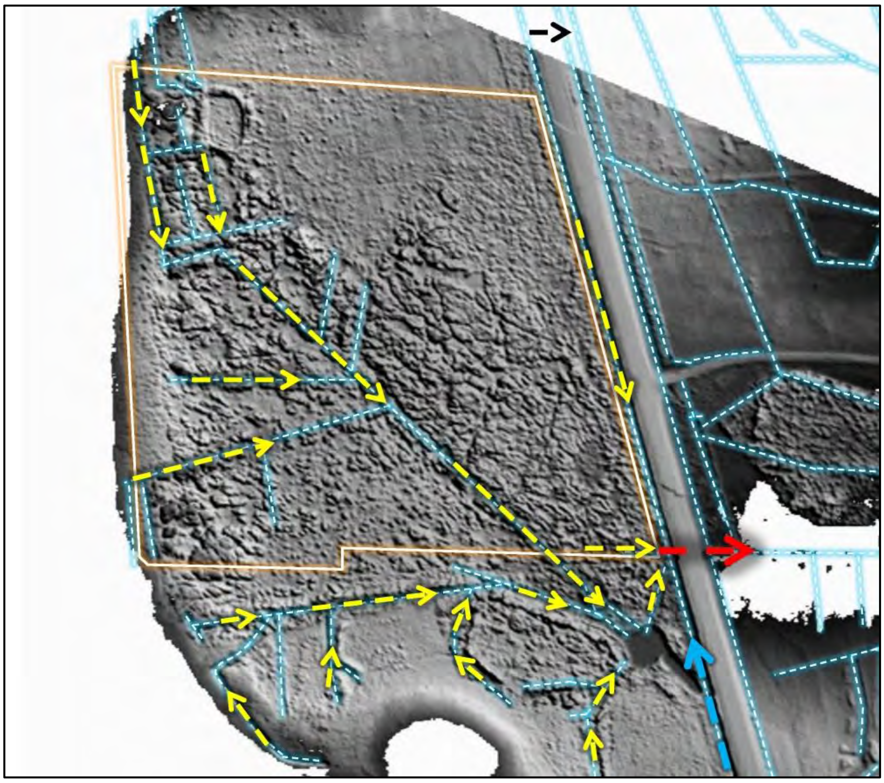


*Figure 4.28: Active drains superimposed on a grey-scale terrain model of Square Waterhole Swamp*

Despite not being maintained, these drains continue to interrupt natural flow dynamics through the peat and prevent the type of slow lateral movement and less defined inundation/saturation pattern that was associated with it. There is also the interesting fact that the site itself has a significant natural lateral west-east gradient across it. This is not a 'wetland basin' feature with a fixed sill level (or static inundation height) – rather, it is more like a sloped 'sponge' of peat that had built up slowly but uniformly over time, kept saturated by its relationship to a groundwater supply that originally passed more slowly through all of it, all the time. As soon as that pattern of hydration and water movement was changed, then changes in eco-hydrological character were inevitable. To highlight this point, consider that between the current saturated western edge of the swamp, the break of slope (groundwater discharge zone) of the hills, is approximately 3m higher than the elevation of the swamp next to the road (Figure 4.29). Further, the elevated roadway itself sits around 1m above the drained peat immediately to its west, as shown in Figure 4.30.

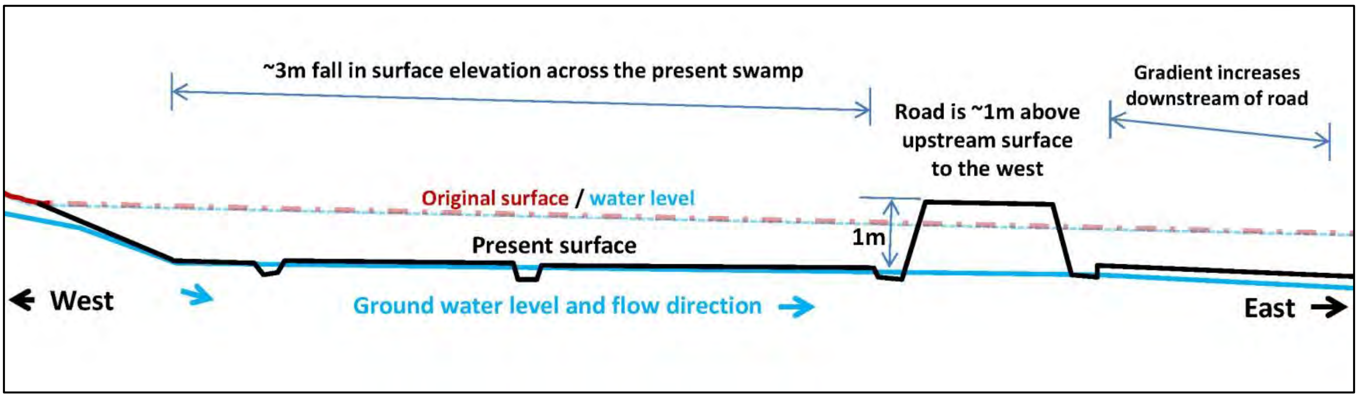



***Figure 4.29: Vertically exaggerated cross-section of the swamp, illustrating key elevation data derived from Digital Elevation Model.*** ***Notes: (1)*** *the degree of peat subsidence is not ascertainable, so this is for illustrative purposes only, to explain/show the processes involved.* ***(2)*** *the road height is vertically exaggerated more than other features (i.e. it is actually lower than some parts of the swamp to its west).*

***Figure 4.30: Looking north along the Victor Harbor Road and across the swamp to the north-west, from the location of the main drain culvert outlet (the SE corner of Hesperilla CP)***

However, despite the swamp shrinking in its overall footprint, the dried surface area of deepest peat in the swamp is also prone first to rapid post-drainage subsidence, and later re-hydration, after contacting the new maximum level of the lowered groundwater table. This means that, in the absence of aggressive drain maintenance, and because there is a fixed physical constraint in place (i.e. the road embankment and culvert sill level), core areas of deepest peat within a site like Hesperilla CP always have the possibility of slowly reverting back to swamp. However, for conservation areas established in the presence of these underlying threats, it is important to remember that this reversion process does not overcome the fact that the site is still hydrologically compromised.

So while the area and quality of swamp habitat is reduced, with floristics simplified, micro-habitats reduced and an interruption of peat forming processes, a site like Hesperilla CP has still managed to retain a suite of recovering biodiversity values that may appear incongruous with a long and intensive history of development. But this is the beauty of how swamp recovery can still occur spontaneously in peat environments, despite drainage, and why a small but complex site like Hesperilla CP makes such a fascinating case study for restoration planning and works.

Notwithstanding the hydrological modifications that have occurred, for a site of its type the swamp is in good condition and may be enhanced further by looking more closely at options to reverse the altered hydrological processes described.

## 5 The impacts of artificial drainage

By combining the various elements of our developing understanding from the previous sections, it is possible to begin to construct a strong conceptual basis for how the hydrological regime at Square Waterhole Swamp is interacting with the artificial drainage infrastructure on site.

In order to do that, the infrastructure on site has been spatially classified and broken into five zones/sites types, colour coded in the diagram below (Figure 5.1) as follows:

1. Red: Former Saturated **B**ank
2. White: **D**ams
3. Blue: Main **P**eat Bed
4. Yellow: **C**ulverts
5. Purple: Roadside Drain **F**lowpath

These five zones form the basis for the discussion that follows in this section, while each numbered area will also be treated individually in the restoration options assessment.

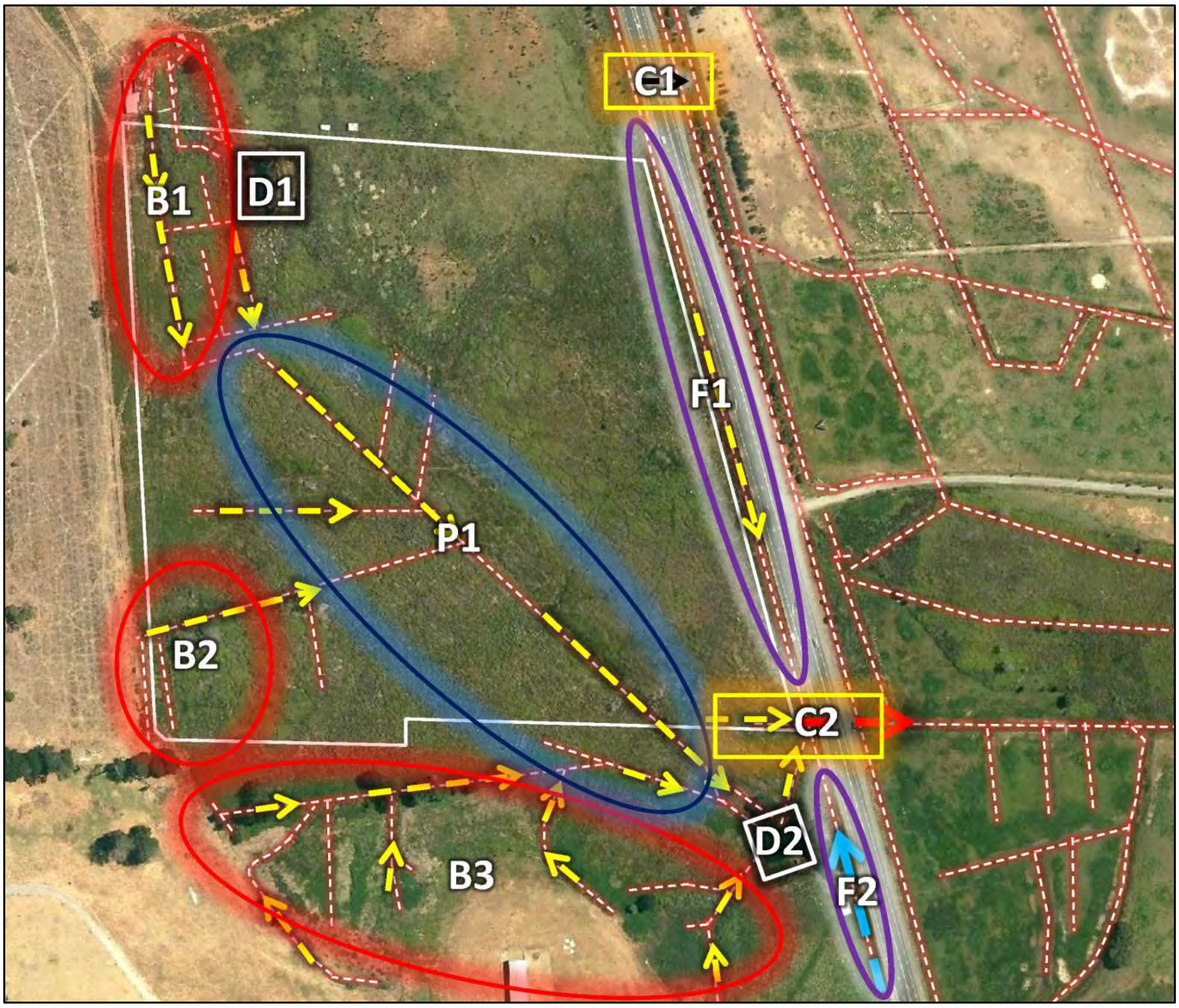



*Figure 5.1: Suggested zones of impact from drainage infrastructure at Hesperilla CP*

## 5.1 ZONE 1: Saturated Banks (B1, B2, B3)

As previously described, a primary source of hydrological input for Square Waterhole Swamp is sub-surface seepage from the adjacent hillsides, particularly from the west and southwest. Along with attempting to draw these flows away from higher ground at the break of slope, perpendicular drains then act to move this water toward the main arterial drainage channels and towards the culvert (at C2). This results in a faster movement of water toward the south eastern corner of the wetland and reduced ability of effected areas of the peat to retain moisture. A symptom of this change is the downward migration of wetland edge, as described in the previous section, with the downward migration of terrestrial species such as bracken and pasture species. The latter of course were deliberately encouraged to displace native wetland species in this zone as part of the agricultural development process.


### *5.1.1* Sub-zone B1/B2

These sub-zones experienced significant development pressure when the site was first developed, but have also undergone substantial spontaneous native vegetation recovery, despite the number of drains present and active (for example see Zone B1 in Figure 5.2). A small number of the N-S drains in Zone B1 actually straddle the boundary and continue up a relatively steep slope into the adjacent private land.

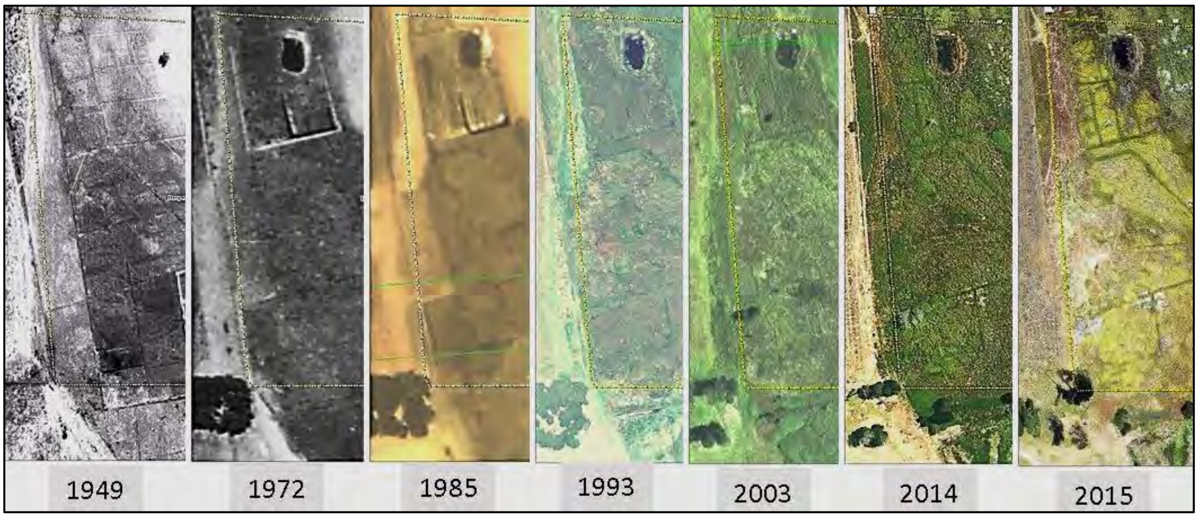
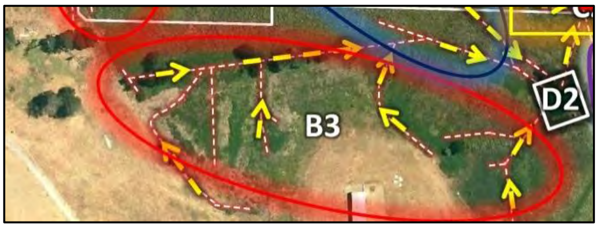



***Figure 5.2: Vegetation change in Zone B1 over time.***

Sub-zones B1 and B2 are situated almost entirely within the Conservation Park's boundaries and the drains in these areas have not been recently maintained nor, prior to that, substantially deepened. This appears to have enabled a slow natural recovery process to commence over recent decades, despite the ongoing presence of the drains and the associated hydrological impacts on soil moisture in the upper peat profile and adjacent slopes. For an example of a drain at the break of slope within the Park in this zone, see Figure 5.3.

***Figure 5.3: Lachlan standing in the bed of the western-most drain in sub-zone B1, which runs along the break of slope. The drier upslope bank is in the right and foreground of the image, while the recovering swamp vegetation can be seen behind. Image taken facing south-east.***

### *5.1.2* Sub-zone B3




This sub-zone, which is part of Square Waterhole Swamp but falls entirely outside of Hesperilla CP, straddles the Alexandrina Council Reserve and two parcels of private land to the south. In contrast to the other bank sub-zones, the drains in this area were more recently excavated (1980s and early 1990s), and are deeper and wider than many other drains across the site, meaning – as a direct consequence – their spoil banks (made up of that excavated material) are higher and drier.

This has created conditions perfect for blackberry to establish and thrive, as the species is particularly well suited to well-drained soils with access to sub-surface permanent moisture – meaning that many of the spoil banks in this sub-zone are heavily infested. This impact is shown in Figure 5.4.

***Figure 5.4: Looking east along the major drain in sub-zone B3, showing how the large spoil banks either side have become completely infested by blackberry thickets.***

Other parts of sub-zone B3 continue to be grazed, meaning that this area does not support the same proportion of high quality remnant swamp vegetation as B1 and B2, despite being of similar elevation to equivalent areas found in the park (Figure 5.5). Subject to agreement from the landholders concerned, this area has excellent restoration potential.

***Figure 5.5: Looking north along the south-western most break of slope drain in in sub-zone B3, a more elevated area of dehydrated former swamp still utilised for grazing. This image illustrates what more of Square Waterhole Swamp would look like, if drainage had been successful. Hesperilla CP is in the middleground, right of image.***

## 5.2 ZONE 2: Dams (D1, D2)

As prominent features within the swamp and permanent waterbodies, the two dams have been isolated in this assessment because they have particular management constraints and/or considerations that need to be taken into account when determining the best course of action for restoration of the wider wetland. Both dams interact directly with groundwater, which is why they remain permanently inundated, but they also have a variable relationship to drainage infrastructure, and occupy different levels on the elevation gradient. In terms of impacts, dam footprints can alter the bathymetry of aquatic systems, create a depressed bed level and point of accumulation which draws water out of surrounding sediments and/or increases flow away from fringing areas. This is a particularly important consideration in peat wetlands where saturated sediments drive site ecology.

### *5.2.1* Sub-site D1


Dam 1 (D1), as previously explained, was constructed in the early 1960s to supply water to the former milk products factory to the north of the swamp. The dam is essentially a window on the water table under that part of the swamp, and ironically is sustained by the very same water source that agricultural drainage activities were concurrently trying to remove from the site. Aside from a couple of minor feeder drains (in Zone B1) that appear to connect them with this feature via surface flows, the dam is otherwise isolated and land-locked by dense swamp vegetation (Figure 5.6).

***Figure 5.6: Looking south-west across the dam in D1, of 1960s construction.***

Being higher up the elevation gradient, the management options for the dam in D1 should be able to be considered independently of surrounding works. This is important because the ongoing status of the easement over the dam (referred to earlier in the report) is likely to have a bearing on whether restoration works are implemented in sub-site D1 in the future.

While this dam would ideally be decommissioned to reduce its proximal impact on the surrounding wetland habitat, further investigation into the legal ramifications of the easement and liaison with the relevant neighbouring landholders, would first be required.

### *5.2.2* Sub-site D2


Dam 2 (D2) was constructed in the 1950s to supply water to the property to the south of the swamp, when the Victor Harbor Road was upgraded. Like D1, site D2 captures surface flows and exposes the groundwater table (Figure 5.7).

***Figure 5.7: Looking south-east across the dam in D2, of 1950s construction.***

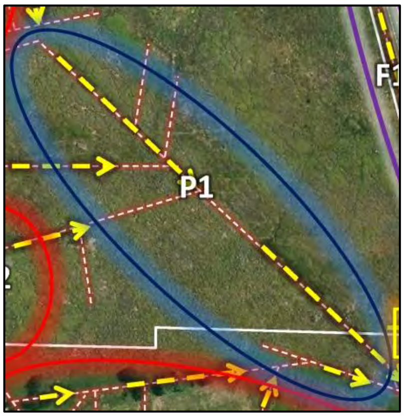
However, unlike the other dam, D2 is situated much lower in the elevation gradient of the site. In fact, as shown in the LiDAR imagery earlier in the report, it is one of the lowest points in the swamp before water exists under the Culverts at C2. It is also the present terminus for almost all artificial drainage coming out of the swamp, before permanently spilling towards C2.

This private dam continues to be used as a private water supply and hence sub-zone D2 will be excluded from consideration for on-ground restoration works. However, the site must feature in our thinking to ensure that:

- The water supply is protected – which is not an issue given the size and depth of the dam and the permanent groundwater discharges that would continue to enter it (irrespective of drain flows).
- The works take into account the location of pumping infrastructure and surface elevations surrounding the dam to ensure access is maintained – which may require closer analysis as part of any works implementation proposals.

Maintaining communication with the owner will be critical to ensuring this area is adequately considered in any future restoration works that may result from this report.

## 5.3 ZONE 3: Main Peat Bed (P1)




Drainage through the centre of the wetland, via a diagonal channel constructed prior to 1950, and then upgraded after 1960, occurs along a continuous downward slope, picking up the discharge from other drains (in sub-zone B1 and B) along the way. This conveys flow from the north-western corner, as well as from drains originating along the western boundary, acting to increase the speed of water movement toward the south eastern corner of the wetland. When first constructed, and prior to the peat subsiding, the intention of this drain was also to dewater the adjacent peat.

Inundation was noticeably deeper (super-saturated or inundated) within Zone P1 in close proximity to this drain, when directly compared with the damp (but less saturated) substrates of the western and northern sections. In diagonally bisecting the wetland, this channel is also reducing the movement of water toward the north eastern portion of the wetland an impact that is likely to be significant.

Indeed a closer inspection of the drains and vegetation association maps together (Figure 5.8), clearly shows how this main drain in particular has shaped the ecology of the wetland as it has recovered after subsiding.

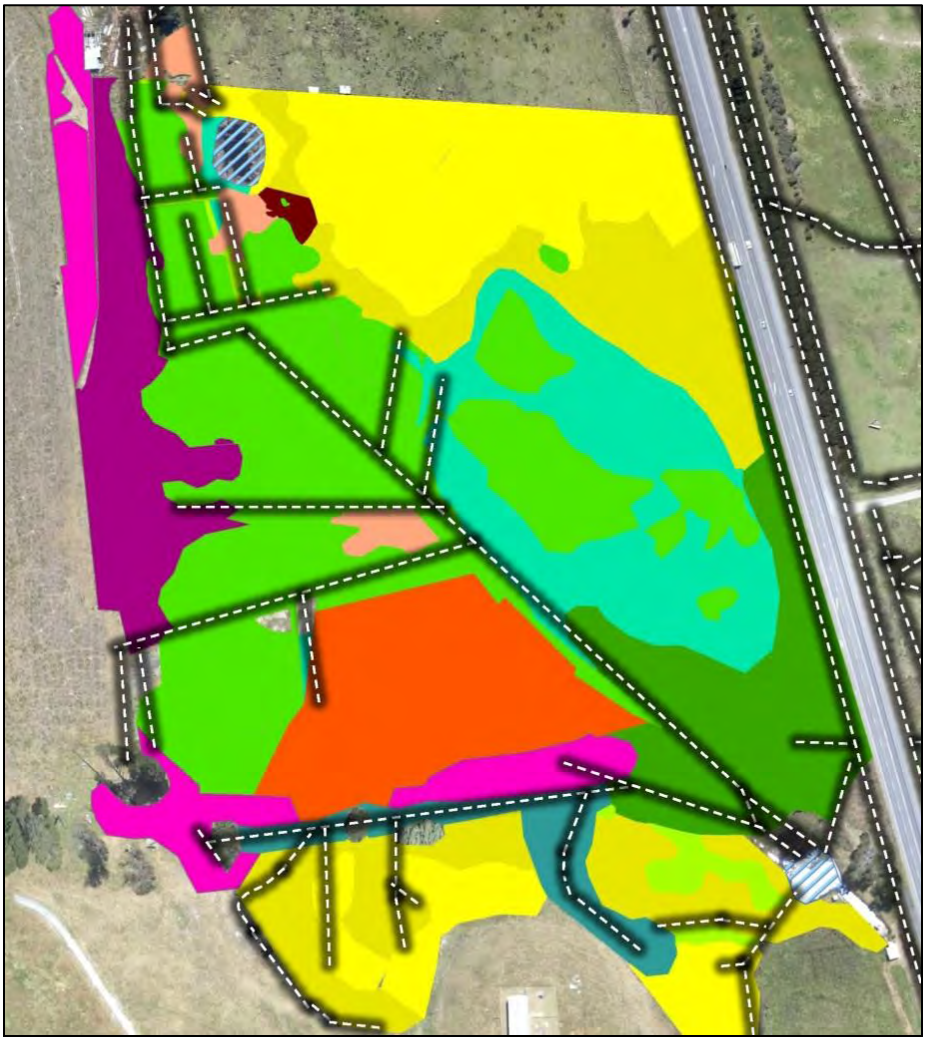


***Figure 5.8: Illustrating the direct relationship between the pattern of historic drainage works and the location of different vegetation types today. Hesperilla CP as we know it has literally been shaped by artificial drainage.***

This relationship is not a coincidence; it is clear case of *cause and effect* and illustrates in detail how manipulating flows over the long-term directly shapes and defines wetland floristics and ecology. It all starts with water regime.

This pattern of vegetation change that corresponds with drain locations is also visible from on the ground. An example from near the southern boundary of the park, looking north-east up the drain, is shown in Figure 5.9.

***Figure 5.9: Looking north-west up the main diagonal drain (sedges) and spoil bank (covered in coral fern). Note the prickly tea-tree dominated vegetation community to the left (south-western side) of the drain, and the sedgeland to the right (north-eastern side).***

This core area of Square Waterhole Swamp in its current state presents some management challenges. Due to how wet the area remains (despite drainage) and the density of swamp vegetation, physical access is not simple. The peat bed also does not have a single fixed sill level (or specific overall target water retention height) that has been breached. Hence there is no single drainage control point that can be pinpointed and repaired or reinstated to achieve restoration. Drainage impacts are therefore diffuse across the peat bed, correlating with proximity (for drawdown effect in adjacent peat) and ground water flow direction (for interception of lateral subsurface flows), and are therefore also significantly influenced by their depth and gradient.

Picture the peat substrate that occupies Square Waterhole Swamp as being the equivalent of a water-filled 'sponge' that slopes from west to east. As more vegetation is deposited and the peat profile grows with time, its water holding capacity also grows and it continues to restrict the movement of water through the system, which in turn maintains the perfect conditions necessary for further development of peat – in short, this is a positive feedback loop. The system relies on a hydrostatic equilibrium between inflows (needed to maintain constant saturation) and outflows (making the system continuously leaky, or it would turn into a lake) – hence the analogy with a sponge.

When a gently sloped peat bed is incised through artificial drainage, dramatic changes can occur, both (a) in the way water moves (drawing it out, channelising it and speeding up its exit), and (b) in the physical properties of the peat itself. These processes are what cause the compaction and subsidence of peat, and have driven parts of the site to become re-saturated as the peat surface has begun interacting with the water table again since being first drained. This has effectively left the peat bed in a 'half-way' state of ecological recovery. Natural values and function have been recovered to the point made possible by the current, modified hydrological regime, but the drains are still preventing water passing through the site from being able to be fully realise its ecological potential.

Reversing the drainage of peat systems therefore needs to accommodate the potential impacts of these processes, and how they are interacting with the site in its present condition, in seeking to restore or improve ecological function.

## 5.4 ZONE 4: Culverts (C1, C2)


There are two sets of culverts in the vicinity of Square Waterhole Swamp, under the Victor Harbor Road.

The first, C1 (Figure 5.10), is a minor, single pipe culvert that doesn't carry permanent flows and is situated significantly higher in the elevation gradient. It is adjacent to the portion of the former swamp that was cleared and more recently used as a paddock for cutting hay. Parts of this area situated outside of the Conservation Park are still used for grazing (see Figure 4.11).

The second, C2 (Figure 5.11), is a major, three pipe culvert that carries permanent discharge from the swamp, drains and dam (situated at D2).


*Figure 5.10: Looking east across the Victor Harbor Road – single pipe culvert, C1. Seasonal catch drain flows enter this culvert from the north.*

*Figure 5.11: Looking south-east across the Victor Harbor Road – triple pipe culvert, C2. Permanent discharges enter this culvert, especially from the south-west and west. Additional seasonal road catch drain flows also reach this exit point from the south and north.*

At C2, outflows of an order of magnitude higher than anything seen within the drains in the wetland itself were observed during ground-truthing surveys in October 2016. This is a key potential control point for manipulating outflows, as part of the wetland restoration process.

## 5.5 ZONE 5: Roadside Drain Flowpaths (F1, F2)


The very first changes to drainage across the swamp in the 1860s, involved clearing a track, digging ditches, installing culverts and building up the first road on its present alignment through the swamp. Hence in this case, for the modern bitumen highway, these road-side drainage channels are not only serving as a means of safely draining water from the road pavement, but they are also inadvertently (but, given their depth most certainly) interfering with the hydration of the margin of Square Waterhole Swamp, to the west.

The effects of catch drain F1 are predominantly local, only conveying flows from between the two culverts (C1 and C2), as shown in Figure 5.12.


*Figure 5.12: Looking north from C2 up the western verge next to the Victor Harbor Road.*

Working with the DPTI and Alexandrina Council to assess options for better managing the gradients and design of the catch drain at F1 to be complementary with swamp hydration is a key opportunity presented by this project.

However, the second catch drain, F2, also conveys flows from an additional seasonal catchment to the south-west, towards Mt Jagged. This catchment formerly flowed into the southern edge of Square Waterhole Swamp, but its natural flow-path has been interrupted by the road, which funnels all seasonal flows toward culvert C2.

Figure 5.13 shows where this channel passes the dam at D2, on its way to the main drain outfall and culverts at C2.


***Figure 5.13: Looking north from the bank between D2 and F2, next to the Victor Harbor Road. Culvert C2 is further north, behind the trees.***

The channel at F2 is especially deep as a result of being required to carry additional flows and maintain effective drainage of the corner of the swamp surrounding the dam (D2). The terms of agreement with the landholder who owns D2, and the inundation regime that is acceptable for this part of the swamp, would determine the specific design solutions that can be proposed at this location to manage the additional inflows in the F2 catch drain.

## 5.6 Summary

As described in this section, for such a small site there are clearly a wide range of eco-hydrological and land management considerations we must consider in designing a potential restoration response to address threats to values of the wetland habitat in Hesperilla CP. Fortunately, with permanent groundwater discharges still hydrating the site, there is excellent scope for improving water management for environmental benefit.

After an effective period of consultation with interested parties throughout this project, it is clear that there is a developing appreciation for the risk posed by historic changes to site drainage as described. The next sections of this report will focus on turning this shared understanding into suggested solutions.

# 6 Setting the goal for hydrological restoration

Historic drainage works at Square Waterhole Swamp aimed to deliberately alter the site to make it more favourable for agricultural production, through the drainage of the peat and establishment of pasture. These works dried slopes, changed the way water moves through the bed of the swamp and also probably increased downstream lateral (sub-surface) drawdown as a result of comprehensive drainage of the areas of wetland on the opposite side of the road. All of these things have had the cumulative effect of speeding up the flow of water out of the system and reducing the extent of saturation.

The goal of restoration therefore should focus on reversing this trend, as captured by the following project aim.

**Restoration Goal:**

> To restore the peat system's processes, ecology and habitat quality, and, if possible, recover some of the former footprint (size) of Square Waterhole Swamp, through implementing measures that will slow down water movement through the site.

**Measures of Success:**

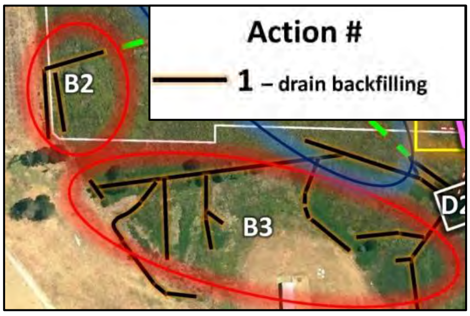
Specific objectives which need to be met, in order to successfully meet this goal are:

- an increase in soil moisture retention in the elevated slopes of the western and south-west areas of the swamp, aiming to restore year-round saturation of peat;
- to use methods that result in the lowest possible disturbance to the most in-tact areas of the peat bed;
- to cause a positive shift in the trajectory of indicative biological and/or hydrological indicators;
- to enhance regeneration of any expected but absent water dependent vegetation types; and
- to involve interest groups and the wider community in planning and works.

# 7 Hydrological management actions

Several interventions are available for changing flow dynamics and increasing hydrological residence time of passing flows within the wetland system. The different actions are explained here with reference to each sub-zone or sub-site described in the previous section.

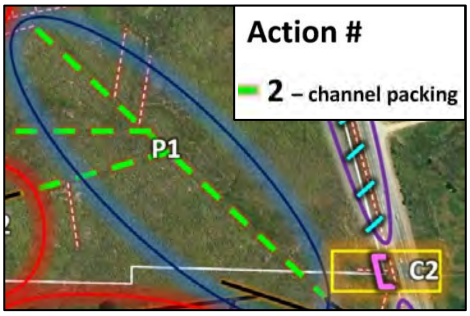
## 7.1 Drain backfilling to re-saturate banks




The primary area where complete drain backfilling is proposed is sub-zone B3, where the network of deeper drains and more degraded habitats occur on the council reserve and private land to the south of the Conservation Park boundary. This proposed activity has the provisional support of all parties (including the two private landholders) concerned. This area has the most significant blackberry infestation and other woody weeds (willows and pines) growing on the spoil banks, which could be readily treated/removed at the same time as remedial earthworks are being undertaken. Additional, smaller areas of complete drain backfilling are proposed on the more disturbed edges of sub-zones B1 and B2, on the far western margin of the swamp within the Conservation Park. These drains are situated at the break of slope and can be accessed from the road reserve, which consists of higher, more disturbed land.

The aim of these works would be to utilise existing spoil bank material, to reinstate a natural continuous slope gradient in these areas of the wetland. This will have the benefit of encouraging water to re-saturate the soil profile in the vicinity of the former drains.

## 7.2 Channel packing to maximise peat re-hydration




Within zone P1 the main drain that diagonally bisects the swamp, it is proposed that works should aim to slow both the movement of drainage water through the site and to prevent the dehydration of the adjacent peat profile. This in turn should encourage increased lateral movement of flows capable of re-saturating more of the wider peatland, including to the north-eastern area left isolated by the drain.

Ideally the best way to minimise these impacts is to fill the entire channel in with appropriate substrate back to natural surface, such as the adjacent overburden from the original excavation. However, this material may no longer be accessible, or its reworking may result in damage to surrounding areas of swamp. An alternative lower impact, albeit much more labour intensive strategy, involves packing the channel with minor regulating structures or erosion resistant organic material at a spacing determined by channel slope. This could be achieved by a staged approach, focussing on the higher gradient sloping sections of drain and then adding in additional blockage points following observation of flows in response to works. The objective would be to create a series of static pools along the length of the drain, such that longitudinal movement of water was minimised, promoting lateral movement of water away from the drain and into surrounding areas of wetland substrate.

Subject to available resources, this approach can also be applied to any additional feeder drains across the site that cannot be accessed for complete backfilling by machinery.

## 7.3 Roadside flow deflection and regulation to minimise drawdown


Since drainage ditches were first dug across the swamp as part of the construction process for the new road alignment in the 1860s, roadside catch drains have played a role in dewatering the edge of the swamp along the road and conveying flows towards culverts for being diverted downstream.

It is suggested that, using the road embankment as a levee, flows be retained on the western (remnant swamp) side of the road, and that this north-south catch drain (F1) be regulated, potentially through the installation of a number of minor flow deflection structures or blocks.

This would entail preventing discharge through the culverts at site C1, but still providing for a gentle southward flow to reach the main drainage outfall and culvert location at C2; more slowly at a level closer to the natural surface of the swamp rather than straight down this presently deepened catch drain. The way to achieve this would be via reducing the flow efficiency of the drain on the western side of the road (by lifting static in-drain water levels at a number of locations along this verge back near to the natural surface level of the peat).

The road embankment has been sufficiently 'built up' as a causeway through this section of formerly continuous swamp and, in combination with the maintenance of outflows from the wetland (at culvert C2), proposed works would never threaten to cause flooding of the road surface. Such works would however capitalise on the fact the road is there, using this key infrastructure to the advantage of the future hydrological management of the site – and turning what is currently a potential threat into a self-sustaining and self-regulating restoration solution.

For these proposed works to proceed, and for finalising the precise design and methods used to implement them, further discussion with Alexandrina Council and significant consultation with road engineers from the DPTI would be required.

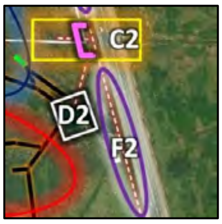
## 7.4 Outflow regulation


This is a key control point, where permanent outflows can potentially be regulated (but not prevented) to achieve a higher static inundation height – ideally back to natural surface of the surrounding peatland – prior to flows exiting the swamp and re-joining the artificial drain downstream. In conjunction with other actions, this would be capable of significantly influencing the rate and magnitude of drawdown on the surrounding peat; essentially taking the impact of this drain at its exit point from the swamp out of the hydrological equation.

A relatively inexpensive, impermanent and adjustable option for initially trialling these works prior to committing to more permanent infrastructure, would be to install a three-sided geo-fabric sandbag spillway at this location. To ensure outflows through the culverts are not compromised, the structure would be set back and tied into the road embankment either side of the concrete wings of the culvert. Building a structure external to the culvert itself, up to the current bed level of the wetland, would allow the drain to spill at a higher level and still drain through an open culvert. This would ensure that high flow events were still catered for without any changes to this existing fixed infrastructure but, crucially, ensure that permanent groundwater baseflows would be regulated, increasing hydrological retention time in the swamp prior to discharge.

Out of courtesy (as no negative impacts on water storage and availability would result – in fact, quite the reverse) consultation during the implementation of this action is recommended with the neighbouring landholder who owns the nearby dam (D2) and associated infrastructure, and is supportive of restoration. As for the previous action, further discussion with Alexandrina Council and significant consultation with road engineers from the Department of Transport would also be required prior to implementation.

## 7.5 Other potential actions




While no changes are suggested for the dam at D2, further consultation with the owner would be required prior to proposing any major changes to the way that the catch drain nearby at F2 currently operates. Key information gaps that would need addressing include understanding: the potential impact of any flow regulation on the adjacent private paddock (which forms part of the original swamp margin); the need to obtain more accurate drain level data; and, some monitoring of inflows during high flow events from the catchment (Mt Jagged) that seasonally discharges into this portion of the swamp. The slope through this area runs uphill to the south, from the lowest point at C2, meaning that this zone (F2) can be investigated further independent of other actions proposed.


Finally, the dam at D1 at this point doesn't form part of the on-ground recommendations due to the complex legal arrangements that cover this part of the site and are still in place from prior to the site's reservation. While removing the dam's influence, in modifying flows through the surrounding peat profile, would make a reasonable long-term goal to work towards, a number of other steps would need to be completed first before any modifications to this part of the site can be made. First and foremost, the nearby property owners to the north (including those on the former milk factory site) who retain access rights to the easement that covers the dam would need to be consulted and a consensus reached about the best way forward.

Ideally, if a consensus to remove the easement could be reached, then it is recommended that DEWNR should offer to cover all costs involved for the dominant title holders. After all, ensuring the future security of water resources in this wetland reserve (and the nationally threatened ecological community it sustains) is of the utmost importance for maintaining the biodiversity values for which the site was proclaimed.

## 7.6 Other considerations

### *7.6.1* Data gaps and monitoring

In line with undertaking hydrological restoration works, a monitoring program should be established to both track changes and also evaluate the forecasts (and the assumptions that underlie them) presented in this report.  A surface water flow gauge board at the outlet drain would be useful in determining surface inflow and outflow volumes and these could be automated using water level data-loggers which, when calibrated with rainfall data and flow measurements, could provide hourly data on flow relationships through the site – both before and after any potential works.

A small network of observation wells (with data loggers) should be installed across the profile of the peatland to capture the before and after impacts of any drainage regulation works. This data would also help to provide a real-time cross section of saturation levels throughout the peat profile of Square Waterhole Swamp, a key measure for determining the impact and success of restoration works.

Assessment of vegetation changes over time, if possible covering the distinct identified vegetation zones, will be important for evaluating the effectiveness for restoration measures to meet their objective of maintaining or improving habitat quality.  Repeated high resolution aerial imagery, coupled with on-ground vegetation monitoring (of current vegetation community distribution, composition and estimates of dominant structural species cover) may be undertaken to establish any changes from an initial baseline survey undertaken around the time when works commence. This should be based on a suitably efficient method capable of revealing hydrological response trends, and ideally implementable on an annual basis at low cost.

A suitable method which has been utilised at other hydrological restoration sites involves cross section transects of the swamp to record dominant species distance positions and cover, for each strata. This method is unlikely to provide sufficient resolution for threatened species and more detailed and considered monitoring would be required for these, should any be recorded at the site in the future.

Bird surveys (for the MLR Southern Emu-wren) have occurred within the park over many years and are likely to continue to provide insights into the effectiveness of restoration for the species preferred habitat and the efficacy of restoration. However, a further fauna component which has received no attention since the reservation of Hesperilla CP is renewed surveys of freshwater fish and other aquatic vertebrates. It is suggested that aquatic fauna monitoring be considered in conjunction with any works, to enable comparison with the previous surveys from last decade (refer to Hammer, 2004).

### *7.6.2* The role of ecological disturbances in habitat recovery

Beyond hydrological restoration, the role of ecological disturbances to encourage positive compositional and structural changes in swamp vegetation with the reserve should be further investigated. Disturbances capable of reducing biomass and competition, such as fire, may help to improve floristic diversity through the creation of open-space and other niches capable of favouring a wider range of flora species with different ecological requirements.

This area of research is the subject of ongoing work by the Conservation Council of SA's Fleurieu Swamps Recovery Program (R. Duffield, pers. comm.).

### *7.6.3* Legislative considerations

***Natural Resources Management Act 2004*** (NRM Act) (SA)

The NRM Act is South Australian legislation responsible for the protection and sustainable management of the State's natural resources. Relevant objects of the Act include seeking to protect biological diversity and supporting and encouraging restoration and rehabilitation of ecological systems, as well as seeking to support sustainable primary and other economic production systems.

One of the tools for managing natural resources under the NRM Act is a requirement for any proponent of on-ground works that may impact upon water resources to first seek a water affecting activity (WAA) permit (for relevant activities as defined under the Act), if required by the relevant regional NRM or Water Allocation Plan.

The present advice of Natural Resources SA MDB is that the type of options identified in this hydrological options report are likely to require a WAA permit and will therefore require further consultation, to determine and initiate permitting requirements under the Act or internal assessment requirements, should any proposed works be funded for implementation in the future (M. van der Wielen, pers. comm.).

***Native Vegetation Act 1991*** (SA)

The *Native Vegetation Act 1991* is the primary legislative instrument in South Australia for ensuring the conservation, protection and enhancement of native vegetation. The Act is predominantly concerned with limiting the clearance of native vegetation, providing incentives to landholders to preserve and enhance native vegetation, and encouraging the re-establishment of native vegetation in parts of the state where native vegetation has been cleared or degraded.

The activities proposed in this hydrological options report, in seeking to enhance the long-term integrity of the wetland ecosystem at Square Waterhole Swamp, are clearly consistent with the objects of the Act. This is despite the fact that recommended works may involve minor, small scale and short-term impacts to the native vegetation that has established in the disturbance footprint of the artificial drains on site in the decades since they were first constructed. Similar situations in the past, where restoration works to reverse past drainage were required to ensure longer-term and larger scale benefits to wetland ecosystems, have involved liaison between the project proponent and the Native Vegetation Council rather than following a formal clearance application process.

Should any of the proposed works be funded for implementation in the future, it is recommended that early contact be made with delegated officers in the Native Vegetation Management Unit (within DEWNR, who service the Native Vegetation Council) to ensure the requirements of the Act at that time are being met.

***Environment Protection & Biodiversity Conservation Act 1999*** (EPBC Act) (Commonwealth)

The EPBC Act is Commonwealth legislation with a primary objective of providing for the protection of the environment, especially matters of national environmental significance. In the case of Hesperilla CP, matters of national environmental significance (under the EPBC Act) include a nationally threatened ecological community and several nationally threatened species. The Act provides a referral system to that is designed to protect these matters from action that could have a ‘significant impact’ and cause potential harm. Proponents are required to self-assess to determine their potential obligations under the Act, with additional provisions for third-party referrals also available.

Carefully planned and managed site-based recovery actions to protect and enhance habitat for threatened species and ecological communities (listed under the EPBC Act) are not typically referred by proponents given that their primary objective is to improve the conservation of matters of national environmental significance. Hence the measured (in some cases staged, trial) actions proposed within this document are not recommended for referral under the EPBC Act.

#### *7.6.4* Impacts on the surrounding landscape and neighbouring landholders

***North of the Park***

A small area of land on the northern boundary (sub-zone B1), could be included in the actions in this assessment with the consent of the owners. Initial conversations with the relevant landholder indicate no objection to works occurring that decommission drains within Hesperilla CP, but also no significant interest for such works to extend beyond the Park's northern boundary. Works in that area can be managed accordingly, with only very minor areas of shallow drain extending beyond the northern Reserve boundary.

***South of the Park***

As previously described the other key neighbouring landholders, especially those who own the other parts of the swamp to the south of the Park boundary, have expressed an interest in the implementation of hydrological restoration options presented in this assessment. Their goodwill and co-operation throughout the investigation so far has been greatly appreciated and could lead to some excellent results for the wider remnant swamp.

***East of the Park***

The downstream neighbour (to the east of the main road) has also been consulted throughout, but their property is not subject to any of the actions proposed in this assessment. All actions and their associated eco-hydrological impact are designed to be contained in the remnant portion of Square Waterhole Swamp situated to the west of the Victor Harbor Road. Should that landholder wish to participate in the restoration of additional portions of the former Square Waterhole Swamp in the future, this is certainly technically feasible, but would require significant additional assessment work to be completed.

# 8 Summary of recommended actions

## 8.1 On-ground works

### *8.1.1* Number and location of on-ground actions

Four key on-ground actions are recommended to achieve a staged process of comprehensive hydrological restoration of the site. These actions are listed below and displayed in the site map in Figure 8.1.

**ACTION 1:** Mechanical drain backfilling to re-saturate banks, with concurrent removal of woody weeds in disturbed areas (especially in B3, south of the Park)

**ACTION 2:** Channel packing to maximise peat re-hydration

**ACTION 3:** Roadside flow deflection and regulation to minimise drawdown

**ACTION 4:** Outflow regulation

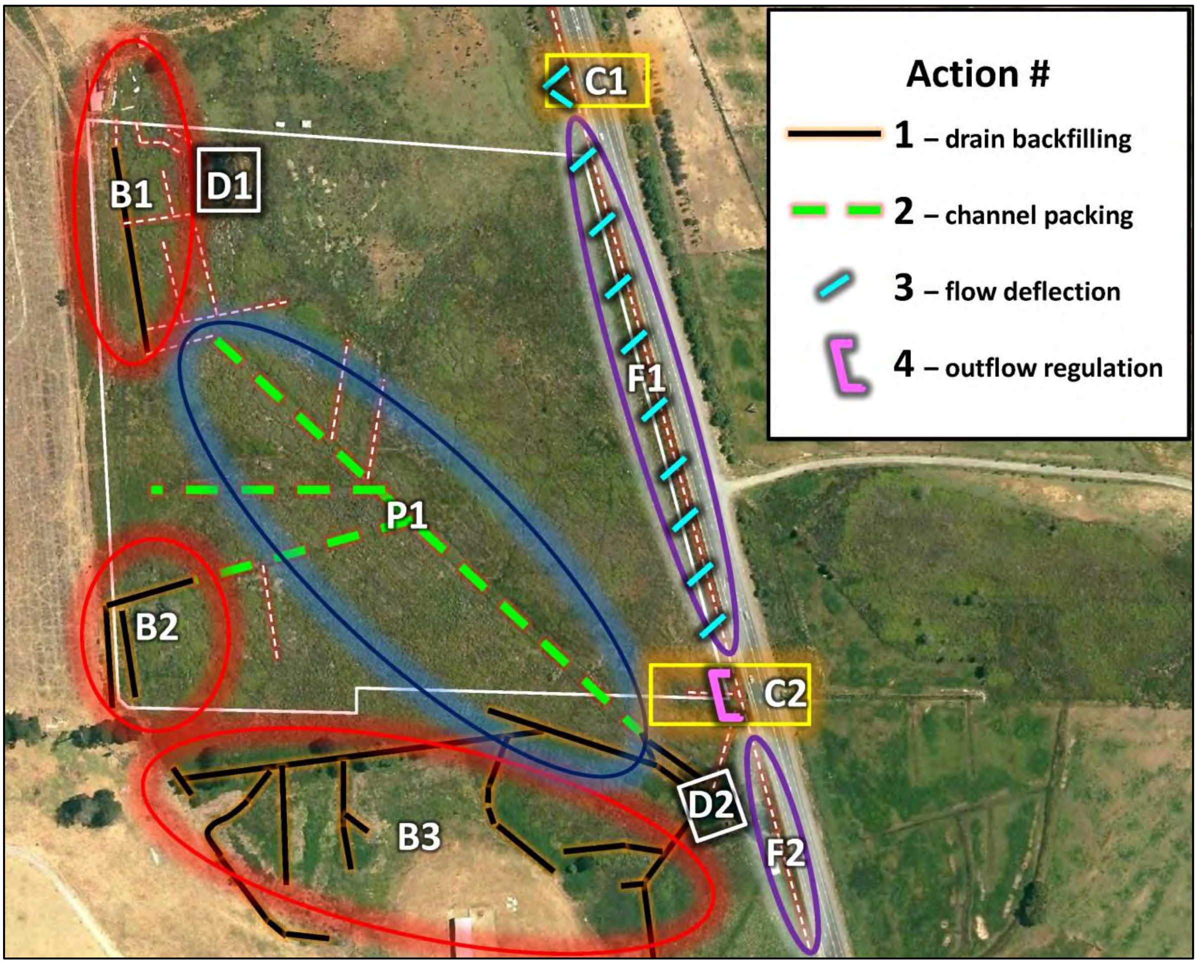



*Figure 8.1: Overview of recommended restoration actions*

### 8.1.2 Additional recommended actions

- Consideration should be given to rationalising fences around the swamp, especially removal of the fence between Hesperilla CP and the Council Reserve (sub-zone B3).
- Further evaluation of the options for managing flows at sub-zone F2 is recommended, in consultation with the private landowner.
- A discussion with the relevant neighbours in relation to the future status of an existing easement over part of the swamp (for access to the dam at D1) is recommended. Until this matter is resolved, it may not be possible to undertake conservation or restoration works at the dam site, hence it may be worthwhile to see if agreement can be reached for voluntary removal of this encumbrance (with the suggestion that DEWNR pay all preparation and transaction costs).

### 8.1.3 Prioritisation of on-ground actions

**Actions 1 and 3 are independent:**

- Action 1 should be completed before Actions 2 and 4, but will require sufficient funding for earthworks and the agreement of the private owners where applicable.
- Action 3 is largely independent of other tasks and could be completed at any time. Sufficient resources (especially time) should be provided for the consultation and design discussions required with DPTI and Alexandrina Council.

**Actions 2 and 4:**

- Should follow Action 1, but in that order.
- If completed manually, Action 2 will be time consuming and labour intensive.
- If conducted as a trial, Action 4 is likely to be relatively inexpensive and simple to complete, but does require sufficient time to be provided for the consultation and design discussions required first with DPTI.

## 8.2 Filling key information gaps

Suggested extra tasks that would help to add value to this project include:

- Using the aerial imagery to evaluate how the vegetation community has changed in association with the observed changes to land-use and drainage since 1950.
- Documenting the trajectory and response of the swamp community in response to hydrological works across multiple sites, to enable the development of a predictive tool capable of aiding the restoration planning process at new sites in the future. This could and should focus on both vegetation communities and the requirements of key species, such as the MLR Southern Emu-wren.
- Assessing the opportunities to undertake:
  - disturbance (biomass reduction) trials to increase habitat complexity.
  - reintroductions of currently absent, swamp-dependant threatened flora species.

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## 10 APPENDIX – Plant species list

Basic flora list for Square Waterhole Swamp (Hesperilla CP and surrounds) on the basis of past CCSA surveys and NGT observations:

| ***Scientific Name*** | **CommonName** |
|---|---|
| **Acetosella vulgaris* | Sorrel |
| **Anthoxanthum odoratum* | Sweet Vernal Grass |
| **Asparagus asparagoides f. asparagoides* | Bridal Creeper |
| *Baumea gunnii* | Slender Twig-rush |
| *Baumea rubiginosa* | Soft Twig-rush |
| *Baumea tetragona* | Square Twig-rush |
| *Blechnum minus* | Soft Water-fern |
| **Callitriche stagnalis* | Common Water Starwort |
| *Carex appressa* | Tall Sedge |
| *Carex fascicularis* | Tassel Sedge |
| *Centella cordifolia* | Native Centella |
| **Cirsium vulgare* | Spear Thistle |
| **Cortaderia sp.* | Pampas Grass |
| *Cyperus sp.* | Flat-sedge |
| *Cyperus tenellus* | Tiny Flat-sedge |
| *Drosera binata* | Forked Sundew |
| *Eleocharis acuta* | Common Spike-rush |
| *Eleocharis gracilis* | Slender Spike-rush |
| *Empodisma minus* | Tangled Rope-rush |
| *Epilobium billardieranum ssp. billardieranum* | Robust Willow-herb |
| *Epilobium hirtigerum* | Hairy Willow-herb |
| *Epilobium pallidiflorum* | Showy Willow-herb |
| *Eucalyptus viminalis ssp.* | Manna Gum |
| *Gahnia sieberiana* | Red-fruit Cutting-grass |
| *Gleichenia microphylla* | Coral Fern |
| *Glyceria australis* | Australian Sweet-grass |
| *Gonocarpus micranthus ssp. micranthus* | Creeping Raspwort |
| *Gratiola peruviana* | Austral Brooklime |
| **Holcus lanatus* | Yorkshire Fog |
| **Hypochaeris radicata* | Rough Cat's Ear |
| *Hypolepis rugosula* | Ruddy Ground-fern |
| *Isolepis inundata* | Swamp Club-rush |
| *Juncus caespiticius* | Grassy Rush |
| *Juncus effusus* | Soft Rush |
| *Juncus pallidus* | Pale Rush |
| *Juncus planifolius* | Broad-leaf Rush |
| *Juncus sarophorus* | Rush |
| **Leontodon taraxacoides ssp. taraxacoides* | Lesser Hawkbit |
| *Lepidosperma longitudinale* | Pithy Sword-sedge |

| | |
|---|---|
| *Leptocarpus tenax* | Slender Twine-rush |
| *Leptospermum continentale* | Prickly Tea-tree |
| *Leucopogon virgatus var. virgatus* | Common Beard-heath |
| *Lobelia anceps* | Angled Lobelia |
| **Lolium perenne* | Perennial Ryegrass |
| **Lotus sp* | Lotus |
| **Lotus subbifiorus* | Hairy Bird's-foot Trefoil |
| **Lotus uliginosus* | Greater Bird's-foot Trefoil |
| *Melaleuca squamea* | Swamp Honey-myrtle |
| *Myriophyllum amphibium* | Broad Milfoil |
| *Patersonia occidentalis* | Long Purple-flag |
| *Persicaria decipiens* | Slender Knotweed |
| **Pinus halepensis* | Aleppo Pine |
| *Pteridium esculentum ssp. esculentum* | Bracken Fern |
| **Rubus umifolius var. ulmifolius* | Blackberry |
| **Rumex conglomeratus* | Clustered Dock |
| **Salix sp.* | Willow |
| *Senecio glomeratus ssp.* | Swamp Groundsel |
| **Senecio pterophorus* | African Daisy |
| **Trifolium sp.* | Clover |
| *Typha domingensis* | Narrow-leaf Bulrush |
| **Ulex europaeus* | Gorse |
| *(various mosses)* | Moss |
| *Viminaria juncea* | Native Broom |
| *Xyris operculata* | Tall Yellow-eye |