Nature Glenelg Trust

Regional, Focussed, On-ground

Gooseneck Swamp Restoration Trial 2013 – Project Summary Report

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June 2014

Project funded by a grant from:

Communities for Nature

Department of Environment and Primary Industries

State Government Victoria

with additional support provided by:

Hamilton Field Naturalists Club Since 1958

Glenelg Hopkins CMA

Parks Victoria

This report may be cited as:

Bachmann, M. and Kivisalu, L. (2014) Gooseneck Swamp Restoration Trial 2013 – Project Summary Report. Nature Glenelg Trust, Mumbannar, Victoria.

Acknowledgements:

- Gavin Cerini, Brolga Recovery Group;
- Doug Craig, Roger Burger and Todd Burger, local private landholders;
- Darren Shelden and Nichole Hertogs, Macquarie Bank Limited;
- Rod Bird, Steve Clark, Jane Hayes and other members of the Hamilton Field Naturalists Club;
- David Roberts and Ryan Duffy, Parks Victoria;
- Adam Bester and Lucy Cameron, Glenelg Hopkins CMA;
- David Pitts, Department of Environment and Primary Industries;
- Dan Anderson, Lachlan Farrington and Bryan Haywood, Nature Glenelg Trust;
- Cath Dickson, Nature Glenelg Trust, for editing the report; and,
- All other volunteers who assisted with the sandbag trial construction and site monitoring.

EXECUTIVE SUMMARY

Gooseneck Swamp is situated within the far south-eastern corner of the Grampians National Park in Victoria's South West. Gooseneck Swamp along with Brady Swamp downstream, are wetlands of the Wannon River floodplain. Although Gooseneck Swamp naturally discharges into Brady Swamp, historically it had to fill to a certain height before the natural discharge channel and wider connecting floodplain would receive flows. As a result, an artificial cutting constructed in the 1950s (through the lunette bank that separates Gooseneck Swamp from Brady Swamp) was causing the swamp to freely drain to its bed level once inflows ceased – both reducing its depth and, more particularly, cutting short its duration of inundation.

Moves to restore Gooseneck Swamp began under the direction of Gavin Cerini (then an officer with the Department of Fisheries and Wildlife) in the mid-1980s, with the property acquired in 1986 from Bob Fraser by the Victorian Government, and eventually incorporated into the Grampians National Park. However, a change of neighbouring land ownership in 1987 stalled plans that were well advanced at that time to restore the hydrology of Gooseneck Swamp, and the project remained idle until 2010 when the Hamilton Field Naturalists Club, Gavin Cerini, Parks Victoria and the Glenelg Hopkins CMA revisited and revived the concept. Nature Glenelg Trust became formally involved in the project, initially at the invitation of the Glenelg Hopkins CMA, in late 2012. By early 2013, funding had been secured from the DEPI Communities for Nature Grant Program to build a sandbag trial structure, with various community members coming together to help complete the works in August 2013.

The trial sandbag structure had immediate impacts on the flow dynamics at Gooseneck Swamp:

- increasing wetland depth by as much as 20 cm;
- reducing outflow drainage efficiency significantly, by causing water to take its original route to Brady Swamp, spilling at higher elevations via the natural overflow point; and,
- preventing the immediate drawdown of water levels to the bed level of the swamp, which the drain had previously caused to occur once inflows ceased (based on flows and rainfall, this would have started to occur in mid-December 2013).

In achieving the above, it is reasonable to conclude that the inundation period for Gooseneck Swamp was extended by as much as 4-6 weeks, creating a wetland refuge for wetland dependant fauna deep into what was a hot and dry summer period with no rainfall.

The value of Gooseneck Swamp as habitat for a wide range of flora and fauna has been demonstrated through the initial baseline monitoring undertaken, again with community volunteer support. It is confirmed as a particularly important site for nationally threatened species of fish, frogs and flora, as well as providing refuge habitat into the summer months for a wide range of waterbirds. Early indications are that the restoration trial will, as expected, significantly enhance the ecological values of the site in all but the driest years (i.e. those years when there are no flows to retain in the swamp).

Due to the early success of the trial and the demonstration that site hydrology is functioning effectively with the structure in place, it is recommended that:

- if possible, site monitoring continue to track the hydrological and ecological response of vegetation communities and key indicator species at the site over coming years; and,
- funding be sought to consolidate the trial structure and reinstate the earthen lunette bank (across the drain cutting); an option with no ongoing maintenance obligations that would permanently restore the natural function of flows between Gooseneck and Brady Swamps.

Table of Contents

1 Project Background

1.1 Introduction

Gooseneck Swamp is situated within the far south-eastern corner of the Grampians National Park in Victoria's South West, approximately 40km east of Hamilton – see Figure 1.

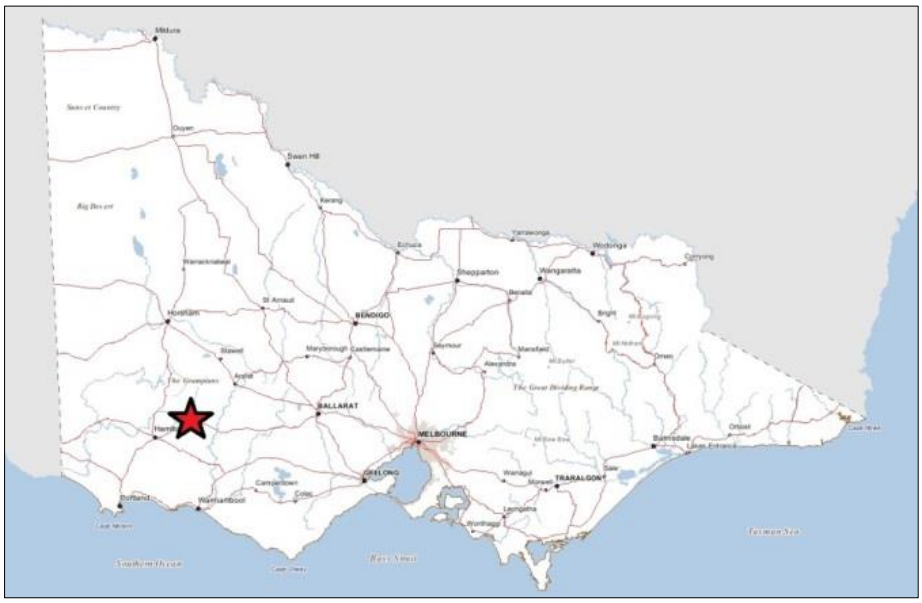


Figure 1 – General location of Gooseneck Swamp

Gooseneck Swamp, along with Brady Swamp downstream (see Figure 2), are wetlands of the Wannon River floodplain, at the terminus of the alluvial delta located where the river reaches the flats after exiting the valley between the Serra and Mt William Ranges of the Grampians.

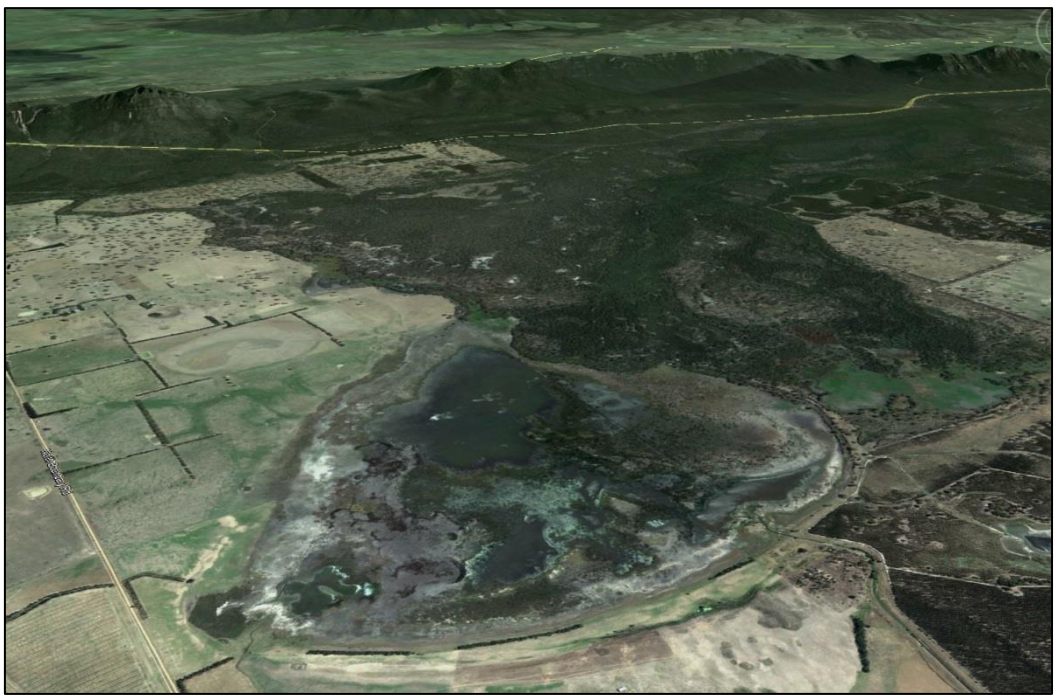


Figure 2 – Oblique view, looking towards the north-west, with Brady Swamp centre, Gooseneck Swamp to the right – at the terminus of the Wannon River delta, which extends back towards the Grampians.

1.2 Site History

At the turn of the last century (around 1900) Heifer Swamp, to the east of Brady and Gooseneck Swamps, was drained for agricultural development, after moves to reclaim the swamp gained traction in the 1890s (for interesting background pre-drainage information, presented in two articles published in 1892, see Appendix 7). Reclaimed land was sold by the government in 1903. At well over 1500 hectares in size, the drainage of this extensive swamp resulted in additional surface water being directed (a) to Gooseneck Swamp (via Walker Swamp) from the north, and (b) directly into the eastern side Brady Swamp from the south. Until the 1950s, the situation remained largely unchanged, with the additional flows supplementing surface flows into these wetlands from the Wannon River (see 1948 image in Figure 4). However in the 1950s, the private landholders of Walker, Gooseneck and Brady Swamps constructed drains through (and breached the natural banks of) each of these wetlands, to reclaim more land by encouraging water to flow into the Wannon River more efficiently (see Figure 3).

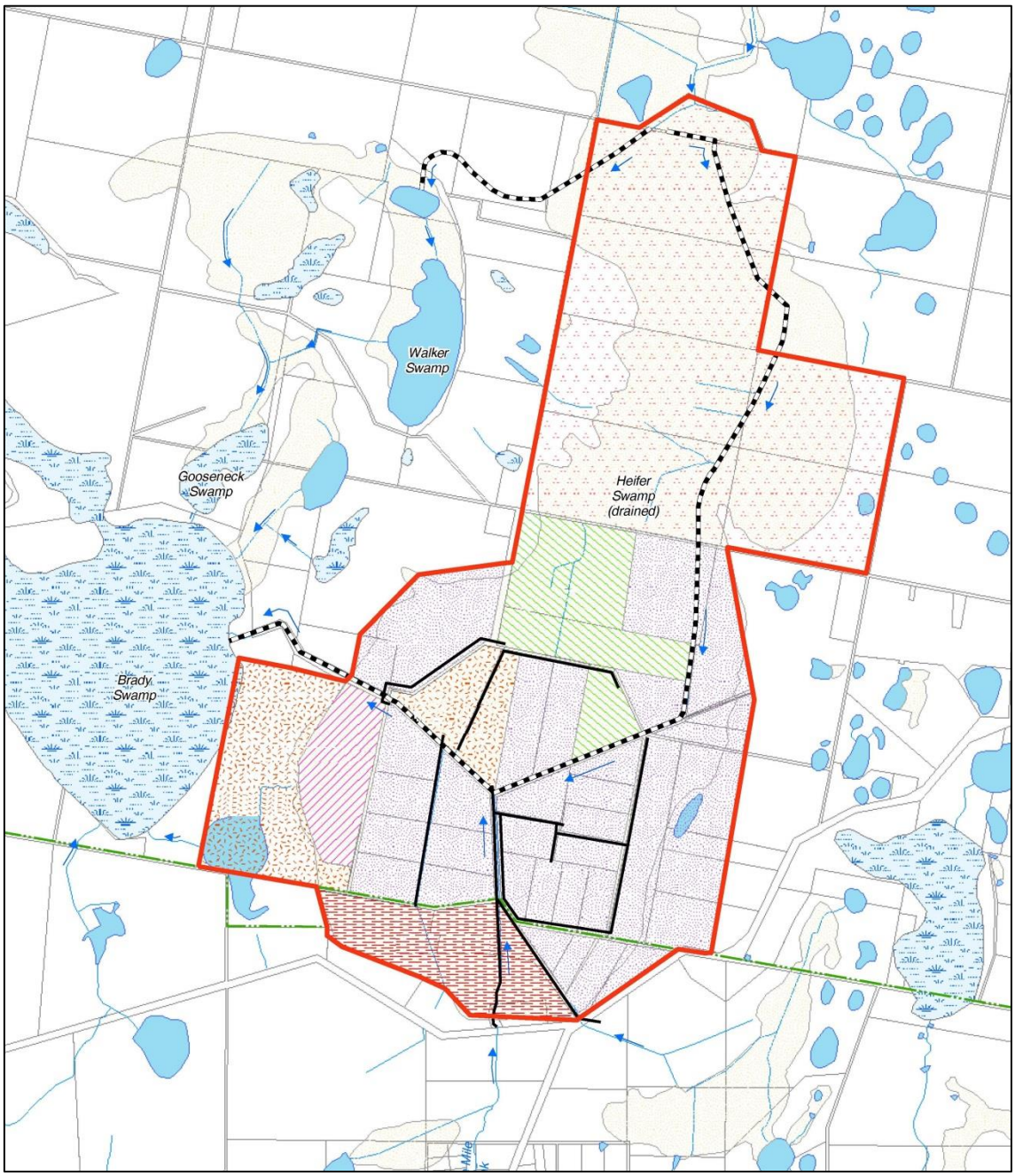


Figure 3 – The Bunnugal Drainage Scheme area (outlined in red), showing the direction of flows (blue arrows)

Figure 4 – 1948 Pre-drainage image of Gooseneck and Brady Swamps, showing the Heifer Swamp (Bunnugal Scheme) drains to the east

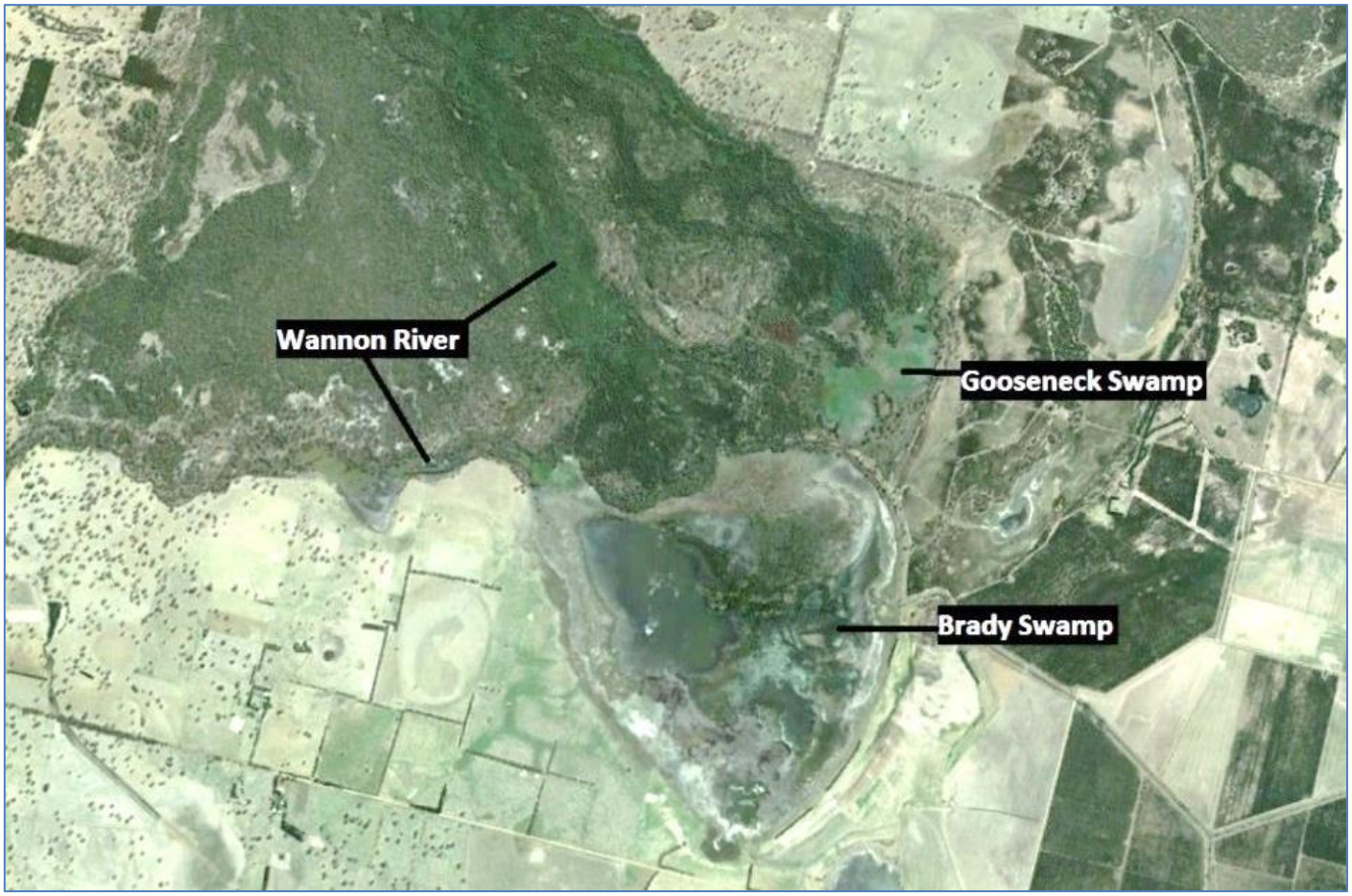


Figure 5 – 2012 Post-drainage image of Gooseneck and Brady Swamps

Although Gooseneck Swamp naturally discharges into Brady Swamp, historically it had to fill to a certain height before the natural discharge channel and wider connecting floodplain would receive flows. As a result, the artificial cutting constructed in the 1950s through the lunette bank that separates Gooseneck Swamp from Brady Swamp, was enabling the swamp to freely drain to its bed level once inflows ceased – both reducing its depth and, more particularly, cutting short its duration of inundation. Figure 6 shows the location of the lunette bank that separates the two swamps, the original flow-path and the artificial cutting.

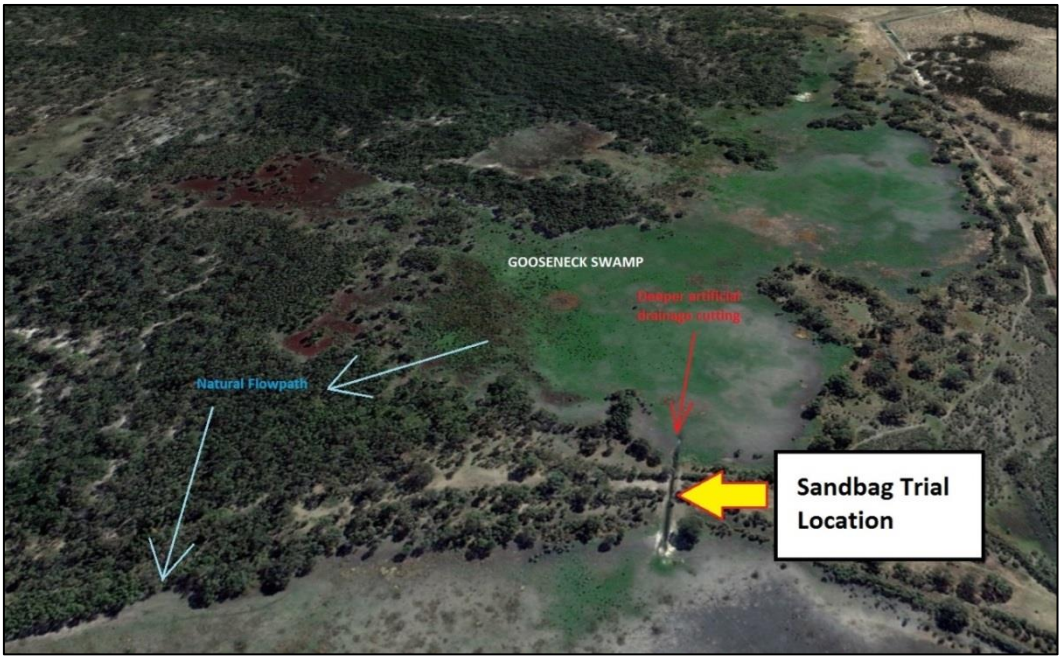


Figure 6 – Modern oblique image (looking north) showing the 1950s cutting in the lunette bank that separates Gooseneck and Brady Swamps (red arrow shows the artificial cutting, while blue arrows indicate natural flow-path)

Moves to restore Gooseneck Swamp began under the direction of Gavin Cerini (then an officer with the Department of Fisheries and Wildlife) in the mid-1980s, with the property acquired in 1986 from Bob Fraser by the Victorian Government, and eventually incorporated into the Grampians National Park (Cerini, unpublished data). To protect the remaining holdings of Bob Fraser to the east of Gooseneck Swamp (land also subject to inundation and perceived to be at risk), conditions of the sale in 1986 were that the Victorian Government would:

- construct a levee bank on the new north-south title boundary east of Gooseneck Swamp, to enable water restoration to the swamp.
- set the levee bank crest level at the same height as the natural bank between Gooseneck and Brady Swamps.
- build the bank wide enough to carry a vehicle track from Lynch`s Crossing Road to Brady Swamp (noting that this width was not achieved).
- install one-way drainage culverts through the bank to maintain drainage of the land Fraser retained.
- construct a new (kangaroo proof) boundary fence on the bank.

Although the necessary preparations were made (as above), plans to re-instate the lunette bank (decommissioning the 80m section of connecting drain) between Gooseneck and Brady Swamp stalled in 1987, after Bob Fraser sold the balance of his land to the east of the swamp. Apparently the new owner or manager of the land east of Gooseneck Swamp threatened legal action if the work proceeded due to concerns about inundation (Cerini, unpublished data).

1.3 Recent Project Background

Due to the impasse, two decades of inaction at Gooseneck Swamp ensued, although local interest in wetland management greatly increased from the late 1990s, in particular through the activities and interests of members of the Hamilton Field Naturalists Club. This level of interest, and the communication associated with it, ultimately led to a landholder meeting at Brady Swamp in 2007 with Parks Victoria and the Glenelg Hopkins CMA, also attended by Rod Bird and Dave Munro (representing the Hamilton Field Naturalists Club), and Gavin Cerini (now a member of the Brolga Recovery Group).

By 2010, these efforts were further rewarded when the Glenelg Hopkins CMA commissioned a new investigation into the restoration potential of a number of southern Grampians wetlands, including Gooseneck and Brady Swamps (refer to Herrmann 2011a, 2011b, 2012; Duggan 2012). In another significant development that had also occurred by this time, the land to the east of Gooseneck Swamp had also changed owners (now Macquarie Bank Limited) providing an opportunity for fresh dialogue in relation to site management options.

Unfortunately it became apparent that the modelling work initially commissioned by the CMA was hampered by a lack of detailed, accurate elevation data, increasing the perceived risk associated with moving immediately to a permanent blockage of the Gooseneck Swamp artificial drainage outlet. This uncertainty, but a strong desire to progress the project, led the Glenelg Hopkins CMA to seek the input of Nature Glenelg Trust in late 2012, to assess the suitability of the site for implementation of a restoration trial.

Over the months that followed, with the support of the Glenelg Hopkins CMA, Parks Victoria and the Hamilton Field Naturalists Club, Nature Glenelg Trust progressed the restoration trial concept by:

- creating a highly accurate GIS-based Digital Elevation Model for the site, using aerial LiDAR imagery flown in January 2013 (funded by the Glenelg Hopkins CMA);
- successfully applying for grant funding from Round 2 of the Communities for Nature Program;
- providing a communication conduit between private landholders and government agencies, and gaining Parks Victoria (landowner) consent to proceed; and,
- negotiating with the new owner to the east (Darren Shelden on behalf of Macquarie Bank Limited), gaining support for the trial to commence in 2013.

By August 2013, just as the Wannon River and Heifer Swamp catchments were beginning to produce flows as a result of late winter rains, all the necessary preparations were in place to proceed with the temporary sandbag restoration trial structure.

2 The Restoration Trial

2.1 Logic and Design of the Restoration Trial

The logic of a wetland restoration trial structure is quite simple. The aim is to provide a temporary, low cost and low risk way of enabling real-time data to be collected in the field, under real conditions – a type of applied science modelling exercise. The very nature of a sandbag structure means that it can also be adjusted up and down in real time, to improve the understanding of site hydrology in response to flows. As long as the parameters of the trial are set by project managers within reasonable confidence limits using available data, then it is an excellent approach for progressing wetland restoration concepts; both in situations where a permanent solution may carry an unsatisfactory level of perceived risk, or where the most suitable option is not yet apparent.

The parameters for the Gooseneck Swamp restoration trial were as follows:

- to achieve a weir retention height capable of restoring flows to the natural outlet, but low enough to still permit over-topping flows under peak conditions;
- to prevent the artificial, rapid drainage of the swamp once inflows cease; and,
- to utilise geo-fabric sandbags to ensure stability and serviceability of the structure for up to 5 years.

The completed structure, illustrating the basic design implemented to achieve and address these considerations is shown in Figure 7.

Figure 7 – Design of the completed structure, meeting the parameters set for the Gooseneck Swamp Restoration Trial

2.2 Implementing the Trial

The site was inspected in early August to assess conditions on the ground (see Figure 8) and revealed that, although the drains upstream had commenced flowing and the connecting drain held a puddle of water, Gooseneck Swamp itself remained dry. So rather than wait another whole year before the trial would commence, the decision was made to plan for the works to occur immediately, in the hope that the swamp would receive sufficient flows in 2013 to begin the restoration trial.

Figure 8 – Conditions looking from the drain towards Gooseneck Swamp on the 9th

Figure 9 – Site conditions upon arrival at the site on the 26th August looking towards Gooseneck Swamp from the drain. The pegs indicate the proposed location of the sandbag weir, and the string-line was used to monitor the downstream change in channel water level in response to the works throughout the day.

The subsequent couple of weeks were very wet in the local catchment – meaning that by the time the day for the works arrived on Monday the 26th August, there was significantly more water around than on the previous visit (see Figure 9). The swamp had gone from being empty to now holding enough water for the artificial drain to have commenced discharging a steady flow.

Before any works commenced, the natural outlet at the western end of the lunette (a short distance away) was checked, only to discover it was completely dry – clearly demonstrating the impact that the artificial cutting is having in removing water from Gooseneck Swamp at elevations below its natural sill level (see Figure 13).

With the change in conditions, some improvisation was required to sufficiently reduce the drain flow rate – to make working on the sandbag weir more feasible. So the first task for the eager "sandbag crew" of 13 volunteers from Nature Glenelg Trust, the Hamilton Field Naturalists Club, Deakin University and local landholders, was to install an "ultra-temporary" hessian bag and log bund upstream of the selected sandbag weir site (Figure 10).

Figure 10 – The First Step – Constructing a hessian sandbag and log bund to reduce flow rate and (to a lesser extent) depth in the channel.

Subsequent to this preparation, and although the wet conditions posed some logistical challenges, once the footing bags of the main sandbag structure were firmly in place, the process of building the trial structure moved along at an excellent pace (Figure 11). Once the structure was above the standing water level, the job of laying sandbags was made somewhat easier and the structure was completed in quick time, having a noticeable and immediate impact on water levels. By the end of Monday the 26th August, a temporary weir height had been achieved that it was hoped would get close to lifting levels sufficiently to reactivate the original flow-path (Figure 12).

Figure 11 – The sandbag crew succeeding in getting the weir to reach the height of the channel water level. Notice the minor drop in water level downstream as the weir under construction starts to hold back water.

After also being informed by a neighbour that water levels upstream of the outlet had risen, a subsequent visit to Gooseneck Swamp on Monday the 2nd of September was an opportunity to investigate how things were responding one week into the trial. It was found that the level had risen by about 20cm from when the structure was completed a week earlier (Figure 13).

Figure 12 – The Gooseneck Swamp Sandbag Crew proudly display the result of a solid day's work (Aidan, Jonathan, Dan, John, Rod, Ken, Rowena, Lauren, Nicki, Doug and Bill – minus Lachlan and Mark from NGT – holding cameras at the time)

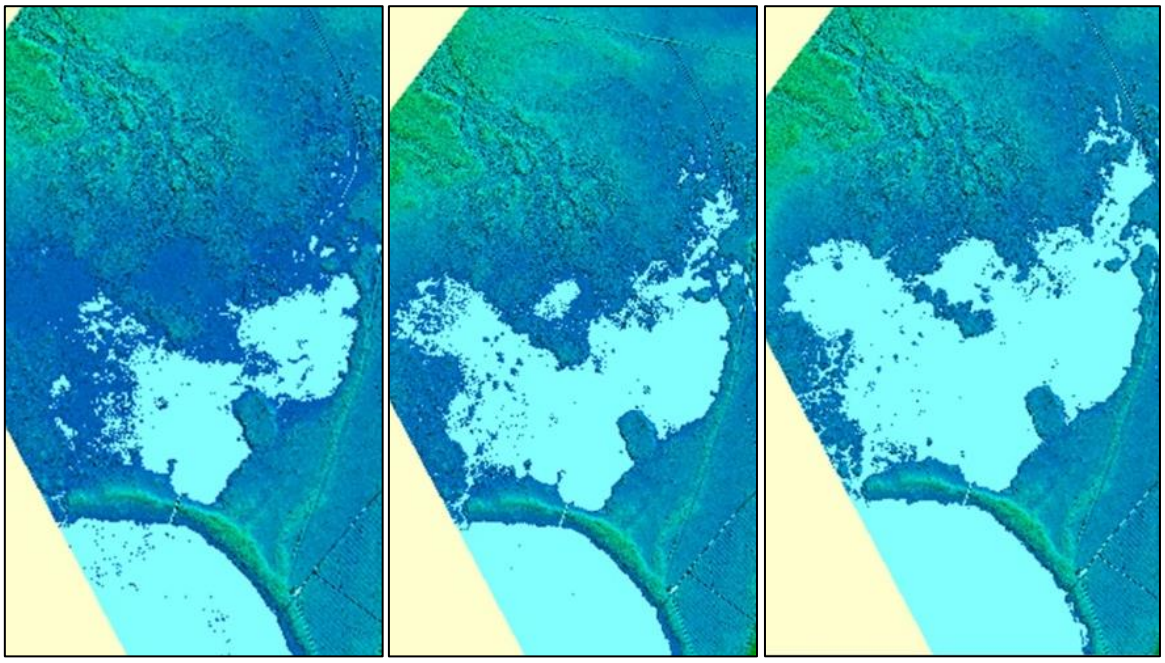
Figure 13 – Gooseneck Swamp gauge board:
53cm 26/08/13
72cm 02/09/13

A short distance away at the end of the lunette (to the west), and the natural outflow between the two swamps was now carrying a significant flow – both in the deeper defined channel and shallow sheet flows over a wider area of floodplain to the west (total of about 50-60m wide). The appearance of the flow-path – which was completely dry one week earlier – was particularly stark – see Figures 14 and 15 for a direct comparison.

Figure 14 – Dry on the 26th August 2013: The natural flow path between Gooseneck Swamp and Brady Swamp, to the west of the artificial cutting in the lunette that separates the two wetlands.

Figure 15 – One week later on the 2nd September 2013: The natural flow path (and 50m wide shallow floodplain to the right of image) now carrying a significant volume of water through to Brady Swamp, at the natural sill level for Gooseneck Swamp.

These observations on-site were also supported by what the Digital Elevation Model had predicted. The swamp was filled to near the 241.6m Australian Height Datum (AHD) level when work started on the sandbag weir on the 26th August. However, one week (and 20cm of increased depth at the weir structure) later: the flow pattern and levels appeared to more closely resemble the 241.8m AHD scenario. At this elevation the natural flow path and associated floodplain at the end of the lunette become active with flows – see Figure 16.



241.6m AHD ***241.7m AHD*** ***241.8m AHD***

Figure 16 – Digital Elevation Model of Gooseneck Swamp, based on LiDAR imagery flown in January 2013

Based on the on-ground observations, the LiDAR information appears to have given us a very accurate indication of what would happen as Gooseneck Swamp levels increased – with a wider expanse of floodplain to the west of the main swamp inundated and the natural flow path to Brady Swamp activated (Figure 17). This information was a key tool utilised for setting the parameters of the trial, including the initial target height for the structure. Hence, used in this way, accurate elevation data is an excellent planning tool for wetland restoration projects.

Figure 17 – A small example of the now inundated Red Gum floodplain west of Gooseneck Swamp – 23rd Nov 2013

Although water now flows out of Gooseneck Swamp at a higher elevation than was the case when water was passing through the artificial drain cutting in the lunette, the capacity of the 50-60m zone of natural overflow between Gooseneck and Brady Swamps (at the western end of the lunette) is large – capable of carrying much higher volumes of water than the drain cutting itself. In this way, Gooseneck Swamp will remain an "open system" capable of enabling water to pass through during higher flows or floods. In fact, from debris in the natural channel, it is clear that the swamp has reached its current level semi-regularly during higher flows in recent years already. The major – and extremely important – difference now is that when inflows cease, the swamp won't empty prematurely into Brady Swamp below its natural sill height, as was previously the case. This should give wetland flora and fauna at the site a much better opportunity to complete their life cycles, and provide refuge habitat that will last longer into the summer months. The change in sill height created by the trial structure can be observed in Figure 18.

Figure 18 – The 45cm difference in water level upstream (top) and downstream (bottom) of the trial structure – a small but significant margin, with additional depth of water over 60-100 hectares of wetland habitat and re-instatement of natural flows, the trial has had a substantial impact.

3 Site Monitoring Program

3.1 Introduction

3.1.1 Objectives

The two main objectives of the wider ecological monitoring program for Gooseneck Swamp are:

1. To establish baseline monitoring data collection and describe the current ecological values present at the wetland site
2. To document subsequent future changes to ecological values following the instalment of the temporary sandbag weir in conjunction with assessment of the hydrological regime

3.1.2 Overview of expected ecological responses

A number of potential ecological responses are expected to occur following the instalment of the temporary sandbag weir. These include:

- During dry (below average rainfall) winter and spring seasons when flows are restricted, the ecological responses are likely to be less pronounced (or possibly non-detectable).
- Subject to adequate rainfall events, with inundation prolonged by preventing water loss through the artificial channel, vegetation dominance and community shift is predicted in Gooseneck Swamp. For example, obligate wetland species may be present or establish given prolonged inundation, and dominate a larger zone of the swamp area.
- Increased depth and duration of inundation around the natural overflow and associated floodplain may occur to the west of Gooseneck Swamp. During periods of high inflow, this may subsequently alter conditions for vegetation growth, and potentially cause a shift in vegetation structure and composition over a wider area of floodplain to the west of the swamp.
- Enhancement and prolonging of suitable habitat conditions for key faunal groups such as frogs, fish and waterbirds to undertake key life stage activities (such as summer breeding) may occur as a result of the enhancement of wetland vegetation and wetland water holding capacity.

A key population of the Wimmera Bottlebrush, *Callistemon wimmerensis*, occurs within the Gooseneck Swamp portion of the Wannon river delta system. This species in listed as Critically Endangered under the *Environment Protection and Biodiversity Conservation Act (EPBC Act) 1999*. The other two known populations of this species along the MacKenzie River in Victoria are thought to have predominantly episodic recruitment, following an environmental flow event which often leads to stands of even-aged cohorts (Threatened Species Scientific Committee, 2010). Stands of this species are found in zones where inundation is seasonal, such as that of floodplains (Figure 19) or stream banks. It is expected that conditions where inundation is static, or where drying is prolonged, are not favourable for the growth and recruitment of the Wimmera Bottlebrush.

Figure 19 – The Wimmera Bottlebrush (larger shrubs in background) in the Wannon River floodplain delta adjacent to Gooseneck Swamp

A stand of this species occurs within the flood zone adjacent to the natural overflow of Gooseneck swamp. Given the anticipated hydrological response of the sandbag weir in the artificial channel and what it known of the biology and preferred habitat of the Wimmera Bottlebrush, a minor increase in the level or duration of inundation within the flood zone of the swamp is not expected to be unfavourable for the species. Furthermore, introducing more frequent inundation events may increase the growth and recruitment potential of the species at this site. However, as little data exists to confirm the likely responses of the species to particular frequencies and levels of inundation, the monitoring project may help address these information gaps. Given its geographically restricted distribution, and low overall population size (noting however that the Gooseneck Swamp system population is itself quite large, consisting of thousands of individuals), pre-empting and evaluating any subsequent responses in the Gooseneck swamp populations as a result of the weir installation is a key issue for consideration.

3.1.3 Limitations

Little ecological data existed for the site prior to the commencement of the sandbagging trial. Ongoing counts of wetland bird occupancy, particularly through the main breeding (spring/summer) period, have been undertaken by the Hamilton Field Naturalists Group (co-ordinated by Rod Bird) since February 2011. No other formal repeated ecological monitoring has been undertaken at the site prior to the trial sandbag weir being put in place.

A highly scientific (i.e. statistically robust) comparison of wetland status before and after the trial at Gooseneck Swamp could not (and for this style of small grant funded project arguably cannot) be undertaken as part of this project for the following reasons:

- The relatively short-notice timing of the (long awaited) opportunity to undertake the sandbag trial and lack of pre-project funds for monitoring (noting that grant programs are more interested in funding actual works, rather than lengthy or extensive monitoring).
- Activation of flows within the swamp system at the time of construction meant that year one monitoring started in the wet.
- The time lag often experienced between initiating a hydrological change and witnessing ecological community shifts is an issue, particularly where hydrological change may be more subtle.
- The large and dynamic catchment supplying water for the site and variable climatic conditions means that the system already experienced (in its drained state) a vast range of existing flow conditions. Hence, the speed or nature of any change observed as a result of the trial will be dictated by the prevailing climatic conditions over several years that follow. A prolonged dry period for instance would not be expected to produce any significant change in site conditions, but importantly (it should be understood) would also not indicate failure of the trial. Teasing apart the various factors influences site hydrology and hence ecological response and project success is a key point to reflect on.

For these reasons, the project and this report focus on providing a review of ecological outcomes for initially meeting the first monitoring objective (see 3.1.1), by providing a detailed baseline account of current ecological values associated with the site, in conjunction with the trial implementation.

3.1.4 Specific Monitoring Aims

In order to develop a comprehensive set of ecological data for the site, a number of key functional groups, hydrological or ecological values were identified, each having its own specific monitoring aim, as outlined below:

- To detect water elevation response post-weir construction and monitor through time
- To record general habitat response and site condition through photopoint monitoring
- To commence more detailed floristic composition, structure, condition and change monitoring in key ecological vegetation communities present at the site
- To identify the abundance and richness of species within key fauna groups, including fish, frogs and birds
- To assess the presence and status of *Callistemon wimmerensis* stands
- To assess the change over time in the above characteristics in conjunction with and following installation of the temporary weir.

3.2 Methods

3.2.1 Water elevation

A gauge board was installed in the artificial channel just upstream of the cutting between Gooseneck and Brady Swamp, as per Figures 20 and 21. It is proposed that the gauge board will be surveyed in at some point in the future to enable levels to be tied to the Australian Height Datum (AHD).

Figure 20 – The gauge board in place in early August 2013, before flows reached the site from the catchment upstream

Figure 21 – The gauge board in September 2013, showing the increments used for measuring water depth

3.2.2 Photopoints

Two locations (with simple landmark reference points) have been established as photopoints. The first is a view over the weir structure, so show the impact of the structure on up and downstream water levels, as well as showing a portion of the swamp upstream. The second is an elevated and open view across the swamp (looking west towards the Grampians) taken from on a large fallen Red Gum trunk, on the eastern margin of the wetland.

3.2.3 Ecological Vegetation Communities

A number of key ecological vegetation community (EVC) types occur within the Gooseneck Swamp system. An assessment of the current condition of the swamp was undertaken using the Index of Wetland Condition (IWC) tool, a standardised method for rapid assessment of wetland condition across Victoria, developed by the Department of Environment and Primary Industries (DEPI). This method allows the monitoring of change in wetland condition based on a reference state, by repeating the site assessments over a regular cycle. Six sub-indices are assessed out of a possible score of 20, each contributing to the overall condition score:

- **Catchment** – Impacting land use within the surrounding catchment, and wetland buffering
- **Physical form** – changes in the wetland size or form, including bathymetry
- **Hydrology** – severity of actions that change the water regime
- **Soils** – soil integrity and impacting processes
- **Water properties** – changes in water quality or risks to quality such as salinity risk
- **Biota** – structure and health of critical vegetation life-forms, and threatening processes

An initial IWC assessment was conducted at Gooseneck Swamp by DEPI in 2010. The outcomes of this assessment will serve as a reference state for the site. Assessments for the Biota sub-index were repeated within each identified wetland Ecological Vegetation Community (EVC) of the wetland perimeter. A second IWC assessment was conducted by NGT staff during November 2013, following the instalment of the sandbag weir.

3.2.4 Frogs

Frog surveys were undertaken using a passive methodology. Digital audio recorders were set up at two locations around wetland sites currently holding water. Figure 22 shows the weatherproof housing that is hung from a tree or strapped to a post, with the digital recorder inside and an external mounted microphone protruding from the base.

Figure 22 – A frog audio recording device is contained within this weatherproof housing

Vegetation composition at each site was recorded during recorder placement. Recorders were programmed to take three separate 5 minute recordings within a 24 hour period, at 5 am, 9 pm and 12 am respectively. Recordings were undertaken for between 7 and 10 consecutive nights.

The first sampling period was within late spring for eight consecutive days. The seasonality and timing of recording aimed to increase the probability of detection of *Litoria raniformis* (Growling

Grass Frog), a regionally important species and listed as nationally vulnerable under the *EPBC Act (1999)*. This method is also generally reliable for detecting a broad range of more common frog species, with the exception of autumn calling species (e.g. *Geocrinia laevis*, Southern Smooth Froglet). Categories of abundance were estimated for each of the two sampling sites after reviewing all recorded audio files during the survey period.

While not timed for inclusion in this report, future recording will also occur during the autumn period to enhance the probability of detection of the regionally rare *Geocrinia laevis* (Southern Smooth Froglet).

3.2.5 Fish

Fish surveys at Gooseneck Swamp aimed to document fish species presence, abundance, and richness. The chosen methodology, seine and dip-netting, was used primarily for increasing probability of detection of the nationally vulnerable (*EPBC Act 1999*) *Galaxiella pusilla* (Dwarf Galaxias), but also provided an opportunistic method for detecting and estimating presence and abundance of other native or exotic species.

A 7 m seine net was dragged (4 times) along 20 m stretches within the swamp water body. Netting was undertaking in the deeper water zones where water column was approximately 400mm deep. After each drag the net was lifted onto dry ground so an examination could be undertaken. A small dip net was also trialled with dip netting happening across various sites for a period of ten minutes; however no fish were captured using this method.

3.2.6 Waterbirds and Raptors

The Hamilton Field Naturalists Club (HFNC), coordinated by Rod Bird, have provided fantastic support for the ecological monitoring of the Gooseneck Swamp, continuing their seasonal waterbird and raptor surveys. Surveys were conducted roughly once every four weeks over autumn, spring and summer. Surveys were undertaken in the early morning, when birds were likely most active.

During the active surveys, participants undertook passive, timed observations using spotting scopes along the east and south-eastern fringe of the swamp, where a large area of waterbody could be observed. Observations were made for up to 15 minutes, from the northeast of the swamp. The information to be recorded for each survey included:

- Site (north or south)
- Date, time, and observer names
- General description of weather conditions
- Species present
- Estimated number of each species present
- Nesting: Species and number of adults present, description of nest position and where possible the number of eggs and chicks present
- Additional observations worth noting.

While walking between observation sites, participants noted any additional observations of wetland and raptor birds, particularly along the northern drain.

3.2.7 *Callistemon wimmerensis* population

Distinct stands of the Wimmera Bottlebrush occur at a number of locations around the Gooseneck Swamp and Brady Swamp Complex (Figure 23). One mature stand occurs within the northwest section of Gooseneck Swamp, along a delta line of the Wannon River. The second, and largest, stand occurs to the southwest of Gooseneck, closer to Brady Swamp, and the third occurs within the southwest floodplain of Gooseneck Swamp. The latter stand was determined as the most likely to be impacted to changes in hydrological regime given its proximity to the swamp and occurrence within the natural overflow and floodplain, and hence is a particular focus for monitoring.

The north-western stand occurs in a drier site than that south-western site, as indicated by the surrounding vegetation types, and site hydrology. Hydrological flows at this site appear to be influenced by the northernmost of the Wannon delta flow-paths. The intention of monitoring this stand was to serve to some degree as a control, being able to assess health and recruitment aspects of a population that is not directly influenced by inundation events of the southwest floodplain.

Recruitment history and condition were assessed for the two stands, by measuring the following parameters of each of, or a subset of individual plants:

- Location
- Height and cohort:
  - Seedling/Juvenile/Mature 1 (DBH* : ≤10 cm)
  - Mature 2 (DBH* : >10, ≤20 cm)
  - Mature 3 (DBH* : >20 cm)
- Circumference
- Percent dieback of foliage
- Average number of flowering inflorescences per branchlet
- Record of inundation at time of survey

*Note: *DBH = Diameter at Breast Height*

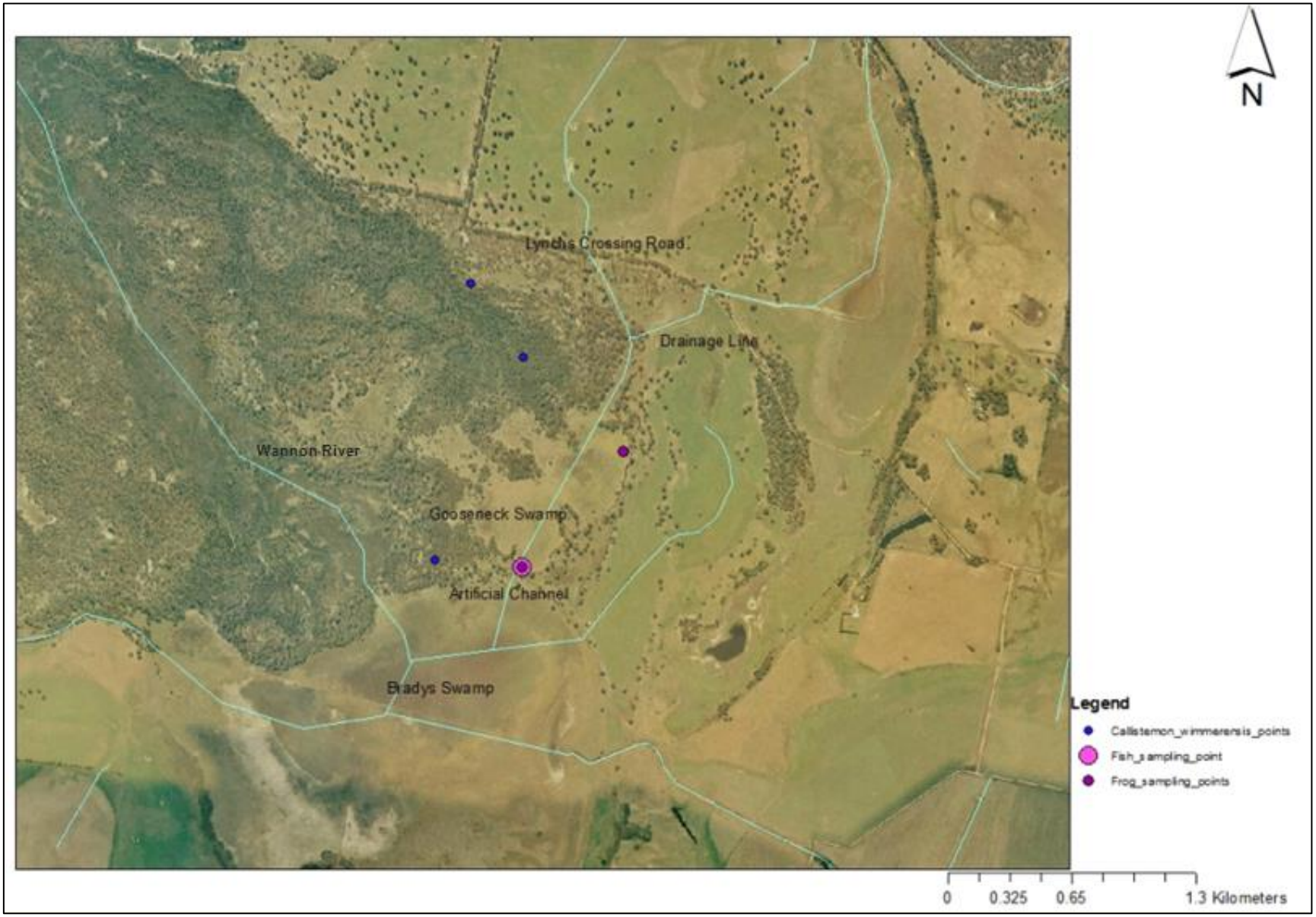


Figure 23 – Aerial map of Gooseneck Swamp system, showing location of Callistemon wimmerensis stands, fauna sampling points, and hydrological features.

3.3 Results

3.3.1 Water elevation monitoring in 2013/14

Water elevation monitoring data was captured by manually recording water levels at the gauge board in the drain upstream of the weir structure (Table 1 and Figure 24) during visits.

From when the trial began in August, through until mid-December 2013, water levels were relatively stable as a result of steady inflows from the Wannon River that continued into the beginning of summer. As soon as inflows ceased (mid-late December), evapotranspiration rates saw swamp water levels drop rapidly – by approximately 20cm per month – until the majority of the swamp was dry by late February.

Table 1 – Gooseneck Swamp: water level depth in the drain upstream of the weir (cm), with timing of weir installation marked with a bold red line.

Date	Water Level (cm)
31/07/2013	0.00
26/08/2013 AM	0.50
26/08/2013 PM	0.53
02/09/2013	0.72
11/09/2013	0.69
02/10/2013	0.68
12/10/2013	0.67
16/11/2013	0.67
23/11/2013	0.70
14/12/2013	0.72
18/01/2014	0.50
11/02/2014	0.32
15/02/2014	0.30
15/03/2014	0.09
12/04/2014	0.00
18/05/2014	0.00
14/06/2014	0.00

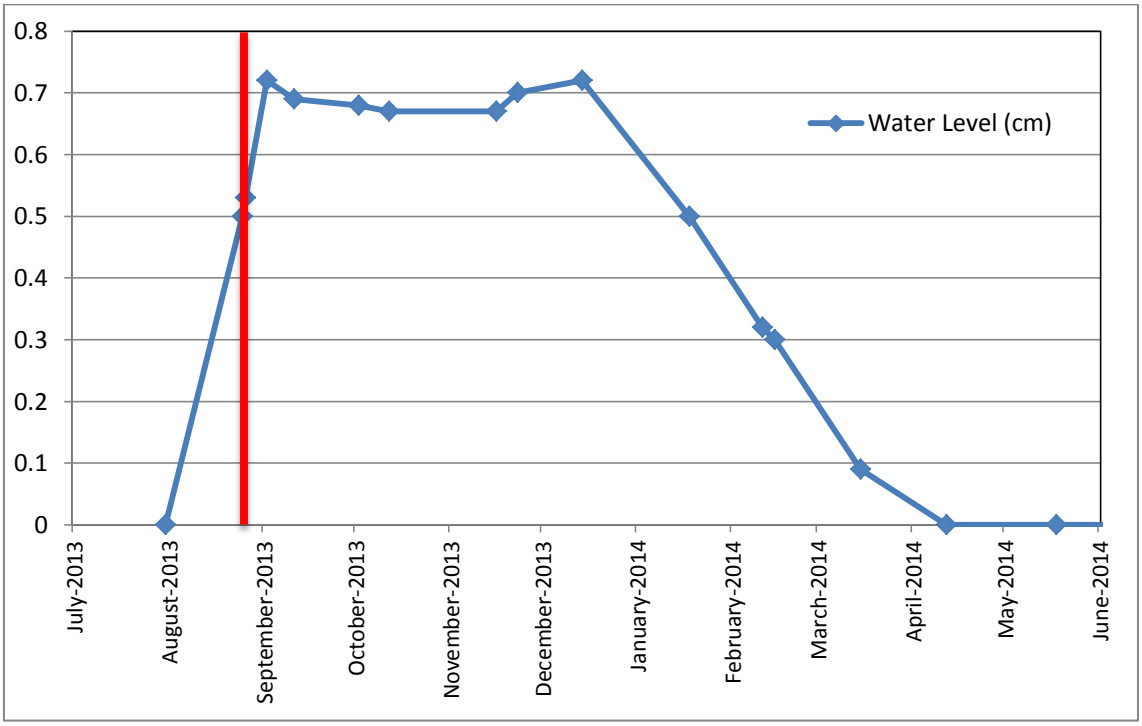


Figure 24 – Gooseneck Swamp: water level depth in the drain upstream of the weir (cm), with timing of weir installation marked with a bold line.

3.3.2 Photopoint monitoring

Two locations were regularly photographed to show the changing conditions at Gooseneck Swamp over the 2013/14 spring and summer.

Site 1: At the structure

26th August 2013

2nd September 2013

2nd October 2013

15th November 2013

14th December 2013

11th February 2014

Site 2: Looking west over the swamp

12th September 2013

15th November 2013

14th December 2013

11th February 2014

3.3.3 Frog Monitoring

Frog surveys using passive recorders were conducted from 15th to 23rd November 2013, with three separate five-minute recordings taken over each 24 hour period. A total of five species were detected, including the three species of the *Limnodynastes* genus, as well as *Litoria raniformis* (Growling Grass Frog, see Figure 25). For a full list of species and records see Appendix 1.

Figure 25 – Growling Grass Frog

The category of abundance (number of frogs calling) at both sampling sites for the Growling Grass Frog was 10-50 individuals. However in some recordings for the southern sample site, the number of individuals calling was likely higher. It was assumed the majority of these fainter calls were originating from further afield, in the larger Brady's Swamp, where the number of individuals heard calling was likely to exceed 50.

3.3.4 Bird Monitoring

Observations of waterbird and raptor species were collated by the HFNC for surveys conducted between 25th February 2011 and 12th April 2014.

A total of 35 bird species have been recorded at Gooseneck Swamp during the surveys, including 26 waterbird species, the *EPBC Act (1999)* Migratory Listed species *Gallinago hardwickii* (Latham's Snipe), state threatened *Grus rubicund* (Brolga) (Flora and Fauna Guarantee Act 1988), and 6 species of birds of prey (Appendix 2).

The trend in observations of water birds during these surveys appears to be influenced by the retention of water, particularly over the summer period, in Gooseneck Swamp. Figure 26 shows the abundance and species diversity recorded for the surveys, presented in conjunction with the monthly rainfall data for Halls Gap.

In 2011, following ample summer rainfall and an above average annual rainfall the previous year, water holding in the Swamp was estimated at above 50% heading into autumn. A substantial number of waterbirds were still observed during the surveys in February and April. During the same period of the following year, with the region recording low rainfall over summer, no birds were observed during survey for February, and the swamp was dry.

In 2013, with a recording of zero rainfall for January at Halls Gap, the Swamp was dry during the waterbird survey in February, and very few birds seen.

Annual rainfall later throughout 2013 was near average for the region, with above average winter rainfall and high rainfall in October. While summer rainfall for 2013-14 was below average, during the survey on 18th January 2014, 430 birds of 15 species were observed, the highest recording since surveys began in 2011, indicating the increased value of wetlands through the summer months as refuge habitat. At that time, the depth gauge installed within the swamp was at 0.50 metres, con-incidentally the same height as water levels prior to the sand bag weir being installed in August 2013. A significant number of birds were also observed in February, with the depth gauge still recording 0.3 metres, although the majority of the swamp was dry by this time (due to the gauge board being situated in one of the last locations to dry out).

Subsequent declines in the observations in March and April 2014 reflect the change in bird presence as the swamp completely dried out – although the swamp vegetation remained lush and green with subsurface soil moisture through the summer and early autumn.

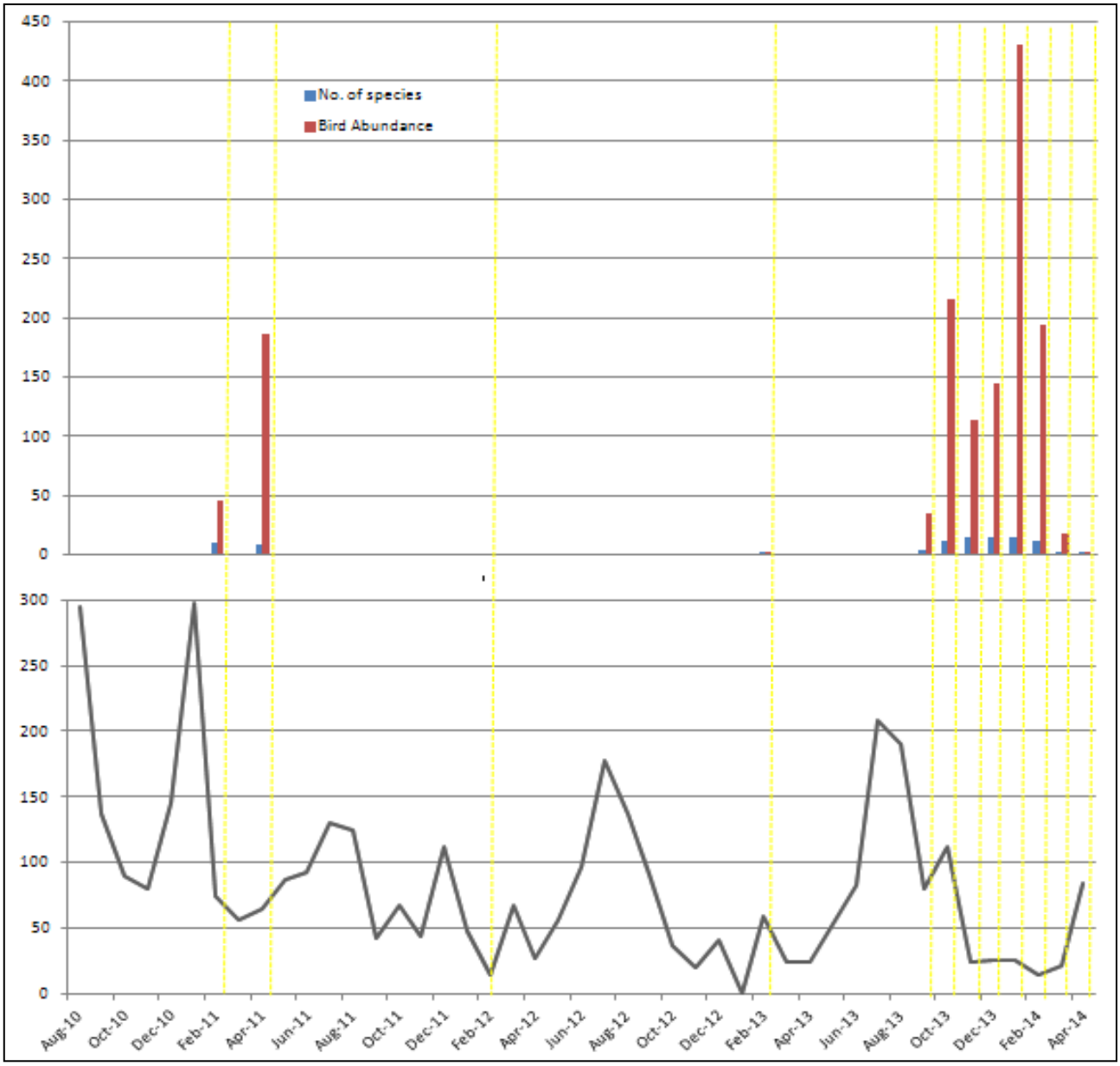


Figure 26 – Graph of bird abundance, and species richness (top) for waterbird surveys conducted between 2011 and 2014 for Gooseneck Swamp, and (below) corresponding rainfall data for Halls Gap (dotted yellow lines indicating time of bird survey).

3.3.5 Fish Monitoring

Fish sampling was conducted on 19th November, 2013. Five individuals were recorded of the two nationally vulnerable (EPBC Act 1999) species (Appendix 4), including one female *Galaxiella pusilla* (Dwarf Galaxias – Figure 27), and four *Nannoperca obscura* (Yarra Pygmy Perch). No exotic species were found during the sampling.

Figure 27 – A male (top) and female (bottom) dwarf galaxias

3.3.6 Callistemon wimmerensis

Callistemon wimmerensis stands were monitored on two occasions, in November 2013 and March 2014. All plants located were mature individuals, and three main cohorts identified based on the Diameter at Breast Height (DBH) of the main stem.

At the time of the November survey, none of the sampled plants were flowering. A number of plants in lower lying sections of the south-west floodplain were inundated at this time (see representative image from September 2013 in Figure 28); however no plants along within the northwest stand were inundated. In the following survey, all sampled plants showed evidence of flowering

Figure 28 – A medium-sized Wimmera Bottlebrush in the inundated south-western floodplain, in September 2013

within the southwest stand, and all but two showed evidence of flowering in the northwest stand. Data collected is summarised in Appendix 3.

The flowering vigour (average number of inflorescence per branchlet) appeared to correlate with the size, using DBH as a proxy measure (Figure 29). However two of the sampled plants in the northwest stand did not flower at all, while all plants within the southwest stand flowered. The southwest stand had a larger diversity in size of plants.

Active searches were undertaken during the March survey to look for new germinants. None were found, however the ability to accurately identify them within the first few months of growth could be a significant factor and hence this requires further investigation. Further active searches will be conducted on a regular basis to assess the presence of seedlings.

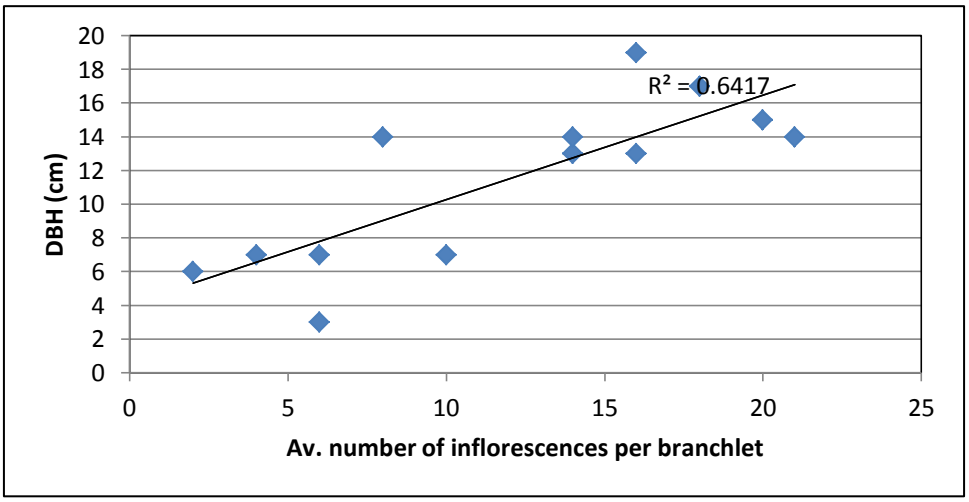


Figure 29 – Correlation of Diameter at Breast Height (cm) and average number of inflorescences/branchlet for sampled Callistemon wimmerensis plants across two sites (non-flowering plants omitted).

3.3.7 Ecological Vegetation Communities

Four key wetland EVCs were identified within the Gooseneck Swamp system, as part of the IWC assessment in 2010 (Figure 30):

1. ***Aquatic Herbland*** – core open wetland area, where semi-permanent to seasonal wetland vegetation is predominant. Dominated by floating and emergent herbaceous aquatic species, typically with at least rootstock tolerant of dry periods
2. ***Tall Marsh*** – shallow (to 1m deep) wetland with closed to open sedgeland dominated by *Typha* spp. and *Phragmites australis*. Dominant along the western fringe of the swamp
3. ***Wet Verge Sedgeland*** – tussock sedge wetland, canopy absent, typically dominated by *Carex appressa*, intermediate between the open aquatic herbland and surrounding treed communities, including River Red Gum swamp. Concentrated to the northern swamp edge.
4. ***Plains Sedgy Woodland*** – open woodland, dominated by River Red Gum, in floodplain areas of swamp. Typically absent of shrubs and understorey.

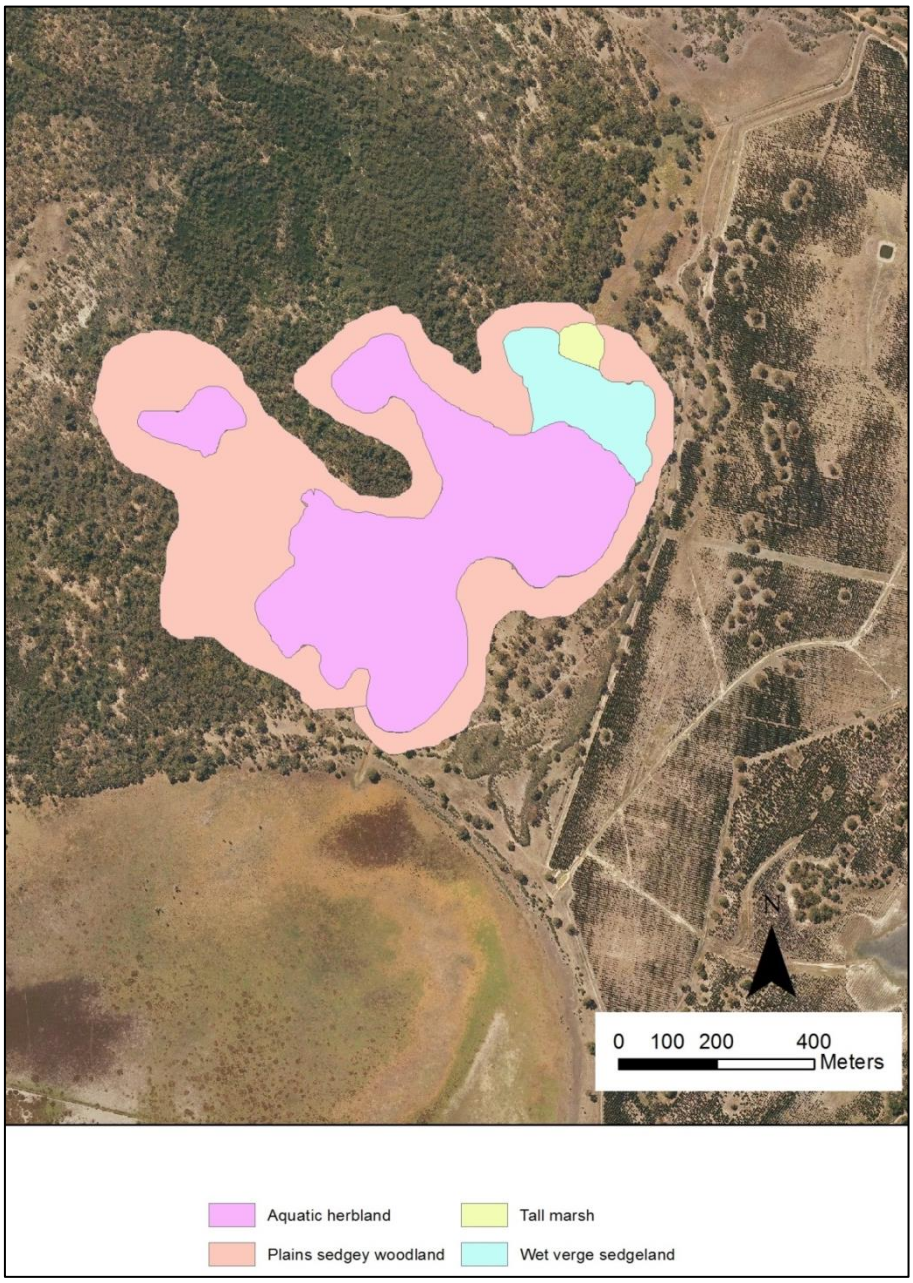


Figure 30 – Current mapping of Ecological Vegetation Classes (EVCs) assessed at Gooseneck Swamp

Appendix 5 provides a list of flora species recorded as part of the vegetation assessments. Results for the IWC for 2010, and 2014 are summarised in Table 2. Category scores for Biota sub-index in 2014 are also outlined in Appendix 6, which have not changed score category since 2010. All EVC areas assessed had 90% or more of the critical life-forms present. The only EVC area not to receive a Biota score of "Good" or above was Plains Sedgy Woodland occurring along the eastern section of the swamp (see Table 2). In this area more than 50% of the woodland was substantially modified by physical disturbance, caused by the presence of the main drainage line, an infrequently used vehicle track, and the proximity of the eastern boundary which lies adjacent to an often grazed blue gum plantation. Within this area, as well as within the Aquatic Herbland, the encroachment of River Red Gum stands has been identified as evidence of an altered hydrological process. Following the installation of the artificial drainage system, it appears likely that more prolonged and frequent drying periods have allowed recruitment of River Red Gums into the wetland zone fringes.

Table 2 – Overall & sub-index scores of the Index of Wetland Condition (IWC) assessment at Gooseneck Swamp, 2010 & 2014.

Wetland ID	**7322285396**	**7322285396**
Vicgrid - East	2275276	2275276
Vicgrid - North	2432595	2432595
Assessment Version	IWC v11-14	IWC v11-14
Assessment Date	21/12/2010	1/11/2014
Wetland catchment score	18	16
Wetland catchment category	Excellent	Moderate
Physical Form score	19.9	19.9
Physical Form category	Excellent	Excellent
Hydrology score	15	20
Hydrology category	Good	Excellent
Water Properties score	15	15
Soils score	20	20
Soils category	Excellent	Excellent
Overall Biota score	17.4	17.4
Biota score category	Good	Good
Assessment Score	**8**	**9**
Assessment Category	**Good**	**Excellent**

The overall assessment score from 2010 IWC was "Good", with this score increasing to "Excellent" in 2014. The Wetland Catchment Category score dropped between years from "Excellent" to "Moderate" given the recent increase in extent (>50%) of non-endemic plantations in the surrounding catchment areas. However the hydrology category has increased from "Good" to "Excellent" given that the open drainage through the swamp was significantly altering the water regime. The installation of the sandbag weir has reduced the hydrological impacts and increased the potential for extending annual inundation duration.

3.4 Discussion

The baseline ecological surveys of Gooseneck Swamp are indicative of a site (and wider system) with high existing values. The condition of vegetation across identified EVCs was found to be generally high; however, there are a number of weed species present at the site. The impact of these species is currently found to be negligible, with species such as *Mentha pulegium* found to be prevalent in some areas of the wetland bed. For example, in November 2013 at the time of the IWC assessment, the cover of *M. pulegium* within the Aquatic Herbland was <5%. By early March 2014, as a result of site drying, this cover was >10%, and up to 40% cover in some areas. The longer-term historical reduction in area of more open wetland communities (and the hydrological change it represents, linked to site drainage and/or upstream Wannon River diversions) is also indicated by the opportunistic recruitment and encroachment of River Red Gum in some areas of Gooseneck Swamp.

Initial assessment of Wimmera Bottlebrush stands showed more range in the size of plants within the southwest stand, which is likely to indicate a more diverse age distribution. However, as there is no reliable method to age this species, determining age on the basis of DBH (Diameter at Breast Height) may not be accurate. A higher proportion of plants within the southwest stand were also found to be flowering. Diversity in age cohorts, and strong flowering vigour may be due to a more regular flooding regime for this stand, however this is difficult to ascertain at this stage in the absence of historic hydrological data and confirming the method of age determination for these plants.

A number of rare and listed fauna and flora species have been recorded at the site. The provision of aquatic vegetation from a number of strata, as well as presence of water, particularly over spring/summer breeding periods, is an important habitat attribute for all of the key fauna groups including frogs, fish and waterbirds.

Historic results from waterbird surveys and regional rainfall data (although limited) are suggestive of a correlation between summer rainfall (hence presence of aquatic habitat) and bird abundance. Following above average summer rainfall in 2010-11, close to 50 waterbirds were recorded in the swamp in February, followed by two dry summers with little surface water in the swamps and low bird numbers. In the current survey year over 2013-14, low summer rainfall was experienced. However, monthly summer surveys found a high abundance and richness of waterbirds, with the highest count occurring in late January. This included the presence of a pair of brolgas, a species that had only been recorded at the site in 2011 when the swamp retained over 60% surface water into autumn after high, unseasonal, summer rainfall events.

Because of the nature of Wannon River catchment flows and the fact that every year is different (and hence cannot be directly compared) it is difficult to make unequivocal conclusions. However, by February 2014 with the trial structure in place, after average rainfall in the winter/spring of 2013 and 2 months of no rainfall along with high evaporation rates, parts of the main swamp at Gooseneck Swamp were still inundated, when local anecdotal evidence suggests it would normally have been dry by this time in similar years previously. While by no means conclusive, this is suggestive of the likely impact that the sandbag weir has had in increasing the duration of inundation. Whether by a matter of weeks or months, basic logic (and observation of its effect) certainly supports the assertion that the weir extended the season for Gooseneck Swamp deeper into the 2013/14 summer – a highly positive outcome for the first year of the trial.

Increased retention of surface water in the swamp as a result of the trial is likely to significantly increase the accessibility of foraging, roosting and nesting habitat for key faunal groups as well as increase available habitat for prey such as invertebrates. In particular, inundation through the summer would assist the germination and retention of emergent and submergent vegetation structures within the Aquatic Herbland habitat area. The submergent and emergent vegetation cover and diversity was notably high throughout the 2013-14 summer period in response to prolonged inundation.

Many studies have indicated that the richness and abundance of waterbird species increases with increasing emergent vegetation cover, especially during breeding periods (Zhijun *et al*. 2010). This is also true for the threatened Growling Grass Frog, where habitat variables including the presence of surface water over summer and representation of vegetation in both emergent and submergent strata have been linked to the presence of breeding populations (Smith *et al.* 2008). Threatened fish species such as the Yarra Pygmy Perch and Dwarf Galaxias are also affiliated with shallow freshwater wetland habitats containing large amounts of aquatic vegetation (Saddler & Hammer 2010). Both these species are thought to have poor dispersal capabilities and rely heavily on frequent and prolonged flooding for the creation of spawning habitat and to increase their probability (through connectivity) of recolonising habitats. Based on the results, it is probable that Gooseneck Swamp has been utilised as an opportunistic, ephemeral habitat for native fish, although achieving permanence of aquatic habitat through wetter summers is now a legitimate goal with the trial structure in place.

Digital elevation modelling has indicated as much as 20cm (as a static level) of additional water is being held in the swamp, given the reactivation of the natural flow path. With additional surface water, topographic variation in the swamp system will allow for a range of water depths and increased structural diversity in wetland habitats. This may increase the habitat potential for a more diverse range of species from important faunal groups discussed, particularly for breeding activities.

A subsequent downstream restoration trial regulating the artificial drain from Brady's Swamp (installed in 2014 – see Figure 31) will have additional benefit, by enhancing multiple, complementary wetlands within the wider wetland complex/mosaic, providing more diverse wetland resources over a wider spatial and temporal scale.

Figure 31 – The trial structure installed on 19th March 2014 at the Brady Swamp artificial drainage outlet, to increase wetland depth and reinvigorate flows down the natural Wannon River flow path

3.5 Summary of Project Outcomes

3.5.1 Hydrological

The trial sandbag structure had immediate impacts on the flow dynamics at Gooseneck Swamp:

- increasing wetland depth by as much as 20 cm;
- reducing outflow drainage efficiency significantly, by causing water to take its original route to Brady Swamp, spilling at higher elevations via the natural overflow point; and,
- preventing the immediate drawdown of water levels to the bed level of the swamp, which the drain previously caused to occur once inflows ceased (based on flows and rainfall, this would have started to occur in mid-December 2013).

In achieving the above, it is reasonable to conclude that the inundation period for Gooseneck Swamp was extended by as much as 4-6 weeks, creating a wetland refuge for wetland dependant fauna deep into what was a hot and dry summer period with no rainfall. In a year with more significant summer rainfall, the impact of the structure (influencing site conditions) would likely be more pronounced.

Before and after photographs below (in Figure 32) at the artificial drainage cutting illustrate the dramatic seasonal change that the site underwent in 2013, at the location of the trial structure.

Looking north from the drain towards Gooseneck Swamp *Looking south towards Brady Swamp via the cutting*

Figure 32 – Showing the seasonal change at the site from May 2013 (above) to September 2013 (below)

3.5.2 Ecological

The value of Gooseneck Swamp as habitat for a wide range of flora and fauna has been demonstrated through the initial baseline monitoring undertaken. It is confirmed as a particularly important site for nationally threatened species of fish, frogs and flora, as well as providing refuge habitat into the summer months for a wide range of waterbirds. Early indications are that the restoration trial will, as expected, significantly enhance the ecological values of the site in all but the driest years (i.e. those years when there are no flows to retain in the swamp).

3.5.3 Community Engagement

The restoration trial has so far involved the local community in the construction of the sandbag weir structure and aspects of the ecological monitoring program.

An information day and bushwalk held in December 2013 also attracted 40 people from across the region that wanted to learn more about the site and its ecological values, and witness the operation of the restoration trial structure (see Figure 33).

Figure 33 – Some of the bushwalkers who came along for the Information Day on the 14th December 2103 stop to pose on the sandbag structure – operating perfectly (with the wetland upstream at full-supply level) heading into the heat of summer.

One of the most rewarding things about the information day was bringing together such a diverse group of people with a common interest in wetland conservation – and to be able to share with them the good news about the early success of the trial. Those in attendance were also fortunate to have the local and historical knowledge of current neighbours on hand, as well as the previous owners of Gooseneck Swamp – Bob and Mal Fraser – who were clearly ahead of their time by recognising the environmental values of the area in the 1980s when they sold the land to the Victorian Government for perpetual protection (it now forms part of the Grampians National Park). Several people also recognised the key role that Gavin Cerini (an apology for the day) played in the efforts to secure and restore Gooseneck Swamp for conservation purposes over many years, and that the trial has been a great way to capitalise on his efforts over many years.

3.6 Recommended Future Work

Due to the early success of the trial and the practical demonstration that site hydrology is functioning effectively with the structure in place, it is recommended that:

- if possible, site monitoring continue to track the hydrological and ecological response of vegetation communities and key indicator species at the site over coming years; and,
- funding be sought to consolidate the trial structure and reinstate the earthen lunette bank (across the drain cutting); an option with no ongoing maintenance obligations that would permanently restore the natural function of flows between Gooseneck and Brady Swamps.

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5 Appendices

5.1 Appendix 1. Results and site descriptions for frog surveys, November 2013.

Site name	Southern Aquatic Herbland	North-east River Redgum Swamp
Date of survey	15/11/2013	15/11/2013
GDA 94 Easting	628491	629025
GDA 94 Northing	5839265	5839874
Habitat Components		
Vegetation Community Description	River Red Gum/Shallow freshwater wetland mosaic	Shallow freshwater wetland
%cover shading of pool	<10	<10
%cover in-pool debris	<5	<5
Submergent Vegetation		
%cover	50	50
%native cover	45	40
dominant species	*Potamogeton tricarinatus, Myriophyllum sp, Lemna sp*	*R. inundatus, Myriophyllum sp, Crassula sp*
Filamentous Algal cover% (F/S)	/	/
Emergent/floating vegetation		
%cover	70	90
%native cover	70	80
dominant species	*Cotula coronopifolia, Eleocharis acuta, Eleocharis sphacelata, Ranunculus inundatus, Neopaxia australasica, Juncus pallidus*	*E. acuta, Juncus sp, J. pallidus, Lilaeopsis polyantha, Crassula helmsii, T. procerum, R. inundatus, Stellaria pungens*
Fringing vegetation		
%cover	80	80
%native cover	70	70
dominant species	*E. camaldulensis, Gahnia filum, Carex appressa, *Mentha pulegium, *Rumex sp*	*E. camaldulensis, Carex appressa, C. tereticaulis, *M. pulegium, Mentha aquatica, *Cirsium vulgare*
Comments	**M. aquatica* very sparse in November, encroached dry Swamp bed in March, 30% cover	**M. aquatica* very sparse in November, encroached dry Swamp bed in March, 30% cover
Frog Species Present		
Crinia signifera	10-50	10-50
Geocrinia laevis		
Limnodynastes dumerilii	10-50	1-9
Limnodynastes peronii	10-50	1-9
Limnodynastes tasmaniensis	10-50	10-50
Litoria ewingii		
Litoria peronii		
Litoria raniformis	10-50	10-50
Neobatrachus pictus		
Neobatrachus sudellii		
Pseudophryne bibronii		
Pseudophryne semimarmorata		

5.2 Appendix 2. Waterbird and Raptor survey results at Gooseneck Swamp, Hamilton Field Naturalists Club, 2011 to 2014 (courtesy R. Bird)

Date	25-Feb-11	16-Apr-11	16-Feb-12	25-Feb-13	11-Sep-13	12-Oct-13	16-Nov-13	14-Dec-13	18-Jan-14	15-Feb-14	15-Mar-14	12-Apr-14
Time						1015-1100	0830-1100	0830-1030	0845-1100	0815-0945	0845-0945	0900-0920
Temperature					M	21°C	12-15°C	15-20°C	22°C	20°C	18°C	18°C
Cloud					5	0	6	6	7	7	6	8
Windspeed					L	F0-4	L	C	C	C	L	nil
Wind direction					SW	N	E				NW	
Rain					nil	nil	nil	nil	nil	nil	S	nil
Water level	M	L	D	D	0.69, M	0.67, M	0.67, M	0.72, M	0.50, M	0.30, VL	0.09, D	D
Water approx. % cover	70%	60%	0%	0%	90%	90%	90%	90%	60%	5%	0%	0%
Vegetation % cover					5 (R)		70 (Az,R)	70 (Az,R)	80	100	100	100
Hoary-headed Grebe								1				
Little Pied Cormorant	1						12	9	1			
Little Black Cormorant							4	1				
Great Cormorant								1				
White-necked Heron	3					11	16	13	26	4		
White-faced Heron	18	70				4	7	3	15	30	16	
Australian White Ibis	1									13	2	
Straw-necked Ibis	3				12			5	2	50		
Royal Spoonbill		12								3		
Yellow-bill Spoonbill		3				1				15		
Black Swan					20	125	7		4			
Australian Shelduck	4	20				15	5					
Musk Duck							1	1				
Pacific Black Duck	6	30			2	52	51	40	110	30		
Grey Teal		40						12	250	40		
Chestnut Teal	2	10					4					
Australasian Shoveler						2			3			
Pink-eared Duck												
Hardhead						1		50				
Purple Swamphen								1				
Dusky Moorhen	4											
Black-tailed Native Hen						2	2	4				

Date	25-Feb-11	16-Apr-11	16-Feb-12	25-Feb-13	11-Sep-13	12-Oct-13	16-Nov-13	14-Dec-13	18-Jan-14	15-Feb-14	15-Mar-14	12-Apr-14
Brolga		2							2			
Masked Lapwing	4						1		2	7		
Black-winged Stilt									8			
Latham's Snipe									3			
Black-shouldered Kite												1
Whistling Kite						1	1	1				
Wedge-tailed Eagle									2			
Swamp Harrier						1	1	1	1			
Nankeen Kestrel							1			1		1
Peregrine Falcon									1			
White-fronted Chat				12								
Little Grassbird								2		1		
Australian Reed-warbler						1						
Total Number of Species	10	8	0	1	3	12	14	16	15	11	2	2
Total Number of Birds	46	187	0	12	34	216	113	145	430	194	18	2
					PBDuck b	BSwan b2	BSwan b4					
						Sheld b12						

Temp (degrees C at start & finish or C = <10, M = 10-20, W = 21-30, H= >30, F = frost).
Cloud (0,1,2,3,4,5,6,7,8 where 0 = no cloud, 8 = complete cover & 4 = 50% cover, etc)
Rain (F = fine, D = drizzle, S = showers)
Wind (C = calm, L = light, M = moderate, S = strong or F0-6
Wind direction (W, NW, N, NE, E etc)
Water depth = reduced level shown on depth marker at old drain outlet, or D = dry, VL = very low (≤2.5 cm), L = low (≤10 cm), M = moderate, H = high
Water cover = approximate spread across the wetland
Vegetation cover = Reeds or Rushes (R), Azolla (Az), Water Ribbons (W)
b = breeding (number of young seen, included in total)

5.3 Appendix 3. Data for *Callistemon wimmerensis* stand monitoring, Gooseneck Swamp

					%dieback		Ave. No inflorescences/branchlet	
Height (m)	Circumference (cm)	DBH	Cohort	Inundation November	15/11/2013	17/03/2014	15/11/2013	17/03/2014
Northwest Stand - Wannon Delta								
4.5	22	7	M2	dry	<5	<5	not flowering	6
6	45	14	M3	dry	<5	7	not flowering	8
4.5	18	6	M2	dry	<5	<5	not flowering	2
5	30	10	M3	dry	<1	<1	not flowering	0
4.5	27	9	M2	dry	<5	<5	not flowering	0
6	42	13	M3	dry	<5	<5	not flowering	16
4.5	22	7	M2	dry	<5	<5	not flowering	10
Southwest Stand - Swamp floodplain								
4.7	22	7	M2	dry	<5	<5	not flowering	4
7	52	17	M3	damp	5	5	not flowering	18
7.5	47	15	M3	inundated (to 4cm)	<5	<5	not flowering	20
7.5	41	13	M3	damp	<5	<5	not flowering	14
7.5	45	14	M3	damp	<5	<5	not flowering	21
6.5	60	19	M3	damp	<1	<1	not flowering	16
6	45	14	M3	inundated (to 3 cm)	<5	<5	not flowering	14
3	10	3	M1	inundated (to 8cm)	<5	<5	not flowering	6

Age Class Categories (Mature)		
M1		Diameter at Breast Height (DBH) ≤10cm, flowering
M2		Diameter at Breast Height (DBH) >10, ≤20cm, flowering
M3		Diameter at Breast Height (DBH) >20cm, flowering

5.4 Appendix 4. Fish sampling results for Gooseneck Swamp, 19th Nov 2013

Date of Survey	19th November 2013	Time	3.30pm
GPS Location	GDA 94 54 H	E 628491	N 5839265
Vegetation parameters		**Water Condition**	
Community type	Aquatic herbland	pH	6.7
Submerged cover %	25	Temp (°C)	16.76
Emergent cover %	20	DO at surface	25%
Fringing cover %	40	EC (mS)	0.517
		Pool Condition	bank level
		Flow	irregular connection
Species	**Total length (mm)**	**Maturity**	**Sex**
Nannoperca obscura	12		
Nannoperca obscura	15		
Nannoperca obscura	19		
Nannoperca obscura	23		
Galaxiella pusilla	23	Mature	Female

5.5 Appendix 5. Flora list for Gooseneck Swamp.

Species	Common name	EVC associations*	Status*
Acacia melanoxylon	Blackwood	ShrubW	
Acacia verticillata	Prickly Acacia	ShrubW	
Austrodanthonia sp.	Wallaby Grass	RGS, ShrubW	
Callistemon wimmerensis	Wimmera Bottlebrush	ShrubW, RGS	CE (National)
Cardamine tenuifolia	Slender Bitter-cress	RGS, AH	E (SA/VIC)
Carex appressa	Tall Sedge	WVS, WVS	
Carex tereticaulis	Rush Sedge	WVS, WVS	
Centipeda cunninghamii	Common Sneezeweed	RGS	
Cotula coronopifolia	Water Buttons	RGS, AH	
Crassula helmsii	WVSamp Stonecrop	AH	
Dianella callicarpa	WVSamp Flax-Lily	RGS	
Eleocharis acuta	Common spike-rush	AH	
Eleocharis sphacelata	Tall Spike-rush	AH	
Eucalyptus camaldulensis subsp. camaldulensis	River Red-Gum	RGS,PSW	
Eucalyptus ovata	WVSamp Gum	RGS	
Gahnia sieberiana	Red fruit Saw-Sedge	ShrubW,WVS	
Juncus kraussii	Jointed rush	WVS, AH	Exotic, noxious
Lachnagrostis sp	Blown Grass	RGS	
Leptospermum continentale	Prickly Tea-tree	ShrubW, RGS	
Lilaeopsis polyantha	Australian Lilaeopsis	AH	
Lobelia anceps	Angled Lobelia	AH	
Lobelia beaugleholei	Showy Lobelia	RGS	R (National/VIC)
*Marrubium vulgare**	Horehound	RGS	
Melaleuca squarrosa	Scented Paperbark	RGS, ShrubW	
*Mentha pulegium**	European Pennyroyal	RGS, AH	Exotic
Myriophyllum sp.	Water Milfoil	AH, WVS	
Neopaxia australasica	White Purselane	AH	
Potamogeton tricarinatus	Floating Pondweed	RGS, AH, WVS	
Ranunculus inundatus	River Buttercup	AH, WVS	
Schoenoplectus pungens	Sharp Club-sedge	AH	
Senecio sp		RGS	
Stellaria pungens	Prickly Starwort	AH	
Triglochin alcockiae	Alcock's Water Ribbons	AH	
Triglochin procerum	Water ribbons	AH	
Typha sp.	Cumbungi	TM,	

***EVC Associations**		***Status**	
River Red Gum Swamp	RGS	R	Rare
Plains Sedgy Woodland	PWVS	E	Endangered
Shrubby Woodland	ShrubW	CE	Critically Endangered
Aquatic Herbland	AH		
Wet Verge Sedgeland	WVS		

5.6 Appendix 6. Biota sub-indices scores for Gooseneck Swamp IWC assessment, November 2013

EVC	932 - Wet Verge Sedgeland	283 - Plains Sedgy Woodland	283 - Plains Sedgy Woodland	821 - Tall Marsh	653 - Aquatic Herbland
Critical lifeform groups Score	21.9	22.5	20	25	25
Weeds Score	18	22	7	25	25
% cover of weeds	< 5	< 5	25 - 50	< 5	< 5
% of weed cover made up of high threat weeds	> 50	< 50	> 50	0	<50
High threat weed species	Cirsium vulgare, Rumex crispus	Holcus lanatus	Cirsium vulgare, Cynosurus echinatus, Holcus lanatus, Hordeum murinum s.l., Mentha pulegium, Rumex crispus		Cirsium vulgare, Mentha pulegium
Indicators of altered processes Score	25	25	15	25	15
Indicators of altered processes	no evidence of the altered process	no evidence of the altered process	altered process identified as 'moderate'	no evidence of the altered process	altered process identified as 'moderate'
What is the altered process (if evident)?			dense red gum thickets of different ages		Red Gum invasion
Vegetation structure and health Score	25	25	25	25	25
Percent of benchmark cover	> 50	> 50	> 50	> 50	> 50
Percent of structural dominants which are healthy	> 70	> 70	> 70	> 70	> 70
Biota score	**17.97**	**18.90**	**13.40**	**20.00**	**18.00**
Biota category	**Good**	**Excellent**	**Moderate**	**Excellent**	**Good**

5.7 Appendix 7. Historical References

The Australasian,
Saturday 9 April 1892, page 7

UNDER THE GRAMPIANS.

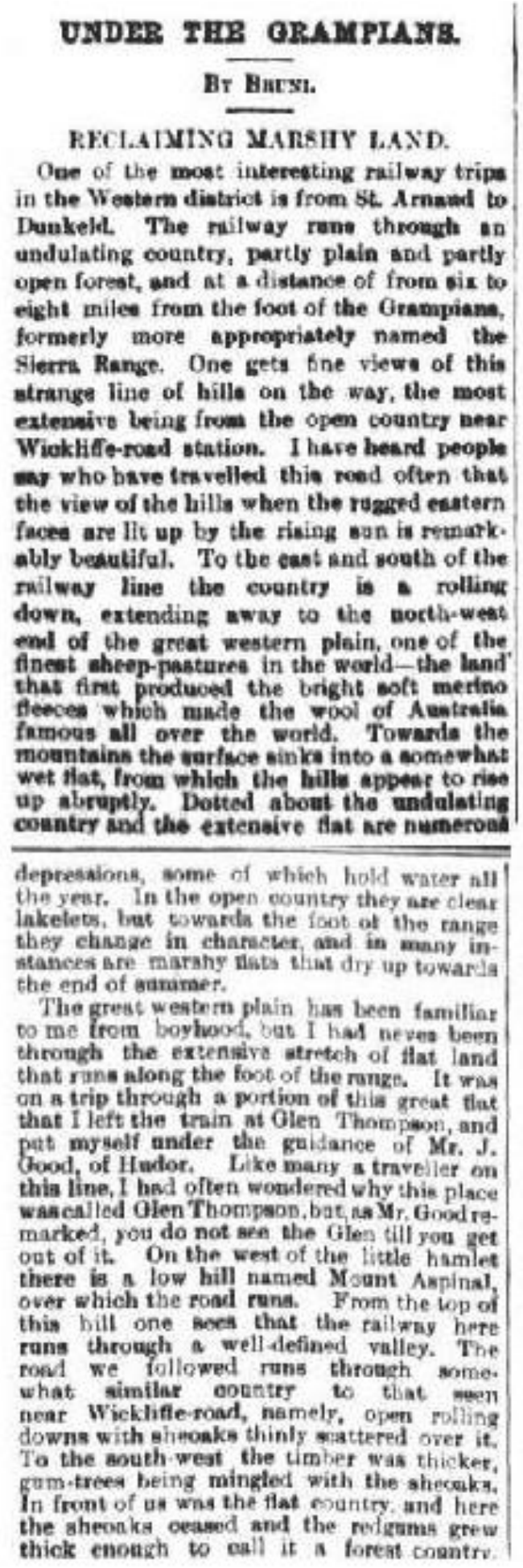
BY BRUNI.

RECLAIMING MARSHY LAND.

One of the most interesting railway trips in the Western district is from St Arnaud to Dunkeld. The railway runs through an undulating country, partly plain and partly open forest, and at a distance of from six to eight miles from the foot of the Grampians, formerly more appropriately named the Sierra Range. One gets fine views of this strange line of hills on the way, the most extensive being from the open country near Wickliffe-road station. I have heard people say who have travelled this road often that the view of the hills when the rugged eastern faces are lit up by the rising sun is remark ably beautiful. To the east and south of the railway line the country is a rolling down, extending away to the north-west end of the great western plain, one of the finest sheep-pastures in the world—the land that first produced the bright soft merino fleeces which made the wool of Australia famous all over the world. Towards the mountains the surface sinks into a somewhat wet flat, from which the hills appear to rise up abruptly. Dotted about the undulating country and the extensive flat are numerous depressions, some of which hold water all the year. In the open country they are clear lakelets, but towards the foot of the range they change.in character, and in many instances are marshy flats that dry up towards the end of summer.

The great western plain has been familiar to me from boyhood, but I had never been through the extensive stretch of flat land that runs along the foot of the range. It was on a trip through a portion of this great flat that I left the train at Glen Thompson, and put myself under the guidance of Mr. J. Good, of Hudor. Like many a traveller on this line, I had often wondered why this place was called Glen Thompson, but, as Mr. Good remarked, you do not see the Glen till you get out of it. On the west of the little hamlet there is a low hill named Mount Aspinal, over which the road runs. From the top of this hill one sees that the railway here runs through a well-defined valley. The road we followed runs through somewhat similar country to that seen near Wickliffe-road, namely, open rolling downs with sheoaks thinly scattered over it.

To the south-west the timber was thicker, gum-trees being mingled with the sheoaks. In front of us was the flat country, and here the sheoaks ceased and the redgums grew thick enough to call it a forest country.



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The grass on these downs is short and fine and not so thick as further away from the hills. To judge it by the invariable bush man's standard it is about sheep to the acre country. I was surprised to see the pastures present such a burned-up appearance.

There was not a trace of green visible in the paddocks; indeed, the country in the North-east district of Victoria is not nearly so dry, though the rainfall in both districts has been extremely scanty for the last four months.

My first halt was at the residence of Mr. G. Mirch, who has resided in this part of Victoria since the old squatting days. He owns a fairly-extensive pastoral property, partly in the timber and partly in the plain, on which he raises an excellent and very profitable description of comeback sheep. The house is situated on a sandy rise to the eastward of a good-sized lakelet, the water in which is quite salt. As Mr. Mirch has resided here for a good many years I was surprised to find the place so bare of anything like a flower garden. The explanation given is a peculiar one. Many years ago there was a very pretty garden round the house, but it became so infested with snakes that it was found necessary to do away with the garden in order that the house might be inhabitable. From what I saw and heard this neighbourhood should be a paradise for sportsmen. The marshes and lakelets are covered with all kinds of ducks and teal, while other aquatic birds and waders are in great variety. Snipe used to be very numerous, but they have been almost driven out of the country by pot-hunters. Wild turkeys are even yet fairly numerous, while at certain times myriads of birds flock down out of the mountains. That curse of Australia, the rabbit, has here a stronghold from which it has been found impossible to dislodge it. The work is carried on unceasingly by Mr. Mirch and his sons, wire netting is used to keep out the enemy, but as yet extermination of the rabbits seems as far off as ever.

As it was late in the day I accepted Mr. Mirch's invitation to remain with him that night, and go on to Mr. Good's place the next day. The sheep on Beulah are come backs of a pronounced merino character. The next change of sire will be to the long-wool. Though the pastures were so dried up the sheep were in excellent condition, and full of life. The wool grown in this country is of a most attractive character, being long in staple, lustrous, and extremely light in condition. It realises a high price in the London market, and is seldom surpassed by the merino clips of the West. The small lake in front, of the house is a most attractive piece of water. It is a favourite haunt of wildfowl, which are here seldom disturbed. Mr. Mirch's sons are excellent shots, and they never return from a shooting excursion empty handed. Mr. Mirch has a peculiar plan


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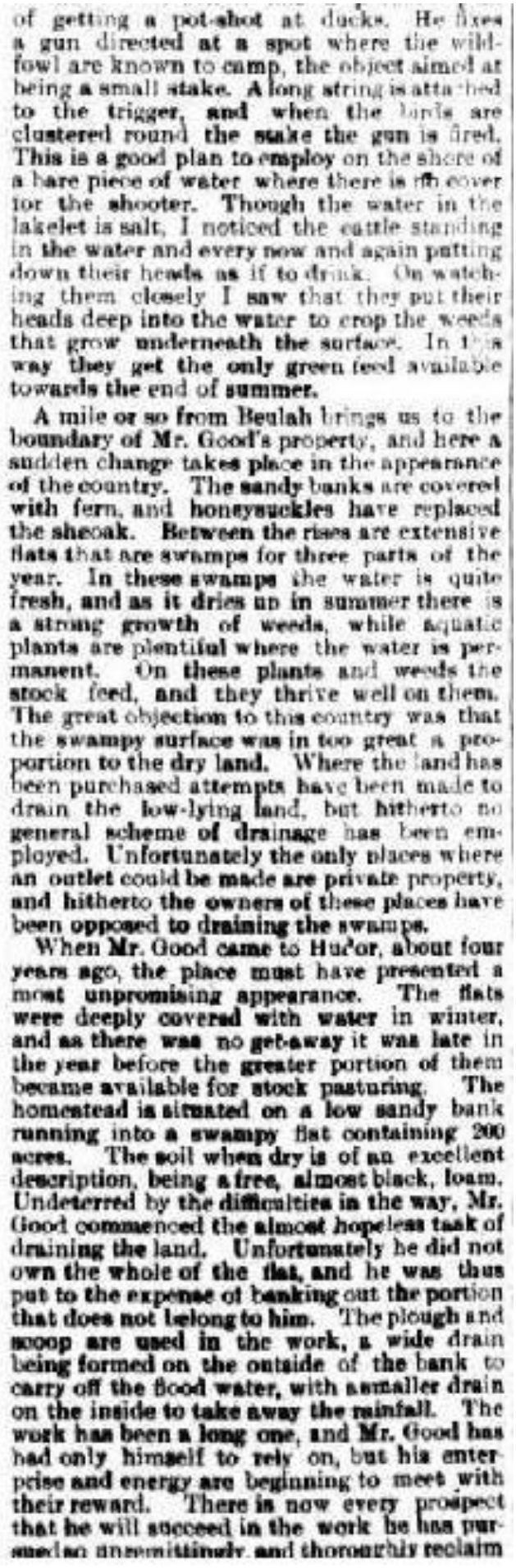
of getting a pot-shot at ducks. He fixes a gun directed at a spot where the wildfowl are known to camp, the object aimed at being a small stake. A long string is attached to the trigger, and when the birds are clustered round the stake the gun is fired.

This is a good plan to employ on the shore of a bare piece of water where there is no cover for the shooter. Though the water in the lakelet is salt, I noticed the cattle standing in the water and every now and again putting down their heads as if to drink. On watching them closely I saw that they put their heads deep into the water to crop the weeds that grow underneath the surface. In this way they get the only green feed available towards the end of summer.

A mile or so from Beulah brings us to the boundary of Mr. Good's property, and here a sudden change takes place in the appearance of the country. The sandy banks are covered with fern, and honeysuckles have replaced the sheoak. Between the rises are extensive flats that are swamps for three parts of the year. In these swamps the water is quite fresh, and as it dries up in summer there is a strong growth of weeds, while aquatic plants are plentiful where the water is permanent. On these plants and weeds the stock feed, and they thrive well on them. The great objection to this country was that the swampy surface was in too great a proportion to the dry land. Where the land has been purchased attempts have been made to drain the low-lying land; but hitherto no general scheme of drainage has been employed. Unfortunately the only places where an outlet could be made are private property, and hitherto the owners of three places have been opposed to draining the swamps.

When Mr. Good came to Hudor, about four years ago, the place must have presented a most unpromising appearance. The flats were deeply covered with water in winter, and as there was no get-away it was late in the year before the greater portion of them became available for stock pasturing. The homestead is situated on a low sandy bank running into a swampy flat containing 200 acres. The soil when dry is of an excellent description, being a free, almost black, loam. Undeterred by the difficulties in the way, Mr. Good commenced the almost hopeless task of draining the land. Unfortunately he did not own the whole of the flat, and he was thus put to the expense of banking out the portion that does not belong to him. The plough and scoop are used in the work, a wide drain being formed on the outside of the bank to carry off the flood water, with a smaller drain on the inside to take away the rainfall. The work has been a long one, and Mr. Good has had only himself to rely on, but his enterprise and energy are beginning to meet with their reward. There is now every prospect that he will succeed in the work he has pursued so unremittingly, and thoroughly reclaim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the flat near his house, the soil of which is of the highest fertility.

Mr. Good has already made an extensive drain to run the water off the 200-acre flat. Near the home there is a slight fall, and here he has erected a most ingenious and effective machine to take the surface water off the land from which the flood water is banked out. Across the large drain he has erected a broad paddle-wheel, which is turned by the stream. This works a wheel set in the small drain' inside the embankment, which as it revolves takes up water and runs it into the larger drain. This water-lifter is a circular box divided into five compartments, and at each revolution it lifts a ton of water. It was planned and constructed by Mr. Good, and from the first trial has acted most effectually. With this wheel in full work, Mr. Good is satisfied he can rapidly drain off all the rainwater that falls on the flat, even in the wettest seasons. The most important work is to make the embankment large enough to keep out the flood that runs through this flat country every winter.

Below the house is another and larger swamp, which in turn is connected with a series of large flats extending for several miles along the foot of the range in the direction of Mount Sturgeon, the extreme southern point of the range. Into this large swamp Mr. Good has run his main drain for a considerable distance, and the result has been highly satisfactory, the pasture being greatly improved for some distance back from the drain.

I was greatly taken with the soil in the drained swamp near Mr. Good's house. When worked it breaks up as fine as garden mould. From experiments made it is admirably fitted for growing roots of all kinds, peas, beans, and eventually oats and barley. A trial crop of peas planted here some time ago met with a curious fate. A heavy fall of rain occurred just as the peas were reaching their full growth. The embankment was not then made up to its present height, and the land was flooded. With the water came a great flock of black swans that cleared up all the peas. Trials with rape have been very successful. The plant thrives well in this deep, rich soil, and gives a large quantity of fodder. This season Mr. Good has sown a considerable area of the swamp with rape, which is coming on well. Mr. Good usually grows a large quantity of fodder for his stock in the autumn, which is here the worst time of the year. This season, owing to the cold late spring and the extremely dry summer, the maize crop is a comparative failure.

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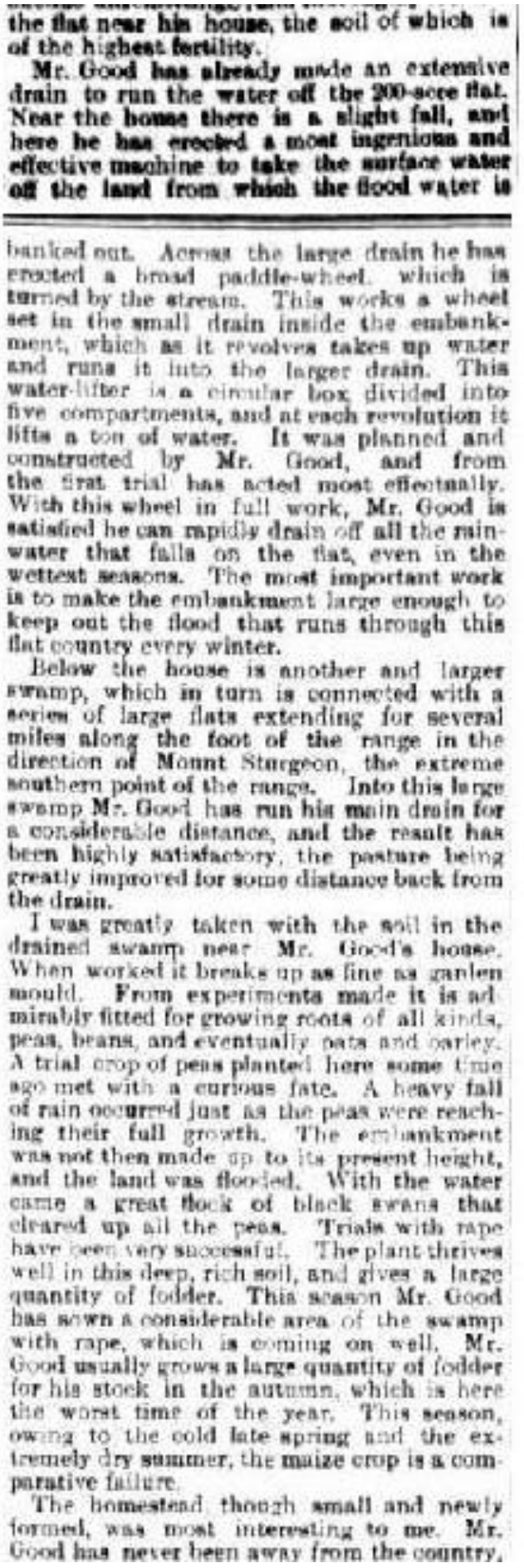

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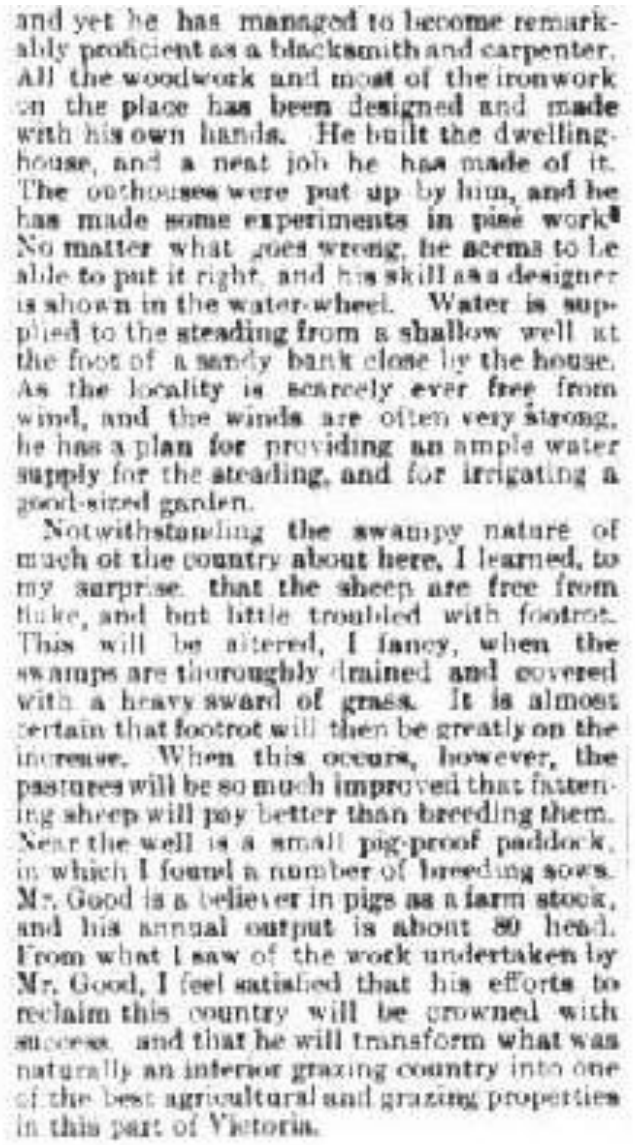
and yet he has managed to become remarkably proficient as a blacksmith and carpenter. All the woodwork and most of the ironwork on the place has been designed and made with his own hands. He built the dwelling house, and a neat job he has made of it.

The outhouses were put up by him, and he has made some experiments in pise work. No matter what goes wrong, he seems to be able to put it right, and his skill as a designer is shown in the water-wheel. Water is supplied to the steading from a shallow well at the foot of a sandy bank close by the house. As the locality is scarcely ever free from wind, and the winds are often very strong, he has a plan for providing an ample water supply for the steading, and for irrigating a good-sized garden.

Notwithstanding the swampy nature of much of the country about here, I learned, to my surprise, that the sheep are free from fluke, and but little troubled with footrot. This will be altered, I fancy, when the swamps are thoroughly drained and covered with a heavy sward of grass. It is almost certain that footrot will then be greatly on the increase. When this occurs, however, the pastures will be so much improved that fattening sheep will pay better than breeding them. Near the well is a small pig-proof paddock, in which I found a number of breeding sows. Mr. Good is a believer in pigs as a farm stock, and his annual output is about 80 head. From what I saw of the work undertaken by Mr. Good, I feel satisfied that his efforts to reclaim this country will be crowned with success, and that he will transform what was naturally an inferior grazing country into one of the best agricultural and grazing properties in this part of Victoria.



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The Australasian,
Saturday 16 April 1892, page 7 & 8

(*note the Wannon River is incorrectly referred to as the Loddon in the article)

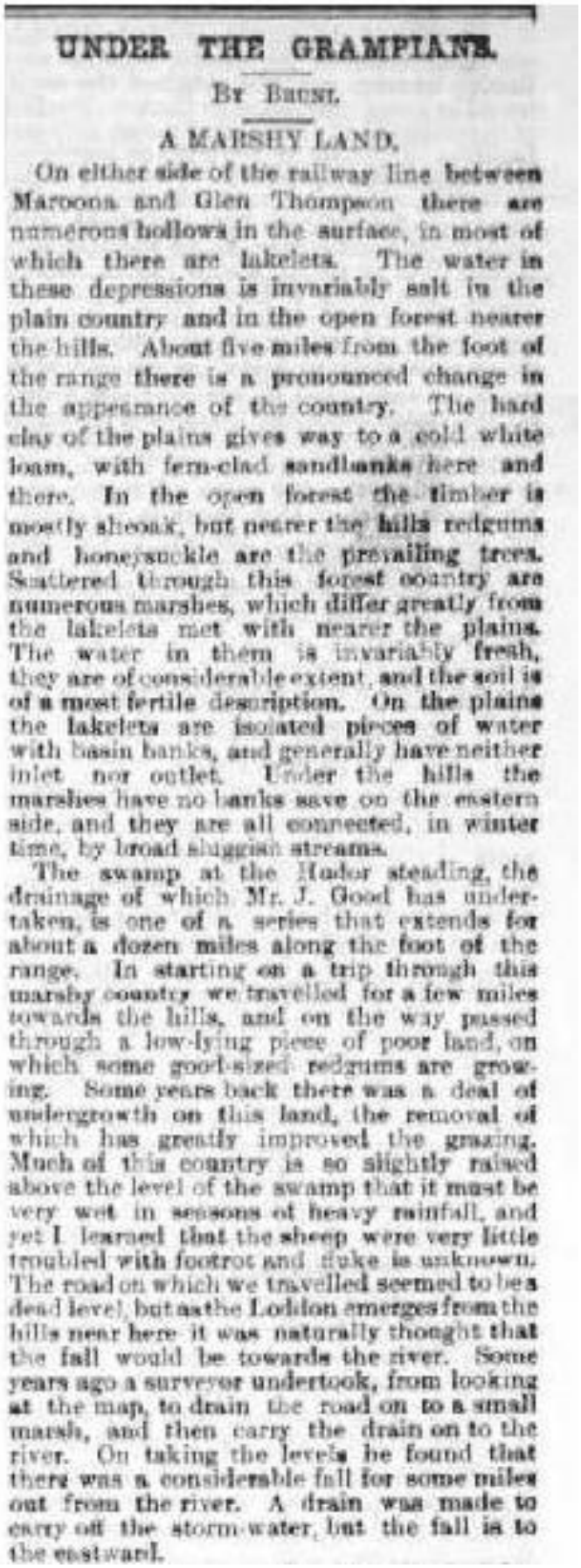
UNDER THE GRAMPIANS.

BY BRUNI.

A MARSHY LAND.

On either side of the railway line between Maroona and Glen Thompson there are numerous hollows in the surface, in most of which there are lakelets. The water in these depressions is invariably salt in the plain country and in the open forest nearer the hills. About five miles from the foot of the range there is a pronounced change in the appearance of the country. The hard clay of the plains gives way to a cold white loam, with fern-clad sandbanks here and there. In the open forest the timber is mostly sheoak, but nearer the hills redgums and honeysuckle are the prevailing trees. Scattered through this forest country are numerous marshes, which differ greatly from the lakelets met with nearer the plains. The water in them is invariably fresh, they are of considerable extent, and the soil is of a most fertile description. On the plains the lakelets are isolated pieces of water with basin banks, and generally have neither inlet nor outlet. Under the hills the marshes have no banks save on the eastern side, and they are all connected, in winter time, by broad sluggish streams.

The swamp at the Hudor steading, the drainage of which Mr. J. Good has undertaken, is one of a series that extends for about a dozen miles along the foot of the range. In starting on a trip through this marshy country we travelled for a few miles towards the hills, and on the way passed through a low-lying piece of poor land, on which some good-sized redgums are growing. Some years back there was a deal of undergrowth on this land, the removal of which has greatly improved the grazing. Much of this country is so slightly raised above the level of the swamp that it must be very wet in seasons of heavy rainfall, and yet I learned that the sheep were very little troubled with footrot and fluke is unknown. The road on which we travelled seemed to be a dead level, but as the Wannon* emerges from the hills near here it was naturally thought that the fall would be towards the river. Some years ago a surveyor undertook, from looking at the map, to drain the road on to a small marsh, and then carry the drain on to the river. On taking the levels he found that there was a considerable fall for some miles out from the river. A drain was made to carry off the storm-water, but the fall is to the eastward.



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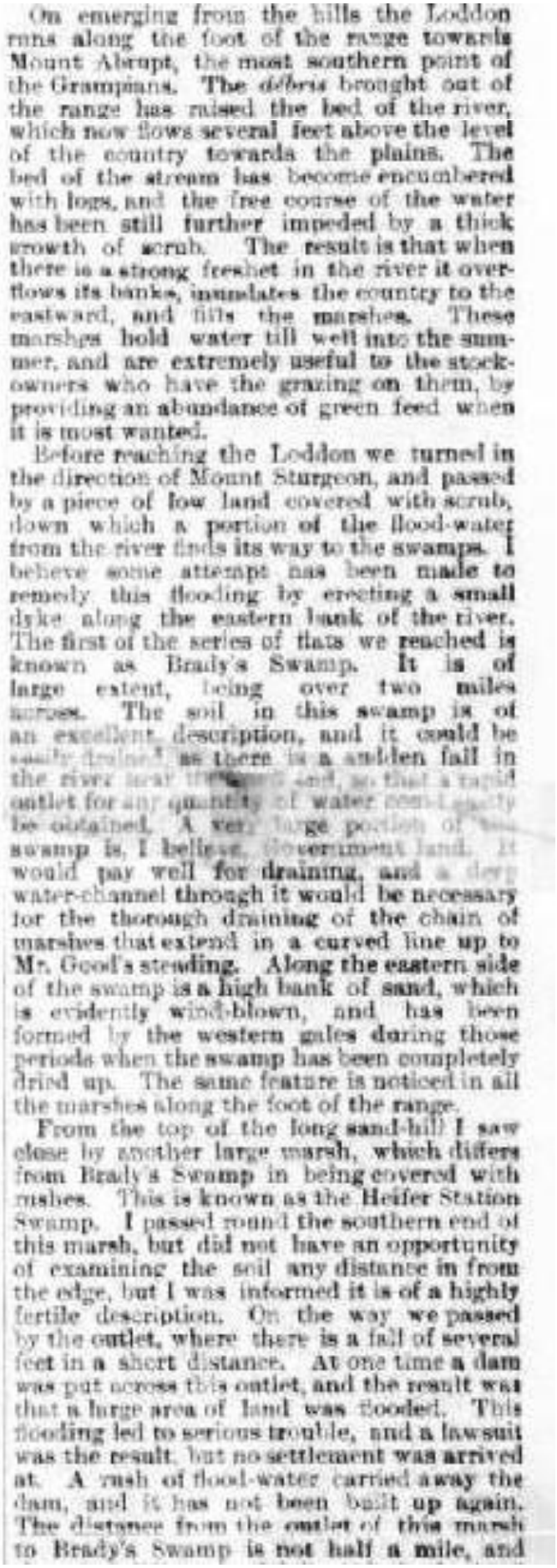
On emerging from the hills the Wannon runs along the foot of the range towards Mount Abrupt, the most southern point of the Grampians. The debris brought out of the range has raised the bed of the river, which now flows several feet above the level of the country towards the plains. The bed of the stream has become encumbered with logs, and the free course of the water has been still further impeded by a thick growth of scrub. The result is that when there is a strong freshet in the river it overflows its banks, inundates the country to the eastward, and fills the marshes. These marshes hold water till well into the summer, and are extremely useful to the stock owners who have the grazing on them, by providing an abundance of green feed when it is most wanted.

Before reaching the Wannon we turned in the direction of Mount Sturgeon, and passed by a piece of low land covered with scrub, down which a portion of the flood-water from the river finds its way to the swamps. I believe some attempt has been made to remedy this flooding by erecting a small dyke along the eastern hank of the river. The first of the series of flats we reached is known as Brady's Swamp. It is of large extent, being over two miles across. The soil in this swamp is of an excellent description, and it could be easily drained as there is a sudden fall in the river near its west end, so that a rapid outlet for any quantity of water could easily be obtained. A very large portion of the swamp is, I believe, Government land. It would pay well for draining, and a deep water-channel through it would be necessary for thorough draining of the chain of marshes that extend in a curved line up to Mr. Good's steading. Along the eastern side of the swamp is a high bank of sand, which is evidently wind-blown, and has been formed by the western gales during those periods when the swamp has been completely dried up. The same feature is noticed in all the marshes along the foot of the range.

From the top of the long sand-hill I saw close by another large marsh, which differs from Brady's Swamp in being covered with rushes. This is known as the Heifer Station Swamp. I passed round the southern end of this marsh, but did not have an opportunity of examining the soil any distance in from the edge, but I was informed it is of a highly fertile description. On the way we passed by the outlet, where there is a fall of several feet in a short distance. At one time a dam was put across this outlet, and the result was that a large area of land was flooded. This flooding led to serious trouble, and a lawsuit was the result, but no settlement was arrived at. A rush of flood-water carried away the dam, and it has not been built up again. The distance from the outlet of this marsh to Brady's Swamp is not half a mile, and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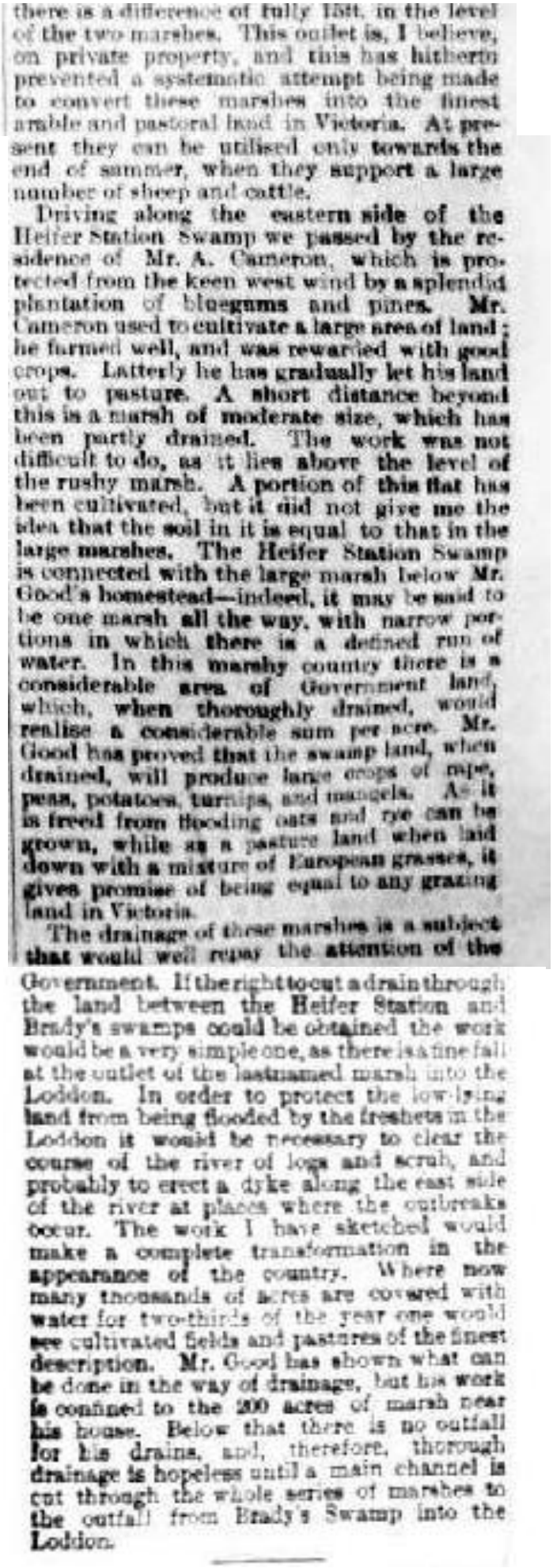
there is a difference of fully 15ft. in the level of the two marshes. This outlet is, I believe, on private property, and this has hitherto prevented a systematic attempt being made to convert these marshes into the finest arable and pastoral land in Victoria. At present they can be utilised only towards the end of summer, when they support a large number of sheep and cattle.

Driving along the eastern side of the Heifer Station Swamp we passed by the residence of Mr. A. Cameron, which is protected from the keen west wind by a splendid plantation of bluegums and pines. Mr. Cameron used to cultivate a large area of land; he farmed well and was rewarded with good crops. Latterly he has gradually let his land out to pasture. A short distance beyond this is a marsh of moderate size, which has been partly drained. The work was not difficult to do, as it lies above the level of the rushy marsh. A portion of this flat has been cultivated, but it did not give me the idea that the soil in it is equal to that in the large marshes. The Heifer Station Swamp is connected with the large marsh below Mr. Good's homestead—indeed, it may be said to be one marsh all the way, with narrow portions in which there is a defined run of water. In this marshy country there is a considerable area of Government land, which, when thoroughly drained, would realise a considerable sum per acre. Mr. Good has proved that the swamp land, when drained, will produce large crops of rape, peas, potatoes, turnips and mangels. As it is freed from flooding, oats and rye can be grown, while as a pasture land when laid down with a mixture of European grasses, it gives promise of being equal to any grazing land in Victoria.

The drainage of these marshes is a subject that would well repay the attention of the Government. If the right to cut a drain through the land between the Heifer Station and Brady's swamps could be obtained the work would be a very simple one, as there is a fine fall at the outlet of the lastnamed marsh into the Wannon. In order to protect the low lying land from being flooded by the freshets in the Wannon it would be necessary to clear the course of the river of logs and scrub, and probably to erect a dyke along the east side of the river at places where the outbreaks occur. The work I have sketched would make a complete transformation in the appearance of the country. Where now many thousands of acres are covered with water for two-thirds of the year one would see cultivated fields and pastures of the finest description. Mr. Good has shown what can be done in the way of drainage, but his work is confined to the 200 acres of marsh near his house. Below that there is no outfall for his drains, and, therefore, thorough drainage is hopeless until a main channel is cut through the whole series of marshes to the outfall from Brady's Swamp into the Wannon.



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