Planning for the future

Derwent Estuary Saltmarsh

Baseline Monitoring and Management

July 2020

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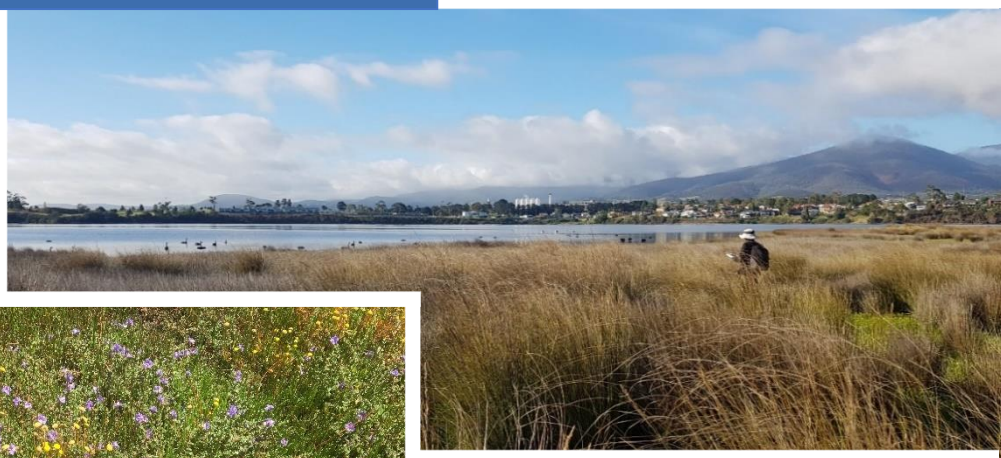

Derwent Estuary Program

UNIVERSITY of TASMANIA

The Derwent Estuary Program (DEP) is a regional partnership between local governments, the Tasmanian State Government, businesses, scientists, and community-based groups to restore and promote our estuary. The DEP was established in 1999 and has been nationally recognised for excellence in coordinating initiatives to reduce water pollution, conserve habitats and species, monitor river health and promote greater use and enjoyment of the foreshore.

Our major sponsors include Brighton, Clarence, Derwent Valley, Glenorchy, Hobart and Kingborough councils, the Tasmanian State Government, TasWater, Tasmanian Ports Corporation, Norske Skog Boyer, Nyrstar Hobart Smelter and Hydro Tasmania.

Contents

1 Project summary

Saltmarshes are well recognised as key environmental assets in the Derwent estuary. Yet, there has been a lack of knowledge about the plants, birds and ongoing human impacts on these wetlands. In response to this information gap, an estuary-wide, cross-tenure saltmarsh survey project commenced in 2018. Plant, bird, and human impact baseline data was collected in field surveys of 20 small and large representative saltmarshes across the estuary. Some limited photographic monitoring was also conducted in select locations. In addition, the past and the future extent of each saltmarsh surveyed was examined using historical aerial photos and modelling of future (potential) saltmarsh extent. This report presents the results of the field surveys, photographic monitoring, and extent modelling, with comments and tailored recommendations provided for each site. The data contributes to a State-wide effort to better map, monitor and manage Tasmanian saltmarshes.

The Derwent Estuary Program (DEP) has worked for several years to improve our knowledge about saltmarshes in the estuary, in particular the Lauderdale saltmarshes (the largest saltmarsh cluster in the Derwent estuary). This project contributes to this effort by providing the first detailed estuary-wide assessment (including the smaller and lesser-studied saltmarshes) of: (i) the current states of saltmarshes; (ii) their future conditions; and importantly, (iii) actions that can be taken by public and private land managers now and in the future, with key areas identified for improved management.

The most common concerns identified from the surveys pertain to weeds, rubbish, soil compaction, limited bird diversity, lack of vegetation buffer zones, and impacts from major developments within and adjacent to the saltmarshes.

Despite these issues, the overriding finding was that the surveyed sites were mostly functioning saltmarshes that, with attention to the issues identified, will continue to perform critical environmental services for years to come. Some key findings and management are summarised below. Section 4 of the report has detailed results of the surveys and Sections 5 and 6 provide site-specific comments, recommendations and actions. Additional information about any aspects of the survey, the sites and the data gathered is available from the DEP.

Key findings and management actions:

- Numerous introduced species were observed at most sites. While it would be preferable to have many of these weeds removed, this is considered unrealistic, and fortunately not all introduced species are highly invasive in saltmarshes. This project highlighted the most concerning species (i.e. in terms of altering saltmarsh function) requiring management. Some landholders will be able to incorporate management of these species into their wider land management tasks, while others will not have this capacity.

  ACTION: DEP to encourage and provide support for weed management at sites where needed by bringing public and private stakeholders and resources together for a collaborative approach.

- Rubbish build-up is occurring in most locations. The origin of the rubbish varies, but it appears mostly to be brought in by tide and currents, with dumping only apparent in a few places. As saltmarshes are fragile environments, especially those with predominantly succulent vegetation, clean-ups need to be conducted with care. While it is important to involve local residents and Coastcare groups, to encourage ownership and caretaking over a particular saltmarsh area, any clean-up needs to be managed sensitively so that compaction of vegetation is kept to a minimum. For some sites, small Clean Up Australia Day events may be appropriate.

- Examining the Future Coastal Refugia Area overlay (Prahalad *et al.*, 2019) across the sites indicates the potential for some saltmarshes to migrate upland as sea levels rise and storm surge height increases. The marshes with adequate refugia area are located across multiple private and public tenures, and despite the modelled 'compatibility' significant goodwill and effort will be required to achieve the desired outcomes. The rest of the sites have limited options for any future retreat due to either topography (high to steep land) or their urban settings, so they will most likely be subject to complete loss or at least shrink, over time. While there is limited potential for retreat for these latter sites, it is still imperative that their current location and surrounding habitat remains able to support a functioning saltmarsh going forward.

  ACTION: DEP to work with public and private landholders to encourage long-term protection of areas with potential as future saltmarsh habitat, as well as current marsh locations.

- Most sites would benefit from additional native plantings in their buffer/fringe zones to encourage terrestrial birds to the saltmarshes and to provide a buffer for introduced species. Conservation Volunteers Australia (CVA) has a wetland focus and has expressed an interest in assisting with small and large saltmarsh projects, and have already assisted the current project with surveys and rubbish in the Jordan River.

  ACTION: DEP to find land management and funding partners to develop an estuary-wide saltmarsh buffer zone planting project, e.g. CVA.

- At several of the saltmarshes surveyed there are at times dogs running off-lead. This is likely to be a common occurrence in our urban to semi-urban marshes, and reflects a frequent disregard to, and/or ignorance of, saltmarsh values. It is a serious problem due to the potential significant disturbance to the many bird species utilising the marshes for roosting, feeding and breeding (Spencer *et al.*, 2009). This problem requires a combination of community awareness-raising, possibly through signs and information delivered in person by council staff and others, and fines given to those dog owners who do not ensure their dogs are kept on lead.

  ACTION: DEP to work with individual councils to encourage saltmarsh and bird values to be interpreted to the local communities in a constructive manner, and to ensure saltmarshes are dog-free areas, or at the very least, on-lead areas.

- Several of the saltmarshes surveyed are impacted by compaction of vegetation from people walking, bike riding and in one case from vehicles. Saltmarshes, especially those with predominantly succulent vegetation, are very sensitive to repeated pedestrian passage. Informal walking tracks within saltmarshes should be avoided and where possible tracks should be consolidated, and ideally raised boardwalks installed, while ensuring they do not alter the hydrology of saltmarsh habitats (Department of Environment and Climate Change NSW, 2008).

  ACTION: Information and designs of boardwalks are available from DEP. DEP can work with councils to ensure track designs are appropriate for saltmarsh conservation.

- Most of the Derwent estuary saltmarshes surveyed are currently classified as AUS (Saltmarsh (undifferentiated) rather than the more specific ASS or ARS (Prahalad *et al.*, 2018). Finer scale vegetation classification will assist both regional and State-wide efforts in conservation planning.

  ACTION: DEP to provide corrections to DPIPWE on TASVEG communities as per data collected.

- The gathering of baseline data is critical for monitoring and comparison between sites and over time. Baseline data allows the effects of management actions to be monitored and provides a foundation for future management and research. It is suggested that these saltmarsh sites are surveyed every two to three years to provide support for management interventions. Additional bird surveys would also be beneficial for obtaining an improved picture of the birds utilising the estuary saltmarshes, at both high and low tides. Future data collection would preferably also include other components of saltmarsh ecology, e.g. fish, invertebrates, water quality, changes to flora and fauna composition, and soil health.

  ACTION: DEP to encourage (possibly coordinate) the next round of monitoring over the summer of 2020/21 or 2021/22, add any new data to the current dataset and continue working with landholders as appropriate.

2 Introduction

2.1 Saltmarshes - importance and threats

The Derwent estuary is the largest estuary in south-eastern Tasmania. The estuary extends from New Norfolk (maximum extent of saltwater) to the mouth of the River Derwent, which lies between Tinderbox and Iron Pot. It is a valuable and productive ecological system that supports important native vegetation remnants, including wetlands.

Saltmarshes are wetland habitats generally defined by the presence of halophytic communities (salt tolerant plants) that can tolerate high salinity levels and are subject to waterlogging (Adam, 1990). They occur in low energy coastal environments where the shoreline is protected, and in Tasmania they occupy the upper intertidal areas starting below the mean high tide mark and extending inland to the extent of storm tide flooding and salt spray (Prahalad *et al.*, 2009; Mount *et al.*, 2010). They rely on tidal connectivity to the sea as their primary driver of development, extent and function (Prahalad *et al.*, 2009). This connectivity can be regular (with the daily semidiurnal tidal flows) or intermittent (with episodic spring tides and storm surges), and can also include groundwater connectivity (Prahalad *et al.*, 2018).

Saltmarshes are critically important habitats that provide a range of ecosystem services. Prahalad and Pearson (2013) summarise these services as: supporting biodiversity, including crucial feeding, roosting and breeding habitats for resident and migratory shorebirds, water birds and many terrestrial bird species; sequestering carbon and attenuating global warming; increasing coastal food production through the production of organic materials that are exported to coastal waters with the tides; providing feeding, resting and nursery habitat for fish; improving the coastal water quality by intercepting land-driven nutrients and stabilising nutrient flows and reducing the likelihood of nutrient spikes in the system that can cause algal blooms; intercepting and settling down suspended sediments in the water column, which is critical for maintaining and enhancing coastal water quality; and for providing opportunities for recreation and education.

Threats to saltmarshes in Tasmania are many and varied. They include drainage and other alterations to natural water patterns; pollution from upstream and local activities, e.g. rubbish dumping, stormwater run-off, and unrestricted stock access; damage from recreational activities, such as off-road driving and informal walking tracks; and the introduction and spread of pest species, e.g. invasive weeds, and pets disturbing the wildlife (DPIPWE, 2000; DEE, 2016). Climate change influences on sea-level, storm-surge, and coastal erosion have also become considerable long-term threats to Tasmanian saltmarshes (Prahalad *et al.*, 2009).

It has been estimated that since 1950 most estuaries in south-east Australia have lost over a quarter of their saltmarsh, with some estuaries losing up to 80 % (DEE, 2016). Close to a half of southern Tasmanian saltmarshes have been lost or degraded due to land use change and impacts (e.g. being seen as waste lands and used as rubbish tips), sporadic and variable management approaches and lack of awareness of the important values provided by these habitats (Prahalad and Pearson, 2013).

2.2 Derwent Estuary Conservation Action Plan

In 2012, DEP and its partners, including a wide range of experts, developed the Derwent Estuary Conservation Action Plan (CAP). An exhaustive process identified and rated all conservation assets in the estuary. Saltmarshes were recognised as a key conservation asset, and given an overall Poor viability rating, based on: (i) historic saltmarsh loss meaning a smaller extent left across the estuary; (ii) the individual patches left are small; and (iii) limited retreat areas to move/migrate to with sea level rise (Einoder *et al.*, 2012).

CAP conservation objectives for saltmarshes included:

> **Objective 1**. By 2015, no reclamation or clearance within high value areas of saltmarsh, wetland, terrestrial foreshore vegetation, and inter-tidal areas, with approvals outside of these areas designed to minimise impacts on existing vegetation.
>
> **Objective 2.** By 2020, maximise the hydrological pathways of wetlands, saltmarshes and the inter-tidal zone, and begin establishing buffers around high priority sites to improve connectivity with adjacent habitat (support life-history cycles), and to provide retreat zones with sea level rise.

Since the CAP process, the DEP has worked extensively on increasing the recognition of the value of wetlands, including saltmarshes, through a range of policy mechanisms, such as the land use planning and approvals process. Notably in 2017, in collaboration with UTAS, the DEP was successful in including a Natural Assets Code as part of the new state-wide planning scheme, which provides provisions and scope for assessing developments within identified Waterway and Coastal Protection Areas and Future Coastal Refugia Areas (Prahalad *et al.*, 2019), see Section 3.4.

2.3 Vegetation community status and priority actions

In August 2013, Subtropical and Temperate Coastal Saltmarsh became one of six listed threatened ecological communities in Tasmania (vulnerable) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.* Tasmanian saltmarshes fall into this category.

The Conservation Advice associated with the federal listing identified key priority conservation actions (Threatened Species Scientific Commitee, 2013):

- *Avoid native vegetation clearance and destruction of the ecological community and its buffer zones; including protecting potential areas of natural retreat.*
- *Collate effective policies and management actions already in progress (including development controls) to support and widely disseminate best practice and lessons learnt.*
- *Undertake surveys to identify areas where natural retreat of Coastal Saltmarsh may be possible and actively manage them to enable natural retreat in the future.*
- *Undertake effective community engagement and education to promote the value of the ecological community (e.g. it is not 'wasteland' as some perceive); also to highlight the*

importance of minimising disturbance (e.g. during recreational activities) and of minimising pollution and littering (e.g. via signage).

- *Liaise with planning authorities to promote the inclusion of Coastal Saltmarsh protection and projected tidal inundation zones in their plans/responses to climate change and sea level rise and in coastal zone management generally.*

Other priority recovery and threat abatement actions from the same Conservation Advice include:

- *Provide appropriate buffer zones around patches of Coastal Saltmarsh to increase resilience and make land available to accommodate landward migration of saltmarshes.*
- *Implement best practice standards for managing remnants on private and public lands (e.g. include 'inundation easements' as part of any foreshore redevelopment).*
- *Monitor the progress of recovery, through improved mapping and condition assessments of Coastal Saltmarsh, and implement effective adaptive management strategies.*
- *Liaise with planning authorities to ensure that planning decisions take into account the protection of Coastal Saltmarsh, with due regard to the need for long-term conservation.*

Wherever possible, these priority actions have been considered throughout this project.

2.4 Relevant additional resources

Much more can be said about the Derwent estuary and the importance of, and threats to, saltmarshes. Therefore, it is suggested that this report is read in conjunction with the following resources that are available from the DEP upon request.

- The Future of the Derwent Estuary Saltmarshes and Tidal Freshwater Wetlands in Response to Sea Level Rise (Prahalad *et al.*, 2009).
- Lauderdale environmental assets: assessment of climate change impact on coastal and marine areas (Whitehead, 2012).
- Mapping coastal saltmarshes in southern Tasmania (Prahalad and Jones, 2013).
- Southern Tasmania coastal saltmarsh futures report. A Preliminary Strategic Assessment (Prahalad and Pearson, 2013).
- State of the Derwent 2015 (Coughanowr *et al.*, 2015).
- The creation and conservation effectiveness of State-wide wetlands and waterways and coastal refugia planning overlays for Tasmania, Australia (Prahalad *et al.*, 2019).

3 Methodology

3.1 Survey overview

The DEP was generously and expertly guided in the surveys by Dr Prahalad (UTAS) and assisted by local bird, wetland and estuary specialists (see Acknowledgements).

In order to obtain baseline data on the state of the Derwent saltmarshes, already-established citizen science methods were utilised to monitor bird abundance and diversity (3.6), vegetation diversity (3.5), and various human impacts (3.7). These indicators were chosen as they are deemed a good starting point to obtain an overview of the condition of the sites, and the tools and protocols were readily available (Dykman and Prahalad, 2018). Detailed field sheets for collecting such data had been developed by Natural Resource Management (NRM) North in collaboration with the University

of Tasmania (NRM North, 2017; Dykman and Prahalad, 2018). This material and other relevant saltmarsh information is freely available on NRM South's Saltmarsh Monitoring webpage https://www.nrmsouth.org.au/saltmarsh-monitoring/.

Surveys were conducted using a point-based 2 ha area search, following BirdLife Australia guidelines (Prahalad *et al.*, 2015). Where the saltmarsh patches were 1-2 ha in area, the whole site was surveyed. For sites > 2 ha, one or more 2 ha areas were surveyed (e.g. Lauderdale's Racecourse Flat Saltmarsh). Patches under 1 ha in area were excluded from this study or used for photo monitoring.

Mapping was undertaken using the Open Source Geographic Information System QGIS. The base layer for all maps is Basemap Orthophoto WMS Version 1.3.0 from Land Tasmania through LISTmap.

Property Services (previously Crown Land Services) and Parks & Wildlife Services (PWS) were contacted for permission to access sites. PWS requested that care be taken to avoid disturbing shorebirds and migratory birds nesting and roosting, in particular at Ralphs Bay and South Arm, and to maintain distance if present.

3.2 Site selection and locations

Saltmarshes are geomorphic landforms and tend to 'cluster' around a coastal landscape feature, for example a creek mouth or sheltered embayment, such as the Windermere Bay saltmarsh at Faulkners Rivulet and the Lauderdale saltmarshes at Ralphs Bay. A 2013 mapping project led by NRM South identified and mapped all the Derwent saltmarsh clusters (Prahalad and Jones, 2013):

- Ralphs Bay - Lauderdale Saltmarsh Cluster (84 ha)
- Ralphs Bay - South Arm Saltmarsh Cluster (31 ha)
- Middle Derwent Estuary Fringing Marshes (8 ha)
- Clarence Plains Rivulet Saltmarsh Cluster (3 ha)
- Browns River Saltmarsh Cluster (2 ha)
- Risdon Cove (piyura kitina) Saltmarsh Cluster (2 ha)

The aim was to monitor at least one site in each cluster, or more in larger clusters. Thus 15 survey sites across 12 saltmarshes were chosen as representative samples of saltmarshes in the Derwent estuary. In addition, five sites in the estuary were chosen for limited survey or photo monitoring only, due to their small size (< 1 ha). Table 1 and Table 2 list the survey sites and photo monitored sites, site codes, and dates of the surveys, and Figure 3-1 shows map locations.

Table 1. The 15 sites surveyed for the Derwent estuary saltmarsh project. There were two surveys of each site; the first involved full surveys of plants, birds and human impacts, and the second visit was for a second bird survey.

	Site codes	Site name	1st survey date	2nd survey date
1	**WB**	Windermere Bay	4 Dec 2018	17 Feb 2019
2	**GP**	Green Point	19 Dec 2018	31 Jan 2019
3	**GB**	Gage Brook	19 Dec 2018	31 Jan 2019
4	**OB**	Old Beach	5 Dec 2018	23 Mar 2019
5	**pk**	piyura kitina (Risdon Cove)	5 Dec 2018	23 Mar 2019
6	**CP**	Clarence Plains	28 Sep 2018	19 Dec 2018
7	**SA1**	South Arm (1)	6 Dec 2018	28 Mar 2019
8	**SA2**	South Arm (2)	6 Dec 2018	28 Mar 2019
9	**SA3**	South Arm (3)	28 Mar 2019	25 Apr 2020
10	**DR**	Dorans Road	6 Dec 2018	28 Mar 2019
11	**RF1**	Racecourse Flats (1)	6 Dec 2018	28 Mar 2019
12	**RF2**	Racecourse Flats (2)	19 Dec 2018	28 Mar 2019
13	**RF3**	Racecourse Flats (3)	28 Mar 2019	25 Apr 2020
14	**RF4**	Racecourse Flats (4)	28 Mar 2019	25 Apr 2020
15	**BR**	Browns River	4 Dec 2018	6 Mar 2019

Table 2. The four photo-monitored sites and one limited survey site as part of the Derwent estuary saltmarsh project.

	Site codes	Site name	Date of site visit/survey	Purpose
1	**SB**	Shag Bay *	5 Dec 2018	Plant survey, observation
2	**WS**	Windermere Bay (south)	4 Dec 2018	Photo monitoring, observation
3	**GA**	Glenorchy Arts & Sculpture Park (GASP)	4 Dec 2018	Photo monitoring, observation
4	**FG**	Faggs Gully Creek (Geilston Bay)	5 Dec 2018	Photo monitoring, observation
5	**MO**	Montrose Bay High School	4 Dec 2018	Photo monitoring, observation

* There was no bird or human impact survey for Shag Bay as the area is < 0.5 ha. and thus, unsuitable for the 2 ha monitoring method used at other full survey sites.

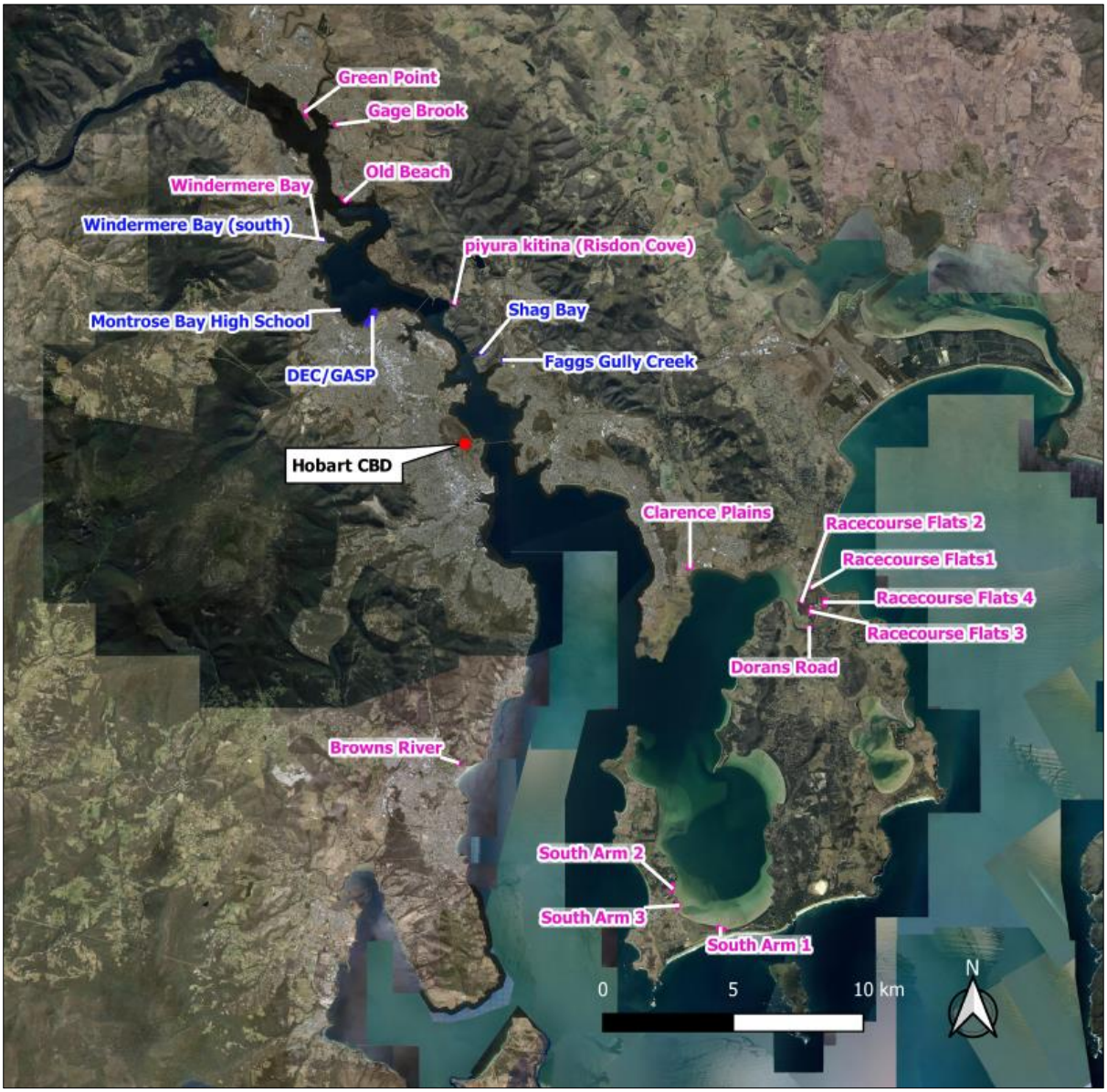

Figure 3-1. Map of the Derwent estuary showing saltmarsh locations included in Derwent estuary saltmarsh project. Pink: survey sites. Blue: limited survey and photo monitored sites.

3.3 Historical images

In addition to collecting on-ground data, sites were also examined using historical aerial images obtained from Land Tasmania, Department of Primary Industries, Parks, Water and Environment (DPIPWE). These images were mostly from 1946 (earliest available date) and provided valuable information about the historical extent of saltmarsh across the estuary. Given the long history of urbanisation and other developments in Hobart, in many cases there had already been significant modification of saltmarshes by the 1940s (e.g. areas in Sullivans Cove, Sandy Bay, New Town Bay, Kangaroo Bay and Montagu Bay). The extent of saltmarsh prior to 1940s in these areas is therefore not known with certainty. A Master's thesis project by Hsuan-Ju (Sandy) Wang (supervised by the co-author, VP) compared 1946 and current aerial images to evaluate the extent of saltmarsh loss and the associated infill development type across the Derwent estuary during this time period. Data sourced from this project is used in this report to compare historic and current extent (Figure 3-2).

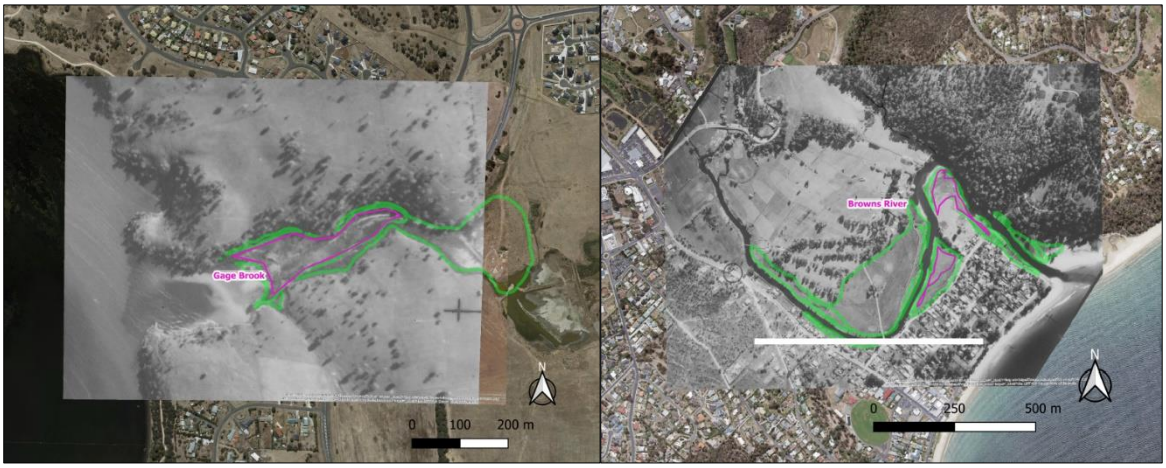

Figure 3-2. Examples of 1946 aerial images in the Derwent estuary. Green polygons: lost marsh since 1946. Pink polygons: survey sites. Left: Gage Brook saltmarsh. Right: Browns River saltmarsh.

3.4 Refugia overlay

Each site was also studied through the filter of the Future Coastal Refugia Area planning overlay, an open source online map application maintained by Land Information System Tasmania (LIST) - available through LISTmap (https://maps.thelist.tas.gov.au/listmap/app/list/map). The Refugia layer shows the potential retreat paths of wetlands when natural processes are allowed to occur, including landward migration due to sea-level rise. The overlay is based on flood inundation modelling and shows the area that is vulnerable to a 1% AEP (annual exceedance probability) storm event by the year 2100. Result categories were developed upon advice from the Tasmanian Planning Commission as to which planning zones were compatible with current land use zoning under the Tasmanian Interim Planning Scheme. Figure 3-3 shows the compatibility categories, separated into modelling of areas where LiDAR DEM (Digital Elevation Model) coverage was available or absent (Prahalad *et al.*, 2019), and an example of its use at Old Beach.

Figure 3-3. Left: Categories for Future Coastal Refugia Area data (The LIST), divided into compatibility zones according to how modelling of future retreat areas fit in with the Tasmanian Interim Planning Scheme. Right: Old Beach saltmarsh (survey area in pink) with the Refugia overlay showing that if the marsh is allowed to migrate inland over time, a large area would be in the Incompatible zone (bright darker green) due to current zoning for housing use.

3.5 Plant surveys

Plants were identified through visual inspection as either present or not present, their flowering status noted, and taxonomically grouped into families and individual species. This was achieved by visually scanning the 2 ha search area with attention to capturing the diversity in the vegetation types (Prahalad *et al.*, 2018).

The species composition was further identified within TASVEG community types, as predominantly Saline Sedgeland/Rushland (ARS) or Succulent Saline Herbland (ASS), by estimating abundance of dominant species such as *Juncus kraussii, Gahnia filum, Sarcocornia* spp. and *Tecticornia arbuscula* (DPIPWE, 2005; Prahalad *et al.*, 2018). Some plant species were also identified according to their occupancy within saltmarshes, i.e. as Obligates, Common, Uncommon or Occasional within saltmarshes, as per Prahalad *et al.* (2018).

Numerous introduced species were encountered, but only a few species were considered to be of management concern (i.e. requiring intervention) and these were noted and their cover estimate recorded separately (Prahalad *et al.*, 2018).

The lateral extent and width (both within a 100 m buffer from the edge of the saltmarsh towards upland) and the vegetation composition of this fringing vegetation around each site (native species relative to introduced species) were also estimated. The estimate of the lateral extent of fringing vegetation was based on the % of the landward boundary of the saltmarsh abutted by non-saltmarsh vegetation including trees, shrubs and grasses. The estimate of the width of fringing vegetation was based on the % of the landward boundary of the saltmarsh abutted by non-saltmarsh vegetation including trees, shrubs and grasses - to a width of 100m or more.

3.6 Bird surveys

Bird species, their numbers and behaviour were recorded during 20-minute survey periods by walking across the site using binoculars and only counting the birds within the saltmarsh. Bird behaviour was noted as either 'feeding, roosting or nesting' (Dykman and Prahalad, 2018). Behaviour was noted to demonstrate the ecological function of the marsh to the birds, and to disaggregate birds flying over the saltmarsh area and thus not utilising the saltmarsh as a habitat (Neckles *et al.*, 2002).

Data on birds included two surveys for all sites, one each for high and low tide (except at Windermere Bay and Browns River where both surveys were at high tide). This was done to account for the potential effect of tidal inundation on bird behaviour. Bird surveys were also controlled for both time of day and weather conditions, by conducting the surveys at similar times before midday and in similar fine weather conditions (Prahalad *et al.*, 2015).

3.7 Human impact surveys

Human impacts were noted across the site and grouped as presence/absence of livestock and feral animal disturbance, inappropriate development within and adjacent to the site, other inappropriate habitat disturbance features (e.g. dumping of rubbish, informal walking tracks) and algal blooms. Percentage groupings were utilised: < 5 %, 5-30 %, 30-70 %, > 70 % (of total area).

4 Overall site results

4.1 Plants

A total of 104 plant species were observed across the sites, which included 42 introduced species. All plant species are listed in Appendix 9.1.

The most commonly observed plant species across the Derwent estuary was *Juncus kraussii* subsp. *australiensis* (sea rush), recorded at 15 sites (including Shag Bay), followed by *Sarcocornia quinqueflora* subsp. *quinqueflora* (beaded glasswort) and *Austrostipa stipoides* (coast speargrass), both recorded at 14 sites. Most of these commonly found species have been identified to be either Obligates or Common in Tasmanian saltmarshes (Table 3) (saltmarsh occupancy for other species can be found in Appendix 9.1).

Table 3. Common plant species observed at a minimum ten of the saltmarsh sites surveyed. All species are native to Tasmania, except *Atriplex prostrata*. Asterisks refer to saltmarsh habitat occupancy code as per Prahalad *et al.* (2018) (Obligate, Common or Occasional in saltmarshes).

Scientific Name	Common Name	WB	GP	GB	OB	pk	CP	SB	SA 1	SA 2	SA 3	DR	RF 1	RF 2	RF 3	RF 4	BR
Juncus kraussii* subsp. *australiensis	Sea rush	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√
Sarcocornia quinqueflora* subsp. *quinqueflora	Beaded glasswort	√		√	√	√	√	√	√	√	√	√	√	√	√		√
****Austrostipa stipoides***	Coast speargrass	√			√	√	√	√	√	√	√	√	√	√	√	√	√
Selliera radicans	Shiny swampmat	√	√	√	√	√	√	√	√		√	√		√		√	√
Samolus repens* var. *repens	Creeping brookweed	√	√	√	√	√	√	√	√	√	√	√		√			√
****Gahnia filum***	Chaffy sawsedge	√		√	√	√	√		√	√	√	√	√	√		√	√
*****Poa* spp.**	Tussock grass	√	√	√	√	√		√		√	√	√	√	√		√	√
****Atriplex prostrata***	Creeping orache	√	√	√	√	√		√	√		√		√	√			√
*****Ficinia nodosa***	Knobby clubsedge	√			√	√		√	√	√	√	√				√	√

* saltmarsh Obligate species, ** saltmarsh Common species, *** saltmarsh Occasional species, **** most *Poa* spp. are Occasional species in saltmarshes (Prahalad *et al.*, 2018).

The sites with the highest plant diversity were SA1 (South Arm Neck) and DR (Dorans Road), and the least diverse site was RF3 (Racecourse Flats) (Figure 4-1). More detailed site-specific results of plant surveys are included in individual site descriptions in Section 5.

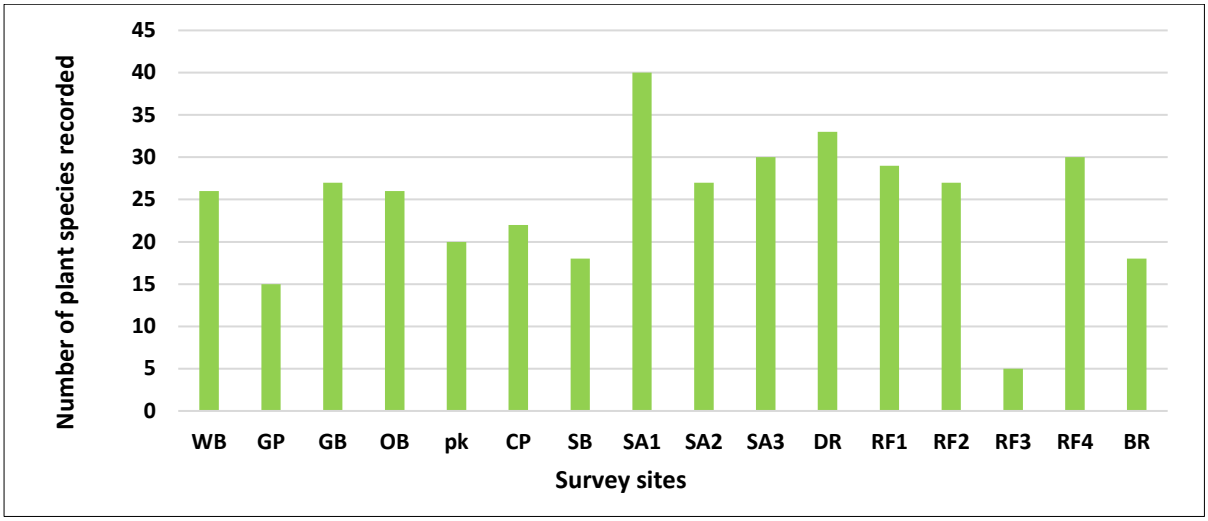

Figure 4-1. Plant diversity; total number of plant species observed at each survey site.

4.1.1 TASVEG communities

The most southern and eastern sites, at South Arm and Lauderdale, were classified as TASVEG community type ASS, whereas all others were ARS. The species composition of ARS and ASS at each site varied greatly. Some sites were predominantly one vegetation type, such as Dorans Road (DR), estimated to be 20% ARS and 80% ASS, and Green Point (GP), with 70% ARS and 30% ASS. Other sites showed less dominance of either vegetation type, such as Old Beach (OB) with 60% ARS and 40% ASS (Table 4). The complete results for the proportion of each TASVEG community found at each site can be found in Appendix 9.2.

Table 4. Percentage ARS and ASS TASVEG community coverage at surveyed sites.

	WB	GP	GB	OB	pk	CP	SB	SA 1	SA 2	SA 3	DR	RF 1	RF 2	RF 3	RF 4	BR
ARS %	75	65	70	60	90	25	60	40	25	40	20	20	30	20	35	75
ASS %	25	35	30	40	10	70	40	60	75	60	80	80	70	80	65	25
Combined TASVEG Class	ARS	ARS	ARS	ARS	ARS	ASS	ARS	ASS	ASS	ASS	ASS	ASS	ASS	ASS	ASS	ARS

4.1.2 Introduced species

Numerous introduced species were observed at most sites, but only a small number were considered to be of management concern, the most common being *Rosa rubiginosa* (sweet briar). These species of management concern include Weeds of National Significance (WoNS, nationally declared), Tasmanian declared weeds (under the Tasmanian *Weed Management Act 1999),* environmental weeds (species that invade bushland and threaten native plants by out-competing them), and non-declared weeds. Invasive species are listed in Table 5, some with approximate coverage indicated.

Table 5. Invasive species observed at saltmarsh sites that require management, with approximate cover in square metres. Ticks indicate presence of weeds with extent unspecified.

Scientific Name	Common Name	Weed status	WB	OB	pk	CP	SA2	DR	RF1	RF2	RF4
***Rubus fruticosus* agg.**	Blackberry	WoNS + Declared Tas.				5 m^2	50-100 m^2				
Chrysanthemoides monilifera* ssp. *monilifera	Boneseed	WoNS + Declared Tas.				2 m^2					
Lycium ferocissimum	African boxthorn	Declared Tas.					10 m^2				
Pinus radiata	Radiata pine	Non-declared					1 m^2				
Rosa rubiginosa	Sweet briar	Non-declared		2 m^2	1 m^2	√	10 m^2			1 m^2	
Juncus acutus	Sharp rush	Non-declared (considered an upcoming potential problem)	√								
Erica lusitanica	Spanish heath	Declared Tas.									√
Coprosma repens	Mirror bush	Environmental weed	√								
***Asparagus* sp.**	Asparagus	Environmental weed	√					√	√		

4.1.3 Fringing vegetation

The lateral extent and width of fringing vegetation varied greatly across sites, as did its composition. Six of 15 sites scored less than 30 % in the lateral extent and width of fringing vegetation categories, while most of same fringing vegetation was made up of native species with only two sites scoring less than 30 % (Table 6). Further details for each site are provided in Section 5.

Table 6. Extent and condition of fringing vegetation adjacent to surveyed sites. Yellow highlights areas of concern.

Site code	Lateral extent	Width	Native vegetation composition
WB	<5%	<5%	>70%
GP	100%	>70%	5-30%
GB	100%	>70%	30-70%
OB	<5%	<5%	100%
pk	30-70%	5-30%	>70%
CP	>70%	30-70%	30-70%
SA1	<5%	<5%	>70%
SA2	100%	>70%	30-70%
SA3	>70%	>70%	>70%
DR	<5%	5-30%	>70%
RF1	<5%	<5%	>70%
RF2	>70%	30-70%	>70%
RF3*	N/A	N/A	N/A
RF4	100%	>70%	>70%
BR	5-30%	<5%	5-30%

* The survey site is a section of saltmarsh entirely within a larger marsh patch thus has no fringe, see Figure 5-25.

4.2 Birds

A total of 40 bird species were identified using the saltmarshes during the surveys. The most commonly observed bird species across the estuary was the Welcome Swallow (*Hirundo neoxena*), recorded at 11 of the 15 sites, followed by the Tasmanian Native-Hen (*Tribonyx mortierii*) at eight sites (Figure 4-2). The number of bird species observed at each site, i.e. the species diversity, is presented in Figure 4-3, with great variation between sites, from 13 species at Windermere Bay to one species at Racecourse Flats 2. All bird species observed at all sites are listed in Appendix 9.3.

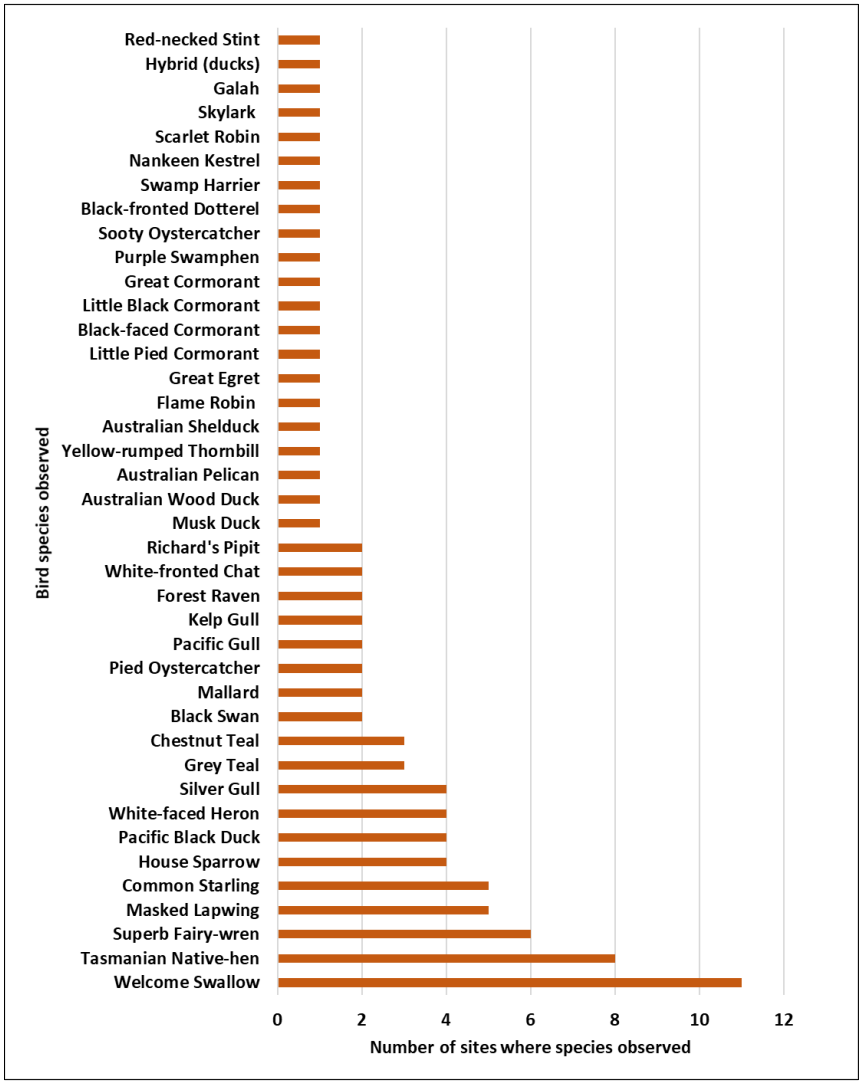

Figure 4-2. Bird species diversity, number of sites where each bird species was observed.

Previous research has divided the 113 bird species that utilise Tasmanian saltmarshes into saltmarsh specialists, saltmarsh generalists, or vagrant bird species that occasionally venture into saltmarshes (Prahalad *et al.*, 2015). The ten most common bird species in this project was categorised similarly, with three specialists, five generalists, and one occasional visitor (Table 7). For a full list of observed species and their classification, see Appendix 9.3.

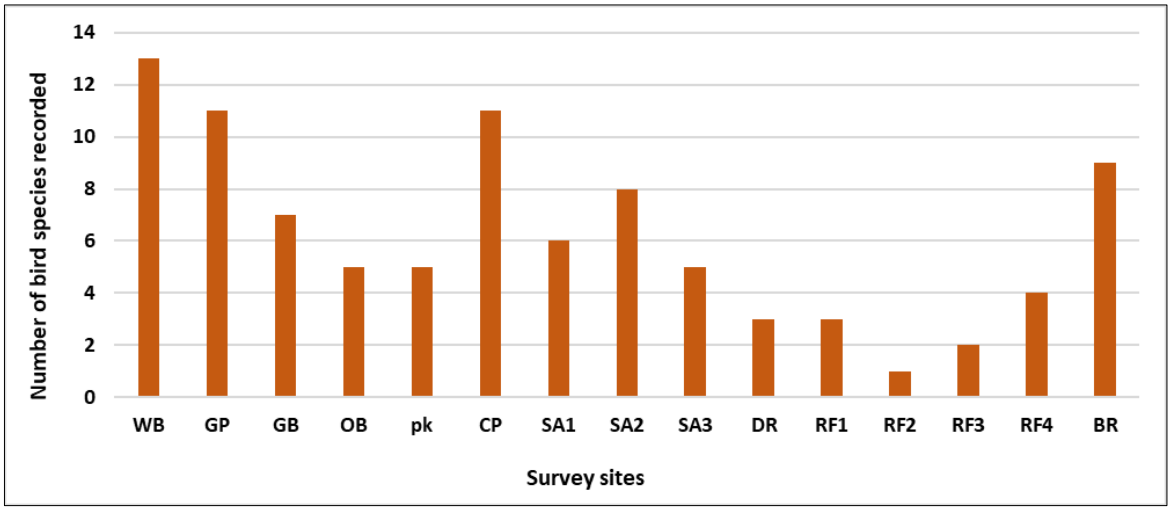

Figure 4-3. Site diversity, number of bird species observed at each survey site (unconfirmed species at OB and SA2 not included – see Appendix 9.3 for details).

Table 7. The 10 most common bird species observed, with saltmarsh specialisation classification according to saltmarsh habitat usage (Prahalad *et al.*, 2015).

	1	2	3	4	5	6	7	8	9	10
Bird species	Welcome Swallow	Tasmanian Native-hen	Superb Fairy-wren	Masked Lapwing	Common Starling	House Sparrow	Pacific Black Duck	White-faced Heron	Silver Gull	Grey Teal
Saltmarsh usage	Generalist	Generalist	Generalist	Specialist	Generalist	Occasional	Generalist	Specialist	Generalist	Specialist

The tide levels were found to affect bird numbers recorded, with substantially more birds observed *within* the saltmarshes at high tide than low tide (Figure 4-4). This is likely to be associated with low tide attracting some species (e.g. shorebirds) to the exposed mudflats. All bird numbers and behaviour per site and per tide level are listed in Appendix 9.3. Incidental sightings, both sightings in the saltmarsh outside the allocated 20 min survey time, and those birds observed adjacent to the site were recorded and are listed in Appendix 9.4. Further comments about bird results are included in the individual site results (Section 5). WB and BR were surveyed twice, but both times at high tide.

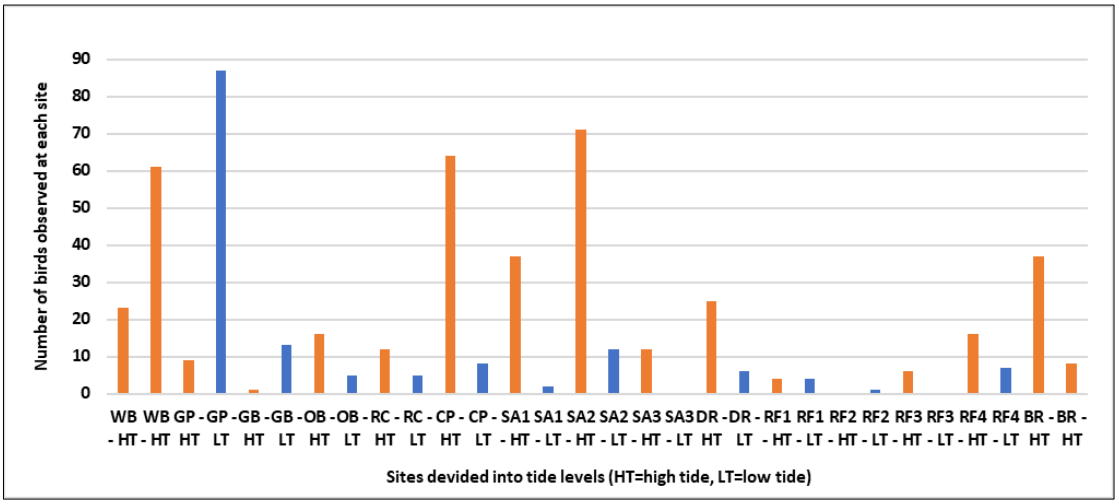

Figure 4-4. Total number of birds observed at each survey site with tide level indicated by colour. HT = high tide (orange), LT = low tide (blue).

4.3 Human impacts

The most common human impact category found across the estuary was 'Major inappropriate development adjacent' to the sites, followed by 'Rubbish debris' and 'Major development within' the sites, as highlighted in Table 8. Additional details for each site are provided in Section 5.

Table 8. Human impact survey results for each survey site with problem areas highlighted.

	Livestock disturbance		Feral animal disturbance		Inappropriate development		Other						Algal blooms	
Site code	Grazing within	Grazing adjacent	Impacts within	Impacts adjacent	Major development within	Major development adjacent	Rubbish debris	Rubbish dumping	Roads	4WD tracks	Drainage channels, levees, ditches	Other inappropriate features	Nuisance algal blooms on saltmarsh platform	Nuisance algal blooms in tidal channels/flats
WB	<5%	<5%	<5%	<5%	5-30%	>70%	5-30%	<5%	<5%	<5%	<5%	30-70%	<5%	5-30%
GP	<5%	<5%	<5%	<5%	<5%	5-30%	5-30%	5-30%	<5%	<5%	<5%	0%	<5%	5-30%
GB	<5%	<5%	<5%	<5%	<5%	5-30%	5-30%	5-30%	<5%	<5%	<5%	0%	<5%	5-30%
OB	<5%	<5%	<5%	<5%	5-30%	>70%	5-30%	<5%	5-30%	<5%	5-30%	<5%	<5%	<5%
pk	<5%	<5%	<5%	<5%	5-30%	30-70%	30-70%	<5%	<5%	<5%	<5%	<5%	<5%	5-30%
CP	<5%	<5%	<5%	5-30%	<5%	5-30%	5-30%	<5%	<5%	<5%	<5%	0%	5-30%	>70%
SA1	<5%	<5%	<5%	<5%	5-30%	30-70%	5-30%	<5%	<5%	<5%	<5%	<5%	<5%	<5%
SA2	<5%	<5%	<5%	<5%	<5%	30-70%	<5%	<5%	<5%	<5%	<5%	<5%	5-30%	<5%
SA3	<5%	<5%	<5%	<5%	<5%	5-30%	5-30%	<5%	<5%	<5%	<5%	5-30%	5-30%	<5%
DR	<5%	<5%	<5%	<5%	5-30%	30-70%	30-70%	<5%	<5%	<5%	5-30%	0%	5-30%	<5%
RF1	<5%	<5%	<5%	<5%	30-70%	>70%	<5%	<5%	<5%	<5%	<5%	0%	<5%	<5%
RF2	<5%	<5%	<5%	<5%	5-30%	30-70%	<5%	<5%	<5%	<5%	30-70%	0%	5-30%	<5%
RF3	<5%	<5%	<5%	<5%	<5%	30-70%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%
RF4	<5%	<5%	5-30%	5-30%	<5%	5-30%	30-70%	<5%	<5%	<5%	<5%	<5%	<5%	<5%
BR	<5%	<5%	<5%	5-30%	30-70%	>70%	5-30%	<5%	5-30%	<5%	<5%	5-30%	<5%	30-70%

4.4 Future extent of saltmarsh

Potential future extent modelling indicated that while some sites have compatible refugia area available, other sites are restricted and may have limited capacity to retreat. Table 9 lists all survey sites with brief comments on possible future saltmarsh extent according to the Future Coastal Refugia Area overlay modelling (Prahalad *et al.*, 2019). Each result is followed by a rating (Good, Fair, Poor) based on both the availability of low-lying areas nearby to retreat to with sea level rise and the land use zoning and ownership of the area. This rating is consistent with the classification used by Prahalad and Pearson (2013), which employs three categories to indicate the availability of low lying areas nearby suitable for saltmarsh: Sufficient room to move; Some room to move; and Backed by steep upland. There are seven Good, four Fair, and six Poor sites. Additional details for each site are provided in Section 5.

Table 9. List of all saltmarsh sites, with comments on potential future saltmarsh extent and an overall Refugia rating for comparison.

	Site code	Coastal Future Refugia Area overlay notes	Refugia rating
Surveyed	**WB**	Significant *Compatible* area available (local govt + public reserve).	Good
	GP	Limited additional area available (steep bank).	Poor
	GB	Limited additional area available.	Poor
	OB	Some *Compatible* area available, rest is *Incompatible* (urban)	Fair
	pk	Significant *Compatible* area available (same private freehold).	Good
	CP	Significant *Compatible* area available (across several private freeholds).	Good
	SA1	Significant *Compatible* area available (same private freehold, road).	Good
	SA2	Limited additional area available (steep bank).	Poor
	SA3	Limited additional area available (steep bank).	Poor
	DR	Limited additional area available (higher ground, road).	Poor
	RFs	Some *Compatible* areas available (across several private freeholds).	Fair
	BR	Some *Compatible* area available, rest is *Case by case*, *Incompatible* (urban).	Fair
Ltd. Survey, photo monitored	**SB**	Some *Compatible* area available.	Fair
	WS	Significant *Compatible* area available (public reserve)	Good
	GA	Significant *Compatible* area available (local govt)	Good
	FG	Only *Case by case*, *Special consideration areas* available, rest *Incompatible* (urban).	Poor
	MB	Significant *Compatible* area available and some *Case by case* (public).	Good

5 Site survey results, notes and recommendations

Section 4 summarised overall results of plants, birds, human impacts and future saltmarsh extent. Site-specific results, notes and recommendations are presented in the following section. This section contains site-specific comments and recommendations.

5.1 Windermere Bay

The Windermere Bay saltmarsh lies within a popular local recreational area and includes a raised boardwalk through sections of the marsh. The survey area, the current extent of saltmarsh, and tenure of the site are shown in Figure 5-1. Note that both Glenorchy City Council (GCC) and Property Services have authority over separate sections of the marsh, which requires consideration in planning any on-ground works on this site.

Figure 5-1. Windermere Bay Saltmarsh. Pink polygon: survey area. Yellow polygon: current extent of saltmarsh. White line: boardwalk. Inset map: land tenure of same area.

Plant diversity (26 species) at Windermere is comparable with other Derwent sites (Figure 4-1). The ten most common species across the estuary, all native, are present here (Table 3). Seven of these plants are categorised as saltmarsh Obligates, six as Common, and four as Occasional in saltmarshes (Appendix 9.1). Whilst there were several weed species observed at this site, only three are of management concern: *Juncus acutus* (spiny rush), which GCC is already actively managing, *Coprosma repens* (mirror bush) and *Asparagus* sp. As is the case with several other Derwent saltmarsh sites, Windermere Bay has limited fringing vegetation (Table 6).

This site had the highest bird diversity (13 species) of the sites surveyed (Figure 4-2). This result might in part be due to both surveys being conducted at high tide (Figure 4-4), and a low tide survey is needed. The area is officially a dog on-lead area, but off-lead dogs are of great concern and an ongoing issue (pers. observation and anecdotal accounts). Community education (e.g. signs), on-ground infrastructure (e.g. fences) and council enforcement is required to effectively manage dogs.

Dog exclusion is especially a priority on the little peninsula on the eastern side of Faulkners Rivulet, as this area appears especially popular with birds (Figure 5-2). Despite this section of marsh

containing much historic infill, at the far end some old deep tyre tracks provide a small amount of tidal connectivity, bringing marine invertebrates into the marsh. This area lends itself to a future restoration project where the old infill could be scraped off and passive revegetation facilitated.

Figure 5-2. Windermere Bay peninsula area. Left: rocks preventing vehicle access to the area with historic infill. Right: old deep tyre tracks provide access for tidal waters to bring invertebrates onto the marsh. Images by DEP 3/9/2019.

Two main issues were prominent in the human impact survey results (Table 8). There was a high degree of 'Inappropriate development' adjacent to site, given that the saltmarsh is surrounded by a large recreational area, including sections partly infilled over historic saltmarsh. Another notable issue identified was mowing of saltmarsh vegetation where it borders the recreational area lawns. Both these issues are partly dealt with in a rehabilitation project designed and implemented by GCC, with a setback allowed for mowing to prevent saltmarsh vegetation being cleared, a proposed saltmarsh boardwalk upgrade and walking track extension (more details below).

Past saltmarsh vegetation extent and potential future extent at this site is considered in the proposed project. Figure 5-3 shows the Future Coastal Refugia Area overlay (blue fill = Compatible zone). This site has adequate potential for the marsh to migrate upland over time, and capacity to expand the current extent of the march, through both passive and active restoration.

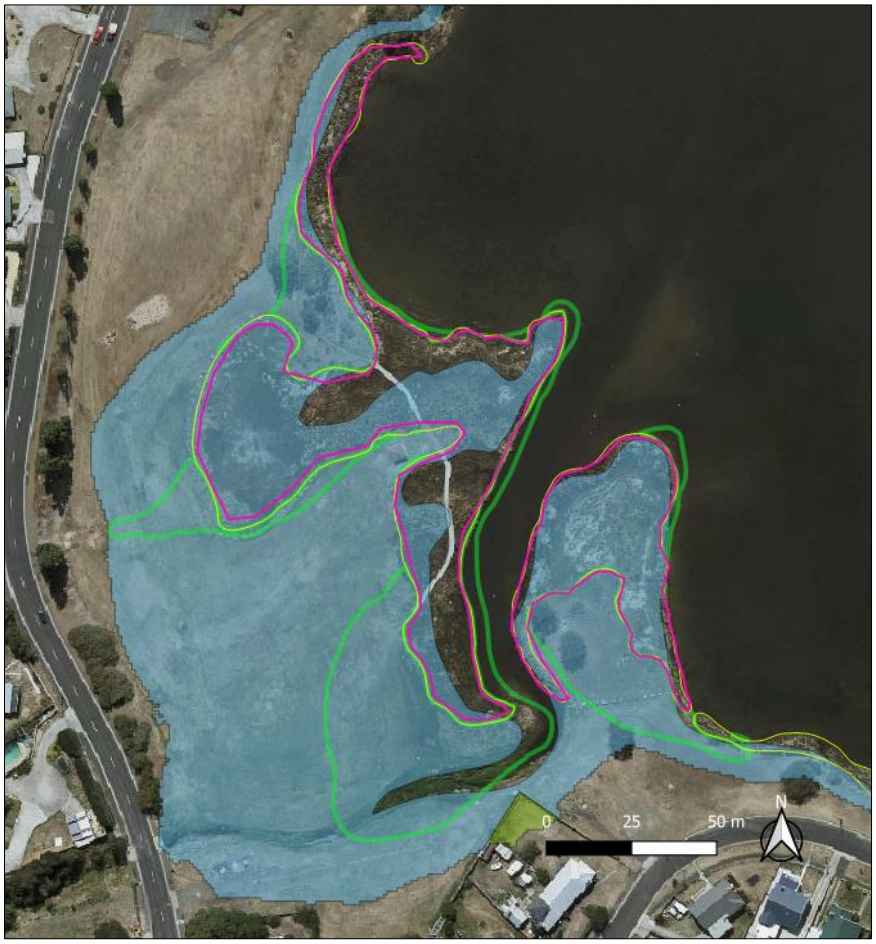

Figure 5-3. Windermere Bay saltmarsh area with Future Coastal Refugia Area overlay (blue fill = Compatible zone). Pink polygon: survey area. Green polygon: estimated loss of saltmarsh since 1946.

5.1.1 Further project proposal details

In collaboration with a cross section of GCC staff, a saltmarsh restoration project has been proposed. This coincides with the council-wide *Paths, Tracks and Trails Survey*, which identified the boardwalk at Windermere as a high community priority to be extended and linked with foreshore paths across Faulkners Rivulet, around the southern side of Windermere Bay and heading south.

A November 2019 joint DEP, UTAS and GCC meeting proposed to bring the saltmarsh restoration proposal and the boardwalk/track extension into one combined project; this has now been accepted by GCC, who anticipate starting the boardwalk project in 12-18 months. The project will require a Management Plan that incorporates the design, building, and installation of the boardwalk, rivulet bridge and walking paths, as well as consideration towards extending the marsh, and its ongoing management. The marsh restoration is to take place after the boardwalk work is completed, so that any access required to build the boardwalk does not affect the saltmarsh restoration process. This will be a collaborative project contributed to by consultants, council staff, UTAS and DEP.

In the immediate future, the passive restoration action of extending the no-mowing areas as per red line in Figure 5-4 was agreed on. DEP and UTAS will monitor the effects of the passive restoration method of limiting mowing.

Figure 5-4. Windermere Bay. Top left: current saltmarsh area with boulders to be extended further. Bottom left: area alongside Faulkners Rivulet where marsh restoration work is planned. Right: red line indicates area for passive restoration by no-mowing; blue polygon indicates area for future active restoration by scalping topsoil. Images by DEP 3/9/2019.

5.1.2 Recommedations

- Expand current no-mowing area to take in additional current saltmarsh vegetation, by moving the current rocks, and adding new rocks (passive restoration) (Figure 5-4).
- In connection with plans for extension of the saltmarsh boardwalk and local walking tracks, scalp/scrape-off topsoil of an area adjacent to Faulkners Rivulet, where marsh used to exist and where it is expected to migrate to in the future. Scraping will bring soil level down to the required inundation height (i.e. the area is open to flooding by spring tides), followed by passive vegetation rehabilitation and no further mowing (Figure 5-4).
- Use above rehabilitation project as a public demonstration to showcase what can be done, to learn from actions, and to educate and engage with the wider community. Install interpretation signs and conduct open days to share information with the community about saltmarsh values and the rehabilitation project.
- Install interpretation signs and conduct community education and outreach about saltmarsh values and off-lead dogs.
- Conduct weed removal as recommended.
- Consider further buffer zone planting to encourage terrestrial birds.

See Section 6.1 for information on Windermere Bay (south), a photo monitored site.

5.2 Jordan River

Two representative sites were chosen in the mouth of the Jordan River: Green Point (GP) and Gage Brook (GB). These sites lie within the River Derwent Marine Conservation Area and a public reserve respectively, spaced just over a kilometre apart. Figure 5-5 shows the location of the survey sites and current extent of saltmarsh.

Figure 5-5. Jordan River mouth. Pink polygons: survey sites at Green Point and Gage Brook saltmarshes. Yellow polygon: current saltmarsh extent. Insert shows land tenures.

The vegetation at these two sites is primarily dominated by saltmarsh sedges and rushes, thus categorised as the TASVEG community of ARS (Table 4). The dominant herbs present were *Samolus repens* (creeping brookweed) and *Selliera radicans* (shiny swampmat), which acted as ground cover underneath mainly *Juncus kraussii* subsp. *australiensis* (sea rush) (Figure 5-7, Figure 5-8). The plant diversity varied between the two sites, with 27 species at GB and 15 at GP (Figure 4-1). There were no weeds within the marshes that warranted special concern, but significant infestations were present adjacent to the sites. This was reflected in the data collected on the fringing vegetation, with both sites having 100 % lateral and > 70 % width buffer zones, but the composition of this buffer vegetation was largely weedy for both sites (Table 6).

Bird species diversity and abundance varied markedly between the two sites, with more species and birds observed at GP (87 birds recorded on a single survey, the most birds across all sites) (Figure 4-2). This is likely due to the larger interface available at GP between the saltmarsh and the adjacent tidal flats for habitat overlap, especially in waterbirds (Figure 5-5). Also, at GB, on the day of the high tide survey, a swamp harrier was roosting nearby, which likely contributed to no other birds being recorded within the survey period at this site. All observed species at both sites, barring the introduced House Sparrow (*Passer domesticus*), are considered saltmarsh specialists or generalists (Appendix 9.3). At both sites more birds were observed at low tide (Figure 4-4).

There has been no loss of saltmarsh habitat at GP since 1946. However, a considerable portion of the north eastern end of GB (Figure 5-6) has been lost to a combination of clearing and road works. In terms of the future, with rising sea levels, the Future Coastal Refugia Area overlay shown in Figure 5-6 indicates that both marshes have limited capacity for future upland retreat. This is despite a lack of urban interference, and rather due to surrounding topography (high to steep land).

Figure 5-6. Jordan River mouth. Pink polygons: survey sites. Green polygons: saltmarsh area lost since 1946. Blue fill: Future Coastal Refugia Area, all in the Compatible zone.

Both GP and GB appear to have limited human disturbance, probably due to their general inaccessibility. Overall, large amounts of different types of rubbish were observed across both sites, most likely arriving with the tide and river flow. Notably, a substantial number of tyres were present at both sites, especially in higher numbers at GP (Figure 5-7, Figure 5-8). In this case, the tyres might have been discarded down the steep bank (as was a pile of fill and an old fridge). Conservation Volunteers Australia (CVA) kindly assisted with the second round of bird surveys and removing a large amount of rubbish from both these two sites at the same time, though not the tyres, which were heavy to be carried out and will require a more dedicated clean-up effort.

5.2.1 Green Point – additional notes

The GP survey site is the largest patch of saltmarsh on the Green Point peninsula (Figure 5-6). The marsh is surrounded on the landward side by a high and very steep bank that is heavily infested with weeds (Figure 5-7). The steepness combined with weed species present, including the spiky *Lycium ferocissimum* (African boxthorn) and *Rosa rubiginosa* (sweet briar), provide the benefit of discouraging most people (perhaps also off-lead dogs) from accessing the saltmarsh. Other weeds on the bank include *Chrysanthemoides monilifera* ssp. *monilifera* (boneseed) and *Pinus radiata* (radiata pine). Another benefit of these introduced species (as opposed to no vegetation cover) is that it provides habitat for birds and other animals. Hence, restoration efforts must survey animal use before clearing the introduced species, and follow any eradication with replanting of mature specimens of native species that can provide alternative habitat.

Figure 5-7. Green Point (GP) saltmarsh in the Jordan River mouth. Top: the entire GP saltmarsh viewed from the top of the steep bank. Mid left: large patch of *Samolus repens* var. *repens* (creeping brookweed). Mid right: numerous tyres on the saltmarsh platform. Bottom: view of steep weed infested bank. Images: DEP 19/12/18.

5.2.2 Gage Brook – additional notes

GB is a large healthy saltmarsh with few weeds and little human interference (except rubbish, mainly tyres). Notably, considerable numbers of crabs were observed, which contribute to the marsh food production, and offer a potential site for future invertebrate studies. The bank south of the marsh is infested with *Chrysanthemoides monilifera* ssp. *monilifera* (boneseed), including a 'sea' of juveniles along the walking path from Stanfield Drive. The bank on the northern side of the marsh contains a comparatively healthy native vegetation cover, with some *Rubus fruticosus* agg. (blackberry) as understorey in places, and *Rumex* sp. (dock) in the buffer zone.

Figure 5-8. Gage Brook Saltmarsh. Top left: one of many tyres found on-site. Top right: *Samolus repens* var. repens (creeping brookweed) in flower. Bottom left: eastern side of saltmarsh infested with *Chrysanthemoides monilifera* ssp. *monilifera* (boneseed). Bottom right: *Juncus krausii* subsp. *australiensis* (sea rush) with vast *Samolus repens* var. *repens* (creeping brookweed) and *Selliera radicans* (shiny swampmat) groundcover. Images: DEP 19/12/18.

5.2.3 Recommendations

Green Point

- Brighton Council (BC) to ensure, with access restrictions and signs, that this site does not become a rubbish dumping site.
- BC to consider strategically targeting the weeds on the steep bank, tackling smaller sections at a time followed by native plantings and/or high-density planting of native trees and scrubs (e.g. *Allocasuarina verticillata, Bursaria spinosa, Dodonaea viscosa*) in amongst the weeds to slowly shade some of them out and provide additional bird habitat.
- Suggest using organic weed killers or manual methods (e.g. slashing, edging) to manage weeds along the pathways around the marsh to avoid run-off of any herbicides down to the marsh.

Gage Brook

- Suggest a weeding program to start on northern side, and then work on bookending *Chrysanthemoides monilifera* ssp. *monilifera* (boneseed) on the southern side, i.e. working from the outside-in, towards the worst part of the infestation.

Green Point & Gage Brook

- BC to organise removal of dumped tyres, e.g. through the Tasmanian Conservation Trust's tyre program (http://www.tastyrecleanup.com/).
- BC to organise bi-annual rubbish clean-ups at GP and GB. Also consider walking through the rest of the Jordan River marshes that may also be require annual rubbish removal (e.g. through CVA or the Bridgewater/Gagebrook Clean Up Group).

5.3 Old Beach

Old Beach saltmarsh covers an area of about 5 ha, bordering the River Derwent Marine Conservation Area and a walking/bike track on the landward side. In the immediate vicinity of the marsh, to the north of the walking track, is a constructed freshwater wetland operating as a Water Sensitive Urban Design (WSUD)/stormwater retention system. The southern end of this saltmarsh, an area of about 2 ha, was selected for survey as part of this project (Figure 5-9).

Figure 5-9. Old Beach. Pink polygon: surveyed site. Yellow polygon: extent of current saltmarsh. Insert shows tenure of same area. Surveyed area is Crown Land (includes one small Crown Land leased and one licenced area).

The vegetation diversity (26 species) was comparable with other sites (Figure 4-1). The surveyed area contained all the ten most common species observed across the estuary (Table 3), with most species being Obligate or Common in saltmarsh habitats (Appendix 9.1). The site contains a large extent of *Juncus kraussii* subsp*. australiensis* (sea rush) and is therefore classed as a ARS community under TASVEG (Table 4). However, there is also a considerable herb cover, especially in the understorey (Appendix 9.1). *Rosa rubiginosa* (sweet briar) was the main introduced species that was noted requiring removal (Table 5).

The saltmarsh at Old Beach is in a vulnerable position. As can be seen in Figure 5-10, residential houses all along the marsh makes upland migration over time, as the sea level rises, 'Incompatible' under the Tasmanian planning scheme (Prahalad *et al.*, 2019). The houses close to the marsh already have saltmarsh vegetation just outside and inside their property boundaries (Figure 5-10). There are also current proposals to build further houses in this area (e.g. at 22-24 Calm Place). This ongoing housing development in the area is the biggest human impact on the saltmarsh (Table 8). There are also enduring threats surrounding the walking track, with issues such as rubbish and off-lead dog management. Rubbish was noted to be scattered throughout site, and anecdotal evidence suggest that it is very common for dogs to be off-lead in this area. This has immense implications for managing for bird values in the area.

Figure 5-10. Left: Old Beach aerial image. Pink polygon: survey area; green polygon: saltmarsh area lost since 1946; fill: Future Coastal Refugia Area – half of it in blue (Compatible zone) and other half in light green (Incompatible zone due to the adjacent residential area). Right: Saltmarsh vegetation growing close right by residential housing at Old Beach. Image: DEP 5 Dec 2018.

Overall observed bird diversity within the marsh was comparatively low (Figure 4-2). Conversely, many more birds were observed adjacent to the marsh, on the shoreline (Appendix 9.3, 9.4), sheltered from land use impacts such as off-lead dogs. Notably, there was a complete lack of fringing vegetation (Table 6) around the site, contributing to the low numbers of terrestrial bird species observed utilising the marsh.

In terms of other human impacts, over 50 square sections were seen removed from the saltmarsh vegetation (Figure 5-11). It was subsequently revealed that at least some of the squares were cut out by a consultant in generating a Coastal Vulnerability Assessment report as part of a nearby proposed multi-storey housing development. Such digging is likely to create ponding where the soil has been removed and, over time, can create more bare ground causing both the loss of saltmarsh and issues with mosquito breeding in these waterlogged pits.

Figure 5-11. Top right: example of a square piece of *Sarcocornia quinqueflora* (beaded glasswort) cut out of saltmarsh at Old Beach. Top left: numerous square sections cut out from the saltmarsh surface. Images by DEP, 5 Dec 2018.

5.3.1 Recommendations

- BC to include the entire ~5 ha saltmarsh area under its Priority Vegetation Area code as part its local provision schedule under the new Statewide Planning Scheme (to align with other BC wetlands already protected by this code).
- BC/Property Services to install interpretation signs (e.g. by the bench on the walking track) explaining saltmarsh values.
- Further, install signs, preferably at each end of the marsh by the walking track, discussing the importance of the bird habitat and why it is important to keep dogs on-lead. Also, occasionally

have council animal control officers on-site to talk with dog walkers as part of community education and enforcement.

- DEP to discuss the multiple pits dug in the saltmarsh with Brighton Council and Property Services and consider infilling the pits with soil to encourage the surrounding vegetation to expand and cover the bug out areas. UTAS can provide recommendations for soil preparation relevant to the local vegetation community type.
- Conduct an annual rubbish pick-up, with ideally the local community to be involved so more people become familiar with and feel ownership of the area (also to help keep dogs out).
- Consider buffer tree planting above the site to encourage terrestrial birds (recognising that this will impact river views from the subdivision).
- BC to remove a 2 m^2 patch of *Rosa rubiginosa* (sweet briar).
- Consider forming a local Coastcare group for Old Beach to help consult with, coordinate and undertake many of the above activities.

5.4 piyura kitina (Risdon Cove)

The property piyura kitina, meaning little native hen, is located at the mouth of Risdon Brook (Figure 5-12) at Risdon Cove. This is a private property managed by the Tasmanian Aboriginal Centre. It contains a saltmarsh cluster about 2 ha in extent, dominated by saline sedges and rushes. The marsh is surrounded by the East Derwent Highway on three sides, but there is a large drain under the under the highway allowing for tidal connectivity between the marsh and wider estuary.

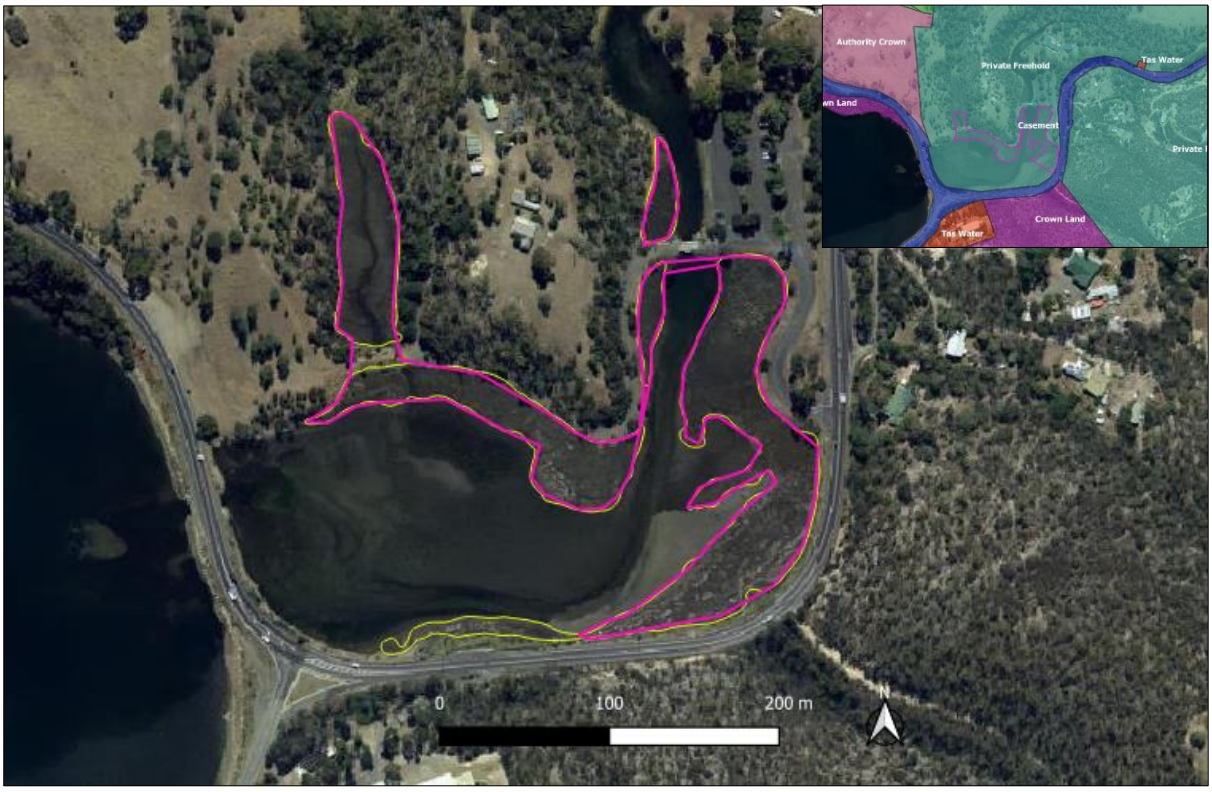

Figure 5-12. The piyura kitina (Risdon Cove) property located at the mouth of Risdon Brook. Pink polygon: surveyed area. Yellow polygon: current saltmarsh extent. Insert shows the land tenure of the area.

This saltmarsh was observed to be the most obvious example of the ARS TASVEG community of any of the sites surveyed, with > 50 % of the survey area covered by *Juncus kraussii* subsp*. australiensis* (sea rush) and 5 - 25 % with *Gahnia filum* (chaffy sawsedge) (Table 4, Appendix 9.1). The vegetation

(20 species) includes all the most common saltmarsh species found across the estuary (Table 3). While a number of weed species were observed, including thistles and various grasses (Appendix 9.1), only *Rosa rubiginosa* (sweet briar) was identified as being in need of removal (Table 5).

Fringing vegetation exists to a reasonable extent both laterally and in width, and its compostion is largely native (Table 6). While some native planting has been undertaken over the years there is room for extending the buffer zone (including trees, shrubs and understorey). Any planting along the road would need to be considered in careful collaboration with the Department of State Growth.

Figure 5-13. Saltmarsh on the piyura kitina (Risdon Cove) property. Top: the large bridge culverts under the East Derwent Highway allow for adequate tidal connectivity between marsh and the Derwent estuary. Bottom: most of the marsh is covered by *Juncus kraussii* subsp*. australiensis* (sea rush) and *Gahnia filum* (chaffy sawsedge), surrounded by lawn grass and roads. Images: DEP 5 Dec 2019.

Observed bird diversity was quite low within the marsh (Figure 4-2). As is common, more birds were utilising the marsh at high tide compared to low tide (Figure 4-4). The numbers of birds and bird species occupying the exposed mudflat adjacent to the saltmarsh at low tide were greater than what was observed *on* the marsh on either survey days (Appendix 9.4). Anecdotal evidence suggests that Black Swans (*Cygnus atratus*) nest in this saltmarsh annually, but were not recorded in our surveys.

The predominant human impacts in this area relate to the grassy lawns, roads and bridges within and adjacent to the site (Figure 5-13, Table 8), which has had a considerable impact on the extent and fragmentation of the marsh (Figure 5-14). There was also significant amount of rubbish throughout the marsh, which will be relatively difficult to access given the muddy substrate. Some minor nuisance algal blooms were observed requiring ongoing monitoring to ensure nutrient enrichment does not intensify. In terms of feral animal impacts, a rabbit was observed during field surveys. Rabbits are apparently living in large numbers across the property, and require monioring to determine their impact on the saltmarsh.

Figure 5-14 shows that there is some room for marsh growth in upland areas over coming years as sea levels rise and much of the upland area is in a *Compatible* zone. However, existing infrasturture such as roads and car parks will limit the extent to which saltmarsh can establish in this zone.

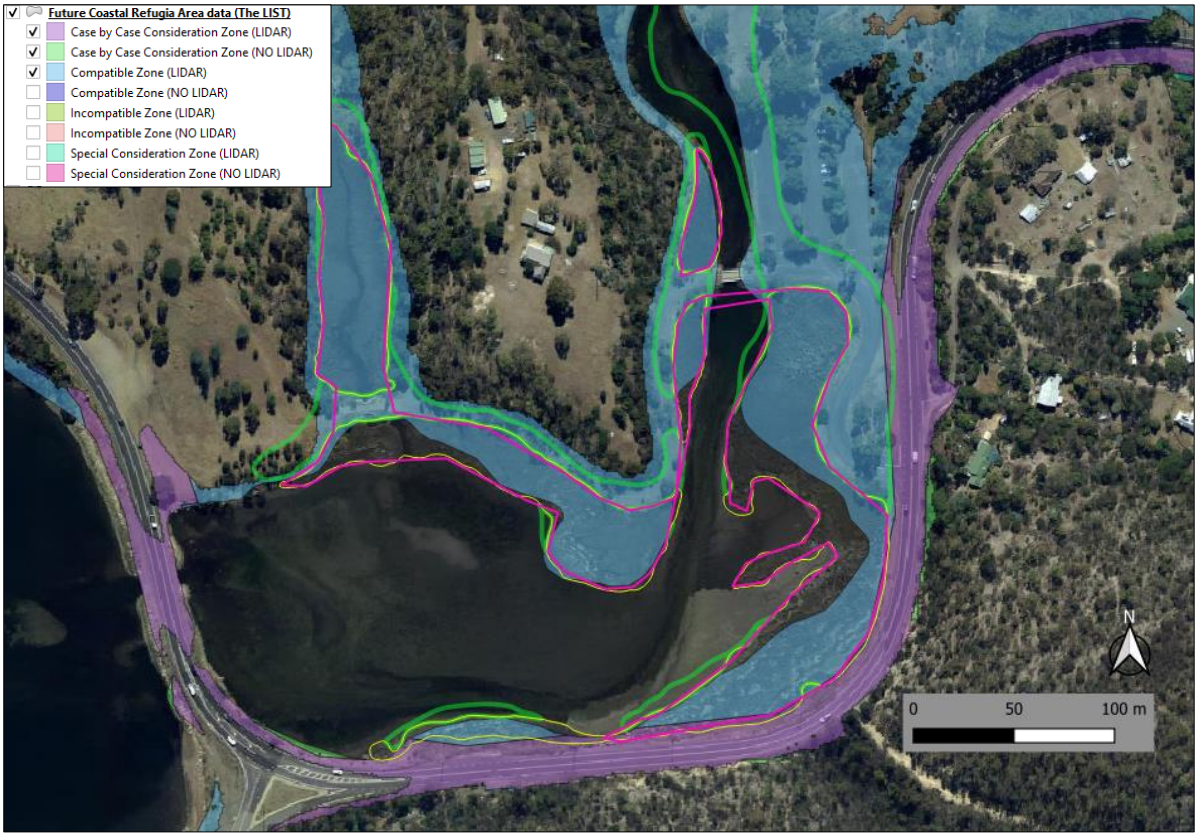

Figure 5-14. The piyura kitina (Risdon Cove) property. Pink poly gon: surveyed area. Green polygon: marsh lost since 1946. In-fill colours are the Future Coastal Refugia Area overlay, showing that most potential future marsh growth is in a Compatible zone.

5.4.1 Recommendations

- Landowners to conduct a rubbish pick-up through the marsh, and follow-up every second year.
- Landowners to work with DEP to increase buffer zone vegetation where feasible.
- Monitor algal growth in the area and if increased cover of algae is noted, landowners could investigate potential sources of nutrients and check the culverts for blockages (in flushing), working with the Department of State Growth where necessary.
- Landowners to remove *Rosa rubiginosa* (sweet briar) as part of ongoing weed management.
- Landowners to manage the areas upland from the marsh with consideration of potential for future retreat areas.

5.5 Clarence Plains

The saltmarsh on the Clarence Plains Rivulet is located on private land (Figure 5-15, Figure 5-16), where the owner, a local subdivision developer, recognises the importance of the saltmarsh and has been developing conservation and restoration plans for the marsh. Part of this includes the provision of a buffer area immediately upland from the marsh, being protected from infill development for the purpose of providing a stormwater drainage basin. The owner is also promoting the importance of the saltmarsh with the local community and potential buyers, as well as providing information about Water Sensitive Urban Design (WSUD) features that are being installed in the newly developed subdivision located immediately above the saltmarsh to protect it from stormwater run-off https://www.northbay.net.au/saltmarsh . A local group, Tranmere and Clarence Plains Land and Coast Care, is also active in the area, through their efforts in community education and restoration of native vegetation in the buffer zone (Figure 5-16) https://www.tacplaci.org.au/rokeby-saltmarsh.

This marsh provides a good example of successful re-vegetation, including on the west side of the rivulet, by the bridge, and on the upland margins of the saltmarsh (Figure 5-16).

Figure 5-15. Clarence Plains Saltmarsh. Pink polygon: surveyed area. Yellow polygon: current saltmarsh extent. Insert: tenure of same area.

The plant diversity is moderately high compared to other sites, with 22 species recorded (Figure 4-1). Eight plant species are classified as saltmarsh Obligates (9.1). The vegetation was predominantly saltmarsh herbs (Figure 5-16), and categorised as a TASVEG ASS community (Table 4). The fringing vegetation and the native vegetation composition are in very good condition at this location (Table 6). Three significant introduced species require removal (Table 5). A patch of *Typha* sp. was also observed, which requires species level identification (Figure 5-16).

A total of 11 bird species were observed at this site, which was one of most diverse sites surveyed in the estuary (Figure 4-2). Notably, Black-fronted Dotterels (*Elseyornis melanops*) were observed during both surveys (Appendix 9.3). All the species recorded were either saltmarsh specialists or generalists (Appendix 9.3).

There were only limited current human impacts on the site, most of which were remnants of historic effects (e.g. off-road vehicle tracks). The presence of rubbish was limited to a few items, which were picked up during the field survey. Some filamentous algae were observed on the marsh (Table 8) and the rivulet also has a considerable amount of algae present, likely due to the lack of 'flushing' by tidal flows. Poor water flow may also have been related to the fish kill in the rivulet that was observed in Sept 2018. TasWater investigated and reported: *The assumption in this instance is that outgoing tidal movement may have lowered the DO/caused stranding and subsequently the fish death occurred* (G. Fitzgibbon, TasWater 4/10/2018). Recently, Clarence City Council addressed this issue by the removal of large rocks under the bridge in an effort to improve water flow between the rivulet and Ralphs Bay (Figure 5-16).

A small portion of current saltmarsh extent and future retreat area exists in nearby properties managed by the Local Council and The Hobart Clinic. Here, current mowing is directly affecting an estimated 0.2 ha area of saltmarsh.

Figure 5-16. Clarence Plains Saltmarsh. Top right: Dead fish observed at the bridge on Droughty Point Road leading into Clarence Plains Rivulet. Image V. Prahalad 28 Sep 2018. Top Left: overview of Clarence Plains Saltmarsh. Bottom right: Saltmarsh education sign located at the marsh. Bottom left: healthy buffer vegetation growing on the western side of the rivulet. Images: DEP 19 Dec 2018.

Historical imagery suggests that the marsh used to be at least twice its current extent (Figure 5-17), and that it was subsequently cleared and infilled, partly with building waste. The Future Coastal Refugia Area overlay indicates that if allowed to migrate, the marsh will spread back over its 'old' ground and extend further upriver as sea levels rise (Figure 5-17).

5.5.1 Recommendations

- Landowner to remove the three introduced species of concern.
- Conduct a bi-annual rubbish pick-up, possibly in collaboration with nearby residents or local Coastcare group as part of education about the site.
- Continue increasing buffer planting around the site to support terrestrial birds and protect site from introduced species.
- With the development of housing nearby, care must be taken to keep dogs and cats from straying onto the saltmarsh.
- Continue monitoring filamentous algae build-up on the marsh and the rivulet, an indication of poor water quality requiring management.
- Consider using the site for developing further saltmarsh-related interpretation material, including as part of a circular walkway with a boardwalk section taking walkers over the rivulet and the saltmarsh.
- A joint management agreement needs to be developed between the three landowners to discourage mowing of the saltmarsh and planting of buffer vegetation.

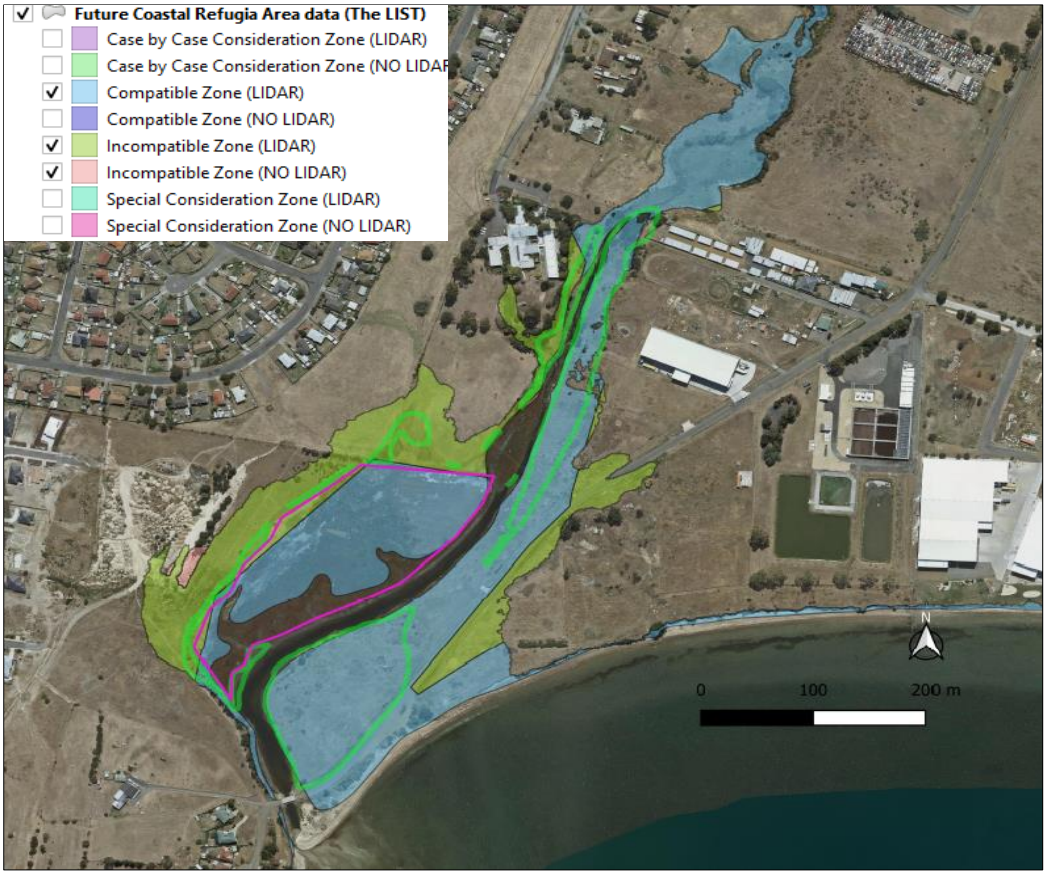

Figure 5-17. Clarence Plains aerial image. Pink polygon: survey area. Green polygon: saltmarsh lost since 1946. Fill: Future Coastal Refugia Area – partly blue (Compatible zone) and partly light green (Incompatible zone).

5.6 South Arm (1)

This survey site is within a large saltmarsh (~12 ha) at the South Arm Neck, located between the South Arm Road and the South Arm Marine Conservation Area (Ralphs Bay) (Figure 5-19). The land tenure spreads over private freehold (predominantly), Conservation Area (Tasmania Parks and Wildlife Service), and Public Reserve (Property Services) (Figure 5-18).

Figure 5-18. South Arm Neck saltmarsh. Pink polygon: survey area. Yellow polygon: current extent of saltmarsh. Insert shows tenures of the area.

The area surveyed had more plant diversity than any other site (Figure 4-1). While most of the common native saltmarsh species observed across the estuary were present here (Table 3), almost half of the species recorded were introduced (Appendix 9.1), especially along the road verges (Figure 5-19). However, in comparison to other sites in the estuary, none of these species were a priority for management intervention (Table 5). This site is an almost equal mix of the TASVEG communities ARS and ASS, with slightly more ASS coverage (Table 4).

The bird diversity was low with six species (39 birds) recorded (Figure 4-2). Of these, Pied Oystercatchers (*Haematopus longirostris*), White-fronted Chats (*Epthianura albifrons*) and Masked Lapwings (*Vanellus miles*) are classified as saltmarsh specialists. Almost all birds were recorded at the high tide survey (Figure 4-4).

Human impact was limited, with little rubbish present on the site. The largest overall impact on the marsh is the location of the South Arm Road that marks the southern edge of the marsh. The road also serves to disconnect the large area of saltmarsh on the landward side that has been cleared and partly infilled (Table 8). Furthermore, the landscape modification in the area has resulted in a complete lack of fringing vegetation (Table 6).

Algal blooms were observed (Figure 5-19) in a relict creek system within the marsh. This creek was closed off from the bay by a raised levee, likely caused by a storm event. Generally, saltmarshes are in low energy environments where the shoreline is protected from high-energy waves. In the case of this location, the coastline is exposed to a high fetch and consequently high-energy waves, a situation now exacerbated by climate change (Mount *et al.*, 2010). This has resulted in the erosion of the saltmarsh, including the loss of large specimens of *Tecticornia arbuscula* (shrubby glasswort) as seen in Figure 5-19. Because of this exposed location, this site is particularly susceptible to rising sea levels and storm events. As sea levels rise, this saltmarsh has 'room to move' over time, as evident in Figure 5-20, with all potential future marsh area being located in the *Compatible* zone, south of the South Arm Road. However, much of this area used to be historic saltmarsh before it was cleared and partly infilled. It is estimated that over 50% of saltmarsh area has been lost due to land clearing.

Figure 5-19. South Arm Neck saltmarsh. Top left: view of marsh looking west. Top right: algal bloom in creek system within the marsh. Bottom left: *Tecticornia arbuscula* (shrubby glasswort) impacted by wave erosion. Bottom right: introduced species common on this site, *Dimorphotheca fruticose* (African daisy). Images: DEP 6 Dec 2018.

Figure 5-20. South Arm Neck Saltmarsh. Pink polygon: survey site. Fill: Future Coastal Refugia Area – blue and dark purple fill indicates all refugia area is the Compatible zone.

5.6.1 Recommendations

- DEP to encourage landowner group (private owners, Clarence City Council, PWS and Property Services) and Dept of State Growth (roadside responsibilities) to develop a collective weed management plan. The local Opossum Bay and South Arm Coastcare group may be able to assist in both planning and on-ground works.
- Landowners to become aware of historic saltmarsh loss and the Future Refugia area and consider saltmarsh restoration and rehabilitation across tenures.

5.7 South Arm (2)

The 2.9 ha area saltmarsh is located against a steep bank and covered by a mix of tenures: two private leaseholds and a Crown land strip, bordering the South Arm Marine Conservation Area (Figure 5-21). Figure 5-22 shows both the view over the marsh (from the top of the bank) and looking back from the coastline towards one of the local residences.

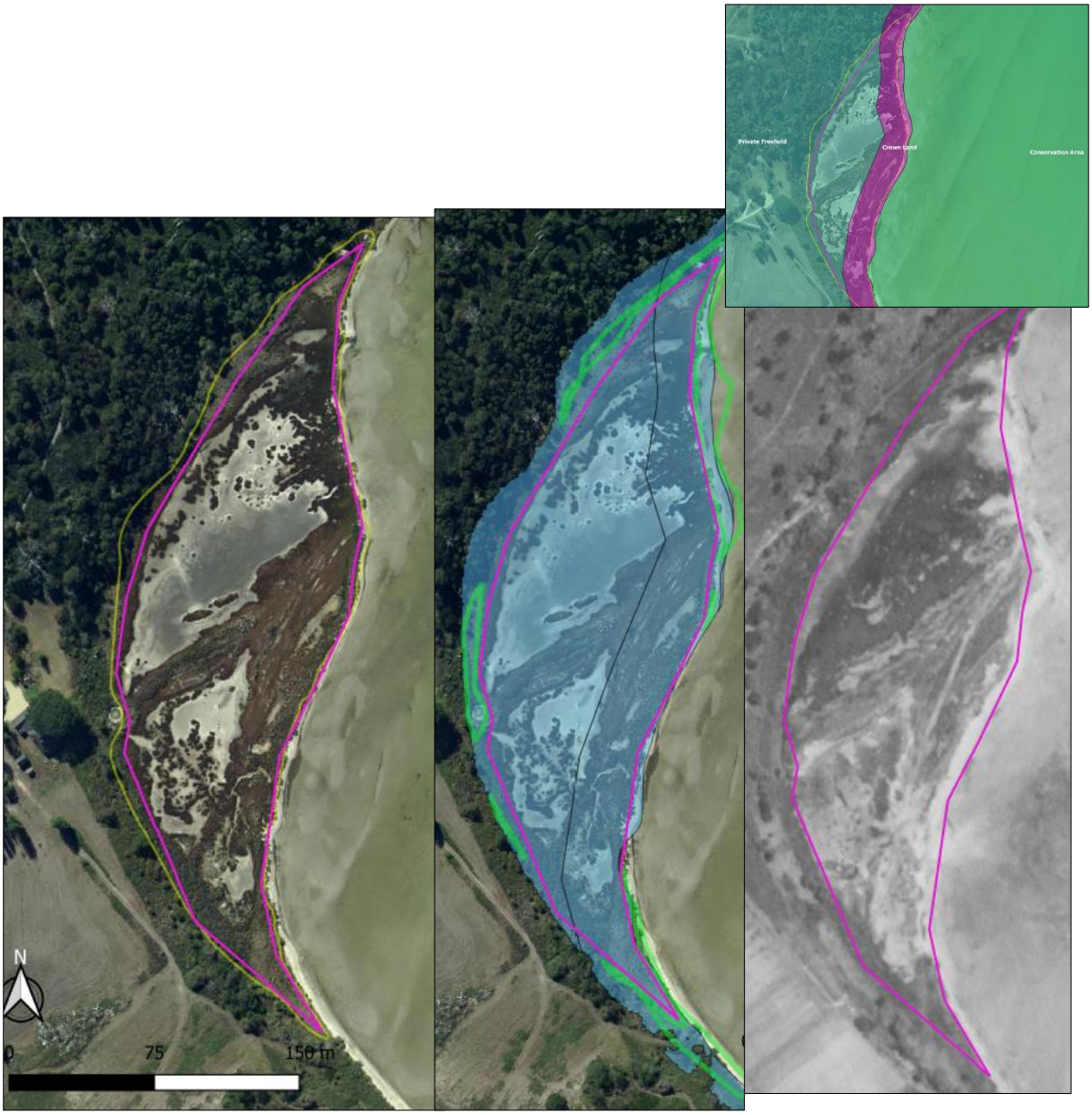

Figure 5-21. South Arm (SA2) saltmarsh. Left image: Pink polygon is the survey area and yellow polygon is the current saltmarsh extent. Middle image: green polygon is the saltmarsh area lost since 1946, blue fill is the Future Coastal Refugia Area layer's Compatible zone. Right image is an aerial photo from 1946. Top insert shows local tenures.

Figure 5-22. South Arm Saltmarsh (SA2). Top: view over the marsh from private property. Image: C. Coughanowr 6 Dec 2019. Bottom: looking south and back up towards the house where the top photo was taken. Image: DEP 6 Dec 2019.

The TASVEG community is predominantly ASS (with only ~ 25 % ARS coverage) (Table 4). Plant diversity is comparable with other estuary sites (Figure 4-1), with 27 species recorded. Over half of the species are classified as either saltmarsh Obligates or Common in saltmarshes (Appendix 9.1). Around the landward edge, there are large areas of introduced species which require removal, including *Rubus fruticosus* agg. (blackberry), *Lycium ferocissimum* (African boxthorn) and *Rosa rubiginosa* (sweet briar) (Table 5). The fringing vegetation extent is good at this site, with 30-70 % of this vegetation assessed as being of native composition (Table 6).

A total of eight bird species were observed (Figure 4-2), with many more birds observed at high tide (71) than low tide (12) (Figure 4-4). Species observed included predominantly saltmarsh habitat generalists, but also a couple of specialists, i.e. Red-necked Stints (*Calidris ruficollis*) and Pied Oystercatchers (*Haematopus longirostris*) (Appendix 9.3). Incidental bird observations (after the official survey time) included Red-capped Plovers (*Charadrius ruficapillus*), Masked Lapwings (*Vanellus miles*) and White-fronted Chats (*Epthianura albifrons*), which are all saltmarsh specialists. This indicates that the site is of likely high bird conservation significance.

Human impact appears limited at this location (Table 8). Except for the tracks down to the saltmarsh and weeds along the landward boundary, there is little evidence of human interference. A small pond has been dug out on the landward boundary of the saltmarsh and is not in use now.

Because of the steep topography backing this saltmarsh there is little room for retreat as the sea levels rise (Figure 5-21). The historical aerial image in Figure 5-21 shows that there is more bare ground now than previously. This may be caused by a changing climate (Prahalad *et al.*, 2011), with longer dry periods having led to reduced biomass, a loss of marsh biodiversity and function. This site could be considered for a student project experimenting with building up soil levels to determine whether vegetation will re-establish in these bare depressions.

5.7.1 Recommendations

- DEP has forwarded contact details for the Opossum Bay and South Arm Coastcare group and the Clarence City Council Weed Officer to the local residents, who have expressed interest in dealing with the weeds. Both the Coastcare group and the council Weed Officer have indicated their willingness to support the locals in this effort.
- UTAS/DEP to consider a student project on this site to investigate saltmarsh rehabilitation methods to re-establish vegetation on bare ground.

5.8 South Arm (3)

The third South Arm site, 1.9 ha in extent, is located between the South Arm Neck and the previous site, South Arm (2). The site covers multiple tenures, with most of the area being located within the South Arm Conservation Area, and smaller sections being private leasehold and Crown Land. Private land was not entered for this survey (Figure 5-23).

The plant diversity on this site compares well with other sites (Figure 4-1), with the ten most common plants across the estuary all being present here (Table 3). Ten of the observed species were saltmarsh Obligates, seven Common, and six species classified as Occasional in saltmarshes (Appendix 9.1). No weeds of management concern were observed within the marsh, but quite a few weeds are located in the buffer zone, including *Lycium ferocissimum* (African boxthorn) and *Chrysanthemoides monilifera* ssp. *monilifera* (boneseed), and ideally need managing to improve surrounding habitat. A vegetated buffer zone extends both laterally and in width (> 70 %), and, despite the introduced species, it is still predominantly of native composition (Table 6).

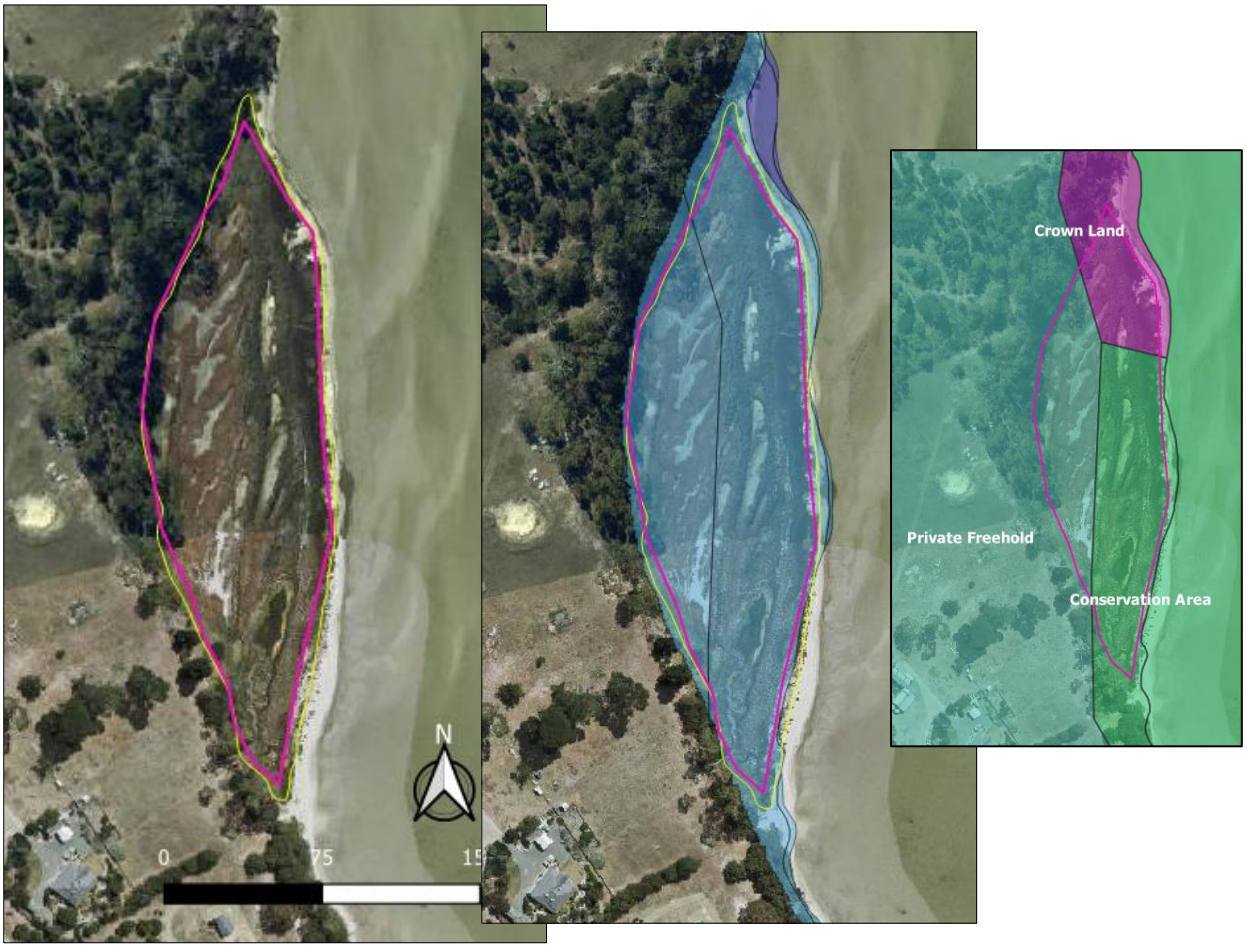

Figure 5-23. South Arm saltmarsh (SA3). Left: pink polygon is the survey area and yellow polygon is the current saltmarsh extent. Middle: fill is Future Coastal Refugia Area with blue and dark purple both being Compatible zones. Right: land tenures of the area.

Bird numbers were very low for this site despite high bird usage of the nearby site, South Arm (2). This may in part have been due to a juvenile Brown Falcon (*Falco berigora*) sitting in a tree just adjacent to the marsh during one survey and two White-bellied Sea-eagles (*Haliaeetus leucogaster*) observed nearby during the second survey. Further, anecdotally, it is understood that dog walkers regularly access this stretch of the coast, which may also have become a deterrent to birds.

Table 8 shows that overall there is limited human impact on this site. Some rubbish was found on site, and there is fencing around the private leasehold (Figure 5-24). It is uncertain whether this fenced marsh area is used for stock grazing. The 1946 aerial image suggests that there has been little loss of marsh since this time. As with nearby site, South Arm (2), this marsh is banked by raised land, (Figure 5-23, middle image), with limited ability for the marsh to establish upland with sea level rise.

5.8.1 Recommendations

- DEP to encourage landowners to collaborate on weed management in the surrounding buffer zone, assisted by the Opossum Bay and South Arm Coastcare group and Clarence City Council.
- DEP to approach private leaseholder and enquire whether site is still used for stock (and if is, identify options to exclude stock access onto the marsh).

Figure 5-24. The various soil rises and depressions across the site. The top image shows the slightly raised dune bank along the coastline with rushes and sedges providing protection for the herb species further within the marsh. Bottom left: fences around private leasehold. Bottom right: old creek (now cut-off at the mouth by a natural levee, likely from a storm over wash), drainage or vehicle line. Images: DEP 28 Mar 2019.

5.9 Lauderdale

The Lauderdale saltmarsh at Ralphs Bay is the largest cluster of saltmarshes associated with the Derwent estuary, covering 84 ha (Prahalad and Jones, 2013). It is made of up several patches, the largest being Racecourse Flats Saltmarsh, 68.5 ha (Prahalad *et al.*, 2009), followed by Dorans Road Saltmarsh (approx. 10 ha). Surveying took place at these two main areas only, as representative locations (Figure 5-25). Clarence City Council (CCC) manages Racecourse Flats, the sports oval, the old Lauderdale tip, and Dorans Road. Department of Parks & Wildlife Services manages the Ralphs Bay Conservation Area, and Department of State Growth manages South Arm Road (Figure 5-25).

A number of studies have taken place over the years at this location, covering topics that include threatened flora, mapping with remote sensing technology, changing local vegetation, temporal changes in saltmarshes, climate change impacts on saltmarshes, and photo monitoring. Reports from these studies are available from the DEP. Currently, a Lauderdale Saltmarsh Reserve Activity Plan (RAP) 2019-2029 is currently being developed by CCC. *The plan seeks to build a shared responsibility among the community and landowners to support the management of priority cultural, social and natural values* (CCC website). DEP and UTAS have contributed to this process and look forward to continuing to assist CCC with management of this important environmental asset.

In the past, as shown in Figure 5-26, it is clear that the saltmarsh previously extended significantly further than at present (current extent depicted in Figure 5-25), and if able to migrate upland as sea levels rise, will cover a larger area again in the future. The Future Coastal Refugia Area overlay shows there to be some capacity for movement, especially in the south eastern area (blue = Compatible zone). There is also some potential refugia area available in the Case by Case Consideration zone, which includes the oval and private leasehold on the south eastern side. The township of Lauderdale is in the Incompatible zone, although north of the canal there is a possibility of extension into a semi-rural area (Special Consideration zone). The area south east of Racecourse Flats is the most promising area for future marsh growth and should be considered in management of the site in the future. Dorans Road Saltmarsh is limited in its ability to transgress upland by Dorans Road and higher ground behind the marsh.

Figure 5-25. Lauderdale saltmarshes. Pink polygon: survey sites. Yellow polygon: current saltmarsh extent. Insert: land tenures of same area.

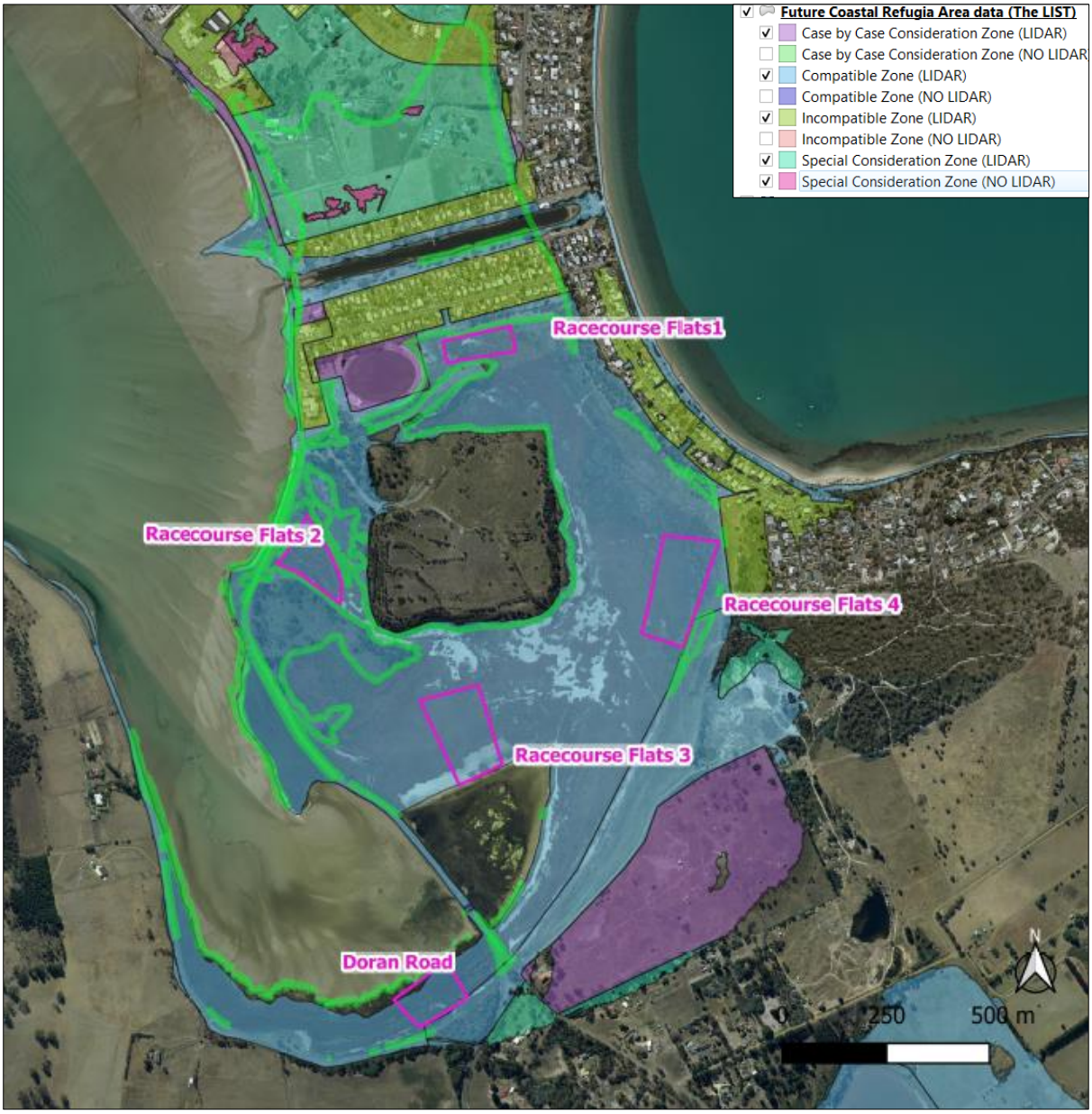

Figure 5-26. Lauderdale aerial image. Pink polygon: survey area. Green polygon: saltmarsh lost since 1946. Fill: Future Coastal Refugia Area. See legend insert and report text for detailed summary.

5.9.1 Racecourse Flats (RF1, RF2, RF3, RF4)

Coastal saltmarshes rely on regular input of saltwater by having a direct link with the marine environment (see Section 2.1), therefore, the lack of tidal connectivity between Racecourse Flats and Ralphs Bay is the biggest issue of concern at this site. The blockage is the South Arm Secondary Road causeway. Three culverts have been installed to provide some limited tidal flow, but unfortunately two of them have been blocked for many years (Figure 5-27), likely predominantly due to the prevailing westerly winds. The only open flow is into East Marsh Lagoon, but this is inadequate, and the lagoon is often eutrophic. Ideally, several large box culverts (e.g. similar to those under the East Derwent Highway at piyura kitina) would be installed to reinstate significant flow into the site, or at the very least the current culverts would be free of blockages. DEP has previously briefed Dept. of State Growth about the situation and received a positive response and understanding of the issues. However due to the lack of funding currently available for culvert upgrades the matter has stalled (following several unsuccessful grants). A positive step is that CCC

has recently worked with Dept. of State Growth on clearing the two blocked culverts. Regrettably, subsequent DEP photo monitoring (2.5 months post-clearing) highlighted the imperative of regular maintenance if the culverts are to stay open (Figure 5-27). The old Lauderdale tip also plays a very significant role, with potential leachate impact requiring investigation prior to any substantial tidal flow increase following culvert clearing.

Figure 5-27. Culvert at creek line near Lauderdale Oval, between Racecourse Flat and Ralphs Bay Conservation Area. Left: previously blocked culvert on day of clean-out. Image: CCC 26 Sept 2019. Right: same culvert almost closed again. Image: DEP 10 Dec 2019.

The composition of the saltmarsh vegetation across Racecourse Flats places all the surveyed sites within the TASVEG community ASS (Table 4). The plant species composition observed at all the RF sites are typical for ASS communities. RF4 was the only estuary site, except GP (an ARS site) where *Sarcocornia quinqueflora* subsp*. quinqueflora* (beaded glasswort) was not observed. Instead, *Sarcocornia blackiana* (thickhead glasswort) was present (Figure 5-28), which is an indicator of drier saltmarsh vegetation (Prahalad, 2012). Research has previously indicated that the lack of tidal connectivity is impacting the ecological values of Racecourse Flats, and that the site is slowly sinking, drying and adapting its vegetation towards more drought tolerant species (Cook, 2012; Prahalad, 2012; Ng, 2016).

Despite the lack of tidal connectivity there is still healthy saltmarsh vegetation growth at Racecourse Flats, with many Obligate and Common saltmarsh species observed (Appendix 9.1), most likely due to saline groundwater and sea spray. The surveyed vegetation at each site was mostly fairly diverse, with the exception of the site RF3, which only had five species (Figure 4-1) and was predominantly a field of *Disphyma crassifolium* subsp*. clavellatum* (roundleaf pigface) (Figure 5-28). The other RF sites all contain a number of sedges, rushes, grasses and other species associated with higher ground and proximity to the landward edge of the marsh (Appendix 9.1). A number of weed species were observed across RF1, RF2 (especially along the road side) and RF4, but only few of serious concern: *Rosa rubiginosa* (sweet briar), *Erica lusitanica* (Spanish heath), and *Asparagus* sp. (Table 5). The southern boundary of RF1 is the most northern section of the old tip site and is weed infested, especially by the Tasmanian declared weed *Foeniculum vulgare* (fennel).

Figure 5-28. Typical Racecourse Flats saltmarsh plant species. Left: *Disphyma crassifolium* subsp. *clavellatum* (roundleaf pigface). Right: *Sarcocornia blackiana* (thickhead glasswort). Images: DEP 2019.

Bird species diversity and bird numbers were low across Racecourse Flats at both tide level surveys (Figure 4-2). Notably, however, the only record of Australasian Pipit (*Anthus novaeseelandiae*) was at Racecourse Flats. Additional species recorded as incidentals included Australasian shelducks (*Tadorna tadornoides*), Black-fronted Dotterels (*Elseyornis melanops*), White-fronted Chats (*Epthianura albifrons*), Common Starlings (*Sturnus vulgaris*) and Superb Fairy-wrens (*Malurus cyaneus*) (Appendix 9.4). The low numbers could in part be due to surveying taking place close to midday on some survey days, compared to earlier survey times elsewhere. Also, the limited buffer zone around these sites may be contributing to overall low numbers.

Like most of the estuary sites, the dominant human impacts across the Racecourse Flats sites fall into the category 'Major inappropriate developments', within and adjacent to the sites. At Racecourse Flats this refers to the road, the oval and old tip (all built on top of saltmarsh), scarring from old vehicle tracks, and rubbish across all sites (Table 8).

One of the areas of concern at Racecourse Flats is the creek system between the oval and the old tip. DEP photo monitoring suggests that there have been algal blooms in this system for a number of years (Figure 5-29). It is uncertain where the additional nutrient causing the eutrophication is coming from, presumably either the old tip or the oval (Figure 5-26). A contributing factor is also the lack of tidal flow into the creek, being cut-off from tidal flooding and not receiving the required regular marine flushing.

5.9.2 Recommendations

- DEP/UTAS to continue supporting the development and implementation of the Lauderdale Saltmarsh RAP.
- CCC, in collaboration with PWS and Dept. of State Growth, to set up a maintenance regime to keep the culverts open.
- CCC to work with oval managers to assess the use of fertiliser, and DEP to continue to photo monitor the creek system.
- CCC to consider collaboration with private land holders to secure areas for future marsh migration south east of Racecourse Flat.
- Remove weeds *Rosa rubiginosa* (sweet briar) at RF2, *Erica lusitanica* (Spanish heath) at RF4, and *Asparagus* sp. at RF1 as part of ongoing whole-of-site weed management.
- CCC has expressed interest in participating in an estuary-wide buffer planting project.
- Bi-annual rubbish removal to be undertaken across the whole site, including along the busy South Arm Road.

Figure 5-29. Creek system between the Lauderdale sports oval and old tip site with algal bloom. Top left: 7 Dec 2016. Top right: 18 Nov 2017. Bottom left: 18 Jan 2018. Bottom right: 11 Oct 2018. Images by DEP.

5.9.3 Dorans Road

Dorans Road saltmarsh is a well-functioning marsh with regular tidal flooding from Ralphs Bay. It is predominantly a TASVEG ASS community with high species diversity (n = 33), having the second highest number of plant species at any site surveyed in the estuary after South Arm (1) (Figure 4-1). Among these species, there were 11 saltmarsh Obligates and six Common species (Appendix 9.1). Eight introduced species were observed (Appendix 9.1), possibly a legacy of past farming activities and proximity to the road. Only one species of management concern was noted, namely the environmental weed *Asparagus* sp. (Table 5).

Only 31 birds from three species were observed within this site: White-fronted Chats (*Epthianura albifrons*)(saltmarsh specialists), Welcome Swallows (*Hirundo neoxena*)(generalists), Superb Fairy-wrens (*Malurus cyaneus*)(generalists), and Pied Oystercatchers (*Haematopus longirostris*) (specialists) adjacent on the mudflats, possibly in part due to the surveys being conducted close to midday on quite warm days.

Human impacts on this site are of mixed concern. The main issues were in the categories 'Major inappropriate development within', representing the historical remnants onsite, i.e. fences and drains (Figure 5-30), 'Major inappropriate developments adjacent', relating to Dorans Road (the road) presenting a major restriction to the future growth of the marsh (Figure 5-26), and 'Rubbish debris', referring to the large amount of rubbish strewn across the entire site, much of which has probably arrived with the tides over many years (some pieces being decades old).

Overall, the main issue of concern for this site is the lack of room to transgress upland over time (Figure 5-26) due to the road and higher land inhibiting retreat. Buffer plantings will improve the fringing vegetation (Table 6) and may help encourage more terrestrial birds into the site.

Figure 5-30. Dorans Road Saltmarsh. Left: section of marsh with predominantly *Sarcocornia quinqueflora* subsp. *quinqueflora* (beaded glasswort) in the foreground and *Tecticornia arbuscula* (shrubby glasswort) in the background. Right: example of historical impacts: farming fences and drains. Images: DEP 6 Dec 2018.

Following vegetation, bird and human impact surveys at Dorans Road saltmarsh, during a separate site visit, it was discovered that people had been accessing the marsh with cars in very recent time (Figure 5-31). The access point will need to be blocked. DEP informed CCC on 16/12/2019.

Figure 5-31. Dorans Road Saltmarsh. Evidence of vehicle accessing the marsh. Image: DEP 13 Dec. 2019.

5.9.4 Recommendations

- CCC to coordinate a large rubbish clean-up and bi-annual follow-ups, possibly in collaboration with local Coastcare group and/or as part of Clean-up Australia Day events.
- Consider additional buffer planting along Dorans Road.
- Remove *Asparagus* sp. as part of broader weed management of the site
- Identify vehicle access point and block off with large rocks or by other means.

5.10 Browns River

The saltmarsh near the mouth of Browns River is divided into two sections, which were both surveyed. These marshes are covered by local government and public reserve tenure (Figure 5-32).

Figure 5-32. Mouth of Browns River at Kingston. Pink polygon: survey area. Yellow polygon: current saltmarsh extent. Insert shows tenures.

The TASVEG community is clearly ARS (25%: ASS, 75%: ARS, Appendix 9.2), with typical saline species including sedges and rushes (DPIPWE, 2005) (Figure 5-33). Plant diversity (n = 18) is comparable with other sites (Figure 4-1), and the site contains all the most commonly found species observed across all sites (Table 3), with six saltmarsh habitat Obligates and five Common species observed (Appendix 9.1). Though there are weeds present none are of concern (Appendix 9.1).

Figure 5-33. Browns River Saltmarsh dominated by *Juncus kraussii* subsp. *australiensis* (sea rush). Image: DEP 4/12/2018.

The available fringing vegetation is limited at this site, both in terms of its lateral extent and width (Table 6). This relates directly to the human impacts on the marsh, which, as is common with other survey sites, is predominantly from inappropriate development within and adjacent to the site (Table 8). The issues here pertain to a substantial amount of historic infill in the area behind the aged care facility and by the playground on the Balmoral Road, and continuous mowing of areas adjacent to the marsh. There is also significant compaction impact from a network of unmanaged walking tracks across the marsh, frequented largely by fishers, but also dogwalkers and other visitors (Figure 5-34). Another notable issue is rubbish, observed right across the site.

Figure 5-34. Browns River Saltmarsh human impacts. Left: historic infill with lawn and bench, and playground infrastructure out of site. Right: informal walking tracks compacting and destroying vegetation. Images: DEP 6/3/19, 4/12/18.

Bird surveys were conducted twice at BR, but both at high tide. The bird diversity was comparable with other sites (Figure 4-2). BR contained more duck species within the marsh than most other sites (Appendix 9.3), with additional species recorded in the waterway adjacent to the marsh (Appendix 9.4). As with other sites, the bird diversity would likely benefit from additional buffer zone plantings, and also from consolidating the numerous walking tracks crossing the northern section. The multiple tracks give people access to much of the area, causing disturbance to birds, compacting the soil and affecting saltmarsh vegetation (Figure 5-34).

When comparing 1946 historic extent with the present day saltmarsh extent, it can be seen that the wider area around the Browns River was already built-up very similarly, with the Kingston Beach Golf Club having by then occupied its present footprint next to the marsh for several decades. The Golf Club website notes that “The Club was officially opened in 1922” and “our proximity to Browns River has historically created drainage issues, however work in recent years has addressed this…” (see http://kbgc.com.au/history/). In 1946, the saltmarsh still covered a larger area than it does at present, with fewer buildings (no aged care facility) and other infrastructure (no playground) close to the marsh. As can be seen in Figure 5-35, sections of the golf course were saltmarsh prior to being cleared, and with limited restoration these would likely become saltmarsh again.

Kingborough Council (KC) worked closely with DEP when the Future Coastal Refugia Area Guidance Map was first developed and has considered possibilities for landward migration (Figure 5-35). Values and future threats to the Browns River saltmarshes have also been detailed in the Kingston Beach Integrated Climate Change and Natural Hazards Project (Kingborough Council, 2016):

> *A future ‘footprint’ of areas suitable for saltmarsh in southern Tasmania has been developed (ibid.). Potentially suitable future areas for the Kingston Beach saltmarshes have been identified further inland. However, any adaptive management approach to saltmarsh transition will need to include consideration of the full range of components, functions and processes of saltmarshes in situ and their interactions with the local environment, catchment, and seascape.*
>
> ***Recommendation**: Assessment of options to facilitate transition of existing saltmarsh to future suitable areas, including assessment of catchment factors.*

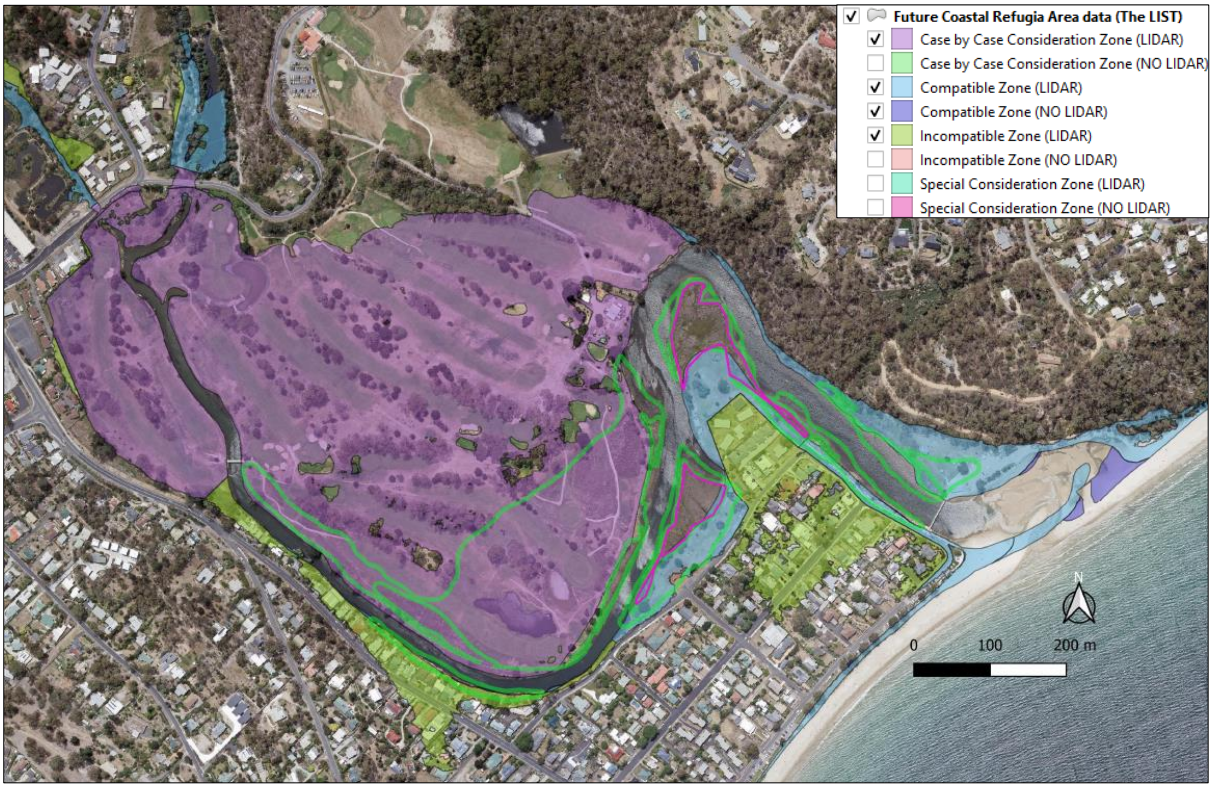

Figure 5-35. Brown River saltmarshes. Pink polygon: survey area. Green polygon: saltmarsh lost since 1946. Fill: Future Coastal Refugia Area – most of it in purple (Case by Case Consideration zone on the golf course) and other half in light green (Incompatible zone due to the adjacent residential area).

5.10.1 Recommendations

- KC to develop a Browns River Saltmarshes concept plan, which includes consolidating the multiple informal tracks across the site that have compacted the marsh significantly.
    - Combine the tracks into one raised boardwalk that suits the need of fishers and walkers (work with fishing and walking community to identify most popular tracks).
    - Consider temporary barriers until boardwalk is installed.
    - Install signage or use other communication to discourage dog walkers and inform locals about the importance of saltmarsh (e.g. social media, local clubs).
- Conduct bi-annual rubbish pick-up; possible project for local Coastcare or Young Explorers groups.
- Encourage more terrestrial birds and protect marshes from weeds by implementing more native plantings in the buffer zone, including close to the age care facility.
- Consider changing the mowing regime in places to encourage saltmarsh expansion.
- Consider bi-annual bird surveys from now on, and in other saltmarsh locations within Kingborough; invite the local Coastcare group to participate and potentially to take some ownership of surveys over time.
- Regarding the consistent poor water quality in Browns River, KC to monitor any algal blooms within the marsh, which will have the potential to affect the function of the wetland. Ideally, conduct sanitary investigation in the Brown River catchment to identify pollution sources.

5.11 Shag Bay (limited survey)

Shag Bay is a small protected embayment located within the East Risdon State Reserve (PWS), containing a saltmarsh patch under 1ha. Two creeks run through the saltmarsh patch. Given the small size of this saltmarsh, only a limited vegetation survey and an incidental bird survey were conducted.

The plant diversity (18 species) was comparable to other sites (Figure 4-1), with an almost equal mix of rushes and herbs (TASVEG: ARS (ARS 60%, ASS 40%) (Figure 5-36). Most of the common plants were present (Table 7), including five saltmarsh habitat Obligates (Appendix 9.1).

Figure 5-36. Shag Bay. Left: Vegetation is a combination of saltmarsh herbs and rushes. Image: DEP 5 Dec 2018. Right: yellow line shows the current saltmarsh extent, and fill shows the Future Coastal Refugia Area (blue indicates Compatible zone and green indicates Special Consideration zone).

The only birds that were recorded were four Superb Fairy-wrens (*Malurus cyaneus*) that were roosting and feeding.

The future retreat options for this saltmarsh are limited, except small zones to the north west of the site, as shown in Figure 5-36.

5.11.1 Recommendations

- The walking track from Geilston Bay to Shag Bay is well placed at the back of the saltmarsh, reducing the effects of soil compaction. It is recommended that track remains in its place.
- Occasional rubbish clean-up events can be initiated with local groups. There has been some interest from locals in forming a 'Friends of Shag Bay' group and this could be promoted through the Clarence City Council.
- The 'Friends of' group can also help assist with weed management around the saltmarsh. The main priority is a large patch of the introduced *Reseda luteola* (wild mignonette) and *Silybum marianum* (milk thistle) on the southern side of the marsh, which are common plants on disturbed ground. DEP has added this site to the PWS list of responsibilities as part of the Derwent Estuary Weed Collaboration.

6 Photo monitored sites

6.1 Windermere Bay south

On the southern side of Windermere Bay there is a thin zone of ARS saltmarsh vegetation, all within Public Reserve tenure. Notably, a large patch of filamentous algae was observed at time of

monitoring (photo monitoring: Figure 6-1). This strip of saltmarsh is currently bordered by a mowed lawn adjacent to a residential area. Figure 6-2 shows the location of photo monitoring (yellow star), the current extent of saltmarsh in the area and where the marsh may migrate upland over time (refugia area). As shown by the inundation modelling, this marsh has the capacity to grow considerably over time, if given the opportunity, and could become an integral part of a future walking experience through Windermere Bay.

Figure 6-1. Photo monitoring site at southern side of Windermere Bay with filamentous algae in the foreground. Image: C. Coughanowr 6 Dec 2018.

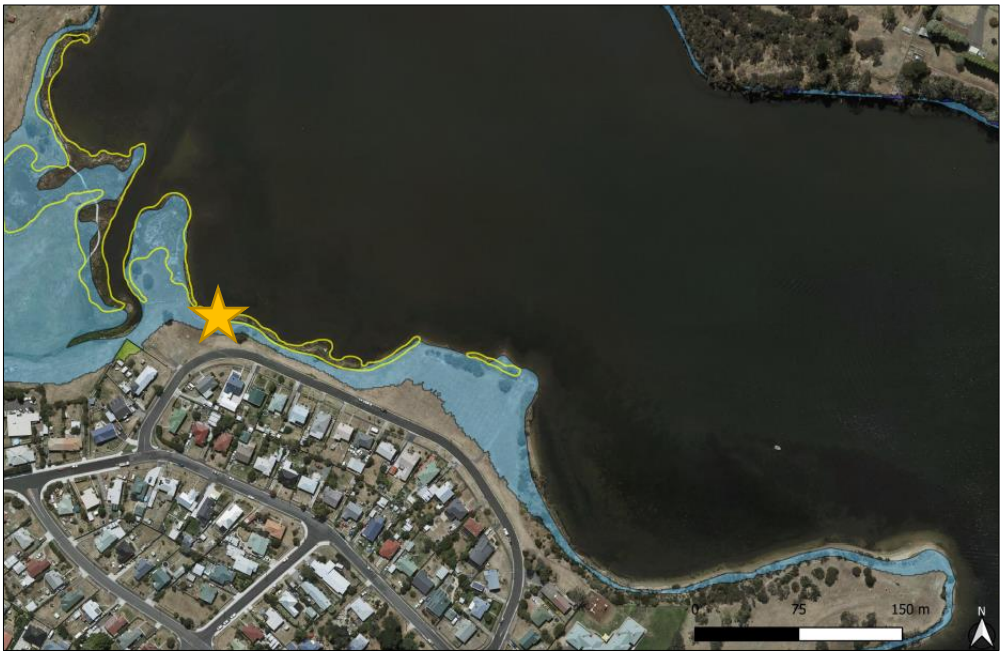

Figure 6-2. Windermere Bay. Yellow polygon: extent of current saltmarsh. Yellow star shows photo monitoring site (looking east). Fill: Coastal Future Refugia Area (blue is a Compatible zone).

6.1.1 Recommendations

- GCC to consider revising mowing regime in places to encourage saltmarsh expansion over time.
- Consider future saltmarsh vegetation expansion when extending the walking path network.
- Observe area for further influx of filamentous algae and identify the species of the algae.
- Remove *Coprosma repens* (mirror bush) as part of ongoing weed management in the bay.

6.2 Glenorchy Art & Sculpture Park (GASP)

The foreshore between GASP and Derwent Entertainment Centre (DEC) is highly modified with a hard concrete and rocky foreshore. But with sea spray and possibly saline groundwater influx, saltmarsh vegetation (TASVEG ASS) is now growing and expanding in places. GCC is actively assisting this expansion near Wilkinsons Point by recently changing their mowing regime in this area. Figure 6-3 is the photo monitored site (looking towards Wilkinsons Point), showing the current extent of saltmarsh. Ongoing photo monitoring will likely capture future expansion towards to footpath.

6.2.1 Recommendations

- GCC to continue to modify mowing regime over time as the saltmarsh vegetation expands.
- Further south, towards the DEC, there is a large patch of low-lying bare ground interspersed with some saltmarsh plants. This area is suitable to be considered for a water sensitive urban wetland area, similar to the existing one in the same location.

Figure 6-3. GASP photo monitoring site, looking north west towards Wilkinsons Point. Image: I Visby 4 Dec 2018. Insert with yellow star shows photo monitoring location on the northern end of the WSUD site.

6.3 Faggs Gully Creek (Geilston Bay)

The mouth of Faggs Gully Creek at Geilston Bay is heavily modified, with very limited saltmarsh vegetation today, compared to 1946 (Figure 6-4).

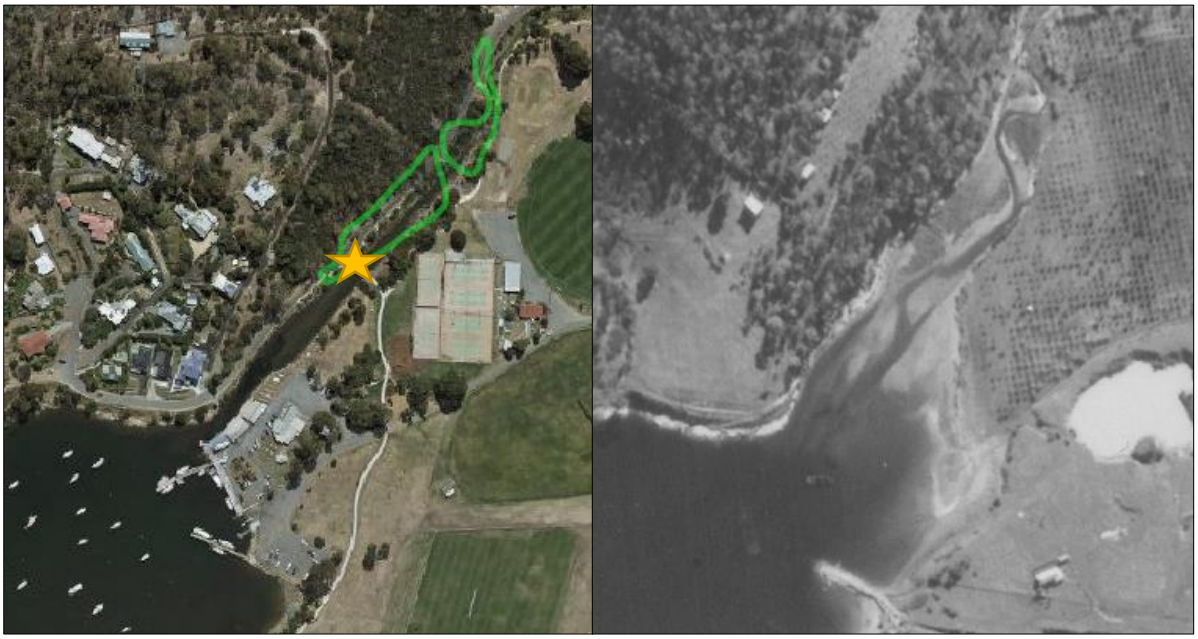

Figure 6-4. Geilston Bay with mouth of Faggs Gully Creek. Left: image from 2018 with green polygon indicating lost saltmarsh since 1946. Right: image from 1946. Yellow star indicates photo monitoring site.

The creek is subject to regular tidal flows, which has allowed for the formation of saltmarsh on the side of the creeks. However, there is little room for upland movement beyond the creek bank due to semi-urban developments. Numerus fish (of unknown species) were observed in the creek during the field visit.

Two images for photo monitoring were taken from the little walking bridge over Faggs Gully Creek, looking both ways (Figure 6-5).

Figure 6-5. Faggs Gully Creek. Photo monitoring images taken from the walking bridge. Top: looking east. Bottom: looking west. Images: DEP 5 Dec 2018.

6.3.1 Recommendations

- Any new developments along the creek can provide for a more gradually sloped bank which would encourage saltmarsh growth and expansion.
- There is approximately a 100 sq m area on the southern side of the creek where the bank gradient could be reduced to create a gradually sloped platform for saltmarsh (also serving to increase fish habitat in the creek).

6.4 Montrose Bay High School

This small fringing marsh on Crown Land (under the authority of the Department of Education) was included for photo monitoring as an example of saltmarsh vegetation that has expanded over relatively few years (pers. obs. V. Prahalad 2018). The foreshore environment here is exposed to wind waves, with obvious impact on the vegetation from wave erosion (Figure 6-6). The marsh is on a strip of land between the foreshore and rocks placed where mowing stops.

Figure 6-6. Three photo monitoring points at Montrose Bay High School. Top: saltmarsh between gravel foreshore and placed rocks. Left: mix of saltmarsh herbs and rushes. Right: section of eroded vegetation. Images: DEP 4 Dec 2018.

The saltmarsh vegetation at this site has the potential for further growth in its current position, and upland migration in the future. Figure 6-7 shows the Coastal Future Refugia Area modelling with a significant compatible area for the marsh to move into (the blue Compatible zone), although additional retreat area is limited by existing infrastructure in the form of roads and carpark.

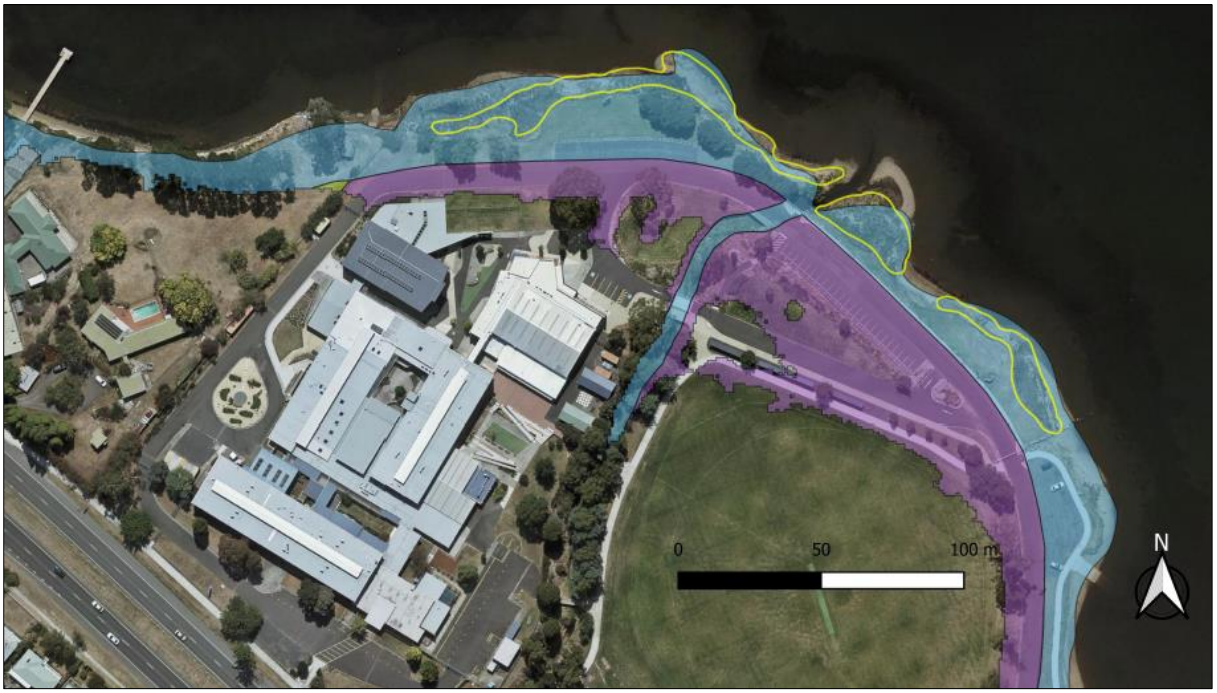

Figure 6-7. Montrose Bay High School saltmarsh. Yellow polygon: extent of current saltmarsh. Fill: Coastal Future Refugia Area (blue = Compatible zone, purple = Case by Case Consideration zone).

6.4.1 Recommendations

- DEP/UTAS to consider talking with the high school about including saltmarsh values in their curriculum (students could actively monitor vegetation changes over time).
- Modify the mowing regime by moving the rocks inland as the marsh grows.
- There are some informal tracks through healthy and thick saltmarsh vegetation in places – school to consider consolidating paths and installing saltmarsh interpretation signs.
- DEP is currently looking into boat wake impacts in the estuary. This site is a potential candidate for boat wake monitoring.
- The highly invasive, introduced saltmarsh plant *Spartina anglica* (rice grass) was last observed at this site in spring 2016; DEP and GCC to continue to monitor for this species.

7 Acknowledgements

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8 References

Adams P. (1990) 'Saltmarsh Ecology.' (Cambridge University Press: Cambridge).

Cook F. (2012) Notes from site visit and scoping of Racecourse Flats saltmarsh restoration. By EcoProTem for Derwent Estuary Program (Hobart, Australia).

Coughanowr C.A., Whitehead J., Whitehead S., Einoder L.E., Taylor U., Weeding B. (2015) The State of the Derwent estuary 2015. A review of environmental data from 2009 to 2014. Derwent Estuary Program (Hobart, Australia).

DEE (2016) Coastal wetlands - mangroves and saltmarshes. Department of Environment and Energy, Commonwealth of Australia (Canberra, Australia).

Department of Environment and Climate Change NSW (2008) Best practice guidelines for coastal saltmarsh. State of NSW (Sydney).

DPIPWE (2000) A wetlands strategy for Tasmania. Department of Primary Industries, Parks, Water and Environment (Hobart, Australia).

DPIPWE (2005) 'From Forest to Fjaeldmark.' (S Harris and A Kitchener, Eds.). (Department of Primary Industries Water and the Environment: Hobart, Australia).

Dykman M., Prahalad V. (2018) Tamar saltmarsh monitoring program: Citizen science monitoring of the tidal treasures of the Tamar river estuary, Tasmania, Australia. *Australian Journal of Maritime*

and Ocean Affairs **10**, 222–240.

Einoder L.E., Coughanowr C.A., Whitehead J., Berkinshaw T.D. (2012) Derwent Estuary Conservation Action Plan, Summery September 2012. Derwent Estuary Program (Hobart, Australia).

Kingborough Council (2016) Kingston Beach Integrated Climate Change and Natural Hazards Project. Climate Planning for Kingborugh Council (Kingston, Tasmania).

Mount R., Prahalad V., Sharples C., Tilden J., Morrison B., Lacey M., Ellison J., Helman M., Newton J. (2010) Circular Head Region Coastal Foreshore Habitats : Sea Level Rise Vulnerability Assessment. Final report. By Blue Wren Group, School of Geography and Environmental Studies, University of Tasmania for Cradle Coast NRM Region and Cradle Coast Authority (Hobart, Australia).

Neckles H. a., Dionne M., Burdick D.M., Roman C.T., Buchsbaum R., Hutchins E. (2002) A monitoring protocol to assess tidal restoration of salt marshes on local and regional scales. *Restoration Ecology* **10**, 556–563.

Ng D. (2016) Change in a Tidally Isolated Saltmarsh in the Derwent Estuary 2012-2016. (unpublished) School of Land & Food, University of Tasmania (Hobart, Australia).

NRM North (2017) Community Saltmarsh Monitoring Handbook. NRM North (Hobart, Australia).

Prahalad V. (2012) Vegetation Community Mapping and Baseline Condition Assessment of the Lauderdale Racecourse Flats Saltmarsh, Derwent Estuary. By University of Tasmania for Derwent Estuary Program (Hobart, Australia).

Prahalad V.N., Harrison-Day V., Latinovic A., Kirkpatrick J.B. (2018) Inventory and Monitoring of the Vascular Plants of Tasmanian Saltmarsh Wetlands. The Tasmanian Naturalist 140 (Hobart, Australia).

Prahalad V., Jones J. (2013) Mapping coastal saltmarshes in Southern Tasmania - Mapping summary. By University of Tasmania for NRM South (Hobart, Australia).

Prahalad V.N., Kirkpatrick J.B., Mount R.E. (2011) Tasmanian coastal saltmarsh community transitions associated with climate change and relative sea level rise 1975-2009. *Australian Journal of Botany* **59**, 741–748.

Prahalad N., Lacey M.J., Mount R.E. (2009) The Future of the Derwent Estuary Saltmarshes and Tidal Freshwater Wetlands in Response to Sea Level Rise. By University of Tasmania for the Derwent Estuary Program and NRM South (Hobart, Australia).

Prahalad V.N., Pearson J. (2013) Southern Tasmanian Coastal Saltmarsh Futures. A Preliminary Strategic Assessment. Prepared for NRM South (Hobart, Australia).

Prahalad V., Whitehead J., Latinovic A., Kirkpatrick J.B. (2019) The creation and conservation effectiveness of State-wide wetlands and waterways and coastal refugia planning overlays for Tasmania, Australia. *Land Use Policy* **81**, 502–512.

Prahalad V., Woehler E., Latinovic A., Mcquillan P. (2015) Inventory and monitoring of the birds of Tasmanian saltmarsh wetlands. BirdLife Tasmania (Hobart, Australia).

Spencer J., Monamy V., Breitfuss M. (2009) Saltmarsh as habitat for birds and other vertebrates. 'Aust. Saltmarsh Ecol.' (Ed N Saintilan)(CSIRO Publishing).

Threatened Species Scientific Commitee (2013) Conservation Advice for Subtropical and Temperate Coastal Saltmarsh. Department of Sustainability, Environment, Water, Population and Communities (Canberra, Australia).

Whitehead J. (2012) Lauderdale environmental assets: Assessment of climate change impacts on coastal and marine areas. Derwent Estuary Program (Hobart, Australia).

9 Appendix

9.1 Plant survey results for each site

Table A1. Plants are primarily listed under plant family headings. Introduced species are indicated by "(i)" after the scientific name, and particularly concerning weeds are listed at the bottom of the table. Saltmarsh habitat occupancy is included for some plants after the common name: Occ = Occasional, Com = Common, Obl = Obligate, Unc = Uncommon.

Scientific Name	Common Name	WB	GP	GB	OB	pk	CP	SB	SA1	SA2	SA3	DR	RF1	RF2	RF3	RF4	BR
Aizoaceae																	
Carpobrotus rossii	Native pigface (Occ)				√				√		√			√			√
Disphyma crassifolium* subsp. *clavellatum	Roundleaf pigface (Com)						√		√	√	√	√	√	√	√	√	
Tetragonia implexicoma	Bower spinach (Occ)								√	√	√	√		√			
Amaranthaceae																	
Hemichroa pentandra	Trailing saltstar (Obl)								√	√	√		√	√		√	
Apiaceae																	
Apium prostratum* subsp. *prostratum* var. *filiforme	Slender sea-celery (Com)	√	√	√		√			√	√	√	√		√			√
Lilaeopsis polyantha	Jointed swampstalks (Com)			√													
Asteraceae																	
***Actites* sp. (i)**	Thistle				√	√											
***Cirsium vulgare* (i)**	spear thistle								√		√						
***Cotula coronopifolia* (i)**	Water buttons (Com)	√		√	√		√						√	√			
***Dimorphotheca fruticose* (i)**	African daisy								√		√						
Leptinella longipes	Coast buttons	√		√													√
***Leontodon saxatilis* (i)**	Hairy hawkbit (Unc)								√			√				√	
Ozothamnus ferrugineus	Tree everlastingbush															√	
Senecio pinnatifolius* var. *pinnatifolius	Common coast groundsel (Unc)																
***Senecio elegans* (i)**	Purple groundsel (Unc)								√								
Senecio minimus	Shrubby fireweed																
***Senecio* spp.**	Groundsel								√	√	√	√	√			√	
***Sonchus oleraceus* (i)**	Common sowthistle								√	√	√	√					
***Sonchus asper* subsp. (i)**	Prickly sowthistle								√								
***Tragopogon porrifolius* subsp. *porrifolius* (i)**	Salsify								√			√	√				
***Urospermum dalechampii* (i)**	False dandelion								√								
***Vellereophyton dealbatum* (i)**	White cudweed (Occ)										√	√				√	
Campanulaceae																	
Lobelia anceps	Angled lobelia (Com)									√	√						
Caryophyllaceae																	

Scientific Name	Common Name	WB	GP	GB	OB	pk	CP	SB	SA1	SA2	SA3	DR	RF1	RF2	RF3	RF4	BR
Spergularia tasmanica	Seaspurrey (Obl)	√					√	√	√		√	√	√	√		√	
Chenopodiaceae																	
Atriplex paludosa* subsp. *paludosa	Marsh saltbush (Obl)								√		√	√	√				
Atriplex cinerea	Grey saltbush (Occ)								√	√	√			√			
***Atriplex prostrata* (i)**	Creeping orache (Com)	√	√	√	√	√		√	√		√		√	√			√
***Atriplex* sp.**	saltbush					√											
***Chenopodium glaucum* (i)**	Pale goosefoot (Occ)			√		√		√	√								
Rhagodia candolleana* subsp. *candolleana	Coastal saltbush (Occ)								√	√	√	√		√			
Sarcocornia blackiana	Thickhead glasswort (Obl)				√		√			√	√	√	√	√	√	√	
Sarcocornia quinqueflora* subsp. *quinqueflora	Beaded glasswort (Obl)	√		√	√	√	√	√	√	√	√	√	√	√	√		√
Suaeda australis	Southern seablite (Obl)	√					√		√		√	√		√			√
Tecticornia arbuscula	Shrubby glasswort (Obl)						√		√			√	√	√			
Convulvulaceae																	
Wilsonia backhousei	Narrowleaf wilsonia (Obl)				√		√				√	√		√		√	
Goodeniaceae																	
Selliera radicans	Shiny swampmat (Obl)	√	√	√	√	√	√	√	√		√	√		√		√	√
Malvaceae																	
Lawrencia spicata	Candle saltmallow (Obl)								√			√	√	√		√	√
Mimosaceae																	
Acacia longifolia* subsp. *sophorae	Coast wattle								√								
Plantaginaceae																	
***Plantago coronopus* subsp. *coronopus* (i)**	Slender buckshorn plantain (Occ)	√	√	√	√	√	√	√	√		√	√	√	√		√	√
***Plantago lanceolate* (i)**	Ribwort plantain												√				
Primulaceae																	
Samolus repens* var. *repens	Creeping brookweed (Obl)	√	√	√	√	√	√	√	√	√	√	√		√			√
***Lysimachia arvensis* (i)**	Scarlet pimpernel					√											
Sapindaceae																	
Dodonaea viscosa* subsp. *spatulata	Broadleaf hopbush											√					
Scrophulariaceae																	
Thyridia repens	Creeping monkeyflower		√	√	√		√										√
Myoporum insulare	Boobialla								√	√			√				
Centrolepidaceae																	
Centrolepis polygyna	Wiry bristlewort (Occ						√										
Cyperaceae																	
Bolboschoenus caldwelli	Sea clubrush (Unc)			√													

Scientific Name	Common Name	WB	GP	GB	OB	pk	CP	SB	SA1	SA2	SA3	DR	RF1	RF2	RF3	RF4	BR
Baumea juncea	Bare twigsedge (Occ)			√													
Ficinia nodosa	Knobby clubsedge (Occ)	√			√	√		√	√	√	√	√				√	√
Gahnia filum	Chaffy sawsedge (Com)	√		√	√	√	√		√	√	√	√	√	√		√	√
Isolepis cernua	Nodding club-rush (Com)		√	√		√		√				√				√	
Schoenoplectus pungens	Sharp clubsedge (Occ)		√	√													
Schoenus nitens	Shiny bog-rush (Com)									√	√					√	
Juncaceae																	
Juncus kraussii* subsp. *australiensis	Sea rush (Obl)	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√
Juncus procerus	Tall rush							√								√	
Juncus revolutus	Creeping rush (Unc)				√								√				
Juncaginaceae																	
Triglochin striata	Streaked arrowgrass (Com)	√	√	√	√				√				√				
Cycnogeton procerum	Greater waterribbons		√	√	√												
Poaceae																	
***Ammophila arenaria* (i)**	Marram grass								√								
***Rytidosperma* sp.**	Wallabygrass															√	
Austrostipa stipoides	Coast speargrass (Com)	√			√	√	√	√	√	√	√	√	√	√	√	√	√
***Bromus* sp. (i)**	Brome											√					
***Cynosurus echinatus* (i)**	Rough dogstail												√				
***Dactylis glomerate* (i)**	Cocksfoot								√								
Deschampsia cespitosa	Tufted hairgrass		√	√													
Dichelachne crinita	longhair plumegrass															√	
Distichlis distichophylla	Australian saltgrass (Com)	√			√	√	√			√		√		√			√
***Holcus lanatus* (i)**	Yorkshire fog									√			√			√	
***Hordeum marinum* (i)**	Barleygrass (Unc)				√												
***Lachnagrostis* sp**	blowngrass			√												√	
***Lolium perenne* (i)**	Perennial ryegrass												√				
***Parapholis incurva* (i)**	Coast barbgrass (Occ)	√			√	√						√					√
Phragmites australis	Southern reed (Occ)	√		√					√								
***Poa* spp.**	Tussockgrass	√	√	√	√	√		√		√	√	√	√	√		√	√
***Polypogon monspeliensis* (i)**	Annual beardgrass (Occ				√			√									
Puccinellia stricta	Australian saltmarshgrass (Obl)	√			√	√	√			√			√	√	√		
***Vulpia* sp. (i)**	Fescue												√				
Restionaceae																	
Apodasmia brownii	Coarse twinerush (Com)	√	√	√	√			√									
Ruppia																	

Scientific Name	Common Name	WB	GP	GB	OB	pk	CP	SB	SA1	SA2	SA3	DR	RF1	RF2	RF3	RF4	BR
Ruppia polycarpa	Manyfruit seatassel (Unc)			√													
Typhaceae																	
***Typha* sp. (i?)**	Cumbungi (Unc)			√			√										
Other less common																	
Acaena novae-zelandiae	Common buzzy	√														√	
***Conyza sumatrensis* (i)**	Fleabane								√								
***Epilobium billardiereanum* subspp.**	Willowherb								√								
***Epilobium* sp.**	Willowherb															√	
Dianella brevicaulis	Shortstem flaxlily										√					√	
***Leucopogon* sp.**	Beardheath													√			
Lomandra longifolia	Sagg															√	
***Medicago* sp. (i)**	Clover								√								
***Melilotus indicus* (i)**	Sweet melilot											√					
***Microtis* sp.**	Onion-orchid																
***Reseda luteola* (i)**	Wild mignonette							√									
***Rumex* sp. (i)**	Dock		√	√												√	
***Rumex crispus* (i)**	Curled dock												√				
***Silybum marianum* (i)**	Milk thistle							√									
Pteridium esculentum	Bracken							√		√							
Introduced species of particular concern																	
***Rubus fruticosus* agg. (i)**	Blackberry						√			√							
***Chrysanthemoides monilifera* ssp. *monilifera* (i)**	Boneseed						√										
***Lycium ferocissimum* (i)**	African boxthorn									√							
***Pinus radiata* (i)**	Radiata pine									√							
***Rosa rubiginosa* (i)**	Sweet briar				√	√	√			√				√			
***Juncus acutus* (i)**	sharp rush	√															
***Erica lusitanica* (i)**	spanish heath															√	
***Coprosma repens* (i)**	mirror bush	√															
***Asperagus* sp. (i)**	Asperagus	√										√	√				

9.2 TASVEG community list

Table A2. Percentage cover of species and taxa within TASVEG communities ASS and ARS at each survey site. Proportion of TASVEG ASS and ARS, and overall TASVEG class is shown at the bottom of the table.

	WB	GP	GB	OB	pk	CP	SB	SA1	SA2	SA3	DR	RF1	RF2	RF3	RF4	BR
ARS																
Juncus kraussii* subsp. *australiensis	25-50	25-50	25-50	25-50	>50	5-25	25-50	<5	<5	5-25	<5	<5	5-25	<5	5-25	>50
Gahnia filum	5-25	0	<5	5-25	5-25	0	<5	5-25	5-25	25-50	5-25	<5	5-25	<5	<5	<5
Austrostipa stipoides	5-25	0	0	5-25	<5	<5	<5	5-25	5-25	5-25	<5	5-25	5-25	<5	5-25	<5
Other rushes, sedges, grasses	5-25	25-50	25-50	<5	<5	<5	25-50	<5	<5	<5	<5	<5	5	5-25	25-50	5-25
ASS																
***Sarcocornia* spp.**	25-50	0	<5	25-50	<5	25-50	25-50	25-50	>50	25-50	25-50	25-50	25-50	25-50	<5	5-25
Tecticornia arbuscula	0	0	0	0	0	25-50	0	25-50	0	0	25-50	25-50	5-25	<5	0	0
Other succulent herbs and shrubs	5-25	25-50	25-50	<5	5-25	5-25	0	5-25	5-25	5-25	5-25	5-25	25-50	25-50	>50	<5
Bare ground	5-25	5-25	<5	5-25	<5	5-25	0	<5	25-50	5-25	5-25	5-25	5-25	5-25	<5	<5
Other woody, scrubs, trees	<5	0	0	<5	<5	<5	0	<5	<5	<5	<5	<5	<5	<5		<5
TASVEG																
ARS	75	65	70	60	90	25	60	40	25	40	20	20	30	20	35	75
ASS	25	35	30	40	10	70	40	60	75	60	80	80	70	80	65	25
Combined TASVEG Class	ARS	ARS	ARS	ARS	ARS	ASS	ARS	ASS	ASS	ASS	ASS	ASS	ASS	ASS	ASS	ARS
						Typha (5%)										

9.3 Bird numbers, behaviours and habitat usage at each site

Table A3. Bird numbers, behaviours and habitat usage at each survey site. Tide level during surveys is indicated for each survey site (HT = high tide, LT = low tide). Number of individuals is shown for each species recorded during each survey, with behaviour observed indicated after number of individuals (F = feeding, R = roosting, N = nesting). Habitat usage category (Prahalad *et al.*, 2015) is indicated after bird common name (H = specialist, M = generalist, L = occasional visitor).

Scientific Name	Common Name	WB - HT	WB - HT	GP - HT	GP - LT	GB - HT	GB - LT	OB - HT	OB - LT	pk - HT	pk - LT	CP - HT	CP - LT	SA1 - HT	SA1 - LT	SA2 - HT	SA2 - LT	SA3 - HT	SA3 - LT	DR - HT	DR - LT	RF1 - HT	RF1 - LT	RF2 - HT	RF2 - LT	RF3 - HT	RF3 - LT	RF4 - HT	RF4 - LT	BR - HT	BR - HT
Waterfowl: geese, swans, ducks																															
Cygnus atratus	Black Swan (M)			1R	31F		5F																								
Biziura lobata	Musk Duck (M)						1F																								
Tadorna tadornoides	Australian Shelduck (H)																									5R					
Anas castanea	Chestnut Teal (H)									2R		14R						5R													
Anas platyrhynchos	Mallard (L)	8R																												4R	
Anas superciliosa	Pacific Black Duck (M)	1R	5R							4R								2R												3R	
Chenonetta jubata	Australian Wood Duck (L)																													4R	
Anas gracilis	Grey Teal (H)				3F		2F					12R																			
Pelican																															
Pelecanus conspicillatus	Australian Pelican (H)				3R																										
Herons, egrets, bitterns																															
Egretta novaehollandiae	White-faced Heron (H)	1R	1F									1R						2F+R												1R	2F
Ardea modesta	Great Egret (H)				1F																										
Cormorants																															
Phalacrocorax melanoleucos	Little Pied Cormorant (M)				1F																										
Phalacrocorax fuscescens	Black-faced Cormorant (L)	1R																													
Phalacrocorax sulcirostris	Little Black Cormorant (M)						1F																								
Phalacrocorax carbo	Great Cormorant (M)				13R +F																										
Rails, crakes, hens, coots																															
Porphyrio porphyrio	Purple Swamphen (M)				3N+F																										
Tribonyx mortierii	Tasmanian Native-hen (M)	2F	1R	1F	1N			2F		2F	5F	4F	3F			3R+F	7F	2R												8R+F (2	4F
Curlews, sandpipers, snipes, godwits																															
Calidris ruficollis	Red-necked Stint (H)															28R +F															
Oystercatchers																															
Haematopus longirostris	Pied Oystercatcher (H)													5F+R		3F+R															
Harmatopus fuliginosus	Sooty Oystercatcher (M)															10R															
Lapwings, plovers, dotterels																															
Elseyornis melanops	Black-fronted Dotterel (H)											1F+R	2R																		
Vanellus miles	Masked Lapwing (H)		30R						5R			2F		2R																2R	2R
Gulls, terns																															
Larus pacificus	Pacific Gull (M)	1R					3R																								
Larus dominicanus	Kelp Gull (M)											2R				10N +8F															
Larus novaehollandiae	Silver Gull (M)		15R									26R						1F												10R	
Kites, hawks, harriers, eagles																															
Circus approximans	Swamp Harrier (H)					1R		1R?																							
Falcons, hobbies, kestrels																															
Falco cenchroides	Nankeen Kestrel (M)						1R																								
Swallows, martins																															
Hirundo neoxena	Welcome Swallow (M)	4F	4F	2F+R	5F			4F		2F			3F			4F+R				12F +R			2F		1F			1F	3F	
Ravens																															
Corvus tasmanicus	Forest Raven (M)											1		1R																	
Fairy-wrens																															
Superb fairy-wren	Superb Fairy-wren (M)			1F						2F		1R		10R +F	4	2F+R	4R+F+N			1R											
Scrubwrens, thornbills																															
Acanthiza chrysorrhoa	Yellow-rumped thornbill																											12F +R			
Chats, honeyeaters																															
Epthianura albifrons	White-fronted Chat (H)													7R+F						12F +R	6F										
Robins																															
Petroica multicolor	Scarlet Robin (L)																1F+R														
Petroica phoenicea	Flame Robin (L)																											2R+F			
Pipits																															
Alauda arvensis	Skylark (M)							1F																							
Anthus novaeseelandiae	Richard's Pipit (M)																									1F		2F+R	6R		
Introduced passerines																															
Passer domesticus	House Sparrow (L)	2F		4F+R	26F +R																		2F							2F	
Sturnus vulgaris	Common Starling (M)	2F						8F						12R +F		3F						4R									
Other																															
Eolophus roseicapilla	Galah	1F																													
	Hybrid (Pacific Black Duck x Mallard)		5F																												

9.4 Additional bird results

Table A4. Additional bird results, including incidental observations, and sightings adjacent to the survey area. Tide level is shown after site code (HT = high tide, LT = low tide). Adjacent = birds observed adjacent to the survey area. Incidental = birds observed outside the 20 min. survey time. Bird behaviour, if observed, is shown in brackets after the bird name, as F = feeding, R = roosting, N = nesting.

Site code + tide level	Incidental sightings + birds observed adjacent to the survey area + bird behaviour.
WB - HT	Adjacent: 2 Black Swans
GP - HT	In adjacent buffer zone: Black Swans, Silver Eyes. Incidentals in opposite marsh: 28 Black Swans, 1 Australian Pelican
GB - HT	Incidental: 1 White-faced Heron
OB - HT	Adjacent: 3 Pelicans, 30 Black Swans, 5 Great Cormorants, 1 Black-faced Cormorant, 1 White-faced Heron
OB - LT	Adjacent: 32 Black Swans, 33 Masked Lapwings, 26 Silver Gulls, 2 Chestnut Teals, 1 Kelp Gull, 1 Pied Oystercatcher, 1 Pacific Black Duck, 3 Little Pied Cormorants, 1 Great Cormorant
pk - HT	Incidentals: 1 Grey Teals, 18 Pacific Black Duck, 1 Great Egret, 2 Wood Ducks
pk - LT	Adjacent on low tide exposed mudflat next to saltmarsh: 2 Black Swans, 5 Tasmanian Native-hens, 8 Pacific Black Ducks, 17 Chestnut Teals, 2 Superb Fairy-wrens, 2 Silver Gulls, 5 Mallards, 3 hybrids (Mallard x Pacific Black Ducks), 6 White-faced Herons, 1 Little Pied Cormorant
SB - HT	Incidentals: 4 Superb Fairy-wrens (R+F)
SA1 - HT	Incidentals: Pied Oystercatcher, Superb Fairy-wren, White-fronted Chat
SA2 - HT	Incidentals: 3 Red-capped Plovers (F), 2 Masked Lapwings (F+R)
SA2 - LT	Incidentals: 8 White-fronted Chats (N)
SA3 - HT	Adjacent: 4 Chestnut Teals, 2 White-bellied Sea-eagles perching nearby. 1 rabbit observed on marsh.
SA3 - LT	Adjacent: 1 juvenile Brown Falcon (R), 4 Grey Fantails
DR - HT	Incidentals: 1 Pied Oystercatcher + 8 White-faced Herons (F+R)
DR - LT	Adjacent in water outside marsh: 4 Pied Oystercatchers. Incidentals: 1 Superb Fairy-wren, 1 White-fronted Chat
RF1 - HT	Incidentals: 2 White-fronted Chats (F), 1 European Starling (F)
RF2 - LT	Incidentals: 1 Black-faced Dotterel (F, R), 3 Superb Fairy-wrens
RF3 - HT	Adjacent: 100+ Common Starlings flying around the site
RF3 - LT	Adjacent: 6 Australasian Shelducks by edge of East Marsh Lagoon, 2 Black-faced Dotterels (N)
RF4 - HT	Adjacent: 5 Noisy Miners, 1 Yellow Wattlebird
BR - HT	Adjacent in buffer: New Holland Honeyeater. Adjacent in the water: Eurasian Coots, Chestnut Teals, Cormorant, Pied Oystercatcher
BR - HT	Adjacent playground: 4 Tasmanian Native-hens