Observation Records and Breeding Summary of Blue-billed Ducks *Oxyura australis* in Victoria from 2015 to mid-2021 Indicating Species Decline.

Based on data from VBA – Victorian Biodiversity Atlas, eBird Australia and Birdata (Birdlife Australia) along with Relevant Site Observations, Lake Knox, Victoria.

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* Blue-billed Ducks - a Female (above) and a Male (below), Lake Knox, Victoria. Photos : Russell Plew

Summary

The Conservation Status of the Blue-billed Duck in Victoria has received a variety of ratings by a number of authorities in recent years –

- **Vulnerable** – DELWP 2021 (SWIFFT – Reference 2 and FFG Threatened List - Reference 6)
- **Threatened** – Flora and Fauna Guarantee Act 1988 (pre-August 2021)
- **Endangered** – The Advisory List of Threatened Vertebrate in Victoria – 2003 (DSE 2003 – Reference 1)

Most recently the Vulnerable status has been advised by DELWP based on a small number of claimed very large sightings going back over the previous decade or more, despite the ongoing reduction of observations sightings and bird numbers as recorded in VBA, eBird and Birdata (Database References 1, 2 & 3) at all reported sites within the State. The species has continued to decline over the course of the last several years. Given the accelerating nature, and damage, of Climate Change, this study seeks to –

- Highlight the ongoing species decline within the State, seeking to restore the species status to Endangered
- Highlight the limited number of habitation sites within the State
- Highlight the very small number of recorded Breeding Sites within the State and their needed higher habitat rating and protection status
- Recognise a minimum Open Water distance required for the Blue-billed Duck to access a waterbody and hence identify a minimum waterbody size required by the Blue-billed Duck
- Identify required characteristics for successful Breeding Habitats
- Designate sites in order of increasing value based on –
    - **Drop-in Habitats** – Low numbers of birds seen periodically with no apparent habitation. These could be migration transit sites or previous habitation sites which have degraded to the point of being unsuitable for habitation. Lowest value (relative to Breeding Habitats)
    - **Loafing Habitats** - High numbers of birds habiting, however no breeding observed. Medium value
    - **Breeding Habitats** - Low numbers of birds due to their high requirement for privacy, security and need for substantial feeding of hatchlings, however very high value of the site due to recruitment of the species. Highest value

With the acceleration of development consuming more greenspace, including wetlands and breeding sites utilised by the Blue-billed Duck, both natural and artificial, there is an urgent need to rethink and implement strategies to protect and enhance breeding sites and hence the species within the State. This report also seeks to recommend breeding habitat site requirements, to both enable the identification and protection of all breeding habitats and for developers, in conjunction with controlling water authorities and environmental agencies, to devise and implement the required features into artificial wetlands as they relate to urban development with the aim of supporting and expanding available habitat for the species. In particular, the report seeks to demonstrate the minimum open water distance of a waterbody required for the birds to enter and exit. This distance was found to be 97m, the birds were not observed within the sightings reports on smaller waterbodies, however the mean open water distance for small waterbodies the ducks use was found to be from 250m to 300m. This distance was further complicated by measurements of the 27 known breeding habitats which showed a minimum open water distance of 140 metres. The implication of this finding questions the relatively small available open water of reed bed stormwater retarding basins typically created by developers for new subdivisions adjacent to natural water courses and claimed to support the species, and potentially other deep and open water species such as the Hardhead Duck.

Key words : Blue-billed Duck, BBD, breeding habitat

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Introduction : The Blue-billed Duck – Suited to Water and Deep-Diving in Preference to Flight

The Blue-billed Duck, BBD, is a deep diving duck, though not belonging to the tribe of 'true diving ducks', Aythyini, primarily filter feeding on the bottom for insects and plant material, requiring deep and open water. They tend to preferentially, although not necessarily exclusively, nest in reed areas dominated by Bull Rush or Cumbungi *Typha* spp.), verging on the deep water. (DSE action statement Blue-billed Duck Ref 1). They are a small duck, up to 40cm in length, with a rounded, heavy body and sit low in the water compared to other waterbirds. The heavy body helps them to dive deep, at least 3m (HANZAB – Reference 7), observed up to 5m. Their legs are set further back on the body with long, strong legs and very large, webbed feet to propel them quickly both under the water and across the surface. They are more at home on the water and will seek to dive under the water when threatened rather than fly. They are seldom seen on land, and the large legs and feet, set further back on the body compared to other ducks, make them ungainly on land, with a wobbling gait similar to penguins - they prefer to stay on the water, largely foraging under the surface. They are seen to survey their surroundings often between dives, and if they perceive a threat they will raise their stiff tail feathers up to 90 degrees, even 100 degrees, past vertical at full alert, depending on the level of perceived threat, plus raise their neck vertically at full alert, head held rigidly horizontal. If they feel in imminent threat, they will dive under water however, keep their feet close to the surface in order to throw water high into the air (up to 1 metre) to distract the threat while they dive deep, turn and swim fast underwater in a random direction, popping up from 1 to several metres away, immediately at alert, scanning for further threats. The distance was observed to be proportional to the perceived threat.

Their wings are also small, relative to body size. After diving to feed they tend to preen and flap their wings for short to extended periods - seen from behind their back and wing muscles are very well developed compared to other ducks, they also flap their wings much faster. It is presumed they need a lot of exercise of their wing muscles as flying requires a lot of strength with very fast wing beats to propel them to flight speed and maintain flight - flight speed has been noted as very fast in order to propel the relatively large and heavy body, much faster than other duck species. A "pattering behaviour" has been noted in a number of studies, and seen numerous times at Lake Knox - BBD's seen to run-fly over the water extremely fast over an extended distance. It has been said it could be an aggressive or mating display (HANZAB – Reference 7), however during the Lake Knox viewing period this "pattering" was noted both when other BBD's were present, however also when they weren't - in equal numbers, indicating it might more likely be a form of flight exercise, if not, serve more than one purpose. Observations of this behaviour when in the presence of other BBD's from both male and female birds indicated it was more likely flight exercise, fun, or a method of rapid transit to prime feeding areas. This behaviour was for distances of around 20 metres to over 100 metres in a few to several seconds - an explosive start, rapidly flapping wings, running on the surface with head and neck stretched forward at 10 to 20 degrees to the horizontal, ending with the wing flapping stopped, legs draped back, surging to a stop on the chest, wings retracted and the bird lost in a surge of waves to the left and right. The speed required for this "pattering" strongly suggests the Blue-billed Duck requires a very long distance to attain flight speed and slowly gain height at a shallow angle. Likewise, the landing is extremely fast and at a shallow angle, more a controlled crash with birds impacting with their chest and stomach, skipping and spinning to an ungraceful stop. The long distance required to attain flight also suggests why they dive for threats rather than fly - they would be a target for predators for an extended period at the water's surface, in a straight line, whereas immediately diving and throwing water high to distract and confuse or dissuade predators, popping up at a random location up to several metres away, is a far safer form of defence given their relative struggle to attain and maintain flight. These many observations over months also rose the hypothesis that the Blue-billed Duck can only access open waterbodies of around 100 metres or more and only if these waterbodies weren't fringed by tall trees - the shallow angle of flight for flight entry too, or exit from, the waterbodies precluding them from small or too enclosed waterbodies.

In order to further explore whether the species observations suggesting a large open water distance requirement to land on or leave a Waterbody were accurate, many observations were required to be tabled

and summarised. The publically accessible Databases of VBA, eBird and Birdata were queried for all Blue-billed Duck observations from 2015 to mid-2021 with findings following.

Methods

VBA, eBird and Birdata Records Summarised and Referenced

See the accompanying Appendix 1: '**Report Reference - Oxyura australis -VBA-Ebird-Birdata-Wetland datasets 2015-to-30August2021.xlsx**' Microsoft Excel file encompassing 15,955 observation records from 2015 to mid-2021 summarised to compile this report. This is the Master Database list of all records and summaries.

The observations were sorted by latitude and longitude in order to identify the waterbody of the observation and numbers of birds. These waterbodies were then viewed in Google Maps 'satellite view' and measured within the web service for total area, circumference, maximum and minimum open water distances. Sites were also further categorised by reports of successful breeding, and hence of far greater species significance as these sites are known to replenish numbers of the species more so than non-breeding Loafing and Drop-In Habitats.

Note that many waterbodies viewed in Google Maps while full or near-full at observation time were shown dry or significantly lower at the time the Google Maps 'satellite view' was taken during a drought period, and hence were measured at the indicated maximum water line as shown by water and vegetation lines around the waterbodies.

Waterbody Site List Showing a Downward Trend in Blue-billed Duck Numbers

The observation records were then tabled in a spreadsheet by the waterbody site and tallied by date. This data clearly shows the trends of Blue-billed Duck numbers at each site.
See the accompanying Appendix 2: '**Report Reference - Blue-bill Numbers tally trends 2015-to-30August2021.xlsx**' Microsoft Excel file

The spreadsheet clearly indicates –

- Sites with ongoing habitation – those with long strings of birds numbers over time
- Possible drop-in-only sites - those with infrequent bird numbers over time
- Sites that had previous habitation, a long string of continuous sightings, however may have degraded to being unsuitable as seen by the end of the continuous sightings with only drop-ins – such as Lakewood Reserve
- Sites where BBD sightings have ended – they may be dry, oversalinated, polluted, lost to development or over-recreation, etc.
- The running total line 4 indicates a downward trend in bird numbers across all sites over time

Waterbody Types Defined in This Study

The Google Maps 'satellite view' showed a range of different waterbody types, both natural and artificial including Wetland, Lake, Farm Dam, Reservoir, Stormwater Treatment Ponds, and Sewage Treatment Plant Ponds. These were classified as follows -

Table 1 - Type of Waterbody

type of waterbody	<5Ha	5-50Ha	>5Ha	total
wetland	24	12	8	44
Farm Dam (private)	11	2		13
Dam	17	4	5	26
Sewage Treatment Plant	20	14	3	37
Stormwater treatment	13			13
Lake	13	28	33	74
total waterbodies	98	60	49	207

Types of waterbodies were divided into 5 categories *Wetland*, *Farm Dam*, *Dam*, *Sewage Treatment Plant* and *Stormwater Treatment Function*. *Farm Dams* and *Sewage Treatment Plant* were easy to define based on location. *Lake* type was used where the waterbody had that name in its location. Some of the waterbodies may also have a stormwater function but many had the word wetland in their location name so were classified as *Wetland*. The *Stormwater Treatment Function* type was used on waterbodies that had a known stormwater treatment function which was particularly common in housing estate developments. The *Dam* classification sometimes could also have been classified as *Lake* as over time the original purpose of the dam had changed and in some cases was functioning as a recreational lake and although it still served the purpose of a dam for water holding purpose it was known as a lake. Many of the larger dams fit this description. Over time the purpose of the waterbody changes to reflect the communities understanding and use of the waterbody and the term *Lake* is more fitting.

These definitions do not impact on the findings, however they do indicate that the changes in a waterbody may impact on the species of bird using the waterbody. This is especially so if there is an increase in human presence on or near the waterbody or in smaller waterbodies as the fringe vegetation reduces open water or where trees get higher on the edges.

The choice for the size of the waterbodies was used after reviewing some studies on waterfowl abundance. Many of these studies look at determining the number of waterbirds, often game ducks that are present in the waterbodies, to help determine abundance as a means of regulating the numbers of birds that can be harvested. The three categories of size were less than 5 hectares, 5 to 50 hectares and more than 50 hectares. In this study the number of waterbodies less than 5 Hectares (50000m2) is just under 50% of the total waterbodies where BBDs were present. This would suggest it might be more useful to further divide that category.

Summary of Data Work Methodology

Data Collation Work Explained

The data was collated in a master spreadsheet for each of the data sets for each of the database sites we selected – VBA, eBird and Birdata. For each dataset from these databases a separate sheet was used and then the data for each site was tallied in a totals sheet, "Site Data summary". This was done by manually working through 15,955 records from the data sets to determine the maximum records across each month. For all sites Google Maps was used to gather data about the size of the waterbody – Area, Perimeter, Open Water Maximum Distance and the Minimum Crossing Distance. This data was recorded separately for each site with a screen captured image and the measurement details on the screen capture.

The maximum distance measurements were recorded based on the use of the embedded line tool dragged across the waterbody to determine the maximum open water distance. These results were then recorded in a summary sheet for each waterbody, combining all the data sets provided for 79 months of data.

Limitations of the Counts Data

Some of the sites had multiple records per month in many months while other sites had few records per month for very few months, likely due to observer (site visitation) bias. This is likely to have an impact on the way that average counts are interpreted and the confidence in the numbers recorded. Any interpretation of these counts should be viewed with those limitations in mind. The number of months with recorded data tries to highlight these limitations. Selected sites will be used to show the variation in patterns across the period investigated and might help focus more attention on where and how data should be collected. The use of the average figures was to try and get a sense of the relative importance of sites to help with further data collection. In 2015 a few records in the VBA dataset obtained across lagoons at the Western Treatment Plant over a few days established the largest records of BBDs in all the data sets, as a result of targeted counts. No similar targeted surveys have occurred since then in any of the datasets. This focused set of surveys places exceptional attention on one waterbody being used by BBDs as opposed to other sites. The large congregation of birds at this site does not adequately address the important role played by other sites where the BBDs go to particularly for breeding purposes as the Western Treatment Plant continues to show no evidence of breeding.

We considered the maximum number of ducks a valid way of determining the suitability of the waterbody to accommodate the BBDs. The table of data from each of the waterbody types shows for each site:

a. the area class of the site;

b. maximum count recorded across all months;

c. the number of months with surveys;

d. the average number of birds per observed month; and,

e. the maximum length of open water in the waterbody.

The maximum length was determined through measurement in Google Maps where a line was placed on the map showing the maximum extent of open water where this was possible to determine. In some sites this was difficult to determine due to fringe vegetation or dry conditions making the edge of the waterbody more difficult to define. This was more significant on the smaller sites with fringe vegetation and on the larger waterbodies which appeared drier. In waterbodies that were dry, or severely diminished in the Map image however full or near-full at the time of sighting, the waterbodies were measured from the clear outside edge indicated by fringing vegetation.

Results

Summary of Database Records Results Tables for Waterbody Types

Table 2 - Dams (Public access)

Wetland	Type of Waterbody	Area Class S=<5Ha M=5-50Ha L=>50Ha	Maximum BBD Count Recorded	Number of Months Surveyed 2015 to Present	Average Number of BBDs per Observed Month	Maximum Open Water Distance
Swan Reach Pond	Dam	S	12	21	4	130
Greigs Rd ponds	Dam	S	5	1	5	135
Eyensbury Discovery Centre dam	Dam	S	16	4	8	140
Twin Dams	Dam	S	5	1	5	145
Bunurong Memorial Park Lake	Dam	S	7	3	5	179
Keysborough golf club lake	Dam	S	2	2	2	184
Growling Frog Golf Course, Yan Yean	Dam	S	3	4	2	225
Timms Road, Poowong North	Dam	S	3	1	3	232
Wilson Botanic Park	Dam	S	1	1	1	235
Springvale Botanical Cemetary dam 1	Dam	S	24	14	7	257
PGH brickworks	Dam	S	6	10	3	258
Lantrak Quarry	Dam	S	2	5	2	307
Tanunda wetlands	Dam	S	20	45	8	335
Bald Hills Reserve	Dam	S	8	21	3	355
Beaufort Reservoir	Dam	S	3	1	3	413
Blue Lake	Dam	S	12	2	7	470
Frankston Nature Conservation Reserve	Dam	S	39	8	13	500
Bittern Reservoir	Dam	M	5	1	5	500
Ondit Quarry	Dam	M	15	9	7	601
Candowie Reservoir	Dam	M	115	9	28	1030
Belfast Lough	Dam	M	22	2	12	2320
Devilbend Reservoir	Dam	L	329	32	42	1830
Moorabool Reservoir Park	Dam	L	20	1	20	1,920
Greenvale Reservoir Park	Dam	L	9	3	7	1980
Merrimu Reservoir	Dam	L	1	1	1	2620
Yan Yean Reservoir	Dam	L	5000	48	666	3140

Table 3 - Farm Dam (Private ownership)

Wetland	Type of Waterbody	Area Class S=<5Ha M=5-50Ha L=>50Ha	Maximum BBD Count Recorded	Number of Months Surveyed 2015 to Present	Average Number of BBDs per Observed Month	Maximum Open Water Distance
Lancefield farm dam	Farm Dam	S	1	1	1	108
Critter's Dam	Farm Dam	S	2	4	2	145
Arthurs Creek Yan Yean farm dam	Farm Dam	S	2	2	2	157
Balbirooroo Wetlands Private Dam	Farm Dam	S	5	3	3	167
Gerangamete Farm Lake	Farm Dam	S	6	4	4	170
Mason Farm	Farm Dam	S	6	4	4	195
Merbein Private Dam	Farm Dam	S	50	2	29	200
Lancefield North Dams	Farm Dam	S	2	2	2	223
Inverleigh small Dam	Farm Dam	S	4	1	4	242
Yarram Creek Private Dam	Farm Dam	S	7	8	3	387
Murroon Private Dam	Farm Dam	S	3	2	2	453
Cargerie Two lakes	Farm Dam	M	2	1	2	317
Jigsaw farms	Farm Dam	M	3	3	3	470

Table 4 - Lake (Small area)

Wetland	Type of Waterbody	Area Class S=<5Ha M=5-50Ha L=>50Ha	Maximum BBD Count Recorded	Number of Months Surveyed 2015 to Present	Average Number of BBDs per Observed Month	Maximum Open Water Distance
Wylies Creek Track	Lake	S	2	18	2	137
Traralgon Railway Conservation Reserve	Lake	S	6	15	2	140
Lake Knox	Lake	S	7	10	4	150
Highlands Lake	Lake	S	12	11	5	229
Fisher Lake	Lake	S	9	2	6	243
Pinkerton Forest Lake	Lake	S	9	2	7	267
Lake Coranderrk	Lake	S	19	14	10	286
Swan Lake	Lake	S	6	11	3	313
Lake Lorne	Lake	S	70	69	15	320
Waterford Valley Lakes	Lake	S	4	8	3	322
Bambra Winchelsea lake	Lake	S	3	1	3	337
Lake Bunga Beach Reserve	Lake	S	12	11	4	354
Lake Caroline	Lake	S	2	2	2	626

Table 5 - Lake (Medium area)

Wetland	Type of Waterbody	Area Class S=<5Ha M=5-50Ha L=>50Ha	Maximum BBD Count Recorded	Number of Months Surveyed 2015 to Present	Average Number of BBDs per Observed Month	Maximum Open Water Distance
Newlands lake reserve	Lake	M	4	2	3	106
Lake Swanee	Lake	M	4	1	4	401
Jells Park Lake	Lake	M	15	53	4	418
Lake Pertobe	Lake	M	30	9	3	428
Karkarook big lake	Lake	M	7	35	2	453
Koorlong Lake	Lake	M	34	6	2	483
Freshwater Lake	Lake	M	150	2	143	534
Lake Ayrey Wildlife Reserve	Lake	M	7	1	7	577
Lake Lascelles	Lake	M	2	2	2	621
Lake Konardin	Lake	M	65	2	65	644
Lake Hattah	Lake	M	65	8	12	708
Round Lake	Lake	M	435	19	15	750
Green Hill Lake	Lake	M	8	2	6	969
Upper Stony Creek Reservoir	Lake	M	30	10	9	991
Deep Lake, Derinallum	Lake	M	159	1	159	1010
Lake Coradgill	Lake	M	100	1	100	1,150
Lake Yando	Lake	M	6	2	6	1210
Lake Hamilton	Lake	M	7	13	3	1,250
St Marys Lake	Lake	M	24	3	18	1280
Lake Elizabeth	Lake	M	155	5	44	1,380
Lysterfield Lake	Lake	M	1	3	1	1560
Tower Hill Wildlife Reserve	Lake	M	310	22	55	1590
Lake Marmal	Lake	M	11	2	10	1,650
Albert Park Lake	Lake	M	2	1	2	1700
Lake Struan	Lake	M	310	16	82	2,660
Lakes Entrance	Lake	M	1	1	1	2660
Little Lake Meran	Lake	M	16	6	9	2,660
Lake Condah Swamp	Lake	M	2	2	2	7863

Table 6 - Lake (Large area)

Wetland	Type of Waterbody	Area Class S=<5Ha M=5-50Ha L=>50Ha	Maximum BBD Count Recorded	Number of Months Surveyed 2015 to Present	Average Number of BBDs per Observed Month	Maximum Open Water Distance
Heywood Lake	Lake	L	25	5	10	1520
Lake Cullulleraine	Lake	L	2	1	2	1530
Lake Kennedy Wildlife Reserve	Lake	L	2	1	2	1,690
Lake Bitterang, Hattah	Lake	L	1	1	1	1720
Lake Terangpom	Lake	L	200	8	102	1740
Lake Murphy, Dingwall	Lake	L	28	1	28	1,780
Lake Milangil	Lake	L	218	4	81	1,870
Lake Mournpall, Hattah	Lake	L	7	1	7	1,890
Lake Elingamite	Lake	L	27	8	14	1,910
Lake Koreetnung	Lake	L	5	1	5	1940
Lake Kramen	Lake	L	25	4	11	2070
Lake Wendouree	Lake	L	52	57	10	2,080
Lake Buninjon	Lake	L	530	1	530	2,270
Lake Cope Cope	Lake	L	7	2	5	2320
Wurdee Buloc Reservoir	Lake	L	500	25	49	2500
Lake Wallawalla	Lake	L	30	1	30	2550
Lake Purrumbette	Lake	L	22	29	8	2,660
Lake Rosine	Lake	L	601	15	89	2,660
Lake Tooliorook	Lake	L	152	6	38	2,660
Lake Victoria	Lake	L	31	2	31	2,660
Lake Muirhead	Lake	L	50	2	26	2,770
Green Lake	Lake	L	2	2	2	2800
Lake Natimuk	Lake	L	8	4	6	2,800
Lake Learmonth	Lake	L	1	1	1	2,880
Lake Modewarre	Lake	L	201	5	56	2,910
Lake Cullen	Lake	L	104	12	25	3,420
Lake Boga	Lake	L	53	2	47	3750
Lake Bael Bael	Lake	L	20	4	11	3860
Lake Linlithgow	Lake	L	2200	12	610	4,130
Lake Lonsdale	Lake	L	800	6	169	4,940
Lake Bolac	Lake	L	4600	21	387	5300
Lake Connewarre	Lake	L	3	1	3	5870
Lake Colac	Lake	L	230	15	30	7,790

Table 7 - Sewage Treatment Plants (Small ponds)

Wetland	Type of Waterbody	Area Class S=<5Ha M=5-50Ha L=>50Ha	Maximum BBD Count Recorded	Number of Months Surveyed 2015 to Present	Average Number of BBDs per Observed Month	Maximum Open Water Distance
Heathcote Water Reclamation Facility	Sewage Treatment	S	1	1	1	119
Cape Paterson Treatment Plant, Wonthaggi	Sewage Treatment	S	6	1	6	182
Aireys Inlet STP	Sewage Treatment	S	1	1	1	238
Hamilton Sewage Farm	Sewage Treatment	S	8	2	5	248
Beveridge recycled water lagoons	Sewage Treatment	S	4	4	3	249
Ouyen Water Storage	Sewage Treatment	S	1	1	1	258
Barwon water treatment plant	Sewage Treatment	S	30	13	11	270
Kilmore sewage ponds	Sewage Treatment	S	2	1	2	272
Seymour Sewage Treatment Plant	Sewage Treatment	S	475	11	73	278
Murchison Sewage Ponds	Sewage Treatment	S	10	1	10	280
Edenhope Sewage Water Dams	Sewage Treatment	S	10	2	7	297
Pakenham WTP	Sewage Treatment	S	60	40	13	303
Wallan Sewerage Treatment Plant	Sewage Treatment	S	5	17	3	304
Broadford Sewage Treatment Plant	Sewage Treatment	S	68	9	36	314
Orbost Water Treatment Plant	Sewage Treatment	S	4	2	3	324
Lakes Entrance Water Treatment Plant	Sewage Treatment	S	24	10	6	350
Aurora Recycled Water Project	Sewage Treatment	S	9	9	6	391
Grants Rd Recycled Water Lagoon	Sewage Treatment	S	1	2	1	409
Bass Coast Water Treatment Plant	Sewage Treatment	S	20	1	20	421
Mildura Water Treatment Plant	Sewage Treatment	S	4	3	3	758

Table 8 - Sewage Treatment Plants (Medium ponds)

Wetland	Type of Waterbody	Area Class S=<5Ha M=5-50Ha L=>50Ha	Maximum BBD Count Recorded	Number of Months Surveyed 2015 to Present	Average Number of BBDs per Observed Month	Maximum Open Water Distance
Horsham Sewage Water Storage Dam	Sewage Treatment	M	30	16	16	193
Maryborough Sewage Ponds	Sewage Treatment	M	4	10	3	211
Bendigo Sewage Ponds	Sewage Treatment	M	46	22	8	319
Eagle Point Water Treatment Plant	Sewage Treatment	M	64	5	27	344
Trafalgar Wastewater Treatment Ponds	Sewage Treatment	M	14	9	5	373
Romsey Sewage Treatment Ponds	Sewage Treatment	M	20	2	11	400
Moe Waste Water Treatment Plant	Sewage Treatment	M	184	11	65	449
Wahgunyah Sewage Ponds	Sewage Treatment	M	11	4	8	450
Tatura Wastewater Treatment Facility	Sewage Treatment	M	12	1	12	527
Drouin Sewage Treatment Ponds	Sewage Treatment	M	212	8	85	532
Bacchus Marsh Water Treatment	Sewage Treatment	M	120	1	120	550
Kyabram wastewater treatment facility	Sewage Treatment	M	9	2	7	565
Bendigo Sewage Ponds - Wallenjoe Rd Ponds	Sewage Treatment	M	30	5	10	720
Swan Hill Sewage Treatment Plant	Sewage Treatment	M	50	15	18	1060

Table 9 - Sewage Treatment Plants (Large ponds)

Wetland	Type of Waterbody	Area Class S=<5Ha M=5-50Ha L=>50Ha	Maximum BBD Count Recorded	Number of Months Surveyed 2015 to Present	Average Number of BBDs per Observed Month	Maximum Open Water Distance
Shepparton Wastewater Treatment Plant	Sewage Treatment	L	16	4	11	270
Eastern Treatment Plant	Sewage Treatment	L	2220	68	188	1210
Western Treatment Plant, Cocoroc - WTP all ponds combined	Sewage Treatment	L	5525	75	226	1580

Table 10 - Stormwater function waterbody (all sizes)

Wetland	Type of Waterbody	Area Class S=<5Ha M=5-50Ha L=>50Ha	Maximum BBD Count Recorded	Number of Months Surveyed 2015 to Present	Average Number of BBDs per Observed Month	Maximum Open Water Distance
Karkarook Horseshoe	Stormwater Function	S	3	19	2	97
Karkarook Park Snakey Pond	Stormwater Function	S	3	9	2	120
Narre Warren North Recreational Reserve	Stormwater Function	S	1	1	1	121
River Gum Creek Reserve	Stormwater Function	S	3	3	3	131
Jacana Wetland	Stormwater Function	S	5	10	2	150
The Keys Wetlands	Stormwater Function	S	6	49	3	164
Casey Fields Lake	Stormwater Function	S	1	1	1	176
Eastone Reserve	Stormwater Function	S	2	3	2	194
Dandenong Valley Wetlands	Stormwater Function	S	7	4	2	200
Drysdale Rec reserve Dam 2	Stormwater Function	S	5	10	3	207
Drysdale Rec reserve Dam 1	Stormwater Function	S	5	11	4	246
Woodlands Industrial Estate	Stormwater Function	S	5	7	2	274
Lakewood reserve	Stormwater Function	S	10	40	4	276

Table 11 - Wetland (Small)

Wetland	Type of Waterbody	Area Class S=<5Ha M=5-50Ha L=>50Ha	Maximum BBD Count Recorded	Number of Months Surveyed 2015 to Present	Average Number of BBDs per Observed Month	Maximum Open Water Distance
Janefield Wetlands	Wetland	S	10	1	10	105
Maurie Jarvis Woodland	Wetland	S	5	3	3	118
Grange Burn Wetland	Wetland	S	5	9	2	132
Gooramadda Road Wetlands	Wetland	S	1	1	1	135
Energy Australia Wetland	Wetland	S	3	1	3	140
Morang Wetlands	Wetland	S	2	3	2	143
Baxters Wetland	Wetland	S	18	15	8	151
Begola Wetland	Wetland	S	80	4	22	155
Balbirooroo Wetlands	Wetland	S	7	19	3	157
Fishers Wetland	Wetland	S	9	4	4	160
Braeside Park Wetland	Wetland	S	64	68	13	175
Westgate Park Wetlands	Wetland	S	3	4	2	176
Yuyana Welands	Wetland	S	20	1	20	224
Banyule Flats Reserve	Wetland	S	2	3	2	226
EA Wetland Morwell	Wetland	S	22	15	5	226
Troups Creek Wetland	Wetland	S	16	5	3	249
Mill Park Lakes	Wetland	S	6	12	2	378
Serendip Sanctuary	Wetland	S	50	33	4	381
Coolart Luxton Lagoon Wetland	Wetland	S	8	31	3	400
Skip Lane Wetland	Wetland	S	5	5	3	404
Luxford Pond	Wetland	S	1	1	1	463
Jawbone Conservation Reserve	Wetland	S	15	72	8	517
Mullawallah Wetland	Wetland	S	27	28	7	625
The Spit Wildlife Reserve	Wetland	S	3	1	3	1320

Table 12 - Wetland (Medium and Large)

Wetland	Type of Waterbody	Area Class S=<5Ha M=5-50Ha L=>50Ha	Maximum BBD Count Recorded	Number of Months Surveyed 2015 to Present	Average Number of BBDs per Observed Month	Maximum Open Water Distance
North Gardens: Lake Wendouree	Wetland	M	6	22	3	130
Edithvale Seaford wetland Seaford swamp	Wetland	M	38	18	13	250
Edithvale Seaford Wetlands Edithvale	Wetland	M	12	40	4	340
Mill Swamp	Wetland	M	2	4	2	456
Fawthrop Lagoon	Wetland	M	1	1	1	464
Krause Swamp	Wetland	M	12	3	8	500
Reedy Lake	Wetland	M	1	1	1	580
Killarney Beach Wetland	Wetland	M	10	2	10	779
Hospital Swamp	Wetland	M	20	3	11	900
Walker Swamp	Wetland	M	504	5	117	1180
MacLeod Morass Wildlife Reserve	Wetland	M	20	22	6	1410
Dumbopperty Swamp	Wetland	M	110	1	110	1650
Winton Wetlands	Wetland	L	2	2	2	1380
Sale Common Nature Reserve	Wetland	L	2	2	2	1420
Connans Swamp	Wetland	L	68	1	68	1640
Cullens Lake Wildlife Reserve	Wetland	L	10	5	4	1850
Hird Swamp	Wetland	L	18	4	6	2399
Johnson Swamp	Wetland	L	11	5	5	2900
Cundare Pool	Wetland	L	327	6	101	3960
Koorangie Wildlife Reserve	Wetland	L	168	3	92	4340

Site Field Observations by the Authors

A summary of database records by itself was not deemed sufficient by the authors, so a number of sites were observed on-site by the authors as follows. At the time of writing due to periodic COVID-19 lockdowns and travel limitations the list is not comprehensive however comprises a subset of waterbody types.

Site Field Observations by John Cull

Field observations occurred across a number of waterbodies during the previous 12 months. This included general observations of the waterbody as well as recording sightings of Blue-billed Ducks (BBD's) at the sites. Sites included: Lake Wendouree, North Gardens Lake Wendouree, Mullawallah Wetlands, Traralgon Railway Conservation Reserve, Braeside Wetlands, Lake Knox, Devilbend Reservoir, Luxton Lagoon Coolart, Balbirooroo Wetland, Springvale Botanical Cemetery, Wilson Botanic gardens, Jawbone Conservation Reserve, Lakewood reserve, Jells Park, Lysterfield Lake, Macleod Morass Wildlife Reserve in Bairnsdale and Jones Bay Wildlife Reserve in Bairnsdale. A number of sites without BBD sightings were also visited including: Croydon Library Pond, Carribbean Lake, Ringwood public golf course dam, Glen Waverly Public Golf Course Dam, Candlebark reserve lakes, Narr Maen Reserve lakes, Lilydale lake, Liverpool Rd Retarding Basin, Birdsland Reserve in Belgrave, Glenfern Valley Bushland Reserve Lake, Blackburn lake and Lake Connewarre Wildlife reserve.

Of particular relevance to our study is Croydon Library Pond which previously had sightings of Blue-billed ducks noted particularly as a refuge site during the millennium drought. (Lorimer - Reference 5) No records of Blue-billed ducks have been recorded there since these dates, and declining water quality and increased vegetation on and around the Pond are likely reducing its suitability for Blue-billed ducks. A series of smaller mostly stormwater treatment wetlands including Heatherdale wetlands, Ringwood Lake, Koolamarra Waters in Rowville, Lakeside Reserve in Rowville, Ferntree Gully Quarry recreation reserve, Tim Neville arboretum, and Stamford Park wetlands in Rowville were visited to investigate characteristics of the site and determine limitations for BBDs. These sites did not have records of BBDs even though BBDs were known to exist in the areas. Despite growing numbers of records being made of birds even during the pandemic limitations of 2020/2021 via eBird checklists, no records were being made of BBDs.

Site Field Observations by Russell Plew

Blue-billed Duck, BBD, observations are hampered by a lack of consistency in the behaviour of the birds. If they do not want to feed they simply will not appear on the waterbody, or they are seen loafing (curled up napping) for the observation period. Waterbodies that are a long distance away from the observer are less likely to provide useful observational data due to fewer trips being undertaken and possibly no sightings being made even though birds may be habiting.

Lake Knox, Lakewood Reserve, Jells Park Lake and other local Knox City Council area lakes are within a few kilometres of the author's address and easy to access frequently, at all times between dawn and dusk. Being familiar with the area and visiting all local waterbodies numerous times, Lake Knox was the only waterbody with significant habitation and breeding over prior years observed, so extensive observations were made during the period of October 2020 to August 2021 (and beyond, in order to gain a full year's observational records). The other waterbodies within Knox were also regularly visited, however in the same period only 1 day of 5 drop-ins to Lakewood Reserve Lake and one male/female BBD pair habiting Jells Park Lake for a short period, were observed. There were also single drop-ins by the Hardhead Ducks, which were much more frequently observed at Lake Knox.

Lake Knox, Knoxfield is a waterbody within Knox with both ongoing BBD habitation and successful breeding. According to a DSE study "There are only 17 wetlands in Victoria where Blue-billed ducks have been recorded breeding. Of these wetlands there are 11 where there has been only one record (DSE 2004 Atlas of Victorian Wildlife)" (DSE Action Statement 174 Ref 1)

Investigations of the data sets by the authors has shown 27 breeding sites with 18 of those sites having breeding in one season only. One site has documented breeding over 4 seasons – Mullawallah Wetlands., and another over 3 seasons - Braeside Park.

Lake Knox as a successful breeding habitat is also significant as the species is noted to congregate in large numbers on loafing habitats, however then disperse across the state to smaller breeding habitats. The Lake is significant by having BBD's in numbers typically less than 10 - a noted species trait (HANZAB – Reference 7) with birds most likely to breed at such sites, where the shy birds have both privacy and security however access to significant feeding for themselves and hatchlings without competition from other hatchings. Lake Knox fits this species trait, with deep and open water, significant aquatic vegetation and ample Reeds (Bull Rush, Cumbungi) for nesting, being directly off the deepest water.

Detailed site observations occurred between October 2020 and August 2021 of Lake Knox in Knoxfield. The records of these observations are contained in iNaturalist (Project - Wildlife of Lake Knox) eBird checklists and Birdata observations. There is also a separate document available with detailed observation notes of the site. The observations show the presence of BBDs living and breeding on the site as well as interactions and presence of other bird species using Lake Knox.

Case Study and Summary of Observations of the Blue-Billed Ducks at Lake Knox – October 2020 to July 2021

The summarised records do not give information on the behaviour of the Blue-billed Duck which would be a useful inclusion. Due to its close proximity to two of the authors (R. Plew and J. Cull) and known ongoing habitation and breeding of the Blue-billed Duck, detailed observations were made at Lake Knox, 609-621 Burwood Hwy, Knoxfield. The lake is a long-established former farm research dam believed to have been an expanded excavation of original shallow wetlands on the site.

The Blue-billed Ducks (BBDs) were observed to be habiting and breeding on Lake Knox in numbers between 1 and 7 throughout the period, typically found in numbers of 3 to 4, either 3 males or 3 males and 1 female, although up to 3 male/female pairs and 2 females and 1 male were observed during this period. Observations were not standardised, being made on different days and at different times from dawn to dusk. Birds were most likely to feed from dawn for generally 2 to 3 hours, late morning for around 2 hours, early afternoon on occasion for around an hour and late afternoon for 2 to 3 hours.

They dive to filter feed on invertebrates and aquatic vegetation (HANZAB – Reference 7) on the lake bottom in benthic vegetation, including Eel Grass *Vallisneria australis*, quickly dipping their heads down into the water, legs wide and frog-kicking down vertically, stiff tail fanned wide and seen last in the dive. The male dives for up to 30 seconds and waits 5 to 10 seconds between dives, sometimes seen taking three deep breaths before the dive – breathe deep, raising the head slightly with bill tucked down (not to be confused with the head bobbing displays to the female, asking to mate). The female dives for generally 35 seconds and can dive again within 2 seconds making her more difficult to see when scanning the lake due to her mottled brown colouring, feathers a close-set alternating wavy mid brown to chestnut brown with grey stripes, dark brown bill, slightly smaller than the male and low to the water due to the species relatively heavy weight compared to other water birds. The brightly coloured male, chestnut body, black neck and head with sky-blue bill, was relatively easy to pick up. If the lake was a little choppy from wind, the female could be detected by watching for the males and where they were looking – their sight-line generally showed the female, although some waiting for the dives was required, watching for the disturbed water of a dive and waiting for her to briefly surface. Between these feeding sessions the males were most likely to curl up to nap on the lake with females

either retiring to a nest or napping in company with males. Note that the napping isn't true sleep – they have their bills tucked into their back feathers however occasionally open their eyes then gently, almost imperceptibly, paddle in a slow circle, surveying their surroundings while appearing to sleep. If the breeze causes them to drift away from their preferred spot on the waterbody, they gently paddle back, not leaving the curled up position, still appearing to sleep. A very subtle behaviour.

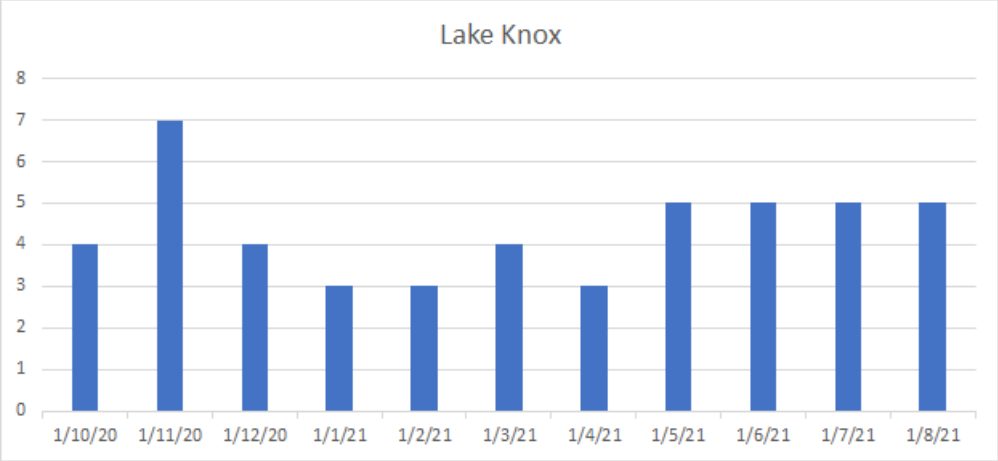


Figure 1 : Lake Knox BBD numbers per month

A number of BBD pairs flew in to the lake, the male and female in close company, maximum monthly numbers shown in Figure 1 above. A number of single females also flew in to the lake, seen diving to feed alone. If a male was present, or subsequently flew in to the lake, he would approach the female progressively from a distance, watching with her watching back. He would mirror dive to feed and slowly get closer to within several to a few metres, bobbing his head, asking to mate – head raised high quickly with bill tucked down, lowering and raising to full extent, pausing to watch for a reaction from the female. The female would either watch between dives or ignore the male, even turning her back. The male would continue to work his way closer, repeating the display – if getting too close the female would open her bill in dissatisfaction and he would retreat and pause in his display or perform short dives while watching the female, seemingly waiting for a chance to display again. The females would reach a point of annoyance, driving at the males, bill open, head stretched forward and either paddling moderately or rushing depending on the level of annoyance. The male would appear to show contrition, staying back, mirror diving or mirror preening, seeming to slowly court the female. If she would continue to show dissatisfaction he would stay away. This would continue for multiple days, around day 3 to 6 the female would accept the male and be seen following or leading as a pair. If paired comfortably, the male would continue with the head bobbing display however would also occasionally pause, looking at the female and flick water towards her with his bill. If the female wasn't interested she would either continue diving to feed, pausing to watch him or turn her back on him while diving to feed. Although closely paired if the male got too close the female would again open her bill in dissatisfaction, head stretched forward to warn him off and if that was not successful, add a short paddle or a rush at him depending on the level of dissatisfaction.

BBD Mating

One mating was observed. The female paddled up to the watching male, turned in front, lying flat to the water, head stretched forward. The male would rapidly climb on top of her back, reach forward, grabbing the skin and feathers at the back of her head in the tip of his bill and vigorously thrust. The pair would twist, the male almost falling off wrapping his wings around the female for stability. She was forced under water, rolling to the side before they broke apart separately and performed a vigorous thrash bathing and preening routine – 10 seconds in total before the preening. The mating female was new on the lake, the previously paired female of the male was 10 metres away, tail rigid at 45 degrees, back arched, appearing unhappy. The male paddled too her performing another head bobbing display which she turned her back on, and he appeared to show

contrition. The new female paddled too him, appearing to attempt to pair, he evaded a number of times while his paired mate had paddled close to the bank. The spurned female paddled to her as she preened, rushing in attack. Fast, wings out, bill pecking in a brief, angry charge before paddling off to preen separately. The male continued to appeal to his paired female who continued to ignore him – tail at 45 degrees, back arched.

Successful BBD Breeding on Lake Knox with Behaviour Observations

For a number of years avid birdwatchers have confirmed BBD breeding on Lake Knox, however photographic evidence was sought due to the lake being planned for destruction, for expanded housing, from early 2022. For the breeding season, from spring 2020 to late summer 2021, a single duckling was hatched on a nest inside the bull rushes (Cumbungi) leading directly onto deep water, at the end of February 2021. The female had not been seen on the lake for just over a month. A closely attending male was also in company following the hatching, acting protectively, however the female would warn him away if he got too close to the duckling. He and another male were seen a few days before the mother and duckling were seen on the lake. It is not known if he was with the female for the month-long nesting period or was a drop-in, staying due to the presence of the female. If the 2 males got too close to the duckling, the protective mother would place herself between them and the duckling, hunch up, bill open, head stretched forward to protectively warn them away, with brief rushes if they did not heed the warning, not straying too far from the duckling. The males would generally comply, staying 5 to 10 metres away or paddling away too another part of the lake to dive and feed.

The mother would bring the duckling onto the lake from 11am to up to 5:30 pm. On cooler days the duckling was later on the lake, from 11:30am and earlier off the lake, up to 4:30 pm. Feeding sessions lasted from 10 minutes to 45 minutes depending on cold to hot weather, and the female would return to the nest with the duckling for periods of 10 minutes to 45 minutes. Shorter periods were spent on the nest on hot days, and longer periods on cold days - presumably to keep the duckling warm. In comparison with other, dabbling duck species, the BBD is a deep diving duck with ducklings self-feeding shortly after hatching. As young birds can't self-regulate their warmth, the frequent deep dives of ducklings to feed for 10's of seconds will chill them, leading to the need to return with their mother to the nest to warm for a period, dependent on the weather and water temperature. Ducklings belonging to typical dabbling duck species are mostly on land with only short surface paddling and hence can be on the lake earlier and later in the day than BBD ducklings. For this reason, traditional dawn and dusk bird sightings could miss the BBD ducklings which may account for the lack of breeding habitat observations. The ecologists working on behalf of the developer missed this and other anecdotally reported hatchings made by birdwatchers at the Lake for a number of years of observations, with the ecologist's observations made around dawn or dusk periodically only.

If other bird species were near the nest when it was time to feed, the shy duckling would stay at the edge of the reeds. The mother would paddle a few metres out onto the lake and turn back, looking expectantly to the duckling. If it did not follow she would paddle closer, performing a few shallow dives, perhaps 30cm deep, ducking and popping up, legs splayed like a frog, as she looked expectantly to the duckling, splashing a little water towards it with her bill, likely reminding the duckling of its hunger and need to feed. Turning back out to the lake and paddling away, the hungry duckling would rush after her. She would dive, looking towards the duckling while the duckling watched. They would often dive in succession, occasionally at the same time. If other birds strayed too close the mother would warn them away, bill open, head stretched forward, sometimes paddling quickly at them. At one point an Australasian Grebe got too close and the duckling opened its bill, head stretched forward and rushed at it (at around a week or 2 old), before returning to its mother. The Grebe is a small bird, however was still twice as large as the duckling. At 2 to 3 weeks old, the mother clearly was now paired with a male, the trio in close company. Another male was attempting to win the mother with head-bobbing displays. She would show disapproval, bill open and leaning forward, and the partner male would paddle at him to drive him away. At one point when the partner male was diving and the rival male displaying to the mother, the duckling rushed at the intruding male, bill open, impacting the shocked male who paddled rapidly away – the trio moving together, appearing to be a small family unit.

Over the period of a month the mother taught the ducking to feed and protected it. Leaving the duckling on its own to dive and feed or curl up napping on the lake – occasionally watching from a distance, appearing to provide some independence training. Mother and duckling looking towards each other periodically, the mother in close company with two males. At the end of these independent sessions, the mother would wait for the duckling around 10 metres from the nest, the duckling rushing in and the pair, or trio, retiring to the nest. At times when the trio came close to the viewing area in the North-West of the lake, the male would patrol protectively in front of the mother and duckling, looking alertly at me until satisfied I was not a threat and returning to dive to feed, and watch, comfortably.

At around a month after hatching, the duckling was much larger and preening away the soft, downy feathers to reveal the wavy adult plumage coming through beneath. A horizontal white stripe of feathers just below the eye, extending from the back of the bill to the back of the head was clearly evident – the much older mother had a hint of the fading white stripe from below and behind the eye to the back of the head. The mother and partner male brought the duckling close to the viewing area. Many other birds were present, with the much larger Pacific Black Ducks getting too close and being warned off by the duckling, head lowered, bill open, paddling at them to no effect which startled the tiny duckling. The Pacific Black Ducks surrounded the shy duckling as they preened and splashed. It raised up, tiny wings flapping and emitting a soft, high-pitched, fluting, clipped, barking-yap sound, a difficult sound that seemed to be coming from a throat not accustomed to making noise. I had never heard the BBD's make noise before and the duckling was yapping like a small dog with a vocal cord issue as it raised up and flapped its wings. Its mother paddled in protectively, the Black ducks parted and the duckling settled down - it was just not comfortable with other birds.

A few days later the mother and partner male were clearly absent from the lake, not seen again. The mother presumably leaving after the prolonged period of months building the nest, keeping the egg or eggs warm, then raising the duckling to the point of independence. The ducking continued to grow on the lake independently – very shy of other birds. It would scan the lake between dives, going to full alert for any threats, tail stiff and past vertical to around 100 degrees, neck stretched vertical with head held tightly and horizontal. If threatened it would dive, kicking feet at the surface to throw water high in the air, close to a metre, and diving deep, turning underwater in a seemingly random direction before popping up a few metres away to scan for threats. After feeding the duckling would preen, the preening session ending in wing flapping. As the wings grew out the flapping sessions would grow longer in duration with wings flapped at increasing speed and force. When close to full wing growth at around 4 months old a “pattering” behaviour was seen - an explosive burst of movement into a run-fly across the surface (long strides maintaining surface contact whilst appearing to fly), neck and head stretched forward, head, neck and body around 30 degrees from horizontal. Short bursts up to 10 metres extending to around 40 metres over time, angle reducing to 20 degrees with increased apparent speed – flight training. This behaviour was seen both when the bird was alone, and in the presence of other birds – both male and female.

A juvenile female, slightly older and possibly also born on the lake, was in close company from around 2 months old. At a distance, when they were apart, it was difficult to tell the duckling from the juvenile female before they joined company, the new juvenile female being slightly larger with more developed wings, the horizontal lines of white feathers below the eyes also showing a slightly different pattern. A rival male would display to the new juvenile female and the duckling would try to intervene and drive him off, however at 3 months old they had clearly paired, and a week later they had left the lake. At around 4 months old the duckling, now clearly a juvenile female, was paired with a male who had been performing the head-bobbing display routine for a few days before they were keeping company, following each other, diving to feed together, often in the company of a friend male. Often, if the juvenile female was absent or napping, the partner male would seek out the friend male.

At 5 and a half months old a pair of new males arrived at the lake, aggressively trying to separate the duckling, now an immature female, from her partner. They would display to her, she would show dissatisfaction – warning them off with bill open. The partner male would paddle at them to drive them away, however the

behaviour would escalate and become aggressive. The males when paddled at by the partner would dive under, pop up at the juvenile female and attack her. These periods of attack would last for up to 10 minutes. The males would paddle away, unsuccessful, and dive to feed around 20 to 40 metres away. Most of the time they would be all diving and feeding closely, even napping closely, however the periods of attack would continue, increasing in frequency. After several days of this escalating behaviour, the friend male of the partner had left the lake.

At around 6 months old, just smaller than an adult female, the duckling had left the lake with the partner male, possibly to explore or evade the increasingly aggressive males, returning after 8 days with her partner. Absence from the lake was confirmed with many drop-in viewings at random times between dawn and dusk. On return the identities of the duckling (now clearly an immature female) and partner male were confirmed by comparing the facial features of the duckling, notably the narrow bill and horizontal white feather stripe pattern on each side of her face, and the bill markings of the male – exact matches. The aggressive males also returned to the lake, after a few days the immature female and partner male left the lake again for a few days and returned – facial and bill markings were compared to confirm identities, with behaviour traits also matching. The duckling/immature female's preferred feeding spots and shy behaviour with other birds also matched. A single aggressive male also returned which seemed to trigger another trip away of a few days. The pair returned, the aggressive males were absent, and the pair were seen entering the reeds in company – presumably nesting, now in early spring (September 2021). They remain in close company on the lake, occasionally in the company of another friend male BBD.

Discussion

Many ecologists choose to observe for periods of generally 1.5 to 3 hours around dawn or leading up to dusk and they are unlikely to observe young BBD ducklings on the lake if they observe during this period. The young were not brought onto the lake during the dawn or dusk observation periods. It was also noted that in the "Healthy Waterways Strategy - Wetlands Monitoring and Evaluation Plan", v1.0 2020 (Reference 4) from Melbourne Water, the expert panel requires waterbody monitoring only in a 3 hour window from dawn or leading up to dusk and only including data entered into the Birdlife Australia online database. This is very restrictive, and, as noted above, likely to miss the presence of Blue-billed Duck hatchlings. The more popular Naturalist databases of iNaturalist and eBird Australia are likely to contain more data, including VBA. This restrictive practice is likely to miss vital species observations, most importantly successful breeding and hence not identify the key *Breeding Habitat Wetlands* - most likely to be lakes as the species requires large bodies of deep and open water, with reed fringes for nesting and protection at the edge of deep water. They simply are not seen on small, shallow, enclosed waterbodies, other than the rare potential for a young bird to drop-in, in error.

Statistical Analysis of the Blue Billed Duck count data – Kevin Newman

The data was combined from the three sources to remove any duplicate records and for statistical analysis. I conducted Analysis of Variance (ANOVA) on the max count recorded at each site using the variables of waterbody type and waterbody area. Analysis was undertaken on the full dataset before removing outliers related to each variable. I then conducted a linear regression analysis using both forward and backward stepwise regression to study the relationship between the count data to waterbody type, waterbody area and max open water values. All statistical analysis were conducted in 'Rstudio Version 1.4.1106' (Reference 5).

Complete dataset

When all sites are considered in the analysis there is a considerable number of observable outliers (Figure 2 and Figure 3). An ANOVA which included both the waterbody type and waterbody area variables, and an interaction between the two showed a significant difference between means of the waterbody area groups ($F_{2,192} = 14.244$, $p < 0.05$) and the interaction term ($F_{7, 192} = 6.793$, $p < 0.05$). A post-hoc Tukey test showed a significant difference between small and large waterbodies (difference in counts -445.10, CI: [-676.05, -

214.16], $p < 0.05$) and medium and large waterbodies (difference in counts -439.50, CI: [-693.65, -185.34], $p < 0.05$]. There was no statistically significant difference between small and medium waterbodies. Post hoc analysis of the interaction between waterbody type and waterbody area showed significant differences across large dams and other waterbodies, as well as large sewage treatment and other waterbodies (Table 13).

Table 13 – Interaction of Waterbody Type and Waterbody Area

Waterbody 1	Waterbody 2	Difference	Lower Bound	Upper Bound	Adjusted *p*
Large sewage treatment	Large Dam	1515.20	71.71	2958.70	0.03
Medium Lake	Large Dam	-1001.80	-1961.44	-44.16	0.03
Small Dam	Large Dam	-1061.92	-2067.50	-56.34	0.03
Small Lake	Large Dam	-1059.42	-2099.56	-19.27	0.04
Small sewage treatment	Large Dam	-1034.65	-2022.56	-46.36	0.03
Small stormwater function	Large Dam	-1067.49	-2107.64	-27.34	0.04
Small wetland	Large dam	-1055.88	-2027.57	-84.20	0.02
Large sewage treatment	Large lake	2261.64	1069.71	3453.56	< 0.001
Large wetland	Large sewage treatment	-2511.25	-389.41	-1173.09	< 0.001
Medium dam	Large sewage treatment	-2547.75	-4057.39	-1038.11	< 0.001
Medium farm dam	Large sewage treatment	-2584.50	-4388.87	-780.13	< 0.001
Medium lake	Large sewage treatment	-2517.00	-3717.76	-1316.24	< 0.001
Medium sewage treatment	Large sewage treatment	-2529.43	-3786.95	-1271.91	< 0.001
Medium wetland	Large sewage treatment	-2525.67	-3801.90	-1249.79	< 0.001
Small dam	Large sewage treatment	-2577.12	-3814.90	-1339.33	< 0.001
Small farm dam	Large sewage treatment	-2579.00	-3866.43	-1291.57	< 0.001
Small lake	Large sewage treatment	-2574.62	-3840.64	-1308.59	< 0.001
Small sewage treatment	Large sewage treatment	-2549.5	-3773.63	-1326.07	< 0.001
Small stormwater function	Large sewage treatment	-2582.69	-3848.72	-1316.66	< 0.001
Small wetland	Large sewage treatment	-2571.08	-3781.49	-1360.68	< 0.001

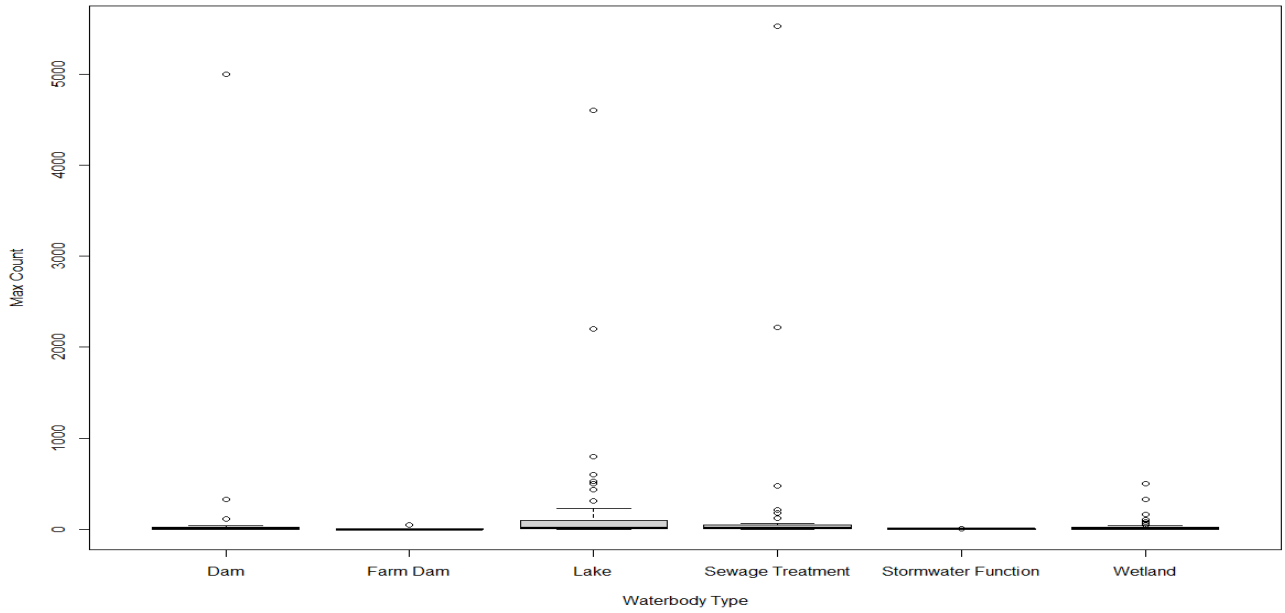


Figure 2 – Boxplot of max count data for the full dataset. Outliers are visible across a number of waterbody types but particularly obvious in dams, lakes and sewage treatment.

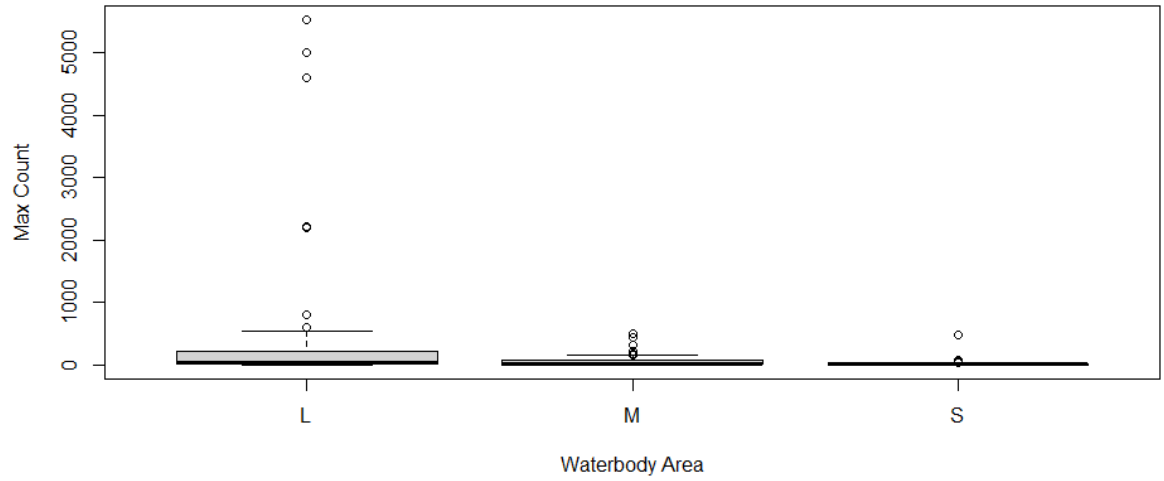


Figure 3 – Boxplot of max count data across waterbody area classes. Outliers are visible across all sizes but significant outliers in the large waterbodies are clearly visible.

Waterbody type – without outliers

I removed initial outliers from the overall data set after splitting the data by waterbody type before running the analysis again on a condensed data set (Figure 4). An ANOVA which included both waterbody type and waterbody area terms and their interaction was significant for waterbody type ($F_{5,155} = 5.178$, $p < 0.001$) and for waterbody area ($F_{2,155} = 3.539$, $p = 0.03$), but not for the interaction term. Post hoc Tukey's HSD test indicated a significant difference between lakes and dams (difference in counts 28.97, CI [2.70,55.24] $p = 0.02$), lakes and farm dams (difference in counts 35.82, CI [1.84,69.81] $p = 0.03$), lakes and stormwater function (difference in counts 35.57, CI [1.59, 69.56] $p = 0.03$) and lakes and wetlands (difference in counts 29.62, CI [6.46,52.77] $p = 0.004$). Post hoc analysis of the waterbody area variable did not show any significant differences between size classes.

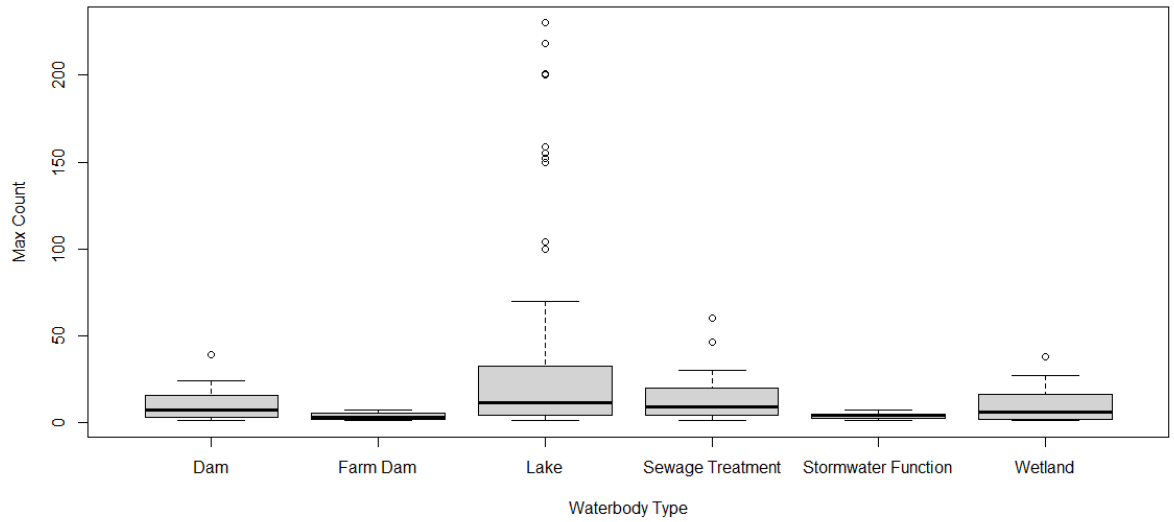


Figure 4 – Boxplot of the data remaining after outliers were removed from the full dataset after splitting the data by waterbody type.

Waterbody area – without outliers

I removed initial outliers from the overall data set after splitting the data by waterbody area before running the analysis again on a condensed data set (Figure 5). An ANOVA which included both waterbody type and waterbody area terms and their interaction was significant for waterbody area ($F_{2,163} = 13.314$, $p < 0.001$), but not for waterbody type or the interaction term. Post hoc Tukey's HSD analysis indicated a significant difference between large and small waterbodies (difference in counts 59.54, CI [27.98,91.11] $p < 0.001$, and large and medium waterbodies (difference in counts 54.08, CI [18.50,89.66] $p = 0.001$).

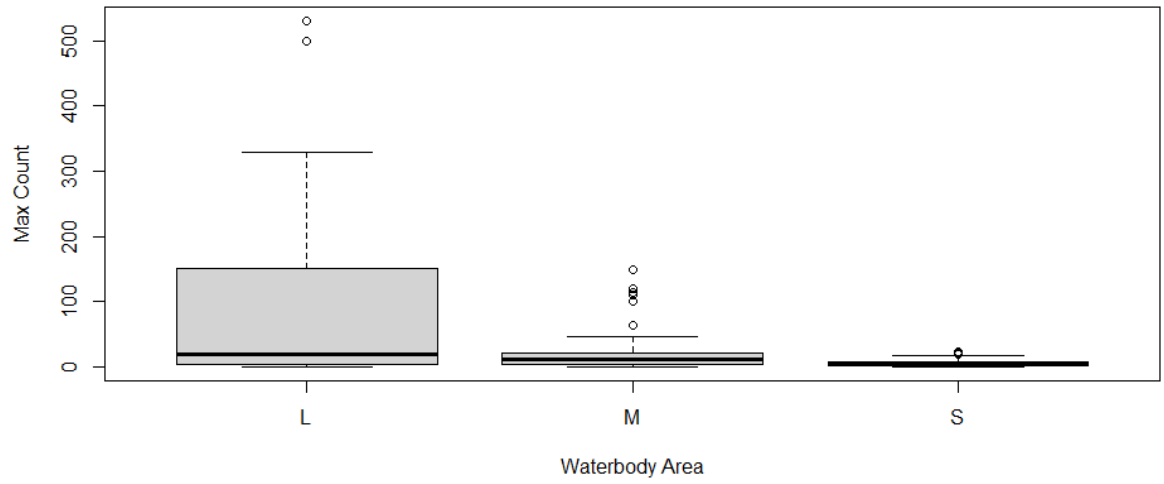


Figure 5 - Boxplot of the data remaining after outliers were removed from the full dataset after splitting the data by waterbody area.

Removing outliers based on the additive model of both waterbody area and waterbody type results in nearly identical results to removing outliers solely based on waterbody type, and so has not been included in these results.

Maximum Open Water

A linear regression analysis which included all variables (Waterbody type, waterbody area and max open water) was statistically significant (Adj. R^2 = 0.1086, F8,198 = 4.138, p < 0.001) and explained 10.86% of the variation in count data. The significant variables in the resulting model were the intercept (or large waterbody area) (p = 0.04), small waterbody area (p = 0.03), medium waterbody area (p = 0.02) and max open water (p = 0.005). After conducting a stepwise regression in both directions, the resulting best fitting model was MaxCount = 296.73217 – 309.98748 * MediumArea – 301.8038 * SmallArea + 0.7652 * MaxOpenWater. This model is statistically significant (Adj. R^2 = 0.093, F3,203 = 8.097, p < 0..001) and explains 9.3% of the variation in Blue-billed Duck max count data (Figure 6).

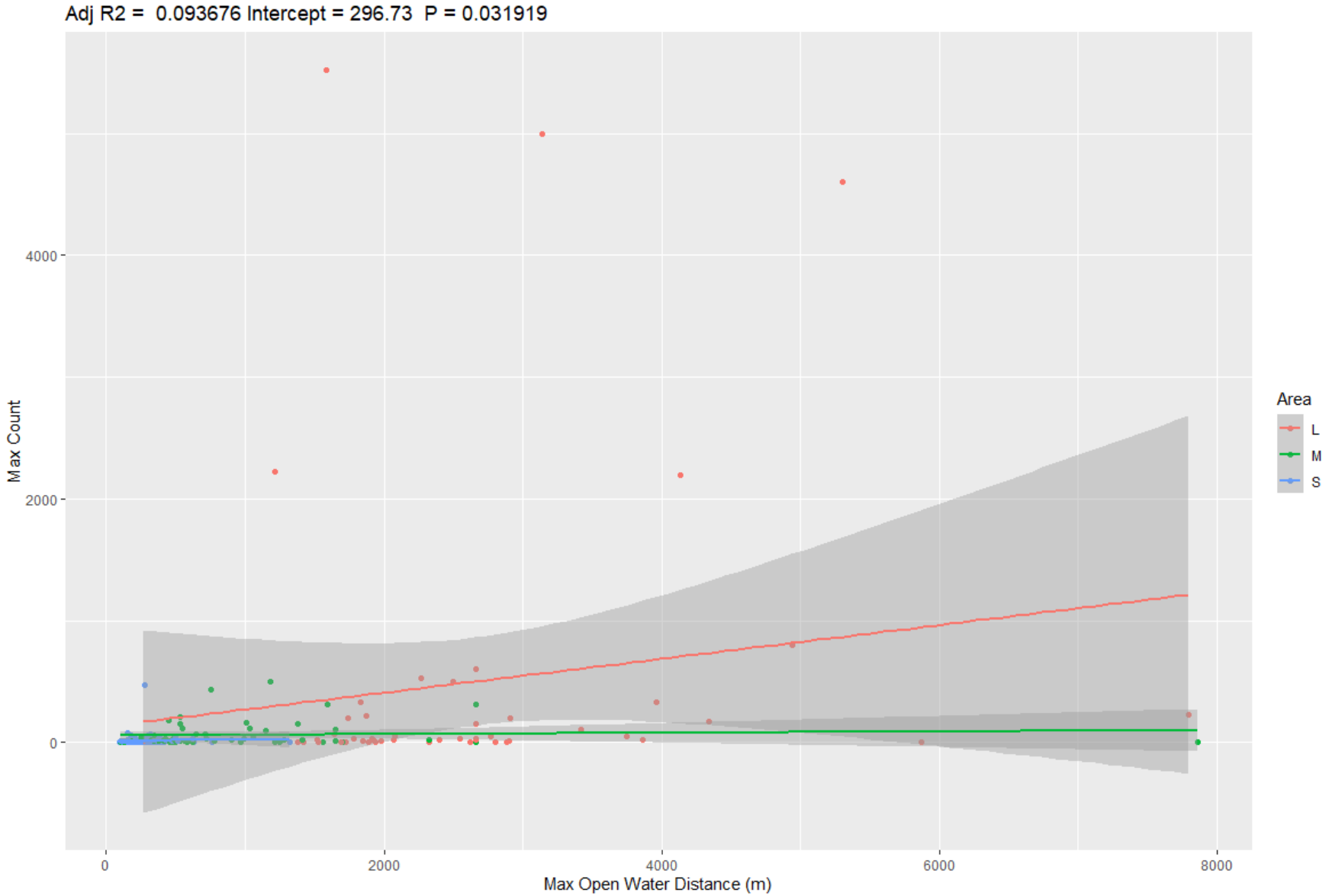


Figure 6 – Linear Relationship between max counts and the variables of max open water distance (m) and waterbody area. Shaded area is 95% confidence intervals.

For small waterbodies the mean open water distance with the least variation is around 250m – 300m (Figure 7). Medium waterbodies show the least variation around 1000m (figure 8) and large waterbodies between 2000 and 3000 m (Figure 9). There is significant variation in the data towards the larger end of each max open water distance due to the outliers present in the dataset.

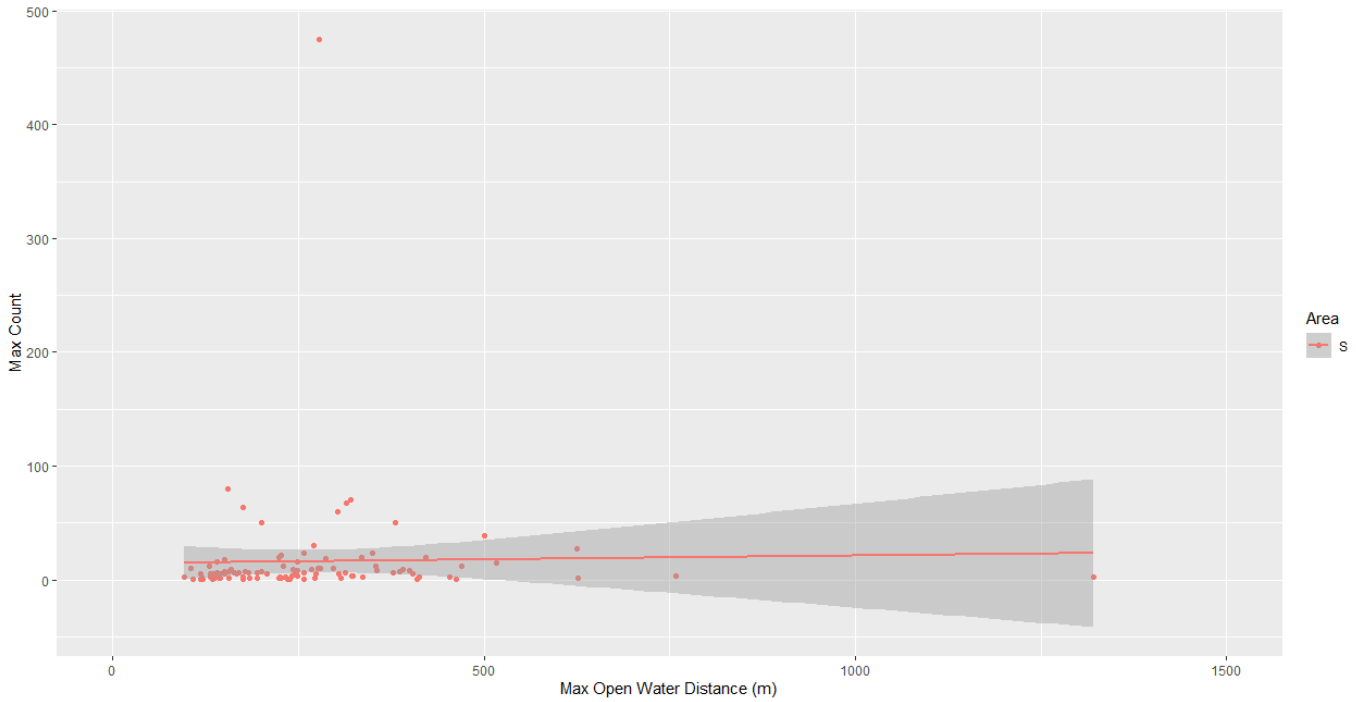


Figure 7 – Linear Relationship between max counts and the variables of max open water distance (m) for small waterbodies. Shaded area is 95% confidence intervals

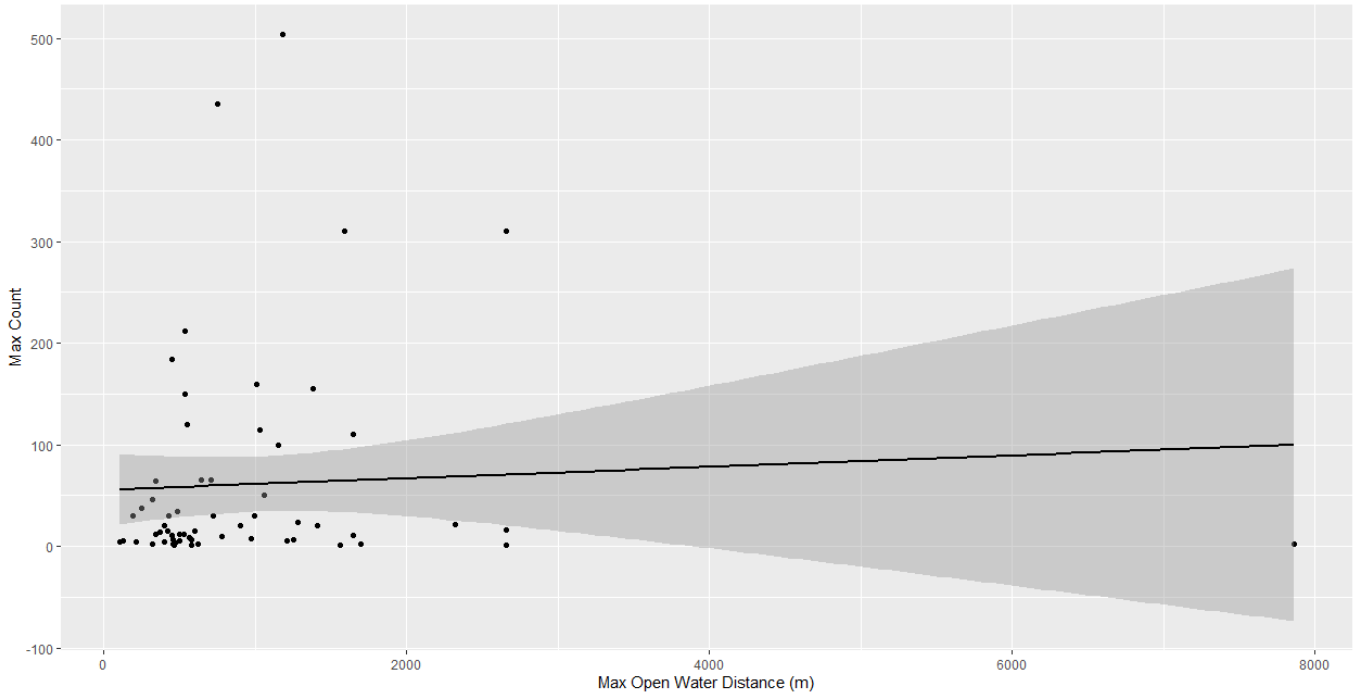


Figure 8 – Linear Relationship between max counts and the variables of max open water distance (m) for medium waterbodies. Shaded area is 95% confidence intervals

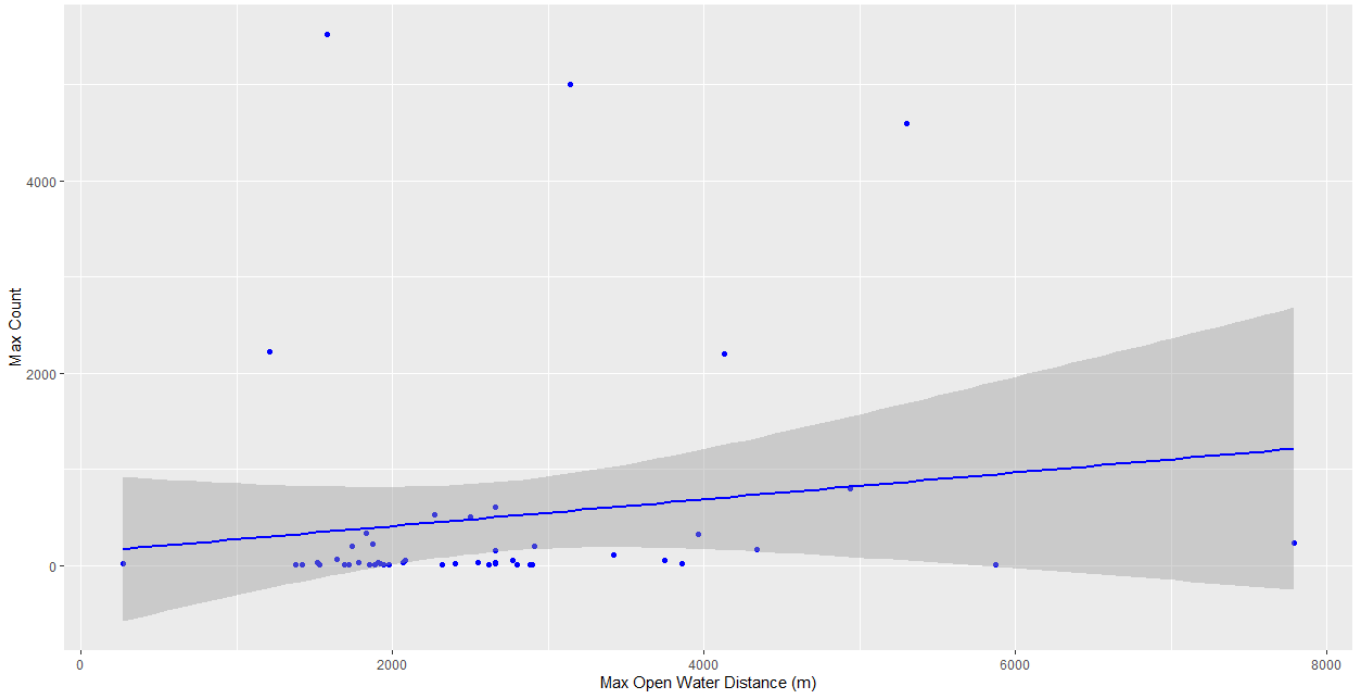


Figure 9 – Linear Relationship between max counts and the variables of max open water distance (m) for large waterbodies. Shaded area is 95% confidence intervals

Blue-billed Duck Habitation Sites Reverting to Drop-in Sites

A number of sites exhibited observation records going back to 2015/2016 which then dropped to zero or infrequent drop-ins. This is particularly so from January 2019 at Lakewood Reserve Lake, Knoxfield.

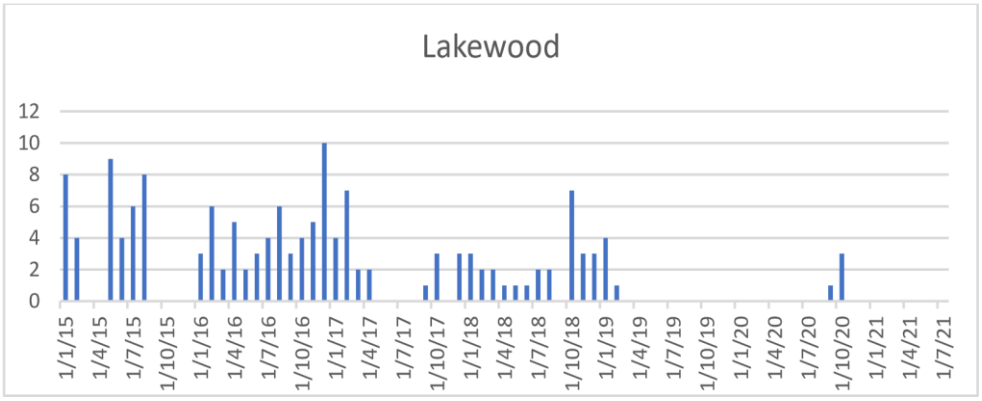


Figure 10 - Lakewood Reserve (maximum counts across the observation period)

The reduction is noted despite the continued regular surveys at the site noting low numbers of other species. This possibly indicates pollution of the waterbody or the presence of European Carp and/or lack of aquatic and fringing nesting vegetation (Reference 3, Purdey-Loyn, 2008). The water appears to sustain little obvious life, no visible aquatic vegetation. The Eurasian (or Australasian) Coot behaviour may indicate water pollution, possibly from backyard runoff from neighbouring properties - where the Coots at all other waterbodies dive to feed for weed, at Lakewood they exclusively feed at the lake edge or on the banks. The water, no longer suitable for feeding, potentially not containing much larger aquatic life (e.g. fish, frogs and submergent plants). Observations of the rare drop-in BBD's and 3 Hardheads showed only a few dives then resting or paddling, strongly suggesting there is little food for diving birds.

A number of artificial wetlands, mostly reed bed stormwater retarding basins for new developments, designed primarily to treat stormwater, also showed initial drop-in records of the BBDs which then dropped to zero. Google Maps 'satellite view' showed these shallow waterbodies quickly overgrown by fringing, then other vegetation, below the required 100 metres of open, unenclosed water. It is no longer possible for the BBDs to access or leave, hence they are no longer visiting.

There were a number of reservoirs with previously significant loafing BBD numbers which then dropped to zero or occasional drop-ins which coincided with the opening of the reservoirs to recreational boating and fishing, such as Devilbend Reservoir, which went from over 200 birds to zero, or occasional drop-ins, shortly after being opened up for recreation.

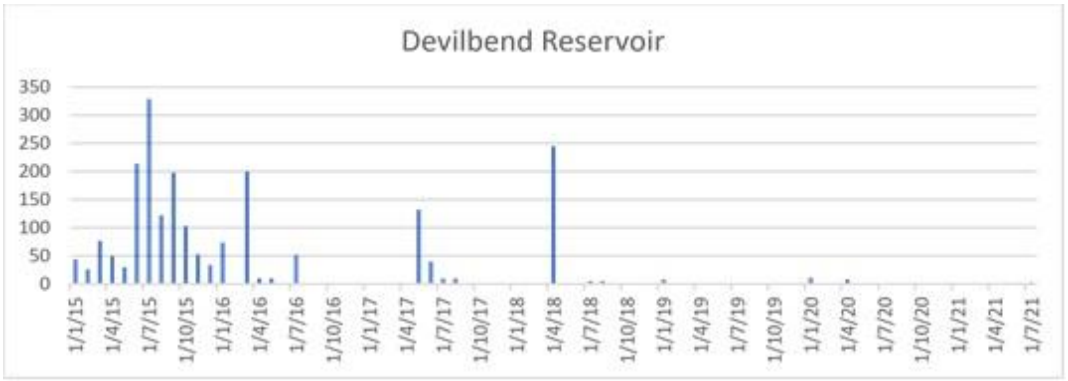


Figure 11 - Devilbend Reservoir

The BBD's are a shy bird, not liking close contact which discourages habitation and nesting. A frequently disturbed or aggravated female won't nest and will seek more sheltered, private, secure habitat.

Blue -Billed duck – Challenges Estimating Population Numbers

The data used in this investigation looks at the maximum number of birds recorded at a site in each month investigated. The authors acknowledge the difficulty in determining actual totals of the species and though this was not the focus of the report, we would like to draw attention to some anomalies that were noticed in the datasets. The following examples will illustrate this point:

"Round Lake and Lake Elizabeth may now be the only wetlands in the region to support regular large flocks of Blue-billed Duck (Purdey & Loyn 2008). Round Lake was closed to hunting in 2015 due to high numbers of Blue-billed Ducks (Purdey & Menkhorst 2015)." (Reference 2)

The author's note the situation at Round Lake and Lake Elizabeth may have changed considerably since the referenced document was published, as it may no longer adequately reflect the current occupation pattern of the birds at different waterbodies.

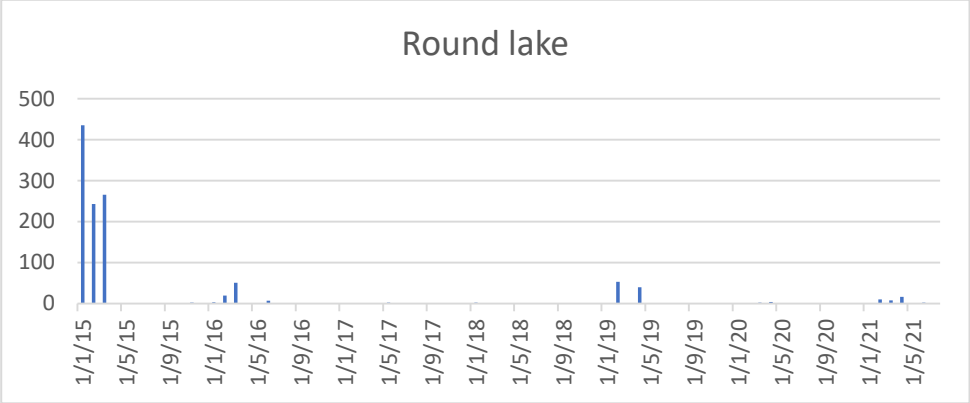


Figure 12 - Blue billed duck numbers at Round Lake

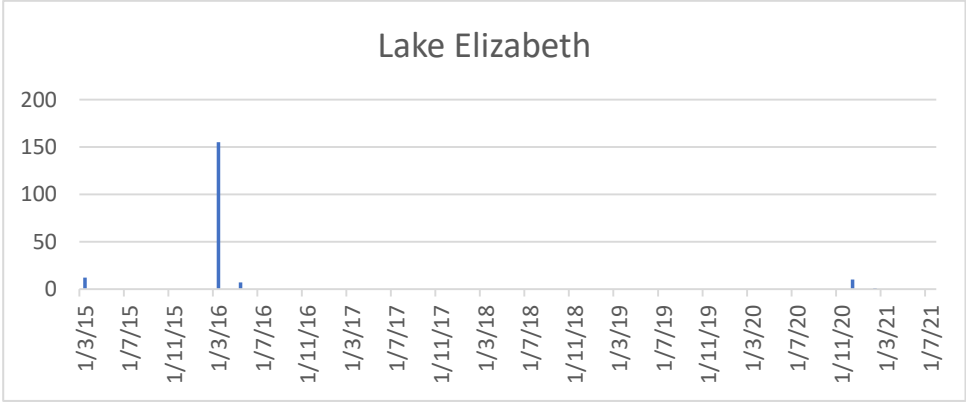


Figure 13 - Blue-billed numbers at Lake Elizabeth

The data shows few records of BBDs at Round Lake and Lake Elizabeth since 2015.

At Lake Elizabeth there have been no big counts in eBird since March 2016 when the highest count was made at 84 while the count in Birdata was 155 (shown in the graph) There were no counts there in eBird between May 2016 (seven birds) and February 2021 (one bird) There were no counts in the VBA at Lake Elizabeth in March 2016.

Since the big counts in 2015 at Round lake there has been one count of 50 in Feb 2019 and 8 other counts with less than 10 birds. Koorangie Wildlife Reserve had an observation record (Feb 2017) of 168 in eBird and Birdata not showing up in VBA. This shows the difficulty tracking bird numbers using online databases. The growth in the use of eBird in particular, highlights the need to verify and utilise all the data in a timely way if it is going to help understand and estimate bird numbers.

The records of Blue-billed duck at sites like Lake Wandella where "the maximum count was 374 at Lake Wandella on 14 March 1992" (Ref 2) have not occurred in our datasets. The waterbody appears dry on current Google maps 'Satellite View'. A number of other dry or near-dry waterbodies exhibited white crusting, indicating a heavy salinity and possibly no longer possible BBD habitat.

The authors note the following selected management actions referred to in the Blue-Billed Duck Action Statement no 174. (Ref 1.)

1. Identify and document key sites.
2. Provide information and advice on the management of Blue-billed ducks.
3. Protect, enhance and restore key sites for Blue-billed ducks in parks and reserves.
4. Protect, enhance and restore key sites for Blue-billed duck in Melbourne Water managed areas via preparation and implementation of management plans.
5. Encourage and promote the protection and enhancement and restoration of key sites.
6. Encourage facilitate and support research into Blue-billed duck including directed studies of breeding biology, habitat and nest requirements.

The authors believe this report draws attention to key elements of the Blue-billed duck survival in terms of waterbody's required for successful habitation especially during the breeding season

Challenges Facing Large Blue-billed Duck Counts on Some Sites

The following graphs and brief summaries highlight the challenges that are faced by amateur enthusiasts estimating bird numbers based on observational data. This is especially true for birds like the Blue-billed duck that move across a range extending from Victoria to southern Quensland. The significant number often refered to in the comments is 2500. This is the number of birds that if exceeded, places the bird in the Vulnerable category rather than Endangered according to IUCN criteria as are also now used to assess species for listing under the the FFG Act for Victoria (and conservation status determinations as they apply elsewhere in Australia).

There are a very low number of counts of large flocks that exceed 2500. There are birds in other places of course at the times of these counts but given that previous published information has determined that almost all the large numbers of birds can be seen at the WTP, the large flock numbers are significant, it seems, when determining the numbers of birds. Most of the large flock counts are much less than 2000 birds, which means by the time one counts birds across many sites then the numbers are close to the 2500 figure. Often there is little information in the notes on the methods used to count the birds in those large flocks to provide confidence in the number counted. This is not to say that the numbers are not accurate but it makes it difficult to validate them when there is little supporting information. Maybe in some cases this is somethig that is available to database administrators but is missing from the published datasets. However, to overcome such limitations, statistically modelling waterbody use may help overcome the need to have highly accurate and regular counts across many sites. Given the impacts of climate change on water levels in lakes used by Blue-billed Ducks we would expect a rigorous and reliable method would be used to determine bird numbers. The variability in the numbers of birds recorded at many sites adds to the challenge of having an accurate number of birds determined.

When examining the numbers of Blue-billed Ducks for this investigation there are many months where the numbers do not add up to 2500. In the last 12 months the COVID-19 pandemic may have had an impact on data collection. However there are many sites where blue-billed duck numbers appear to be on the decline even in the face of continued consistent monitoring (This is documented in another report pending publication).

The use of three generations or 10 years to establish trends in bird numbers seems a long time. In this period climate change has had a significant effect on temperatures and rainfall across the range of the Blue-billed duck (Reference 8). It is likely the impact on the birds numbers will have happened before there are accepted counts. In drought, it is noted the BBBD's flock to loafing habitats such as deep water habitats and Water Treatment Plants which have a steady replenishment of water (Reference 8), however aren't noted to breed there. As climate change is expected to lead to prolonged droughts, less breeding results as birds remain loafing, reducing ongoing replacement/recruitment of the species due to distributed breeding habitats drying and overgrowing with the accompanying shorter breeding periods between the lengthening droughts along with the potential for permanent loss of many breeding habitats.

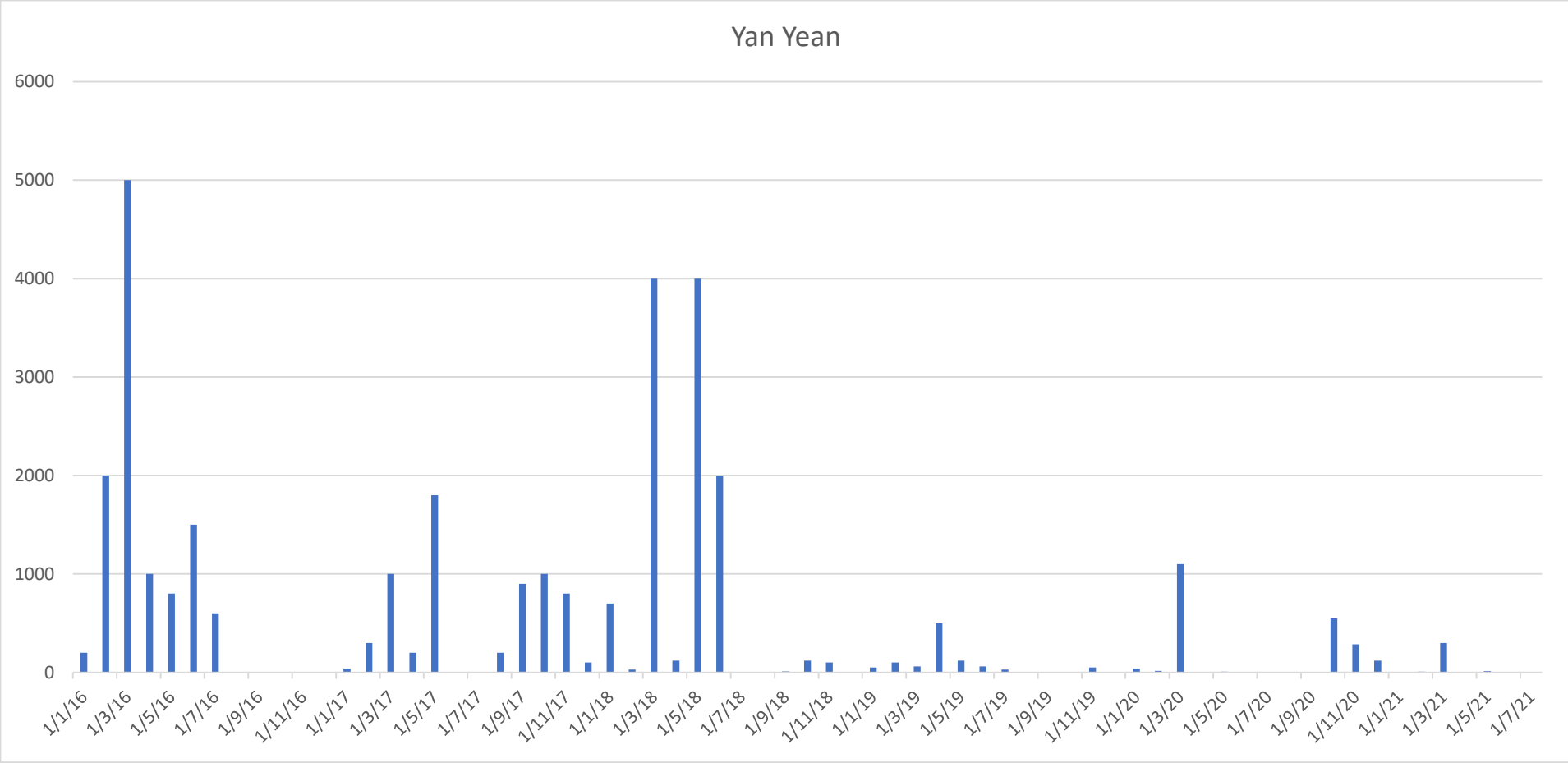


Figure 14 - BBDs at Yan Yean

On the basis of these figures Yan Yean was a significant site for BBDs between 2016 and 2018 with very large numbers reported once in 2016 (March 5000) and twice in 2018 (Mar 4000, May 4000). There were five other times where numbers in excess of 1000 were reported with the latest report of 1100 birds in Mar 2020. There is a note from Yan Yean about the difficulty of accurately reporting large numbers when 4000 was reported.

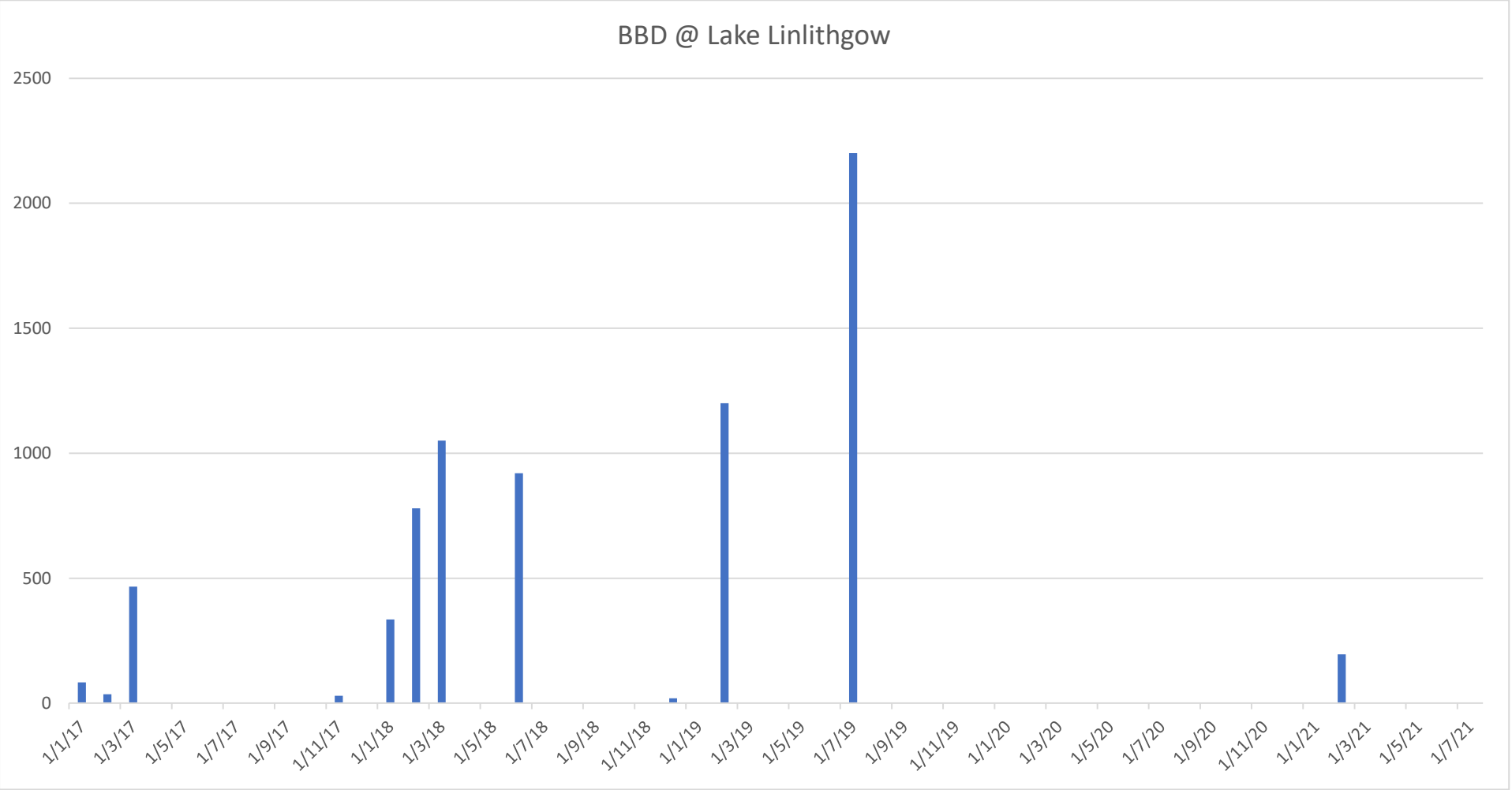


Figure 15 - BBD at Lake Linlithgow

This is a site touted as a popular site for BBDs with large numbers congregating. In July 2019 numbers of 2200 were reported. But less than 2500. The total across all sites for that month was 3635 but of course there can be double counting across sites to achieve that number. Since 2019 totals reported there have been considerably lower. This might be a good example of how changing environmental conditions influence where birds congregate.

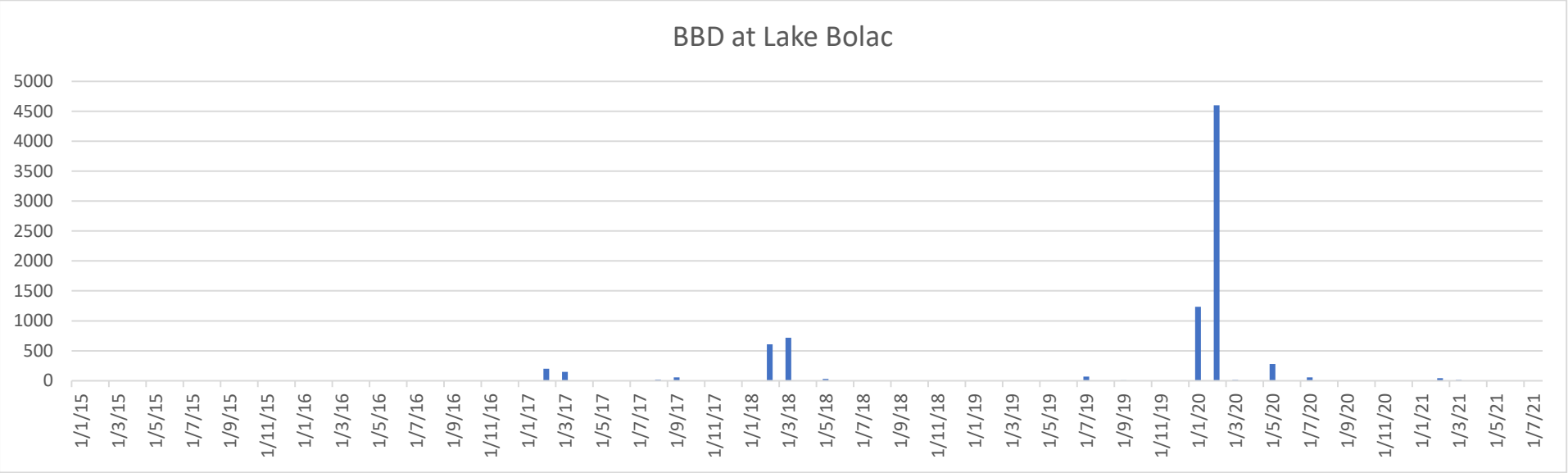


Figure 16 - BBD at Lake Bolac

A single very high number of 4600 BBDs was reported at Lake Bolac in February 2020 from one reported sighting. In January, 1235 birds were reported there again from a single record. Where did the birds come from in February to increase that number or was the count in January an underestimate? This highlights the big variation in bird count estimates at a site.

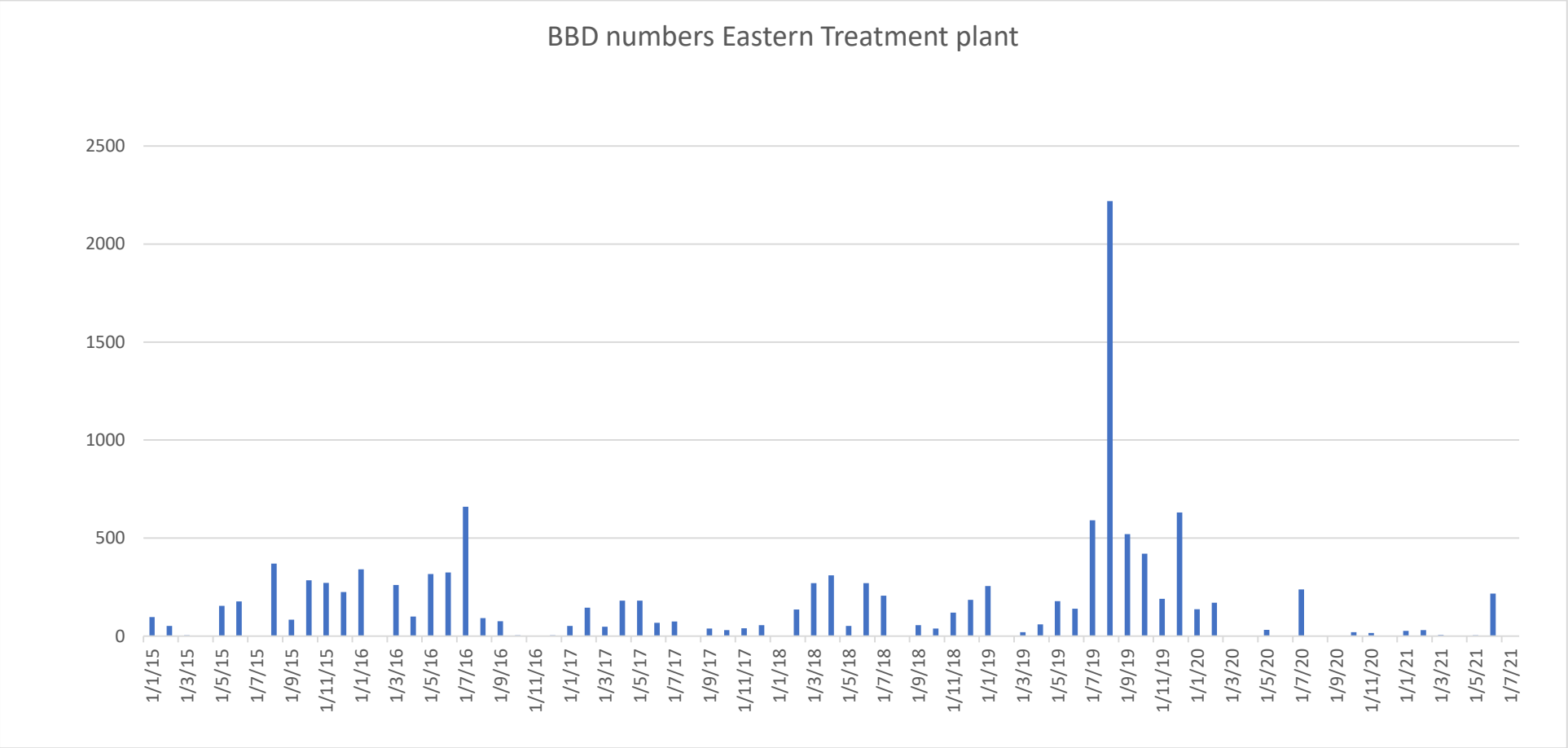


Figure 17 - BBD numbers at Eastern Treatment Plant

Only one count at this site of very high numbers in excess of 2000 in August 2019 (2200). The totals from all sites in this month was 2394 which is less than 2500.

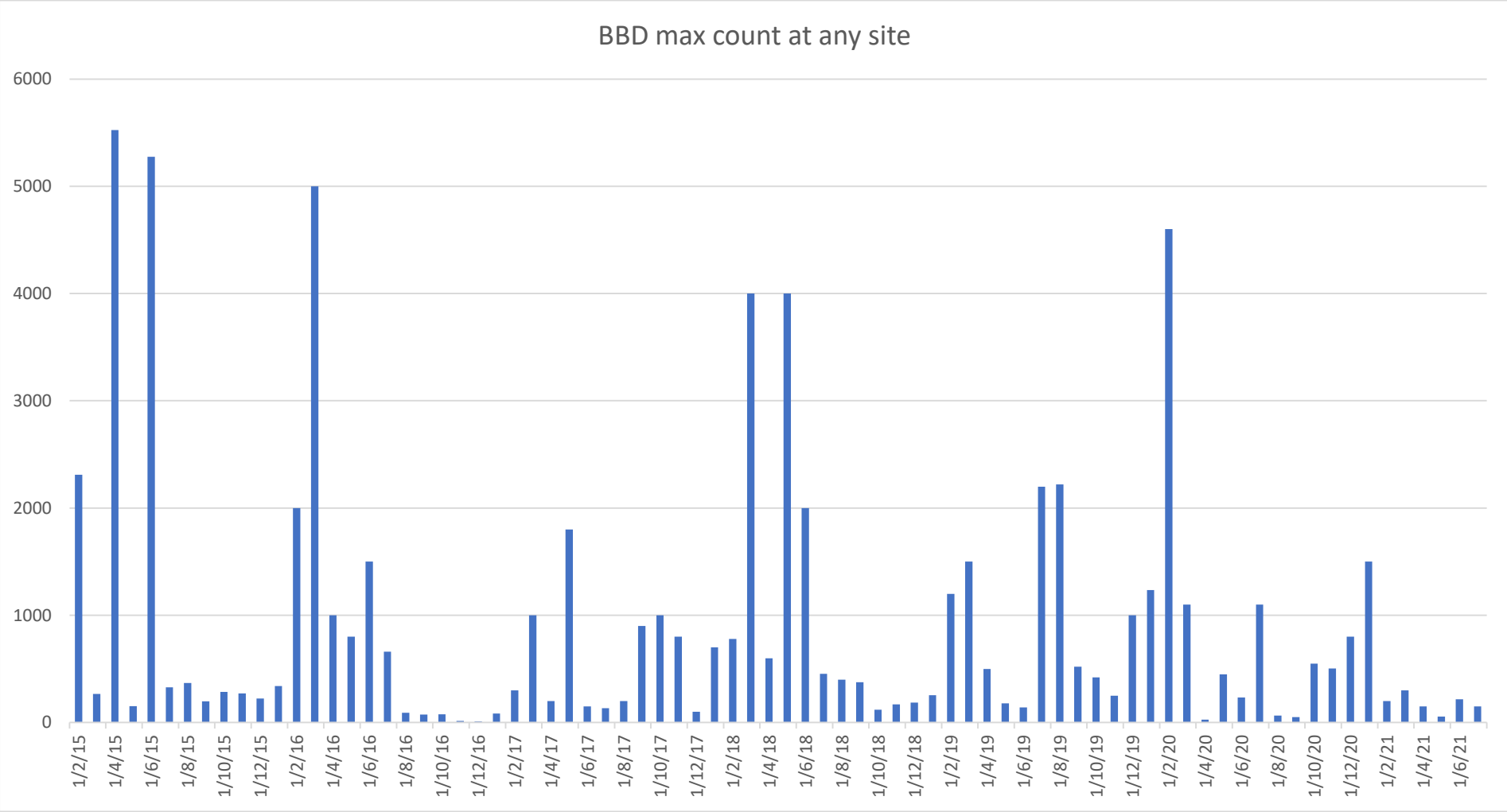


Figure 18 - BBD max count at any site

There are only 6 counts at any one site where the number exceeds 2500. Lake Bolac (Feb 2020) Yan Yean (Mar 2018, May 2018 Mar 2016) WTP (Apr 2015, Jun 2015). One of those counts at Yan Yean included a note that the number was an estimate and difficult to determine. The counts at Yan Yean and Lake Bolac are single observation records at the site on one day. The count at WTP was based on accumulated numbers across multiple ponds at the site on the same day by the same person.

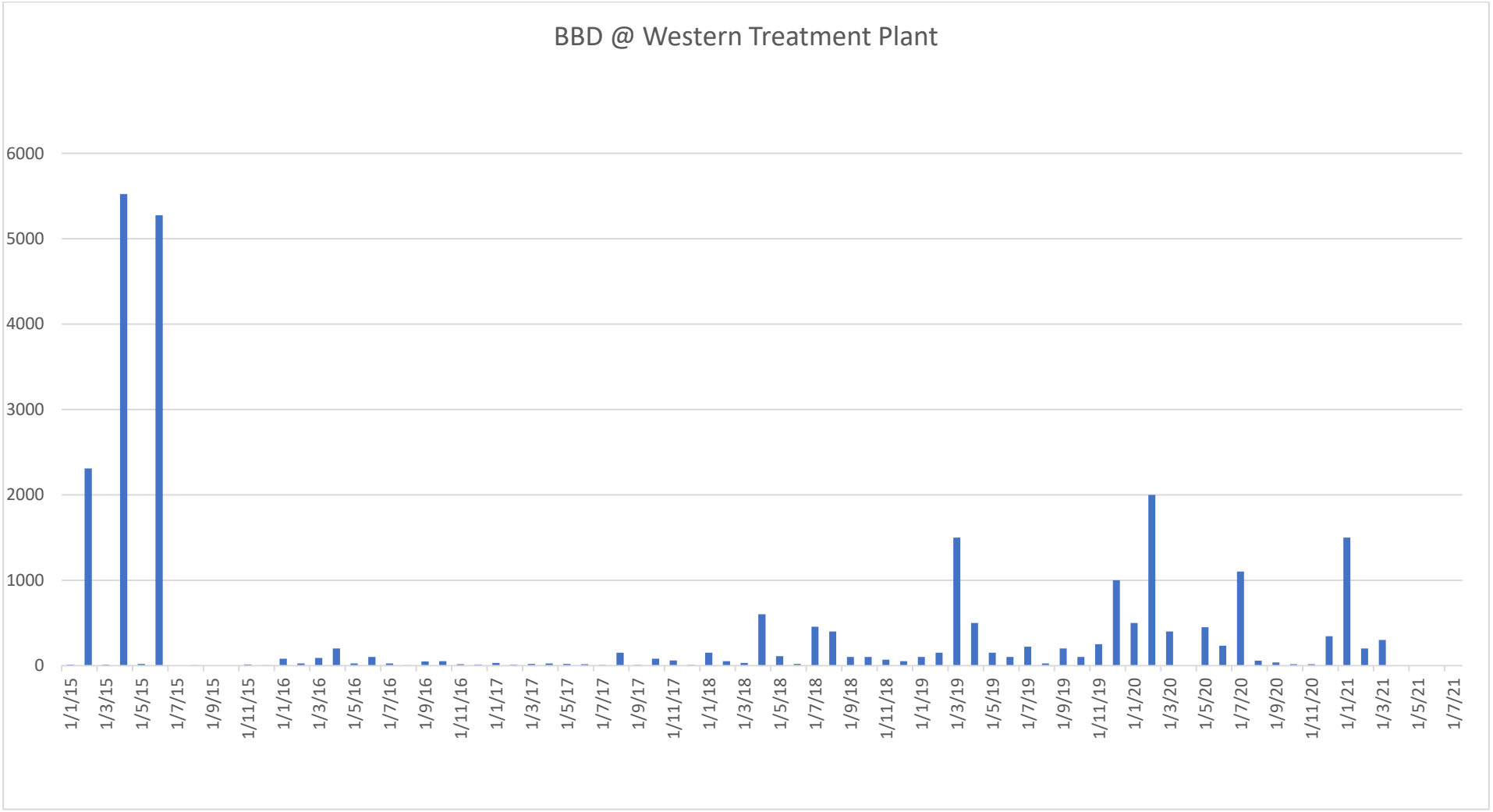


Figure 19 - BBD @ WTP

In 2015 counts occurred across a few days where most sites were counted by one observer and these numbers added together on those days to work out the total number of birds. We could not see any evidence of this occurring after 2015 and the maximum count at the WTP has not exceeded 2000 since then. It has been reported that the WTP has up to 90% of the population of the birds. If this applied since 2016 then the total population of the birds from 2016 would be less than 2500. (2500=0.9x), (x= 2500/0.9), x= 2222. In other words based on these figures and numbers at the WTP the population would be 2222.

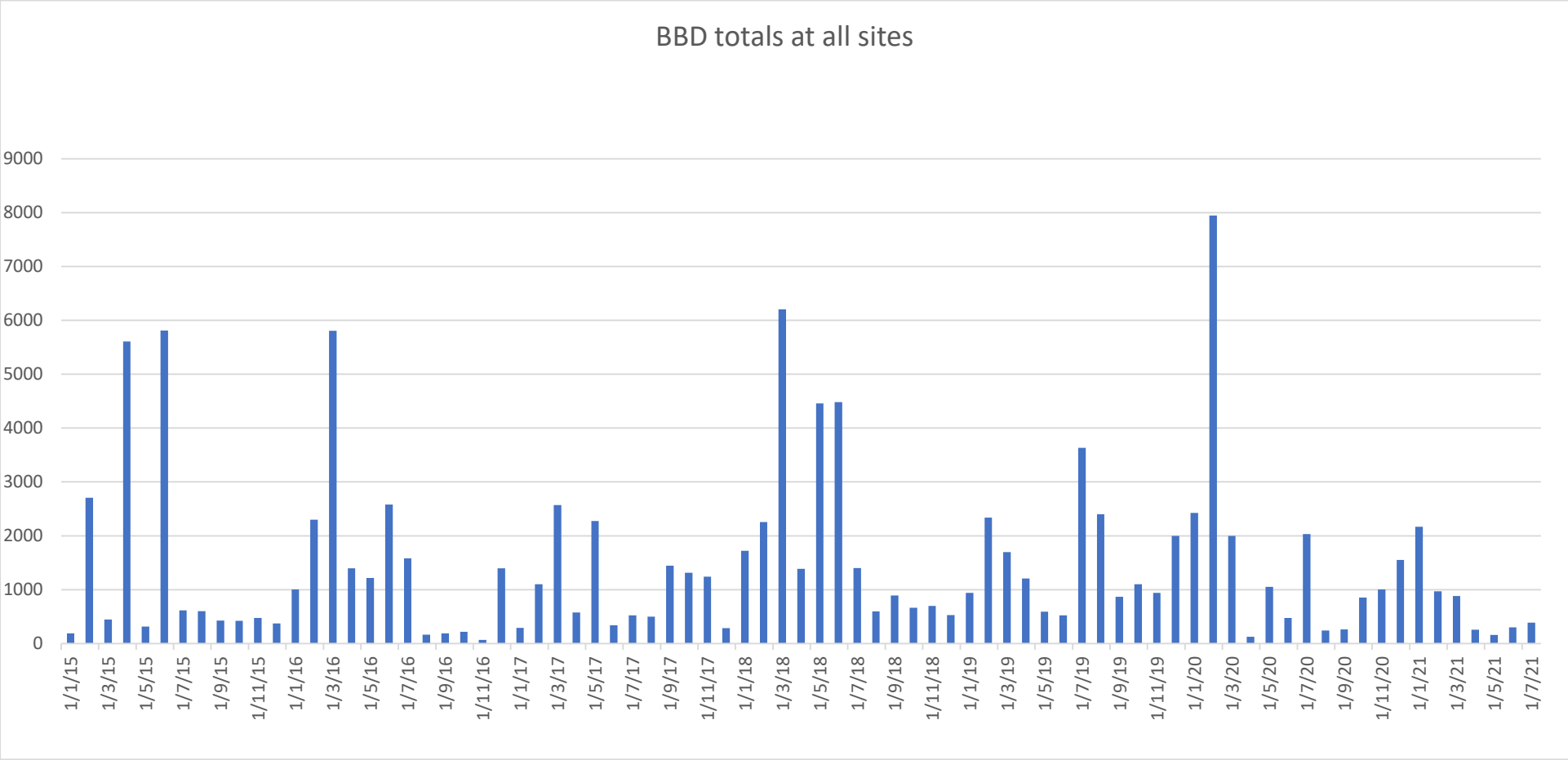


Figure 20 - BBD totals across all sites

There are only 8 months where totals exceeded 2500. In 70 months the totals were under 2500. There were 62 months where the totals were under 2000. These totals add up all of the sites so the maximum numbers could be counting birds that move from one site to another during that month. It does highlight the challenges in estimating numbers. A very large number at one site clearly make a significant impact on representing the count numbers in this format. Of note are the totals in relation to the individual counts at specific sites. Lake Linlithgow, Lake Bolac, Western Treatment Plant, Eastern Treatment Plant and Yan Yean Reservoir.

Blue-billed Duck Breeding Sites Details

Despite the sometimes very large numbers of Blue-billed Ducks on loafing sites, there is little to no breeding recorded on them. To get very large numbers of Blue-billed Ducks breeding sites are required – far more significant to the loafing sites or drop-in sites, they replenish the numbers of the species. Little is known of breeding sites and ongoing official records indicate there are 17 known breeding sites in Victoria (Purdey-Loyn, 2008 - Reference 3), however analysis of the database records shows 27 sites where breeding has occurred. These breeding sites arguably need to be protected and enhanced, with further research needed to encourage and expand breeding to other sites. The following tables show the known breeding sites within Victoria with the breeding dates, locations and very importantly, duckling numbers and the most recent breeding dates, indicating the rarity of recorded breeding within the state.

Table 14 - Breeding locations of Blue-billed ducks *Oxyura australis* with Breeding Seasons noted 2015-2021

Wetland	Breeding season	Maximum number of ducklings observed	LATITUDE	LONGITUDE	Area - m²	Maximum Open Water Distance - m
Bendigo Sewage Ponds	2018/2019	4	-36.6911	144.3054	305,278	319
Bendigo Sewage Ponds	2019/2020	x	-36.6911	144.3054	305,278	319
Braeside Park Wetland	2018/2019	2	-38.0075	145.1292	99,717	307
Braeside Park Wetland	2019/2020	4	-38.008	145.1273	99,717	307
Braeside Park Wetland	2020/2021	5	-38.008	145.1273	99,717	307
Coolart Luxton Lagoon	2019/2020	x	-38.387	145.1412	22,955	400
Coolart Luxton Lagoon	2020/2021	3	-38.387	145.1412	22,295	400
Edithvale Seaford Wetlands Edithvale	2017/2018	5	-38.0349	145.1265	27,617	310
Edithvale Seaford Wetlands Edithvale	2019/2020	5	-38.0283	145.1214	27,617	310
Edithvale Seaford Wetlands Seaford swamp	2020/2021	4	-38.0958	145.1386	27,617	310
Gerangamete Farm Lake	2018/2019	1	-38.4659	143.6711	12,258	170
Gerangamete Farm Lake	2020/2021	1	-38.4649	143.6649	12,258	170
Grange Burn Wetland	2020/2021	1	-37.7411	142.0108	17,619	132
Highlands lake	2020/2021	4	-37.5919	144.9038	30,963	229
Hird Swamp	2020/2021	12	-35.857	144.0969	3,020,000	2,399
Jawbone Conservation Reserve	2019/2020	x	-37.8608	144.875	85,994	517
Jawbone Conservation Reserve	2020/2021	1	-37.8608	144.875	85,994	517
Jells Park Lake	2018/2019	3	-37.8982	145.1998	102,741	418
Johnson Swamp	2019/2020	11	-35.8207	144.0786	2,940,000	2,900
Lake Bael Bael	2017/2018	4	-35.7021	143.7472	2,870,000	3,860
Lake Knox	2020/2021	1	-37.8701	145.256	15,005	150
Lake Lorne	2016/2017	10	-38.1812	144.5576	76,904	320
Lake Purrumbete	2016/2017	3	-38.2802	143.2315	4,770,000	2,660
Lake Purrumbete	2020/2021	2	-38.2802	143.2315	4,770,000	2,660

Wetland	Breeding season	Maximum number of ducklings observed	LATITUDE	LONGITUDE	Area - m²	Maximum Open Water Distance - m
Lake Wendouree	2015/2016	10	-37.5498	143.8334	2,110,000	2,080
Lake Wendouree	2017/2018	6	-37.5464	143.8234	2,110,000	2,080
Lake Yando	2020/2021	3	-36.0373	143.7822	318,613	1,210
Lakewood Reserve	2016/2017	5	-37.8797	145.249	32,097	276
Mason Farm	2016/2017	x	-38.2446	144.5879	5,388	195
Mullawallah Wetland	2017/2018	6	-37.5369	143.7871	290,722	625
Mullawallah Wetland	2018/2019	2	-37.5349	143.7978	290,722	625
Mullawallah Wetland	2019/2020	x	-37.5369	143.7871	290,722	625
Mullawallah Wetland	2020/2021	2	-37.5369	143.7871	290,722	625
North Gardens: Lake Wendouree	2018/2019	3	-37.5435	143.8265	131,130	130
Richardsons Lagoon	2020/2021	2	-36.0265	144.5634	259,924	998
Serendip Sanctuary	2019/2020	x	-38.0023	144.4094	27,901	381
Tanunda Wetland	2016/2017	3	-37.6754	145.0815	35,289	335
Tanunda Wetland	2020/2021	3	-37.6754	145.0815	35,289	335
Traralgon Railway Conservation Reserve	2017/2018	2	-38.2108	146.5306	21,815	140
Traralgon Railway Conservation Reserve	2020/2021	1	-38.2108	146.5306	21,815	140
Walker swamp	2020/2021	5	-37.5781	142.4761	447,395	1,180
Yarram Creek private dam	2017/2018	x	-38.2314	144.5809	42,955	387

- ***Note*** : The maximum open water distance of all breeding habitats showed a minimum of 140 metres.

Map View of Recorded BBD Breeding Sites, Victoria available at -

http://www.easymapmaker.com/map/bluebillbreeding

Showing Individual Breeding Site Locations spread across Victoria.

All VBA, eBird and Birdata Records Indicating Blue-billed Duck Breeding

See the accompanying Appendix 3: '**Report Reference - Blue-bill Breeding Records 2015-to-30August2021.xlsx**' Microsoft Excel file encompassing all observation records or breeding from 2015 to mid-2021 summarised to compile this report.

Table 15 - Ducklings Maximum Noted at a Site

Wetland	Number of breeding seasons in records	Ducklings maximum	Last recorded breeding date	Notes
Hird Swamp	1	12	23/02/2021	
Johnson Swamp	1	11	27/04/2020	
Lake Lorne	1	10	13/02/2017	
Mullawallah Wetland	4	6	1203/2021	
Lake Wendouree	1	6	22/09/19	
Braeside Park Wetland	3	5	12/03/2021	
Edithvale Seaford Wetlands Edithvale	2	5	31/12/2020	RAMSAR site
Lakewood Reserve	1	5	22/02/2017	
Walker swamp	1	5	11/02/2021	
Bendigo Sewage Ponds	2	4	21/1/2020	
Edithvale Seaford Wetlands Seaford swamp	1	4	31/12/2020	RAMSAR site
Highlands Lake	1	4	23/03/2021	
Lake Bael Bael	1	4	14/11/2017	
Coolart Luxton Lagoon	2	3	6/02/2021	
Lake Purrumbete	2	3	28/02/2021	
Tanunda Wetland	2	3	11/11/2020	
Jells Park Lake	1	3	14/11/2018	
Lake Yando	1	3	29/03/2021	
North Gardens: Lake Wendouree	1	3	11/12/2018	
Traralgon Railway Conservation Reserve	2	2	21/01/2021	
Richardsons Lagoon	1	2	4/01/2021	
Gerangamete Farm Lake	2	1	9/12/2020	
Jawbone Conservation Reserve	2	1	22/10/2020	
Grange Burn Wetland	1	1	27/12/2020	
Lake Knox	1	1	5/03/2021	
Mason Farm	1		23/02/2017	no numbers indicated
Serendip Sanctuary	1		22/10/2019	no numbers indicated
Yarram Creek private dam	1		8/09/2018	no numbers indicated

Table 16 - Most recent breeding records

Wetland	Number of breeding seasons in records	Ducklings maximum	Last breeding date record
Lake Yando	1	3	29/03/2021
Highlands Lake	1	4	23/03/2021
Mullawallah Wetland	4	6	12/03/2021
Braeside Park Wetland	3	5	12/03/2021
Lake Knox	1	1	5/03/2021
Lake Purrumbete	2	3	28/02/2021
Hird Swamp	1	12	23/02/2021
Walker swamp	1	5	11/02/2021
Coolart Luxton Lagoon	2	3	6/02/2021
Traralgon Railway Conservation Reserve	2	2	21/01/2021
Richardsons Lagoon	1	2	4/01/2021
Edithvale Seaford Wetlands Edithvale	2	5	31/12/2020
Edithvale Seaford Wetlands Seaford swamp	1	4	31/12/2020
Grange Burn Wetland	1	1	27/12/2020
Gerangamete Farm Lake	2	1	9/12/2020
Tanunda Wetland	2	3	11/11/2020
Jawbone Conservation Reserve	2	1	22/10/2020
Johnson Swamp	1	11	27/04/2020
Bendigo Sewage Ponds	2	4	21/01/2020
Serendip Sanctuary	1		22/10/2019
Lake Wendouree	1	6	22/09/2019
North Gardens: Lake Wendouree	1	3	11/12/2018
Jells Park Lake	1	3	14/11/2018
Yarram Creek private dam	1		8/09/2018
Lake Bael Bael	1	4	14/11/2017
Mason Farm	1		23/02/2017
Lakewood Reserve	1	5	22/02/2017
Lake Lorne	1	10	13/02/2017

* 3 site observations indicated ducklings, however did not specify numbers

Table 17 - Ducklings most recorded sites with breeding

Wetland	Number of breeding seasons in records	Ducklings maximum	Notes
Mullawallah Wetland	4	6	Presence of water milfoil
Braeside Park Wetland	3	5	
Edithvale Seaford Wetlands Edithvale	2	5	RAMSAR site
Bendigo Sewage Ponds	2	4	
Coolart Luxton Lagoon	2	3	
Lake Purrumbete	2	3	
Tanunda Wetland	2	3	
Traralgon Railway Conservation Reserve	2	2	Former water storage for steam trains
Gerangamete Farm Lake	2	1	
Jawbone Conservation Reserve	2	1	
Hird Swamp	1	12	
Johnson Swamp	1	11	
Lake Lorne	1	10	
Lake Wendouree	1	6	
Lakewood Reserve	1	5	
Walker swamp	1	5	
Edithvale Seaford Wetlands Seaford swamp	1	4	RAMSAR site
Highlands Lake	1	4	
Lake Bael Bael	1	4	
Jells Park Lake	1	3	
Lake Yando	1	3	
North Gardens: Lake Wendouree	1	3	
Richardsons Lagoon	1	2	
Grange Burn Wetland	1	1	
Lake Knox	1	1	
Mason Farm	1		no numbers indicated
Serendip Sanctuary	1		no numbers indicated
Yarram Creek private dam	1		no numbers indicated

Physical Characteristics of Breeding Sites

In order to potentially encourage further breeding with artificial wetland creation or enhancement of existing wetlands, it is important to look at the location of breeding sites and closeness of human habitation including whether sites are open to recreation and the amount of recreation, form of the wetland, site area and maximum open water distance for the birds to enter and exit the site, and the features of the wetland that encourage the birds to breed. A brief summary of the recorded breeding sites is outlined below.

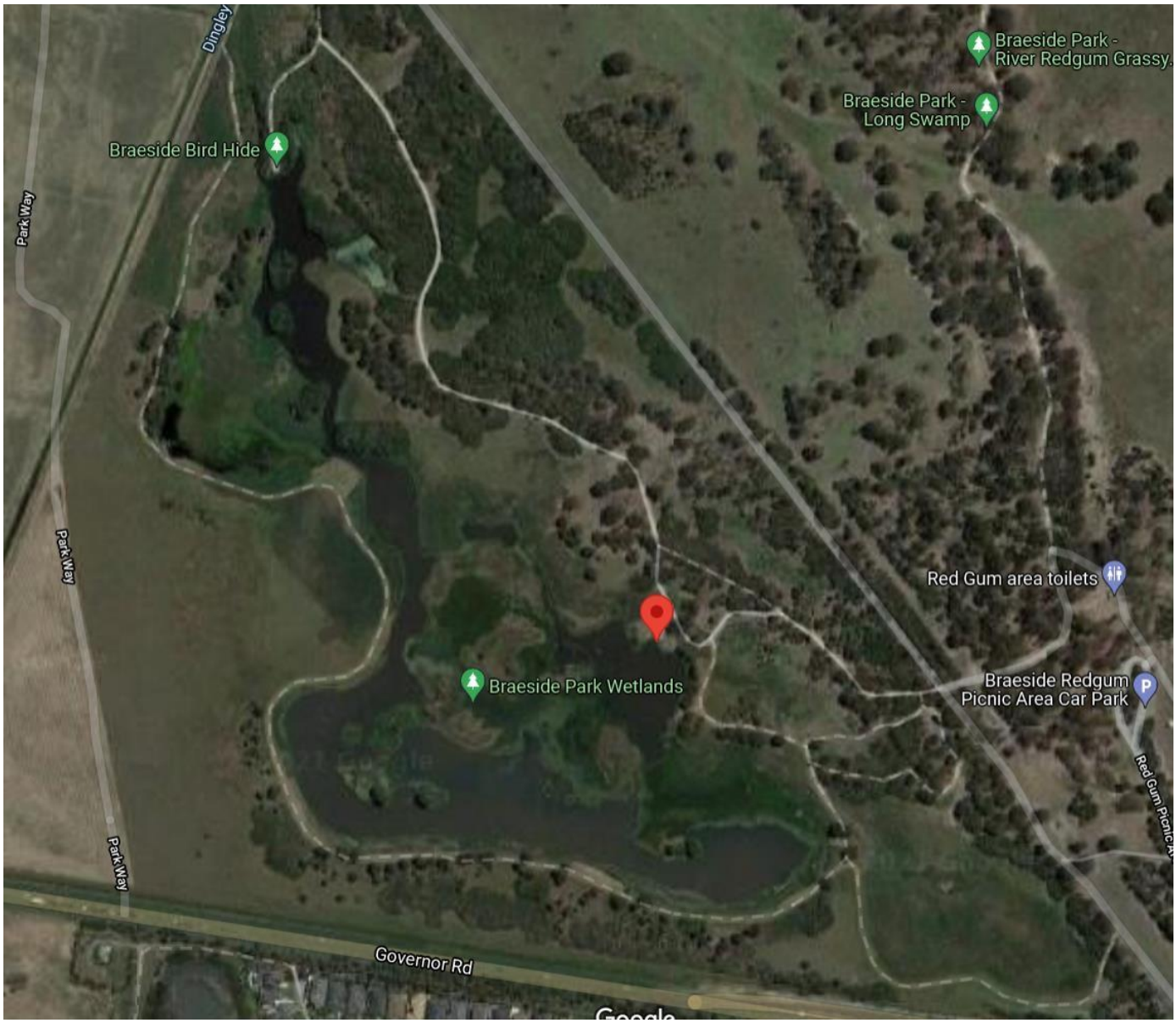
Bendigo Sewage Ponds

Latitude / Longitude -36.6911 144.3054
Last Recorded BBD Breeding 21-01-2020

Site Area - 182,973.90 m²
Maximum Open Water Distance - 798m

Notes : The site has a number of ponds, the largest was measured and has two small islands with sheltering vegetation on the water. A smaller lake above has sheltering vegetation at the edges and emergent aquatic vegetation.

Braeside Park Wetlands
Latitude / Longitude -38.007464 145.129221
Last Recorded BBD Breeding 12-03-2021



Site Area - 99,717 m²
Maximum Open Water Distance - 307m

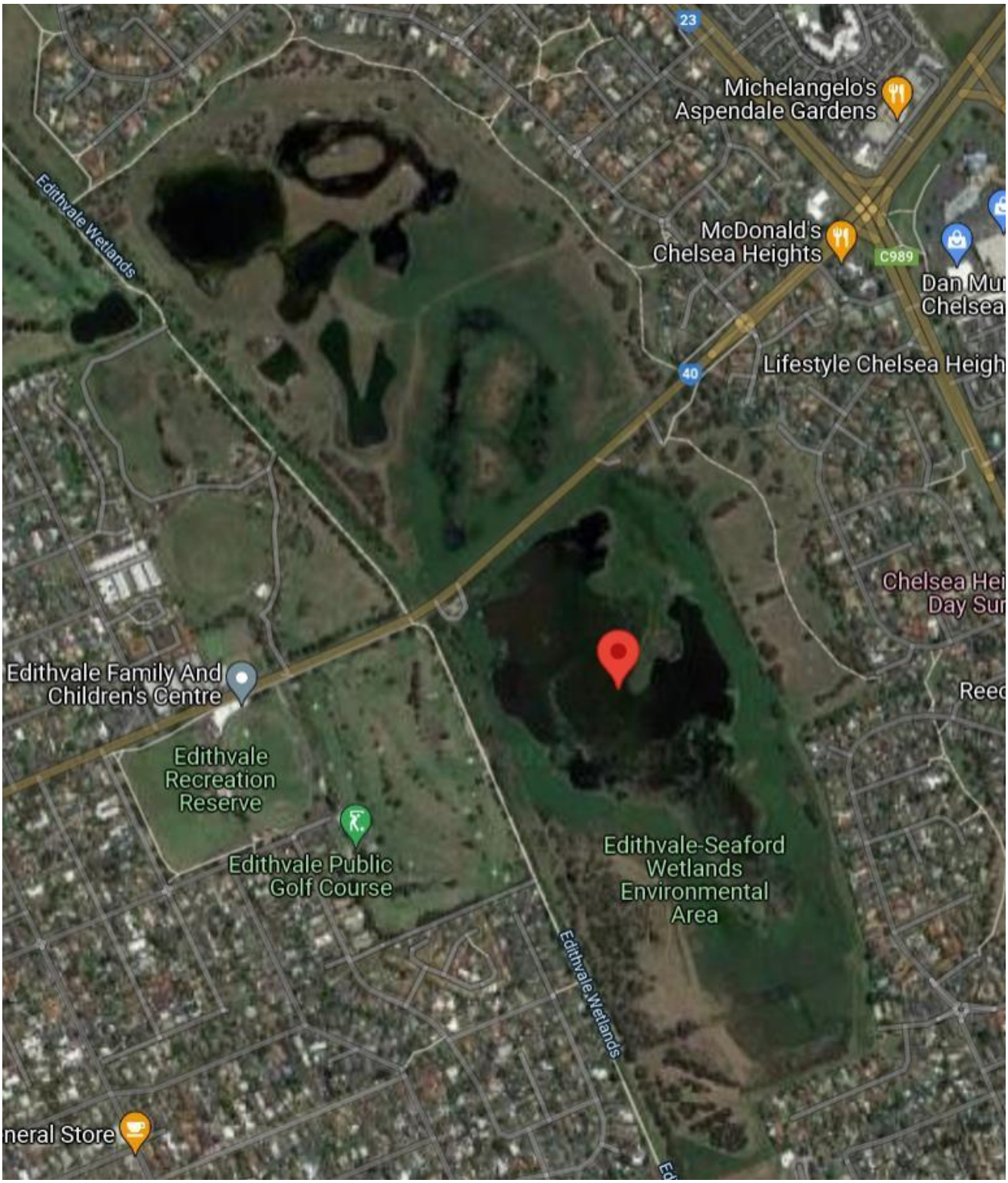
Notes : The site has a number of islands for security with abundant nesting vegetation and visible aquatic vegetation for support of invertebrates for feeding.

Coolart Luxton Lagoon
Latitude / Longitude -38.3869777 145.1411913
Last Recorded BBD Breeding 06-02-2021

Site Area - 22, 955 m²
Maximum Open Water Distance - 400m

Notes : Shown mainly dry. Variable water level, however fringing nesting areas, potentially islands depending on the water level. Aquatic vegetation evident.

Edithvale Seaford Wetlands Edithvale
Latitude / Longitude -38.0348690491179 145.126540660858
Last Recorded BBD Breeding 31-12-2020



Site Area - 600,338 m²
Maximum Open Water Distance - 250m

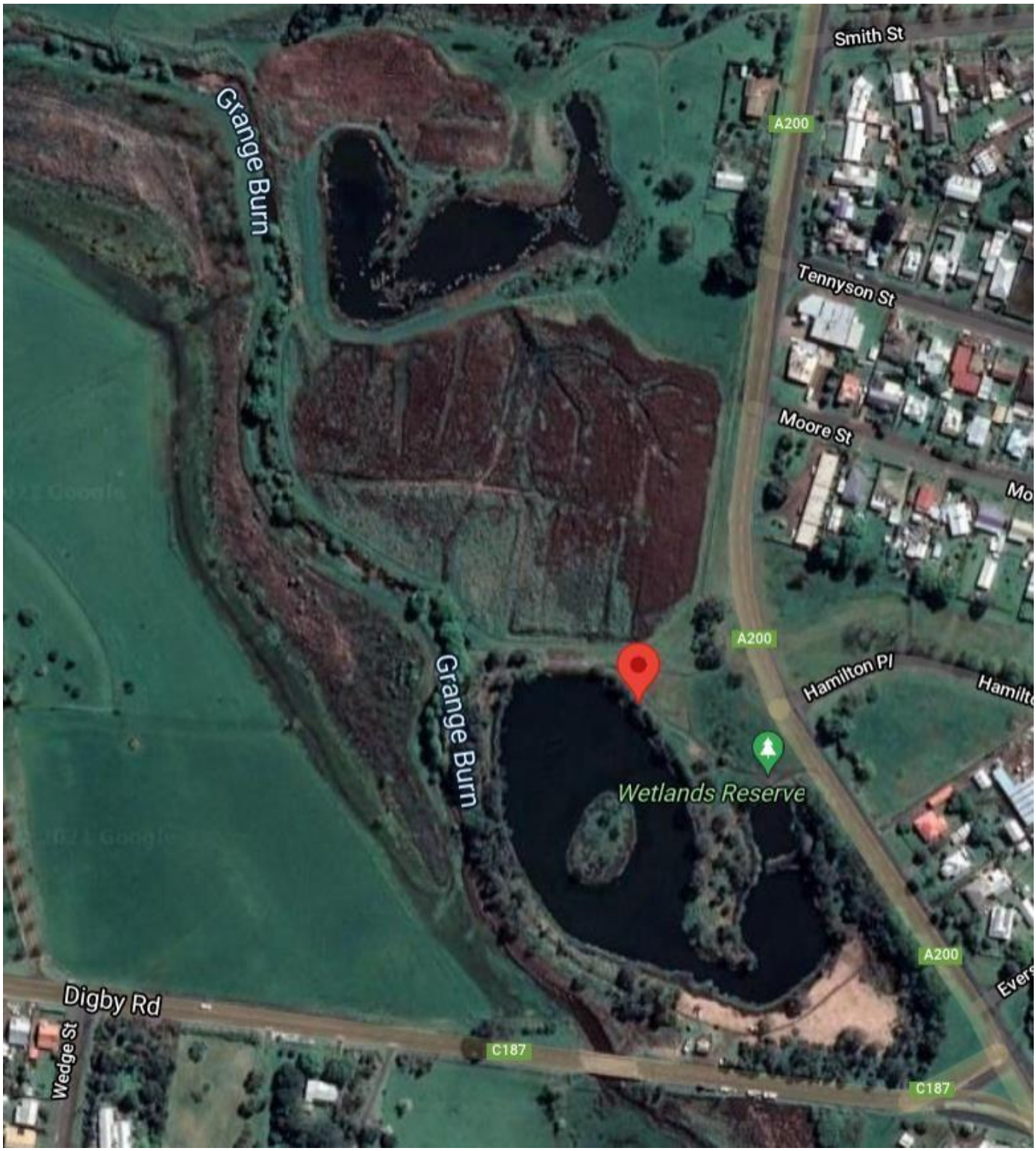
Notes : Variable water level. Aquatic vegetation. Nesting vegetation at the fringes with possible islands depending on water level.

Gerangamete Farm Lake
Latitude / Longitude -38.4659174 143.6710614
Last Recorded BBD Breeding 09-12-2020

Site Area - 12, 258 m²
Maximum Open Water Distance - 170m

Notes : Large, central island with nesting vegetation and aquatic vegetation.

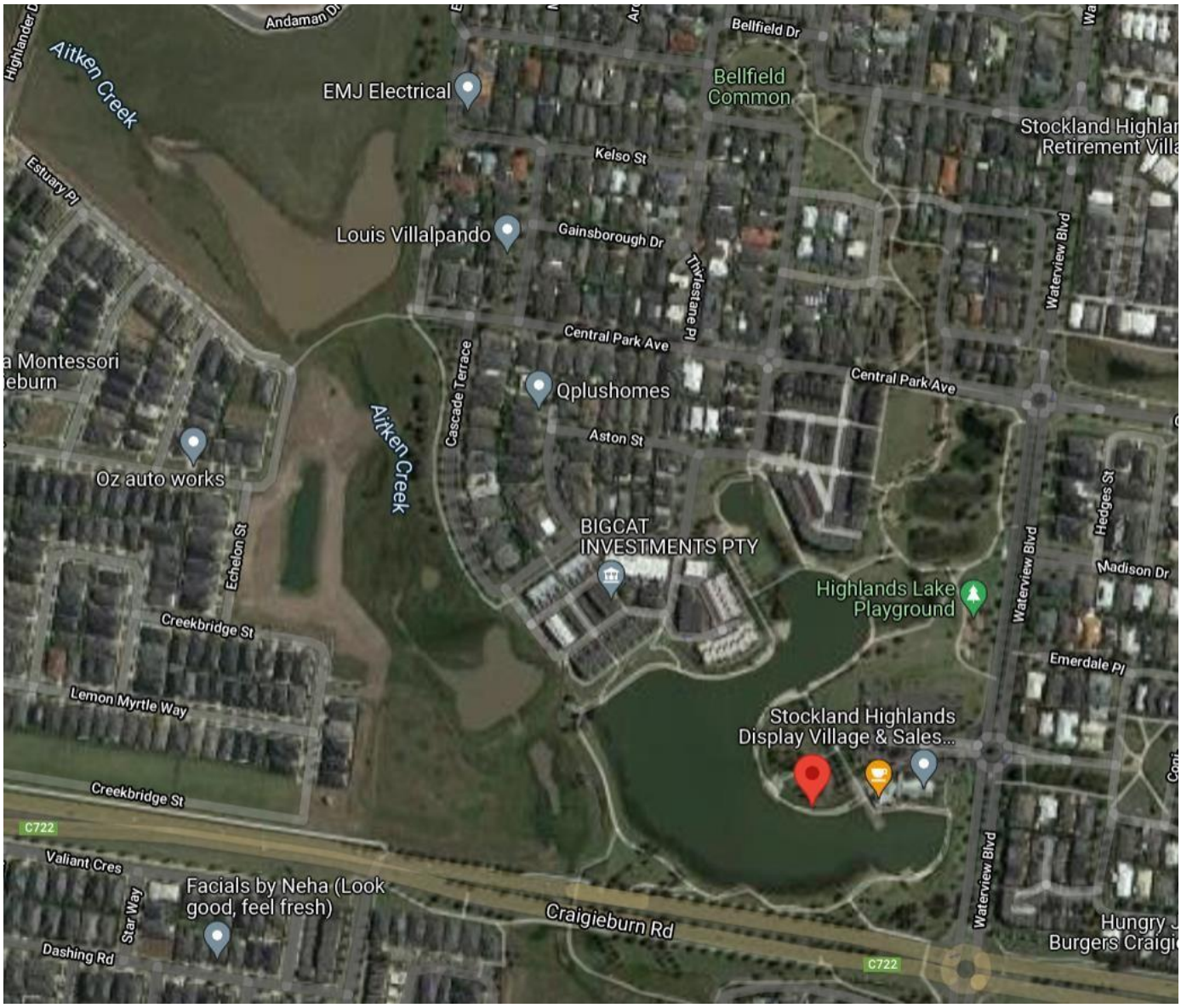
Grange Burn Wetland
Latitude / Longitude 37.7419709 142.0115483
Last Recoded BBD Breeding 27-12-2020



Site Area - 17,114 m²
Maximum Open Water Distance - 132m

Notes : Central island with nesting vegetation and aquatic vegetation.

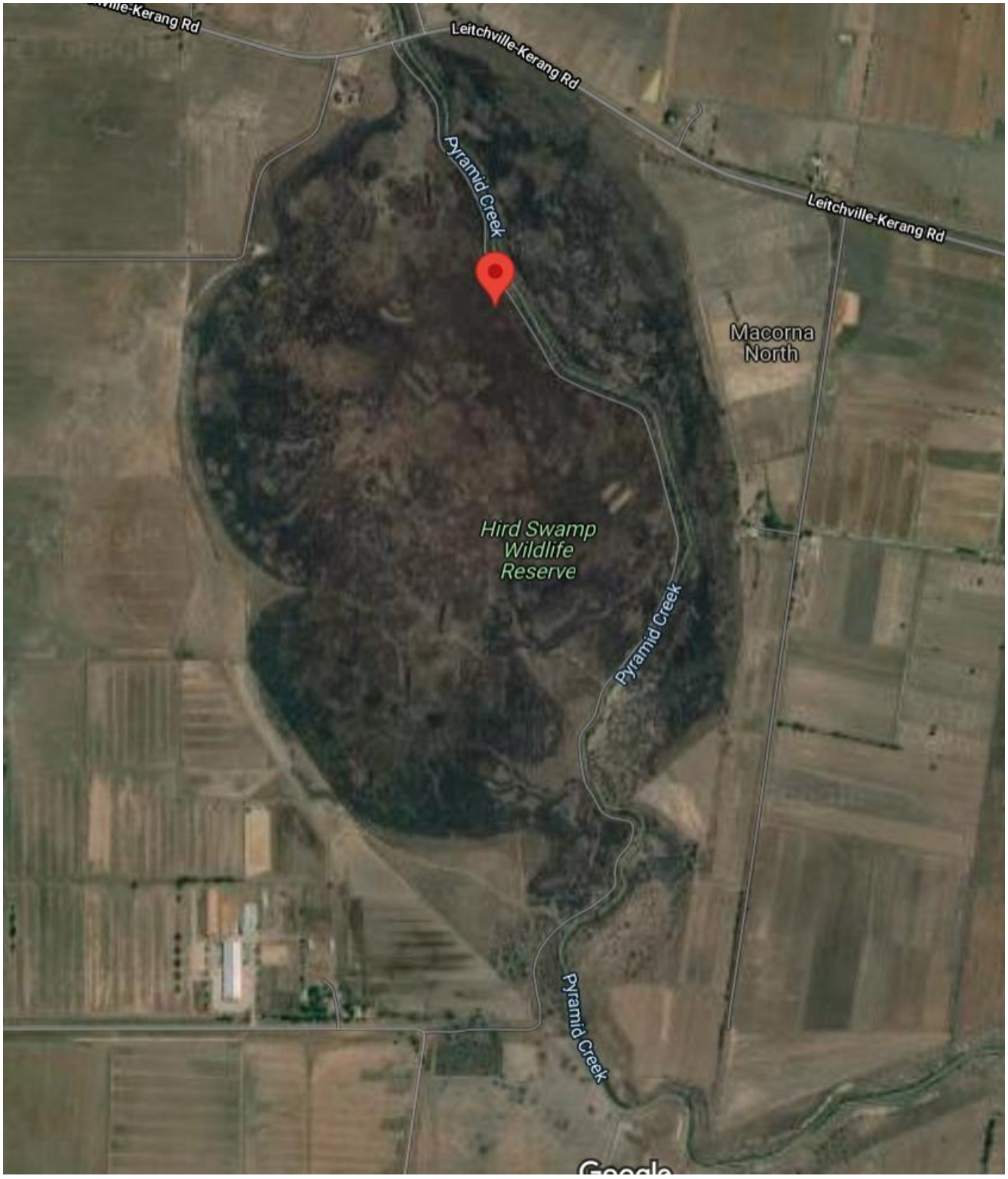
Highlands Lake
Latitude / Longitude -37.5918799189459 144.903802307263
Last Recoded BBD Breeding 23-03-2021



Site Area - 30,963 m²
Maximum Open Water Distance - 229m

Notes : Fringing vegetation for potential nesting with some visible aquatic vegetation.

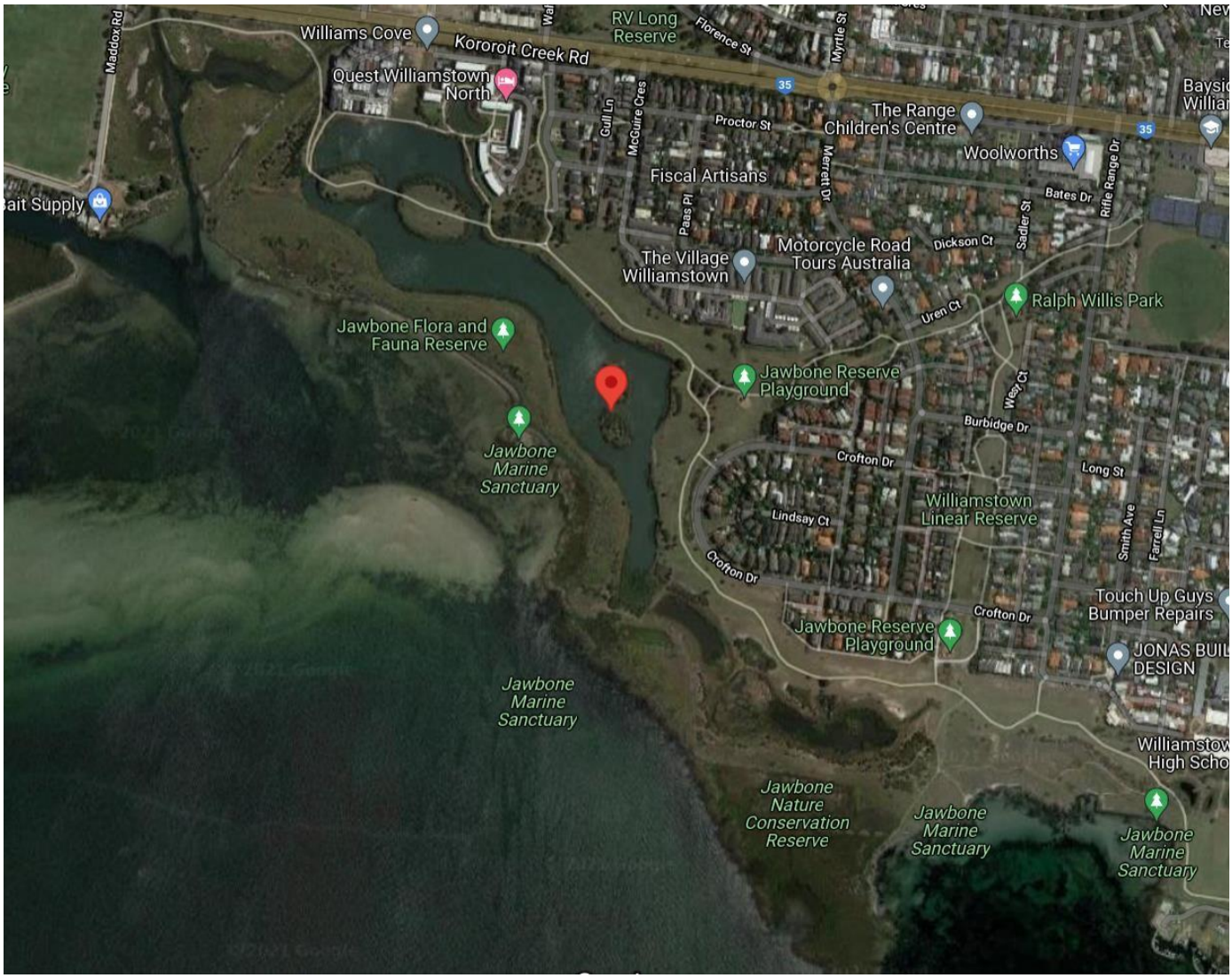
Hird Swamp
Latitude / Longitude 35.8570192658945 144.096915386617
Last recorded breeding 23-02-2021



Site Area - 3,020,000 m²
Maximum Open Water Distance - 2,399m

Notes : Shown dry in Google Maps. Potential breeding after heavy rain with small islands and nesting vegetation for security.

Jawbone Conservation Reserve
Latitude / Longitude -37.860833 144.875
Last Recoded BBD Breeding 22-10-2020



Site Area - 85,994 m²
Maximum Open Water Distance - 517m

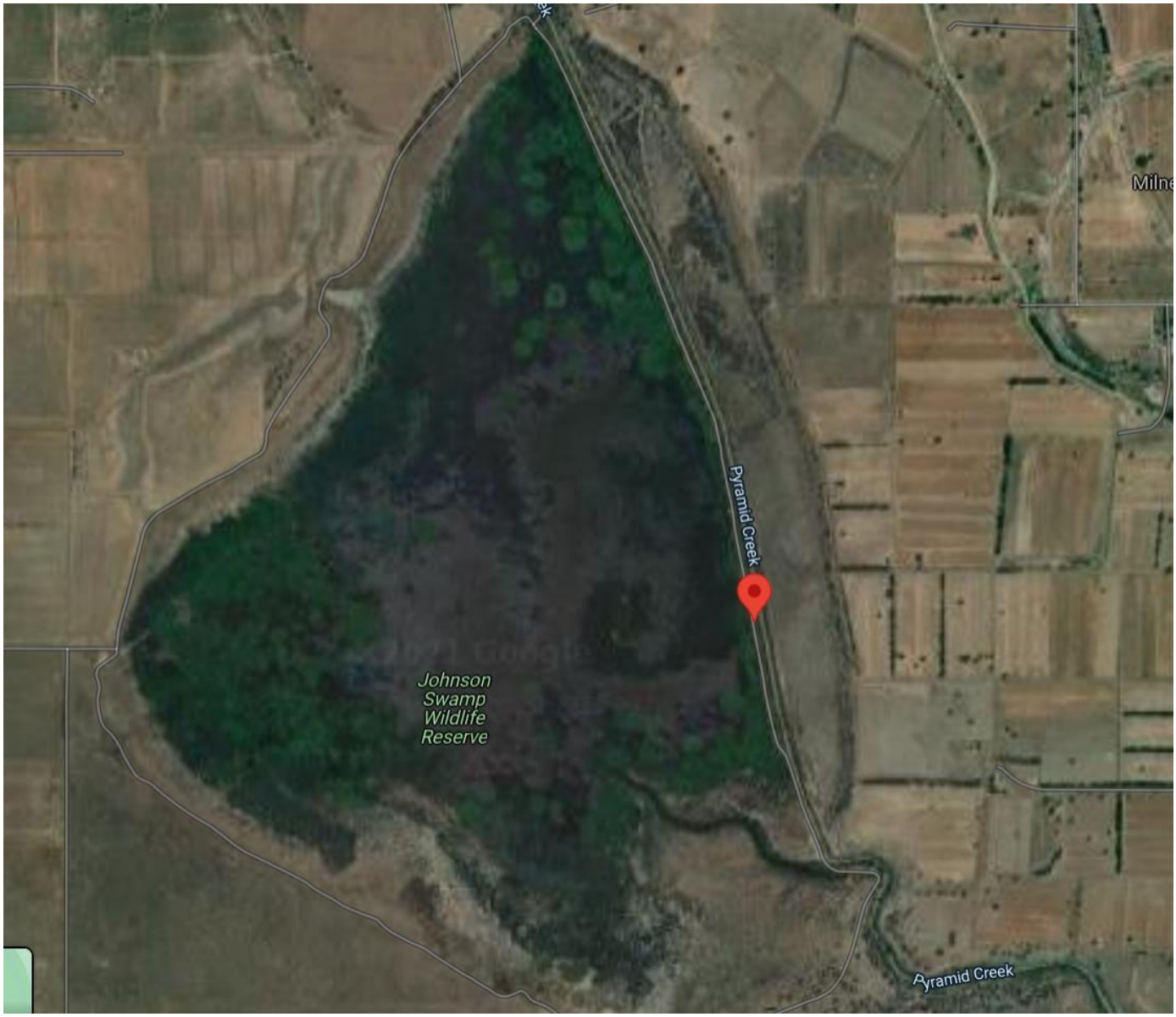
Notes : Small islands with nesting vegetation for security. Aquatic vegetation.

Jells Park Lake
Latitude / Longitude 37.8981684 145.1998361
Last recorded BBD breeding 14-11-2018

Site Area - 102,741 m²
Maximum Open Water Distance - 418m

Notes : Islands with bullrushes (Cumbungi) for habitation, however currently full of nesting Australian Ibis. Ample bullrushes (Cumbungi) around the lake and some aquatic vegetation, however heavy, close pedestrian traffic and fishing. Only drop-in sightings for some years.

Johnson Swamp
Latitude / Longitude -35.8206917206159 144.07859321697
Last recorded BBD breeding 27-04-2020



Site Area - 2,940,000 m²
Maximum Open Water Distance - 1,860m

Notes : Shallow and shown mostly dry in satellite view. Suspect breeding only after a heavy wet season.

Lake Bael Bael
Latitude / Longitude 35.702105141278 143.747204197704
Last recorded BBD breeding 14-11-2017

Site Area - 2,870,000 m²
Maximum Open Water Distance - 3,860m

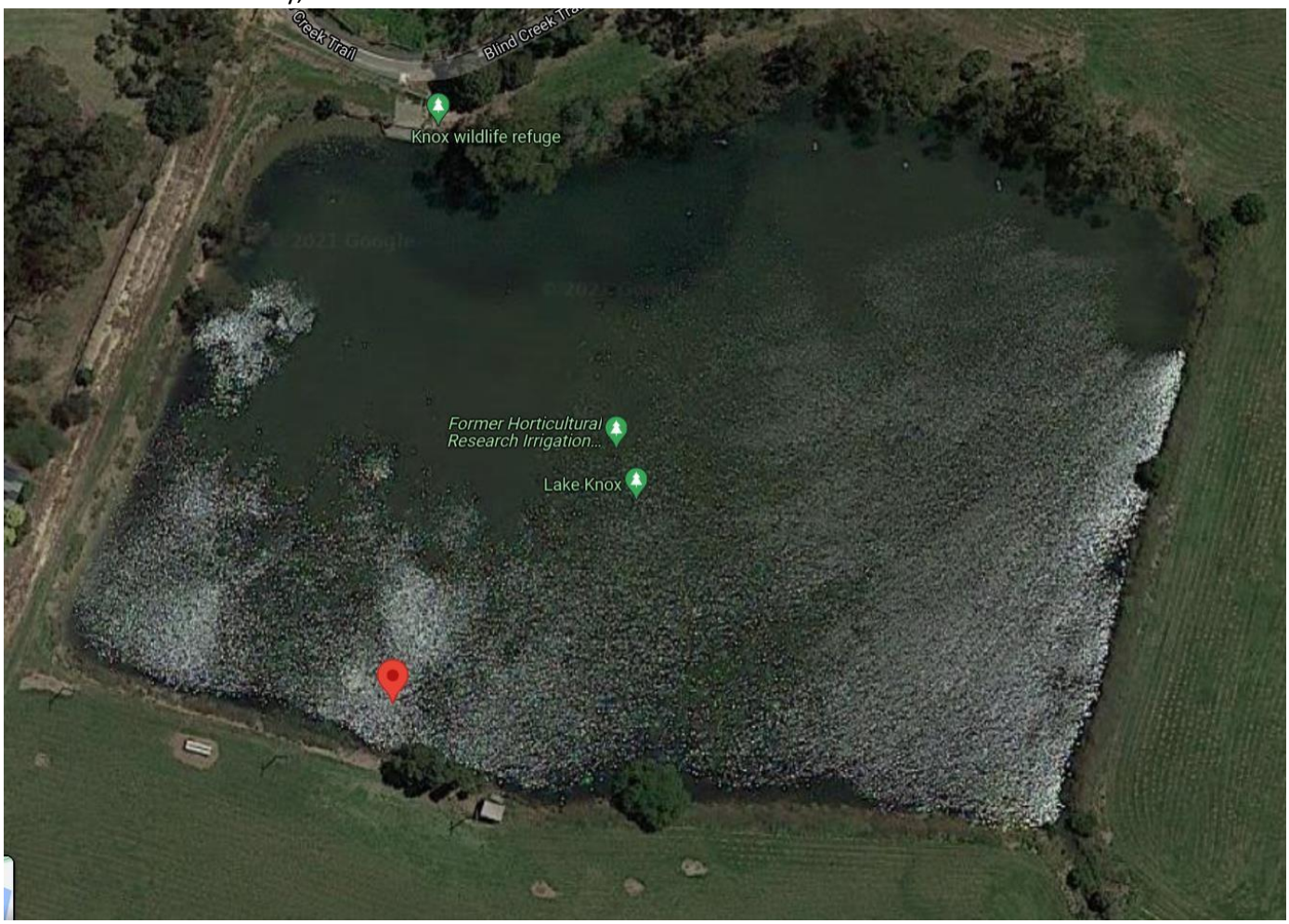
Notes : Shown mostly dry, potentially saline by the white, shoreline residue. Some nesting vegetation and aquatic vegetation, however no breeding recorded since 2017.

Lake Knox

Latitude / Longitude 37.8704 145.2556

Last recorded BBD breeding 05-03-2021

- 609-621 Burwood Hwy, Knoxfield



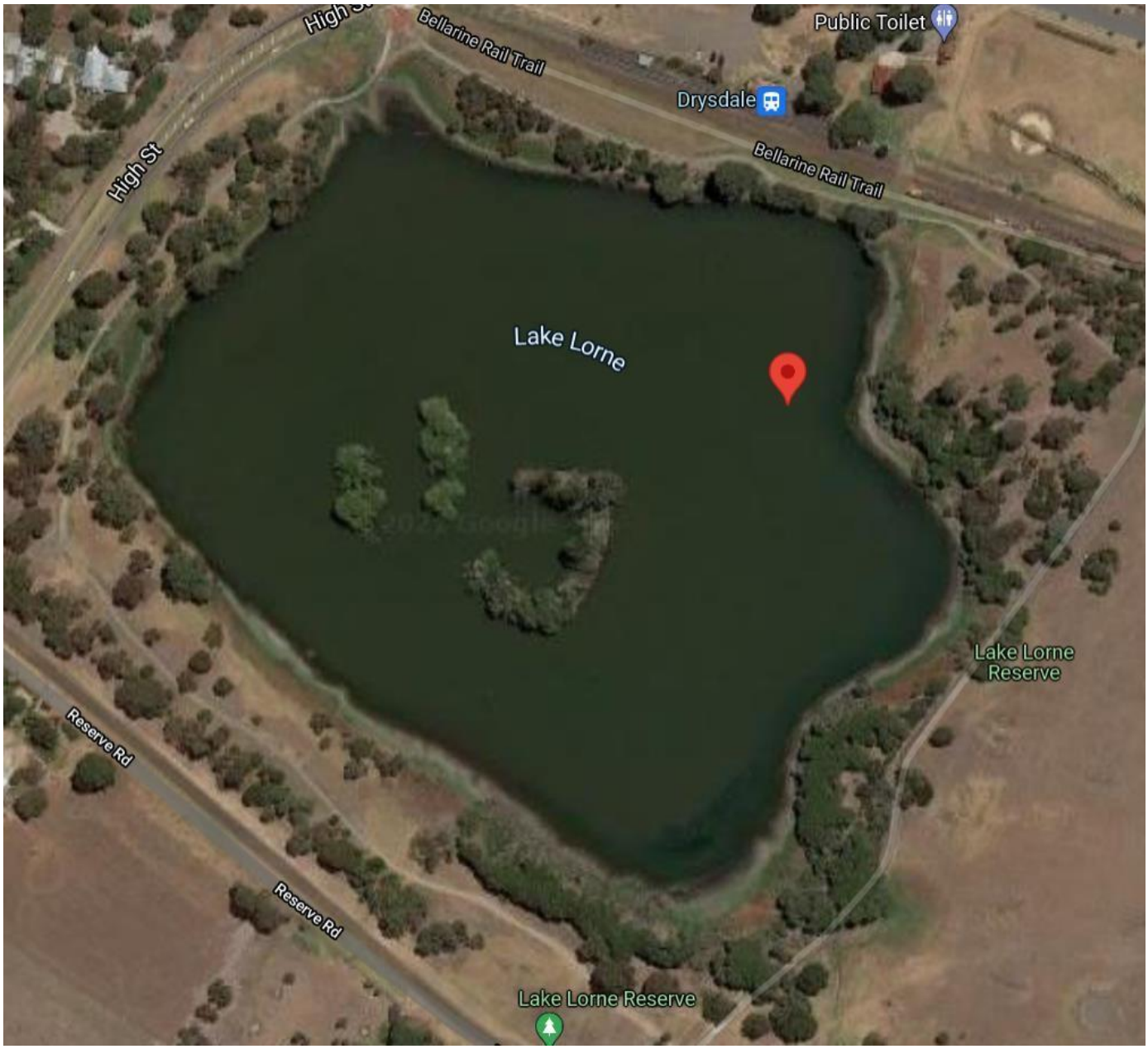
Site Area - 15,005 m²

Maximum Open Water Distance - 150m

Notes : Abundant aquatic vegetation – both Ribbon Weed *Cynogeton procerum* and Eel Grass and other species. 40m x 3m bullrushes (Cumbungi) for nesting off a steep bank directly onto deep water along the southern bank in the south-west with further potential nesting vegetation in the hidden north-east bank area plus noted nesting in the lower emerging branches of the central-east tree on the southern bank.

- **This Breeding Site is currently at risk** due to plans by Development Victoria from 2022 to pump out and fill in the lake for expansion of a new housing development, replaced with a much smaller reed bed retarding basin to the north-east aimed at stormwater treatment with overflow into the adjacent Blind Creek. With an estimated maximum 67m or less of open water access due to shallow verges designed to overgrow with fringing vegetation in the longer term, mainly Cumbungi, it is highly unlikely the Blue-billed Duck will be able to access the replacement site – the open water distance too short to either fly in or fly out. The plans show three 2m deep pools with balancing pipes between which also suggests likely overgrowth between the deeper pools which would further limit the open water distance to potentially around 15m.

Lake Lorne
Latitude / Longitude 38.1812382 144.5575991
Last recorded BBD breeding 13-02-2017



Site Area - 76,904 m²
Maximum Open Water Distance - 320m

Notes : Some nesting security on a central island with limited nesting vegetation. Limited aquatic vegetation.

Lake Purrumbete
Latitude / Longitude 38.28023 143.2315
Last Recoded BBD Breeding 28-02-2021

Site Area - 4,770,000 m²
Maximum Open Water Distance - 2,660 m

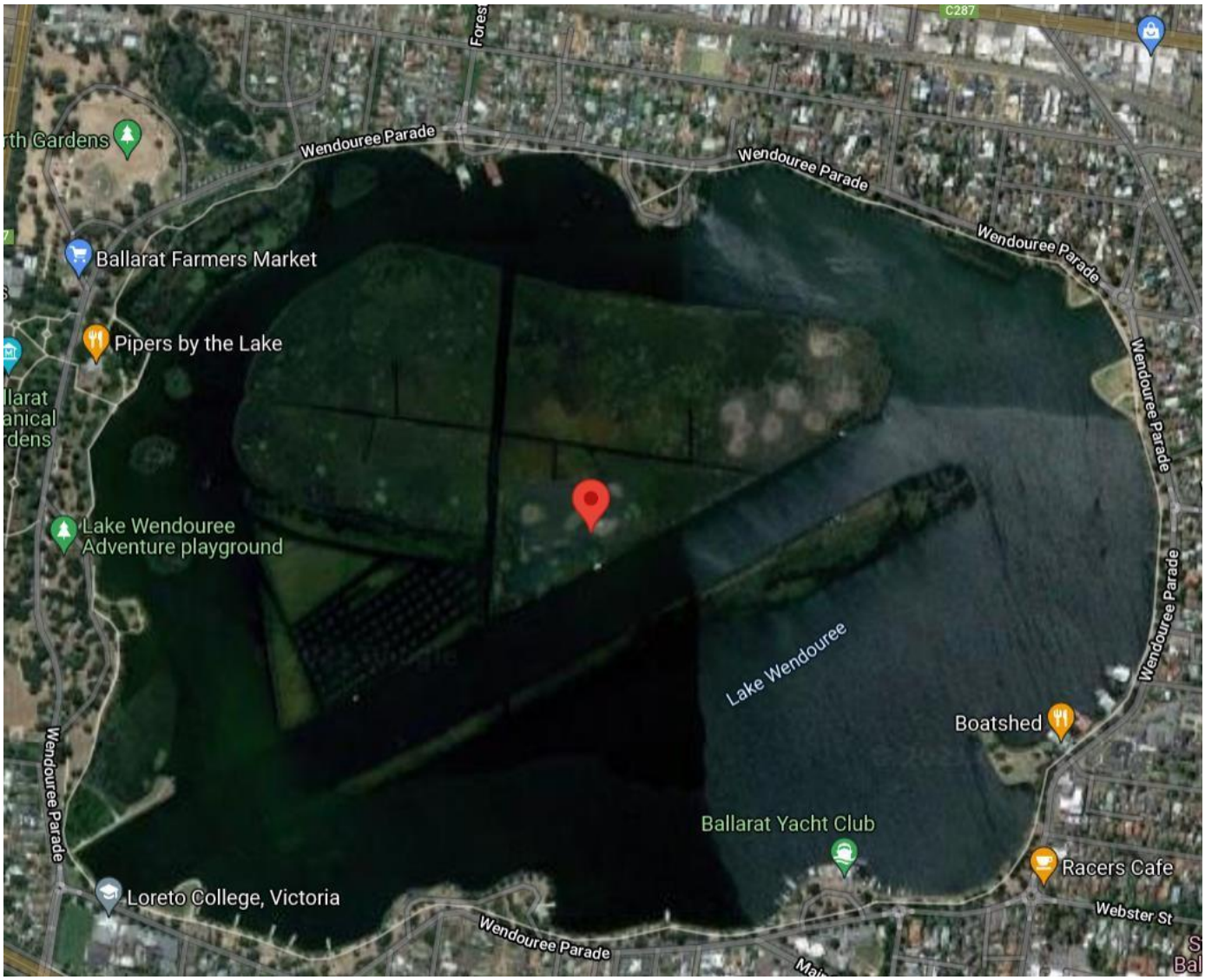
Notes : Potential secure nesting island habitat in the south-western corner with aquatic vegetation.

Lake Wendouree

Latitude / Longitude 37.5498309 143.8333511

* Includes Fairyland which is a section of canal loops off the main lake

Last Recorded BBD Breeding 22-09-2019



Site Area - 2,110,000 m²

Maximum Open Water Distance - 2,080m

Notes : Busy water sport lake with some large and small islands and potential nesting habitat with aquatic vegetation, with mention of the Fairyland canal and island area in the North-West to the right of “Ballarat Farmers Market”.

Lake Yando
Latitude / Longitude -36.0373467049722 143.782154470682
Last Recorded BBD Breeding 29-03-2021

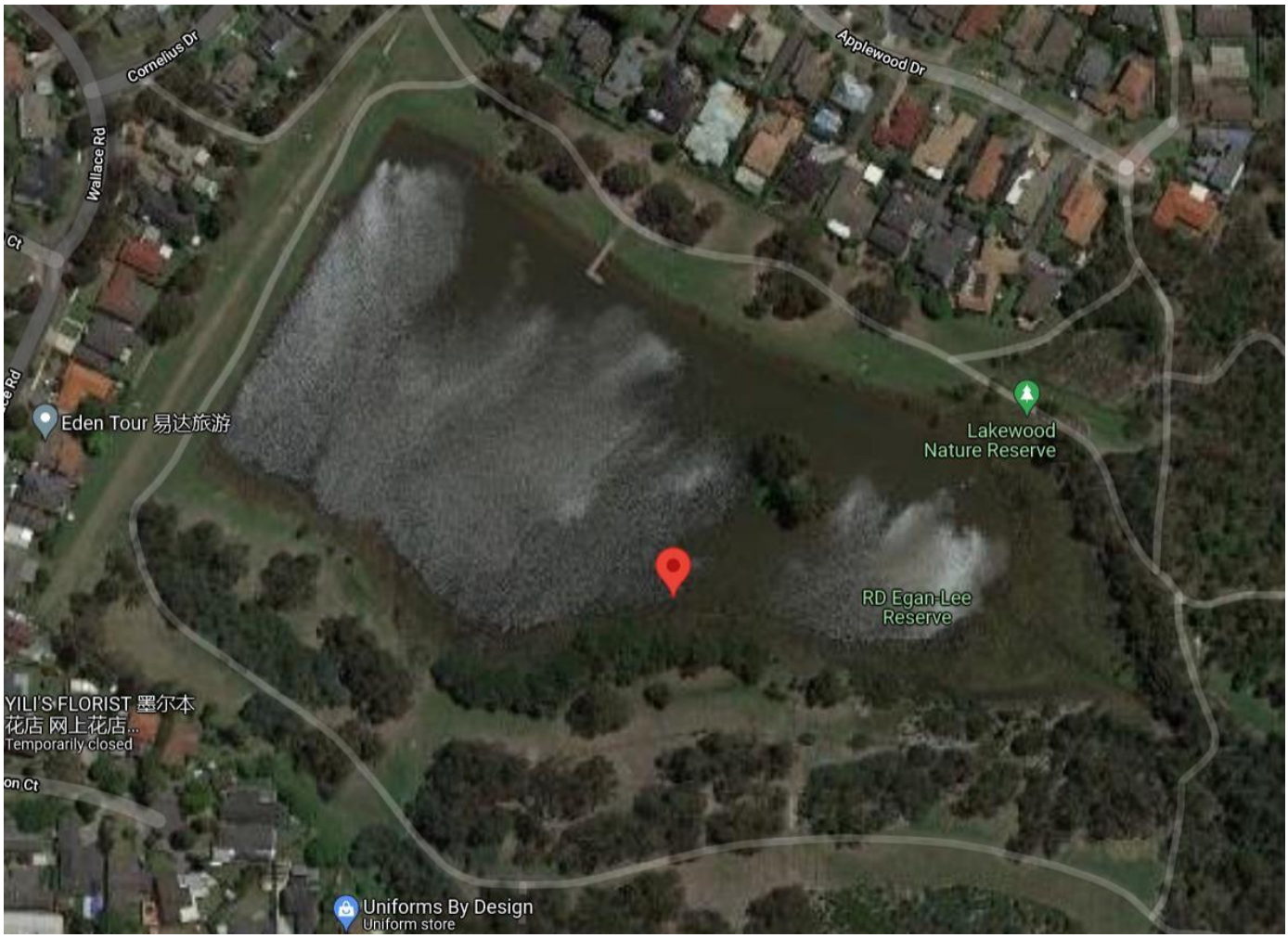
Site Area - 318,613 m²
Maximum Open Water Distance - 1,210m

Notes : Many potential nesting areas and abundant aquatic vegetation.

Lakewood Reserve

Latitude / Longitude 37.87973 145.24904

Last Recorded BBD Breeding 22-02-2017



Site Area - 32,097 m²

Maximum Open Water Distance - 276m

Notes : Suspect dead, polluted water from adjacent backyard runoff. No aquatic vegetation, no bullrushes (Cumbungi) for nesting. BBD's and Hardheads occasional drop-ins for the last few years, however seen paddling around, only a few, unsuccessful dives to feed then leaving the site. The Eurasian (Australasian) Coots are an indicator – feeding in the lakes at all other locations however feeding at the edges or on the bank at this shallow, artificial stormwater retarding lake which is a shallow 'V' overflowing into a water-level drain to the North-West.

Mason Farm Dam
Latitude / Longitude -38.2445877 144.5878994
Last Recoded BBD Breeding 23-02-2017

Site Area - 5,388 m²
Maximum Open Water Distance - 195 m

Notes : Some potential small nesting area in the south-east corner (marginal) with some aquatic vegetation. A single female choosing to breed, possibly due to isolation and privacy.

Mullawallah Wetland (aka Winters Swamp)
Latitude / Longitude -37.5348791 143.7977529
Last Recorded BBD Breeding 12-03-2021

Site Area - 290,722 m²
Maximum Open Water Distance - 625m

Notes : Shallow, potential nesting habit islands with aquatic vegetation during heavy rain periods filling the wetland.

North Gardens: Lake Wendouree

Latitude / Longitude -37.5434714 143.8265383

* Wetland Lakes connected to the main Lake Wendouree so BBD's can access from the main lake

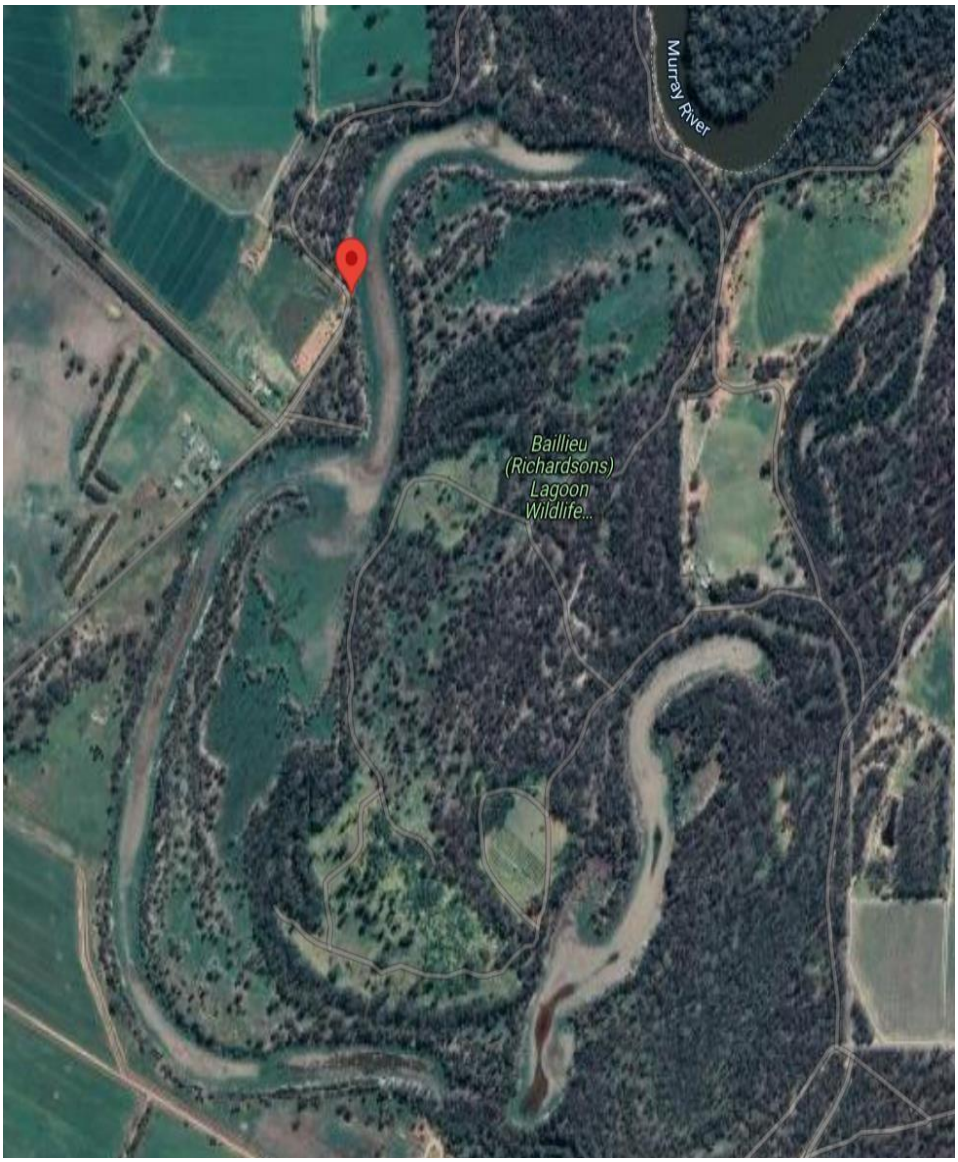
Last Recorded BBD Breeding 11-12-2018

Site Area - 13,130 m²

Maximum Open Water Distance - 130m (note tall trees either side)

Notes : Connects to Lake Wendouree (seen in the south-east corner, see Lake Wendouree above in this document) via pipes and channel in the south-east. Nesting habitat around islands for security with aquatic vegetation and access to Lake Wendouree. There are trees either side potentially impeding flight access which could reduce the open water distance to around 110 metres (estimate).

Richardsons Lagoon
Latitude / Longitude 36.0264794715084 144.563371902466
Last Recorded BBD Breeding 04-01-2021



Site Area - 259,924 m² * spur section adjacent to the GPS pin extending above and below, measured at the maximum high water mark (temporary Murray River overflow wetland)
Maximum Open Water Distance - 998 m

Notes : Normally dry floodwater spur off the Murray River, Torrumbarry, with a number of shallow ponds – not really possible to measure accurately. Some possible sheltered habitat vegetation depending on the water level.

Serendip Sanctuary
Latitude / Longitude 38.002341 144.409424
Last Recorded BBD Breeding 22-10-2019

Site Area - 27,901 m²
Maximum Open Water Distance - 381m

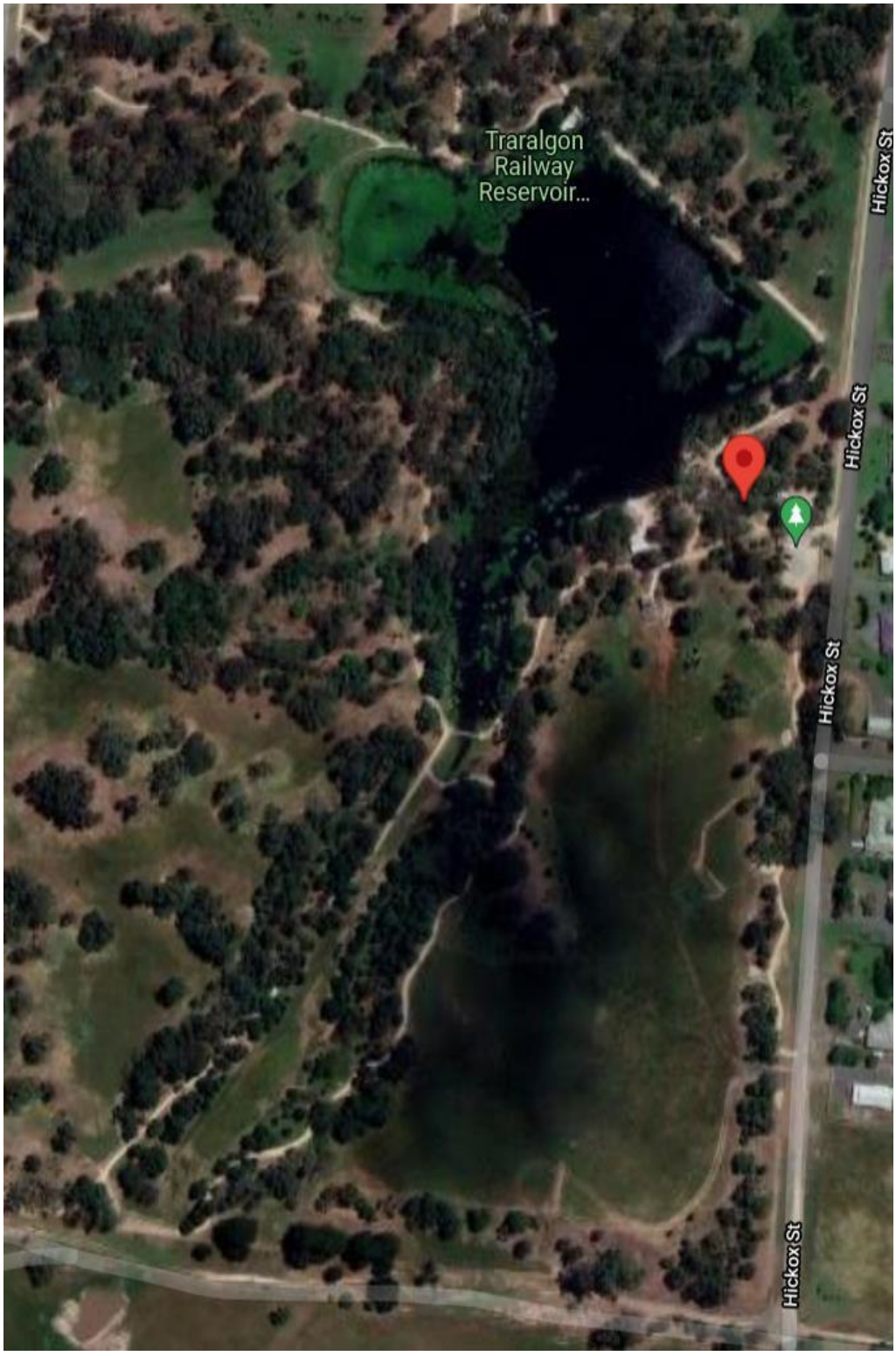
Notes : Potential secure nesting habitat islands or nesting in fringing vegetation. Ample aquatic vegetation.

Tanunda Wetland
Latitude / Longitude 37.67537 145.08149
Last Recorded BBD Breeding 11-11-2020

Site Area - 35,289 m²
Maximum Open Water Distance - 335m

Notes : Fringing nesting habitat, multiple ponds with aquatic vegetation.

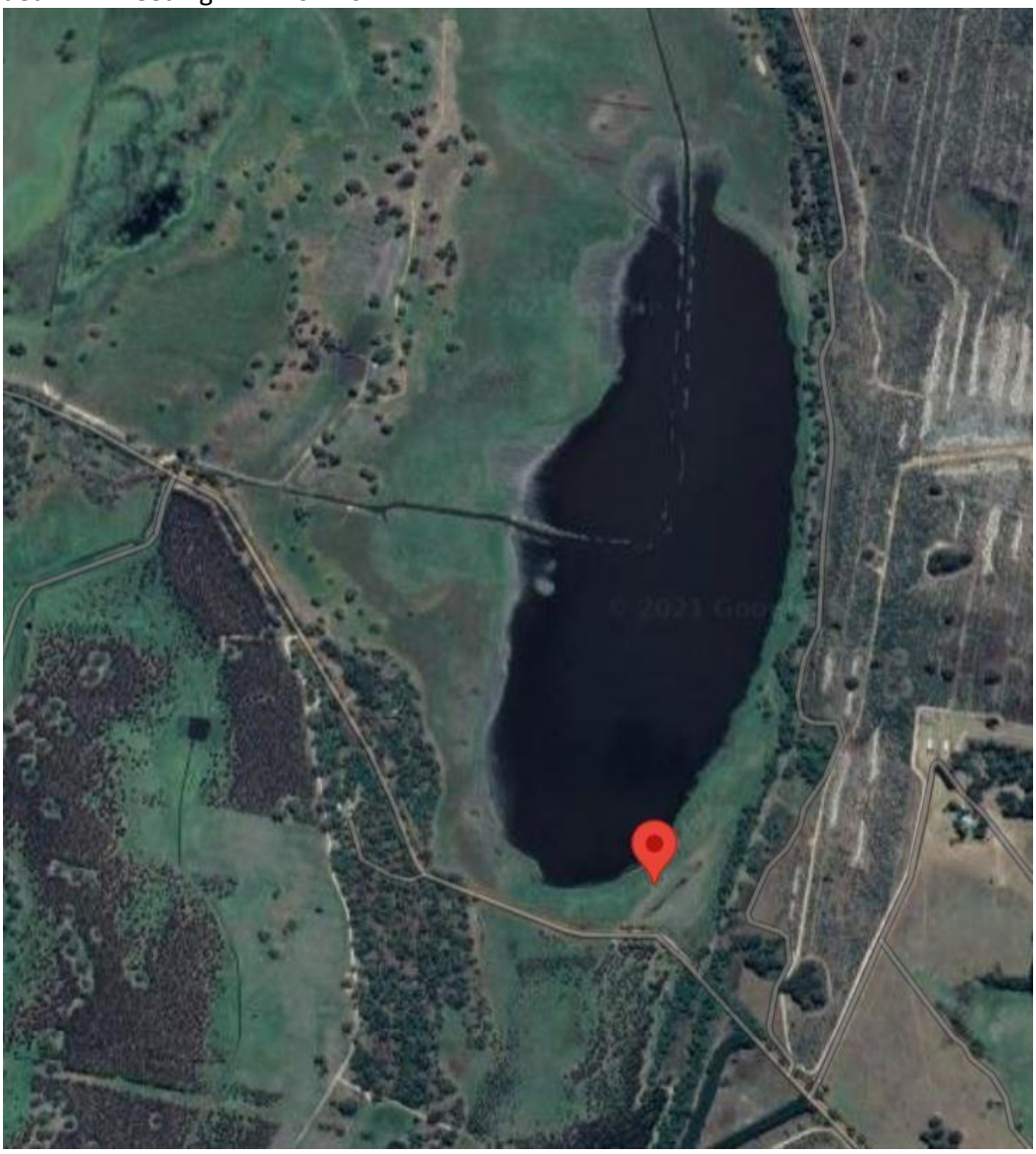
Traralgon Railway Conservation Reserve
Latitude / Longitude -38.21077 146.53055
Last Recorded BBD Breeding 21-01-2021



Site Area - 21,815 m²
Maximum Open Water Distance - 140m

Notes : Island nesting areas with ample aquatic vegetation.

Walker Swamp
Latitude / Longitude -37.5780736 142.4760937
Last Recorded BBD Breeding 11-02-2021



Site Area - 447,395 m²
Maximum Open Water Distance - 1,180m

Notes : Limited nesting habitat, some aquatic vegetation. 1.84km from other potential habitat in the Brady Swamp Wildlife Reserve to the South-West.

Yarram Creek private dam
Latitude / Longitude -38.23143 144.58093
Last Recorded BBD Breeding 08-09-2018

Site Area - 42,995 m²
Maximum Open Water Distance - 387m

Notes : Some potential nesting habitat on the central island. Limited aquatic vegetation.

Maximum Open Water Distance of BBD Breeding Habitats.

One significant characteristic of the Breeding Habitats was the maximum open water distance. When looking at the 27 known breeding habitats, as found from the records of observations in the three databases from 2015 to mid-2021, they showed **a *minimum* of 140 metres**. This is a significant finding towards the creation of any artificial waterbodies claimed to serve the requirements of the Blue-billed Duck species for breeding. The BBD's are indicating through their choices of sites for habitation, and most importantly breeding, that they are not selecting small waterbodies.

Male to Female Numbers Discrepancy in Observations

A limited search of records for a number of sites was made to look at the male to female observations numbers since the authors noted a male to female ratio of from 1-to-2 to as little as 1-to-4 generally on sites attended personally for observations. Records generally indicate total number of birds without specifying the sexes of the birds. Given the clear physical differences between at least the adults of the species, it is an area of interest and potential further investigation.

Note : The totals of each sex shown below will most likely comprise the same birds counted multiple times. Given the migratory nature of the species, a fair representation of species numbers can only be taken for sightings made across multiple sites on a single day. For example – 200 birds on one large site one day, then flying to another large site the next day and counted again does not mean there are 400 birds (i.e. it is 200 counted twice).

Lake Wendouree Male to Female Numbers 2017

Lake Wendouree was a key site for the observers making note of the ratio of the sexes.

Table 18 - Lake Wendouree Male to Female Numbers 2017

Date	Number of Males	Number of Females
5/03/2017	1	0
2/04/2017	1	0
14/04/2017	0	1
19/04/2017	1	0
16/08/2017	1	1
6/09/2017	2	2
8/09/2017	2	2
20/09/2017	0	2
22/09/2017	1	1
25/09/2017	2	6
2/10/2017	3	3
3/10/2017	1	1
10/10/2017	1	0
14/10/2017	4	4
18/10/2017	1	1
24/10/2017	4	1
5/11/2017	7	1
6/11/2017	4	3
8/11/2017	2	2
10/11/2017	2	0
17/11/2017	0	1
17/11/2017	1	1
10/12/2017	1	1
11/12/2017	0	1
22/12/2017	2	1
30/12/2017	1	2
31/12/2017	0	1
31/12/2017	0	1
31/12/2017	0	1
Totals	**45**	**41**

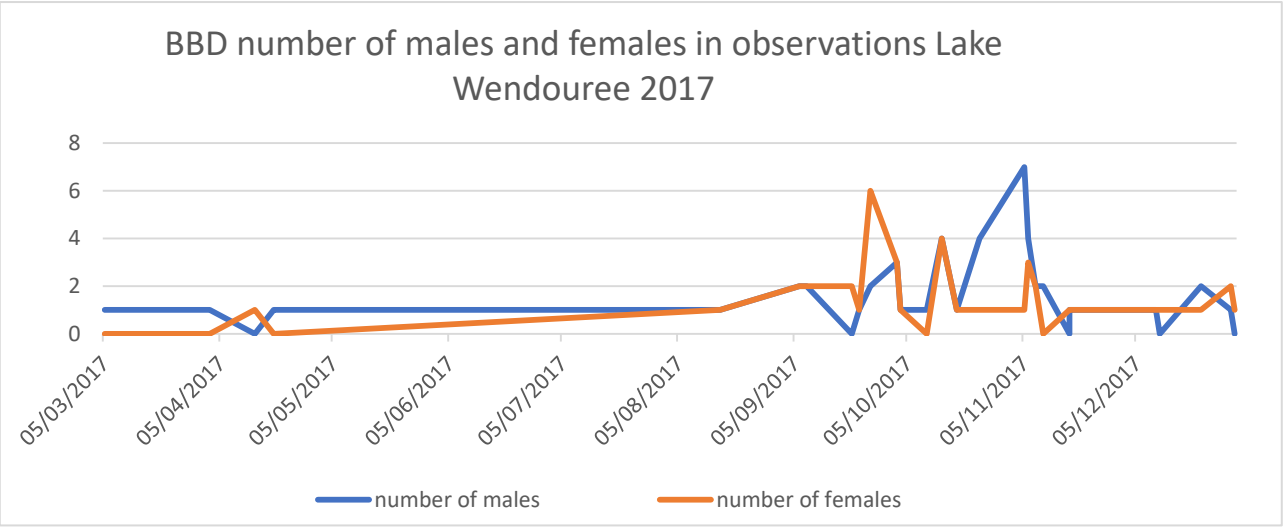


Figure 21 - Lake Wendouree Male to Female Numbers 2017

Lake Wendouree Male to Female Numbers 2018

Table 19 - Lake Wendouree Male to Female Numbers 2018

Date	Number of Males	Number of Females	Date	Number of Males	Number of Females	Date	Number of Males	Number of Females
1/01/2018	2	1	27/08/2018	4	2	26/10/2018	0	1
5/01/2018	1	1	31/08/2018	5	3	26/10/2018	1	0
23/01/2018	2	0	1/09/2018	5	2	29/10/2018	0	1
25/01/2018	2	1	2/09/2018	2	0	29/10/2018	1	3
9/02/2018	2	0	3/09/2018	4	1	2/11/2018	1	0
18/02/2018	1	0	4/09/2018	5	2	3/11/2018	0	1
19/02/2018	2	1	5/09/2018	2	0	17/11/2018	2	2
4/06/2018	1	2	5/09/2018	5	3	18/11/2018	1	0
11/07/2018	3	0	7/09/2018	3	1	22/11/2018	2	0
16/07/2018	1	0	8/09/2018	2	1	24/11/2018	3	2
17/07/2018	1	0	24/09/2018	5	3	4/12/2018	2	0
18/07/2018	2	2	25/09/2018	4	2	6/12/2018	2	1
23/07/2018	3	1	28/09/2018	2	1	7/12/2018	1	0
24/07/2018	1	3	30/09/2018	3	0	9/12/2018	3	2
25/07/2018	1	2	2/10/2018	1	0	10/12/2018	2	1
27/07/2018	0	2	5/10/2018	3	1	18/12/2018	3	1
30/07/2018	5	4	7/10/2018	2	1	20/12/2018	7	4
31/07/2018	2	4	9/10/2018	0	1	22/12/2018	1	0
3/08/2018	5	3	9/10/2018	1	0	23/12/2018	5	0
5/08/2018	5	3	12/10/2018	1	0	24/12/2018	2	0
6/08/2018	5	3	14/10/2018	1	0	24/12/2018	9	2
10/08/2018	2	2	14/10/2018	3	0	27/12/2018	5	2
14/08/2018	5	3	14/10/2018	5	1	30/12/2018	3	2
15/08/2018	3	1	15/10/2018	3	0	**Totals**	**206**	**97**
17/08/2018	4	2	17/10/2018	3	0			
18/08/2018	1	0	19/10/2018	0	1			
22/08/2018	4	3	21/10/2018	3	0			

24/08/2018	4	0	22/10/2018	1	1
26/08/2018	0	1	22/10/2018	1	0
			24/10/2018	1	0

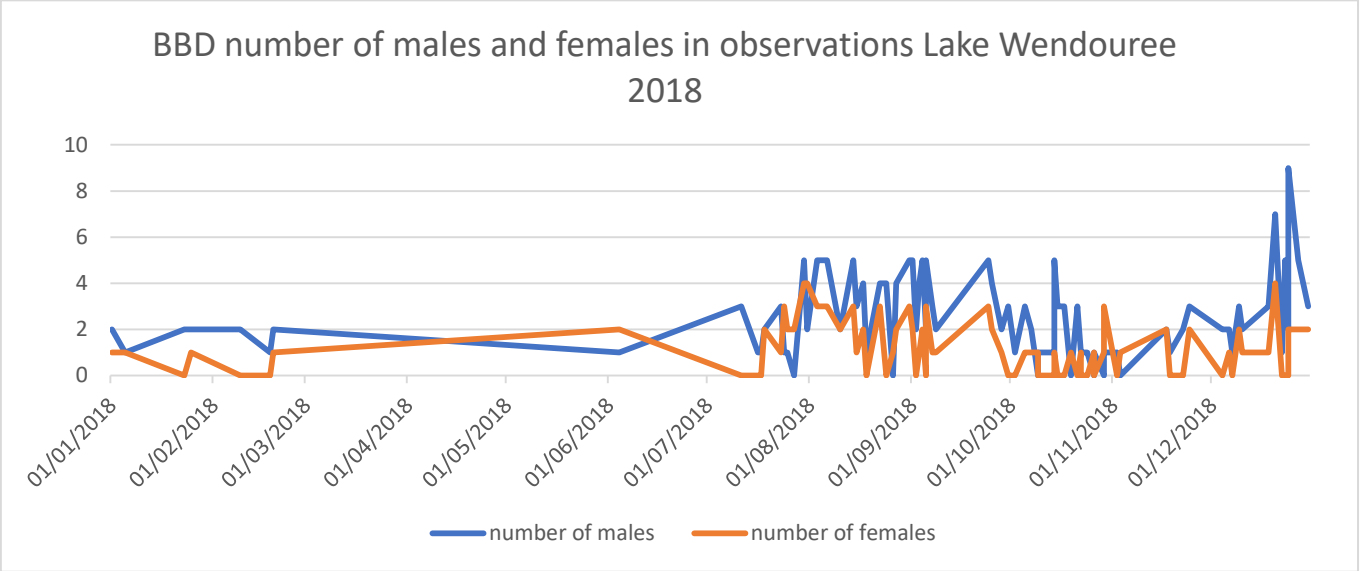


Figure 22 - Lake Wendouree Male to Female Numbers 2018

Lake Wendouree Male to Female Numbers 2019

Table 20 - Lake Wendouree Male to Female Numbers 2019

Date	Number of Males	Number of Females	Date	Number of Males	Number of Females
1/01/2019	0	1	18/07/2019	1	0
5/01/2019	0	1	19/07/2019	2	0
6/01/2019	1	0	27/08/2019	1	1
8/01/2019	1	0	12/09/2019	0	1
10/01/2019	1	0	14/09/2019	1	1
15/01/2019	1	0	17/09/2019	0	1
18/01/2019	1	0	26/09/2019	2	0
21/01/2019	1	0	5/10/2019	1	1
23/01/2019	1	0	11/10/2019	1	0
24/01/2019	1	0	17/10/2019	1	0
26/01/2019	1	0	23/10/2019	1	0
28/01/2019	1	1	31/10/2019	1	0
29/01/2019	1	0	7/11/2019	1	0
7/02/2019	1	0	18/11/2019	0	1
8/02/2019	1	0	18/11/2019	1	0
14/02/2019	0	1	19/11/2019	0	1
16/02/2019	0	1	28/11/2019	1	0
27/05/2019	1	0	8/12/2019	2	1
29/05/2019	1	1	9/12/2019	0	1
18/06/2019	1	4	14/12/2019	1	1
20/06/2019	2	2	20/12/2019	1	1
21/06/2019	2	2	26/12/2019	0	1
1/07/2019	2	3	30/12/2019	2	1
12/07/2019	1	1	31/12/2019	1	1
14/07/2019	3	4	**Totals**	**48**	**36**

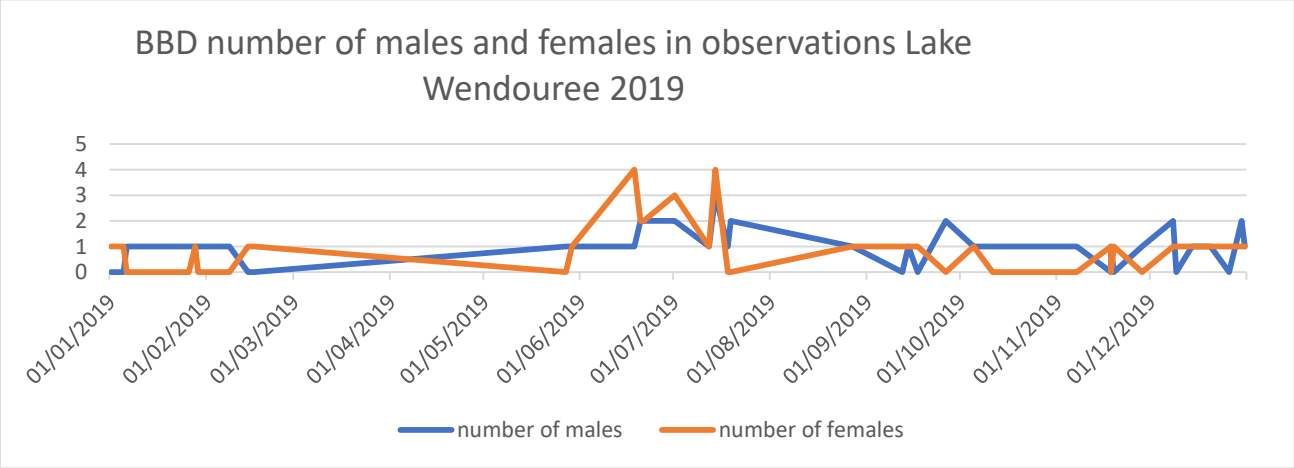


Figure 23 - Lake Wendouree Male to Female Numbers 2019

Braeside Park Male to Female Numbers 2016

Braeside Park in Melbourne's south-east is an interesting study in a close metropolitan area.

Table 21 - Braeside Park Male to Female Numbers 2016

Date	Number of Males	Number of Females
26/06/2016	1	0
3/07/2016	2	0
16/07/2016	1	0
19/07/2016	2	1
4/08/2016	4	0
8/08/2016	6	2
13/08/2016	3	0
14/08/2016	7	1
17/08/2016	4	1
3/09/2016	2	0
20/09/2016	5	2
6/10/2016	1	1
25/10/2016	1	0
10/11/2016	2	0
15/11/2016	1	0
27/11/2016	2	0
Totals	**44**	**8**

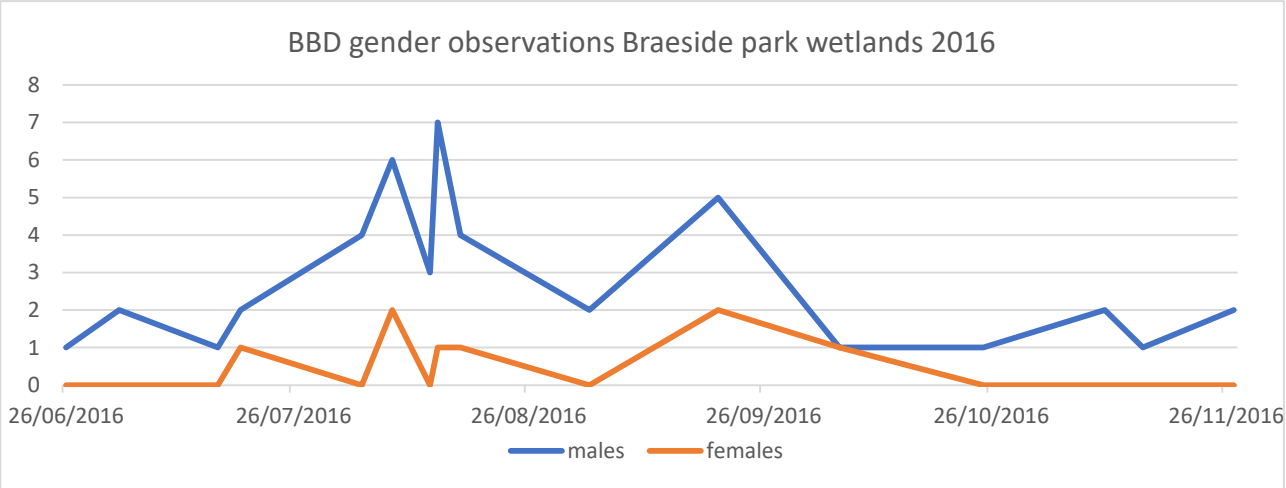


Figure 24 - Braeside Park Male to Female Numbers 2016

Braeside Park Male to Female Numbers 2017

Table 22 - Braeside Park Male to Female Numbers 2017

Date	Number of Males	Number of Females	Date	Number of Males	Number of Females
1/01/2017	2	1	24/06/2017	8	4
27/02/2017	0	1	28/06/2017	5	3
17/03/2017	1	0	7/07/2017	5	2
12/04/2017	0	1	10/07/2017	6	5
17/04/2017	1	0	17/07/2017	6	6
24/04/2017	2	0	23/07/2017	4	1
29/04/2017	2	3	28/07/2017	10	6
5/05/2017	3	3	1/08/2017	7	4
9/05/2017	3	1	9/08/2017	1	1
14/05/2017	3	3	20/08/2017	7	6
17/05/2017	3	3	26/08/2017	10	2
23/05/2017	4	1	1/09/2017	6	5
25/05/2017	2	4	9/09/2017	10	5
27/05/2017	4	4	16/09/2017	2	1
29/05/2017	4	2	10/10/2017	9	4
1/06/2017	2	2	2/11/2017	2	1
7/06/2017	5	2	9/11/2017	2	1
12/06/2017	4	3	27/11/2017	5	2
20/06/2017	4	3	17/12/2017	5	1
			Totals	**159**	**97**

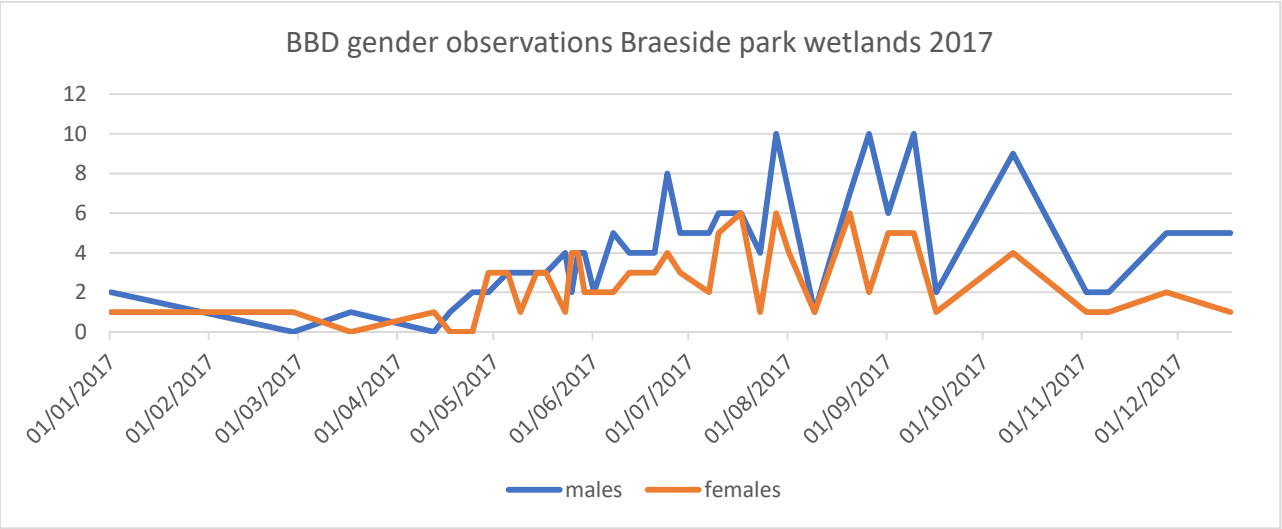


Figure 25 - Braeside Park Male to Female Numbers 2017

Braeside Park Male to Female Numbers 2018

Table 23 - Braeside Park Male to Female Numbers 2018

Date	Number of Males	Number of Females	Date	Number of Males	Number of Females
5/01/2018	4	2	20/08/2018	14	8
4/02/2018	3	1	23/08/2018	7	6
18/02/2018	4	4	28/08/2018	12	5
4/03/2018	3	0	5/09/2018	13	5
4/04/2018	2	0	9/09/2018	10	9
21/04/2018	3	2	13/09/2018	7	3
29/04/2018	2	0	20/09/2018	5	4
13/05/2018	2	1	23/09/2018	13	6
21/05/2018	1	0	25/09/2018	12	6
26/05/2018	6	0	30/09/2018	8	7
28/05/2018	6	1	3/10/2018	10	8
1/06/2018	7	1	14/10/2018	4	1
6/06/2018	5	1	19/10/2018	6	4
10/06/2018	7	4	29/10/2018	6	4
15/06/2018	6	2	3/11/2018	2	2
20/06/2018	8	3	4/11/2018	8	6
24/06/2018	8	1	9/11/2018	6	5
29/06/2018	6	4	11/11/2018	10	5
1/07/2018	9	4	15/11/2018	9	6
6/07/2018	10	5	25/11/2018	8	6
12/07/2018	10	5	29/11/2018	7	3
19/07/2018	11	5	9/12/2018	3	1
22/07/2018	9	5	19/12/2018	5	0
28/07/2018	7	6	22/12/2018	8	2
5/08/2018	9	7	26/12/2018	2	0
12/08/2018	12	9	**Totals**	**355**	**185**

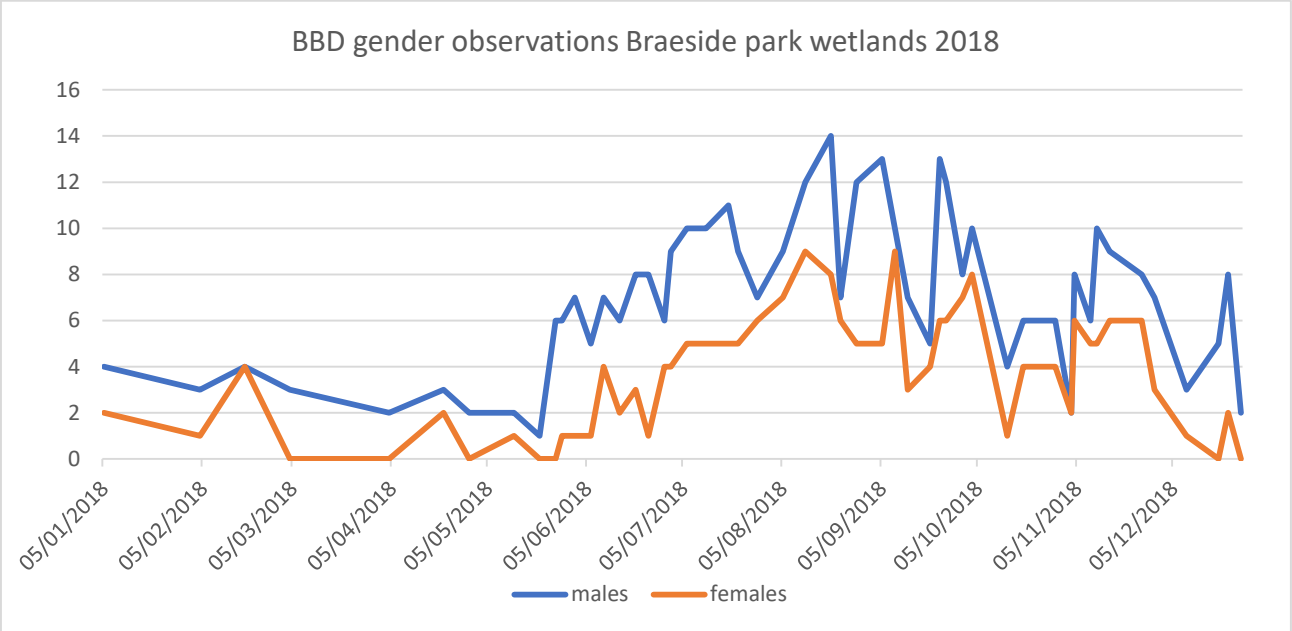


Figure 26 - Braeside Park Male to Female Numbers 2018

Braeside Park Male to Female Numbers 2019

Table 24 - Braeside Park Male to Female Numbers 2019

Date	Number of Males	Number of Females	Date	Number of Males	Number of Females	Date	Number of Males	Number of Females
1/01/2019	1	0	24/04/2019	2	0	17/09/2019	1	1
5/01/2019	3	0	1/05/2019	2	0	20/09/2019	2	2
12/01/2019	4	1	5/05/2019	1	0	22/09/2019	3	4
21/01/2019	4	0	30/05/2019	2	1	26/09/2019	4	4
27/01/2019	5	2	31/05/2019	2	1	29/09/2019	4	2
4/02/2019	4	0	2/06/2019	3	1	4/10/2019	5	4
7/02/2019	0	1	4/06/2019	3	1	6/10/2019	3	3
10/02/2019	5	3	6/06/2019	2	1	10/10/2019	9	1
15/02/2019	6	2	13/06/2019	2	2	13/10/2019	6	1
17/02/2019	6	0	15/06/2019	3	0	18/10/2019	1	1
25/02/2019	4	0	15/06/2019	3	2	20/10/2019	7	2
27/02/2019	6	1	23/06/2019	5	3	25/10/2019	5	4
3/03/2019	0	1	26/06/2019	6	4	27/10/2019	8	4
5/03/2019	6	1	3/07/2019	9	1	30/10/2019	8	4
5/03/2019	6	2	7/07/2019	6	2	6/11/2019	8	2
7/03/2019	4	2	14/07/2019	5	4	11/11/2019	5	4
8/03/2019	2	2	19/07/2019	7	3	16/11/2019	4	2
11/03/2019	3	1	25/07/2019	4	1	24/11/2019	7	2
15/03/2019	4	2	28/07/2019	5	2	29/11/2019	4	4
17/03/2019	6	1	2/08/2019	3	4	5/12/2019	6	3
19/03/2019	2	1	4/08/2019	5	5	8/12/2019	7	6
20/03/2019	0	2	11/08/2019	10	5	13/12/2019	6	4
24/03/2019	1	1	20/08/2019	4	3	15/12/2019	8	7
29/03/2019	1	0	23/08/2019	5	2	22/12/2019	7	6
31/03/2019	6	2	30/08/2019	4	2	26/12/2019	5	1
3/04/2019	1	2	3/09/2019	4	4			
5/04/2019	1	1	4/09/2019	8	4	**Totals**	**356**	**177**
7/04/2019	2	0	8/09/2019	5	4			
11/04/2019	4	0	11/09/2019	4	4			
14/04/2019	1	1	14/09/2019	1	1			

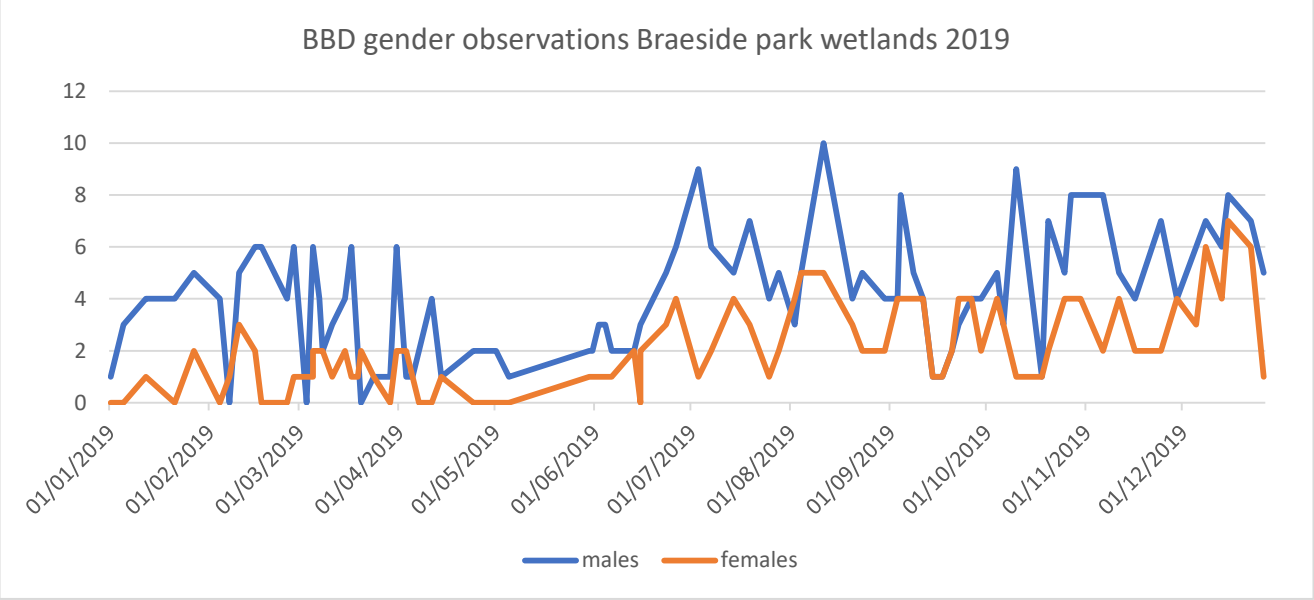


Figure 27 - Braeside Park Male to Female Numbers 2016

Lake Knox Male to Female Numbers Late-2020/mid-2021

Lake Knox, an outer metro site, was attended regularly by two of the authors (R. Plew and J. Cull) which enabled more frequent observation numbers

Table 25 - Lake Knox Male to Female Numbers Late 2020/mid-2021

Date	Males	Females/Duckling/Immature Females
October Week 3 & 4 2020	3	1
November Week 1 & 2 2020	4	3
November Week 3 & 4 2020	3	2
December Week 1 & 2 2020	3	0
December Week 3 & 4 2020	3	1
January Week 1 & 2 2021	2	2
January Week 3 & 4 2021	2	1
February Week 1 & 2 2021	2	1
February Week 3 & 4 2021	3	1
March Week 1 & 2 2021	2	2
March Week 3 & 4 2021	2	2
April Week 1 & 2 2021	1	3
April Week 3 & 4 2021	1	2
May Week 1 & 2 2021	2	3
May Week 3 & 4 2021	1	2
June Week 1 & 2 2021	3	2
June Week 3 & 4 2021	3	2
July Week 1 & 2 2021	3	1
July Week 3 & 4 2021	4	1
August Week 1 & 2 2021	4	1
August Week 3 & 4 2021	3	1
Totals	**54**	**16**

- *Note* : March Week 1 a duckling was born which was an immature female and in April another immature female was noted on the lake so these were included in the Females/Duckling/Immature Females column

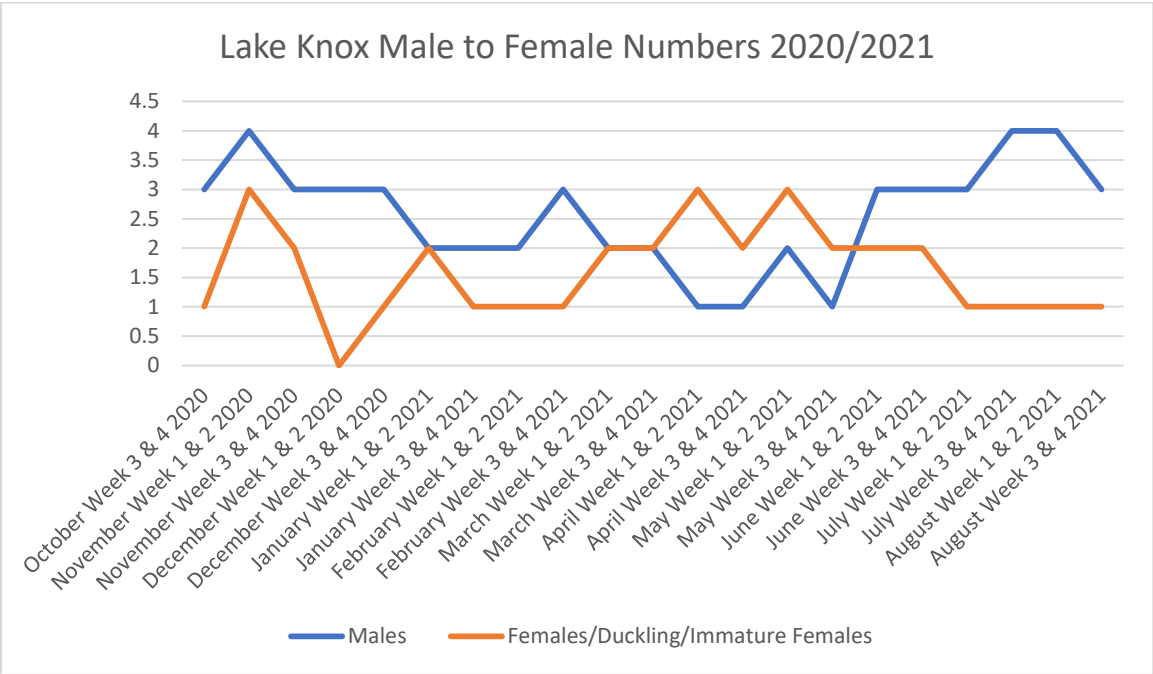


Figure 28 - Lake Knox Male to Female Numbers Late 2020/mid-2021

Generally across sites, the gender ratio shows more males to females. If the males and females are born in equal numbers it raises the question – Where are the missing females? It is noted the females being a mottled brown and slightly smaller are more difficult to pick up however the trend is significant. No conclusion could be drawn and it is a potential area of further research.

Conclusion to BBD Observation Records Deep-dive and Minimum Open Water Distance Required plus Breeding Habitat Requirements

Three Main BBD Habitat Types Identified and their Different Values

The records study indicated three main habitat types for the Blue-billed Duck –

- **Breeding Habitat** - Widely distributed sites, smaller in nature with fewer BBD's residing, in numbers typically less than 10. These habitats have the highest value as they replenish the species and require an increased level of protection.
- **Loafing Habitat** - This habitat type had typically high to very high numbers of BBD's on much higher water areas including on many artificial sewage treatment and settling ponds. There was no reported breeding on these sites which gives them a medium rating as they are not directly contributing to replenishment, or recruitment, of the species.
- **Drop-in Habitat** - BBD's were infrequently observed and generally only for the day as seen in the observations per site over time spreadsheet. These could be transit sites for migration or, perhaps more likely, have unfavourable characteristics such as pollution with little to no feeding, little aquatic vegetation, little fringing vegetation suitable for nesting, shallow and hence transient nature – disappearing in drought times. Some sites with prior ongoing habitation were seen to drop into this category suggesting habitat quality decline – due potentially to pollution, salinity, European Carp infestation (Reference 3, Purdey-Loyn, 2008), and increasing recreational use. This is the least value habitat type.

Suggested Minimum Open Water Distance Required for the BBD Habitats of 110m

A search of 15,955 observations records of the BBDs from 2015 to mid-2021 was made in order to identify the observation location and the dimensions and area of the waterbodies – notably searching for the minimum open water distance required by the BBD. Records were obtained from the VBA – which included some iNaturalist records, along with all eBird and Birdata records from 2015 to the July/August 2021. This records check and summary strongly suggested the BBD requires from 97 metres of clear, open water, unimpeded by surrounding trees, to enter or exit a waterbody, however this was one sighting. 110 metres had more sightings suggesting that was the more reasonable minimum distance required. This is further complicated by the finding from the 27 known breeding habitats, where the lowest maximum open water distance was 140 metres. The ducks were not observed on smaller waterbodies unless they were either connected directly to a larger body, or unenclosed by tall trees allowing a theoretical shorter fly-hop onto the smaller body, presumed to enter and exit via flight from the larger waterbody also present.

Personal site observations strongly suggested the relatively long open water distance required by the species to be most likely due to –

- The relatively heavy body weight of the BBD compared to other water birds and the small wing-to-body ratio of the BBD requiring a much higher surface speed required to achieve and maintain flight
- The shallow angle of ascent from and descent onto a waterbody due to the above weight and low wing-to-body ratio

A Note on the Minimum Open Water Distance Required for Blue-billed Ducks

While local observations by the authors and the analysis of 15,955 records from VBA, eBird and Birdata showed the Minimum Open Water Distance Required by the Blue-billed Duck of 97 metres, this does not preclude the species from limited access to smaller waterbodies. Newly fledged birds, lighter weight than older adults, will explore and discover the limits of site access of waterbodies, learning what is possible to access and exit and what is not. The lack of sightings on smaller waterbodies does not mean the birds do not occasionally access

smaller sites, however the vast number of records above this 97 metre mark and those sites showing clear ongoing habitation being much larger strongly suggests an extra margin required to 110 metres or more if creating an artificial waterbody to attract Blue-billed Duck habitation and breeding.

Suggested Required Characteristics for BBD Breeding Habitats – the Most Important Habitat Type

There were a small number of records indicating breeding of the species - these breeding habitat sites shared common traits -

- At least 140 metres of deep and open water with no possibility of overgrowth and not impeded by tall trees and other high vegetation.
- Significant visible aquatic vegetation such as Ribbon Weed, and benthic vegetation such as Eel Grass to support a wide range of invertebrates.
- Significant areas of fringing Bull Rush (Cumbungi) for nesting which verges the deep and open water.
- An absence of European Carp which cloud the water and damage or destroy Benthic vegetation, the turbidity reducing or stopping the growth or regeneration of the vegetation, reducing invertebrates (Reference 3, Purdey-Loyn, 2008).

Other sites with significant bird numbers, loafing/feeding habitats, typically water treatment plants or reservoirs, showed no breeding, no or little visible aquatic vegetation, and little or no fringing Bull Rush (Cumbungi) for nesting. These “Loafing Habitats”, although with significant numbers of birds, are far less significant than the breeding habitats that replenish the species.

Other sites with smaller bird numbers and very few observation records were typically around 100 to 130 metres in open water length, however could be narrow, relatively shallow, have no or little visible aquatic vegetation, and no fringing Bull Rush (Cumbungi). The few observations and low numbers suggest birds were dropping-in for the day, some feeding or attempting to feed, then leaving the site as it was unsuitable for habitation. These day-tripping or drop-in habitats are considered the least valued habitat category. These habitats are also possibly used for resting and feeding on longer flight migration trips, so may still serve an important purpose.

This records search and summary then strongly suggests that any artificial waterbody created specifically for the Blue-billed Duck requires the following:

- A minimum clear, open water distance of at least 140 metres. This cannot be restricted by fringing vegetation such as reeds to tall trees which would then require compensation for the shallow flight ascension or landing angle, significantly increasing the open water distance to allow for this obstacle clearance by the BBD’s. Given the artificial waterbody design requirement for ‘safety’ of a shallow gradient, the potential of this for future overgrowth from reeds and other aquatic vegetation would require that additional calculation to be made in addition to the minimum open water distance, significantly increasing the size of artificial waterbodies for BBD’s.
- Deep water - from a minimum of 1.5 to 2 metres, up to 5 metres for the variety of aquatic plants, insects, invertebrates, etc. that the BBD’s require for feeding - deep and cold water, not shallow and warm, to ensure no future overgrowth by fringing vegetation and less likelihood of drying out during the prolonged drought periods predicted for accelerating climate change.
- A variety of aquatic vegetation such as Ribbon Weed and benthic vegetation such as Eel Grass etc. to encourage and sustain a large variety of seeds and fruits, insects/larvae, invertebrates, etc. for feeding.
- Bull Rush (Cumbungi) for nesting, verging directly onto the deep and open water, for security of the BBD’s in escaping predators in a dive and for close feeding of newly hatched BBD’s. Also for the frequent return to the nest of the young to warm up after diving to feed sessions.

- Ideally closed to recreational use, with breeding habitats preferably fenced to keep out predators such as foxes, dogs and cats. Close human contact without fencing disturbs the birds which are seen to retreat 50 to 150 metres away, depending on size of waterbody. Close approach by the birds to people is seen in fenced situations, under the bird's control. The birds are seen to be aggravated by close human approach without fencing which also discourages nesting and hence disturbed birds leaving the site and no breeding.

BBD Conservation Status Linked to High Claimed Numbers on Non-breeding Loafing Habitats Driving Destruction of Breeding Habitats and Species Decline

There were relatively low numbers of reported sightings with huge BBD numbers, however no photographic evidence provided or explanation of the method used to estimate these numbers. The site observations spreadsheet tracking BBD numbers over time indicates the species is in decline within Victoria. With the species more routinely observed on widely distributed sites, with bird counts typically less than 10, there would be an issue if the potential future of the species is pinned on a conservation status which is mainly informed by these unsubstantiated high numbers on a relatively few non-breeding loafing habitats.

These loafing habitats continue to show no breeding and the ongoing loss of breeding habitats to development, which are characterised by less than 10 BBD's, continues to be based on the noted trait of the species to breed on widely distributed sites in numbers typically less than 10. To then base the destruction of these highest value habitats based on the species trait for privacy or seclusion we believe is contributing to the ongoing decline. If breeding habitats are removed or otherwise negatively impacted due to the typically low numbers of BBD's, there will continue to be a decline in the high numbers claimed to be observed on loafing habitats. Further research into breeding habitats specifically, and their characteristics, is urgently suggested to stop and reverse the decline and protect these most valued habitats.

Recommended Areas for Further Research into the Blue-billed Duck

As this study is based primarily on the database records search with a relatively small inclusion of limited onsite species observations, it indicates a number of potential areas for further research –

- Standards for BBD count estimates based on sightings including photographic evidence rather than guesstimates and potential misidentification with other mixed similar species such as the Chestnut Teal and Grey Teal. A number of sightings were shown to be misidentified Chestnut Teal, or mixing with Teal, which are very similar from a distance. Lack of evidence in number counts has the potential for parties with vested interests making false claims without evidence, inflating numbers to lower the Conservation Status in favour of greenspace development and habitat destruction.
- Standards for observation periods and practices. For example the 'Healthy Waterways Strategy – Wetlands Monitoring and Evaluation Plan, v1.0 2020', page 86 (Reference 4), advises observations must be completed within 3 hours of sunrise and sightings recorded only in Birdlife Australia (Birdata). It was noted the female BBD on Lake Knox only brought the ducking onto the lake when the temperature rose – after this 3 hour window. How many breeding events are missed by this restrictive practice and how many valuable observations are overlooked by only scrutinising this one source? Other popular sources include eBird and iNaturalist along with VBA.
- Given accelerating climate change, research into whether increasingly shorter timeframes for habitat checks and population counts to inform conservation status and hence conservation actions is required in order to minimise the potential of species decline or loss due to longer droughts with large non-breeding flocks on Water Treatment Plants and other deeper loafing habitats with shorter intervening periods for breeding (Reference 8), along with the potential loss of many breeding habitats due to drying and overgrowth. The decades-old timeframes need to be revised to take into account the accelerating decline of the environment and habitat. A conservation status based on claimed numbers a decade or more ago, when more recent observations indicate rapid declines, is a potentially destructive practice.

A weighting of recent counts over increasingly dated counts is potentially a more accurate conservation status indicator.

- A study into the trend of habitat loss to development, salinity, overgrowth, loss to increasing predicted droughts due to accelerating climate change, invasive species such as European Carp (Purdey-Loyn, 2008 – Reference 3) or other over-breeding competing species such as Eurasian Coot, etc.
- Greater scrutiny of a wider number of potential habitats during the breeding season to ascertain where the species is breeding and in what numbers. The large loafing habitat sightings are ultimately sourced from a widely distributed and unknown number of breeding habitat locations. Not knowing where they are breeding could lead unknowingly to breeding habitat destruction and ongoing decline of the species.
- Research into the characteristics of the different habitat types and what makes them suitable for both ongoing habitation and breeding, including depth requirements for this deep-diving species and the benthic vegetation supporting invertebrate species and the vegetation itself required for feeding (HANZAB – Reference 7) which is impacted by turbidity and water column temperature. Importantly, research into the lake and wetland habitats, both natural and artificial, that don't have BBD habitation to understand why not and avoid those negative traits in artificial wetland design. A higher habitat rating for breeding habits should result in a greater level of protection and resources for enhancement of pest, pollution and weed control measures.
- Research into the flight characteristics of the BBD – relative weight of the bird and the small wing-to-body ratio, speed required for flight, minimum distance for both take-off and landing, angle of ascent and descent which would impact the ability for obstacle clearance – such as the closeness and height of fringing vegetation. A greater understanding of these characteristics will point to waterbody sizes they simply cannot access.
- The number of ducklings per hatching and whether there may be a declining trend.
- The male-to-female ratio on habitats. It is assumed there is an equal ratio, however the records search and on-site observations showed a higher male-to-female ratio.

Literature References

1. Flora and Fauna Guarantee, Victoria Action Statement No 174 Blue-billed duck *Oxyura australis* Department of Sustainability and Environment 2003 (DSE 2003) https://www.environment.vic.gov.au/__data/assets/pdf_file/0026/32858/Blue-billed_Duck_Oxyura_australis.pdf
2. SWIFFT State Wide Integrated Flora and Fauna teams – Blue-billed duck http://www.swifft.net.au/cb_pages/sp_blue-billed_duck.php
3. Wetland use by Blue-billed Ducks Oxyura australis during Summer Waterfowl Counts in north-west Victoria, 1984-2008 Dan Purdey and Richard Loyn Arthur Rylah Institute for Environmental Research (Unpublished 2008)
4. Healthy Waterways Strategy – Wetlands Monitoring and Evaluation Plan, v1.0 2020 https://healthywaterways.com.au/sites/default/files/2021-03/HWS-Wetlands-Monitoring-and-Evaluation-Plan-v1.0-2020.pdf
5. Biodiversity in Maroondah Volume 1 February 2019 Graeme S. Lorimer Maroondah City Council Draft version - Biodiversity in Maroondah_Volume 1
6. Flora and Fauna Guarantee Act 1988 – Threatened List https://www.environment.vic.gov.au/__data/assets/pdf_file/0031/536089/FFG-Threatened-List-August-2021-v2.pdf
7. Marchant S. & Higgins P. eds. 1990 The Handbook of Australian, New Zealand and Antarctic Birds Vol 1 - Blue-billed Duck, pages 1142 to 1151 (HANZAB)
8. Waterbird Monitoring at the Western Treatment Plant 2000-12 https://www.researchgate.net/publication/287699205_Waterbird_monitoring_at_the_Western_Treatment_Plant_2000-12_The_effects_of_climate_and_sewage_treatment_processes_on_waterbird_populations

Database and Statistical References

1. VBA – The Victorian Biodiversity Atlas https://vba.dse.vic.gov.au/vba/#/
2. eBird Australia https://ebird.org/australia/home
3. Birdata – BirdLife Australia https://birdata.birdlife.org.au/
4. iNaturalist Australia https://www.inaturalist.org/projects/wildlife-of-lake-knox
5. R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Appendices

Appendix 1 : Report Reference - Oxyura-Australis -VBA-Ebird-Birdata-Wetland datasets 2015-to-30August2021.xlxs

The reference source of 15,955 records of Blue-billed Duck observations for Victoria from VBA – Victorian Biodiversity Atlas, eBird Australia and Birdata – BirdLife Australia, from 2015 to mid-2021

Appendix 2 : Report Reference - Blue-bill Numbers tally trends 2015-to-30August2021.xlsx
The reference data records sorted by habitat site showing Blue-billed Duck tallies for Victoria from 2015 to mid-2021 indicating the declining species trend and potentially changes of site quality from ongoing habitat to infrequent drop-ins to no sightings.

Appendix 3 : Report Reference - Blue-bill Breeding Records 2015-to-30August2021.xlsx
A subset of the reference data showing all sites in Victoria that showed successful breeding – 27 sites from 2015 to mid-2021.

* A mother Blue-billed Duck warns off a male Blue-billed Duck too close to her Duckling, March 2021. Photo : Joshua Tomlinson

* A Female Blue-billed Duck and her Duckling, Lake Knox, March 6th 2021. Photo : Joshua Tomlinson